

Sage for Undergraduates  
authored by Gregory Bard  
indexed by Tahnee Cooper

Term Page Number(s)

- absolute value 10, 255
- acceleration function 79-80
- addition 1
- air resistance 84
- amicable pairs of numbers 152, 153
  - anchor 314
  - arbitrary lists 222
  - array, looping 274, 275
    - arrays 270-279
  - artery blockage 69-72
    - artery length 70
    - artery radius 70
    - aspect ratio 112
    - assertions 281
      - assume 60
      - asymptotes 13, 14
    - averaging numbers 276-277
      - B! 86-91
    - balancing reactions 74-79
      - binary 165
      - binomial 155, 156
      - biology 69-72
    - boolean variables 194
      - braces 2
      - brackets 2
      - break 265
      - capitalization 4, 5
    - Cardano's cubic formula 43
      - case/switch 281
      - chemistry 73-79, 161-163
      - coinage 228-230
    - combinations 155-157

- commands 4, 302
- commas 2, 3, 303
- comments 244
- common ratio 186
- comparators 257
- compiler 282
- complex numbers 7, 43, 124, 125
  - complex roots 126
- composition of functions 33
  - constraints 191-193
- continued fractions 188, 189
  - contour plot 106-114, 120-122
  - control flow 249-262
  - convergents 188, 189
- converting degrees and radians 8
  - convex functions 180, 181
  - coordinate 15, 16
    - cos 7
    - cot 8
  - Coulomb's law 120
- counter-battery fire 83
  - cross product 146
  - cryptology 85-91
  - csc 8
- cube roots 124-127
- curl 212-216
- cutting-and-pasting into template 293
  - debug 281, 282
  - decimal 3, 4, 32
  - define function 30, 31, 196
- degenerate system 317
- degrees of freedom 317
  - demand curve 94
  - derivatives 49-51
- derivatives, partial 136, 137, 182, 207, 208
  - derivatives, plot 50
  - determinants 145, 146, 169, 170, 208
- determines variable 314
- differential equations 195-203
- display source code 47

- divergence 210-212
- division 1
- divisors 36, 151-154
- docstring 229
- domain 128
- dot product 146
- dummy variable notation 324, 325
- early termination 255-257
  - eigenvalue 169-172, 180
  - eigenvectors 169-172
  - else 260-263
- error message 300, 301
- Euler's Phi function 149-151
  - evaluate 2, 4
  - exceptions 258-260
- expanded form 35
  - exponential 4, 5
  - exponents 1
  - factor 35, 36
  - factorial 155, 156, 167, 263, 264
- feasible points 190
- Fermat's Little Theorem 87-90
  - for loop 220-228
  - free variable 314
- generate tables 220, 221
- geometric series 186, 187
- global variable 232
  - gradients 117-118, 120-122, 137, 183
  - graph 2D 9-18
- graph hyperactive functions 99-100
  - graph, implicit function 104-106
  - graph, restrict x-values 128
- greatest common denominator 147, 148
- greatest common divisor 35
  - gridlines 15, 16
  - guess 263
- half-evaluation 130
  - help 47-49, 304
- hexadecimal 165
- higher-order roots 4

huge numbers 167, 168  
hyperbolic trig functions 157  
    if 249-251, 257  
    if-then-else 260-263  
    if-then-else, nested 281  
    indentation 221, 303  
industrial optimization 72-73  
inequalities, systems of 189-195  
    infeasible points 190  
infinite sums and series 184-188  
infinitely many solutions 29, 30  
    initial-value 198, 199  
insert into web template 292-294  
    installing sage 327-329  
integer linear programs 194  
    integral 51-60, 97-98  
    integral, definite 52  
integral, error function 59  
    integral, impossible 53, 54  
    integral, improper 57, 58  
    integral, indefinite 51, 52  
    integral, multiple 216, 217  
integration, by partial fractions 56, 57  
    interact, integral 297, 298  
interact, tangent line 287-294  
    interacts, building 286-298  
interest, compound 1, 6, 46, 131-134, 221  
    interest, simple 1  
internet connection 300, 301  
inverse trig functions 8  
    iteration 242, 243  
lagrange multipliers 181-184  
laplace transforms 203-205  
    laplacian 208, 209, 211, 212  
    latex 97, 168, 169, 205  
least common multiple 148, 149  
    least squares 173-175  
lemniscate 103, 104  
    limits 158, 159, 224-226  
line breaks 302

linear programming 189-195  
linear systems 20, 21, 25-26, 39, 40, 173-175, 313-326  
list notation 37, 38  
list operations 272-274  
lists 270-279  
lists of points 270, 271  
local variable 231  
log-log plot 122-124  
logarithms 5, 6, 42  
logical operators 280  
loop accumulators 223  
loops 220-228, 233-248  
matrices 19-29, 137-146, 169-175  
matrix coordinates 23  
matrix exponentiation 138  
matrix factorizations 172, 173  
matrix inverses 141, 142  
matrix multiplication 138  
matrix, hessian 180, 207-209  
matrix, jacobian 209-211  
matrix, kernel of a 143-145  
matrix, permutation 321  
matrix, reduced row echelon form 19, 20, 22-29, 139-142, 321  
matrix, rook 321  
matrix, vandermonde 26, 27  
max 155  
max and min 180, 208  
maximizations 190, 191  
maximizing profit 64-68  
maximizing revenue 64-68  
microeconomics 64-69, 112-114  
min 155  
minimizations 179-184, 191  
minimize costs 64-68  
modular arithmetic 154  
mortgage 131-134  
multiplication 1, 3  
multiplication, implicit 299, 300  
multivariable formulas 38, 39, 129, 130  
multivariate functions 34, 129

Newton's formula for gravity 134-136, 177-179  
    Newton's method 235-248, 251-257  
Newton's method, for loop 238, 239  
    Newton's method, tabular 237  
Newton's method, while loop 264, 265  
    non-linear systems 40-42  
        nullity 143, 144, 317  
        number theory 147-155  
numerical approximation 4, 241  
    octal 165  
odd roots of negative numbers 126-128  
optimization, constrained 181  
optimization, unconstrained 179-181  
    outputs, display 37, 40, 41  
    parabola 9  
parallel tangent lines 246-248  
    parameters 201-203, 242, 243  
    parentheses 2, 3, 302  
    permutations 155-157  
personal finance 131-134  
    physics 79-85, 118-121, 134-136, 177-179  
    pi 4  
    pivot 314, 321  
    plot 9, 10, 11  
plot, add arrows 96-97  
    plot, add text 96-97  
    plot, color 190  
plot, dashed line 98-99  
plot, dotted line 98-99  
    plot, function 31,32  
    plot, grids 95-96  
    plot, integral 97-98  
    plot, label axes 93-94  
plot, multiple graphs 15, 16, 17, 18, 50  
plot, parametric 2D 114-116  
    plot, polar 100-104  
point of agreement 246  
Poiseuille's Law 69-72  
polyhedron 194  
polynomials 34-37

present value of an annuity 2  
price-demand curve 26,27  
    prime numbers 148-151, 264  
quartic equation 168, 169  
    quick search 48  
    quotes 14  
    range 10  
reciprocal trig functions 8  
    recursion 281  
regression 163-165  
reimann 184, 185  
remove 273  
repeated roots 265-267  
resources 309-311  
resources, programming 279, 280  
    return 255  
return only certain roots 278, 279  
    roots 36, 42, 44, 45  
    rounding 155  
SageMathCloud 305-307  
saturation point 65  
    save graph 10  
scatter plots 159-163  
    scope 281  
    sec 8  
    selectors 296, 297  
share your results 60-62  
share your results, QR code reader 61  
    share your results, save as 61  
share your results, save as PDF 62  
    shipping costs 72  
    shuffle 273  
    simulations 282  
    sin 7, 11  
single-variable formulas 37, 38  
    sliders 291-293  
slope field 199-201  
smooth numbers 86, 87  
    source code 47  
speed of sage 166, 167

- square root 3, 6, 7
  - strings 281
- subroutines 228-235, 288-292
- subtraction 1
  - sudoku 165, 166
  - sum 224
- summation identities 185
  - summation proof 187
  - syntax 299
- tab completion 4
  - tan 8
- Taylor polynomials 175-179, 226, 227
- thermodynamics 109-112
  - timed out 301
- torpedo problem 201-203
  - trial division 267-269
- trigonometry 7, 8
- trigonometry, hyperbolic 157
- variable data types 280
  - variable, define 38, 39, 300
  - variables 32, 33
    - vector 146, 147
- vector calculus 206-217
  - vector length 146
- vector notation 206, 207
  - vector plots 91, 116-122, 201, 214, 216
- velocity function 79, 81, 82, 203
- verbosity control 249-251
- viewing window 12, 13
  - viscosity 70
- volume flow rate 70
- wasteful loops 223
- while loop 263-270