

Index

- (function definition), 49
- (line continuation), 23
- (tuple), 38
- * (*list* replication), 32
- * (multiplication), 28, 109
- ** (exponentiation), 28
- **kwargs, 55
- *args, 54
- + (addition), 28
- + (list concatenation), 32
- (subtraction), 28
- 1 (wildcard value), 87
- .ipynb, 13
- .pyc, 26
- / (division), 28
- // (integer division), 28
- : (block definition), 22
- : (slicing), 34
- ; (separation), 23
- = (assignment), 25
- == (equal to), 29
- [] (indexing), 33
- [] (list), 32
- # (comment), 22
- % (modulo operator), 28
- % (string formatting), 59
- < (less than), 29
- <= (less than or equal to), 29
- > (greater than), 29
- >= (greater than or equal to), 29
- __init__, 65
- __init__.py, 275
- __main__, 26
- __name__, 26
- __pycache__, 26
- __repr__, 65
- \ (line continuation), 23
- { } (dictionary), 41
- { } (string formatting), 57
- ~ (bitwise negation), 100
- != (not equal to), 29
- @ (matmul, np), 109
- """ (docstring), 23
- addition (+), 28
- all(), 38
- Anaconda, 9
- and, 29
- Anderson–Darling test, 146
- AndersonResult, 146
- any(), 38
- append() (list), 33
- argument (function), 50
- array (NumPy), 72
- assignment operation (=), 25
- ax, 160
 - annotate(), 164
 - bar(), 173
 - clabel(), 178
 - colorbar(), 168
 - contour(), 178
 - errorbar(), 171
 - fill_between(), 172
 - grid(), 164
 - imshow(), 175
 - plt.legend(), 164
 - mplot3d(), 182
 - plot_surface(), 183
 - plot_wireframe(), 183
 - polar(), 174
 - set_title(), 161
 - set_xlabel(), 161
 - set_xlim(), 162
 - set_xscale(), 162
 - set_xticklabels(), 163
 - set_xticks(), 163
 - set_ylabel(), 161
 - set_ylim(), 162
 - set_yscale(), 162
 - set_yticklabels(), 163
 - set_yticks(), 163
 - set_zlim3d(), 182
 - text(), 164
- axes (Matplotlib), 160

- axis (NumPy), 79
- axis (Pandas), 229
- Binder, 17
- binomial distribution, 143
- bisection method, 129
- bitwise negation (`~`), 100
- block, 22
- boolean*, 29
- bottleneck*, 251
- boundary value problem, 151
- break**, 47
- Brent's algorithm, 124
- broadcasting (NumPy), 84
- built-in function*, 22
- bytecode*, 11, 26
- C, 2, 31
- Cholesky decomposition, 138
- class, 63
 - `__add__`, 65
 - attribute, 65
 - `class`, 64
 - constructor, 65
 - `__init__`, 65
 - instance, 65
 - method, 65
 - `__mul__`, 65
 - `self`, 65
- `close()`, 60
- `cmath`, 31
- CoCalc, 17
- code cell, 13
- Colab, 17
- colormap* (Matplotlib), 167
- comma-separated values file, 113, 243
- comment (`#`), 22
- comparison operator, 29
- compiled language, 2, 11
- compiler, 11
- complex*, 30
- complex
 - `complex()`, 31
 - `conjugate()`, 31
 - `imag`, 31
 - `real`, 31
- complex numbers, 30
- component-wise operations, 77
- compound figure*, 159
- Conda, 9, 10
 - Environment, 9
- context manager, 60
- `continue`, 46
- copy*, 36
 - deep*, 36, 79
 - shallow*, 36, 79
- `csv` file, 113, 243
- cubic interpolation, 132
- cubic spline, 133
- cumulative distribution function, 141
- Dask, 264
- DataFrame* (Pandas), 216
- datetime64* (Pandas), 237
- decomposition, 136
 - Cholesky, 138
 - LU, 137
 - QR, 138
 - SVD, 138
- `def` (function definition), 49
- degrees*, 95
- DeprecationWarning, 63
- DescribeResult, 139
- `df`, 217
 - `abs()`, 239
 - `agg()`, 239
 - `apply()`, 240
 - `assign()`, 226
 - `columns`, 218
 - `count()`, 239
 - `cummax()`, 239
 - `cummin()`, 239
 - `cumprod()`, 239
 - `cumsum()`, 239
 - `describe()`, 220
 - `dropna()`, 233
 - `fillna()`, 233
 - `groupby()`, 247
 - `head()`, 219
 - `hist()`, 242
 - `iloc`, 221
 - `index`, 218
 - `interpolate()`, 234
 - `isna()`, 232
 - `iterrows()`, 246
 - `loc`, 222
 - `max()`, 239
 - `mean()`, 239
 - `median()`, 239
 - `min()`, 239
 - `mode()`, 239
 - `notna()`, 233
 - `plot()`, 241
 - `quantile()`, 239
 - `set_index()`, 218
 - `std()`, 239
 - `prod()`, 239
 - `tail()`, 219
 - `to_csv()`, 245
 - `to_excel()`, 246
 - `to_sql()`, 246
 - `unique()`, 235
 - `value_counts()`, 235
 - `var()`, 239

- dictionary*, 41
- division (/), 28
 - integer (/), 28
- docstring*, 18, 23, 50
- dot mechanism*, 66
- dtype* (NumPy), 79
- dynamic typing*, 24
- eigenvalue, 110, 136, 192
- eigenvector, 110, 136, 192
- elif, 43
- else, 43, 47
- embarrassingly parallel*, 259
- Enneper's minimal surface, 184
- equal to (==), 29
- eval(), 40
- except, 62
- exception*, 62
- explicit type conversion, 29, 41, 74
- exponential decay, 148
- exponentiation (**), 28
- f2py, 265
- factorial function, 121
- False, 29
- file processing mode, 60
- filter(), 37
- float, 28
- float(), 29
- for (loop), 44
- Fortran, 2, 31, 265
- function, 49
 - anonymous*, 56
 - argument
 - *args, 54
 - keyword, 54
 - **kwargs, 55
 - positional, 54
 - body*, 50
 - def, 49
 - docstring*, 50
- garbage collection*, 25
- git, 268
 - add, 269
 - branch, 272
 - checkout, 271, 273
 - commit, 270
 - init, 268
 - log, 271
 - main branch*, 272
 - merge conflict, 274
 - push, 277
 - remote add, 277
 - reset, 272
 - restore, 271
 - staging, 269
 - status, 269
- GitHub, 277
- Google Colab, 17
- GPU, 264
- graphical user interface, 2
- Graphics Processing Unit*, 264
- greater than (>), 29
- greater than or equal to (>=), 29
- grid values, 82
- GUI, 2
- harmonic oscillator, 149
- id(), 24
- IDE, 16
 - PyCharm, 17
 - Spyder, 16
 - Thonny, 16
 - VSCode, 17
- identifier*, 24
- identity*, 23
- if, 42
 - elif, 43
 - else, 43
- imaginary unit (j), 30
- immutable*, 38
- import, 26
- indentation, 22
- IndentationError, 62
- index* (Pandas), 215, 216
- index order*, 87
- IndexError, 62
- indexing ([]), 33
- initial value problem, 148
- inner join*, 230, 231
- input(), 56
- int, 28
- int(), 29
- integer*, 28
- integer division (/), 28
- interpolation
 - cubic, 133, 134
 - linear, 132, 134
 - nearest neighbor, 134
 - polynomial, 107
- interpreted language, 3, 11
- interpreter, 11
- IPython, 12
- item* (*dictionary*), 41
- iterable*, 44
- iterator*, 44
- j (imaginary unit), 30
- Jupyter, 12
 - Hub, 16
 - Lab, 16
 - Notebook, 13

- Project, 12
- server, 13
- key (dictionary)*, 41
- KeyError, 62
- Kolmogorov–Smirnov test, 146
- KstestResult, 147
- lambda, 56
- lambda calculus, 56
- language binding, 265
- least squares, 127
- len(), 36, 75
- less than (<), 29
- less than or equal to (<=), 29
- Levenberg–Marquardt algorithm, 128
- licensing, 276
- line continuation, 23
- line magic, 15
- linear least squares, 127
- Lissajous figures, 182
- list, 32
 - list(), 37
 - append(), 33
 - comprehension, 48
 - concatenation (+), 33
 - instantiation ([]), 32
 - multiplication (*), 32
 - mutability, 35
 - nested list, 32
 - sum(), 36
- logical array, 97, 99, 224
- loop
 - for loop, 44
 - while loop, 46
- LU decomposition, 137
- magic, 15
- magic command, 15
- __main__, 26, 27
- map(), 38
- markdown, 13
- math, 18, 94
- mathematical operators (built-in), 28
- mathematical operators (NumPy), 77
- Matplotlib, 156
 - annotations, 164
 - axis labels, 157
 - axis range, 162
 - axis scale, 162
 - axis ticks, 163
 - backend, 157
 - Agg, 157
 - bar plots, 173
 - color-coding, 166
 - colorbar, 168
 - colors, 166
 - compound figure, 179
 - contour plots, 178
 - error bars, 171
 - figure size, 162
 - filled areas, 172
 - frontend, 156
 - frontend, 156
 - grid, 164
 - image plots, 175
 - interactive plotting, 158, 184
 - legend, 164
 - line plot, 169
 - line style, 169
 - line width, 170
 - mathematical formulae, 165
 - plot title, 157
 - plt (Matplotlib), 156
 - polar plots, 174
 - pylab, 156
 - pyplot, 156
 - save plot, 159
 - scatter plot, 170
 - tick labels, 163
 - transparency, 164
 - viridis, 167
- matrix, 80, 108
 - determinant, 110, 136, 192
 - inversion, 136, 192
 - multiplication, 86, 109, 192
 - norm, 136
 - notation, 80
 - transpose, 109
- max(), 75
- module, 26
- modulo operator (%), 28
- multiplication operator (*), 28, 109
- multiprocessing, 263
 - Pool, 263
- mutable, 35
- __name__, 26
- NameError, 62
- namespace, 26, 50
- nan, 231
- narrowing, 29
- ndim (NumPy), 79
- Newton’s method, 130
- None, 50
- Normal distribution, 139
 - multivariate, 142
- not, 29
- not equal to (!=), 29
- Notebook, 13
- np, 72
 - && (bitwise and), 98
 - ndarray, 72
 - @ (matmul), 109

- abs(), 94
- add(), 94
- all(), 98
- any(), 98
- append(), 92, 93
- arange(), 81
- arange(), 76
- arccos(), 94
- arccosh(), 94
- arcsin(), 94
- arcsinh(), 94
- arctan(), 94
- arctan2(), 94
- arctanh(), 94
- argmax(), 101
- argmin(), 101
- argsort(), 100
- array*, 72
 - array(), 73
 - astype(), 74
 - dtype, 74, 79
 - empty(), 81
 - image form, 81
 - look-alike constructors, 81
 - matrix form, 81
 - ndim, 74, 79
 - ones(), 81
 - ragged, 80
 - shape, 74, 79
 - size, 74
 - T, 88
 - trailing axis, 80
 - zeros(), 81
- average(), 105
- bitwise (and), 98
- bitwise (or), 98
- bitwise operators, 98
- broadcasting, 84
- concatenate(), 89
- conjugate(), 94
- corrcoef(), 106
- correlate(), 106
- cos(), 94
- cosh(), 94
- cov(), 106
- cumsum(), 96
- deg2rad(), 94
- delete(), 93
- divide(), 94
- dot(), 86
- dstack(), 91
- e, 101
- empty(), 77
- equal(), 94
- exp(), 94
- expand_dims(), 91
- eye(), 110
- flip(), 89
- fliplr(), 89
- flipud(), 89
- floor(), 94
- gcd(), 94
- greater(), 94
- greater_equal(), 94
- histogram(), 105, 242
- hstack(), 91
- identity(), 109
- index order, 87
- insert(), 93
- isfinite(), 105
- isnan(), 105
- less_equal(), 94
- linalg, 110, 135
 - det(), 110
 - eig(), 110
 - eig(), 136
 - inv(), 110
 - norm(), 111
 - solve(), 111
- linspace(), 75, 81
- load(), 115
- loadtxt(), 114
- log(), 94
- log10(), 94
- logical_and(), 94
- logical_not(), 94
- logical_or(), 94
- logspace(), 76, 81
- look-alike constructors, 77
- ma, 119
 - (masked array), 116
- ma (masked array)
 - compressed(), 116
 - filled(), 116
- matmul(), 109
- mean(), 105
- median(), 105
- meshgrid(), 82
- mgrid, 82
- min(), 105
- multiply(), 94
- nan, 231
- nanmean(), 105
- nanmedian(), 105
- nanstd(), 105
- nanvar(), 105
- not_equal(), 94
- ogrid, 83
- ones(), 77
- pi, 101
- poly(), 107
- polyadd(), 108

- polyder(), 108
- polyfit(), 107
- polyint(), 108
- polydiv(), 108
- polysub(), 108
- polyval(), 108
- power(), 94
- rad2deg(), 94
- random, 102, 118
 - default_rng(), 102
 - normal(), 103
 - normal(), 104, 140
 - rand(), 104
 - random(), 102
 - seed value, 103
 - seed(), 104
- ravel(), 88
- remainder(), 94
- np.reshape(), 86
- reshape(), 92
- roots(), 107
- rot90(), 89
- s_(), 94
- save(), 115
- savetxt(), 114
- sign(), 94
- sin(), 94
- sinh(), 122
- sinh(), 94
- sort(), 100
- sqrt(), 94
- squeeze(), 91
- stack(), 90
- std(), 105
- structured array, 117
- subtract(), 94
- T, 109
- tan(), 94
- tanh(), 94
- transpose(), 109
- transpose(), 88
- var(), 105
- vstack(), 91, 110
- where(), 101
- zeros(), 77
- NumFOCUS, 6
- NumPy, 72

- object, 23
 - identifier, 24
 - identity, 23
 - type, 24
- object oriented programming, 66
- OdeResult, 148
- open(), 60
- open-source software, 2
- OptimizeResult, 125

- or, 29
- outer join, 230, 231

- package, 27
- Pandas, 214
 - column, 222
 - DataFrame, 216
 - df, 217
 - index, 215, 216
 - inplace, 246
 - Series, 214
- pass, 50
- pd, 214
 - concat(), 227
 - DataFrame, 216, 217
 - merge(), 231
 - read_csv(), 244
 - read_excel(), 246
 - read_sql(), 246
 - Series, 214
 - argmax(), 215
 - argsort(), 215
 - cumsum(), 215
 - dt, 238
 - isna(), 232
 - mean(), 215
 - min(), 215
 - notna(), 233
 - std(), 215
 - str, 236
 - values, 215
 - to_datetime(), 237
- Pearson correlation coefficient, 144
- PEP, 6
- pickle, 115
 - dump(), 115
 - load(), 115
- pip, 10, 275
- plt (Matplotlib), 156
 - add_subplot(), 160
 - axes, 159
 - bar(), 173
 - clabel(), 178
 - cmap keyword, 167
 - colorbar(), 168
 - colormap, 167
 - contour(), 178
 - errorbar(), 171
 - figure, 159
 - figure size, 162
 - figure(), 159, 162
 - fill_between(), 172
 - get_backend(), 157
 - get_cmap(), 168
 - grid(), 164
 - imshow(), 175
 - mplot3d(), 182

- plot(), 157, 169
- plot_surface(), 183
- plot_wireframe(), 183
- polar(), 174
- savefig(), 159
- show(), 157
- subplots(), 160, 162, 180
- subplots_adjust(), 180
- tight_layout(), 180
- title(), 157
- xlabel(), 157
- ylabel(), 157
- polynomial, 107
 - interpolation, 107
- print(), 57
 - format(), 57
- probability density function, 141
- probability distribution, 139
- probability mass function, 143
- process, 260
- proprietary software, 1
 - .py, 26, 27
 - .pyc, 26
 - __pycache__, 26
- PyCharm, 17
- PyPI, 10
- Python, 5
 - history, 6
 - installation, 8
 - interpreter, 11
 - Monty Python, 7
 - overview, 5
 - Package Index, 277
 - PyPI, 277
 - Python 2.x, 6
 - Python 3.x, 6
 - Software Foundation, 6
 - Zen, 7
- Python Package Index, 10
- pythonic, 7
- QR decomposition, 138
- quadrature, 122
- radians, 95
- raise, 63
- range(), 45
- RangeIndex, 218
- raster image, 159
- readlines(), 60
- reference, 18
- relational operator, 29
- return, 50
- RootResults, 130
- Runge–Kutta, 149
- Sackmesser, 139
- scientific software, 1
- SciKits, 153
- SciPy, 6
- scipy
 - constants, 121
 - c, 121
 - light_year, 121
 - physical_constants, 121
 - integrate, 122
 - dblquad(), 123
 - nquad(), 123
 - OdeResult, 148
 - quad(), 122
 - simps(), 124
 - solve_bvp(), 151
 - tplquad(), 123
 - interpolate, 131
 - CubicSpline, 133
 - griddata(), 133
 - interpId(), 131
- linalg, 134
 - cho_solve(), 138
 - cholesky(), 138
 - det(), 136
 - eig(), 136
 - inv(), 136
 - lu(), 137
 - lu_factor(), 137
 - norm(), 136
 - qr(), 138
 - solve(), 137
 - solve_banded(), 137
 - solve_triangular(), 137
 - svd(), 138
- optimize, 124
 - curve_fit(), 127
 - least_squares(), 127
 - lsq_linear(), 127
 - minimize(), 125
 - minimize_scalar(), 124
 - OptimizeResult, 125
 - root(), 129
 - root_scalar(), 129
 - RootResults, 130
- sparse, 138
 - linalg, 138
- special, 120
 - factorial(), 121
- stats, 138
 - anderson(), 146
 - AndersonResult, 146
 - binom(), 143
 - describe(), 139
 - DescribeResult, 139
 - ks_2samp(), 146

- kstest(), 146
 - KstestResult, 147
 - multivariate.normal(), 142
 - norm(), 139
 - pearsonr(), 144
- SciPy, 120
- scope, 50
- seed value, 103
- sequence, 32
- Series (Pandas), 214
- set, 42
 - intersection(), 42
 - union(), 42
- setup.py, 275
 - develop, 276
 - install, 276
- setuptools, 275
 - find.packages(), 275
 - setup(), 275
- shape (NumPy), 79
- Simpson's rule, 124
- slicing
 - operator (:), 34
- Spyder, 16
- StackOverflow, 19
- string, 39
 - eval(), 40
 - replace(), 41
 - split(), 40
 - str(), 39
 - strip(), 40
- Sturm–Liouville problem, 151
- subtraction (-), 28
- sum(), 36, 75
- SVD decomposition, 138
- lazy integration, 194
- sympy
 - And, 210
 - cancel(), 198
 - cos(), 188
 - Derivative(), 193
 - diff(), 193
 - E, 189
 - Eq(), 199
 - evalf(), 191
 - exp(), 188
 - expand(), 197
 - expand.trig(), 198
 - factor(), 197
 - function, 188
 - I, 189
 - init.printing(), 188
 - Integral(), 194
 - integrate(), 193
 - lambdify(), 191
 - lazy differentiation, 193
 - limit(), 196
 - linsolve(), 200, 202
 - Matrix, 191
 - det(), 192
 - eigenvecs(), 192
 - inv(), 192
 - T, 192
 - N(), 191
 - oo, 189
 - pi, 189
 - plotting
 - plot(), 207
 - plot3d(), 212
 - plot3d.parametric_line(), 211
 - plot_implicit(), 209
 - plot_parametric(), 207
 - Rational(), 190
 - roots(), 200
 - S(), 190
 - solvers
 - nsolve(), 204
 - solve(), 200, 203
 - solveset(), 200
 - subs(), 189
 - substitution, 189
 - symbolic equality, 197
 - symbols, 187
 - symbols
 - cancel(), 198
 - diff(), 193
 - doit(), 193
 - expand(), 197
 - factor(), 197
 - integrate(), 193
 - is.integer, 189
 - is.real, 189
 - remove0(), 196
 - series(), 196
 - subs(), 189
 - symbols(), 187
 - sympify(), 190
 - type, 189
- SyntaxError, 62
- Thonny, 16
- thread, 260
- threading, 260
- time, 73, 250
 - sleep(), 260
 - time(), 250
- timeit, 252
 - %timeit, 253
 - %timeit, 252
- traceback, 19, 60
- trigonometric functions, 95
- True, 29
- try, 62

tuple, 38
 instantiation (`()`), 38
type, 24
`type()`, 24
`TypeError`, 62

ufunc, 94
universal function, 94
unix time, 251

value (dictionary), 41
`ValueError`, 62
vector, 73
vector file, 159

vectorization, 79, 121
version control, 267, 268
viridis, 167
VSCoDe, 17

warnings, 63
while, 46
widening, 29, 78
with, 60
`write()`, 60
`writelines()`, 60

`ZeroDivisionError`, 101
`zip()`, 37