

**Brookhaven National Laboratory SciComp 101**  
Foundations of Scientific Computing using Python

| Topics | Source Code File |
|--------|------------------|
|--------|------------------|

**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 | <b>mc_parabola.py</b> |

### 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        | <b>plot_trajectory.py</b> |

### Session 14 - Coding for Biology and Chemistry

|  |                             |
|--|-----------------------------|
| Genetic Homologs                                 | seq_lrss.py                 |
| Genotypes, Punnett Squares                       | mendelian_inheritance.py    |
| Balancing Ionic Equations                        | stoichiometry.py            |
| <b>TASK 14</b> - Combustion Reaction of Gasoline | <b>octane_combustion.py</b> |

### Session 15 - Coding for Physics

|  |                             |
|--|-----------------------------|
| Equation of Motion, Kinematics               | projectile_motion.py        |
| Exponential Decay, Euler's Method, Carbon-14 | nuclear_decay.py            |
| Simple Harmonic Motion                       | pendulum.py                 |
| <b>TASK 15</b> - Newtonian Kinematics        | <b>rocket_propulsion.py</b> |

### Session 16 - Linear Equations

|  |                          |
|--|--------------------------|
| Vector & Matrix Algebra                              | matrix_multiplication.py |
| Determinants   | matrix_determinants.py   |
| Coefficient Matrix and Value Vector                  | cramers_rule.py          |
| <b>TASK 16</b> - Solving Systems of Linear Equations | <b>solve_4x4.ipynb</b>   |

### 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 | <b>maze.csv.pickle</b> |

### Session 18 - Dynamical Systems

|  |                      |
|--|----------------------|
| Affine Transformation, Sierpinski's Triangle | ifs_triangle         |
| Transformation Matrices, Barnsley's Fern     | if_fern.py           |
| Iterated Function Systems, BNL Letters       | ifs_bnl.py           |
| Barnsley's Collage Theorem                   | ifs_hexagonal.py     |
| <b>TASK 18</b> - Create a Square Fractal     | <b>ifs_square.py</b> |

**Session 19 - Continued Fractions**

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

**Session 20 - Machine Learning**

|   |                     |
|---|---------------------|
| Method of Least Squares, Ideal Gas Law          | identify_element.py |
| k-Means Clustering, Cluster Eviction            | k_means.py          |
| <b>TASK 20</b> - Primality Testing Optimization | prime_racer.py      |

**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 |
| Group Theory - Rotations and Permutations | four_solutions.py   |