Goulib Documentation

Release 1.9.23

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Contents

library of useful Python code for scientific + technical applications

see the IPython notebook for an overview of features

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installation “pip install Goulib”

distribution https://pypi.python.org/pypi/Goulib

documentation https://readthedocs.org/

notebook http://nbviewer.ipython.org/github/Goulu/Goulib/blob/master/notebook.ipynb

source https://github.com/goulu/Goulib

CHAPTER 1

Requirements

Goulib uses "lazy" requirements. Many modules and functions do not require any other packages, packages listed in requirements.txt are needed only by some classes or functions

Sphinx is needed to generate this documentation, Pythoscope is used to generate nose unit tests

CHAPTER 2

Modules

colors	color conversion in various colorspaces and palettes
container	advanced containers : Record (struct), and INFINITE Sequence
datetime2	additions to `datetime` standard library
decorators	useful decorators
drawing	Read/Write and handle vector graphics in .dxf, .svg and .pdf formats
expr	simple symbolic math expressions
geom	2D geometry
geom3d	3D geometry
graph	efficient Euclidian Graphs for `networkx` and related algorithms
image	
interval	operations on [a..b[intervals
itertools2	additions to `itertools` standard library
markup	simple HTML/XML generation (forked from markup)
math2	more math than `math` standard library, without numpy
motion	motion simulation (kinematics)
optim	various optimization algorithms : knapsack, traveling salesman, simulated annealing, differential evolution
piecewise	piecewise-defined functions
plot	plotable rich object display on IPython/Jupyter notebooks
polynomial	simple manipulation of polynomials (without SimPy) see http://docs.sympy.org/dev/modules/polys/reference.html if you need more …
statemachine	
stats	very basic statistics functions

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table	"mini pandas.DataFrame" Table class with Excel + CSV I/O, easy access to columns, HTML output, and much more.
tests	utilities for unit tests (using nose)
workdays	WorkCalendar class with datetime operations on working hours, handling holidays merges and improves BusinessHours and workdays packages

2.1 Goulib.colors module

color conversion in various colorspaces and palettes

`Goulib.colors.`**`rgb2hex`**(*c*, *illuminant='ignore'*)

`Goulib.colors.`**`hex2rgb`**(*c*, *illuminant='ignore'*)

`Goulib.colors.`**`rgb2cmyk`**(*rgb*, ***kwargs*)

Parameters **`rgb`** – 3-tuple of floats of red,green,blue in [0..1] range

Returns 4-tuple of floats (cyan, magenta, yellow, black) in [0..1] range

`Goulib.colors.`**`cmyk2rgb`**(*cmyk*, ***kwargs*)

Parameters **`cmyk`** – 4-tuple of floats (cyan, magenta, yellow, black) in [0..1] range

Result 3-tuple of floats (red,green,blue)

warning : rgb is out the [0..1] range for some cmyk

`Goulib.colors.`**`xyz2xyy`**(*xyz*, ***kwargs*)

Convert from XYZ to xyY

Based on formula from http://brucelindbloom.com/Eqn_XYZ_to_xyY.html

Implementation Notes: 1. Watch out for black, where X = Y = Z = 0. In that case, x and y are set

to the chromaticity coordinates of the reference whitepoint.

2. The output Y value is in the nominal range [0.0, Y[XYZ]].

`Goulib.colors.`**`xyy2xyz`**(*xyY*, ***kwargs*)

Convert from xyY to XYZ to

Based on formula from http://brucelindbloom.com/Eqn_xyY_to_XYZ.html

Implementation Notes:

1. Watch out for the case where y = 0. In that case, you may want to set X = Y = Z = 0.
2. The output XYZ values are in the nominal range [0.0, 1.0].

`Goulib.colors.`**`converter`**(*c*, *illuminant='ignore'*)

`Goulib.colors.`**`convert`**(*color*, *source*, *target*)

convert a color between colorspaces, eventually using intermediary steps

class `Goulib.colors.`**`Color`**(*value*, *space='RGB'*, *name=None*, *illuminant='D65'*)

Bases: `object`

A color with math operations and conversions Color is immutable (._values caches representations) constructor :param value: string color name, hex string, or values tuple :param space: string defining the color space of value :param name: string for color name :param illuminant: string in {"A", "D50", "D55", "D65", "D75", "E"}

- D65 is used by default in skimage, see http://scikit-image.org/docs/dev/api/skimage.color.html
- D50 is used in Pantone and other graphic arts

`__init__`(*value*, *space='RGB'*, *name=None*, *illuminant='D65'*)
constructor :param value: string color name, hex string, or values tuple :param space: string defining the color space of value :param name: string for color name :param illuminant: string in {"A", "D50", "D55", "D65", "D75", "E"}

- D65 is used by default in skimage, see http://scikit-image.org/docs/dev/api/skimage.color.html
- D50 is used in Pantone and other graphic arts

`name`

`convert`(*target*, ***kwargs*)

Parameters **`target`** – str of desired colorspace, or none for default

Returns color in target colorspace

`str`(*mode=None*)

`native`

`rgb`

`hex`

`lab`

`luv`

`cmyk`

`hsv`

`xyz`

`xyY`

`__hash__`()
Return hash(self).

`__repr__`()
Return repr(self).

`compose`(*other*, *f*, *mode='rgb'*)
compose colors in given mode

`__add__`(*other*)

`__radd__`(*other*)
only to allow sum(colors) easily

`__sub__`(*other*)

`__mul__`(*factor*)

`__neg__`()
complementary color

`deltaE`(*other*)
color difference according to CIEDE2000 https://en.wikipedia.org/wiki/Color_difference

isclose(*other*, *abs_tol=1*)
http://zschuessler.github.io/DeltaE/learn/ <= 1.0 Not perceptible by human eyes. 1 - 2 Perceptible through close observation. 2 - 10 Perceptible at a glance. 11 - 49 Colors are more similar than opposite 100 Colors are exact opposite

__eq__(*other*)
Return self==value.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class `Goulib.colors.`**Palette**(*data=[]*, *keys=256*)
Bases: `collections.OrderedDict`

dict of Colors indexed by anything

__init__(*data=[]*, *keys=256*)
Initialize self. See help(type(self)) for accurate signature.

update(*data*, *keys=256*)
updates the dictionary with new colors :param data: colors to add :param keys: keys to use in dict, or int to discretize the Colormap

index(*c*, *dE=5*)

Returns key of c or nearest color, None if distance is larger than deltaE

__repr__()
Return repr(self).

patches(*wide=64*, *size=(16, 16)*)
Image made of each palette color

pil

Returns a sequence of integers, or a string containing a binary

representation of the palette. In both cases, the palette contents should be ordered (r, g, b, r, g, b, ...). The palette can contain up to 768 entries (3*256). If a shorter palette is given, it is padded with zeros. #http://effbot.org/zone/creating-palette-images.htm

sorted(*key=<function Palette.<lambda>>*)

__class__
alias of `builtins.type`

__contains__()
True if D has a key k, else False.

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
Return state information for pickling

__reduce_ex__()
helper for pickle

__reversed__(*) <==> reversed(od*)

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__() → size of D in memory, in bytes

__str__
Return str(self).

clear() → None. Remove all items from od.

copy() → a shallow copy of od

fromkeys(*S*[, *v*]) → New ordered dictionary with keys from S.
If not specified, the value defaults to None.

get(*k*[, *d*]) → D[k] if k in D, else d. d defaults to None.

items() → a set-like object providing a view on D's items

keys() → a set-like object providing a view on D's keys

move_to_end()
Move an existing element to the end (or beginning if last==False).

Raises KeyError if the element does not exist. When last=True, acts like a fast version of self[key]=self.pop(key).

pop(*k*[, *d*]) → v, remove specified key and return the corresponding
value. If key is not found, d is returned if given, otherwise KeyError is raised.

popitem() → (k, v), return and remove a (key, value) pair.
Pairs are returned in LIFO order if last is true or FIFO order if false.

setdefault(*k*[, *d*]) → od.get(k,d), also set od[k]=d if k not in od

values() → an object providing a view on D's values

Goulib.colors.**ColorTable**(*colors*, *key=None*, *width=10*)

Goulib.colors.**color_to_aci**(*x*, *nearest=True*)

Returns int Autocad Color Index of color x

Goulib.colors.**aci_to_color**(*x*, *block_color=None*, *layer_color=None*)

`Goulib.colors.`**`deltaE`**`(`*c1*, *c2*`)`

`Goulib.colors.`**`nearest_color`**`(`*c*, *l=None*, *opt=<built-in function min>*, *comp=<function deltaE>*`)`

Parameters

- **`x`** – Color
- **`l`** – list or dict of Color, color by default
- **`opt`** – with opt=max you can find the most different color ...

Returns nearest Color of x in l

`Goulib.colors.`**`color_range`**`(`*n*, *start*, *end*, *space='hsv'*`)`

Parameters

- **`n`** – int number of colors to generate
- **`start`** – string hex color or color name
- **`end`** – string hex color or color name

Result list of n Color interpolated between start and end, included

`Goulib.colors.`**`lambda2RGB`**`(`*wavelength*`)`

`Goulib.colors.`**`RGB2lambda`**`(`*R*, *G*, *B*`)`

Returns 0 if indeciferable

2.2 Goulib.container module

advanced containers : Record (struct), and INFINITE Sequence

`class` `Goulib.container.`**`Record`**`(`**args*, ***kwargs*`)`

Bases: `collections.OrderedDict`

mimics a Pascal record or a C struct

`__init__``(`**args*, ***kwargs*`)`

Initialize self. See help(type(self)) for accurate signature.

`__getattr__``(`*name*`)`

`__setattr__``(`*name*, *value*`)`

Implement setattr(self, name, value).

`__str__``()`

Return str(self).

`__class__`

alias of `builtins.type`

`__contains__``()`

True if D has a key k, else False.

`__delattr__`

Implement delattr(self, name).

`__delitem__`

Delete self[key].

`__dir__``()` → list

default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
Return state information for pickling

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__reversed__(*) <==> reversed(od*)

__setitem__
Set self[key] to value.

__sizeof__() → size of D in memory, in bytes

clear() → None. Remove all items from od.

copy() → a shallow copy of od

fromkeys(*S*[, *v*]) → New ordered dictionary with keys from S.
If not specified, the value defaults to None.

get(*k*[, *d*]) → D[k] if k in D, else d. d defaults to None.

items() → a set-like object providing a view on D's items

keys() → a set-like object providing a view on D's keys

move_to_end()

Move an existing element to the end (or beginning if last==False).

Raises KeyError if the element does not exist. When last=True, acts like a fast version of self[key]=self.pop(key).

pop(*k*[, *d*]) → v, remove specified key and return the corresponding

value. If key is not found, d is returned if given, otherwise KeyError is raised.

popitem() → (k, v), return and remove a (key, value) pair.

Pairs are returned in LIFO order if last is true or FIFO order if false.

setdefault(*k*[, *d*]) → od.get(k,d), also set od[k]=d if k not in od

update([*E*], ***F*) → None. Update D from dict/iterable E and F.

If E is present and has a .keys() method, then does: for k in E: D[k] = E[k] If E is present and lacks a .keys() method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k]

values() → an object providing a view on D's values

class Goulib.container.**Sequence**(*iterf=None*, *itemf=None*, *containf=None*, *desc=”*, *timeout=0*)

Bases: object

combines a generator and a read-only list used for INFINITE numeric (integer) sequences

Parameters

- **iterf** – optional iterator, or a function returning an iterator
- **itemf** – optional function(i) returning the i-th element
- **containf** – optional function(n) return bool True if n belongs to Sequence
- **desc** – string description

__init__(*iterf=None*, *itemf=None*, *containf=None*, *desc=”*, *timeout=0*)

Parameters

- **iterf** – optional iterator, or a function returning an iterator
- **itemf** – optional function(i) returning the i-th element
- **containf** – optional function(n) return bool True if n belongs to Sequence
- **desc** – string description

__repr__()

Return repr(self).

save(*filename*, *comment=None*, *n=1000*, *maxtime=10*)

__iter__()

reset the generator

Returns a tee-ed copy of iterf, optionally timeout decorated

__getitem__(*i*)

index(*v*)

__contains__(*n*)

__add__(*other*)

__sub__(*other*)

__mul__(*other*)

`__div__`(*other*)

`__truediv__`(*other*)

`__or__`(*other*)

Returns Sequence with items from both (sorted) operand Sequences

`__and__`(*other*)

Returns Sequence with items in both operands

`__mod__`(*other*)

Returns Sequence with items from left operand not in right

`apply`(*f, containf=None, desc="*)

`filter`(*f, desc="*)

`__le__`(*other*)
Return self<=value.

`__gt__`(*other*)
Return self>value.

`accumulate`(*op=<built-in function add>, skip_first=False*)

`pairwise`(*op, skip_first=False*)

`sort`(*key=None, buffer=100*)

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__hash__`
Return hash(self).

`__lt__`
Return self<value.

`__ne__`
Return self!=value.

`__new__`()
Create and return a new object. See help(type) for accurate signature.

`__reduce__`()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

unique(*buffer=100*)

Parameters buffer – int number of last elements found.

if two identical elements are separated by more than this number of elements in self, they might be generated twice in the resulting Sequence :return: Sequence made of unique elements of this one

product(*other*, *op=<built-in function sum>*, *buffer=100*)
cartesian product

2.3 Goulib.datetime2 module

additions to `datetime` standard library

class Goulib.datetime2.**datetime2**(**args*, ***kwargs*)
Bases: `datetime.datetime`

__init__(**args*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

__sub__(*other*)
Return self-value.

__add__
Return self+value.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
Formats self with strftime.

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__radd__
Return value+self.

__reduce__() -> (*cls*, *state*)

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__rsub__
Return value-self.

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

astimezone()
tz -> convert to local time in new timezone tz

combine()
date, time -> datetime with same date and time fields

ctime()
Return ctime() style string.

date()
Return date object with same year, month and day.

day

dst()
Return self.tzinfo.dst(self).

fromordinal()
int -> date corresponding to a proleptic Gregorian ordinal.

fromtimestamp()
timestamp[, tz] -> tz's local time from POSIX timestamp.

hour

isocalendar()
Return a 3-tuple containing ISO year, week number, and weekday.

isoformat()
[sep] -> string in ISO 8601 format, YYYY-MM-DDTHH:MM:SS[.mmmmmm][+HH:MM].

sep is used to separate the year from the time, and defaults to 'T'.

isoweekday()
Return the day of the week represented by the date. Monday == 1 … Sunday == 7

max = datetime.datetime(9999, 12, 31, 23, 59, 59, 999999)

microsecond

min = datetime.datetime(1, 1, 1, 0, 0)

minute

month

now()
Returns new datetime object representing current time local to tz.

tz Timezone object.

If no tz is specified, uses local timezone.

replace()
Return datetime with new specified fields.

resolution = datetime.timedelta(0, 0, 1)

second

strftime()
format -> strftime() style string.

strptime()
string, format -> new datetime parsed from a string (like time.strptime()).

time()
Return time object with same time but with tzinfo=None.

timestamp()
Return POSIX timestamp as float.

timetuple()
Return time tuple, compatible with time.localtime().

timetz()
Return time object with same time and tzinfo.

today()
Current date or datetime: same as self.__class__.fromtimestamp(time.time()).

toordinal()
Return proleptic Gregorian ordinal. January 1 of year 1 is day 1.

tzinfo

tzname()
Return self.tzinfo.tzname(self).

utcfromtimestamp()
Construct a naive UTC datetime from a POSIX timestamp.

utcnow()
Return a new datetime representing UTC day and time.

utcoffset()
Return self.tzinfo.utcoffset(self).

utctimetuple()
Return UTC time tuple, compatible with time.localtime().

weekday()
Return the day of the week represented by the date. Monday == 0 … Sunday == 6

year

class Goulib.datetime2.**date2**
Bases: `datetime.date`

init__(**args*, ***kwargs*)

__add__
Return self+value.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
Formats self with strftime.

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__radd__
Return value+self.

__reduce__(*) -> (cls, state*)

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__rsub__
Return value-self.

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

__sub__
Return self-value.

ctime()
Return ctime() style string.

day

fromordinal()
int -> date corresponding to a proleptic Gregorian ordinal.

fromtimestamp()
timestamp -> local date from a POSIX timestamp (like time.time()).

isocalendar()
Return a 3-tuple containing ISO year, week number, and weekday.

isoformat()
Return string in ISO 8601 format, YYYY-MM-DD.

isoweekday()
Return the day of the week represented by the date. Monday == 1 … Sunday == 7

max = datetime.date(9999, 12, 31)

min = datetime.date(1, 1, 1)

month

replace()
Return date with new specified fields.

resolution = datetime.timedelta(1)

strftime()
format -> strftime() style string.

timetuple()
Return time tuple, compatible with time.localtime().

today()
Current date or datetime: same as self.__class__.fromtimestamp(time.time()).

toordinal()
Return proleptic Gregorian ordinal. January 1 of year 1 is day 1.

weekday()
Return the day of the week represented by the date. Monday == 0 … Sunday == 6

year

class Goulib.datetime2.**time2**(**args*, ***kwargs*)
Bases: datetime.time

__init__(**args*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
Formats self with strftime.

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__() -> (*cls*, *state*)

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

dst()
Return self.tzinfo.dst(self).

hour

isoformat()
Return string in ISO 8601 format, HH:MM:SS[.mmmmmm][+HH:MM].

max = datetime.time(23, 59, 59, 999999)

microsecond

min = datetime.time(0, 0)

minute

replace()
Return time with new specified fields.

resolution = datetime.timedelta(0, 0, 1)

second

strftime()
format -> strftime() style string.

tzinfo

tzname()
Return self.tzinfo.tzname(self).

utcoffset()
Return self.tzinfo.utcoffset(self).

class Goulib.datetime2.**timedelta2**(**args*, ***kwargs*)
Bases: `datetime.timedelta`

__init__(**args*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

isoformat()

__abs__
abs(self)

__add__
Return self+value.

__bool__
self != 0

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__divmod__
Return divmod(self, value).

__eq__
Return self==value.

__floordiv__
Return self//value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__mod__
Return self%value.

__mul__
Return self*value.

__ne__
Return self!=value.

__neg__
-self

__new__()
Create and return a new object. See help(type) for accurate signature.

__pos__
+self

__radd__
Return value+self.

__rdivmod__
Return divmod(value, self).

__reduce__(*) -> (cls, state*)

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__rfloordiv__
Return value//self.

__rmod__
Return value%self.

__rmul__
Return value*self.

__rsub__
Return value-self.

__rtruediv__
Return value/self.

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

__sub__
Return self-value.

__truediv__
Return self/value.

days
Number of days.

max = datetime.timedelta(999999999, 86399, 999999)

microseconds
Number of microseconds (>= 0 and less than 1 second).

min = datetime.timedelta(-999999999)

resolution = datetime.timedelta(0, 0, 1)

seconds
Number of seconds (>= 0 and less than 1 day).

total_seconds()
Total seconds in the duration.

Goulib.datetime2.**datetimef**(*d*, *t=None*, *fmt='%Y-%m-%d'*)
"converts something to a datetime :param d: can be:

- datetime : result is a copy of d with time optionally replaced
- date : result is date at time t, (00:00AM by default)
- int or float : if fmt is None, d is considered as Excel date numeric format (see http://answers.oreilly.com/topic/1694-how-excel-stores-date-and-time-values/)
- string or specified format: result is datetime parsed using specified format string

Parameters

- **fmt** – format string. See http://docs.python.org/2/library/datetime.html#strftime-strptime-behavior
- **t** – optional time. replaces the time of the datetime obtained from d. Allows datetimef(date,time)

Returns datetime

`Goulib.datetime2.`**`datef`**(*d*, *fmt='%Y-%m-%d'*)
converts something to a date. See datetimef

`Goulib.datetime2.`**`timef`**(*t*, *fmt='%H:%M:%S'*)
converts something to a time. See datetimef

`Goulib.datetime2.`**`fmt2regex`**(*fmt*)
converts a date/time format string to the regex that comiles it

Parameters **`fmt`** – string

Returns compiled regex

`Goulib.datetime2.`**`timedeltaf`**(*t*, *fmt=None*)
converts something to a timedelta.

Parameters **`t`** – can be:

- already a timedelta, or a time, or a int/float giving a number of days (Excel)
- or a string in HH:MM:SS format by default
- or a string in timedelta str() output format

`Goulib.datetime2.`**`strftimedelta`**(*t*, *fmt='%H:%M:%S'*)

Parameters **`t`** – float seconds or timedelta

`Goulib.datetime2.`**`tdround`**(*td*, *s=1*)
return timedelta rounded to s seconds

`Goulib.datetime2.`**`minutes`**(*td*)

Parameters **`td`** – timedelta

Returns float timedelta in minutes

`Goulib.datetime2.`**`hours`**(*td*)

Parameters **`td`** – timedelta

Returns float timedelta in hours

`Goulib.datetime2.`**`daysgen`**(*start*, *length*, *step=datetime.timedelta(1)*)
returns a range of dates or datetimes

`Goulib.datetime2.`**`days`**(*start*, *length*, *step=datetime.timedelta(1)*)

`Goulib.datetime2.`**`timedelta_sum`**(*timedeltas*)

`Goulib.datetime2.`**`timedelta_div`**(*t1*, *t2*)
divides a timedelta by a timedelta or a number. should be a method of timedelta…

`Goulib.datetime2.`**`timedelta_mul`**(*t1*, *t2*)
multiplies a timedelta. should be a method of timedelta…

`Goulib.datetime2.`**`time_sub`**(*t1*, *t2*)
substracts 2 time. should be a method of time…

`Goulib.datetime2.`**`time_add`**(*t*, *d*)
adds delta to time. should be a method of time…

`Goulib.datetime2.`**`add_months`**(*date*, *months*)

`Goulib.datetime2.`**`date_add`**(*date*, *years=0*, *months=0*, *weeks=0*, *days=0*)

Goulib.datetime2.**equal**(*a*, *b*, *epsilon=datetime.timedelta(0, 0, 500000)*)
approximately equal. Use this instead of a==b :return: True if a and b are less than seconds apart

Goulib.datetime2.**datetime_intersect**(*t1*, *t2*)
returns timedelta overlap between 2 intervals (tuples) of datetime

Goulib.datetime2.**time_intersect**(*t1*, *t2*)
returns timedelta overlap between 2 intervals (tuples) of time

2.4 Goulib.decorators module

useful decorators

Goulib.decorators.**memoize**(*obj*)
speed up repeated calls to a function by caching its results in a dict index by params :see: https://en.wikipedia.org/wiki/Memoization

Goulib.decorators.**debug**(*func*)

Goulib.decorators.**nodebug**(*func*)

Goulib.decorators.**get_thread_pool**()

Goulib.decorators.**timeout**(*timeout*)

Goulib.decorators.**itimeout**(*iterable*, *timeout*)
timeout for loops :param iterable: any iterable :param timeout: float max running time in seconds :yield: items in iterator until timeout occurs :raise: multiprocessing.TimeoutError if timeout occured

class Goulib.decorators.**MultiMethod**(*name*)
Bases: object

__init__(*name*)
Initialize self. See help(type(self)) for accurate signature.

__call__(**args*)
Call self as a function.

register(*types*, *function*)

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.decorators.**multimethod**(**types*)
allows to overload functions for various parameter types

@multimethod(int, int) def foo(a, b):

…code for two ints…

@multimethod(float, float): def foo(a, b):

…code for two floats…

@multimethod(str, str): def foo(a, b):

…code for two strings…

2.5 Goulib.drawing module

Read/Write and handle vector graphics in .dxf, .svg and .pdf formats

requires

- svg.path for svg input
- matplotlib for bitmap + svg and pdf output
- dxfwrite for dxf output

optional

- dxfgrabber for dxf input
- pdfminer.six for pdf input

`Goulib.drawing.`**`Trans`**(*scale=1*, *offset=None*, *rotation=None*)

Parameters

- **`scale`** – float or (scalex,scaley) tuple of scale factor
- **`offset`** – `Vector3`
- **`rotation`** – float angle in degrees

Returns `Matrix3` of generalized scale+offset+rotation

`class` `Goulib.drawing.`**`BBox`**(*p1=None*, *p2=None*)

Bases: `Goulib.interval.Box`

bounding box

Parameters

- **`pt1`** – `Point2` first corner (any)
- **`pt2`** – `Point2` opposite corner (any)

`__init__`(*p1=None*, *p2=None*)

Parameters

- **`pt1`** – `Point2` first corner (any)
- **`pt2`** – `Point2` opposite corner (any)

`xmin`

`ymin`

`xmax`

`ymax`

`xmed`

`ymed`

`width`

`height`

`area`

`__contains__`(*other*)

Returns True if other lies in bounding box.

`__iadd__`(*pt*)

enlarge box if required to contain specified point :param pt1: `geom.Point2` point to add

`__call__`()

Returns list of flatten corners

`size`()

Returns `geom.Vector2` with xy sizes

`center`()

Returns Pt center

trans(*trans*)

Parameters **trans** – Xform

Returns *BBox* = self transformed by trans

class Goulib.drawing.**Entity**

Bases: *Goulib.plot.Plot*

Base class for all drawing entities

color = 'black'

setattr(***kwargs*)

set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

end

__repr__()

Return repr(self).

center

bbox()

Returns *BBox* bounding box of Entity

isclosed()

isline()

isvertical(*tol=0.01*)

ishorizontal(*tol=0.01*)

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

static from_svg(*path, color*)

Parameters **path** – svg path

Returns Entity of correct subtype

static from_pdf(*path, trans, color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_dxf(*e, mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

class Goulib.drawing.**Spline**(*points*)
Bases: *Goulib.drawing.Entity*, *Goulib.geom.Geometry*

cubic spline segment

Parameters points – list of (x,y) tuples

__init__(*points*)

Parameters points – list of (x,y) tuples

start

end

xy

length

Returns float (very) approximate length

bbox()

Returns *BBox* bounding box of Entity

swap()
swap start and end

__abstractmethods__ = frozenset()

class Goulib.drawing.**Group**
Bases: `list`, `Goulib.drawing._Group`

group of Entities but it is a Geometry since we can intersect, connect and compute distances between Groups

color
str(object='') -> str str(bytes_or_buffer[, encoding[, errors]]) -> str

Create a new string object from the given object. If encoding or errors is specified, then the object must expose a data buffer that will be decoded using the given encoding and error handler. Otherwise, returns the result of object.__str__() (if defined) or repr(object). encoding defaults to sys.getdefaultencoding(). errors defaults to 'strict'.

layer

append(*entity*, ***kwargs*)
append entity to group :param entity: Entity :param kwargs: dict of attributes copied to entity :return: Group (or Chain) to which the entity was added, or None if entity was None

extend(*iterable*) → None – extend list by appending elements from the iterable

__copy__()

swap()
swap start and end

chainify(*mergeable*)
merge all possible entities into chains

from_dxf(*dxf, layers=None, only=[], ignore=['POINT'], trans=Matrix3(1.0, 0, 0, 0, 1.0, 0, 0, 0, 1.0), flatten=False*)

Parameters

- **dxf** – dxf.entity
- **layers** – list of layer names to consider. entities not on these layers are ignored. default=None: all layers are read
- **only** – list of dxf entity types names that are read. default=[]: all are read
- **ignore** – list of dxf entity types names that are ignored. default=['POINT']: points and null length segments are ignored
- **trans** – *Trans* optional transform matrix

Parm flatten bool flatten block structure

Returns *Entity* of correct subtype

__abstractmethods__ = frozenset()

class Goulib.drawing.**Instance**(*group, trans*)
Bases: Goulib.drawing._Group

Parameters

- **group** – Group
- **trans** – optional mat3 of transformation

__init__(*group, trans*)

Parameters

- **group** – Group
- **trans** – optional mat3 of transformation

static from_dxf(*e, blocks, mat3*)

Parameters

- **e** – dxf.entity
- **blocks** – dict of Groups indexed by name
- **mat3** – Matrix3 transform

__repr__()
Return repr(self).

__iter__()

__abstractmethods__ = frozenset()

class Goulib.drawing.**Chain**(*data=[]*)

Bases: `Goulib.drawing.Group`

group of contiguous Entities (Polyline or similar)

__init__(*data=[]*)

Initialize self. See help(type(self)) for accurate signature.

start

end

__repr__()

Return repr(self).

contiguous(*edge*, *abs_tol=1e-06*, *allow_swap=True*)

check if edge can be appended to the chain :param edge: `Entity` to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :return: int,bool index where to append in chain, swap of edge required

append(*entity*, *tol=1e-06*, *allow_swap=True*, *mergeable=None*, ***attrs*)

append entity to chain, ensuring contiguity :param entity: `Entity` to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :param mergeable: function of the form f(e1,e2) returning True if entities e1,e2 can be merged :param attrs: attributes passed to Group.append :return: self, or None if edge is not contiguous

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

See http://www.adobe.com/content/dam/Adobe/en/devnet/acrobat/pdfs/PDF32000_2008.pdf p. 132

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

to_dxf(*split=False*, ***attr*)

Parameters

- **split** – bool if True, each segment in Chain is saved separately
- **attr** – dict of graphic attributes

Returns polyline or list of entities along the chain

__abstractmethods__ = frozenset()

Goulib.drawing.**chains**(*group*, *tol=1e-06*, *mergeable=None*)

build chains from all possible segments in group :param mergeable: function(e1,e2) returning True if entities e1,e2 can be merged

class Goulib.drawing.**Rect**(**args*)

Bases: *Goulib.drawing.Chain*

a rectangle starting at low/left and going trigowise through top/right

__init__(**args*)

Initialize self. See help(type(self)) for accurate signature.

p1

p2

__repr__()

Return repr(self).

__abstractmethods__ = frozenset()

class Goulib.drawing.**Text**(*text*, *point*, *size=12*, *rotation=0*)

Bases: *Goulib.drawing.Entity*

Parameters

- **text** – string
- **point** – Point2
- **size** – size in points
- **rotation** – float angle in degrees trigowise

__init__(*text*, *point*, *size=12*, *rotation=0*)

Parameters

- **text** – string
- **point** – Point2
- **size** – size in points
- **rotation** – float angle in degrees trigowise

bbox()

Returns *BBox* bounding box of Entity

length

Returns float length of the text contour in mm

intersect(*other*)

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

class Goulib.drawing.**Drawing**(*data=[]*, ***kwargs*)

Bases: *Goulib.drawing.Group*

list of Entities representing a vector graphics drawing

__init__(*data=[]*, ***kwargs*)

Initialize self. See help(type(self)) for accurate signature.

load (*filename*, ***kwargs*)

read_pdf (*filename*, ***kwargs*)
reads a vector graphics on a .pdf file only the first page is parsed

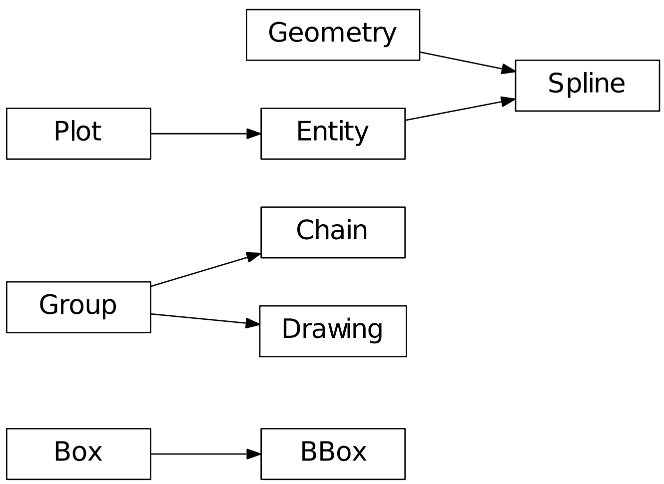
read_svg (*content*, ***kwargs*)
appends svg content to drawing :param content: string, either filename or svg content

__abstractmethods__ = frozenset()

read_dxf (*filename*, *options=None*, ***kwargs*)
reads a .dxf file :param filename: string path to .dxf file to read :param options: passed to `from_dxf`

save (*filename*, ***kwargs*)
save graph in various formats

2.5.1 Classes



Read/Write and handle vector graphics in .dxf, .svg and .pdf formats

requires

- svg.path for svg input
- matplotlib for bitmap + svg and pdf output
- dxfwrite for dxf output

optional

- dxfgrabber for dxf input
- pdfminer.six for pdf input

`Goulib.drawing.`**Trans** (*scale=1*, *offset=None*, *rotation=None*)

Parameters

- **scale** – float or (scalex,scaley) tuple of scale factor

- **offset** – `Vector3`
- **rotation** – float angle in degrees

Returns `Matrix3` of generalized scale+offset+rotation

class `Goulib.drawing.`**BBox**(*p1=None*, *p2=None*)

Bases: *Goulib.interval.Box*

bounding box

Parameters

- **pt1** – `Point2` first corner (any)
- **pt2** – `Point2` opposite corner (any)

__init__(*p1=None*, *p2=None*)

Parameters

- **pt1** – `Point2` first corner (any)
- **pt2** – `Point2` opposite corner (any)

xmin

ymin

xmax

ymax

xmed

ymed

width

height

area

__contains__(*other*)

Returns True if other lies in bounding box.

__iadd__(*pt*)

enlarge box if required to contain specified point :param pt1: `geom.Point2` point to add

__call__()

Returns list of flatten corners

size()

Returns `geom.Vector2` with xy sizes

center()

Returns Pt center

trans(*trans*)

Parameters **trans** – Xform

Returns *BBox* = self transformed by trans

`__add__`(*other*)
enlarge box if required to contain specified point :param other: `Box` or (list of) N-tuple point(s) :return: new Box containing both

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__delitem__`
Delete self[key].

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__getitem__`()
x.__getitem__(y) <==> x[y]

`__gt__`
Return self>value.

`__hash__ = None`

`__imul__`
Implement self*=value.

`__iter__`
Implement iter(self).

`__le__`
Return self<=value.

`__len__`
Return len(self).

`__lt__`
Return self<value.

`__mul__`
Return self*value.n

`__ne__`
Return self!=value.

`__new__`()
Create and return a new object. See help(type) for accurate signature.

`__nonzero__`()

`__reduce__`()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

append(*object*) → None – append object to end

clear() → None – remove all items from L

copy() → list – a shallow copy of L

corner(*n*)
return n-th corner of box 0-th corner is "start" made of all minimal values of intervals -1.th corner is "end", made of all maximal values of intervals

count(*value*) → integer – return number of occurrences of value

empty()

Returns True iff Box is empty.

end

extend(*iterable*) → None – extend list by appending elements from the iterable

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

max

min

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

reverse()
L.reverse() – reverse *IN PLACE*

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

start

class Goulib.drawing.**Entity**
Bases: *Goulib.plot.Plot*

Base class for all drawing entities

color = 'black'

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

end

__repr__()
Return repr(self).

center

bbox()

Returns *BBox* bounding box of Entity

isclosed()

isline()

isvertical(*tol=0.01*)

ishorizontal(*tol=0.01*)

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

draw (*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

html (***kwargs*)

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

save (*filename*, ***kwargs*)

svg (***kwargs*)

class Goulib.drawing.**Spline** (*points*)
Bases: *Goulib.drawing.Entity*, *Goulib.geom.Geometry*

cubic spline segment

Parameters **points** – list of (x,y) tuples

__init__ (*points*)

Parameters **points** – list of (x,y) tuples

start

end

xy

length

Returns float (very) approximate length

bbox ()

Returns *BBox* bounding box of Entity

swap ()
swap start and end

__abstractmethods__ = frozenset()

__class__
alias of abc.ABCMeta

__contains__ (*pt*)

__delattr__
Implement delattr(self, name).

__dir__ () → list
default dir() implementation

__eq__
Return self==value.

__format__ ()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

center

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

intersect(*other*)

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

svg(***kwargs*)

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

class Goulib.drawing.**Group**
Bases: list, Goulib.drawing._Group

group of Entities but it is a Geometry since we can intersect, connect and compute distances between Groups

color
str(object='') -> str str(bytes_or_buffer[, encoding[, errors]]) -> str

Create a new string object from the given object. If encoding or errors is specified, then the object must expose a data buffer that will be decoded using the given encoding and error handler. Otherwise, returns the result of object.__str__() (if defined) or repr(object). encoding defaults to sys.getdefaultencoding(). errors defaults to 'strict'.

layer

append(*entity*, ***kwargs*)
append entity to group :param entity: Entity :param kwargs: dict of attributes copied to entity :return: Group (or Chain) to which the entity was added, or None if entity was None

extend(*iterable*) → None – extend list by appending elements from the iterable

__copy__()

swap()
swap start and end

chainify(*mergeable*)
merge all possible entities into chains

from_dxf(*dxf, layers=None, only=[], ignore=['POINT'], trans=Matrix3(1.0, 0, 0, 0, 1.0, 0, 0, 0, 1.0), flatten=False*)

Parameters

- **dxf** – dxf.entity
- **layers** – list of layer names to consider. entities not on these layers are ignored. default=None: all layers are read
- **only** – list of dxf entity types names that are read. default=[]: all are read
- **ignore** – list of dxf entity types names that are ignored. default=['POINT']: points and null length segments are ignored
- **trans** – *Trans* optional transform matrix

Parm flatten bool flatten block structure

Returns *Entity* of correct subtype

__abstractmethods__ = frozenset()

__add__
Return self+value.

__class__
alias of abc.ABCMeta

__contains__
Return key in self.

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iadd__
Implement self+=value.

__imul__
Implement self*=value.

__init__
Initialize self. See help(type(self)) for accurate signature.

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

bbox(*filter=None*)

Parameters **filter** – optional function(entity):bool returning True if entity should be considered in box

Returns *BBox* bounding box of Entity

center

clear() → None – remove all items from L

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static **figure**(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static **from_pdf**(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static **from_svg**(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

intersect(*other*)

Parameters **other** – *geom.Entity*

Result generate tuples (Point2,Entity_self) of intersections between other and each Entity

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

length

patches(***kwargs*)

Returns list of `Patch` corresponding to group

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

reverse()
L.reverse() – reverse *IN PLACE*

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

start

svg(***kwargs*)

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf(***kwargs*)

Returns flatten list of dxf entities

class `Goulib.drawing.`**Instance**(*group*, *trans*)
Bases: `Goulib.drawing._Group`

Parameters

- **group** – Group
- **trans** – optional mat3 of transformation

__init__(*group*, *trans*)

Parameters

- **group** – Group
- **trans** – optional mat3 of transformation

static from_dxf(*e*, *blocks*, *mat3*)

Parameters

- **e** – dxf.entity
- **blocks** – dict of Groups indexed by name
- **mat3** – Matrix3 transform

__repr__()
Return repr(self).

__iter__()

__abstractmethods__ = frozenset()

__class__
alias of `abc.ABCMeta`

__contains__(*pt*)

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

bbox(*filter=None*)

Parameters **filter** – optional function(entity):bool returning True if entity should be considered in box

Returns *BBox* bounding box of Entity

center

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

intersect(*other*)

Parameters **other** – *geom.Entity*

Result generate tuples (Point2,Entity_self) of intersections between other and each Entity

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

length

patches(***kwargs*)

Returns list of Patch corresponding to group

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg(***kwargs*)

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf(***kwargs*)

Returns flatten list of dxf entities

class Goulib.drawing.**Chain**(*data=[]*)
Bases: *Goulib.drawing.Group*

group of contiguous Entities (Polyline or similar)

__init__(*data=[]*)
Initialize self. See help(type(self)) for accurate signature.

start

end

__repr__()
Return repr(self).

contiguous(*edge*, *abs_tol=1e-06*, *allow_swap=True*)
check if edge can be appended to the chain :param edge: *Entity* to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :return: int,bool index where to append in chain, swap of edge required

append(*entity*, *tol=1e-06*, *allow_swap=True*, *mergeable=None*, ***attrs*)
append entity to chain, ensuring contiguity :param entity: *Entity* to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :param mergeable: function of the form f(e1,e2) returning True if entities e1,e2 can be merged :param attrs: attributes passed to Group.append :return: self, or None if edge is not contiguous

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

See http://www.adobe.com/content/dam/Adobe/en/devnet/acrobat/pdfs/PDF32000_2008.pdf p. 132

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

to_dxf(*split=False*, ***attr*)

Parameters

- **split** – bool if True, each segment in Chain is saved separately
- **attr** – dict of graphic attributes

Returns polyline or list of entities along the chain

__abstractmethods__ = frozenset()

__add__
Return self+value.

__class__
alias of abc.ABCMeta

__contains__
Return key in self.

__copy__()

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iadd__
Implement self+=value.

__imul__
Implement self*=value.

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

bbox(*filter=None*)

Parameters **filter** – optional function(entity):bool returning True if entity should be considered in box

Returns *BBox* bounding box of Entity

center

chainify(*mergeable*)
merge all possible entities into chains

clear() → None – remove all items from L

color
str(object='') -> str str(bytes_or_buffer[, encoding[, errors]]) -> str

Create a new string object from the given object. If encoding or errors is specified, then the object must expose a data buffer that will be decoded using the given encoding and error handler. Otherwise, returns the result of object.__str__() (if defined) or repr(object). encoding defaults to sys.getdefaultencoding(). errors defaults to 'strict'.

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

extend(*iterable*) → None – extend list by appending elements from the iterable

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

html(***kwargs*)

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

intersect(*other*)

Parameters **other** – *geom.Entity*

Result generate tuples (Point2,Entity_self) of intersections between other and each Entity

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

layer

length

patches(***kwargs*)

Returns list of `Patch` corresponding to group

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

reverse()
L.reverse() – reverse *IN PLACE*

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

svg(***kwargs*)

swap()
swap start and end

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

Goulib.drawing.**chains**(*group*, *tol=1e-06*, *mergeable=None*)
build chains from all possible segments in group :param mergeable: function(e1,e2) returning True if entities e1,e2 can be merged

class Goulib.drawing.**Rect**(**args*)
Bases: `Goulib.drawing.Chain`

a rectangle starting at low/left and going trigowise through top/right

__init__(**args*)
Initialize self. See help(type(self)) for accurate signature.

p1

p2

__repr__()
Return repr(self).

__abstractmethods__ = frozenset()

__add__
Return self+value.

__class__
alias of `abc.ABCMeta`

__contains__
Return key in self.

__copy__()

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iadd__
Implement self+=value.

__imul__
Implement self*=value.

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

append(*entity*, *tol=1e-06*, *allow_swap=True*, *mergeable=None*, ***attrs*)
append entity to chain, ensuring contiguity :param entity: *Entity* to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :param mergeable: function of the form f(e1,e2) returning True if entities e1,e2 can be merged :param attrs: attributes passed to Group.append :return: self, or None if edge is not contiguous

bbox(*filter=None*)

Parameters **filter** – optional function(entity):bool returning True if entity should be considered in box

Returns *BBox* bounding box of Entity

center

chainify(*mergeable*)
merge all possible entities into chains

clear() → None – remove all items from L

color
str(object='') -> str str(bytes_or_buffer[, encoding[, errors]]) -> str

Create a new string object from the given object. If encoding or errors is specified, then the object must expose a data buffer that will be decoded using the given encoding and error handler. Otherwise, returns the result of object.__str__() (if defined) or repr(object). encoding defaults to sys.getdefaultencoding(). errors defaults to 'strict'.

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

contiguous(*edge*, *abs_tol=1e-06*, *allow_swap=True*)
check if edge can be appended to the chain :param edge: *Entity* to append :param tol: float tolerance on contiguity :param allow_swap: if True (default), tries to swap edge or self to find contiguity :return: int,bool index where to append in chain, swap of edge required

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

extend(*iterable*) → None – extend list by appending elements from the iterable

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

See http://www.adobe.com/content/dam/Adobe/en/devnet/acrobat/pdfs/PDF32000_2008.pdf p. 132

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

intersect(*other*)

Parameters **other** – *geom.Entity*

Result generate tuples (Point2,Entity_self) of intersections between other and each Entity

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

layer

length

patches(***kwargs*)

Returns list of `Patch` corresponding to group

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

point (*u*)

Returns Point2 or Point3 at parameter u

pop (*[index]*) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove (*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

reverse ()
L.reverse() – reverse *IN PLACE*

save (*filename*, ***kwargs*)

setattr (***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

sort (*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

start

svg (***kwargs*)

swap ()
swap start and end

tangent (*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf (*split=False*, ***attr*)

Parameters

- **split** – bool if True, each segment in Chain is saved separately
- **attr** – dict of graphic attributes

Returns polyline or list of entities along the chain

class Goulib.drawing.**Text** (*text*, *point*, *size=12*, *rotation=0*)
Bases: *Goulib.drawing.Entity*

Parameters

- **text** – string
- **point** – Point2
- **size** – size in points
- **rotation** – float angle in degrees trigowise

__init__ (*text*, *point*, *size=12*, *rotation=0*)

Parameters

- **text** – string
- **point** – Point2
- **size** – size in points

- **rotation** – float angle in degrees trigowise

bbox()

Returns *BBox* bounding box of Entity

length

Returns float length of the text contour in mm

intersect(*other*)

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

center

color = 'black'

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save (*filename*, ***kwargs*)

setattr (***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg (***kwargs*)

class Goulib.drawing.**Drawing** (*data=[]*, ***kwargs*)
Bases: *Goulib.drawing.Group*

list of Entities representing a vector graphics drawing

__init__ (*data=[]*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

load (*filename*, ***kwargs*)

read_pdf (*filename*, ***kwargs*)
reads a vector graphics on a .pdf file only the first page is parsed

read_svg (*content*, ***kwargs*)
appends svg content to drawing :param content: string, either filename or svg content

__abstractmethods__ = frozenset()

__add__
Return self+value.

__class__
alias of abc.ABCMeta

__contains__
Return key in self.

__copy__ ()

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__ () → list
default dir() implementation

__eq__
Return self==value.

__format__ ()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__ ()
x.__getitem__(y) <==> x[y]

`__gt__`
Return self>value.

`__hash__ = None`

`__iadd__`
Implement self+=value.

`__imul__`
Implement self*=value.

`__iter__`
Implement iter(self).

`__le__`
Return self<=value.

`__len__`
Return len(self).

`__lt__`
Return self<value.

`__mul__`
Return self*value.n

`__ne__`
Return self!=value.

`__new__()`
Create and return a new object. See help(type) for accurate signature.

`__reduce__()`
helper for pickle

`__reduce_ex__()`
helper for pickle

`__repr__`
Return repr(self).

`__reversed__()`
L.__reversed__() – return a reverse iterator over the list

`__rmul__`
Return self*value.

`__setattr__`
Implement setattr(self, name, value).

`__setitem__`
Set self[key] to value.

`__sizeof__()`
L.__sizeof__() – size of L in memory, in bytes

`__str__`
Return str(self).

`append`(*entity*, ***kwargs*)
append entity to group :param entity: Entity :param kwargs: dict of attributes copied to entity :return: Group (or Chain) to which the entity was added, or None if entity was None

`bbox`(*filter=None*)

Parameters **filter** – optional function(entity):bool returning True if entity should be considered in box

Returns *BBox* bounding box of Entity

center

chainify (*mergeable*)
merge all possible entities into chains

clear () → None – remove all items from L

color
str(object='') -> str str(bytes_or_buffer[, encoding[, errors]]) -> str

Create a new string object from the given object. If encoding or errors is specified, then the object must expose a data buffer that will be decoded using the given encoding and error handler. Otherwise, returns the result of object.__str__() (if defined) or repr(object). encoding defaults to sys.getdefaultencoding(). errors defaults to 'strict'.

connect (*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

copy () → list – a shallow copy of L

count (*value*) → integer – return number of occurrences of value

distance (*other*)

draw (*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

extend (*iterable*) → None – extend list by appending elements from the iterable

static figure (*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

from_dxf (*dxf, layers=None, only=[], ignore=['POINT'], trans=Matrix3(1.0, 0, 0, 0, 1.0, 0, 0, 0, 1.0), flatten=False*)

Parameters

- **dxf** – dxf.entity
- **layers** – list of layer names to consider. entities not on these layers are ignored. default=None: all layers are read
- **only** – list of dxf entity types names that are read. default=[]: all are read
- **ignore** – list of dxf entity types names that are ignored. default=['POINT']: points and null length segments are ignored
- **trans** – *Trans* optional transform matrix

Parm flatten bool flatten block structure

Returns *Entity* of correct subtype

static from_pdf (*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

intersect(*other*)

Parameters **other** – *geom.Entity*

Result generate tuples (Point2,Entity_self) of intersections between other and each Entity

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

layer

length

patches(***kwargs*)

Returns list of `Patch` corresponding to group

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

read_dxf(*filename*, *options=None*, ***kwargs*)
reads a .dxf file :param filename: string path to .dxf file to read :param options: passed to `from_dxf`

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

reverse()
L.reverse() – reverse *IN PLACE*

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

start

svg (***kwargs*)

swap ()
swap start and end

tangent (*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf (***kwargs*)

Returns flatten list of dxf entities

save (*filename*, ***kwargs*)
save graph in various formats

2.6 Goulib.expr module

simple symbolic math expressions

Goulib.expr.**eval** (*node*, ***kwargs*)
safe eval of ast node : only functions and _operators listed above can be used

Parameters

- **node** – ast.AST to evaluate
- **ctx** – dict of varname : value to substitute in node

Returns number or expression string

Goulib.expr.**get_function_source** (*f*)
returns cleaned code of a function or lambda currently only supports: - lambda x:formula_of_(x) - def anything(x): return formula_of_(x)

Goulib.expr.**plouffe** (*f*, *epsilon=1e-06*)

class Goulib.expr.**Expr** (*f*, ***kwargs*)
Bases: *Goulib.plot.Plot*

Math expressions that can be evaluated like standard functions combined using standard operators and plotted in IPython/Jupyter notebooks

Parameters f – function or operator, Expr to copy construct, or formula string

__init__ (*f*, ***kwargs*)

Parameters f – function or operator, Expr to copy construct, or formula string

isNum

isconstant

Returns True if Expr evaluates to a constant number or bool

__call__ (*x=None*, ***kwargs*)
evaluate the Expr at x OR compose self(x())

__float__ ()

__repr__ ()
Return repr(self).

__str__()
Return str(self).

latex()

Returns string LaTex formula

points(*xmin=-1*, *xmax=1*, *step=0.1*)

Returns x,y lists of float : points for a line plot

apply(*f*, *right=None*)
function composition self o f = f(self(x))

applx(*f*, *var='x'*)
function composition f o self = self(f(x))

__eq__(*other*)
Return self==value.

__ne__(*other*)
Return self!=value.

__lt__(*other*)
Return self<value.

__le__(*other*)
Return self<=value.

__ge__(*other*)
Return self>=value.

__gt__(*other*)
Return self>value.

__add__(*right*)

__sub__(*right*)

__neg__()

__mul__(*right*)

__rmul__(*right*)

__truediv__(*right*)

__pow__(*right*)

__div__(*right*)

__invert__()

__and__(*right*)

__or__(*right*)

__xor__(*right*)

__lshift__(*dx*)

__rshift__(*dx*)

complexity()
measures the complexity of Expr :return: int, sum of the precedence of used ops

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__getattribute__
Return getattr(self, name).

__hash__ = None

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

html(***kwargs*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

svg(***kwargs*)

Goulib.expr.**add_function**(*f*, *s=None*, *r=None*, *l=None*)
add a function to those allowed in Expr.

Parameters

- **f** – function
- **s** – string representation, should be formula-like
- **r** – repr representation, should be cut&pastable in a calculator, or in python …
- **l** – LaTeX representation

Goulib.expr.**add_constant**(*c*, *name*, *s=None*, *r=None*, *l=None*)
add a constant to those recognized in Expr.

Parameters

- **c** – constant
- **s** – string representation, should be formula-like
- **r** – repr representation, should be cut&pastable in a calculator, or in python …
- **l** – LaTeX representation

Goulib.expr.**add_module**(*module*)

class Goulib.expr.**TextVisitor**(*dialect*, *operators={<class '_ast.GtE'>: (<built-in function ge>, 600, ' >= ', ' >= ', ' \gec '), <class '_ast.Invert'>: (<built-in function not_>, 1300, '~', '~', '\sim '), <class '_ast.USub'>: (<built-in function neg>, 1150, '-', '-', '-'), <class '_ast.Gt'>: (<built-in function gt>, 600, ' > ', ' > ', ' \gtr '), <class '_ast.Pow'>: (<function pow>, 1400, '^', '**', '^'), <class '_ast.Num'>: (None, 9000), <class '_ast.Or'>: (<built-in function or_>, 300, ' or ', ' or ', ' \vee '), <class '_ast.Div'>: (<built-in function truediv>, 1201, '/', '/', '\frac{%s}{%s}'), <class '_ast.Name'>: (None, 9000), <class '_ast.BitXor'>: (<built-in function xor>, 800, ' xor ', ' xor ', ' xor '), <class '_ast.FloorDiv'>: (<built-in function floordiv>, 1201, '//', '//', '\left\lfloor\frac{%s}{%s}\right\rfloor'), <class '_ast.Sub'>: (<built-in function sub>, 1101, '-', '-', '-'), <class '_ast.LShift'>: (<built-in function lshift>, 1000, ' << ', ' << ', ' \ll '), <class '_ast.Not'>: (<built-in function not_>, 500, 'not ', 'not ', '\neg'), <class '_ast.Lt'>: (<built-in function lt>, 600, ' < ', ' < ', ' \ltr '), <class '_ast.Mod'>: (<built-in function mod>, 1200, ' mod ', '%', ' \bmod '), <class '_ast.Eq'>: (<built-in function eq>, 600, '=', ' == ', ' = '), <class '_ast.Mult'>: (<built-in function mul>, 1200, '*', '*', ' \cdot '), <class '_ast.And'>: (<built-in function and_>, 400, ' and ', ' and ', ' \wedge '), <class '_ast.RShift'>: (<built-in function rshift>, 1000, ' >> ', ' >> ', ' \gg '), <class '_ast.UAdd'>: (<built-in function pos>, 1150, '+', '+', '+'), <class '_ast.LtE'>: (<built-in function le>, 600, ' <= ', ' <= ', ' \leq '), <class '_ast.Add'>: (<built-in function add>, 1100, '+', '+', '+'), <class '_ast.Call'>: (None, 9000)}*, *functions={'abs': (<built-in function abs>, 9999, None, None, '\lvert{%s}\rvert'), 'acos': (<built-in function acos>, 9999, None, None, '\arccos'), 'acosh': (<built-in function acosh>, 9999, None, None, '\cosh^{-1}'), 'asin': (<built-in function asin>, 9999, None, None, '\arcsin'), 'asinh': (<built-in function asinh>, 9999, None, None, '\sinh^{-1}'), 'atan': (<built-in function atan>, 9999, None, None, '\arctan'), 'atan2': (<built-in function atan2>, 9999, None, None, None), 'atanh': (<built-in function atanh>, 9999, None, None, '\tanh^{-1}'), 'ceil': (<built-in function ceil>, 9999, None, None, '\left\lceil{%s}\right\rceil'), 'copysign': (<built-in function copysign>, 9999, None, None, None), 'cos': (<built-in function cos>, 9999, None, None, None), 'cosh': (<built-in function cosh>, 9999, None, None, None), 'degrees': (<built-in function degrees>, 9999, None, None, '%s\cdot\frac{360}{2\pi}'), 'erf': (<built-in function erf>, 9999, None, None, None), 'erfc': (<built-in function erfc>, 9999, None, None, None), 'exp': (<built-in function exp>, 9999, None, None, 'e^{%s}'), 'expm1': (<built-in function expm1>, 9999, None, None, 'e^{%s}-1'), 'fabs': (<built-in function fabs>, 9999, None, None, '\lvert{%s}\rvert'), 'factorial': (<built-in function factorial>, 9999, '%s!', 'fact', '%s!'), 'factorial2': (<function factorial2 at 0x7f8b7cf24400>, 9999, '%s!', 'fact', '%s!!'), 'floor': (<built-in function floor>, 9999, None, None, '\left\lfloor{%s}\right\rfloor'), 'fmod': (<built-in function fmod>, 9999, None, None, None), 'frexp': (<built-in function frexp>, 9999, None, None, None), 'fsum': (<built-in function fsum>, 9999, None, None, None), 'gamma': (<built-in function gamma>, 9999, None, None, '\Gamma'), 'gcd': (<built-in function gcd>, 9999, None, None, None), 'hypot': (<built-in function hypot>, 9999, None, None, None), 'isclose': (<built-in function isclose>, 9999, None, None, None), 'isfinite': (<built-in function isfinite>, 9999, None, None, None), 'isinf': (<built-in function isinf>, 9999, None, None, None), 'isnan': (<built-in function isnan>, 9999,* Bases: `ast.NodeVisitor`

Parameters **`dialect`** – int index in _operators of symbols to use

__init__(*dialect, operators={<class '_ast.GtE'>: (<built-in function ge>, 600, ' >= ', ' >= ', ' \\gec '), <class '_ast.Invert'>: (<built-in function not_>, 1300, '~', '~', '\\sim '), <class '_ast.USub'>: (<built-in function neg>, 1150, '-', '-', '-'), <class '_ast.Gt'>: (<built-in function gt>, 600, ' > ', ' > ', ' \\gtr '), <class '_ast.Pow'>: (<function pow>, 1400, '^', '**', '^'), <class '_ast.Num'>: (None, 9000), <class '_ast.Or'>: (<built-in function or_>, 300, ' or ', ' or ', ' \\vee '), <class '_ast.Div'>: (<built-in function truediv>, 1201, '/', '/', '\\frac{%s}{%s}'), <class '_ast.Name'>: (None, 9000), <class '_ast.BitXor'>: (<built-in function xor>, 800, ' xor ', ' xor ', ' xor '), <class '_ast.FloorDiv'>: (<built-in function floordiv>, 1201, '//', '//', '\\left\\lfloor\\frac{%s}{%s}\\right\\rfloor'), <class '_ast.Sub'>: (<built-in function sub>, 1101, '-', '-', '-'), <class '_ast.LShift'>: (<built-in function lshift>, 1000, ' << ', ' << ', ' \\ll '), <class '_ast.Not'>: (<built-in function not_>, 500, 'not ', 'not ', '\\neg'), <class '_ast.Lt'>: (<built-in function lt>, 600, ' < ', ' < ', ' \\ltr '), <class '_ast.Mod'>: (<built-in function mod>, 1200, ' mod ', '%', ' \\bmod '), <class '_ast.Eq'>: (<built-in function eq>, 600, '=', ' == ', ' = '), <class '_ast.Mult'>: (<built-in function mul>, 1200, '*', '*', ' \\cdot '), <class '_ast.And'>: (<built-in function and_>, 400, ' and ', ' and ', ' \\wedge '), <class '_ast.RShift'>: (<built-in function rshift>, 1000, ' >> ', ' >> ', ' \\gg '), <class '_ast.UAdd'>: (<built-in function pos>, 1150, '+', '+', '+'), <class '_ast.LtE'>: (<built-in function le>, 600, ' <= ', ' <= ', ' \\leq '), <class '_ast.Add'>: (<built-in function add>, 1100, '+', '+', '+'), <class '_ast.Call'>: (None, 9000)}, functions={'abs': (<built-in function abs>, 9999, None, None, '\\lvert{%s}\\rvert'), 'acos': (<built-in function acos>, 9999, None, None, '\\arccos'), 'acosh': (<built-in function acosh>, 9999, None, None, '\\cosh^{-1}'), 'asin': (<built-in function asin>, 9999, None, None, '\\arcsin'), 'asinh': (<built-in function asinh>, 9999, None, None, '\\sinh^{-1}'), 'atan': (<built-in function atan>, 9999, None, None, '\\arctan'), 'atan2': (<built-in function atan2>, 9999, None, None, None), 'atanh': (<built-in function atanh>, 9999, None, None, '\\tanh^{-1}'), 'ceil': (<built-in function ceil>, 9999, None, None, '\\left\\lceil{%s}\\right\\rceil'), 'copysign': (<built-in function copysign>, 9999, None, None, None), 'cos': (<built-in function cos>, 9999, None, None, None), 'cosh': (<built-in function cosh>, 9999, None, None, None), 'degrees': (<built-in function degrees>, 9999, None, None, '%s\\cdot\\frac{360}{2\\pi}'), 'erf': (<built-in function erf>, 9999, None, None, None), 'erfc': (<built-in function erfc>, 9999, None, None, None), 'exp': (<built-in function exp>, 9999, None, None, 'e^{%s}'), 'expm1': (<built-in function expm1>, 9999, None, None, 'e^{%s}-1'), 'fabs': (<built-in function fabs>, 9999, None, 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'trunc': (<built-in function trunc>, 9999, None, None, '\\left\\lfloor{%s}\\right\\rfloor')}*)

Parameters **`dialect`** – int index in _operators of symbols to use

`prec`(*op*)
calculate the precedence of op

`visit_Call`(*n*)

`visit_Name`(*n*)

`visit_NameConstant`(*node*)

`visit_UnaryOp`(*n*)

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__gt__`
Return self>value.

`__hash__`
Return hash(self).

`__le__`
Return self<=value.

`__lt__`
Return self<value.

`__ne__`
Return self!=value.

`__new__`()
Create and return a new object. See help(type) for accurate signature.

`__reduce__`()
helper for pickle

`__reduce_ex__`()
helper for pickle

`__repr__`
Return repr(self).

`__setattr__`
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

visit(*node*)
Visit a node.

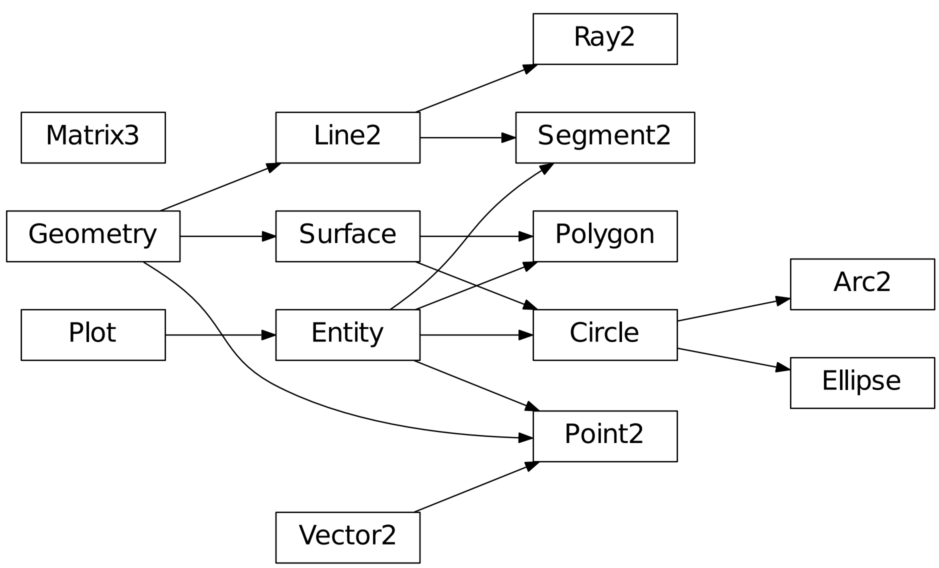
visit_BinOp(*n*)

visit_Compare(*n*)

visit_Num(*n*)

generic_visit(*n*)
Called if no explicit visitor function exists for a node.

2.7 Goulib.geom module



2D geometry

class Goulib.geom.**Geometry**(**args*)
Bases: `object`

The following classes are available for dealing with simple 2D geometry. The interface to each shape is similar; in particular, the `connect` and `distance` methods are defined identically for each.

For example, to find the closest point on a line to a circle:

```
>>> circ = Circle(Point2(3., 2.), 2.)
>>> line = Line2(Point2(0., 0.), Point2(-1., 1.))
>>> line.connect(circ).p1
Point2(0.50, -0.50)
```

To find the corresponding closest point on the circle to the line:

```
>>> line.connect(circ).p2
Point2(1.59, 0.59)
```

this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

point(*u*)

Returns Point2 or Point3 at parameter u

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

intersect(*other*)

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

__contains__(*pt*)

__abstractmethods__ = frozenset()

__class__
alias of `abc.ABCMeta`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.geom.**argPair**(*x*, *y=None*)
Process a pair of values passed in various ways.

class Goulib.geom.**Vector2**(**args*)
Bases: object

Mutable 2D vector:

Construct a vector in the obvious way:

```
>>> Vector2(1.5, 2.0)
Vector2(1.50, 2.00)

>>> Vector3(1.0, 2.0, 3.0)
Vector3(1.00, 2.00, 3.00)
```

Element access

Components may be accessed as attributes (examples that follow use *Vector3*, but all results are similar for *Vector2*, using only the *x* and *y* components):

```
>>> v = Vector3(1, 2, 3)
>>> v.x
1
>>> v.y
2
>>> v.z
3
```

Vectors support the list interface via slicing:

```
>>> v = Vector3(1, 2, 3)
>>> len(v)
3
>>> v[0]
1
>>> v[:]
(1, 2, 3)
```

You can also "swizzle" the components (*a la* GLSL or Cg):

```
>>> v = Vector3(1, 2, 3)
>>> v.xyz
(1, 2, 3)
>>> v.zx
(3, 1)
>>> v.zzzz
(3, 3, 3, 3)
```

Operators

Addition and subtraction are supported via operator overloading (note that in-place operators perform faster than those that create a new object):

```
>>> v1 = Vector3(1, 2, 3)
>>> v2 = Vector3(4, 5, 6)
>>> v1 + v2
Vector3(5.00, 7.00, 9.00)
>>> v1 -= v2
>>> v1
Vector3(-3.00, -3.00, -3.00)
```

Multiplication and division can be performed with a scalar only:

```
>>> Vector3(1, 2, 3) * 2
Vector3(2.00, 4.00, 6.00)
>>> v1 = Vector3(1., 2., 3.)
>>> v1 /= 2
>>> v1
Vector3(0.50, 1.00, 1.50)
```

The magnitude of a vector can be found with `abs`:

```
>>> v = Vector3(1., 2., 3.)
>>> abs(v)
3.7416573867739413
```

A vector can be normalized in-place (note that the in-place method also returns `self`, so you can chain it with further operators):

```
>>> v = Vector3(1., 2., 3.)
>>> v.normalize()
Vector3(0.27, 0.53, 0.80)
>>> v
Vector3(0.27, 0.53, 0.80)
```

The following methods do *not* alter the original vector or their arguments:

`magnitude()` Returns the magnitude of the vector; equivalent to `abs(v)`. Example:

```
>>> v = Vector3(1., 2., 3.)
>>> v.magnitude()
3.7416573867739413
```

magnitude_squared() Returns the sum of the squares of each component. Useful for comparing the length of two vectors without the expensive square root operation. Example:

```
>>> v = Vector3(1., 2., 3.)
>>> v.magnitude_squared()
14.0
```

normalized() Return a unit length vector in the same direction. Note that this method differs from `normalize` in that it does not modify the vector in-place. Example:

```
>>> v = Vector3(1., 2., 3.)
>>> v.normalized()
Vector3(0.27, 0.53, 0.80)
>>> v
Vector3(1.00, 2.00, 3.00)
```

dot(other) Return the scalar "dot" product of two vectors. Example:

```
>>> v1 = Vector3(1., 2., 3.)
>>> v2 = Vector3(4., 5., 6.)
>>> v1.dot(v2)
32.0
```

cross() and cross(other) Return the cross product of a vector (for **Vector2**), or the cross product of two vectors (for **Vector3**). The return type is a vector. Example:

```
>>> v1 = Vector3(1., 2., 3.)
>>> v2 = Vector3(4., 5., 6.)
>>> v1.cross(v2)
Vector3(-3.00, 6.00, -3.00)
```

In two dimensions there can be no argument to `cross`:

```
>>> v1 = Vector2(1., 2.)
>>> v1.cross()
Vector2(2.00, -1.00)
```

reflect(normal) Return the vector reflected about the given normal. In two dimensions, *normal* is the normal to a line, in three dimensions it is the normal to a plane. The normal must have unit length. Example:

```
>>> v = Vector3(1., 2., 3.)
>>> v.reflect(Vector3(0, 1, 0))
Vector3(1.00, -2.00, 3.00)
>>> v = Vector2(1., 2.)
>>> v.reflect(Vector2(1, 0))
Vector2(-1.00, 2.00)
```

rotate_around(axes, theta) For 3D vectors, return the vector rotated around axis by the angle theta.

```
>>> v = Vector3(1., 2., 3.)
>>> axes = Vector3(1.,1.,0)
```

(continues on next page)

(continued from previous page)

```
>>> v.rotate_around(axes,math.pi/4)
Vector3(2.65, 0.35, 2.62)
```

Constructor. :param *args: x,y values

__init__(**args*)
Constructor. :param *args: x,y values

xy

Returns tuple (x,y)

__repr__()
Return repr(self).

__hash__()
Return hash(self).

__eq__(*other*)
Tests for equality include comparing against other sequences:

```
>>> v2 = Vector2(1, 2)
>>> v2 == Vector2(3, 4)
```

False >>> v2 != Vector2(1, 2) False >>> v2 == (1, 2) True

```
>>> v3 = Vector3(1, 2, 3)
>>> v3 == Vector3(3, 4, 5)
False
>>> v3 != Vector3(1, 2, 3)
False
>>> v3 == (1, 2, 3)
True
```

__len__()

__iter__()

__add__(*other*)

__radd__(*other*)

__iadd__(*other*)

__sub__(*other*)

__rsub__(*other*)
Point2 - Vector 2 substraction :param other: Point2 or (x,y) tuple :return: Vector2

__mul__(*other*)

__rmul__(*other*)

__imul__(*other*)

__div__(*other*)

__rdiv__(*other*)

__floordiv__(*other*)

__rfloordiv__(*other*)

__truediv__(*other*)

__rtruediv__(*other*)

__neg__()

__pos__()

__abs__()

mag()

length

mag2()

normalize()

normalized()

dot(*other*)

cross()

reflect(*normal*)

angle(*other=None*, *unit=False*)
angle between two vectors. :param unit: bool True if vectors are unit vectors. False increases computations :return: float angle in radians to the other vector, or self direction if other=None

project(*other*)
Return the projection (the component) of the vector on other.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.geom.**Point2**(**args*)
Bases: `Goulib.geom.Vector2`, *Goulib.geom.Geometry*, *Goulib.drawing.Entity*

A point on a 2D plane. Construct in the obvious way:

```
>>> p = Point2(1.0, 2.0)
>>> p
```

Point2(1.00, 2.00)

Point2 subclasses **Vector2**, so all of **Vector2** operators and methods apply. In particular, subtracting two points gives a vector:

```
>>> Point2(2.0, 3.0) - Point2(1.0, 0.0)
```

Vector2(1.00, 3.00)

connect(other) Returns a **Segment2** which is the minimum length line segment that can connect the two shapes. *other* may be a **Point2**, **Line2**, **Ray2**, **Segment2** or **Circle**.

Constructor. :param *args: x,y values

distance(*other*)
absolute minimum distance to other object :param other: Point2, Line2 or Circle :return: float positive distance between self and other

__contains__(*pt*)

Returns True if self and pt are the same point, False otherwise

needed for coherency

intersect(*other*)
Point2/object intersection :return: Point2 copy of self if on other object, None if not

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

__abs__()

__abstractmethods__ = frozenset()

__add__(*other*)

__class__
alias of `abc.ABCMeta`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__div__(*other*)

__eq__(*other*)
Tests for equality include comparing against other sequences:

```
>>> v2 = Vector2(1, 2)
>>> v2 == Vector2(3, 4)
```

False >>> v2 != Vector2(1, 2) False >>> v2 == (1, 2) True

```
>>> v3 = Vector3(1, 2, 3)
>>> v3 == Vector3(3, 4, 5)
False
>>> v3 != Vector3(1, 2, 3)
False
>>> v3 == (1, 2, 3)
True
```

__floordiv__(*other*)

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__()
Return hash(self).

__iadd__(*other*)

__imul__(*other*)

__init__(**args*)
Constructor. :param *args: x,y values

__iter__()

__le__
Return self<=value.

__len__()

__lt__
Return self<value.

__mul__(*other*)

__ne__
Return self!=value.

__neg__()

__new__()
Create and return a new object. See help(type) for accurate signature.

__pos__()

__radd__(*other*)

__rdiv__(*other*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__rfloordiv__(*other*)

__rmul__(*other*)

__rsub__(*other*)
Point2 - Vector 2 substraction :param other: Point2 or (x,y) tuple :return: Vector2

__rtruediv__(*other*)

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

__sub__(*other*)

__truediv__(*other*)

angle(*other=None*, *unit=False*)
angle between two vectors. :param unit: bool True if vectors are unit vectors. False increases computations :return: float angle in radians to the other vector, or self direction if other=None

bbox()

Returns `BBox` bounding box of Entity

center

color = 'black'

cross()

dot(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters path – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters path – svg path

Returns Entity of correct subtype

html(***kwargs*)

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

length

mag()

mag2()

normalize()

normalized()

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 or Point3 at parameter u

project(*other*)
Return the projection (the component) of the vector on other.

reflect(*normal*)

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg(***kwargs*)

tangent (*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf (***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

xy

Returns tuple (x,y)

Goulib.geom.**Polar** (*mag*, *angle*)

class Goulib.geom.**Line2** (**args*)

Bases: *Goulib.geom.Geometry*

A **Line2** is a line on a 2D plane extending to infinity in both directions; a **Ray2** has a finite end-point and extends to infinity in a single direction; a **Segment2** joins two points.

All three classes support the same constructors, operators and methods, but may behave differently when calculating intersections etc.

You may construct a line, ray or line segment using any of:

- another line, ray or line segment
- two points
- a point and a vector
- a point, a vector and a length

For example:

```
>>> Line2(Point2(1.0, 1.0), Point2(2.0, 3.0))
Line2(<1.00, 1.00> + u<1.00, 2.00>)
>>> Line2(Point2(1.0, 1.0), Vector2(1.0, 2.0))
Line2(<1.00, 1.00> + u<1.00, 2.00>)
>>> Ray2(Point2(1.0, 1.0), Vector2(1.0, 2.0), 1.0)
Ray2(<1.00, 1.00> + u<0.45, 0.89>)
```

Internally, lines, rays and line segments store a Point2 *p* and a Vector2 *v*. You can also access (but not set) the two endpoints *p1* and *p2*. These may or may not be meaningful for all types of lines.

The following methods are supported by all three classes:

intersect(other) If *other* is a **Line2**, **Ray2** or **Segment2**, returns a **Point2** of intersection, or None if the lines are parallel.

If *other* is a **Circle**, returns a **Segment2** or **Point2** giving the part of the line that intersects the circle, or None if there is no intersection.

connect(other) Returns a **Segment2** which is the minimum length line segment that can connect the two shapes. For two parallel lines, this line segment may be in an arbitrary position. *other* may be a **Point2**, **Line2**, **Ray2**, **Segment2** or **Circle**.

distance(other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

Segment2 also has a *length* property which is read-only.

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__eq__(*other*)
lines are "equal" only if base points and vector are strictly equal. to compare if lines are "same", use line1.distance(line2)==0

__repr__()
Return repr(self).

point(*u*)

Returns Point2 at parameter u

tangent(*u*)

Returns Vector2 tangent at parameter u. Warning : tangent is generally not a unit vector

intersect(*other*)

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

__abstractmethods__ = frozenset()

__class__
alias of `abc.ABCMeta`

__contains__(*pt*)

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

distance(*other*)

class Goulib.geom.**Ray2**(**args*)
Bases: *Goulib.geom.Line2*

__abstractmethods__ = frozenset()

__class__
alias of abc.ABCMeta

__contains__(*pt*)

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)
lines are "equal" only if base points and vector are strictly equal. to compare if lines are "same", use line1.distance(line2)==0

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

intersect(*other*)

point(*u*)

Returns Point2 at parameter u

tangent(*u*)

Returns Vector2 tangent at parameter u. Warning : tangent is generally not a unit vector

class Goulib.geom.**Segment2**(**args*)
Bases: *Goulib.geom.Line2*, *Goulib.drawing.Entity*

p1

p2

__repr__()
Return repr(self).

__abs__()

mag2()

length

swap()

midpoint()

bisect()

__abstractmethods__ = frozenset()

__class__
alias of abc.ABCMeta

__contains__(*pt*)

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)
lines are "equal" only if base points and vector are strictly equal. to compare if lines are "same", use line1.distance(line2)==0

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

bbox()

Returns `BBox` bounding box of Entity

center

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters path – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters path – svg path

Returns Entity of correct subtype

html(***kwargs*)

intersect(*other*)

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

patches(***kwargs*)

Returns list of (a single) `Patch` corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 at parameter u

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg(***kwargs*)

tangent(*u*)

Returns Vector2 tangent at parameter u. Warning : tangent is generally not a unit vector

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

class Goulib.geom.**Surface**(**args*)

Bases: *Goulib.geom.Geometry*

this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

length

area

center

__abstractmethods__ = frozenset()

__class__

alias of abc.ABCMeta

__contains__(*pt*)

__delattr__

Implement delattr(self, name).

__dir__() → list

default dir() implementation

__eq__

Return self==value.

__format__()

default object formatter

__ge__

Return self>=value.

__getattribute__

Return getattr(self, name).

__gt__

Return self>value.

__hash__

Return hash(self).

__init__(**args*)

this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__le__

Return self<=value.

__lt__

Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

intersect(*other*)

point(*u*)

Returns Point2 or Point3 at parameter u

tangent(*u*)

Returns Vector2 or Vector3 tangent at parameter u

class Goulib.geom.**Polygon**(*args*)
Bases: *Goulib.geom.Surface*, *Goulib.drawing.Entity*

Parameters **args** – can be

- Polygon
- iterator of points

__init__(*args*)

Parameters **args** – can be

- Polygon
- iterator of points

__repr__()
Return repr(self).

xy

Returns tuple (x,y)

__iter__()

__abs__()

Returns float perimeter

area

center
centroid

Returns Point2 centroid of the Polygon

__contains__(*pt*)

__abstractmethods__ = frozenset()

__class__
alias of `abc.ABCMeta`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

bbox()

Returns BBox bounding box of Entity

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – drawing.BBox bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html(***kwargs*)

intersect(*other*)

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

length

patches(***kwargs*)

Returns list of (a single) Patch corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

point (*u*)

Returns Point2 or Point3 at parameter u

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save (*filename*, ***kwargs*)

setattr (***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg (***kwargs*)

tangent (*u*)

Returns Vector2 or Vector3 tangent at parameter u

to_dxf (***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

class Goulib.geom.**Circle** (**args*)
Bases: *Goulib.geom.Surface*, *Goulib.drawing.Entity*

Circles are constructed with a center **Point2** and a radius:

```
>>> c = Circle(Point2(1.0, 1.0), 0.5)
>>> c
```

Circle(<1.00, 1.00>, radius=0.50)

Internally there are two attributes: *c*, giving the center point and *r*, giving the radius.

The following methods are supported:

connect (other) Returns a **Segment2** which is the minimum length line segment that can connect the two shapes. *other* may be a **Point2**, **Line2**, **Ray2**, **Segment2** or **Circle**.

distance (other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

Parameters **args** – can be

- Circle
- center, point on circle
- center, radius

__init__ (**args*)

Parameters **args** – can be

- Circle
- center, point on circle
- center, radius

`__eq__`(*other*)
Return self==value.

`__repr__`()
Return repr(self).

`__abs__`()

Returns float perimeter

`center`

`area`

`point`(*u*)

Returns Point2 at angle u radians

`tangent`(*u*)

Returns Vector2 tangent at angle u. Warning : tangent has magnitude r != 1

`__contains__`(*pt*)

Returns True if pt is ON or IN the circle

`intersect`(*other*)

Parameters **`other`** – Line2, Ray2 or Segment2**, **Ray2** or **Segment2**, returns

a **Segment2** giving the part of the line that intersects the circle, or None if there is no intersection.

`connect`(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

`swap`()

`__abstractmethods__ = frozenset()`

`__class__`
alias of `abc.ABCMeta`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__gt__`
Return self>value.

`__hash__ = None`

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

bbox()

Returns `BBox` bounding box of Entity

color = 'black'

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html (***kwargs*)

isclosed ()

ishorizontal (*tol=0.01*)

isline ()

isvertical (*tol=0.01*)

length

patches (***kwargs*)

Returns list of (a single) `Patch` corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save (*filename*, ***kwargs*)

setattr (***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg (***kwargs*)

to_dxf (***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

Goulib.geom.**circle_from_3_points** (*a*, *b*, *c*)
constructs Circle passing through 3 distinct points :param a,b,c: Point2 :return: the unique Circle through the three points a, b, c

Goulib.geom.**arc_from_3_points** (*a*, *b*, *c*)
constructs Arc2 starting in a, going through b and ending in c :param a,b,c: Point2 :return: the unique Arc2 starting in a, going through b and ending in c

class Goulib.geom.**Arc2** (*center*, *p1=0*, *p2=6.283185307179586*, *r=None*, *dir=1*)
Bases: `Goulib.geom.Circle`

Parameters

- **center** – Point2 or (x,y) tuple
- **p1** – starting Point2 or angle in radians
- **p2** – ending Point2 or angle in radians
- **r** – float radius, needed only if p1 or p2 is an angle
- **dir** – arc direction. +1 is trig positive (CCW) and -1 is Clockwise

`__init__`(*center*, *p1=0*, *p2=6.283185307179586*, *r=None*, *dir=1*)

Parameters

- **`center`** – Point2 or (x,y) tuple
- **`p1`** – starting Point2 or angle in radians
- **`p2`** – ending Point2 or angle in radians
- **`r`** – float radius, needed only if p1 or p2 is an angle
- **`dir`** – arc direction. +1 is trig positive (CCW) and -1 is Clockwise

`angle`(*b=None*)

Returns float signed arc angle

`__abs__`()

Returns float arc length

`point`(*u*)

Returns Point2 at parameter u

`tangent`(*u*)

Returns Vector2 tangent at parameter u

`__eq__`(*other*)
Return self==value.

`__repr__`()
Return repr(self).

`swap`()

`__contains__`(*pt*)

Returns True if pt is ON the Arc

`intersect`(*other*)

Parameters **`other`** – Line2, Ray2 or Segment2**, **Ray2** or **Segment2**, returns

a **Segment2** giving the part of the line that intersects the circle, or None if there is no intersection.

`__abstractmethods__ = frozenset()`

`__class__`
alias of `abc.ABCMeta`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

area

bbox()

Returns `BBox` bounding box of Entity

center

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – `drawing.BBox` bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity

- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf (*path*, *trans*, *color*)

Parameters **path** – pdf path

Returns Entity of correct subtype

static from_svg (*path*, *color*)

Parameters **path** – svg path

Returns Entity of correct subtype

html (***kwargs*)

isclosed ()

ishorizontal (*tol=0.01*)

isline ()

isvertical (*tol=0.01*)

length

patches (***kwargs*)

Returns list of (a single) `Patch` corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

render (*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save (*filename*, ***kwargs*)

setattr (***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg (***kwargs*)

to_dxf (***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

class Goulib.geom.**Ellipse** (**args*)
Bases: *Goulib.geom.Circle*

Parameters **args** – can be

- Ellipse
- center, corner point
- center, r1,r2,angle

__init__(**args*)

Parameters **args** – can be

- Ellipse
- center, corner point
- center, r1,r2,angle

__repr__()
Return repr(self).

__eq__(*other*)
Return self==value.

__abs__()

Returns float perimeter

__abstractmethods__ = frozenset()

__class__
alias of `abc.ABCMeta`

__contains__(*pt*)

Returns True if pt is ON or IN the circle

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

area

bbox()

Returns BBox bounding box of Entity

center

color = 'black'

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

distance(*other*)

draw(*fig=None*, ***kwargs*)
draw entities :param fig: matplotlib figure where to draw. figure(g) is called if missing :return: fig,patch

end

static figure(*box*, ***kwargs*)

Parameters

- **box** – drawing.BBox bounds and clipping box
- **kwargs** – parameters passed to *~matplotlib.pyplot.figure*

Returns matplotlib axis suitable for drawing

static from_dxf(*e*, *mat3*)

Parameters

- **e** – dxf.entity
- **mat3** – Matrix3 transform

Returns Entity of correct subtype

static from_pdf(*path*, *trans*, *color*)

Parameters path – pdf path

Returns Entity of correct subtype

static from_svg(*path*, *color*)

Parameters path – svg path

Returns Entity of correct subtype

html(***kwargs*)

intersect(*other*)

Parameters other – Line2, Ray2 or Segment2**, **Ray2** or **Segment2**, returns a **Segment2** giving the part of the line that intersects the circle, or None if there is no intersection.

isclosed()

ishorizontal(*tol=0.01*)

isline()

isvertical(*tol=0.01*)

length

patches(***kwargs*)

Returns list of (a single) `Patch` corresponding to entity

Note this is the only method that needs to be overridden in descendants for draw, render and IPython _repr_xxx_ to work

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

point(*u*)

Returns Point2 at angle u radians

render(*fmt*, ***kwargs*)
render graph to bitmap stream :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)

setattr(***kwargs*)
set (graphic) attributes to entity :param kwargs: dict of attributes copied to entity

start

svg(***kwargs*)

swap()

tangent(*u*)

Returns Vector2 tangent at angle u. Warning : tangent has magnitude r != 1

to_dxf(***attr*)

Parameters **attr** – dict of attributes passed to the dxf entity, overriding those defined in self

Returns dxf entity

class Goulib.geom.**Matrix3**(**args*)
Bases: `object`

Two matrix classes are supplied, *Matrix3*, a 3x3 matrix for working with 2D affine transformations, and *Matrix4*, a 4x4 matrix for working with 3D affine transformations.

The default constructor intializes the matrix to the identity:

```
>>> Matrix3()
Matrix3([    1.00      0.00      0.00
             0.00      1.00      0.00
             0.00      0.00      1.00])
>>> Matrix4()
Matrix4([    1.00      0.00      0.00      0.00
             0.00      1.00      0.00      0.00
```

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```
              0.00      0.00      1.00      0.00
              0.00      0.00      0.00      1.00])
```

Element access

Internally each matrix is stored as a set of attributes named `a` to `p`. The layout for Matrix3 is:

```
# a b c
# e f g
# i j k
```

and for Matrix4:

```
# a b c d
# e f g h
# i j k l
# m n o p
```

If you wish to set or retrieve a number of elements at once, you can do so with a slice:

```
>>> m = Matrix4()
>>> m[:]
[1.0, 0, 0, 0, 0, 1.0, 0, 0, 0, 0, 1.0, 0, 0, 0, 0, 1.0]
>>> m[12:15] = (5, 5, 5)
>>> m
Matrix4([     1.00      0.00      0.00      5.00
              0.00      1.00      0.00      5.00
              0.00      0.00      1.00      5.00
              0.00      0.00      0.00      1.00])
```

Note that slices operate in column-major order, which makes them suitable for working directly with OpenGL's `glLoadMatrix` and `glGetFloatv` functions.

Class constructors

There are class constructors for the most common types of transform.

`new_identity` Equivalent to the default constructor. Example:

```
>>> m = Matrix4.new_identity()
>>> m
Matrix4([     1.00      0.00      0.00      0.00
              0.00      1.00      0.00      0.00
              0.00      0.00      1.00      0.00
              0.00      0.00      0.00      1.00])
```

`new_scale(x, y)` and `new_scale(x, y, z)` The former is defined on **Matrix3**, the latter on **Matrix4**. Equivalent to the OpenGL call `glScalef`. Example:

```
>>> m = Matrix4.new_scale(2.0, 3.0, 4.0)
>>> m
Matrix4([     2.00      0.00      0.00      0.00
              0.00      3.00      0.00      0.00
              0.00      0.00      4.00      0.00
              0.00      0.00      0.00      1.00])
```

`new_translate(x, y)` and `new_translate(x, y, z)` The former is defined on **Matrix3**, the latter on **Matrix4**. Equivalent to the OpenGL call `glTranslatef`. Example:

```
>>> m = Matrix4.new_translate(3.0, 4.0, 5.0)
>>> m
Matrix4([    1.00      0.00      0.00      3.00
             0.00      1.00      0.00      4.00
             0.00      0.00      1.00      5.00
             0.00      0.00      0.00      1.00])
```

new_rotate(angle) Create a **Matrix3** for a rotation around the origin. *angle* is specified in radians, anti-clockwise. This is not implemented in **Matrix4** (see below for equivalent methods). Example:

```
>>> import math
>>> m = Matrix3.new_rotate(math.pi / 2)
>>> m
Matrix3([    0.00     -1.00      0.00
             1.00      0.00      0.00
             0.00      0.00      1.00])
```

The following constructors are defined for **Matrix4** only.

new_rotatex(angle), new_rotatey(angle), new_rotatez(angle) Create a **Matrix4** for a rotation around the X, Y or Z axis, respectively. *angle* is specified in radians. Example:

```
>>> m = Matrix4.new_rotatex(math.pi / 2)
>>> m
Matrix4([    1.00      0.00      0.00      0.00
             0.00      0.00     -1.00      0.00
             0.00      1.00      0.00      0.00
             0.00      0.00      0.00      1.00])
```

new_rotate_axis(angle, axis) Create a **Matrix4** for a rotation around the given axis. *angle* is specified in radians, and *axis* must be an instance of **Vector3**. It is not necessary to normalize the axis. Example:

```
>>> m = Matrix4.new_rotate_axis(math.pi / 2, Vector3(1.0, 0.0, 0.0))
>>> m
Matrix4([    1.00      0.00      0.00      0.00
             0.00      0.00     -1.00      0.00
             0.00      1.00      0.00      0.00
             0.00      0.00      0.00      1.00])
```

new_rotate_euler(heading, attitude, bank) Create a **Matrix4** for the given Euler rotation. *heading* is a rotation around the Y axis, *attitude* around the X axis and *bank* around the Z axis. All rotations are performed simultaneously, so this method avoids "gimbal lock" and is the usual method for implemented 3D rotations in a game. Example:

```
>>> m = Matrix4.new_rotate_euler(math.pi / 2, math.pi / 2, 0.0)
>>> m
Matrix4([    0.00     -0.00      1.00      0.00
             1.00      0.00     -0.00      0.00
            -0.00      1.00      0.00      0.00
             0.00      0.00      0.00      1.00])
```

new_perspective(fov_y, aspect, near, far) Create a **Matrix4** for projection onto the 2D viewing plane. This method is equivalent to the OpenGL call `gluPerspective`. *fov_y* is the view angle in the Y direction, in radians. *aspect* is the aspect ration *width* / *height* of the viewing plane. *near* and *far* are the distance to the near and far clipping planes. They must be positive and non-zero. Example:

```
>>> m = Matrix4.new_perspective(math.pi / 2, 1024.0 / 768, 1.0, 100.0)
>>> m
Matrix4([    0.75      0.00      0.00      0.00
             0.00      1.00      0.00      0.00
             0.00      0.00     -1.02     -2.02
             0.00      0.00     -1.00      0.00])
```

Operators

Matrices of the same dimension may be multiplied to give a new matrix. For example, to create a transform which translates and scales:

```
>>> m1 = Matrix3.new_translate(5.0, 6.0)
>>> m2 = Matrix3.new_scale(1.0, 2.0)
>>> m1 * m2
Matrix3([    1.00      0.00      5.00
             0.00      2.00      6.00
             0.00      0.00      1.00])
```

Note that multiplication is not commutative (the order that you apply transforms matters):

```
>>> m2 * m1
Matrix3([    1.00      0.00      5.00
             0.00      2.00     12.00
             0.00      0.00      1.00])
```

In-place multiplication is also permitted (and optimised):

```
>>> m1 *= m2
>>> m1
Matrix3([    1.00      0.00      5.00
             0.00      2.00      6.00
             0.00      0.00      1.00])
```

Multiplying a matrix by a vector returns a vector, and is used to transform a vector:

```
>>> m1 = Matrix3.new_rotate(math.pi / 2)
>>> m1 * Vector2(1.0, 1.0)
Vector2(-1.00, 1.00)
```

Note that translations have no effect on vectors. They do affect points, however:

```
>>> m1 = Matrix3.new_translate(5.0, 6.0)
>>> m1 * Vector2(1.0, 2.0)
Vector2(1.00, 2.00)
>>> m1 * Point2(1.0, 2.0)
Point2(6.00, 8.00)
```

Multiplication is currently incorrect between matrices and vectors – the projection component is ignored. Use the **Matrix4.transform** method instead.

Matrix4 also defines **transpose** (in-place), **transposed** (functional), **determinant** and **inverse** (functional) methods.

A **Matrix3** can be multiplied with a **Vector2** or any of the 2D geometry objects (**Point2**, **Line2**, **Circle**, etc).

A **Matrix4** can be multiplied with a **Vector3** or any of the 3D geometry objects (**Point3**, **Line3**, **Sphere**, etc).

For convenience, each of the matrix constructors are also available as in-place operators. For example, instead of writing:

```
>>> m1 = Matrix3.new_translate(5.0, 6.0)
>>> m2 = Matrix3.new_scale(1.0, 2.0)
>>> m1 *= m2
```

you can apply the scale directly to *m1*:

```
>>> m1 = Matrix3.new_translate(5.0, 6.0)
>>> m1.scale(1.0, 2.0)
Matrix3([    1.00      0.00      5.00
             0.00      2.00      6.00
             0.00      0.00      1.00])
>>> m1
Matrix3([    1.00      0.00      5.00
             0.00      2.00      6.00
             0.00      0.00      1.00])
```

Note that these methods operate in-place (they modify the original matrix), and they also return themselves as a result. This allows you to chain transforms together directly:

```
>>> Matrix3().translate(1.0, 2.0).rotate(math.pi / 2).scale(4.0, 4.0)
Matrix3([    0.00     -4.00      1.00
             4.00      0.00      2.00
             0.00      0.00      1.00])
```

All constructors have an equivalent in-place method. For **Matrix3**, they are `identity`, `translate`, `scale` and `rotate`. For **Matrix4**, they are `identity`, `translate`, `scale`, `rotatex`, `rotatey`, `rotatez`, `rotate_axis` and `rotate_euler`. Both **Matrix3** and **Matrix4** also have an in-place `transpose` method.

The `copy` method is also implemented in both matrix classes and behaves in the obvious way.

`__init__`(**args*)
    Initialize self. See help(type(self)) for accurate signature.

`__repr__`()
    Return repr(self).

`__iter__`()

`__getitem__`(*key*)

`__setitem__`(*key*, *value*)

`__eq__`(*other*)
    Return self==value.

`__sub__`(*other*)

`__imul__`(*other*)

`__mul__`(*other*)

`__call__`(*other*)
    Call self as a function.

`__class__`
    alias of `builtins.type`

`__delattr__`
    Implement delattr(self, name).

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__slotnames__ = []

__str__
Return str(self).

identity()

scale(*x*, *y=None*)

offset()

angle(*angle=0*)

Parameters **angle** – angle in radians of a unit vector starting at origin

Returns float bearing in radians of the transformed vector

mag(*v=None*)
Return the net (uniform) scaling of this transform.

translate(**args*)

Parameters ***args** – x,y values

rotate(*angle*)

classmethod new_identity()

classmethod new_scale(*x*, *y*)

classmethod new_translate(*x*, *y*)

classmethod new_rotate(*angle*)

mag2()

__abs__()

transpose()

transposed()

determinant()

inverse()

orientation()

Returns 1 if matrix is right handed, -1 if left handed

2.8 Goulib.geom3d module

3D geometry

class Goulib.geom3d.**Vector3**(**args*)

Bases: object

Mutable 3D Vector. See 'Vector2'documentation

Constructor. :param *args: x,y,z values

__init__(**args*)

Constructor. :param *args: x,y,z values

xyz

Returns tuple (x,y,z)

__repr__()

Return repr(self).

__eq__(*other*)

Return self==value.

__ne__(*other*)

Return self!=value.

__bool__()

__nonzero__()

__len__()

__iter__()

__add__(*other*)

__radd__(*other*)

__iadd__(*other*)

__sub__(*other*)

__rsub__(*other*)

__mul__(*other*)

__rmul__(*other*)

__imul__(*other*)

__div__(*other*)

__rdiv__(*other*)

__floordiv__(*other*)

__rfloordiv__(*other*)

__truediv__(*other*)

__rtruediv__(*other*)

__neg__()

__pos__()

__abs__()

mag()

mag2()

normalize()

normalized()

dot(*other*)

cross(*other*)

reflect(*normal*)

rotate_around(*axis*, *theta*)
Return the vector rotated around axis through angle theta. Right hand rule applies

angle(*other*)
angle between two vectors. :param other: Vector3 :return: float angle in radians to the other vector, or self direction if other=None

project(*other*)
Return one vector projected on the vector other

__hash__ = None

class Goulib.geom3d.**Point3**(**args*)
Bases: *Goulib.geom3d.Vector3*, *Goulib.geom.Geometry*

A point on a 3D plane. Construct in the obvious way:

```
>>> p = Point3(1.0, 2.0, 3.0)
>>> p
Point3(1.00, 2.00, 3.00)
```

Point3 subclasses **Vector3**, so all of **Vector3** operators and methods apply. In particular, subtracting two points gives a vector:

```
>>> Point3(1.0, 2.0, 3.0) - Point3(1.0, 0.0, -2.0)
Vector3(0.00, 2.00, 5.00)
```

The following methods are also defined:

intersect (other) If *other* is a **Sphere**, returns `True` iff the point lies within the sphere.

connect (other) Returns a **LineSegment3** which is the minimum length line segment that can connect the two shapes. *other* may be a **Point3**, **Line3**, **Ray3**, **LineSegment3**, **Sphere** or **Plane**.

distance (other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

Constructor. :param *args: x,y,z values

intersect (*other*)
Point3/object intersection :return: self Point3 if on other object, None if not

connect (*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

__abstractmethods__ = frozenset()

class Goulib.geom3d.**Line3** (**args*)
Bases: *Goulib.geom.Geometry*

A **Line3** is a line on a 3D plane extending to infinity in both directions; a **Ray3** has a finite end-point and extends to infinity in a single direction; a **LineSegment3** joins two points.

All three classes support the same constructors, operators and methods, but may behave differently when calculating intersections etc.

You may construct a line, ray or line segment using any of:

- another line, ray or line segment
- two points
- a point and a vector
- a point, a vector and a length

For example:

```
>>> Line3(Point3(1.0, 1.0, 1.0), Point3(1.0, 2.0, 3.0))
Line3(<1.00, 1.00, 1.00> + u<0.00, 1.00, 2.00>)
>>> Line3(Point3(0.0, 1.0, 1.0), Vector3(1.0, 1.0, 2.0))
Line3(<0.00, 1.00, 1.00> + u<1.00, 1.00, 2.00>)
>>> Ray3(Point3(1.0, 1.0, 1.0), Vector3(1.0, 1.0, 2.0), 1.0)
Ray3(<1.00, 1.00, 1.00> + u<0.41, 0.41, 0.82>)
```

Internally, lines, rays and line segments store a Point3 *p* and a Vector3 *v*. You can also access (but not set) the two endpoints *p1* and *p2*. These may or may not be meaningful for all types of lines.

The following methods are supported by all three classes:

intersect (other) If *other* is a **Sphere**, returns a **LineSegment3** which is the intersection of the sphere and line, or `None` if there is no intersection.

If *other* is a **Plane**, returns a **Point3** of intersection, or `None`.

connect (other) Returns a **LineSegment3** which is the minimum length line segment that can connect the two shapes. For two parallel lines, this line segment may be in an arbitrary position. *other* may be a **Point3**, **Line3**, **Ray3**, **LineSegment3**, **Sphere** or **Plane**.

distance (other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

LineSegment3 also has a *length* property which is read-only.

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__repr__()
Return repr(self).

p1

p2

point(*u*)

Returns Point3 at parameter u

intersect(*other*)

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

__abstractmethods__ = frozenset()

class Goulib.geom3d.**Ray3**(**args*)
Bases: *Goulib.geom3d.Line3*

__abstractmethods__ = frozenset()

class Goulib.geom3d.**Segment3**(**args*)
Bases: *Goulib.geom3d.Line3*

__repr__()
Return repr(self).

__abs__()

mag2()

swap()

length

__abstractmethods__ = frozenset()

Goulib.geom3d.**Spherical**(*r*, *theta*, *phi*)

class Goulib.geom3d.**Sphere**(**args*)
Bases: *Goulib.geom.Geometry*

Spheres are constructed with a center **Point3** and a radius:

```
>>> s = Sphere(Point3(1.0, 1.0, 1.0), 0.5)
>>> s
```

Sphere(<1.00, 1.00, 1.00>, radius=0.50)

Internally there are two attributes: *c*, giving the center point and *r*, giving the radius.

The following methods are supported:

intersect(other): If *other* is a **Point3**, returns `True` iff the point lies within the sphere.

If *other* is a **Line3**, **Ray3** or **LineSegment3**, returns a **LineSegment3** giving the intersection, or `None` if the line does not intersect the sphere.

distance(other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

Parameters **args** – can be

- Sphere
- center, point on sphere
- center, radius

__init__(**args*)

Parameters **args** – can be

- Sphere
- center, point on sphere
- center, radius

__repr__()
Return repr(self).

__contains__(*pt*)

Returns True if pt is ON or IN the sphere

point(*u*, *v*)

Parameters

- **u** – float angle from “north pole” (=radians(90-lat) in radians
- **v** – float angle from 0 meridian

Returns Point3 on sphere at specified coordinates

intersect(*other*)

connect(*other*)
minimal joining segment between Sphere and other 3D Object :param other: Point3, Line3, Sphere, Plane :return: LineSegment3 of minimal length

distance_on_sphere(*phi1*, *theta1*, *phi2*, *theta2*)

Parameters

- **phi1** – float angle from “north pole” (=radians(90-lat) in radians
- **theta1** – float angle from 0 meridian
- **phi2** – float angle from “north pole” (=radians(90-lat) in radians
- **theta2** – float angle from 0 meridian

__abstractmethods__ = frozenset()

class Goulib.geom3d.**Plane**(**args*)
Bases: *Goulib.geom.Geometry*

Planes can be constructed with any of:

- three **Point3**’s lying on the plane
- a **Point3** on the plane and the **Vector3** normal

- a **Vector3** normal and *k*, described below.

Internally, planes are stored with the normal *n* and constant *k* such that *n.p* = *k* for any point on the plane *p*.

The following methods are supported:

intersect(other) If *other* is a **Line3**, **Ray3** or **LineSegment3**, returns a **Point3** of intersection, or `None` if there is no intersection.

If *other* is a **Plane**, returns the **Line3** of intersection.

connect(other) Returns a **LineSegment3** which is the minimum length line segment that can connect the two shapes. *other* may be a **Point3**, **Line3**, **Ray3**, **LineSegment3**, **Sphere** or **Plane**.

distance(other) Returns the absolute minimum distance to *other*. Internally this simply returns the length of the result of `connect`.

__init__(**args*)
this constructor is called by descendant classes at copy it is replaced to copy some graphics attributes in module drawings

__repr__()
Return repr(self).

intersect(*other*)

connect(*other*)

Returns Geometry shortest (Segment2 or Segment3) that connects self to other

__abstractmethods__ = frozenset()

class Goulib.geom3d.**Matrix4**(**args*)
Bases: `object`

__init__(**args*)
Initialize self. See help(type(self)) for accurate signature.

__repr__()
Return repr(self).

__iter__()

__getitem__(*key*)

__setitem__(*key*, *value*)

__mul__(*other*)

__call__(*other*)
Call self as a function.

__imul__(*other*)

transform(*other*)

identity()

scale(*x*, *y*, *z*)

translate(*x*, *y*, *z*)

rotatex(*angle*)

rotatey(*angle*)

rotatez(*angle*)

rotate_axis (*angle*, *axis*)

rotate_euler (*heading*, *attitude*, *bank*)

rotate_triple_axis (*x*, *y*, *z*)

transpose ()

transposed ()

classmethod new (**values*)

classmethod new_identity ()

classmethod new_scale (*x*, *y*, *z*)

classmethod new_translate (*x*, *y*, *z*)

classmethod new_rotatex (*angle*)

classmethod new_rotatey (*angle*)

classmethod new_rotatez (*angle*)

classmethod new_rotate_axis (*angle*, *axis*)

classmethod new_rotate_euler (*heading*, *attitude*, *bank*)

classmethod new_rotate_triple_axis (*x*, *y*, *z*)

classmethod new_look_at (*eye*, *at*, *up*)

classmethod new_perspective (*fov_y*, *aspect*, *near*, *far*)

determinant ()

inverse ()

class Goulib.geom3d.**Quaternion** (*w=1*, *x=0*, *y=0*, *z=0*)

Bases: `object`

A quaternion represents a three-dimensional rotation or reflection transformation. They are the preferred way to store and manipulate rotations in 3D applications, as they do not suffer the same numerical degradation that matrices do.

The quaternion constructor initializes to the identity transform:

```
>>> q = Quaternion()
>>> q
Quaternion(real=1.00, imag=<0.00, 0.00, 0.00>)
```

Element access

Internally, the quaternion is stored as four attributes: `x`, `y` and `z` forming the imaginary vector, and `w` the real component.

Constructors

Rotations can be formed using the constructors:

new_identity() Equivalent to the default constructor.

new_rotate_axis(angle, axis) Equivalent to the Matrix4 constructor of the same name. *angle* is specified in radians, *axis* is an instance of **Vector3**. It is not necessary to normalize the axis. Example:

```
>>> q = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q
Quaternion(real=0.71, imag=<0.71, 0.00, 0.00>)
```

new_rotate_euler(heading, attitude, bank) Equivalent to the Matrix4 constructor of the same name. *heading* is a rotation around the Y axis, *attitude* around the X axis and *bank* around the Z axis. All angles are given in radians. Example:

```
>>> q = Quaternion.new_rotate_euler(math.pi / 2, math.pi / 2, 0)
>>> q
Quaternion(real=0.50, imag=<0.50, 0.50, 0.50>)
```

new_interpolate(q1, q2, t) Create a quaternion which gives a (SLERP) interpolated rotation between *q1* and *q2*. *q1* and *q2* are instances of **Quaternion**, and *t* is a value between 0.0 and 1.0. For example:

```
>>> q1 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q2 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(0, 1, 0))
>>> for i in range(11):
...     print Quaternion.new_interpolate(q1, q2, i / 10.0)
...
Quaternion(real=0.71, imag=<0.71, 0.00, 0.00>)
Quaternion(real=0.75, imag=<0.66, 0.09, 0.00>)
Quaternion(real=0.78, imag=<0.61, 0.17, 0.00>)
Quaternion(real=0.80, imag=<0.55, 0.25, 0.00>)
Quaternion(real=0.81, imag=<0.48, 0.33, 0.00>)
Quaternion(real=0.82, imag=<0.41, 0.41, 0.00>)
Quaternion(real=0.81, imag=<0.33, 0.48, 0.00>)
Quaternion(real=0.80, imag=<0.25, 0.55, 0.00>)
Quaternion(real=0.78, imag=<0.17, 0.61, 0.00>)
Quaternion(real=0.75, imag=<0.09, 0.66, 0.00>)
Quaternion(real=0.71, imag=<0.00, 0.71, 0.00>)
```

Operators

Quaternions may be multiplied to compound rotations. For example, to rotate 90 degrees around the X axis and then 90 degrees around the Y axis:

```
>>> q1 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q2 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(0, 1, 0))
>>> q1 * q2
Quaternion(real=0.50, imag=<0.50, 0.50, 0.50>)
```

Multiplying a quaternion by a vector gives a vector, transformed appropriately:

```
>>> q = Quaternion.new_rotate_axis(math.pi / 2, Vector3(0, 1, 0))
>>> q * Vector3(1.0, 0, 0)
Vector3(0.00, 0.00, -1.00)
```

Similarly, any 3D object can be multiplied (e.g., **Point3**, **Line3**, **Sphere**, etc):

```
>>> q * Ray3(Point3(1., 1., 1.), Vector3(1., 1., 1.))
Ray3(<1.00, 1.00, -1.00> + u<1.00, 1.00, -1.00>)
```

As with the matrix classes, the constructors are also available as in-place operators. These are named `identity`, `rotate_euler` and `rotate_axis`. For example:

```
>>> q1 = Quaternion()
>>> q1.rotate_euler(math.pi / 2, math.pi / 2, 0)
Quaternion(real=0.50, imag=<0.50, 0.50, 0.50>)
>>> q1
Quaternion(real=0.50, imag=<0.50, 0.50, 0.50>)
```

Quaternions are usually unit length, but you may wish to use sized quaternions. In this case, you can find the magnitude using `abs`, `magnitude` and `magnitude_squared`, as with the vector classes. Example:

```
>>> q1 = Quaternion()
>>> abs(q1)
1.0
>>> q1.magnitude()
1.0
```

Similarly, the class implements `normalize` and `normalized` in the same way as the vectors.

The following methods do not alter the quaternion:

conjugated() Returns a quaternion that is the conjugate of the instance. For example:

```
>>> q1 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q1.conjugated()
Quaternion(real=0.71, imag=<-0.71, -0.00, -0.00>)
>>> q1
Quaternion(real=0.71, imag=<0.71, 0.00, 0.00>)
```

get_angle_axis() Returns a tuple (angle, axis), giving the angle to rotate around an axis equivalent to the quaternion. For example:

```
>>> q1 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q1.get_angle_axis()
(1.5707963267948966, Vector3(1.00, 0.00, 0.00))
```

get_matrix() Returns a **Matrix4** implementing the transformation of the quaternion. For example:

```
>>> q1 = Quaternion.new_rotate_axis(math.pi / 2, Vector3(1, 0, 0))
>>> q1.get_matrix()
Matrix4([    1.00      0.00      0.00      0.00
             0.00      0.00     -1.00      0.00
             0.00      1.00      0.00      0.00
             0.00      0.00      0.00      1.00])
```

__init__(*w=1, x=0, y=0, z=0*)
Initialize self. See help(type(self)) for accurate signature.

__repr__()
Return repr(self).

__mul__(*other*)

__imul__(*other*)

mag2()

__abs__()

mag()

identity()

rotate_axis(*angle*, *axis*)

rotate_euler(*heading*, *attitude*, *bank*)

rotate_matrix(*m*)

conjugated()

normalize()

normalized()

get_angle_axis()

get_euler()

get_matrix()

classmethod new_identity()

classmethod new_rotate_axis(*angle*, *axis*)

classmethod new_rotate_euler(*heading*, *attitude*, *bank*)

classmethod new_rotate_matrix(*m*)

classmethod new_interpolate(*q1*, *q2*, *t*)

2.9 Goulib.graph module

efficient Euclidian Graphs for `networkx` and related algorithms

requires

- networkx
- matplotlib

optional

- scipy for delauney triangulation
- rtree for faster GeoGraph algorithms

class Goulib.graph.**index**

Bases: `object`

class Property

Bases: `object`

set_dimension(*n*)

class Index(*properties*)

Bases: `dict`

fallback for rtree.index

__init__(*properties*)

Initialize self. See help(type(self)) for accurate signature.

count(*ignored*)

insert(*k*, *p*, *_*)

delete(*k*, *_*)

nearest (*p*, *num_results*, *objects='raw'*)
very inefficient, but remember it's a fallback…

class Goulib.graph.**AGraph**
Bases: object

Goulib.graph.**to_networkx_graph** (*data*, *create_using=None*, *multigraph_input=False*)
Make a NetworkX graph from a known data structure. enhances *networkx.convert.to_networkx_graph* :param data: any type handled by *convert.to_networkx_graph*, plus: * scipy.spatial.qhull.Delaunay to enable building a graph from a delauney triangulation

If create_using is a :class:'GeoGraph'and data is a Graph where nodes have a 'pos' attribute, then this attribute will be used to rename nodes as (x,y,…) tuples suitable for GeoGraph.

class Goulib.graph.**GeoGraph** (*data=None*, *nodes=None*, ***kwargs*)
Bases: Goulib.graph._Geo, networkx.classes.multigraph.MultiGraph

Undirected graph with nodes positions can be set to non multiedges anytime with attribute multi=False

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

__init__ (*data=None*, *nodes=None*, ***kwargs*)

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

class Goulib.graph.**DiGraph** (*data=None*, *nodes=None*, ***kwargs*)
Bases: Goulib.graph._Geo, networkx.classes.multidigraph.MultiDiGraph

directed graph with nodes positions can be set to non multiedges anytime with attribute multi=False

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

__init__ (*data=None*, *nodes=None*, ***kwargs*)

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

Goulib.graph.**figure** (*g*, *box=None*, ***kwargs*)

Parameters

- **g** – _Geo derived Graph
- **box** – optional interval.Box if g has no box

Returns matplotlib axis suitable for drawing graph g

Goulib.graph.**draw_networkx** (*g*, *pos=None*, ***kwargs*)
improves nx.draw_networkx :param g: NetworkX Graph :param pos: can be either :

- optional dictionary of (x,y) node positions
- function of the form lambda node:(x,y) that maps node positions.

- None. in this case, nodes are directly used as positions if graph is a GeoGraph, otherwise nx.draw_shell is used

  Parameters `**kwargs` – passed to nx.draw method as described in http://networkx.lanl.gov/reference/generated/networkx.drawing.nx_pylab.draw_networkx.html with one tweak:

- if edge_color is a function of the form lambda data:color string, it is mapped over all edges

`Goulib.graph.`**`to_drawing`**(*g*, *d=None*, *edges=[]*)
draws Graph to a *Drawing* :param g: `Graph` :param d: existing `Drawing` to draw onto, or None to create a new Drawing :param edges: iterable of edges (with data) that will be added, in the same order. By default all edges are drawn :return: `Drawing`

Graph edges with an 'entity' property

`Goulib.graph.`**`write_dxf`**(*g*, *filename*)
writes `networkx.Graph` in .dxf format

`Goulib.graph.`**`write_dot`**(*g*, *filename*)

`Goulib.graph.`**`to_json`**(*g*, ***kwargs*)

Returns string JSON representation of a graph

`Goulib.graph.`**`write_json`**(*g*, *filename*, ***kwargs*)
write a JSON file, suitable for D*.js representation

`Goulib.graph.`**`read_json`**(*filename*, *directed=False*, *multigraph=True*, *attrs=None*)

`Goulib.graph.`**`delauney_triangulation`**(*nodes*, *qhull_options=''*, *incremental=False*, ***kwargs*)
https://en.wikipedia.org/wiki/Delaunay_triangulation :param nodes: _Geo graph or list of (x,y) or (x,y,z) node positions :param qhull_options: string passed to `scipy.spatial.Delaunay()`, which passes it to Qhull (http://www.qhull.org/) *'Qt' ensures all points are connected *'Qz' required when nodes lie on a sphere *'QJ' solves some singularity situations

Parameters `kwargs` – passed to the *GeoGraph* constructor

Returns *GeoGraph* with delauney triangulation between nodes

`Goulib.graph.`**`euclidean_minimum_spanning_tree`**(*nodes*, ***kwargs*)

Parameters `nodes` – list of (x,y) nodes positions

Returns *GeoGraph* with minimum spanning tree between nodes

see https://en.wikipedia.org/wiki/Euclidean_minimum_spanning_tree

`Goulib.graph.`**`points_on_sphere`**(*N*)

2.9.1 Classes

efficient Euclidian Graphs for `networkx` and related algorithms

requires

- networkx
- matplotlib

optional

- scipy for delauney triangulation
- rtree for faster GeoGraph algorithms

class Goulib.graph.**index**
Bases: object

class Property
Bases: object

set_dimension(*n*)

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Index(*properties*)
Bases: `dict`

fallback for rtree.index

__init__(*properties*)
Initialize self. See help(type(self)) for accurate signature.

count(*ignored*)

insert(*k*, *p*, *_*)

delete(*k*, *_*)

nearest(*p*, *num_results*, *objects='raw'*)
very inefficient, but remember it's a fallback...

__class__
alias of `builtins.type`

__contains__()
True if D has a key k, else False.

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__() → size of D in memory, in bytes

__str__
Return str(self).

clear() → None. Remove all items from D.

copy() → a shallow copy of D

fromkeys()
Returns a new dict with keys from iterable and values equal to value.

get(*k*[, *d*]) → D[k] if k in D, else d. d defaults to None.

items() → a set-like object providing a view on D's items

keys() → a set-like object providing a view on D's keys

pop(*k*[, *d*]) → v, remove specified key and return the corresponding value.
If key is not found, d is returned if given, otherwise KeyError is raised

popitem() → (k, v), remove and return some (key, value) pair as a
2-tuple; but raise KeyError if D is empty.

setdefault(*k*[, *d*]) → D.get(k,d), also set D[k]=d if k not in D

update([*E*], ***F*) → None. Update D from dict/iterable E and F.
If E is present and has a .keys() method, then does: for k in E: D[k] = E[k] If E is present and lacks a .keys() method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k]

values() → an object providing a view on D's values

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.graph.**AGraph**
Bases: `object`

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

`Goulib.graph.`**to_networkx_graph**(*data*, *create_using=None*, *multigraph_input=False*)
Make a NetworkX graph from a known data structure. enhances *networkx.convert.to_networkx_graph* :param data: any type handled by *convert.to_networkx_graph*, plus: * `scipy.spatial.qhull.Delaunay` to enable building a graph from a delauney triangulation

If create_using is a :class:‘GeoGraph‘and data is a Graph where nodes have a ‘pos’ attribute, then this attribute will be used to rename nodes as (x,y,. . .) tuples suitable for GeoGraph.

class `Goulib.graph.`**GeoGraph**(*data=None*, *nodes=None*, ***kwargs*)
Bases: `Goulib.graph._Geo`, `networkx.classes.multigraph.MultiGraph`

Undirected graph with nodes positions can be set to non multiedges anytime with attribute multi=False

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

__init__(*data=None*, *nodes=None*, ***kwargs*)

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

__bool__()

Returns True if graph has at least one node

__class__
alias of `builtins.type`

__contains__(*n*)
Return True if n is a node, False otherwise. Use: 'n in G'.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> 1 in G
True
```

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)

Returns True if self and other are equal

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__(*n*)
Return a dict of neighbors of node n. Use: 'G[n]'.

n [node] A node in the graph.

adj_dict [dictionary] The adjacency dictionary for nodes connected to n.

G[n] is the same as G.adj[n] and similar to G.neighbors(n) (which is an iterator over G.adj[n])

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G[0]
AtlasView({1: {}})
```

__gt__
Return self>value.

__hash__ = None

`__iter__`()
Iterate over the nodes. Use: 'for n in G'.

niter [iterator] An iterator over all nodes in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> [n for n in G]
[0, 1, 2, 3]
>>> list(G)
[0, 1, 2, 3]
```

`__le__`
Return self<=value.

`__len__`()
Return the number of nodes. Use: 'len(G)'.

nnodes [int] The number of nodes in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> len(G)
4
```

`__lt__`
Return self<value.

`__ne__`
Return self!=value.

`__new__`()
Create and return a new object. See help(type) for accurate signature.

`__nonzero__`()

Returns True if graph has at least one node

`__reduce__`()
helper for pickle

`__reduce_ex__`()
helper for pickle

`__repr__`
Return repr(self).

`__setattr__`
Implement setattr(self, name, value).

`__sizeof__`() → int
size of object in memory, in bytes

`__str__`()

Returns string representation, used mainly for logging and debugging

`add_cycle`(*nodes*, ***attr*)

`add_edge`(*u*, *v*, *key=None*, ***attr*)
add an edge to graph

Returns edge key

`add_edge2`(*u*, *v*, *key=None*, ***attrs*)
add an edge to graph :return: edge data from created or existing edge

add_edges_from (*ebunch_to_add*, ***attr*)
Add all the edges in ebunch_to_add.

ebunch_to_add [container of edges] Each edge given in the container will be added to the graph. The edges can be:

- 2-tuples (u, v) or
- 3-tuples (u, v, d) for an edge data dict d, or
- 3-tuples (u, v, k) for not iterable key k, or
- 4-tuples (u, v, k, d) for an edge with data and key k

attr [keyword arguments, optional] Edge data (or labels or objects) can be assigned using keyword arguments.

A list of edge keys assigned to the edges in *ebunch*.

add_edge : add a single edge add_weighted_edges_from : convenient way to add weighted edges

Adding the same edge twice has no effect but any edge data will be updated when each duplicate edge is added.

Edge attributes specified in an ebunch take precedence over attributes specified via keyword arguments.

Default keys are generated using the method `new_edge_key()`. This method can be overridden by subclassing the base class and providing a custom `new_edge_key()` method.

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_edges_from([(0, 1), (1, 2)]) # using a list of edge tuples
>>> e = zip(range(0, 3), range(1, 4))
>>> G.add_edges_from(e) # Add the path graph 0-1-2-3
```

Associate data to edges

```
>>> G.add_edges_from([(1, 2), (2, 3)], weight=3)
>>> G.add_edges_from([(3, 4), (1, 4)], label='WN2898')
```

add_node (*p*, ***attr*)
add a node or return one already very close :return (x,y,…) node id

add_nodes_from (*nodes*, ***attr*)

add_path (*nodes*, ***attr*)

add_star (*nodes*, ***attr*)

add_weighted_edges_from (*ebunch_to_add*, *weight='weight'*, ***attr*)
Add weighted edges in *ebunch_to_add* with specified weight attr

ebunch_to_add [container of edges] Each edge given in the list or container will be added to the graph. The edges must be given as 3-tuples (u, v, w) where w is a number.

weight [string, optional (default= 'weight')] The attribute name for the edge weights to be added.

attr [keyword arguments, optional (default= no attributes)] Edge attributes to add/update for all edges.

add_edge : add a single edge add_edges_from : add multiple edges

Adding the same edge twice for Graph/DiGraph simply updates the edge data. For MultiGraph/MultiDiGraph, duplicate edges are stored.

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_weighted_edges_from([(0, 1, 3.0), (1, 2, 7.5)])
```

adj

Graph adjacency object holding the neighbors of each node.

This object is a read-only dict-like structure with node keys and neighbor-dict values. The neighbor-dict is keyed by neighbor to the edgekey-data-dict. So *G.adj[3][2][0]['color'] = 'blue'* sets the color of the edge *(3, 2, 0)* to *"blue"*.

Iterating over G.adj behaves like a dict. Useful idioms include *for nbr, nbrdict in G.adj[n].items():*.

The neighbor information is also provided by subscripting the graph. So *for nbr, foovalue in G[node].data('foo', default=1):* works.

For directed graphs, *G.adj* holds outgoing (successor) info.

adjacency()

Return an iterator over (node, adjacency dict) tuples for all nodes.

For directed graphs, only outgoing neighbors/adjacencies are included.

adj_iter [iterator] An iterator over (node, adjacency dictionary) for all nodes in the graph.

```
>>> G = nx.path_graph(4)   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> [(n, nbrdict) for n, nbrdict in G.adjacency()]
[(0, {1: {}}), (1, {0: {}, 2: {}}), (2, {1: {}, 3: {}}), (3, {2: {}})]
```

adjlist_inner_dict_factory

alias of `builtins.dict`

adjlist_outer_dict_factory

alias of `builtins.dict`

box()

Returns nodes bounding box as (xmin,ymin,. . .),(xmax,ymax,. . .)

box_size()

Returns (x,y) size

clear()

closest_edges(*p*, *data=False*)

Returns container of edges close to p and distance

closest_nodes(*p*, *n=1*, *skip=False*)

nodes closest to a given position :param p: (x,y) position tuple :param skip: optional bool to skip n itself :return: list of nodes, minimal distance

contiguity(*pts*)

Returns int number of points from pts already in graph

copy()

Returns copy of self graph

degree

A DegreeView for the Graph as G.degree or G.degree().

The node degree is the number of edges adjacent to the node. The weighted node degree is the sum of the edge weights for edges incident to that node.

This object provides an iterator for (node, degree) as well as lookup for the degree for a single node.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

weight [string or None, optional (default=None)] The name of an edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1. The degree is the sum of the edge weights adjacent to the node.

If a single node is requested deg : int

Degree of the node, if a single node is passed as argument.

OR if multiple nodes are requested nd_iter : iterator

The iterator returns two-tuples of (node, degree).

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.degree(0) # node 0 with degree 1
1
>>> list(G.degree([0, 1]))
[(0, 1), (1, 2)]
```

dist (*u*, *v*)

Returns float distance between nodes u and v

draw (***kwargs*)
draw graph with default params

edge_attr_dict_factory
alias of `builtins.dict`

edge_key_dict_factory
alias of `builtins.dict`

edge_subgraph (*edges*)
Returns the subgraph induced by the specified edges.

The induced subgraph contains each edge in *edges* and each node incident to any one of those edges.

edges [iterable] An iterable of edges in this graph.

G [Graph] An edge-induced subgraph of this graph with the same edge attributes.

The graph, edge, and node attributes in the returned subgraph view are references to the corresponding attributes in the original graph. The view is read-only.

To create a full graph version of the subgraph with its own copy of the edge or node attributes, use:

```
>>> G.edge_subgraph(edges).copy()
```

```
>>> G = nx.path_graph(5)
>>> H = G.edge_subgraph([(0, 1), (3, 4)])
>>> list(H.nodes)
[0, 1, 3, 4]
>>> list(H.edges)
[(0, 1), (3, 4)]
```

edges
Return an iterator over the edges.

edges(self, nbunch=None, data=False, keys=False, default=None)

The EdgeView provides set-like operations on the edge-tuples as well as edge attribute lookup. When called, it also provides an EdgeDataView object which allows control of access to edge attributes (but does not provide set-like operations). Hence, *G.edges[u, v]['color']* provides the value of the color attribute for edge *(u, v)* while *for (u, v, c) in G.edges(data='color', default='red'):* iterates through all the edges yielding the color attribute.

Edges are returned as tuples with optional data and keys in the order (node, neighbor, key, data).

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

data [string or bool, optional (default=False)] The edge attribute returned in 3-tuple (u, v, ddict[data]). If True, return edge attribute dict in 3-tuple (u, v, ddict). If False, return 2-tuple (u, v).

keys [bool, optional (default=False)] If True, return edge keys with each edge.

default [value, optional (default=None)] Value used for edges that don't have the requested attribute. Only relevant if data is not True or False.

edges [MultiEdgeView] A view of edge attributes, usually it iterates over (u, v) (u, v, k) or (u, v, k, d) tuples of edges, but can also be used for attribute lookup as *edges[u, v, k]['foo']*.

Nodes in nbunch that are not in the graph will be (quietly) ignored. For directed graphs this returns the out-edges.

```
>>> G = nx.MultiGraph()    # or MultiDiGraph
>>> nx.add_path(G, [0, 1, 2])
>>> key = G.add_edge(2, 3, weight=5)
>>> [e for e in G.edges()]
[(0, 1), (1, 2), (2, 3)]
>>> G.edges.data() # default data is {} (empty dict)
MultiEdgeDataView([(0, 1, {}), (1, 2, {}), (2, 3, {'weight': 5})])
>>> G.edges.data('weight', default=1)
MultiEdgeDataView([(0, 1, 1), (1, 2, 1), (2, 3, 5)])
>>> G.edges(keys=True) # default keys are integers
MultiEdgeView([(0, 1, 0), (1, 2, 0), (2, 3, 0)])
>>> G.edges.data(keys=True)
MultiEdgeDataView([(0, 1, 0, {}), (1, 2, 0, {}), (2, 3, 0, {'weight': 5})])
>>> G.edges.data('weight', default=1, keys=True)
MultiEdgeDataView([(0, 1, 0, 1), (1, 2, 0, 1), (2, 3, 0, 5)])
>>> G.edges([0, 3])
MultiEdgeDataView([(0, 1), (3, 2)])
>>> G.edges(0)
MultiEdgeDataView([(0, 1)])
```

fresh_copy()

get_edge_data(*u*, *v*, *key=None*, *default=None*)

Return the attribute dictionary associated with edge (u, v).

This is identical to *G[u][v][key]* except the default is returned instead of an exception is the edge doesn't exist.

u, v : nodes

default [any Python object (default=None)] Value to return if the edge (u, v) is not found.

key [hashable identifier, optional (default=None)] Return data only for the edge with specified key.

edge_dict [dictionary] The edge attribute dictionary.

```
>>> G = nx.MultiGraph() # or MultiDiGraph
>>> key = G.add_edge(0, 1, key='a', weight=7)
>>> G[0][1]['a']  # key='a'
{'weight': 7}
>>> G.edges[0, 1, 'a']  # key='a'
{'weight': 7}
```

Warning: we protect the graph data structure by making *G.edges* and *G[1][2]* read-only dict-like structures. However, you can assign values to attributes in e.g. *G.edges[1, 2, 'a']* or *G[1][2]['a']* using an additional bracket as shown next. You need to specify all edge info to assign to the edge data associated with an edge.

```
>>> G[0][1]['a']['weight'] = 10
>>> G.edges[0, 1, 'a']['weight'] = 10
>>> G[0][1]['a']['weight']
10
>>> G.edges[1, 0, 'a']['weight']
10
```

```
>>> G = nx.MultiGraph() # or MultiDiGraph
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.get_edge_data(0, 1)
{0: {}}
>>> e = (0, 1)
>>> G.get_edge_data(*e) # tuple form
{0: {}}
>>> G.get_edge_data('a', 'b', default=0) # edge not in graph, return 0
0
```

has_edge (*u*, *v*, *key=None*)

Return True if the graph has an edge between nodes u and v.

This is the same as *v in G[u] or key in G[u][v]* without KeyError exceptions.

u, v [nodes] Nodes can be, for example, strings or numbers.

key [hashable identifier, optional (default=None)] If specified return True only if the edge with key is found.

edge_ind [bool] True if edge is in the graph, False otherwise.

Can be called either using two nodes u, v, an edge tuple (u, v), or an edge tuple (u, v, key).

```
>>> G = nx.MultiGraph()   # or MultiDiGraph
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.has_edge(0, 1)  # using two nodes
True
>>> e = (0, 1)
>>> G.has_edge(*e)  #  e is a 2-tuple (u, v)
True
>>> G.add_edge(0, 1, key='a')
'a'
>>> G.has_edge(0, 1, key='a')  # specify key
True
>>> e=(0, 1, 'a')
>>> G.has_edge(*e) # e is a 3-tuple (u, v, 'a')
True
```

The following syntax are equivalent:

```
>>> G.has_edge(0, 1)
True
>>> 1 in G[0]  # though this gives :exc:`KeyError` if 0 not in G
True
```

has_node(*n*)
Return True if the graph contains the node n.

Identical to *n in G*

n : node

```
>>> G = nx.path_graph(3)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.has_node(0)
True
```

It is more readable and simpler to use

```
>>> 0 in G
True
```

html(***kwargs*)

is_directed()
Return True if graph is directed, False otherwise.

is_multigraph()
used internally in constructor

length(*edges=None*)

Parameters edges – iterator over edges either as (u,v,data) or (u,v,key,data). If None, all edges are taken

Returns sum of 'length' attributes of edges

multi

name
String identifier of the graph.

This graph attribute appears in the attribute dict G.graph keyed by the string *"name"*. as well as an attribute (technically a property) *G.name*. This is entirely user controlled.

nbunch_iter(*nbunch=None*)
Return an iterator over nodes contained in nbunch that are also in the graph.

The nodes in nbunch are checked for membership in the graph and if not are silently ignored.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

niter [iterator] An iterator over nodes in nbunch that are also in the graph. If nbunch is None, iterate over all nodes in the graph.

NetworkXError If nbunch is not a node or or sequence of nodes. If a node in nbunch is not hashable.

Graph.__iter__

When nbunch is an iterator, the returned iterator yields values directly from nbunch, becoming exhausted when nbunch is exhausted.

To test whether nbunch is a single node, one can use "if nbunch in self:", even after processing with this routine.

If nbunch is not a node or a (possibly empty) sequence/iterator or None, a `NetworkXError` is raised. Also, if any object in nbunch is not hashable, a `NetworkXError` is raised.

neighbors (*n*)

Return an iterator over all neighbors of node n.

This is identical to *iter(G[n])*

n [node] A node in the graph

neighbors [iterator] An iterator over all neighbors of node n

NetworkXError If the node n is not in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> [n for n in G.neighbors(0)]
[1]
```

It is usually more convenient (and faster) to access the adjacency dictionary as `G[n]`:

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_edge('a', 'b', weight=7)
>>> G['a']
AtlasView({'b': {'weight': 7}})
>>> G = nx.path_graph(4)
>>> [n for n in G[0]]
[1]
```

new_edge_key (*u*, *v*)

Return an unused key for edges between nodes *u* and *v*.

The nodes *u* and *v* do not need to be already in the graph.

In the standard MultiGraph class the new key is the number of existing edges between *u* and *v* (increased if necessary to ensure unused). The first edge will have key 0, then 1, etc. If an edge is removed further new_edge_keys may not be in this order.

u, v : nodes

key : int

node

A NodeView of the Graph as G.nodes or G.nodes().

Can be used as *G.nodes* for data lookup and for set-like operations. Can also be used as *G.nodes(data='color', default=None)* to return a NodeDataView which reports specific node data but no set operations. It presents a dict-like interface as well with *G.nodes.items()* iterating over *(node, nodedata)* 2-tuples and *G.nodes[3]['foo']* providing the value of the *foo* attribute for node *3*. In addition, a view *G.nodes.data('foo')* provides a dict-like interface to the *foo* attribute of each node. *G.nodes.data('foo', default=1)* provides a default for nodes that do not have attribute *foo*.

data [string or bool, optional (default=False)] The node attribute returned in 2-tuple (n, ddict[data]). If True, return entire node attribute dict as (n, ddict). If False, return just the nodes n.

default [value, optional (default=None)] Value used for nodes that don't have the requested attribute. Only relevant if data is not True or False.

NodeView Allows set-like operations over the nodes as well as node attribute dict lookup and calling to get a NodeDataView. A NodeDataView iterates over *(n, data)* and has no set operations. A NodeView iterates over *n* and includes set operations.

When called, if data is False, an iterator over nodes. Otherwise an iterator of 2-tuples (node, attribute value) where the attribute is specified in *data*. If data is True then the attribute becomes the entire data dictionary.

If your node data is not needed, it is simpler and equivalent to use the expression `for n in G`, or `list(G)`.

There are two simple ways of getting a list of all nodes in the graph:

```
>>> G = nx.path_graph(3)
>>> list(G.nodes)
[0, 1, 2]
>>> list(G)
[0, 1, 2]
```

To get the node data along with the nodes:

```
>>> G.add_node(1, time='5pm')
>>> G.nodes[0]['foo'] = 'bar'
>>> list(G.nodes(data=True))
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
>>> list(G.nodes.data())
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
```

```
>>> list(G.nodes(data='foo'))
[(0, 'bar'), (1, None), (2, None)]
>>> list(G.nodes.data('foo'))
[(0, 'bar'), (1, None), (2, None)]
```

```
>>> list(G.nodes(data='time'))
[(0, None), (1, '5pm'), (2, None)]
>>> list(G.nodes.data('time'))
[(0, None), (1, '5pm'), (2, None)]
```

```
>>> list(G.nodes(data='time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
>>> list(G.nodes.data('time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
```

If some of your nodes have an attribute and the rest are assumed to have a default attribute value you can create a dictionary from node/attribute pairs using the *default* keyword argument to guarantee the value is never None:

```
>>> G = nx.Graph()
>>> G.add_node(0)
>>> G.add_node(1, weight=2)
>>> G.add_node(2, weight=3)
>>> dict(G.nodes(data='weight', default=1))
{0: 1, 1: 2, 2: 3}
```

node_dict_factory
alias of `builtins.dict`

nodes
A NodeView of the Graph as G.nodes or G.nodes().

Can be used as *G.nodes* for data lookup and for set-like operations. Can also be used as *G.nodes(data='color', default=None)* to return a NodeDataView which reports specific node data but no set operations. It presents a dict-like interface as well with *G.nodes.items()* iterating over *(node, nodedata)* 2-tuples and *G.nodes[3]['foo']* providing the value of the *foo* attribute for node *3*. In addition, a view *G.nodes.data('foo')* provides a dict-like interface to the *foo* attribute of each node. *G.nodes.data('foo', default=1)* provides a default for nodes that do not have attribute *foo*.

data [string or bool, optional (default=False)] The node attribute returned in 2-tuple (n, ddict[data]). If True, return entire node attribute dict as (n, ddict). If False, return just the nodes n.

default [value, optional (default=None)] Value used for nodes that don't have the requested attribute. Only relevant if data is not True or False.

NodeView Allows set-like operations over the nodes as well as node attribute dict lookup and calling to get a NodeDataView. A NodeDataView iterates over *(n, data)* and has no set operations. A NodeView iterates over *n* and includes set operations.

When called, if data is False, an iterator over nodes. Otherwise an iterator of 2-tuples (node, attribute value) where the attribute is specified in *data*. If data is True then the attribute becomes the entire data dictionary.

If your node data is not needed, it is simpler and equivalent to use the expression `for n in G`, or `list(G)`.

There are two simple ways of getting a list of all nodes in the graph:

```
>>> G = nx.path_graph(3)
>>> list(G.nodes)
[0, 1, 2]
>>> list(G)
[0, 1, 2]
```

To get the node data along with the nodes:

```
>>> G.add_node(1, time='5pm')
>>> G.nodes[0]['foo'] = 'bar'
>>> list(G.nodes(data=True))
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
>>> list(G.nodes.data())
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
```

```
>>> list(G.nodes(data='foo'))
[(0, 'bar'), (1, None), (2, None)]
>>> list(G.nodes.data('foo'))
[(0, 'bar'), (1, None), (2, None)]
```

```
>>> list(G.nodes(data='time'))
[(0, None), (1, '5pm'), (2, None)]
>>> list(G.nodes.data('time'))
[(0, None), (1, '5pm'), (2, None)]
```

```
>>> list(G.nodes(data='time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
>>> list(G.nodes.data('time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
```

If some of your nodes have an attribute and the rest are assumed to have a default attribute value you can create a dictionary from node/attribute pairs using the *default* keyword argument to guarantee the value is never None:

```
>>> G = nx.Graph()
>>> G.add_node(0)
>>> G.add_node(1, weight=2)
>>> G.add_node(2, weight=3)
>>> dict(G.nodes(data='weight', default=1))
{0: 1, 1: 2, 2: 3}
```

nodes_with_selfloops()

number_of_edges(*u=None*, *v=None*)
Return the number of edges between two nodes.

u, v [nodes, optional (Gefault=all edges)] If u and v are specified, return the number of edges between u and v. Otherwise return the total number of all edges.

nedges [int] The number of edges in the graph. If nodes *u* and *v* are specified return the number of edges between those nodes. If the graph is directed, this only returns the number of edges from *u* to *v*.

size

For undirected multigraphs, this method counts the total number of edges in the graph:

```
>>> G = nx.MultiGraph()
>>> G.add_edges_from([(0, 1), (0, 1), (1, 2)])
[0, 1, 0]
>>> G.number_of_edges()
3
```

If you specify two nodes, this counts the total number of edges joining the two nodes:

```
>>> G.number_of_edges(0, 1)
2
```

For directed multigraphs, this method can count the total number of directed edges from *u* to *v*:

```
>>> G = nx.MultiDiGraph()
>>> G.add_edges_from([(0, 1), (0, 1), (1, 0)])
[0, 1, 0]
>>> G.number_of_edges(0, 1)
2
>>> G.number_of_edges(1, 0)
1
```

number_of_nodes(*doublecheck=False*)

number_of_selfloops()

order()
Return the number of nodes in the graph.

nnodes [int] The number of nodes in the graph.

number_of_nodes, __len__ which are identical

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

pos (*nodes=None*)

Parameters **nodes** – a single node, an iterator of all nodes if None

Returns the position of node(s)

remove_edge (*u*, *v=None*, *key=None*, *clean=False*)

Parameters

- **u** – Node or Edge (Nodes tuple)
- **v** – Node if u is a single Node
- **clean** – bool removes disconnected nodes. must be False for certain nx algos to work

Result return attributes of removed edge

remove edge from graph. NetworkX graphs do not remove unused nodes

remove_edges_from (*ebunch*)
Remove all edges specified in ebunch.

ebunch: list or container of edge tuples Each edge given in the list or container will be removed from the graph. The edges can be:

- 2-tuples (u, v) All edges between u and v are removed.
- 3-tuples (u, v, key) The edge identified by key is removed.
- 4-tuples (u, v, key, data) where data is ignored.

remove_edge : remove a single edge

Will fail silently if an edge in ebunch is not in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> ebunch=[(1, 2), (2, 3)]
>>> G.remove_edges_from(ebunch)
```

Removing multiple copies of edges

```
>>> G = nx.MultiGraph()
>>> keys = G.add_edges_from([(1, 2), (1, 2), (1, 2)])
>>> G.remove_edges_from([(1, 2), (1, 2)])
>>> list(G.edges())
[(1, 2)]
>>> G.remove_edges_from([(1, 2), (1, 2)]) # silently ignore extra copy
>>> list(G.edges) # now empty graph
[]
```

remove_node (*n*)

Parameters **n** – node tuple

remove node from graph and rtree

remove_nodes_from(*nodes*)
Remove multiple nodes.

nodes [iterable container] A container of nodes (list, dict, set, etc.). If a node in the container is not in the graph it is silently ignored.

remove_node

```
>>> G = nx.path_graph(3)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> e = list(G.nodes)
>>> e
[0, 1, 2]
>>> G.remove_nodes_from(e)
>>> list(G.nodes)
[]
```

render(*fmt='svg'*, ***kwargs*)
render graph to bitmap stream :param fmt: string defining the format. 'svg' by default for INotepads :return: matplotlib figure as a byte stream in specified format

save(*filename*, ***kwargs*)
save graph in various formats

selfloop_edges(*data=False*, *keys=False*, *default=None*)

shortest_path(*source=None*, *target=None*)

size(*weight=None*)
Return the number of edges or total of all edge weights.

weight [string or None, optional (default=None)] The edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1.

size [numeric] The number of edges or (if weight keyword is provided) the total weight sum.

If weight is None, returns an int. Otherwise a float (or more general numeric if the weights are more general).

number_of_edges

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.size()
3
```

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_edge('a', 'b', weight=2)
>>> G.add_edge('b', 'c', weight=4)
>>> G.size()
2
>>> G.size(weight='weight')
6.0
```

stats()

Returns dict of graph data to use in __repr__ or usable otherwise

subgraph(*nodes*)
Return a SubGraph view of the subgraph induced on *nodes*.

The induced subgraph of the graph contains the nodes in *nodes* and the edges between those nodes.

nodes [list, iterable] A container of nodes which will be iterated through once.

G [SubGraph View] A subgraph view of the graph. The graph structure cannot be changed but node/edge attributes can and are shared with the original graph.

The graph, edge and node attributes are shared with the original graph. Changes to the graph structure is ruled out by the view, but changes to attributes are reflected in the original graph.

To create a subgraph with its own copy of the edge/node attributes use: G.subgraph(nodes).copy()

For an inplace reduction of a graph to a subgraph you can remove nodes: G.remove_nodes_from([n for n in G if n not in set(nodes)])

Subgraph views are sometimes NOT what you want. In most cases where you want to do more than simply look at the induced edges, it makes more sense to just create the subgraph as its own graph with code like:

```
# Create a subgraph SG based on a (possibly multigraph) G
SG = G.__class__()
SG.add_nodes_from((n, G.nodes[n]) for n in largest_wcc)
if SG.is_multigraph:
    SG.add_edges_from((n, nbr, key, d)
        for n, nbrs in G.adj.items() if n in largest_wcc
        for nbr, keydict in nbrs.items() if nbr in largest_wcc
        for key, d in keydict.items())
else:
    SG.add_edges_from((n, nbr, d)
        for n, nbrs in G.adj.items() if n in largest_wcc
        for nbr, d in nbrs.items() if nbr in largest_wcc)
SG.graph.update(G.graph)
```

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> H = G.subgraph([0, 1, 2])
>>> list(H.edges)
[(0, 1), (1, 2)]
```

svg (***kwargs*)

to_directed (*as_view=False*)

Return a directed representation of the graph.

G [MultiDiGraph] A directed graph with the same name, same nodes, and with each edge (u, v, data) replaced by two directed edges (u, v, data) and (v, u, data).

This returns a "deepcopy" of the edge, node, and graph attributes which attempts to completely copy all of the data and references.

This is in contrast to the similar D=DiGraph(G) which returns a shallow copy of the data.

See the Python copy module for more information on shallow and deep copies, https://docs.python.org/2/library/copy.html.

Warning: If you have subclassed MultiGraph to use dict-like objects in the data structure, those changes do not transfer to the MultiDiGraph created by this method.

```
>>> G = nx.Graph()   # or MultiGraph, etc
>>> G.add_edge(0, 1)
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1), (1, 0)]
```

If already directed, return a (deep) copy

```
>>> G = nx.DiGraph()   # or MultiDiGraph, etc
>>> G.add_edge(0, 1)
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1)]
```

to_directed_class()

Returns the class to use for empty directed copies.

If you subclass the base classes, use this to designate what directed class to use for *to_directed()* copies.

to_undirected(*as_view=False*)

Return an undirected copy of the graph.

G [Graph/MultiGraph] A deepcopy of the graph.

copy, add_edge, add_edges_from

This returns a "deepcopy" of the edge, node, and graph attributes which attempts to completely copy all of the data and references.

This is in contrast to the similar *G = nx.MultiGraph(D)* which returns a shallow copy of the data.

See the Python copy module for more information on shallow and deep copies, https://docs.python.org/2/library/copy.html.

Warning: If you have subclassed MultiiGraph to use dict-like objects in the data structure, those changes do not transfer to the MultiGraph created by this method.

```
>>> G = nx.path_graph(2)   # or MultiGraph, etc
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1), (1, 0)]
>>> G2 = H.to_undirected()
>>> list(G2.edges)
[(0, 1)]
```

to_undirected_class()

Returns the class to use for empty undirected copies.

If you subclass the base classes, use this to designate what directed class to use for *to_directed()* copies.

tol

update(*edges=None*, *nodes=None*)

Update the graph using nodes/edges/graphs as input.

Like dict.update, this method takes a graph as input, adding the graph's noes and edges to this graph. It can also take two inputs: edges and nodes. Finally it can take either edges or nodes. To specify only nodes the keyword *nodes* must be used.

The collections of edges and nodes are treated similarly to the add_edges_from/add_nodes_from methods. When iterated, they should yield 2-tuples (u, v) or 3-tuples (u, v, datadict).

edges [Graph object, collection of edges, or None] The first parameter can be a graph or some edges. If it has attributes *nodes* and *edges*, then it is taken to be a Graph-like object and those attributes are used as collections of nodes and edges to be added to the graph. If the first parameter does not have those attributes, it is treated as a collection of edges and added to the graph. If the first argument is None, no edges are added.

nodes [collection of nodes, or None] The second parameter is treated as a collection of nodes to be added to the graph unless it is None. If *edges is None* and *nodes is None* an exception is raised. If the first parameter is a Graph, then *nodes* is ignored.

```
>>> G = nx.path_graph(5)
>>> G.update(nx.complete_graph(range(4,10)))
>>> from itertools import combinations
>>> edges = ((u, v, {'power': u * v})
...          for u, v in combinations(range(10, 20), 2)
...          if u * v < 225)
>>> nodes = [1000]  # for singleton, use a container
>>> G.update(edges, nodes)
```

It you want to update the graph using an adjacency structure it is straightforward to obtain the edges/nodes from adjacency. The following examples provide common cases, your adjacency may be slightly different and require tweaks of these examples.

```
>>> # dict-of-set/list/tuple
>>> adj = {1: {2, 3}, 2: {1, 3}, 3: {1, 2}}
>>> e = [(u, v) for u, nbrs in adj.items() for v in  nbrs]
>>> G.update(edges=e, nodes=adj)
```

```
>>> DG = nx.DiGraph()
>>> # dict-of-dict-of-attribute
>>> adj = {1: {2: 1.3, 3: 0.7}, 2: {1: 1.4}, 3: {1: 0.7}}
>>> e = [(u, v, {'weight': d}) for u, nbrs in adj.items()
...      for v, d in nbrs.items()]
>>> DG.update(edges=e, nodes=adj)
```

```
>>> # dict-of-dict-of-dict
>>> adj = {1: {2: {'weight': 1.3}, 3: {'color': 0.7, 'weight':1.2}}}
>>> e = [(u, v, {'weight': d}) for u, nbrs in adj.items()
...      for v, d in nbrs.items()]
>>> DG.update(edges=e, nodes=adj)
```

```
>>> # predecessor adjacency (dict-of-set)
>>> pred = {1: {2, 3}, 2: {3}, 3: {3}}
>>> e = [(v, u) for u, nbrs in pred.items() for v in nbrs]
```

```
>>> # MultiGraph dict-of-dict-of-dict-of-attribute
>>> MDG = nx.MultiDiGraph()
>>> adj = {1: {2: {0: {'weight': 1.3}, 1: {'weight': 1.2}}},
...        3: {2: {0: {'weight': 0.7}}}}
>>> e = [(u, v, ekey, d) for u, nbrs in adj.items()
...      for v, keydict in nbrs.items()
...      for ekey, d in keydict.items()]
>>> MDG.update(edges=e)
```

add_edges_from: add multiple edges to a graph add_nodes_from: add multiple nodes to a graph

class Goulib.graph.**DiGraph**(*data=None*, *nodes=None*, ***kwargs*)

Bases: `Goulib.graph._Geo`, `networkx.classes.multidigraph.MultiDiGraph`

directed graph with nodes positions can be set to non multiedges anytime with attribute multi=False

Parameters

- **data** – see *to_networkx_graph()* for valid types

- **kwargs** – other parameters will be copied as attributes, especially:

__init__(*data=None*, *nodes=None*, ***kwargs*)

Parameters

- **data** – see *to_networkx_graph()* for valid types
- **kwargs** – other parameters will be copied as attributes, especially:

__bool__()

Returns True if graph has at least one node

__class__
alias of `builtins.type`

__contains__(*n*)
Return True if n is a node, False otherwise. Use: 'n in G'.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> 1 in G
True
```

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)

Returns True if self and other are equal

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__(*n*)
Return a dict of neighbors of node n. Use: 'G[n]'.

n [node] A node in the graph.

adj_dict [dictionary] The adjacency dictionary for nodes connected to n.

G[n] is the same as G.adj[n] and similar to G.neighbors(n) (which is an iterator over G.adj[n])

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G[0]
AtlasView({1: {}})
```

__gt__
Return self>value.

__hash__ = None

__iter__()
Iterate over the nodes. Use: 'for n in G'.

niter [iterator] An iterator over all nodes in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> [n for n in G]
[0, 1, 2, 3]
>>> list(G)
[0, 1, 2, 3]
```

__le__
Return self<=value.

__len__()
Return the number of nodes. Use: 'len(G)'.

nnodes [int] The number of nodes in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> len(G)
4
```

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__nonzero__()

Returns True if graph has at least one node

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__()

Returns string representation, used mainly for logging and debugging

add_cycle(*nodes*, ***attr*)

add_edge(*u*, *v*, *key=None*, ***attr*)
add an edge to graph

Returns edge key

add_edge2(*u*, *v*, *key=None*, ***attrs*)
add an edge to graph :return: edge data from created or existing edge

add_edges_from(*ebunch_to_add*, ***attr*)
Add all the edges in ebunch_to_add.

ebunch_to_add [container of edges] Each edge given in the container will be added to the graph. The edges can be:

- 2-tuples (u, v) or
- 3-tuples (u, v, d) for an edge data dict d, or
- 3-tuples (u, v, k) for not iterable key k, or
- 4-tuples (u, v, k, d) for an edge with data and key k

attr [keyword arguments, optional] Edge data (or labels or objects) can be assigned using keyword arguments.

A list of edge keys assigned to the edges in *ebunch*.

add_edge : add a single edge add_weighted_edges_from : convenient way to add weighted edges

Adding the same edge twice has no effect but any edge data will be updated when each duplicate edge is added.

Edge attributes specified in an ebunch take precedence over attributes specified via keyword arguments.

Default keys are generated using the method `new_edge_key()`. This method can be overridden by subclassing the base class and providing a custom `new_edge_key()` method.

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_edges_from([(0, 1), (1, 2)]) # using a list of edge tuples
>>> e = zip(range(0, 3), range(1, 4))
>>> G.add_edges_from(e) # Add the path graph 0-1-2-3
```

Associate data to edges

```
>>> G.add_edges_from([(1, 2), (2, 3)], weight=3)
>>> G.add_edges_from([(3, 4), (1, 4)], label='WN2898')
```

add_node(*p*, ***attr*)
add a node or return one already very close :return (x,y,…) node id

add_nodes_from(*nodes*, ***attr*)

add_path(*nodes*, ***attr*)

add_star(*nodes*, ***attr*)

add_weighted_edges_from(*ebunch_to_add*, *weight='weight'*, ***attr*)
Add weighted edges in *ebunch_to_add* with specified weight attr

ebunch_to_add [container of edges] Each edge given in the list or container will be added to the graph. The edges must be given as 3-tuples (u, v, w) where w is a number.

weight [string, optional (default= 'weight')] The attribute name for the edge weights to be added.

attr [keyword arguments, optional (default= no attributes)] Edge attributes to add/update for all edges.

add_edge : add a single edge add_edges_from : add multiple edges

Adding the same edge twice for Graph/DiGraph simply updates the edge data. For MultiGraph/MultiDiGraph, duplicate edges are stored.

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_weighted_edges_from([(0, 1, 3.0), (1, 2, 7.5)])
```

adj
Graph adjacency object holding the neighbors of each node.

This object is a read-only dict-like structure with node keys and neighbor-dict values. The neighbor-dict is keyed by neighbor to the edgekey-dict. So *G.adj[3][2][0]['color'] = 'blue'* sets the color of the edge *(3, 2, 0)* to *"blue"*.

Iterating over G.adj behaves like a dict. Useful idioms include *for nbr, datadict in G.adj[n].items():*.

The neighbor information is also provided by subscripting the graph. So *for nbr, foovalue in G[node].data('foo', default=1):* works.

For directed graphs, *G.adj* holds outgoing (successor) info.

adjacency()
Return an iterator over (node, adjacency dict) tuples for all nodes.

For directed graphs, only outgoing neighbors/adjacencies are included.

adj_iter [iterator] An iterator over (node, adjacency dictionary) for all nodes in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> [(n, nbrdict) for n, nbrdict in G.adjacency()]
[(0, {1: {}}), (1, {0: {}, 2: {}}), (2, {1: {}, 3: {}}), (3, {2: {}})]
```

adjlist_inner_dict_factory
alias of `builtins.dict`

adjlist_outer_dict_factory
alias of `builtins.dict`

box()

Returns nodes bounding box as (xmin,ymin,. . .),(xmax,ymax,. . .)

box_size()

Returns (x,y) size

clear()

closest_edges(*p*, *data=False*)

Returns container of edges close to p and distance

closest_nodes(*p*, *n=1*, *skip=False*)
nodes closest to a given position :param p: (x,y) position tuple :param skip: optional bool to skip n itself :return: list of nodes, minimal distance

contiguity(*pts*)

Returns int number of points from pts already in graph

copy()

Returns copy of self graph

degree
A DegreeView for the Graph as G.degree or G.degree().

The node degree is the number of edges adjacent to the node. The weighted node degree is the sum of the edge weights for edges incident to that node.

This object provides an iterator for (node, degree) as well as lookup for the degree for a single node.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

weight [string or None, optional (default=None)] The name of an edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1. The degree is the sum of the edge weights adjacent to the node.

If a single nodes is requested deg : int

Degree of the node

OR if multiple nodes are requested nd_iter : iterator

The iterator returns two-tuples of (node, degree).

out_degree, in_degree

```
>>> G = nx.MultiDiGraph()
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.degree(0) # node 0 with degree 1
1
>>> list(G.degree([0, 1, 2]))
[(0, 1), (1, 2), (2, 2)]
```

dist (*u*, *v*)

Returns float distance between nodes u and v

draw (***kwargs*)

draw graph with default params

edge_attr_dict_factory

alias of `builtins.dict`

edge_key_dict_factory

alias of `builtins.dict`

edge_subgraph (*edges*)

Returns the subgraph induced by the specified edges.

The induced subgraph contains each edge in *edges* and each node incident to any one of those edges.

edges [iterable] An iterable of edges in this graph.

G [Graph] An edge-induced subgraph of this graph with the same edge attributes.

The graph, edge, and node attributes in the returned subgraph view are references to the corresponding attributes in the original graph. The view is read-only.

To create a full graph version of the subgraph with its own copy of the edge or node attributes, use:

```
>>> G.edge_subgraph(edges).copy()
```

```
>>> G = nx.path_graph(5)
>>> H = G.edge_subgraph([(0, 1), (3, 4)])
>>> list(H.nodes)
[0, 1, 3, 4]
>>> list(H.edges)
[(0, 1), (3, 4)]
```

edges

An OutMultiEdgeView of the Graph as G.edges or G.edges().

edges(self, nbunch=None, data=False, keys=False, default=None)

The OutMultiEdgeView provides set-like operations on the edge-tuples as well as edge attribute lookup. When called, it also provides an EdgeDataView object which allows control of access to edge attributes (but does not provide set-like operations). Hence, *G.edges[u, v]['color']* provides the value of the color attribute for edge *(u, v)* while *for (u, v, c) in G.edges(data='color', default='red'):* iterates through all the edges yielding the color attribute with default *'red'* if no color attribute exists.

Edges are returned as tuples with optional data and keys in the order (node, neighbor, key, data).

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

data [string or bool, optional (default=False)] The edge attribute returned in 3-tuple (u, v, ddict[data]). If True, return edge attribute dict in 3-tuple (u, v, ddict). If False, return 2-tuple (u, v).

keys [bool, optional (default=False)] If True, return edge keys with each edge.

default [value, optional (default=None)] Value used for edges that don't have the requested attribute. Only relevant if data is not True or False.

edges [EdgeView] A view of edge attributes, usually it iterates over (u, v) (u, v, k) or (u, v, k, d) tuples of edges, but can also be used for attribute lookup as *edges[u, v, k]['foo']*.

Nodes in nbunch that are not in the graph will be (quietly) ignored. For directed graphs this returns the out-edges.

```
>>> G = nx.MultiDiGraph()
>>> nx.add_path(G, [0, 1, 2])
>>> key = G.add_edge(2, 3, weight=5)
>>> [e for e in G.edges()]
[(0, 1), (1, 2), (2, 3)]
>>> list(G.edges(data=True)) # default data is {} (empty dict)
[(0, 1, {}), (1, 2, {}), (2, 3, {'weight': 5})]
>>> list(G.edges(data='weight', default=1))
[(0, 1, 1), (1, 2, 1), (2, 3, 5)]
>>> list(G.edges(keys=True)) # default keys are integers
[(0, 1, 0), (1, 2, 0), (2, 3, 0)]
>>> list(G.edges(data=True, keys=True))
[(0, 1, 0, {}), (1, 2, 0, {}), (2, 3, 0, {'weight': 5})]
>>> list(G.edges(data='weight', default=1, keys=True))
[(0, 1, 0, 1), (1, 2, 0, 1), (2, 3, 0, 5)]
>>> list(G.edges([0, 2]))
[(0, 1), (2, 3)]
>>> list(G.edges(0))
[(0, 1)]
```

in_edges, out_edges

fresh_copy()

get_edge_data(*u*, *v*, *key=None*, *default=None*)

Return the attribute dictionary associated with edge (u, v).

This is identical to *G[u][v][key]* except the default is returned instead of an exception is the edge doesn't exist.

u, v : nodes

default [any Python object (default=None)] Value to return if the edge (u, v) is not found.

key [hashable identifier, optional (default=None)] Return data only for the edge with specified key.

edge_dict [dictionary] The edge attribute dictionary.

```
>>> G = nx.MultiGraph() # or MultiDiGraph
>>> key = G.add_edge(0, 1, key='a', weight=7)
>>> G[0][1]['a']  # key='a'
{'weight': 7}
>>> G.edges[0, 1, 'a']  # key='a'
{'weight': 7}
```

Warning: we protect the graph data structure by making *G.edges* and *G[1][2]* read-only dict-like structures. However, you can assign values to attributes in e.g. *G.edges[1, 2, 'a']* or *G[1][2]['a']* using an additional bracket as shown next. You need to specify all edge info to assign to the edge data associated with an edge.

```
>>> G[0][1]['a']['weight'] = 10
>>> G.edges[0, 1, 'a']['weight'] = 10
>>> G[0][1]['a']['weight']
10
>>> G.edges[1, 0, 'a']['weight']
10
```

```
>>> G = nx.MultiGraph() # or MultiDiGraph
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.get_edge_data(0, 1)
{0: {}}
>>> e = (0, 1)
>>> G.get_edge_data(*e) # tuple form
{0: {}}
>>> G.get_edge_data('a', 'b', default=0) # edge not in graph, return 0
0
```

has_edge (*u*, *v*, *key=None*)
Return True if the graph has an edge between nodes u and v.

This is the same as *v in G[u] or key in G[u][v]* without KeyError exceptions.

u, v [nodes] Nodes can be, for example, strings or numbers.

key [hashable identifier, optional (default=None)] If specified return True only if the edge with key is found.

edge_ind [bool] True if edge is in the graph, False otherwise.

Can be called either using two nodes u, v, an edge tuple (u, v), or an edge tuple (u, v, key).

```
>>> G = nx.MultiGraph()   # or MultiDiGraph
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.has_edge(0, 1)  # using two nodes
True
>>> e = (0, 1)
>>> G.has_edge(*e)  #  e is a 2-tuple (u, v)
True
>>> G.add_edge(0, 1, key='a')
'a'
>>> G.has_edge(0, 1, key='a')  # specify key
True
>>> e=(0, 1, 'a')
```

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```
>>> G.has_edge(*e) # e is a 3-tuple (u, v, 'a')
True
```

The following syntax are equivalent:

```
>>> G.has_edge(0, 1)
True
>>> 1 in G[0]  # though this gives :exc:`KeyError` if 0 not in G
True
```

has_node (*n*)

Return True if the graph contains the node n.

Identical to *n in G*

n : node

```
>>> G = nx.path_graph(3)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.has_node(0)
True
```

It is more readable and simpler to use

```
>>> 0 in G
True
```

has_predecessor (*u*, *v*)

Return True if node u has predecessor v.

This is true if graph has the edge u<-v.

has_successor (*u*, *v*)

Return True if node u has successor v.

This is true if graph has the edge u->v.

html (***kwargs*)

in_degree

A DegreeView for (node, in_degree) or in_degree for single node.

The node in-degree is the number of edges pointing in to the node. The weighted node degree is the sum of the edge weights for edges incident to that node.

This object provides an iterator for (node, degree) as well as lookup for the degree for a single node.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

weight [string or None, optional (default=None)] The edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1. The degree is the sum of the edge weights adjacent to the node.

If a single node is requested deg : int

Degree of the node

OR if multiple nodes are requested nd_iter : iterator

The iterator returns two-tuples of (node, in-degree).

degree, out_degree

```
>>> G = nx.MultiDiGraph()
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.in_degree(0) # node 0 with degree 0
0
>>> list(G.in_degree([0, 1, 2]))
[(0, 0), (1, 1), (2, 1)]
```

in_edges

An InMultiEdgeView of the Graph as G.in_edges or G.in_edges().

in_edges(self, nbunch=None, data=False, keys=False, default=None)

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

data [string or bool, optional (default=False)] The edge attribute returned in 3-tuple (u, v, ddict[data]). If True, return edge attribute dict in 3-tuple (u, v, ddict). If False, return 2-tuple (u, v).

keys [bool, optional (default=False)] If True, return edge keys with each edge.

default [value, optional (default=None)] Value used for edges that don't have the requested attribute. Only relevant if data is not True or False.

in_edges [InMultiEdgeView] A view of edge attributes, usually it iterates over (u, v) or (u, v, k) or (u, v, k, d) tuples of edges, but can also be used for attribute lookup as *edges[u, v, k]['foo']*.

edges

is_directed()

Return True if graph is directed, False otherwise.

is_multigraph()

used internally in constructor

length(*edges=None*)

Parameters **edges** – iterator over edges either as (u,v,data) or (u,v,key,data). If None, all edges are taken

Returns sum of 'length' attributes of edges

multi

name

String identifier of the graph.

This graph attribute appears in the attribute dict G.graph keyed by the string *"name"*. as well as an attribute (technically a property) *G.name*. This is entirely user controlled.

nbunch_iter(*nbunch=None*)

Return an iterator over nodes contained in nbunch that are also in the graph.

The nodes in nbunch are checked for membership in the graph and if not are silently ignored.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

niter [iterator] An iterator over nodes in nbunch that are also in the graph. If nbunch is None, iterate over all nodes in the graph.

NetworkXError If nbunch is not a node or or sequence of nodes. If a node in nbunch is not hashable.

Graph.__iter__

When nbunch is an iterator, the returned iterator yields values directly from nbunch, becoming exhausted when nbunch is exhausted.

To test whether nbunch is a single node, one can use "if nbunch in self:", even after processing with this routine.

If nbunch is not a node or a (possibly empty) sequence/iterator or None, a `NetworkXError` is raised. Also, if any object in nbunch is not hashable, a `NetworkXError` is raised.

neighbors(*n*)
Return an iterator over successor nodes of n.

A successor of n is a node m such that there exists a directed edge from n to m.

n [node] A node in the graph

NetworkXError If n is not in the graph.

predecessors

neighbors() and successors() are the same.

new_edge_key(*u*, *v*)
Return an unused key for edges between nodes *u* and *v*.

The nodes *u* and *v* do not need to be already in the graph.

In the standard MultiGraph class the new key is the number of existing edges between *u* and *v* (increased if necessary to ensure unused). The first edge will have key 0, then 1, etc. If an edge is removed further new_edge_keys may not be in this order.

u, v : nodes

key : int

node
A NodeView of the Graph as G.nodes or G.nodes().

Can be used as *G.nodes* for data lookup and for set-like operations. Can also be used as *G.nodes(data='color', default=None)* to return a NodeDataView which reports specific node data but no set operations. It presents a dict-like interface as well with *G.nodes.items()* iterating over *(node, nodedata)* 2-tuples and *G.nodes[3]['foo']* providing the value of the *foo* attribute for node *3*. In addition, a view *G.nodes.data('foo')* provides a dict-like interface to the *foo* attribute of each node. *G.nodes.data('foo', default=1)* provides a default for nodes that do not have attribute *foo*.

data [string or bool, optional (default=False)] The node attribute returned in 2-tuple (n, ddict[data]). If True, return entire node attribute dict as (n, ddict). If False, return just the nodes n.

default [value, optional (default=None)] Value used for nodes that don't have the requested attribute. Only relevant if data is not True or False.

NodeView Allows set-like operations over the nodes as well as node attribute dict lookup and calling to get a NodeDataView. A NodeDataView iterates over *(n, data)* and has no set operations. A NodeView iterates over *n* and includes set operations.

When called, if data is False, an iterator over nodes. Otherwise an iterator of 2-tuples (node, attribute value) where the attribute is specified in *data*. If data is True then the attribute becomes the entire data dictionary.

If your node data is not needed, it is simpler and equivalent to use the expression `for n in G`, or `list(G)`.

There are two simple ways of getting a list of all nodes in the graph:

```
>>> G = nx.path_graph(3)
>>> list(G.nodes)
[0, 1, 2]
>>> list(G)
[0, 1, 2]
```

To get the node data along with the nodes:

```
>>> G.add_node(1, time='5pm')
>>> G.nodes[0]['foo'] = 'bar'
>>> list(G.nodes(data=True))
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
>>> list(G.nodes.data())
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
```

```
>>> list(G.nodes(data='foo'))
[(0, 'bar'), (1, None), (2, None)]
>>> list(G.nodes.data('foo'))
[(0, 'bar'), (1, None), (2, None)]
```

```
>>> list(G.nodes(data='time'))
[(0, None), (1, '5pm'), (2, None)]
>>> list(G.nodes.data('time'))
[(0, None), (1, '5pm'), (2, None)]
```

```
>>> list(G.nodes(data='time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
>>> list(G.nodes.data('time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
```

If some of your nodes have an attribute and the rest are assumed to have a default attribute value you can create a dictionary from node/attribute pairs using the *default* keyword argument to guarantee the value is never None:

```
>>> G = nx.Graph()
>>> G.add_node(0)
>>> G.add_node(1, weight=2)
>>> G.add_node(2, weight=3)
>>> dict(G.nodes(data='weight', default=1))
{0: 1, 1: 2, 2: 3}
```

node_dict_factory
alias of `builtins.dict`

nodes
A NodeView of the Graph as G.nodes or G.nodes().

Can be used as *G.nodes* for data lookup and for set-like operations. Can also be used as *G.nodes(data='color', default=None)* to return a NodeDataView which reports specific node data but no set operations. It presents a dict-like interface as well with *G.nodes.items()* iterating over *(node, nodedata)* 2-tuples and *G.nodes[3]['foo']* providing the value of the *foo* attribute for node *3*. In addition, a view *G.nodes.data('foo')* provides a dict-like interface to the *foo* attribute of each node. *G.nodes.data('foo', default=1)* provides a default for nodes that do not have attribute *foo*.

data [string or bool, optional (default=False)] The node attribute returned in 2-tuple (n, ddict[data]). If True, return entire node attribute dict as (n, ddict). If False, return just the nodes n.

default [value, optional (default=None)] Value used for nodes that don't have the requested attribute. Only relevant if data is not True or False.

NodeView Allows set-like operations over the nodes as well as node attribute dict lookup and calling to get a NodeDataView. A NodeDataView iterates over *(n, data)* and has no set operations. A NodeView iterates over *n* and includes set operations.

When called, if data is False, an iterator over nodes. Otherwise an iterator of 2-tuples (node, attribute value) where the attribute is specified in *data*. If data is True then the attribute becomes the entire data dictionary.

If your node data is not needed, it is simpler and equivalent to use the expression `for n in G`, or `list(G)`.

There are two simple ways of getting a list of all nodes in the graph:

```
>>> G = nx.path_graph(3)
>>> list(G.nodes)
[0, 1, 2]
>>> list(G)
[0, 1, 2]
```

To get the node data along with the nodes:

```
>>> G.add_node(1, time='5pm')
>>> G.nodes[0]['foo'] = 'bar'
>>> list(G.nodes(data=True))
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
>>> list(G.nodes.data())
[(0, {'foo': 'bar'}), (1, {'time': '5pm'}), (2, {})]
```

```
>>> list(G.nodes(data='foo'))
[(0, 'bar'), (1, None), (2, None)]
>>> list(G.nodes.data('foo'))
[(0, 'bar'), (1, None), (2, None)]
```

```
>>> list(G.nodes(data='time'))
[(0, None), (1, '5pm'), (2, None)]
>>> list(G.nodes.data('time'))
[(0, None), (1, '5pm'), (2, None)]
```

```
>>> list(G.nodes(data='time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
>>> list(G.nodes.data('time', default='Not Available'))
[(0, 'Not Available'), (1, '5pm'), (2, 'Not Available')]
```

If some of your nodes have an attribute and the rest are assumed to have a default attribute value you can create a dictionary from node/attribute pairs using the *default* keyword argument to guarantee the value is never None:

```
>>> G = nx.Graph()
>>> G.add_node(0)
>>> G.add_node(1, weight=2)
>>> G.add_node(2, weight=3)
```

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```
>>> dict(G.nodes(data='weight', default=1))
{0: 1, 1: 2, 2: 3}
```

nodes_with_selfloops()

number_of_edges(*u=None*, *v=None*)
Return the number of edges between two nodes.

u, v [nodes, optional (Gefault=all edges)] If u and v are specified, return the number of edges between u and v. Otherwise return the total number of all edges.

nedges [int] The number of edges in the graph. If nodes *u* and *v* are specified return the number of edges between those nodes. If the graph is directed, this only returns the number of edges from *u* to *v*.

size

For undirected multigraphs, this method counts the total number of edges in the graph:

```
>>> G = nx.MultiGraph()
>>> G.add_edges_from([(0, 1), (0, 1), (1, 2)])
[0, 1, 0]
>>> G.number_of_edges()
3
```

If you specify two nodes, this counts the total number of edges joining the two nodes:

```
>>> G.number_of_edges(0, 1)
2
```

For directed multigraphs, this method can count the total number of directed edges from *u* to *v*:

```
>>> G = nx.MultiDiGraph()
>>> G.add_edges_from([(0, 1), (0, 1), (1, 0)])
[0, 1, 0]
>>> G.number_of_edges(0, 1)
2
>>> G.number_of_edges(1, 0)
1
```

number_of_nodes(*doublecheck=False*)

number_of_selfloops()

order()
Return the number of nodes in the graph.

nnodes [int] The number of nodes in the graph.

number_of_nodes, __len__ which are identical

out_degree
Return an iterator for (node, out-degree) or out-degree for single node.

out_degree(self, nbunch=None, weight=None)

The node out-degree is the number of edges pointing out of the node. This function returns the out-degree for a single node or an iterator for a bunch of nodes or if nothing is passed as argument.

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

weight [string or None, optional (default=None)] The edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1. The degree is the sum of the edge weights.

If a single node is requested deg : int

Degree of the node

OR if multiple nodes are requested nd_iter : iterator

The iterator returns two-tuples of (node, out-degree).

degree, in_degree

```
>>> G = nx.MultiDiGraph()
>>> nx.add_path(G, [0, 1, 2, 3])
>>> G.out_degree(0) # node 0 with degree 1
1
>>> list(G.out_degree([0, 1, 2]))
[(0, 1), (1, 1), (2, 1)]
```

out_edges

An OutMultiEdgeView of the Graph as G.edges or G.edges().

edges(self, nbunch=None, data=False, keys=False, default=None)

The OutMultiEdgeView provides set-like operations on the edge-tuples as well as edge attribute lookup. When called, it also provides an EdgeDataView object which allows control of access to edge attributes (but does not provide set-like operations). Hence, *G.edges[u, v][‘color’]* provides the value of the color attribute for edge *(u, v)* while *for (u, v, c) in G.edges(data=’color’, default=’red’):* iterates through all the edges yielding the color attribute with default *‘red’* if no color attribute exists.

Edges are returned as tuples with optional data and keys in the order (node, neighbor, key, data).

nbunch [single node, container, or all nodes (default= all nodes)] The view will only report edges incident to these nodes.

data [string or bool, optional (default=False)] The edge attribute returned in 3-tuple (u, v, ddict[data]). If True, return edge attribute dict in 3-tuple (u, v, ddict). If False, return 2-tuple (u, v).

keys [bool, optional (default=False)] If True, return edge keys with each edge.

default [value, optional (default=None)] Value used for edges that don’t have the requested attribute. Only relevant if data is not True or False.

edges [EdgeView] A view of edge attributes, usually it iterates over (u, v) (u, v, k) or (u, v, k, d) tuples of edges, but can also be used for attribute lookup as *edges[u, v, k][‘foo’]*.

Nodes in nbunch that are not in the graph will be (quietly) ignored. For directed graphs this returns the out-edges.

```
>>> G = nx.MultiDiGraph()
>>> nx.add_path(G, [0, 1, 2])
>>> key = G.add_edge(2, 3, weight=5)
>>> [e for e in G.edges()]
[(0, 1), (1, 2), (2, 3)]
>>> list(G.edges(data=True)) # default data is {} (empty dict)
[(0, 1, {}), (1, 2, {}), (2, 3, {'weight': 5})]
>>> list(G.edges(data='weight', default=1))
[(0, 1, 1), (1, 2, 1), (2, 3, 5)]
>>> list(G.edges(keys=True)) # default keys are integers
[(0, 1, 0), (1, 2, 0), (2, 3, 0)]
```

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```
>>> list(G.edges(data=True, keys=True))
[(0, 1, 0, {}), (1, 2, 0, {}), (2, 3, 0, {'weight': 5})]
>>> list(G.edges(data='weight', default=1, keys=True))
[(0, 1, 0, 1), (1, 2, 0, 1), (2, 3, 0, 5)]
>>> list(G.edges([0, 2]))
[(0, 1), (2, 3)]
>>> list(G.edges(0))
[(0, 1)]
```

in_edges, out_edges

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

pos (*nodes=None*)

Parameters nodes – a single node, an iterator of all nodes if None

Returns the position of node(s)

pred
Graph adjacency object holding the predecessors of each node.

This object is a read-only dict-like structure with node keys and neighbor-dict values. The neighbor-dict is keyed by neighbor to the edgekey-dict. So *G.adj[3][2][0][‘color’] = ‘blue’* sets the color of the edge *(3, 2, 0)* to *“blue”*.

Iterating over G.adj behaves like a dict. Useful idioms include *for nbr, datadict in G.adj[n].items():*.

predecessors (*n*)
Return an iterator over predecessor nodes of n.

A predecessor of n is a node m such that there exists a directed edge from m to n.

n [node] A node in the graph

NetworkXError If n is not in the graph.

successors

remove_edge (*u*, *v=None*, *key=None*, *clean=False*)

Parameters

- **u** – Node or Edge (Nodes tuple)
- **v** – Node if u is a single Node
- **clean** – bool removes disconnected nodes. must be False for certain nx algos to work

Result return attributes of removed edge

remove edge from graph. NetworkX graphs do not remove unused nodes

remove_edges_from (*ebunch*)
Remove all edges specified in ebunch.

ebunch: list or container of edge tuples Each edge given in the list or container will be removed from the graph. The edges can be:

- 2-tuples (u, v) All edges between u and v are removed.

- 3-tuples (u, v, key) The edge identified by key is removed.
- 4-tuples (u, v, key, data) where data is ignored.

remove_edge : remove a single edge

Will fail silently if an edge in ebunch is not in the graph.

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> ebunch=[(1, 2), (2, 3)]
>>> G.remove_edges_from(ebunch)
```

Removing multiple copies of edges

```
>>> G = nx.MultiGraph()
>>> keys = G.add_edges_from([(1, 2), (1, 2), (1, 2)])
>>> G.remove_edges_from([(1, 2), (1, 2)])
>>> list(G.edges())
[(1, 2)]
>>> G.remove_edges_from([(1, 2), (1, 2)]) # silently ignore extra copy
>>> list(G.edges) # now empty graph
[]
```

remove_node (*n*)

Parameters **n** – node tuple

remove node from graph and rtree

remove_nodes_from (*nodes*)
Remove multiple nodes.

nodes [iterable container] A container of nodes (list, dict, set, etc.). If a node in the container is not in the graph it is silently ignored.

remove_node

```
>>> G = nx.path_graph(3)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> e = list(G.nodes)
>>> e
[0, 1, 2]
>>> G.remove_nodes_from(e)
>>> list(G.nodes)
[]
```

render (*fmt='svg'*, ***kwargs*)
render graph to bitmap stream :param fmt: string defining the format. 'svg' by default for INotepads :return: matplotlib figure as a byte stream in specified format

reverse (*copy=True*)
Return the reverse of the graph.

The reverse is a graph with the same nodes and edges but with the directions of the edges reversed.

copy [bool optional (default=True)] If True, return a new DiGraph holding the reversed edges. If False, the reverse graph is created using a view of the original graph.

save (*filename*, ***kwargs*)
save graph in various formats

selfloop_edges (*data=False*, *keys=False*, *default=None*)

shortest_path (*source=None*, *target=None*)

size(*weight=None*)

Return the number of edges or total of all edge weights.

weight [string or None, optional (default=None)] The edge attribute that holds the numerical value used as a weight. If None, then each edge has weight 1.

size [numeric] The number of edges or (if weight keyword is provided) the total weight sum.

If weight is None, returns an int. Otherwise a float (or more general numeric if the weights are more general).

number_of_edges

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.size()
3
```

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> G.add_edge('a', 'b', weight=2)
>>> G.add_edge('b', 'c', weight=4)
>>> G.size()
2
>>> G.size(weight='weight')
6.0
```

stats()

Returns dict of graph data to use in __repr__ or usable otherwise

subgraph(*nodes*)

Return a SubGraph view of the subgraph induced on *nodes*.

The induced subgraph of the graph contains the nodes in *nodes* and the edges between those nodes.

nodes [list, iterable] A container of nodes which will be iterated through once.

G [SubGraph View] A subgraph view of the graph. The graph structure cannot be changed but node/edge attributes can and are shared with the original graph.

The graph, edge and node attributes are shared with the original graph. Changes to the graph structure is ruled out by the view, but changes to attributes are reflected in the original graph.

To create a subgraph with its own copy of the edge/node attributes use: G.subgraph(nodes).copy()

For an inplace reduction of a graph to a subgraph you can remove nodes: G.remove_nodes_from([n for n in G if n not in set(nodes)])

Subgraph views are sometimes NOT what you want. In most cases where you want to do more than simply look at the induced edges, it makes more sense to just create the subgraph as its own graph with code like:

```
# Create a subgraph SG based on a (possibly multigraph) G
SG = G.__class__()
SG.add_nodes_from((n, G.nodes[n]) for n in largest_wcc)
if SG.is_multigraph:
    SG.add_edges_from((n, nbr, key, d)
        for n, nbrs in G.adj.items() if n in largest_wcc
        for nbr, keydict in nbrs.items() if nbr in largest_wcc
        for key, d in keydict.items())
else:
```

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```
    SG.add_edges_from((n, nbr, d)
        for n, nbrs in G.adj.items() if n in largest_wcc
        for nbr, d in nbrs.items() if nbr in largest_wcc)
SG.graph.update(G.graph)
```

```
>>> G = nx.path_graph(4)  # or DiGraph, MultiGraph, MultiDiGraph, etc
>>> H = G.subgraph([0, 1, 2])
>>> list(H.edges)
[(0, 1), (1, 2)]
```

succ

Graph adjacency object holding the successors of each node.

This object is a read-only dict-like structure with node keys and neighbor-dict values. The neighbor-dict is keyed by neighbor to the edgekey-dict. So *G.adj[3][2][0]['color'] = 'blue'* sets the color of the edge *(3, 2, 0)* to *"blue"*.

Iterating over G.adj behaves like a dict. Useful idioms include *for nbr, datadict in G.adj[n].items():*.

The neighbor information is also provided by subscripting the graph. So *for nbr, foovalue in G[node].data('foo', default=1):* works.

For directed graphs, *G.succ* is identical to *G.adj*.

successors(*n*)

Return an iterator over successor nodes of n.

A successor of n is a node m such that there exists a directed edge from n to m.

n [node] A node in the graph

NetworkXError If n is not in the graph.

predecessors

neighbors() and successors() are the same.

svg(***kwargs*)

to_directed(*as_view=False*)

Return a directed representation of the graph.

G [MultiDiGraph] A directed graph with the same name, same nodes, and with each edge (u, v, data) replaced by two directed edges (u, v, data) and (v, u, data).

This returns a "deepcopy" of the edge, node, and graph attributes which attempts to completely copy all of the data and references.

This is in contrast to the similar D=DiGraph(G) which returns a shallow copy of the data.

See the Python copy module for more information on shallow and deep copies, https://docs.python.org/2/library/copy.html.

Warning: If you have subclassed MultiGraph to use dict-like objects in the data structure, those changes do not transfer to the MultiDiGraph created by this method.

```
>>> G = nx.Graph()   # or MultiGraph, etc
>>> G.add_edge(0, 1)
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1), (1, 0)]
```

If already directed, return a (deep) copy

```
>>> G = nx.DiGraph()   # or MultiDiGraph, etc
>>> G.add_edge(0, 1)
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1)]
```

to_directed_class()

Returns the class to use for empty directed copies.

If you subclass the base classes, use this to designate what directed class to use for *to_directed()* copies.

to_undirected(*reciprocal=False*, *as_view=False*)

Return an undirected representation of the digraph.

reciprocal [bool (optional)] If True only keep edges that appear in both directions in the original digraph.

as_view [bool (optional, default=False)] If True return an undirected view of the original directed graph.

G [MultiGraph] An undirected graph with the same name and nodes and with edge (u, v, data) if either (u, v, data) or (v, u, data) is in the digraph. If both edges exist in digraph and their edge data is different, only one edge is created with an arbitrary choice of which edge data to use. You must check and correct for this manually if desired.

MultiGraph, copy, add_edge, add_edges_from

This returns a "deepcopy" of the edge, node, and graph attributes which attempts to completely copy all of the data and references.

This is in contrast to the similar D=MultiiGraph(G) which returns a shallow copy of the data.

See the Python copy module for more information on shallow and deep copies, https://docs.python.org/2/library/copy.html.

Warning: If you have subclassed MultiDiGraph to use dict-like objects in the data structure, those changes do not transfer to the MultiGraph created by this method.

```
>>> G = nx.path_graph(2)   # or MultiGraph, etc
>>> H = G.to_directed()
>>> list(H.edges)
[(0, 1), (1, 0)]
>>> G2 = H.to_undirected()
>>> list(G2.edges)
[(0, 1)]
```

to_undirected_class()

Returns the class to use for empty undirected copies.

If you subclass the base classes, use this to designate what directed class to use for *to_directed()* copies.

tol

update(*edges=None*, *nodes=None*)

Update the graph using nodes/edges/graphs as input.

Like dict.update, this method takes a graph as input, adding the graph's noes and edges to this graph. It can also take two inputs: edges and nodes. Finally it can take either edges or nodes. To specify only nodes the keyword *nodes* must be used.

The collections of edges and nodes are treated similarly to the add_edges_from/add_nodes_from methods. When iterated, they should yield 2-tuples (u, v) or 3-tuples (u, v, datadict).

edges [Graph object, collection of edges, or None] The first parameter can be a graph or some edges. If it has attributes *nodes* and *edges*, then it is taken to be a Graph-like object and those attributes are used as collections of nodes and edges to be added to the graph. If the first parameter does not have those attributes, it is treated as a collection of edges and added to the graph. If the first argument is None, no edges are added.

nodes [collection of nodes, or None] The second parameter is treated as a collection of nodes to be added to the graph unless it is None. If *edges is None* and *nodes is None* an exception is raised. If the first parameter is a Graph, then *nodes* is ignored.

```
>>> G = nx.path_graph(5)
>>> G.update(nx.complete_graph(range(4,10)))
>>> from itertools import combinations
>>> edges = ((u, v, {'power': u * v})
...          for u, v in combinations(range(10, 20), 2)
...          if u * v < 225)
>>> nodes = [1000]  # for singleton, use a container
>>> G.update(edges, nodes)
```

It you want to update the graph using an adjacency structure it is straightforward to obtain the edges/nodes from adjacency. The following examples provide common cases, your adjacency may be slightly different and require tweaks of these examples.

```
>>> # dict-of-set/list/tuple
>>> adj = {1: {2, 3}, 2: {1, 3}, 3: {1, 2}}
>>> e = [(u, v) for u, nbrs in adj.items() for v in  nbrs]
>>> G.update(edges=e, nodes=adj)
```

```
>>> DG = nx.DiGraph()
>>> # dict-of-dict-of-attribute
>>> adj = {1: {2: 1.3, 3: 0.7}, 2: {1: 1.4}, 3: {1: 0.7}}
>>> e = [(u, v, {'weight': d}) for u, nbrs in adj.items()
...      for v, d in nbrs.items()]
>>> DG.update(edges=e, nodes=adj)
```

```
>>> # dict-of-dict-of-dict
>>> adj = {1: {2: {'weight': 1.3}, 3: {'color': 0.7, 'weight':1.2}}}
>>> e = [(u, v, {'weight': d}) for u, nbrs in adj.items()
...      for v, d in nbrs.items()]
>>> DG.update(edges=e, nodes=adj)
```

```
>>> # predecessor adjacency (dict-of-set)
>>> pred = {1: {2, 3}, 2: {3}, 3: {3}}
>>> e = [(v, u) for u, nbrs in pred.items() for v in nbrs]
```

```
>>> # MultiGraph dict-of-dict-of-dict-of-attribute
>>> MDG = nx.MultiDiGraph()
>>> adj = {1: {2: {0: {'weight': 1.3}, 1: {'weight': 1.2}}},
...        3: {2: {0: {'weight': 0.7}}}}
>>> e = [(u, v, ekey, d) for u, nbrs in adj.items()
...      for v, keydict in nbrs.items()
...      for ekey, d in keydict.items()]
>>> MDG.update(edges=e)
```

add_edges_from: add multiple edges to a graph add_nodes_from: add multiple nodes to a graph

`Goulib.graph.`**`figure`**(*g*, *box=None*, ***kwargs*)

Parameters

- **g** – _Geo derived Graph
- **box** – optional interval.Box if g has no box

Returns matplotlib axis suitable for drawing graph g

Goulib.graph.**draw_networkx**(*g*, *pos=None*, ***kwargs*)

improves nx.draw_networkx :param g: NetworkX Graph :param pos: can be either :

- optional dictionary of (x,y) node positions
- function of the form lambda node:(x,y) that maps node positions.
- None. in this case, nodes are directly used as positions if graph is a GeoGraph, otherwise nx.draw_shell is used

Parameters **kwargs – passed to nx.draw method as described in http://networkx.lanl.gov/reference/generated/networkx.drawing.nx_pylab.draw_networkx.html with one tweak:

- if edge_color is a function of the form lambda data:color string, it is mapped over all edges

Goulib.graph.**to_drawing**(*g*, *d=None*, *edges=[]*)

draws Graph to a *Drawing* :param g: `Graph` :param d: existing `Drawing` to draw onto, or None to create a new Drawing :param edges: iterable of edges (with data) that will be added, in the same order. By default all edges are drawn :return: `Drawing`

Graph edges with an 'entity' property

Goulib.graph.**write_dxf**(*g*, *filename*)

writes `networkx.Graph` in .dxf format

Goulib.graph.**write_dot**(*g*, *filename*)

Goulib.graph.**to_json**(*g*, ***kwargs*)

Returns string JSON representation of a graph

Goulib.graph.**write_json**(*g*, *filename*, ***kwargs*)

write a JSON file, suitable for D*.js representation

Goulib.graph.**read_json**(*filename*, *directed=False*, *multigraph=True*, *attrs=None*)

Goulib.graph.**delauney_triangulation**(*nodes*, *qhull_options=''*, *incremental=False*, ***kwargs*)

https://en.wikipedia.org/wiki/Delaunay_triangulation :param nodes: _Geo graph or list of (x,y) or (x,y,z) node positions :param qhull_options: string passed to `scipy.spatial.Delaunay()`, which passes it to Qhull (http://www.qhull.org/) *'Qt' ensures all points are connected *'Qz' required when nodes lie on a sphere *'QJ' solves some singularity situations

Parameters kwargs – passed to the *GeoGraph* constructor

Returns *GeoGraph* with delauney triangulation between nodes

Goulib.graph.**euclidean_minimum_spanning_tree**(*nodes*, ***kwargs*)

Parameters nodes – list of (x,y) nodes positions

Returns *GeoGraph* with minimum spanning tree between nodes

see https://en.wikipedia.org/wiki/Euclidean_minimum_spanning_tree

Goulib.graph.**points_on_sphere**(*N*)

2.10 Goulib.image module

class Goulib.image.**Mode**(*name*, *nchannels*, *type*, *min*, *max*)
Bases: object

__init__(*name*, *nchannels*, *type*, *min*, *max*)
Initialize self. See help(type(self)) for accurate signature.

__repr__()
Return repr(self).

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.image.**nchannels**(*arr*)

Goulib.image.**guessmode**(*arr*)

Goulib.image.**adapt_rgb**(*func*)
Decorator that adapts to RGB(A) images to a gray-scale filter. :param apply_to_rgb: function

Function that returns a filtered image from an image-filter and RGB image. This will only be called if the image is RGB-like.

class Goulib.image.**Image**(*data=None*, *mode=None*, ***kwargs*)
Bases: *Goulib.plot.Plot*

Parameters data – can be either:

- *PIL.Image* : makes a copy
- string : path of image to load
- memoryview (extracted from a db blob)
- None : creates an empty image with kwargs parameters:

** size : (y,x) pixel size tuple ** mode : 'F' (gray) by default ** color: to fill None=black by default ** colormap: Palette or matplotlib colormap

__init__(*data=None*, *mode=None*, ***kwargs*)

Parameters data – can be either:

- *PIL.Image* : makes a copy
- string : path of image to load
- memoryview (extracted from a db blob)
- None : creates an empty image with kwargs parameters:

** size : (y,x) pixel size tuple ** mode : 'F' (gray) by default ** color: to fill None=black by default ** colormap: Palette or matplotlib colormap

shape

size

nchannels

npixels

__nonzero__()

__lt__(*other*)
is smaller

load(*path*)

save(*path*, *autoconvert=True*, *format_str=None*, ***kwargs*)
saves an image :param path: string with path/filename.ext :param autoconvert: bool, if True converts color planes formats to RGB :param format_str: str of file format. set to 'PNG' by skimage.io.imsave :param kwargs: optional params passed to skimage.io.imsave: :return: self for chaining

render(*fmt='PNG'*, ***kwargs*)

static open(*path*)
PIL(low) compatibility

static new(*mode*, *size*, *color='black'*)
PIL(low) compatibility

pil
convert to PIL(low) Image :see: http://effbot.org/imagingbook/concepts.htm

getdata(*dtype=<class 'numpy.uint8'>*, *copy=True*)

split(*mode=None*)

getpixel(*yx*)

putpixel(*yx*, *value*)

getpalette(*maxcolors=256*)

setpalette(*p*)

getcolors(*maxcolors=256*)

Returns an unsorted list of (count, color) tuples,

where count is the number of times the corresponding color occurs in the image. If the maxcolors value is exceeded, the method stops counting and returns None. The default maxcolors value is 256. To make sure you get all colors in an image, you can pass in size[0]*size[1] (but make sure you have lots of memory before you do that on huge images).

replace(*pairs*)
replace a color by another currently works only for indexed color images :param pairs: iterable of (from,to) ints

optimize(*maxcolors=256*)
remove unused colors from the palette

crop(*lurb*)

Parameters **lurl** – 4-tuple with left,up,right,bottom int coordinates

Returns Image

__getitem__(*slice*)

resize(*size*, *filter=None*, ***kwargs*)
Resize image

Returns a resized copy of image.

Parameters

- **size** – int tuple (width, height) requested size in pixels
- **filter** –
  - NEAREST (use nearest neighbour),
  - BILINEAR (linear interpolation in a 2x2 environment),
  - BICUBIC (cubic spline interpolation in a 4x4 environment)
  - ANTIALIAS (a high-quality downsampling filter)
- **kwargs** – extra parameters passed to skimage.transform.resize

rotate(*angle*, ***kwargs*)
Rotate image

Returns a rotated copy of image.

Parameters

- **angle** – float rotation angle in degrees in counter-clockwork direction
- **kwargs** – extra parameters passed to skimage.transform.rotate

flip (*flipx=True*, *flipy=False*)
Flip image

Returns a flipped copy of image.

Parameters

- **flipx** – bool flip X direction
- **flipy** – bool flip Y direction
- **kwargs** – extra parameters passed to skimage.transform.rotate

paste (*image*, *box*, *mask=None*)
Pastes another image into this image.

Parameters

- **image** – image to paste, or color given as a single numerical value for single-band images, and a tuple for multi-band images.
- **box** – 2-tuple giving the upper left corner or 4-tuple defining the left, upper, right, and lower pixel coordinate, or None (same as (0, 0)). If a 4-tuple is given, the size of the pasted image must match the size of the region.

:param mask:optional image to update only the regions indicated by the mask. You can use either "1", "L" or "RGBA" images (in the latter case, the alpha band is used as mask). Where the mask is 255, the given image is copied as is. Where the mask is 0, the current value is preserved. Intermediate values can be used for transparency effects. Note that if you paste an "RGBA" image, the alpha band is ignored. You can work around this by using the same image as both source image and mask.

threshold (*level=None*)

quantize (*colors=256*, *method=None*, *kmeans=0*, *palette=None*)
(PIL.Image compatible) Convert the image to 'P' mode with the specified number of colors. :param colors: The desired number of colors, <= 256 :param method: 0 = median cut

1 = maximum coverage 2 = fast octree 3 = libimagequant

Parameters

- **kmeans** – Integer
- **palette** – Quantize to the `PIL.ImagingPalette` palette.

Returns A new image

convert (*mode*, ***kwargs*)
convert image mode :param mode: string destination mode :param kwargs: optional params passed to converter(s). can contain: * palette : to force using a palette instead of the image's one for indexed images :return: image in desired mode

__repr__ ()
Return repr(self).

average_hash (*hash_size=8*)
Average Hash

See http://www.hackerfactor.com/blog/index.php?/archives/432-Looks-Like-It.html

Parameters **hash_size** – int sqrt of the hash size. 8 (64 bits) is perfect for usual photos

Returns int of hash_size**2 bits

perceptual_hash (*hash_size=8, highfreq_factor=4*)
Perceptual Hash

See http://www.hackerfactor.com/blog/index.php?/archives/432-Looks-Like-It.html

Parameters **hash_size** – int sqrt of the hash size. 8 (64 bits) is perfect for usual photos

Returns int of hash_size**2 bits

dist (*other, method=<function Image.perceptual_hash>, hash_size=8, symmetries=False*)
distance between images

Parameters **hash_size** – int sqrt of the hash size. 8 (64 bits) is perfect for usual photos

Returns float =0 if images are equal or very similar (same average_hash) =1 if images are completely decorrelated (half of the hash bits are the same by luck) =2 if images are inverted

__hash__ ()
Return hash(self).

__abs__ ()

Returns float Frobenius norm of image

invert ()

__neg__ ()

__inv__ ()

grayscale (*mode=None*)
convert (color) to grayscale :param mode: string target mode (should be in 'FUIL') or automatic if none

colorize (*color0, color1=None*)
colorize a grayscale image

Parameters **color0,color1** – 2 colors. - If only one is specified, image is colorized from white (for 0) to the specified color (for 1) - if 2 colors are specified, image is colorized from color0 (for 0) to color1 (for 1)

Returns RGB(A) color

dither (*method=None, n=2*)

normalize (*newmax=None, newmin=None*)

filter (*f*)

correlation (*other*)
Compute the correlation between two, single-channel, grayscale input images. The second image must be smaller than the first. :param other: the Image we're looking for

scale (*s*)
resize image by factor s

Parameters **s** – (sx, sy) tuple of float scaling factor, or scalar s=sx=sy

Returns Image scaled

shift(*dx*, *dy*, ***kwargs*)

expand(*size*, *ox=None*, *oy=None*)

Returns image in larger canvas size, pasted at ox,oy

compose(*other*, *a=0.5*, *b=0.5*, *mode=None*)
compose new image from a*self + b*other

add(*other*, *pos=(0, 0)*, *alpha=1*, *mode=None*)
simply adds other image at px,py (subbixel) coordinates

__add__(*other*)

__radd__(*other*)
only to allow sum(images) easily

sub(*other*, *pos=(0, 0)*, *alpha=1*, *mode=None*)

__sub__(*other*)

deltaE(*other*)

__mul__(*other*)

__div__(*f*)

__truediv__(*f*)

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__le__
Return self<=value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

html(***kwargs*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

svg(***kwargs*)

Goulib.image.**alpha_composite**(*front*, *back*)
Alpha composite two RGBA images.

Source: http://stackoverflow.com/a/9166671/284318

Keyword Arguments: front – PIL RGBA Image object back – PIL RGBA Image object

The algorithm comes from http://en.wikipedia.org/wiki/Alpha_compositing

Goulib.image.**alpha_composite_with_color**(*image*, *color=(255, 255, 255)*)
Alpha composite an RGBA image with a single color image of the specified color and the same size as the original image.

Keyword Arguments: image – PIL RGBA Image object color – Tuple r, g, b (default 255, 255, 255)

Goulib.image.**pure_pil_alpha_to_color_v1**(*image*, *color=(255, 255, 255)*)
Alpha composite an RGBA Image with a specified color.

NOTE: This version is much slower than the alpha_composite_with_color solution. Use it only if numpy is not available.

Source: http://stackoverflow.com/a/9168169/284318

Keyword Arguments: image – PIL RGBA Image object color – Tuple r, g, b (default 255, 255, 255)

Goulib.image.**pure_pil_alpha_to_color_v2**(*image*, *color=(255, 255, 255)*)
Alpha composite an RGBA Image with a specified color.

Simpler, faster version than the solutions above.

Source: http://stackoverflow.com/a/9459208/284318

Keyword Arguments: image – PIL RGBA Image object color – Tuple r, g, b (default 255, 255, 255)

Goulib.image.**disk**(*radius*, *antialias=1*)

Goulib.image.**fspecial**(*name*, ***kwargs*)
mimics the Matlab image toolbox fspecial function http://www.mathworks.com/help/images/ref/fspecial.html?refresh=true

Goulib.image.**normalize**(*a*, *newmax=255*, *newmin=0*)

Goulib.image.**read_pdf**(*filename*, ***kwargs*)
reads a bitmap graphics on a .pdf file only the first page is parsed

`Goulib.image.`**`fig2img`**(*fig*)

Convert a Matplotlib figure to a PIL Image in RGBA format and return it

Parameters **`fig`** – matplotlib figure

Returns PIL image

`Goulib.image.`**`quantize`**(*image*, *N=2*, *L=None*)

Quantize a gray image. :param image: ndarray input image. :param N: int number of quantization levels. :param L: float max value.

`Goulib.image.`**`randomize`**(*image*, *N=2*, *L=None*)

`class` `Goulib.image.`**`Ditherer`**(*name*, *method*)

Bases: `object`

`__init__`(*name*, *method*)

Initialize self. See help(type(self)) for accurate signature.

`__call__`(*image*, *N=2*)

Call self as a function.

`__repr__`()

Return repr(self).

`__class__`

alias of `builtins.type`

`__delattr__`

Implement delattr(self, name).

`__dir__`() → list

default dir() implementation

`__eq__`

Return self==value.

`__format__`()

default object formatter

`__ge__`

Return self>=value.

`__getattribute__`

Return getattr(self, name).

`__gt__`

Return self>value.

`__hash__`

Return hash(self).

`__le__`

Return self<=value.

`__lt__`

Return self<value.

`__ne__`

Return self!=value.

`__new__`()

Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.image.**ErrorDiffusion**(*name*, *positions*, *weights*, *wsum=None*)
Bases: *Goulib.image.Ditherer*

__init__(*name*, *positions*, *weights*, *wsum=None*)
Initialize self. See help(type(self)) for accurate signature.

__call__(*image*, *N=2*)
Call self as a function.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.image.**FloydSteinberg**
Bases: *Goulib.image.ErrorDiffusion*

__init__()
Initialize self. See help(type(self)) for accurate signature.

__call__(*image*, *N=2*)
Call self as a function.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.image.**dither**(*image*, *method=3*, *N=2*)
Quantize a gray image, using dithering. :param image: ndarray input image. :param method: key in dithering dict :param N: int number of quantization levels. References ——— http://www.efg2.com/Lab/Library/ImageProcessing/DHALF.TXT

Goulib.image.**gray2bool**(*image*, *method=3*, *N=2*)
Quantize a gray image, using dithering. :param image: ndarray input image. :param method: key in dithering dict :param N: int number of quantization levels. References ——— http://www.efg2.com/Lab/Library/ImageProcessing/DHALF.TXT

Goulib.image.**rgb2cmyk**(*rgb*)

Goulib.image.**cmyk2rgb**(*cmyk*)

Goulib.image.**gray2rgb**(*im*, *color0=(0, 0, 0)*, *color1=(1, 1, 1)*)

Goulib.image.**bool2rgb**(*im*, *color0=(0, 0, 0)*, *color1=(1, 1, 1)*)

Goulib.image.**bool2gray**(*im*)

Goulib.image.**rgb2rgba**(*array*)

Goulib.image.**palette**(*im*, *ncolors*, *tol=0.01*)
extract the color palette of image array (in its own colorspace. use Lab for best results) :param im: nparray (x,y,n) containing image :param ncolors: int number of colors :param tol: tolerance for precision/speed compromise. 1/100 means about 100 points per color are taken for kmeans segmentation :return: array of ncolors most used in image (center of kmeans centroids)

Goulib.image.**lab2ind**(*im*, *colors=256*)
convert a Lab image to indexed colors :param a: nparray (x,y,n) containing image :param colors: int number of colors or predefined Palette :ref: http://scikit-learn.org/stable/auto_examples/cluster/plot_color_quantization.html

Goulib.image.**ind2any**(*im*, *palette*, *dest*)

Goulib.image.**ind2rgb**(*im*, *palette*)

Goulib.image.**convert**(*a*, *source*, *target*, ***kwargs*)
convert an image between modes, eventually using intermediary steps :param a: nparray (x,y,n) containing image :param source: string : key of source image mode in modes :param target: string : key of target image mode in modes

2.11 Goulib.interval module

operations on [a..b[intervals

`Goulib.interval.in_interval`(*interval*, *x*, *closed=True*)

Returns bool True if x is in interval [a,b] or [b,a] (tuple)

`Goulib.interval.intersect`(*t1*, *t2*)

Returns bool True if intervals [t1[[t2[intersect

`Goulib.interval.intersection`(*t1*, *t2*)

Returns tuple intersection between 2 intervals (tuples),

or None if intervals don't intersect

`Goulib.interval.intersectlen`(*t1*, *t2*, *none=0*)

Parameters

- **t1** – interval 1 (tuple)
- **t2** – interval 2 (tuple)
- **none** – value to return when t1 does not intersect t2

Returns len of intersection between 2 intervals (tuples),

or none if intervals don't intersect

class `Goulib.interval.Interval`(*start*, *end*)

Bases: `list`

Represents an interval. Defined as half-open interval [start,end), which includes the start position but not the end. Start and end do not have to be numeric types. They might especially be time, date or timedate as used in datetime2

inspired from http://code.activestate.com/recipes/576816-interval/ alternatives could be https://pypi.python.org/pypi/interval/

(outdated, no more doc) or https://pypi.python.org/pypi/pyinterval/

Construct, start must be <= end.

`__init__`(*start*, *end*)

Construct, start must be <= end.

`start`

The interval's start

`end`

The interval's end

`__str__`()

Return str(self).

`__repr__`()

Return repr(self).

`__hash__`()

Return hash(self).

`__lt__`(*other*)

Return self<value.

__eq__(*other*)
Return self==value.

size

center

separation(*other*)

Returns distance between self and other, negative if overlap

overlap(*other*, *allow_contiguous=False*)

Returns True iff self intersects other.

intersection(*other*)

Returns Intersection with other, or None if no intersection.

__iadd__(*other*)
expands self to contain other.

hull(*other*)

Returns new Interval containing both self and other.

__add__(*other*)
Return self+value.

__contains__(*x*)

Returns True if x in self.

subset(*other*)

Returns True iff self is subset of other.

proper_subset(*other*)

Returns True iff self is proper subset of other.

empty()

Returns True iff self is empty.

__nonzero__()

singleton()

Returns True iff self.end - self.start == 1.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__imul__
Implement self*=value.

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

append(*object*) → None – append object to end

clear() → None – remove all items from L

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

extend(*iterable*) → None – extend list by appending elements from the iterable

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

reverse()
L.reverse() – reverse *IN PLACE*

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

class Goulib.interval.**Intervals**(*iterable=None*, *key=<function identity>*)
Bases: `sortedcontainers.sortedlist.SortedKeyList`

a list of intervals kept in ascending order

Initialize sorted-key list instance.

Optional *iterable* argument provides an initial iterable of values to initialize the sorted-key list.

Optional *key* argument defines a callable that, like the *key* argument to Python's *sorted* function, extracts a comparison key from each value. The default is the identity function.

Runtime complexity: *O(n*log(n))*

```
>>> from operator import neg
>>> skl = SortedKeyList(key=neg)
>>> skl
SortedKeyList([], key=<built-in function neg>)
>>> skl = SortedKeyList([3, 1, 2], key=neg)
>>> skl
SortedKeyList([3, 2, 1], key=<built-in function neg>)
```

Parameters

- **iterable** – initial values (optional)
- **key** – function used to extract comparison key (optional)

update(*iterable*)
Update the list by adding all elements from *iterable*.

add(*item*)
Add *value* to sorted-key list.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList(key=neg)
>>> skl.add(3)
>>> skl.add(1)
>>> skl.add(2)
>>> skl
SortedKeyList([3, 2, 1], key=<built-in function neg>)
```

Parameters **value** – value to add to sorted-key list

insert(*item*)
Raise not-implemented error.

Raises `NotImplementedError` – use `sl.add(value)` instead

`__iadd__`(*item*)

Update sorted list with values from *other*.

`sl.__iadd__(other)` <==> `sl += other`

Values in *other* do not need to be in sorted order.

Runtime complexity: *O(k*log(n))* – approximate.

```
>>> sl = SortedList('bat')
>>> sl += 'cat'
>>> sl
SortedList(['a', 'a', 'b', 'c', 't', 't'])
```

Parameters **`other`** – other iterable

Returns existing sorted list

`__add__`(*item*)

Return new sorted-key list containing all values in both sequences.

`skl.__add__(other)` <==> `skl + other`

Values in *other* do not need to be in sorted-key order.

Runtime complexity: *O(n*log(n))*

```
>>> from operator import neg
>>> skl1 = SortedKeyList([5, 4, 3], key=neg)
>>> skl2 = SortedKeyList([2, 1, 0], key=neg)
>>> skl1 + skl2
SortedKeyList([5, 4, 3, 2, 1, 0], key=<built-in function neg>)
```

Parameters **`other`** – other iterable

Returns new sorted-key list

`__call__`(*x*)

returns intervals containing x

`__str__`()

string representation : like a list of Intervals

`DEFAULT_LOAD_FACTOR = 1000`

`__abstractmethods__ = frozenset()`

`__class__`

alias of `abc.ABCMeta`

`__contains__`(*value*)

Return true if *value* is an element of the sorted-key list.

`skl.__contains__(value)` <==> `value in skl`

Runtime complexity: *O(log(n))*

```
>>> from operator import neg
>>> skl = SortedKeyList([1, 2, 3, 4, 5], key=neg)
>>> 3 in skl
True
```

Parameters **value** – search for value in sorted-key list

Returns true if *value* in sorted-key list

__copy__()

Return a shallow copy of the sorted-key list.

Runtime complexity: *O(n)*

Returns new sorted-key list

__delattr__

Implement delattr(self, name).

__delitem__(*index*)

Remove value at *index* from sorted list.

`sl.__delitem__(index)` <==> `del sl[index]`

Supports slicing.

Runtime complexity: *O(log(n))* – approximate.

```
>>> sl = SortedList('abcde')
>>> del sl[2]
>>> sl
SortedList(['a', 'b', 'd', 'e'])
>>> del sl[:2]
>>> sl
SortedList(['d', 'e'])
```

Parameters **index** – integer or slice for indexing

Raises **IndexError** – if index out of range

__dir__() → list

default dir() implementation

__eq__(*other*)

Return true if and only if sorted list is equal to *other*.

`sl.__eq__(other)` <==> `sl == other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **other** – *other* sequence

Returns true if sorted list is equal to *other*

__format__()

default object formatter

__ge__(*other*)

Return true if and only if sorted list is greater than or equal to *other*.

`sl.__ge__(other) <==> sl >= other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **other** – *other* sequence

Returns true if sorted list is greater than or equal to *other*

__getattribute__
Return getattr(self, name).

__getitem__(*index*)
Lookup value at *index* in sorted list.

`sl.__getitem__(index) <==> sl[index]`

Supports slicing.

Runtime complexity: *O(log(n))* – approximate.

```
>>> sl = SortedList('abcde')
>>> sl[1]
'b'
>>> sl[-1]
'e'
>>> sl[2:5]
['c', 'd', 'e']
```

Parameters **index** – integer or slice for indexing

Returns value or list of values

Raises **IndexError** – if index out of range

__gt__(*other*)
Return true if and only if sorted list is greater than *other*.

`sl.__gt__(other) <==> sl > other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **other** – *other* sequence

Returns true if sorted list is greater than *other*

__hash__ = None

__imul__(*num*)
Update the sorted list with *num* shallow copies of values.

`sl.__imul__(num) <==> sl *= num`

Runtime complexity: *O(n*log(n))*

```
>>> sl = SortedList('abc')
>>> sl *= 3
>>> sl
SortedList(['a', 'a', 'a', 'b', 'b', 'b', 'c', 'c', 'c'])
```

Parameters **num** (*int*) – count of shallow copies

Returns existing sorted list

`__init__`(*iterable=None, key=<function identity>*)
Initialize sorted-key list instance.

Optional *iterable* argument provides an initial iterable of values to initialize the sorted-key list.

Optional *key* argument defines a callable that, like the *key* argument to Python's *sorted* function, extracts a comparison key from each value. The default is the identity function.

Runtime complexity: *O(n*log(n))*

```
>>> from operator import neg
>>> skl = SortedKeyList(key=neg)
>>> skl
SortedKeyList([], key=<built-in function neg>)
>>> skl = SortedKeyList([3, 1, 2], key=neg)
>>> skl
SortedKeyList([3, 2, 1], key=<built-in function neg>)
```

Parameters

- **`iterable`** – initial values (optional)
- **`key`** – function used to extract comparison key (optional)

`__iter__`()
Return an iterator over the sorted list.

`sl.__iter__()` <==> `iter(sl)`

Iterating the sorted list while adding or deleting values may raise a `RuntimeError` or fail to iterate over all values.

`__le__`(*other*)
Return true if and only if sorted list is less than or equal to *other*.

`sl.__le__(other)` <==> `sl <= other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **`other`** – *other* sequence

Returns true if sorted list is less than or equal to *other*

`__len__`()
Return the size of the sorted list.

`sl.__len__()` <==> `len(sl)`

Returns size of sorted list

`__lt__`(*other*)
Return true if and only if sorted list is less than *other*.

`sl.__lt__(other)` <==> `sl < other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **`other`** – *other* sequence

Returns true if sorted list is less than *other*

__mul__(*num*)

Return new sorted-key list with *num* shallow copies of values.

`skl.__mul__(num) <==> skl * num`

Runtime complexity: *O(n*log(n))*

```
>>> from operator import neg
>>> skl = SortedKeyList([3, 2, 1], key=neg)
>>> skl * 2
SortedKeyList([3, 3, 2, 2, 1, 1], key=<built-in function neg>)
```

Parameters **num** (*int*) – count of shallow copies

Returns new sorted-key list

__ne__(*other*)

Return true if and only if sorted list is not equal to *other*.

`sl.__ne__(other) <==> sl != other`

Comparisons use lexicographical order as with sequences.

Runtime complexity: *O(n)*

Parameters **other** – *other* sequence

Returns true if sorted list is not equal to *other*

static __new__(*cls*, *iterable=None*, *key=<function identity>*)

Create new sorted list or sorted-key list instance.

Optional *key*-function argument will return an instance of subtype `SortedKeyList`.

```
>>> sl = SortedList()
>>> isinstance(sl, SortedList)
True
>>> sl = SortedList(key=lambda x: -x)
>>> isinstance(sl, SortedList)
True
>>> isinstance(sl, SortedKeyList)
True
```

Parameters

- **iterable** – initial values (optional)
- **key** – function used to extract comparison key (optional)

Returns sorted list or sorted-key list instance

__radd__(*other*)

Return new sorted-key list containing all values in both sequences.

`skl.__add__(other) <==> skl + other`

Values in *other* do not need to be in sorted-key order.

Runtime complexity: *O(n*log(n))*

```
>>> from operator import neg
>>> skl1 = SortedKeyList([5, 4, 3], key=neg)
>>> skl2 = SortedKeyList([2, 1, 0], key=neg)
>>> skl1 + skl2
SortedKeyList([5, 4, 3, 2, 1, 0], key=<built-in function neg>)
```

Parameters **other** – other iterable

Returns new sorted-key list

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return string representation of sorted-key list.

`skl.__repr__()` <==> `repr(skl)`

Returns string representation

__reversed__()
Return a reverse iterator over the sorted list.

`sl.__reversed__()` <==> `reversed(sl)`

Iterating the sorted list while adding or deleting values may raise a `RuntimeError` or fail to iterate over all values.

__rmul__(*num*)
Return new sorted list with *num* shallow copies of values.

`sl.__mul__(num)` <==> `sl * num`

Runtime complexity: *O(n*log(n))*

```
>>> sl = SortedList('abc')
>>> sl * 3
SortedList(['a', 'a', 'a', 'b', 'b', 'b', 'c', 'c', 'c'])
```

Parameters **num** (`int`) – count of shallow copies

Returns new sorted list

__setattr__
Implement setattr(self, name, value).

__setitem__(*index*, *value*)
Raise not-implemented error.

`sl.__setitem__(index, value)` <==> `sl[index] = value`

Raises **NotImplementedError** – use `del sl[index]` and `sl.add(value)` instead

__sizeof__() → int
size of object in memory, in bytes

__slots__ = ()

append(*value*)
Raise not-implemented error.

Implemented to override *MutableSequence.append* which provides an erroneous default implementation.

Raises `NotImplementedError` – use `sl.add(value)` instead

bisect(*value*)
Return an index to insert *value* in the sorted-key list.

Similar to *bisect_left*, but if *value* is already present, the insertion point with be after (to the right of) any existing values.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_right(1)
5
```

Parameters **value** – insertion index of value in sorted-key list

Returns index

bisect_key(*key*)
Return an index to insert *key* in the sorted-key list.

Similar to *bisect_key_left*, but if *key* is already present, the insertion point with be after (to the right of) any existing keys.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_key_right(-1)
5
```

Parameters **key** – insertion index of key in sorted-key list

Returns index

bisect_key_left(*key*)
Return an index to insert *key* in the sorted-key list.

If the *key* is already present, the insertion point will be before (to the left of) any existing keys.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_key_left(-1)
4
```

Parameters **key** – insertion index of key in sorted-key list

Returns index

bisect_key_right (*key*)
Return an index to insert *key* in the sorted-key list.

Similar to *bisect_key_left*, but if *key* is already present, the insertion point with be after (to the right of) any existing keys.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_key_right(-1)
5
```

Parameters **key** – insertion index of key in sorted-key list

Returns index

bisect_left (*value*)
Return an index to insert *value* in the sorted-key list.

If the *value* is already present, the insertion point will be before (to the left of) any existing values.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_left(1)
4
```

Parameters **value** – insertion index of value in sorted-key list

Returns index

bisect_right (*value*)
Return an index to insert *value* in the sorted-key list.

Similar to *bisect_left*, but if *value* is already present, the insertion point with be after (to the right of) any existing values.

Similar to the *bisect* module in the standard library.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedList([5, 4, 3, 2, 1], key=neg)
>>> skl.bisect_right(1)
5
```

Parameters **value** – insertion index of value in sorted-key list

Returns index

clear ()
Remove all values from sorted-key list.

Runtime complexity: *O(n)*

copy()

Return a shallow copy of the sorted-key list.

Runtime complexity: *O(n)*

Returns new sorted-key list

count(*value*)

Return number of occurrences of *value* in the sorted-key list.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([4, 4, 4, 4, 3, 3, 3, 2, 2, 1], key=neg)
>>> skl.count(2)
2
```

Parameters **value** – value to count in sorted-key list

Returns count

discard(*value*)

Remove *value* from sorted-key list if it is a member.

If *value* is not a member, do nothing.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([5, 4, 3, 2, 1], key=neg)
>>> skl.discard(1)
>>> skl.discard(0)
>>> skl == [5, 4, 3, 2]
True
```

Parameters **value** – *value* to discard from sorted-key list

extend(*values*)

Raise not-implemented error.

Implemented to override *MutableSequence.extend* which provides an erroneous default implementation.

Raises `NotImplementedError` – use `sl.update(values)` instead

index(*value, start=None, stop=None*)

Return first index of value in sorted-key list.

Raise ValueError if *value* is not present.

Index must be between *start* and *stop* for the *value* to be considered present. The default value, None, for *start* and *stop* indicate the beginning and end of the sorted-key list.

Negative indices are supported.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([5, 4, 3, 2, 1], key=neg)
>>> skl.index(2)
3
>>> skl.index(0)
```

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```
Traceback (most recent call last):
  ...
ValueError: 0 is not in list
```

Parameters

- **value** – value in sorted-key list
- **start** (*int*) – start index (default None, start of sorted-key list)
- **stop** (*int*) – stop index (default None, end of sorted-key list)

Returns index of value

Raises ValueError – if value is not present

irange(*minimum=None*, *maximum=None*, *inclusive=(True*, *True)*, *reverse=False*)

Create an iterator of values between *minimum* and *maximum*.

Both *minimum* and *maximum* default to *None* which is automatically inclusive of the beginning and end of the sorted-key list.

The argument *inclusive* is a pair of booleans that indicates whether the minimum and maximum ought to be included in the range, respectively. The default is `(True, True)` such that the range is inclusive of both minimum and maximum.

When *reverse* is *True* the values are yielded from the iterator in reverse order; *reverse* defaults to *False*.

```
>>> from operator import neg
>>> skl = SortedKeyList([11, 12, 13, 14, 15], key=neg)
>>> it = skl.irange(14.5, 11.5)
>>> list(it)
[14, 13, 12]
```

Parameters

- **minimum** – minimum value to start iterating
- **maximum** – maximum value to stop iterating
- **inclusive** – pair of booleans
- **reverse** (*bool*) – yield values in reverse order

Returns iterator

irange_key(*min_key=None*, *max_key=None*, *inclusive=(True*, *True)*, *reverse=False*)

Create an iterator of values between *min_key* and *max_key*.

Both *min_key* and *max_key* default to *None* which is automatically inclusive of the beginning and end of the sorted-key list.

The argument *inclusive* is a pair of booleans that indicates whether the minimum and maximum ought to be included in the range, respectively. The default is `(True, True)` such that the range is inclusive of both minimum and maximum.

When *reverse* is *True* the values are yielded from the iterator in reverse order; *reverse* defaults to *False*.

```
>>> from operator import neg
>>> skl = SortedKeyList([11, 12, 13, 14, 15], key=neg)
>>> it = skl.irange_key(-14, -12)
>>> list(it)
[14, 13, 12]
```

Parameters

- **min_key** – minimum key to start iterating
- **max_key** – maximum key to stop iterating
- **inclusive** – pair of booleans
- **reverse** (*bool*) – yield values in reverse order

Returns iterator

islice (*start=None*, *stop=None*, *reverse=False*)

Return an iterator that slices sorted list from *start* to *stop*.

The *start* and *stop* index are treated inclusive and exclusive, respectively.

Both *start* and *stop* default to *None* which is automatically inclusive of the beginning and end of the sorted list.

When *reverse* is *True* the values are yielded from the iterator in reverse order; *reverse* defaults to *False*.

```
>>> sl = SortedList('abcdefghij')
>>> it = sl.islice(2, 6)
>>> list(it)
['c', 'd', 'e', 'f']
```

Parameters

- **start** (*int*) – start index (inclusive)
- **stop** (*int*) – stop index (exclusive)
- **reverse** (*bool*) – yield values in reverse order

Returns iterator

key

Function used to extract comparison key from values.

pop (*index=-1*)

Remove and return value at *index* in sorted list.

Raise `IndexError` if the sorted list is empty or index is out of range.

Negative indices are supported.

Runtime complexity: *O(log(n))* – approximate.

```
>>> sl = SortedList('abcde')
>>> sl.pop()
'e'
>>> sl.pop(2)
'c'
>>> sl
SortedList(['a', 'b', 'd'])
```

Parameters **index** (*int*) – index of value (default -1)

Returns value

Raises **IndexError** – if index is out of range

remove(*value*)

Remove *value* from sorted-key list; *value* must be a member.

If *value* is not a member, raise ValueError.

Runtime complexity: *O(log(n))* – approximate.

```
>>> from operator import neg
>>> skl = SortedKeyList([1, 2, 3, 4, 5], key=neg)
>>> skl.remove(5)
>>> skl == [4, 3, 2, 1]
True
>>> skl.remove(0)
Traceback (most recent call last):
  ...
ValueError: 0 not in list
```

Parameters **value** – *value* to remove from sorted-key list

Raises **ValueError** – if *value* is not in sorted-key list

reverse()

Raise not-implemented error.

Sorted list maintains values in ascending sort order. Values may not be reversed in-place.

Use `reversed(sl)` for an iterator over values in descending sort order.

Implemented to override *MutableSequence.reverse* which provides an erroneous default implementation.

Raises **NotImplementedError** – use `reversed(sl)` instead

class Goulib.interval.**Box**(**args*)

Bases: `list`

a N dimensional rectangular box defined by a list of N Intervals

__init__(**args*)

Initialize self. See help(type(self)) for accurate signature.

corner(*n*)

return n-th corner of box 0-th corner is "start" made of all minimal values of intervals -1.th corner is "end", made of all maximal values of intervals

start

end

min

max

size

center

__call__()

Returns tuple of all intervals as tuples

`__iadd__`(*other*)
enlarge box if required to contain specified point :param other: *`Box`* or (list of) N-tuple point(s)

`__add__`(*other*)
enlarge box if required to contain specified point :param other: *`Box`* or (list of) N-tuple point(s) :return: new Box containing both

`__contains__`(*other*)

Returns True if x in self.

`__nonzero__`()

`empty`()

Returns True iff Box is empty.

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__delitem__`
Delete self[key].

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__getitem__`()
x.__getitem__(y) <==> x[y]

`__gt__`
Return self>value.

`__hash__ = None`

`__imul__`
Implement self*=value.

`__iter__`
Implement iter(self).

`__le__`
Return self<=value.

`__len__`
Return len(self).

`__lt__`
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

append(*object*) → None – append object to end

clear() → None – remove all items from L

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

extend(*iterable*) → None – extend list by appending elements from the iterable

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

insert()
L.insert(index, object) – insert object before index

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

reverse()
L.reverse() – reverse *IN PLACE*

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

2.12 Goulib.itertools2 module

additions to `itertools` standard library

`Goulib.itertools2.`**`identity`**(*x*)
Do nothing and return the variable untouched

`Goulib.itertools2.`**`isiterable`**(*obj*)

Result bool True if obj is iterable (but not a string)

`Goulib.itertools2.`**`iscallable`**(*f*)

`Goulib.itertools2.`**`any`**(*seq*, *pred=<class 'bool'>*)

Result bool True if pred(x) is True for at least one element in the iterable

`Goulib.itertools2.`**`all`**(*seq*, *pred=<class 'bool'>*)

Result bool True if pred(x) is True for all elements in the iterable

`Goulib.itertools2.`**`no`**(*seq*, *pred=<class 'bool'>*)

Result bool True if pred(x) is False for every element in the iterable

`Goulib.itertools2.`**`index`**(*value*, *iterable*)

Result integer index of value in iterable

`Goulib.itertools2.`**`first`**(*iterable*)

Result first element in the iterable

`Goulib.itertools2.`**`last`**(*iterable*)

Result last element in the iterable

`Goulib.itertools2.`**`takeevery`**(*n*, *iterable*, *start=0*)
Take an element from iterator every n elements

`Goulib.itertools2.`**`every`**(*n*, *iterable*, *start=0*)
Take an element from iterator every n elements

`Goulib.itertools2.`**`take`**(*n*, *iterable*)

Result first n items from iterable

`Goulib.itertools2.`**`drop`**(*n*, *iterable*)
Drop n elements from iterable and return the rest

`Goulib.itertools2.`**`enumerates`**(*iterable*)
generalizes enumerate to dicts :result: key,value pair for whatever iterable type

`Goulib.itertools2.`**`ilen`**(*it*)

Result int length exhausting an iterator

`Goulib.itertools2.`**`irange`**(*start_or_end*, *optional_end=None*)

Result iterable that counts from start to end (both included).

`Goulib.itertools2.`**`arange`**(*start*, *stop=None*, *step=1*)
range for floats or other types (*numpy.arange* without numpy)

Parameters

- **`start`** – optional number. Start of interval. The interval includes this value. The default start value is 0.

- **stop** – number. End of interval. The interval does not include this value, except in some cases where step is not an integer and floating point round-off affects the length of out.
- **step** – optional number. Spacing between values. For any output out, this is the distance between two adjacent values, out[i+1] - out[i]. The default step size is 1.

Result iterator

`Goulib.itertools2.`**`linspace`**(*start*, *end*, *n=100*)
iterator over n values linearly interpolated between (and including) start and end *numpy.linspace* without numpy

Parameters

- **start** – number, or iterable vector
- **end** – number, or iterable vector
- **n** – int number of interpolated values

Result iterator

`Goulib.itertools2.`**`flatten`**(*l*, *donotrecursein=(<class 'str'>,)*)
iterator to flatten (depth-first) structure

Parameters

- **l** – iterable structure
- **donotrecursein** – iterable types in which algo doesn't recurse string type by default

`Goulib.itertools2.`**`itemgetter`**(*iterable*, *i*)

`Goulib.itertools2.`**`recurse`**(*f*, *x*)

`Goulib.itertools2.`**`swap`**(*iterable*)

`Goulib.itertools2.`**`tee`**(*iterable*, *n=2*, *copy=None*)
tee or copy depending on type and goal

Parameters

- **iterable** – any iterable
- **n** – int number of tees/copies to return
- **copy** – optional copy function, for exemple copy.copy or copy.deepcopy

Result tee of iterable if it's an iterator or generator, or (deep)copies for other types

this function is useful to avoid side effects at a lower memory cost depending on the case

`Goulib.itertools2.`**`groups`**(*iterable*, *n*, *step=None*)
Make groups of 'n' elements from the iterable advancing 'step' elements on each iteration

`Goulib.itertools2.`**`pairwise`**(*iterable*, *op=None*, *loop=False*)
iterates through consecutive pairs

Parameters

- **iterable** – input iterable s1,s2,s3, ... sn
- **op** – optional operator to apply to each pair
- **loop** – boolean True if last pair should be (sn,s1) to close the loop

Result pairs iterator (s1,s2), (s2,s3) ... (si,si+1), ... (sn-1,sn) + optional pair to close the loop

`Goulib.itertools2.`**`select`**(*it1*, *it2*, *op*)

Goulib.itertools2.**shape**(*iterable*)
shape of a mutidimensional array, without numpy

Parameters **iterable** – iterable of iterable … of iterable or numpy arrays…

Result list of n ints corresponding to iterable's len of each dimension

Warning if iterable is not a (hyper) rect matrix, shape is evaluated from

the [0,0,…0] element … :see: http://docs.scipy.org/doc/numpy-1.10.1/reference/generated/numpy.ndarray.shape.html

Goulib.itertools2.**ndim**(*iterable*)
number of dimensions of a mutidimensional array, without numpy

Parameters **iterable** – iterable of iterable … of iterable or numpy arrays…

Result int number of dimensions

Goulib.itertools2.**reshape**(*data*, *dims*)

Result data as a n-dim matrix

Goulib.itertools2.**compose**(*f*, *g*)
Compose two functions -> compose(f, g)(x) -> f(g(x))

Goulib.itertools2.**iterate**(*func*, *arg*)
After Haskell's iterate: apply function repeatedly.

Goulib.itertools2.**accumulate**(*iterable*, *func=<built-in function add>*, *skip_first=False*)
Return running totals. extends *python.accumulate*

accumulate([1,2,3,4,5]) –> 1 3 6 10 15 # accumulate([1,2,3,4,5], operator.mul) –> 1 2 6 24 120

Goulib.itertools2.**record**(*iterable*, *it=count(0)*, *max=0*)
return the index and value of iterable which exceed previous max

Goulib.itertools2.**record_index**(*iterable*, *it=count(0)*, *max=0*)

Goulib.itertools2.**record_value**(*iterable*, *it=count(0)*, *max=0*)

Goulib.itertools2.**tails**(*seq*)
Get tails of a sequence

tails([1,2,3]) -> [1,2,3], [2,3], [3], [].

Goulib.itertools2.**ireduce**(*func*, *iterable*, *init=None*)
Like *python.reduce* but using iterators (a.k.a scanl)

Goulib.itertools2.**occurences**(*iterable*)
count number of occurences of each item in a finite iterable

Parameters **iterable** – finite iterable

Returns dict of int count indexed by item

Goulib.itertools2.**compress**(*iterable*, *key=<function identity>*, *buffer=None*)
generates (item,count) pairs by counting the number of consecutive items in iterable)

Parameters

- **iterable** – iterable, possibly infinite
- **key** – optional function defining which elements are considered equal
- **buffer** – optional integer. if defined, iterable is sorted with this buffer

`Goulib.itertools2.`**`unique`**(*iterable*, *key=None*, *buffer=100*)
generate unique elements, preserving order. :param iterable: iterable, possibly infinite :param key: optional function defining which elements are considered equal :param buffer: optional integer defining how many of the last unique elements to keep in memory mandatory if iterable is infinite

unique('AAAABBBCCDAABBB') –> A B C D # unique('ABBCcAD', str.lower) –> A B C D

`Goulib.itertools2.`**`count_unique`**(*iterable*, *key=None*)
Count unique elements

count_unique('AAAABBBCCDAABBB') –> 4 # count_unique('ABBCcAD', str.lower) –> 4

`Goulib.itertools2.`**`combinations_with_replacement`**(*iterable*, *r*)
combinations_with_replacement('ABC', 2) –> AA AB AC BB BC CC same as combinations_with_replacement except it doesn't generate duplicates

`Goulib.itertools2.`**`takenth`**(*n*, *iterable*, *default=None*)

Result nth item of iterable

`Goulib.itertools2.`**`nth`**(*n*, *iterable*, *default=None*)

Result nth item of iterable

`Goulib.itertools2.`**`icross`**(**sequences*)
Cartesian product of sequences (recursive version)

`Goulib.itertools2.`**`quantify`**(*iterable*, *pred=<class 'bool'>*)

Result int count how many times the predicate is true

`Goulib.itertools2.`**`interleave`**(*l1*, *l2*)

Parameters

- **`l1`** – iterable
- **`l2`** – iterable of same length, or 1 less than l1

Result iterable interleaving elements from l1 and l2, starting by l1[0]

`Goulib.itertools2.`**`shuffle`**(*ary*)

Param array to shuffle by Fisher-Yates algorithm

Result shuffled array (IN PLACE!)

See http://www.drgoulu.com/2013/01/19/comment-bien-brasser-les-cartes/

`Goulib.itertools2.`**`rand_seq`**(*size*)

Result range(size) shuffled

`Goulib.itertools2.`**`all_pairs`**(*size*)
generates all i,j pairs for i,j from 0-size

`Goulib.itertools2.`**`index_min`**(*values*, *key=<function identity>*)

Result min_index, min_value

`Goulib.itertools2.`**`index_max`**(*values*, *key=<function identity>*)

Result max_index, max_value

`Goulib.itertools2.`**`best`**(*iterable*, *key=None*, *n=1*, *reverse=False*)
generate items corresponding to the n best values of key sort order

`Goulib.itertools2.`**`sort_indexes`**(*iterable*, *key=<function identity>*, *reverse=False*)

Returns iterator over indexes of iterable that correspond to the sorted iterable

`Goulib.itertools2.filter2(iterable, condition)`
like *python.filter* but returns 2 lists : - list of elements in iterable that satisfy condition - list of those that don't

`Goulib.itertools2.ifind(iterable, f, reverse=False)`
iterates through items in iterable where f(item) == True.

`Goulib.itertools2.iremove(iterable, f)`
removes items from an iterable based on condition :param iterable: iterable . will be modified in place :param f: function of the form lambda line:bool returning True if item should be removed :yield: removed items backwards

`Goulib.itertools2.removef(iterable, f)`
removes items from an iterable based on condition :param iterable: iterable . will be modified in place :param f: function of the form lambda line:bool returning True if item should be removed :result: list of removed items.

`Goulib.itertools2.find(iterable, f)`
Return first item in iterable where f(item) == True.

`Goulib.itertools2.isplit(iterable, sep, include_sep=False)`
split iterable by separators or condition :param sep: value or function(item) returning True for items that separate :param include_sep: bool. If True the separators items are included in output, at beginning of each sub-iterator :result: iterates through slices before, between, and after separators

`Goulib.itertools2.split(iterable, sep, include_sep=False)`
like https://docs.python.org/2/library/stdtypes.html#str.split, but for iterable :param sep: value or function(item) returning True for items that separate :param include_sep: bool. If True the separators items are included in output, at beginning of each sub-iterator :result: list of iterable slices before, between, and after separators

`Goulib.itertools2.dictsplit(dic, keys)`
extract keys from dic :param dic: dict source :param keys: iterable of dict keys :result: dict,dict : the first contains entries present in source, the second the remaining entries

`Goulib.itertools2.next_permutation(seq, pred=<function <lambda>>)`
Like C++ std::next_permutation() but implemented as generator. see http://blog.bjrn.se/2008/04/lexicographic-permutations-using.html :param seq: iterable :param pred: a function (a,b) that returns a negative number if a<b, like cmp(a,b) in Python 2.7

class `Goulib.itertools2.iter2(iterable)`
Bases: `object`

Takes in an object that is iterable. http://code.activestate.com/recipes/578092-flattening-an-arbitrarily-deep-list-or-any-iterato/ Allows for the following method calls (that should be built into iterators anyway…) calls: - append - appends another iterable onto the iterator. - insert - only accepts inserting at the 0 place, inserts an iterable before other iterables. - adding. an iter2 object can be added to another object that is iterable. i.e. iter2 + iter (not iter + iter2). It's best to make all objects iter2 objects to avoid syntax errors. :D

`__init__(iterable)`
Initialize self. See help(type(self)) for accurate signature.

`append(iterable)`

`insert(place, iterable)`

`__add__(iterable)`

`__next__()`

`next()`

`__iter__()`

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.itertools2.**subdict**(*d*, *keys*)
extract "sub-dictionary" :param d: dict :param keys: container of keys to extract: :result: dict: :see: http://stackoverflow.com/questions/5352546/best-way-to-extract-subset-of-key-value-pairs-from-python-dictionary-object/5352649#5352649

exception Goulib.itertools2.**SortingError**
Bases: `Exception`

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

Goulib.itertools2.**ensure_sorted**(*iterable*, *key=None*)
makes sure iterable is sorted according to key

Yields items of iterable

Raise SortingError if not

Goulib.itertools2.**sorted_iterable**(*iterable*, *key=None*, *buffer=100*)
sorts an "almost sorted" (infinite) iterable

Parameters

- **iterable** – iterable
- **key** – function used as sort key
- **buffer** – int size of buffer. elements to swap should not be further than that

Goulib.itertools2.**diff**(*iterable1*, *iterable2*)
generate items in sorted iterable1 that are not in sorted iterable2

Goulib.itertools2.**intersect**(**iterables*)
generates itersection of N iterables

Parameters iterables – any number of SORTED iterables

Yields elements that belong to all iterables

See http://stackoverflow.com/questions/969709/joining-a-set-of-ordered-integer-yielding-python-iterators

Goulib.itertools2.**product**(**iterables*, ***kwargs*)
Cartesian product of (infinite) input iterables.

Parameters

- **iterables** – any number of iterables
- **repeat** – integer optional number of repetitions

See http://stackoverflow.com/questions/12093364/cartesian-product-of-large-iterators-itertools

class Goulib.itertools2.**keep**(*iterable*)
Bases: collections.abc.Iterator

iterator that keeps the last value

__init__(*iterable*)
Initialize self. See help(type(self)) for accurate signature.

__next__()
Return the next item from the iterator. When exhausted, raise StopIteration

next()
Return the next item from the iterator. When exhausted, raise StopIteration

__abstractmethods__ = frozenset()

__class__
alias of abc.ABCMeta

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__iter__()

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__slots__ = ()

__str__
Return str(self).

Goulib.itertools2.**first_match**(*iter1*, *iter2*, *limit=None*)
” :param limit: int max number of loops :return: integer i first index where iter1[i]==iter2[i]

Goulib.itertools2.**floyd**(*iterable*, *limit=1000000.0*)
Detect a cycle in iterable using Floyd "tortue hand hare" algorithm

See https://en.wikipedia.org/wiki/Cycle_detection#Floyd's_Tortoise_and_Hare

Parameters

- **iterable** – iterable
- **limit** – int limit to prevent infinite loop. no limit if None

Result (i,l) tuple of integers where i=index of cycle start, l=length if no cycle is found, return (None,None)

Goulib.itertools2.**brent**(*iterable*, *limit=1000000.0*)
Detect a cycle in iterable using Floyd "tortue hand hare" algorithm

See https://en.wikipedia.org/wiki/Cycle_detection#Brent's_algorithm

Parameters

- **iterable** – iterable
- **limit** – int limit to prevent infinite loop. no limit if None

Result (i,l) tuple of integers where i=index of cycle start, l=length if no cycle is found, return (None,None)

Goulib.itertools2.**detect_cycle**(*iterable*, *limit=1000000.0*)

2.13 Goulib.markup module

simple HTML/XML generation (forked from markup)

Goulib.markup.**cgiprint**(*line="*, *unbuff=True*, *line_end='\r\n'*)

Print to the stdout. :param line: string to print, followed by line_end :param unbuff: boolean, True to flush the buffer after every write. :param line_end: string to print after each line. By default this is

, which is the standard specified by the RFC for http headers.

Goulib.markup.**style_dict2str**(*style*)

Goulib.markup.**style_str2dict**(*style*)

Goulib.markup.**tag**(*tag*, *between*, ***kwargs*)
generate full tag.

class Goulib.markup.**element**(*tag*, *case='lower'*, *parent=None*)
Bases: object

This class handles the addition of a new element.

__init__(*tag*, *case='lower'*, *parent=None*)
Initialize self. See help(type(self)) for accurate signature.

__call__(**args*, ***kwargs*)
Call self as a function.

render(*t*, *single*, *args*, ***kwargs*)
Append the actual tags to content.

close()
Append a closing tag unless element has only opening tag.

open(***kwargs*)
Append an opening tag.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.markup.**page**(*mode='strict_html'*, *case='lower'*, *onetags=None*, *twotags=None*, *separator='n'*, *class_=None*)
Bases: `object`

This is our main class representing a document. Elements are added as attributes of an instance of this class.

Stuff that effects the whole document.

Parameters **mode** – string. can be either:

- 'strict_html' for HTML 4.01 (default)
- 'html' alias for 'strict_html'
- 'loose_html' to allow some deprecated elements
- 'xml' to allow arbitrary elements

Parameters **case** – string. can be either:

- 'lower' element names will be printed in lower case (default)
- 'upper' they will be printed in upper case
- 'given' element names will be printed as they are given

Parameters

- **onetags** – list or tuple of valid elements with opening tags only
- **twotags** – list or tuple of valid elements with both opening and closing tags

these two keyword arguments may be used to select the set of valid elements in 'xml' mode invalid elements will raise appropriate exceptions

Parameters

- **separator** – string to place between added elements, defaults to newline
- **class** – a class that will be added to every element if defined

__init__(*mode='strict_html', case='lower', onetags=None, twotags=None, separator='\n', class_=None*)

Stuff that effects the whole document.

Parameters **mode** – string. can be either:

- 'strict_html' for HTML 4.01 (default)
- 'html' alias for 'strict_html'
- 'loose_html' to allow some deprecated elements
- 'xml' to allow arbitrary elements

Parameters **case** – string. can be either:

- 'lower' element names will be printed in lower case (default)
- 'upper' they will be printed in upper case
- 'given' element names will be printed as they are given

Parameters

- **onetags** – list or tuple of valid elements with opening tags only
- **twotags** – list or tuple of valid elements with both opening and closing tags

these two keyword arguments may be used to select the set of valid elements in 'xml' mode invalid elements will raise appropriate exceptions

Parameters

- **`separator`** – string to place between added elements, defaults to newline
- **`class`** – a class that will be added to every element if defined

`__getattr__`(*attr*)

`__str__`()
Return str(self).

`__call__`(*escape=False*)
Return the document as a string.

escape – False print normally

True replace < and > by < and > the default escape sequences in most browsers

`add`(*text*)
This is an alias to addcontent.

`addfooter`(*text*)
Add some text to the bottom of the document

`addheader`(*text*)
Add some text to the top of the document

`addcontent`(*text*)
Add some text to the main part of the document

`init`(*lang='en'*, *css=None*, *metainfo=None*, *title=None*, *header=None*, *footer=None*, *charset=None*, *encoding=None*, *doctype=None*, *bodyattrs=None*, *script=None*, *base=None*)
This method is used for complete documents with appropriate doctype, encoding, title, etc information. For an /XML snippet omit this method.

lang – language, usually a two character string, will appear as <html lang='en'> in html mode (ignored in xml mode)

css – Cascading Style Sheet filename as a string or a list of strings for multiple css files (ignored in xml mode)

metainfo – a dictionary in the form { 'name':'content' } to be inserted into meta element(s) as <meta name='name' content='content'> (ignored in xml mode)

base – set the <base href="…"> tag in <head>

bodyattrs –a dictionary in the form { 'key':'value', … } which will be added as attributes of the <body> element as <body key='value' … > (ignored in xml mode)

script – dictionary containing src:type pairs, <script type='text/type' src=src></script> or a list of ['src1', 'src2', …] in which case 'javascript' is assumed for all

title – the title of the document as a string to be inserted into a title element as <title>my title</title> (ignored in xml mode)

header – some text to be inserted right after the <body> element (ignored in xml mode)

footer – some text to be inserted right before the </body> element (ignored in xml mode)

charset – a string defining the character set, will be inserted into a <meta http-equiv='Content-Type' content='text/html; charset=myset'> element (ignored in xml mode)

encoding – a string defining the encoding, will be put into to first line of the document as <?xml version='1.0' encoding='myencoding' ?> in xml mode (ignored in html mode)

doctype – the document type string, defaults to <!DOCTYPE HTML PUBLIC '-//W3C//DTD HTML 4.01 Transitional//EN'> in html mode (ignored in xml mode)

css (*filelist*)
This convenience function is only useful for html. It adds css stylesheet(s) to the document via the <link> element.

metainfo (*mydict*)
This convenience function is only useful for html. It adds meta information via the <meta> element, the argument is a dictionary of the form { 'name':'content' }.

scripts (*mydict*)
Only useful in html, mydict is dictionary of src:type pairs or a list of script sources ['src1', 'src2', ...] in which case 'javascript' is assumed for type. Will be rendered as <script type='text/type' src=src></script>

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__ () → list
default dir() implementation

__eq__
Return self==value.

__format__ ()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__ ()
Create and return a new object. See help(type) for accurate signature.

__reduce__ ()
helper for pickle

__reduce_ex__ ()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

Goulib.markup.**escape**(*text*, *newline=False*)
Escape special html characters.

Goulib.markup.**unescape**(*text*)
Inverse of escape.

class Goulib.markup.**dummy**
Bases: `object`

A dummy class for attaching attributes.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.markup.**russell**
Bases: `object`

A dummy class that contains anything.

__contains__(*item*)

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

exception Goulib.markup.**MarkupError**
Bases: Exception

All our exceptions subclass this.

__str__()
Return str(self).

__cause__
exception cause

__class__
alias of builtins.type

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

exception Goulib.markup.**ClosingError**(*tag*)
Bases: *Goulib.markup.MarkupError*

__init__(*tag*)
Initialize self. See help(type(self)) for accurate signature.

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

exception Goulib.markup.**OpeningError**(*tag*)
Bases: `Goulib.markup.MarkupError`

__init__(*tag*)
Initialize self. See help(type(self)) for accurate signature.

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

exception Goulib.markup.**ArgumentError**(*tag*)
Bases: *Goulib.markup.MarkupError*

__init__(*tag*)
Initialize self. See help(type(self)) for accurate signature.

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

exception Goulib.markup.**InvalidElementError**(*tag*, *mode*)
Bases: *Goulib.markup.MarkupError*

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__init__(*tag*, *mode*)
Initialize self. See help(type(self)) for accurate signature.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

exception Goulib.markup.**DeprecationError**(*tag*)
Bases: *Goulib.markup.MarkupError*

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

__init__(*tag*)
Initialize self. See help(type(self)) for accurate signature.

exception Goulib.markup.**ModeError**(*mode*)
Bases: *Goulib.markup.MarkupError*

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

__init__(*mode*)
Initialize self. See help(type(self)) for accurate signature.

exception Goulib.markup.**CustomizationError**
Bases: *Goulib.markup.MarkupError*

__cause__
exception cause

__class__
alias of `builtins.type`

__context__
exception context

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__setstate__()

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__suppress_context__

__traceback__

args

with_traceback()
Exception.with_traceback(tb) – set self.__traceback__ to tb and return self.

__init__()
Initialize self. See help(type(self)) for accurate signature.

2.14 Goulib.math2 module

more math than `math` standard library, without numpy

`Goulib.math2.`**cmp**(*x*, *y*)
Compare the two objects x and y and return an integer according to the outcome. The return value is negative if x < y, zero if x == y and strictly positive if x > y.

`Goulib.math2.`**allclose**(*a*, *b*, *rel_tol=1e-09*, *abs_tol=0.0*)

Returns True if two arrays are element-wise equal within a tolerance.

`Goulib.math2.`**is_number**(*x*)

Returns True if x is a number of any type, including Complex

`Goulib.math2.`**is_complex**(*x*)

`Goulib.math2.`**is_real**(*x*)

`Goulib.math2.`**sign**(*number*)

Returns 1 if number is positive, -1 if negative, 0 if ==0

`Goulib.math2.`**rint**(*v*)

Returns int value nearest to float v

`Goulib.math2.`**is_integer**(*x*, *rel_tol=0*, *abs_tol=0*)

Returns True if float x is an integer within tolerances

`Goulib.math2.`**int_or_float**(*x*, *rel_tol=0*, *abs_tol=0*)

Parameters **x** – int or float

Returns int if x is (almost) an integer, otherwise float

`Goulib.math2.`**format**(*x*, *decimals=3*)
formats a float with given number of decimals, but not an int

Returns string repr of x with decimals if not int

`Goulib.math2.`**gcd**(**args*)
greatest common divisor of an arbitrary number of args

`Goulib.math2.`**lcm**(**args*)
least common multiple of any number of integers

`Goulib.math2.`**xgcd**(*a*, *b*)
Extended GCD

Returns (gcd, x, y) where gcd is the greatest common divisor of a and b

with the sign of b if b is nonzero, and with the sign of a if b is 0. The numbers x,y are such that gcd = ax+by.

`Goulib.math2.`**coprime**(**args*)

Returns True if args are coprime to each other

`Goulib.math2.`**`coprimes_gen`**(*limit*)
generates coprime pairs using Farey sequence

`Goulib.math2.`**`carmichael`**(*n*)
Carmichael function :return : int smallest positive integer m such that a^m mod n = 1 for every integer a between 1 and n that is coprime to n. :param n: int :see: https://en.wikipedia.org/wiki/Carmichael_function :see: https://oeis.org/A002322

also known as the reduced totient function or the least universal exponent function.

`Goulib.math2.`**`is_primitive_root`**(*x*, *m*, *s={}*)
returns True if x is a primitive root of m

Parameters **s** – set of coprimes to m, if already known

`Goulib.math2.`**`primitive_root_gen`**(*m*)
generate primitive roots modulo m

`Goulib.math2.`**`primitive_roots`**(*modulo*)

`Goulib.math2.`**`quad`**(*a*, *b*, *c*, *allow_complex=False*)
solves quadratic equations aX^2+bX+c=0

Parameters

- **a,b,c** – floats
- **allow_complex** – function returns complex roots if True

Returns x1,x2 real or complex solutions

`Goulib.math2.`**`ceildiv`**(*a*, *b*)

`Goulib.math2.`**`ipow`**(*x*, *y*, *z=0*)

Parameters

- **x** – number (int or float)
- **y** – int power
- **z** – int optional modulus

Returns (x**y) % z as integer if possible

`Goulib.math2.`**`pow`**(*x*, *y*, *z=0*)

Returns (x**y) % z as integer

`Goulib.math2.`**`sqrt`**(*n*)
square root :return: int, float or complex depending on n

`Goulib.math2.`**`isqrt`**(*n*)
integer square root

Returns largest int x for which x * x <= n

`Goulib.math2.`**`icbrt`**(*n*)
integer cubic root

Returns largest int x for which x * x * x <= n

`Goulib.math2.`**`is_square`**(*n*)

`Goulib.math2.`**`introot`**(*n*, *r=2*)
integer r-th root

Returns int, greatest integer less than or equal to the r-th root of n.

For negative n, returns the least integer greater than or equal to the r-th root of n, or None if r is even.

`Goulib.math2.`**`is_power`**`(`*n*`)`

Returns integer that, when squared/cubed/etc, yields n,

or 0 if no such integer exists. Note that the power to which this number is raised will be prime.

`Goulib.math2.`**`multiply`**`(`*x*, *y*`)`

Karatsuba fast multiplication algorithm

https://en.wikipedia.org/wiki/Karatsuba_algorithm

Copyright (c) 2014 Project Nayuki http://www.nayuki.io/page/karatsuba-multiplication

`Goulib.math2.`**`accsum`**`(`*it*`)`

Yield accumulated sums of iterable: accsum(count(1)) -> 1,3,6,10,...

`Goulib.math2.`**`cumsum`**`(`*it*`)`

Yield accumulated sums of iterable: accsum(count(1)) -> 1,3,6,10,...

`Goulib.math2.`**`mul`**`(`*nums*, *init=1*`)`

Returns Product of nums

`Goulib.math2.`**`dot_vv`**`(`*a*, *b*, *default=0*`)`

dot product for vectors

Parameters

- **a** – vector (iterable)
- **b** – vector (iterable)
- **default** – default value of the multiplication operator

`Goulib.math2.`**`dot_mv`**`(`*a*, *b*, *default=0*`)`

dot product for vectors

Parameters

- **a** – matrix (iterable or iterables)
- **b** – vector (iterable)
- **default** – default value of the multiplication operator

`Goulib.math2.`**`dot_mm`**`(`*a*, *b*, *default=0*`)`

dot product for matrices

Parameters

- **a** – matrix (iterable or iterables)
- **b** – matrix (iterable or iterables)
- **default** – default value of the multiplication operator

`Goulib.math2.`**`dot`**`(`*a*, *b*, *default=0*`)`

dot product

general but slow : use dot_vv, dot_mv or dot_mm if you know a and b's dimensions

`Goulib.math2.`**`zeros`**`(`*shape*`)`

See https://docs.scipy.org/doc/numpy/reference/generated/numpy.zeros.html

`Goulib.math2.`**`diag`**(*v*)
Create a two-dimensional array with the flattened input as a diagonal.

Parameters **`v`** – If v is a 2-D array, return a copy of its diagonal. If v is a 1-D array, return a 2-D array with v on the diagonal

See https://docs.scipy.org/doc/numpy/reference/generated/numpy.diag.html#numpy.diag

`Goulib.math2.`**`identity`**(*n*)

`Goulib.math2.`**`eye`**(*n*)

`Goulib.math2.`**`transpose`**(*m*)

Returns matrix m transposed

`Goulib.math2.`**`maximum`**(*m*)
Compare N arrays and returns a new array containing the element-wise maxima

Parameters **`m`** – list of arrays (matrix)

Returns list of maximal values found in each column of m

See http://docs.scipy.org/doc/numpy/reference/generated/numpy.maximum.html

`Goulib.math2.`**`minimum`**(*m*)
Compare N arrays and returns a new array containing the element-wise minima

Parameters **`m`** – list of arrays (matrix)

Returns list of minimal values found in each column of m

See http://docs.scipy.org/doc/numpy/reference/generated/numpy.minimum.html

`Goulib.math2.`**`vecadd`**(*a*, *b*, *fillvalue=0*)
addition of vectors of inequal lengths

`Goulib.math2.`**`vecsub`**(*a*, *b*, *fillvalue=0*)
substraction of vectors of inequal lengths

`Goulib.math2.`**`vecneg`**(*a*)
unary negation

`Goulib.math2.`**`vecmul`**(*a*, *b*)
product of vectors of inequal lengths

`Goulib.math2.`**`vecdiv`**(*a*, *b*)
quotient of vectors of inequal lengths

`Goulib.math2.`**`veccompare`**(*a*, *b*)
compare values in 2 lists. returns triple number of pairs where [a<b, a==b, a>b]

`Goulib.math2.`**`sat`**(*x*, *low=0*, *high=None*)
saturates x between low and high

`Goulib.math2.`**`norm_2`**(*v*)

Returns "normal" euclidian norm of vector v

`Goulib.math2.`**`norm_1`**(*v*)

Returns "manhattan" norm of vector v

`Goulib.math2.`**`norm_inf`**(*v*)

Returns infinite norm of vector v

`Goulib.math2.`**`norm`**(*v*, *order=2*)

See http://docs.scipy.org/doc/numpy/reference/generated/numpy.linalg.norm.html

`Goulib.math2.`**`dist`**(*a*, *b*, *norm=<function norm_2>*)

`Goulib.math2.`**`vecunit`**(*v*, *norm=<function norm_2>*)

Returns vector normalized

`Goulib.math2.`**`hamming`**(*s1*, *s2*)
Calculate the Hamming distance between two iterables

`Goulib.math2.`**`sets_dist`**(*a*, *b*)

See http://stackoverflow.com/questions/11316539/calculating-the-distance-between-two-unordered-sets

`Goulib.math2.`**`sets_levenshtein`**(*a*, *b*)
levenshtein distance on sets

See http://en.wikipedia.org/wiki/Levenshtein_distance

`Goulib.math2.`**`levenshtein`**(*seq1*, *seq2*)
levenshtein distance

Returns distance between 2 iterables

See http://en.wikipedia.org/wiki/Levenshtein_distance

`Goulib.math2.`**`recurrence`**(*signature*, *values*, *cst=0*, *max=None*, *mod=0*)
general generator for recurrences

Parameters

- **`signature`** – factors defining the recurrence
- **`values`** – list of initial values

`Goulib.math2.`**`fibonacci_gen`**(*max=None*, *mod=0*)
Generate fibonacci serie

`Goulib.math2.`**`fibonacci`**(*n*, *mod=0*)
fibonacci series n-th element

Parameters

- **`n`** – int can be extremely high, like 1e19 !
- **`mod`** – int optional modulo

`Goulib.math2.`**`is_fibonacci`**(*n*)
returns True if n is in Fibonacci series

`Goulib.math2.`**`pisano_cycle`**(*mod*)

`Goulib.math2.`**`pisano_period`**(*mod*)

`Goulib.math2.`**`collatz`**(*n*)

`Goulib.math2.`**`collatz_gen`**(*n=0*)

`Goulib.math2.`**`collatz_period`**(*n*)

`Goulib.math2.`**`pascal_gen`**()
Pascal's triangle read by rows: C(n,k) = binomial(n,k) = n!/(k!*(n-k)!), 0<=k<=n.

https://oeis.org/A007318

`Goulib.math2.`**`catalan`**(*n*)
Catalan numbers: C(n) = binomial(2n,n)/(n+1) = (2n)!/(n!(n+1)!).

Goulib.math2.**catalan_gen**()

Generate Catalan numbers: C(n) = binomial(2n,n)/(n+1) = (2n)!/(n!(n+1)!). Also called Segner numbers.

Goulib.math2.**is_pythagorean_triple**(*a*, *b*, *c*)

Goulib.math2.**primitive_triples**()

generates primitive Pythagorean triplets x<y<z

sorted by hypotenuse z, then longest side y through Berggren's matrices and breadth first traversal of ternary tree :see: https://en.wikipedia.org/wiki/Tree_of_primitive_Pythagorean_triples

Goulib.math2.**triples**()

generates all Pythagorean triplets triplets x<y<z sorted by hypotenuse z, then longest side y

Goulib.math2.**divisors**(*n*)

Parameters **n** – int

Returns all divisors of n: divisors(12) -> 1,2,3,6,12

including 1 and n, except for 1 which returns a single 1 to avoid messing with sum of divisors...

Goulib.math2.**proper_divisors**(*n*)

Returns all divisors of n except n itself.

Goulib.math2.**sieve**(*n*, *oneisprime=False*)

prime numbers from 2 to a prime < n Very fast (n<10,000,000) in 0.4 sec.

Example: >>>prime_sieve(25) [2, 3, 5, 7, 11, 13, 17, 19, 23]

Algorithm & Python source: Robert William Hanks http://stackoverflow.com/questions/17773352/python-sieve-prime-numbers

Goulib.math2.**primes**(*n*)

memoized list of n first primes

Warning do not call with large n, use prime_gen instead

Goulib.math2.**is_prime_euler**(*n*, *eb=(2,)*)

Euler's primality test

Parameters

- **n** – int number to test
- **eb** – test basis

Returns False if not prime, True if prime, but also for many pseudoprimes...

See https://en.wikipedia.org/wiki/Euler_pseudoprime

Goulib.math2.**is_prime**(*n*, *oneisprime=False*, *tb=(3, 5, 7, 11)*, *eb=(2,)*, *mrb=None*)

main primality test.

Parameters

- **n** – int number to test
- **oneisprime** – bool True if 1 should be considered prime (it was, a long time ago)
- **tb** – trial division basis
- **eb** – Euler's test basis
- **mrb** – Miller-Rabin basis, automatic if None

See https://en.wikipedia.org/wiki/Baillie%E2%80%93PSW_primality_test

It's an implementation of the BPSW test (Baillie-Pomerance-Selfridge-Wagstaff) with some prefiltes for speed and is deterministic for all numbers less than 2^64 Iin fact, while infinitely many false positives are conjectured to exist, no false positives are currently known. The prefilters consist of trial division against 2 and the elements of the tuple tb, checking whether n is square, and Euler's primality test to the bases in the tuple eb. If the number is less than 3825123056546413051, we use the Miller-Rabin test on a set of bases for which the test is known to be deterministic over this range.

`Goulib.math2.`**`nextprime`**(*n*)
Determines, with some semblance of efficiency, the least prime number strictly greater than n.

`Goulib.math2.`**`prevprime`**(*n*)
Determines, very inefficiently, the largest prime number strictly smaller than n.

`Goulib.math2.`**`primes_gen`**(*start=2*, *stop=None*)
generate prime numbers from start

`Goulib.math2.`**`random_prime`**(*bits*)
returns a random number of the specified bit length

`Goulib.math2.`**`euclid_gen`**()
generates Euclid numbers: 1 + product of the first n primes

`Goulib.math2.`**`prime_factors`**(*num*, *start=2*)
generates all prime factors (ordered) of num

`Goulib.math2.`**`lpf`**(*n*)
greatest prime factor

`Goulib.math2.`**`gpf`**(*n*)
greatest prime factor

`Goulib.math2.`**`prime_divisors`**(*num*, *start=2*)
generates unique prime divisors (ordered) of num

`Goulib.math2.`**`is_multiple`**(*n*, *factors*)
return True if n has ONLY factors as prime factors

`Goulib.math2.`**`factorize`**(*n*)
find the prime factors of n along with their frequencies. Example:

```
>>> factor(786456)
[(2,3), (3,3), (11,1), (331,1)]
```

`Goulib.math2.`**`factors`**(*n*)

`Goulib.math2.`**`number_of_divisors`**(*n*)

`Goulib.math2.`**`omega`**(*n*)
Number of distinct primes dividing n

`Goulib.math2.`**`bigomega`**(*n*)
Number of prime divisors of n counted with multiplicity

`Goulib.math2.`**`moebius`**(*n*)
Möbius (or Moebius) function mu(n). mu(1) = 1; mu(n) = (-1)^k if n is the product of k different primes; otherwise mu(n) = 0.

`Goulib.math2.`**`euler_phi`**(*n*)
Euler totient function

See http://stackoverflow.com/questions/1019040/how-many-numbers-below-n-are-coprimes-to-n

Goulib.math2.**totient**(*n*)
Euler totient function

See http://stackoverflow.com/questions/1019040/how-many-numbers-below-n-are-coprimes-to-n

Goulib.math2.**kempner**(*n*)
"Kempner function, also called Smarandache function

Returns int smallest positive integer m such that n divides m!.

Parameters **n** – int

See https://en.wikipedia.org/wiki/Kempner_function

See http://mathworld.wolfram.com/SmarandacheFunction.html

Goulib.math2.**prime_ktuple**(*constellation*)
generates tuples of primes with specified differences

Parameters **constellation** – iterable of int differences betwwen primes to return

Note negative int means the difference must NOT be prime

See https://en.wikipedia.org/wiki/Prime_k-tuple

(0, 2) twin primes (0, 4) cousin primes (0, 6) sexy primes (0, 2, 6), (0, 4, 6) prime triplets (0, 6, 12, -18) sexy prime triplets (0, 2, 6, 8) prime quadruplets (0, 6, 12, 18) sexy prime quadruplets (0, 2, 6, 8, 12), (0, 4, 6, 10, 12) quintuplet primes (0, 4, 6, 10, 12, 16) sextuplet primes

Goulib.math2.**twin_primes**()

Goulib.math2.**cousin_primes**()

Goulib.math2.**sexy_primes**()

Goulib.math2.**sexy_prime_triplets**()

Goulib.math2.**sexy_prime_quadruplets**()

Goulib.math2.**lucas_lehmer**(*p*)
Lucas Lehmer primality test for Mersenne exponent p

Parameters **p** – int

Returns True if 2^p-1 is prime

Goulib.math2.**digits_gen**(*num*, *base=10*)
generates int digits of num in base BACKWARDS

Goulib.math2.**digits**(*num*, *base=10*, *rev=False*)

Returns list of digits of num expressed in base, optionally reversed

Goulib.math2.**digsum**(*num*, *f=None*, *base=10*)
sum of digits

Parameters

- **num** – number
- **f** – int power or function applied to each digit
- **base** – optional base

Returns sum of f(digits) of num

digsum(num) -> sum of digits digsum(num,base=2) -> number of 1 bits in binary represenation of num digsum(num,2) -> sum of the squares of digits digsum(num,f=lambda x:x**x) -> sum of the digits elevaed to their own power

`Goulib.math2.`**`integer_exponent`**(*a*, *b=10*)

Returns int highest power of b that divides a.

See https://reference.wolfram.com/language/ref/IntegerExponent.html

`Goulib.math2.`**`trailing_zeros`**(*a*, *b=10*)

Returns int highest power of b that divides a.

See https://reference.wolfram.com/language/ref/IntegerExponent.html

`Goulib.math2.`**`power_tower`**(*v*)

Returns v[0]**v[1]**v[2] . . .

See http://ajcr.net#Python-power-tower/

`Goulib.math2.`**`carries`**(*a*, *b*, *base=10*, *pos=0*)

Returns int number of carries required to add a+b in base

`Goulib.math2.`**`powertrain`**(*n*)

Returns v[0]**v[1]*v[2]**v[3] . . . **(v[-1] or 0)

Author # Chai Wah Wu, Jun 16 2017

See http://oeis.org/A133500

`Goulib.math2.`**`str_base`**(*num*, *base=10*, *numerals='0123456789abcdefghijklmnopqrstuvwxyz'*)

Returns string representation of num in base

Parameters

- **num** – int number (decimal)
- **base** – int base, 10 by default
- **numerals** – string with all chars representing numbers in base base. chars after the base-th are ignored

`Goulib.math2.`**`int_base`**(*num*, *base*)

Returns int representation of num in base

Parameters

- **num** – int number (decimal)
- **base** – int base, <= 10

`Goulib.math2.`**`num_from_digits`**(*digits*, *base=10*)

Parameters

- **digits** – string or list of digits representing a number in given base
- **base** – int base, 10 by default

Returns int number

`Goulib.math2.`**`reverse`**(*i*)

`Goulib.math2.`**`is_palindromic`**(*num*, *base=10*)
Check if 'num' in base 'base' is a palindrome, that's it, if it can be read equally from left to right and right to left.

`Goulib.math2.`**`is_anagram`**(*num1*, *num2*, *base=10*)
Check if 'num1' and 'num2' have the same digits in base

`Goulib.math2.`**`is_pandigital`**(*num*, *base=10*)

Returns True if num contains all digits in specified base

`Goulib.math2.`**`bouncy`**(*n*, *up=False*, *down=False*)

Parameters

- **n** – int number to test
- **up** – bool
- **down** – bool

bouncy(x) returns True for Bouncy numbers (digits form a strictly non-monotonic sequence) (A152054) bouncy(x,True,None) returns True for Numbers with digits in nondecreasing order (OEIS A009994) bouncy(x,None,True) returns True for Numbers with digits in nonincreasing order (OEIS A009996)

`Goulib.math2.`**`repunit_gen`**(*base=10*, *digit=1*)
generate repunits

`Goulib.math2.`**`repunit`**(*n*, *base=10*, *digit=1*)

Returns nth repunit

`Goulib.math2.`**`rational_form`**(*numerator*, *denominator*)
information about the decimal representation of a rational number.

Returns 5 integer : integer, decimal, shift, repeat, cycle

- shift is the len of decimal with leading zeroes if any
- cycle is the len of repeat with leading zeroes if any

`Goulib.math2.`**`rational_str`**(*n*, *d*)

`Goulib.math2.`**`rational_cycle`**(*num*, *den*)
periodic part of the decimal expansion of num/den. Any initial 0's are placed at end of cycle.

See https://oeis.org/A036275

`Goulib.math2.`**`tetrahedral`**(*n*)

Returns int n-th tetrahedral number

See https://en.wikipedia.org/wiki/Tetrahedral_number

`Goulib.math2.`**`sum_of_squares`**(*n*)

Returns 1^2 + 2^2 + 3^2 + … + n^2

See https://en.wikipedia.org/wiki/Square_pyramidal_number

`Goulib.math2.`**`pyramidal`**(*n*)

Returns 1^2 + 2^2 + 3^2 + … + n^2

See https://en.wikipedia.org/wiki/Square_pyramidal_number

`Goulib.math2.`**`sum_of_cubes`**(*n*)

Returns 1^3 + 2^3 + 3^3 + … + n^3

See https://en.wikipedia.org/wiki/Squared_triangular_number

`Goulib.math2.`**`bernouilli_gen`**(*init=1*)

generator of Bernouilli numbers

Parameters **`init`** – int -1 or +1.

- -1 for "first Bernoulli numbers" with B1=-1/2
- +1 for "second Bernoulli numbers" with B1=+1/2

https://en.wikipedia.org/wiki/Bernoulli_number https://rosettacode.org/wiki/Bernoulli_numbers#Python:_Optimised_task_algorithm

`Goulib.math2.`**`bernouilli`**(*n*, *init=1*)

`Goulib.math2.`**`faulhaber`**(*n*, *p*)

sum of the p-th powers of the first n positive integers

Returns 1^p + 2^p + 3^p + … + n^p

See https://en.wikipedia.org/wiki/Faulhaber%27s_formula

`Goulib.math2.`**`is_happy`**(*n*)

`Goulib.math2.`**`lychrel_seq`**(*n*)

`Goulib.math2.`**`lychrel_count`**(*n*, *limit=96*)

number of lychrel iterations before n becomes palindromic

Parameters

- **`n`** – int number to test
- **`limit`** – int max number of loops. default 96 corresponds to the known most retarded non lychrel number

Warning there are palindrom lychrel numbers such as 4994

`Goulib.math2.`**`is_lychrel`**(*n*, *limit=96*)

Warning there are palindrom lychrel numbers such as 4994

`Goulib.math2.`**`polygonal`**(*s*, *n*)

`Goulib.math2.`**`triangle`**(*n*)

Returns nth triangle number, defined as the sum of [1,n] values.

See http://en.wikipedia.org/wiki/Triangular_number

`Goulib.math2.`**`triangular`**(*n*)

Returns nth triangle number, defined as the sum of [1,n] values.

See http://en.wikipedia.org/wiki/Triangular_number

`Goulib.math2.`**`is_triangle`**(*x*)

Returns True if x is a triangle number

`Goulib.math2.`**`is_triangular`**(*x*)

Returns True if x is a triangle number

`Goulib.math2.`**`square`**(*n*)

`Goulib.math2.`**`pentagonal`**`(`*n*`)`

Returns nth pentagonal number

See https://en.wikipedia.org/wiki/Pentagonal_number

`Goulib.math2.`**`is_pentagonal`**`(`*n*`)`

Returns True if x is a pentagonal number

`Goulib.math2.`**`hexagonal`**`(`*n*`)`

Returns nth hexagonal number

See https://en.wikipedia.org/wiki/Hexagonal_number

`Goulib.math2.`**`is_hexagonal`**`(`*n*`)`

`Goulib.math2.`**`heptagonal`**`(`*n*`)`

`Goulib.math2.`**`is_heptagonal`**`(`*n*`)`

`Goulib.math2.`**`octagonal`**`(`*n*`)`

`Goulib.math2.`**`is_octagonal`**`(`*n*`)`

`Goulib.math2.`**`partition`**`(`*n*`)`
The partition function p(n)

gives the number of partitions of a nonnegative integer n into positive integers. (There is one partition of zero into positive integers, i.e. the empty partition, since the empty sum is defined as 0.)

See http://oeis.org/wiki/Partition_function https://oeis.org/A000041

`Goulib.math2.`**`partitionsQ`**`(`*n*, *d=0*`)`

`Goulib.math2.`**`get_cardinal_name`**`(`*num*`)`
Get cardinal name for number (0 to 1 million)

`Goulib.math2.`**`abundance`**`(`*n*`)`

`Goulib.math2.`**`is_perfect`**`(`*n*`)`

Returns -1 if n is deficient, 0 if perfect, 1 if abundant

See https://en.wikipedia.org/wiki/Perfect_number,

https://en.wikipedia.org/wiki/Abundant_number, https://en.wikipedia.org/wiki/Deficient_number

`Goulib.math2.`**`number_of_digits`**`(`*num*, *base=10*`)`
Return number of digits of num (expressed in base 'base')

`Goulib.math2.`**`chakravala`**`(`*n*`)`
solves x^2 - n*y^2 = 1 for x,y integers

https://en.wikipedia.org/wiki/Pell%27s_equation https://en.wikipedia.org/wiki/Chakravala_method

`Goulib.math2.`**`factorialk`**`(`*n*, *k*`)`
Multifactorial of n of order k, n(!!...!).

This is the multifactorial of n skipping k values. For example, factorialk(17, 4) = 17!!!! = 17 * 13 * 9 * 5 * 1

In particular, for any integer n, we have factorialk(n, 1) = factorial(n) factorialk(n, 2) = factorial2(n)

Parameters **`n`** – int Calculate multifactorial. If *n* < 0, the return value is 0.

:param k : int Order of multifactorial. :return: int Multifactorial of *n*.

Goulib.math2.**factorial2**(*n*)

Goulib.math2.**factorial_gen**(*f=<function <lambda>>*)
Generator of factorial :param f: optional function to apply at each step

Goulib.math2.**binomial**(*n, k*)
binomial coefficient "n choose k" :param: n, k int :return: int, number of ways to chose n items in k, unordered

See https://en.wikipedia.org/wiki/binomial

Goulib.math2.**choose**(*n, k*)
binomial coefficient "n choose k" :param: n, k int :return: int, number of ways to chose n items in k, unordered

See https://en.wikipedia.org/wiki/binomial

Goulib.math2.**ncombinations**(*n, k*)
binomial coefficient "n choose k" :param: n, k int :return: int, number of ways to chose n items in k, unordered

See https://en.wikipedia.org/wiki/binomial

Goulib.math2.**binomial_exponent**(*n, k, p*)

Returns int largest power of p that divides binomial(n,k)

Goulib.math2.**log_factorial**(*n*)

Returns float approximation of ln(n!) by Ramanujan formula

Goulib.math2.**log_binomial**(*n, k*)

Returns float approximation of ln(binomial(n,k))

Goulib.math2.**ilog**(*a, b, upper_bound=False*)
discrete logarithm x such that b^x=a

Parameters

- **a,b** – integer
- **upper_bound** – bool. if True, returns smallest x such that b^x>=a

Returns x integer such that b^x=a, or upper_bound, or None

https://en.wikipedia.org/wiki/Discrete_logarithm

Goulib.math2.**angle**(*u, v, unit=True*)

Parameters

- **u,v** – iterable vectors
- **unit** – bool True if vectors are unit vectors. False increases computations

Returns float angle n radians between u and v unit vectors i

Goulib.math2.**sin_over_x**(*x*)
numerically safe sin(x)/x

Goulib.math2.**slerp**(*u, v, t*)
spherical linear interpolation

Parameters

- **u,v** – 3D unit vectors
- **t** – float in [0,1] interval

Returns vector interpolated between u and v

`Goulib.math2.`**`proportional`**(*nseats*, *votes*)
assign n seats proportionaly to votes using the https://en.wikipedia.org/wiki/Hagenbach-Bischoff_quota method

Parameters

- **`nseats`** – int number of seats to assign
- **`votes`** – iterable of int or float weighting each party

Result list of ints seats allocated to each party

`Goulib.math2.`**`triangular_repartition`**(*x*, *n*)
divide 1 into n fractions such that:

- their sum is 1
- they follow a triangular linear repartition (sorry, no better name for now) where x/1 is the maximum

`Goulib.math2.`**`rectangular_repartition`**(*x*, *n*, *h*)
divide 1 into n fractions such that:

- their sum is 1
- they follow a repartition along a pulse of height h<1

`Goulib.math2.`**`de_bruijn`**(*k*, *n*)
De Bruijn sequence for alphabet k and subsequences of length n.

https://en.wikipedia.org/wiki/De_Bruijn_sequence

`Goulib.math2.`**`mod_inv`**(*a*, *b*)

`Goulib.math2.`**`mod_div`**(*a*, *b*, *m*)

Returns x such that (b*x) mod m = a mod m

`Goulib.math2.`**`mod_fact`**(*n*, *m*)

Returns n! mod m

`Goulib.math2.`**`chinese_remainder`**(*m*, *a*)
http://en.wikipedia.org/wiki/Chinese_remainder_theorem

Parameters

- **`m`** – list of int moduli
- **`a`** – list of int remainders

Returns smallest int x such that x mod ni=ai

`Goulib.math2.`**`mod_binomial`**(*n*, *k*, *m*, *q=None*)
calculates C(n,k) mod m for large n,k,m

Parameters

- **`n`** – int total number of elements
- **`k`** – int number of elements to pick
- **`m`** – int modulo (or iterable of (m,p) tuples used internally)
- **`q`** – optional int power of m for prime m, used internally

`Goulib.math2.`**`baby_step_giant_step`**(*y*, *a*, *n*)
solves Discrete Logarithm Problem (DLP) y = a**x mod n

`Goulib.math2.`**`mod_matmul`**(*A*, *B*, *mod=0*)

Goulib.math2.**mod_matpow**(*M*, *power*, *mod=0*)

Goulib.math2.**matrix_power**(*M*, *power*, *mod=0*)

Goulib.math2.**mod_sqrt**(*n*, *p*)
modular sqrt(n) mod p

Goulib.math2.**mod_fac**(*n*, *mod*, *mod_is_prime=False*)
modular factorial : return n! % modulo if module is prime, use Wilson's theorem https://en.wikipedia.org/wiki/Wilson%27s_theorem

Goulib.math2.**pi_digits_gen**()
generates pi digits as a sequence of INTEGERS ! using Jeremy Gibbons spigot generator

:see :http://www.cs.ox.ac.uk/people/jeremy.gibbons/publications/spigot.pdf

Goulib.math2.**pfactor**(*n*)
Helper function for sprp.

Returns the tuple (x,y) where n - 1 == (2 ** x) * y and y is odd. We have this bit separated out so that we don't waste time recomputing s and d for each base when we want to check n against multiple bases.

Goulib.math2.**sprp**(*n*, *a*, *s=None*, *d=None*)
Checks n for primality using the Strong Probable Primality Test to base a. If present, s and d should be the first and second items, respectively, of the tuple returned by the function pfactor(n)

Goulib.math2.**jacobi**(*a*, *p*)
Computes the Jacobi symbol (alp), where p is a positive odd number. :see: https://en.wikipedia.org/wiki/Jacobi_symbol

Goulib.math2.**pollardRho_brent**(*n*)
Brent's improvement on Pollard's rho algorithm.

Returns int n if n is prime

otherwise, we keep chugging until we find a factor of n strictly between 1 and n. :see: https://en.wikipedia.org/wiki/Pollard%27s_rho_algorithm

Goulib.math2.**pollard_pm1**(*n*, *B1=100*, *B2=1000*)
Pollard's p+1 algorithm, two-phase version.

Returns n if n is prime; otherwise, we keep chugging until we find a factor of n strictly between 1 and n.

Goulib.math2.**mlucas**(*v*, *a*, *n*)
Helper function for williams_pp1(). Multiplies along a Lucas sequence modulo n.

Goulib.math2.**williams_pp1**(*n*)
Williams' p+1 algorithm. :return: n if n is prime otherwise, we keep chugging until we find a factor of n strictly between 1 and n.

Goulib.math2.**ecadd**(*p1*, *p2*, *p0*, *n*)

Goulib.math2.**ecdub**(*p*, *A*, *n*)

Goulib.math2.**ecmul**(*m*, *p*, *A*, *n*)

Goulib.math2.**factor_ecm**(*n*, *B1=10*, *B2=20*)
Factors n using the elliptic curve method, using Montgomery curves and an algorithm analogous to the two-phase variant of Pollard's p-1 method. :return: n if n is prime otherwise, we keep chugging until we find a factor of n strictly between 1 and n

Goulib.math2.**legendre**(*a*, *p*)
Functions to comptue the Legendre symbol (alp). The return value isn't meaningful if p is composite :see: https://en.wikipedia.org/wiki/Legendre_symbol

Goulib.math2.**legendre2**(*a*, *p*)
Functions to comptue the Legendre symbol (alp). The return value isn't meaningful if p is composite :see: https://en.wikipedia.org/wiki/Legendre_symbol

2.15 Goulib.motion module

motion simulation (kinematics)

class Goulib.motion.**PVA**(*funcs*)
Bases: *Goulib.plot.Plot*

represents a function of time returning position, velocity, and acceleration

__init__(*funcs*)
Initialize self. See help(type(self)) for accurate signature.

__call__(*t*, *t0=0*)
Call self as a function.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

html(***kwargs*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

svg(***kwargs*)

class Goulib.motion.**Segment**(*t0*, *t1*, *funcs*)
Bases: *Goulib.motion.PVA*

a PVA defined between 2 times, null elsewhere

__init__(*t0*, *t1*, *funcs*)
Initialize self. See help(type(self)) for accurate signature.

dt()

start()

startPos()

startSpeed()

startAcc()

startJerk()

startTime()

end()

endPos()

endSpeed()

endAcc()

endJerk()

endTime()

timeWhenPosBiggerThan(*pos*, *resolution=0.01*)
search the first time when the position is bigger than pos :params pos: the pos that must at least be reached :params resolution: the time resolution in sec

__call__(*t*)
Call self as a function.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

html(***kwargs*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

render (*fmt='svg', **kwargs*)

save (*filename, **kwargs*)

svg (***kwargs*)

class Goulib.motion.**Segments** (*segments=[], label='Segments'*)

Bases: `Goulib.motion.Segment`

can be initialized with a list of segment (that of course can also be a Segments) :param label: a label can be given

__init__ (*segments=[], label='Segments'*)

can be initialized with a list of segment (that of course can also be a Segments) :param label: a label can be given

__str__ ()

Return str(self).

html ()

update ()

yet only calculates t0 and t1

insert (*segment, autoJoin=True*)

insert a segment into Segments :param segment: the segment to add. must be in a range that is not already defined or it will rise a value error exception :param autoJoin: if True and the added segment has the same starting position as the last segment's end

> and both velocity are 0 then a segment of (pos,v=0,a=0) is automatically added. this help discribing movements only where there is curently a movement

add (*segments, autoJoin=True*)

add a segment or a list of segment to the segments

start ()

end ()

__call__ (*t*)

Call self as a function.

__class__

alias of `builtins.type`

__delattr__

Implement delattr(self, name).

__dir__ () → list

default dir() implementation

__eq__

Return self==value.

__format__ ()

default object formatter

__ge__

Return self>=value.

__getattribute__

Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

dt()

endAcc()

endJerk()

endPos()

endSpeed()

endTime()

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

startAcc()

startJerk()

startPos()

startSpeed()

startTime()

svg(***kwargs*)

timeWhenPosBiggerThan (*pos*, *resolution=0.01*)
search the first time when the position is bigger than pos :params pos: the pos that must at least be reached :params resolution: the time resolution in sec

class Goulib.motion.**SegmentPoly** (*t0*, *t1*, *p*)
Bases: *Goulib.motion.Segment*

a segment defined by a polynomial position law

__init__ (*t0*, *t1*, *p*)
Initialize self. See help(type(self)) for accurate signature.

__call__ (*t*)
Call self as a function.

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__ () → list
default dir() implementation

__eq__
Return self==value.

__format__ ()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__ ()
Create and return a new object. See help(type) for accurate signature.

__reduce__ ()
helper for pickle

__reduce_ex__ ()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

dt()

end()

endAcc()

endJerk()

endPos()

endSpeed()

endTime()

html(***kwargs*)

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

start()

startAcc()

startJerk()

startPos()

startSpeed()

startTime()

svg(***kwargs*)

timeWhenPosBiggerThan(*pos*, *resolution=0.01*)
search the first time when the position is bigger than pos :params pos: the pos that must at least be reached :params resolution: the time resolution in sec

Goulib.motion.**ramp**(*dp*, *v0*, *v1*, *a*)

Parameters

- **dp** – float delta position or None if unknown
- **v0** – float initial velocity or None if unknown
- **v1** – float final velocity or None if unknown
- **a** – float acceleration

Returns float shortest time to accelerate between constraints

Goulib.motion.**trapeze**(*dp*, *vmax*, *a*, *v0=0*, *v2=0*)

Parameters

- **dp** – float delta position
- **vmax** – float maximal velocity
- **a** – float acceleration
- **v0** – float initial velocity, 0 by default
- **v2** – float final velocity, 0 by default

Returns tuple of 6 values:

- time at end of acceleration
- position at end of acceleration
- velocity at end of acceleration
- time at begin of deceleration
- position at begin of deceleration
- total time

`Goulib.motion.`**`Segment2ndDegree`**(*t0*, *t1*, *start*, *end=None*)

calculates a constant acceleration Segment between start and end

Parameters

- **t0,t1** – float start,end time. one of both may be None for undefined
- **start** – (position, velocity, acceleration) float tuple. some values may be None for undefined
- **end** – (position, velocity, acceleration) float tuple. some values may be None for undefined

Returns *SegmentPoly*

the function can cope with almost any combination of defined/undefined parameters, among others (see tests):

- Segment2ndDegree(t0,t1,(p0,v0),p1) # time interval and start + end positions + initial speed
- Segment2ndDegree(t0,t1,(p0,v0,a)) # time interval and start with acceleration
- Segment2ndDegree(t0,t1,None,(p1,v1,a)) # time interval and end pva
- Segment2ndDegree(t0,None,(p0,v0),(p1,v1)) # start + end positions + velocities
- Segment2ndDegree(t0,None,(p0,v0,a),(None,v1)) # start pva + end velocity
- Segment2ndDegree(None,t1,p0,(p1,v1,a)) # end pva + start position

the function also accepts some combinations of overconstraining parameters:

- Segment2ndDegree(t0,t1,(p0,v0,a),p1) # time interval, start pva, end position => adjust t1
- Segment2ndDegree(t0,t1,(p0,v0,a),(None,v1)) # time interval, start pva, v1=max vel => adjust t1

Raises **ValueError** – when not enough parameters are specified to define the Segment univoquely

`Goulib.motion.`**`Segment4thDegree`**(*t0*, *t1*, *start*, *end*)

smooth trajectory from an initial position and initial speed (p0,v0) to a final position and speed (p1,v1) * if t1<=t0, t1 is calculated

`Goulib.motion.`**`SegmentsTrapezoidalSpeed`**(*t0*, *p0*, *p3*, *a*, *T=0*, *vmax=inf*, *v0=0*, *v3=0*)

Parameters

- **t0** – float start time
- **p0** – float start position
- **p3** – float end position
- **a** – float specified acceleration. if =0, use specified time
- **T** – float specified time. if =0 (default), use specified acceleration
- **vmax** – float max speed. default is infinity (i.e. triangular speed)
- **v0** – initial speed
- **v3** – final speed if T <> 0 then v3 = v0 v1 +——-+

  / / + v3

v0 +

| | |

t0 t1 t2 t3

2.16 Goulib.optim module

various optimization algorithms : knapsack, traveling salesman, simulated annealing, differential evolution

class Goulib.optim.**ObjectiveFunction**(*objective_function*)

Bases: object

class to wrap an objective function and keep track of the best solution evaluated

__init__(*objective_function*)
Initialize self. See help(type(self)) for accurate signature.

__call__(*solution*)
Call self as a function.

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.optim.**nelder_mead**(*f*, *x_start*, *step=0.1*, *no_improve_thr=1e-05*, *no_improv_break=10*, *max_iter=0*, *alpha=1.0*, *gamma=2.0*, *rho=-0.5*, *sigma=0.5*)
Pure Python implementation of the Nelder-Mead algorithm. also called "downhill simplex method" taken from https://github.com/fchollet/nelder-mead

Reference: https://en.wikipedia.org/wiki/Nelder%E2%80%93Mead_method :param f: function to optimize, must return a scalar score

and operate over a numpy array of the same dimensions as x_start

Parameters

- **x_start** – (numpy array) initial position
- **step** – (float) look-around radius in initial step
- **no_improv_break** (*no_improv_thr,*) – (float,int): break after no_improv_break iterations with an improvement lower than no_improv_thr
- **max_iter** – (int): always break after this number of iterations. Set it to 0 to loop indefinitely.
- **gamma, rho, sigma** (*alpha,*) – (floats): parameters of the algorithm (see Wikipedia page for reference)

class Goulib.optim.**BinDict**(*capacity*, *f=<function _Bin.<lambda>>*)
Bases: Goulib.optim._Bin, dict

a container with a limited capacity :param capacity: int,flot,tuple of whatever defines the capacity of the Bin :param f: function f(x) returning the capacity used by item x. Must return the empty capacity when f(0) is called

__isub__(*key*)
removal of an element : MUST BE OVERLOADED by subclasses and called AFTER item is removed

__delitem__(*key*)
removal of an element : MUST BE OVERLOADED by subclasses and called AFTER item is removed

__iadd__(*key*, *item*)
addition of an element : MUST BE OVERLOADED by subclasses

__setitem__(*key*, *item*)
addition of an element : MUST BE OVERLOADED by subclasses

__class__
alias of `builtins.type`

__contains__()
True if D has a key k, else False.

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__init__(*capacity*, *f=<function _Bin.<lambda>>*)
a container with a limited capacity :param capacity: int,flot,tuple of whatever defines the capacity of the Bin :param f: function f(x) returning the capacity used by item x. Must return the empty capacity when f(0) is called

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → size of D in memory, in bytes

__str__
Return str(self).

clear() → None. Remove all items from D.

copy() → a shallow copy of D

fits(*item*)

Returns bool True if item fits in bin without exceeding capacity

fromkeys()
Returns a new dict with keys from iterable and values equal to value.

get(*k*[, *d*]) → D[k] if k in D, else d. d defaults to None.

items() → a set-like object providing a view on D's items

keys() → a set-like object providing a view on D's keys

pop(*k*[, *d*]) → v, remove specified key and return the corresponding value.
If key is not found, d is returned if given, otherwise KeyError is raised

popitem() → (k, v), remove and return some (key, value) pair as a
2-tuple; but raise KeyError if D is empty.

setdefault(*k*[, *d*]) → D.get(k,d), also set D[k]=d if k not in D

size()

update([*E*], ***F*) → None. Update D from dict/iterable E and F.
If E is present and has a .keys() method, then does: for k in E: D[k] = E[k] If E is present and lacks a .keys() method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k]

values() → an object providing a view on D's values

class Goulib.optim.**BinList**(*capacity*, *f=<function _Bin.<lambda>>*)
Bases: Goulib.optim._Bin, list

a container with a limited capacity :param capacity: int,flot,tuple of whatever defines the capacity of the Bin :param f: function f(x) returning the capacity used by item x. Must return the empty capacity when f(0) is called

__iadd__(*item*)
addition of an element : MUST BE OVERLOADED by subclasses

append(*item*)
addition of an element : MUST BE OVERLOADED by subclasses

insert (*i*, *item*)
L.insert(index, object) – insert object before index

extend (*iterable*) → None – extend list by appending elements from the iterable

__isub__ (*item*)
removal of an element : MUST BE OVERLOADED by subclasses and called AFTER item is removed

remove (*item*)
removal of an element : MUST BE OVERLOADED by subclasses and called AFTER item is removed

pop ([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

__setitem__ (*i*, *item*)
called when replacing a value in list

__add__
Return self+value.

__class__
alias of `builtins.type`

__contains__
Return key in self.

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__ () → list
default dir() implementation

__eq__
Return self==value.

__format__ ()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__getitem__ ()
x.__getitem__(y) <==> x[y]

__gt__
Return self>value.

__hash__ = None

__imul__
Implement self*=value.

__init__ (*capacity*, *f=<function _Bin.<lambda>>*)
a container with a limited capacity :param capacity: int,flot,tuple of whatever defines the capacity of the Bin :param f: function f(x) returning the capacity used by item x. Must return the empty capacity when f(0) is called

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

__str__
Return str(self).

clear() → None – remove all items from L

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

fits(*item*)

Returns bool True if item fits in bin without exceeding capacity

index(*value*[, *start*[, *stop*]]) → integer – return first index of value.
Raises ValueError if the value is not present.

reverse()
L.reverse() – reverse *IN PLACE*

size()

sort(*key=None*, *reverse=False*) → None – stable sort *IN PLACE*

`Goulib.optim.`**`first_fit_decreasing`**(*items*, *bins*, *maxbins=0*)
fit items in bins using the "first fit decreasing" method :param items: iterable of items :param bins: iterable of Bin s. Must have at least one Bin :return: list of items that didn't fit. (bins are filled by side-effect)

`Goulib.optim.`**`hillclimb`**(*init_function*, *move_operator*, *objective_function*, *max_evaluations*)
hillclimb until either max_evaluations is reached or we are at a local optima

`Goulib.optim.`**`hillclimb_and_restart`**(*init_function*, *move_operator*, *objective_function*, *max_evaluations*)
repeatedly hillclimb until max_evaluations is reached

`Goulib.optim.`**`P`**(*prev_score*, *next_score*, *temperature*)

`Goulib.optim.`**`kirkpatrick_cooling`**(*start_temp*, *alpha*)

`Goulib.optim.`**`anneal`**(*init_function*, *move_operator*, *objective_function*, *max_evaluations*, *start_temp*, *alpha*)

`Goulib.optim.`**`reversed_sections`**(*tour*)
generator to return all possible variations where the section between two cities are swapped

`Goulib.optim.`**`swapped_cities`**(*tour*)
generator to create all possible variations where two cities have been swapped

`Goulib.optim.`**`tour_length`**(*points*, *dist*, *tour=None*)
generator of point-to-point distances along a tour

`Goulib.optim.`**`tsp`**(*points*, *dist*, *max_iterations=100*, *start_temp=None*, *alpha=None*, *close=True*, *rand=True*)
Traveling Salesman Problem @see http://en.wikipedia.org/wiki/Travelling_salesman_problem @param points : iterable containing all points @param dist : function returning the distance between 2 points : def dist(a,b): @param max_iterations :max number of optimization steps @param start_temp, alpha : params for the simulated annealing algorithm. if None, hill climbing is used @param close : computes closed TSP. if False, open TSP starting at points[0] @return iterations,score,best : number of iterations used, minimal length found, best path as list of indexes of points

`class` `Goulib.optim.`**`DifferentialEvolution`**(*evaluator*, *population_size=50*, *f=None*, *cr=0.9*, *eps=0.01*, *n_cross=1*, *max_iter=10000*, *monitor_cycle=200*, *out=None*, *show_progress=False*, *show_progress_nth_cycle=1*, *insert_solution_vector=None*, *dither_constant=0.4*)
Bases: `object`

This is a python implementation of differential evolution taken from http://cci.lbl.gov/cctbx_sources/scitbx/differential_evolution.py

It assumes an evaluator class is passed in that has the following functionality data members:

n :: The number of parameters domain :: a list [(low,high)]*n

with approximate upper and lower limits for each parameter

x :: a place holder for a final solution

also a function called 'target' is needed. This function should take a parameter vector as input and return a the function to be minimized.

The code below was implemented on the basis of the following sources of information: 1. http://www.icsi.berkeley.edu/~storn/code.html 2. http://www.daimi.au.dk/~krink/fec05/articles/JV_ComparativeStudy_CEC04.pdf 3. http://ocw.mit.edu/NR/rdonlyres/Sloan-School-of-Management/15-099Fall2003/A40397B9-E8FB-4B45-A41B-D1F69218901F/0/ses2_storn_price.pdf

The developers of the differential evolution method have this advice: (taken from ref. 1)

If you are going to optimize your own objective function with DE, you may try the following classical settings for the input file first: Choose method e.g. DE/rand/1/bin, set the number of parents NP to 10 times the number of parameters, select weighting factor F=0.8, and crossover constant CR=0.9. It has been found recently that selecting F from the interval [0.5, 1.0] randomly for each generation or for each difference vector, a technique called dither, improves convergence behaviour significantly, especially for noisy objective functions. It has also been found that setting CR to a low value, e.g. CR=0.2 helps optimizing separable functions since it fosters the search along the coordinate axes. On the contrary this choice is not effective if parameter dependence is encountered, something which is frequently occuring in real-world optimization problems rather than artificial test functions. So for parameter dependence the choice of CR=0.9 is more appropriate. Another interesting empirical finding is that rasing NP above, say, 40 does not substantially improve the convergence, independent of the number of parameters. It is worthwhile to experiment with these suggestions. Make sure that you initialize your parameter vectors by exploiting their full numerical range, i.e. if a parameter is allowed to exhibit values in the range [-100, 100] it's a good idea to pick the initial values from this range instead of unnecessarily restricting diversity.

Keep in mind that different problems often require different settings for NP, F and CR (have a look into the different papers to get a feeling for the settings). If you still get misconvergence you might want to try a different method. We mostly use DE/rand/1/... or DE/best/1/... . The crossover method is not so important although Ken Price claims that binomial is never worse than exponential. In case of misconvergence also check your choice of objective function. There might be a better one to describe your problem. Any knowledge that you have about the problem should be worked into the objective function. A good objective function can make all the difference.

Note: NP is called population size in the routine below.) Note: [0.5,1.0] dither is the default behavior unless f is set to a value other then None.

`__init__`(*evaluator*, *population_size=50*, *f=None*, *cr=0.9*, *eps=0.01*, *n_cross=1*, *max_iter=10000*, *monitor_cycle=200*, *out=None*, *show_progress=False*, *show_progress_nth_cycle=1*, *insert_solution_vector=None*, *dither_constant=0.4*)
Initialize self. See help(type(self)) for accurate signature.

`optimize`()

`make_random_population`()

`score_population`()

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__gt__`
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

evolve()

2.17 Goulib.piecewise module

piecewise-defined functions

class Goulib.piecewise.**Piecewise**(*init=[], default=0, period=(-inf, inf)*)
Bases: *Goulib.expr.Expr*

piecewise function defined by a sorted list of (startx, Expr)

__init__(*init=[], default=0, period=(-inf, inf)*)

Parameters f – function or operator, Expr to copy construct, or formula string

__getitem__(*i*)

is_periodic()

__str__()
Return str(self).

__repr__()
Return repr(self).

index(*x*)
return index of piece

__call__(*x*)
returns value of Expr at point x

insort (*x*, *v=None*)
insert a point (or returns it if it already exists) note : method name follows bisect.insort convention

__iter__ ()
iterators through discontinuities. take the opportunity to delete redundant tuples

append (*x*, *y=None*)
appends a (x,y) piece. In fact inserts it at correct position

extend (*iterable*)
appends an iterable of (x,y) values

iapply (*f*, *right*)
apply function to self

apply (*f*, *right=None*)
apply function to copy of self

applx (*f*)
apply a function to each x value

__lshift__ (*dx*)

__rshift__ (*dx*)

__add__ (*right*)

__and__ (*right*)

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__ () → list
default dir() implementation

__div__ (*right*)

__eq__ (*other*)
Return self==value.

__float__ ()

__format__ ()
default object formatter

__ge__ (*other*)
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__ (*other*)
Return self>value.

__hash__ = None

__invert__ ()

__le__ (*other*)
Return self<=value.

__lt__ (*other*)
Return self<value.

__mul__(*right*)

__ne__(*other*)
Return self!=value.

__neg__()

__new__()
Create and return a new object. See help(type) for accurate signature.

__or__(*right*)

__pow__(*right*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__rmul__(*right*)

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__sub__(*right*)

__truediv__(*right*)

__xor__(*right*)

complexity()
measures the complexity of Expr :return: int, sum of the precedence of used ops

html(***kwargs*)

isNum

isconstant

Returns True if Expr evaluates to a constant number or bool

latex()

Returns string LaTex formula

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

svg(***kwargs*)

points(*xmin=None*, *xmax=None*)

Returns x,y lists of float : points for a line plot

2.18 Goulib.plot module

plotable rich object display on IPython/Jupyter notebooks

class Goulib.plot.**Plot**

Bases: object

base class for plotable rich object display on IPython notebooks inspired from http://nbviewer.ipython.org/github/ipython/ipython/blob/3607712653c66d63e0d7f13f073bde8c0f209ba8/docs/examples/notebooks/display_protocol.ipynb

render (*fmt='svg'*, ***kwargs*)

save (*filename*, ***kwargs*)

html (***kwargs*)

svg (***kwargs*)

png (***kwargs*)

plot (***kwargs*)

renders on IPython Notebook (alias to make usage more straightforward)

__class__

alias of builtins.type

__delattr__

Implement delattr(self, name).

__dir__ () → list

default dir() implementation

__eq__

Return self==value.

__format__ ()

default object formatter

__ge__

Return self>=value.

__getattribute__

Return getattr(self, name).

__gt__

Return self>value.

__hash__

Return hash(self).

__init__

Initialize self. See help(type(self)) for accurate signature.

__le__

Return self<=value.

__lt__

Return self<value.

__ne__

Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.plot.**render**(*plotables*, *fmt='svg'*, ***kwargs*)
renders several Plot objects

Goulib.plot.**png**(*plotables*, ***kwargs*)

Goulib.plot.**svg**(*plotables*, ***kwargs*)

Goulib.plot.**plot**(*plotables*, ***kwargs*)

Goulib.plot.**save**(*plotables*, *filename*, ***kwargs*)

2.19 Goulib.polynomial module

simple manipulation of polynomials (without SimPy) see http://docs.sympy.org/dev/modules/polys/reference.html if you need more ...

class Goulib.polynomial.**Polynomial**(*val*)
Bases: *Goulib.expr.Expr*

Param val can be:

- an iterable of the factors in ascending powers order : Polynomial([1,2,3]) holds 3*x^2+2*x+1
- a string of the form "ax^n + b*x^m + ... + c x + d" where a,b,c,d, are floats and n,m ... are integers the 'x' variable name is fixed, and the spaces and '*' chars are optional. terms can be in any order, and even "overlap" : Polynomial('3x+x^2-x') holds x^2+2*x

__init__(*val*)

Param val can be:

- an iterable of the factors in ascending powers order : Polynomial([1,2,3]) holds 3*x^2+2*x+1
- a string of the form "ax^n + b*x^m + ... + c x + d" where a,b,c,d, are floats and n,m ... are integers the 'x' variable name is fixed, and the spaces and '*' chars are optional. terms can be in any order, and even "overlap" : Polynomial('3x+x^2-x') holds x^2+2*x

__lt__(*other*)
Return self<value.

__eq__(*other*)
Return self==value.

__add__(*other*)

__radd__(*other*)

__sub__(*other*)

__rsub__(*other*)

__mul__(*other*)

__rmul__(*other*)

__neg__()

__pow__(*e*)

integral()

derivative()

__and__(*right*)

__call__(*x=None*, ***kwargs*)
evaluate the Expr at x OR compose self(x())

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__div__(*right*)

__float__()

__format__()
default object formatter

__ge__(*other*)
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__(*other*)
Return self>value.

__hash__ = None

__invert__()

__le__(*other*)
Return self<=value.

__lshift__(*dx*)

__ne__(*other*)
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__or__(*right*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__rshift__(*dx*)

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__truediv__(*right*)

__xor__(*right*)

applx(*f*, *var='x'*)
function composition f o self = self(f(x))

apply(*f*, *right=None*)
function composition self o f = f(self(x))

complexity()
measures the complexity of Expr :return: int, sum of the precedence of used ops

html(***kwargs*)

isNum

isconstant

Returns True if Expr evaluates to a constant number or bool

latex()

Returns string LaTex formula

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

points(*xmin=-1*, *xmax=1*, *step=0.1*)

Returns x,y lists of float : points for a line plot

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

svg(***kwargs*)

Goulib.polynomial.**plist**(*term*)
Force term to have the form of a polynomial list

`Goulib.polynomial.`**`peval`**(*plist*, *x*, *x2=None*)
Eval the plist at value x. If two values are given, the difference between the second and the first is returned. This latter feature is included for the purpose of evaluating definite integrals.

`Goulib.polynomial.`**`integral`**(*plist*)
Return a new plist corresponding to the integral of the input plist. This function uses zero as the constant term, which is okay when evaluating a definite integral, for example, but is otherwise ambiguous.

The math forces the coefficients to be turned into floats. Consider importing __future__ division to simplify this.

`Goulib.polynomial.`**`derivative`**(*plist*)
Return a new plist corresponding to the derivative of the input plist.

`Goulib.polynomial.`**`add`**(*p1*, *p2*)
Return a new plist corresponding to the sum of the two input plists.

`Goulib.polynomial.`**`sub`**(*p1*, *p2*)

`Goulib.polynomial.`**`mult_const`**(*p*, *c*)
Return a new plist corresponding to the input plist multplied by a const

`Goulib.polynomial.`**`multiply`**(*p1*, *p2*)
Return a new plist corresponding to the product of the two input plists

`Goulib.polynomial.`**`mult_one`**(*p*, *c*, *i*)
Return a new plist corresponding to the product of the input plist p with the single term c*x^i

`Goulib.polynomial.`**`power`**(*p*, *e*)
Return a new plist corresponding to the e-th power of the input plist p

`Goulib.polynomial.`**`parse_string`**(*s*)
Do very, very primitive parsing of a string into a plist. 'x' is the only term considered for the polynomial, and this routine can only handle terms of the form: 7x^2 + 6x - 5 and will choke on seemingly simple forms such as x^2*7 - 1 or x**2 - 1

`Goulib.polynomial.`**`tostring`**(*p*, ***kwargs*)
Convert a plist into a string. This looks overly complex at first, but most of the complexity is caused by special cases.

2.20 Goulib.stats module

very basic statistics functions

`Goulib.stats.`**`mean_var`**(*data*)
mean and variance by stable algorithm :param :return: float (mean, variance) of data uses a stable algo by Knuth

`Goulib.stats.`**`mean`**(*data*)

Returns mean of data

`Goulib.stats.`**`avg`**(*data*)

Returns mean of data

`Goulib.stats.`**`variance`**(*data*)

Returns variance of data, faster (?) if mean is already available

`Goulib.stats.`**`var`**(*data*)

Returns variance of data, faster (?) if mean is already available

Goulib.stats.**stddev**(*data*)

Returns standard deviation of data

Goulib.stats.**confidence_interval**(*data*, *conf=0.95*)

Returns (low,high) bounds of 95% confidence interval of data

Goulib.stats.**median**(*data*, *is_sorted=False*)

Returns median of data

Goulib.stats.**mode**(*data*, *is_sorted=False*)

Returns mode (most frequent value) of data

Goulib.stats.**kurtosis**(*data*)

Goulib.stats.**covariance**(*data1*, *data2*)

Goulib.stats.**stats**(*l*)

Returns min,max,sum,sum2,avg,var of a list

class Goulib.stats.**Stats**(*data=[]*, *mean=None*, *var=None*)

Bases: object

an object that computes mean, variance and modes of data that is appended to it as in a list (but actual values are not stored)

__init__(*data=[]*, *mean=None*, *var=None*)

Initialize self. See help(type(self)) for accurate signature.

__repr__()

Return repr(self).

append(*x*)

add data x to Stats

extend(*data*)

remove(*data*)

remove data from Stats :param data: value or iterable of values

sum

sum1

sum2

mean

avg

average

mu

variance

var

stddev

sigma

__add__(*other*)

__sub__(*other*)

__mul__(*other*)

__neg__()

__pow__(*n*)

covariance(*other*)

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.stats.**Discrete**(*data*)
Bases: `Goulib.stats.Stats`

discrete probability density function

Parameters data – can be:

- list of equiprobable values (uniform distribution)
- dict of x:p values:probability pairs

`__init__`(*data*)

Parameters data – can be:

- list of equiprobable values (uniform distribution)
- dict of x:p values:probability pairs

`__call__`(*x*)
Call self as a function.

`__add__`(*other*)

`__class__`
alias of `builtins.type`

`__delattr__`
Implement delattr(self, name).

`__dir__`() → list
default dir() implementation

`__eq__`
Return self==value.

`__format__`()
default object formatter

`__ge__`
Return self>=value.

`__getattribute__`
Return getattr(self, name).

`__gt__`
Return self>value.

`__hash__`
Return hash(self).

`__le__`
Return self<=value.

`__lt__`
Return self<value.

`__mul__`(*other*)

`__ne__`
Return self!=value.

`__neg__`()

`__new__`()
Create and return a new object. See help(type) for accurate signature.

__pow__(*n*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

__sub__(*other*)

append(*x*)
add data x to Stats

average

avg

covariance(*other*)

extend(*data*)

mean

mu

remove(*data*)
remove data from Stats :param data: value or iterable of values

sigma

stddev

sum

sum1

sum2

var

variance

class Goulib.stats.**PDF**(*pdf*, *data=[]*)
Bases: *Goulib.expr.Expr*, *Goulib.stats.Stats*

probability density function

__init__(*pdf*, *data=[]*)

Parameters **f** – function or operator, Expr to copy construct, or formula string

__call__(*x=None*, ***kwargs*)
evaluate the Expr at x OR compose self(x())

__add__(*right*)

__and__(*right*)

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__div__(*right*)

__eq__(*other*)
Return self==value.

__float__()

__format__()
default object formatter

__ge__(*other*)
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__(*other*)
Return self>value.

__hash__ = None

__invert__()

__le__(*other*)
Return self<=value.

__lshift__(*dx*)

__lt__(*other*)
Return self<value.

__mul__(*right*)

__ne__(*other*)
Return self!=value.

__neg__()

__new__()
Create and return a new object. See help(type) for accurate signature.

__or__(*right*)

__pow__(*right*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__rmul__(*right*)

__rshift__(*dx*)

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

__sub__(*right*)

__truediv__(*right*)

__xor__(*right*)

append(*x*)
add data x to Stats

applx(*f*, *var='x'*)
function composition f o self = self(f(x))

apply(*f*, *right=None*)
function composition self o f = f(self(x))

average

avg

complexity()
measures the complexity of Expr :return: int, sum of the precedence of used ops

covariance(*other*)

extend(*data*)

html(***kwargs*)

isNum

isconstant

Returns True if Expr evaluates to a constant number or bool

latex()

Returns string LaTex formula

mean

mu

plot(***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png(***kwargs*)

points(*xmin=-1*, *xmax=1*, *step=0.1*)

Returns x,y lists of float : points for a line plot

remove(*data*)
remove data from Stats :param data: value or iterable of values

render(*fmt='svg'*, ***kwargs*)

save(*filename*, ***kwargs*)

sigma

stddev

sum

sum1

sum2

svg(***kwargs*)

var

variance

Goulib.stats.**normal_pdf**(*x*, *mu*, *sigma*)
Return the probability density function at x

class Goulib.stats.**Normal**(*data=[]*, *mean=0*, *var=1*)
Bases: *Goulib.stats.PDF*

represents a normal distributed variable the base class (list) optionally contains data

if data is specified, it it used to fit a normal law

__init__(*data=[]*, *mean=0*, *var=1*)
if data is specified, it it used to fit a normal law

__str__()
Return str(self).

latex()

Returns string LaTex formula

linear(*a*, *b=0*)

Returns a*self+b

__mul__(*a*)

__div__(*a*)

__truediv__(*a*)

__add__(*other*)

__radd__(*other*)

__neg__()

__sub__(*other*)

__rsub__(*other*)

covariance(*other*)

cov(*other*)

pearson(*other*)

correlation(*other*)

corr(*other*)

__and__(*right*)

__call__(*x=None*, ***kwargs*)
evaluate the Expr at x OR compose self(x())

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)
Return self==value.

__float__()

__format__()
default object formatter

__ge__(*other*)
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__(*other*)
Return self>value.

__hash__ = None

__invert__()

__le__(*other*)
Return self<=value.

__lshift__(*dx*)

__lt__(*other*)
Return self<value.

__ne__(*other*)
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__or__(*right*)

__pow__(*right*)

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__rmul__(*right*)

__rshift__(*dx*)

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__xor__ (*right*)

append (*x*)
add data x to Stats

applx (*f*, *var='x'*)
function composition f o self = self(f(x))

apply (*f*, *right=None*)
function composition self o f = f(self(x))

average

avg

complexity ()
measures the complexity of Expr :return: int, sum of the precedence of used ops

extend (*data*)

html (***kwargs*)

isNum

isconstant

Returns True if Expr evaluates to a constant number or bool

mean

mu

plot (***kwargs*)
renders on IPython Notebook (alias to make usage more straightforward)

png (***kwargs*)

points (*xmin=-1*, *xmax=1*, *step=0.1*)

Returns x,y lists of float : points for a line plot

remove (*data*)
remove data from Stats :param data: value or iterable of values

render (*fmt='svg'*, ***kwargs*)

save (*filename*, ***kwargs*)

sigma

stddev

sum

sum1

sum2

svg (***kwargs*)

var

variance

Goulib.stats.**linear_regression** (*x*, *y*, *conf=None*)

Parameters

- **x,y** – iterable data

- **conf** – float confidence level [0..1]. If None, confidence intervals are not returned

Returns b0,b1,b2, (b0

Return the linear regression parameters and their <prob> confidence intervals.

ex: >>> linear_regression([.1,.2,.3],[10,11,11.5],0.95)

2.21 Goulib.table module

"mini pandas.DataFrame" Table class with Excel + CSV I/O, easy access to columns, HTML output, and much more.

Goulib.table.**attr**(*args*)

class Goulib.table.**Cell**(*data=None*, *align=None*, *fmt=None*, *tag=None*, *style={}*)
Bases: object

Table cell with HTML attributes

Parameters

- **data** – cell value(s) of any type
- **align** – string for HTML align attribute
- **fmt** – format string applied applied to data
- **tag** – called to build each cell. defaults to 'td'
- **style** – dict or string for HTML style attribute

__init__(*data=None*, *align=None*, *fmt=None*, *tag=None*, *style={}*)

Parameters

- **data** – cell value(s) of any type
- **align** – string for HTML align attribute
- **fmt** – format string applied applied to data
- **tag** – called to build each cell. defaults to 'td'
- **style** – dict or string for HTML style attribute

__repr__()
Return repr(self).

static read(*x*)
interprets x as int, float, string or None

html(***kwargs*)

Returns string HTML formatted cell:

- if data is int, default align="right"
- if data is float, default align="right" and fmt='%0.2f'
- if data is timedelta, align = "right" and formatting is done by datetime2.strftimedelta()

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.table.**Row**(*data*, *align=None*, *fmt=None*, *tag=None*, *style={}*)
Bases: object

Table row with HTML attributes

Parameters

- **data** – (list of) cell value(s) of any type
- **align** – (list of) string for HTML align attribute
- **fmt** – (list of) format string applied applied to data
- **tag** – (list of) tags called to build each cell. defaults to 'td'

- **style** – (list of) dict or string for HTML style attribute

__init__(*data*, *align=None*, *fmt=None*, *tag=None*, *style={}*)

Parameters

- **data** – (list of) cell value(s) of any type
- **align** – (list of) string for HTML align attribute
- **fmt** – (list of) format string applied applied to data
- **tag** – (list of) tags called to build each cell. defaults to 'td'
- **style** – (list of) dict or string for HTML style attribute

__repr__()
Return repr(self).

html(*cell_args={}*, ***kwargs*)
return in HTML format

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

class Goulib.table.**Table**(*data=[]*, ***kwargs*)
Bases: list

Table class with CSV I/O, easy access to columns, HTML output

inits a table, optionally by reading a Excel, csv or html file :param data: list of list of cells, or string as filename :param titles: optional list of strings used as column id :param footer: optional list of functions used as column reducers

__init__(*data=[]*, ***kwargs*)
inits a table, optionally by reading a Excel, csv or html file :param data: list of list of cells, or string as filename :param titles: optional list of strings used as column id :param footer: optional list of functions used as column reducers

__repr__()

Returns repr string of titles+5 first lines

__str__()

Returns string of full tables with linefeeds

html(*head=None*, *foot=None*, *colstyle={}*, ***kwargs*)
HTML representation of table

Parameters

- **head** – optional column headers, .titles by default
- **foot** – optional column footers, .footer by default
- **style** – (list of) dict of style attributes
- **kwargs** – optional parameters passed along to tag('table'... except: * start=optional start row * stop=optional end row used to display a subset of lines. in this case rows with '...' cells are displayed before and/or after the lines

Returns string HTML representation of table

load(*filename*, ***kwargs*)

read_element(*element*, ***kwargs*)
read table from a DOM element. :Warning: drops all formatting

read_html(*filename*, ***kwargs*)
read first table in HTML file

read_json(*filename*, ***kwargs*)
appends a json file made of lines dictionaries

read_xls(*filename*, ***kwargs*)
appends an Excel table

read_csv(*filename*, ***kwargs*)
appends a .csv or similar file to the table

save(*filename*, ***kwargs*)

write_xlsx(*filename*, ***kwargs*)

json(***kwargs*)

Returns string JSON representation of table

write_csv(*filename*, ***kwargs*)
write the table in Excel csv format, optionally transposed

__eq__(*other*)
compare 2 Tables contents, mainly for tests

ncols()

Returns number of columns, ignoring title

find_col(*title*)
finds a column from a part of the title

icol(*column*)
iterates a column

col(*column*, *title=False*)

cols(*title=False*)
iterator through columns

transpose(*titles_column=0*)
transpose table :param: titles_column :return: Table where rows are made from self's columns and vice-versa

index(*value*, *column=0*)

Returns int row number of first line where column contains value

__getitem__(*n*)
x.__getitem__(y) <==> x[y]

get(*row*, *col*)

set(*row*, *col*, *value*)

setcol(*col*, *value*, *i=0*)
set column values :param col: int or string column index :param value: single value assigned to whole column or iterable assigned to each cell :param i: optional int : index of first row to assign

append(*line*)
appends a line to table :param line: can be either: * a list * a dict or column names:values

addcol(*title*, *val=None*, *i=0*)
add column to the right

sort(*by*, *reverse=False*)
sort by column

rowasdict(*i*)
returns a line as a dict

asdict()

groupby_gen(*by*, *sort=True*, *removecol=True*)
generates subtables

groupby(*by*, *sort=True*, *removecol=True*)
ordered dictionary of subtables

hierarchy(*by='Level'*, *factory=<function Table.<lambda>>*, *linkfct=<function Table.<lambda>>*)
builds a structure from a table containing a "level" column

applyf(*by*, *f*, *skiperrors=False*)
apply a function to a column :param by: column name of number :param f: function of the form lambda cell:content :param skiperrors: bool. if True, errors while running f are ignored :return: bool True if ok, False if skiperrors==True and conversion failed

to_datetime(*by*, *fmt='%Y-%m-%d %H:%M:%S'*, *skiperrors=False*)
convert a column to datetime

to_date(*by*, *fmt='%Y-%m-%d'*, *skiperrors=False*)
convert a column to date

to_time(*by*, *fmt='%H:%M:%S'*, *skiperrors=False*)
convert a column to time

__add__
Return self+value.

__class__
alias of `builtins.type`

__contains__
Return key in self.

__delattr__
Implement delattr(self, name).

__delitem__
Delete self[key].

__dir__() → list
default dir() implementation

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__ = None

__iadd__
Implement self+=value.

__imul__
Implement self*=value.

__iter__
Implement iter(self).

__le__
Return self<=value.

__len__
Return len(self).

__lt__
Return self<value.

__mul__
Return self*value.n

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__reversed__()
L.__reversed__() – return a reverse iterator over the list

__rmul__
Return self*value.

__setattr__
Implement setattr(self, name, value).

__setitem__
Set self[key] to value.

__sizeof__()
L.__sizeof__() – size of L in memory, in bytes

clear() → None – remove all items from L

copy() → list – a shallow copy of L

count(*value*) → integer – return number of occurrences of value

extend(*iterable*) → None – extend list by appending elements from the iterable

insert()
L.insert(index, object) – insert object before index

pop([*index*]) → item – remove and return item at index (default last).
Raises IndexError if list is empty or index is out of range.

remove(*value*) → None – remove first occurrence of value.
Raises ValueError if the value is not present.

reverse()
L.reverse() – reverse *IN PLACE*

to_timedelta(*by*, *fmt=None*, *skiperrors=False*)
convert a column to time

total(*funcs*)
build a footer row by appling funcs to all columns

remove_lines_where(*f*, *value=(None, 0, ”)*)

Parameters **f** – function of the form lambda line:bool returning True if line should be removed

Returns int number of lines removed

2.22 Goulib.tests module

utilities for unit tests (using nose)

Goulib.tests.**pprint_gen**(*iterable, indices=[0, 1, 2, -3, -2, -1], sep='...'*)
generates items at specified indices

Goulib.tests.**pprint**(*iterable, indices=[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, -3, -2, -1], timeout=1*)

class Goulib.tests.**TestCase**(*methodName='runTest'*)
Bases: unittest.case.TestCase

Create an instance of the class that will use the named test method when executed. Raises a ValueError if the instance does not have a method with the specified name.

assertSequenceEqual(*seq1, seq2, msg=None, seq_type=None, places=7, delta=None, reltol=None*)
An equality assertion for ordered sequences (like lists and tuples). constraints on seq1,seq2 from unittest.TestCase.assertSequenceEqual are mostly removed

Parameters

- **seq2** (*seq1,*) – iterables to compare for (quasi) equality
- **msg** – optional string message to use on failure instead of a list of differences
- **places** – int number of digits to consider in float comparisons. If None, enforces strict equality
- **delta** – optional float absolute tolerance value
- **reltol** – optional float relative tolerance value

base_types = ((<class 'int'>,), (<class 'str'>,), <class 'str'>, <class 'bool'>, <clas

assertEqual(*first, second, places=7, msg=None, delta=None, reltol=None*)
automatically calls assertAlmostEqual when needed :param first, second: objects to compare for (quasi) equality :param places: int number of digits to consider in float comparisons.

If None, forces strict equality

Parameters

- **msg** – optional string error message to display in case of failure
- **delta** – optional float absolute tolerance value
- **reltol** – optional float relative tolerance value

assertCountEqual(*seq1, seq2, msg=None*)
compare iterables converted to sets : order has no importance

__call__(**args, **kwds*)
Call self as a function.

__class__
alias of builtins.type

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__(*other*)
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__()
Return hash(self).

__init__(*methodName='runTest'*)
Create an instance of the class that will use the named test method when executed. Raises a ValueError if the instance does not have a method with the specified name.

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__()
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__()
Return str(self).

addCleanup(*function*, **args*, ***kwargs*)
Add a function, with arguments, to be called when the test is completed. Functions added are called on a LIFO basis and are called after tearDown on test failure or success.

Cleanup items are called even if setUp fails (unlike tearDown).

addTypeEqualityFunc(*typeobj*, *function*)
Add a type specific assertEqual style function to compare a type.

This method is for use by TestCase subclasses that need to register their own type equality functions to provide nicer error messages.

Args:

typeobj: The data type to call this function on when both values are of the same type in assertEqual().

function: The callable taking two arguments and an optional msg= argument that raises self.failureException with a useful error message when the two arguments are not equal.

assertAlmostEqual (*first*, *second*, *places=None*, *msg=None*, *delta=None*)
Fail if the two objects are unequal as determined by their difference rounded to the given number of decimal places (default 7) and comparing to zero, or by comparing that the between the two objects is more than the given delta.

Note that decimal places (from zero) are usually not the same as significant digits (measured from the most signficant digit).

If the two objects compare equal then they will automatically compare almost equal.

assertAlmostEquals (***kwargs*)

assertDictContainsSubset (*subset*, *dictionary*, *msg=None*)
Checks whether dictionary is a superset of subset.

assertDictEqual (*d1*, *d2*, *msg=None*)

assertEquals (***kwargs*)

assertFalse (*expr*, *msg=None*)
Check that the expression is false.

assertGreater (*a*, *b*, *msg=None*)
Just like self.assertTrue(a > b), but with a nicer default message.

assertGreaterEqual (*a*, *b*, *msg=None*)
Just like self.assertTrue(a >= b), but with a nicer default message.

assertIn (*member*, *container*, *msg=None*)
Just like self.assertTrue(a in b), but with a nicer default message.

assertIs (*expr1*, *expr2*, *msg=None*)
Just like self.assertTrue(a is b), but with a nicer default message.

assertIsInstance (*obj*, *cls*, *msg=None*)
Same as self.assertTrue(isinstance(obj, cls)), with a nicer default message.

assertIsNone (*obj*, *msg=None*)
Same as self.assertTrue(obj is None), with a nicer default message.

assertIsNot (*expr1*, *expr2*, *msg=None*)
Just like self.assertTrue(a is not b), but with a nicer default message.

assertIsNotNone (*obj*, *msg=None*)
Included for symmetry with assertIsNone.

assertLess (*a*, *b*, *msg=None*)
Just like self.assertTrue(a < b), but with a nicer default message.

assertLessEqual (*a*, *b*, *msg=None*)
Just like self.assertTrue(a <= b), but with a nicer default message.

assertListEqual (*list1*, *list2*, *msg=None*)
A list-specific equality assertion.

Args: list1: The first list to compare. list2: The second list to compare. msg: Optional message to use on failure instead of a list of differences.

assertLogs (*logger=None*, *level=None*)
Fail unless a log message of level *level* or higher is emitted on *logger_name* or its children. If omitted, *level* defaults to INFO and *logger* defaults to the root logger.

This method must be used as a context manager, and will yield a recording object with two attributes: *output* and *records*. At the end of the context manager, the *output* attribute will be a list of the matching formatted log messages and the *records* attribute will be a list of the corresponding LogRecord objects.

Example:

```
with self.assertLogs('foo', level='INFO') as cm:
    logging.getLogger('foo').info('first message')
    logging.getLogger('foo.bar').error('second message')
self.assertEqual(cm.output, ['INFO:foo:first message',
                             'ERROR:foo.bar:second message'])
```

assertMultiLineEqual (*first*, *second*, *msg=None*)
Assert that two multi-line strings are equal.

assertNotAlmostEqual (*first*, *second*, *places=None*, *msg=None*, *delta=None*)
Fail if the two objects are equal as determined by their difference rounded to the given number of decimal places (default 7) and comparing to zero, or by comparing that the between the two objects is less than the given delta.

Note that decimal places (from zero) are usually not the same as significant digits (measured from the most signficant digit).

Objects that are equal automatically fail.

assertNotAlmostEquals (***kwargs*)

assertNotEqual (*first*, *second*, *msg=None*)
Fail if the two objects are equal as determined by the '!=' operator.

assertNotEquals (***kwargs*)

assertNotIn (*member*, *container*, *msg=None*)
Just like self.assertTrue(a not in b), but with a nicer default message.

assertNotIsInstance (*obj*, *cls*, *msg=None*)
Included for symmetry with assertIsInstance.

assertNotRegex (*text*, *unexpected_regex*, *msg=None*)
Fail the test if the text matches the regular expression.

assertNotRegexpMatches (***kwargs*)

assertRaises (*expected_exception*, **args*, ***kwargs*)
Fail unless an exception of class expected_exception is raised by the callable when invoked with specified positional and keyword arguments. If a different type of exception is raised, it will not be caught, and the test case will be deemed to have suffered an error, exactly as for an unexpected exception.

If called with the callable and arguments omitted, will return a context object used like this:

```
with self.assertRaises(SomeException):
    do_something()
```

An optional keyword argument 'msg' can be provided when assertRaises is used as a context object.

The context manager keeps a reference to the exception as the 'exception' attribute. This allows you to inspect the exception after the assertion:

```
with self.assertRaises(SomeException) as cm:
    do_something()
the_exception = cm.exception
self.assertEqual(the_exception.error_code, 3)
```

assertRaisesRegex(*expected_exception*, *expected_regex*, **args*, ***kwargs*)
Asserts that the message in a raised exception matches a regex.

Args: expected_exception: Exception class expected to be raised. expected_regex: Regex (re pattern object or string) expected

to be found in error message.

args: Function to be called and extra positional args. kwargs: Extra kwargs. msg: Optional message used in case of failure. Can only be used

when assertRaisesRegex is used as a context manager.

assertRaisesRegexp(***kwargs*)

assertRegex(*text*, *expected_regex*, *msg=None*)
Fail the test unless the text matches the regular expression.

assertRegexpMatches(***kwargs*)

assertSetEqual(*set1*, *set2*, *msg=None*)
A set-specific equality assertion.

Args: set1: The first set to compare. set2: The second set to compare. msg: Optional message to use on failure instead of a list of

differences.

assertSetEqual uses ducktyping to support different types of sets, and is optimized for sets specifically (parameters must support a difference method).

assertTrue(*expr*, *msg=None*)
Check that the expression is true.

assertTupleEqual(*tuple1*, *tuple2*, *msg=None*)
A tuple-specific equality assertion.

Args: tuple1: The first tuple to compare. tuple2: The second tuple to compare. msg: Optional message to use on failure instead of a list of

differences.

assertWarns(*expected_warning*, **args*, ***kwargs*)
Fail unless a warning of class warnClass is triggered by the callable when invoked with specified positional and keyword arguments. If a different type of warning is triggered, it will not be handled: depending on the other warning filtering rules in effect, it might be silenced, printed out, or raised as an exception.

If called with the callable and arguments omitted, will return a context object used like this:

```
with self.assertWarns(SomeWarning):
    do_something()
```

An optional keyword argument 'msg' can be provided when assertWarns is used as a context object.

The context manager keeps a reference to the first matching warning as the 'warning' attribute; similarly, the 'filename' and 'lineno' attributes give you information about the line of Python code from which the warning was triggered. This allows you to inspect the warning after the assertion:

```
with self.assertWarns(SomeWarning) as cm:
    do_something()
the_warning = cm.warning
self.assertEqual(the_warning.some_attribute, 147)
```

assertWarnsRegex(*expected_warning*, *expected_regex*, **args*, ***kwargs*)

Asserts that the message in a triggered warning matches a regexp. Basic functioning is similar to assertWarns() with the addition that only warnings whose messages also match the regular expression are considered successful matches.

Args: expected_warning: Warning class expected to be triggered. expected_regex: Regex (re pattern object or string) expected

to be found in error message.

args: Function to be called and extra positional args. kwargs: Extra kwargs. msg: Optional message used in case of failure. Can only be used

when assertWarnsRegex is used as a context manager.

assert_(***kwargs*)

countTestCases()

debug()

Run the test without collecting errors in a TestResult

defaultTestResult()

doCleanups()

Execute all cleanup functions. Normally called for you after tearDown.

fail(*msg=None*)

Fail immediately, with the given message.

failIf(***kwargs*)

failIfAlmostEqual(***kwargs*)

failIfEqual(***kwargs*)

failUnless(***kwargs*)

failUnlessAlmostEqual(***kwargs*)

failUnlessEqual(***kwargs*)

failUnlessRaises(***kwargs*)

failureException

alias of `builtins.AssertionError`

id()

longMessage = True

maxDiff = 640

run(*result=None*)

setUp()

Hook method for setting up the test fixture before exercising it.

classmethod setUpClass()

Hook method for setting up class fixture before running tests in the class.

shortDescription()
Returns a one-line description of the test, or None if no description has been provided.

The default implementation of this method returns the first line of the specified test method's docstring.

skipTest(*reason*)
Skip this test.

subTest(*msg=None*, ***params*)
Return a context manager that will return the enclosed block of code in a subtest identified by the optional message and keyword parameters. A failure in the subtest marks the test case as failed but resumes execution at the end of the enclosed block, allowing further test code to be executed.

tearDown()
Hook method for deconstructing the test fixture after testing it.

classmethod tearDownClass()
Hook method for deconstructing the class fixture after running all tests in the class.

Goulib.tests.**pep8**(*name*)

Goulib.tests.**setlog**(*level=20*, *fmt='%(levelname)s:%(filename)s:%(funcName)s: %(message)s'*)
initializes logging :param level: logging level :param fmt: string

Goulib.tests.**runmodule**(*level=20*, *verbosity=1*, *argv=[]*)

Parameters **argv** – optional list of string with additional options passed to nose.run

see http://nose.readthedocs.org/en/latest/usage.html

Goulib.tests.**runtests**(*level=20*, *verbosity=1*, *argv=[]*)

Parameters **argv** – optional list of string with additional options passed to nose.run

see http://nose.readthedocs.org/en/latest/usage.html

2.23 Goulib.workdays module

WorkCalendar class with datetime operations on working hours, handling holidays merges and improves BusinessHours and workdays packages

class Goulib.workdays.**WorkCalendar**(*worktime=[datetime.time(0, 0), datetime.time(23, 59, 59, 999999)], parent=[], weekends=(5, 6), holidays=set()*)
Bases: object

WorkCalendar class with datetime operations on working hours

MON = 0

TUE = 1

WED = 2

THU = 3

FRI = 4

SAT = 5

SUN = 6

__init__(*worktime=[datetime.time(0, 0), datetime.time(23, 59, 59, 999999)], parent=[], weekends=(5, 6), holidays=set()*)
Initialize self. See help(type(self)) for accurate signature.

start

end

setworktime (*worktime*)

addholidays (*days*)
add day(s) to to known holidays. dates with year==4 (to allow Feb 29th) apply every year note : holidays set may contain weekends too.

isworkday (*day*)
@return True if day is a work day

isworktime (*time*)
@return True if you're supposed to work at that time

nextworkday (*day*)
@return next work day

prevworkday (*day*)
@return previous work day

range (*start*, *end*)
range of workdays between start (included) and end (not included)

workdays (*start_date*, *ndays*)
list of ndays workdays from start

workday (*start_date*, *ndays*)
Same as Excel WORKDAY function. Returns a date that is the indicated number of working days before or after the starting date. Working days exclude weekends and any dates identified as holidays. Use WORKDAY to exclude weekends or holidays when you calculate invoice due dates, expected delivery times, or the number of days of work performed.

cast (*time*, *retro=False*)
force time to be in workhours

worktime (*day*)
@return interval of time worked a given day

workdatetime (*day*)
@return interval of datetime worked a given day

diff (*t1*, *t2*)
@return timedelta worktime between t1 and t2 (= t2-t1)

gethours (*t1*, *t2*)
@return fractional work hours between t1 and t2 (= t2-t1)

plus (*start*, *t*)
@return start time + t work time (positive or negative)

minus (*start*, *t*)
@return start time - t work time (positive or negative)

networkdays (*start_date*, *end_date*)
Same as Excel NETWORKDAYS function. Returns the number of whole working days between start_date and end_date (inclusive of both start_date and end_date). Working days exclude weekends and any dates identified in holidays. Use NETWORKDAYS to calculate employee benefits that accrue based on the number of days worked during a specific term

__class__
alias of `builtins.type`

__delattr__
Implement delattr(self, name).

__dir__() → list
default dir() implementation

__eq__
Return self==value.

__format__()
default object formatter

__ge__
Return self>=value.

__getattribute__
Return getattr(self, name).

__gt__
Return self>value.

__hash__
Return hash(self).

__le__
Return self<=value.

__lt__
Return self<value.

__ne__
Return self!=value.

__new__()
Create and return a new object. See help(type) for accurate signature.

__reduce__()
helper for pickle

__reduce_ex__()
helper for pickle

__repr__
Return repr(self).

__setattr__
Implement setattr(self, name, value).

__sizeof__() → int
size of object in memory, in bytes

__str__
Return str(self).

Goulib.workdays.**FullTime = <Goulib.workdays.WorkCalendar object>**
compatibility with http://pypi.python.org/pypi/BusinessHours

Goulib.workdays.**workday**(*start_date*, *ndays*, *holidays=[]*)
Same as Excel WORKDAY function. Returns a date that is the indicated number of working days before or after the starting date. Working days exclude weekends and any dates identified as holidays. Use WORKDAY to exclude weekends or holidays when you calculate invoice due dates, expected delivery times, or the number of days of work performed.

`Goulib.workdays.`**`networkdays`**(*start_date*, *end_date*, *holidays=[]*)

Same as Excel NETWORKDAYS function. Returns the number of whole working days between start_date and end_date (inclusive of both start_date and end_date). Working days exclude weekends and any dates identified in holidays. Use NETWORKDAYS to calculate employee benefits that accrue based on the number of days worked during a specific term

CHAPTER 3

Classes

CHAPTER 4

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