SpiceyPy Documentation

Release 5.1.0

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Jul 10, 2022

CONTENTS

CHAPTER

ONE

INTRODUCTION

SpiceyPy is a python wrapper for the SPICE Toolkit. SPICE provides access and tools to interact with planetary and spacecraft ephemeris and ancillary engineering information. Please visit the NAIF website for more details about SPICE.

IMPORTANT: The code is provided "as is", use at your own risk.

CHAPTER

TWO

CITING SPICEYPY

If you are publishing work that uses SpiceyPy, please cite SpiceyPy and the SPICE toolkit. SpiceyPy can be cited using the JOSS DOI (*https://doi.org/10.21105/joss.02050*) or with the following:

> Annex et al., (2020). SpiceyPy: a Pythonic Wrapper for the SPICE Toolkit. Journal of Open Source Software, 5(46), 2050, https://doi.org/10.21105/joss.02050

Instructions for how to cite the SPICE Toolkit are available on the NAIF website:

> https://naif.jpl.nasa.gov/naif/credit.html.

To cite information about SpiceyPy usage statistics, please cite my 2017 and or 2019 abstracts as appropriate below:

1. 2017 abstract: https://ui.adsabs.harvard.edu/abs/2017LPICo1986.7081A/abstract.
2. 2019 abstract: https://ui.adsabs.harvard.edu/abs/2019LPICo2151.7043A/abstract.

CHAPTER

THREE

DOCUMENTATION OVERVIEW

This is the documentation for SpiceyPy. The documentation for each function in the wrapper is in large part copied from the "Abstract" and "Brief_I/O" sections of the corresponding CSPICE function documentation. Each wrapper function has a link back to the corresponding original CSPICE function documentation hosted at the NAIF website. For more in-depth information about SPICE, please visit the NAIF website or click here to view the entire CSPICE documentation.

The intent of the function doc-strings is to serve only as a quick reference to what the parameter's expected types are for the purpose of getting started with the wrapper. As each function has a link to the CSPICE documentation for that function, more detailed explanations are deferred to the NAIF via those links.

Contents:

3.1 Citing SpiceyPy

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3.2 Installation

SpiceyPy is currently supported on Mac, Linux, FreeBSD, and Windows systems.

If you are new to python, it is a good idea to read a bit about it first https://docs.python-guide.org. For new installations of python, it is encouraged to install and or update: pip, setuptools, wheel, and numpy first before installing SpiceyPy

```
pip install -U pip setuptools wheel
pip install -U numpy
```

Then to install SpiceyPy, simply run:

```
pip install spiceypy
```

3.2.1 If you use anaconda/miniconda/conda run:

```
conda config --add channels conda-forge
conda install spiceypy
```

If no error was returned you have successfully installed SpiceyPy. To verify this you can list the installed packages via this pip command:

```
pip list
```

You should see spicepy in the output of this command. Or you can start a python interpreter and try importing SpiceyPy like so:

As of 04/10/2021, spiceypy has experimental support for 64bit ARM processors for linux and macos (linux-aarch64 & osx-arm64) via the conda-forge distribution.

```
import spiceypy

# print out the toolkit version installed
print(spiceypy.tkvrsn('TOOLKIT'))
```

This should print out the toolkit version without any errors. You have now verified that SpiceyPy is installed.

3.2.2 Offline installation

If you need to install SpiceyPy without a network or if you have a prebuilt shared library at hand, you can override the default behaviour of SpiceyPy by using the CSPICE_SRC_DIR and CSPICE_SHARED_LIB environment variables respectively.

For example, if you have downloaded SpiceyPy and the CSPICE toolkit, and extracted CSPICE to /tmp/cspice you can run:

```
export CSPICE_SRC_DIR="/tmp/cspice"
pip install .
```

Or if you have a shared library of CSPICE located at /tmp/cspice.so, you can run:

```
export CSPICE_SHARED_LIB="/tmp/libcspice.so"
pip install .
```

Both examples above assume you have cloned the SpiceyPy repository and are running those commands within the project directory.

Note: As of version 4.0.3 you can also add libcspice to you LD_LIBRARY_PATH or use the CSPICE_SHARED_LIB environment variable at runtime (prior to importing spiceypy) to override which cspice shared library is used.

3.2.3 A simple example program

This script calls the spiceypy function 'tkvrsn' and outputs the return value.

```
File tkvrsn.py

   from __future__ import print_function
   import spiceypy

   def print_ver():
           """Prints the TOOLKIT version
           """
           print(spiceypy.tkvrsn('TOOLKIT'))

   if __name__ == '__main__':
           print_ver()
```

From the command line, execute the function:

```
$ python tkvrsn.py
CSPICE_N0066
```

From Python, execute the function:

```
$ python
>>> import tkvrsn
>>> tkvrsn.print_ver()
CSPICE_N0066
```

3.2.4 SpiceyPy Documentation

The current version of SpiceyPy does not provide extensive documentation, but there are several ways to navigate your way through the Python version of the toolkit. One simple way is to use the standard Python mechanisms. All interfaces implemented in SpiceyPy can be listed using the standard built-in function dir(), which returns an alphabetized list of names comprising (among) other things, the API names. If you need to get additional information about an API parameters, the standard built-in function help() could be used:

```
>>> import spiceypy
>>> help(spiceypy.tkvrsn)
```

which produces

```
Help on function tkvrsn in module spiceypy.spiceypy:

tkvrsn(item)
    Given an item such as the Toolkit or an entry point name, return
    the latest version string.

    https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tkvrsn_c.
html

    :param item: Item for which a version string is desired.
    :type item: str
```

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```
    :return: the latest version string.
    :rtype: str
```

As indicated in the help on the function, the complete documentation is available on the CSPICE toolkit version. Therefore it is recommended to have the CSPICE toolkit version installed locally in order to access its documentation offline.

3.3 Common Issues

3.3.1 SSL Alert Handshake Issue

Attention: As of 2020, users are not likely to experience this issue with python version 3.7 and above, and for newer 3.6.X releases. Users running older operating systems are encouraged to update to newer versions of python if they are attempting to install version 3.0.0 or above. See other sections of this document for more information.

In early 2017, JPL updated to a TLS1.2 certificate and enforced https connections causing installation issues for users, in particular for macOS users, with OpenSSL versions older than 1.0.1g. This is because older versions of OpenSSL still distributed in some environments which are incompatible with TLS1.2. As of late 2017 SpiceyPy has been updated with a strategy that can mitigate this issue on some systems, but it may not be totally reliable due to known deficiencies in setuptools and pip.

Another solution is to configure a new python installation that is linked against a newer version of OpenSSL, the easiest way to do this is to install python using homebrew, once this is done spiceypy can be installed to this new installation of python (IMHO this is the best option).

If your python 3.6 distribution was installed from the packages available at python.org an included command "Install Certificates.command" should be run before attempting to install SpiceyPy again. That command installs the certifi package that can also be install using pip.

Alternatively, installing an anaconda or miniconda python distribution and installing SpiceyPy using the conda command above is another possible work around.

Users continuing to have issues should report an issue to the github repository.

Supporting links:

- https://bugs.python.org/issue29065
- https://github.com/psf/requests/issues/2022
- https://pyfound.blogspot.com/2017/01/time-to-upgrade-your-python-tls-v12.html
- https://www.python.org/dev/peps/pep-0518
- https://github.com/AndrewAnnex/SpiceyPy/pull/202

3.4 How to install from source (for bleeding edge updates)

Attention: If you have used the pip or conda install commands above you do not need to do any of the following commands. Installing from source is intended for advanced users. Users on machines running Windows should take note that attempting to install from source will require software such as visual studio and additional environment configuration. Given the complexity of this Windows users are highly encouraged to stick with the releases made available through PyPi/Conda-Forge.

If you wish to install from source, first simply clone the repository by running the following in your favorite shell:

```
git clone https://github.com/AndrewAnnex/SpiceyPy.git
```

If you do not have git, you can also directly download the source code from the GitHub repo for SpiceyPy at https://github.com/AndrewAnnex/SpiceyPy

To install the library, simply change into the root directory of the project and then run:

```
pip install .
```

The installation script will download the appropriate version of the SPICE toolkit for your system, and will build a shared library from the included static library files. Then the installation script will install SpiceyPy along with the generated shared library into your site-packages directory.

3.5 Change Log

All notable changes to SpiceyPy will be documented here

The format is based on Keep a Changelog and this project tries to adhere to Semantic Versioning.

3.5.1 [5.1.0] - 2022-07-09

adds wrappers for the majority of new function in n67

Added

- azlcpo
- azlrec
- chbigr
- chbint
- chbval
- ckfrot
- ckfxfm
- ckgr02
- ckgr03
- ckmeta

- cknr02
- cknr03
- dafhsf
- dasadc
- dasadd
- dasadi
- dashfs
- daslla
- dasllc
- dasonw
- dasops
- dasrdd
- dasrdi
- dasudd
- dasudi
- daswbr
- dazldr
- dlabns
- dlaens
- dlaopn
- dnearp
- drdazl
- ednmpt
- edpnt
- evsgp4
- getfvn
- hrmesp
- invstm
- lgresp
- lgrint
- qderiv
- recazl
- stlabx
- tagnpt
- tkfram
- tparch

- trgsep
- twovxf
- vprojg

Fixed

- fixed docstring for frinfo
- fixed freebsd support in getspice

3.5.2 [5.0.1] - 2022-03-23

minor update to make ld_library_path update safer

Fixed

- override of ld_library_path is now temporary

Changed

- updated copyrights for 2022

3.5.3 [5.0.0] - 2022-02-17

Changed

- switched to N67 CSPICE, no new wrapper functions yet
- removed deprecated named args mentioned in 4.0.1 release notes

Removed

- deprecation warnings for params of mtxmg, mtxvg, mxm, mxmg, mxmt, mxmtg, mxvg, vtmvg, xposeg, unormg, vaddg, vdistg, vdotg, vequg, vhatg, vminug, vnromg, vrelg, vsclg, vsepg, vsubg, vzerog
- ncol/nrow params for: mtxmg, mtxvg, mxm, mxmg, mxmt, mxmtg, mxvg, vtmvg, xposeg
- ndim param for: unormg, vaddg, vdistg, vdotg, vequg, vhatg, vminug, vnromg, vrelg, vsclg, vsepg, vsubg, vzerog

3.5.4 [4.0.3] - 2021-11-14

Added

- changelog now rendered in docs
- runtime override of cspice via env var or ld_library_path
- pyproject.toml and setup.cfg
- CSPICE N66 patches from NAIF/conda-forge feedstock
- builds for aarch64 and macos arm64

Changed

- switched to src layout
- switched "cspice.dll/.so" to "libcspice.dll/so"
- updated get_spice.py to build cspice from source
- moved most metadata to setup.cfg
- updated ci workflows to build wheels for major platforms using cibuildwheels
- updated install commands in docs to use pip instead of setup.py

3.5.5 [4.0.2] - 2021-08-13

Fixed

- getfat variables size #420
- safer cleanups in tests

3.5.6 [4.0.1] - 2021-05-31

Added

- docs info about ARM support, currently limited to conda-forge spiceypy
- docs citation info/basic intro
- hash checksums for test kernels
- offline install ci tests
- warn_deprecated_args function to aid future deprecations

Deprecated

- added deprecation warnings for ncol/nrow params for: mtxmg, mtxvg, mxm, mxmg, mxmt, mxmtg, mxvg, vtmvg, xposeg pending next major release.
- added deprecation warnings for ndim param for: unormg, vaddg, vdistg, vdotg, vequg, vhatg, vminug, vnromg, vrelg, vsclg, vsepg, vsubg, vzerog pending next major release.

Changed

- copyright year
- a number of typehints to accept np.ndarray
- changed test_wrapper to use a pytest autouse fixture to call reset/kclear automatically for most tests

Fixed

- missing docs for xf2eul
- numpy bool_ deprecation warnings
- numpy float warning
- type hint for appndd

3.5.7 [4.0.0] - 2020-12-07

Added

- bodeul

Changed

- main branch is now the default branch
- switched to use 'fromisoformat' in datetime2et

Fixed

- fixed nintvls spelling inconsistency

3.5.8 [3.1.1] - 2020-05-25

Fixed

- missing get_spice.py in manifest

3.5.9 [3.1.0] - 2020-05-25

Added

- added irfnam, irfnum, irfrot, irftrn
- added kpsolv, kepleq
- better exceptions, many hundred spice toolkit defined exceptions
- copy button to docs codeblocks
- added CSPICE_SRC_DRI envvar override to specify cspice src directory during install
- added CSPICE_SHARED_LIB envvar override to specify cspice.so/.dll/.dylib during install

Changed

- switch to codecov for code coverage
- various support type changes
- renamed getspice.py to get_spice.py

Fixed

- fixed missing doc strings for callbacks

Removed

- coveralls
- test cmd class in setup.py
- direct references to deprecated numpy matrix class

3.5.10 [3.0.2] - 2020-02-19

Added

- et2datetime function
- funding.yml

Changed

- changed http to https in docs/docstrings

Fixed

- many small issues with the docs
- author name in joss paper
- fixing SyntaxWarning in python 3.8
- year in docs
- issue with urllib usage in gettestkernels

3.5.11 [3.0.1] - 2020-01-10

Changed

- removed old logic from getspice for old openssl versions

Removed

- import of six in getspice

3.5.12 [3.0.0] - 2020-01-09

Added

- Python 3.8 support

Changed

- using black for code linting
- now using type hints
- vectorized functions now return numpy arrays instead of lists of arrays

Deprecated

- python 3.5
- python 2.7

3.5.13 [2.3.2] - 2019-12-19

Added

- wrapper for ev2lin
- numpy string support

Fixed

- some equality checks

Changed

- updated MANIFEST.in to include test code
- vectorization of et2utc
- vectorization of scencd
- vectroization of sc2e

3.5.14 [2.3.1] - 2019-10-18

Changed

- updated MANIFEST.in to include test code

3.5.15 [2.3.0] - 2019-09-25

Added

- wrapper for tkfram
- wrapper for ckfrot
- wrapper for zzdynrot

Fixed

- issue with dafgda absolute value problem, see issue #302

3.5.16 [2.2.1] - 2019-08-19

Changed

- set numpy version to 1.16.4 for python 2
- other dependency changes to setup.py and requirements.txt

Fixed

- typo in a unit test fixed

3.5.17 [2.2.0] - 2019-02-24

Added

- gfevnt wrapper
- easier spice cell inits
- python datetime to et converter
- issue template
- code of conduct
- NAIF python lessons to docs

Changed

- functions that modify a results spicecell now optionally create a return spicecell
- convrt now "vectorized"
- prioritized citation info in readme

Removed

- removed anaconda build steps from appveyor, conda-fordge replaces it

Fixed

- newlines in changelog

3.5.18 [2.1.2] - 2018-08-17

Added

- python 3.7 builds on travis / appveyor

Changed

- numpy to ctypes and back conversions improved

Removed

- a few bool related internal things in support_types
- conda builds on appveyor removed in favor of conda-forge distribution of spiceypy

Fixed

- issues relating to c_bool usage. everything is now c_int

3.5.19 [2.1.1] - 2018-04-24

Added

- wrapper functions for gffove and gfocce and associated callbacks
- proxymanager for spice download by B. Seignovert

Changed

- simplifications in libspicehelper

Fixed

- issue with cassini example in doc
- termpt docstring by Marcel Stefko
- various things in ci build configs
- missing dll/so file issue with pip installs

3.5.20 [2.1.0] - 2017-11-09

Added

- Completed wrapping of all new N66 DSK functions
- 3.6 classifier
- context manager for turning on/off found flag catches
- contributor guide
- freebsd support
- added tests for dozens of functions, wrapped almost all remaining functions

Fixed

- added six and numpy to setup_requires setup.py kwargs
- bugs in some tests

Changed

- changed naming of vectorToList to cVectorToPython
- Updated getspice module to use urllib3 for OpenSSL library versions older than OpenSSL 1.0.1g.
- getspice module provides now a class that handles the downloading and unpacking of N066 CSPICE distribution.
- Updated setup to pack the CSPICE installation code into a class that extends the setuptools.command.install command.
- made vectorized functions more consistent
- changed tests to point to smaller kernel set hosted on github

3.5.21 [2.0.0] - 2017-06-09

Added

- Implemented most of the new functions from N66 SPICE
- IntMatrixType support type
- SpiceDLADescr struct

Changed

- now backing N66 CSPICE
- now builds 2.7, 3.4, 3.5, 3.6

Deprecated

- 32 bit builds

Fixed

- toPythonString now strips whitespace

3.5.22 [1.1.1] - 2017-04-23

Added

- added python3.6 builds

Fixed

- fixed formatting on changelog
- fixed issues with rtd builds

Changed

- version updated
- converted all downloads to use https

3.5.23 [1.1.0] - 2016-10-19

Added

- wrapper functions and tests for fovray, fovtrg, pxfrm2, occult #158
- wrapper functions and tests for spklef, spkopa, spkpds, spksub, spkuds, spkuef #155
- tests for srxpt and sincpt #154
- a bunch of other tests for CK related functions
- example added to docs
- automated artifact deployments (mostly) to pypi and conda cloud

Fixed

- improved use of six api to have better spicecells

Changed

- Start versioning based on the current English version at 0.3.0 to help
- refactored tests to be cleaner with kernel files
- fixed spice toolkit version to N65 pending new toolkit release.

3.5.24 [1.0.0] - 2016-03-27

Added

- DOI citation information

Changed

- updated versions for pytest, coverage, coveralls
- README updates

3.5.25 [0.7.0] - 2016-03-26

Added

- python wheel builds in appveyor #117
- wrapper for gfilum function

Changed

- converted README to rst format

Fixed

- inconsistencies in doc strings #143
- issue #136

3.5.26 [0.6.8] - 2016-03-07

Got to a semi complete api here, lots of commits before things so this version can be considered a bit of a baseline

Added

- many things

Changed

- the game

Deprecated

- nothing important

Removed

- what had to go

Fixed

- it

3.6 Cassini Position Example

Below is an example that uses spiceypy to plot the position of the Cassini spacecraft relative to the barycenter of Saturn.

```
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
```

First import spiceypy and test it out.

```
import spiceypy as spice
```

```
# Print out the toolkit version
spice.tkvrsn("TOOLKIT")
```

```
'CSPICE_N0066'
```

We will need to load some kernels. You will need to download the following kernels from the NAIF servers via the links provided. After the kernels have been downloaded to a common directory write a metakernel containing the file names for each downloaded kernel (provided after the links). I named the metakernel 'cassMetaK.txt' for this example. For more on defining meta kernels in spice, please consult the Kernel Required Reading.

- naif0009.tls
- cas00084.tsc
- cpck05Mar2004.tpc
- cas_v37.tf
- 04135_04171pc_psiv2.bc
- 030201AP_SK_SM546_T45.bsp
- cas_iss_v09.ti
- 020514_SE_SAT105.bsp
- 981005_PLTEPH-DE405S.bsp

```
# The meta kernel file contains entries pointing to the following SPICE kernels, which␣
↪the user needs to download.
#   https://naif.jpl.nasa.gov/pub/naif/generic_kernels/lsk/a_old_versions/naif0009.tls
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/sclk/cas00084.tsc
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/pck/cpck05Mar2004.tpc
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/fk/release.11/cas_v37.tf
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/ck/04135_04171pc_psiv2.bc
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/spk/030201AP_SK_SM546_T45.bsp
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/ik/release.11/cas_iss_v09.ti
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/spk/020514_SE_SAT105.bsp
#   https://naif.jpl.nasa.gov/pub/naif/CASSINI/kernels/spk/981005_PLTEPH-DE405S.bsp
#
#   The following is the contents of a metakernel that was saved with
#   the name 'cassMetaK.txt'.
#   \begindata
#   KERNELS_TO_LOAD=(
#   'naif0009.tls',
#   'cas00084.tsc',
#   'cpck05Mar2004.tpc',
#   '020514_SE_SAT105.bsp',
#   '981005_PLTEPH-DE405S.bsp',
#   '030201AP_SK_SM546_T45.bsp',
#   '04135_04171pc_psiv2.bc',
#   'cas_v37.tf',
#   'cas_iss_v09.ti')
#   \begintext
#

spice.furnsh("./cassMetaK.txt")
```

```
step = 4000
# we are going to get positions between these two dates
utc = ['Jun 20, 2004', 'Dec 1, 2005']

# get et values one and two, we could vectorize str2et
etOne = spice.str2et(utc[0])
etTwo = spice.str2et(utc[1])
print("ET One: {}, ET Two: {}".format(etOne, etTwo))
```

```
ET One: 140961664.18440723, ET Two: 186667264.18308285
```

```
# get times
times = [x*(etTwo-etOne)/step + etOne for x in range(step)]

# check first few times:
print(times[0:3])
```

```
[140961664.18440723, 140973090.5844069, 140984516.98440656]
```

```
# check the documentation on spkpos before continuing
help(spice.spkpos)
```

```
Help on function spkpos in module spiceypy.spiceypy:

spkpos(targ: str, et: Union[float, numpy.ndarray], ref: str, abcorr: str, obs: str) ->␣
↪Union[Tuple[numpy.ndarray, float], Tuple[numpy.ndarray, numpy.ndarray]]
    Return the position of a target body relative to an observing
    body, optionally corrected for light time (planetary aberration)
    and stellar aberration.

    https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkpos_c.html

    :param targ: Target body name.
    :param et: Observer epoch.
    :param ref: Reference frame of output position vector.
    :param abcorr: Aberration correction flag.
    :param obs: Observing body name.
    :return:
            Position of target,
            One way light time between observer and target.
```

```
#Run spkpos as a vectorized function
positions, lightTimes = spice.spkpos('Cassini', times, 'J2000', 'NONE', 'SATURN␣
↪BARYCENTER')

# Positions is a 3xN vector of XYZ positions
print("Positions: ")
print(positions[0])

# Light times is a N vector of time
print("Light Times: ")
```

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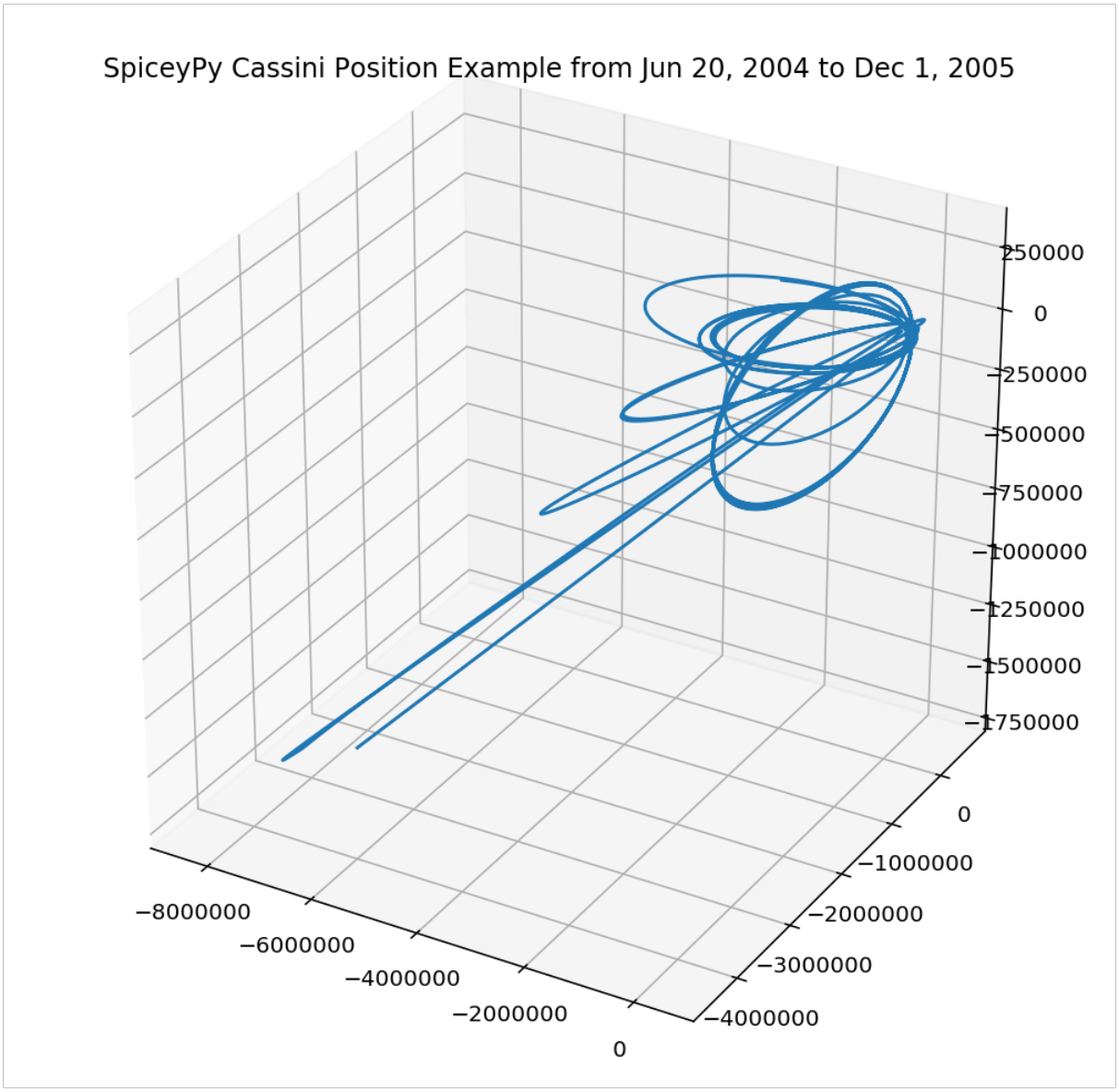
```
print(lightTimes[0])
```

```
Positions:
[-5461446.61080924 -4434793.40785864 -1200385.93315424]
Light Times:
23.8062238783
```

```
# Clean up the kernels
spice.kclear()
```

We will use matplotlib's 3D plotting to visualize Cassini's coordinates. We first convert the positions list to a 2D numpy array for easier indexing in the plot.

```
positions = positions.T # positions is shaped (4000, 3), let's transpose to (3, 4000) for␣
↪easier indexing
fig = plt.figure(figsize=(9, 9))
ax  = fig.add_subplot(111, projection='3d')
ax.plot(positions[0], positions[1], positions[2])
plt.title('SpiceyPy Cassini Position Example from Jun 20, 2004 to Dec 1, 2005')
plt.show()
```



3.7 Cells Explained

Spice Cells are data structures included in SPICE and serve as the equivalents to lists and sets for CSPICE. For more primary documentation on cells, please see the Cells required reading. For SpiceyPy, cells can be constructed in a variety of ways, shown below.

```
import spiceypy as spice

# create a spice bool cell using a function
bool_cell = spice.cell_bool(10)

# create a spice time cell using a function
```

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```
time_cell = spice.cell_time(10)

# create a spice int cell using a function
int_cell = spice.cell_int(10)

# create a spice double cell using a function
double_cell = spice.cell_double(10)

# create a spice char cell using a function
char_cell = spice.cell_char(10, 10)
```

One can also use provided classes to provide easier type checking, in future versions SpiceyPy this may become default.

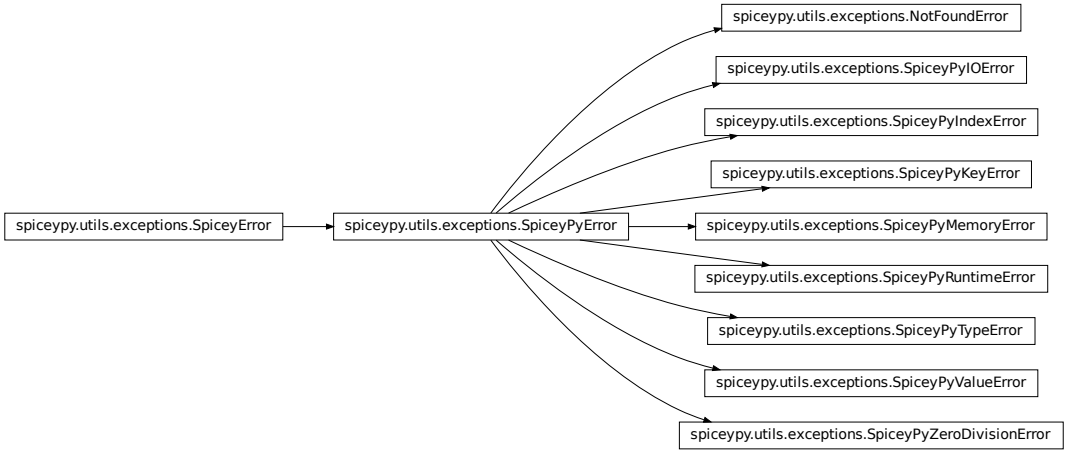
```
import spiceypy as spice

# create a spice bool cell using a function
bool_cell = spice.Cell_Bool(10)

# create a spice time cell using a function
time_cell = spice.Cell_Time(10)

# create a spice int cell using a function
int_cell = spice.Cell_Int(10)

# create a spice double cell using a function
double_cell = spice.Cell_Double(10)

# create a spice char cell using a function
char_cell = spice.Cell_Char(10, 10)
```

3.8 Exceptions in SpiceyPy

SpiceyPy by default checks the spice error system for errors after all function calls and will raise an exception containing the error information when the spice indicates an error has occurred.

3.8.1 Exception Hierarchy Basics

SpiceyPy exceptions are all based on the *spiceypy.utils.exceptions.SpiceyError* exception. SpiceyError is subclassed by *spiceypy.utils.exceptions.SpiceyPyError* to present a more consistent exception class for the user. SpiceyPyError is subclassed by a number of exceptions that also inherit from some of the common builtin Python exceptions:



Spice defines hundreds of errors in the format "SPICE(ERROR_NAME)" which are also included in SpiceyPy by a slightly different naming convention, where a Spice error "SPICE(QUERYFAILURE)" will correspond to the SpiceyPy exception *spiceypy.utils.exceptions.SpiceQUERYFAILURE*.

These errors will inherit the appropriate parent SpiceyPyError with builtin exception mix-in if the correct corresponding exception type is known. For example, *spiceypy.utils.exceptions.SpiceDIVIDEBYZERO* is a subclass of the *spiceypy.utils.exceptions.SpiceyPyZeroDivisionError*.

spiceypy.utils.exceptions.SpiceyPyZeroDivisionError in turn, is a subclass of *spiceypy.utils.exceptions.SpiceyPyError* and the built in `ZeroDivisionError`.

By subclassing the errors in this way, users can tune how granular their exception handling code will respond. For most users the top level SpiceyError and SpiceyPyError will be sufficient for their needs.

3.8.2 Exception Contents

The exception message is a string that follows the format used elsewhere in spice and includes the toolkit version, the short description, explanation, long format description, and traceback (of spice calls). Read the NAIF tutorial on exceptions here. These values are stored in parameters of the exception object.

Here is an example of the exception message text:

```
spice.furnsh("/tmp/_null_kernel.txt")
```

will result in the following exception message which is also a parameter of the exception object.

```
================================================================================

Toolkit version: CSPICE66

SPICE(NOSUCHFILE) --

The attempt to load "/tmp/_null_kernel.txt" by the routine FURNSH failed. It could not␣
↪be located.

furnsh_c --> FURNSH --> ZZLDKER

================================================================================
```

SpiceyErrors, SpiceyPyErrors, and all subclasses of SpiceyPyErrors contain the following parameters that the user can access:

1. tkvsn, the toolkit version of cspice used for example: "CSPICE66".
2. short, the short error description which is the same as the granular exception object type when possible, for example: "SPICE(NOSUCHFILE)".
3. explain, if present is the explanation from spice for the error.
4. long, the long error message description from spice, for example: "The attempt to load "/tmp/_null_kernel.txt" by the routine FURNSH failed. It could not be located."
5. traceback, sequence of calls within spice leading to the error, for example: "furnsh_c –> FURNSH –> ZZLDKER".
6. message, the full exception message following the spice template from the example above.

3.8.3 Not Found Errors

Also, by default SpiceyPy captures the 'found' flags some functions return as it is not idiomatic to python as a *spiceypy.utils.exceptions.NotFoundError* . This can be temporarily disabled using the *spiceypy.spiceypy.no_found_check()* context manager that allows the found flag to be returned to the user for action. Outside of that context SpiceyPy functions will revert to default behavior. For vectorized functions, the found parameter of the exception will contain an iterable of the found flags to help track down failed calls.

```
import spiceypy as spice

spice.bodc2n(-9991) # will raise an exception

with spice.no_found_check():
    name, found = spice.bodc2n(-9991) # found is now available, no exception raised!
    assert not found # found is going to be False in this case.

spice.bodc2n(-9991) # will raise an exception again
```

There is also an accompanying context manager for enabling the default SpiceyPy behavior within a code block like so:

```
import spiceypy as spice

spice.bodc2n(-9991) # will raise an exception
```

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```
with spice.found_check():
    name = spice.bodc2n(-9991) # will also raise an exception
```

In addition, for advanced users there are two function *spiceypy.spiceypy.found_check_off()* and *spiceypy.spiceypy.found_check_on()* which will disable and enable the behavior without use of the context manager. Additionally, a method *spiceypy.spiceypy.get_found_catch_state()* allows users to query the current state of found flag catching setting.

3.9 Lessons

Here listed are the various SPICE lessons provided by the NAIF translated to use python code examples. Please refer to the NAIF lesson files for the kernel files needed to complete the exercises and to obtain the full content naiflessons.

Contents:

3.9.1 Basics of SpiceyPy

Environment Set-up

Follow the installation instructions provided in the *installation section*.

Confirm SpiceyPy installation

There are multiple ways to verify your SpiceyPy installation. The first test is to simply run

```
pip list
```

You should see SpiceyPy in the list of your installed packages. If SpiceyPy is not present in the list then a configuration issue in your environment caused SpiceyPy to be installed in a non-standard way. Note this is an error prone to systems with multiple installed python versions.

If SpiceyPy is present in the pip list, then SpiceyPy is installed. Another verification step is within the python REPL run:

```
import spiceypy as spice
```

The version of the installed cspice toolkit (note: not SpiceyPy's version) should be printed out. Otherwise the Python interpreter should output an explanatory error message.

A simple example program

The following calls the SPICE function *spiceypy.spiceypy.tkvrsn()* which outputs the version of cspice that SpiceyPy is wrapping.

```
import spiceypy as spice

spice.tkvrsn('TOOLKIT')
```

This should output the following string:

```
'CSPICE_N0066'
```

3.9.2 Remote Sensing Hands-On Lesson, using CASSINI

November 20, 2017

Overview

In this lesson you will develop a series of simple programs that demonstrate the usage of SpiceyPy to compute a variety of different geometric quantities applicable to experiments carried out by a remote sensing instrument flown on an interplanetary spacecraft. This particular lesson focuses on a framing camera flying on the Cassini spacecraft, but many of the concepts are easily extended and generalized to other scenarios.

References

This section lists SPICE documents referred to in this lesson.

In some cases the lesson explanations also refer to the information provided in the meta-data area of the kernels used in the lesson examples. It is especially true in case of the FK and IK files, which often contain comprehensive descriptions of the frames, instrument FOVs, etc. Since both the FK and IK are text kernels, the information provided in them can be viewed using any text editor, while the meta information provided in binary kernels—SPKs and CKs—can be viewed using "commnt" or" spacit" utility programs located in "cspice/exe" of Toolkit installation tree.

Tutorials

The following SPICE tutorials serve as references for the discussions in this lesson:

```
Name              Lesson steps/functions it describes
---------------   -------------------------------------------
Time              Time Conversion
SCLK and LSK      Time Conversion
SPK               Obtaining Ephemeris Data
Frames            Reference Frames
Using Frames      Reference Frames
PCK               Planetary Constants Data
CK                Spacecraft Orientation Data
DSK               Detailed Target Shape (Topography) Data
```

These tutorials are available from the NAIF ftp server at JPL:

```
https://naif.jpl.nasa.gov/naif/tutorials.html
```

Required Readings

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The Required Reading documents are provided with the Toolkit and are located under the "cspice/doc" directory in the CSPICE Toolkit installation tree.

```
Name             Lesson steps/functions that it describes
---------------  ----------------------------------------
ck.req           Obtaining spacecraft orientation data
dsk.req          Obtaining detailed body shape data
frames.req       Using reference frames
naif_ids.req     Determining body ID codes
pck.req          Obtaining planetary constants data
sclk.req         SCLK time conversion
spk.req          Obtaining ephemeris Data
time.req         Time conversion
```

The Permuted Index

Tip:

The Permuted Index is also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/info/cspice_idx.html.

Another useful document distributed with the Toolkit is the permuted index. This is located under the "cspice/doc" directory in the C installation tree.

This text document provides a simple mechanism by which users can discover which SpiceyPy functions perform functions of interest, as well as the names of the source files that contain these functions.

SpiceyPy API Documentation

A SpiceyPy function's parameters specification is available using the built-in Python help system.

For example, the Python help function

```
>>> import spiceypy
>>> help(spiceypy.str2et)
```

describes of the str2et function's parameters, while the document

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html
```

describes extensively the str2et functionality.

Kernels Used

The following kernels are used in examples provided in this lesson:

```
#  FILE NAME                 TYPE DESCRIPTION
-- ------------------------- ---- ----------------------------------
1  naif0008.tls              LSK  Generic LSK
2  cas00084.tsc              SCLK Cassini SCLK
3  981005_PLTEPH-DE405S.bsp  SPK  Solar System Ephemeris
4  020514_SE_SAT105.bsp      SPK  Saturnian Satellite Ephemeris
5  030201AP_SK_SM546_T45.bsp SPK  Cassini Spacecraft SPK
6  cas_v37.tf                FK   Cassini FK
7  04135_04171pc_psiv2.bc    CK   Cassini Spacecraft CK
8  cpck05Mar2004.tpc         PCK  Cassini Project PCK
9  phoebe_64q.bds            DSK  Phoebe DSK
10 cas_iss_v09.ti            IK   ISS Instrument Kernel
```

These SPICE kernels are included in the lesson package available from the NAIF server at JPL:

```
ftp://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Lessons/
```

In addition to these kernels, the extra credit exercises require the following kernels:

```
#  FILE NAME       TYPE DESCRIPTION
-- --------------- ---- ------------------------------------------------
11 jup310_2004.bsp SPK  Generic Jovian Satellite Ephemeris
```

These SPICE kernels are available from the NAIF server at JPL:

```
https://naif.jpl.nasa.gov/pub/naif/generic_kernels/spk/satellites/
```

SpiceyPy Modules Used

This section provides a complete list of the functions and kernels that are suggested for usage in each of the exercises in this lesson. (You may wish to not look at this list unless/until you "get stuck" while working on your own.)

```
CHAPTER EXERCISE   FUNCTIONS        NON-VOID         KERNELS
------- ---------  ---------------  ---------------  ----------
   1    convtm     spiceypy.furnsh  spiceypy.str2et  1,2
                   spiceypy.unload  spiceypy.etcal
                                    spiceypy.timout
                                    spiceypy.sce2s

        extra (*)                   spiceypy.unitim  1,2
                                    spiceypy.sct2e
                                    spiceypy.et2utc
                                    spiceypy.scs2e

   2    getsta     spiceypy.furnsh  spiceypy.str2et  1,3-5
                   spiceypy.unload  spiceypy.spkezr
                                    spiceypy.spkpos
                                    spiceypy.vnorm
                                    spiceypy.convrt
```

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```
      extra (*)  spiceypy.kclear                  1,3-5,11

  3   xform      spiceypy.furnsh  spiceypy.str2et  1-8
                 spiceypy.unload  spiceypy.spkezr
                                  spiceypy.sxform
                                  spiceypy.mxvg
                                  spiceypy.spkpos
                                  spiceypy.pxform
                                  spiceypy.mxv
                                  spiceypy.convrt
                                  spiceypy.vsep

      extra (*)  spiceypy.kclear                  1-8

  4   subpts     spiceypy.furnsh  spiceypy.str2et  1,3-5,8,9
                 spiceypy.unload  spiceypy.subpnt
                                  spiceypy.vnorm
                                  spiceypy.subslr

      extra (*)  spiceypy.kclear  spiceypy.reclat  1,3-5,8
                                  spiceypy.dpr
                                  spiceypy.bodvrd
                                  spiceypy.recpgr

  5   fovint     spiceypy.furnsh  spiceypy.str2et  1-10
                 spiceypy.unload  spiceypy.bodn2c
                                  spiceypy.getfov
                                  spiceypy.sincpt
                                  spiceypy.reclat
                                  spiceypy.dpr
                                  spiceypy.illumf
                                  spiceypy.et2lst


  (*) Additional APIs and kernels used in Extra Credit tasks.
```

Use the Python built-in help system on the various functions listed above for the API parameters' description, and refer to the headers of their corresponding CSPICE versions for detailed interface specifications.

Time Conversion (convtm)

Task Statement

Write a program that prompts the user for an input UTC time string, converts it to the following time systems and output formats:

```
1.   Ephemeris Time (ET) in seconds past J2000

2.   Calendar Ephemeris Time
```

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```
3.    Spacecraft Clock Time
```

and displays the results. Use the program to convert "2004 jun 11 19:32:00" UTC into these alternate systems.

Learning Goals

Familiarity with the various time conversion and parsing functions available in the Toolkit. Exposure to source code headers and their usage in learning to call functions.

Approach

The solution to the problem can be broken down into a series of simple steps:

```
--    Decide which SPICE kernels are necessary. Prepare a meta-kernel
      listing the kernels and load it into the program.

--    Prompt the user for an input UTC time string.

--    Convert the input time string into ephemeris time expressed as
      seconds past J2000 TDB. Display the result.

--    Convert ephemeris time into a calendar format. Display the
      result.

--    Convert ephemeris time into a spacecraft clock string. Display
      the result.
```

You may find it useful to consult the permuted index, the headers of various source modules, and the "Time Required Reading" (time.req) and" SCLK Required Reading" (sclk.req) documents.

When completing the "calendar format" step above, consider using one of two possible methods: spiceypy.etcal or spiceypy.timout.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'convtm.tm'. Its contents follow:

```
KPL/MK

   This is the meta-kernel used in the solution of the "Time
   Conversion" task in the Remote Sensing Hands On Lesson.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File name                   Contents
   -------------------------   -----------------------------
   naif0008.tls                Generic LSK
```

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```
   cas00084.tsc                Cassini SCLK


   \begindata
   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls',
                       'kernels/sclk/cas00084.tsc' )
   \begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution convtm
#
from __future__ import print_function
from builtins import input

import spiceypy

def convtm():
    #
    # Local Parameters
    #
    METAKR = 'convtm.tm'
    SCLKID = -82

    spiceypy.furnsh( METAKR )

    #
    # Prompt the user for the input time string.
    #
    utctim = input( 'Input UTC Time: ' )

    print( 'Converting UTC Time: {:s}'.format( utctim ) )

    #
    # Convert utctim to ET.
    #
    et = spiceypy.str2et( utctim )

    print( '   ET Seconds Past J2000: {:16.3f}'.format( et ) )

    #
    # Now convert ET to a calendar time string.
    # This can be accomplished in two ways.
    #
    calet = spiceypy.etcal( et )

    print( '   Calendar ET (etcal):   {:s}'.format( calet ) )

    #
    # Or use timout for finer control over the
```

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```
    # output format. The picture below was built
    # by examining the header of timout.
    #
    calet = spiceypy.timout( et, 'YYYY-MON-DDTHR:MN:SC ::TDB' )

    print( '   Calendar ET (timout):  {:s}'.format( calet ) )

    #
    # Convert ET to spacecraft clock time.
    #
    sclkst = spiceypy.sce2s( SCLKID, et )

    print( '   Spacecraft Clock Time: {:s}'.format( sclkst ) )

    spiceypy.unload( METAKR )

if __name__ == '__main__':
    convtm()
```

Solution Sample Output

Execute the program:

```
Input UTC Time: 2004 jun 11 19:32:00
Converting UTC Time: 2004 jun 11 19:32:00
   ET Seconds Past J2000:    140254384.185
   Calendar ET (etcal):   2004 JUN 11 19:33:04.184
   Calendar ET (timout):  2004-JUN-11T19:33:04
   Spacecraft Clock Time: 1/1465674964.105
```

Extra Credit

In this "extra credit" section you will be presented with more complex tasks, aimed at improving your understanding of time conversions, the Toolkit routines that deal with them, and some common errors that may happen during the execution of these conversions.

These "extra credit" tasks are provided as task statements, and unlike the regular tasks, no approach or solution source code is provided. In the next section, you will find the numeric solutions (when applicable) and answers to the questions asked in these tasks.

Task statements and questions

```
1.   Extend your program to convert the input UTC time string to TDB
     Julian Date. Convert "2004 jun 11 19:32:00" UTC.

2.   Remove the LSK from the original meta-kernel and run your
     program again, using the same inputs as before. Has anything
     changed? Why?

3.   Remove the SCLK from the original meta-kernel and run your
     program again, using the same inputs as before. Has anything
     changed? Why?
```

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```
4.   Modify your program to perform conversion of UTC or ephemeris
     time, to a spacecraft clock string using the NAIF ID for the
     CASSINI ISS NAC camera. Convert "2004 jun 11 19:32:00" UTC.

5.   Find the earliest UTC time that can be converted to CASSINI
     spacecraft clock.

6.   Extend your program to convert the spacecraft clock time
     obtained in the regular task back to UTC Time and present it in
     ISO calendar date format, with a resolution of milliseconds.

7.   Examine the contents of the generic LSK and the CASSINI SCLK
     kernels. Can you understand and explain what you see?
```

Solutions and answers

```
 1.   Two methods exist in order to convert ephemeris time to Julian
      Date: spiceypy.unitim and spiceypy.timout. The difference
      between them is the type of output produced by each method.
      spiceypy.unitim returns the double precision value of an input
      epoch, while spiceypy.timout returns the string representation
      of the ephemeris time in Julian Date format (when picture input
      is set to 'JULIAND.######### ::TDB'). Refer to the function
      header for further details. The solution for the requested
      input UTC string is:

   Julian Date TDB:   2453168.3146318

 2.   When running the original program without the LSK kernel, an
      error is produced:

Traceback (most recent call last):
  File "convtm.py", line 67, in <module>
    convtm()
  File "convtm.py", line 30, in convtm
    et = spiceypy.str2et( utctim )
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 76, in with_errcheck
    check_for_spice_error(f)
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 59, in check_for_spice_error
    raise stypes.SpiceyError(msg)
spiceypy.utils.support_types.SpiceyError:
================================================================
===========

Toolkit version: N0066

SPICE(NOLEAPSECONDS) --

The variable that points to the leapseconds (DELTET/DELTA_AT) could n
```

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```
ot be located in the kernel pool.  It is likely that the leapseconds
kernel has not been loaded via the routine FURNSH.

str2et_c --> STR2ET --> TTRANS

================================================================================

      This error is triggered by spiceypy.str2et because the variable
      that points to the leapseconds is not present in the kernel
      pool and therefore the program lacks data required to perform
      the requested UTC to ephemeris time conversion.

      By default, SPICE will report, as a minimum, a short
      descriptive message and a expanded form of this short message
      where more details about the error are provided. If this error
      message is not sufficient for you to understand what has
      happened, you could go to the "Exceptions" section in the
      SPICELIB or CSPICE headers of the function that has triggered
      the error and find out more information about the possible
      causes.

 3.   When running the original program without the SCLK kernel, an
      error is produced:

Traceback (most recent call last):
  File "convtm.py", line 67, in <module>
    convtm()
  File "convtm.py", line 58, in convtm
    sclkst = spiceypy.sce2s( SCLKID, et )
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 76, in with_errcheck
    check_for_spice_error(f)
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 59, in check_for_spice_error
    raise stypes.SpiceyError(msg)
spiceypy.utils.support_types.SpiceyError:
================================================================================

Toolkit version: N0066

SPICE(KERNELVARNOTFOUND) --
The Variable Was not Found in the Kernel Pool.
SCLK_DATA_TYPE_82 not found. Did you load the SCLK kernel?

sce2s_c --> SCE2S --> SCE2T --> SCTYPE --> SCLI01

================================================================================

      This error is triggered by spiceypy.sce2s. In this case the
```

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```
     error message may not give you enough information to understand
     what has actually happened. Nevertheless, the expanded form of
     this short message clearly indicates that the SCLK kernel for
     the spacecraft ID -82 has not been loaded.

     The UTC string to ephemeris time conversion and the conversion
     of ephemeris time into a calendar format worked normally as
     these conversions only require the LSK kernel to be loaded.

4.   The first thing you need to do is to find out what the NAIF ID
     is for the CASSINI ISS NAC camera. In order to do so, examine
     the ISS instrument kernel listed above and look for the "NAIF
     ID Code to Name Mapping" and there, for the NAIF ID given to
     CASSINI_ISS_NAC (which is -82360). Then replace in your code
     the SCLK ID -82 with -82360. After executing the program using
     the original meta-kernel, you will be getting the same error as
     in the previous task. Despite the error being exactly the same,
     this case is different. Generally, spacecraft clocks are
     associated with the spacecraft ID and not with its payload,
     sensors or structures IDs. Therefore, in order to do
     conversions from/to spacecraft clock for payload, sensors or
     spacecraft structures, the spacecraft ID must be used.

     Note that this does not need to be true for all missions or
     payloads, as SPICE does not restrict the SCLKs to spacecraft
     IDs only. Please refer to your mission's SCLK kernels for
     particulars.

5.   Use spiceypy.sct2e with the encoding of the Cassini spacecraft
     clock time set to 0.0 ticks and convert the resulting ephemeris
     time to UTC using either spiceypy.timout or spiceypy.et2utc.
     The solution for the requested SCLK string is:

  Earliest UTC convertible to SCLK: 1980-01-01T00:00:00.000

6.   Use spiceypy.scs2e with the SCLK string obtained in the
     computations performed in the regular tasks and convert the
     resulting ephemeris time to UTC using either spiceypy.et2utc,
     with 'ISOC' format and 3 digits precision, or using
     spiceypy.timout using the time picture 'YYYY-MM-DDTHR:MN:SC.###
     ::RND'. The solution of the requested conversion is:

  Spacecraft Clock Time:          1/1465674964.105
  UTC time from spacecraft clock: 2004-06-11T19:31:59.999
```

Obtaining Target States and Positions (getsta)

Task Statement

Write a program that prompts the user for an input UTC time string, computes the following quantities at that epoch:

```
1.   The apparent state of Phoebe as seen from CASSINI in the J2000
     frame, in kilometers and kilometers/second. This vector itself
     is not of any particular interest, but it is a useful
     intermediate quantity in some geometry calculations.

2.   The apparent position of the Earth as seen from CASSINI in the
     J2000 frame, in kilometers.

3.   The one-way light time between CASSINI and the apparent
     position of Earth, in seconds.

4.   The apparent position of the Sun as seen from Phoebe in the
     J2000 frame (J2000), in kilometers.

5.   The actual (geometric) distance between the Sun and Phoebe, in
     astronomical units.
```

and displays the results. Use the program to compute these quantities at "2004 jun 11 19:32:00" UTC.

Learning Goals

Understand the anatomy of an spiceypy.spkezr call. Discover the difference between spiceypy.spkezr and spiceypy.spkpos. Familiarity with the Toolkit utility "brief". Exposure to unit conversion with SpiceyPy.

Approach

The solution to the problem can be broken down into a series of simple steps:

```
--   Decide which SPICE kernels are necessary. Prepare a meta-kernel
     listing the kernels and load it into the program.

--   Prompt the user for an input time string.

--   Convert the input time string into ephemeris time expressed as
     seconds past J2000 TDB.

--   Compute the state of Phoebe relative to CASSINI in the J2000
     reference frame, corrected for aberrations.

--   Compute the position of Earth relative to CASSINI in the J2000
     reference frame, corrected for aberrations. (The function in
     the library that computes this also returns the one-way light
     time between CASSINI and Earth.)

--   Compute the position of the Sun relative to Phoebe in the J2000
```

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```
     reference frame, corrected for aberrations.

--   Compute the position of the Sun relative to Phoebe without
     correcting for aberration.

     Compute the length of this vector. This provides the desired
     distance in kilometers.

--   Convert the distance in kilometers into AU.
```

You may find it useful to consult the permuted index, the headers of various source modules, and the "SPK Required Reading" (spk.req) document.

When deciding which SPK files to load, the Toolkit utility "brief" may be of some use.

"brief" is located in the" cspice/exe"directory for C toolkits. Consult its user's guide available in "cspice/doc/brief.ug" for details.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'getsta.tm'. Its contents follow:

```
KPL/MK

   This is the meta-kernel used in the solution of the
   "Obtaining Target States and Positions" task in the
   Remote Sensing Hands On Lesson.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File name                   Contents
   -------------------------   -----------------------------
   naif0008.tls                Generic LSK
   981005_PLTEPH-DE405S.bsp    Solar System Ephemeris
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK


   \begindata
   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls',
                       'kernels/spk/981005_PLTEPH-DE405S.bsp',
                       'kernels/spk/020514_SE_SAT105.bsp',
                       'kernels/spk/030201AP_SK_SM546_T45.bsp' )
   \begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution getsta.py
#
from __future__ import print_function
from builtins import input

import spiceypy

def getsta():
    #
    # Local parameters
    #
    METAKR = 'getsta.tm'

    #
    # Load the kernels that this program requires.  We
    # will need a leapseconds kernel to convert input
    # UTC time strings into ET.  We also will need the
    # necessary SPK files with coverage for the bodies
    # in which we are interested.
    #
    spiceypy.furnsh( METAKR )

    #
    #Prompt the user for the input time string.
    #
    utctim = input( 'Input UTC Time: ' )

    print( 'Converting UTC Time: {:s}'.format(utctim)  )

    #
    #Convert utctim to ET.
    #
    et = spiceypy.str2et( utctim )

    print( '   ET seconds past J2000: {:16.3f}'.format(et) )

    #
    # Compute the apparent state of Phoebe as seen from
    # CASSINI in the J2000 frame.  All of the ephemeris
    # readers return states in units of kilometers and
    # kilometers per second.
    #
    [state, ltime] = spiceypy.spkezr( 'PHOEBE', et,      'J2000',
                                      'LT+S',   'CASSINI'       )

    print( '   Apparent state of Phoebe as seen '
           'from CASSINI in the J2000\n'
           '      frame (km, km/s):'              )

    print( '      X = {:16.3f}'.format(state[0])       )
    print( '      Y = {:16.3f}'.format(state[1])       )
    print( '      Z = {:16.3f}'.format(state[2])       )
```

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```
    print( '     VX = {:16.3f}'.format(state[3])       )
    print( '     VY = {:16.3f}'.format(state[4])       )
    print( '     VZ = {:16.3f}'.format(state[5])       )

    #
    # Compute the apparent position of Earth as seen from
    # CASSINI in the J2000 frame.  Note: We could have
    # continued using spkezr and simply ignored the
    # velocity components.
    #
    [pos, ltime] = spiceypy.spkpos( 'EARTH', et,        'J2000',
                                    'LT+S',  'CASSINI',         )

    print( '   Apparent position of Earth as '
           'seen from CASSINI in the J2000\n'
           '      frame (km):'                )
    print( '      X = {:16.3f}'.format(pos[0])  )
    print( '      Y = {:16.3f}'.format(pos[1])  )
    print( '      Z = {:16.3f}'.format(pos[2])  )

    #
    # We need only display LTIME, as it is precisely the
    # light time in which we are interested.
    #
    print( '   One way light time between CASSINI and '
           'the apparent position\n'
           '      of Earth (seconds):'
           ' {:16.3f}'.format(ltime) )

    #
    # Compute the apparent position of the Sun as seen from
    # PHOEBE in the J2000 frame.
    #
    [pos, ltime] = spiceypy.spkpos( 'SUN',  et,       'J2000',
                                    'LT+S', 'PHOEBE',         )

    print( '   Apparent position of Sun as '
           'seen from Phoebe in the\n'
           '       J2000 frame (km):'           )
    print( '      X = {:16.3f}'.format(pos[0])  )
    print( '      Y = {:16.3f}'.format(pos[1])  )
    print( '      Z = {:16.3f}'.format(pos[2])  )

    #
    # Now we need to compute the actual distance between
    # the Sun and Phoebe.  The above spkpos call gives us
    # the apparent distance, so we need to adjust our
    # aberration correction appropriately.
    #
    [pos, ltime] = spiceypy.spkpos( 'SUN',  et,      'J2000',
                                    'NONE', 'PHOEBE'         )
```

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```
    #
    # Compute the distance between the body centers in
    # kilometers.
    #
    dist = spiceypy.vnorm( pos )

    #
    # Convert this value to AU using convrt.
    #
    dist = spiceypy.convrt( dist, 'KM', 'AU' )

    print( '   Actual distance between Sun and '
           'Phoebe body centers:\n'
           '      (AU): {:16.3f}'.format(dist) )

    spiceypy.unload( METAKR )

if __name__ == '__main__':
    getsta()
```

Solution Sample Output

Execute the program:

```
Input UTC Time: 2004 jun 11 19:32:00
Converting UTC Time: 2004 jun 11 19:32:00
   ET seconds past J2000:    140254384.185
   Apparent state of Phoebe as seen from CASSINI in the J2000
      frame (km, km/s):
      X =         -119.921
      Y =         2194.139
      Z =          -57.639
     VX =           -5.980
     VY =           -2.119
     VZ =           -0.295
   Apparent position of Earth as seen from CASSINI in the J2000
      frame (km):
      X =    353019393.123
      Y =  -1328180352.140
      Z =   -568134171.697
   One way light time between CASSINI and the apparent position
      of Earth (seconds):         4960.427
   Apparent position of Sun as seen from Phoebe in the
       J2000 frame (km):
      X =    376551465.272
      Y =  -1190495630.303
      Z =   -508438699.110
   Actual distance between Sun and Phoebe body centers:
      (AU):            9.012
```

Extra Credit

In this "extra credit" section you will be presented with more complex tasks, aimed at improving your understanding of state computations, particularly the application of the different light time and stellar aberration corrections available in the spiceypy.spkezr function, and some common errors that may happen when computing these states.

These "extra credit" tasks are provided as task statements, and unlike the regular tasks, no approach or solution source code is provided. In the next section, you will find the numeric solutions (when applicable) and answers to the questions asked in these tasks.

Task statements and questions

```
1.   Remove the Solar System ephemerides SPK from the original
     meta-kernel and run your program again, using the same inputs
     as before. Has anything changed? Why?

2.   Extend your program to compute the geometric position of
     Jupiter as seen from Saturn in the J2000 frame (J2000), in
     kilometers.

3.   Extend, or modify, your program to compute the position of the
     Sun as seen from Saturn in the J2000 frame (J2000), in
     kilometers, using the following light time and aberration
     corrections: NONE, LT and LT+S. Explain the differences.

4.   Examine the CASSINI frames definition kernel and the ISS
     instrument kernel to find the SPICE ID/name definitions.
```

Solutions and answers

```
 1.   When running the original program without the Solar System
      ephemerides SPK, an error is produced by spiceypy.spkezr:

Traceback (most recent call last):
  File "getsta.py", line 128, in <module>
    getsta()
  File "getsta.py", line 47, in getsta
    'LT+S',   'CASSINI'       )
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 76, in with_errcheck
    check_for_spice_error(f)
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 59, in check_for_spice_error
    raise stypes.SpiceyError(msg)
spiceypy.utils.support_types.SpiceyError:
================================================================================
===========

Toolkit version: N0066

SPICE(SPKINSUFFDATA) --

Insufficient ephemeris data has been loaded to compute the state of -
82 (CASSINI) relative to 0 (SOLAR SYSTEM BARYCENTER) at the ephemeris
```

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```
 epoch 2004 JUN 11 19:33:04.184.

spkezr_c --> SPKEZR --> SPKEZ --> SPKACS --> SPKGEO

================================================================================

      This error is generated when trying to compute the apparent
      state of Phoebe as seen from CASSINI in the J2000 frame because
      despite both Phoebe and CASSINI ephemeris data being relative
      to the Saturn Barycenter, the state of the spacecraft with
      respect to the solar system barycenter is required to compute
      the light time and stellar aberrations. The loaded SPK data are
      enough to compute geometric states of CASSINI with respect to
      the Saturn Barycenter, and geometric states of Phoebe with
      respect to the Saturn Barycenter, but insufficient to compute
      the state of the spacecraft relative to the Solar System
      Barycenter because the SPK data needed to compute geometric
      states of Saturn Barycenter relative to the Solar System
      barycenter are no longer loaded. Run "brief" on the SPKs used
      in the original task to find out which ephemeris objects are
      available from those kernels. If you want to find out what is
      the 'center of motion' for the ephemeris object(s) included in
      an SPK, use the -c option when running "brief":


BRIEF -- Version 4.0.0, September 8, 2010 -- Toolkit Version N0066


Summary for: kernels/spk/981005_PLTEPH-DE405S.bsp

Bodies: MERCURY BARYCENTER (1) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        VENUS BARYCENTER (2) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        EARTH BARYCENTER (3) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        MARS BARYCENTER (4) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        JUPITER BARYCENTER (5) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        SATURN BARYCENTER (6) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        URANUS BARYCENTER (7) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        NEPTUNE BARYCENTER (8) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        PLUTO BARYCENTER (9) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        SUN (10) w.r.t. SOLAR SYSTEM BARYCENTER (0)
        MERCURY (199) w.r.t. MERCURY BARYCENTER (1)
        VENUS (299) w.r.t. VENUS BARYCENTER (2)
        MOON (301) w.r.t. EARTH BARYCENTER (3)
        EARTH (399) w.r.t. EARTH BARYCENTER (3)
        MARS (499) w.r.t. MARS BARYCENTER (4)
        Start of Interval (UTC)             End of Interval (UTC)
        ----------------------------        -------------------------
----
        2004-JUN-11 05:00:00.000            2004-JUN-12 12:00:00.000
```

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```
Summary for: kernels/spk/020514_SE_SAT105.bsp

Bodies: MIMAS (601) w.r.t. SATURN BARYCENTER (6)
        ENCELADUS (602) w.r.t. SATURN BARYCENTER (6)
        TETHYS (603) w.r.t. SATURN BARYCENTER (6)
        DIONE (604) w.r.t. SATURN BARYCENTER (6)
        RHEA (605) w.r.t. SATURN BARYCENTER (6)
        TITAN (606) w.r.t. SATURN BARYCENTER (6)
        HYPERION (607) w.r.t. SATURN BARYCENTER (6)
        IAPETUS (608) w.r.t. SATURN BARYCENTER (6)
        PHOEBE (609) w.r.t. SATURN BARYCENTER (6)
        SATURN (699) w.r.t. SATURN BARYCENTER (6)
        Start of Interval (UTC)             End of Interval (UTC)
        ----------------------------        -------------------------
----
        2004-JUN-11 05:00:00.000            2004-JUN-12 12:00:00.000


Summary for: kernels/spk/030201AP_SK_SM546_T45.bsp

Body: CASSINI (-82) w.r.t. SATURN BARYCENTER (6)
      Start of Interval (UTC)             End of Interval (UTC)
      ----------------------------        -------------------------
--
      2004-JUN-11 05:00:00.000            2004-JUN-12 12:00:00.000



 2.   If you run your extended program with the original meta-kernel,
      the SPICE(SPKINSUFFDATA) error should be produced by the
      spiceypy.spkpos function because you have not loaded enough
      ephemeris data to compute the position of Jupiter with respect
      to Saturn. The loaded SPKs contain data for Saturn relative to
      the Solar System Barycenter, and for the Jupiter System
      Barycenter relative to the Solar System Barycenter, but the
      data for Jupiter relative to the Jupiter System Barycenter are
      missing:


   Additional kernels required for this task:

   File name               Contents
   ----------------------  ---------------------------------
   jup310_2004.bsp         Generic Jovian Satellite Ephemeris


   available in the NAIF server at:

https://naif.jpl.nasa.gov/pub/naif/generic_kernels/spk/satellites/


      Download the relevant SPK, add it to the meta-kernel and run
```

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```
      again your extended program. The solution for the input UTC
      time "2004 jun 11 19:32:00" when using the downloaded Jovian
      Satellite Ephemeris SPK:

   Actual position of Jupiter as seen from Saturn in the
      J2000 frame (km):
      X =   -436016583.291
      Y =  -1094176737.323
      Z =   -446585337.431

 3.   When using 'NONE' aberration corrections, spiceypy.spkpos
      returns the geometric position of the target body relative to
      the observer. If 'LT' is used, the returned vector corresponds
      to the position of the target at the moment it emitted photons
      arriving at the observer at `et'. If 'LT+S' is used instead,
      the returned vector takes into account the observer's velocity
      relative to the solar system barycenter. The solution for the
      input UTC time "2004 jun 11 19:32:00" is:


   Actual (geometric) position of Sun as seen from Saturn in the
      J2000 frame (km):
      X =    367770592.367
      Y =  -1197330367.359
      Z =   -510369088.677
   Light-time corrected position of Sun as seen from Saturn in the
      J2000 frame (km):
      X =    367770572.921
      Y =  -1197330417.733
      Z =   -510369109.509
   Apparent position of Sun as seen from Saturn in the
      J2000 frame (km):
      X =    367726456.168
      Y =  -1197342627.879
      Z =   -510372252.747
```

Spacecraft Orientation and Reference Frames (xform)

Task Statement

Write a program that prompts the user for an input time string, computes and displays the following at the epoch of interest:

```
1.   The apparent state of Phoebe as seen from CASSINI in the
     IAU_PHOEBE body-fixed frame. This vector itself is not of any
     particular interest, but it is a useful intermediate quantity
     in some geometry calculations.

2.   The angular separation between the apparent position of Earth
     as seen from CASSINI and the nominal boresight of the CASSINI
     high gain antenna (HGA).
```

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```
    The HGA boresight direction is provided by the kernel variable
    TKFRAME_-82101_BORESIGHT, which is defined in the Cassini frame
    kernel cited above in the section "Kernels Used." In this
    kernel, the HGA boresight vector is expressed relative to the
    CASSINI_HGA reference frame.
```

Use the program to compute these quantities at the epoch "2004 jun 11 19:32:00" UTC.

Learning Goals

Familiarity with the different types of kernels involved in chaining reference frames together, both inertial and non-inertial. Discover some of the matrix and vector math functions. Understand the difference between spiceypy.pxform and spiceypy.sxform.

Approach

The solution to the problem can be broken down into a series of simple steps:

```
--   Decide which SPICE kernels are necessary. Prepare a meta-kernel
     listing the kernels and load it into the program.

--   Prompt the user for an input time string.

--   Convert the input time string into ephemeris time expressed as
     seconds past J2000 TDB.

--   Compute the state of Phoebe relative to CASSINI in the J2000
     reference frame, corrected for aberrations.

--   Compute the state transformation matrix from J2000 to
     IAU_PHOEBE at the epoch, adjusted for light time.

--   Multiply the state of Phoebe relative to CASSINI in the J2000
     reference frame by the state transformation matrix computed in
     the previous step.

--   Compute the position of Earth relative to CASSINI in the J2000
     reference frame, corrected for aberrations.

--   Determine what the nominal boresight of the CASSINI high gain
     antenna is by examining the frame kernel's content.

--   Compute the rotation matrix from the CASSINI high gain antenna
     frame to J2000.

--   Multiply the nominal boresight expressed in the CASSINI high
     gain antenna frame by the rotation matrix from the previous
     step.
```

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```
--   Compute the separation between the result of the previous step
     and the apparent position of the Earth relative to CASSINI in
     the J2000 frame.
```

HINT: Several of the steps above may be compressed into a single step using SpiceyPy functions with which you are already familiar. The "long way" presented above is intended to facilitate the introduction of the functions spiceypy.pxform and spiceypy.sxform.

You may find it useful to consult the permuted index, the headers of various source modules, and the following toolkit documentation:

```
1.   Frames Required Reading (frames.req)

2.   PCK Required Reading (pck.req)

3.   SPK Required Reading (spk.req)

4.   CK Required Reading (ck.req)
```

This particular example makes use of many of the different types of SPICE kernels. You should spend a few moments thinking about which kernels you will need and what data they provide.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'xform.tm'. Its contents follow:

```
KPL/MK

   This is the meta-kernel used in the solution of the "Spacecraft
   Orientation and Reference Frames" task in the Remote Sensing
   Hands On Lesson.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File name                   Contents
   -------------------------   -----------------------------
   naif0008.tls                Generic LSK
   cas00084.tsc                Cassini SCLK
   981005_PLTEPH-DE405S.bsp    Solar System Ephemeris
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK
   cas_v37.tf                  Cassini FK
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK
   cpck05Mar2004.tpc           Cassini Project PCK


   \begindata
   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls',
                       'kernels/sclk/cas00084.tsc',
```

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```
                        'kernels/spk/981005_PLTEPH-DE405S.bsp',
                        'kernels/spk/020514_SE_SAT105.bsp',
                        'kernels/spk/030201AP_SK_SM546_T45.bsp',
                        'kernels/fk/cas_v37.tf',
                        'kernels/ck/04135_04171pc_psiv2.bc',
                        'kernels/pck/cpck05Mar2004.tpc' )
   \begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution xform.py
#
from __future__ import print_function
from builtins import input

import spiceypy

def xform():
    #
    # Local parameters
    #
    METAKR = 'xform.tm'

    #
    # Load the kernels that this program requires.  We
    # will need:
    #
    #    A leapseconds kernel
    #    A spacecraft clock kernel for CASSINI
    #    The necessary ephemerides
    #    A planetary constants file (PCK)
    #    A spacecraft orientation kernel for CASSINI (CK)
    #    A frame kernel (TF)
    #
    spiceypy.furnsh( METAKR )

    #
    #  Prompt the user for the input time string.
    #
    utctim = input( 'Input UTC Time: ' )

    print( 'Converting UTC Time: {:s}'.format(utctim)  )

    #
    #Convert utctim to ET.
    #
    et = spiceypy.str2et( utctim )

    print( '   ET seconds past J2000: {:16.3f}'.format(et) )
```

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```
    #
    # Compute the apparent state of Phoebe as seen from
    # CASSINI in the J2000 frame.
    #
    [state, ltime] = spiceypy.spkezr( 'PHOEBE', et,      'J2000',
                                      'LT+S',   'CASSINI'       )
    #
    # Now obtain the transformation from the inertial
    # J2000 frame to the non-inertial body-fixed IAU_PHOEBE
    # frame.  Since we want the apparent position, we
    # need to subtract ltime from et.
    #
    sform = spiceypy.sxform( 'J2000', 'IAU_PHOEBE', et-ltime )

    #
    # Now rotate the apparent J2000 state into IAU_PHOEBE
    # with the following matrix multiplication:
    #
    bfixst = spiceypy.mxvg ( sform, state, 6, 6 )

    #
    # Display the results.
    #
    print( '   Apparent state of Phoebe as seen '
           'from CASSINI in the IAU_PHOEBE\n'
           '      body-fixed frame (km, km/s):'      )
    print( '      X = {:19.6f}'.format(bfixst[0])    )
    print( '      Y = {:19.6f}'.format(bfixst[1])    )
    print( '      Z = {:19.6f}'.format(bfixst[2])    )
    print( '     VX = {:19.6f}'.format(bfixst[3])    )
    print( '     VY = {:19.6f}'.format(bfixst[4])    )
    print( '     VZ = {:19.6f}'.format(bfixst[5])    )

    #
    # It is worth pointing out, all of the above could
    #  have been done with a single use of spkezr:
    #
    [state, ltime] = spiceypy.spkezr(
                       'PHOEBE', et,      'IAU_PHOEBE',
                       'LT+S',   'CASSINI'              )
    #
    # Display the results.
    #
    print( '   Apparent state of Phoebe as seen '
           'from CASSINI in the IAU_PHOEBE\n'
           '      body-fixed frame (km, km/s) '
           'obtained using spkezr directly:'        )
    print( '      X = {:19.6f}'.format(state[0])    )
    print( '      Y = {:19.6f}'.format(state[1])    )
    print( '      Z = {:19.6f}'.format(state[2])    )
    print( '     VX = {:19.6f}'.format(state[3])    )
    print( '     VY = {:19.6f}'.format(state[4])    )
```

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```
    print( '     VZ = {:19.6f}'.format(state[5])    )

    #
    # Note that the velocity found by using spkezr
    # to compute the state in the IAU_PHOEBE frame differs
    # at the few mm/second level from that found previously
    # by calling spkezr and then sxform. Computing
    # velocity via a single call to spkezr as we've
    # done immediately above is slightly more accurate because
    # it accounts for the effect of the rate of change of
    # light time on the apparent angular velocity of the
    # target's body-fixed reference frame.
    #
    # Now we are to compute the angular separation between
    # the apparent position of the Earth as seen from the
    # orbiter and the nominal boresight of the high gain
    # antenna.  First, compute the apparent position of
    # the Earth as seen from CASSINI in the J2000 frame.
    #
    [pos, ltime] = spiceypy.spkpos( 'EARTH', et,      'J2000',
                                    'LT+S',  'CASSINI'        )

    #
    # Now compute the location of the antenna boresight
    # at this same epoch.  From reading the frame kernel
    # we know that the antenna boresight is nominally the
    # +Z axis of the CASSINI_HGA frame defined there.
    #
    bsight = [ 0.0, 0.0, 1.0]

    #
    # Now compute the rotation matrix from CASSINI_HGA into
    # J2000.
    #
    pform = spiceypy.pxform( 'CASSINI_HGA', 'J2000', et )

    #
    # And multiply the result to obtain the nominal
    # antenna boresight in the J2000 reference frame.
    #
    bsight = spiceypy.mxv( pform, bsight )

    #
    # Lastly compute the angular separation.
    #
    sep =  spiceypy.convrt( spiceypy.vsep(bsight, pos),
                            'RADIANS', 'DEGREES'       )

    print( '   Angular separation between the '
           'apparent position of\n'
           '      Earth and the CASSINI high '
           'gain antenna boresight (degrees):\n'
```

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```
            '      {:16.3f}'.format(sep)        )

    #
    # Or alternatively we can work in the antenna
    # frame directly.
    #
    [pos, ltime] = spiceypy.spkpos(
                      'EARTH', et,      'CASSINI_HGA',
                      'LT+S',  'CASSINI'               )

    #
    # The antenna boresight is the Z-axis in the
    # CASSINI_HGA frame.
    #
    bsight = [ 0.0, 0.0, 1.0 ]

    #
    # Lastly compute the angular separation.
    #
    sep =  spiceypy.convrt( spiceypy.vsep(bsight, pos),
                            'RADIANS', 'DEGREES'       )

    print( '   Angular separation between the '
           'apparent position of\n'
           '      Earth and the CASSINI high '
           'gain antenna boresight computed\n'
           '      using vectors in the CASSINI_HGA '
           'frame (degrees):\n'
           '      {:16.3f}'.format(sep)            )

    spiceypy.unload( METAKR )

if __name__ == '__main__':
    xform()
```

Solution Sample Output

Execute the program:

```
Input UTC Time: 2004 jun 11 19:32:00
Converting UTC Time: 2004 jun 11 19:32:00
   ET seconds past J2000:    140254384.185
   Apparent state of Phoebe as seen from CASSINI in the IAU_PHOEBE
      body-fixed frame (km, km/s):
      X =        -1982.639762
      Y =         -934.530471
      Z =         -166.562595
     VX =            3.970833
     VY =           -3.812498
     VZ =           -2.371663
   Apparent state of Phoebe as seen from CASSINI in the IAU_PHOEBE
      body-fixed frame (km, km/s) obtained using spkezr directly:
      X =        -1982.639762
```

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```
     Y =          -934.530471
     Z =          -166.562595
    VX =             3.970832
    VY =            -3.812496
    VZ =            -2.371663
  Angular separation between the apparent position of
     Earth and the CASSINI high gain antenna boresight (degrees):
               71.924
  Angular separation between the apparent position of
     Earth and the CASSINI high gain antenna boresight computed
     using vectors in the CASSINI_HGA frame (degrees):
               71.924
```

Extra Credit

In this "extra credit" section you will be presented with more complex tasks, aimed at improving your understanding of frame transformations, and some common errors that may happen when computing them.

These "extra credit" tasks are provided as task statements, and unlike the regular tasks, no approach or solution source code is provided. In the next section, you will find the numeric solutions (when applicable) and answers to the questions asked in these tasks.

Task statements and questions

```
1.   Run the original program using the input UTC time "2004 jun 11
     18:25:00". Explain what happens.

2.   Compute the angular separation between the apparent position of
     the Sun as seen from CASSINI and the nominal boresight of the
     CASSINI high gain antenna (HGA). Is the HGA illuminated?
```

Solutions and answers

```
 1.   When running the original software using as input the UTC time
      string "2004 jun 11 18:25:00":

Traceback (most recent call last):
  File "xform.py", line 183, in <module>
    xform()
  File "xform.py", line 130, in xform
    pform = spiceypy.pxform( 'CASSINI_HGA', 'J2000', et )
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 76, in with_errcheck
    check_for_spice_error(f)
  File "/home/bsemenov/local/lib/python3.5/site-packages/spiceypy/spi
ceypy.py", line 59, in check_for_spice_error
    raise stypes.SpiceyError(msg)
spiceypy.utils.support_types.SpiceyError:
================================================================================

Toolkit version: N0066
```

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```
SPICE(NOFRAMECONNECT) --

At epoch 1.4025036418463E+08 TDB (2004 JUN 11 18:26:04.184 TDB), ther
e is insufficient information available to transform from reference f
rame -82101 (CASSINI_HGA) to reference frame 1 (J2000). Frame CASSINI
_HGA could be transformed to frame -82000 (CASSINI_SC_COORD). The lat
ter is a CK frame; a CK file containing data

pxform_c --> PXFORM --> REFCHG

================================================================================

      spiceypy.pxform returns the SPICE(NOFRAMECONNECT) error, which
      indicates that there are not sufficient data to perform the
      transformation from the CASSINI_HGA frame to J2000 at the
      requested epoch. If you summarize the CASSINI spacecraft CK
      using the "ckbrief" utility program with the -dump option
      (display interpolation intervals boundaries) you will find that
      the CK contains gaps within its segment:


CKBRIEF -- Version 6.1.0, June 27, 2014 -- Toolkit Version N0066


Summary for: kernels/ck/04135_04171pc_psiv2.bc

Segment No.: 1

Object:  -82000
  Interval Begin UTC       Interval End UTC         AV
  ------------------------ ------------------------ ---
  2004-JUN-11 05:00:00.000 2004-JUN-11 09:25:02.019 Y
  2004-JUN-11 09:26:14.019 2004-JUN-11 18:24:37.152 Y
  2004-JUN-11 18:26:13.152 2004-JUN-12 05:53:26.012 Y
  2004-JUN-12 05:54:56.012 2004-JUN-12 10:32:08.016 Y
  2004-JUN-12 10:33:26.016 2004-JUN-12 11:59:59.998 Y



      whereas if you had used ckbrief without -dump you would have
      gotten the following information (only CK segment begin/end
      times):


CKBRIEF -- Version 6.1.0, June 27, 2014 -- Toolkit Version N0066


Summary for: kernels/ck/04135_04171pc_psiv2.bc

Object:  -82000
```

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```
  Interval Begin UTC       Interval End UTC         AV
  ------------------------ ------------------------ ---
  2004-JUN-11 05:00:00.000 2004-JUN-12 11:59:59.998 Y



       which has insufficient detail to reveal the problem.

 2.    By computing the apparent position of the Sun as seen from
       CASSINI in the CASSINI_HGA frame, and the angular separation
       between this vector and the nominal boresight of the CASSINI
       high gain antenna (+Z-axis of the CASSINI_HGA frame), you will
       find whether the HGA is illuminated. The solution for the input
       UTC time "2004 jun 11 19:32:00" is:

Angular separation between the apparent position of the Sun and the
nominal boresight of the CASSINI high gain antenna (degrees):
     73.130

HGA illumination:
   CASSINI high gain antenna IS illuminated.

       since the angular separation is smaller than 90 degrees.
```

Computing Sub-s/c and Sub-solar Points on an Ellipsoid and a DSK (subpts)

Task Statement

Write a program that prompts the user for an input UTC time string and computes the following quantities at that epoch:

```
1.    The apparent sub-observer point of CASSINI on Phoebe, in the
      body fixed frame IAU_PHOEBE, in kilometers.

2.    The apparent sub-solar point on Phoebe, as seen from CASSINI in
      the body fixed frame IAU_PHOEBE, in kilometers.
```

The program computes each point twice: once using an ellipsoidal shape model and the

```
near point/ellipsoid
```

definition, and once using a DSK shape model and the

```
nadir/dsk/unprioritized
```

definition.

The program displays the results. Use the program to compute these quantities at “2004 jun 11 19:32:00” UTC.

Learning Goals

Discover higher level geometry calculation functions in SpiceyPy and their usage as it relates to CASSINI.

Approach

This particular problem is more of an exercise in searching the permuted index to find the appropriate functions and then reading their headers to understand how to call them.

One point worth considering: how would the results change if the sub-solar and sub-observer points were computed using the

```
intercept/ellipsoid
```

and

```
intercept/dsk/unprioritized
```

definitions? Which definition is appropriate?

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'subpts.tm'. Its contents follow:

```
KPL/MK

   This is the meta-kernel used in the solution of the
   "Computing Sub-spacecraft and Sub-solar Points" task
   in the Remote Sensing Hands On Lesson.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File name                     Contents
   ---------------------------   -----------------------------
   naif0008.tls                  Generic LSK
   981005_PLTEPH-DE405S.bsp      Solar System Ephemeris
   020514_SE_SAT105.bsp          Saturnian Satellite Ephemeris
   030201AP_SK_SM546_T45.bsp     Cassini Spacecraft SPK
   cpck05Mar2004.tpc             Cassini Project PCK
   phoebe_64q.bds                Phoebe DSK


   \begindata
   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls',
                       'kernels/spk/981005_PLTEPH-DE405S.bsp',
                       'kernels/spk/020514_SE_SAT105.bsp',
                       'kernels/spk/030201AP_SK_SM546_T45.bsp',
                       'kernels/pck/cpck05Mar2004.tpc'
                       'kernels/dsk/phoebe_64q.bds' )
```

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```
   \begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution subpts.py
#
from __future__ import print_function
from builtins import input

#
# SpiceyPy package:
#
import spiceypy

def subpts():
    #
    # Local parameters
    #
    METAKR = 'subpts.tm'

    #
    # Load the kernels that this program requires.  We
    # will need:
    #
    #    A leapseconds kernel
    #    The necessary ephemerides
    #    A planetary constants file (PCK)
    #    A DSK file containing Phoebe shape data
    #
    spiceypy.furnsh( METAKR )

    #
    #Prompt the user for the input time string.
    #
    utctim = input( 'Input UTC Time: ' )

    print( ' Converting UTC Time: {:s}'.format(utctim)  )

    #
    #Convert utctim to ET.
    #
    et = spiceypy.str2et( utctim )

    print( '   ET seconds past J2000: {:16.3f}'.format(et) )

    for  i  in range(2):

        if  i  == 0:
            #
```

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```
            # Use the "near point" sub-point definition
            # and an ellipsoidal model.
            #
            method = 'NEAR POINT/Ellipsoid'

        else:
            #
            # Use the "nadir" sub-point definition
            # and a DSK model.
            #
            method = 'NADIR/DSK/Unprioritized'

        print( '\n Sub-point/target shape model: {:s}\n'.format(
            method )  )

        #
        # Compute the apparent sub-observer point of CASSINI
        # on Phoebe.
        #
        [spoint, trgepc, srfvec] = spiceypy.subpnt(
                                 method,       'PHOEBE',  et,
                                 'IAU_PHOEBE', 'LT+S', 'CASSINI' )

        print( '   Apparent sub-observer point of CASSINI '
               'on Phoebe in the\n'
               '   IAU_PHOEBE frame (km):' )
        print( '      X = {:16.3f}'.format(spoint[0])              )
        print( '      Y = {:16.3f}'.format(spoint[1])              )
        print( '      Z = {:16.3f}'.format(spoint[2])              )
        print( '    ALT = {:16.3f}'.format(spiceypy.vnorm(srfvec)) )

        #
        # Compute the apparent sub-solar point on Phoebe
        # as seen from CASSINI.
        #
        [spoint, trgepc, srfvec] = spiceypy.subslr(
                        method,       'PHOEBE',  et,
                        'IAU_PHOEBE', 'LT+S', 'CASSINI' )

        print( '   Apparent sub-solar point on Phoebe '
               'as seen from CASSINI in\n'
               '   the IAU_PHOEBE frame (km):'  )
        print( '      X = {:16.3f}'.format(spoint[0])   )
        print( '      Y = {:16.3f}'.format(spoint[1])   )
        print( '      Z = {:16.3f}'.format(spoint[2])   )

    #
    # End of computation block for "method"
    #
    print( " )

    spiceypy.unload( METAKR )
```

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```
if __name__ == '__main__':
    subpts()
```

Solution Sample Output

Execute the program:

```
Input UTC Time: 2004 jun 11 19:32:00
 Converting UTC Time: 2004 jun 11 19:32:00
   ET seconds past J2000:    140254384.185

 Sub-point/target shape model: NEAR POINT/Ellipsoid

   Apparent sub-observer point of CASSINI on Phoebe in the
   IAU_PHOEBE frame (km):
      X =           104.498
      Y =            45.269
      Z =             7.383
    ALT =          2084.116
   Apparent sub-solar point on Phoebe as seen from CASSINI in
   the IAU_PHOEBE frame (km):
      X =            78.681
      Y =            76.879
      Z =           -21.885

 Sub-point/target shape model: NADIR/DSK/Unprioritized

   Apparent sub-observer point of CASSINI on Phoebe in the
   IAU_PHOEBE frame (km):
      X =            95.373
      Y =            40.948
      Z =             6.610
    ALT =          2094.242
   Apparent sub-solar point on Phoebe as seen from CASSINI in
   the IAU_PHOEBE frame (km):
      X =            79.111
      Y =            77.338
      Z =           -22.028
```

Extra Credit

In this "extra credit" section you will be presented with more complex tasks, aimed at improving your understanding of spiceypy.subpnt and spiceypy.subslr functions.

These "extra credit" tasks are provided as task statements, and unlike the regular tasks, no approach or solution source code is provided. In the next section, you will find the numeric solutions (when applicable) and answers to the questions asked in these tasks.

Task statements and questions

```
1.   Recompute the apparent sub-solar point on Phoebe as seen from
     CASSINI in the body fixed frame IAU_PHOEBE in kilometers using
     the 'Intercept/ellipsoid' method at "2004 jun 11 19:32:00".
     Explain the differences.

2.   Compute the geometric sub-spacecraft point of CASSINI on Phoebe
     in the body fixed frame IAU_PHOEBE in kilometers using the
     'Near point/ellipsoid' method at "2004 jun 11 19:32:00".

3.   Transform the sub-spacecraft Cartesian coordinates obtained in
     the previous task to planetocentric and planetographic
     coordinates. When computing planetographic coordinates,
     retrieve Phoebe's radii by calling spiceypy.bodvrd and use the
     first element of the returned radii values as Phoebe's
     equatorial radius. Explain why planetocentric and
     planetographic latitudes and longitudes are different. Explain
     why the planetographic altitude for a point on the surface of
     Phoebe is not zero and whether this is correct or not.
```

Solutions and answers

```
1.   The differences observed are due to the computation method. The
     "Intercept/ellipsoid" method defines the sub-solar point as
     the target surface intercept of the line containing the Sun and
     the target's center, while the "Near point/ellipsoid" method
     defines the sub-solar point as the the nearest point on the
     target relative to the Sun. Since Phoebe is not spherical,
     these two points are not the same:

  Apparent sub-solar point on Phoebe as seen from CASSINI in
  the IAU_PHOEBE frame using the 'Near Point: ellipsoid' method
  (km):
     X =           78.681
     Y =           76.879
     Z =          -21.885

  Apparent sub-solar point on Phoebe as seen from CASSINI in
  the IAU_PHOEBE frame using the 'Intercept: ellipsoid' method
  (km):
     X =           74.542
     Y =           79.607
     Z =          -24.871

2.   The geometric sub-spacecraft point of CASSINI on Phoebe in the
     body fixed frame IAU_PHOEBE in kilometers at "2004 jun 11
     19:32:00" UTC epoch is:

  Geometric sub-spacecraft point of CASSINI on Phoebe in
  the IAU_PHOEBE frame using the 'Near Point: ellipsoid' method
  (km):
     X =          104.497
     Y =           45.270
     Z =            7.384
```

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```
3.   The sub-spacecraft point of CASSINI on Phoebe in planetocentric
     and planetographic coordinates at "2004 jun 11 19:32:00" UTC
     epoch is:

  Planetocentric coordinates of the CASSINI
  sub-spacecraft point on Phoebe (degrees, km):
  LAT =            3.710
  LON =           23.423
  R   =          114.121

  Planetographic coordinates of the CASSINI
  sub-spacecraft point on Phoebe (degrees, km):
  LAT =            4.454
  LON =          336.577
  ALT =           -0.831

     The planetocentric and planetographic longitudes are different
     ("graphic" = 360 - "centric") because planetographic
     longitudes on Phoebe are measured positive west as defined by
     Phoebe's rotation direction.

     The planetocentric and planetographic latitudes are different
     because the planetocentric latitude was computed as the angle
     between the direction from the center of the body to the point
     and the equatorial plane, while the planetographic latitude was
     computed as the angle between the surface normal at the point
     and the equatorial plane.

     The planetographic altitude is non zero because it was computed
     using a different and incorrect Phoebe surface model: a
     spheroid with equal equatorial radii. The surface point
     returned by spiceypy.subpnt was computed by treating Phoebe as
     a triaxial ellipsoid with different equatorial radii. The
     planetographic latitude is also incorrect because it is based
     on the normal to the surface of the spheroid rather than the
     ellipsoid, In general planetographic coordinates cannot be used
     for bodies with shapes modeled as triaxial ellipsoids.
```

Intersecting Vectors with an Ellipsoid and a DSK (fovint)

Task Statement

Write a program that prompts the user for an input UTC time string and, for that time, computes the intersection of the CASSINI ISS NAC camera boresight and field of view (FOV) boundary vectors with the surface of Phoebe. Compute each intercept twice: once with Phoebe's shape modeled as an ellipsoid, and once with Phoebe's shape modeled by DSK data. The program presents each point of intersection as

```
1.   A Cartesian vector in the IAU_PHOEBE frame
```

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```
2.   Planetocentric (latitudinal) coordinates in the IAU_PHOEBE
     frame.
```

For each of the camera FOV boundary and boresight vectors, if an intersection is found, the program displays the results of the above computations, otherwise it indicates no intersection exists.

At each point of intersection compute the following:

```
3.   Phase angle

4.   Solar incidence angle

5.   Emission angle
```

These angles should be computed using both ellipsoidal and DSK shape models.

Additionally compute the local solar time at the intercept of the camera boresight with the surface of Phoebe, using both ellipsoidal and DSK shape models.

Use this program to compute values at the epoch:

```
"2004 jun 11 19:32:00" UTC
```

Learning Goals

Understand how field of view parameters are retrieved from instrument kernels. Learn how various standard planetary constants are retrieved from text PCKs. Discover how to compute the intersection of field of view vectors with target bodies whose shapes are modeled as ellipsoids or provided by DSKs. Discover another high level geometry function and another time conversion function in SpiceyPy.

Approach

This problem can be broken down into several simple, small steps:

```
--   Decide which SPICE kernels are necessary. Prepare a meta-kernel
     listing the kernels and load it into the program. Remember, you
     will need to find a kernel with information about the CASSINI
     NAC camera.

--   Prompt the user for an input time string.

--   Convert the input time string into ephemeris time expressed as
     seconds past J2000 TDB.

--   Retrieve the FOV (field of view) configuration for the CASSINI
     NAC camera.
```

For each vector in the set of boundary corner vectors, and for the boresight vector, perform the following operations:

```
--   Compute the intercept of the vector with Phoebe modeled as an
     ellipsoid or using DSK data
```

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```
--    If this intercept is found, convert the position vector of the
      intercept into planetocentric coordinates.

      Then compute the phase, solar incidence, and emission angles at
      the intercept. Otherwise indicate to the user no intercept was
      found for this vector.

--    Compute the planetocentric longitude of the boresight
      intercept.
```

Finally

```
--    Compute the local solar time at the boresight intercept
      longitude on a 24-hour clock. The input time for this
      computation should be the TDB observation epoch minus one-way
      light time from the boresight intercept to the spacecraft.
```

It may be useful to consult the CASSINI ISS instrument kernel to determine the name of the NAC camera as well as its configuration. This exercise may make use of some of the concepts and (loosely) code from the "Spacecraft Orientation and Reference Frames" task.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'fovint.tm'. Its contents follow:

```
KPL/MK

   This is the meta-kernel used in the solution of the
   "Intersecting Vectors with a Triaxial Ellipsoid" task
   in the Remote Sensing Hands On Lesson.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File name                   Contents
   -------------------------   -----------------------------
   naif0008.tls                Generic LSK
   cas00084.tsc                Cassini SCLK
   981005_PLTEPH-DE405S.bsp    Solar System Ephemeris
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK
   cas_v37.tf                  Cassini FK
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK
   cpck05Mar2004.tpc           Cassini Project PCK
   cas_iss_v09.ti              ISS Instrument Kernel
   phoebe_64q.bds              Phoebe DSK


   \begindata
   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls',
```

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```
                        'kernels/sclk/cas00084.tsc',
                        'kernels/spk/981005_PLTEPH-DE405S.bsp',
                        'kernels/spk/020514_SE_SAT105.bsp',
                        'kernels/spk/030201AP_SK_SM546_T45.bsp',
                        'kernels/fk/cas_v37.tf',
                        'kernels/ck/04135_04171pc_psiv2.bc',
                        'kernels/pck/cpck05Mar2004.tpc',
                        'kernels/ik/cas_iss_v09.ti'
                        'kernels/dsk/phoebe_64q.bds' )
   \begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution fovint.py
#
from __future__ import print_function
from builtins import input

#
# SpiceyPy package:
#
import spiceypy
from spiceypy.utils.support_types import SpiceyError

def fovint():
    #
    # Local parameters
    #
    METAKR = 'fovint.tm'
    ROOM   = 4

    #
    # Load the kernels that this program requires.  We
    # will need:
    #
    #    A leapseconds kernel.
    #    A SCLK kernel for CASSINI.
    #    Any necessary ephemerides.
    #    The CASSINI frame kernel.
    #    A CASSINI C-kernel.
    #    A PCK file with Phoebe constants.
    #    The CASSINI ISS I-kernel.
    #    A DSK file containing Phoebe shape data.
    #
    spiceypy.furnsh( METAKR )

    #
    #Prompt the user for the input time string.
    #
    utctim = input( 'Input UTC Time: ' )
```

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```
print( 'Converting UTC Time: {:s}'.format(utctim)  )

#
#Convert utctim to ET.
#
et = spiceypy.str2et( utctim )

print( '  ET seconds past J2000: {:16.3f}\n'.format(et) )

#
# Now we need to obtain the FOV configuration of
# the ISS NAC camera.  To do this we will need the
# ID code for CASSINI_ISS_NAC.
#
try:
    nacid = spiceypy.bodn2c( 'CASSINI_ISS_NAC' )

except SpiceyError:
    #
    # Stop the program if the code was not found.
    #
    print( 'Unable to locate the ID code for '
               'CASSINI_ISS_NAC'               )
    raise

#
# Now retrieve the field of view parameters.
#
[ shape,  insfrm,
  bsight, n,      bounds ] = spiceypy.getfov( nacid, ROOM )

#
# `bounds' is a numpy array. We'll convert it to a list.
#
# Rather than treat BSIGHT as a separate vector,
# copy it into the last slot of BOUNDS.
#
bounds = bounds.tolist()
bounds.append( bsight )

#
# Set vector names to be used for output.
#
vecnam = [ 'Boundary Corner 1',
           'Boundary Corner 2',
           'Boundary Corner 3',
           'Boundary Corner 4',
           'Cassini NAC Boresight' ]

#
# Set values of "method" string that specify use of
```

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```
    # ellipsoidal and DSK (topographic) shape models.
    #
    # In this case, we can use the same methods for calls to both
    # spiceypy.sincpt and spiceypy.ilumin. Note that some SPICE
    # routines require different "method" inputs from those
    # shown here. See the API documentation of each routine
    # for details.
    #
    method = [ 'Ellipsoid', 'DSK/Unprioritized']

    #
    # Get ID code of Phoebe. We'll use this ID code later, when we
    # compute local solar time.
    #
    try:
        phoeid = spiceypy.bodn2c( 'PHOEBE' )
    except:
        #
        # The ID code for PHOEBE is built-in to the library.
        # However, it is good programming practice to get
        # in the habit of handling exceptions that may
        # be thrown when a quantity is not found.
        #
        print( 'Unable to locate the body ID code '
               'for Phoebe.'                       )
        raise

    #
    # Now perform the same set of calculations for each
    # vector listed in the BOUNDS array. Use both
    # ellipsoidal and detailed (DSK) shape models.
    #
    for i  in  range(5):
        #
        # Call sincpt to determine coordinates of the
        # intersection of this vector with the surface
        # of Phoebe.
        #
        print( 'Vector: {:s}\n'.format( vecnam[i] ) )

        for  j  in range(2):

            print ( ' Target shape model: {:s}\n'.format(
                                        method[j]      )  )
            try:

                [point, trgepc, srfvec ] = spiceypy.sincpt(
                    method[j],    'PHOEBE',  et,
                    'IAU_PHOEBE', 'LT+S',    'CASSINI',
                    insfrm,       bounds[i]              )

                #
```

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```
                # Now, we have discovered a point of intersection.
                # Start by displaying the position vector in the
                # IAU_PHOEBE frame of the intersection.
                #
                print( '  Position vector of surface intercept '
                       'in the IAU_PHOEBE frame (km):'           )
                print( '     X   = {:16.3f}'.format( point[0] )  )
                print( '     Y   = {:16.3f}'.format( point[1] )  )
                print( '     Z   = {:16.3f}'.format( point[2] )  )

                #
                # Display the planetocentric latitude and longitude
                # of the intercept.
                #
                [radius, lon, lat] = spiceypy.reclat( point )

                print( '  Planetocentric coordinates of '
                       'the intercept (degrees):'          )
                print( '     LAT = {:16.3f}'.format(
                                  lat * spiceypy.dpr() )  )
                print( '     LON = {:16.3f}'.format(
                                  lon * spiceypy.dpr() )  )
                #
                # Compute the illumination angles at this
                # point.
                #
                [ trgepc, srfvec, phase, solar,      \
                  emissn, visibl, lit           ] =  \
                    spiceypy.illumf(
                        method[j],   'PHOEBE', 'SUN',     et,
                       'IAU_PHOEBE', 'LT+S',   'CASSINI', point )

                print( '  Phase angle (degrees):           '
                       '{:16.3f}'.format( phase*spiceypy.dpr() )  )
                print( '  Solar incidence angle (degrees): '
                       '{:16.3f}'.format( solar*spiceypy.dpr() )  )
                print( '  Emission angle (degrees):        '
                       '{:16.3f}'.format( emissn*spiceypy.dpr())  )
                print( '  Observer visible:  {:s}'.format(
                    str(visibl) )  )
                print( '  Sun visible:       {:s}'.format(
                    str(lit)    )  )

                if  i  ==  4:
                    #
                    # Compute local solar time corresponding
                    # to the light time corrected TDB epoch
                    # at the boresight intercept.
                    #
                    [hr, mn, sc, time, ampm] = spiceypy.et2lst(
                        trgepc,
                        phoeid,
```

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```
                        lon,
                        'PLANETOCENTRIC' )

                    print( '\n  Local Solar Time at boresight '
                           'intercept (24 Hour Clock):\n'
                           '     {:s}'.format( time )       )
                #
                # End of LST computation block.
                #

            except SpiceyError as exc:
                #
                # Display a message if an exception was thrown.
                # For simplicity, we treat this as an indication
                # that the point of intersection was not found,
                # although it could be due to other errors.
                # Otherwise, continue with the calculations.
                #
                print( 'Exception message is: {:s}'.format(
                          exc.value ))
            #
            # End of SpiceyError try-catch block.
            #
            print( " )
        #
        # End of target shape model loop.
        #
    #
    # End of vector loop.
    #

    spiceypy.unload( METAKR )

if __name__ == '__main__':
     fovint()
```

Solution Sample Output

Execute the program:

```
Input UTC Time: 2004 jun 11 19:32:00
Converting UTC Time: 2004 jun 11 19:32:00
  ET seconds past J2000:    140254384.185

Vector: Boundary Corner 1

 Target shape model: Ellipsoid

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           91.026
     Y   =           67.190
     Z   =            2.030
  Planetocentric coordinates of the intercept (degrees):
```

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```
    LAT =            1.028
    LON =           36.432
  Phase angle (degrees):                    28.110
  Solar incidence angle (degrees):          16.121
  Emission angle (degrees):                 14.627
  Observer visible:  true
  Sun visible:       true

 Target shape model: DSK/Unprioritized

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
    X   =           78.770
    Y   =           61.570
    Z   =            0.964
  Planetocentric coordinates of the intercept (degrees):
    LAT =            0.552
    LON =           38.013
  Phase angle (degrees):                    28.110
  Solar incidence angle (degrees):          31.132
  Emission angle (degrees):                 16.539
  Observer visible:  true
  Sun visible:       true

Vector: Boundary Corner 2

 Target shape model: Ellipsoid

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
    X   =           89.991
    Y   =           66.726
    Z   =           14.733
  Planetocentric coordinates of the intercept (degrees):
    LAT =            7.492
    LON =           36.556
  Phase angle (degrees):                    27.894
  Solar incidence angle (degrees):          22.894
  Emission angle (degrees):                 14.988
  Observer visible:  true
  Sun visible:       true

 Target shape model: DSK/Unprioritized

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
    X   =           76.586
    Y   =           60.579
    Z   =           13.657
  Planetocentric coordinates of the intercept (degrees):
    LAT =            7.962
    LON =           38.344
  Phase angle (degrees):                    27.894
  Solar incidence angle (degrees):          32.013
  Emission angle (degrees):                 11.845
```

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```
  Observer visible:  true
  Sun visible:       true

Vector: Boundary Corner 3

 Target shape model: Ellipsoid

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           80.963
     Y   =           76.643
     Z   =           14.427
  Planetocentric coordinates of the intercept (degrees):
     LAT =            7.373
     LON =           43.430
  Phase angle (degrees):                    28.171
  Solar incidence angle (degrees):          21.315
  Emission angle (degrees):                 21.977
  Observer visible:  true
  Sun visible:       true

 Target shape model: DSK/Unprioritized

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           68.677
     Y   =           71.100
     Z   =           13.444
  Planetocentric coordinates of the intercept (degrees):
     LAT =            7.745
     LON =           45.993
  Phase angle (degrees):                    28.171
  Solar incidence angle (degrees):          36.039
  Emission angle (degrees):                 14.474
  Observer visible:  true
  Sun visible:       true

Vector: Boundary Corner 4

 Target shape model: Ellipsoid

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           81.997
     Y   =           77.106
     Z   =            1.698
  Planetocentric coordinates of the intercept (degrees):
     LAT =            0.865
     LON =           43.239
  Phase angle (degrees):                    28.385
  Solar incidence angle (degrees):          13.882
  Emission angle (degrees):                 21.763
  Observer visible:  true
  Sun visible:       true
```

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```
 Target shape model: DSK/Unprioritized

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           73.186
     Y   =           73.131
     Z   =            0.934
  Planetocentric coordinates of the intercept (degrees):
     LAT =            0.517
     LON =           44.978
  Phase angle (degrees):                    28.385
  Solar incidence angle (degrees):          41.268
  Emission angle (degrees):                 17.493
  Observer visible:  true
  Sun visible:       true

Vector: Cassini NAC Boresight

 Target shape model: Ellipsoid

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           86.390
     Y   =           72.089
     Z   =            8.255
  Planetocentric coordinates of the intercept (degrees):
     LAT =            4.196
     LON =           39.844
  Phase angle (degrees):                    28.139
  Solar incidence angle (degrees):          18.247
  Emission angle (degrees):                 17.858
  Observer visible:  true
  Sun visible:       true

  Local Solar Time at boresight intercept (24 Hour Clock):
     11:31:50

 Target shape model: DSK/Unprioritized

  Position vector of surface intercept in the IAU_PHOEBE frame (km):
     X   =           74.326
     Y   =           66.602
     Z   =            7.247
  Planetocentric coordinates of the intercept (degrees):
     LAT =            4.153
     LON =           41.863
  Phase angle (degrees):                    28.139
  Solar incidence angle (degrees):          33.200
  Emission angle (degrees):                 9.230
  Observer visible:  true
  Sun visible:       true

  Local Solar Time at boresight intercept (24 Hour Clock):
     11:39:55
```

Extra Credit

There are no "extra credit" tasks for this step of the lesson.

3.9.3 Geometric Event Finding Hands-On Lesson, using MEX

November 20, 2017

Overview

This lesson illustrates how the Geometry Finder (GF) subsystem of the SpiceyPy Toolkit can be used to find time intervals when specified geometric conditions are satisfied.

In this lesson the student is asked to construct a program that finds the time intervals, within a specified time range, when the Mars Express Orbiter (MEX) is visible from the DSN station DSS-14. Possible occultation of the spacecraft by Mars is to be considered.

References

This section lists SPICE documents referred to in this lesson.

In some cases the lesson explanations also refer to the information provided in the meta-data area of the kernels used in the lesson examples. It is especially true in case of the FK and IK files, which often contain comprehensive descriptions of the frames, instrument FOVs, etc. Since both FK and IK are text kernels, the information provided in them can be viewed using any text editor, while the meta information provided in binary kernels – SPKs and CKs – can be viewed using "commnt" or" spacit" utility programs located in "cspice/exe" of Toolkit installation tree.

The following SPICE tutorials serve as references for the discussions in this lesson:

```
Name              Lesson steps/functions it describes
----------------  -----------------------------------------------
Time              Time Conversion
SCLK and LSK      Time Conversion
SPK               Obtaining Ephemeris Data
Frames            Reference Frames
Using Frames      Reference Frames
PCK               Planetary Constants Data
Lunar-Earth PCK   Lunar and Earth Orientation Data
GF                The SPICE Geometry Finder (GF) subsystem
```

These tutorials are available from the NAIF ftp server at JPL:

```
https://naif.jpl.nasa.gov/naif/tutorials.html
```

Required Readings

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The Required Reading documents are provided with the Toolkit and are located under the "cspice/doc" directory in the CSPICE Toolkit installation tree.

```
Name             Lesson steps/functions that it describes
---------------  ----------------------------------------
cells.req        Cell/window initialization
frames.req       Using reference frames
gf.req           The SPICE geometry finder (GF) subsystem
kernel.req       Loading SPICE kernels
naif_ids.req     Body and reference frame names
pck.req          Obtaining planetary constants data
spk.req          Computing positions and velocities
time.req         UTC to ET time conversion
windows.req      The SPICE window data type
```

The Permuted Index

Tip:

The Permuted Index is also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/info/cspice_idx.html.

Another useful document distributed with the Toolkit is the permuted index. This is located under the "cspice/doc" directory in the C installation tree.

This text document provides a simple mechanism by which users can discover which SpiceyPy functions perform functions of interest, as well as the names of the source files that contain these functions.

SpiceyPy API Documentation

A SpiceyPy function's parameters specification is available using the built-in Python help system.

For example, the Python help function

```
>>> import spiceypy
>>> help(spiceypy.str2et)
```

describes of the str2et function's parameters, while the document

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html
```

describes extensively the str2et functionality.

Kernels Used

The following kernels are used in examples provided in this lesson:

```
#  FILE NAME                      TYPE DESCRIPTION
-- ------------------------------ ---- ------------------------------
1  de405xs.bsp                    SPK  Planetary ephemeris SPK,
                                       subsetted to cover only time
                                       range of interest
2  earthstns_itrf93_050714.bsp    SPK  DSN station SPK
3  earth_topo_050714.tf           FK   DSN station frame definitions
4  earth_000101_060525_060303.bpc PCK  Binary PCK for Earth
5  naif0008.tls                   LSK  Generic LSK
6  ORMM__040501000000_00076XS.BSP SPK  MEX Orbiter trajectory SPK,
                                       subsetted to cover only time
                                       range of interest
7  pck00008.tpc                   PCK  Generic PCK
8  mars_lowres.bds                DSK  Low-resolution Mars DSK
```

These SPICE kernels are included in the lesson package available from the NAIF server at JPL:

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Lessons/
```

SpiceyPy Modules Used

This section provides a complete list of the functions and kernels that are suggested for usage in each of the exercises in this lesson. (You may wish to not look at this list unless/until you "get stuck" while working on your own.)

```
CHAPTER EXERCISE   FUNCTIONS        NON-VOID         KERNELS
------- ---------  ---------------  ---------------  ----------
   1    viewpr     spiceypy.furnsh  spiceypy.rpd     1-7
                   spiceypy.wninsd  spiceypy.str2et
                   spiceypy.gfposc  spiceypy.timout
                   spiceypy.unload  spiceypy.wncard
                                    spiceypy.wnfetd

   2    visibl     spiceypy.furnsh  spiceypy.rpd     1-8
                   spiceypy.wninsd  spiceypy.str2et
                   spiceypy.gfposc  spiceypy.timout
                   spiceypy.gfoclt  spiceypy.wndifd
                   spiceypy.unload  spiceypy.wncard
                                    spiceypy.wnfetd

        extra (*)  spiceypy.gfdist  spiceypy.repmc   1,5-7
                   spiceypy.kclear  spiceypy.repmf


   (*) Additional APIs and kernels used in Extra Credit tasks.
```

Use the Python built-in help system on the various functions listed above for the API parameters' description, and refer to the headers of their corresponding CSPICE versions for detailed interface specifications.

Find View Periods

Task Statement

Write a program that finds the set of time intervals, within the time range

```
2004 MAY 2 TDB
2004 MAY 6 TDB
```

when the Mars Express Orbiter (MEX) is visible from the DSN station DSS-14. These time intervals are frequently called "view periods."

The spacecraft is considered visible if its apparent position (that is, its position corrected for light time and stellar aberration) has elevation of at least 6 degrees in the topocentric reference frame DSS-14_TOPO. In this exercise, we ignore the possibility of occultation of the spacecraft by Mars.

Use a search step size that ensures that no view periods of duration 5 minutes or longer will be missed by the search.

Display the start and stop times of these intervals using TDB calendar dates and millisecond precision.

Learning Goals

Exposure to SPICE GF event finding routines. Familiarity with SPICE windows and routines that manipulate them. Exposure to SPICE time parsing and output formatting routines.

Approach

Solution steps

A possible solution could consist of the following steps:

Preparation:

```
1.   Decide what SPICE kernels are necessary. Use the SPICE summary
     tool BRIEF to examine the coverage of the binary kernels and
     verify the availability of required data.

2.   Create a meta-kernel listing the SPICE kernels to be loaded.
     (Hint: consult a programming example tutorial, or the
     Introduction to Kernels tutorial, for a reminder of how to do
     this.)

     Name the meta-kernel 'viewpr.tm'.
```

Next, write a program that performs the following steps:

```
1.   Use spiceypy.furnsh to load the meta-kernel.

2.   Create confinement and output SpiceyPy windows using
     stypes.SPICEDOUBLE_CELL.

3.   Insert the given time bounds into the confinement window using
     spiceypy.wninsd.
```

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```
4.   Select a step size for searching for visibility state
     transitions: in this case, each target rise or set event is a
     state transition.

     The step size must be large enough so the search proceeds with
     reasonable speed, but small enough so that no visibility
     transition events---that is, target rise or set events---are
     missed.

5.   Use the GF routine spiceypy.gfposc to find the window of times,
     within the confinement window, during which the MEX spacecraft
     is above the elevation limit as seen from DSN station DSS-14,
     in the reference frame DSS-14_TOPO.

     Use light time and stellar aberration corrections for the
     apparent position of the spacecraft as seen from the station.

6.   Fetch and display the contents of the result window. Use
     spiceypy.wnfetd to extract from the result window the start and
     stop times of each time interval. Display each of the intervals
     in the result window as a pair of start and stop times. Express
     each time as a TDB calendar date using the routine
     spiceypy.timout.
```

You may find it useful to consult the references listed above. In particular, the header of the SPICE GF function spiceypy.gfposc contains pertinent documentation.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'viewpr.tm'. Its contents follow:

```
KPL/MK

   Example meta-kernel for geometric event finding hands-on
   coding lesson.

      Version 2.0.0 13-JUL-2017 (JDR)

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File Name                       Description
   ------------------------------  ------------------------------
   de405xs.bsp                     Planetary ephemeris SPK,
                                   subsetted to cover only
                                   time range of interest.
   earthstns_itrf93_050714.bsp     DSN station SPK.
   earth_topo_050714.tf            DSN station frame definitions.
   earth_000101_060525_060303.bpc  Binary PCK for Earth.
   naif0008.tls                    Generic LSK.
```

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```
   ORMM__040501000000_00076XS.BSP  MEX Orbiter trajectory SPK,
                                   subsetted to cover only
                                   time range of interest.
   pck00008.tpc                    Generic PCK.


\begindata

   KERNELS_TO_LOAD = (

            'kernels/spk/de405xs.bsp'
            'kernels/spk/earthstns_itrf93_050714.bsp'
            'kernels/fk/earth_topo_050714.tf'
            'kernels/pck/earth_000101_060525_060303.bpc'
            'kernels/lsk/naif0008.tls'
            'kernels/spk/ORMM__040501000000_00076XS.BSP'
            'kernels/pck/pck00008.tpc'
                      )

\begintext
```

Solution Code

The example program below shows one possible solution.

```
#
# Solution viewpr
#
from __future__ import print_function
import spiceypy.utils.support_types as stypes
import spiceypy

def viewpr():
    #
    # Local Parameters
    #
    METAKR = 'viewpr.tm'
    TDBFMT = 'YYYY MON DD HR:MN:SC.### (TDB) ::TDB'
    MAXIVL = 1000
    MAXWIN = 2 * MAXIVL

    #
    # Load the meta-kernel.
    #
    spiceypy.furnsh( METAKR )

    #
    # Assign the inputs for our search.
    #
    # Since we're interested in the apparent location of the
    # target, we use light time and stellar aberration
    # corrections. We use the "converged Newtonian" form
    # of the light time correction because this choice may
```

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```
    # increase the accuracy of the occultation times we'll
    # compute using gfoclt.
    #
    srfpt  = 'DSS-14'
    obsfrm = 'DSS-14_TOPO'
    target = 'MEX'
    abcorr = 'CN+S'
    start  = '2004 MAY 2 TDB'
    stop   = '2004 MAY 6 TDB'
    elvlim =  6.0

    #
    # The elevation limit above has units of degrees; we convert
    # this value to radians for computation using SPICE routines.
    # We'll store the equivalent value in radians in revlim.
    #
    revlim = spiceypy.rpd() * elvlim

    #
    # Since SPICE doesn't directly support the AZ/EL coordinate
    # system, we use the equivalent constraint
    #
    #    latitude > revlim
    #
    # in the latitudinal coordinate system, where the reference
    # frame is topocentric and is centered at the viewing location.
    #
    crdsys = 'LATITUDINAL'
    coord  = 'LATITUDE'
    relate = '>'

    #
    # The adjustment value only applies to absolute extrema
    # searches; simply give it an initial value of zero
    # for this inequality search.
    #
    adjust = 0.0

    #
    # stepsz is the step size, measured in seconds, used to search
    # for times bracketing a state transition. Since we don't expect
    # any events of interest to be shorter than five minutes, and
    # since the separation between events is well over 5 minutes,
    # we'll use this value as our step size. Units are seconds.
    #
    stepsz = 300.0

    #
    # Display a banner for the output report:
    #
    print( '\n{:s}\n'.format(
           'Inputs for target visibility search:' )  )
```

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```
    print( '   Target                        = '
           '{:s}'.format( target )  )
    print( '   Observation surface location = '
           '{:s}'.format( srfpt  )  )
    print( '   Observer\'s reference frame   = '
           '{:s}'.format( obsfrm )  )
    print( '   Elevation limit (degrees)    = '
           '{:f}'.format( elvlim )  )
    print( '   Aberration correction        = '
           '{:s}'.format( abcorr )  )
    print( '   Step size (seconds)          = '
           '{:f}'.format( stepsz )  )

    #
    # Convert the start and stop times to ET.
    #
    etbeg = spiceypy.str2et( start )
    etend = spiceypy.str2et( stop  )

    #
    # Display the search interval start and stop times
    # using the format shown below.
    #
    #    2004 MAY 06 20:15:00.000 (TDB)
    #
    timstr = spiceypy.timout( etbeg, TDBFMT )
    print( '   Start time                   = '
           '{:s}'.format(timstr) )

    timstr = spiceypy.timout( etend, TDBFMT )
    print( '   Stop time                    = '
           '{:s}'.format(timstr) )

    print( ' ' )

    #
    # Initialize the "confinement" window with the interval
    # over which we'll conduct the search.
    #
    cnfine = stypes.SPICEDOUBLE_CELL(2)
    spiceypy.wninsd( etbeg, etend, cnfine )

    #
    # In the call below, the maximum number of window
    # intervals gfposc can store internally is set to MAXIVL.
    # We set the cell size to MAXWIN to achieve this.
    #
    riswin = stypes.SPICEDOUBLE_CELL( MAXWIN )

    #
    # Now search for the time period, within our confinement
```

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```
    # window, during which the apparent target has elevation
    # at least equal to the elevation limit.
    #
    spiceypy.gfposc( target, obsfrm, abcorr, srfpt,
                     crdsys, coord,  relate, revlim,
                     adjust, stepsz, MAXIVL, cnfine, riswin )

    #
    # The function wncard returns the number of intervals
    # in a SPICE window.
    #
    winsiz = spiceypy.wncard( riswin )

    if winsiz == 0:

        print( 'No events were found.' )

    else:

        #
        # Display the visibility time periods.
        #
        print( 'Visibility times of {0:s} '
               'as seen from {1:s}:\n'.format(
                target, srfpt )                )

        for  i  in  range(winsiz):
            #
            # Fetch the start and stop times of
            # the ith interval from the search result
            # window riswin.
            #
            [intbeg, intend] = spiceypy.wnfetd( riswin, i )

            #
            # Convert the rise time to a TDB calendar string.
            #
            timstr = spiceypy.timout( intbeg, TDBFMT )

            #
            # Write the string to standard output.
            #
            if  i  ==  0:

                print( 'Visibility or window start time:'
                       '  {:s}'.format( timstr )          )
            else:

                print( 'Visibility start time:          '
                       '  {:s}'.format( timstr )          )

            #
```

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```
            # Convert the set time to a TDB calendar string.
            #
            timstr = spiceypy.timout( intend, TDBFMT )

            #
            # Write the string to standard output.
            #
            if  i  ==  (winsiz-1):

                print( 'Visibility or window stop time: '
                       '  {:s}'.format( timstr )          )
            else:

                print( 'Visibility stop time:           '
                       '  {:s}'.format( timstr )          )

            print( ' ' )

    spiceypy.unload( METAKR )

if __name__ == '__main__':
    viewpr()
```

Solution Sample Output

Numerical results shown for this example may differ across platforms since the results depend on the SPICE kernels used as input and on the host platform's arithmetic implementation.

Execute the program. The output is:

```
Inputs for target visibility search:

   Target                        = MEX
   Observation surface location = DSS-14
   Observer's reference frame    = DSS-14_TOPO
   Elevation limit (degrees)     = 6.000000
   Aberration correction         = CN+S
   Step size (seconds)           = 300.000000
   Start time                    = 2004 MAY 02 00:00:00.000 (TDB)
   Stop time                     = 2004 MAY 06 00:00:00.000 (TDB)

Visibility times of MEX as seen from DSS-14:

Visibility or window start time:  2004 MAY 02 00:00:00.000 (TDB)
Visibility stop time:             2004 MAY 02 05:35:03.096 (TDB)

Visibility start time:            2004 MAY 02 16:09:14.078 (TDB)
Visibility stop time:             2004 MAY 03 05:33:57.257 (TDB)

Visibility start time:            2004 MAY 03 16:08:02.279 (TDB)
Visibility stop time:             2004 MAY 04 05:32:50.765 (TDB)

Visibility start time:            2004 MAY 04 16:06:51.259 (TDB)
```

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```
Visibility stop time:              2004 MAY 05 05:31:43.600 (TDB)

Visibility start time:             2004 MAY 05 16:05:40.994 (TDB)
Visibility or window stop time:    2004 MAY 06 00:00:00.000 (TDB)
```

Find Times when Target is Visible

Task Statement

Extend the program of the previous chapter to find times when the MEX orbiter is:

```
--    Above the elevation limit in the DSS-14_TOPO topocentric
      reference frame.

--    and is not occulted by Mars
```

Finding time intervals that satisfy the second condition requires a search for occultations of the spacecraft by Mars. Perform this search twice: once using an ellipsoidal shape model for Mars, and once using a DSK shape model.

Compute the final results twice as well, using the results of both occultation searches.

For each of the two shape model cases, store the set of time intervals when the spacecraft is visible in a SpiceyPy window. We'll call this the "result window."

Display each of the intervals in each result window as a pair of start and stop times. Express each time as a TDB calendar date using the same format as in the previous program.

Learning Goals

Familiarity with the GF occultation finding routine spiceypy.gfoclt. Experience with Digital Shape Kernel (DSK) shape models. Further experience with the SpiceyPy window functions.

Approach

Solution steps

A possible solution would consist of the following steps:

```
1.    Use the meta-kernel from the previous chapter as the starting
      point. Add more kernels to it as needed.

      Name the meta-kernel 'visibl.tm'.

2.    Include the code from the program of the previous chapter in a
      new source file; modify this code to create the new program.

3.    Your program will need additional windows to capture the
      results of occultation searches performed using both
      ellipsoidal and DSK shape models. Additional windows will be
      needed to compute the set differences of the elevation search
      ("view period") window and each of the occultation search
```

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```
     windows. Further details are provided below.

     Create additional output SpiceyPy windows using
     stypes.SPICEDOUBLE_CELL.

4.   The remaining steps can be performed twice: once using an
     ellipsoidal shape model for Mars, and once using a DSK Mars
     shape model. Alternatively, two copies of the entire solution
     program can be created: one for each shape model.

5.   Search for occultations of the MEX orbiter as seen from DSS-14
     using spiceypy.gfoclt. Use as the confinement window for this
     search the result window from the elevation search performed by
     spiceypy.gfposc.

     Since occultations occur when the apparent MEX spacecraft
     position is behind the apparent figure of Mars, light time
     correction must be performed for the occultation search. To
     improve accuracy of the occultation state determination, use
     "converged Newtonian" light time correction.

6.   Use the SpiceyPy window subtraction routine spiceypy.wndifd to
     subtract the window of times when the spacecraft is occulted
     from the window of times when the spacecraft is above the
     elevation limit. The difference window is the final result.

7.   Modify the code to display the contents of the difference
     window.
```

This completes the assignment.

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'visibl.tm'. Its contents follow:

```
KPL/MK

   Example meta-kernel for geometric event finding hands-on
   coding lesson.

      Version 3.0.0 26-OCT-2017 (BVS)

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

   File Name                     Description
   ------------------------------  ------------------------------
   de405xs.bsp                   Planetary ephemeris SPK,
                                 subsetted to cover only
                                 time range of interest.
```

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```
   earthstns_itrf93_050714.bsp     DSN station SPK.
   earth_topo_050714.tf            DSN station frame definitions.
   earth_000101_060525_060303.bpc  Binary PCK for Earth.
   naif0008.tls                    Generic LSK.
   ORMM__040501000000_00076XS.BSP  MEX Orbiter trajectory SPK,
                                   subsetted to cover only
                                   time range of interest.
   pck00008.tpc                    Generic PCK.
   mars_lowres.bds                 Low-resolution Mars DSK.


\begindata

   KERNELS_TO_LOAD = (

            'kernels/spk/de405xs.bsp'
            'kernels/spk/earthstns_itrf93_050714.bsp'
            'kernels/fk/earth_topo_050714.tf'
            'kernels/pck/earth_000101_060525_060303.bpc'
            'kernels/lsk/naif0008.tls'
            'kernels/spk/ORMM__040501000000_00076XS.BSP'
            'kernels/pck/pck00008.tpc'
            'kernels/dsk/mars_lowres.bds'
                     )

\begintext
```

Solution Code

```
#
# Solution visibl
#
from __future__ import print_function

#
# SpiceyPy package:
#
import spiceypy.utils.support_types as stypes
import spiceypy

def visibl():
    #
    # Local Parameters
    #
    METAKR = 'visibl.tm'
    SCLKID = -82
    TDBFMT = 'YYYY MON DD HR:MN:SC.### TDB ::TDB'
    MAXIVL = 1000
    MAXWIN = 2 * MAXIVL

    #
    # Load the meta-kernel.
```

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```
    #
    spiceypy.furnsh( METAKR )

    #
    # Assign the inputs for our search.
    #
    # Since we're interested in the apparent location of the
    # target, we use light time and stellar aberration
    # corrections. We use the "converged Newtonian" form
    # of the light time correction because this choice may
    # increase the accuracy of the occultation times we'll
    # compute using gfoclt.
    #
    srfpt  = 'DSS-14'
    obsfrm = 'DSS-14_TOPO'
    target = 'MEX'
    abcorr = 'CN+S'
    start  = '2004 MAY 2 TDB'
    stop   = '2004 MAY 6 TDB'
    elvlim =  6.0

    #
    # The elevation limit above has units of degrees; we convert
    # this value to radians for computation using SPICE routines.
    # We'll store the equivalent value in radians in revlim.
    #
    revlim = spiceypy.rpd() * elvlim

    #
    # We model the target shape as a point. We either model the
    # blocking body's shape as an ellipsoid, or we represent
    # its shape using actual topographic data. No body-fixed
    # reference frame is required for the target since its
    # orientation is not used.
    #
    back   = target
    bshape = 'POINT'
    bframe = ' '
    front  = 'MARS'
    fshape = 'ELLIPSOID'
    fframe = 'IAU_MARS'

    #
    # The occultation type should be set to 'ANY' for a point
    # target.
    #
    occtyp = 'any'

    #
    # Since SPICE doesn't directly support the AZ/EL coordinate
    # system, we use the equivalent constraint
    #
```

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```
    #    latitude > revlim
    #
    # in the latitudinal coordinate system, where the reference
    # frame is topocentric and is centered at the viewing location.
    #
    crdsys = 'LATITUDINAL'
    coord  = 'LATITUDE'
    relate = '>'

    #
    # The adjustment value only applies to absolute extrema
    # searches; simply give it an initial value of zero
    # for this inequality search.
    #
    adjust = 0.0

    #
    # stepsz is the step size, measured in seconds, used to search
    # for times bracketing a state transition. Since we don't expect
    # any events of interest to be shorter than five minutes, and
    # since the separation between events is well over 5 minutes,
    # we'll use this value as our step size. Units are seconds.
    #
    stepsz = 300.0

    #
    # Display a banner for the output report:
    #
    print( '\n{:s}\n'.format(
           'Inputs for target visibility search:' )  )

    print( '   Target                        = '
           '{:s}'.format( target )  )
    print( '   Observation surface location = '
           '{:s}'.format( srfpt  )  )
    print( '   Observer\'s reference frame   = '
           '{:s}'.format( obsfrm )  )
    print( '   Blocking body                 = '
           '{:s}'.format( front  )  )
    print( '   Blocker\'s reference frame    = '
           '{:s}'.format( fframe )  )
    print( '   Elevation limit (degrees)    = '
           '{:f}'.format( elvlim )  )
    print( '   Aberration correction         = '
           '{:s}'.format( abcorr )  )
    print( '   Step size (seconds)           = '
           '{:f}'.format( stepsz )  )

    #
    # Convert the start and stop times to ET.
    #
    etbeg = spiceypy.str2et( start )
```

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```
    etend = spiceypy.str2et( stop  )

    #
    # Display the search interval start and stop times
    # using the format shown below.
    #
    #    2004 MAY 06 20:15:00.000 (TDB)
    #
    btmstr = spiceypy.timout( etbeg, TDBFMT )
    print( '   Start time                  = '
           '{:s}'.format(btmstr) )

    etmstr = spiceypy.timout( etend, TDBFMT )
    print( '   Stop time                   = '
           '{:s}'.format(etmstr) )

    print( ' ' )

    #
    # Initialize the "confinement" window with the interval
    # over which we'll conduct the search.
    #
    cnfine = stypes.SPICEDOUBLE_CELL(2)
    spiceypy.wninsd( etbeg, etend, cnfine )

    #
    # In the call below, the maximum number of window
    # intervals gfposc can store internally is set to MAXIVL.
    # We set the cell size to MAXWIN to achieve this.
    #
    riswin = stypes.SPICEDOUBLE_CELL( MAXWIN )

    #
    # Now search for the time period, within our confinement
    # window, during which the apparent target has elevation
    # at least equal to the elevation limit.
    #
    spiceypy.gfposc( target, obsfrm, abcorr, srfpt,
                     crdsys, coord,  relate, revlim,
                     adjust, stepsz, MAXIVL, cnfine, riswin )

    #
    # Now find the times when the apparent target is above
    # the elevation limit and is not occulted by the
    # blocking body (Mars). We'll find the window of times when
    # the target is above the elevation limit and *is* occulted,
    # then subtract that window from the view period window
    # riswin found above.
    #
    # For this occultation search, we can use riswin as
    # the confinement window because we're not interested in
    # occultations that occur when the target is below the
```

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```
    # elevation limit.
    #
    # Find occultations within the view period window.
    #
    print( ' Searching using ellipsoid target shape model...' )

    eocwin = stypes.SPICEDOUBLE_CELL( MAXWIN )

    fshape = 'ELLIPSOID'

    spiceypy.gfoclt( occtyp, front,  fshape,  fframe,
                     back,   bshape, bframe,  abcorr,
                     srfpt,  stepsz, riswin,  eocwin )
    print( ' Done.' )

    #
    # Subtract the occultation window from the view period
    # window: this yields the time periods when the target
    # is visible.
    #
    evswin = spiceypy.wndifd( riswin, eocwin )

    #
    #  Repeat the search using low-resolution DSK data
    # for the front body.
    #
    print( ' Searching using DSK target shape model...' )

    docwin = stypes.SPICEDOUBLE_CELL( MAXWIN )

    fshape = 'DSK/UNPRIORITIZED'

    spiceypy.gfoclt( occtyp, front,  fshape,  fframe,
                     back,   bshape, bframe,  abcorr,
                     srfpt,  stepsz, riswin,  docwin )
    print( ' Done.\n' )

    dvswin = spiceypy.wndifd( riswin, docwin )

    #
    # The function wncard returns the number of intervals
    # in a SPICE window.
    #
    winsiz = spiceypy.wncard( evswin )

    if winsiz == 0:

        print( 'No events were found.' )

    else:
        #
        # Display the visibility time periods.
```

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```
        #
        print( 'Visibility start and stop times of '
               '{0:s} as seen from {1:s}\n'
               'using both ellipsoidal and DSK '
               'target shape models:\n'.format(
                   target, srfpt )                )

        for  i  in  range(winsiz):
            #
            # Fetch the start and stop times of
            # the ith interval from the ellipsoid
            # search result window evswin.
            #
            [intbeg, intend] = spiceypy.wnfetd( evswin, i )

            #
            # Convert the rise time to TDB calendar strings.
            # Write the results.
            #
            btmstr = spiceypy.timout( intbeg, TDBFMT )
            etmstr = spiceypy.timout( intend, TDBFMT )

            print( ' Ell: {:s} : {:s}'.format( btmstr, etmstr ) )

            #
            # Fetch the start and stop times of
            # the ith interval from the DSK
            # search result window dvswin.
            #
            [dintbg, dinten] = spiceypy.wnfetd( dvswin, i )

            #
            # Convert the rise time to TDB calendar strings.
            # Write the results.
            #
            btmstr = spiceypy.timout( dintbg, TDBFMT )
            etmstr = spiceypy.timout( dinten, TDBFMT )

            print( ' DSK: {:s} : {:s}\n'.format( btmstr, etmstr ) )
        #
        # End of result display loop.
        #

    spiceypy.unload( METAKR )

if __name__ == '__main__':
    visibl()
```

Solution Sample Output

Numerical results shown for this example may differ across platforms since the results depend on the SPICE kernels used as input and on the host platform's arithmetic implementation.

Execute the program. The output is:

```
Inputs for target visibility search:

   Target                        = MEX
   Observation surface location = DSS-14
   Observer's reference frame    = DSS-14_TOPO
   Blocking body                 = MARS
   Blocker's reference frame     = IAU_MARS
   Elevation limit (degrees)     = 6.000000
   Aberration correction         = CN+S
   Step size (seconds)           = 300.000000
   Start time                    = 2004 MAY 02 00:00:00.000 TDB
   Stop time                     = 2004 MAY 06 00:00:00.000 TDB

 Searching using ellipsoid target shape model...
 Done.
 Searching using DSK target shape model...
 Done.

Visibility start and stop times of MEX as seen from DSS-14
using both ellipsoidal and DSK target shape models:

 Ell: 2004 MAY 02 00:00:00.000 TDB : 2004 MAY 02 04:49:30.827 TDB
 DSK: 2004 MAY 02 00:00:00.000 TDB : 2004 MAY 02 04:49:32.645 TDB

 Ell: 2004 MAY 02 16:09:14.078 TDB : 2004 MAY 02 20:00:22.514 TDB
 DSK: 2004 MAY 02 16:09:14.078 TDB : 2004 MAY 02 20:00:23.980 TDB

 Ell: 2004 MAY 02 21:01:38.222 TDB : 2004 MAY 03 03:35:42.256 TDB
 DSK: 2004 MAY 02 21:01:43.195 TDB : 2004 MAY 03 03:35:44.140 TDB

 Ell: 2004 MAY 03 04:36:42.484 TDB : 2004 MAY 03 05:33:57.257 TDB
 DSK: 2004 MAY 03 04:36:46.856 TDB : 2004 MAY 03 05:33:57.257 TDB

 Ell: 2004 MAY 03 16:08:02.279 TDB : 2004 MAY 03 18:46:26.013 TDB
 DSK: 2004 MAY 03 16:08:02.279 TDB : 2004 MAY 03 18:46:27.306 TDB

 Ell: 2004 MAY 03 19:46:54.618 TDB : 2004 MAY 04 02:21:44.562 TDB
 DSK: 2004 MAY 03 19:46:59.723 TDB : 2004 MAY 04 02:21:46.574 TDB

 Ell: 2004 MAY 04 03:21:56.347 TDB : 2004 MAY 04 05:32:50.765 TDB
 DSK: 2004 MAY 04 03:22:00.850 TDB : 2004 MAY 04 05:32:50.765 TDB

 Ell: 2004 MAY 04 16:06:51.259 TDB : 2004 MAY 04 17:32:25.809 TDB
 DSK: 2004 MAY 04 16:06:51.259 TDB : 2004 MAY 04 17:32:27.118 TDB

 Ell: 2004 MAY 04 18:32:05.975 TDB : 2004 MAY 05 01:07:48.264 TDB
 DSK: 2004 MAY 04 18:32:11.046 TDB : 2004 MAY 05 01:07:50.061 TDB

 Ell: 2004 MAY 05 02:07:11.601 TDB : 2004 MAY 05 05:31:43.600 TDB
 DSK: 2004 MAY 05 02:07:16.241 TDB : 2004 MAY 05 05:31:43.600 TDB

 Ell: 2004 MAY 05 16:05:40.994 TDB : 2004 MAY 05 16:18:35.560 TDB
 DSK: 2004 MAY 05 16:05:40.994 TDB : 2004 MAY 05 16:18:36.994 TDB
```

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```
 Ell: 2004 MAY 05 17:17:27.717 TDB : 2004 MAY 05 23:54:04.672 TDB
 DSK: 2004 MAY 05 17:17:32.375 TDB : 2004 MAY 05 23:54:06.221 TDB
```

Extra Credit

In this "extra credit" section you will be presented with more complex tasks, aimed at improving your understanding of the geometry event finding subsystem and particularly the spiceypy.gfposc and spiceypy.gfdist functions.

These "extra credit" tasks are provided as task statements, and unlike the regular tasks, no approach or solution source code is provided. In the next section, you will find the numeric solutions to the questions asked in these tasks.

Task statements

```
1.   Write a program that finds the times, within the time range

     2004 MAY 2 TDB
     2004 MAY 6 TDB

     when the MEX spacecraft crosses Mars' equator. Display the
     results using TDB calendar dates and millisecond precision.

2.   Write a program that finds the times, within the time range

     2004 MAY 2 TDB
     2004 MAY 6 TDB

     when the MEX spacecraft is at periapsis. Display the results
     using TDB calendar dates and millisecond precision.

3.   Write a program that finds the times, within the time range

     2004 MAY 2 TDB
     2004 MAY 6 TDB

     when the MEX spacecraft is at apoapsis. Display the results
     using TDB calendar dates and millisecond precision.
```

Solutions

```
 1.   Solution for the equator crossing search, using spiceypy.gfposc
      for the MEX spacecraft latitude in the Mars body-fixed frame
      equal to 0 degrees:


Inputs for equator crossing search:

   Target                         = MEX
```

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```
   Observer                      = MARS
   Observer's reference frame    = IAU_MARS
   Latitude limit (degrees)      = 0.000000
   Aberration correction         = NONE
   Step size (seconds)           = 300.000000
   Start time                    = 2004 MAY 02 00:00:00.000 (TDB)
   Stop time                     = 2004 MAY 06 00:00:00.000 (TDB)

MEX MARS equator crossing times:

 Equator crossing or start time:  2004 MAY 02 05:00:08.334 (TDB)
 Equator crossing time:           2004 MAY 02 06:15:13.074 (TDB)
 Equator crossing time:           2004 MAY 02 12:35:14.856 (TDB)
 Equator crossing time:           2004 MAY 02 13:50:09.161 (TDB)
 Equator crossing time:           2004 MAY 02 20:10:24.439 (TDB)
 Equator crossing time:           2004 MAY 02 21:25:10.344 (TDB)
 Equator crossing time:           2004 MAY 03 03:45:26.758 (TDB)
 Equator crossing time:           2004 MAY 03 05:00:04.086 (TDB)
 Equator crossing time:           2004 MAY 03 11:20:32.419 (TDB)
 Equator crossing time:           2004 MAY 03 12:34:57.968 (TDB)
 Equator crossing time:           2004 MAY 03 18:55:34.883 (TDB)
 Equator crossing time:           2004 MAY 03 20:09:53.063 (TDB)
 Equator crossing time:           2004 MAY 04 02:30:35.509 (TDB)
 Equator crossing time:           2004 MAY 04 03:44:42.753 (TDB)
 Equator crossing time:           2004 MAY 04 10:05:41.638 (TDB)
 Equator crossing time:           2004 MAY 04 11:19:38.397 (TDB)
 Equator crossing time:           2004 MAY 04 17:40:41.405 (TDB)
 Equator crossing time:           2004 MAY 04 18:54:31.413 (TDB)
 Equator crossing time:           2004 MAY 05 01:15:45.967 (TDB)
 Equator crossing time:           2004 MAY 05 02:29:25.294 (TDB)
 Equator crossing time:           2004 MAY 05 08:50:53.931 (TDB)
 Equator crossing time:           2004 MAY 05 10:04:26.915 (TDB)
 Equator crossing time:           2004 MAY 05 16:25:58.350 (TDB)
 Equator crossing or stop time:   2004 MAY 05 17:39:23.889 (TDB)

 2.   Solution for the periapsis search, using spiceypy.gfdist for
      the MEX spacecraft distance from Mars at a local minimum:


Inputs for periapsis search:

   Target                        = MEX
   Observer                      = MARS
   Aberration correction         = NONE
   Step size (seconds)           = 300.000000
   Start time                    = 2004 MAY 02 00:00:00.000 (TDB)
   Stop time                     = 2004 MAY 06 00:00:00.000 (TDB)

MEX periapsis times:

 Periapsis or start time:         2004 MAY 02 05:57:51.000 (TDB)
 Periapsis time:                  2004 MAY 02 13:32:43.325 (TDB)
```

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```
 Periapsis time:                  2004 MAY 02 21:07:41.124 (TDB)
 Periapsis time:                  2004 MAY 03 04:42:30.648 (TDB)
 Periapsis time:                  2004 MAY 03 12:17:21.143 (TDB)
 Periapsis time:                  2004 MAY 03 19:52:12.267 (TDB)
 Periapsis time:                  2004 MAY 04 03:26:57.755 (TDB)
 Periapsis time:                  2004 MAY 04 11:01:49.826 (TDB)
 Periapsis time:                  2004 MAY 04 18:36:38.448 (TDB)
 Periapsis time:                  2004 MAY 05 02:11:28.558 (TDB)
 Periapsis time:                  2004 MAY 05 09:46:26.309 (TDB)
 Periapsis or end time:           2004 MAY 05 17:21:18.875 (TDB)

 3.    Solution for the apoapsis search, using spiceypy.gfdist for the
       MEX spacecraft distance from Mars at a local maximum:


Inputs for apoapsis search:

   Target                      = MEX
   Observer                    = MARS
   Aberration correction       = NONE
   Step size (seconds)         = 300.000000
   Start time                  = 2004 MAY 02 00:00:00.000 (TDB)
   Stop time                   = 2004 MAY 06 00:00:00.000 (TDB)

MEX apoapsis times:

 Apoapsis or start time:          2004 MAY 02 02:10:24.948 (TDB)
 Apoapsis time:                   2004 MAY 02 09:45:19.189 (TDB)
 Apoapsis time:                   2004 MAY 02 17:20:14.194 (TDB)
 Apoapsis time:                   2004 MAY 03 00:55:07.633 (TDB)
 Apoapsis time:                   2004 MAY 03 08:29:57.890 (TDB)
 Apoapsis time:                   2004 MAY 03 16:04:48.524 (TDB)
 Apoapsis time:                   2004 MAY 03 23:39:36.745 (TDB)
 Apoapsis time:                   2004 MAY 04 07:14:25.662 (TDB)
 Apoapsis time:                   2004 MAY 04 14:49:15.904 (TDB)
 Apoapsis time:                   2004 MAY 04 22:24:05.351 (TDB)
 Apoapsis time:                   2004 MAY 05 05:58:59.270 (TDB)
 Apoapsis time:                   2004 MAY 05 13:33:54.433 (TDB)
 Apoapsis or stop time:           2004 MAY 05 21:08:50.211 (TDB)
```

3.9.4 In-situ Sensing Hands-On Lesson, using CASSINI

November 20, 2017

Overview

In this lesson you will develop a simple program illustrating how SPICE can be used to compute various kinds of geometry information applicable to the experiments carried out by an in-situ instrument flown on an interplanetary spacecraft.

References

This section lists SPICE documents referred to in this lesson.

In some cases the lesson explanations also refer to the information provided in the meta-data area of the kernels used in the lesson examples. It is especially true in case of the FK and IK files, which often contain comprehensive descriptions of the frames, instrument FOVs, etc. Since both FK and IK are text kernels, the information provided in them can be viewed using any text editor, while the meta information provided in binary kernels – SPKs and CKs – can be viewed using "commnt" or "spacit" utility programs located in "cspice/exe" of Toolkit installation tree.

The following SPICE tutorials serve as references for the discussions in this lesson:

```
Name              Lesson steps/functions it describes
---------------   -----------------------------------------------
Time              UTC to ET and SCLK to ET
Loading Kernels   Loading SPICE kernels
SCLK              SCLK to ET time conversion
SPK               Computing positions and velocities
Frames            Computing transformations between frames
```

These tutorials are available from the NAIF ftp server at JPL:

```
https://naif.jpl.nasa.gov/naif/tutorials.html
```

Required Readings

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The Required Reading documents are provided with the Toolkit and are located under the "cspice/doc" directory in the CSPICE Toolkit installation tree.

```
Name             Lesson steps/functions that it describes
---------------  ----------------------------------------
kernel.req       Loading SPICE kernels
naif_ids.req     Body and reference frame names
spk.req          Computing positions and velocities
sclk.req         SCLK to ET time conversion
time.req         UTC to ET time conversion
```

The Permuted Index

Tip:

The Permuted Index is also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/info/cspice_idx.html.

Another useful document distributed with the Toolkit is the permuted index. This is located under the "cspice/doc" directory in the C installation tree.

This text document provides a simple mechanism by which users can discover which SpiceyPy functions perform functions of interest, as well as the names of the source files that contain these functions.

SpiceyPy API Documentation

A SpiceyPy function's parameters specification is available using the built-in Python help system.

For example, the Python help function

```
>>> import spiceypy
>>> help(spiceypy.str2et)
```

describes of the str2et function's parameters, while the document

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html
```

describes extensively the str2et functionality.

Kernels Used

The following kernels are used in examples provided in this lesson:

```
#  FILE NAME                 TYPE DESCRIPTION
-- ------------------------- ---- ----------------------------------
1  naif0008.tls              LSK  Generic LSK
2  cas00084.tsc              SCLK Cassini SCLK
3  020514_SE_SAT105.bsp      SPK  Saturnian Satellite Ephemeris SPK
4  030201AP_SK_SM546_T45.bsp SPK  Cassini Spacecraft SPK
5  981005_PLTEPH-DE405S.bsp  SPK  Planetary Ephemeris SPK
6  sat128.bsp                SPK  Saturnian Satellite Ephemeris SPK
7  04135_04171pc_psiv2.bc    CK   Cassini Spacecraft CK
8  cas_v37.tf                FK   Cassini FK
9  cpck05Mar2004.tpc         PCK  Cassini project PCK
```

These SPICE kernels are included in the lesson package available from the NAIF server at JPL:

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Lessons/
```

SpiceyPy Modules Used

This section provides a complete list of the functions and kernels that are suggested for usage in each of the exercises in this lesson. (You may wish to not look at this list unless/until you "get stuck" while working on your own.)

CHAPTER	EXERCISE	FUNCTIONS	NON-VOID	KERNELS
1	convrt	spiceypy.furnsh spiceypy.unload	spiceypy.str2et	1
2	sclket	spiceypy.furnsh spiceypy.unload	spiceypy.str2et spiceypy.scs2e	1,2
3	getsta	spiceypy.furnsh spiceypy.unload	spiceypy.str2et spiceypy.scs2e spiceypy.spkezr	1-6
4	soldir	spiceypy.furnsh spiceypy.unload	spiceypy.str2et spiceypy.scs2e spiceypy.spkezr spiceypy.spkpos spiceypy.vhat	1-8
5	sscpnt	spiceypy.furnsh spiceypy.unload	spiceypy.str2et spiceypy.scs2e spiceypy.spkezr spiceypy.spkpos spiceypy.vhat spiceypy.subpnt spiceypy.reclat spiceypy.pxform spiceypy.mxv spiceypy.dpr	1-9
6	scvel	spiceypy.furnsh spiceypy.unload	spiceypy.str2et spiceypy.scs2e spiceypy.spkezr spiceypy.spkpos spiceypy.vhat spiceypy.subpnt spiceypy.reclat spiceypy.pxform spiceypy.mxv spiceypy.dpr	1-9

Use the Python built-in help system on the various functions listed above for the API parameters' description, and refer to the headers of their corresponding CSPICE versions for detailed interface specifications.

Step-1: "UTC to ET"

"UTC to ET" Task Statement

Write a program that computes and prints the Ephemeris Time (ET) corresponding to "2004-06-11T19:32:00" UTC, as the number of ephemeris seconds past J2000, .

"UTC to ET" Hints

Find out what SPICE kernel(s) is(are) needed to support this conversion. Reference the "time.req" and/or "Time" tutorial.

Find necessary kernel(s) on the NAIF's FTP site.

Find out what routine should be called to load necessary kernel(s). Reference the "kernel.req" and/or "Loading Kernels" tutorial.

Find the "loader" routine calling sequence specification. Look at the "time.req"and that routine's source code header. This routine may be an entry point, in which case there will be no source file with the same name. To find out in which source file this entry point is, search for its name in the "Permuted Index".

Find the routine(s) used to convert time between UTC and ET. Look at the "time.req" and/or "Time" tutorial.

Find the "converter" routine(s) calling sequence specification. Look in the "time.req" and the routine's source code header.

Put all calls together in a program, add variable declarations (the routine header's "Declarations" and "Examples" sections are a good place to look for declaration specification and examples) and output print statements.

"UTC to ET" Solution Steps

Only one kernel file is needed to support this conversion – an LSK file "naif0008.tls".

As any other SPICE kernel this file can be loaded by the spiceypy.furnsh function. For that, the name of the file can be provided as a sole argument of this routine:

```
...
lskfile = 'naif0008.tls'

spiceypy.furnsh(lskfile)
```

or it can be listed in a meta-kernel:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.

\begindata
   KERNELS_TO_LOAD = (
```

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```
                      'kernels/lsk/naif0008.tls'
                      )
\begintext
```

the name of which, let's call it "convrt.tm", can be then provided as a sole argument of the *spiceypy.spiceypy.furnsh()* routine:

```
mkfile = 'convrt.tm'
spiceypy.furnsh(mkfile)
```

While the second option seems to involve a bit more work – it requires making an extra file – it is a much better way to go if you plan to load more kernels as you extend the program. With the meta-kernel approach simply adding more kernels to the list in KERNEL_TO_LOAD without changing the program code will accomplish that.

The highest level SpiceyPy time routine converting UTC to ET is spiceypy.str2et *spiceypy.spiceypy.str2et()* .

It has two arguments – input time string representing UTC in a variety of formats (see *spiceypy.spiceypy.str2et()* header's section "Particulars" for the complete description of input time formats) and output DP number of ET seconds past J2000. A call to spiceypy.str2et converting a given UTC to ET could look like this:

```
utc =  '2004-06-11T19:32:00'
et = spiceypy.str2et(utc)
```

By combining *spiceypy.spiceypy.furnsh()* and *spiceypy.spiceypy.str2et()* calls and required declarations and by adding a simple print statement, one would get a complete program that prints ET for the given UTC epoch.

Use of SpiceyPy calls in a Python script requires the SpiceyPy package to be installed in your Python distribution, either using pip or conda, and imported within the script.

When you execute the script, "convrt", it produces the following output:

```
> python convrt.py
UTC        = 2004-06-11T19:32:00
ET         =     140254384.184625
```

"UTC to ET" Code

Program "convrt.py":

```
from __future__ import print_function
import spiceypy

def convrt():

    mkfile = 'convrt.tm'
    spiceypy.furnsh(mkfile)

    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC        = {:s}'.format(utc))
    print('ET         = {:20.6f}'.format(et))
```

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```
    spiceypy.unload(mkfile)


if __name__ == '__main__':
    convrt()
```

Meta-kernel file "convrt.tm":

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                  Generic LSK.

\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     )
\begintext
```

Step-2: "SCLK to ET"

"SCLK to ET" Task Statement

Extend the program from Step-1 to compute and print ET for the following CASSINI on-board clock epoch "1465674964.105".

"SCLK to ET" Hints

Find out what additional (to those already loaded in Step-1) SPICE kernel(s) is(are) needed to support SCLK to ET conversion. Look at the "sclk.req" and/or "SCLK" tutorial.

Find necessary kernel(s) on the NAIF's FTP site.

Modify the program or meta-kernel to load this (these) kernels.

Find the routine(s) needed to convert time between SCLK and ET. Look at the "sclk.req" and/or "Time" and "SCLK" tutorials.

Find the "converter" routine's calling sequence specification. Look in the "sclk.req" and the routine's source code header.

Look at "naif_ids.req" and the comments in the additional kernel(s) that you have loaded for information on proper values of input arguments of this routine.

Add calls to the "converter" routine(s), necessary variable declarations (the routine header's" Declarations"and "Examples" sections are a good place to look for declaration specification and examples), and output print statements to the program.

"SCLK to ET" Solution Steps

A CASSINI SCLK file is needed additionally to the LSK file loaded in the Step-1 to support this conversion.

No code change is needed in the loading portion of the program if a meta-kernel approach was used in the Step-1. The program will load the file if it will be added to the list of kernels in the KERNELS_TO_LOAD variable:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.

\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     )
\begintext
```

The highest level SpiceyPy routine converting SCLK to ET is spiceypy.scs2e *spiceypy.spiceypy.scs2e()* .

It has three arguments – NAIF ID for CASSINI s/c (-82 as described by "naif_ids.req" document), input time string representing CASSINI SCLK, and output DP number of ET seconds past J2000. A call to spiceypy.str2et converting given SCLK to ET could look like this:

```
scid = -82
sclk = '1465674964.105'
et = spiceypy.scs2e(scid, sclk)
```

By adding the spiceypy.scs2e call, required declarations and a simple print statement, one would get a complete program that prints ET for the given SCLK epoch.

When you execute the script, "sclket", it produces the following output:

```
> python convrt.py
UTC        = 2004-06-11T19:32:00
ET         =     140254384.184625
SCLK       = 1465674964.105
ET         =     140254384.183426
```

"SCLK to ET" Code

Program "sclket.py":

```
from __future__ import print_function
import spiceypy

def sclket():

    mkfile = 'sclket.tm'
    spiceypy.furnsh(mkfile)

    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC       = {:s}'.format(utc))
    print('ET        = {:20.6f}'.format(et))

    scid = -82
    sclk = '1465674964.105'
    et = spiceypy.scs2e(scid, sclk)

    print('SCLK      = {:s}'.format(sclk))
    print('ET        = {:20.6f}'.format(et))

    spiceypy.unload(mkfile)


if __name__ == '__main__':
    sclket()
```

Meta-kernel file "sclket.tm":

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.

\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     )
\begintext
```

Step-3: "Spacecraft State"

"Spacecraft State" Task Statement

Extend the program from Step-2 to compute geometric state – position and velocity – of the CASSINI spacecraft with respect to the Sun in the Ecliptic frame at the epoch specified by SCLK time from Step-2.

"Spacecraft State" Hints

Find out what additional (to those already loaded in Steps-1&2) SPICE kernel(s) is(are) needed to support state computation. Look at the "spk.req" and/or "SPK" tutorial.

Find necessary kernel(s) on the NAIF's FTP site.

Verify that the kernels contain enough data to compute the state of interest. Use "brief" utility program located under "toolkit/exe" directory for that.

Modify the meta-kernel to load this(these) kernels.

Determine the routine(s) needed to compute states. Look at the "spk.req" and/or "SPK" tutorial presentation.

Find the the routine(s) calling sequence specification. Look in the "spk.req" and the routine's source code header.

Reference the "naif_ids.req" and "frames.req"and the routine(s) header "Inputs" and "Particulars" sections to determine proper values of the input arguments of this routine.

Add calls to the routine(s), necessary variable declarations and output print statements to the program.

"Spacecraft State" Solution Steps

A CASSINI spacecraft trajectory SPK and generic planetary ephemeris SPK files are needed to support computation of the state of interest.

The file names can be added to the meta-kernel to get them loaded into the program:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.

\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
```

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```
                      'kernels/spk/030201AP_SK_SM546_T45.bsp'
                      'kernels/spk/981005_PLTEPH-DE405S.bsp'
                      'kernels/spk/sat128.bsp'
                      )
\begintext
```

The highest level SpiceyPy routine computing states is spiceypy.spkezr *spiceypy.spiceypy.spkezr()* .

We are interested in computing CASSINI position and velocity with respect to the Sun, therefore the target and observer names should be set to 'CASSINI' and 'Sun' (both names can be found in "naif_ids.req").

The state should be in ecliptic frame, therefore the name of the frame in which the state should be computed is 'ECLIPJ2000' (see "frames.req" document.)

Since we need only the geometric position, the 'abcorr' argument of the routine should be set to 'NONE' (see aberration correction discussion in the *spiceypy.spiceypy.spkezr()* .

Putting it all together, we get:

```
target = 'CASSINI'
frame  = 'ECLIPJ2000'
corrtn = 'NONE'
observ = 'SUN'

state, ltime = spiceypy.spkezr(target, et, frame,
                               corrtn, observ)
```

When you execute the script, "getsta", it produces the following output:

```
> python getsta.py
UTC        = 2004-06-11T19:32:00
ET         =     140254384.184625
SCLK       = 1465674964.105
ET         =     140254384.183426
 X         =    -376599061.916539
 Y         =    1294487780.929154
 Z         =      -7064853.054698
VX         =            -5.164226
VY         =             0.801719
VZ         =             0.040603
```

"Spacecraft State" Code

Program "getsta.py":

```
from __future__ import print_function
import spiceypy

def getsta():

    mkfile = 'getsta.tm'
    spiceypy.furnsh(mkfile)
```

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```
    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC       = {:s}'.format(utc))
    print('ET        = {:20.6f}'.format(et))

    scid = -82
    sclk = '1465674964.105'
    et = spiceypy.scs2e(scid, sclk)

    print('SCLK      = {:s}'.format(sclk))
    print('ET        = {:20.6f}'.format(et))

    target = 'CASSINI'
    frame  = 'ECLIPJ2000'
    corrtn = 'NONE'
    observ = 'SUN'

    state, ltime = spiceypy.spkezr(target, et, frame,
                                   corrtn, observ)

    print(' X        = {:20.6f}'.format(state[0]))
    print(' Y        = {:20.6f}'.format(state[1]))
    print(' Z        = {:20.6f}'.format(state[2]))
    print('VX        = {:20.6f}'.format(state[3]))
    print('VY        = {:20.6f}'.format(state[4]))
    print('VZ        = {:20.6f}'.format(state[5]))

    spiceypy.unload(mkfile)


if __name__ == '__main__':
    getsta()
```

Meta-kernel file “getsta.tm”:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ----------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.

\begindata
```

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```
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
                     'kernels/spk/sat128.bsp'
                     )
\begintext
```

Step-4: "Sun Direction"

"Sun Direction" Task Statement

Extend the program from Step-3 to compute apparent direction of the Sun in the INMS frame at the epoch specified by SCLK time from Step-2.

"Sun Direction" Hints

Determine the additional SPICE kernels needed to support the direction computation, knowing that they should provide the s/c and instrument frame orientation. Retrieve these kernels from the NAIF's FTP site.

Verify that the orientation data in the kernels have adequate coverage to support computation of the direction of interest. Use "ckbrief" utility program located under" toolkit/exe" directory for that.

Modify the meta-kernel to load this(these) kernels.

Determine the proper input arguments for the spiceypy.spkpos call to calculate the direction (which is the position portion of the output state). Look through the Frames Kernel find the name of the frame to used.

Add calls to the routine(s), necessary variable declarations and output print statements to the program.

"Sun Direction" Solution Steps

A CASSINI spacecraft orientation CK file, providing s/c orientation with respect to an inertial frame, and CASSINI FK file, providing orientation of the INMS frame with respect to the s/c frame, are needed additionally to already loaded kernels to support computation of this direction.

The file names can be added to the meta-kernel to get them loaded into the program:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
```

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```
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK.
   cas_v37.tf                  Cassini FK.


\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
                     'kernels/spk/sat128.bsp'
                     'kernels/ck/04135_04171pc_psiv2.bc'
                     'kernels/fk/cas_v37.tf'
                     )
\begintext
```

The same highest level SpiceyPy routine computing positions, spiceypy.spkpos, can be used to compute this direction.

Since this is the direction of the Sun as seen from the s/c, the target argument should be set to 'Sun' and the observer argument should be set to 'CASSINI'. The name of the INMS frame is 'CASSINI_INMS', the definition and description of this frame are provided in the CASSINI FK file, "cassini_v02.tf".

Since the apparent, or 'as seen', position is sought for, the 'abcorr' argument of the routine should be set to 'LT+S' (see aberration correction discussion in the ("cspice/src/cspice/spkpos_c.c")

If desired, the position can then be turned into a unit vector using spiceypy.vhat function (https://spiceypy.readthedocs.io/en/main/documentation.html#spiceypy.spiceypy.vhat). Putting it all together, we get:

```
target = 'SUN'
frame  = 'CASSINI_INMS'
corrtn = 'LT+S'
observ = 'CASSINI'

sundir, ltime = spiceypy.spkpos(target, et, frame,
                                corrtn, observ)
sundir = spiceypy.vhat(sundir)
```

When you execute the script, "soldir", it produces the following output:

```
> python soldir.py
UTC        = 2004-06-11T19:32:00
ET         =     140254384.184625
SCLK       = 1465674964.105
ET         =     140254384.183426
 X         =    -376599061.916539
 Y         =    1294487780.929154
 Z         =      -7064853.054698
VX         =            -5.164226
VY         =             0.801719
VZ         =             0.040603
```

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```
SUNDIR(X) =             -0.290204
SUNDIR(Y) =              0.881631
SUNDIR(Z) =              0.372167
```

"Sun Direction" Code

Program "soldir.py":

```
from __future__ import print_function
import spiceypy

def soldir():

    mkfile = 'soldir.tm'
    spiceypy.furnsh(mkfile)

    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC       = {:s}'.format(utc))
    print('ET        = {:20.6f}'.format(et))

    scid = -82
    sclk = '1465674964.105'
    et = spiceypy.scs2e(scid, sclk)

    print('SCLK      = {:s}'.format(sclk))
    print('ET        = {:20.6f}'.format(et))

    target = 'CASSINI'
    frame  = 'ECLIPJ2000'
    corrtn = 'NONE'
    observ = 'SUN'

    state, ltime = spiceypy.spkezr(target, et, frame,
                                   corrtn, observ)

    print(' X        = {:20.6f}'.format(state[0]))
    print(' Y        = {:20.6f}'.format(state[1]))
    print(' Z        = {:20.6f}'.format(state[2]))
    print('VX        = {:20.6f}'.format(state[3]))
    print('VY        = {:20.6f}'.format(state[4]))
    print('VZ        = {:20.6f}'.format(state[5]))

    target = 'SUN'
    frame  = 'CASSINI_INMS'
    corrtn = 'LT+S'
    observ = 'CASSINI'

    sundir, ltime = spiceypy.spkpos(target, et, frame,
                                    corrtn, observ)
```

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```
    sundir = spiceypy.vhat(sundir)

    print('SUNDIR(X) = {:20.6f}'.format(sundir[0]))
    print('SUNDIR(Y) = {:20.6f}'.format(sundir[1]))
    print('SUNDIR(Z) = {:20.6f}'.format(sundir[2]))

    spiceypy.unload(mkfile)


if __name__ == '__main__':
    soldir()
```

Meta-kernel file "soldir.tm":

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK.
   cas_v37.tf                  Cassini FK.


\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
                     'kernels/spk/sat128.bsp'
                     'kernels/ck/04135_04171pc_psiv2.bc'
                     'kernels/fk/cas_v37.tf'
                     )
\begintext
```

Step-5: "Sub-Spacecraft Point"

"Sub-Spacecraft Point" Task Statement

Extend the program from Step-4 to compute planetocentric longitude and and latitude of the sub-spacecraft point on Phoebe, and the direction from the spacecraft to that point in the INMS frame.

"Sub-Spacecraft Point" Hints

Find the SpiceyPy routine that computes sub-observer point coordinates. Use "Most Used SpiceyPy APIs" or" subpt" cookbook program for that.

Refer to the routine's header to determine the additional kernels needed for this direction computation. Get these kernels from the NAIF's FTP site. Modify the meta-kernel to load this(these) kernels.

Determine the proper input arguments for the routine. Refer to the routine's header for that information.

Convert the surface point Cartesian vector returned by this routine to latitudinal coordinates. Use "Permuted Index" to find the routine that does this conversion. Refer to the routine's header for input/output argument specifications.

Since the Cartesian vector from the spacecraft to the sub-spacecraft point is computed in the Phoebe body-fixed frame, it should be transformed into the instrument frame get the direction we are looking for. Refer to "frames.req" and/or" Frames" tutorial to determine the name of the routine computing transformations and use it to compute transformation from Phoebe body-fixed to the INMS frame.

Using "Permuted Index" find the routine that multiplies 3x3 matrix by 3d vector and use it to rotate the vector to the instrument frame.

Add calls to the routine(s), necessary variable declarations and output print statements to the program.

"Sub-Spacecraft Point" Solution Steps

The *spiceypy.spiceypy.subpnt()* routine can be used to compute the sub-observer point and the vector from the observer to that point with a single call. To determine this point as the closest point on the Phoebe ellipsoid, the 'method' argument has to be set to 'NEAR POINT: ELLIPSOID'. For our case the 'target' is 'PHOEBE', the target body-fixed frame is 'IAU_PHOEBE', and the observer is 'CASSINI'.

Since the s/c is close to Phoebe, light time does not need to be taken into account and, therefore, the 'abcorr' argument can be set to 'NONE'.

In order for spiceypy.subpnt to compute the nearest point location, a PCK file containing Phoebe radii has to be loaded into the program (see "Files" section of the routine's header.) All other files required for this computation are already being loaded by the program. With PCK file name added to it, the updated meta-kernel will look like this:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
```

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```
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK.
   cas_v37.tf                  Cassini FK.
   cpck05Mar2004.tpc           Cassini project PCK.


\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
                     'kernels/spk/sat128.bsp'
                     'kernels/ck/04135_04171pc_psiv2.bc'
                     'kernels/fk/cas_v37.tf'
                     'kernels/pck/cpck05Mar2004.tpc'
                     )
\begintext
```

The sub-spacecraft point Cartesian vector can be converted to planetocentric radius, longitude and latitude using the spiceypy.reclat routine *spiceypy.spiceypy.reclat()* .

The vector from the spacecraft to the sub-spacecraft point returned by spiceypy.subpnt has to be rotated from the body-fixed frame to the instrument frame. The name of the routine that computes 3x3 matrices rotating vectors from one frame to another is spiceypy.pxform *spiceypy.spiceypy.pxform()* .

In our case the "from' argument should be set to 'IAU_PHOEBE' and the 'to' argument should be set to 'CASSINI_INMS'

The vector should be then multiplied by this matrix to rotate it to the instrument frame. The spiceypy.mxv routine performs that function *spiceypy.spiceypy.mxv()* .

After applying the rotation, normalize the resultant vector using the spiceypy.vhat function.

For output the longitude and latitude angles returned by spiceypy.reclat in radians can be converted to degrees by multiplying by spiceypy.dpr function *spiceypy.spiceypy.dpr()* .

Putting it all together, we get:

```
method = 'NEAR POINT: ELLIPSOID'
target = 'PHOEBE'
frame  = 'IAU_PHOEBE'
corrtn = 'NONE'
observ = 'CASSINI'

spoint, trgepc, srfvec = spiceypy.subpnt(method, target, et,
                                         frame, corrtn, observ)

srad, slon, slat = spiceypy.reclat(spoint)

fromfr = 'IAU_PHOEBE'
tofr   = 'CASSINI_INMS'
```

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```
m2imat = spiceypy.pxform(fromfr, tofr, et)

sbpdir = spiceypy.mxv(m2imat, srfvec)
sbpdir = spiceypy.vhat(sbpdir)

print('LON       = {:20.6f}'.format(slon * spiceypy.dpr()))
print('LAT       = {:20.6f}'.format(slat * spiceypy.dpr()))
```

When you execute the script, "sscpnt", it produces the following output:

```
> python sscpnt.py
UTC       = 2004-06-11T19:32:00
ET        =     140254384.184625
SCLK      = 1465674964.105
ET        =     140254384.183426
 X        =    -376599061.916539
 Y        =    1294487780.929154
 Z        =      -7064853.054698
VX        =             -5.164226
VY        =              0.801719
VZ        =              0.040603
SUNDIR(X) =             -0.290204
SUNDIR(Y) =              0.881631
SUNDIR(Z) =              0.372167
LON       =             23.423158
LAT       =              3.709797
SBPDIR(X) =             -0.000776
SBPDIR(Y) =             -0.999873
SBPDIR(Z) =             -0.015905
```

"Sub-Spacecraft Point" Code

Program

```
from __future__ import print_function
import spiceypy

def sscpnt():

    mkfile = 'sscpnt.tm'
    spiceypy.furnsh(mkfile)

    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC       = {:s}'.format(utc))
    print('ET        = {:20.6f}'.format(et))

    scid = -82
    sclk = '1465674964.105'
```

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```
    et = spiceypy.scs2e(scid, sclk)

    print('SCLK      = {:s}'.format(sclk))
    print('ET        = {:20.6f}'.format(et))

    target = 'CASSINI'
    frame  = 'ECLIPJ2000'
    corrtn = 'NONE'
    observ = 'SUN'

    state, ltime = spiceypy.spkezr(target, et, frame,
                                   corrtn, observ)

    print(' X         = {:20.6f}'.format(state[0]))
    print(' Y         = {:20.6f}'.format(state[1]))
    print(' Z         = {:20.6f}'.format(state[2]))
    print('VX         = {:20.6f}'.format(state[3]))
    print('VY         = {:20.6f}'.format(state[4]))
    print('VZ         = {:20.6f}'.format(state[5]))

    target = 'SUN'
    frame  = 'CASSINI_INMS'
    corrtn = 'LT+S'
    observ = 'CASSINI'

    sundir, ltime = spiceypy.spkpos(target, et, frame,
                                    corrtn, observ)
    sundir = spiceypy.vhat(sundir)

    print('SUNDIR(X) = {:20.6f}'.format(sundir[0]))
    print('SUNDIR(Y) = {:20.6f}'.format(sundir[1]))
    print('SUNDIR(Z) = {:20.6f}'.format(sundir[2]))

    method = 'NEAR POINT: ELLIPSOID'
    target = 'PHOEBE'
    frame  = 'IAU_PHOEBE'
    corrtn = 'NONE'
    observ = 'CASSINI'

    spoint, trgepc, srfvec = spiceypy.subpnt(method, target, et,
                                             frame, corrtn, observ)

    srad, slon, slat = spiceypy.reclat(spoint)

    fromfr = 'IAU_PHOEBE'
    tofr   = 'CASSINI_INMS'

    m2imat = spiceypy.pxform(fromfr, tofr, et)

    sbpdir = spiceypy.mxv(m2imat, srfvec)
    sbpdir = spiceypy.vhat(sbpdir)
```

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```
    print('LON       = {:20.6f}'.format(slon * spiceypy.dpr()))
    print('LAT       = {:20.6f}'.format(slat * spiceypy.dpr()))
    print('SBPDIR(X) = {:20.6f}'.format(sbpdir[0]))
    print('SBPDIR(Y) = {:20.6f}'.format(sbpdir[1]))
    print('SBPDIR(Z) = {:20.6f}'.format(sbpdir[2]))

    spiceypy.unload(mkfile)


if __name__ == '__main__':
    sscpnt()
```

Meta-kernel file "sscpnt.tm":

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------  ---------------------------------
   naif0008.tls                Generic LSK.
   cas00084.tsc                Cassini SCLK.
   020514_SE_SAT105.bsp        Saturnian Satellite Ephemeris SPK.
   030201AP_SK_SM546_T45.bsp   Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp    Planetary Ephemeris SPK.
   sat128.bsp                  Saturnian Satellite Ephemeris SPK.
   04135_04171pc_psiv2.bc      Cassini Spacecraft CK.
   cas_v37.tf                  Cassini FK.
   cpck05Mar2004.tpc           Cassini project PCK.


\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
                     'kernels/spk/sat128.bsp'
                     'kernels/ck/04135_04171pc_psiv2.bc'
                     'kernels/fk/cas_v37.tf'
                     'kernels/pck/cpck05Mar2004.tpc'
                     )
\begintext
```

Step-6: "Spacecraft Velocity"

"Spacecraft Velocity" Task Statement

Extend the program from Step-5 to compute the spacecraft velocity with respect to Phoebe in the INMS frame.

"Spacecraft Velocity" Hints

Compute velocity of the spacecraft with respect to Phoebe in some inertial frame, for example J2000. Recall that velocity is the last three components of the state vector returned by spiceypy.spkezr.

Since the velocity vector is computed in the inertial frame, it should be rotated to the instrument frame. Look at the previous step the routine that compute necessary rotation and rotate vectors.

Add calls to the routine(s), necessary variable declarations and output print statements to the program.

"Spacecraft Velocity" Solution Steps

All kernels required for computations in this step are already being loaded by the program, therefore, the meta-kernel does not need to be changed.

The spacecraft velocity vector is the last three components of the state returned by spiceypy.spkezr. To compute velocity of CASSINI with respect to Phoebe in the J2000 inertial frame the spiceypy.spkezr arguments should be set to 'CASSINI' (TARG), 'PHOEBE' (OBS), 'J2000' (REF) and 'NONE' (ABCORR).

The computed velocity vector has to be rotated from the J2000 frame to the instrument frame. The spiceypy.pxform routine used in the previous step can be used to compute the rotation matrix needed for that. In this case the frame name arguments should be set to 'J2000' (FROM) and 'CASSINI_INMS' (TO).

As in the previous step the difference vector should be then multiplied by this rotation matrix using the spiceypy.mxv routine. After applying the rotation, normalize the resultant vector using the spiceypy.vhat routine.

Putting it all together, we get:

```
target = 'CASSINI'
frame  = 'J2000'
corrtn = 'NONE'
observ = 'PHOEBE'

state, ltime = spiceypy.spkezr(target, et, frame,
                               corrtn, observ)
scvdir = state[3:6]

fromfr = 'J2000'
tofr   = 'CASSINI_INMS'
j2imat = spiceypy.pxform(fromfr, tofr, et)

scvdir = spiceypy.mxv(j2imat, scvdir)
scvdir = spiceypy.vhat(scvdir)
```

When you execute the script, "scvel", it produces the following output:

```
> python scvel.py
UTC       = 2004-06-11T19:32:00
```

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(continued from previous page)

```
ET         =     140254384.184625
SCLK       = 1465674964.105
ET         =     140254384.183426
 X         =    -376599061.916539
 Y         =    1294487780.929154
 Z         =      -7064853.054698
VX         =            -5.164226
VY         =             0.801719
VZ         =             0.040603
SUNDIR(X)  =            -0.290204
SUNDIR(Y)  =             0.881631
SUNDIR(Z)  =             0.372167
LON        =            23.423158
LAT        =             3.709797
SBPDIR(X)  =            -0.000776
SBPDIR(Y)  =            -0.999873
SBPDIR(Z)  =            -0.015905
SCVDIR(X)  =             0.395785
SCVDIR(Y)  =            -0.292808
SCVDIR(Z)  =             0.870413
```

Note that computing the spacecraft velocity in the instrument frame by a single call to spiceypy.spkezr by specifying 'CASSINI_INMS' in the 'ref' argument returns an incorrect result. Such computation will take into account the spacecraft angular velocity from the CK files, which should not be considered in this case.

"Spacecraft Velocity" Code Program "scvel.py":

```
from __future__ import print_function
import spiceypy

def scvel():

    mkfile = 'scvel.tm'
    spiceypy.furnsh(mkfile)

    utc =  '2004-06-11T19:32:00'
    et = spiceypy.str2et(utc)

    print('UTC        = {:s}'.format(utc))
    print('ET         = {:20.6f}'.format(et))

    scid = -82
    sclk = '1465674964.105'
    et = spiceypy.scs2e(scid, sclk)

    print('SCLK       = {:s}'.format(sclk))
    print('ET         = {:20.6f}'.format(et))

    target = 'CASSINI'
    frame  = 'ECLIPJ2000'
    corrtn = 'NONE'
```

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```
    observ = 'SUN'

    state, ltime = spiceypy.spkezr(target, et, frame,
                                   corrtn, observ)

    print(' X        = {:20.6f}'.format(state[0]))
    print(' Y        = {:20.6f}'.format(state[1]))
    print(' Z        = {:20.6f}'.format(state[2]))
    print('VX        = {:20.6f}'.format(state[3]))
    print('VY        = {:20.6f}'.format(state[4]))
    print('VZ        = {:20.6f}'.format(state[5]))

    target = 'SUN'
    frame  = 'CASSINI_INMS'
    corrtn = 'LT+S'
    observ = 'CASSINI'

    sundir, ltime = spiceypy.spkpos(target, et, frame,
                                    corrtn, observ)
    sundir = spiceypy.vhat(sundir)

    print('SUNDIR(X) = {:20.6f}'.format(sundir[0]))
    print('SUNDIR(Y) = {:20.6f}'.format(sundir[1]))
    print('SUNDIR(Z) = {:20.6f}'.format(sundir[2]))

    method = 'NEAR POINT: ELLIPSOID'
    target = 'PHOEBE'
    frame  = 'IAU_PHOEBE'
    corrtn = 'NONE'
    observ = 'CASSINI'

    spoint, trgepc, srfvec = spiceypy.subpnt(method, target, et,
                                             frame, corrtn, observ)

    srad, slon, slat = spiceypy.reclat(spoint)

    fromfr = 'IAU_PHOEBE'
    tofr   = 'CASSINI_INMS'

    m2imat = spiceypy.pxform(fromfr, tofr, et)

    sbpdir = spiceypy.mxv(m2imat, srfvec)
    sbpdir = spiceypy.vhat(sbpdir)

    print('LON       = {:20.6f}'.format(slon * spiceypy.dpr()))
    print('LAT       = {:20.6f}'.format(slat * spiceypy.dpr()))
    print('SBPDIR(X) = {:20.6f}'.format(sbpdir[0]))
    print('SBPDIR(Y) = {:20.6f}'.format(sbpdir[1]))
    print('SBPDIR(Z) = {:20.6f}'.format(sbpdir[2]))

    target = 'CASSINI'
    frame  = 'J2000'
```

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```
    corrtn = 'NONE'
    observ = 'PHOEBE'

    state, ltime = spiceypy.spkezr(target, et, frame,
                                   corrtn, observ)
    scvdir = state[3:6]

    fromfr = 'J2000'
    tofr   = 'CASSINI_INMS'
    j2imat = spiceypy.pxform(fromfr, tofr, et)

    scvdir = spiceypy.mxv(j2imat, scvdir)
    scvdir = spiceypy.vhat(scvdir)

    print('SCVDIR(X) = {:20.6f}'.format(scvdir[0]))
    print('SCVDIR(Y) = {:20.6f}'.format(scvdir[1]))
    print('SCVDIR(Z) = {:20.6f}'.format(scvdir[2]))

    spiceypy.unload(mkfile)


if __name__ == '__main__':
    scvel()
```

Meta-kernel file “scvel.tm”:

```
KPL/MK

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:


   File Name                     Description
   --------------------------    ---------------------------------
   naif0008.tls                  Generic LSK.
   cas00084.tsc                  Cassini SCLK.
   020514_SE_SAT105.bsp          Saturnian Satellite Ephemeris SPK.
   030201AP_SK_SM546_T45.bsp     Cassini Spacecraft SPK.
   981005_PLTEPH-DE405S.bsp      Planetary Ephemeris SPK.
   sat128.bsp                    Saturnian Satellite Ephemeris SPK.
   04135_04171pc_psiv2.bc        Cassini Spacecraft CK.
   cas_v37.tf                    Cassini FK.
   cpck05Mar2004.tpc             Cassini project PCK.


\begindata
   KERNELS_TO_LOAD = (
                     'kernels/lsk/naif0008.tls'
                     'kernels/sclk/cas00084.tsc'
                     'kernels/spk/020514_SE_SAT105.bsp'
                     'kernels/spk/030201AP_SK_SM546_T45.bsp'
                     'kernels/spk/981005_PLTEPH-DE405S.bsp'
```

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```
                    'kernels/spk/sat128.bsp'
                    'kernels/ck/04135_04171pc_psiv2.bc'
                    'kernels/fk/cas_v37.tf'
                    'kernels/pck/cpck05Mar2004.tpc'
                    )
\begintext
```

3.9.5 Binary PCK Hands-On Lesson

November 20, 2017

Overview

In this lesson you will develop two programs that demonstrate geometric computations using "high-accuracy" Earth and Moon binary PCKs. The programs also demonstrate use of frame kernels and SPK files normally used together with these high-accuracy PCKs.

References

This section lists SPICE documents referred to in this lesson.

The following SPICE tutorials serve as references for the discussions in this lesson:

```
Name              Lesson steps/functions it describes
----------------  -----------------------------------------------
Frames            Moon rotation, Earth rotation
PCK               Moon rotation, Earth rotation
"High Accuracy
Orientation and
Body-Fixed
frames for Moon
and Earth"
(backup)          Moon rotation, Earth rotation
```

These tutorials are available from the NAIF ftp server at JPL:

```
https://naif.jpl.nasa.gov/naif/tutorials.html
```

Required Readings

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The Required Reading documents are provided with the Toolkit and are located under the "cspice/doc" directory in the CSPICE Toolkit installation tree.

```
Name             Lesson steps/functions that it describes
---------------  ----------------------------------------
frames.req       Using reference frames
pck.req          Obtaining planetary constants data
spk.req          Obtaining ephemeris data
time.req         Time conversion
```

The Permuted Index

Tip:

The Permuted Index is also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/info/cspice_idx.html.

Another useful document distributed with the Toolkit is the permuted index. This is located under the "cspice/doc" directory in the C installation tree.

This text document provides a simple mechanism by which users can discover which SpiceyPy functions perform functions of interest, as well as the names of the source files that contain these functions.

SpiceyPy API Documentation

A SpiceyPy function's parameters specification is available using the built-in Python help system.

For example, the Python help function

```
>>> import spiceypy
>>> help(spiceypy.str2et)
```

describes of the str2et function's parameters, while the document

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html
```

describes extensively the str2et functionality.

Kernels Used

The following kernels are used in examples provided in this lesson:

```
#  FILE NAME                       TYPE DESCRIPTION
-- ------------------------------- ---- ------------------------------
1  naif0008.tls                    LSK  Generic LSK
2  de414_2000_2020.bsp             SPK  Solar System Ephemeris
3  moon_060721.tf                  FK   Lunar FK
4  pck00008.tpc                    PCK  NAIF text PCK
5  moon_pa_de403_1950-2198.bpc     PCK  Moon binary PCK
6  earthstns_itrf93_050714.bsp     SPK  DSN station Ephemeris
7  earth_topo_050714.tf            FK   Earth topocentric FK
8  earth_000101_070725_070503.bpc  PCK  Earth binary PCK
```

These SPICE kernels are included in the lesson package available from the NAIF server at JPL:

```
ftp://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Lessons/
```

SpiceyPy Modules Used

This section provides a complete list of the functions and kernels that are suggested for usage in each of the exercises in this lesson. (You may wish to not look at this list unless/until you "get stuck" while working on your own.)

CHAPTER	EXERCISE	FUNCTIONS	NON-VOID	KERNELS
1	mrotat	spiceypy.furnsh	spiceypy.str2et	1-5
		spiceypy.unload	spiceypy.spkpos	
			spiceypy.reclat	
			spiceypy.dpr	
			spiceypy.vsep	
			spiceypy.subpnt	
			spiceypy.vdist	
2	erotat	spiceypy.furnsh	spiceypy.str2et	1-2,4,6-8
		spiceypy.unload	spiceypy.spkpos	
			spiceypy.reclat	
			spiceypy.dpr	
			spiceypy.vsep	
			spiceypy.spd	
			spiceypy.timout	
			spiceypy.pxform	
			spiceypy.twopi	
			spiceypy.subslr	
			spiceypy.vdist	

Use the Python built-in help system on the various functions listed above for the API parameters' description, and refer to the headers of their corresponding CSPICE versions for detailed interface specifications.

Moon rotation (mrotat)

Task Statement

Write a program that performs the following computations:

```
1.   Convert the time string 2007 JAN 1 00:00:00 UTC to a double
     precision number representing seconds past J2000 TDB.

     In the following instructions, we'll call the result of this
     computation ET.

2.   Compute the apparent position of the Earth as seen from the
     Moon in the IAU_MOON reference frame at the epoch ET. Use light
     time and stellar aberration corrections. Use spiceypy.reclat to
     compute the planetocentric longitude and latitude of the Earth
     position vector; display these coordinates in degrees.

3.   Repeat the computation of step 2 using the MOON_ME reference
```

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```
     frame. Display the results as above.

4.   Compute the angular separation of the position vectors found in
     steps 2 and 3. Display the result in degrees.

5.   Repeat the computation of step 2 using the MOON_PA reference
     frame. Display the results as above.

6.   Compute the angular separation of the position vectors found in
     steps 3 and 5 (these vectors are expressed in the MOON_ME and
     MOON_PA frames). Display the result in degrees.

7.   Compute the apparent sub-Earth point on the Moon at ET,
     expressed in the MOON_ME reference frame and using light time
     and stellar aberration corrections. Convert the sub-Earth point
     to latitudinal coordinates using spiceypy.reclat. Display the
     longitude and latitude of the sub-Earth point in degrees.

8.   Repeat step 7, now using the MOON_PA frame.

9.   Compute the distance between the two sub-Earth points found
     above in steps 7 and 8. Display the result in kilometers.
```

Learning Goals

Familiarity with SPICE kernels required to obtain high-accuracy orientation of the Moon. Understanding the differences between results obtained using low and high-accuracy Moon orientation data. Understanding the difference between the MOON_ME and MOON_PA frames.

Approach

The following "tips" may simplify the solution process.

```
--   Examine the SPICE kernels provided with this lesson. Use BRIEF
     to find coverage periods of SPK kernels and binary PCKs. Use
     COMMNT to view the comment areas of binary PCKs. Examine text
     kernels, in particular text kernel comments, using a text
     editor or browser.

--   Decide which SPICE kernels are necessary. Prepare a meta-kernel
     listing the kernels and load it into the program.

--   Consult the above list titled "SpiceyPy Modules Used" to see
     which routines are needed.

--   The computational steps listed above should be followed in the
     order shown.
```

You may find it useful to consult the permuted index, the headers of various source modules, and the tutorials titled "PCK" and" High Accuracy Orientation and Body-Fixed frames for Moon and Earth."

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'mrotat.tm'. Its contents follow:

```
KPL/MK

Meta-kernel for the "Moon Rotation" task in the Binary PCK
Hands On Lesson.

The names and contents of the kernels referenced by this
meta-kernel are as follows:

File name                     Contents
---------------------------   -------------------------------------
naif0008.tls                  Generic LSK
de414_2000_2020.bsp           Solar System Ephemeris
moon_060721.tf                Lunar FK
pck00008.tpc                  NAIF text PCK
moon_pa_de403_1950-2198.bpc   Moon binary PCK

\begindata

   KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls'
                       'kernels/spk/de414_2000_2020.bsp'
                       'kernels/fk/moon_060721.tf'
                       'kernels/pck/pck00008.tpc'
                       'kernels/pck/moon_pa_de403_1950-2198.bpc' )
\begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution mrotat
#
from __future__ import print_function
#
# SpiceyPy package:
#
import spiceypy

def mrotat():
    #
    # Local parameters
    #
    METAKR = 'mrotat.tm'

    #
    # Load the kernels that this program requires.
    #
    spiceypy.furnsh( METAKR )
```

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```
#
# Convert our UTC string to seconds past J2000 TDB.
#
timstr = '2007 JAN 1 00:00:00'
et     = spiceypy.str2et( timstr )

#
# Look up the apparent position of the Earth relative
# to the Moon's center in the IAU_MOON frame at ET.
#
[imoonv, ltime] = spiceypy.spkpos(
    'earth', et, 'iau_moon', 'lt+s', 'moon' )

#
#Express the Earth direction in terms of longitude
#and latitude in the IAU_MOON frame.
#
[r, lon, lat] = spiceypy.reclat( imoonv )

print( '\n'
       'Moon-Earth direction using low accuracy\n'
       'PCK and IAU_MOON frame:\n'
       'Earth lon (deg):        {0:15.6f}\n'
       'Earth lat (deg):        {1:15.6f}\n'.format(
           lon * spiceypy.dpr(),
           lat * spiceypy.dpr() )  )
#
# Look up the apparent position of the Earth relative
# to the Moon's center in the MOON_ME frame at ET.
#
[mmoonv, ltime] = spiceypy.spkpos( 'earth', et, 'moon_me',
                                   'lt+s', 'moon'        )
#
# Express the Earth direction in terms of longitude
# and latitude in the MOON_ME frame.
#
[r, lon, lat] = spiceypy.reclat( mmoonv )

print( 'Moon-Earth direction using high accuracy\n'
       'PCK and MOON_ME frame:\n'
       'Earth lon (deg):        {0:15.6f}\n'
       'Earth lat (deg):        {1:15.6f}\n'.format(
           lon * spiceypy.dpr(),
           lat * spiceypy.dpr() )  )
#
# Find the angular separation of the Earth position
# vectors in degrees.
#
sep = spiceypy.dpr() * spiceypy.vsep( imoonv, mmoonv )

print( 'For IAU_MOON vs MOON_ME frames:' )
```

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```
    print( 'Moon-Earth vector separation angle (deg):     '
           '{:15.6f}\n'.format( sep )  )
    #
    # Look up the apparent position of the Earth relative
    # to the Moon's center in the MOON_PA frame at ET.
    #
    [pmoonv, ltime] = spiceypy.spkpos( 'earth', et, 'moon_pa',
                                       'lt+s',  'moon'        )
    #
    # Express the Earth direction in terms of longitude
    # and latitude in the MOON_PA frame.
    #
    [r, lon, lat] = spiceypy.reclat( pmoonv )

    print( 'Moon-Earth direction using high accuracy\n'
           'PCK and MOON_PA frame:\n'
           'Earth lon (deg):        {0:15.6f}\n'
           'Earth lat (deg):        {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr() )  )
    #
    # Find the angular separation of the Earth position
    # vectors in degrees.
    #
    sep = spiceypy.dpr() * spiceypy.vsep( pmoonv, mmoonv )

    print( 'For MOON_PA vs MOON_ME frames:' )
    print( 'Moon-Earth vector separation angle (deg):     '
           '{:15.6f}\n'.format( sep )  )
    #
    # Find the apparent sub-Earth point on the Moon at ET
    # using the MOON_ME frame.
    #
    [msub, trgepc, srfvec ] = spiceypy.subpnt(
        'near point: ellipsoid', 'moon',
        et,  'moon_me', 'lt+s',  'earth' )
    #
    # Display the sub-point in latitudinal coordinates.
    #
    [r, lon, lat] = spiceypy.reclat( msub )

    print( 'Sub-Earth point on Moon using high accuracy\n'
           'PCK and MOON_ME frame:\n'
           'Sub-Earth lon (deg):   {0:15.6f}\n'
           'Sub-Earth lat (deg):   {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr()  )  )
    #
    # Find the apparent sub-Earth point on the Moon at
    # ET using the MOON_PA frame.
    #
    [psub, trgepc, srfvec] = spiceypy.subpnt(
```

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```
        'near point: ellipsoid',  'moon',
         et,   'moon_pa', 'lt+s', 'earth'    )
    #
    # Display the sub-point in latitudinal coordinates.
    #
    [r, lon, lat] = spiceypy.reclat( psub )

    print( 'Sub-Earth point on Moon using high accuracy\n'
           'PCK and MOON_PA frame:\n'
           'Sub-Earth lon (deg):   {0:15.6f}\n'
           'Sub-Earth lat (deg):   {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr() )  )
    #
    # Find the distance between the sub-Earth points
    # in km.
    #
    dist = spiceypy.vdist( msub, psub )

    print( 'Distance between sub-Earth points (km): '
           '{:15.6f}\n'.format( dist )  )

    spiceypy.unload( METAKR )

if __name__ == '__main__':
     mrotat()
```

Solution Sample Output

Execute the program:

```
Moon-Earth direction using low accuracy
PCK and IAU_MOON frame:
Earth lon (deg):               3.613102
Earth lat (deg):              -6.438342

Moon-Earth direction using high accuracy
PCK and MOON_ME frame:
Earth lon (deg):               3.611229
Earth lat (deg):              -6.439501

For IAU_MOON vs MOON_ME frames:
Moon-Earth vector separation angle (deg):            0.002194

Moon-Earth direction using high accuracy
PCK and MOON_PA frame:
Earth lon (deg):               3.593319
Earth lat (deg):              -6.417582

For MOON_PA vs MOON_ME frames:
Moon-Earth vector separation angle (deg):            0.028235

Sub-Earth point on Moon using high accuracy
```

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```
PCK and MOON_ME frame:
Sub-Earth lon (deg):          3.611419
Sub-Earth lat (deg):         -6.439501

Sub-Earth point on Moon using high accuracy
PCK and MOON_PA frame:
Sub-Earth lon (deg):          3.593509
Sub-Earth lat (deg):         -6.417582

Distance between sub-Earth points (km):        0.856182
```

Earth rotation (erotat)

Task Statement

Write a program that performs the following computations:

```
1.   Convert the time string 2007 JAN 1 00:00:00 UTC to a double
     precision number representing seconds past J2000 TDB.

     In the following instructions, we'll call the result of this
     computation ET.

2.   Compute the apparent position of the Moon as seen from the
     Earth in the IAU_EARTH reference frame at the epoch ET. Use
     light time and stellar aberration corrections. Display the
     planetocentric longitude and latitude of the Moon position
     vector in degrees.

3.   Repeat the first computation using the ITRF93 reference frame.
     Display the results as above.

4.   Compute the angular separation of the position vectors found
     the the previous two steps. Display the result in degrees.
```

The following computations (steps 5-10) examine the cause of the angular offset found above, which is attributable to the rotation between the ITRF93 and IAU_EARTH frames. Steps 11 and up don't rely on the results of steps 5-10, so steps 5-10 may be safely skipped if they're not of interest to you.

For each of the two epochs ET and ET + 100 days, examine the differences between the axes of the ITRF93 and IAU_EARTH frames using the following method:

```
 5.   Convert the epoch of interest to a string in the format style
      "2007-MAY-16 02:29:00.000 (UTC)." Display this string.

 6.   Look up the 3x3 position transformation matrix that converts
      vectors from the IAU_EARTH to the ITRF93 frame at the epoch of
      interest. We'll call the returned matrix RMAT.

 7.   Extract the first row of RMAT into a 3-vector, which we'll call
      ITRFX. This is the X-axis of the ITRF93 frame expressed
```

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```
      relative to the IAU_EARTH frame.

 8.   Extract the third row of RMAT into a 3-vector, which we'll call
      ITRFZ. This is the Z-axis of the ITRF93 frame expressed
      relative to the IAU_EARTH frame.

 9.   Compute the angular separation between the vector ITRFX and the
      X-axis (1, 0, 0) of the IAU_EARTH frame. Display the result in
      degrees.

10.   Compute the angular separation between the vector ITRFZ and the
      Z-axis (0, 0, 1) of the IAU_EARTH frame. Display the result in
      degrees.
```

This is the end of the computations to be performed for the epochs ET and ET + 100 days. The following steps are part of a new computation.

Find the azimuth and elevation of the apparent position of the Moon as seen from the DSN station DSS-13 by the following steps:

```
11.   Find the apparent position vector of the Moon relative to the
      DSN station DSS-13 in the topocentric reference frame
      DSS-13_TOPO at epoch ET. Use light time and stellar aberration
      corrections.

      For this step, you'll need to have loaded a station SPK file
      providing geocentric station position vectors, as well as a
      frame kernel specifying topocentric reference frames centered
      at the respective DSN stations. (Other kernels will be needed
      as well; you must choose these.)

12.   Convert the position vector to latitudinal coordinates. Use the
      routine spiceypy.reclat for this computation.

13.   Compute the Moon's azimuth and elevation as follows: azimuth is
      the negative of topocentric longitude and lies within the range
      0-360 degrees; elevation is equal to the topocentric latitude.
      Display the results in degrees.
```

The next computations demonstrate "high-accuracy" geometric computations using the Earth as the target body. These computations are *not* realistic; they are simply meant to demonstrate SPICE system features used for geometry computations involving the Earth as a target body. For example, the same basic techniques would be used to find the sub-solar point on the Earth as seen from an Earth-orbiting spacecraft.

```
14.   Compute the apparent sub-solar point on the Earth at ET,
      expressed relative to the IAU_EARTH reference frame, using
      light time and stellar aberration corrections and using the Sun
      as the observer. Convert the sub-solar point to latitudinal
      coordinates using spiceypy.reclat. Display the longitude and
      latitude of the sub-solar point in degrees.

15.   Repeat the sub-solar point computation described above, using
      the ITRF93 Earth body-fixed reference frame. Display the
```

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```
      results as above.

16.   Compute the distance between the two sub-solar points found
      above. Display the result in kilometers.
```

Learning Goals

Familiarity with SPICE kernels required to obtain high-accuracy orientation of the Earth. Understanding the differences between results obtained using low and high-accuracy Earth orientation data.

Understanding of topocentric frames and computation of target geometry relative to a surface location on the Earth. Knowledge of SPICE kernels required to support such computations.

Approach

The following "tips" may simplify the solution process.

```
--    Examine the SPICE kernels provided with this lesson. Use BRIEF
      to find coverage periods of SPK kernels and binary PCKs. Use
      COMMNT to view the comment areas of binary PCKs. Examine text
      kernels, in particular text kernel comments, using a text
      editor or browser.

--    Decide which SPICE kernels are necessary. Prepare a meta-kernel
      listing the kernels and load it into the program.

--    Consult the above list titled "SpiceyPy Modules Used" to see
      which routines are needed. Note the functions used to provide
      the values "seconds per day," "degrees per radian," and "2
      times Pi."

--    Examine the header of the function spiceypy.reclat. Note that
      this function may be used for coordinate conversions in
      situations where the input rectangular coordinates refer to any
      reference frame, not only a body-centered, body-fixed frame
      whose X-Y plane coincides with the body's equator.

--    The computational steps listed above should be followed in the
      order shown, but steps 5-10 may be omitted.
```

You may find it useful to consult the permuted index, the headers of various source modules, and the tutorials titled "PCK" and" High Accuracy Orientation and Body-Fixed frames for Moon and Earth."

Solution

Solution Meta-Kernel

The meta-kernel we created for the solution to this exercise is named 'erotat.tm'. Its contents follow:

```
KPL/MK

Meta-kernel for the "Earth Rotation" task
in the Binary PCK Hands On Lesson.

The names and contents of the kernels referenced by this
meta-kernel are as follows:

File name                       Contents
-----------------------------   ---------------------------------
naif0008.tls                    Generic LSK
de414_2000_2020.bsp             Solar System Ephemeris
earthstns_itrf93_050714.bsp     DSN station Ephemeris
earth_topo_050714.tf            Earth topocentric FK
pck00008.tpc                    NAIF text PCK
earth_000101_070725_070503.bpc  Earth binary PCK


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KERNELS_TO_LOAD = ( 'kernels/lsk/naif0008.tls'
                    'kernels/spk/de414_2000_2020.bsp'
                    'kernels/spk/earthstns_itrf93_050714.bsp'
                    'kernels/fk/earth_topo_050714.tf'
                    'kernels/pck/pck00008.tpc'
                    'kernels/pck/earth_000101_070725_070503.bpc' )

\begintext
```

Solution Source Code

A sample solution to the problem follows:

```
#
# Solution mrotat
#
from __future__ import print_function
#
# SpiceyPy package:
#
import spiceypy

def erotat():
    #
    # Local parameters
    #
    METAKR = 'erotat.tm'
```

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```
    x = [ 1.0, 0.0, 0.0 ]
    z = [ 0.0, 0.0, 1.0 ]

    #
    # Load the kernels that this program requires.
    #
    spiceypy.furnsh( METAKR )

    #
    # Convert our UTC string to seconds past J2000 TDB.
    #
    timstr = '2007 JAN 1 00:00:00'
    et     = spiceypy.str2et( timstr )

    #
    # Look up the apparent position of the Moon relative
    # to the Earth's center in the IAU_EARTH frame at ET.
    #
    [lmoonv, ltime] = spiceypy.spkpos( 'moon', et, 'iau_earth',
                                       'lt+s', 'earth'        )
    #
    # Express the Moon direction in terms of longitude
    # and latitude in the IAU_EARTH frame.
    #
    [r, lon, lat] = spiceypy.reclat( lmoonv )

    print( 'Earth-Moon direction using low accuracy\n'
           'PCK and IAU_EARTH frame:\n'
           'Moon lon (deg):        {0:15.6f}\n'
           'Moon lat (deg):        {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr() )  )
    #
    # Look up the apparent position of the Moon relative
    # to the Earth's center in the ITRF93 frame at ET.
    #
    [hmoonv, ltime] = spiceypy.spkpos( 'moon', et, 'ITRF93',
                                       'lt+s', 'earth'      )
    #
    # Express the Moon direction in terms of longitude
    # and latitude in the ITRF93 frame.
    #
    [r, lon, lat] = spiceypy.reclat( hmoonv )

    print( 'Earth-Moon direction using high accuracy\n'
           'PCK and ITRF93 frame:\n'
           'Moon lon (deg):        {0:15.6f}\n'
           'Moon lat (deg):        {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr() )  )
    #
    # Find the angular separation of the Moon position
```

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```
    # vectors in degrees.
    #
    sep = spiceypy.dpr() * spiceypy.vsep( lmoonv, hmoonv )

    print( 'Earth-Moon vector separation angle (deg):     '
           '{:15.6f}\n'.format( sep )  )

    #
    # Next, express the +Z and +X axes of the ITRF93 frame in
    # the IAU_EARTH frame. We'll do this for two times: et
    # and et + 100 days.
    #
    for  i  in range(2):
        #
        # Set the time, expressing the time delta in
        # seconds.
        #
        t = et + i*spiceypy.spd()*100

        #
        # Convert the TDB time T to a string for output.
        #
        outstr = spiceypy.timout(
            t, 'YYYY-MON-DD HR:MN:SC.### (UTC)' )

        print( 'Epoch: {:s}'.format( outstr ) )

        #
        # Find the rotation matrix for conversion of
        # position vectors from the IAU_EARTH to the
        # ITRF93 frame.
        #
        rmat  = spiceypy.pxform( 'iau_earth', 'itrf93', t )
        itrfx = rmat[0]
        itrfz = rmat[2]

        #
        # Display the angular offsets of the ITRF93
        # +X and +Z axes from their IAU_EARTH counterparts.
        #
        sep = spiceypy.vsep( itrfx, x )

        print( 'ITRF93 - IAU_EARTH +X axis separation '
               'angle (deg): {:13.6f}'.format(
                   sep * spiceypy.dpr() )  )

        sep = spiceypy.vsep( itrfz, z )

        print( 'ITRF93 - IAU_EARTH +Z axis separation '
               'angle (deg): {:13.6f}\n'.format(
                   sep * spiceypy.dpr() )  )
```

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```
    #
    # Find the azimuth and elevation of apparent
    # position of the Moon in the local topocentric
    # reference frame at the DSN station DSS-13.
    # First look up the Moon's position relative to the
    # station in that frame.
    #
    [topov, ltime] = spiceypy.spkpos( 'moon', et, 'DSS-13_TOPO',
                                      'lt+s', 'DSS-13'         )

    #
    # Express the station-moon direction in terms of longitude
    # and latitude in the DSS-13_TOPO frame.
    #
    [r, lon, lat] = spiceypy.reclat( topov )

    #
    # Convert to azimuth-elevation.
    #
    az = -lon

    if  az < 0.0:
        az += spiceypy.twopi()

    el = lat

    print( 'DSS-13-Moon az/el using high accuracy '
           'PCK and DSS-13_TOPO frame:\n'
           'Moon Az (deg):        {0:15.6f}\n'
           'Moon El (deg):        {1:15.6f}\n'.format(
               az * spiceypy.dpr(),
               el * spiceypy.dpr() )  )

    #
    # Find the sub-solar point on the Earth at ET using the
    # Earth body-fixed frame IAU_EARTH. Treat the Sun as
    # the observer.
    #
    [lsub, trgepc, srfvec] = spiceypy.subslr(
        'near point: ellipsoid', 'earth', et,
        'IAU_EARTH',             'lt+s',  'sun' );

    #
    # Display the sub-point in latitudinal coordinates.
    #
    [r, lon, lat] = spiceypy.reclat( lsub )

    print( 'Sub-Solar point on Earth using low accuracy\n'
           'PCK and IAU_EARTH frame:\n'
           'Sub-Solar lon (deg):   {0:15.6f}\n'
           'Sub-Solar lat (deg):   {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
```

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```
                lat * spiceypy.dpr() )  )

    #
    # Find the sub-solar point on the Earth at ET using the
    # Earth body-fixed frame ITRF93. Treat the Sun as
    # the observer.
    #
    [hsub, trgepc, srfvec] = spiceypy.subslr(
        'near point: ellipsoid', 'earth', et,
        'ITRF93',                'lt+s',  'sun' );

    #
    # Display the sub-point in latitudinal coordinates.
    #
    [r, lon, lat] = spiceypy.reclat( hsub )

    print( 'Sub-Solar point on Earth using '
           'high accuracy \nPCK and ITRF93 frame:\n'
           'Sub-Solar lon (deg):   {0:15.6f}\n'
           'Sub-Solar lat (deg):   {1:15.6f}\n'.format(
               lon * spiceypy.dpr(),
               lat * spiceypy.dpr() )  )

    #
    # Find the distance between the sub-solar point
    # vectors in km.
    #
    dist = spiceypy.vdist( lsub, hsub )

    print( 'Distance between sub-solar points (km): '
           '{:15.6f}'.format( dist )  )


    spiceypy.unload( METAKR )

if __name__ == '__main__':
     erotat()
```

Solution Sample Output

Execute the program:

```
Earth-Moon direction using low accuracy
PCK and IAU_EARTH frame:
Moon lon (deg):             -35.496272
Moon lat (deg):              26.416959

Earth-Moon direction using high accuracy
PCK and ITRF93 frame:
Moon lon (deg):             -35.554286
Moon lat (deg):              26.419156

Earth-Moon vector separation angle (deg):            0.052002
```

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```
Epoch: 2007-JAN-01 00:00:00.000 (UTC)
ITRF93 - IAU_EARTH +X axis separation angle (deg):      0.057677
ITRF93 - IAU_EARTH +Z axis separation angle (deg):      0.002326

Epoch: 2007-APR-10 23:59:59.998 (UTC)
ITRF93 - IAU_EARTH +X axis separation angle (deg):      0.057787
ITRF93 - IAU_EARTH +Z axis separation angle (deg):      0.002458

DSS-13-Moon az/el using high accuracy PCK and DSS-13_TOPO frame:
Moon Az (deg):              72.169006
Moon El (deg):              20.689488

Sub-Solar point on Earth using low accuracy
PCK and IAU_EARTH frame:
Sub-Solar lon (deg):       -177.100531
Sub-Solar lat (deg):        -22.910377

Sub-Solar point on Earth using high accuracy
PCK and ITRF93 frame:
Sub-Solar lon (deg):       -177.157874
Sub-Solar lat (deg):        -22.912593

Distance between sub-solar points (km):        5.881861
```

3.9.6 Other Stuff (Python)

November 20, 2017

The extensive scope of the SpiceyPy system's functionality includes features the average user may not expect or appreciate, features NAIF refers to as "Other Stuff." This workbook includes a set of lessons to introduce the beginning to moderate user to such features.

The lessons provide a brief description to several related sets of routines, associated reference documents, a programming task designed to teach the use of the routines, and an example solution to the programming problem.

Overview

This workbook contains lessons to demonstrate use of the less celebrated SpiceyPy routines.

```
1.   Kernel Management with the Kernel Subsystem

2.   The Kernel Pool

3.   Coordinate Conversions

4.   Advanced Time Manipulation Routines

5.   Error Handling

6.   Windows and Cells
```

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```
7.   Utility and Constants Routines
```

References

This section lists SPICE documents referred to in this lesson.

The following SPICE tutorials serve as references for the discussions in this lesson:

```
Name              Lesson steps/functions it describes
---------------   -----------------------------------------------
concepts          Concepts of space geometry and time
intro_to_kernels  Using kernels, meta-kernels
time              Time systems, conversions and formats
lsk_and_sclk      LSK and SCLK
derived_quant     "high-level" observation geometry computations
other_functions   Intro to some SPICE "low level" computations
exceptions        built-in mechanism for trapping/handling errors
```

These tutorials are available from the NAIF ftp server at JPL:

```
https://naif.jpl.nasa.gov/naif/tutorials.html
```

Required Readings

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The Required Reading documents are provided with the Toolkit and are located under the "cspice/doc" directory in the CSPICE Toolkit installation tree.

```
Name             Lesson steps/functions that it describes
---------------  ----------------------------------------
cells.req        The SPICE cell data type
error.req        The SPICE error handling system
kernel.req       Loading SPICE kernels
time.req         Time conversion
windows.req      The SPICE window data type
```

The Permuted Index

Tip:

The Permuted Index is also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/info/cspice_idx.html.

Another useful document distributed with the Toolkit is the permuted index. This is located under the "cspice/doc" directory in the C installation tree.

This text document provides a simple mechanism by which users can discover which SpiceyPy functions perform functions of interest, as well as the names of the source files that contain these functions.

SpiceyPy API Documentation

A SpiceyPy function's parameters specification is available using the built-in Python help system.

For example, the Python help function

```
>>> import spiceypy
>>> help(spiceypy.str2et)
```

describes of the str2et function's parameters, while the document

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html
```

describes extensively the str2et functionality.

Kernels Used

The following kernels are used in examples provided in this lesson:

```
#  FILE NAME     TYPE DESCRIPTION
-- ------------ ---- -------------------------------------------------
1  naif0008.tls LSK  Generic LSK
2  de405s.bsp   SPK  Planet Ephemeris SPK
3  pck00008.tpc PCK  Generic PCK
```

These SPICE kernels are included in the lesson package available from the NAIF server at JPL:

```
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Lessons/
```

SpiceyPy Modules Used

This section provides a complete list of the functions and kernels that are suggested for usage in each of the exercises in this lesson. (You may wish to not look at this list unless/until you "get stuck" while working on your own.)

```
CHAPTER EXERCISE   FUNCTIONS        NON-VOID         KERNELS
------- ---------  ---------------  ---------------  ----------
   1    kpool      spiceypy.furnsh  spiceypy.ktotal  1-3
                   spiceypy.unload  spiceypy.kdata
```

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```
                spiceypy.kclear

2    kervar     spiceypy.furnsh  spiceypy.gnpool  1-3
                spiceypy.kclear  spiceypy.dtpool
                                 spiceypy.gdpool
                                 spiceypy.gcpool

3    coord      spiceypy.furnsh  spiceypy.dpr     1-3
                spiceypy.kclear  spiceypy.str2et
                                 spiceypy.bodvrd
                                 spiceypy.spkpos
                                 spiceypy.recrad
                                 spiceypy.reclat
                                 spiceypy.recsph
                                 spiceypy.recgeo

4    xtic       spiceypy.furnsh  spiceypy.str2et  1
                spiceypy.tsetyr  spiceypy.timout
                spiceypy.kclear  spiceypy.tpictr
                                 spiceypy.jyear

5    aderr      spiceypy.furnsh  spiceypy.spkezr  1-3
                spiceypy.kclear

6    win        spiceypy.furnsh  spiceypy.str2et  1-3
                spiceypy.wninsd  spiceypy.wnvald
                spiceypy.kclear  spiceypy.wnintd
                                 spiceypy.card
                                 spiceypy.wnfetd
                                 spiceypy.et2utc
                                 spiceypy.wnsumd

7    units                       spiceypy.tkvrsn
                                 spiceypy.convrt

     xconst                      spiceypy.spd
                                 spiceypy.dpr
                                 spiceypy.rpd
                                 spiceypy.clight
                                 spiceypy.j2100
                                 spiceypy.j2000
                                 spiceypy.tyear
                                 spiceypy.halfpi
```

Use the Python built-in help system on the various functions listed above for the API parameters' description, and refer to the headers of their corresponding CSPICE versions for detailed interface specifications.

NAIF Documentation

The technical complexity of the various SPICE subsystems mandates an extensive, user-friendly documentation set. The set differs somewhat depending on your choice of development language but provides the same information with regards to SPICE operation. The sources for a user needing information concerning SPICE are:

```
--   Required Readings and Users Guides

--   Library Source Code Documentation

--   API Documentation

--   Tutorials
```

Required Reading and Users Guides

Tip:

The Required Readings are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/index.html.

The User Guides are also available on the NAIF website at:
https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/ug/index.html

---

NAIF Required Reading (*.req) documents introduce the functionality of particular Spice subsystems:

```
abcorr.req
cells.req
ck.req
daf.req
das.req
dla.req
dsk.req
ek.req
ellipses.req
error.req
frames.req
gf.req
kernel.req
naif_ids.req
pck.req
planes.req
problems.req
rotation.req
scanning.req
sclk.req
sets.req
spc.req
spk.req
symbols.req
time.req
windows.req
```

NAIF Users Guides (*.ug) describe the proper use of particular SpiceyPy tools:

```
brief.ug
chronos.ug
ckbrief.ug
commnt.ug
convert.ug
dskbrief.ug
dskexp.ug
frmdiff.ug
inspekt.ug
mkdsk.ug
mkspk.ug
msopck.ug
simple.ug
spacit.ug
spkdiff.ug
spkmerge.ug
states.ug
subpt.ug
tictoc.ug
tobin.ug
toxfr.ug
version.ug
```

These text documents exist in the 'doc' directory of the main CSPICE Toolkit directory:

```
../cspice/doc/
```

HTML format documentation

The SpiceyPy distributions include HTML versions of Required Readings and Users Guides, accessible from the HTML documentation directory:

```
../cspice/doc/html/index.html
```

Library Source Code Documentation

All SPICELIB and CSPICE source files include usage and design information incorporated in a comment block known as the "header." (Every toolkit includes either the SPICELIB or CSPICE library.)

A header consists of several marked sections:

```
--   Procedure: Routine name and one line expansion of the routine's
     name.

--   Abstract: A tersely worded explanation describing the routine.

--   Copyright: An identification of the copyright holder for the
     routine.

--   Required_Reading: A list of SpiceyPy required reading documents
     relating to the routine.
```

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```
--   Brief_I/O: A table of arguments, identifying each as either
     input, output, or both, with a very brief description of the
     variable.

--   Detailed_Input & Detailed_Output: An elaboration of the
     Brief_I/O section providing comprehensive information on
     argument use.

--   Parameters: Description and declaration of any parameters
     (constants) specific to the routine.

--   Exceptions: A list of error conditions the routine detects and
     signals plus a discussion of any other exceptional conditions
     the routine may encounter.

--   Files: A list of other files needed for the routine to operate.

--   Particulars: A discussion of the routine's function (if
     needed). This section may also include information relating to
     "how" and "why" the routine performs an operation and to
     explain functionality of routines that operate by side effects.

--   Examples: Descriptions and code snippets concerning usage of
     the routine.

--   Restrictions: Restrictions or warnings concerning use.

--   Literature_References: A list of sources required to understand
     the algorithms or data used in the routine.

--   Author_and_Institution: The names and affiliations for authors
     of the routine.

--   Version: A list of edits and the authors of those edits made to
     the routine since initial delivery to the SpiceyPy system.
```

The source code for SpiceyPy products is stored in 'src' sub-directory of the main SpiceyPy directory:

API Documentation

The SpiceyPy package is documented in "readthedocs" website:

```
https://spiceypy.readthedocs.io/en/main/index.html
```

Each API documentation page is in large part copied from the "Abstract" and" Brief_I/O" sections of the corresponding CSPICE function documentation. Each API page includes a link to the API documentation for the CSPICE routine called by the SpiceyPy interface.

This SpiceyPy API documentation (the same information as in the website but without hyperlinks) is also available from the Python built-in help system:

```
>>> help ( spiceypy.str2et )
Help on function str2et in module spiceypy.spiceypy:

str2et(*args, **kwargs)
    Convert a string representing an epoch to a double precision
    value representing the number of TDB seconds past the J2000
    epoch corresponding to the input epoch.

       ...

    :param time: A string representing an epoch.
    :type time: str
    :return: The equivalent value in seconds past J2000, TDB.
    :rtype: float
```

In order to have offline access to the documentation it is recommended to have the CSPICE Toolkit installed locally. The CSPICE package includes the CSPICE Reference Guide, an index of all CSPICE wrapper APIs with hyperlinks to API specific documentation. Each API documentation page includes cross-links to any other wrapper API mentioned in the document and links to the wrapper source code.

```
...cspice/doc/html/cspice/index.html
```

Text kernels

Several workbooks use SPICE text kernels. SPICE identifies a text kernel as an ASCII text file containing the mark-up tags the kernel subsystem requires to identify data assignments in that file, and "name=value" data assignments.

The subsystem uses two tags:

```
\begintext
```

and

```
\begindata
```

to mark information blocks within the text kernel. The *\begintext* tag specifies all text following the tag as comment information to be ignored by the subsystem.

Things to know:

```
1.   The \begindata tag marks the start of a data definition block.
     The subsystem processes all text following this marker as SPICE
     kernel data assignments until finding a \begintext marker.

2.   The kernel subsystem defaults to the \begintext mode until the
     parser encounters a \begindata tag. Once in \begindata mode the
     subsystem processes all text as variable assignments until the
     next \begintext tag.

3.   Enter the tags as the only text on a line, i.e.:


  \begintext
```

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```
    ... commentary information on the data assignments ...

  \begindata

    ... data assignments ...


4.   CSPICE delivery N0059 added to the CSPICE and Icy text kernel
     parsers the functionality to read non native text kernels, i.e.
     a Unix compiled library can read a MS Windows native text
     kernel, a MS Windows compiled library can read a Unix native
     text kernel. Mice acquires this capability from CSPICE.

5.   With regards to the FORTRAN distribution, as of delivery N0057
     the spiceypy.furnsh call includes a line terminator check,
     signaling an error on any attempt to read non-native text
     kernels.
```

Text kernel format

Scalar assignments.

```
VAR_NAME_DP  = 1.234
VAR_NAME_INT = 1234
VAR_NAME_STR = 'FORBIN'
```

Please note the use of a single quote in string assignments.

Vector assignments. Vectors must contain the same type data.

```
VEC_NAME_DP  = ( 1.234   , 45.678  , 901234.5 )
VEC_NAME_INT = ( 1234    , 456     , 789      )
VEC_NAME_STR = ( 'FORBIN', 'FALKEN', 'ROBUR'  )

also

VEC_NAME_DP  = ( 1.234,
                 45.678,
                 901234.5 )

VEC_NAME_STR = ( 'FORBIN',
                 'FALKEN',
                 'ROBUR' )
```

Time assignments.

```
TIME_VAL = @31-JAN-2003-12:34:56.798
TIME_VEC = ( @01-DEC-2004, @15-MAR-2004 )
```

The at-sign character '@' indicates a time string. The pool subsystem converts the strings to double precision TDB (a numeric value). Please note, the time strings must not contain embedded blanks. WARNING - a TDB string is not the same as a UTC string.

The above examples depict direct assignments via the '=' operator. The kernel pool also permits incremental assignments via the '+=' operator.

Please refer to the kernels required reading, kernel.req, for additional information.

Lesson 1: Kernel Management with the Kernel Subsystem

Task Statement

Write a program to load a meta kernel, interrogate the SpiceyPy system for the names and types of all loaded kernels, then demonstrate the unload functionality and the resulting effects.

Learning Goals

This lesson demonstrates use of the kernel subsystem to load, unload, and list loaded kernels.

This lesson requires creation of a SPICE meta kernel.

Code Solution

First, create a meta text kernel:

You can use two versions of a meta kernel with code examples (kpool.tm) in this lesson. Either a kernel with explicit path information:

```
KPL/MK

\begindata

   KERNELS_TO_LOAD = ( 'kernels/spk/de405s.bsp',
                       'kernels/pck/pck00008.tpc',
                       'kernels/lsk/naif0008.tls' )

\begintext
```

... or a more generic meta kernel using the PATH_VALUES/PATH_SYMBOLS functionality to declare path names as variables:

```
KPL/MK

   Define the paths to the kernel directory. Use the PATH_SYMBOLS
   as aliases to the paths.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

      File Name        Description
      ---------------  -------------------------------
      naif0008.tls     Generic LSK.
      de405s.bsp       Planet Ephemeris SPK.
      pck00008.tpc     Generic PCK.
```

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```
\begindata

   PATH_VALUES     = ( 'kernels/lsk',
                       'kernels/spk',
                       'kernels/pck' )

   PATH_SYMBOLS    = ( 'LSK', 'SPK', 'PCK' )

   KERNELS_TO_LOAD = ( '$LSK/naif0008.tls',
                       '$SPK/de405s.bsp',
                       '$PCK/pck00008.tpc' )

\begintext
```

Now the solution source code:

```
from __future__ import print_function

#
# Import the CSPICE-Python interface.
#
import spiceypy

def kpool():

    #
    # Assign the path name of the meta kernel to META.
    #
    META = 'kpool.tm'


    #
    # Load the meta kernel then use KTOTAL to interrogate the SPICE
    # kernel subsystem.
    #
    spiceypy.furnsh( META )


    count = spiceypy.ktotal( 'ALL' );
    print( 'Kernel count after load:        {0}\n'.format(count))


    #
    # Loop over the number of files; interrogate the SPICE system
    # with spiceypy.kdata for the kernel names and the type.
    # 'found' returns a boolean indicating whether any kernel files
    # of the specified type were loaded by the kernel subsystem.
    # This example ignores checking 'found' as kernels are known
    # to be loaded.
    #
    for i in range(0, count):
```

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```
        [ file, type, source, handle] = spiceypy.kdata(i, 'ALL');
        print( 'File   {0}'.format(file) )
        print( 'Type   {0}'.format(type) )
        print( 'Source {0}\n'.format(source) )


    #
    # Unload one kernel then check the count.
    #
    spiceypy.unload( 'kernels/spk/de405s.bsp')
    count = spiceypy.ktotal( 'ALL' );

    #
    # The subsystem should report one less kernel.
    #
    print( 'Kernel count after one unload:  {0}'.format(count))

    #
    # Now unload the meta kernel. This action unloads all
    # files listed in the meta kernel.
    #
    spiceypy.unload( META )


    #
    # Check the count; spiceypy should return a count of zero.
    #
    count = spiceypy.ktotal( 'ALL');
    print( 'Kernel count after meta unload: {0}'.format(count))


    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear

if __name__ == '__main__':
   kpool()
```

Run the code example

First we see the number of all loaded kernels returned from the spiceypy.ktotal call.

Then the spiceypy.kdata loop returns the name of each loaded kernel, the type of kernel (SPK, CK, TEXT, etc.) and the source of the kernel - the mechanism that loaded the kernel. The source either identifies a meta kernel, or contains an empty string. An empty source string indicates a direct load of the kernel with a spiceypy.furnsh call.

```
Kernel count after load:        4

File   kpool.tm
Type   META
Source
```

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```
File   kernels/lsk/naif0008.tls
Type   TEXT
Source kpool.tm

File   kernels/spk/de405s.bsp
Type   SPK
Source kpool.tm

File   kernels/pck/pck00008.tpc
Type   TEXT
Source kpool.tm

Kernel count after one unload:  3
Kernel count after meta unload: 0
```

Lesson 2: The Kernel Pool

Task Statement

Write a program to retrieve particular string and numeric text kernel variables, both scalars and arrays. Interrogate the kernel pool for assigned variable names.

Learning Goals

The lesson demonstrates the SpiceyPy system's facility to retrieve different types of data (string, numeric, scalar, array) from the kernel pool.

For the code examples, use this generic text kernel (kervar.tm) containing PCK-type data, kernels to load, and example time strings:

```
KPL/MK

   Name the kernels to load. Use path symbols.

   The names and contents of the kernels referenced by this
   meta-kernel are as follows:

      File Name        Description
      ---------------  ------------------------------
      naif0008.tls     Generic LSK.
      de405s.bsp       Planet Ephemeris SPK.
      pck00008.tpc     Generic PCK.


\begindata

   PATH_VALUES     = ('kernels/spk',
                      'kernels/pck',
                      'kernels/lsk')
```

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```
   PATH_SYMBOLS    = ('SPK' , 'PCK' , 'LSK' )

   KERNELS_TO_LOAD = ( '$SPK/de405s.bsp',
                       '$PCK/pck00008.tpc',
                       '$LSK/naif0008.tls')

\begintext

Ring model data.

\begindata

   BODY699_RING1_NAME     = 'A Ring'
   BODY699_RING1          = (122170.0 136780.0 0.1 0.1 0.5)

   BODY699_RING1_1_NAME   = 'Encke Gap'
   BODY699_RING1_1        = (133405.0 133730.0 0.0 0.0 0.0)

   BODY699_RING2_NAME     = 'Cassini Division'
   BODY699_RING2          = (117580.0 122170.0 0.0 0.0 0.0)

\begintext

The kernel pool recognizes values preceded by '@' as time
values. When read, the kernel subsystem converts these
representations into double precision ephemeris time.

Caution: The kernel subsystem interprets the time strings
identified by '@' as TDB. The same string passed as input
to @STR2ET is processed as UTC.

The three expressions stored in the EXAMPLE_TIMES array represent
the same epoch.

\begindata

   EXAMPLE_TIMES       = ( @APRIL-1-2004-12:34:56.789,
                           @4/1/2004-12:34:56.789,
                           @JD2453097.0242684
                         )

\begintext
```

The main references for pool routines are found in the help command, the CSPICE source files or the API documentation for the particular routines.

Code Solution

```
from __future__ import print_function

#
# Import the CSPICE-Python interface.
#
import spiceypy
from spiceypy.utils.support_types import SpiceyError

def kervar():

    #
    # Define the max number of kernel variables
    # of concern for this examples.
    #
    N_ITEMS =  20

    #
    # Load the example kernel containing the kernel variables.
    # The kernels defined in KERNELS_TO_LOAD load into the
    # kernel pool with this call.
    #
    spiceypy.furnsh( 'kervar.tm' )

    #
    # Initialize the start value. This value indicates
    # index of the first element to return if a kernel
    # variable is an array. START = 0 indicates return everything.
    # START = 1 indicates return everything but the first element.
    #
    START = 0

    #
    # Set the template for the variable names to find. Let's
    # look for all variables containing  the string RING.
    # Define this with the wildcard template '*RING*'. Note:
    # the template '*RING' would match any variable name
    # ending with the RING string.
    #
    tmplate = '*RING*'

    #
    # We're ready to interrogate the kernel pool for the
    # variables matching the template. spiceypy.gnpool tells us:
    #
    #  1. Does the kernel pool contain any variables that
    #     match the template (value of found).
    #  2. If so, how many variables?
    #  3. The variable names. (cvals, an array of strings)
    #
```

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```
    try:
        cvals = spiceypy.gnpool( tmplate, START, N_ITEMS )
        print( 'Number variables matching template: {0}'.\
        format( len(cvals)) )
    except SpiceyError:
        print( 'No kernel variables matched template.' )
        return


    #
    # Okay, now we know something about the kernel pool
    # variables of interest to us. Let's find out more...
    #
    for cval in cvals:

        #
        # Use spiceypy.dtpool to return the dimension and type,
        # C (character) or N (numeric), of each pool
        # variable name in the cvals array. We know the
        # kernel data exists.
        #
        [dim, type] = spiceypy.dtpool( cval )

        print( '\n' + cval )
        print( ' Number items: {0}   Of type: {1}\n'.\
        format(dim, type) )

        #
        # Test character equality, 'N' or 'C'.
        #
        if type == 'N':

            #
            # If 'type' equals 'N', we found a numeric array.
            # In this case any numeric array will be an array
            # of double precision numbers ('doubles').
            # spiceypy.gdpool retrieves doubles from the
            # kernel pool.
            #
            dvars = spiceypy.gdpool( cval, START, N_ITEMS )
            for dvar in dvars:
                print('  Numeric value: {0:20.6f}'.format(dvar))

        elif type == 'C':

            #
            # If 'type' equals 'C', we found a string array.
            # spiceypy.gcpool retrieves string values from the
            # kernel pool.
            #
            cvars = spiceypy.gcpool( cval, START, N_ITEMS )
```

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```
            for cvar in cvars:
                print('  String value: {0}\n'.format(cvar))

        else:

            #
            # This block should never execute.
            #
            print('Unknown type. Code error.')


    #
    # Now look at the time variable EXAMPLE_TIMES. Extract this
    # value as an array of doubles.
    #
    dvars = spiceypy.gdpool( 'EXAMPLE_TIMES', START, N_ITEMS )

    print( 'EXAMPLE_TIMES' )

    for dvar in dvars:
        print('  Time value:    {0:20.6f}'.format(dvar))

    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear

if __name__ == '__main__':
   kervar()
```

Run the code example

The program runs and first reports the number of kernel pool variables matching the template, 6.

The program then loops over the spiceypy.dtpool 6 times, reporting the name of each pool variable, the number of data items assigned to that variable, and the variable type. Within the spiceypy.dtpool loop, a second loop outputs the contents of the data variable using spiceypy.gcpool or spiceypy.gdpool.

```
Number variables matching template: 6

BODY699_RING1_1
 Number items: 5   Of type: N

  Numeric value:        133405.000000
  Numeric value:        133730.000000
  Numeric value:             0.000000
  Numeric value:             0.000000
  Numeric value:             0.000000

BODY699_RING1
 Number items: 5   Of type: N

  Numeric value:        122170.000000
```

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```
  Numeric value:         136780.000000
  Numeric value:              0.100000
  Numeric value:              0.100000
  Numeric value:              0.500000

BODY699_RING2
 Number items: 5   Of type: N

  Numeric value:         117580.000000
  Numeric value:         122170.000000
  Numeric value:              0.000000
  Numeric value:              0.000000
  Numeric value:              0.000000

BODY699_RING1_1_NAME
 Number items: 1   Of type: C

  String value: Encke Gap


BODY699_RING2_NAME
 Number items: 1   Of type: C

  String value: Cassini Division


BODY699_RING1_NAME
 Number items: 1   Of type: C

  String value: A Ring

EXAMPLE_TIMES
  Time value:         134094896.789000
  Time value:         134094896.789000
  Time value:         134094896.789753
```

Note the final time value differs from the previous values in the final three decimal places despite the intention that all three strings represent the same time. This results from round-off when converting a decimal Julian day representation to the seconds past J2000 ET representation.

Related Routines

```
--    spiceypy.gipool retrieves integer values from the kernel
      subsystem.
```

Lesson 3: Coordinate Conversions

Task Statement

Write a program to convert a Cartesian 3-vector representing some location to the other coordinate representations. Use the position of the Moon with respect to Earth in an inertial and non-inertial reference frame as the example vector.

Learning Goals

The SpiceyPy system provides functions to convert coordinate tuples between Cartesian and various non Cartesian coordinate systems including conversion between geodetic and rectangular coordinates.

This lesson presents these coordinate transform routines for rectangular, cylindrical, and spherical systems.

Code Solution

```
from __future__ import print_function
from builtins import input
import sys

#
# Import the CSPICE-Python interface.
#
import spiceypy

def coord():

    #
    # Define the inertial and non inertial frame names.
    #
    # Initialize variables or set type. All variables
    # used in a PROMPT construct must be initialized
    # as strings.
    #
    INRFRM = 'J2000'
    NONFRM = 'IAU_EARTH'
    r2d = spiceypy.dpr()

    #
    # Load the needed kernels using a spiceypy.furnsh call on the
    # meta kernel.
    #
    spiceypy.furnsh( 'coord.tm' )
```

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```
    #
    # Prompt the user for a time string. Convert the
    # time string to ephemeris time J2000 (ET).
    #
    timstr = input( 'Time of interest: ')
    et     = spiceypy.str2et( timstr )

    #
    # Access the kernel pool data for the triaxial radii of the
    # Earth, rad[1][0] holds the equatorial radius, rad[1][2]
    # the polar radius.
    #
    rad = spiceypy.bodvrd( 'EARTH', 'RADII', 3 )

    #
    # Calculate the flattening factor for the Earth.
    #
    #          equatorial_radius - polar_radius
    # flat =   ________________________________
    #
    #                equatorial_radius
    #
    flat = (rad[1][0] - rad[1][2])/rad[1][0]

    #
    # Make the spiceypy.spkpos call to determine the apparent
    # position of the Moon w.r.t. to the Earth at 'et' in the
    # inertial frame.
    #
    [pos, ltime] = spiceypy.spkpos('MOON', et, INRFRM,
                                   'LT+S','EARTH'    )

    #
    # Show the current frame and time.
    #
    print( ' Time : {0}'.format(timstr) )
    print( ' Inertial Frame: {0}\n'.format(INRFRM) )

    #
    # First convert the position vector
    # X = pos(1), Y = pos(2), Z = pos(3), to RA/DEC.
    #
    [ range, ra, dec ] = spiceypy.recrad( pos )

    print('   Range/Ra/Dec' )
    print('    Range: {0:20.6f}'.format(range) )
    print('    RA   : {0:20.6f}'.format(ra * r2d) )
    print('    DEC  : {0:20.6f}'.format(dec* r2d) )

    #
    # ...latitudinal coordinates...
    #
```

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```
    [ range, lon, lat ] = spiceypy.reclat( pos )
    print('   Latitudinal ' )
    print('    Rad  : {0:20.6f}'.format(range) )
    print('    Lon  : {0:20.6f}'.format(lon * r2d) )
    print('    Lat  : {0:20.6f}'.format(lat * r2d) )

    #
    # ...spherical coordinates use the colatitude,
    # the angle from the Z axis.
    #
    [ range, colat, lon ] = spiceypy.recsph( pos )
    print( '   Spherical' )
    print('    Rad  : {0:20.6f}'.format(range) )
    print('    Lon  : {0:20.6f}'.format(lon   * r2d) )
    print('    Colat: {0:20.6f}'.format(colat * r2d) )

    #
    # Make the spiceypy.spkpos call to determine the apparent
    # position of the Moon w.r.t. to the Earth at 'et' in the
    # non-inertial, body fixed, frame.
    #
    [pos, ltime] = spiceypy.spkpos('MOON', et, NONFRM,
                                   'LT+S','EARTH')

    print()
    print( '  Non-inertial Frame: {0}'.format(NONFRM) )

    #
    # ...latitudinal coordinates...
    #
    [ range, lon, lat ] = spiceypy.reclat( pos )
    print('   Latitudinal ' )
    print('    Rad  : {0:20.6f}'.format(range) )
    print('    Lon  : {0:20.6f}'.format(lon * r2d) )
    print('    Lat  : {0:20.6f}'.format(lat * r2d) )

    #
    # ...spherical coordinates use the colatitude,
    # the angle from the Z axis.
    #
    [ range, colat, lon ] = spiceypy.recsph( pos )
    print( '   Spherical' )
    print('    Rad  : {0:20.6f}'.format(range) )
    print('    Lon  : {0:20.6f}'.format(lon   * r2d) )
    print('    Colat: {0:20.6f}'.format(colat * r2d) )

    #
    # ...finally, convert the position to geodetic coordinates.
    #
    [ lon, lat, range ] = spiceypy.recgeo( pos, rad[1][0], flat )
    print( '   Geodetic' )
    print('    Rad  : {0:20.6f}'.format(range) )
```

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```
    print('    Lon  : {0:20.6f}'.format(lon * r2d) )
    print('    Lat  : {0:20.6f}'.format(lat * r2d) )
    print()

    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear


if __name__ == '__main__':
   coord()
```

Run the code example

Input "Feb 3 2002 TDB" to calculate the Moon's position. (the 'TDB' tag indicates a Barycentric Dynamical Time value).

```
Time of interest: Feb 3 2002 TDB
```

Examine the Moon position in the J2000 inertial frame, display the time and frame:

```
Time : Feb 3 2002 TDB
 Inertial Frame: J2000
```

Convert the Moon Cartesian coordinates to right ascension declination.

```
Range/Ra/Dec
 Range:        369340.815193
 RA   :           203.643686
 DEC  :            -4.979010
```

Latitudinal. Note the difference in the expressions for longitude and right ascension though they represent a measure of the same quantity. The RA/DEC system measures RA in the interval [0,2Pi). Latitudinal coordinates measures longitude in the interval (-Pi,Pi].

```
Latitudinal
 Rad  :        369340.815193
 Lon  :          -156.356314
 Lat  :            -4.979010
```

Spherical. Note the difference between the expression of latitude in the Latitudinal system and the corresponding Spherical colatitude. The spherical coordinate system uses the colatitude, the angle measure away from the positive Z axis. Latitude is the angle between the position vector and the x-y (equatorial) plane with positive angle defined as toward the positive Z direction

```
Spherical
 Rad  :        369340.815193
 Lon  :          -156.356314
 Colat:            94.979010
```

The same position look-up in a body fixed (non-inertial) frame, IAU_EARTH.

```
Non-inertial Frame: IAU_EARTH
```

Latitudinal coordinates return the geocentric latitude.

```
Latitudinal
 Rad  :        369340.815193
 Lon  :            70.986950
 Lat  :            -4.989675
```

Spherical.

```
Spherical
 Rad  :        369340.815193
 Lon  :            70.986950
 Colat:            94.989675
```

Geodetic. The cartographic lat/lon.

```
Geodetic
 Rad  :        362962.836755
 Lon  :            70.986950
 Lat  :            -4.990249
```

Related Routines

```
--   spiceypy.latrec, latitudinal to rectangular

--   spiceypy.latcyl, latitudinal to cylindrical

--   spiceypy.latsph, latitudinal to spherical

--   spiceypy.reccyl, rectangular to cylindrical

--   spiceypy.sphrec, spherical to rectangular

--   spiceypy.sphcyl, spherical to cylindrical

--   spiceypy.sphlat, spherical to latitudinal

--   spiceypy.cyllat, cylindrical to latitudinal

--   spiceypy.cylsph, cylindrical to spherical

--   spiceypy.cylrec, cylindrical to rectangular

--   spiceypy.georec, geodetic to rectangular
```

Lesson 4: Advanced Time Manipulation Routines

Task Statement

Demonstrate the advanced functions of the time utilities with regard to formatting of time strings for output. Formatting options include altering calendar representations of the time strings. Convert time-date strings between different SpiceyPy-supported formats.

Learning Goals

Introduce the routines used for advanced manipulation of time strings. Understand the concept of ephemeris time (ET) as used in SpiceyPy.

Code Solution

Caution: Be sure to assign sufficient string lengths for time formats/pictures.

```
from __future__ import print_function

#
# Import the CSPICE-Python interface.
#
import spiceypy

def xtic():

    #
    # Assign the META variable to the name of the meta-kernel
    # that contains the LSK kernel and create an arbitrary
    # time string.
    #
    CALSTR    = 'Mar 15, 2003 12:34:56.789 AM PST'
    META      = 'xtic.tm'
    AMBIGSTR  = 'Mar 15, 79 12:34:56'
    T_FORMAT1 = 'Wkd Mon DD HR:MN:SC PDT YYYY ::UTC-7'
    T_FORMAT2 = 'Wkd Mon DD HR:MN ::UTC-7 YR (JULIAND.##### JDUTC)'

    #
    # Load the meta-kernel.
    #
    spiceypy.furnsh( META )
    print( 'Original time string     : {0}'.format(CALSTR) )

    #
    # Convert the time string to the number of ephemeris
    # seconds past the J2000 epoch. This is the most common
    # internal time representation used by the CSPICE
    # system; CSPICE refers to this as ephemeris time (ET).
    #
    et = spiceypy.str2et( CALSTR )
    print( 'Corresponding ET         : {0:20.6f}\n'.format(et) )
```

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```
    #
    # Make a picture of an output format. Describe a Unix-like
    # time string then send the picture and the 'et' value through
    # spiceypy.timout to format and convert the ET representation
    # of the time string into the form described in
    # spiceypy.timout. The '::UTC-7' token indicates the time
    # zone for the `timstr' output - PDT. 'PDT' is part of the
    # output, but not a time system token.
    #
    timstr = spiceypy.timout( et, T_FORMAT1)
    print( 'Time in string format 1  : {0}'.format(timstr) )

    timstr = spiceypy.timout( et, T_FORMAT2)
    print( 'Time in string format 2  : {0}'.format(timstr) )

    #
    # Why create a picture by hand when spiceypy can do it for
    # you? Input a string to spiceypy.tpictr with the format of
    # interest. `ok' returns a boolean indicating whether an
    # error occurred while parsing the picture string, if so,
    # an error diagnostic message returns in 'xerror'. In this
    # example the picture string is known as correct.
    #
    pic = '12:34:56.789 P.M. PDT January 1, 2006'
    [ pictr, ok, xerror] = spiceypy.tpictr(pic)

    if not bool(ok):
        print( xerror )
        exit


    timstr = spiceypy.timout( et, pictr)
    print( 'Time in string format 3  : {0}'.format( timstr ) )

    #
    # Two digit year representations often cause problems due to
    # the ambiguity of the century. The routine spiceypy.tsetyr
    # gives the user the ability to set a default range for 2
    # digit year representation. SPICE uses 1969AD as the default
    # start year so the numbers inclusive of 69 to 99 represent
    # years 1969AD to 1999AD, the numbers inclusive of 00 to 68
    # represent years 2000AD to 2068AD.
    #
    # The defined time string 'AMBIGSTR' contains a two-digit
    # year. Since the SPICE base year is 1969, the time subsystem
    # interprets the string as 1979.
    #
    et1 = spiceypy.str2et( AMBIGSTR )

    #
    # Set 1980 as the base year causes SPICE to interpret the
```

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```
    # time string's "79" as 2079.
    #
    spiceypy.tsetyr( 1980 )
    et2 = spiceypy.str2et( AMBIGSTR )

    #
    # Calculate the number of years between the two ET
    # representations, ~100.
    #
    print( 'Years between evaluations: {0:20.6f}'.\
    format( (et2 - et1)/spiceypy.jyear()))

    #
    # Reset the default year to 1969.
    #
    spiceypy.tsetyr( 1969 )

    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear


if __name__ == '__main__':
   xtic()
```

Run the code example

```
Original time string     : Mar 15, 2003 12:34:56.789 AM PST
Corresponding ET         :     100989360.974561

Time in string format 1  : Sat Mar 15 01:34:56 PDT 2003
Time in string format 2  : Sat Mar 15 01:34  03 (2452713.85760 JDUTC)
Time in string format 3  : 01:34:56.789 A.M. PDT March 15, 2003
Years between evaluations:           100.000000
```

Lesson 5: Error Handling

Task Statement

Write an interactive program to return a state vector based on a user's input. Code the program with the capability to recover from user input mistakes, inform the user of the mistake, then continue to run.

Learning Goals

Learn how to write a program that has the capability to recover from expected SPICE errors.

The SpiceyPy error subsystem differs from CSPICE and SPICELIB packages in that the user cannot alter the state of the error subsystem, rather the user can respond to an error signal using try-except blocks. This block natively receives and processes any SpiceyError exception signaled from SpiceyPy. The user can therefore "catch" an error signal so as to respond in an appropriate manner.

Code Solution

```
from __future__ import print_function
from builtins import input

#
# Import the CSPICE-Python interface.
#
import spiceypy
from spiceypy.utils.support_types import SpiceyError

def aderr():

    #
    # Set initial parameters.
    #
    SPICETRUE =  True
    SPICEFALSE=  False
    doloop    =  SPICETRUE

    #
    # Load the data we need for state evaluation.
    #
    spiceypy.furnsh( 'aderr.tm' )

    #
    # Start our input query loop to the user.
    #
    while (doloop):

        #
        # For simplicity, we request only one input.
        # The program calculates the state vector from
        # Earth to the user specified target 'targ' in the
        # J2000 frame, at ephemeris time zero, using
        # aberration correction LT+S (light time plus
        # stellar aberration).
        #
        targ = input( 'Target: ' )


        if targ == 'NONE':
            #
```

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```
            # An exit condition. If the user inputs NONE
            # for a target name, set the loop to stop...
            #
            doloop = SPICEFALSE

        else:

          #
          # ...otherwise evaluate the state between the Earth
          # and the target. Initialize an error handler.
          #
          try:

              #
              # Perform the state lookup.
              #
              [state, ltime] = spiceypy.spkezr(targ, 0., 'J2000',
                                               'LT+S',   'EARTH')

              #
              # No error, output the state.
              #
              print( 'R : {0:20.6f} {1:20.6f} '
                     '{2:20.5f}'.format(*state[0:3]))
              print( 'V : {0:20.6f} {1:20.6f} '
                     '{2:20.6f}'.format(*state[3:6]) )
              print( 'LT: {0:20.6f}\n'.format(float(ltime)))

          except SpiceyError as err:

             #
             # What if spiceypy.spkezr signaled an error?
             # Then spiceypy signals an error to python.
             #
             # Examine the value of 'e' to retrieve the
             # error message.
             #
            print( err )
            print( )


    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear


if __name__ == '__main__':
   aderr()
```

Run the code example

Now run the code with various inputs to observe behavior. Begin the run using known astronomical bodies, e.g.

"Moon", "Mars", "Pluto barycenter" and "Puck". Recall the SpiceyPy default units are kilometers, kilometers per second, kilograms, and seconds. The 'R' marker identifies the (X,Y,Z) position of the body in kilometers, the 'V' marker identifies the velocity of the body in kilometers per second, and the 'LT' marker identifies the one-way light time between the bodies at the requested evaluation time.

```
Target: Moon
R :       -291584.616595       -266693.402359         -76095.64756
V :             0.643439            -0.666066            -0.301310
LT:             1.342311

Target: Mars
R :     234536077.419136    -132584383.595569      -63102685.70619
V :            30.961373            28.932996            13.113031
LT:           923.001080

Target: Pluto barycenter
R :   -1451304742.838526   -4318174144.406321     -918251433.58736
V :            35.079843             3.053138            -0.036762
LT:         15501.258293

Target: Puck

================================================================================
===========

Toolkit version: N0066

SPICE(SPKINSUFFDATA) --

Insufficient ephemeris data has been loaded to compute the state of 7
15 (PUCK) relative to 0 (SOLAR SYSTEM BARYCENTER) at the ephemeris ep
och 2000 JAN 01 12:00:00.000.

spkezr_c --> SPKEZR --> SPKEZ --> SPKACS --> SPKAPS --> SPKLTC --> SP
KGEO

================================================================================
===========

Target:
```

Perplexing. What happened?

The kernel files named in meta.tm did not include ephemeris data for Puck. When the SPK subsystem tried to evaluate Puck's position, the evaluation failed due to lack of data, so an error signaled.

The above error signifies an absence of state information at ephemeris time 2000 JAN 01 12:00:00.000 (the requested time, ephemeris time zero).

Try another look-up, this time for "Casper"

```
Target: Casper

================================================================================
===========
```

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```
Toolkit version: N0066

SPICE(IDCODENOTFOUND) --

The target, 'Casper', is not a recognized name for an ephemeris objec
t. The cause of this problem may be that you need an updated version
of the SPICE Toolkit. Alternatively you may call SPKEZ directly if yo
u know the SPICE ID codes for both 'Casper' and 'EARTH'

spkezr_c --> SPKEZR

================================================================================

Target:
```

An easy to understand error. The SPICE system does not contain information on a body named 'Casper.'

Another look-up, this time, "Venus".

```
Target: Venus
R :     -80970027.540532    -139655772.573898      -53860125.95820
V :            31.166910           -27.001056           -12.316514
LT:           567.655074

Target:
```

The look-up succeeded despite two errors in our run. The SpiceyPy system can respond to error conditions (not system errors) in much the same fashion as languages with catch/throw instructions.

Lesson 6: Windows, and Cells

Programming task

Given the times of line-of-sight for a vehicle from a ground station and the times for an acceptable Sun-station-vehicle phase angle, write a program to determine the time intervals common to both configurations.

Learning Goals

SpiceyPy implementation of SPICE cells consists of a class that provides an interface to the underlying CSPICE cell structure.

A user should create cells by use of the appropriate SpiceyPy calls. NAIF recommends against manual creation of cells.

A 'window' is a type of cell containing ordered, double precision values describing a collection of zero or more intervals.

We define an interval, 'i', as all double precision values bounded by and including an ordered pair of numbers,

```
[ a , b ]
   i   i
```

where

```
a    <   b
 i   -    i
```

The intervals within a window are both ordered and disjoint. That is, the beginning of each interval is greater than the end of the previous interval:

```
b  <  a
 i     i+1
```

A common use of the windows facility is to calculate the intersection set of a number of time intervals.

Code Solution

```
from __future__ import print_function

#
# Import the CSPICE-Python interface.
#
import spiceypy

def win():

    MAXSIZ = 8

    #
    # Define a set of time intervals. For the purposes of this
    # tutorial program, define time intervals representing
    # an unobscured line of sight between a ground station
    # and some body.
    #
    los = [ 'Jan 1, 2003 22:15:02', 'Jan 2, 2003  4:43:29',
            'Jan 4, 2003  9:55:30', 'Jan 4, 2003 11:26:52',
            'Jan 5, 2003 11:09:17', 'Jan 5, 2003 13:00:41',
            'Jan 6, 2003 00:08:13', 'Jan 6, 2003  2:18:01' ]

    #
    # A second set of intervals representing the times for which
    # an acceptable phase angle exists between the ground station,
    # the body and the Sun.
    #
    phase = [ 'Jan 2, 2003 00:03:30', 'Jan 2, 2003 19:00:00',
              'Jan 3, 2003  8:00:00', 'Jan 3, 2003  9:50:00',
              'Jan 5, 2003 12:00:00', 'Jan 5, 2003 12:45:00',
              'Jan 6, 2003 00:30:00', 'Jan 6, 2003 23:00:00' ]

    #
    # Load our meta kernel for the leapseconds data.
    #
    spiceypy.furnsh( 'win.tm' )
```

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```
    #
    # SPICE windows consist of double precision values; convert
    # the string time tags defined in the 'los' and 'phase'
    # arrays to double precision ET. Store the double values
    # in the 'loswin' and 'phswin' windows.
    #
    los_et = spiceypy.str2et( los   )
    phs_et = spiceypy.str2et( phase )

    loswin = spiceypy.stypes.SPICEDOUBLE_CELL( MAXSIZ )
    phswin = spiceypy.stypes.SPICEDOUBLE_CELL( MAXSIZ )

    for i in range(0, int( MAXSIZ/2 ) ):
        spiceypy.wninsd( los_et[2*i], los_et[2*i+1], loswin )
        spiceypy.wninsd( phs_et[2*i], phs_et[2*i+1], phswin )

    spiceypy.wnvald( MAXSIZ, MAXSIZ, loswin )
    spiceypy.wnvald( MAXSIZ, MAXSIZ, phswin )

    #
    # The issue for consideration, at what times do line of
    # sight events coincide with acceptable phase angles?
    # Perform the set operation AND on loswin, phswin,
    # (the intersection of the time intervals)
    # place the results in the window 'sched'.
    #
    sched = spiceypy.wnintd( loswin, phswin )

    print( 'Number data values in sched : '
           '{0:2d}'.format(spiceypy.card(sched)) )

    #
    # Output the results. The number of intervals in 'sched'
    # is half the number of data points (the cardinality).
    #
    print( ' ' )
    print( 'Time intervals meeting defined criterion.' )

    for i in range( spiceypy.card(sched)//2):

       #
       # Extract from the derived 'sched' the values defining the
       # time intervals.
       #
       [left, right ] = spiceypy.wnfetd( sched, i )

       #
       # Convert the ET values to UTC for human comprehension.
       #
       utcstr_l = spiceypy.et2utc( left , 'C', 3 )
       utcstr_r = spiceypy.et2utc( right, 'C', 3 )
```

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```
        #
        # Output the UTC string and the corresponding index
        # for the interval.
        #
        print( '{0:2d}   {1}   {2}'.format(i, utcstr_l, utcstr_r))


    #
    # Summarize the 'sched' window.
    #
    [meas, avg, stddev, small, large] = spiceypy.wnsumd( sched )

    print( '\nSummary of sched window\n' )

    print( 'o Total measure of sched    : {0:16.6f}'.format(meas))
    print( 'o Average measure of sched  : {0:16.6f}'.format(avg))
    print( 'o Standard deviation of ' )
    print( '  the measures in sched     : '
           '{0:16.6f}'.format(stddev))

    #
    # The values for small and large refer to the indexes of the
    # values in the window ('sched'). The shortest interval is
    #
    #      [ sched.base[ sched.data + small]
    #        sched.base[ sched.data + small +1]  ];
    #
    # the longest is
    #
    #      [ sched.base[ sched.data + large]
    #        sched.base[ sched.data + large +1]  ];
    #
    # Output the interval indexes for the shortest and longest
    # intervals. As Python bases an array index on 0, the interval
    # index is half the array index.
    #
    print( 'o Index of shortest interval: '
           '{0:2d}'.format(int(small/2)) )
    print( 'o Index of longest interval : '
           '{0:2d}'.format(int(large/2)) )

    #
    # Done. Unload the kernels.
    #
    spiceypy.kclear

if __name__ == '__main__':
   win()
```

Run the code example

The output window has the name `sched' (schedule).

Output the amount of data held in `sched' compared to the maximum possible amount.

```
Number data values in sched :  6
```

List the time intervals for which a line of sight exists during the time of a proper phase angle.

```
Time intervals meeting defined criterion.
 0   2003 JAN 02 00:03:30.000   2003 JAN 02 04:43:29.000
 1   2003 JAN 05 12:00:00.000   2003 JAN 05 12:45:00.000
 2   2003 JAN 06 00:30:00.000   2003 JAN 06 02:18:01.000
```

Finally, an analysis of the `sched' data. The measure of an interval [a,b] (a <= b) equals b-a. Real values output in units of seconds.

```
Summary of sched window

o Total measure of sched    :     25980.000009
o Average measure of sched  :      8660.000003
o Standard deviation of
  the measures in sched     :      5958.550217
o Index of shortest interval:  1
o Index of longest interval :  0
```

Related Routines

```
--   spiceypy.wncomd determines the compliment of a window with
     respect to a defined interval.

--   spiceypy.wncond contracts a window's intervals.

--   spiceypy.wndifd : Calculate the difference between two windows;
     i.e. every point existing in the first but not the second.

--   spiceypy.wnelmd returns TRUE or FALSE if a value exists in a
     window.

--   spiceypy.wnexpd expands the size of the intervals in a window.

--   spiceypy.wnextd extracts a window's endpoints .

--   spiceypy.wnfild fills gaps between intervals in a window.

--   spiceypy.wnfltd filter/removes small intervals from a window.

--   spiceypy.wnincd determines if an interval exists within a
     window.

--   spiceypy.wninsd inserts an interval into a window.

--   spiceypy.wnreld compares two windows. Comparison operations
     available, equality '=', inequality '<>', subset '<=' and '>=',
     proper subset '<' and '>'.

--   spiceypy.wnunid calculates the union of two windows.
```

Lesson 7: Utility and Constants Routines

Task Statement

Write an interactive program to convert values between various units. Demonstrate the flexibility of the unit conversion routine, the string equality function, and show the version ID function.

Learning Goals

SpiceyPy provides several routines to perform commonly needed tasks. Among these:

SpiceyPy also includes a set of functions that return constant values often used in astrodynamics, time calculations, and geometry.

Code Solution

```
from __future__ import print_function
from builtins import input

#
# Import the CSPICE-Python interface.
#
import spiceypy


def tostan(alias):

    value = alias

    #
    # As a convenience, let's alias a few common terms
    # to their appropriate counterpart.
    #
    if alias == 'meter':

        #
        # First, a 'meter' by any other name is a
        # 'METER' and smells as sweet ...
        #
        value = 'METERS'

    elif (alias == 'klicks')        \
        or (alias == 'kilometers')  \
        or (alias =='kilometer'):

        #
        # ... 'klicks' and 'KILOMETERS' and 'KILOMETER'
        # identifies 'KM'....
        #
        value = 'KM'
```

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```
    elif alias == 'secs':

        #
        # ... 'secs' to 'SECONDS'.
        #
        value = 'SECONDS'

    elif alias == 'miles':

        #
        # ... and finally 'miles' to 'STATUTE_MILES'.
        # Normal people think in statute miles.
        # Only sailors think in nautical miles - one
        # minute of arc at the equator.
        #
        value = 'STATUTE_MILES'

    else:
        pass


    #
    # Much better. Now return. If the input matched
    # none of the aliases, this function did nothing.
    #
    return value

def units():

    #
    # Display the Toolkit version string with a spiceypy.tkvrsn
    # call.
    #
    vers = spiceypy.tkvrsn( 'TOOLKIT' )
    print('\nConvert demo program compiled against CSPICE '
          'Toolkit ' + vers)

    #
    # The user first inputs the name of a unit of measure.
    # Send the name through tostan for de-aliasing.
    #
    funits = input( 'From Units : '  )
    funits = tostan( funits )

    #
    # Input a double precision value to express in a new
    # unit format.
    #
    fvalue = float(input( 'From Value : ' ))

    #
    # Now the user inputs the name of the output units.
```

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```
    # Again we send the units name through tostan for
    # de-aliasing.
    #
    tunits = input( 'To Units   : ' )
    tunits = tostan( tunits )

    tvalue = spiceypy.convrt( fvalue, funits, tunits)
    print( '{0:12.5f} {1}'.format(tvalue, tunits) )

if __name__ == '__main__':
   units()
```

Run the code example

Run a few conversions through the application to ensure it works. The intro banner gives us the Toolkit version against which the application was linked:

```
Convert demo program compiled against CSPICE Toolkit CSPICE_N0066
From Units : klicks
From Value : 3
To Units   : miles
     1.86411 STATUTE_MILES
```

Now we know. Three kilometers equals 1.864 miles.

Legend states Pheidippides ran from the Marathon Plain to Athens. The modern marathon race (inspired by this event) spans 26.2 miles. How far in kilometers?

```
Convert demo program compiled against CSPICE Toolkit CSPICE_N0066
From Units : miles
From Value : 26.2
To Units   : km
    42.16481 km
```

Task Statement

Write a program to output SpiceyPy constants and use those constants to calculate some rudimentary values.

Code Solution

```
from __future__ import print_function

#
# Import the CSPICE-Python interface.
#
import spiceypy

def xconst():

    #
    # All the function have the same calling sequence:
```

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```
    #
    #    VALUE = function_name()
    #
    #    some_procedure( function_name() )
    #
    # First a simple example using the seconds per day
    # constant...
    #
    print( 'Number of (S)econds (P)er (D)ay         : '
           '{0:19.12f}'.format(spiceypy.spd() ))

    #
    # ...then show the value of degrees per radian, 180/Pi...
    #
    print( 'Number of (D)egrees (P)er (R)adian      : '
           '{0:19.16f}'.format(spiceypy.dpr() ))

    #
    # ...and the inverse, radians per degree, Pi/180.
    # It is obvious spiceypy.dpr() equals 1.d/spiceypy.rpd(), or
    # more simply spiceypy.dpr() * spiceypy.rpd() equals 1
    #
    print( 'Number of (R)adians (P)er (D)egree      : '
           '{0:19.16f}'.format(spiceypy.rpd() ))

    #
    # What's the value for the astrophysicist's favorite
    # physical constant (in a vacuum)?
    #
    print( 'Speed of light in KM per second         : '
           '{0:19.12f}'.format(spiceypy.clight() ))

    #
    # How long (in Julian days) from the J2000 epoch to the
    # J2100 epoch?
    #
    print( 'Number of days between epochs J2000')
    print( '  and J2100                             : '
           '{0:19.12f}'.format(  spiceypy.j2100()
                              - spiceypy.j2000() ))

    #
    # Redo the calculation returning seconds...
    #
    print( 'Number of seconds between epochs' )
    print( '  J2000 and J2100                       : '
           '{0:19.5f}'.format(spiceypy.spd() *          \
           (spiceypy.j2100() - spiceypy.j2000() ) ))


    #
    # ...then tropical years.
```

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```
    #
    val =(spiceypy.spd()/spiceypy.tyear()    ) *        \
         (spiceypy.j2100()- spiceypy.j2000() )
    print( 'Number of tropical years between' )
    print( '  epochs J2000 and J2100                : '
           '{0:19.12f}'.format(val))


    #
    # Finally, how can I convert a radian value to degrees.
    #
    print( 'Number of degrees in Pi/2 radians of arc: '
           '{0:19.16f}'.format(  spiceypy.halfpi()
                              * spiceypy.dpr()      ))

    #
    # and degrees to radians.
    #
    print( 'Number of radians in 250 degrees of arc : '
           '{0:19.16f}'.format(250. * spiceypy.rpd() ))

if __name__ == '__main__':
   xconst()
```

Run the code example

```
Number of (S)econds (P)er (D)ay         :  86400.000000000000
Number of (D)egrees (P)er (R)adian      : 57.2957795130823229
Number of (R)adians (P)er (D)egree      :  0.0174532925199433
Speed of light in KM per second         : 299792.457999999984
Number of days between epochs J2000
  and J2100                             :  36525.000000000000
Number of seconds between epochs
  J2000 and J2100                       :    3155760000.00000
Number of tropical years between
  epochs J2000 and J2100                :    100.002135902909
Number of degrees in Pi/2 radians of arc: 90.0000000000000000
Number of radians in 250 degrees of arc :  4.3633231299858242
```

Related Routines

```
--   spiceypy.b1900 : Julian Date of the epoch Besselian Date 1900.0

--   spiceypy.b1950 : Julian date of the epoch Besselian Date 1950.0

--   spiceypy.j1900 : Julian date of 1900 JAN 0.5 this corresponds
     to calendar date 1899 DEC 31 12:00:00

--   spiceypy.j1950 : Julian date of 1950 JAN 1.0 this corresponds
     to calendar date 1950 JAN 01 00:00:00
```

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```
--   spiceypy.twopi : double precision value of 2 * Pi

--   spiceypy.pi : double precision value of Pi

--   spiceypy.jyear : seconds per Julian year (365.25 Julian days)
```

3.10 SpiceyPy package

3.10.1 spiceypy module

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`spiceypy.spiceypy.appndc`(*item*, *cell*)

Append an item to a character cell.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/appndc_c.html

Parameters

- **item** (Union[str, Iterable[str], ndarray, str_]) – The item to append.
- **cell** (Union[*Cell_Char*, *SpiceCell*]) – The cell to append to.

Return type
None

`spiceypy.spiceypy.appndd`(*item*, *cell*)

Append an item to a double precision cell.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/appndd_c.html

Parameters

- **item** (Union[float, Iterable[float]]) – The item to append.
- **cell** (Union[*SpiceCell*, *Cell_Double*]) – The cell to append to.

Return type
None

spiceypy.spiceypy.**appndi**(*item*, *cell*)

Append an item to an integer cell.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/appndi_c.html

Parameters

- **item** (Union[Iterable[int], int]) – The item to append.
- **cell** (Union[*SpiceCell*, *Cell_Int*]) – The cell to append to.

Return type
None

spiceypy.spiceypy.**axisar**(*axis*, *angle*)

Construct a rotation matrix that rotates vectors by a specified angle about a specified axis.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/axisar_c.html

Parameters

- **axis** (Union[ndarray, Iterable[float]]) – Rotation axis.
- **angle** (float) – Rotation angle, in radians.

Return type
ndarray

Returns
Rotation matrix corresponding to axis and angle.

spiceypy.spiceypy.**azlcpo**(*method*, *target*, *et*, *abcorr*, *azccw*, *elplsz*, *obspos*, *obsctr*, *obsref*)

Return the azimuth/elevation coordinates of a specified target relative to an "observer," where the observer has constant position in a specified reference frame. The observer's position is provided by the calling program rather than by loaded SPK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/azlcpo_c.html

Parameters

- **method** (str) – Method to obtain the surface normal vector.
- **target** (str) – Name of target ephemeris object.
- **et** (float) – Observation epoch.
- **abcorr** (str) – Aberration correction.
- **azccw** (bool) – Flag indicating how azimuth is measured.
- **elplsz** (bool) – Flag indicating how elevation is measured.
- **obspos** (ndarray) – Observer position relative to center of motion.
- **obsctr** (str) – Center of motion of observer.
- **obsref** (str) – Body fixed body centered frame of observer's center.

Return type
Tuple[ndarray, float]

Returns
State of target with respect to observer, in azimuth/elevation coordinates. and One way light time between target and observer.

spiceypy.spiceypy.**azlrec**(*range*, *az*, *el*, *azccw*, *elplsz*)

Convert from range, azimuth and elevation of a point to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/azlrec_c.html

Parameters

- **range** (float) – Distance of the point from the origin.
- **az** (float) – Azimuth in radians.
- **el** (float) – Elevation in radians.
- **azccw** (bool) – Flag indicating how azimuth is measured.
- **elplsz** (bool) – Flag indicating how elevation is measured.

Return type
ndarray

Returns
Rectangular coordinates of a point.

spiceypy.spiceypy.**b1900**()

Return the Julian Date corresponding to Besselian Date 1900.0.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/b1900_c.html

Return type
float

Returns
The Julian Date corresponding to Besselian Date 1900.0.

spiceypy.spiceypy.**b1950**()

Return the Julian Date corresponding to Besselian Date 1950.0.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/b1950_c.html

Return type
float

Returns
The Julian Date corresponding to Besselian Date 1950.0.

spiceypy.spiceypy.**badkpv**(*caller*, *name*, *comp*, *insize*, *divby*, *intype*)

Determine if a kernel pool variable is present and if so that it has the correct size and type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/badkpv_c.html

Parameters

- **caller** (str) – Name of the routine calling this routine.
- **name** (str) – Name of a kernel pool variable.
- **comp** (str) – Comparison operator.
- **insize** (int) – Expected size of the kernel pool variable.
- **divby** (int) – A divisor of the size of the kernel pool variable.
- **intype** (str) – Expected type of the kernel pool variable

Return type
bool

Returns
returns false if the kernel pool variable is OK.

spiceypy.spiceypy.**bltfrm**(*frmcls*, *out_cell=None*)

Return a SPICE set containing the frame IDs of all built-in frames of a specified class.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bltfrm_c.html

Parameters

- **frmcls** (int) – Frame class.
- **out_cell** (Optional[*SpiceCell*]) – Optional SpiceInt Cell that is returned

Return type
SpiceCell

Returns
Set of ID codes of frames of the specified class.

spiceypy.spiceypy.**bodc2n**(*code*, *lenout=256*)

Translate the SPICE integer code of a body into a common name for that body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodc2n_c.html

Parameters

- **code** (int) – Integer ID code to be translated into a name.
- **lenout** (int) – Maximum length of output name.

Return type
Tuple[str, bool]

Returns
A common name for the body identified by code.

spiceypy.spiceypy.**bodc2s**(*code*, *lenout=256*)

Translate a body ID code to either the corresponding name or if no name to ID code mapping exists, the string representation of the body ID value.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodc2s_c.html

Parameters

- **code** (int) – Integer ID code to translate to a string.
- **lenout** (int) – Maximum length of output name.

Return type
str

Returns
String corresponding to 'code'.

spiceypy.spiceypy.**boddef**(*name*, *code*)

Define a body name/ID code pair for later translation via *bodn2c()* or *bodc2n()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/boddef_c.html

Parameters

- **name** (str) – Common name of some body.
- **code** (int) – Integer code for that body.

Return type
None

spiceypy.spiceypy.**bodeul**(*body*, *et*)

Return the Euler angles needed to compute the transformation from inertial to body-fixed coordinates for any body in the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/bodeul.html

Parameters

- **body** (int) – NAIF ID code of body.
- **et** (float) – Epoch of transformation in seconds past J2000 TDB.

Return type
Tuple[float, float, float, float]

Returns
Right ascension of the (IAU) north pole in radians. Declination of the (IAU) north pole of the body in radians. Prime meridian rotation angle in radians. Angle between the prime meridian and longitude of longest axis in radians.

spiceypy.spiceypy.**bodfnd**(*body*, *item*)

Determine whether values exist for some item for any body in the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodfnd_c.html

Parameters

- **body** (int) – ID code of body.
- **item** (str) – Item to find ("RADII", "NUT_AMP_RA", etc.).

Return type
bool

Returns
True if the item is in the kernel pool, and is False if it is not.

spiceypy.spiceypy.**bodn2c**(*name*)

Translate the name of a body or object to the corresponding SPICE integer ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodn2c_c.html

Parameters
name (str) – Body name to be translated into a SPICE ID code.

Return type
Tuple[int, bool]

Returns
SPICE integer ID code for the named body.

spiceypy.spiceypy.**bods2c**(*name*)

Translate a string containing a body name or ID code to an integer code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bods2c_c.html

Parameters
name (str) – String to be translated to an ID code.

Return type
Tuple[int, bool]

Returns
Integer ID code corresponding to name.

spiceypy.spiceypy.**bodvar**(*body*, *item*, *dim*)

Deprecated: This routine has been superseded by *bodvcd()* and *bodvrd()*. This routine is supported for purposes of backward compatibility only.

Return the values of some item for any body in the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodvar_c.html

Parameters

- **body** (int) – ID code of body.
- **item** (str) – Item for which values are desired, ("RADII", "NUT_PREC_ANGLES", etc.)
- **dim** (int) – Number of values returned.

Return type
ndarray

Returns
values

spiceypy.spiceypy.**bodvcd**(*bodyid*, *item*, *maxn*)

Fetch from the kernel pool the double precision values of an item associated with a body, where the body is specified by an integer ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodvcd_c.html

Parameters

- **bodyid** (int) – Body ID code.
- **item** (str) – Item for which values are desired, ("RADII", "NUT_PREC_ANGLES", etc.)
- **maxn** (int) – Maximum number of values that may be returned.

Return type
Tuple[int, ndarray]

Returns
dim, values

spiceypy.spiceypy.**bodvrd**(*bodynm*, *item*, *maxn*)

Fetch from the kernel pool the double precision values of an item associated with a body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodvrd_c.html

Parameters

- **bodynm** (str) – Body name.
- **item** (str) – Item for which values are desired, ("RADII", "NUT_PREC_ANGLES", etc.)
- **maxn** (int) – Maximum number of values that may be returned.

Return type
Tuple[int, ndarray]

Returns
tuple of (dim, values)

spiceypy.spiceypy.**brcktd**(*number*, *end1*, *end2*)

Bracket a number. That is, given a number and an acceptable interval, make sure that the number is contained in the interval. (If the number is already in the interval, leave it alone. If not, set it to the nearest endpoint of the interval.)

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/brcktd_c.html

Parameters

- **number** (float) – Number to be bracketed.
- **end1** (float) – One of the bracketing endpoints for number.
- **end2** (float) – The other bracketing endpoint for number.

Return type
float

Returns
value within an interval

spiceypy.spiceypy.**brckti**(*number*, *end1*, *end2*)

Bracket a number. That is, given a number and an acceptable interval, make sure that the number is contained in the interval. (If the number is already in the interval, leave it alone. If not, set it to the nearest endpoint of the interval.)

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/brckti_c.html

Parameters

- **number** (int) – Number to be bracketed.
- **end1** (int) – One of the bracketing endpoints for number.
- **end2** (int) – The other bracketing endpoint for number.

Return type
int

Returns
value within an interval

spiceypy.spiceypy.**bschoc**(*value*, *ndim*, *lenvals*, *array*, *order*)

Do a binary search for a given value within a character string array, accompanied by an order vector. Return the index of the matching array entry, or -1 if the key value is not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bschoc_c.html

Parameters

- **value** (Union[str_, str]) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **lenvals** (int) – String length.
- **array** (Union[ndarray, Iterable[str]]) – Character string array to search.
- **order** (Union[ndarray, Iterable[int]]) – Order vector.

Return type
int

Returns
index

spiceypy.spiceypy.**bschoi**(*value*, *ndim*, *array*, *order*)

Do a binary search for a given value within an integer array, accompanied by an order vector. Return the index of the matching array entry, or -1 if the key value is not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bschoi_c.html

Parameters

- **value** (int) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **array** (Union[ndarray, Iterable[int]]) – Integer array to search.
- **order** (Union[ndarray, Iterable[int]]) – Order vector.

Return type
int

Returns
index

spiceypy.spiceypy.**bsrchc**(*value*, *ndim*, *lenvals*, *array*)

Do a binary earch for a given value within a character string array. Return the index of the first matching array entry, or -1 if the key value was not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bsrchc_c.html

Parameters

- **value** (str) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – Character string array to search.

Return type
int

Returns
index

spiceypy.spiceypy.**bsrchd**(*value*, *ndim*, *array*)

Do a binary search for a key value within a double precision array, assumed to be in increasing order. Return the index of the matching array entry, or -1 if the key value is not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bsrchd_c.html

Parameters

- **value** (float) – Value to find in array.
- **ndim** (int) – Dimension of array.
- **array** (ndarray) – Array to be searched.

Return type
int

Returns
index

spiceypy.spiceypy.**bsrchi**(*value*, *ndim*, *array*)

Do a binary search for a key value within an integer array, assumed to be in increasing order. Return the index of the matching array entry, or -1 if the key value is not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bsrchi_c.html

Parameters

- **value** (int) – Value to find in array.
- **ndim** (int) – Dimension of array.
- **array** (ndarray) – Array to be searched.

Return type
int

Returns
index

spiceypy.spiceypy.**card**(*cell*)

Return the cardinality (current number of elements) in a cell of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/card_c.html

Parameters
cell (*SpiceCell*) – Input cell.

Return type
int

Returns
the number of elements in a cell of any data type.

spiceypy.spiceypy.**ccifrm**(*frclss*, *clssid*, *lenout=256*)

Return the frame name, frame ID, and center associated with a given frame class and class ID.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ccifrm_c.html

Parameters

- **frclss** (int) – Class of frame.
- **clssid** (int) – Class ID of frame.
- **lenout** (int) – Maximum length of output string.

Return type
Tuple[int, str, int, bool]

Returns
the frame name, frame ID, center.

spiceypy.spiceypy.**cell_bool**(*cell_size*)

Return type
SpiceCell

spiceypy.spiceypy.**cell_char**(*cell_size*, *length*)

Return type
SpiceCell

spiceypy.spiceypy.**cell_double**(*cell_size*)

Return type
SpiceCell

spiceypy.spiceypy.**cell_int**(*cell_size*)

Return type
SpiceCell

spiceypy.spiceypy.**cell_time**(*cell_size*)

Return type
SpiceCell

spiceypy.spiceypy.**cgv2el**(*center*, *vec1*, *vec2*)

Form a SPICE ellipse from a center vector and two generating vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cgv2el_c.html

Parameters

- **center** (Union[ndarray, Iterable[float]]) – Center Vector
- **vec1** (Union[ndarray, Iterable[float]]) – Vector 1
- **vec2** (Union[ndarray, Iterable[float]]) – Vector 2

Return type
Ellipse

Returns
Ellipse

spiceypy.spiceypy.**chbder**(*cp*, *degp*, *x2s*, *x*, *nderiv*)

Given the coefficients for the Chebyshev expansion of a polynomial, this returns the value of the polynomial and its first nderiv derivatives evaluated at the input X.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chbder_c.html

Parameters

- **cp** (Union[ndarray, Iterable[float]]) – degp+1 Chebyshev polynomial coefficients.
- **degp** (int) – Degree of polynomial.
- **x2s** (Union[ndarray, Iterable[float]]) – Transformation parameters of polynomial.
- **x** (float) – Value for which the polynomial is to be evaluated
- **nderiv** (int) – The number of derivatives to compute

Return type
ndarray

Returns
Array of the derivatives of the polynomial

spiceypy.spiceypy.**chbigr**(*degp*, *cp*, *x2s*, *x*)

Evaluate an indefinite integral of a Chebyshev expansion at a specified point `x' and return the value of the input expansion at `x' as well. The constant of integration is selected to make the integral zero when `x' equals the abscissa value x2s[0].

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chbigr_c.html

Parameters

- **degp** (int) – Degree of input Chebyshev expansion.
- **cp** (ndarray) – Chebyshev coefficients of input expansion.
- **x2s** (ndarray) – Transformation parameters.
- **x** (float) – Abscissa value of evaluation.

Return type
Tuple[float, float]

Returns
Input expansion evaluated at xIntegral evaluated at x.

spiceypy.spiceypy.**chbint**(*cp*, *degp*, *x2s*, *x*)

Return the value of a polynomial and its derivative, evaluated at the input `x', using the coefficients of the Chebyshev expansion of the polynomial.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chbint_c.html

Parameters

- **cp** (ndarray) – degp 1 Chebyshev polynomial coefficients.
- **degp** (int) – Degree of polynomial.
- **x2s** (ndarray) – Transformation parameters of polynomial.
- **x** (float) – Value for which the polynomial is to be evaluated.

Return type
Tuple[float, float]

Returns
Value of the polynomial at xValue of the derivative of the polynomial at X.

spiceypy.spiceypy.**chbval**(*cp*, *degp*, *x2s*, *x*)

Return the value of a polynomial evaluated at the input `x' using the coefficients for the Chebyshev expansion of the polynomial.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chbval_c.html

Parameters

- **cp** (ndarray) – degp 1 Chebyshev polynomial coefficients.
- **degp** (int) – Degree of polynomial.
- **x2s** (ndarray) – Transformation parameters of polynomial.
- **x** (float) – Value for which the polynomial is to be evaluated.

Return type
float

Returns
Value of the polynomial at x.

spiceypy.spiceypy.**check_for_spice_error**(*f*)

Internal decorator function to check spice error system for failed calls

Parameters
f (Optional[Callable]) – function

Raises
stypes.SpiceyError –

Return type
None

spiceypy.spiceypy.**chkin**(*module*)

Inform the SPICE error handling mechanism of entry into a routine.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chkin_c.html

Parameters
module (str) – The name of the calling routine.

Return type
None

spiceypy.spiceypy.**chkout**(*module*)

Inform the SPICE error handling mechanism of exit from a routine.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/chkout_c.html

Parameters
module (str) – The name of the calling routine.

Return type
None

spiceypy.spiceypy.**cidfrm**(*cent*, *lenout=256*)

Retrieve frame ID code and name to associate with a frame center.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cidfrm_c.html

Parameters

- **cent** (int) – An object to associate a frame with.
- **lenout** (int) – Available space in output string frname.

Return type
Tuple[int, str, bool]

Returns
frame ID code, name to associate with a frame center.

spiceypy.spiceypy.**ckcls**(*handle*)

Close an open CK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckcls_c.html

Parameters
handle (int) – Handle of the CK file to be closed.

Return type
None

spiceypy.spiceypy.**ckcov**(*ck*, *idcode*, *needav*, *level*, *tol*, *timsys*, *cover=None*)

Find the coverage window for a specified object in a specified CK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckcov_c.html

Parameters

- **ck** (str) – Name of CK file.
- **idcode** (int) – ID code of object.
- **needav** (bool) – Flag indicating whether angular velocity is needed.

- **level** (str) – Coverage level: (SEGMENT OR INTERVAL)
- **tol** (float) – Tolerance in ticks.
- **timsys** (str) – Time system used to represent coverage.
- **cover** (Optional[*SpiceCell*]) – Window giving coverage for idcode.

Return type
SpiceCell

Returns
coverage window for a specified object in a specified CK file

spiceypy.spiceypy.**ckfrot**(*inst*, *et*)

Find the rotation from a C-kernel Id to the native frame at the time requested.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckfrot_c.html

Parameters

- **inst** (int) – NAIF instrument ID
- **et** (float) – Epoch measured in seconds past J2000

Return type
Tuple[ndarray, int, bool]

Returns
Rotation matrix from the input frame to the returned reference frame, id for the reference frame

spiceypy.spiceypy.**ckfxfm**(*inst*, *et*)

Find the state transformation matrix from a C-kernel (CK) frame with the specified frame class ID (CK ID) to the base frame of the highest priority CK segment containing orientation and angular velocity data for this CK frame at the time requested.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckfxfm_c.html

Parameters

- **inst** (int) – Frame class ID CK ID of a CK frame.
- **et** (float) – Epoch measured in seconds past J2000 TDB.

Return type
Tuple[ndarray, int, bool]

Returns
Transformation from CK frame to frame ref, Frame ID of the base reference.

spiceypy.spiceypy.**ckgp**(*inst*, *sclkdp*, *tol*, *ref*)

Get pointing (attitude) for a specified spacecraft clock time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckgp_c.html

Parameters

- **inst** (int) – NAIF ID of instrument, spacecraft, or structure.
- **sclkdp** (Union[float, int]) – Encoded spacecraft clock time.
- **tol** (int) – Time tolerance.
- **ref** (str) – Reference frame.

Return type
Tuple[ndarray, float, bool]

Returns
C-matrix pointing data, Output encoded spacecraft clock time

spiceypy.spiceypy.**ckgpav**(*inst*, *sclkdp*, *tol*, *ref*)

Get pointing (attitude) and angular velocity for a specified spacecraft clock time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckgpav_c.html

Parameters

- **inst** (int) – NAIF ID of instrument, spacecraft, or structure.
- **sclkdp** (float) – Encoded spacecraft clock time.
- **tol** (Union[float, int]) – Time tolerance.
- **ref** (str) – Reference frame.

Return type
Tuple[ndarray, ndarray, float, bool]

Returns
C-matrix pointing data, Angular velocity vector, Output encoded spacecraft clock time.

spiceypy.spiceypy.**ckgr02**(*handle*, *descr*, *recno*)

Return a specified pointing instance from a CK type 02 segment. The segment is identified by a CK file handle and segment descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckgr02_c.html

Parameters

- **handle** (int) – The handle of the CK file containing the segment.
- **descr** (ndarray) – The segment descriptor.
- **recno** (int) – The number of the pointing record to be returned.

Return type
ndarray

Returns
The pointing record.

spiceypy.spiceypy.**ckgr03**(*handle*, *descr*, *recno*)

Return a specified pointing instance from a CK type 03 segment. The segment is identified by a CK file handle and segment descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckgr03_c.html

Parameters

- **handle** (int) – The handle of the CK file containing the segment.
- **descr** (ndarray) – The segment descriptor.
- **recno** (int) – The number of the pointing instance to be returned.

Return type
ndarray

Returns
The pointing record.

spiceypy.spiceypy.**cklpf**(*filename*)

Load a CK pointing file for use by the CK readers. Return that file's handle, to be used by other CK routines to refer to the file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cklpf_c.html

Parameters
filename (str) – Name of the CK file to be loaded.

Return type
int

Returns
Loaded file's handle.

spiceypy.spiceypy.**ckmeta**(*ckid*, *meta*)

Return (depending upon the user's request) the ID code of either the spacecraft or spacecraft clock associated with a C-Kernel ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckmeta_c.html

Parameters

- **ckid** (int) – The ID code for some C kernel object.
- **meta** (str) – The kind of meta data requested SPK or SCLK.

Return type
int

Returns
The requested SCLK or spacecraft ID code.

spiceypy.spiceypy.**cknr02**(*handle*, *descr*)

Return the number of pointing records in a CK type 02 segment. The segment is identified by a CK file handle and segment descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cknr02_c.html

Parameters

- **handle** (int) – The handle of the CK file containing the segment.
- **descr** (ndarray) – The descriptor of the type 2 segment.

Return type
int

Returns
The number of records in the segment.

spiceypy.spiceypy.**cknr03**(*handle*, *descr*)

Return the number of pointing instances in a CK type 03 segment. The segment is identified by a CK file handle and segment descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cknr03_c.html

Parameters

- **handle** (int) – The handle of the CK file containing the segment.
- **descr** (ndarray) – The descriptor of the type 3 segment.

Return type
int

Returns
The number of pointing instances in the segment.

spiceypy.spiceypy.**ckobj**(*ck*, *out_cell=None*)

Find the set of ID codes of all objects in a specified CK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckobj_c.html

Parameters

- **ck** (str) – Name of CK file.
- **out_cell** (Optional[*SpiceCell*]) – Optional user provided Spice Int cell.

Return type
SpiceCell

Returns
Set of ID codes of objects in CK file.

spiceypy.spiceypy.**ckopn**(*filename*, *ifname*, *ncomch*)

Open a new CK file, returning the handle of the opened file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckopn_c.html

Parameters

- **filename** (str) – The name of the CK file to be opened.
- **ifname** (str) – The internal filename for the CK.
- **ncomch** (int) – The number of characters to reserve for comments.

Return type
int

Returns
The handle of the opened CK file.

spiceypy.spiceypy.**ckupf**(*handle*)

Unload a CK pointing file so that it will no longer be searched by the readers.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckupf_c.html

Parameters
handle (int) – Handle of CK file to be unloaded

Return type
None

spiceypy.spiceypy.**ckw01**(*handle*, *begtim*, *endtim*, *inst*, *ref*, *avflag*, *segid*, *nrec*, *sclkdp*, *quats*, *avvs*)

Add a type 1 segment to a C-kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckw01_c.html

Parameters

- **handle** (int) – Handle of an open CK file.
- **begtim** (float) – The beginning encoded SCLK of the segment.
- **endtim** (float) – The ending encoded SCLK of the segment.
- **inst** (int) – The NAIF instrument ID code.
- **ref** (str) – The reference frame of the segment.

- **avflag** (bool) – True if the segment will contain angular velocity.
- **segid** (str) – Segment identifier.
- **nrec** (int) – Number of pointing records.
- **sclkdp** (Union[ndarray, Iterable[float]]) – Encoded SCLK times.
- **quats** (Union[ndarray, Iterable[Iterable[float]]]) – Quaternions representing instrument pointing.
- **avvs** (Union[ndarray, Iterable[Iterable[float]]]) – Angular velocity vectors.

Return type
None

spiceypy.spiceypy.**ckw02**(*handle*, *begtim*, *endtim*, *inst*, *ref*, *segid*, *nrec*, *start*, *stop*, *quats*, *avvs*, *rates*)

Write a type 2 segment to a C-kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckw02_c.html

Parameters

- **handle** (int) – Handle of an open CK file.
- **begtim** (float) – The beginning encoded SCLK of the segment.
- **endtim** (float) – The ending encoded SCLK of the segment.
- **inst** (int) – The NAIF instrument ID code.
- **ref** (str) – The reference frame of the segment.
- **segid** (str) – Segment identifier.
- **nrec** (int) – Number of pointing records.
- **start** (ndarray) – Encoded SCLK interval start times.
- **stop** (ndarray) – Encoded SCLK interval stop times.
- **quats** (ndarray) – Quaternions representing instrument pointing.
- **avvs** (ndarray) – Angular velocity vectors.
- **rates** (Union[ndarray, Iterable[float]]) – Number of seconds per tick for each interval.

Return type
None

spiceypy.spiceypy.**ckw03**(*handle*, *begtim*, *endtim*, *inst*, *ref*, *avflag*, *segid*, *nrec*, *sclkdp*, *quats*, *avvs*, *nints*, *starts*)

Add a type 3 segment to a C-kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckw03_c.html

Parameters

- **handle** (int) – Handle of an open CK file.
- **begtim** (float) – The beginning encoded SCLK of the segment.
- **endtim** (float) – The ending encoded SCLK of the segment.
- **inst** (int) – The NAIF instrument ID code.
- **ref** (str) – The reference frame of the segment.
- **avflag** (bool) – True if the segment will contain angular velocity.

- **segid** (str) – Segment identifier.
- **nrec** (int) – Number of pointing records.
- **sclkdp** (ndarray) – Encoded SCLK times.
- **quats** (ndarray) – Quaternions representing instrument pointing.
- **avvs** (ndarray) – Angular velocity vectors.
- **nints** (int) – Number of intervals.
- **starts** (Union[ndarray, Iterable[float]]) – Encoded SCLK interval start times.

Return type
None

spiceypy.spiceypy.**ckw05**(*handle*, *subtype*, *degree*, *begtim*, *endtim*, *inst*, *ref*, *avflag*, *segid*, *sclkdp*, *packts*, *rate*, *nints*, *starts*)

Write a type 5 segment to a CK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckw05_c.html

Parameters

- **handle** (int) – Handle of an open CK file.
- **subtype** (int) – CK type 5 subtype code. Can be: 0, 1, 2, 3 see naif docs via link above.
- **degree** (int) – Degree of interpolating polynomials.
- **begtim** (float) – The beginning encoded SCLK of the segment.
- **endtim** (float) – The ending encoded SCLK of the segment.
- **inst** (int) – The NAIF instrument ID code.
- **ref** (str) – The reference frame of the segment.
- **avflag** (bool) – True if the segment will contain angular velocity.
- **segid** (str) – Segment identifier.
- **sclkdp** (ndarray) – Encoded SCLK times.
- **packts** (Sequence[Iterable[float]]) – Array of packets.
- **rate** (float) – Nominal SCLK rate in seconds per tick.
- **nints** (int) – Number of intervals.
- **starts** (ndarray) – Encoded SCLK interval start times.

Return type
None

spiceypy.spiceypy.**clight**()

Return the speed of light in a vacuum (IAU official value, in km/sec).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/clight_c.html

Return type
float

Returns
The function returns the speed of light in vacuum (km/sec).

spiceypy.spiceypy.**clpool**()

Remove all variables from the kernel pool. Watches on kernel variables are retained.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/clpool_c.html

Return type
None

spiceypy.spiceypy.**cltext**(*fname*)

Internal undocumented command for closing a text file opened by RDTEXT.

No URL available; relevant lines from SPICE source:

FORTRAN SPICE, rdtext.f:

```
C$Procedure  CLTEXT ( Close a text file opened by RDTEXT)
      ENTRY  CLTEXT ( FILE )
      CHARACTER*(*)       FILE
C     VARIABLE  I/O  DESCRIPTION
C     --------  ---  --------------------------------------------------
C     FILE       I   Text file to be closed.
```

CSPICE, rdtext.c:

```
/* $Procedure  CLTEXT ( Close a text file opened by RDTEXT) */
/* Subroutine */ int cltext_(char *file, ftnlen file_len)
```

Parameters
fname (str) – Text file to be closed.

Return type
None

spiceypy.spiceypy.**cmprss**(*delim*, *n*, *instr*, *lenout=256*)

Compress a character string by removing occurrences of more than N consecutive occurrences of a specified character.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cmprss_c.html

Parameters

- **delim** (str) – Delimiter to be compressed.
- **n** (int) – Maximum consecutive occurrences of delim.
- **instr** (str) – Input string.
- **lenout** (int) – Optional available space in output string.

Return type
str

Returns
Compressed string.

spiceypy.spiceypy.**cnmfrm**(*cname*, *lenout=256*)

Retrieve frame ID code and name to associate with an object.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cnmfrm_c.html

Parameters

- **cname** (str) – Name of the object to find a frame for.
- **lenout** (int) – Maximum length available for frame name.

Return type
Tuple[int, str, bool]

Returns
The ID code of the frame associated with cname, The name of the frame with ID frcode.

spiceypy.spiceypy.**conics**(*elts*, *et*)

Determine the state (position, velocity) of an orbiting body from a set of elliptic, hyperbolic, or parabolic orbital elements.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/conics_c.html

Parameters

- **elts** (ndarray) – Conic elements.
- **et** (float) – Input time.

Return type
ndarray

Returns
State of orbiting body at et.

spiceypy.spiceypy.**convrt**(*x*, *inunit*, *outunit*)

Take a measurement X, the units associated with X, and units to which X should be converted; return Y the value of the measurement in the output units.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/convrt_c.html

Parameters

- **x** (Union[float, Iterable[float]]) – Number representing a measurement in some units.
- **inunit** (str) – The units in which x is measured.
- **outunit** (str) – Desired units for the measurement.

Return type
Union[ndarray, float]

Returns
The measurment in the desired units.

spiceypy.spiceypy.**copy**(*cell*)

Copy the contents of a SpiceCell of any data type to another cell of the same type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/copy_c.html

Parameters
cell (*SpiceCell*) – Cell to be copied.

Return type
SpiceCell

Returns
New cell

spiceypy.spiceypy.**cpos**(*string*, *chars*, *start*)

Find the first occurrence in a string of a character belonging to a collection of characters, starting at a specified location, searching forward.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cpos_c.html

Parameters

- **string** (str) – Any character string.
- **chars** (str) – A collection of characters.
- **start** (int) – Position to begin looking for one of chars.

Return type
int

Returns
The index of the first character of str at or following index start that is in the collection chars.

spiceypy.spiceypy.**cposr**(*string*, *chars*, *start*)

Find the first occurrence in a string of a character belonging to a collection of characters, starting at a specified location, searching in reverse.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cposr_c.html

Parameters

- **string** (str) – Any character string.
- **chars** (str) – A collection of characters.
- **start** (int) – Position to begin looking for one of chars.

Return type
int

Returns
The index of the last character of str at or before index start that is in the collection chars.

spiceypy.spiceypy.**cvpool**(*agent*)

Indicate whether or not any watched kernel variables that have a specified agent on their notification list have been updated.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cvpool_c.html

Parameters
agent (str) – Name of the agent to check for notices.

Return type
bool

Returns
True if variables for "agent" have been updated.

spiceypy.spiceypy.**cyllat**(*r*, *lonc*, *z*)

Convert from cylindrical to latitudinal coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cyllat_c.html

Parameters

- **r** (float) – Distance of point from z axis.
- **lonc** (float) – Cylindrical angle of point from XZ plane(radians).

- **z** (float) – Height of point above XY plane.

Return type
Tuple[float, float, float]

Returns
Distance, Longitude (radians), and Latitude of point (radians).

spiceypy.spiceypy.**cylrec**(*r*, *lon*, *z*)

Convert from cylindrical to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cylrec_c.html

Parameters

- **r** (float) – Distance of a point from z axis.
- **lon** (float) – Angle (radians) of a point from xZ plane.
- **z** (float) – Height of a point above xY plane.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**cylsph**(*r*, *lonc*, *z*)

Convert from cylindrical to spherical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cylsph_c.html

Parameters

- **r** (float) – Rectangular coordinates of the point.
- **lonc** (float) – Angle (radians) of point from XZ plane.
- **z** (float) – Height of point above XY plane.

Return type
Tuple[float, float, float]

Returns
Distance of point from origin, Polar angle (co-latitude in radians) of point, Azimuthal angle (longitude) of point (radians).

spiceypy.spiceypy.**dafac**(*handle*, *buffer*)

Add comments from a buffer of character strings to the comment area of a binary DAF file, appending them to any comments which are already present in the file's comment area.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafac_c.html

Parameters

- **handle** (int) – handle of a DAF opened with write access.
- **buffer** (Sequence[str]) – Buffer of comments to put into the comment area.

Return type
None

spiceypy.spiceypy.**dafbbs**(*handle*)

Begin a backward search for arrays in a DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafbbs_c.html

Parameters
handle (int) – Handle of DAF to be searched.

Return type
None

spiceypy.spiceypy.**dafbfs**(*handle*)

Begin a forward search for arrays in a DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafbfs_c.html

Parameters
handle (int) – Handle of file to be searched.

Return type
None

spiceypy.spiceypy.**dafcls**(*handle*)

Close the DAF associated with a given handle.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafcls_c.html

Parameters
handle (int) – Handle of DAF to be closed.

Return type
None

spiceypy.spiceypy.**dafcs**(*handle*)

Select a DAF that already has a search in progress as the one to continue searching.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafcs_c.html

Parameters
handle (int) – Handle of DAF to continue searching.

Return type
None

spiceypy.spiceypy.**dafdc**(*handle*)

Delete the entire comment area of a specified DAF file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafdc_c.html

Parameters
handle (int) – The handle of a binary DAF opened for writing.

Return type
None

spiceypy.spiceypy.**dafec**(*handle*, *bufsiz*, *lenout=256*)

Extract comments from the comment area of a binary DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafec_c.html

Parameters

- **handle** (int) – Handle of binary DAF opened with read access.
- **bufsiz** (int) – Maximum size, in lines, of buffer.
- **lenout** (int) – Length of strings in output buffer.

Return type
Tuple[int, Iterable[str], bool]

Returns
Number of extracted comment lines, buffer where extracted comment lines are placed, Indicates whether all comments have been extracted.

spiceypy.spiceypy.**daffna**()

Find the next (forward) array in the current DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/daffna_c.html

Return type
bool

Returns
True if an array was found.

spiceypy.spiceypy.**daffpa**()

Find the previous (backward) array in the current DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/daffpa_c.html

Return type
bool

Returns
True if an array was found.

spiceypy.spiceypy.**dafgda**(*handle*, *begin*, *end*)

Read the double precision data bounded by two addresses within a DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafgda_c.html

Parameters
- **handle** (int) – Handle of a DAF.
- **begin** (int) – Initial address within file.
- **end** (int) – Final address within file.

Return type
ndarray

Returns
Data contained between begin and end.

spiceypy.spiceypy.**dafgh**()

Return (get) the handle of the DAF currently being searched.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafgh_c.html

Return type
int

Returns
Handle for current DAF.

spiceypy.spiceypy.**dafgn**(*lenout=256*)

Return (get) the name for the current array in the current DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafgn_c.html

Parameters
lenout (int) – Length of array name string.

Return type
str

Returns
Name of current array.

spiceypy.spiceypy.**dafgs**(*n=125*)

Return (get) the summary for the current array in the current DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafgs_c.html

Parameters
n (int) – Optional length N for result Array, defaults to 125.

Return type
ndarray

Returns
Summary for current array.

spiceypy.spiceypy.**dafgsr**(*handle*, *recno*, *begin*, *end*)

Read a portion of the contents of (words in) a summary record in a DAF file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafgsr_c.html

Parameters

- **handle** (int) – Handle of DAF.
- **recno** (int) – Record number; word indices are 1-based, 1 to 128 inclusive.
- **begin** (int) – Index of first word to read from record, will be clamped > 0.
- **end** (int) – Index of last word to read, wll be clamped < 129

Return type
Tuple[ndarray, bool]

Returns
Contents of request sub-record

spiceypy.spiceypy.**dafhsf**(*handle*)

Return the summary format associated with a handle.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafhsf_c.html

Parameters
handle (int) – Handle of a DAF file.

Return type
Tuple[int, int]

Returns
Number of double precision components in summariesNumber of integer components in summaries.

spiceypy.spiceypy.**dafopr**(*fname*)

Open a DAF for subsequent read requests.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafopr_c.html

Parameters
fname (str) – Name of DAF to be opened.

Return type
int

Returns
Handle assigned to DAF.

spiceypy.spiceypy.**dafopw**(*fname*)

Open a DAF for subsequent write requests.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafopw_c.html

Parameters
fname (str) – Name of DAF to be opened.

Return type
int

Returns
Handle assigned to DAF.

spiceypy.spiceypy.**dafps**(*nd*, *ni*, *dc*, *ic*)

Pack (assemble) an array summary from its double precision and integer components.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafps_c.html

Parameters

- **nd** (int) – Number of double precision components.
- **ni** (int) – Number of integer components.
- **dc** (ndarray) – Double precision components.
- **ic** (ndarray) – Integer components.

Return type
ndarray

Returns
Array summary.

spiceypy.spiceypy.**dafrda**(*handle*, *begin*, *end*)

Read the double precision data bounded by two addresses within a DAF.

Deprecated: This routine has been superseded by *dafgda()* and *dafgsr()*. This routine is supported for purposes of backward compatibility only.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafrda_c.html

Parameters

- **handle** (int) – Handle of a DAF.
- **begin** (int) – Initial address within file.
- **end** (int) – Final address within file.

Return type
ndarray

Returns
Data contained between begin and end.

spiceypy.spiceypy.**dafrfr**(*handle*, *lenout=256*)

Read the contents of the file record of a DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafrfr_c.html

Parameters

- **handle** (int) – Handle of an open DAF file.
- **lenout** (int) – Available room in the output string

Return type
Tuple[int, int, str, int, int, int]

Returns
Number of double precision components in summaries, Number of integer components in summaries, Internal file name, Forward list pointer, Backward list pointer, Free address pointer.

spiceypy.spiceypy.**dafrs**(*insum*)

Change the summary for the current array in the current DAF.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafrs_c.html

Parameters
insum (ndarray) – New summary for current array.

Return type
None

spiceypy.spiceypy.**dafus**(*insum*, *nd*, *ni*)

Unpack an array summary into its double precision and integer components.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dafus_c.html

Parameters

- **insum** (ndarray) – Array summary.
- **nd** (int) – Number of double precision components.
- **ni** (int) – Number of integer components.

Return type
Tuple[ndarray, ndarray]

Returns
Double precision components, Integer components.

spiceypy.spiceypy.**dasac**(*handle*, *buffer*)

Add comments from a buffer of character strings to the comment area of a binary DAS file, appending them to any comments which are already present in the file's comment area.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasac_c.html

Parameters

- **handle** (int) – DAS handle of a file opened with write access.
- **buffer** (Sequence[str]) – Buffer of lines to be put into the comment area.

Return type
None

spiceypy.spiceypy.**dasadc**(*handle*, *n*, *bpos*, *epos*, *datlen*, *data*)

Add character data to a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasadc_c.html

Parameters

- **handle** (int) – DAS file handle.
- **n** (int) – Number of characters to add to file.
- **bpos** (int) – Begin positions of substrings.
- **epos** (int) – End positions of substrings.
- **datlen** (int) – Common length of the character arrays in data.
- **data** (Sequence[str]) – Array providing the set of substrings to be added.

Return type
None

spiceypy.spiceypy.**dasadd**(*handle*, *n*, *data*)

Add an array of double precision numbers to a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasadd_c.html

Parameters

- **handle** (int) – DAS file handle.
- **n** (int) – Number of d p numbers to add to DAS file.
- **data** (ndarray) – Array of d p numbers to add.

Return type
None

spiceypy.spiceypy.**dasadi**(*handle*, *n*, *data*)

Add an array of integers to a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasadi_c.html

Parameters

- **handle** (int) – DAS file handle.
- **n** (int) – Number of integers to add to DAS file.
- **data** (ndarray) – Array of integers to add.

Return type
None

spiceypy.spiceypy.**dascls**(*handle*)

Close a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dascls_c.html

Parameters
handle (int) – Handle of an open DAS file.

Return type
None

spiceypy.spiceypy.**dasdc**(*handle*)

Delete the entire comment area of a previously opened binary DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasdc_c.html

Parameters
handle (int) – The handle of a binary DAS file opened for writing.

Return type
None

spiceypy.spiceypy.**dasec**(*handle*, *bufsiz=256*, *buflen=256*)

Extract comments from the comment area of a binary DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasec_c.html

Parameters

- **handle** (int) – Handle of binary DAS file open with read access.
- **bufsiz** (int) – Maximum size, in lines, of buffer.
- **buflen** (int) – Line length associated with buffer.

Return type
Tuple[int, Iterable[str], int]

Returns
Number of comments extracted from the DAS file, Buffer in which extracted comments are placed, Indicates whether all comments have been extracted.

spiceypy.spiceypy.**dashfn**(*handle*, *lenout=256*)

Return the name of the DAS file associated with a handle.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dashfn_c.html

Parameters

- **handle** (int) – Handle of a DAS file.
- **lenout** (int) – Length of output file name string.

Return type
str

Returns
Corresponding file name.

spiceypy.spiceypy.**dashfs**(*handle*)

Return a file summary for a specified DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dashfs_c.html

Parameters
handle (int) – Handle of a DAS file.

Return type
Tuple[int, int, int, int, int, ndarray, ndarray, ndarray]

Returns
Number of reserved records in file, Number of characters in use in reserved rec area, Number of comment records in file, Number of characters in use in comment area, Number of first free record, Array of last logical addresses for each data type, Record number of last descriptor of each data type, Word number of last descriptor of each data type.

spiceypy.spiceypy.**daslla**(*handle*)

Return last DAS logical addresses of character, double precision and integer type that are currently in use in a specified DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/daslla_c.html

Parameters
handle (int) – DAS file handle.

Return type
Tuple[int, int, int]

Returns
Last character address in use, Last double precision address in use, Last integer address in use.

spiceypy.spiceypy.**dasllc**(*handle*)

Close the DAS file associated with a given handle, without flushing buffered data or segregating the file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasllc_c.html

Parameters
handle (int) – Handle of a DAS file to be closed.

Return type
None

spiceypy.spiceypy.**dasonw**(*fname*, *ftype*, *ifname*, *ncomr*)

Open a new DAS file and set the file type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasonw_c.html

Parameters

- **fname** (str) – Name of a DAS file to be opened.
- **ftype** (str) – type
- **ifname** (str) – internal file name
- **ncomr** (int) – amount of comment area

Return type
int

Returns
Handle to new DAS file

spiceypy.spiceypy.**dasopr**(*fname*)

Open a DAS file for reading.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasopr_c.html

Parameters
fname (str) – Name of a DAS file to be opened.

Return type
int

Returns
Handle assigned to the opened DAS file.

spiceypy.spiceypy.**dasops**()

Open a scratch DAS file for writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasops_c.html

Return type
int

Returns
Handle assigned to a scratch DAS file.

spiceypy.spiceypy.**dasopw**(*fname*)

Open a DAS file for writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasopw_c.html :type fname: str :param fname: Name of a DAS file to be opened. :rtype: int :return: Handle assigned to the opened DAS file.

spiceypy.spiceypy.**dasrdd**(*handle*, *first*, *last*)

Read double precision data from a range of DAS logical addresses.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasrdd_c.html

Parameters

- **handle** (int) – DAS file handle.
- **first** (int) – start of range of DAS double precision.
- **last** (int) – end of range of DAS double precision.

Return type
ndarray

Returns
Data having addresses first through last.

spiceypy.spiceypy.**dasrdi**(*handle*, *first*, *last*)

Read integer data from a range of DAS logical addresses.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasrdi_c.html

Parameters

- **handle** (int) – DAS file handle.
- **first** (int) – start of range of DAS double precision.
- **last** (int) – end of range of DAS double precision.

Return type
ndarray

Returns
Data having addresses first through last.

spiceypy.spiceypy.**dasrfr**(*handle*, *lenout=256*)

Return the contents of the file record of a specified DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasrfr_c.html

Parameters

- **handle** (int) – DAS file handle.
- **lenout** (int) – length of output strs

Return type
Tuple[str, str, int, int, int, int]

Returns
ID word, DAS internal file name, Number of reserved records in file, Number of characters in use in reserved rec. area, Number of comment records in file, Number of characters in use in comment area.

spiceypy.spiceypy.**dasudd**(*handle*, *first*, *last*, *data*)

Update data in a specified range of double precision addresses in a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasudd_c.html

Parameters
- **handle** (int) – DAS file handle.
- **first** (int) – first address
- **last** (int) – Range of d p addresses to write to.
- **data** (ndarray) – An array of d p numbers.

Return type
None

spiceypy.spiceypy.**dasudi**(*handle*, *first*, *last*, *data*)

Update data in a specified range of integer addresses in a DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dasudi_c.html

Parameters
- **handle** (int) – DAS file handle.
- **first** (int) – first integer addresses to write to.
- **last** (int) – last integer addresses to write to.
- **data** (ndarray) – An array of integers.

Return type
None

spiceypy.spiceypy.**daswbr**(*handle*)

Write out all buffered records of a specified DAS file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/daswbr_c.html

Parameters
handle (int) – Handle of DAS file.

Return type
None

spiceypy.spiceypy.**datetime2et**(*dt*)

Converts a standard Python datetime to a double precision value representing the number of TDB seconds past the J2000 epoch corresponding to the input epoch.

Timezone-naive datetimes will be assumed to be UTC, timezone-aware datetimes will be handled correctly by converting to UTC before passing them to CSPICE.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/time.html#The%20J2000%20Epoch

Parameters
dt (Union[Iterable[datetime], datetime]) – A standard Python datetime

Return type
Union[ndarray, float]

Returns
The equivalent value in seconds past J2000, TDB.

spiceypy.spiceypy.**dazldr**(*x*, *y*, *z*, *azccw*, *elplsz*)

Compute the Jacobian matrix of the transformation from rectangular to azimuth/elevation coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dazldr_c.html

Parameters

- **x** (float) – x coordinate of point.
- **y** (float) – y coordinate of point.
- **z** (float) – z coordinate of point.
- **azccw** (bool) – Flag indicating how azimuth is measured.
- **elplsz** (bool) – Flag indicating how elevation is measured.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**dcyldr**(*x*, *y*, *z*)

This routine computes the Jacobian of the transformation from rectangular to cylindrical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dcyldr_c.html

Parameters

- **x** (float) – X-coordinate of point.
- **y** (float) – Y-coordinate of point.
- **z** (float) – Z-coordinate of point.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**deltet**(*epoch*, *eptype*)

Return the value of Delta ET (ET-UTC) for an input epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/deltet_c.html

Parameters

- **epoch** (float) – Input epoch (seconds past J2000).
- **eptype** (str) – Type of input epoch (“UTC” or “ET”).

Return type
float

Returns
Delta ET (ET-UTC) at input epoch.

spiceypy.spiceypy.**det**(*m1*)

Compute the determinant of a double precision 3x3 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/det_c.html

Parameters
m1 (ndarray) – Matrix whose determinant is to be found.

Return type
float

Returns
The determinant of the matrix.

spiceypy.spiceypy.**dgeodr**(*x*, *y*, *z*, *re*, *f*)

This routine computes the Jacobian of the transformation from rectangular to geodetic coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dgeodr_c.html

Parameters
- **x** (float) – X-coordinate of point.
- **y** (float) – Y-coordinate of point.
- **z** (float) – Z-coord
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**diags2**(*symmat*)

Diagonalize a symmetric 2x2 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/diags2_c.html

Parameters
symmat (Union[ndarray, Iterable[Iterable[float]]]) – A symmetric 2x2 matrix.

Return type
Tuple[ndarray, ndarray]

Returns
A diagonal matrix similar to symmat, A rotation used as the similarity transformation.

spiceypy.spiceypy.**diff**(*a*, *b*)

Take the difference of two sets of any data type to form a third set. https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/diff_c.html

Parameters
- **a** (*SpiceCell*) – First input set.
- **b** (*SpiceCell*) – Second input set.

Return type
SpiceCell

Returns
Difference of a and b.

spiceypy.spiceypy.**dlabbs**(*handle*)

Begin a backward segment search in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlabbs_c.html

Parameters
handle (int) – Handle of open DLA file.

Return type
Tuple[*SpiceDLADescr*, bool]

Returns
Descriptor of last segment in DLA file

spiceypy.spiceypy.**dlabfs**(*handle*)

Begin a forward segment search in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlabfs_c.html

Parameters
handle (int) – Handle of open DLA file.

Return type
Tuple[*SpiceDLADescr*, bool]

Returns
Descriptor of next segment in DLA file

spiceypy.spiceypy.**dlabns**(*handle*)

Begin a new segment in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlabns_c.html

Parameters
handle (int) – Handle of open DLA file.

Return type
None

spiceypy.spiceypy.**dlaens**(*handle*)

End a new segment in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlaens_c.html

Parameters
handle (int) – Handle of open DLA file.

Return type
None

spiceypy.spiceypy.**dlafns**(*handle*, *descr*)

Find the segment following a specified segment in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlafns_c.html

Parameters

- **handle** (int) – Handle of open DLA file.
- **descr** (*SpiceDLADescr*) – Descriptor of a DLA segment.

Return type
Tuple[*SpiceDLADescr*, bool]

Returns
Descriptor of next segment in DLA file

spiceypy.spiceypy.**dlafps**(*handle*, *descr*)

Find the segment preceding a specified segment in a DLA file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlafps_c.html

Parameters

- **handle** (int) – Handle of open DLA file.
- **descr** (*SpiceDLADescr*) – Descriptor of a segment in DLA file.

Return type
Tuple[*SpiceDLADescr*, bool]

Returns
Descriptor of previous segment in DLA file

spiceypy.spiceypy.**dlaopn**(*fname*, *ftype*, *ifname*, *ncomch*)

Open a new DLA file and set the file type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlaopn_c.html

Parameters

- **fname** (str) – Name of a DLA file to be opened.
- **ftype** (str) – Mnemonic code for type of data in the DLA file.
- **ifname** (str) – Internal file name.
- **ncomch** (int) – Number of comment characters to allocate.

Return type
int

Returns
Handle assigned to the opened DLA file.

spiceypy.spiceypy.**dlatdr**(*x*, *y*, *z*)

This routine computes the Jacobian of the transformation from rectangular to latitudinal coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dlatdr_c.html

Parameters

- **x** (float) – X-coordinate of point.
- **y** (float) – Y-coordinate of point.
- **z** (float) – Z-coord

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**dnearp**(*state*, *a*, *b*, *c*)

Compute the state (position and velocity) of an ellipsoid surface point nearest to the position component of a specified state.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dnearp_c.html

Parameters

- **state** (ndarray) – State of an object in body fixed coordinates.

- **a** (float) – Length of semi axis parallel to X axis.
- **b** (float) – Length of semi axis parallel to Y axis.
- **c** (float) – Length on semi axis parallel to Z axis.

Return type
Tuple[ndarray, ndarray, bool]

Returns
State of the nearest point on the ellipsoid, Altitude and derivative of altitude

spiceypy.spiceypy.**dp2hx**(*number*, *lenout=256*)

Convert a double precision number to an equivalent character string using base 16 "scientific notation."

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dp2hx_c.html

Parameters

- **number** (float) – D.p. number to be converted.
- **lenout** (int) – Available space for output string.

Return type
str

Returns
Equivalent character string, left justified.

spiceypy.spiceypy.**dpgrdr**(*body*, *x*, *y*, *z*, *re*, *f*)

This routine computes the Jacobian matrix of the transformation from rectangular to planetographic coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dpgrdr_c.html

Parameters

- **body** (str) – Body with which coordinate system is associated.
- **x** (float) – X-coordinate of point.
- **y** (float) – Y-coordinate of point.
- **z** (int) – Z-coordinate of point.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**dpmax**()

Return the value of the largest (positive) number representable in a double precision variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dpmax_c.html

Return type
float

Returns
The largest (positive) number representable in a double precision variable.

spiceypy.spiceypy.**dpmin**()

Return the value of the smallest (negative) number representable in a double precision variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dpmin_c.html

Return type
float

Returns
The smallest (negative) number that can be represented in a double precision variable.

spiceypy.spiceypy.**dpr**()

Return the number of degrees per radian.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dpr_c.html

Return type
float

Returns
The number of degrees per radian.

spiceypy.spiceypy.**drdazl**(*range*, *az*, *el*, *azccw*, *elplsz*)

Compute the Jacobian matrix of the transformation from azimuth/elevation to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdazl_c.html

Parameters

- **range** (float) – Distance of a point from the origin.
- **az** (float) – Azimuth of input point in radians.
- **el** (float) – Elevation of input point in radians.
- **azccw** (bool) – Flag indicating how azimuth is measured.
- **elplsz** (bool) – Flag indicating how elevation is measured.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**drdcyl**(*r*, *lon*, *z*)

This routine computes the Jacobian of the transformation from cylindrical to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdcyl_c.html

Parameters

- **r** (float) – Distance of a point from the origin.
- **lon** (float) – Angle of the point from the xz plane in radians.
- **z** (float) – Height of the point above the xy plane.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**drdgeo**(*lon*, *lat*, *alt*, *re*, *f*)

This routine computes the Jacobian of the transformation from geodetic to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdgeo_c.html

Parameters

- **lon** (float) – Geodetic longitude of point (radians).
- **lat** (float) – Geodetic latitude of point (radians).
- **alt** (float) – Altitude of point above the reference spheroid.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**drdlat**(*r*, *lon*, *lat*)

Compute the Jacobian of the transformation from latitudinal to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdlat_c.html

Parameters

- **r** (float) – Distance of a point from the origin.
- **lon** (float) – Angle of the point from the XZ plane in radians.
- **lat** (float) – Angle of the point from the XY plane in radians.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**drdpgr**(*body*, *lon*, *lat*, *alt*, *re*, *f*)

This routine computes the Jacobian matrix of the transformation from planetographic to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdpgr_c.html

Parameters

- **body** (str) – Body with which coordinate system is associated.
- **lon** (float) – Planetographic longitude of a point (radians).
- **lat** (float) – Planetographic latitude of a point (radians).
- **alt** (int) – Altitude of a point above reference spheroid.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**drdsph**(*r*, *colat*, *lon*)

This routine computes the Jacobian of the transformation from spherical to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/drdsph_c.html

Parameters

- **r** (float) – Distance of a point from the origin.
- **colat** (float) – Angle of the point from the positive z-axis.
- **lon** (float) – Angle of the point from the xy plane.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**dskb02**(*handle*, *dladsc*)

Return bookkeeping data from a DSK type 2 segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskb02_c.html

Parameters

- **handle** (int) – DSK file handle
- **dladsc** (*SpiceDLADescr*) – DLA descriptor

Return type
Tuple[int, int, int, ndarray, float, ndarray, ndarray, int, int, int, int]

Returns
bookkeeping data from a DSK type 2 segment

spiceypy.spiceypy.**dskcls**(*handle*, *optmiz=False*)

Close a DSK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskcls_c.html

Parameters

- **handle** (int) – Handle assigned to the opened DSK file.
- **optmiz** (bool) – Flag indicating whether to segregate the DSK.

Return type
None

Returns

spiceypy.spiceypy.**dskd02**(*handle*, *dladsc*, *item*, *start*, *room*)

Fetch double precision data from a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskd02_c.html

Parameters

- **handle** (int) – DSK file handle
- **dladsc** (*SpiceDLADescr*) – DLA descriptor
- **item** (int) – Keyword identifying item to fetch
- **start** (int) – Start index

- **room** (int) – Amount of room in output array

Return type
ndarray

Returns
Array containing requested item

spiceypy.spiceypy.**dskgd**(*handle*, *dladsc*)

Return the DSK descriptor from a DSK segment identified by a DAS handle and DLA descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskgd_c.html

Parameters

- **handle** (int) – Handle assigned to the opened DSK file.
- **dladsc** (*SpiceDLADescr*) – DLA segment descriptor.

Return type
SpiceDSKDescr

Returns
DSK segment descriptor.

spiceypy.spiceypy.**dskgtl**(*keywrd*)

Retrieve the value of a specified DSK tolerance or margin parameter.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskgtl_c.html

Parameters
keywrd (int) – Code specifying parameter to retrieve.

Return type
float

Returns
Value of parameter.

spiceypy.spiceypy.**dski02**(*handle*, *dladsc*, *item*, *start*, *room*)

Fetch integer data from a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dski02_c.html

Parameters

- **handle** (int) – DSK file handle.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor.
- **item** (int) – Keyword identifying item to fetch.
- **start** (int) – Start index.
- **room** (int) – Amount of room in output array.

Return type
ndarray

Returns
Array containing requested item.

spiceypy.spiceypy.**dskmi2**(*vrtces*, *plates*, *finscl*, *corscl*, *worksz*, *voxpsz*, *voxlsz*, *makvtl*, *spxisz*)

Make spatial index for a DSK type 2 segment. The index is returned as a pair of arrays, one of type int and one of type float. These arrays are suitable for use with the DSK type 2 writer dskw02.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskmi2_c.html

Parameters

- **vrtces** (ndarray) – Vertices
- **plates** (ndarray) – Plates
- **finscl** (float) – Fine voxel scale
- **corscl** (int) – Coarse voxel scale
- **worksz** (int) – Workspace size
- **voxpsz** (int) – Voxel plate pointer array size
- **voxlsz** (int) – Voxel plate list array size
- **makvtl** (bool) – Vertex plate list flag
- **spxisz** (int) – Spatial index integer component size

Return type
Tuple[ndarray, ndarray]

Returns
double precision and integer components of the spatial index of the segment.

spiceypy.spiceypy.**dskn02**(*handle*, *dladsc*, *plid*)

Compute the unit normal vector for a specified plate from a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskn02_c.html

Parameters

- **handle** (int) – DSK file handle.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor.
- **plid** (int) – Plate ID.

Return type
ndarray

Returns
late's unit normal vector.

spiceypy.spiceypy.**dskobj**(*dsk*)

Find the set of body ID codes of all objects for which topographic data are provided in a specified DSK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskobj_c.html

Parameters
dsk (str) – Name of DSK file.

Return type
SpiceCell

Returns
Set of ID codes of objects in DSK file.

spiceypy.spiceypy.**dskopn**(*fname*, *ifname*, *ncomch*)

Open a new DSK file for subsequent write operations.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskopn_c.html

Parameters

- **fname** (str) – Name of a DSK file to be opened.
- **ifname** (str) – Internal file name.
- **ncomch** (int) – Number of comment characters to allocate.

Return type
int

Returns
Handle assigned to the opened DSK file.

spiceypy.spiceypy.**dskp02**(*handle*, *dladsc*, *start*, *room*)

Fetch triangular plates from a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskp02_c.html

Parameters

- **handle** (int) – DSK file handle.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor.
- **start** (int) – Start index.
- **room** (int) – Amount of room in output array.

Return type
ndarray

Returns
Array containing plates.

spiceypy.spiceypy.**dskrb2**(*vrtces*, *plates*, *corsys*, *corpar*)

Determine range bounds for a set of triangular plates to be stored in a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskrb2_c.html

Parameters

- **vrtces** (ndarray) – Vertices
- **plates** (ndarray) – Plates
- **corsys** (int) – DSK coordinate system code
- **corpar** (ndarray) – DSK coordinate system parameters

Return type
Tuple[float, float]

Returns
Lower and Upper bound on range of third coordinate

spiceypy.spiceypy.**dsksrf**(*dsk*, *bodyid*)

Find the set of surface ID codes for all surfaces associated with a given body in a specified DSK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dsksrf_c.html

Parameters

- **dsk** (str) – Name of DSK file.
- **bodyid** (int) – Integer body ID code.

Return type
SpiceCell

Returns
Set of ID codes of surfaces in DSK file.

spiceypy.spiceypy.**dskstl**(*keywrd*, *dpval*)

Set the value of a specified DSK tolerance or margin parameter.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskstl_c.html

Parameters

- **keywrd** (int) – Code specifying parameter to set.
- **dpval** (float) – Value of parameter.

Return type
None

Returns

spiceypy.spiceypy.**dskv02**(*handle*, *dladsc*, *start*, *room*)

Fetch vertices from a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskv02_c.html

Parameters

- **handle** (int) – DSK file handle.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor.
- **start** (int) – Start index.
- **room** (int) – Amount of room in output array.

Return type
ndarray

Returns
Array containing vertices.

spiceypy.spiceypy.**dskw02**(*handle*, *center*, *surfid*, *dclass*, *fname*, *corsys*, *corpar*, *mncor1*, *mxcor1*, *mncor2*, *mxcor2*, *mncor3*, *mxcor3*, *first*, *last*, *vrtces*, *plates*, *spaixd*, *spaixi*)

Write a type 2 segment to a DSK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskw02_c.html

Parameters

- **handle** (int) – Handle assigned to the opened DSK file
- **center** (int) – Central body ID code
- **surfid** (int) – Surface ID code
- **dclass** (int) – Data class
- **fname** (str) – Reference frame
- **corsys** (int) – Coordinate system code
- **corpar** (ndarray) – Coordinate system parameters

- **mncor1** (float) – Minimum value of first coordinate
- **mxcor1** (float) – Maximum value of first coordinate
- **mncor2** (float) – Minimum value of second coordinate
- **mxcor2** (float) – Maximum value of second coordinate
- **mncor3** (float) – Minimum value of third coordinate
- **mxcor3** (float) – Maximum value of third coordinate
- **first** (float) – Coverage start time
- **last** (float) – Coverage stop time
- **vrtces** (ndarray) – Vertices
- **plates** (ndarray) – Plates
- **spaixd** (ndarray) – Double precision component of spatial index
- **spaixi** (ndarray) – Integer component of spatial index

Return type
None

spiceypy.spiceypy.**dskx02**(*handle*, *dladsc*, *vertex*, *raydir*)

Determine the plate ID and body-fixed coordinates of the intersection of a specified ray with the surface defined by a type 2 DSK plate model.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskx02_c.html

Parameters

- **handle** (int) – Handle of DSK kernel containing plate model.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor of plate model segment.
- **vertex** (ndarray) – Ray's vertex in the body fixed frame.
- **raydir** (ndarray) – Ray direction in the body fixed frame.

Return type
Tuple[int, ndarray, bool]

Returns
ID code of the plate intersected by the ray, Intercept, and Flag indicating whether intercept exists.

spiceypy.spiceypy.**dskxsi**(*pri*, *target*, *srflst*, *et*, *fixref*, *vertex*, *raydir*)

Compute a ray-surface intercept using data provided by multiple loaded DSK segments. Return information about the source of the data defining the surface on which the intercept was found: DSK handle, DLA and DSK descriptors, and DSK data type-dependent parameters.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskxsi_c.html

Parameters

- **pri** (bool) – Data prioritization flag.
- **target** (str) – Target body name.
- **srflst** (Sequence[int]) – Surface ID list.
- **et** (float) – Epoch, expressed as seconds past J2000 TDB.
- **fixref** (str) – Name of target body-fixed reference frame.

- **vertex** (ndarray) – Vertex of ray.
- **raydir** (ndarray) – Direction vector of ray.

Return type
Tuple[ndarray, int, *SpiceDLADescr*, *SpiceDSKDescr*, ndarray, ndarray, bool]

Returns
Intercept point, Handle of segment contributing surface data, DLADSC, DSKDSC, Double precision component of source info, Integer component of source info

spiceypy.spiceypy.**dskxv**(*pri*, *target*, *srflst*, *et*, *fixref*, *vtxarr*, *dirarr*)

Compute ray-surface intercepts for a set of rays, using data provided by multiple loaded DSK segments.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskxv_c.html

Parameters

- **pri** (bool) – Data prioritization flag.
- **target** (str) – Target body name.
- **srflst** (Sequence[int]) – Surface ID list.
- **et** (float) – Epoch, expressed as seconds past J2000 TDB.
- **fixref** (str) – Name of target body-fixed reference frame.
- **vtxarr** (Sequence[ndarray]) – Array of vertices of rays.
- **dirarr** (Sequence[ndarray]) – Array of direction vectors of rays.

Return type
Tuple[ndarray, ndarray]

Returns
Intercept point array and Found flag array.

spiceypy.spiceypy.**dskz02**(*handle*, *dladsc*)

Return plate model size parameters—plate count and vertex count—for a type 2 DSK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dskz02_c.html

Parameters

- **handle** (int) – DSK file handle.
- **dladsc** (*SpiceDLADescr*) – DLA descriptor.

Return type
Tuple[int, int]

Returns
Number of vertices, Number of plates.

spiceypy.spiceypy.**dsphdr**(*x*, *y*, *z*)

This routine computes the Jacobian of the transformation from rectangular to spherical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dsphdr_c.html

Parameters

- **x** (float) – X-coordinate of point.
- **y** (float) – Y-coordinate of point.
- **z** (float) – Z-coordinate of point.

Return type
ndarray

Returns
Matrix of partial derivatives.

spiceypy.spiceypy.**dtpool**(*name*)

Return the data about a kernel pool variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dtpool_c.html

Parameters
name (str) – Name of the variable whose value is to be returned.

Return type
Tuple[int, str, bool]

Returns
Number of values returned for name, Type of the variable "C", "N", or "X".

spiceypy.spiceypy.**ducrss**(*s1*, *s2*)

Compute the unit vector parallel to the cross product of two 3-dimensional vectors and the derivative of this unit vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ducrss_c.html

Parameters

- **s1** (ndarray) – Left hand state for cross product and derivative.
- **s2** (ndarray) – Right hand state for cross product and derivative.

Return type
ndarray

Returns
Unit vector and derivative of the cross product.

spiceypy.spiceypy.**dvcrss**(*s1*, *s2*)

Compute the cross product of two 3-dimensional vectors and the derivative of this cross product.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvcrss_c.html

Parameters

- **s1** (ndarray) – Left hand state for cross product and derivative.
- **s2** (ndarray) – Right hand state for cross product and derivative.

Return type
ndarray

Returns
State associated with cross product of positions.

spiceypy.spiceypy.**dvdot**(*s1*, *s2*)

Compute the derivative of the dot product of two double precision position vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvdot_c.html

Parameters

- **s1** (Sequence[float]) – First state vector in the dot product.
- **s2** (Sequence[float]) – Second state vector in the dot product.

Return type
`float`

Returns
The derivative of the dot product.

`spiceypy.spiceypy.dvhat(s1)`

Find the unit vector corresponding to a state vector and the derivative of the unit vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvhat_c.html

Parameters
s1 (ndarray) – State to be normalized.

Return type
`ndarray`

Returns
Unit vector s1 / abs(s1), and its time derivative.

`spiceypy.spiceypy.dvnorm(state)`

Function to calculate the derivative of the norm of a 3-vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvnorm_c.html

Parameters
state (ndarray) – A 6-vector composed of three coordinates and their derivatives.

Return type
`float`

Returns
The derivative of the norm of a 3-vector.

`spiceypy.spiceypy.dvpool(name)`

Delete a variable from the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvpool_c.html

Parameters
name (str) – Name of the kernel variable to be deleted.

Return type
`None`

`spiceypy.spiceypy.dvsep(s1, s2)`

Calculate the time derivative of the separation angle between two input states, S1 and S2.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/dvsep_c.html

Parameters

- **s1** (ndarray) – State vector of the first body.
- **s2** (ndarray) – State vector of the second body.

Return type
`float`

Returns
The time derivative of the angular separation between S1 and S2.

spiceypy.spiceypy.**edlimb**(*a*, *b*, *c*, *viewpt*)

Find the limb of a triaxial ellipsoid, viewed from a specified point.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/edlimb_c.html

Parameters

- **a** (float) – Length of ellipsoid semi-axis lying on the x-axis.
- **b** (float) – Length of ellipsoid semi-axis lying on the y-axis.
- **c** (float) – Length of ellipsoid semi-axis lying on the z-axis.
- **viewpt** (Iterable[float]) – Location of viewing point.

Return type
Ellipse

Returns
Limb of ellipsoid as seen from viewing point.

spiceypy.spiceypy.**ednmpt**(*a*, *b*, *c*, *normal*)

Return the unique point on an ellipsoid's surface where the outward normal direction is a given vector.

Parameters

- **a** (float) – Length of the ellipsoid semi-axis along the X-axis.
- **b** (float) – Length of the ellipsoid semi-axis along the Y-axis.
- **c** (float) – Length of the ellipsoid semi-axis along the Z-axis.
- **normal** (ndarray) – Outward normal direction.

Return type
ndarray

Returns
Point where outward normal is parallel to `normal'.

spiceypy.spiceypy.**edpnt**(*p*, *a*, *b*, *c*)

Scale a point so that it lies on the surface of a specified triaxial ellipsoid that is centered at the origin and aligned with the Cartesian coordinate axes.

Parameters

- **p** (ndarray) – A point in three-dimensional space.
- **a** (float) – Semi-axis length in the X direction.
- **b** (float) – Semi-axis length in the Y direction.
- **c** (float) – Semi-axis length in the Z direction.

Return type
ndarray

Returns
Point on ellipsoid.

spiceypy.spiceypy.**edterm**(*trmtyp*, *source*, *target*, *et*, *fixref*, *abcorr*, *obsrvr*, *npts*)

Compute a set of points on the umbral or penumbral terminator of a specified target body, where the target shape is modeled as an ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/edterm_c.html

Parameters

- **trmtyp** (str) – Terminator type.
- **source** (str) – Light source.
- **target** (str) – Target body.
- **et** (float) – Observation epoch.
- **fixref** (str) – Body-fixed frame associated with target.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Observer.
- **npts** (int) – Number of points in terminator set.

Return type
Tuple[float, ndarray, ndarray]

Returns
Epoch associated with target center, Position of observer in body-fixed frame, Terminator point set.

spiceypy.spiceypy.**ekacec**(*handle*, *segno*, *recno*, *column*, *nvals*, *cvals*, *isnull*)

Add data to a character column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekacec_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be added.
- **column** (str) – Column name.
- **nvals** (int) – Number of values to add to column.
- **cvals** (Iterable[str]) – Character values to add to column.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekaced**(*handle*, *segno*, *recno*, *column*, *nvals*, *dvals*, *isnull*)

Add data to an double precision column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekaced_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be added.
- **column** (str) – Column name.
- **nvals** (int) – Number of values to add to column.
- **dvals** (Union[ndarray, Iterable[float]]) – Double precision values to add to column.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekacei**(*handle*, *segno*, *recno*, *column*, *nvals*, *ivals*, *isnull*)

Add data to an integer column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekacei_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be added.
- **column** (str) – Column name.
- **nvals** (int) – Number of values to add to column.
- **ivals** (Union[ndarray, Iterable[int]]) – Integer values to add to column.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekaclc**(*handle*, *segno*, *column*, *vallen*, *cvals*, *entszs*, *nlflgs*, *rcptrs*, *wkindx*)

Add an entire character column to an EK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekaclc_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Number of segment to add column to.
- **column** (str) – Column name.
- **vallen** (int) – Length of character values.
- **cvals** (Iterable[str]) – Character values to add to column.
- **entszs** (Union[ndarray, Iterable[int]]) – Array of sizes of column entries.
- **nlflgs** (Iterable[bool]) – Array of null flags for column entries.
- **rcptrs** (ndarray) – Record pointers for segment.
- **wkindx** (Union[ndarray, Iterable[int]]) – Work space for column index.

Return type
ndarray

Returns
Work space for column index.

spiceypy.spiceypy.**ekacld**(*handle*, *segno*, *column*, *dvals*, *entszs*, *nlflgs*, *rcptrs*, *wkindx*)

Add an entire double precision column to an EK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekacld_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Number of segment to add column to.

- **column** (str) – Column name.
- **dvals** (Union[ndarray, Iterable[float]]) – Double precision values to add to column.
- **entszs** (Union[ndarray, Iterable[int]]) – Array of sizes of column entries.
- **nlflgs** (Iterable[bool]) – Array of null flags for column entries.
- **rcptrs** (ndarray) – Record pointers for segment.
- **wkindx** (Union[ndarray, Iterable[int]]) – Work space for column index.

Return type
ndarray

Returns
Work space for column index.

spiceypy.spiceypy.**ekacli**(*handle*, *segno*, *column*, *ivals*, *entszs*, *nlflgs*, *rcptrs*, *wkindx*)

Add an entire integer column to an EK segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekacli_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Number of segment to add column to.
- **column** (str) – Column name.
- **ivals** (Union[ndarray, Iterable[int]]) – Integer values to add to column.
- **entszs** (Union[ndarray, Iterable[int]]) – Array of sizes of column entries.
- **nlflgs** (Iterable[bool]) – Array of null flags for column entries.
- **rcptrs** (ndarray) – Record pointers for segment.
- **wkindx** (Union[ndarray, Iterable[int]]) – Work space for column index.

Return type
ndarray

Returns
Work space for column index.

spiceypy.spiceypy.**ekappr**(*handle*, *segno*)

Append a new, empty record at the end of a specified E-kernel segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekappr_c.html

Parameters

- **handle** (int) – File handle.
- **segno** (int) – Segment number.

Return type
int

Returns
Number of appended record.

spiceypy.spiceypy.**ekbseg**(*handle*, *tabnam*, *cnames*, *decls*)

Start a new segment in an E-kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekbseg_c.html

Parameters

- **handle** (int) – File handle.
- **tabnam** (str) – Table name.
- **cnames** (Sequence[str]) – Names of columns.
- **decls** (Sequence[str]) – Declarations of columns.

Return type
int

Returns
Segment number.

spiceypy.spiceypy.**ekccnt**(*table*)

Return the number of distinct columns in a specified, currently loaded table.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekccnt_c.html

Parameters
table (str) – Name of table.

Return type
int

Returns
Count of distinct, currently loaded columns.

spiceypy.spiceypy.**ekcii**(*table*, *cindex*, *lenout=256*)

Return attribute information about a column belonging to a loaded EK table, specifying the column by table and index.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekcii_c.html

Parameters

- **table** (str) – Name of table containing column.
- **cindex** (int) – Index of column whose attributes are to be found.
- **lenout** (int) – Maximum allowed length of column name.

Return type
Tuple[str, *SpiceEKAttDsc*]

Returns
Name of column, Column attribute descriptor.

spiceypy.spiceypy.**ekcls**(*handle*)

Close an E-kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekcls_c.html

Parameters
handle (int) – EK file handle.

Return type
None

spiceypy.spiceypy.**ekdelr**(*handle*, *segno*, *recno*)

Delete a specified record from a specified E-kernel segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekdelr_c.html

Parameters

- **handle** (int) – File handle.
- **segno** (int) – Segment number.
- **recno** (int) – Record number.

Return type
None

spiceypy.spiceypy.**ekffld**(*handle*, *segno*, *rcptrs*)

Complete a fast write operation on a new E-kernel segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekffld_c.html

Parameters

- **handle** (int) – File handle.
- **segno** (int) – Segment number.
- **rcptrs** (ndarray) – Record pointers.

Return type
None

spiceypy.spiceypy.**ekfind**(*query*, *lenout=256*)

Find E-kernel data that satisfy a set of constraints.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekfind_c.html

Parameters

- **query** (str) – Query specifying data to be found.
- **lenout** (int) – Declared length of output error message string.

Return type
Tuple[int, int, str]

Returns
Number of matching rows, Flag indicating whether query parsed correctly, Parse error description.

spiceypy.spiceypy.**ekgc**(*selidx*, *row*, *element*, *lenout=256*)

Return an element of an entry in a column of character type in a specified row.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekgc_c.html

Parameters

- **selidx** (int) – Index of parent column in SELECT clause.
- **row** (int) – Row to fetch from.
- **element** (int) – Index of element, within column entry, to fetch.
- **lenout** (int) – Maximum length of column element.

Return type
Tuple[str, int, bool]

Returns
Character string element of column entry, Flag indicating whether column entry was null.

spiceypy.spiceypy.**ekgd**(*selidx*, *row*, *element*)

Return an element of an entry in a column of double precision type in a specified row.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekgd_c.html

Parameters

- **selidx** (int) – Index of parent column in SELECT clause.
- **row** (int) – Row to fetch from.
- **element** (int) – Index of element, within column entry, to fetch.

Return type
Tuple[float, int, bool]

Returns
Double precision element of column entry, Flag indicating whether column entry was null.

spiceypy.spiceypy.**ekgi**(*selidx*, *row*, *element*)

Return an element of an entry in a column of integer type in a specified row.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekgi_c.html

Parameters

- **selidx** (int) – Index of parent column in SELECT clause.
- **row** (int) – Row to fetch from.
- **element** (int) – Index of element, within column entry, to fetch.

Return type
Tuple[int, int, bool]

Returns
Integer element of column entry, Flag indicating whether column entry was null.

spiceypy.spiceypy.**ekifld**(*handle*, *tabnam*, *ncols*, *nrows*, *cnmlen*, *cnames*, *declen*, *decls*)

Initialize a new E-kernel segment to allow fast writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekifld_c.html

Parameters

- **handle** (int) – File handle.
- **tabnam** (str) – Table name.
- **ncols** (int) – Number of columns in the segment.
- **nrows** (int) – Number of rows in the segment.
- **cnmlen** (int) – Length of names in in column name array.
- **cnames** (Iterable[str]) – Names of columns.
- **declen** (int) – Length of declaration strings in declaration array.
- **decls** (Iterable[str]) – Declarations of columns.

Return type
Tuple[int, ndarray]

Returns
Segment number, Array of record pointers.

spiceypy.spiceypy.**ekinsr**(*handle*, *segno*, *recno*)

Add a new, empty record to a specified E-kernel segment at a specified index.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekinsr_c.html

Parameters

- **handle** (int) – File handle.
- **segno** (int) – Segment number.
- **recno** (int) – Record number.

Return type
None

spiceypy.spiceypy.**eklef**(*fname*)

Load an EK file, making it accessible to the EK readers.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eklef_c.html

Parameters
fname (str) – Name of EK file to load.

Return type
int

Returns
File handle of loaded EK file.

spiceypy.spiceypy.**eknelt**(*selidx*, *row*)

Return the number of elements in a specified column entry in the current row.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eknelt_c.html

Parameters

- **selidx** (int) – Index of parent column in SELECT clause.
- **row** (int) – Row containing element.

Return type
int

Returns
The number of elements in entry in current row.

spiceypy.spiceypy.**eknseg**(*handle*)

Return the number of segments in a specified EK.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eknseg_c.html

Parameters
handle (int) – EK file handle.

Return type
int

Returns
The number of segments in the specified E-kernel.

spiceypy.spiceypy.**ekntab**()

Return the number of loaded EK tables.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekntab_c.html

Return type
int

Returns
The number of loaded EK tables.

spiceypy.spiceypy.**ekopn**(*fname*, *ifname*, *ncomch*)

Open a new E-kernel file and prepare the file for writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekopn_c.html

Parameters

- **fname** (str) – Name of EK file.
- **ifname** (str) – Internal file name.
- **ncomch** (int) – The number of characters to reserve for comments.

Return type
int

Returns
Handle attached to new EK file.

spiceypy.spiceypy.**ekopr**(*fname*)

Open an existing E-kernel file for reading.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekopr_c.html

Parameters
fname (str) – Name of EK file.

Return type
int

Returns
Handle attached to EK file.

spiceypy.spiceypy.**ekops**()

Open a scratch (temporary) E-kernel file and prepare the file for writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekops_c.html

Return type
int

Returns
Handle attached to new EK file.

spiceypy.spiceypy.**ekopw**(*fname*)

Open an existing E-kernel file for writing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekopw_c.html

Parameters
fname (str) – Name of EK file.

Return type
int

Returns
Handle attached to EK file.

spiceypy.spiceypy.**ekpsel**(*query*, *msglen*, *tablen*, *collen*)

Parse the SELECT clause of an EK query, returning full particulars concerning each selected item.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekpsel_c.html note: oddly docs at url are incomplete/incorrect.

Parameters

- **query** (str) – EK query.
- **msglen** (int) – Available space in the output error message string.
- **tablen** (int) – UNKNOWN? Length of Table?
- **collen** (int) – UNKOWN? Length of Column?

Return type
Tuple[int, ndarray, ndarray, ndarray, ndarray, Iterable[str], Iterable[str], int, str]

Returns
Number of items in SELECT clause of query, Begin positions of expressions in SELECT clause, End positions of expressions in SELECT clause, Data types of expressions, Classes of expressions, Names of tables qualifying SELECT columns, Names of columns in SELECT clause of query, Error flag, Parse error message.

spiceypy.spiceypy.**ekrcec**(*handle*, *segno*, *recno*, *column*, *lenout*, *nelts=100*)

Read data from a character column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekrcec_c.html

Parameters

- **handle** (int) – Handle attached to EK file.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record from which data is to be read.
- **column** (str) – Column name.
- **lenout** (int) – Maximum length of output strings.
- **nelts** (int) – Number of elements to allow for (default=100)

Return type
Tuple[int, Iterable[str], bool]

Returns
Number of values in column entry, Character values in column entry, Flag indicating whether column entry is null.

spiceypy.spiceypy.**ekrced**(*handle*, *segno*, *recno*, *column*, *nelts=100*)

Read data from a double precision column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekrced_c.html

Parameters

- **handle** (int) – Handle attached to EK file.
- **segno** (int) – Index of segment containing record.

- **recno** (int) – Record from which data is to be read.
- **column** (str) – Column name.
- **nelts** (int) – room for data default 100

Return type
Tuple[int, ndarray, bool]

Returns
Number of values in column entry, Float values in column entry, Flag indicating whether column entry is null.

spiceypy.spiceypy.**ekrcei**(*handle*, *segno*, *recno*, *column*, *nelts=100*)

Read data from an integer column in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekrcei_c.html

Parameters

- **handle** (int) – Handle attached to EK file.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record from which data is to be read.
- **column** (str) – Column name.
- **nelts** (int) – room for data default 100

Return type
Tuple[int, ndarray, bool]

Returns
Number of values in column entry, Integer values in column entry, Flag indicating whether column entry is null.

spiceypy.spiceypy.**ekssum**(*handle*, *segno*)

Return summary information for a specified segment in a specified EK.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekssum_c.html

Parameters

- **handle** (int) – Handle of EK.
- **segno** (int) – Number of segment to be summarized.

Return type
SpiceEKSegSum

Returns
EK segment summary.

spiceypy.spiceypy.**ektnam**(*n*, *lenout=256*)

Return the name of a specified, loaded table.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ektnam_c.html

Parameters

- **n** (int) – Index of table.
- **lenout** (int) – Maximum table name length.

Return type
str

Returns
Name of table.

spiceypy.spiceypy.**ekucec**(*handle*, *segno*, *recno*, *column*, *nvals*, *cvals*, *isnull*)

Update a character column entry in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekucec_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be updated.
- **column** (str) – Column name.
- **nvals** (int) – Number of values in new column entry.
- **cvals** (Iterable[str]) – Character values comprising new column entry.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekuced**(*handle*, *segno*, *recno*, *column*, *nvals*, *dvals*, *isnull*)

Update a double precision column entry in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekuced_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be updated.
- **column** (str) – Column name.
- **nvals** (int) – Number of values in new column entry.
- **dvals** (Union[ndarray, Iterable[float]]) – Double precision values comprising new column entry.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekucei**(*handle*, *segno*, *recno*, *column*, *nvals*, *ivals*, *isnull*)

Update an integer column entry in a specified EK record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekucei_c.html

Parameters

- **handle** (int) – EK file handle.
- **segno** (int) – Index of segment containing record.
- **recno** (int) – Record to which data is to be updated.
- **column** (str) – Column name.
- **nvals** (int) – Number of values in new column entry.

- **ivals** (Union[ndarray, Iterable[int]]) – Integer values comprising new column entry.
- **isnull** (bool) – Flag indicating whether column entry is null.

Return type
None

spiceypy.spiceypy.**ekuef**(*handle*)

Unload an EK file, making its contents inaccessible to the EK reader routines, and clearing space in order to allow other EK files to be loaded.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ekuef_c.html

Parameters
handle (int) – Handle of EK file.

Return type
None

spiceypy.spiceypy.**el2cgv**(*ellipse*)

Convert an ellipse to a center vector and two generating vectors. The selected generating vectors are semi-axes of the ellipse.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/el2cgv_c.html

Parameters
ellipse (*Ellipse*) – An Ellipse

Return type
Tuple[ndarray, ndarray, ndarray]

Returns
Center and semi-axes of ellipse.

spiceypy.spiceypy.**elemc**(*item*, *inset*)

Determine whether an item is an element of a character set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/elemc_c.html

Parameters

- **item** (str) – Item to be tested.
- **inset** (*SpiceCell*) – Set to be tested.

Return type
bool

Returns
True if item is an element of set.

spiceypy.spiceypy.**elemd**(*item*, *inset*)

Determine whether an item is an element of a double precision set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/elemd_c.html

Parameters

- **item** (float) – Item to be tested.
- **inset** (*SpiceCell*) – Set to be tested.

Return type
bool

Returns
True if item is an element of set.

spiceypy.spiceypy.**elemi**(*item*, *inset*)

Determine whether an item is an element of an integer set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/elemi_c.html

Parameters

- **item** (int) – Item to be tested.
- **inset** (*SpiceCell*) – Set to be tested.

Return type
bool

Returns
True if item is an element of set.

spiceypy.spiceypy.**eqncpv**(*et*, *epoch*, *eqel*, *rapol*, *decpol*)

Compute the state (position and velocity of an object whose trajectory is described via equinoctial elements relative to some fixed plane (usually the equatorial plane of some planet).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eqncpv_c.html

Parameters

- **et** (float) – Epoch in seconds past J2000 to find state.
- **epoch** (float) – Epoch of elements in seconds past J2000.
- **eqel** (Iterable[float]) – Array of equinoctial elements
- **rapol** (float) – Right Ascension of the pole of the reference plane.
- **decpol** (float) – Declination of the pole of the reference plane.

Return type
ndarray

Returns
State of the object described by eqel.

spiceypy.spiceypy.**eqstr**(*a*, *b*)

Determine whether two strings are equivalent.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eqstr_c.html

Parameters

- **a** (str) – Arbitrary character string.
- **b** (str) – Arbitrary character string.

Return type
bool

Returns
True if A and B are equivalent.

spiceypy.spiceypy.**erract**(*op*, *lenout*, *action=None*)

Retrieve or set the default error action. spiceypy sets the default error action to "report" on init.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/erract_c.html

Parameters

- **op** (str) – peration, “GET” or “SET”.
- **lenout** (int) – Length of list for output.
- **action** (Optional[str]) – Error response action.

Return type
str

Returns
Error response action.

spiceypy.spiceypy.**errch**(*marker*, *string*)

Substitute a character string for the first occurrence of a marker in the current long error message.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/errch_c.html

Parameters

- **marker** (str) – A substring of the error message to be replaced.
- **string** (str) – The character string to substitute for marker.

Return type
None

spiceypy.spiceypy.**errdev**(*op*, *lenout*, *device*)

Retrieve or set the name of the current output device for error messages.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/errdev_c.html

Parameters

- **op** (str) – The operation, “GET” or “SET”.
- **lenout** (int) – Length of device for output.
- **device** (str) – The device name.

Return type
str

Returns
The device name.

spiceypy.spiceypy.**errdp**(*marker*, *number*)

Substitute a double precision number for the first occurrence of a marker found in the current long error message.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/errdp_c.html

Parameters

- **marker** (str) – A substring of the error message to be replaced.
- **number** (float) – The d.p. number to substitute for marker.

Return type
None

spiceypy.spiceypy.**errint**(*marker*, *number*)

Substitute an integer for the first occurrence of a marker found in the current long error message.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/errint_c.html

Parameters

- **marker** (str) – A substring of the error message to be replaced.
- **number** (int) – The integer to substitute for marker.

Return type
None

spiceypy.spiceypy.**errprt**(*op*, *lenout*, *inlist*)

Retrieve or set the list of error message items to be output when an error is detected.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/errprt_c.html

Parameters

- **op** (str) – The operation, "GET" or "SET".
- **lenout** (int) – Length of list for output.
- **inlist** (str) – Specification of error messages to be output.

Return type
str

Returns
A list of error message items.

spiceypy.spiceypy.**esrchc**(*value*, *array*)

Search for a given value within a character string array. Return the index of the first equivalent array entry, or -1 if no equivalent element is found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/esrchc_c.html

Parameters

- **value** (str) – Key value to be found in array.
- **array** (Sequence[str]) – Character string array to search.

Return type
int

Returns
The index of the first array entry equivalent to value, or -1 if none is found.

spiceypy.spiceypy.**et2datetime**(*et*)

Convert an input time from ephemeris seconds past J2000 to a standard Python datetime.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/req/time.html#The%20J2000%20Epoch

Parameters
et (Union[Iterable[float], float]) – Input epoch, given in ephemeris seconds past J2000.

Return type
Union[ndarray, datetime]

Returns
Output datetime object in UTC

spiceypy.spiceypy.**et2lst**(*et*, *body*, *lon*, *typein*, *timlen=256*, *ampmlen=256*)

Given an ephemeris epoch, compute the local solar time for an object on the surface of a body at a specified longitude.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/et2lst_c.html

Parameters

- **et** (float) – Epoch in seconds past J2000 epoch.
- **body** (int) – ID-code of the body of interest.
- **lon** (float) – Longitude of surface point (RADIANS).
- **typein** (str) – Type of longitude "PLANETOCENTRIC", etc.
- **timlen** (int) – Available room in output time string.
- **ampmlen** (int) – Available room in output ampm string.

Return type
Tuple[int, int, int, str, str]

Returns
Local hour on a "24 hour" clock, Minutes past the hour, Seconds past the minute, String giving local time on 24 hour clock, String giving time on A.M. / P.M. scale.

spiceypy.spiceypy.**et2utc**(*et*, *format_str*, *prec*, *lenout=256*)

Convert an input time from ephemeris seconds past J2000 to Calendar, Day-of-Year, or Julian Date format, UTC.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/et2utc_c.html

Parameters

- **et** (Union[float, Iterable[float]]) – Input epoch, given in ephemeris seconds past J2000.
- **format_str** (str) – Format of output epoch.
- **prec** (int) – Digits of precision in fractional seconds or days.
- **lenout** (int) – The length of the output string plus 1.

Return type
Union[ndarray, str]

Returns
Output time string in UTC

spiceypy.spiceypy.**etcal**(*et*, *lenout=256*)

Convert from an ephemeris epoch measured in seconds past the epoch of J2000 to a calendar string format using a formal calendar free of leapseconds.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/etcal_c.html

Parameters

- **et** (Union[float, ndarray]) – Ephemeris time measured in seconds past J2000.
- **lenout** (int) – Length of output string.

Return type
Union[str, Iterable[str]]

Returns
A standard calendar representation of et.

spiceypy.spiceypy.**eul2m**(*angle3*, *angle2*, *angle1*, *axis3*, *axis2*, *axis1*)

Construct a rotation matrix from a set of Euler angles.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eul2m_c.html

Parameters

- **angle3** (float) – Rotation angle about third rotation axis (radians).

- **angle2** (float) – Rotation angle about second rotation axis (radians).
- **angle1** (float) – Rotation angle about first rotation axis (radians).
- **axis3** (int) – Axis number of third rotation axis.
- **axis2** (int) – Axis number of second rotation axis.
- **axis1** (int) – Axis number of first rotation axis.]

Return type
ndarray

Returns
Product of the 3 rotations.

spiceypy.spiceypy.**eul2xf**(*eulang*, *axisa*, *axisb*, *axisc*)

This routine computes a state transformation from an Euler angle factorization of a rotation and the derivatives of those Euler angles.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eul2xf_c.html

Parameters

- **eulang** (Sequence[float]) – An array of Euler angles and their derivatives.
- **axisa** (int) – Axis A of the Euler angle factorization.
- **axisb** (int) – Axis B of the Euler angle factorization.
- **axisc** (int) – Axis C of the Euler angle factorization.

Return type
ndarray

Returns
A state transformation matrix.

spiceypy.spiceypy.**ev2lin**(*et*, *geophs*, *elems*)

This routine evaluates NORAD two-line element data for near-earth orbiting spacecraft (that is spacecraft with orbital periods less than 225 minutes).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/ev2lin.html

Parameters

- **et** (float) – Epoch in seconds past ephemeris epoch J2000.
- **geophs** (Sequence[float]) – Geophysical constants
- **elems** (Sequence[float]) – Two-line element data

Return type
ndarray

Returns
Evaluated state

spiceypy.spiceypy.**evsgp4**(*et*, *geophs*, *elems*)

Evaluate NORAD two-line element data for earth orbiting spacecraft. This evaluator uses algorithms as described in Vallado 2006

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/evsgp4_c.html

Parameters

- **et** (float) – Epoch in seconds past ephemeris epoch J2000.

- **geophs** (Sequence[float]) – Geophysical constants
- **elems** (Sequence[float]) – Two-line element data

Return type
ndarray

Returns
Evaluated state

spiceypy.spiceypy.**exists**(*fname*)

Determine whether a file exists.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/exists_c.html

Parameters
fname (str) – Name of the file in question.

Return type
bool

Returns
True if the file exists, False otherwise.

spiceypy.spiceypy.**expool**(*name*)

Confirm the existence of a kernel variable in the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/expool_c.html

Parameters
name (str) – Name of the variable whose value is to be returned.

Return type
bool

Returns
True when the variable is in the pool.

spiceypy.spiceypy.**failed**()

True if an error condition has been signalled via sigerr_c.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/failed_c.html

Return type
bool

Returns
a boolean

spiceypy.spiceypy.**fn2lun**(*fname*)

Internal undocumented command for mapping name of open file to its FORTRAN (F2C) logical unit.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/fn2lun.html

Parameters
fname (str) – name of the file to be mapped to its logical unit.

Return type
int

Returns
the FORTRAN (F2C) logical unit associated with the filename.

spiceypy.spiceypy.**found_check**()

Temporarily enables spiceypy default behavior which raises exceptions for false found flags for certain spice functions. All spice functions executed within the context manager will check the found flag return parameter and the found flag will be removed from the return for the given function. For Example bodc2n in spiceypy is normally called like:

```
name = spice.bodc2n(399)
```

With the possibility that an exception is thrown in the even of a invalid ID:

```
name = spice.bodc2n(-999991) # throws a SpiceyError
```

With this function however, we can use it as a context manager to do this:

```
with spice.found_check():
    found = spice.bodc2n(-999991) # will raise an exception!
```

Within the context any spice functions called that normally check the found flags will pass through the check without raising an exception if they are false.

Return type
Iterator[None]

spiceypy.spiceypy.**found_check_off**()

Method that turns off found catching

Return type
None

spiceypy.spiceypy.**found_check_on**()

Method that turns on found catching

Return type
None

spiceypy.spiceypy.**fovray**(*inst*, *raydir*, *rframe*, *abcorr*, *observer*, *et*)

Determine if a specified ray is within the field-of-view (FOV) of a specified instrument at a given time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/fovray_c.html

Parameters

- **inst** (str) – Name or ID code string of the instrument.
- **raydir** (Union[ndarray, Iterable[float]]) – Ray's direction vector.
- **rframe** (str) – Body-fixed, body-centered frame for target body.
- **abcorr** (str) – Aberration correction flag.
- **observer** (str) – Name or ID code string of the observer.
- **et** (float) – Time of the observation (seconds past J2000).

Return type
bool

Returns
Visibility flag

spiceypy.spiceypy.**fovtrg**(*inst*, *target*, *tshape*, *tframe*, *abcorr*, *observer*, *et*)

Determine if a specified ephemeris object is within the field-of-view (FOV) of a specified instrument at a given time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/fovtrg_c.html

Parameters

- **inst** (str) – Name or ID code string of the instrument.
- **target** (str) – Name or ID code string of the target.
- **tshape** (str) – Type of shape model used for the target.
- **tframe** (str) – Body-fixed, body-centered frame for target body.
- **abcorr** (str) – Aberration correction flag.
- **observer** (str) – Name or ID code string of the observer.
- **et** (float) – Time of the observation (seconds past J2000).

Return type
bool

Returns
Visibility flag

spiceypy.spiceypy.**frame**(*x*)

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/frame_c.html

Parameters
x (Union[ndarray, Iterable[float]]) – Input vector. A parallel unit vector on output.

Return type
Tuple[ndarray, ndarray, ndarray]

Returns
a tuple of 3 list[3]

spiceypy.spiceypy.**frinfo**(*frcode*)

Retrieve the minimal attributes associated with a frame needed for converting transformations to and from it.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/frinfo_c.html

Parameters
frcode (int) – the idcode for some frame.

Return type
Tuple[int, int, int, bool]

Returns
a tuple of attributes associated with the frame.

spiceypy.spiceypy.**frmnam**(*frcode*, *lenout=256*)

Retrieve the name of a reference frame associated with a SPICE ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/frmnam_c.html

Parameters

- **frcode** (int) – an integer code for a reference frame
- **lenout** (int) – Maximum length of output string.

Return type
str

Returns
the name associated with the reference frame.

spiceypy.spiceypy.**fromisoformat**(*s*)

spiceypy.spiceypy.**ftncls**(*unit*)

Close a file designated by a Fortran-style integer logical unit.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ftncls_c.html

Parameters
unit (int) – Fortran-style logical unit.

Return type
None

spiceypy.spiceypy.**furnsh**(*path*)

Load one or more SPICE kernels into a program.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/furnsh_c.html

Parameters
path (Union[str, Iterable[str]]) – one or more paths to kernels

Return type
None

spiceypy.spiceypy.**gcpool**(*name*, *start*, *room*, *lenout=256*)

Return the character value of a kernel variable from the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gcpool_c.html

Parameters

- **name** (str) – Name of the variable whose value is to be returned.
- **start** (int) – Which component to start retrieving for name.
- **room** (int) – The largest number of values to return.
- **lenout** (int) – The length of the output string.

Return type
Tuple[Iterable[str], bool]

Returns
Values associated with name.

spiceypy.spiceypy.**gdpool**(*name*, *start*, *room*)

Return the d.p. value of a kernel variable from the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gdpool_c.html

Parameters

- **name** (str) – Name of the variable whose value is to be returned.
- **start** (int) – Which component to start retrieving for name.
- **room** (int) – The largest number of values to return.

Return type
Tuple[ndarray, bool]

Returns
Values associated with name.

spiceypy.spiceypy.**georec**(*lon*, *lat*, *alt*, *re*, *f*)

Convert geodetic coordinates to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/georec_c.html

Parameters

- **lon** (float) – Geodetic longitude of point (radians).
- **lat** (float) – Geodetic latitude of point (radians).
- **alt** (float) – Altitude of point above the reference spheroid.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Rectangular coordinates of point.

spiceypy.spiceypy.**get_found_catch_state**()

Returns the current found catch state

Return type
bool

Returns

spiceypy.spiceypy.**getelm**(*frstyr*, *lineln*, *lines*)

Given a the "lines" of a two-line element set, parse the lines and return the elements in units suitable for use in SPICE software.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getelm_c.html

Parameters

- **frstyr** (int) – Year of earliest representable two-line elements.
- **lineln** (int) – Length of strings in lines array.
- **lines** (Iterable[str]) – A pair of "lines" containing two-line elements.

Return type
Tuple[float, ndarray]

Returns
The epoch of the elements in seconds past J2000, The elements converted to SPICE units.

spiceypy.spiceypy.**getfat**(*file*)

Determine the file architecture and file type of most SPICE kernel files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getfat_c.html

Parameters
file (str) – The name of a file to be examined.

Return type
Tuple[str, str]

Returns
The architecture of the kernel file, The type of the kernel file.

spiceypy.spiceypy.**getfov**(*instid*, *room*, *shapelen=256*, *framelen=256*)

This routine returns the field-of-view (FOV) parameters for a specified instrument.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getfov_c.html

Parameters

- **instid** (int) – NAIF ID of an instrument.
- **room** (int) – Maximum number of vectors that can be returned.
- **shapelen** (int) – Space available in the string shape.
- **framelen** (int) – Space available in the string frame.

Return type
Tuple[str, str, ndarray, int, ndarray]

Returns
Instrument FOV shape, Name of the frame in which FOV vectors are defined, Boresight vector, Number of boundary vectors returned, FOV boundary vectors.

spiceypy.spiceypy.**getfvn**(*inst*, *room*, *shapelen=256*, *framelen=256*)

Return the field-of-view (FOV) parameters for a specified instrument. The instrument is specified by name.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getfvn_c.html

Parameters

- **inst** (str) – Name of an instrument.
- **room** (int) – Maximum number of vectors that can be returned.
- **shapelen** (int) – Space available in the string shape.
- **framelen** (int) – Space available in the string frame.

Return type
Tuple[str, str, ndarray, int, ndarray]

Returns
Instrument FOV shape, Name of the frame in which FOV vectors are defined, Boresight vector, Number of boundary vectors returned, FOV boundary vectors.

spiceypy.spiceypy.**getmsg**(*option*, *lenout=256*)

Retrieve the current short error message, the explanation of the short error message, or the long error message.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getmsg_c.html

Parameters

- **option** (str) – Indicates type of error message.
- **lenout** (int) – Available space in the output string msg.

Return type
str

Returns
The error message to be retrieved.

spiceypy.spiceypy.**gfbail**()

Indicate whether an interrupt signal (SIGINT) has been received.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfbail_c.html

Return type
bool

Returns
True if an interrupt signal has been received by the GF handler.

spiceypy.spiceypy.**gfclrh**()

Clear the interrupt signal handler status, so that future calls to *gfbail()* will indicate no interrupt was received.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfclrh_c.html

Return type
None

spiceypy.spiceypy.**gfdist**(*target*, *abcorr*, *obsrvr*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Return the time window over which a specified constraint on observer-target distance is met.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfdist_c.html

Parameters

- **target** (str) – Name of the target body.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **relate** (str) – Relational operator.
- **refval** (int) – Reference value.
- **adjust** (float) – Adjustment value for absolute extrema searches.
- **step** (float) – Step size used for locating extrema and roots.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is confined.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfevnt**(*udstep*, *udrefn*, *gquant*, *qnpars*, *lenvals*, *qpnams*, *qcpars*, *qdpars*, *qipars*, *qlpars*, *op*, *refval*, *tol*, *adjust*, *rpt*, *udrepi*, *udrepu*, *udrepf*, *nintvls*, *bail*, *udbail*, *cnfine*, *result=None*)

Determine time intervals when a specified geometric quantity satisfies a specified mathematical condition.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfevnt_c.html

Parameters

- **udstep** (CFunctionType) – Name of the routine that computes and returns a
- **udrefn** (CFunctionType) – Name of the routine that computes a refined time
- **gquant** (str) – Type of geometric quantity
- **qnpars** (int) – Number of quantity definition parameters
- **lenvals** (int) – Length of strings in qpnams and qcpars

- **qpnams** (Iterable[str]) – Names of quantity definition parameters
- **qcpars** (Iterable[str]) – Array of character quantity definition parameters
- **qdpars** (Union[ndarray, Iterable[float]]) – Array of double precision quantity definition
- **qipars** (Union[ndarray, Iterable[int]]) – Array of integer quantity definition parameters
- **qlpars** (Union[ndarray, Iterable[int]]) – Array of logical quantity definition parameters
- **op** (str) – Operator that either looks for an extreme value
- **refval** (float) – Reference value
- **tol** (float) – Convergence tolerance in seconds
- **adjust** (float) – Absolute extremum adjustment value
- **rpt** (int) – Progress reporter on TRUE or off FALSE
- **udrepi** (CFunctionType) – Function that initializes progress reporting
- **udrepu** (CFunctionType) – Function that updates the progress report
- **udrepf** (CFunctionType) – Function that finalizes progress reporting
- **nintvls** (int) – Workspace window interval count
- **bail** (int) – Logical indicating program interrupt monitoring
- **udbail** (CFunctionType) – Name of a routine that signals a program interrupt
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results

spiceypy.spiceypy.**gffove**(*inst*, *tshape*, *raydir*, *target*, *tframe*, *abcorr*, *obsrvr*, *tol*, *udstep*, *udrefn*, *rpt*, *udrepi*, *udrepu*, *udrepf*, *bail*, *udbail*, *cnfine*, *result=None*)

Determine time intervals when a specified target body or ray intersects the space bounded by the field-of-view (FOV) of a specified instrument. Report progress and handle interrupts if so commanded.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gffove_c.html

Parameters

- **inst** (str) – Name of the instrument
- **tshape** (str) – Type of shape model used for target body
- **raydir** (Union[ndarray, Iterable[float]]) – Ray s direction vector
- **target** (str) – Name of the target body
- **tframe** (str) – Body fixed body centered frame for target body
- **abcorr** (str) – Aberration correction flag
- **obsrvr** (str) – Name of the observing body
- **tol** (float) – Convergence tolerance in seconds
- **udstep** (CFunctionType) – Name of the routine that returns a time step
- **udrefn** (CFunctionType) – Name of the routine that computes a refined time
- **rpt** (int) – Progress report flag

- **udrepi** (CFunctionType) – Function that initializes progress reporting.
- **udrepu** (CFunctionType) – Function that updates the progress report
- **udrepf** (CFunctionType) – Function that finalizes progress reporting
- **bail** (int) – Logical indicating program interrupt monitoring
- **udbail** (CFunctionType) – Name of a routine that signals a program interrupt
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results

spiceypy.spiceypy.**gfilum**(*method*, *angtyp*, *target*, *illumn*, *fixref*, *abcorr*, *obsrvr*, *spoint*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Return the time window over which a specified constraint on the observed phase, solar incidence, or emission angle at a specifed target body surface point is met.

Parameters

- **method** (str) – Shape model used to represent the surface of the target body.
- **angtyp** (str) – The type of illumination angle for which a search is to be performed.
- **target** (str) – Name of a target body.
- **illumn** (str) – Name of the illumination source.
- **fixref** (str) – Name of the body-fixed, body-centered reference frame associated with the target body.
- **abcorr** (str) – The aberration corrections to be applied.
- **obsrvr** (str) – Name of an observing body.
- **spoint** (Union[ndarray, Iterable[float]]) – Body-fixed coordinates of a target surface point.
- **relate** (str) – Relational operator used to define a constraint on a specified illumination angle.
- **refval** (float) – Reference value used with 'relate' to define an equality or inequality to be satisfied by the specified illumination angle.
- **adjust** (float) – Parameter used to modify searches for absolute extrema.
- **step** (float) – Step size to be used in the search.
- **nintvls** (int) – Number of intervals that can be accommodated by each of the dynamically allocated workspace windows used internally by this routine.
- **cnfine** (*SpiceCell*) – Window that confines the time period over which the specified search is conducted. This can be updated by gfilum
- **result** (Optional[*SpiceCell*]) – Optional SPICE Window of intervals in the confinement window that the illumination angle constraint is satisfied.

Return type

SpiceCell

spiceypy.spiceypy.**gfinth**(*sigcode*)

Respond to the interrupt signal SIGINT: save an indication that the signal has been received. This routine restores itself as the handler for SIGINT.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfinth_c.html

Parameters
sigcode (int) – Interrupt signal ID code.

Return type
None

spiceypy.spiceypy.**gfocce**(*occtyp*, *front*, *fshape*, *fframe*, *back*, *bshape*, *bframe*, *abcorr*, *obsrvr*, *tol*, *udstep*, *udrefn*, *rpt*, *udrepi*, *udrepu*, *udrepf*, *bail*, *udbail*, *cnfine*, *result=None*)

Determine time intervals when an observer sees one target occulted by another. Report progress and handle interrupts if so commanded.

The surfaces of the target bodies may be represented by triaxial ellipsoids or by topographic data provided by DSK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfocce_c.html

Parameters

- **occtyp** (str) – Type of occultation
- **front** (str) – Name of body occulting the other
- **fshape** (str) – Type of shape model used for front body
- **fframe** (str) – Body fixed body centered frame for front body
- **back** (str) – Name of body occulted by the other
- **bshape** (str) – Type of shape model used for back body
- **bframe** (str) – Body fixed body centered frame for back body
- **abcorr** (str) – Aberration correction flag
- **obsrvr** (str) – Name of the observing body
- **tol** (float) – Convergence tolerance in seconds
- **udstep** (CFunctionType) – Name of the routine that returns a time step
- **udrefn** (CFunctionType) – Name of the routine that computes a refined time
- **rpt** (int) – Progress report flag
- **udrepi** (CFunctionType) – Function that initializes progress reporting.
- **udrepu** (CFunctionType) – Function that updates the progress report
- **udrepf** (CFunctionType) – Function that finalizes progress reporting
- **bail** (int) – Logical indicating program interrupt monitoring
- **udbail** (CFunctionType) – Name of a routine that signals a program interrupt
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

spiceypy.spiceypy.**gfoclt**(*occtyp*, *front*, *fshape*, *fframe*, *back*, *bshape*, *bframe*, *abcorr*, *obsrvr*, *step*, *cnfine*, *result=None*)

Determine time intervals when an observer sees one target occulted by, or in transit across, another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfoclt_c.html

Parameters

- **occtyp** (str) – Type of occultation.

- **front** (str) – Name of body occulting the other.
- **fshape** (str) – Type of shape model used for front body.
- **fframe** (str) – Body-fixed, body-centered frame for front body.
- **back** (str) – Name of body occulted by the other.
- **bshape** (str) – Type of shape model used for back body.
- **bframe** (str) – Body-fixed, body-centered frame for back body.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **step** (float) – Step size in seconds for finding occultation events.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfpa**(*target*, *illmin*, *abcorr*, *obsrvr*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Determine time intervals for which a specified constraint on the phase angle between an illumination source, a target, and observer body centers is met.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfpa_c.html

Parameters

- **target** (str) – Name of the target body.
- **illmin** (str) – Name of the illuminating body.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Adjustment value for absolute extrema searches.
- **step** (float) – Step size used for locating extrema and roots.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfposc**(*target*, *inframe*, *abcorr*, *obsrvr*, *crdsys*, *coord*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Determine time intervals for which a coordinate of an observer-target position vector satisfies a numerical constraint.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfposc_c.html

Parameters

- **target** (str) – Name of the target body.

- **inframe** (str) – Name of the reference frame for coordinate calculations.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **crdsys** (str) – Name of the coordinate system containing COORD
- **coord** (str) – Name of the coordinate of interest
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Adjustment value for absolute extrema searches.
- **step** (float) – Step size used for locating extrema and roots.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfrefn**(*t1*, *t2*, *s1*, *s2*)

For those times when we can't do better, we use a bisection method to find the next time at which to test for state change.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrefn_c.html

Parameters

- **t1** (float) – One of two values bracketing a state change.
- **t2** (float) – The other value that brackets a state change.
- **s1** (Union[bool, int]) – State at t1.
- **s2** (Union[bool, int]) – State at t2.

Return type
float

Returns
New value at which to check for transition.

spiceypy.spiceypy.**gfrepf**()

Finish a GF progress report.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrepf_c.html

Return type
None

spiceypy.spiceypy.**gfrepi**(*window*, *begmss*, *endmss*)

This entry point initializes a search progress report.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrepi_c.html

Parameters

- **window** (Union[*SpiceCell*, LP_SpiceCell]) – A window over which a job is to be performed.
- **begmss** (str) – Beginning of the text portion of the output message.

- **endmss** (str) – End of the text portion of the output message.

Return type
None

spiceypy.spiceypy.**gfrepu**(*ivbeg*, *ivend*, *time*)

This function tells the progress reporting system how far a search has progressed.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrepu_c.html

Parameters

- **ivbeg** (float) – Start time of work interval.
- **ivend** (float) – End time of work interval.
- **time** (float) – Current time being examined in the search process.

Return type
None

spiceypy.spiceypy.**gfrfov**(*inst*, *raydir*, *rframe*, *abcorr*, *obsrvr*, *step*, *cnfine*, *result=None*)

Determine time intervals when a specified ray intersects the space bounded by the field-of-view (FOV) of a specified instrument.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrfov_c.html

Parameters

- **inst** (str) – Name of the instrument.
- **raydir** (ndarray) – Ray's direction vector.
- **rframe** (str) – Reference frame of ray's direction vector.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **step** (float) – Step size in seconds for finding FOV events.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfrr**(*target*, *abcorr*, *obsrvr*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result*)

Determine time intervals for which a specified constraint on the observer-target range rate is met.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfrr_c.html

Parameters

- **target** (str) – Name of the target body.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Adjustment value for absolute extrema searches.
- **step** (float) – Step size used for locating extrema and roots.

- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (*SpiceCell*) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfsep**(*targ1*, *shape1*, *inframe1*, *targ2*, *shape2*, *inframe2*, *abcorr*, *obsrvr*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Determine time intervals when the angular separation between the position vectors of two target bodies relative to an observer satisfies a numerical relationship.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfsep_c.html

Parameters

- **targ1** (str) – Name of first body.
- **shape1** (str) – Name of shape model describing the first body.
- **inframe1** (str) – The body-fixed reference frame of the first body.
- **targ2** (str) – Name of second body.
- **shape2** (str) – Name of the shape model describing the second body.
- **inframe2** (str) – The body-fixed reference frame of the second body
- **abcorr** (str) – Aberration correction flag
- **obsrvr** (str) – Name of the observing body.
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Absolute extremum adjustment value.
- **step** (float) – Step size in seconds for finding angular separation events.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfsntc**(*target*, *fixref*, *method*, *abcorr*, *obsrvr*, *dref*, *dvec*, *crdsys*, *coord*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result=None*)

Determine time intervals for which a coordinate of an surface intercept position vector satisfies a numerical constraint.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfsntc_c.html

Parameters

- **target** (str) – Name of the target body.
- **fixref** (str) – Body fixed frame associated with the target.
- **method** (str) – Name of method type for surface intercept calculation.
- **abcorr** (str) – Aberration correction flag

- **obsrvr** (str) – Name of the observing body.
- **dref** (str) – Reference frame of direction vector of dvec.
- **dvec** (Union[ndarray, Iterable[float]]) – Pointing direction vector from the observer.
- **crdsys** (str) – Name of the coordinate system containing COORD.
- **coord** (str) – Name of the coordinate of interest
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Absolute extremum adjustment value.
- **step** (float) – Step size in seconds for finding angular separation events.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gfsstp**(*step*)

Set the step size to be returned by *gfstep()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfsstp_c.html

Parameters
step (float) – Time step to take.

Return type
None

spiceypy.spiceypy.**gfstep**(*time*)

Return the time step set by the most recent call to *gfsstp()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfstep_c.html

Parameters
time (float) – Ignored ET value.

Return type
float

Returns
Time step to take.

spiceypy.spiceypy.**gfstol**(*value*)

Override the default GF convergence value used in the high level GF routines.

Default value is 1.0e-6

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfstol_c.html

Parameters
value (float) – Double precision value returned or to store.

Return type
None

spiceypy.spiceypy.**gfsubc**(*target*, *fixref*, *method*, *abcorr*, *obsrvr*, *crdsys*, *coord*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result*)

Determine time intervals for which a coordinate of an subpoint position vector satisfies a numerical constraint.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfsubc_c.html

Parameters

- **target** (str) – Name of the target body.
- **fixref** (str) – Body fixed frame associated with the target.
- **method** (str) – Name of method type for subpoint calculation.
- **abcorr** (str) – Aberration correction flag
- **obsrvr** (str) – Name of the observing body.
- **crdsys** (str) – Name of the coordinate system containing COORD.
- **coord** (str) – Name of the coordinate of interest
- **relate** (str) – Relational operator.
- **refval** (float) – Reference value.
- **adjust** (float) – Adjustment value for absolute extrema searches.
- **step** (float) – Step size used for locating extrema and roots.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (*SpiceCell*) – Optional SPICE window containing results.

Return type
SpiceCell

spiceypy.spiceypy.**gftfov**(*inst*, *target*, *tshape*, *tframe*, *abcorr*, *obsrvr*, *step*, *cnfine*, *result=None*)

Determine time intervals when a specified ephemeris object intersects the space bounded by the field-of-view (FOV) of a specified instrument.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gftfov_c.html

Parameters

- **inst** (str) – Name of the instrument.
- **target** (str) – Name of the target body.
- **tshape** (str) – Type of shape model used for target body.
- **tframe** (str) – Body-fixed, body-centered frame for target body.
- **abcorr** (str) – Aberration correction flag.
- **obsrvr** (str) – Name of the observing body.
- **step** (float) – Step size in seconds for finding FOV events.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (Optional[*SpiceCell*]) – Optional pass-in SpiceCell for results

Return type
SpiceCell

Returns
SpiceCell containing set of time intervals, within the confinement period, when the target body is visible

spiceypy.spiceypy.**gfudb**(*udfuns*, *udfunb*, *step*, *cnfine*, *result*)

Perform a GF search on a user defined boolean quantity.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfudb_c.html

Parameters

- **udfuns** (CFunctionType) – Name of the routine that computes a scalar quantity of interest corresponding to an 'et'.
- **udfunb** (CFunctionType) – Name of the routine returning the boolean value corresponding to an 'et'.
- **step** (float) – Step size used for locating extrema and roots.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (*SpiceCell*) – SPICE window containing results.

Returns
result

spiceypy.spiceypy.**gfuds**(*udfuns*, *udqdec*, *relate*, *refval*, *adjust*, *step*, *nintvls*, *cnfine*, *result*)

Perform a GF search on a user defined scalar quantity.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gfuds_c.html

Parameters

- **udfuns** (CFunctionType) – Name of the routine that computes the scalar quantity of interest at some time.
- **udqdec** (CFunctionType) – Name of the routine that computes whether the scalar quantity is decreasing.
- **relate** (str) – Operator that either looks for an extreme value (max, min, local, absolute) or compares the geometric quantity value and a number.
- **refval** (float) – Value used as reference for scalar quantity condition.
- **adjust** (float) – Allowed variation for absolute extremal geometric conditions.
- **step** (float) – Step size used for locating extrema and roots.
- **nintvls** (int) – Workspace window interval count.
- **cnfine** (*SpiceCell*) – SPICE window to which the search is restricted.
- **result** (*SpiceCell*) – SPICE window containing results.

Return type
SpiceCell

Returns
result

spiceypy.spiceypy.**gipool**(*name*, *start*, *room*)

Return the integer value of a kernel variable from the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gipool_c.html

Parameters

- **name** (str) – Name of the variable whose value is to be returned.
- **start** (int) – Which component to start retrieving for name.
- **room** (int) – The largest number of values to return.

Return type
Tuple[ndarray, bool]

Returns
Values associated with name.

spiceypy.spiceypy.**gnpool**(*name*, *start*, *room*, *lenout=256*)

Return names of kernel variables matching a specified template.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gnpool_c.html

Parameters

- **name** (str) – Template that names should match.
- **start** (int) – Index of first matching name to retrieve.
- **room** (int) – The largest number of values to return.
- **lenout** (int) – Length of strings in output array kvars.

Return type
Tuple[Iterable[str], bool]

Returns
Kernel pool variables whose names match name.

spiceypy.spiceypy.**halfpi**()

Return half the value of pi (the ratio of the circumference of a circle to its diameter).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/halfpi_c.html

Return type
float

Returns
Half the value of pi.

spiceypy.spiceypy.**hrmesp**(*first*, *step*, *yvals*, *x*)

Evaluate, at a specified point, a Hermite interpolating polynomial for a specified set of equally spaced abscissa values and corresponding pairs of function and function derivative values.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/hrmesp_c.html

Parameters

- **first** (float) – First abscissa value.
- **step** (float) – Step size.
- **yvals** (ndarray) – Ordinate and derivative values.
- **x** (float) – Point at which to interpolate the polynomial.

Return type
Tuple[float, float]

Returns
Interpolated function value and derivative at x

spiceypy.spiceypy.**hrmint**(*xvals*, *yvals*, *x*)

Evaluate a Hermite interpolating polynomial at a specified abscissa value.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/hrmint_c.html

Parameters

- **xvals** (Sequence[float]) – Abscissa values.
- **yvals** (Sequence[float]) – Ordinate and derivative values.
- **x** (int) – Point at which to interpolate the polynomial.

Return type
Tuple[float, float]

Returns
Interpolated function value at x and the Interpolated function's derivative at x

spiceypy.spiceypy.**hx2dp**(*string*)

Convert a string representing a double precision number in a base 16 scientific notation into its equivalent double precision number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/hx2dp_c.html

Parameters
string (str) – Hex form string to convert to double precision.

Return type
Union[float, str]

Returns
Double precision value to be returned, Or Error Message.

spiceypy.spiceypy.**ident**()

This routine returns the 3x3 identity matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ident_c.html

Return type
ndarray

Returns
The 3x3 identity matrix.

spiceypy.spiceypy.**illum**(*target*, *et*, *abcorr*, *obsrvr*, *spoint*)

Deprecated: This routine has been superseded by the CSPICE routine ilumin. This routine is supported for purposes of backward compatibility only.

Find the illumination angles at a specified surface point of a target body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/illum_c.html

Parameters

- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000.
- **abcorr** (str) – Desired aberration correction.
- **obsrvr** (str) – Name of observing body.
- **spoint** (ndarray) – Body-fixed coordinates of a target surface point.

Return type
Tuple[float, float, float]

Returns
Phase angle, Solar incidence angle, and Emission angle at the surface point.

spiceypy.spiceypy.**illumf**(*method*, *target*, *ilusrc*, *et*, *fixref*, *abcorr*, *obsrvr*, *spoint*)

Compute the illumination angles—phase, incidence, and emission—at a specified point on a target body. Return logical flags indicating whether the surface point is visible from the observer's position and whether the surface point is illuminated.

The target body's surface is represented using topographic data provided by DSK files, or by a reference ellipsoid.

The illumination source is a specified ephemeris object.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/illumf_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **ilusrc** (str) – Name of illumination source.
- **et** (float) – Epoch in ephemeris seconds past J2000.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Desired aberration correction.
- **obsrvr** (str) – Name of observing body.
- **spoint** (ndarray) – Body-fixed coordinates of a target surface point.

Return type
Tuple[float, ndarray, float, float, float, bool, bool]

Returns
Target surface point epoch, Vector from observer to target surface point, Phase angle at the surface point, Source incidence angle at the surface point, Emission angle at the surface point, Visibility flag, Illumination flag

spiceypy.spiceypy.**illumg**(*method*, *target*, *ilusrc*, *et*, *fixref*, *abcorr*, *obsrvr*, *spoint*)

Find the illumination angles (phase, incidence, and emission) at a specified surface point of a target body.

The surface of the target body may be represented by a triaxial ellipsoid or by topographic data provided by DSK files.

The illumination source is a specified ephemeris object. param method: Computation method.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/illumg_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **ilusrc** (str) – Name of illumination source.
- **et** (float) – Epoch in ephemeris seconds past J2000.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Desired aberration correction.

- **obsrvr** (str) – Name of observing body.
- **spoint** (ndarray) – Body-fixed coordinates of a target surface point.

Return type
Tuple[float, ndarray, float, float, float]

Returns
Target surface point epoch, Vector from observer to target surface point, Phase angle at the surface point, Source incidence angle at the surface point, Emission angle at the surface point,

spiceypy.spiceypy.**ilumin**(*method*, *target*, *et*, *fixref*, *abcorr*, *obsrvr*, *spoint*)

Find the illumination angles (phase, solar incidence, and emission) at a specified surface point of a target body.

This routine supersedes illum.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ilumin_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Desired aberration correction.
- **obsrvr** (str) – Name of observing body.
- **spoint** (ndarray) – Body-fixed coordinates of a target surface point.

Return type
Tuple[float, ndarray, float, float, float]

Returns
Target surface point epoch, Vector from observer to target surface point, Phase angle, Solar incidence angle, and Emission angle at the surface point.

spiceypy.spiceypy.**inedpl**(*a*, *b*, *c*, *plane*)

Find the intersection of a triaxial ellipsoid and a plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/inedpl_c.html

Parameters

- **a** (float) – Length of ellipsoid semi-axis lying on the x-axis.
- **b** (float) – Length of ellipsoid semi-axis lying on the y-axis.
- **c** (float) – Length of ellipsoid semi-axis lying on the z-axis.
- **plane** (*Plane*) – Plane that intersects ellipsoid.

Return type
Tuple[*Ellipse*, bool]

Returns
Intersection ellipse.

spiceypy.spiceypy.**inelpl**(*ellips*, *plane*)

Find the intersection of an ellipse and a plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/inelpl_c.html

Parameters

- **ellips** (*Ellipse*) – A SPICE ellipse.
- **plane** (*Plane*) – A SPICE plane.

Return type
Tuple[int, ndarray, ndarray]

Returns
Number of intersection points of plane and ellipse, Point 1, Point 2.

spiceypy.spiceypy.**inrypl**(*vertex*, *direct*, *plane*)

Find the intersection of a ray and a plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/inrypl_c.html

Parameters

- **vertex** (Iterable[float]) – Vertex vector of ray.
- **direct** (Iterable[float]) – Direction vector of ray.
- **plane** (*Plane*) – A SPICE plane.

Return type
Tuple[int, ndarray]

Returns
Number of intersection points of ray and plane, Intersection point, if nxpts == 1.

spiceypy.spiceypy.**insrtc**(*item*, *inset*)

Insert an item into a character set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/insrtc_c.html

Parameters

- **item** (Union[str, Iterable[str]]) – Item to be inserted.
- **inset** (*SpiceCell*) – Insertion set.

Return type
None

spiceypy.spiceypy.**insrtd**(*item*, *inset*)

Insert an item into a double precision set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/insrtd_c.html

Parameters

- **item** (Union[float, Iterable[float]]) – Item to be inserted.
- **inset** (*SpiceCell*) – Insertion set.

Return type
None

spiceypy.spiceypy.**insrti**(*item*, *inset*)

Insert an item into an integer set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/insrti_c.html

Parameters

- **item** (Union[Iterable[int], int]) – Item to be inserted.

- **inset** (*SpiceCell*) – Insertion set.

Return type
None

spiceypy.spiceypy.**inter**(*a*, *b*)

Intersect two sets of any data type to form a third set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/inter_c.html

Parameters

- **a** (*SpiceCell*) – First input set.
- **b** (*SpiceCell*) – Second input set.

Return type
SpiceCell

Returns
Intersection of a and b.

spiceypy.spiceypy.**intmax**()

Return the value of the largest (positive) number representable in a int variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/intmax_c.html

Return type
int

Returns
The largest (positive) number representablein a Int variable.

spiceypy.spiceypy.**intmin**()

Return the value of the smallest (negative) number representable in a SpiceInt variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/intmin_c.html

Return type
int

Returns
The smallest (negative) number representablein a Int variable.

spiceypy.spiceypy.**invert**(*m*)

Generate the inverse of a 3x3 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/invert_c.html

Parameters
m (ndarray) – Matrix to be inverted.

Return type
ndarray

Returns
Inverted matrix (m1)^-1

spiceypy.spiceypy.**invort**(*m*)

Given a matrix, construct the matrix whose rows are the columns of the first divided by the length squared of the the corresponding columns of the input matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/invort_c.html

Parameters
m (ndarray) – A 3x3 Matrix.

Return type
ndarray

Returns
m after transposition and scaling of rows.

spiceypy.spiceypy.**invstm**(*mat*)

Return the inverse of a state transformation matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/invstm_c.html

Parameters
mat (ndarray) – A state transformation matrix.

Return type
ndarray

Returns
The inverse of `mat'.

spiceypy.spiceypy.**irfnam**(*index*)

Return the name of one of the standard inertial reference frames supported by *irfrot()*

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/irfnam.html

Parameters
index (int) – Index of a standard inertial reference frame.

Return type
str

Returns
is the name of the frame.

spiceypy.spiceypy.**irfnum**(*name*)

Return the index of one of the standard inertial reference frames supported by *irfrot()*

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/irfnum.html

Parameters
name (str) – Name of standard inertial reference frame.

Return type
int

Returns
is the index of the frame.

spiceypy.spiceypy.**irfrot**(*refa*, *refb*)

Compute the matrix needed to rotate vectors between two standard inertial reference frames.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/irfrot.html

Parameters

- **refa** (int) – index of first reference frame.
- **refb** (int) – index of second reference frame.

Return type
ndarray

Returns
rotation from frame A to frame B.

spiceypy.spiceypy.**irftrn**(*refa*, *refb*)

Return the matrix that transforms vectors from one specified inertial reference frame to another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/irftrn.html

Parameters

- **refa** (str) – Name of reference frame to transform vectors FROM.
- **refb** (str) – Name of reference frame to transform vectors TO.

Return type
ndarray

Returns
REFA-to-REFB transformation matrix.

spiceypy.spiceypy.**isordv**(*array*, *n*)

Determine whether an array of n items contains the integers 0 through n-1.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/isordv_c.html

Parameters

- **array** (Union[ndarray, Iterable[int]]) – Array of integers.
- **n** (int) – Number of integers in array.

Return type
bool

Returns
The function returns True if the array contains the integers 0 through n-1, otherwise it returns False.

spiceypy.spiceypy.**isrchc**(*value*, *ndim*, *lenvals*, *array*)

Search for a given value within a character string array. Return the index of the first matching array entry, or -1 if the key value was not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/isrchc_c.html

Parameters

- **value** (str) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – Character string array to search.

Return type
int

Returns
The index of the first matching array element or -1 if the value is not found.

spiceypy.spiceypy.**isrchd**(*value*, *ndim*, *array*)

Search for a given value within a double precision array. Return the index of the first matching array entry, or -1 if the key value was not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/isrchd_c.html

Parameters

- **value** (float) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **array** (Union[ndarray, Iterable[float]]) – Double Precision array to search.

Return type
int

Returns
The index of the first matching array element or -1 if the value is not found.

spiceypy.spiceypy.**isrchi**(*value*, *ndim*, *array*)

Search for a given value within an integer array. Return the index of the first matching array entry, or -1 if the key value was not found.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/isrchi_c.html

Parameters

- **value** (int) – Key value to be found in array.
- **ndim** (int) – Dimension of array.
- **array** (Union[ndarray, Iterable[int]]) – Integer array to search.

Return type
int

Returns
The index of the first matching array element or -1 if the value is not found.

spiceypy.spiceypy.**isrot**(*m*, *ntol*, *dtol*)

Indicate whether a 3x3 matrix is a rotation matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/isrot_c.html

Parameters

- **m** (ndarray) – A matrix to be tested.
- **ntol** (float) – Tolerance for the norms of the columns of m.
- **dtol** (float) – Tolerance for the determinant of a matrix whose columns are the unitized columns of m.

Return type
bool

Returns
True if and only if m is a rotation matrix.

spiceypy.spiceypy.**iswhsp**(*string*)

Return a boolean value indicating whether a string contains only white space characters.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/iswhsp_c.html

Parameters
string (str) – String to be tested.

Return type
bool

Returns
the boolean value True if the string is empty or contains only white space characters; otherwise it returns the value False.

spiceypy.spiceypy.**j1900**()

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/j1900_c.html

Return type
float

Returns
Julian Date of 1899 DEC 31 12:00:00

spiceypy.spiceypy.**j1950**()

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/j1950_c.html

Return type
float

Returns
Julian Date of 1950 JAN 01 00:00:00

spiceypy.spiceypy.**j2000**()

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/j2000_c.html

Return type
float

Returns
Julian Date of 2000 JAN 01 12:00:00

spiceypy.spiceypy.**j2100**()

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/j2100_c.html

Return type
float

Returns
Julian Date of 2100 JAN 01 12:00:00

spiceypy.spiceypy.**jyear**()

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/jyear_c.html

Return type
float

Returns
number of seconds in a julian year

spiceypy.spiceypy.**kclear**()

Clear the KEEPER subsystem: unload all kernels, clear the kernel pool, and re-initialize the subsystem. Existing watches on kernel variables are retained.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kclear_c.html

Return type
None

spiceypy.spiceypy.**kdata**(*which*, *kind*, *fillen=256*, *typlen=256*, *srclen=256*)

Return data for the nth kernel that is among a list of specified kernel types.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kdata_c.html

Parameters

- **which** (int) – Index of kernel to fetch from the list of kernels.
- **kind** (str) – The kind of kernel to which fetches are limited.
- **fillen** (int) – Available space in output file string.
- **typlen** (int) – Available space in output kernel type string.
- **srclen** (int) – Available space in output source string.

Return type
Tuple[str, str, str, int, bool]

Returns
The name of the kernel file, The type of the kernel, Name of the source file used to load file, The handle attached to file.

spiceypy.spiceypy.**kepleq**(*ml*, *h*, *k*)

This function solves the equinoctial version of Kepler's equation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/kepleq.html

Parameters

- **ml** (float) – Mean longitude
- **h** (float) – h component of equinoctial elements
- **k** (float) – k component of equinoctial elements

Return type
float

Returns
the value of F such that ML = F + h*COS(F) - k*SIN(F)

spiceypy.spiceypy.**kinfo**(*file*, *typlen=256*, *srclen=256*)

Return information about a loaded kernel specified by name.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kinfo_c.html

Parameters

- **file** (str) – Name of a kernel to fetch information for
- **typlen** (int) – Available space in output kernel type string.
- **srclen** (int) – Available space in output source string.

Return type
Tuple[str, str, int, bool]

Returns
The type of the kernel, Name of the source file used to load file, The handle attached to file.

spiceypy.spiceypy.**kplfrm**(*frmcls*, *out_cell=None*)

Return a SPICE set containing the frame IDs of all reference frames of a given class having specifications in the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kplfrm_c.html

Parameters

- **frmcls** (int) – Frame class.

- **out_cell** (Optional[*SpiceCell*]) – Optional output Spice Int Cell

Return type
SpiceCell

Returns
Set of ID codes of frames of the specified class.

spiceypy.spiceypy.**kpsolv**(*evec*)

This routine solves the equation X = < EVEC, U(X) > where U(X) is the unit vector [Cos(X), SIN(X)] and < , > denotes the two-dimensional dot product.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/kpsolv.html

Parameters
evec (Tuple[float, float]) – A 2-vector whose magnitude is less than 1.

Return type
float

Returns
the value of X such that X = EVEC(1)COS(X) + EVEC(2)SIN(X).

spiceypy.spiceypy.**ktotal**(*kind*)

Return the current number of kernels that have been loaded via the KEEPER interface that are of a specified type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ktotal_c.html

Parameters
kind (str) – A list of kinds of kernels to count.

Return type
int

Returns
The number of kernels of type kind.

spiceypy.spiceypy.**kxtrct**(*keywd*, *terms*, *nterms*, *instring*, *termlen=256*, *stringlen=256*, *substrlen=256*)

Locate a keyword in a string and extract the substring from the beginning of the first word following the keyword to the beginning of the first subsequent recognized terminator of a list.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kxtrct_c.html

Parameters

- **keywd** (str) – Word that marks the beginning of text of interest.
- **terms** (Sequence[str]) – Set of words, any of which marks the end of text.
- **nterms** (int) – Number of terms.
- **instring** (str) – String containing a sequence of words.
- **termlen** (int) – Length of strings in string array term.
- **stringlen** (int) – Available space in argument string.
- **substrlen** (int) – Available space in output substring.

Return type
Tuple[str, str, bool]

Returns
String containing a sequence of words, String from end of keywd to beginning of first terms item found.

spiceypy.spiceypy.**lastnb**(*string*)

Return the zero based index of the last non-blank character in a character string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lastnb_c.html

Parameters
string (str) – Input character string.

Return type
int

Returns

spiceypy.spiceypy.**latcyl**(*radius*, *lon*, *lat*)

Convert from latitudinal coordinates to cylindrical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/latcyl_c.html

Parameters

- **radius** (float) – Distance of a point from the origin.
- **lon** (float) – Angle of the point from the XZ plane in radians.
- **lat** (float) – Angle of the point from the XY plane in radians.

Return type
Tuple[float, float, float]

Returns
(r, lonc, z)

spiceypy.spiceypy.**latrec**(*radius*, *longitude*, *latitude*)

Convert from latitudinal coordinates to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/latrec_c.html

Parameters

- **radius** (float) – Distance of a point from the origin.
- **longitude** (float) – Longitude of point in radians.
- **latitude** (float) – Latitude of point in radians.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**latsph**(*radius*, *lon*, *lat*)

Convert from latitudinal coordinates to spherical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/latsph_c.html

Parameters

- **radius** (float) – Distance of a point from the origin.
- **lon** (float) – Angle of the point from the XZ plane in radians.

- **lat** (float) – Angle of the point from the XY plane in radians.

Return type
Tuple[float, float, float]

Returns
(rho colat, lons)

spiceypy.spiceypy.**latsrf**(*method*, *target*, *et*, *fixref*, *lonlat*)

Map array of planetocentric longitude/latitude coordinate pairs to surface points on a specified target body.

The surface of the target body may be represented by a triaxial ellipsoid or by topographic data provided by DSK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/latsrf_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in TDB seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **lonlat** (Sequence[Sequence[float]]) – Array of longitude/latitude coordinate pairs.

Return type
ndarray

Returns
Array of surface points.

spiceypy.spiceypy.**lcase**(*instr*, *lenout=256*)

Convert the characters in a string to lowercase.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lcase_c.html

Parameters

- **instr** (str) – Input string.
- **lenout** (int) – Maximum length of output string.

Return type
str

Returns
Output string, all lowercase.

spiceypy.spiceypy.**ldpool**(*filename*)

Load the variables contained in a NAIF ASCII kernel file into the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ldpool_c.html

Parameters
filename (str) – Name of the kernel file.

Return type
None

spiceypy.spiceypy.**lgresp**(*first*, *step*, *yvals*, *x*)

Evaluate a Lagrange interpolating polynomial for a specified set of coordinate pairs whose first components are equally spaced, at a specified abscissa value.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lgresp_c.html

Parameters

- **first** (float) – First abscissa value.
- **step** (float) – Step Size.
- **yvals** (ndarray) – Ordinate Values.
- **x** (float) – Point at which to interpolate the polynomial.

Return type
float

Returns
The function returns the value at `x' of the unique polynomial of degree n-1 that fits the points in the plane defined by `first', `step', and `yvals'.

spiceypy.spiceypy.**lgrind**(*xvals*, *yvals*, *x*)

Evaluate a Lagrange interpolating polynomial for a specified set of coordinate pairs, at a specified abscissa value. Return the value of both polynomial and derivative.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lgrind_c.html

Parameters

- **xvals** (Sequence[float]) – Abscissa values.
- **yvals** (Sequence[float]) – Ordinate values.
- **x** (float) – Point at which to interpolate the polynomial.

Return type
Tuple[float, float]

Returns
Polynomial value at x, Polynomial derivative at x.

spiceypy.spiceypy.**lgrint**(*xvals*, *yvals*, *x*)

Evaluate a Lagrange interpolating polynomial for a specified set of coordinate pairs, at a specified abscissa value.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lgrint_c.html

Parameters

- **xvals** (ndarray) – Abscissa values.
- **yvals** (ndarray) – Ordinate values.
- **x** (float) – Point at which to interpolate the polynomial.

Return type
float

Returns
The function returns the value at `x' of the unique polynomial of degree n-1 that fits the points in the plane defined by `xvals' and `yvals'.

spiceypy.spiceypy.**limbpt**(*method*, *target*, *et*, *fixref*, *abcorr*, *corloc*, *obsrvr*, *refvec*, *rolstp*, *ncuts*, *schstp*, *soltol*, *maxn*)

Find limb points on a target body. The limb is the set of points of tangency on the target of rays emanating from the observer. The caller specifies half-planes bounded by the observer-target center vector in which to search for limb points.

The surface of the target body may be represented either by a triaxial ellipsoid or by topographic data.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/limbpt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **corloc** (str) – Aberration correction locus.
- **obsrvr** (str) – Name of observing body.
- **refvec** (Union[ndarray, Iterable[float]]) – Reference vector for cutting half-planes.
- **rolstp** (float) – Roll angular step for cutting half-planes.
- **ncuts** (int) – Number of cutting half-planes.
- **schstp** (float) – Angular step size for searching.
- **soltol** (float) – Solution convergence tolerance.
- **maxn** (int) – Maximum number of entries in output arrays.

Return type
Tuple[ndarray, ndarray, ndarray, ndarray]

Returns
Counts of limb points corresponding to cuts, Limb points, Times associated with limb points, Tangent vectors emanating from the observer

spiceypy.spiceypy.**lmpool**(*cvals*)

Load the variables contained in an internal buffer into the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lmpool_c.html

Parameters
cvals (Union[ndarray, Iterable[str]]) – list of strings.

Return type
None

spiceypy.spiceypy.**lparse**(*inlist*, *delim*, *nmax*)

Parse a list of items delimited by a single character.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lparse_c.html

Parameters

- **inlist** (str) – list of items delimited by delim.
- **delim** (str) – Single character used to delimit items.

- **nmax** (int) – Maximum number of items to return.

Return type
Iterable[str]

Returns
Items in the list, left justified.

spiceypy.spiceypy.**lparsm**(*inlist*, *delims*, *nmax*, *lenout=None*)

Parse a list of items separated by multiple delimiters.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lparsm_c.html

Parameters

- **inlist** (str) – list of items delimited by delims.
- **delims** (str) – Single characters which delimit items.
- **nmax** (int) – Maximum number of items to return.
- **lenout** (Optional[int]) – Optional Length of strings in item array.

Return type
Iterable[str]

Returns
Items in the list, left justified.

spiceypy.spiceypy.**lparss**(*inlist*, *delims*, *nmax=20*, *length=50*)

Parse a list of items separated by multiple delimiters, placing the resulting items into a set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lparss_c.html

Parameters

- **inlist** (str) – list of items delimited by delims.
- **delims** (str) – Single characters which delimit items.
- **nmax** (int) – Optional nmax of spice set.
- **length** (int) – Optional length of strings in spice set

Return type
SpiceCell

Returns
Set containing items in the list, left justified.

spiceypy.spiceypy.**lspcn**(*body*, *et*, *abcorr*)

Compute L_s, the planetocentric longitude of the sun, as seen from a specified body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lspcn_c.html

Parameters

- **body** (str) – Name of central body.
- **et** (float) – Epoch in seconds past J2000 TDB.
- **abcorr** (str) – Aberration correction.

Return type
float

Returns
planetocentric longitude of the sun

spiceypy.spiceypy.**lstlec**(*string*, *n*, *lenvals*, *array*)

Given a character string and an ordered array of character strings, find the index of the largest array element less than or equal to the given string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstlec_c.html

Parameters

- **string** (str) – Upper bound value to search against.
- **n** (int) – Number elements in array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – Array of possible lower bounds.

Return type
int

Returns
index of the last element of array that is lexically less than or equal to string.

spiceypy.spiceypy.**lstled**(*x*, *n*, *array*)

Given a number x and an array of non-decreasing floats find the index of the largest array element less than or equal to x.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstled_c.html

Parameters

- **x** (float) – Value to search against.
- **n** (int) – Number elements in array.
- **array** (Union[ndarray, Iterable[float]]) – Array of possible lower bounds

Return type
int

Returns
index of the last element of array that is less than or equal to x.

spiceypy.spiceypy.**lstlei**(*x*, *n*, *array*)

Given a number x and an array of non-decreasing ints, find the index of the largest array element less than or equal to x.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstlei_c.html

Parameters

- **x** (int) – Value to search against.
- **n** (int) – Number elements in array.
- **array** (Union[ndarray, Iterable[int]]) – Array of possible lower bounds

Return type
int

Returns
index of the last element of array that is less than or equal to x.

spiceypy.spiceypy.**lstltc**(*string*, *n*, *lenvals*, *array*)

Given a character string and an ordered array of character strings, find the index of the largest array element less than the given string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstltc_c.html

Parameters

- **string** (str) – Upper bound value to search against.
- **n** (int) – Number elements in array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – Array of possible lower bounds

Return type
int

Returns
index of the last element of array that is lexically less than string.

spiceypy.spiceypy.**lstltd**(*x*, *n*, *array*)

Given a number x and an array of non-decreasing floats find the index of the largest array element less than x.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstltd_c.html

Parameters

- **x** (float) – Value to search against
- **n** (int) – Number elements in array
- **array** (Union[ndarray, Iterable[float]]) – Array of possible lower bounds

Return type
int

Returns
index of the last element of array that is less than x.

spiceypy.spiceypy.**lstlti**(*x*, *n*, *array*)

Given a number x and an array of non-decreasing int, find the index of the largest array element less than x.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lstlti_c.html

Parameters

- **x** (int) – Value to search against
- **n** (int) – Number elements in array
- **array** (Union[ndarray, Iterable[int]]) – Array of possible lower bounds

Return type
int

Returns
index of the last element of array that is less than x.

spiceypy.spiceypy.**ltime**(*etobs*, *obs*, *direct*, *targ*)

This routine computes the transmit (or receive) time of a signal at a specified target, given the receive (or transmit) time at a specified observer. The elapsed time between transmit and receive is also returned.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ltime_c.html

Parameters

- **etobs** (float) – Epoch of a signal at some observer
- **obs** (int) – NAIF ID of some observer
- **direct** (str) – Direction the signal travels ("->" or "<-")
- **targ** (int) – NAIF ID of the target object

Return type
Tuple[float, float]

Returns
epoch and time

spiceypy.spiceypy.**lx4dec**(*string*, *first*)

Scan a string from a specified starting position for the end of a decimal number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lx4dec_c.html

Parameters

- **string** (str) – Any character string.
- **first** (int) – First character to scan from in string.

Return type
Tuple[int, int]

Returns
last and nchar

spiceypy.spiceypy.**lx4num**(*string*, *first*)

Scan a string from a specified starting position for the end of a number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lx4num_c.html

Parameters

- **string** (str) – Any character string.
- **first** (int) – First character to scan from in string.

Return type
Tuple[int, int]

Returns
last and nchar

spiceypy.spiceypy.**lx4sgn**(*string*, *first*)

Scan a string from a specified starting position for the end of a signed integer.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lx4sgn_c.html

Parameters

- **string** (str) – Any character string.
- **first** (int) – First character to scan from in string.

Return type
Tuple[int, int]

Returns
last and nchar

spiceypy.spiceypy.**lx4uns**(*string*, *first*)

Scan a string from a specified starting position for the end of an unsigned integer.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lx4uns_c.html

Parameters

- **string** (str) – Any character string.
- **first** (int) – First character to scan from in string.

Return type
Tuple[int, int]

Returns
last and nchar

spiceypy.spiceypy.**lxqstr**(*string*, *qchar*, *first*)

Lex (scan) a quoted string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/lxqstr_c.html

Parameters

- **string** (str) – String to be scanned.
- **qchar** (str) – Quote delimiter character.
- **first** (int) – Character position at which to start scanning.

Return type
Tuple[int, int]

Returns
last and nchar

spiceypy.spiceypy.**m2eul**(*r*, *axis3*, *axis2*, *axis1*)

Factor a rotation matrix as a product of three rotations about specified coordinate axes.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/m2eul_c.html

Parameters

- **r** (Union[ndarray, Iterable[Iterable[float]]]) – A rotation matrix to be factored
- **axis3** (int) – third rotation axes.
- **axis2** (int) – second rotation axes.
- **axis1** (int) – first rotation axes.

Return type
Tuple[float, float, float]

Returns
Third, second, and first Euler angles, in radians.

spiceypy.spiceypy.**m2q**(*r*)

Find a unit quaternion corresponding to a specified rotation matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/m2q_c.html

Parameters
r (ndarray) – A rotation matrix to be factored

Return type
ndarray

Returns
A unit quaternion representing the rotation matrix

spiceypy.spiceypy.**matchi**(*string*, *templ*, *wstr*, *wchr*)

Determine whether a string is matched by a template containing wild cards. The pattern comparison is case-insensitive.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/matchi_c.html

Parameters

- **string** (str) – String to be tested.
- **templ** (str) – Template (with wild cards) to test against string.
- **wstr** (str) – Wild string token.
- **wchr** (str) – Wild character token.

Return type
bool

Returns
The function returns True if string matches templ, else False

spiceypy.spiceypy.**matchw**(*string*, *templ*, *wstr*, *wchr*)

Determine whether a string is matched by a template containing wild cards.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/matchw_c.html

Parameters

- **string** (str) – String to be tested.
- **templ** (str) – Template (with wild cards) to test against string.
- **wstr** (str) – Wild string token.
- **wchr** (str) – Wild character token.

Return type
bool

Returns
The function returns True if string matches templ, else False

spiceypy.spiceypy.**mequ**(*m1*)

Set one double precision 3x3 matrix equal to another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mequ_c.html

Parameters
m1 (ndarray) – input matrix.

Return type
ndarray

Returns
Output matrix equal to m1.

spiceypy.spiceypy.**mequg**(*m1*, *nr*, *nc*)

Set one double precision matrix of arbitrary size equal to another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mequg_c.html

Parameters

- **m1** (ndarray) – Input matrix.
- **nr** (int) – Row dimension of m1.
- **nc** (int) – Column dimension of m1.

Return type
ndarray

Returns
Output matrix equal to m1

spiceypy.spiceypy.**mtxm**(*m1*, *m2*)

Multiply the transpose of a 3x3 matrix and a 3x3 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mtxm_c.html

Parameters

- **m1** (ndarray) – 3x3 double precision matrix.
- **m2** (ndarray) – 3x3 double precision matrix.

Return type
ndarray

Returns
The produce m1 transpose times m2.

spiceypy.spiceypy.**mtxmg**(*m1*, *m2*)

Multiply the transpose of a matrix with another matrix, both of arbitrary size.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mtxmg_c.html

Parameters

- **m1** (ndarray) – N x M double precision matrix.
- **m2** (ndarray) – N x O double precision matrix.
- **ncol1** – Column dimension of m1 and row dimension of mout.
- **nr1r2** – Row dimension of m1 and m2.
- **ncol2** – Column dimension of m2.

Return type
ndarray

Returns
Transpose of m1 times m2 (O x M).

spiceypy.spiceypy.**mtxv**(*m1*, *vin*)

Multiplies the transpose of a 3x3 matrix on the left with a vector on the right.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mtxv_c.html

Parameters

- **m1** (ndarray) – 3x3 double precision matrix.
- **vin** (ndarray) – 3-dimensional double precision vector.

Return type
ndarray

Returns
3-dimensional double precision vector.

spiceypy.spiceypy.**mtxvg**(*m1*, *v2*)

Multiply the transpose of a matrix and a vector of arbitrary size.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mtxvg_c.html

Parameters

- **m1** (ndarray) – Left-hand matrix to be multiplied.
- **v2** (ndarray) – Right-hand vector to be multiplied.

Return type
ndarray

Returns
Product vector m1 transpose * v2.

spiceypy.spiceypy.**mxm**(*m1*, *m2*)

Multiply two 3x3 matrices.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxm_c.html

Parameters

- **m1** (Union[ndarray, Iterable[Iterable[float]]]) – 3x3 double precision matrix.
- **m2** (Union[ndarray, Iterable[Iterable[float]]]) – 3x3 double precision matrix.

Return type
ndarray

Returns
3x3 double precision matrix.

spiceypy.spiceypy.**mxmg**(*m1*, *m2*)

Multiply two double precision matrices of arbitrary size.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxmg_c.html

Parameters

- **m1** (Union[ndarray, Iterable[Iterable[float]]]) – nrow1 X ncol1 double precision matrix.
- **m2** (Union[ndarray, Iterable[Iterable[float]]]) – ncol1 X ncol2 double precision matrix.

Return type
ndarray

Returns
nrow1 X ncol2 double precision matrix.

spiceypy.spiceypy.**mxmt**(*m1*, *m2*)

Multiply a 3x3 matrix and the transpose of another 3x3 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxmt_c.html

Parameters

- **m1** (Union[ndarray, Iterable[Iterable[float]]]) – 3x3 double precision matrix.
- **m2** (Union[ndarray, Iterable[Iterable[float]]]) – 3x3 double precision matrix.

Return type
ndarray

Returns
The product m1 times m2 transpose.

spiceypy.spiceypy.**mxmtg**(*m1*, *m2*)

Multiply a matrix and the transpose of a matrix, both of arbitrary size.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxmtg_c.html

Parameters

- **m1** (Union[ndarray, Iterable[Iterable[float]]]) – Left-hand matrix to be multiplied.
- **m2** (Union[ndarray, Iterable[Iterable[float]]]) – Right-hand matrix whose transpose is to be multiplied

Return type
ndarray

Returns
Product matrix.

spiceypy.spiceypy.**mxv**(*m1*, *vin*)

Multiply a 3x3 double precision matrix with a 3-dimensional double precision vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxv_c.html

Parameters

- **m1** (ndarray) – 3x3 double precision matrix.
- **vin** (ndarray) – 3-dimensional double precision vector.

Return type
ndarray

Returns
3-dimensional double precision vector.

spiceypy.spiceypy.**mxvg**(*m1*, *v2*)

Multiply a matrix and a vector of arbitrary size.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxvg_c.html

Parameters

- **m1** (Union[ndarray, Iterable[Iterable[float]]]) – Left-hand matrix to be multiplied.
- **v2** (Union[ndarray, Iterable[Iterable[float]]]) – Right-hand vector to be multiplied.

Return type
ndarray

Returns
Product vector m1*v2

spiceypy.spiceypy.**namfrm**(*frname*)

Look up the frame ID code associated with a string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/namfrm_c.html

Parameters
frname (str) – The name of some reference frame.

Return type
int

Returns
The SPICE ID code of the frame.

spiceypy.spiceypy.**ncpos**(*string*, *chars*, *start*)

Find the first occurrence in a string of a character NOT belonging to a collection of characters, starting at a specified location searching forward.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ncpos_c.html

Parameters

- **string** (str) – Any character string.
- **chars** (str) – A collection of characters.
- **start** (int) – Position to begin looking for one not in chars.

Return type
int

Returns
index

spiceypy.spiceypy.**ncposr**(*string*, *chars*, *start*)

Find the first occurrence in a string of a character NOT belonging to a collection of characters, starting at a specified location, searching in reverse.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ncposr_c.html

Parameters

- **string** (str) – Any character string.
- **chars** (str) – A collection of characters.
- **start** (int) – Position to begin looking for one of chars.

Return type
int

Returns
index

spiceypy.spiceypy.**nearpt**(*positn*, *a*, *b*, *c*)

locates the point on the surface of an ellipsoid that is nearest to a specified position. It also returns the altitude of the position above the ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/nearpt_c.html

Parameters

- **positn** (Union[ndarray, Iterable[float]]) – Position of a point in bodyfixed frame.
- **a** (float) – Length of semi-axis parallel to x-axis.
- **b** (float) – Length of semi-axis parallel to y-axis.
- **c** (float) – Length on semi-axis parallel to z-axis.

Return type
Tuple[ndarray, float]

Returns
Point on the ellipsoid closest to positn, Altitude of positn above the ellipsoid.

spiceypy.spiceypy.**no_found_check**()

Temporarily disables spiceypy default behavior which raises exceptions for false found flags for certain spice functions. All spice functions executed within the context manager will no longer check the found flag return parameter and the found flag will be included in the return for the given function. For Example bodc2n in spiceypy is normally called like:

```
name = spice.bodc2n(399)
```

With the possibility that an exception is thrown in the even of a invalid ID:

```
name = spice.bodc2n(-999991) # throws a SpiceyError
```

With this function however, we can use it as a context manager to do this:

```
with spice.no_found_check():
    name, found = spice.bodc2n(-999991) # found is false, no exception raised!
```

Within the context any spice functions called that normally check the found flags will pass through the check without raising an exception if they are false.

Return type
Iterator[None]

spiceypy.spiceypy.**npedln**(*a*, *b*, *c*, *linept*, *linedr*)

Find nearest point on a triaxial ellipsoid to a specified line and the distance from the ellipsoid to the line.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/npedln_c.html

Parameters

- **a** (float) – Length of ellipsoid's semi-axis in the x direction
- **b** (float) – Length of ellipsoid's semi-axis in the y direction
- **c** (float) – Length of ellipsoid's semi-axis in the z direction
- **linept** (Union[ndarray, Iterable[float]]) – Length of ellipsoid's semi-axis in the z direction
- **linedr** (Union[ndarray, Iterable[float]]) – Direction vector of line

Return type
Tuple[ndarray, float]

Returns
Nearest point on ellipsoid to line, Distance of ellipsoid from line

spiceypy.spiceypy.**npelpt**(*point*, *ellips*)

Find the nearest point on an ellipse to a specified point, both in three-dimensional space, and find the distance between the ellipse and the point. https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/npelpt_c.html

Parameters

- **point** (Union[ndarray, Iterable[float]]) – Point whose distance to an ellipse is to be found.
- **ellips** (*Ellipse*) – An ellipse.

Return type
Tuple[ndarray, float]

Returns
Nearest point on ellipsoid to line, Distance of ellipsoid from line

spiceypy.spiceypy.**nplnpt**(*linpt*, *lindir*, *point*)

Find the nearest point on a line to a specified point, and find the distance between the two points.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/nplnpt_c.html

Parameters

- **linpt** (Union[ndarray, Iterable[float]]) – Point on a line
- **lindir** (Union[ndarray, Iterable[float]]) – line's direction vector
- **point** (Union[ndarray, Iterable[float]]) – A second point.

Return type
Tuple[ndarray, float]

Returns
Nearest point on the line to point, Distance between point and pnear

spiceypy.spiceypy.**nvc2pl**(*normal*, *constant*)

Make a plane from a normal vector and a constant.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/nvc2pl_c.html

Parameters

- **normal** (Iterable[float]) – A normal vector defining a plane.
- **constant** (float) – A constant defining a plane.

Return type
Plane

Returns
plane

spiceypy.spiceypy.**nvp2pl**(*normal*, *point*)

Make a plane from a normal vector and a point.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/nvp2pl_c.html

Parameters

- **normal** (Union[ndarray, Iterable[float]]) – A normal vector defining a plane.
- **point** (Union[ndarray, Iterable[float]]) – A point defining a plane.

Return type
Plane

Returns
plane

spiceypy.spiceypy.**occult**(*target1*, *shape1*, *frame1*, *target2*, *shape2*, *frame2*, *abcorr*, *observer*, *et*)

Determines the occultation condition (not occulted, partially, etc.) of one target relative to another target as seen by an observer at a given time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/occult_c.html

Parameters

- **target1** (str) – Name or ID of first target.
- **shape1** (str) – Type of shape model used for first target.
- **frame1** (str) – Body-fixed, body-centered frame for first body.
- **target2** (str) – Name or ID of second target.
- **shape2** (str) – Type of shape model used for second target.
- **frame2** (str) – Body-fixed, body-centered frame for second body.
- **abcorr** (str) – Aberration correction flag.
- **observer** (str) – Name or ID of the observer.
- **et** (float) – Time of the observation (seconds past J2000).

Return type
int

Returns
Occultation identification code.

spiceypy.spiceypy.**ordc**(*item*, *inset*)

The function returns the ordinal position of any given item in a character set. If the item does not appear in the set, the function returns -1.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ordc_c.html

Parameters

- **item** (str) – An item to locate within a set.
- **inset** (*SpiceCell*) – A set to search for a given item.

Return type
int

Returns
the ordinal position of item within the set

spiceypy.spiceypy.**ordd**(*item*, *inset*)

The function returns the ordinal position of any given item in a double precision set. If the item does not appear in the set, the function returns -1.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ordd_c.html

Parameters

- **item** (float) – An item to locate within a set.
- **inset** (*SpiceCell*) – A set to search for a given item.

Return type
int

Returns
the ordinal position of item within the set

spiceypy.spiceypy.**orderc**(*array*, *ndim=None*)

Determine the order of elements in an array of character strings.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/orderc_c.html

Parameters

- **array** (Sequence[str]) – Input array.
- **ndim** (Optional[int]) – Optional Length of input array

Return type
ndarray

Returns
Order vector for array.

spiceypy.spiceypy.**orderd**(*array*, *ndim=None*)

Determine the order of elements in a double precision array.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/orderd_c.html

Parameters

- **array** (Sequence[float]) – Input array.
- **ndim** (Optional[int]) – Optional Length of input array

Return type
ndarray

Returns
Order vector for array.

spiceypy.spiceypy.**orderi**(*array*, *ndim=None*)

Determine the order of elements in an integer array.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/orderi_c.html

Parameters

- **array** (Sequence[int]) – Input array.
- **ndim** (Optional[int]) – Optional Length of input array

Return type
ndarray

Returns
Order vector for array.

spiceypy.spiceypy.**ordi**(*item*, *inset*)

The function returns the ordinal position of any given item in an integer set. If the item does not appear in the set, the function returns -1.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ordi_c.html

Parameters

- **item** (int) – An item to locate within a set.
- **inset** (*SpiceCell*) – A set to search for a given item.

Return type
int

Returns
the ordinal position of item within the set

spiceypy.spiceypy.**oscelt**(*state*, *et*, *mu*)

Determine the set of osculating conic orbital elements that corresponds to the state (position, velocity) of a body at some epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/oscelt_c.html

Parameters

- **state** (ndarray) – State of body at epoch of elements.
- **et** (float) – Epoch of elements.
- **mu** (Union[float, int]) – Gravitational parameter (GM) of primary body.

Return type
ndarray

Returns
Equivalent conic elements

spiceypy.spiceypy.**oscltx**(*state*, *et*, *mu*)

Determine the set of osculating conic orbital elements that corresponds to the state (position, velocity) of a body at some epoch. In additional to the classical elements, return the true anomaly, semi-major axis, and period, if applicable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/oscltx_c.html

Parameters

- **state** (ndarray) – State of body at epoch of elements.
- **et** (float) – Epoch of elements.
- **mu** (int) – Gravitational parameter (GM) of primary body.

Return type
ndarray

Returns
Extended set of classical conic elements.

spiceypy.spiceypy.**pckcls**(*handle*)

Close an open PCK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckcls_c.html

Parameters
handle (int) – Handle of the PCK file to be closed.

Return type
None

spiceypy.spiceypy.**pckcov**(*pck*, *idcode*, *cover*)

Find the coverage window for a specified reference frame in a specified binary PCK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckcov_c.html

Parameters

- **pck** (str) – Name of PCK file.
- **idcode** (int) – Class ID code of PCK reference frame.
- **cover** (*SpiceCell*) – Window giving coverage in pck for idcode.

Return type
None

spiceypy.spiceypy.**pckfrm**(*pck*, *ids*)

Find the set of reference frame class ID codes of all frames in a specified binary PCK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckfrm_c.html

Parameters

- **pck** (str) – Name of PCK file.
- **ids** (*SpiceCell*) – Set of frame class ID codes of frames in PCK file.

Return type
None

spiceypy.spiceypy.**pcklof**(*filename*)

Load a binary PCK file for use by the readers. Return the handle of the loaded file which is used by other PCK routines to refer to the file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pcklof_c.html

Parameters
filename (str) – Name of the file to be loaded.

Return type
int

Returns
Loaded file's handle.

spiceypy.spiceypy.**pckopn**(*name*, *ifname*, *ncomch*)

Create a new PCK file, returning the handle of the opened file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckopn_c.html

Parameters

- **name** (str) – The name of the PCK file to be opened.
- **ifname** (str) – The internal filename for the PCK.
- **ncomch** (int) – The number of characters to reserve for comments.

Return type
int

Returns
The handle of the opened PCK file.

spiceypy.spiceypy.**pckuof**(*handle*)

Unload a binary PCK file so that it will no longer be searched by the readers.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckuof_c.html

Parameters
handle (int) – Handle of PCK file to be unloaded

Return type
None

spiceypy.spiceypy.**pckw02**(*handle*, *classid*, *frname*, *first*, *last*, *segid*, *intlen*, *n*, *polydg*, *cdata*, *btime*)

Write a type 2 segment to a PCK binary file given the file handle, frame class ID, base frame, time range covered by the segment, and the Chebyshev polynomial coefficients.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pckw02_c.html

Parameters

- **handle** (int) – Handle of binary PCK file open for writing.
- **classid** (int) – Frame class ID of body-fixed frame.
- **frname** (str) – Name of base reference frame.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **intlen** (float) – Length of time covered by logical record.
- **n** (int) – Number of logical records in segment.
- **polydg** (int) – Chebyshev polynomial degree.
- **cdata** (Union[ndarray, Iterable[float]]) – Array of Chebyshev coefficients.
- **btime** (float) – Begin time of first logical record.

Return type
None

spiceypy.spiceypy.**pcpool**(*name*, *cvals*)

This entry point provides toolkit programmers a method for programmatically inserting character data into the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pcpool_c.html

Parameters

- **name** (str) – The kernel pool name to associate with cvals.
- **cvals** (Sequence[str]) – An array of strings to insert into the kernel pool.

Return type
None

spiceypy.spiceypy.**pdpool**(*name*, *dvals*)

This entry point provides toolkit programmers a method for programmatically inserting double precision data into the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pdpool_c.html

Parameters

- **name** (str) – The kernel pool name to associate with dvals.
- **dvals** (Union[ndarray, Iterable[float]]) – An array of values to insert into the kernel pool.

Return type
None

spiceypy.spiceypy.**pgrrec**(*body*, *lon*, *lat*, *alt*, *re*, *f*)

Convert planetographic coordinates to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pgrrec_c.html

Parameters

- **body** (str) – Body with which coordinate system is associated.
- **lon** (float) – Planetographic longitude of a point (radians).
- **lat** (float) – Planetographic latitude of a point (radians).
- **alt** (int) – Altitude of a point above reference spheroid.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**phaseq**(*et*, *target*, *illmn*, *obsrvr*, *abcorr*)

Compute the apparent phase angle for a target, observer, illuminator set of ephemeris objects.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/phaseq_c.html

Parameters

- **et** (float) – Ephemeris seconds past J2000 TDB.
- **target** (str) – Target body name.
- **illmn** (str) – Illuminating body name.
- **obsrvr** (str) – Observer body.
- **abcorr** (str) – Aberration correction flag.

Return type
float

Returns
Value of phase angle.

spiceypy.spiceypy.**pi**()

Return the value of pi (the ratio of the circumference of a circle to its diameter).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pi_c.html

Return type
float

Returns
value of pi.

spiceypy.spiceypy.**pipool**(*name*, *ivals*)

This entry point provides toolkit programmers a method for programmatically inserting integer data into the kernel pool.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pipool_c.html

Parameters

- **name** (str) – The kernel pool name to associate with values.
- **ivals** (ndarray) – An array of integers to insert into the pool.

Return type
None

spiceypy.spiceypy.**pjelpl**(*elin*, *plane*)

Project an ellipse onto a plane, orthogonally.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pjelpl_c.html

Parameters

- **elin** (*Ellipse*) – A SPICE ellipse to be projected.
- **plane** (*Plane*) – A plane onto which elin is to be projected.

Return type
Ellipse

Returns
A SPICE ellipse resulting from the projection.

spiceypy.spiceypy.**pl2nvc**(*plane*)

Return a unit normal vector and constant that define a specified plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pl2nvc_c.html

Parameters
plane (*Plane*) – A SPICE plane.

Return type
Tuple[ndarray, float]

Returns
A normal vector and constant defining the geometric plane represented by plane.

spiceypy.spiceypy.**pl2nvp**(*plane*)

Return a unit normal vector and point that define a specified plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pl2nvp_c.html

Parameters
plane (*Plane*) – A SPICE plane.

Return type
Tuple[ndarray, ndarray]

Returns
A unit normal vector and point that define plane.

spiceypy.spiceypy.**pl2psv**(*plane*)

Return a point and two orthogonal spanning vectors that generate a specified plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pl2psv_c.html

Parameters
plane (*Plane*) – A SPICE plane.

Return type
Tuple[ndarray, ndarray, ndarray]

Returns
A point in the input plane and two vectors spanning the input plane.

spiceypy.spiceypy.**pltar**(*vrtces*, *plates*)

Compute the total area of a collection of triangular plates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pltar_c.html

Parameters

- **vrtces** (Sequence[Iterable[float]]) – Array of vertices.
- **plates** (Sequence[Iterable[int]]) – Array of plates.

Return type
float

Returns
total area of the set of plates

spiceypy.spiceypy.**pltexp**(*iverts*, *delta*)

Expand a triangular plate by a specified amount. The expanded plate is co-planar with, and has the same orientation as, the original. The centroids of the two plates coincide.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pltexp_c.html

Parameters

- **iverts** (Iterable[Iterable[float]]) – Vertices of the plate to be expanded.
- **delta** (float) – Fraction by which the plate is to be expanded.

Return type
ndarray

Returns
Vertices of the expanded plate.

spiceypy.spiceypy.**pltnp**(*point*, *v1*, *v2*, *v3*)

Find the nearest point on a triangular plate to a given point.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pltnp_c.html

Parameters

- **point** (Union[ndarray, Iterable[float]]) – A point in 3-dimensional space.
- **v1** (Union[ndarray, Iterable[float]]) – Vertices of a triangular plate.
- **v2** (Union[ndarray, Iterable[float]]) – Vertices of a triangular plate.
- **v3** (Union[ndarray, Iterable[float]]) – Vertices of a triangular plate.

Return type
Tuple[ndarray, float]

Returns
the nearest point on a triangular plate to a given point and distance

spiceypy.spiceypy.**pltnrm**(*v1*, *v2*, *v3*)

Compute an outward normal vector of a triangular plate. The vector does not necessarily have unit length.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pltnrm_c.html

Parameters

- **v1** (Iterable[float]) – Vertices of a plate.
- **v2** (Union[ndarray, Iterable[float]]) – Vertices of a plate.

- **v3** (Iterable[float]) – Vertices of a plate.

Return type
ndarray

Returns
Plate's outward normal vector.

spiceypy.spiceypy.**pltvol**(*vrtces*, *plates*)

Compute the volume of a three-dimensional region bounded by a collection of triangular plates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pltvol_c.html

Parameters

- **vrtces** (Sequence[Iterable[float]]) – Array of vertices.
- **plates** (Sequence[Iterable[int]]) – Array of plates.

Return type
float

Returns
the volume of the spatial region bounded by the plates.

spiceypy.spiceypy.**polyds**(*coeffs*, *deg*, *nderiv*, *t*)

Compute the value of a polynomial and it's first n derivatives at the value t.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/polyds_c.html

Parameters

- **coeffs** (Union[ndarray, Iterable[float]]) – Coefficients of the polynomial to be evaluated.
- **deg** (int) – Degree of the polynomial to be evaluated.
- **nderiv** (int) – Number of derivatives to compute.
- **t** (int) – Point to evaluate the polynomial and derivatives

Return type
ndarray

Returns
Value of polynomial and derivatives.

spiceypy.spiceypy.**pos**(*string*, *substr*, *start*)

Find the first occurrence in a string of a substring, starting at a specified location, searching forward.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pos_c.html

Parameters

- **string** (str) – Any character string.
- **substr** (str) – Substring to locate in the character string.
- **start** (int) – Position to begin looking for substr in string.

Return type
int

Returns
The index of the first occurrence of substr in string at or following index start.

spiceypy.spiceypy.**posr**(*string*, *substr*, *start*)

Find the first occurrence in a string of a substring, starting at a specified location, searching backward.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/posr_c.html

Parameters

- **string** (str) – Any character string.
- **substr** (str) – Substring to locate in the character string.
- **start** (int) – Position to begin looking for substr in string.

Return type
int

Returns
The index of the last occurrence of substr in string at or preceding index start.

spiceypy.spiceypy.**prop2b**(*gm*, *pvinit*, *dt*)

Given a central mass and the state of massless body at time t_0, this routine determines the state as predicted by a two-body force model at time t_0 + dt.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/prop2b_c.html

Parameters

- **gm** (float) – Gravity of the central mass.
- **pvinit** (ndarray) – Initial state from which to propagate a state.
- **dt** (float) – Time offset from initial state to propagate to.

Return type
ndarray

Returns
The propagated state.

spiceypy.spiceypy.**prsdp**(*string*)

Parse a string as a double precision number, encapsulating error handling.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/prsdp_c.html

Parameters
string (str) – String representing a d.p. number.

Return type
float

Returns
D.p. value obtained by parsing string.

spiceypy.spiceypy.**prsint**(*string*)

Parse a string as an integer, encapsulating error handling.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/prsint_c.html

Parameters
string (str) – String representing an integer.

Return type
int

Returns
Integer value obtained by parsing string.

spiceypy.spiceypy.**psv2pl**(*point*, *span1*, *span2*)

Make a CSPICE plane from a point and two spanning vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/psv2pl_c.html

Parameters

- **point** (ndarray) – A Point.
- **span1** (ndarray) – First Spanning vector.
- **span2** (ndarray) – Second Spanning vector.

Return type
Plane

Returns
A SPICE plane.

spiceypy.spiceypy.**pxform**(*fromstr*, *tostr*, *et*)

Return the matrix that transforms position vectors from one specified frame to another at a specified epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pxform_c.html

Parameters

- **fromstr** (str) – Name of the frame to transform from.
- **tostr** (str) – Name of the frame to transform to.
- **et** (float) – Epoch of the rotation matrix.

Return type
ndarray

Returns
A rotation matrix.

spiceypy.spiceypy.**pxfrm2**(*frame_from*, *frame_to*, *etfrom*, *etto*)

Return the 3x3 matrix that transforms position vectors from one specified frame at a specified epoch to another specified frame at another specified epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pxfrm2_c.html

Parameters

- **frame_from** (str) – Name of the frame to transform from.
- **frame_to** (str) – Name of the frame to transform to.
- **etfrom** (float) – Evaluation time of frame_from.
- **etto** (float) – Evaluation time of frame_to.

Return type
ndarray

Returns
A position transformation matrix from frame_from to frame_to

spiceypy.spiceypy.**q2m**(*q*)

Find the rotation matrix corresponding to a specified unit quaternion.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/q2m_c.html

Parameters
q (ndarray) – A unit quaternion.

Return type
ndarray

Returns
A rotation matrix corresponding to q

spiceypy.spiceypy.**qcktrc**(*tracelen=256*)

Return a string containing a traceback.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/qcktrc_c.html

Parameters
tracelen (int) – Maximum length of output traceback string.

Return type
str

Returns
A traceback string.

spiceypy.spiceypy.**qderiv**(*f0*, *f2*, *delta*)

Estimate the derivative of a function by finding the derivative of a quadratic approximating function. This derivative estimate is equivalent to that found by computing the average of forward and backward differences.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/qderiv_c.html

Parameters

- **f0** (ndarray) – Function values at left endpoint.
- **f2** (ndarray) – Function values at right endpoint.
- **delta** (float) – Separation of abscissa points.

Return type
ndarray

Returns
Derivative vector.

spiceypy.spiceypy.**qdq2av**(*q*, *dq*)

Derive angular velocity from a unit quaternion and its derivative with respect to time.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/qdq2av_c.html

Parameters

- **q** (ndarray) – Unit SPICE quaternion.
- **dq** (Union[ndarray, Iterable[float]]) – Derivative of q with respect to time

Return type
ndarray

Returns
Angular velocity defined by q and dq.

spiceypy.spiceypy.**qxq**(*q1*, *q2*)

Multiply two quaternions.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/qxq_c.html

Parameters

- **q1** (Union[ndarray, Iterable[float]]) – First SPICE quaternion.

- **q2** (Union[ndarray, Iterable[float]]) – Second SPICE quaternion.

Return type
ndarray

Returns
Product of q1 and q2.

spiceypy.spiceypy.**radrec**(*inrange*, *re*, *dec*)

Convert from range, right ascension, and declination to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/radrec_c.html

Parameters

- **inrange** (float) – Distance of a point from the origin.
- **re** (float) – Right ascension of point in radians.
- **dec** (float) – Declination of point in radians.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**rav2xf**(*rot*, *av*)

This routine determines a state transformation matrix from a rotation matrix and the angular velocity of the rotation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rav2xf_c.html

Parameters

- **rot** (Union[ndarray, Iterable[Iterable[float]]]) – Rotation matrix.
- **av** (Union[ndarray, Iterable[float]]) – Angular velocity vector.

Return type
ndarray

Returns
State transformation associated with rot and av.

spiceypy.spiceypy.**raxisa**(*matrix*)

Compute the axis of the rotation given by an input matrix and the angle of the rotation about that axis.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/raxisa_c.html

Parameters
matrix (ndarray) – Rotation matrix.

Return type
Tuple[ndarray, float]

Returns
Axis of the rotation, Angle through which the rotation is performed

spiceypy.spiceypy.**rdtext**(*file*, *lenout=256*)

Read the next line of text from a text file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rdtext_c.html

Parameters

- **file** (str) – Name of text file.
- **lenout** (int) – Available room in output line.

Return type
Tuple[str, bool]

Returns
Next line from the text file, End-of-file indicator

spiceypy.spiceypy.**recazl**(*rectan*, *azccw*, *elplsz*)

Convert rectangular coordinates of a point to range, azimuth and elevation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recazl_c.html

Parameters

- **rectan** (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.
- **azccw** (bool) – Flag indicating how Azimuth is measured.
- **elplsz** (bool) – Flag indicating how Elevation is measured.

Return type
Tuple[float, float, float]

Returns
Distance of the point from the origin, Azimuth in radians, Elevation in radians.

spiceypy.spiceypy.**reccyl**(*rectan*)

Convert from rectangular to cylindrical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reccyl_c.html

Parameters
rectan (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.

Return type
Tuple[float, float, float]

Returns
Distance from z axis, Angle (radians) from xZ plane, Height above xY plane.

spiceypy.spiceypy.**recgeo**(*rectan*, *re*, *f*)

Convert from rectangular coordinates to geodetic coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recgeo_c.html

Parameters

- **rectan** (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
Tuple[float, float, float]

Returns
Geodetic longitude (radians), Geodetic latitude (radians), Altitude above reference spheroid

spiceypy.spiceypy.**reclat**(*rectan*)

Convert from rectangular coordinates to latitudinal coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reclat_c.html

Parameters
rectan (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.

Return type
Tuple[float, float, float]

Returns
Distance from the origin, Longitude in radians, Latitude in radians

spiceypy.spiceypy.**recpgr**(*body*, *rectan*, *re*, *f*)

Convert rectangular coordinates to planetographic coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recpgr_c.html

Parameters

- **body** (str) – Body with which coordinate system is associated.
- **rectan** (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.
- **re** (float) – Equatorial radius of the reference spheroid.
- **f** (float) – Flattening coefficient.

Return type
Tuple[float, float, float]

Returns
Planetographic longitude (radians), Planetographic latitude (radians), Altitude above reference spheroid

spiceypy.spiceypy.**recrad**(*rectan*)

Convert rectangular coordinates to range, right ascension, and declination.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recrad_c.html

Parameters
rectan (Union[ndarray, Iterable[float]]) – Rectangular coordinates of a point.

Return type
Tuple[float, float, float]

Returns
Distance of the point from the origin, Right ascension in radians, Declination in radians

spiceypy.spiceypy.**recsph**(*rectan*)

Convert from rectangular coordinates to spherical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recrad_c.html

Parameters
rectan (ndarray) – Rectangular coordinates of a point.

Return type
Tuple[float, float, float]

Returns
Distance from the origin, Angle from the positive Z-axis, Longitude in radians.

spiceypy.spiceypy.**removc**(*item*, *inset*)

Remove an item from a character set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/removc_c.html

Parameters

- **item** (str) – Item to be removed.
- **inset** (*SpiceCell*) – Set to be updated.

Return type
None

spiceypy.spiceypy.**removd**(*item*, *inset*)

Remove an item from a double precision set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/removd_c.html

Parameters

- **item** (float) – Item to be removed.
- **inset** (*SpiceCell*) – Set to be updated.

Return type
None

spiceypy.spiceypy.**removi**(*item*, *inset*)

Remove an item from an integer set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/removi_c.html

Parameters

- **item** (int) – Item to be removed.
- **inset** (*SpiceCell*) – Set to be updated.

Return type
None

spiceypy.spiceypy.**reordc**(*iorder*, *ndim*, *lenvals*, *array*)

Re-order the elements of an array of character strings according to a given order vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reordc_c.html

Parameters

- **iorder** (Union[ndarray, Iterable[int]]) – Order vector to be used to re-order array.
- **ndim** (int) – Dimension of array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – Array to be re-ordered.

Return type
Iterable[str]

Returns
Re-ordered Array.

spiceypy.spiceypy.**reordd**(*iorder*, *ndim*, *array*)

Re-order the elements of a double precision array according to a given order vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reordd_c.html

Parameters

- **iorder** (Union[ndarray, Iterable[int]]) – Order vector to be used to re-order array.
- **ndim** (int) – Dimension of array.

- **array** (Union[ndarray, Iterable[float]]) – Array to be re-ordered.

Return type
ndarray

Returns
Re-ordered Array.

spiceypy.spiceypy.**reordi**(*iorder*, *ndim*, *array*)

Re-order the elements of an integer array according to a given order vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reordi_c.html

Parameters

- **iorder** (Union[ndarray, Iterable[int]]) – Order vector to be used to re-order array.
- **ndim** (int) – Dimension of array.
- **array** (Union[ndarray, Iterable[int]]) – Array to be re-ordered.

Return type
ndarray

Returns
Re-ordered Array.

spiceypy.spiceypy.**reordl**(*iorder*, *ndim*, *array*)

Re-order the elements of a logical (Boolean) array according to a given order vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reordl_c.html

Parameters

- **iorder** (Union[ndarray, Iterable[int]]) – Order vector to be used to re-order array.
- **ndim** (int) – Dimension of array.
- **array** (Iterable[bool]) – Array to be re-ordered.

Return type
ndarray

Returns
Re-ordered Array.

spiceypy.spiceypy.**repmc**(*instr*, *marker*, *value*, *lenout=None*)

Replace a marker with a character string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmc_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (str) – Replacement value.
- **lenout** (Optional[int]) – Optional available space in output string

Return type
str

Returns
Output string.

spiceypy.spiceypy.**repmct**(*instr*, *marker*, *value*, *repcase*, *lenout=None*)

Replace a marker with the text representation of a cardinal number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmc_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (int) – Replacement value.
- **repcase** (str) – Case of replacement text.
- **lenout** (Optional[int]) – Optional available space in output string

Return type
str

Returns
Output string.

spiceypy.spiceypy.**repmd**(*instr*, *marker*, *value*, *sigdig*)

Replace a marker with a double precision number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmd_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (float) – Replacement value.
- **sigdig** (int) – Significant digits in replacement text.

Return type
str

Returns
Output string.

spiceypy.spiceypy.**repmf**(*instr*, *marker*, *value*, *sigdig*, *informat*, *lenout=None*)

Replace a marker in a string with a formatted double precision value.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmf_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (float) – Replacement value.
- **sigdig** (int) – Significant digits in replacement text.
- **informat** (str) – Format 'E' or 'F'.
- **lenout** (Optional[int]) – Optional available space in output string.

Return type
str

Returns
Output string.

spiceypy.spiceypy.**repmi**(*instr*, *marker*, *value*, *lenout=None*)

Replace a marker with an integer.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmi_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (int) – Replacement value.
- **lenout** (Optional[int]) – Optional available space in output string.

Return type
str

Returns
Output string.

spiceypy.spiceypy.**repmot**(*instr*, *marker*, *value*, *repcase*, *lenout=None*)

Replace a marker with the text representation of an ordinal number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/repmot_c.html

Parameters

- **instr** (str) – Input string.
- **marker** (str) – Marker to be replaced.
- **value** (int) – Replacement value.
- **repcase** (str) – Case of replacement text.
- **lenout** (Optional[int]) – Optional available space in output string.

Return type
str

Returns
Output string.

spiceypy.spiceypy.**reset**()

Reset the SPICE error status to a value of "no error." As a result, the status routine, failed, will return a value of False

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reset_c.html

Return type
None

spiceypy.spiceypy.**return_c**()

True if SPICE routines should return immediately upon entry.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/return_c.html

Return type
bool

Returns
True if SPICE routines should return immediately upon entry.

spiceypy.spiceypy.**rotate**(*angle*, *iaxis*)

Calculate the 3x3 rotation matrix generated by a rotation of a specified angle about a specified axis. This rotation is thought of as rotating the coordinate system.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rotate_c.html

Parameters

- **angle** (float) – Angle of rotation (radians).
- **iaxis** (int) – Axis of rotation X=1, Y=2, Z=3.

Return type
ndarray

Returns
Resulting rotation matrix

spiceypy.spiceypy.**rotmat**(*m1*, *angle*, *iaxis*)

Rotmat applies a rotation of angle radians about axis iaxis to a matrix. This rotation is thought of as rotating the coordinate system.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rotmat_c.html

Parameters

- **m1** (ndarray) – Matrix to be rotated.
- **angle** (float) – Angle of rotation (radians).
- **iaxis** (int) – Axis of rotation X=1, Y=2, Z=3.

Return type
ndarray

Returns
Resulting rotated matrix.

spiceypy.spiceypy.**rotvec**(*v1*, *angle*, *iaxis*)

Transform a vector to a new coordinate system rotated by angle radians about axis iaxis. This transformation rotates v1 by angle radians about the specified axis.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rotvec_c.html

Parameters

- **v1** (Iterable[float]) – Vector whose coordinate system is to be rotated.
- **angle** (float) – Angle of rotation (radians).
- **iaxis** (int) – Axis of rotation X=1, Y=2, Z=3.

Return type
ndarray

Returns
the vector expressed in the new coordinate system.

spiceypy.spiceypy.**rpd**()

Return the number of radians per degree.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rpd_c.html

Return type
float

Returns
The number of radians per degree, pi/180.

spiceypy.spiceypy.**rquad**(*a*, *b*, *c*)

Find the roots of a quadratic equation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/rquad_c.html

Parameters

- **a** (float) – Coefficient of quadratic term.
- **b** (float) – Coefficient of linear term.
- **c** (float) – Constant.

Return type
Tuple[ndarray, ndarray]

Returns
Root built from positive and negative discriminant term.

spiceypy.spiceypy.**saelgv**(*vec1*, *vec2*)

Find semi-axis vectors of an ellipse generated by two arbitrary three-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/saelgv_c.html

Parameters

- **vec1** (Union[ndarray, Iterable[float]]) – First vector used to generate an ellipse.
- **vec2** (Union[ndarray, Iterable[float]]) – Second vector used to generate an ellipse.

Return type
Tuple[ndarray, ndarray]

Returns
Semi-major axis of ellipse, Semi-minor axis of ellipse.

spiceypy.spiceypy.**scard**(*incard*, *cell*)

Set the cardinality of a SPICE cell of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scard_c.html

Parameters

- **incard** (int) – Cardinality of (number of elements in) the cell.
- **cell** (*SpiceCell*) – The cell.

Return type
SpiceCell

Returns
The updated Cell.

spiceypy.spiceypy.**scdecd**(*sc*, *sclkdp*, *lenout=256*, *mxpart=None*)

Convert double precision encoding of spacecraft clock time into a character representation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scdecd_c.html

Parameters

- **sc** (int) – NAIF spacecraft identification code.
- **sclkdp** (float) – Encoded representation of a spacecraft clock count.

- **lenout** (int) – Maximum allowed length of output SCLK string.
- **mxpart** (Optional[int]) – Maximum number of spacecraft clock partitions.

Return type
str

Returns
Character representation of a clock count.

spiceypy.spiceypy.**sce2c**(*sc*, *et*)

Convert ephemeris seconds past J2000 (ET) to continuous encoded spacecraft clock "ticks". Non-integral tick values may be returned.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sce2c_c.html

Parameters

- **sc** (int) – NAIF spacecraft ID code.
- **et** (float) – Ephemeris time, seconds past J2000.

Return type
float

Returns
SCLK, encoded as ticks since spacecraft clock start. sclkdp need not be integral.

spiceypy.spiceypy.**sce2s**(*sc*, *et*, *lenout=256*)

Convert an epoch specified as ephemeris seconds past J2000 (ET) to a character string representation of a spacecraft clock value (SCLK).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sce2s_c.html

Parameters

- **sc** (int) – NAIF spacecraft clock ID code.
- **et** (float) – Ephemeris time, specified as seconds past J2000.
- **lenout** (int) – Maximum length of output string.

Return type
str

Returns
An SCLK string.

spiceypy.spiceypy.**sce2t**(*sc*, *et*)

Convert ephemeris seconds past J2000 (ET) to integral encoded spacecraft clock ("ticks"). For conversion to fractional ticks, (required for C-kernel production), see the routine *sce2c()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sce2t_c.html

Parameters

- **sc** (int) – NAIF spacecraft ID code.
- **et** (float) – Ephemeris time, seconds past J2000.

Return type
float

Returns
SCLK, encoded as ticks since spacecraft clock start.

spiceypy.spiceypy.**scencd**(*sc*, *sclkch*, *mxpart=None*)

Encode character representation of spacecraft clock time into a double precision number.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scencd_c.html

Parameters

- **sc** (int) – NAIF spacecraft identification code.
- **sclkch** (Union[str, Iterable[str]]) – Character representation of a spacecraft clock.
- **mxpart** (Optional[int]) – Maximum number of spacecraft clock partitions.

Return type
Union[float, ndarray]

Returns
Encoded representation of the clock count.

spiceypy.spiceypy.**scfmt**(*sc*, *ticks*, *lenout=256*)

Convert encoded spacecraft clock ticks to character clock format.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scfmt_c.html

Parameters

- **sc** (int) – NAIF spacecraft identification code.
- **ticks** (float) – Encoded representation of a spacecraft clock count.
- **lenout** (int) – Maximum allowed length of output string.

Return type
str

Returns
Character representation of a clock count.

spiceypy.spiceypy.**scpart**(*sc*)

Get spacecraft clock partition information from a spacecraft clock kernel file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scpart_c.html

Parameters
sc (int) – NAIF spacecraft identification code.

Return type
Tuple[ndarray, ndarray]

Returns
The number of spacecraft clock partitions, Array of partition start times, Array of partition stop times.

spiceypy.spiceypy.**scs2e**(*sc*, *sclkch*)

Convert a spacecraft clock string to ephemeris seconds past J2000 (ET).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scs2e_c.html

Parameters

- **sc** (int) – NAIF integer code for a spacecraft.
- **sclkch** (str) – An SCLK string.

Return type
float

Returns
Ephemeris time, seconds past J2000.

spiceypy.spiceypy.**sct2e**(*sc*, *sclkdp*)

Convert encoded spacecraft clock ("ticks") to ephemeris seconds past J2000 (ET).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sct2e_c.html

Parameters

- **sc** (int) – NAIF spacecraft ID code.
- **sclkdp** (Union[float, Iterable[float]]) – SCLK, encoded as ticks since spacecraft clock start.

Return type
Union[float, ndarray]

Returns
Ephemeris time, seconds past J2000.

spiceypy.spiceypy.**sctiks**(*sc*, *clkstr*)

Convert a spacecraft clock format string to number of "ticks".

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sctiks_c.html

Parameters

- **sc** (int) – NAIF spacecraft identification code.
- **clkstr** (str) – Character representation of a spacecraft clock.

Return type
float

Returns
Number of ticks represented by the clock string.

spiceypy.spiceypy.**sdiff**(*a*, *b*)

Take the symmetric difference of two sets of any data type to form a third set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sdiff_c.html

Parameters

- **a** (*SpiceCell*) – First input set.
- **b** (*SpiceCell*) – Second input set.

Return type
SpiceCell

Returns
Symmetric difference of a and b.

spiceypy.spiceypy.**set_c**(*a*, *op*, *b*)

Given a relational operator, compare two sets of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/set_c.html

Parameters

- **a** (*SpiceCell*) – First set.
- **op** (str) – Comparison operator.

- **b** (*SpiceCell*) – Second set.

Return type
bool

Returns
The function returns the result of the comparison.

spiceypy.spiceypy.**setmsg**(*message*)

Set the value of the current long error message.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/setmsg_c.html

Parameters
message (str) – A long error message.

Return type
None

spiceypy.spiceypy.**shellc**(*ndim*, *lenvals*, *array*)

Sort an array of character strings according to the ASCII collating sequence using the Shell Sort algorithm.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/shellc_c.html

Parameters

- **ndim** (int) – Dimension of the array.
- **lenvals** (int) – String length.
- **array** (Iterable[str]) – The array to be sorted.

Return type
Iterable[str]

Returns
The sorted array.

spiceypy.spiceypy.**shelld**(*ndim*, *array*)

Sort a double precision array using the Shell Sort algorithm.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/shelld_c.html

Parameters

- **ndim** (int) – Dimension of the array.
- **array** (Union[ndarray, Iterable[float]]) – The array to be sorted.

Return type
ndarray

Returns
The sorted array.

spiceypy.spiceypy.**shelli**(*ndim*, *array*)

Sort an integer array using the Shell Sort algorithm.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/shelli_c.html

Parameters

- **ndim** (int) – Dimension of the array.
- **array** (Union[ndarray, Iterable[int]]) – The array to be sorted.

Return type
ndarray

Returns
The sorted array.

spiceypy.spiceypy.**sigerr**(*message*)

Inform the CSPICE error processing mechanism that an error has occurred, and specify the type of error.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sigerr_c.html

Parameters
message (str) – A short error message.

Return type
None

spiceypy.spiceypy.**sincpt**(*method*, *target*, *et*, *fixref*, *abcorr*, *obsrvr*, *dref*, *dvec*)

Given an observer and a direction vector defining a ray, compute the surface intercept of the ray on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

This routine supersedes *srfxpt()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sincpt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.
- **dref** (str) – Reference frame of ray's direction vector.
- **dvec** (ndarray) – Ray's direction vector.

Return type
Tuple[ndarray, float, ndarray, bool]

Returns
Surface intercept point on the target body, Intercept epoch, Vector from observer to intercept point.

spiceypy.spiceypy.**size**(*cell*)

Return the size (maximum cardinality) of a SPICE cell of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/size_c.html

Parameters
cell (*SpiceCell*) – Input cell.

Return type
int

Returns
The size of the input cell.

spiceypy.spiceypy.**spd**()

Return the number of seconds in a day.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spd_c.html

Return type
float

Returns
The number of seconds in a day.

spiceypy.spiceypy.**sphcyl**(*radius*, *colat*, *slon*)

This routine converts from spherical coordinates to cylindrical coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sphcyl_c.html

Parameters

- **radius** (float) – Distance of point from origin.
- **colat** (float) – Polar angle (co-latitude in radians) of point.
- **slon** (float) – Azimuthal angle (longitude) of point (radians).

Return type
Tuple[float, float, float]

Returns
Distance of point from z axis, angle (radians) of point from XZ plane, Height of point above XY plane.

spiceypy.spiceypy.**sphlat**(*r*, *colat*, *lons*)

Convert from spherical coordinates to latitudinal coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sphlat_c.html

Parameters

- **r** (float) – Distance of the point from the origin.
- **colat** (float) – Angle of the point from positive z axis (radians).
- **lons** (float) – Angle of the point from the XZ plane (radians).

Return type
Tuple[float, float, float]

Returns
Distance of a point from the origin, Angle of the point from the XZ plane in radians, Angle of the point from the XY plane in radians.

spiceypy.spiceypy.**sphrec**(*r*, *colat*, *lon*)

Convert from spherical coordinates to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sphrec_c.html

Parameters

- **r** (float) – Distance of a point from the origin.
- **colat** (float) – Angle of the point from the positive Z-axis.
- **lon** (float) – Angle of the point from the XZ plane in radians.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**spice_error_check**(*f*)

Decorator for spiceypy hooking into spice error system. If an error is detected, an output similar to outmsg

Returns

spiceypy.spiceypy.**spice_found_exception_thrower**(*f*)

Decorator for wrapping functions that use status codes

Return type
Callable

spiceypy.spiceypy.**spk14a**(*handle*, *ncsets*, *coeffs*, *epochs*)

Add data to a type 14 SPK segment associated with handle. See also *spk14b()* and *spk14e()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spk14a_c.html

Parameters

- **handle** (int) – The handle of an SPK file open for writing.
- **ncsets** (int) – The number of coefficient sets and epochs.
- **coeffs** (Union[ndarray, Iterable[float]]) – The collection of coefficient sets.
- **epochs** (Union[ndarray, Iterable[float]]) – The epochs associated with the coefficient sets.

Return type
None

spiceypy.spiceypy.**spk14b**(*handle*, *segid*, *body*, *center*, *framename*, *first*, *last*, *chbdeg*)

Begin a type 14 SPK segment in the SPK file associated with handle. See also *spk14a()* and *spk14e()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spk14b_c.html

Parameters

- **handle** (int) – The handle of an SPK file open for writing.
- **segid** (str) – The string to use for segment identifier.
- **body** (int) – The NAIF ID code for the body of the segment.
- **center** (int) – The center of motion for body.
- **framename** (str) – The reference frame for this segment.
- **first** (float) – The first epoch for which the segment is valid.
- **last** (float) – The last epoch for which the segment is valid.
- **chbdeg** (int) – The degree of the Chebyshev Polynomial used.

Return type
None

spiceypy.spiceypy.**spk14e**(*handle*)

End the type 14 SPK segment currently being written to the SPK file associated with handle. See also *spk14a()* and *spk14b()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spk14e_c.html

Parameters
handle (int) – The handle of an SPK file open for writing.

Return type
None

spiceypy.spiceypy.**spkacs**(*targ*, *et*, *ref*, *abcorr*, *obs*)

Return the state (position and velocity) of a target body relative to an observer, optionally corrected for light time and stellar aberration, expressed relative to an inertial reference frame.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkacs_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Inertial reference frame of output state.
- **abcorr** (str) – Aberration correction flag.
- **obs** (int) – Observer.

Return type
Tuple[ndarray, float, float]

Returns
State of target, One way light time between observer and target, Derivative of light time with respect to time.

spiceypy.spiceypy.**spkapo**(*targ*, *et*, *ref*, *sobs*, *abcorr*)

Return the position of a target body relative to an observer, optionally corrected for light time and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkapo_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Inertial reference frame of observer's state.
- **sobs** (ndarray) – State of observer wrt. solar system barycenter.
- **abcorr** (str) – Aberration correction flag.

Return type
Tuple[ndarray, float]

Returns
Position of target, One way light time between observer and target.

spiceypy.spiceypy.**spkapp**(*targ*, *et*, *ref*, *sobs*, *abcorr*)

Deprecated: This routine has been superseded by *spkaps()*. This routine is supported for purposes of backward compatibility only.

Return the state (position and velocity) of a target body relative to an observer, optionally corrected for light time and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkapp_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Inertial reference frame of observer's state.
- **sobs** (ndarray) – State of observer wrt. solar system barycenter.
- **abcorr** (str) – Aberration correction flag.

Return type
Tuple[ndarray, float]

Returns
State of target, One way light time between observer and target.

spiceypy.spiceypy.**spkaps**(*targ*, *et*, *ref*, *abcorr*, *stobs*, *accobs*)

Given the state and acceleration of an observer relative to the solar system barycenter, return the state (position and velocity) of a target body relative to the observer, optionally corrected for light time and stellar aberration. All input and output vectors are expressed relative to an inertial reference frame.

This routine supersedes *spkapp()*.

SPICE users normally should call the high-level API routines *spkezr()* or *spkez()* rather than this routine. https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkaps_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Inertial reference frame of output state.
- **abcorr** (str) – Aberration correction flag.
- **stobs** (ndarray) – State of the observer relative to the SSB.
- **accobs** (Iterable[float]) – Acceleration of the observer relative to the SSB.

Return type
Tuple[ndarray, float, float]

Returns
State of target, One way light time between observer and target, Derivative of light time with respect to time.

spiceypy.spiceypy.**spkcls**(*handle*)

Close an open SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcls_c.html

Parameters
handle (int) – Handle of the SPK file to be closed.

Return type
None

spiceypy.spiceypy.**spkcov**(*spk*, *idcode*, *cover=None*)

Find the coverage window for a specified ephemeris object in a specified SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcov_c.html

Parameters

- **spk** (str) – Name of SPK file.

- **idcode** (int) – ID code of ephemeris object.
- **cover** (Optional[*SpiceCell*]) – Optional SPICE Window giving coverage in "spk" for "idcode".

Return type
SpiceCell

spiceypy.spiceypy.**spkcpo**(*target*, *et*, *outref*, *refloc*, *abcorr*, *obspos*, *obsctr*, *obsref*)

Return the state of a specified target relative to an "observer," where the observer has constant position in a specified reference frame. The observer's position is provided by the calling program rather than by loaded SPK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcpo_c.html

Parameters

- **target** (str) – Name of target ephemeris object.
- **et** (float) – Observation epoch.
- **outref** (str) – Reference frame of output state.
- **refloc** (str) – Output reference frame evaluation locus.
- **abcorr** (str) – Aberration correction.
- **obspos** (Union[ndarray, Iterable[float]]) – Observer position relative to center of motion.
- **obsctr** (str) – Center of motion of observer.
- **obsref** (str) – Frame of observer position.

Return type
Tuple[ndarray, float]

Returns
State of target with respect to observer, One way light time between target and observer.

spiceypy.spiceypy.**spkcpt**(*trgpos*, *trgctr*, *trgref*, *et*, *outref*, *refloc*, *abcorr*, *obsrvr*)

Return the state, relative to a specified observer, of a target having constant position in a specified reference frame. The target's position is provided by the calling program rather than by loaded SPK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcpt_c.html

Parameters

- **trgpos** (Union[ndarray, Iterable[float]]) – Target position relative to center of motion.
- **trgctr** (str) – Center of motion of target.
- **trgref** (str) – Observation epoch.
- **et** (float) – Observation epoch.
- **outref** (str) – Reference frame of output state.
- **refloc** (str) – Output reference frame evaluation locus.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing ephemeris object.

Return type
Tuple[ndarray, float]

Returns
State of target with respect to observer, One way light time between target and observer.

spiceypy.spiceypy.**spkcvo**(*target*, *et*, *outref*, *refloc*, *abcorr*, *obssta*, *obsepc*, *obsctr*, *obsref*)

Return the state of a specified target relative to an "observer," where the observer has constant velocity in a specified reference frame. The observer's state is provided by the calling program rather than by loaded SPK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcvo_c.html

Parameters

- **target** (str) – Name of target ephemeris object.
- **et** (float) – Observation epoch.
- **outref** (str) – Reference frame of output state.
- **refloc** (str) – Output reference frame evaluation locus.
- **abcorr** (str) – Aberration correction.
- **obssta** (Union[ndarray, Iterable[float]]) – Observer state relative to center of motion.
- **obsepc** (float) – Epoch of observer state.
- **obsctr** (str) – Center of motion of observer.
- **obsref** (str) – Frame of observer state.

Return type
Tuple[ndarray, float]

Returns
State of target with respect to observer, One way light time between target and observer.

spiceypy.spiceypy.**spkcvt**(*trgsta*, *trgepc*, *trgctr*, *trgref*, *et*, *outref*, *refloc*, *abcorr*, *obsrvr*)

Return the state, relative to a specified observer, of a target having constant velocity in a specified reference frame. The target's state is provided by the calling program rather than by loaded SPK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkcvt_c.html

Parameters

- **trgsta** (Union[ndarray, Iterable[float]]) – Target state relative to center of motion.
- **trgepc** (float) – Epoch of target state.
- **trgctr** (str) – Center of motion of target.
- **trgref** (str) – Frame of target state.
- **et** (float) – Observation epoch.
- **outref** (str) – Reference frame of output state.
- **refloc** (str) – Output reference frame evaluation locus.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing ephemeris object.

Return type
Tuple[ndarray, float]

Returns
State of target with respect to observer, One way light time between target and observer.

spiceypy.spiceypy.**spkez**(*targ*, *et*, *ref*, *abcorr*, *obs*)

Return the state (position and velocity) of a target body relative to an observing body, optionally corrected for light time (planetary aberration) and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkez_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Reference frame of output state vector.
- **abcorr** (str) – Aberration correction flag.
- **obs** (int) – Observing body.

Return type
Tuple[ndarray, float]

Returns
State of target, One way light time between observer and target.

spiceypy.spiceypy.**spkezp**(*targ*, *et*, *ref*, *abcorr*, *obs*)

Return the position of a target body relative to an observing body, optionally corrected for light time (planetary aberration) and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkezp_c.html

Parameters

- **targ** (int) – Target body NAIF ID code.
- **et** (float) – Observer epoch.
- **ref** (str) – Reference frame of output position vector.
- **abcorr** (str) – Aberration correction flag.
- **obs** (int) – Observing body NAIF ID code.

Return type
Tuple[ndarray, float]

Returns
Position of target, One way light time between observer and target.

spiceypy.spiceypy.**spkezr**(*targ*, *et*, *ref*, *abcorr*, *obs*)

Return the state (position and velocity) of a target body relative to an observing body, optionally corrected for light time (planetary aberration) and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkezr_c.html

Parameters

- **targ** (str) – Target body name.
- **et** (Union[ndarray, float]) – Observer epoch.
- **ref** (str) – Reference frame of output state vector.
- **abcorr** (str) – Aberration correction flag.
- **obs** (str) – Observing body name.

Return type
Union[Tuple[ndarray, float], Tuple[Iterable[ndarray], Iterable[float]]]

Returns
State of target, One way light time between observer and target.

spiceypy.spiceypy.**spkgeo**(*targ*, *et*, *ref*, *obs*)

Compute the geometric state (position and velocity) of a target body relative to an observing body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkgeo_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Target epoch.
- **ref** (str) – Target reference frame.
- **obs** (int) – Observing body.

Return type
Tuple[ndarray, float]

Returns
State of target, Light time.

spiceypy.spiceypy.**spkgps**(*targ*, *et*, *ref*, *obs*)

Compute the geometric position of a target body relative to an observing body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkgps_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Target epoch.
- **ref** (str) – Target reference frame.
- **obs** (int) – Observing body.

Return type
Tuple[ndarray, float]

Returns
Position of target, Light time.

spiceypy.spiceypy.**spklef**(*filename*)

Load an ephemeris file for use by the readers. Return that file's handle, to be used by other SPK routines to refer to the file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spklef_c.html

Parameters
filename (str) – Name of the file to be loaded.

Return type
int

Returns
Loaded file's handle.

spiceypy.spiceypy.**spkltc**(*targ*, *et*, *ref*, *abcorr*, *stobs*)

Return the state (position and velocity) of a target body relative to an observer, optionally corrected for light time, expressed relative to an inertial reference frame.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkltc_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Observer epoch.
- **ref** (str) – Inertial reference frame of output state.
- **abcorr** (str) – Aberration correction flag.
- **stobs** (ndarray) – State of the observer relative to the SSB.

Return type
Tuple[ndarray, float, float]

Returns
One way light time between observer and target, Derivative of light time with respect to time

spiceypy.spiceypy.**spkobj**(*spk*, *out_cell=None*)

Find the set of ID codes of all objects in a specified SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkobj_c.html

Parameters

- **spk** (str) – Name of SPK file.
- **out_cell** (Optional[*SpiceCell*]) – Optional Spice Int Cell.

Return type
SpiceCell

spiceypy.spiceypy.**spkopa**(*filename*)

Open an existing SPK file for subsequent write.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkopa_c.html

Parameters
filename (str) – The name of an existing SPK file.

Return type
int

Returns
A handle attached to the SPK file opened to append.

spiceypy.spiceypy.**spkopn**(*filename*, *ifname*, *ncomch*)

Create a new SPK file, returning the handle of the opened file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkopn_c.html

Parameters

- **filename** (str) – The name of the new SPK file to be created.
- **ifname** (str) – The internal filename for the SPK file.
- **ncomch** (int) – The number of characters to reserve for comments.

Return type
int

Returns
The handle of the opened SPK file.

spiceypy.spiceypy.**spkpds**(*body*, *center*, *framestr*, *typenum*, *first*, *last*)

Perform routine error checks and if all check pass, pack the descriptor for an SPK segment

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkpds_c.html

Parameters

- **body** (int) – The NAIF ID code for the body of the segment.
- **center** (int) – The center of motion for body.
- **framestr** (str) – The frame for this segment.
- **typenum** (int) – The type of SPK segment to create.
- **first** (float) – The first epoch for which the segment is valid.
- **last** (float) – The last epoch for which the segment is valid.

Return type
ndarray

Returns
An SPK segment descriptor.

spiceypy.spiceypy.**spkpos**(*targ*, *et*, *ref*, *abcorr*, *obs*)

Return the position of a target body relative to an observing body, optionally corrected for light time (planetary aberration) and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkpos_c.html

Parameters

- **targ** (str) – Target body name.
- **et** (Union[float, ndarray]) – Observer epoch.
- **ref** (str) – Reference frame of output position vector.
- **abcorr** (str) – Aberration correction flag.
- **obs** (str) – Observing body name.

Return type
Union[Tuple[ndarray, float], Tuple[ndarray, ndarray]]

Returns
Position of target, One way light time between observer and target.

spiceypy.spiceypy.**spkpvn**(*handle*, *descr*, *et*)

For a specified SPK segment and time, return the state (position and velocity) of the segment's target body relative to its center of motion.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkpvn_c.html

Parameters

- **handle** (int) – File handle.
- **descr** (ndarray) – Segment descriptor.
- **et** (float) – Evaluation epoch.

Return type
Tuple[int, ndarray, int]

Returns
Segment reference frame ID code, Output state vector, Center of state.

spiceypy.spiceypy.**spksfs**(*body*, *et*, *idlen*)

Search through loaded SPK files to find the highest-priority segment applicable to the body and time specified.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spksfs_c.html

Parameters

- **body** (int) – Body ID.
- **et** (float) – Ephemeris time.
- **idlen** (int) – Length of output segment ID string.

Return type
Tuple[int, ndarray, str, bool]

Returns
Handle of file containing the applicable segment, Descriptor of the applicable segment, Identifier of the applicable segment.

spiceypy.spiceypy.**spkssb**(*targ*, *et*, *ref*)

Return the state (position and velocity) of a target body relative to the solar system barycenter.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkssb_c.html

Parameters

- **targ** (int) – Target body.
- **et** (float) – Target epoch.
- **ref** (str) – Target reference frame.

Return type
ndarray

Returns
State of target.

spiceypy.spiceypy.**spksub**(*handle*, *descr*, *identin*, *begin*, *end*, *newh*)

Extract a subset of the data in an SPK segment into a separate segment.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spksub_c.html

Parameters

- **handle** (int) – Handle of source segment.
- **descr** (ndarray) – Descriptor of source segment.
- **identin** (str) – Indentifier of source segment.
- **begin** (float) – Beginning (initial epoch) of subset.
- **end** (float) – End (fincal epoch) of subset.
- **newh** (int) – Handle of new segment.

Return type
None

spiceypy.spiceypy.**spkuds**(*descr*)

Unpack the contents of an SPK segment descriptor.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkuds_c.html

Parameters
descr (ndarray) – An SPK segment descriptor.

Return type
Tuple[int, int, int, int, float, float, int, int]

Returns
The NAIF ID code for the body of the segment, The center of motion for body, The ID code for the frame of this segment, The type of SPK segment, The first epoch for which the segment is valid, The last epoch for which the segment is valid, Beginning DAF address of the segment, Ending DAF address of the segment.

spiceypy.spiceypy.**spkuef**(*handle*)

Unload an ephemeris file so that it will no longer be searched by the readers.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkuef_c.html

Parameters
handle (int) – Handle of file to be unloaded

Return type
None

spiceypy.spiceypy.**spkw02**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *intlen*, *n*, *polydg*, *cdata*, *btime*)

Write a type 2 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw02_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **intlen** (float) – Length of time covered by logical record.
- **n** (int) – Number of coefficient sets.
- **polydg** (int) – Chebyshev polynomial degree.
- **cdata** (Union[ndarray, Iterable[float]]) – Array of Chebyshev coefficients.
- **btime** (float) – Begin time of first logical record.

Return type
None

spiceypy.spiceypy.**spkw03**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *intlen*, *n*, *polydg*, *cdata*, *btime*)

Write a type 3 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw03_c.html

Parameters

- **handle** (int) – Handle of SPK file open for writing.
- **body** (int) – NAIF code for ephemeris object.
- **center** (int) – NAIF code for the center of motion of the body.
- **inframe** (str) – Reference frame name.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **intlen** (float) – Length of time covered by record.
- **n** (int) – Number of records in segment.
- **polydg** (int) – Chebyshev polynomial degree.
- **cdata** (Union[ndarray, Iterable[float]]) – Array of Chebyshev coefficients.
- **btime** (float) – Begin time of first record.

Return type
None

spiceypy.spiceypy.**spkw05**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *gm*, *n*, *states*, *epochs*)

Write an SPK segment of type 5 given a time-ordered set of discrete states and epochs, and the gravitational parameter of a central body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw05_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **gm** (float) – Gravitational parameter of central body.
- **n** (int) – Number of states and epochs.
- **states** (Union[ndarray, Iterable[Iterable[float]]]) – States.
- **epochs** (Union[ndarray, Iterable[float]]) – Epochs.

Return type
None

spiceypy.spiceypy.**spkw08**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *degree*, *n*, *states*, *epoch1*, *step*)

Write a type 8 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw08_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – NAIF code for an ephemeris object.
- **center** (int) – NAIF code for center of motion of "body".
- **inframe** (str) – Reference frame name.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **degree** (int) – Degree of interpolating polynomials.
- **n** (int) – Number of states.
- **states** (Union[ndarray, Iterable[Iterable[float]]]) – Array of states.
- **epoch1** (float) – Epoch of first state in states array.
- **step** (float) – Time step separating epochs of states.

Return type
None

spiceypy.spiceypy.**spkw09**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *degree*, *n*, *states*, *epochs*)

Write a type 9 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw09_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – NAIF code for an ephemeris object.
- **center** (int) – NAIF code for center of motion of "body".
- **inframe** (str) – Reference frame name.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **degree** (int) – Degree of interpolating polynomials.
- **n** (int) – Number of states.
- **states** (Union[ndarray, Iterable[Iterable[float]]]) – Array of states.
- **epochs** (Union[ndarray, Iterable[float]]) – Array of epochs corresponding to states.

Return type
None

spiceypy.spiceypy.**spkw10**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *consts*, *n*, *elems*, *epochs*)

Write an SPK type 10 segment to the DAF open and attached to the input handle.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw10_c.html

Parameters

- **handle** (int) – The handle of a DAF file open for writing.
- **body** (int) – The NAIF ID code for the body of the segment.

- **center** (int) – The center of motion for body.
- **inframe** (str) – The reference frame for this segment.
- **first** (float) – The first epoch for which the segment is valid.
- **last** (float) – The last epoch for which the segment is valid.
- **segid** (str) – The string to use for segment identifier.
- **consts** (Union[ndarray, Iterable[float]]) – The array of geophysical constants for the segment.
- **n** (int) – The number of element/epoch pairs to be stored.
- **elems** (Union[ndarray, Iterable[float]]) – The collection of "two-line" element sets.
- **epochs** (Union[ndarray, Iterable[float]]) – The epochs associated with the element sets.

Return type
None

spiceypy.spiceypy.**spkw12**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *degree*, *n*, *states*, *epoch0*, *step*)

Write a type 12 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw12_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – NAIF code for an ephemeris object.
- **center** (int) – NAIF code for center of motion of body.
- **inframe** (str) – Reference frame name.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **degree** (int) – Degree of interpolating polynomials.
- **n** (int) – Number of states.
- **states** (Union[ndarray, Iterable[Iterable[float]]]) – Array of states.
- **epoch0** (float) – Epoch of first state in states array.
- **step** (float) – Time step separating epochs of states.

Return type
None

spiceypy.spiceypy.**spkw13**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *degree*, *n*, *states*, *epochs*)

Write a type 13 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw13_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – NAIF code for an ephemeris object.
- **center** (int) – NAIF code for center of motion of body.

- **inframe** (str) – Reference frame name.
- **first** (float) – Start time of interval covered by segment.
- **last** (float) – End time of interval covered by segment.
- **segid** (str) – Segment identifier.
- **degree** (int) – Degree of interpolating polynomials.
- **n** (int) – Number of states.
- **states** (Union[ndarray, Iterable[Iterable[float]]]) – Array of states.
- **epochs** (Union[ndarray, Iterable[float]]) – Array of epochs corresponding to states.

Return type
None

spiceypy.spiceypy.**spkw15**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *epoch*, *tp*, *pa*, *p*, *ecc*, *j2flg*, *pv*, *gm*, *j2*, *radius*)

Write an SPK segment of type 15 given a type 15 data record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw15_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **epoch** (float) – Epoch of the periapse.
- **tp** (ndarray) – Trajectory pole vector.
- **pa** (ndarray) – Periapsis vector.
- **p** (float) – Semi-latus rectum.
- **ecc** (float) – Eccentricity.
- **j2flg** (float) – J2 processing flag.
- **pv** (Union[ndarray, Iterable[float]]) – Central body pole vector.
- **gm** (float) – Central body GM.
- **j2** (float) – Central body J2.
- **radius** (float) – Equatorial radius of central body.

Return type
None

spiceypy.spiceypy.**spkw17**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *epoch*, *eqel*, *rapol*, *decpol*)

Write an SPK segment of type 17 given a type 17 data record.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw17_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **epoch** (float) – Epoch of elements in seconds past J2000.
- **eqel** (Iterable[float]) – Array of equinoctial elements.
- **rapol** (float) – Right Ascension of the pole of the reference plane.
- **decpol** (float) – Declination of the pole of the reference plane.

Return type
None

spiceypy.spiceypy.**spkw18**(*handle*, *subtyp*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *degree*, *packts*, *epochs*)

Write a type 18 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw18_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.
- **subtyp** (int) – SPK type 18 subtype code.
- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **degree** (int) – Degree of interpolating polynomials.
- **packts** (Sequence[Iterable[float]]) – data packets
- **epochs** (Sequence[float]) – Array of epochs corresponding to states.

Return type
None

spiceypy.spiceypy.**spkw20**(*handle*, *body*, *center*, *inframe*, *first*, *last*, *segid*, *intlen*, *n*, *polydg*, *cdata*, *dscale*, *tscale*, *initjd*, *initfr*)

Write a type 20 segment to an SPK file.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkw20_c.html

Parameters

- **handle** (int) – Handle of an SPK file open for writing.

- **body** (int) – Body code for ephemeris object.
- **center** (int) – Body code for the center of motion of the body.
- **inframe** (str) – The reference frame of the states.
- **first** (float) – First valid time for which states can be computed.
- **last** (float) – Last valid time for which states can be computed.
- **segid** (str) – Segment identifier.
- **intlen** (float) – Length of time covered by logical record (days).
- **n** (int) – Number of logical records in segment.
- **polydg** (int) – Chebyshev polynomial degree.
- **cdata** (ndarray) – Array of Chebyshev coefficients and positions.
- **dscale** (float) – Distance scale of data.
- **tscale** (float) – Time scale of data.
- **initjd** (float) – Integer part of begin time (TDB Julian date) of first record.
- **initfr** (float) – Fractional part of begin time (TDB Julian date) of first record.

Return type
None

spiceypy.spiceypy.**srfc2s**(*code*, *bodyid*, *srflen=256*)

Translate a surface ID code, together with a body ID code, to the corresponding surface name. If no such name exists, return a string representation of the surface ID code.

note: from NAIF if isname is false, this case is not treated as an error.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfc2s_c.html

Parameters

- **code** (int) – Integer surface ID code to translate to a string.
- **bodyid** (int) – ID code of body associated with surface.
- **srflen** (int) – Available space in output string.
- **srflen** – int

Return type
Tuple[str, bool]

Returns
String corresponding to surface ID code.

spiceypy.spiceypy.**srfcss**(*code*, *bodstr*, *srflen=256*)

Translate a surface ID code, together with a body string, to the corresponding surface name. If no such surface name exists, return a string representation of the surface ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfcss_c.html

Parameters

- **code** (int) – Integer surface ID code to translate to a string.
- **bodstr** (str) – Name or ID of body associated with surface.
- **srflen** (int) – Available space in output string.

- **srflen** – int

Return type
Tuple[str, bool]

Returns
String corresponding to surface ID code.

spiceypy.spiceypy.**srfnrm**(*method*, *target*, *et*, *fixref*, *srfpts*)

Map array of surface points on a specified target body to the corresponding unit length outward surface normal vectors.

The surface of the target body may be represented by a triaxial ellipsoid or by topographic data provided by DSK files.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfnrm_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in TDB seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **srfpts** (ndarray) – Array of surface points.

Return type
ndarray

Returns
Array of outward, unit length normal vectors.

spiceypy.spiceypy.**srfrec**(*body*, *longitude*, *latitude*)

Convert planetocentric latitude and longitude of a surface point on a specified body to rectangular coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfrec_c.html

Parameters

- **body** (int) – NAIF integer code of an extended body.
- **longitude** (float) – Longitude of point in radians.
- **latitude** (float) – Latitude of point in radians.

Return type
ndarray

Returns
Rectangular coordinates of the point.

spiceypy.spiceypy.**srfs2c**(*srfstr*, *bodstr*)

Translate a surface string, together with a body string, to the corresponding surface ID code. The input strings may contain names or integer ID codes.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfs2c_c.html

Parameters

- **srfstr** (str) – Surface name or ID string.
- **bodstr** (str) – Body name or ID string.

Return type
Tuple[int, bool]

Returns
Integer surface ID code.

spiceypy.spiceypy.**srfscc**(*srfstr*, *bodyid*)

Translate a surface string, together with a body ID code, to the corresponding surface ID code. The input surface string may contain a name or an integer ID code.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfscc_c.html

Parameters

- **srfstr** (str) – Surface name or ID string.
- **bodyid** (int) – ID code of body associated with surface.

Return type
Tuple[int, bool]

Returns
Integer surface ID code.

spiceypy.spiceypy.**srfxpt**(*method*, *target*, *et*, *abcorr*, *obsrvr*, *dref*, *dvec*)

Deprecated: This routine has been superseded by the CSPICE routine *sincpt()*. This routine is supported for purposes of backward compatibility only.

Given an observer and a direction vector defining a ray, compute the surface intercept point of the ray on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/srfxpt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (Union[float, Iterable[float]]) – Epoch in ephemeris seconds past J2000 TDB.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.
- **dref** (str) – Reference frame of input direction vector.
- **dvec** (ndarray) – Ray's direction vector.

Return type
Union[Tuple[ndarray, float, float, ndarray, bool], Tuple[ndarray, ndarray, ndarray, ndarray, ndarray]]

Returns
Surface intercept point on the target body, Distance from the observer to the intercept point, Intercept epoch, Observer position relative to target center.

spiceypy.spiceypy.**ssize**(*newsize*, *cell*)

Set the size (maximum cardinality) of a CSPICE cell of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ssize_c.html

Parameters

- **newsize** (int) – Size (maximum cardinality) of the cell.

- **cell** (*SpiceCell*) – The cell.

Return type
SpiceCell

Returns
The updated cell.

spiceypy.spiceypy.**stelab**(*pobj*, *vobs*)

Correct the apparent position of an object for stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/stelab_c.html

Parameters

- **pobj** (ndarray) – Position of an object with respect to the observer.
- **vobs** (ndarray) – Velocity of the observer with respect to the Solar System barycenter.

Return type
ndarray

Returns
Apparent position of the object with respect to the observer, corrected for stellar aberration.

spiceypy.spiceypy.**stlabx**(*pobj*, *vobs*)

Correct the position of a target for the stellar aberration effect on radiation transmitted from a specified observer to the target.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/stlabx_c.html

Parameters

- **pobj** (ndarray) – Position of an object with respect to the observer.
- **vobs** (ndarray) – Velocity of the observer with respect to the Solar System barycenter.

Return type
ndarray

Returns
Corrected position of the object.

spiceypy.spiceypy.**stpool**(*item*, *nth*, *contin*, *lenout=256*)

Retrieve the nth string from the kernel pool variable, where the string may be continued across several components of the kernel pool variable.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/stpool_c.html

Parameters

- **item** (str) – Name of the kernel pool variable.
- **nth** (int) – Index of the full string to retrieve.
- **contin** (str) – Character sequence used to indicate continuation.
- **lenout** (int) – Available space in output string.

Return type
Tuple[str, int, bool]

Returns
A full string concatenated across continuations, The number of characters in the full string value.

spiceypy.spiceypy.**str2et**(*time*)

Convert a string representing an epoch to a double precision value representing the number of TDB seconds past the J2000 epoch corresponding to the input epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html

Parameters
time (Union[str, Iterable[str]]) – A string representing an epoch.

Return type
Union[float, ndarray]

Returns
The equivalent value in seconds past J2000, TDB.

spiceypy.spiceypy.**subpnt**(*method*, *target*, *et*, *fixref*, *abcorr*, *obsrvr*)

Compute the rectangular coordinates of the sub-observer point on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

This routine supersedes *subpt()*.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subpnt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.

Return type
Tuple[ndarray, float, ndarray]

Returns
Sub-observer point on the target body, Sub-observer point epoch, Vector from observer to sub-observer point.

spiceypy.spiceypy.**subpt**(*method*, *target*, *et*, *abcorr*, *obsrvr*)

Deprecated: This routine has been superseded by the CSPICE routine *subpnt()*. This routine is supported for purposes of backward compatibility only.

Compute the rectangular coordinates of the sub-observer point on a target body at a particular epoch, optionally corrected for planetary (light time) and stellar aberration. Return these coordinates expressed in the body-fixed frame associated with the target body. Also, return the observer's altitude above the target body.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subpt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (Union[float, Iterable[float]]) – Epoch in ephemeris seconds past J2000 TDB.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.

Return type
Union[Tuple[ndarray, ndarray], Tuple[ndarray, float]]

Returns
Sub-observer point on the target body, Altitude of the observer above the target body.

spiceypy.spiceypy.**subslr**(*method*, *target*, *et*, *fixref*, *abcorr*, *obsrvr*)

Compute the rectangular coordinates of the sub-solar point on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

This routine supersedes subsol_c.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subslr_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.

Return type
Tuple[ndarray, float, ndarray]

Returns
Sub-solar point on the target body, Sub-solar point epoch, Vector from observer to sub-solar point.

spiceypy.spiceypy.**subsol**(*method*, *target*, *et*, *abcorr*, *obsrvr*)

Deprecated: This routine has been superseded by the CSPICE routine *subslr()*. This routine is supported for purposes of backward compatibility only.

Determine the coordinates of the sub-solar point on a target body as seen by a specified observer at a specified epoch, optionally corrected for planetary (light time) and stellar aberration.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subsol_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **abcorr** (str) – Aberration correction.
- **obsrvr** (str) – Name of observing body.

Return type
ndarray

Returns
Sub-solar point on the target body.

spiceypy.spiceypy.**sumad**(*array*)

Return the sum of the elements of a double precision array.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sumad_c.html

Parameters
array (Sequence[float]) – Input Array.

Return type
float

Returns
The sum of the array.

spiceypy.spiceypy.**sumai**(*array*)

Return the sum of the elements of an integer array.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sumai_c.html

Parameters
array (Sequence[int]) – Input Array.

Return type
int

Returns
The sum of the array.

spiceypy.spiceypy.**surfnm**(*a*, *b*, *c*, *point*)

This routine computes the outward-pointing, unit normal vector from a point on the surface of an ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/surfnm_c.html

Parameters

- **a** (float) – Length of the ellisoid semi-axis along the x-axis.
- **b** (float) – Length of the ellisoid semi-axis along the y-axis.
- **c** (float) – Length of the ellisoid semi-axis along the z-axis.
- **point** (Union[ndarray, Iterable[float]]) – Body-fixed coordinates of a point on the ellipsoid'

Return type
ndarray

Returns
Outward pointing unit normal to ellipsoid at point.

spiceypy.spiceypy.**surfpt**(*positn*, *u*, *a*, *b*, *c*)

Determine the intersection of a line-of-sight vector with the surface of an ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/surfpt_c.html

Parameters

- **positn** (Union[ndarray, Iterable[float]]) – Position of the observer in body-fixed frame.
- **u** (Union[ndarray, Iterable[float]]) – Vector from the observer in some direction.
- **a** (float) – Length of the ellisoid semi-axis along the x-axis.
- **b** (float) – Length of the ellisoid semi-axis along the y-axis.
- **c** (float) – Length of the ellisoid semi-axis along the z-axis.

Return type
Tuple[ndarray, bool]

Returns
Point on the ellipsoid pointed to by u.

spiceypy.spiceypy.**surfpv**(*stvrtx*, *stdir*, *a*, *b*, *c*)

Find the state (position and velocity) of the surface intercept defined by a specified ray, ray velocity, and ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/surfpv_c.html

Parameters

- **stvrtx** (Union[ndarray, Iterable[float]]) – State of ray's vertex.
- **stdir** (Union[ndarray, Iterable[float]]) – State of ray's direction vector.
- **a** (float) – Length of the ellisoid semi-axis along the x-axis.
- **b** (float) – Length of the ellisoid semi-axis along the y-axis.
- **c** (float) – Length of the ellisoid semi-axis along the z-axis.

Return type
Tuple[ndarray, bool]

Returns
State of surface intercept.

spiceypy.spiceypy.**swpool**(*agent*, *nnames*, *lenvals*, *names*)

Add a name to the list of agents to notify whenever a member of a list of kernel variables is updated.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/swpool_c.html

Parameters

- **agent** (str) – The name of an agent to be notified after updates.
- **nnames** (int) – The number of variables to associate with agent.
- **lenvals** (int) – Length of strings in the names array.
- **names** (Iterable[str]) – Variable names whose update causes the notice.

Return type
None

spiceypy.spiceypy.**sxform**(*instring*, *tostring*, *et*)

Return the state transformation matrix from one frame to another at a specified epoch.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sxform_c.html

Parameters

- **instring** (str) – Name of the frame to transform from.
- **tostring** (str) – Name of the frame to transform to.
- **et** (Union[float, ndarray]) – Epoch of the state transformation matrix.

Return type
ndarray

Returns
A state transformation matrix.

spiceypy.spiceypy.**szpool**(*name*)

Return the kernel pool size limitations.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/szpool_c.html

Parameters
name (str) – Name of the parameter to be returned.

Return type
Tuple[int, bool]

Returns
Value of parameter specified by name,

spiceypy.spiceypy.**tangpt**(*method*, *target*, *et*, *fixref*, *abcorr*, *corloc*, *obsrvr*, *dref*, *dvec*)

Compute, for a given observer, ray emanating from the observer, and target, the "tangent point": the point on the ray nearest to the target's surface. Also compute the point on the target's surface nearest to the tangent point.

The locations of both points are optionally corrected for light time and stellar aberration.

The surface shape is modeled as a triaxial ellipsoid.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tangpt_c.html

Parameters

- **method** (str) – Computation method.
- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **corloc** (str) – Aberration correction locus: "TANGENT POINT" or "SURFACE POINT".
- **obsrvr** (str) – Name of observing body.
- **dref** (str) – Reference frame of ray direction vector.
- **dvec** (Union[ndarray, Iterable[float]]) – Ray direction vector.

Return type
Tuple[ndarray, float, float, ndarray, float, ndarray]

Returns
"Tangent point": point on ray nearest to surface, Altitude of tangent point above surface, Distance of tangent point from observer, Point on surface nearest to tangent point, Epoch associated with correction locus, Vector from observer to surface point `srfpt'.

spiceypy.spiceypy.**termpt**(*method*, *ilusrc*, *target*, *et*, *fixref*, *abcorr*, *corloc*, *obsrvr*, *refvec*, *rolstp*, *ncuts*, *schstp*, *soltol*, *maxn*)

Find terminator points on a target body. The caller specifies half-planes, bounded by the illumination source center-target center vector, in which to search for terminator points.

The terminator can be either umbral or penumbral. The umbral terminator is the boundary of the region on the target surface where no light from the source is visible. The penumbral terminator is the boundary of the region on the target surface where none of the light from the source is blocked by the target itself.

The surface of the target body may be represented either by a triaxial ellipsoid or by topographic data.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/termpt_c.html

Parameters

- **method** (str) – Computation method.
- **ilusrc** (str) – Illumination source.

- **target** (str) – Name of target body.
- **et** (float) – Epoch in ephemeris seconds past J2000 TDB.
- **fixref** (str) – Body-fixed, body-centered target body frame.
- **abcorr** (str) – Aberration correction.
- **corloc** (str) – Aberration correction locus.
- **obsrvr** (str) – Name of observing body.
- **refvec** (Union[ndarray, Iterable[float]]) – Reference vector for cutting half-planes.
- **rolstp** (float) – Roll angular step for cutting half-planes.
- **ncuts** (int) – Number of cutting half-planes.
- **schstp** (float) – Angular step size for searching.
- **soltol** (float) – Solution convergence tolerance.
- **maxn** (int) – Maximum number of entries in output arrays.

Return type
Tuple[ndarray, ndarray, ndarray, ndarray]

Returns
Counts of terminator points corresponding to cuts, Terminator points, Times associated with terminator points, Terminator vectors emanating from the observer

spiceypy.spiceypy.**timdef**(*action*, *item*, *lenout*, *value=None*)

Set and retrieve the defaults associated with calendar input strings.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/timdef_c.html

Parameters

- **action** (str) – the kind of action to take "SET" or "GET".
- **item** (str) – the default item of interest.
- **lenout** (int) – the length of list for output.
- **value** (Optional[str]) – the optional string used if action is "SET"

Return type
str

Returns
the value associated with the default item.

spiceypy.spiceypy.**timout**(*et*, *pictur*, *lenout=256*)

This vectorized routine converts an input epoch represented in TDB seconds past the TDB epoch of J2000 to a character string formatted to the specifications of a user's format picture.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/timout_c.html

Parameters

- **et** (Union[ndarray, float]) – An epoch in seconds past the ephemeris epoch J2000.
- **pictur** (str) – A format specification for the output string.
- **lenout** (int) – The length of the output string plus 1.

Return type
Union[ndarray, str]

Returns
A string representation of the input epoch.

spiceypy.spiceypy.**tipbod**(*ref*, *body*, *et*)

Return a 3x3 matrix that transforms positions in inertial coordinates to positions in body-equator-and-prime-meridian coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tipbod_c.html

Parameters

- **ref** (str) – ID of inertial reference frame to transform from.
- **body** (int) – ID code of body.
- **et** (float) – Epoch of transformation.

Return type
ndarray

Returns
Transformation (position), inertial to prime meridian.

spiceypy.spiceypy.**tisbod**(*ref*, *body*, *et*)

Return a 6x6 matrix that transforms states in inertial coordinates to states in body-equator-and-prime-meridian coordinates.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tisbod_c.html

Parameters

- **ref** (str) – ID of inertial reference frame to transform from.
- **body** (int) – ID code of body.
- **et** (float) – Epoch of transformation.

Return type
ndarray

Returns
Transformation (state), inertial to prime meridian.

spiceypy.spiceypy.**tkfram**(*typid*)

This routine returns the rotation from the input frame specified by ID to the associated frame given by FRAME.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/FORTRAN/spicelib/tkfram.html

Parameters
typid (int) – Class identification code for the instrument

Return type
Tuple[ndarray, int, bool]

Returns
Rotation matrix from the input frame to the returned reference frame, id for the reference frame

spiceypy.spiceypy.**tkvrsn**(*item*)

Given an item such as the Toolkit or an entry point name, return the latest version string.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tkvrsn_c.html

Parameters
item (str) – Item for which a version string is desired.

Return type
str

Returns
the latest version string.

spiceypy.spiceypy.**tparch**(*type*)

Restrict the set of strings that are recognized by SPICE time parsing routines to those that have standard values for all time components.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tparch_c.html

Parameters
type (str) – String: Use "YES" to restrict time inputs.

Return type
None

spiceypy.spiceypy.**tparse**(*instring*, *lenout=256*)

Parse a time string and return seconds past the J2000 epoch on a formal calendar.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tparse_c.html

Parameters

- **instring** (str) – Input time string, UTC.
- **lenout** (int) – Available space in output error message string.

Return type
Tuple[float, str]

Returns
Equivalent UTC seconds past J2000, Descriptive error message.

spiceypy.spiceypy.**tpictr**(*sample*, *lenout=256*, *lenerr=256*)

Given a sample time string, create a time format picture suitable for use by the routine timout.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tpictr_c.html

Parameters

- **sample** (str) – A sample time string.
- **lenout** (int) – The length for the output picture string.
- **lenerr** (int) – The length for the output error string.

Return type
Tuple[str, int, str]

Returns
A format picture that describes sample, Flag indicating whether sample parsed successfully, Diagnostic returned if sample cannot be parsed

spiceypy.spiceypy.**trace**(*matrix*)

Return the trace of a 3x3 matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/trace_c.html

Parameters
matrix (Union[ndarray, Iterable[Iterable[float]]]) – 3x3 matrix of double precision numbers.

Return type
`float`

Returns
The trace of matrix.

`spiceypy.spiceypy.trcdep()`

Return the number of modules in the traceback representation.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/trcdep_c.html

Return type
`int`

Returns
The number of modules in the traceback.

`spiceypy.spiceypy.trcnam(index, namlen=256)`

Return the name of the module having the specified position in the trace representation. The first module to check in is at index 0.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/trcnam_c.html

Parameters

- **index** (`int`) – The position of the requested module name.
- **namlen** (`int`) – Available space in output name string.

Return type
`str`

Returns
The name at position index in the traceback.

`spiceypy.spiceypy.trcoff()`

Disable tracing.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/trcoff_c.html

Return type
`None`

`spiceypy.spiceypy.trgsep(et, targ1, shape1, frame1, targ2, shape2, frame2, obsrvr, abcorr)`

Compute the angular separation in radians between two spherical or point objects.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/trgsep_c.html

Parameters

- **et** (`float`) – Ephemeris seconds past J2000 TDB.
- **targ1** (`str`) – First target body name.
- **shape1** (`str`) – First target body shape.
- **frame1** (`str`) – Reference frame of first target (UNUSED).
- **targ2** (`str`) – Second target body name.
- **shape2** (`str`) – First target body shape.
- **frame2** (`str`) – Reference frame of second target (UNUSED).
- **obsrvr** (`str`) – Observing body name.

- **abcorr** (str) – Aberration corrections flag.

Return type
float

Returns
angular separation in radians.

spiceypy.spiceypy.**tsetyr**(*year*)

Set the lower bound on the 100 year range.

Default value is 1969

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tsetyr_c.html

Parameters
year (int) – Lower bound on the 100 year interval of expansion

Return type
None

spiceypy.spiceypy.**twopi**()

Return twice the value of pi (the ratio of the circumference of a circle to its diameter).

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/twopi_c.html

Return type
float

Returns
Twice the value of pi.

spiceypy.spiceypy.**twovec**(*axdef*, *indexa*, *plndef*, *indexp*)

Find the transformation to the right-handed frame having a given vector as a specified axis and having a second given vector lying in a specified coordinate plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/twovec_c.html

Parameters

- **axdef** (Union[ndarray, Iterable[float]]) – Vector defining a principal axis.
- **indexa** (int) – Principal axis number of axdef (X=1, Y=2, Z=3).
- **plndef** (Union[ndarray, Iterable[float]]) – Vector defining (with axdef) a principal plane.
- **indexp** (int) – Second axis number (with indexa) of principal plane.

Return type
ndarray

Returns
Output rotation matrix.

spiceypy.spiceypy.**twovxf**(*axdef*, *indexa*, *plndef*, *indexp*)

Find the state transformation from a base frame to the right-handed frame defined by two state vectors: one state vector defining a specified axis and a second state vector defining a specified coordinate plane.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/twovxf_c.html

Parameters

- **axdef** (Union[ndarray, Iterable[float]]) – Vector defining a principal axis.

- **indexa** (int) – Principal axis number of axdef (X=1, Y=2, Z=3).
- **plndef** (Union[ndarray, Iterable[float]]) – Vector defining (with axdef) a principal plane.
- **indexp** (int) – Second axis number (with indexa) of principal plane.

Return type
ndarray

Returns
Output rotation matrix.

spiceypy.spiceypy.**txtopn**(*fname*)

Internal undocumented command for opening a new text file for subsequent write access.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ftncls_c.html#Files https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ftncls_c.html#Examples

Parameters
fname (str) – name of the new text file to be opened.

Return type
int

Returns
FORTRAN logical unit of opened file

spiceypy.spiceypy.**tyear**()

Return the number of seconds in a tropical year.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tyear_c.html

Return type
float

Returns
The number of seconds in a tropical year.

spiceypy.spiceypy.**ucase**(*inchar*, *lenout=None*)

Convert the characters in a string to uppercase.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ucase_c.html

Parameters

- **inchar** (str) – Input string.
- **lenout** (Optional[int]) – Optional Maximum length of output string.

Return type
str

Returns
Output string, all uppercase.

spiceypy.spiceypy.**ucrss**(*v1*, *v2*)

Compute the normalized cross product of two 3-vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ucrss_c.html

Parameters

- **v1** (ndarray) – Left vector for cross product.

- **v2** (ndarray) – Right vector for cross product.

Return type
ndarray

Returns
Normalized cross product v1xv2 / abs(v1xv2).

spiceypy.spiceypy.**uddc**(*udfunc*, *x*, *dx*)

SPICE private routine intended solely for the support of SPICE routines. Users should not call this routine directly due to the volatile nature of this routine.

This routine calculates the derivative of 'udfunc' with respect to time for 'et', then determines if the derivative has a negative value.

Use the @spiceypy.utils.callbacks.SpiceUDFUNS dectorator to wrap a given python function that takes one parameter (float) and returns a float. For example:

```
@spiceypy.utils.callbacks.SpiceUDFUNS
def udfunc(et_in):
    pos, new_et = spice.spkpos("MERCURY", et_in, "J2000", "LT+S", "MOON")
    return new_et

is_negative = spice.uddc(udfunc, et, 1.0)
```

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/uddc_c.html

Parameters

- **udfunc** (CFunctionType) – Name of the routine that computes the scalar value of interest.
- **x** (float) – Independent variable of 'udfunc'.
- **dx** (float) – Interval from 'x' for derivative calculation.

Return type
bool

Returns
Boolean indicating if the derivative is negative.

spiceypy.spiceypy.**uddf**(*udfunc*, *x*, *dx*)

Routine to calculate the first derivative of a caller-specified function using a three-point estimation.

Use the @spiceypy.utils.callbacks.SpiceUDFUNS dectorator to wrap a given python function that takes one parameter (float) and returns a float. For example:

```
@spiceypy.utils.callbacks.SpiceUDFUNS
def udfunc(et_in):
    pos, new_et = spice.spkpos("MERCURY", et_in, "J2000", "LT+S", "MOON")
    return new_et

deriv = spice.uddf(udfunc, et, 1.0)
```

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/uddf_c.html

Parameters

- **udfunc** (CFunctionType) – Name of the routine that computes the scalar value of interest.
- **x** (float) – Independent variable of 'udfunc'.

- **dx** (float) – Interval from 'x' for derivative calculation.

Return type
float

Returns
Approximate derivative of 'udfunc' at 'x'

spiceypy.spiceypy.**udf**(*x*)

No-op routine for with an argument signature matching udfuns. Allways returns 0.0 .

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/udf_c.html

Parameters
x (float) – Double precision value, unused.

Return type
float

Returns
Double precision value, unused.

spiceypy.spiceypy.**union**(*a*, *b*)

Compute the union of two sets of any data type to form a third set.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/union_c.html

Parameters

- **a** (*SpiceCell*) – First input set.
- **b** (*SpiceCell*) – Second input set.

Return type
SpiceCell

Returns
Union of a and b.

spiceypy.spiceypy.**unitim**(*epoch*, *insys*, *outsys*)

Transform time from one uniform scale to another. The uniform time scales are TAI, TDT, TDB, ET, JED, JDTDB, JDTDT.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/unitim_c.html

Parameters

- **epoch** (float) – An epoch to be converted.
- **insys** (str) – The time scale associated with the input epoch.
- **outsys** (str) – The time scale associated with the function value.

Return type
float

Returns
The float in outsys that is equivalent to the epoch on the insys time scale.

spiceypy.spiceypy.**unload**(*filename*)

Unload a SPICE kernel.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/unload_c.html

Parameters
filename (Union[str, Iterable[str]]) – The name of a kernel to unload.

Return type
None

spiceypy.spiceypy.**unorm**(*v1*)

Normalize a double precision 3-vector and return its magnitude.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/unorm_c.html

Parameters
v1 (ndarray) – Vector to be normalized.

Return type
Tuple[ndarray, float]

Returns
Unit vector of v1, Magnitude of v1.

spiceypy.spiceypy.**unormg**(*v1*)

Normalize a double precision vector of arbitrary dimension and return its magnitude.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/unormg_c.html

Parameters
v1 (ndarray) – Vector to be normalized.

Return type
Tuple[ndarray, float]

Returns
Unit vector of v1, Magnitude of v1.

spiceypy.spiceypy.**utc2et**(*utcstr*)

Convert an input time from Calendar or Julian Date format, UTC, to ephemeris seconds past J2000.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/utc2et_c.html

Parameters
utcstr (str) – Input time string, UTC.

Return type
float

Returns
Output epoch, ephemeris seconds past J2000.

spiceypy.spiceypy.**vadd**(*v1*, *v2*)

Add two 3 dimensional vectors. https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vadd_c.html

Parameters

- **v1** (Union[ndarray, Iterable[float]]) – First vector to be added.
- **v2** (Union[ndarray, Iterable[float]]) – Second vector to be added.

Return type
ndarray

Returns
v1+v2

spiceypy.spiceypy.**vaddg**(*v1*, *v2*)

Add two n-dimensional vectors https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vaddg_c.html

Parameters

- **v1** (Union[ndarray, Iterable[float]]) – First vector to be added.
- **v2** (Union[ndarray, Iterable[float]]) – Second vector to be added.

Return type
ndarray

Returns
v1+v2

spiceypy.spiceypy.**valid**(*insize*, *n*, *inset*)

Create a valid CSPICE set from a CSPICE Cell of any data type.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/valid_c.html

Parameters

- **insize** (int) – Size (maximum cardinality) of the set.
- **n** (int) – Initial no. of (possibly non-distinct) elements.
- **inset** (*SpiceCell*) – Set to be validated.

Return type
SpiceCell

Returns
validated set

spiceypy.spiceypy.**vcrss**(*v1*, *v2*)

Compute the cross product of two 3-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vcrss_c.html

Parameters

- **v1** (ndarray) – Left hand vector for cross product.
- **v2** (ndarray) – Right hand vector for cross product.

Return type
ndarray

Returns
Cross product v1 x v2.

spiceypy.spiceypy.**vdist**(*v1*, *v2*)

Return the distance between two three-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vdist_c.html

Parameters

- **v1** (ndarray) – First vector in the dot product.
- **v2** (ndarray) – Second vector in the dot product.

Return type
float

Returns
the distance between v1 and v2

spiceypy.spiceypy.**vdistg**(*v1*, *v2*)

Return the distance between two vectors of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vdistg_c.html

Parameters

- **v1** (ndarray) – ndim-dimensional double precision vector.
- **v2** (ndarray) – ndim-dimensional double precision vector.

Return type
float

Returns
the distance between v1 and v2

spiceypy.spiceypy.**vdot**(*v1*, *v2*)

Compute the dot product of two double precision, 3-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vdot_c.html

Parameters

- **v1** (ndarray) – First vector in the dot product.
- **v2** (ndarray) – Second vector in the dot product.

Return type
float

Returns
dot product of v1 and v2.

spiceypy.spiceypy.**vdotg**(*v1*, *v2*)

Compute the dot product of two double precision vectors of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vdotg_c.html

Parameters

- **v1** (ndarray) – First vector in the dot product.
- **v2** (ndarray) – Second vector in the dot product.

Return type
float

Returns
dot product of v1 and v2.

spiceypy.spiceypy.**vequ**(*v1*)

Make one double precision 3-dimensional vector equal to another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vequ_c.html

Parameters
v1 (ndarray) – 3-dimensional double precision vector.

Return type
ndarray

Returns
3-dimensional double precision vector set equal to vin.

spiceypy.spiceypy.**vequg**(*v1*)

Make one double precision vector of arbitrary dimension equal to another.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vequg_c.html

Parameters

- **v1** (ndarray) – ndim-dimensional double precision vector.
- **ndim** – Dimension of vin (and also vout).

Return type
ndarray

Returns
ndim-dimensional double precision vector set equal to vin.

spiceypy.spiceypy.**vhat**(*v1*)

Find the unit vector along a double precision 3-dimensional vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vhat_c.html

Parameters
v1 (ndarray) – Vector to be unitized.

Return type
ndarray

Returns
Unit vector v / abs(v).

spiceypy.spiceypy.**vhatg**(*v1*)

Find the unit vector along a double precision vector of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vhatg_c.html

Parameters
v1 (ndarray) – Vector to be normalized.

Return type
ndarray

Returns
Unit vector v / abs(v).

spiceypy.spiceypy.**vlcom**(*a*, *v1*, *b*, *v2*)

Compute a vector linear combination of two double precision, 3-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vlcom_c.html

Parameters

- **a** (float) – Coefficient of v1
- **v1** (Union[ndarray, Iterable[float]]) – Vector in 3-space
- **b** (float) – Coefficient of v2
- **v2** (Union[ndarray, Iterable[float]]) – Vector in 3-space

Return type
ndarray

Returns
Linear Vector Combination a*v1 + b*v2.

spiceypy.spiceypy.**vlcom3**(*a*, *v1*, *b*, *v2*, *c*, *v3*)

This subroutine computes the vector linear combination a*v1 + b*v2 + c*v3 of double precision, 3-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vlcom3_c.html

Parameters

- **a** (float) – Coefficient of v1
- **v1** (Union[ndarray, Iterable[float]]) – Vector in 3-space
- **b** (float) – Coefficient of v2
- **v2** (Union[ndarray, Iterable[float]]) – Vector in 3-space
- **c** (float) – Coefficient of v3
- **v3** (Union[ndarray, Iterable[float]]) – Vector in 3-space

Return type
ndarray

Returns
Linear Vector Combination a*v1 + b*v2 + c*v3

spiceypy.spiceypy.**vlcomg**(*n*, *a*, *v1*, *b*, *v2*)

Compute a vector linear combination of two double precision vectors of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vlcomg_c.html

Parameters

- **n** (int) – Dimension of vector space
- **a** (float) – Coefficient of v1
- **v1** (Union[ndarray, Iterable[float]]) – Vector in n-space
- **b** (float) – Coefficient of v2
- **v2** (Union[ndarray, Iterable[float]]) – Vector in n-space

Return type
ndarray

Returns
Linear Vector Combination a*v1 + b*v2

spiceypy.spiceypy.**vminug**(*vin*)

Negate a double precision vector of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vminug_c.html

Parameters
vin (ndarray) – ndim-dimensional double precision vector to be negated.

Return type
ndarray

Returns
ndim-dimensional double precision vector equal to -vin.

spiceypy.spiceypy.**vminus**(*vin*)

Negate a double precision 3-dimensional vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vminus_c.html

Parameters
vin (ndarray) – Vector to be negated.

Return type
ndarray

Returns
Negated vector -v1.

spiceypy.spiceypy.**vnorm**(*v*)

Compute the magnitude of a double precision, 3-dimensional vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vnorm_c.html

Parameters
v (ndarray) – Vector whose magnitude is to be found.

Return type
float

Returns
magnitude of v calculated in a numerically stable way

spiceypy.spiceypy.**vnormg**(*v*)

Compute the magnitude of a double precision vector of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vnormg_c.html

Parameters
v (ndarray) – Vector whose magnitude is to be found.

Return type
float

Returns
magnitude of v calculated in a numerically stable way

spiceypy.spiceypy.**vpack**(*x*, *y*, *z*)

Pack three scalar components into a vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vpack_c.html

Parameters

- **x** (float) – first scalar component
- **y** (float) – second scalar component
- **z** (float) – third scalar component

Return type
ndarray

Returns
Equivalent 3-vector.

spiceypy.spiceypy.**vperp**(*a*, *b*)

Find the component of a vector that is perpendicular to a second vector. All vectors are 3-dimensional.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vperp_c.html

Parameters

- **a** (ndarray) – The vector whose orthogonal component is sought.
- **b** (ndarray) – The vector used as the orthogonal reference.

Return type
ndarray

Returns
The component of a orthogonal to b.

spiceypy.spiceypy.**vprjp**(*vin*, *plane*)

Project a vector onto a specified plane, orthogonally.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vprjp_c.html

Parameters

- **vin** (Union[ndarray, Iterable[float]]) – The projected vector.
- **plane** (*Plane*) – Plane containing vin.

Return type
ndarray

Returns
Vector resulting from projection.

spiceypy.spiceypy.**vprjpi**(*vin*, *projpl*, *invpl*)

Find the vector in a specified plane that maps to a specified vector in another plane under orthogonal projection.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vprjpi_c.html

Parameters

- **vin** (Union[ndarray, Iterable[float]]) – The projected vector.
- **projpl** (*Plane*) – Plane containing vin.
- **invpl** (*Plane*) – Plane containing inverse image of vin.

Return type
Tuple[ndarray, bool]

Returns
Inverse projection of vin.

spiceypy.spiceypy.**vproj**(*a*, *b*)

Find the projection of one vector onto another vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vproj_c.html

Parameters

- **a** (ndarray) – The vector to be projected.
- **b** (ndarray) – The vector onto which a is to be projected.

Return type
ndarray

Returns
The projection of a onto b.

spiceypy.spiceypy.**vprojg**(*a*, *b*)

Find the projection of one vector onto another vector. All vectors are of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vprojg_c.html

Parameters

- **a** (ndarray) – The vector to be projected.
- **b** (ndarray) – The vector onto which a is to be projected.

Return type
ndarray

Returns
The projection of a onto b.

spiceypy.spiceypy.**vrel**(*v1*, *v2*)

Return the relative difference between two 3-dimensional vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vrel_c.html

Parameters

- **v1** (Union[ndarray, Iterable[float]]) – First vector
- **v2** (Union[ndarray, Iterable[float]]) – Second vector

Return type
float

Returns
the relative difference between v1 and v2.

spiceypy.spiceypy.**vrelg**(*v1*, *v2*)

Return the relative difference between two vectors of general dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vrelg_c.html

Parameters

- **v1** (Union[ndarray, Iterable[float]]) – First vector
- **v2** (Union[ndarray, Iterable[float]]) – Second vector

Return type
float

Returns
the relative difference between v1 and v2.

spiceypy.spiceypy.**vrotv**(*v*, *axis*, *theta*)

Rotate a vector about a specified axis vector by a specified angle and return the rotated vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vrotv_c.html

Parameters

- **v** (ndarray) – Vector to be rotated.
- **axis** (ndarray) – Axis of the rotation.
- **theta** (float) – Angle of rotation (radians).

Return type
ndarray

Returns
Result of rotating v about axis by theta

spiceypy.spiceypy.**vscl**(*s*, *v1*)

Multiply a scalar and a 3-dimensional double precision vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vscl_c.html

Parameters

- **s** (float) – Scalar to multiply a vector
- **v1** (ndarray) – Vector to be multiplied

Return type
ndarray

Returns
Product vector, s*v1.

spiceypy.spiceypy.**vsclg**(*s*, *v1*)

Multiply a scalar and a double precision vector of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vsclg_c.html

Parameters

- **s** (float) – Scalar to multiply a vector
- **v1** (ndarray) – Vector to be multiplied

Return type
ndarray

Returns
Product vector, s*v1.

spiceypy.spiceypy.**vsep**(*v1*, *v2*)

Find the separation angle in radians between two double precision, 3-dimensional vectors. This angle is defined as zero if either vector is zero.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vsep_c.html

Parameters

- **v1** (ndarray) – First vector
- **v2** (ndarray) – Second vector

Return type
float

Returns
separation angle in radians

spiceypy.spiceypy.**vsepg**(*v1*, *v2*)

Find the separation angle in radians between two double precision vectors of arbitrary dimension. This angle is defined as zero if either vector is zero.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vsepg_c.html

Parameters

- **v1** (ndarray) – First vector
- **v2** (ndarray) – Second vector

Return type
`float`

Returns
separation angle in radians

`spiceypy.spiceypy.vsub(v1, v2)`

Compute the difference between two 3-dimensional, double precision vectors.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vsub_c.html

Parameters

- **v1** (ndarray) – First vector (minuend).
- **v2** (ndarray) – Second vector (subtrahend).

Return type
`ndarray`

Returns
Difference vector, v1 - v2.

`spiceypy.spiceypy.vsubg(v1, v2)`

Compute the difference between two double precision vectors of arbitrary dimension.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vsubg_c.html

Parameters

- **v1** (ndarray) – First vector (minuend).
- **v2** (ndarray) – Second vector (subtrahend).

Return type
`ndarray`

Returns
Difference vector, v1 - v2.

`spiceypy.spiceypy.vtmv(v1, matrix, v2)`

Multiply the transpose of a 3-dimensional column vector a 3x3 matrix, and a 3-dimensional column vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vtmv_c.html

Parameters

- **v1** (ndarray) – 3 dimensional double precision column vector.
- **matrix** (ndarray) – 3x3 double precision matrix.
- **v2** (ndarray) – 3 dimensional double precision column vector.

Return type
`float`

Returns
the result of (v1**t * matrix * v2).

`spiceypy.spiceypy.vtmvg(v1, matrix, v2)`

Multiply the transpose of a n-dimensional column vector a nxm matrix, and a m-dimensional column vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vtmvg_c.html

Parameters

- **v1** (ndarray) – n-dimensional double precision column vector.
- **matrix** (ndarray) – nxm double precision matrix.
- **v2** (ndarray) – m-dimensional double porecision column vector.

Return type
float

Returns
the result of (v1**t * matrix * v2)

spiceypy.spiceypy.**vupack**(*v*)

Unpack three scalar components from a vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vupack_c.html

Parameters
v (ndarray) – Vector

Return type
Tuple[float, float, float]

Returns
(x, y, z)

spiceypy.spiceypy.**vzero**(*v*)

Indicate whether a 3-vector is the zero vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vzero_c.html

Parameters
v (ndarray) – Vector to be tested

Return type
bool

Returns
true if and only if v is the zero vector

spiceypy.spiceypy.**vzerog**(*v*)

Indicate whether a general-dimensional vector is the zero vector.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/vzerog_c.html

Parameters
v (ndarray) – Vector to be tested

Return type
bool

Returns
true if and only if v is the zero vector

spiceypy.spiceypy.**warn_deprecated_args**(***kwargs*)

Return type
None

spiceypy.spiceypy.**wncard**(*window*)

Return the cardinality (number of intervals) of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wncard_c.html

Parameters
window (*SpiceCell*) – Input window

Return type
int

Returns
the cardinality of the input window.

spiceypy.spiceypy.**wncomd**(*left*, *right*, *window*)

Determine the complement of a double precision window with respect to a specified interval.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wncomd_c.html

Parameters

- **left** (float) – left endpoints of complement interval.
- **right** (float) – right endpoints of complement interval.
- **window** (*SpiceCell*) – Input window

Return type
SpiceCell

Returns
Complement of window with respect to left and right.

spiceypy.spiceypy.**wncond**(*left*, *right*, *window*)

Contract each of the intervals of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wncond_c.html

Parameters

- **left** (float) – Amount added to each left endpoint.
- **right** (float) – Amount subtracted from each right endpoint.
- **window** (*SpiceCell*) – Window to be contracted

Return type
SpiceCell

Returns
Contracted Window.

spiceypy.spiceypy.**wndifd**(*a*, *b*)

Place the difference of two double precision windows into a third window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wndifd_c.html

Parameters

- **a** (*SpiceCell*) – Input window A.
- **b** (*SpiceCell*) – Input window B.

Return type
SpiceCell

Returns
Difference of a and b.

spiceypy.spiceypy.**wnelmd**(*point*, *window*)

Determine whether a point is an element of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnelmd_c.html

Parameters

- **point** (float) – Input point.
- **window** (*SpiceCell*) – Input window

Return type
bool

Returns
returns True if point is an element of window.

spiceypy.spiceypy.**wnexpd**(*left*, *right*, *window*)

Expand each of the intervals of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnexpd_c.html

Parameters

- **left** (float) – Amount subtracted from each left endpoint.
- **right** (float) – Amount added to each right endpoint.
- **window** (*SpiceCell*) – Window to be expanded.

Return type
SpiceCell

Returns
Expanded Window.

spiceypy.spiceypy.**wnextd**(*side*, *window*)

Extract the left or right endpoints from a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnextd_c.html

Parameters

- **side** (str) – Extract left "L" or right "R" endpoints.
- **window** (*SpiceCell*) – Window to be extracted.

Return type
SpiceCell

Returns
Extracted Window.

spiceypy.spiceypy.**wnfetd**(*window*, *n*)

Fetch a particular interval from a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnfetd_c.html

Parameters

- **window** (*SpiceCell*) – Input window
- **n** (int) – Index of interval to be fetched.

Return type
Tuple[float, float]

Returns
Left, right endpoints of the nth interval.

spiceypy.spiceypy.**wnfild**(*small*, *window*)

Fill small gaps between adjacent intervals of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnfild_c.html

Parameters

- **small** (float) – Limiting measure of small gaps.
- **window** (*SpiceCell*) – Window to be filled

Return type
SpiceCell

Returns
Filled Window.

spiceypy.spiceypy.**wnfltd**(*small*, *window*)

Filter (remove) small intervals from a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnfltd_c.html

Parameters

- **small** (float) – Limiting measure of small intervals.
- **window** (*SpiceCell*) – Window to be filtered.

Return type
SpiceCell

Returns
Filtered Window.

spiceypy.spiceypy.**wnincd**(*left*, *right*, *window*)

Determine whether an interval is included in a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnincd_c.html

Parameters

- **left** (float) – Left interval
- **right** (float) – Right interval
- **window** (*SpiceCell*) – Input window

Return type
bool

Returns
Returns True if the input interval is included in window.

spiceypy.spiceypy.**wninsd**(*left*, *right*, *window*)

Insert an interval into a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wninsd_c.html

Parameters

- **left** (float) – Left endpoints of new interval.
- **right** (float) – Right endpoints of new interval.

- **window** (*SpiceCell*) – Input window.

Return type
None

spiceypy.spiceypy.**wnintd**(*a*, *b*)

Place the intersection of two double precision windows into a third window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnintd_c.html

Parameters

- **a** (*SpiceCell*) – Input window A.
- **b** (*SpiceCell*) – Input window B.

Return type
SpiceCell

Returns
Intersection of a and b.

spiceypy.spiceypy.**wnreld**(*a*, *op*, *b*)

Compare two double precision windows.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnreld_c.html

Parameters

- **a** (*SpiceCell*) – First window.
- **op** (str) – Comparison operator.
- **b** (*SpiceCell*) – Second window.

Return type
bool

Returns
The result of comparison: a (op) b.

spiceypy.spiceypy.**wnsumd**(*window*)

Summarize the contents of a double precision window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnsumd_c.html

Parameters
window (*SpiceCell*) – Window to be summarized.

Return type
Tuple[float, float, float, int, int]

Returns
Total measure of intervals in window, Average measure, Standard deviation, Location of shortest interval, Location of longest interval.

spiceypy.spiceypy.**wnunid**(*a*, *b*)

Place the union of two double precision windows into a third window.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnunid_c.html

Parameters

- **a** (*SpiceCell*) – Input window A.
- **b** (*SpiceCell*) – Input window B.

Return type
SpiceCell

Returns
Union of a and b.

spiceypy.spiceypy.**wnvald**(*insize*, *n*, *window*)

Form a valid double precision window from the contents of a window array.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/wnvald_c.html

Parameters

- **insize** (int) – Size of window.
- **n** (int) – Original number of endpoints.
- **window** (*SpiceCell*) – Input window.

Return type
SpiceCell

Returns
The union of the intervals in the input cell.

spiceypy.spiceypy.**writln**(*line*, *unit*)

Internal undocumented command for writing a text line to a logical unit

No URL available; relevant lines from SPICE source:

FORTRAN SPICE, writln.f:

```
C$Procedure      WRITLN ( Write a text line to a logical unit )
      SUBROUTINE WRITLN ( LINE, UNIT )
      CHARACTER*(*)      LINE
      INTEGER            UNIT

C     Variable  I/O  Description
C     --------  ---  --------------------------------------------------
C     LINE       I   The line which is to be written to UNIT.
C     UNIT       I   The Fortran unit number to use for output.
```

CSPICE, writln.c:

```
/* $Procedure      WRITLN ( Write a text line to a logical unit ) */
/* Subroutine */ int writln_(char *line, integer *unit, ftnlen line_len)
```

Parameters

- **line** (str) – The line which is to be written to UNIT.
- **unit** (int) – The Fortran unit number to use for output.

Return type
None

spiceypy.spiceypy.**xf2eul**(*xform*, *axisa*, *axisb*, *axisc*)

Convert a state transformation matrix to Euler angles and their derivatives with respect to a specified set of axes.

The companion routine *eul2xf()* converts Euler angles and their derivatives with respect to a specified set of axes to a state transformation matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xf2eul_c.html

Parameters

- **xform** (ndarray) – state transformation matrix
- **axisa** (int) – Axis A of the Euler angle factorization.
- **axisb** (int) – Axis B of the Euler angle factorization.
- **axisc** (int) – Axis C of the Euler angle factorization.

Return type
Tuple[ndarray, int]

Returns
(eulang, unique)

spiceypy.spiceypy.**xf2rav**(*xform*)

This routine determines the rotation matrix and angular velocity of the rotation from a state transformation matrix.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xf2rav_c.html

Parameters
xform (ndarray) – state transformation matrix

Return type
Tuple[ndarray, ndarray]

Returns
rotation associated with xform, angular velocity associated with xform.

spiceypy.spiceypy.**xfmsta**(*input_state*, *input_coord_sys*, *output_coord_sys*, *body*)

Transform a state between coordinate systems.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xfmsta_c.html

Parameters

- **input_state** (ndarray) – Input state.
- **input_coord_sys** (str) – Current (input) coordinate system.
- **output_coord_sys** (str) – Desired (output) coordinate system.
- **body** (str) – Name or NAIF ID of body with which coordinates are associated (if applicable).

Return type
ndarray

Returns
Converted output state

spiceypy.spiceypy.**xpose**(*m*)

Transpose a 3x3 matrix

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xpose_c.html

Parameters
m (Union[ndarray, Iterable[Iterable[float]]]) – Matrix to be transposed

Return type
ndarray

Returns
Transposed matrix

spiceypy.spiceypy.**xpose6**(*m*)

Transpose a 6x6 matrix

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xpose6_c.html

Parameters
m (Union[ndarray, Iterable[Iterable[float]]]) – Matrix to be transposed

Return type
ndarray

Returns
Transposed matrix

spiceypy.spiceypy.**xposeg**(*matrix*)

Transpose a matrix of arbitrary size in place, the matrix need not be square.

https://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/xposeg_c.html

Parameters
matrix (Union[ndarray, Iterable[Iterable[float]]]) – Matrix to be transposed

Return type
ndarray

Returns
Transposed matrix

spiceypy.spiceypy.**zzdynrot**(*typid*, *center*, *et*)

Find the rotation from a dynamic frame ID to the associated frame at the time requested

Parameters

- **typid** (int) – ID code for the dynamic frame
- **center** (int) – the ID for the center of the frame
- **et** (float) – Epoch measured in seconds past J2000

Return type
Tuple[ndarray, int]

Returns
Rotation matrix from the input frame to the returned associated frame, id for the associated frame

3.10.2 spiceypy.utils.support_types module

class spiceypy.utils.support_types.**Cell_Bool**(*size*)

Bases: *SpiceCell*

class spiceypy.utils.support_types.**Cell_Char**(*size*, *length*)

Bases: *SpiceCell*

class spiceypy.utils.support_types.**Cell_Double**(*size*)

Bases: *SpiceCell*

class spiceypy.utils.support_types.**Cell_Int**(*size*)

Bases: *SpiceCell*

class spiceypy.utils.support_types.**Cell_Time**(*size*)

Bases: *SpiceCell*

class spiceypy.utils.support_types.**DataType**

Bases: object

BOOL = 4

CHR = 0

DP = 1

INT = 2

SPICE_BOOL = 4

SPICE_CHR = 0

SPICE_DP = 1

SPICE_INT = 2

SPICE_TIME = 3

TIME = 3

class spiceypy.utils.support_types.DoubleArrayType

Bases: object

Class type that will handle all double vectors, inspiration from python cookbook 3rd edition

from_list(*param*)

from_ndarray(*param*)

from_param(*param*)

class spiceypy.utils.support_types.DoubleMatrixType

Bases: object

Class type that will handle all 2d double arrays, inspiration from python cookbook 3rd edition

from_list(*param*)

from_ndarray(*param*)

from_param(*param*)

class spiceypy.utils.support_types.Ellipse

Bases: Structure

property center

property semi_major

property semi_minor

class spiceypy.utils.support_types.IntArrayType

Bases: object

Class type that will handle all int vectors, inspiration from python cookbook 3rd edition

from_list(*param*)

from_ndarray(*param*)

from_param(*param*)

class spiceypy.utils.support_types.IntMatrixType

Bases: object

Class type that will handle all 2d int arrays, inspiration from python cookbook 3rd edition

from_list(*param*)

from_ndarray(*param*)

from_param(*param*)

class spiceypy.utils.support_types.Plane

Bases: Structure

property constant

property normal

spiceypy.utils.support_types.**SPICEBOOL_CELL**(*size*)

Returns a Bool Spice Cell with a given size :type size: int :param size: number of elements :rtype: *SpiceCell* :return: empty Spice Cell

spiceypy.utils.support_types.**SPICECHAR_CELL**(*size*, *length*)

Returns a Char Spice Cell with a given size :type size: int :param size: number of elements :type length: int :param length: width of elements :rtype: *SpiceCell* :return: empty Spice Cell

spiceypy.utils.support_types.**SPICEDOUBLE_CELL**(*size*)

Returns a Double Spice Cell with a given size :type size: int :param size: number of elements :rtype: *SpiceCell* :return: empty Spice Cell

spiceypy.utils.support_types.**SPICEINT_CELL**(*size*)

Returns a Int Spice Cell with a given size :type size: int :param size: number of elements :rtype: *SpiceCell* :return: empty Spice Cell

spiceypy.utils.support_types.**SPICETIME_CELL**(*size*)

Returns a Time Spice Cell with a given size :type size: int :param size: number of elements :return: empty Spice Cell

class spiceypy.utils.support_types.**SpiceCell**(*dtype=None*, *length=None*, *size=None*, *card=None*, *isSet=None*, *base=None*, *data=None*)

Bases: Structure

CTRLBLOCK = 6

DATATYPES_ENUM = {'bool': 4, 'char': 0, 'double': 1, 'int': 2, 'time': 3}

DATATYPES_GET = [<function _char_getter>, <function _double_getter>, <function _int_getter>, <function _int_getter>, <function _int_getter>]

adjust

Structure/Union member

base

Structure/Union member

baseSize = 6

classmethod bool(*size*)

card

Structure/Union member

classmethod character(*size*, *length*)

data

Structure/Union member

classmethod double(*size*)

dtype

Structure/Union member

init

Structure/Union member

classmethod integer(*size*)

isSet

Structure/Union member

is_bool()

is_char()

is_double()

is_int()

is_set()

is_time()

length

Structure/Union member

minCharLen = 6

reset()

size

Structure/Union member

classmethod time(*size*)

spiceypy.utils.support_types.**SpiceCellPointer**

alias of LP_SpiceCell

class spiceypy.utils.support_types.**SpiceDLADescr**

Bases: Structure

property bwdptr

property cbase

property csize

property dbase

property dsize

property fwdptr

property ibase

property isize

class spiceypy.utils.support_types.**SpiceDSKDescr**

Bases: Structure

property center

property co1max

property co1min

property co2max

property co2min

property co3max

property co3min

property corpar

property corsys

property dclass

property dtype

property frmcde

property start

property stop

property surfce

class spiceypy.utils.support_types.SpiceEKAttDsc

Bases: Structure

property cclass

property dtype

property indexd

property nullok

property size

property strlen

class spiceypy.utils.support_types.SpiceEKDataType

Bases: c_int

SPICE_BOOL = 4

SPICE_CHR = 0

SPICE_DP = 1

SPICE_INT = 2

SPICE_TIME = 3

class spiceypy.utils.support_types.SpiceEKExprClass

Bases: c_int

SPICE_EK_EXP_COL = 0

SPICE_EK_EXP_EXPR = 2

SPICE_EK_EXP_FUNC = 1

class spiceypy.utils.support_types.**SpiceEKSegSum**

Bases: Structure

property cdescrs

property cnames

property ncols

property nrows

property tabnam

class spiceypy.utils.support_types.**SpiceSPK18Subtype**

Bases: c_int

S18TP0 = 0

S18TP1 = 1

spiceypy.utils.support_types.**c_int_vector_to_bool_python**(*x*)

spiceypy.utils.support_types.**c_matrix_to_numpy**(*x*)

Convert a ctypes 2d array (or matrix) into a numpy array for python use

Parameters
x – thing to convert

Returns
numpy.ndarray

spiceypy.utils.support_types.**c_vector_to_python**(*x*)

Convert the c vector data into the correct python data type (numpy arrays or strings)

Parameters
x – ctypes array

Returns
Iterable

spiceypy.utils.support_types.**dynamically_instantiate_spiceyerror**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=''*)

Dynamically creates a SpiceyPyException which is a subclass of SpiceyError and may also be subclassed to other exceptions such as IOError and such depending on the Short description

Parameters

- **short** (str) –
- **explain** (str) –
- **long** (str) –
- **traceback** (str) –
- **found** (str) –

Returns

spiceypy.utils.support_types.**empty_char_array**(*x_len=None*, *y_len=None*)

spiceypy.utils.support_types.**empty_double_matrix**(*x=3*, *y=3*)

spiceypy.utils.support_types.**empty_double_vector**(*n*)

spiceypy.utils.support_types.**empty_int_matrix**(*x=3*, *y=3*)

spiceypy.utils.support_types.**empty_int_vector**(*n*)

spiceypy.utils.support_types.**empty_spice_ek_data_type_vector**(*n*)

spiceypy.utils.support_types.**empty_spice_ek_expr_class_vector**(*n*)

spiceypy.utils.support_types.**is_iterable**(*i*)

From stackoverflow https://stackoverflow.com/questions/1055360/how-to-tell-a-variable-is-iterable-but-not-a-string/44328500#44328500 :param i: input collection :rtype: `bool` :return: if the input is iterable but not a string

spiceypy.utils.support_types.**list_to_char_array**(*arg*, *x_len=None*, *y_len=None*)

spiceypy.utils.support_types.**list_to_char_array_ptr**(*input*, *x_len=None*, *y_len=None*)

spiceypy.utils.support_types.**short_to_spiceypy_exception_class**(*short*)

Lookup the correct Spice Exception class

Parameters

short (`str`) – Spice error system short description key

Return type

Type[*SpiceyError*]

Returns

SpiceyError

spiceypy.utils.support_types.**string_to_char_p**(*inobject*, *inlen=None*)

convert a python string to a char_p

Parameters

- **inobject** – input string, int for getting null string of length of int
- **inlen** – optional parameter, length of a given string can be specified

Returns

spiceypy.utils.support_types.**to_double_matrix**(*x*)

spiceypy.utils.support_types.**to_double_vector**(*x*)

spiceypy.utils.support_types.**to_int_matrix**(*x*)

spiceypy.utils.support_types.**to_int_vector**(*x*)

spiceypy.utils.support_types.**to_python_string**(*in_string*)

3.10.3 spiceypy.utils.callbacks module

spiceypy.utils.callbacks.**CallUDFUNS**(*f*, *x*)

We are given a UDF CFUNCTYPE and want to call it in python

Parameters

- **f** (CFunctionType) – SpiceUDFUNS
- **x** (float) – some scalar

Return type
float

Returns
value

spiceypy.utils.callbacks.**SpiceUDBAIL**(*f*)

Decorator for wrapping python functions in spice udbail callback type

Parameters
f (Callable[[], Union[bool, int]]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udbail function

spiceypy.utils.callbacks.**SpiceUDFUNB**(*f*)

Decorator for wrapping python functions in spice udfunb callback type

Parameters
f (Callable[[CFunctionType, float], int]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udfunb function

spiceypy.utils.callbacks.**SpiceUDFUNC**(*f*)

Decorator for wrapping python functions in spice udfunc callback type

Parameters
f (Callable[[float], float]) – function that has one argument of type float, and returns a float

Return type
CFunctionType

Returns
wrapped udfunc function

spiceypy.utils.callbacks.**SpiceUDFUNS**(*f*)

Decorator for wrapping python functions in spice udfuns callback type

Parameters
f (Callable[[float], float]) – function that has one argument of type float, and returns a float

Return type
CFunctionType

Returns
wrapped udfunc function

spiceypy.utils.callbacks.**SpiceUDREFN**(*f*)

Decorator for wrapping python functions in spice udrefn callback type

Parameters
f (Callable[[float, float, Union[bool, int], Union[bool, int]], float]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udrefn function

spiceypy.utils.callbacks.**SpiceUDREPF**(*f*)

Decorator for wrapping python functions in spice udrepf callback type

Parameters
f (Callable) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udrepf function

spiceypy.utils.callbacks.**SpiceUDREPI**(*f*)

Decorator for wrapping python functions in spice udfrepi callback type

Parameters
f (Callable[[Union[*SpiceCell*, LP_SpiceCell], str, str], None]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udrepi function

spiceypy.utils.callbacks.**SpiceUDREPU**(*f*)

Decorator for wrapping python functions in spice udrepu callback type

Parameters
f (Callable[[float, float, float], None]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udrepu function

spiceypy.utils.callbacks.**SpiceUDSTEP**(*f*)

Decorator for wrapping python functions in spice udstep callback type

Parameters
f (Callable[[float], float]) – function to be wrapped

Return type
CFunctionType

Returns
wrapped udstep function

3.10.4 spiceypy.utils.exceptions module

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exception spiceypy.utils.exceptions.**NotFoundError**(*message=None*, *found=False*)

Bases: *SpiceyPyError*

A NotFound Error from Spice

exception spiceypy.utils.exceptions.**SpiceADDRESSOUTOFBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceAGENTLISTOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceALLGONE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceAMBIGTEMPL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceARRAYSHAPEMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceARRAYSIZEMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceARRAYTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceAVALOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceAXISUNDERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADACTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADADDRESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADANGLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADANGLEUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADANGRATEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADANGULARRATE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADANGULARRATEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADARCHITECTURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADARCHTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADARRAYSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceBADATTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADATTRIBUTE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADATTRIBUTES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADAUVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADAVFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADAVFRAMEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADAXIS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADAXISLENGTH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADAXISNUMBERS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADBLOCKSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADBODYID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADBORESIGHTSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADBOUNDARY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADCATALOGFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCENTERNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCHECKFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCKTYPESPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOARSEVOXSCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADCOLUMDECL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOLUMNCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOLUMNDECL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOMMENTAREA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADCOMPNUMBER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOORDBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOORDSYS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADCOORDSYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADCURVETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDAFTRANSFERFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDASCOMMENTAREA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADDASDIRECTORY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDASFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDASTRANSFERFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDATALINE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDATAORDERTOKEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDATATYPEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDEFAULTVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADDESCRTIMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADDIMENSIONS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDIRECTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADDOUBLEPRECISION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADDOWNSAMPLINGTOL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADECCENTRICITY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADENDPOINTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADEULERANGLEUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFILEFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFILETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADFINEVOXELSCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADFORMATSPECIFIER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFORMATSTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADFRAMECLASS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADFRAMESPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFROMTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFROMTIMESYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADFROMTIMETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADGEFVERSION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADGEOMETRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADGM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADHARDSPACE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADHERMITDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADINITSTATE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceBADINPUTDATALINE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINPUTETTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINPUTTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINPUTUTCTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINSTRUMENTID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADINTEGER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLAGRANGEDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLATITUDEBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLATITUDERANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLATUSRECTUM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADLEAPSECONDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLIMBLOCUSMIX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADLINEPERRECCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLISTFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADLONGITUDERANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADMATRIX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADMEANMOTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADMECCENTRICITY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADMETHODSYNTAX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADMSOPQUATERNION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADNOFDIGITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADNOFSTATES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADNUMBEROFPOINTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADOFFSETANGLES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADOFFSETANGUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADOFFSETAXESFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADOFFSETAXISXYZ**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADOUTPUTTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADPCKVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADPECCENTRICITY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADPERIAPSEVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADPICTURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADPLATECOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADPODLOCATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADPRECVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADPRIORITYSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADQUATSIGN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADQUATTHRESHOLD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADRADIUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADRADIUSCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADRATEFRAMEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADRATETHRESHOLD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADRECORDCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADREFVECTORSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADROTATIONAXISXYZ**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADROTATIONSORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADROTATIONTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADROTAXESFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADROWCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSEMIAXIS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADSEMILATUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSHAPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSOLDAY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSOLINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSOLTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSOURCERADIUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSPICEQUATERNION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSTARINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSTARTTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSTDIONAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSTOPTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADSUBSCRIPT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSUBSTR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSUBSTRINGBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADSURFACEMAP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTABLEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTERMLOCUSMIX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTIMECASE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTIMECOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTIMEFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTIMEITEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADTIMEOFFSET**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTIMESPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyValueError*

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Bases: *SpiceyPyValueError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTLECOVERAGEPAD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTLEPADS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTOTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTOTIMESYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTOTIMETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADTYPESHAPECOMBO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADVARASSIGN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBADVARIABLESIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADVARIABLETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyTypeError*

exception spiceypy.utils.exceptions.**SpiceBADVARNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBADVECTOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADVERTEXCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBADVERTEXINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIndexError*

exception spiceypy.utils.exceptions.**SpiceBADWINDOWSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBARRAYTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBARYCENTEREPHEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBARYCENTERIDCODE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBEFOREBEGSTR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKCOMMANDLINE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceBLANKFILETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKINPUTTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKMODULENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBLANKNAMEASSIGNED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKOUTPTFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKSCLKSTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLANKTIMEFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBLOCKSNOTEVEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBODIESNOTDISTINCT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBODYANDCENTERSAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBODYIDNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceBODYNAMENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceBOGUSENTRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBORESIGHTMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBOUNDARYMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBOUNDARYTOOBIG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceBOUNDSDISAGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBOUNDSOUTOFORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceBUFFEROVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceBUFFERSIZESMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBUFFERTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceBUG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceBUGWRITEFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCALLCKBSSFIRST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCALLEDOUTOFORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCALLZZDSKBSSFIRST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANNOTFINDGRP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANNOTGETPACKET**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANNOTMAKEFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANNOTPICKFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANTFINDFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceCANTGETROTATIONTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCANTUSEPERIAPEPOCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCBNOSUCHSTR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCELLARRAYTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCELLTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceCKBOGUSENTRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCKINSUFFDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceCKNONEXISTREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCKTOOMANYFILES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceCKUNKNOWNDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCKWRONGDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCLIBCALLFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCLUSTERWRITEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCMDERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCMDPARSEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOARSEGRIDOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOLDESCTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOLUMNTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceCOMMANDTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOMMENTTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceCOMMFILENOTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOORDSYSNOTREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceCOUNTTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceCOVERAGEGAP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceCROSSANGLEMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDAFBADCRECLEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFBADRECLEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFBEGGTEND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFCRNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFDPWRITEFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFFRNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFFTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceDAFILLEGWRITE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFIMPROPOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFINVALIDACCESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFINVALIDPARAMS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNEGADDR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFNEWCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOIDWORD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOIFNMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNONAMEMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNORESV**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOSEARCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFNOSUCHADDR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOSUCHFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOSUCHHANDLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOSUCHUNIT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFNOWRITE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFOPENFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFREADFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDAFRWCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDAFWRITEFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASFILEREADFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASFILEWRITEFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASFTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceDASIDWORDNOTKNOWN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASIMPROPOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASINVALIDACCESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASINVALIDCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASINVALIDTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASNOIDWORD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASNOSUCHADDRESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASNOSUCHFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASNOSUCHHANDLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASNOSUCHUNIT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASNOTEMPTY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASOPENCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASOPENFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASREADFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDASRWCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceDASWRITEFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDATAITEMLIMITEXCEEDED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDATAREADFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDATATYPENOTRECOG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDATAWIDTHERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDATEEXPECTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDECODINGERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDEGENERATECASE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDEGENERATEINTERVAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDEGENERATESURFACE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDEPENDENTVECTORS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDEVICENAMETOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceDIFFLINETOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDIFFLINETOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDIMENSIONTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDISARRAY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDISORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDIVIDEBYZERO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyZeroDivisionError*

exception spiceypy.utils.exceptions.**SpiceDSKBOGUSENTRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDSKDATANOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDSKTARGETMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDSKTOOMANYFILES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceDTOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDUBIOUSMETHOD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceDUPLICATETIMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceECCOUTOFBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceECCOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceEKCOLATTRTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceEKCOLDESCTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceEKCOLNUMMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEKFILETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceEKIDTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceEKMISSINGCOLUMN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEKNOSEGMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceEKSEGMENTTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceEKSEGTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEKTABLELISTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceELEMENTSTOOSHORT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceEMBEDDEDBLANK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEMPTYINPUTFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEMPTYSEGMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceEMPTYSTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceENDOFFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceENDPOINTSMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceERROREXIT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEVECOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEVENHERMITDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEVILBOGUSENTRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceEXTERNALOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFACENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFAKESCLKEXISTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILARCHMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILARCMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEALREADYEXISTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEALREADYOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILECURRENTLYOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILEDELETEFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEDOESNOTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILEEXISTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEISNOTSPK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILENAMETOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILENOTCONNECTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILENOTOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEOPENCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEOPENERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEOPENFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEOPENFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILEREADERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEREADFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceFILETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILETRUNCATED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFILEWRITEFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFIRSTRECORDMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFMTITEMLIMITEXCEEDED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATDATAMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATDOESNTAPPLY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATITEMLIMITEXCEEDED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATNOTAPPLICABLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFORMATSTRINGTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFOVTOOWIDE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEAIDCODENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEBIDCODENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEDATANOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEDEFERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEIDNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEINFONOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMEMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceFRAMENAMENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceFRAMENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFRAMENOTRECOGNIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceFTPXFERERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceGRIDTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceHANDLENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceHASHISFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceHLULOCKFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceIDCODENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceIDSTRINGTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceIDWORDNOTKNOWN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceILLEGALCHARACTER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceILLEGALOPTIONNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceILLEGSHIFTDIR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceILLEGTEMPL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceIMMUTABLEVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceIMPROPERFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceIMPROPEROPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINACTIVEOBJECT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCOMPATIBLEEOL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCOMPATIBLENUMREF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCOMPATIBLESCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINCOMPATIBLEUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINCOMPLETEELEMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCOMPLETEFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCOMPLETFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTCENTERID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTELEMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTENTTIMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTSTARTTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCONSISTSTOPTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINCORRECTUSAGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINDEFINITELOCALSECOND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINDEXOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIndexError*

exception spiceypy.utils.exceptions.**SpiceINDEXTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINPUTDOESNOTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINPUTFILENOTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINPUTOUTOFBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINPUTOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINPUTSTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINQUIREERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceINQUIREFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceINSUFFICIENTANGLES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINSUFFICIENTDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINSUFFLEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceINSUFPTRSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINTERVALSTARTNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINTINDEXTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINTLENNOTPOS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINTOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALDDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALDINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIndexError*

exception spiceypy.utils.exceptions.**SpiceINVALIDACCESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDACTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDADD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDADDRESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDANGLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDARCHTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceINVALIDARGUMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDARRAYRANK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDARRAYSHAPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDARRAYTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyTypeError*

exception spiceypy.utils.exceptions.**SpiceINVALIDAXES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDAXIS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDAXISLENGTH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCARDINALITY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCASE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCHECKOUT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCLUSTERNUM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCOLUMN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCONSTSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDATACOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDESCRTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDIMENSION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDIRECTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDDIVISOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDELLIPSE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDENDPNTSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDENDPTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDEPOCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFILETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFIXREF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFOV**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDFRAMEDEF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDHANDLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDINDEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIndexError*

exception spiceypy.utils.exceptions.**SpiceINVALIDINTEGER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDLIMBTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDLISTITEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDLOCUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDLONEXTENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDMETADATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDMETHOD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDMSGTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNODE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMBEROFINTERVALS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMBEROFRECORDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMINT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMINTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDNUMRECS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDOCCTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDOPERATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDOPTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDPLANE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDPOINT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDRADII**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDRADIUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDREFFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDREFVAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDROLLSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSCLKRATE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSCLKSTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSCLKTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSEARCHSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSELECTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSHADOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSHAPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSHAPECOMBO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSIGNAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSTARTTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSTATE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSTEPSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSUBLIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDSUBTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTABLENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTABLESIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTARGET**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTERMTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTEXT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTIMEFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTIMESTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTLEORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTOL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTOLERANCE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyTypeError*

exception spiceypy.utils.exceptions.**SpiceINVALIDUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceINVALIDVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVALIDVERTEX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceINVERSTARTSTOPTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceIRFNOTREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceITEMNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceITEMNOTRECOGNIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceITERATIONEXCEEDED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceKERNELNOTLOADED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceKERNELPOOLFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceKERNELVARNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceKERVARSETOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceKERVARTOOBIG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceKEYWORDNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLBCORRUPTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLBINSUFPTRSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLBLINETOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLBNOSUCHLINE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLBTOOMANYLINES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLOWERBOUNDTOOLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceLSKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMALFORMEDSEGMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMALLOCCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMALLOCFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceMALLOCFAILURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceMARKERNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMEMALLOCFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceMESSAGETOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceMISMATCHFROMTIMETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISMATCHOUTPUTFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISMATCHTOTIMETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGARGUMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGCENTER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGCOLSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGCOORDBOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGCOORDSYS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceMISSINGDATACLASS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGDATAORDERTK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGEOT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGEPOCHTOKEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGGEOCONSTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGHEIGHTREF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGHSCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGKPV**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGLEFTCOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGLEFTRTFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGNCAPFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGNCOLS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGNROWS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGPLATETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGROWMAJFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGROWSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGSCAPFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGSURFACE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGTIMEINFO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceMISSINGTLEIDKEYWORD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGTLEKEYWORD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGTOPCOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGTOPDOWNFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceMISSINGVOXELSCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMISSINGWRAPFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceMSGNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNAMENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNAMENOTRECOGNIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNAMENOTUNIQUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNAMESDONOTMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNAMESNOTRESOLVED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNAMETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNARATESFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNEGATIVETOL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOACCEPTABLEDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOANGULARRATEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOARRAYSTARTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOATTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOAVDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOBODYID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCANDOSPKSPCKS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCENTERIDORNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCKSEGMENTTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCLASS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOCOLUMN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOCOMMENTSFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCONVERG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCONVERGENCE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOCURRENTARRAY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNODATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODATAORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODATATYPEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODELIMCHARACTER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODETOOFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODSKSEGMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNODSKSEGMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOENVVARIABLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOEULERANGLEUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFILENAMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFILES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFILESPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOFRAMECONNECT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFRAMEDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFRAMEINFO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOFRAMENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFRAMESKERNELNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFREELOGICALUNIT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFREENODES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFROMTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOFROMTIMESYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOHEADNODE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOINFO**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOINPUTDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOINPUTFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOINSTRUMENTID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOINTERCEPT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOINTERVAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOKERNELLOADED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLANDINGTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLEAPSECONDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLINESPERRECCOUNT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLISTFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLOADEDDSKFILES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOLOADEDFILES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNOLSKFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOMOREROOM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceNONCONICMOTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNONCONTIGUOUSARRAY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNONDISTINCTPAIR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONEMPTYENTRY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONEMPTYTREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONEXISTELEMENTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONINTEGERFIELD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONNUMERICSTRING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPOSBUFLENGTH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPOSITIVEAXIS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPOSITIVEMASS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNONPOSITIVERADIUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPOSITIVESCALE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNONPOSITIVEVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPOSPACKETSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPRINTABLECHARS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNONPRINTINGCHAR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONPRINTINGCHARS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNONUNITQUATERNION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOOBJECTIDORNAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOOFFSETANGLEAXES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOOFFSETANGLEUNITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOOUTPUTFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOOUTPUTSPKTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOPARTITION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOPATHVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOPICTURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOPLATES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOPOLYNOMIALDEGREE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOPRECESSIONTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOPRIORITIZATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOPRODUCERID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOROTATIONORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSCID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSCLKFILENAMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSECONDLINE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSEGMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSEGMENTSFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNOSEPARATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOSLKFILENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSOLMARKER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSPACECRAFTID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSTARTTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSTOPTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSUCHFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNOSUCHHANDLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSUCHSYMBOL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSUNGM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOSURFACENAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTABINARYKERNEL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTACKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTADAFFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNOTADASFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceNOTADPNUMBER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTANDPNUMBER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTANINTEGER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTANINTEGERNUMBER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTANINTNUMBER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTAPCKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTAROTATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTASET**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyTypeError*

exception spiceypy.utils.exceptions.**SpiceNOTATEXTFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTATRANSFERFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTCOMPUTABLE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTDIMENSIONALLYEQUIV**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTDISJOINT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTDISTINCT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTENOUGHPEAS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTIMETYPEFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTINDEXED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTINITIALIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceNOTINPART**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTISOFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTLEDATAFOROBJECT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTLEGALCB**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTOTIME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTOTIMESYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTPOSITIVE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTPRINTABLECHARS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTRANSLATION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceNOTRECOGNIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTSEMCHECKED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTSUPPORTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNOTTWOFIELDSCLK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTTWOMODULI**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOTTWOOFFSETS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNOUNITSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNULLPOINTER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNUMBEREXPECTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNUMCOEFFSNOTPOS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNUMCONSTANTSNEG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNUMERICOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNUMPACKETSNOTPOS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceNUMPARTSUNEQUAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceNUMSTATESNOTPOS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceOBJECTLISTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOBJECTSTOOCLOSE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOBSIDCODENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceORBITDECAY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTOFPLACEDELIMITER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTOFROOM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceOUTPUTERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTPUTFILEEXISTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTPUTISNOTSPK**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTPUTTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceOUTPUTTOOSHORT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePARSERNOTREADY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePASTENDSTR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePATHMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePATHTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePCKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePCKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePCKFILETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpicePCKKRECTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePCKRECTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePLATELISTTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpicePOINTEROUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTERSETTOOBIG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTERTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTNOTINSEGMENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTNOTONSURFACE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpicePOINTOFFSURFACE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePOINTONZAXIS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpicePOINTTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePTRARRAYTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpicePUTCMLCALLEDTWICE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpicePUTCMLNOTCALLED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceQPARAMOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceQUERYFAILURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceQUERYNOTPARSED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRADIIOUTOFORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRAYISZEROVECTOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREADFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREADFAILURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRECORDNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRECURSIONTOODEEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRECURSIVELOADING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceREFANGLEMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceREFNOTREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREFVALNOTINTEGER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREFVECTORMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceREPORTTOOWIDE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREQUESTOUTOFBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceREQUESTOUTOFORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceRWCONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSBINSUFPTRSIZE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSBTOOMANYSTRS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSCLKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSCLKTRUNCATED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSEGIDTOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSEGMENTNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSEGMENTTABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSEGTABLETOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSEGTYPECONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSETEXCESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceSETTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSETUPDOESNOTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSHAPEMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSHAPENOTSUPPORTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSIGNALFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceSIGNALFAILURE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceSINGULARMATRIX**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSIZEMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPACETOONARROW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPCRFLNOTCALLED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPICEISTIRED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKDOESNTEXIST**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKFILETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceSPKINSUFFDATA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceSPKINVALIDOPTION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceSPKNOTASUBSET**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceSPKRECTOOLARGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKREFNOTSUPP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKSTRUCTUREERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPKTYPENOTSUPP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceSPKTYPENOTSUPPORTD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPURIOUSFLAG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSPURIOUSKEYWORD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTRINGCONVERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTRINGCOPYFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTRINGCREATEFAIL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTRINGTOOLSHORT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSTRINGTOOSHORT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSTRINGTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSTRINGTRUNCATED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSUBORBITAL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSUBPOINTNOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceSYNTAXERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceSYSTEMCALLFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTABLENOTLOADED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceTARGETMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTARGIDCODENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTIMECONFLICT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTIMEOUTOFBOUNDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTIMESDONTMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTIMESOUTOFORDER**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTIMESYSTEMPROBLEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTIMEZONEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWINPUTLINES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWPACKETS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWPLATES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWSTATES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWVERTICES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTOOFEWWINDOWS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYCOLUMNS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYFIELDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYFILESOPEN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYHITS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYITERATIONS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYKEYWORDS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYPAIRS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYPARTS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYPEAS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYPLATES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYSURFACES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYVERTICES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTOOMANYWATCHES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTRACEBACKOVERFLOW**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceTRACESTACKEMPTY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyRuntimeError*

exception spiceypy.utils.exceptions.**SpiceTRANSFERFILE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTRANSFERFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTWOSCLKFILENAMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTYPEMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyTypeError*

exception spiceypy.utils.exceptions.**SpiceTYPENOTSUPPORTED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceTYPESMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNALLOCATEDNODE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNBALACEDPAIR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNBALANCEDGROUP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNBALANCEDPAIR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNDEFINEDFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceUNEQUALTIMESTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNINITIALIZED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNINITIALIZEDHASH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNINITIALIZEDVALUE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNITSMISSING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceUNITSNOTREC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceUNKNONWNTIMESYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNBFF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNCKMETA**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNCOMPARE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNDATATYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNFILARC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNFRAMESPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNFRAMETYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNOP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNPACKETDIR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNSPKTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceUNKNOWNSYSTEM**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNRECOGNIZEDFRAME**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNRECOGNIZEDTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNRECOGNPRECTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNRESOLVEDNAMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNRESOLVEDTIMES**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPBINARYARCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPORTEDARCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPORTEDBFF**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPORTEDMETHOD**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPORTEDSPEC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyIOError*

exception spiceypy.utils.exceptions.**SpiceUNSUPPTEXTFORMAT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUNTITLEDHELP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUPDATEPENDING**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUSAGEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceUTFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceVALUEOUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceVALUETABLEFULL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceVARIABLENOTFOUND**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyKeyError*

exception spiceypy.utils.exceptions.**SpiceVARNAMETOOLONG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceVECTORTOOBIG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceVERSIONMISMATCH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceVERTEXNOTINGRID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceVOXELGRIDTOOBIG**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceWIDTHTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceWINDOWEXCESS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceWINDOWSTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceWINDOWTOOSMALL**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

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Bases: *SpiceyPyMemoryError*

exception spiceypy.utils.exceptions.**SpiceWRITEERROR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceWRONGCKTYPE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceWRONGCONIC**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

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Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceYEAROUTOFRANGE**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZEROAXISLENGTH**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceZEROBOUNDSEXTENT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZEROFRAMEID**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceZEROLENGTHCOLUMN**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZEROPOSITION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZEROQUATERNION**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZERORADIUS**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceZEROSTEP**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceZEROVECTOR**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZEROVELOCITY**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyValueError*

exception spiceypy.utils.exceptions.**SpiceZZHOLDDGETFAILED**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceZZHOLDNOPUT**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*

exception spiceypy.utils.exceptions.**SpiceyError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: `Exception`

SpiceyError wraps CSPICE errors for use in Python.

exception spiceypy.utils.exceptions.**SpiceyPyError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyError*

Thin wrapping exception for SpiceyError.

In SpiceyPy versions 3.0.2 and prior, the base exception was a SpiceyError SpiceyPyError is a slightly more verbose and correct error name.

exception spiceypy.utils.exceptions.**SpiceyPyIOError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, `OSError`

SpiceyPyError mixed with IOError

exception spiceypy.utils.exceptions.**SpiceyPyIndexError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, `IndexError`

SpiceyPyError mixed with IndexError

exception spiceypy.utils.exceptions.**SpiceyPyKeyError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, KeyError

SpiceyPyError mixed with KeyError

exception spiceypy.utils.exceptions.**SpiceyPyMemoryError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, MemoryError

SpiceyPyError mixed with MemoryError

exception spiceypy.utils.exceptions.**SpiceyPyRuntimeError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, RuntimeError

SpiceyPyError mixed with RuntimeError

exception spiceypy.utils.exceptions.**SpiceyPyTypeError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, TypeError

SpiceyPyError mixed with TypeError

exception spiceypy.utils.exceptions.**SpiceyPyValueError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, ValueError

SpiceyPyError mixed with ValueError

exception spiceypy.utils.exceptions.**SpiceyPyZeroDivisionError**(*short=''*, *explain=''*, *long=''*, *traceback=''*, *found=False*)

Bases: *SpiceyPyError*, ZeroDivisionError

SpiceyPyError mixed with ZeroDivisionError

3.10.5 spiceypy.utils.libspice module

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spiceypy.utils.libspicehelper.**s_dla_p**

alias of LP_SpiceDLADescr

spiceypy.utils.libspicehelper.**s_dsk_p**
alias of LP_SpiceDSKDescr

spiceypy.utils.libspicehelper.**s_eka_p**
alias of LP_SpiceEKAttDsc

spiceypy.utils.libspicehelper.**s_eks_p**
alias of LP_SpiceEKSegSum

spiceypy.utils.libspicehelper.**s_elip_p**
alias of LP_Ellipse

spiceypy.utils.libspicehelper.**s_plan_p**
alias of LP_Plane

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