

# Brookhaven National Laboratory SciComp 101

## Foundations of Scientific Computing using Python

Topics	Source Code File
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### Session 01 - Introducing Scientific Computing

SciComp vs. CompSci, Workshop Overview	
SciComp as the Pathway to Internships	
Job Opportunities in Scientific Computing	
Using the Thonny IDE	hello_world.py
<b>TASK 01</b> - Code Editing and Managing Files	my_quip.py

### Session 02 - Python Fundamentals

Order of Operations (PEMDAS)	pemdas.py
Variables and Dimensional Analysis	age_in_weeks.py
NumPy Arrays, Indexes, and Element Values	numpy_arrays.py
Vectorized Operations	gauss_summation.py
<b>TASK 02</b> - Time Conversion	age_in_seconds.py

### Session 03 - Making Line Graphs

Plotting (matplotlib)	line_graphs.py
Linear Graphs and Intersection Points	fahrenheit_to_celsius.py
Infinite Sums & Convergence	basel_problem.py
Pseudo Random Number Generators	coprime_probability.py
<b>TASK 03</b> - Fundamental Theorem of Algebra	plot_quintic.py

### Session 04 - Functions and Logic

Functions, Boolean Conditions, Mod Operator	perfect_numbers.py
Estimation of the Base of Natural Logarithm	random_straws.py
Numba, Histograms, Probability Distributions	collatz_conjecture.py
Population Pairwise Comparison	birthday_paradox.py
<b>TASK 04</b> - Infinite Series	leibniz_formula.py

### Session 05 - Square Roots and Areas

Iterative Root Finding, Epsilon as Error	newton_sqrt.py
Numeric Precision, Rate of Convergence	herons_method.py
Complex Number Algebra	euler_identity.py
Integration using Riemann Sums	circle_area.py
<b>TASK 05</b> - Power Series	logarithm_series.py

### Session 06 - Polar Coordinates

Polar to Cartesian Coordinate Conversion	plot_circle.py
Polar Projection, Parametric Equations	plot_rose_curves.py
Sinusoid Superposition, Angle Product Identity	plot_superposition.py
Brownian Motion	random_walk.py
<b>TASK 06</b> - Radius of Curvature	archimedes_spiral.py

**Session 07 - Probability and Statistics**

Mean, Variance, Std Deviation	hero_abilities.py
Median and Mode	common_statistics.py
Moment of Distribution	uniform_variance.py
Normal Distribution, Central Limit Theorem	pachinko_normal.py
Gauss Circle Problem	lattice_circle.py
<b>TASK 07</b> - Maxwell/Boltzmann Distribution	<b>maxwell_boltzmann.py</b>

**Session 08 - Histograms and Code Breaking**

Encodings, ASCII, UTF-8	reverse_string.py
Reading Text Files	freq_histogram.py
Frequency Analysis, Bigrams	caesar_decrypt.py
Bigram Frequency Analysis	bigram_frequency.py
Bigram Cryptanalysis	bigram_decrypt.py
<b>TASK 08</b> - Decrypt File	<b>ciphertext2.txt</b>

**Session 09 - Measuring Waves**

Nyquist Sampling - Known Wavelength	nyquist_known.py
Nyquist Sampling - Unknown Wavelength	nyquist_unknown.py
Frequency, Phase, Superposition	standing_waves.py
Surface Sampling	sampling_circle.py
<b>TASK 09</b> - Angle Product Identity	<b>werner_formula.py</b>

**Session 10 - Random Numbers and Algorithms**

Encoding, Python Lists	list_cards.py
Boolean Data Type, Helper Data Structures	dealer_bogus.py
Random Numbers, Instrumentation	dealer_slow.py
Randomness without Reptition	dealer_fast.py
Algorithmic Efficiency	prime_racer1-3.py
<b>TASK 10</b> - Number Theory	<b>lcm_from_gcd.py</b>

**Session 11 - 3D Graphics**

3D Cartesian Coordinates	plot3d_monolith.py
Oblique Projection, Vertices, Facets	plot3d_pyramid.py
Helical Spirals	plot3d_helix.py
Spherical Coordinates	plot3d_sphere.py
Volume of Revolution	plot3d_torus.py
Surface Plot, Mesh Grid	plot3d_surface.py
<b>TASK 11</b> - Cylindrical Coordinates	<b>plot3d_cylinder.py</b>

**Session 12 - Monte Carlo Methods**

Random Sampling	mc_circle_prng.py
Fixed Grid	mc_circle_grid.py
Quasi-Random Numbers	mc_circle_halton.py
Pythagorean Theorem	mc_sphere.py
Halton QRNG - Four Dimensions	mc_hypersphere.py
High Dimensional Hyperspheres	mc_high_dimensions.py
<b>TASK 12</b> - Area of a Parabola	mc_parabola.py

**Session 13 - Using Data Files**

Key-Value Pairs, REPL	python_dictionaries.py
JSON Format	write_json.py
Comparing Isotope Half-life	read_json.py
Periodic Table of Elements	plot_liquid_range.py
Linear Regression - Gaussian Line of Best Fit	identify_element.py
<b>TASK 13</b> - Cosmic Ray Kinematics	plot_trajectory.py

**Session 14 - Coding for Physics**

Equation of Motion, Kinematics	projectile_motion.py
Exponential Decay, Euler's Method, Carbon-14	nuclear_decay.py
Simple Harmonic Motion	simple_pendulum.py
Differential Equations, Runge-Kutta (RK4)	nonlinear_ode.py
<b>TASK 15</b> - Newtonian Kinematics	rocket_propulsion.py

**Session 15 - Coding for Biology and Chemistry**

Genetic Homologs	seq_lrss.py
DNA Transcription, Codons, Open Reading Frames	seq_orf.py
Epidemiology, S-I-R Compartment Model	epidemiology.py
Balancing Ionic Equations	stoichiometry.py
<b>TASK 14</b> - Combustion Reaction of Gasoline	octane_combustion.py

**Session 16 - Linear Equations**

Vector Algebra, Norm, Dot Product	dot_product.py
Basis Set, Orthogonality	basis_vectors.py
Matrices, Dimensions, Shape	matrix_shape.py
Matrix Multiplication	matrix_multiplication.py
Matrix Determinants and Inversion	matrix_determinant.py
Cramer's Rule, Matrix Algebra	solve_3x3.py
<b>TASK 16</b> - Solving Systems of Linear Equations	solve_4x4.py

**Session 17 - Maze Searching**

Binary Encoding and Binary Data Files	maze_draw.py
Depth First Search, Recursion, Stacks	maze_search.py
Adjacency Matrices	maze_adjacency.py
<b>TASK 17</b> - Network Branching Factor	maze.csv.pickle

**Session 18 - Dynamical Systems**

Stable Orbits, Strange Attractors, Bifurcation	logistics_map.py
Copmplex Iteration, Escape Time, Color Spaces	mandlebrot_set.py
Affine Transformation, Sierpinski's Triangle	ifs_triangle
Transformation Matrices, Barnsley's Fern	if_fern.py
Iterated Function Systems, Information Density	ifs_bnl.py
Barnsley's Collage Theorem	ifs_square.py
<b>TASK 18</b> - Create a Hexagonal Fractal	<b>ifs_hexagonal.py</b>

**Session 19 - Continued Fractions**

Continued Fractions Taxonomy	std_cf.py
Generalized Continued Fractions	gen_cf.py
Period of Continued Fraction Expansion	pells_equation.py
<b>TASK 19</b> - Binary Digit Population Count	<b>hamming_weight.py</b>

**Session 20 - Machine Learning**

Convex Hull, Dot Product, Jarvis March	convex_hull.py
k-Means Clustering, Cluster Eviction	k_means.py
<b>TASK 20</b> - Factoring a Quadratic	<b>factor_quadratic.py</b>

**Session 21 - Jenga Blocks**

Center of Mass, Object Oriented Design	jenga_14.py
Cantilever Equilibrium	jenga_15.py
Moment of Inertia, Tipping Point	plot_centers.py

**Session 22 - Scramble Squares**

Integer Encoding, Recursive Search	scramble_squares.py
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