Survey of Scientific Computing (SciComp 105) Syllabus

Topics	Lab Title	Lab #	Source Code File	MiniSem
Session 01 - Learning Python				1
Defining Scientific Computing	Amazon Cloud, Remote Desktop			
Python and Visual Studio Code	Hello World!	lab1	hello_world.py	
Program Structure, Variables	Age in Seconds	lab2	age_converter.py	
For Loops, Absolute Zero	Temperature Conversion	lab3	temperature_converter.py	
Session 02 - Algebra				2
Python for loops and range()	Gaussian Sum	lab1	gaussian_sum.py	
Python while loops	Euclid's GCD	lab2	euclid_gcd.py	
Iterative Root Finding, Epsilon as Error	Newton's Method for Square Roots	lab3	newton_sqrt.py	
Mpmath Arbitrary Precision Module	Roots of Googol	lab4	big_sqrt.py	
Greek Geometry	Heron's Formula	lab5	herons_method.py	
Nested Loops	Factoring Quadratics	lab6	factor_quadratic.py	
Session 03 - Algorithms				
Encoding, Python Lists	Card Encoding	lab1	list_cards.py	
Boolean Data Type, Helper Data Structures	Unique Random Sequence	lab2	dealer_bogus.py	
Random Numbers, Instrumentation	Slow Card Dealer	lab3	dealer_slow.py	
Algorithmic Efficiency	Fast Card Dealer	lab4	dealer_fast.py	
Implementation Optimization	Primality Race	lab5	prime_racer1,2,3,4.py	
Python Lists, Sort Algorithms	Bubble Sort	lab6	sort_list.py	
NumPy Arrays, Functional Programming	NumPy Quicksort	lab7	sort_array.py	
Session 04 - 2D Graphics				3
Matplotlib Graphics	Setting axes limits, decorating plots	lab1	plot_parabola.py	
Python Sympy Module	Zeros of a Polyomial	lab2	plot_polynomial.py	
2D Polar Coordinates	Draw Circle	lab3	plot_circle.py	
2D Translations and Scaling	Draw Olympic Rings	lab4	plot_rings.py	
Parametric Curves	Polar Sinusoids (Rose Curves)	lab5	plot_rose_curves.py	
Pyplot Programming	Combining Multiple Graphs	lab6	plot_multigraphs.py	
Session 05 - Number Theory				
Modulus Operator	Perfect Numbers	lab1	perfect_numbers.py	
Infinite Series, Convergence	Basel Problem	lab2	basel_series.py	
Modulus Operator	Euler's Totient	lab3	euler_totient.py	
Number Theory	Goldbach's Conjecture	lab4	goldbach_conjecture.py	
Collatz Conjecture	Stopping Time Histogram	lab5	collatz_conjecture.py	
Session 06 - Geometry				
Greek Geometry	Heron's Formula	lab1	herons_formula.py	
Triangle Geometry	Euler's Line	lab2	euler_line.py	
Session 07 - Statistics				
Statistics (Mean, Variance)	Hero Abilities	lab1	hero_abilities.py	
Statistical Analysis	Mean vs Median vs. Mode	lab2	statistics.py	
Biased vs. Unbiased Estimators	Bessel's Correction to Sample Variance	lab3	bessel_correction.py	
Normal Distribution, Chi Squared	Pachinko Distribution	lab4	pachinko_normal.py	
Session 08 - Linear Algebra				
Matrix Nomenclature & Structure	Matrix Multiplication	lab1	matrix_multiply.py	
Linear Algebra	Determinants	lab2	matrix_determinant.py	
Systems of Linear Equations	Cramer's Rule	lab3	cramers_rule.py	
Session 09 - Problem Set 1				
Python loops, if-else conditionals	Sum of Multiples of 7 & 11 < 1900	q1	sum_multiples.py	
Sigma Notation, Accumulator	Gaussian Sums	q2	sum_squares.py	
Temperature Conversion	Celsius to Fahrenheit	q3	temperature_converter2.py	
Base Conversion	Population Count	q4	hamming_weight.py	
Number Theory, Random Numbers	LCM from GCD	q5	lcm_gcd.py	
Systems of Linear Equations	Cramer's Rule	q6	solve_4x4.py	
Algorithm Analysis, Run time Order	Bubble Sort vs. Quicksort	q7	qsort_median3.py	

Session 10 - Mazes				
Binary Encoding	Create, Encode, Draw 2D Maze	lab1	maze_draw.py	
Search Pattern (Depth-First)	Search 2D Maze with Breadcrumbs	lab2	maze_search.py	
Adjacency Matrix	Search 2D Maze with Path Limiter	lab3	maze_adjaceny.py	
Session 11 - Calculus				4
Numerical Integration	Derive Simpson's Rule	lab1	simpsons_rule.py	
Numerical Integration	Left-Hand Rule vs. Simpson's Rule	lab2	circle_area.py	
Cummulative Distribution Function	Simpson's Rule, Standard Normal	lab3	stdnormal_area.py	
Adaptive Quadrature	Dynamic Midpoint Integrator	lab4	adaptive_quadrature.py	
Analytic Continuation	Euler Gamma vs Factorial	lab5	plot_euler_gamma.py	
Session 12 - Encryption				5
Strings, Char Position (Index)	Python Strings, Encoding	lab1	reverse_string.py	
ASCII, Frequency Histograms	Matplotlib Bins	lab2	freq_histogram.py	
Cryptography, Caesar Shift Encoding	Caesar Shift Decoding	lab3	caesar_decrypt.py	
Bigram Frequency Analysis	Python Collections Counter	lab4	bigram_frequency_ciphertext.py	
Cryptanalysis	Python Text File I/O	lab5	bigram_decrypt.py	
Session 13 - Jenga Blocks				
Object Oriented Design	Jenga Cantilever 14 Construction	lab1	jenga_14.py	
Equilibrium Simulation	Jenga Cantilever 15 Construction	lab2	jenga_15.py	
Functional Equations	Center of Mass Equations	lab3	<ppt only>	
Session 14 - Chemistry				6
Computational Chemistry, CSV Files	Balancing Ionic Equations	lab1	stoichiometry.py	
Session 15 - 3D Graphics				7
Oblique Projection, Vertices, Facets	Draw Monolith	lab1	plot3d_monolith.py	
3D Cartesian Coordinates	Draw Pyramid	lab2	plot3d_pyramid.py	
3D Spherical Coordinates	Draw Sphere	lab3	plot3d_sphere.py	
3D Cylindrical Coordinates	Draw Cylinder	lab4	plot3d_cylinder.py	
Surface of Revolution, Facet Shading	Draw Torus	lab5	plot3d_torus.py	
Session 16 - Complex Algebra				
Complex Algebra	Multiplication & Exponentiation	lab1	complex_algebra.py	
Gaussian Integers	Complex Factorization	lab2	complex_factorization.py	
Taylor Series	Euler's Identity	lab3	euler_identity.py	
Complex Numbers and Trigonometry	Euler's Equation	lab4	euler_formula.py	
Session 17 - Experiments in Math				8
Moment of Distribution	Variance of Uniform Distribution	lab1	uniform_variance.py	
NumPy GCD	Relationship to Euler's Basel Problem	lab2	coprime_probabilty.py	
Numba Native Compilation	Birthday Problem	lab3	birthday_paradox.py	
Experimental Mathematics	Random Straws	lab4	random_straws.py	
Lattice Points	Gauss Circle Problem	lab5	lattice_circle.py	
Session 18 - Continued Fractions				9
Continued Fractions Taxonomy	Generate Standard CF	lab1	continued_fractions.py	
Period of Continued Fraction Expansion	Pell's Equation	lab2	pells_equation.py	
Session 19 - Problem Set 2				
Continued Fractions	Generate Standard CF	q1	stdcf_biersach.py	
Cryptanalysis, Caesar Shift Decoding	ciphertext2.txt	q2	decrypt_ciphertext2.py	
Balancing Chemical Equations	Combustion Reaction of Octane	q3	octane_combustion.py	
Session 20 - Scramble Squares				
Binary Encoding, Recursive Search	Scramble Squares Solution	lab1	scramble_squares	
Session 21 - Waves				
Nyquist Sampling	Known Sinusoid Frequency	lab2	nyquist_known.py	
Nyquist Sampling	Unknown Sinusoid Frequency	lab3	nyquist_unknown.py	

Session 22 - Clustering				10
Data Clustering & Outlier Detection	k-Means Clustering, Cluster Eviction	lab1	k_means.py	
Machine Learning	Python Sklearn Module (KMeans)	lab2	k_means_sklearn.py	
Spectral Clustering KMeans	Eigenvectors, Eigenvalues	lab3	k_means_spectral.py	
Dimensionally Reduction	Principal Component Analysis	lab4	plot_pca_3d.py	
Session 23 - Physics				11
Computational Physics, Projectile Motion	Circus Cannon	lab1	projectile_motion.py	
Differential Equations	Medical Tracers: Fluorine-18 Decay	lab2	nuclear_decay.py (Carbon-14)	
Euler's Method	Radioactive Dating: Carbon-14 Decay	lab3	nuclear_decay.py (Fluorine-18)	
Euler-Cromer Method	Simple Pendulum	lab4	pendulum.py	
Runge-Kutta 4th Order	Non-linear First Order Differential Eqn	lab5	ode_rk4.py	
Using RK4	Simple Pendulum	lab6	pendulum_rk4.py	
NumPy Initial Value Problem Solver	Simple Pendulum	lab7	pendulum_scipy.py	
Damped Oscillator	Oscillations and Damping Criticality	lab8	pendulum_damped.py	
Coupled Pendulums	Harmonograph, Halo Orbits	lab9	harmonograph.py	
Session 24 - Monte Carlo				12
Monte Carlo Integration, 2D Circle PRNG	2D Circle Area	lab1	mc_circle_prng.py	
Neideritter QRNG	2D Circle Area	lab2	mc_circle_qrng.py	
Monte Carlo Estimation	First Sigma in Standard Normal	lab3	mc_std_normal.py	
Neideritter QRNG	3D Sphere Volume	lab4	mc_sphere_qrng.py	
Halton QRNG	4D Hypersphere Content	lab5	mc_hypersphere.py	
5D High Dimensional Hyperspheres	High Dimensional Hyperspheres	lab6	mc_high_dimensions.py	
Radial Spatial Distribution	Sampling using Polar Coordinates	lab7	surface_sampling_circle.py	
Spherical Spatial Distribution	Sampling using Spherical Coordinates	lab8	surface_sampling_sphere.py	
Session 25 - Modelling				13
Computational Earth Science	Contour Interpolation (IDW)	lab1	idw.py	
Measuring Goodness of Fit	Root Mean Squared (RMS) Deviation	lab2	idw_min_rmsd.py	
Reel-To-Reel Stopping Time	Quadratic Least Squares	lab3	quadratic_regression.py	
Reel-To-Reel Stopping Time	sklearn.linear_module	lab4	quadratic_regression_sklearn.py	
Newtonian Kinematics (d=1/2at^2+vt)	Quadratic Least Squares	lab5	kinematics_regression.py	
Session 26 - Biology				14
DNA Sequences, Genetic Homology	Gene Subsequences (LRSS)	lab1	seq_lrss.py	
DNA Base Pairs, String Operations	Open Reading Frames	lab2	seq_orf.py	
Compartment Models in Epidemiology	Kermack and KcKendrick S-I-R	lab3	epidemiology_sir.py	
Lotka–Volterra equations	Coupled Non-Linear ODEs	lab4	predator_prey.py	
Session 27 - Dynamical Systems				15
Dynamical Systems	Logistics Map	lab1	logistics_map.py	
Complex Set Iteration	Mandelbrot Set	lab2	mandlebrot_set.py	
Affine Transformations	Draw Sierpinski's Triangle	lab3	ifs_triangle.py	
Transformation Matrices	Draw Barnsley's Fern	lab4	ifs_fern.py	
Iterated Function Systems	Draw BNL	lab5	ifs_bnl.py	
Iterated Function Systems	Draw Square	lab6	ifs_square.py	
Session 28 - Riemann Hypothesis				
Number Theory, Sieves	Prime Counting Function	lab1	riemann_pi.py	
Analytic Continuation	Euler Gamma and Eta Functions	lab2	gamma_eta.py	
Riemann Hypothesis	Eta vs. Zeta	lab3	riemann_hypothesis.py	
Session 29 - Fourier Analysis				16
Time vs Frequency Domains, CSV Files	Sample Complicated Wave	lab1	make_samples.py	
Discrete Fourier Transform	Reconstruct Complicated Wave	lab2	fourier_discrete.py (samples)	
Signals Analysis	Arecibo Signals	lab3	fourier_discrete.py (space signals)	
Fourier Power Spectrum	Sunspot Cycle Analysis	lab4	fourier_discrete.py (sun spots)	
Discrete Fourier Transform	High Frequency Filter	lab5	fourier_filter.py	
Session 30 - Problem Set 3				
Surface Interpolation	Interpolate Ocean Floor	q1	idw2.py	
Measuring Goodness of Fit	Root Mean Squared (RMS) Deviation	q2	idw2_min_rmsd.py	
Wave Equation	Using Matplotlib	lab1	sinewave_7x13.py	
Iterated Function Systems	Regular Hexagon	q4	ifs_hexagon.py	