

Survey of Scientific Computing (SciComp 301) Syllabus

Topics	Lab Title	Lab #	Lab Folder	Points	Student PPT
Session 01 - SciComp Overview					https://bit.ly/2Mun62e
Defining Scientific Computing					
Course Outline & Grading					
Hello Problems 1 - 11	Pythagorean Theorem, Quadratic Formula		<paper only>		
Session 02 - Code Structure, Variables					https://bit.ly/2Bji9Vs
Amazon Cloud, Remote Desktop	Hello World!	lab1	hello-world		x
Program Structure, Variables	Age in Seconds	lab2	age-converter		x
For Loops, Absolute Zero	Temperature Conversion	lab3	temperature-converter		x
Session 03 - Loops, Conditionals, Modulus					https://bit.ly/2OJmbIx
If/Else, Modulus	Perfect Numbers	lab1	perfect-numbers		x
While Loops	Newton's Method for Square Roots	lab2	newton-sqrt		x
Vectors, Long Arithmetic	Root of Google	lab3	bigint-sqrt		x
Nested Loops	Factoring Quadratics	lab4	factor-quadratic		x
Numerical Integration	Derive Simpson's Rule	lab5	simpsons-rule		x
Numerical Integration	Left-Hand Rule vs. Simpson's Rule	lab6	circle-area		x
Session 04 - Vectors, Random Numbers, Timing					https://bit.ly/2MykYq3
Encoding, Vectors	Card Encoding	lab1	list-cards		x
Boolean Data Type, Helper Data Structures	Unique Random Sequence	lab2	dealer-bogus		x
Random Numbers, Instrumentation	Slow Card Dealer	lab3	dealer-slow		x
Algorithmic Efficiency	Fast Card Dealer	lab4	dealer-fast		x
Precomputation, Vectors	Primality Race	lab5	primality-race-v1		x
Session 05 - 2D Graphics, Polar Coordinates					https://bit.ly/2My5Ysc
Allegro Graphics	Draw Triangle	lab1	draw-triangle		x
2D Cartesian, Solve Quadratic	Draw Rectangle	lab2	draw-rectangle		x
2D Polar Coordinates	Draw Circle	lab3	draw-circle		x
2D Translations and Scaling	Draw Olympic Rings	lab4	draw-rings		x
Parametric Curves	Polar Sinusoids (Rose Curves)	lab5	draw-curves		x
Session 06 - Statistics, Euler Line					https://bit.ly/2wboIn3
Statistics (Mean, Variance)	Hero Abilities	lab1	hero-abilities		x
Moment of Distribution	Variance of Uniform Distribution	lab2	uniform-variance		x
Experimental Mathematics	Random Straws	lab3	random-straws		x
Triangle Geometry	Euler's Line	lab4	euler-line		x
Session 07 - Creating a New Project					https://bit.ly/2vS1MtX
Code Blocks Project Files	Sum of Squares	lab1	sum-squares		x
stdafx.h, using namespace std;	Bubble Sort	lab2	bubble-sort		x
Debug vs. Release Build	Euler's Totient	lab3	euler-totient		x
Greek Geometry	Heron's Formula	lab4	herons-formula		x
Range Based For Loop	Mean, Median, Mode	lab5	statistics		x
Session 08 - Algorithms, Series Convergence					https://bit.ly/2OVVqR6
Infinite Series, Convergence	Basel Problem	lab1	basel-series		x
Algorithms	Euclid's GCD	lab2	euclid-gcd		x
Series Estimation	Coprime Probability	lab3	coprime-probability		x
Probability Theory	Birthday Paradox	lab4	birthday-paradox		x
EXAM # 1					https://bit.ly/2mA4jE3
Iterative Root Finding	Heron's Method	q01	herons-method	15	x
Adaptive Quadrature	Dynamic Midpoint Integrator	q02	adaptive-quadrature	10	x
For Loops, Mod Operator, if() Statement	Sum of Multiples of 7 & 11 < 1900	q03	sum-multiples	10	x
Temerature Conversion	Celsius to Farenheit	q04	temperature-converter2	5	x
Algorithm Analysis, Run time Order	Bubble Sort vs. Quicksort	q05	qsort-median3	10	x
Number Theory, Random Numbers	LCM from GCD	q06	lcm-gcd	5	x
Vector Algebra	Vector Addition	q07	vector-addition	5	x
Base Conversion	Population Count	q08	hamming-weight	20	x
Statistical Analysis	Mean vs Median vs. Mode	q09	multi-modal	10	x
Group Theory, Algebraic Structure	Lattice Points in 2D Circle	q10	lattice-circle	10	x
				100	

Session 09 - Equilibrium Simulation				https://bit.ly/2MEDMEO	
Sigma Notation, Accumulator	Gaussian Sums	lab1	gauss-sum		x
Object Oriented Design	Jenga Cantilever 14 Construction	lab2	jenga-14		x
Equilibrium Simulation	Jenga Cantilever 15 Construction	lab3	jenga-15		x
Functional Equations	Center of Mass Equations		<ppt only>		
Session 10 - Matrix Algebra, Number Theory				https://goo.gl/gNQ62Z	
Matrix Nomenclature & Structure	Matrix Multiplication	lab1	matrix-multiply		
Linear Algebra	Determinants	lab2	matrix-determinant		
Systems of Linear Equations	Cramer's Rule	lab3	cramers-rule		
Number Theory	Goldbach's Conjecture	lab4	goldbach-conjecture		
Session 11 - Complex Algebra				https://bit.ly/2N5zXYH	
Complex Algebra	Multiplication & Exponentiation	lab1	complex-algebra		x
Gaussian Integers	Complex Factorization	lab2	complex-factorization		x
Taylor Series	Euler's Identity	lab3	euler-identity		x
Complex Numbers and Trigonometry	Euler's Equation	lab4	euler-equation		x
Analytic Continuation	Euler Gamma vs Factorial	lab5	euler-gamma		x
Riemann Hypothesis	Eta vs. Zeta	lab6	riemann-hypothesis		x
Session 12 - Continued Fractions, Chi Squared				https://bit.ly/2C6zaml	
Continued Fractions Taxonomy	Generate Standard CF	lab1	stdcf-encode		x
Continued Fraction Algorithms	Expand Standard CF	lab2	stdcf-decode		x
Period of Continued Fraction Expansion	Pell's Equation	lab3	pells-equation		x
Normal Distribution, Chi Squared	Pachinko Distribution	lab4	pachinko-normal		x
Session 13 - CERN ROOT, Nyquist Sampling				https://bit.ly/2MZCT9x	
Using CERN ROOT	Known Sinusoid Frequency	lab1	nyquist-known		x
Nyquist Sampling	Unknown Sinusoid Frequency	lab2	nyquist-unknown		x
Collatz Conjecture	Stopping Time Histogram	lab3	collatz-conjecture		x
Session 14 - Cryptanalysis, Anagrams				https://bit.ly/2NBRK6V	
Strings, Char Position (Index)	Reverse a String	lab1	reverse-string		x
ASCII, Frequency Histograms	gettysburg.txt	lab2	freq_histogram		x
Cryptography, Caesar Shift Encoding	ciphertext1.txt	lab3	freq_histogram		x
Cryptanalysis	Caesar Shift Decoding	lab4	caesar-decrypt		x
Bigram Frequency Analysis	Bigram Analysis	lab5	freq-bigrams		x
Permutations	Heap's Algorithm	lab6	anagrams-slow		x
Dictionary Sort	Lambda Expression	lab7	anagrams-fast		x
Search with Wildcard Matching	Compound Anagrams	lab8	anagrams-compound		x
Session 15 - Combinatorics, Encoding, Search				https://bit.ly/2oGGStH	
Combinatorics	Scramble Squares Analysis	lab1	factorial-recursive		x
Binary Encoding, Recursive Search	Scramble Squares Solution	lab2	scramble-squares		x
Session 16 - 3D Graphics, Vector Algebra				https://bit.ly/2MTJ4g8	
Sizing The World Rectangle	Draw Polynomial	lab1	draw-polynomial		x
Oblique Projection, Vertices, Facets	Draw Monolith	lab2	draw-monolith		x
3D Cartesian Coordinates	Draw Pyramid	lab3	draw-pyramid		x
3D Spherical Coordinates	Draw Sphere	lab4	draw-sphere		x
Vector Algebra, Back face Culling	Draw Sphere	lab4	draw-sphere		x
Surface of Revolution, Facet Shading	Draw Torus	lab5	draw-torus		x
Session 17 - Computational Chemistry, Clustering				https://bit.ly/2NQdBHY	
Computational Chemistry, CSV Files	Balancing Ionic Equations	lab1	stoichiometry		x
kMeans Clustering	Outlier Classification & Normal Ejection	lab2	kmeans		x
Session 18 - Computational Biology, Earth Science				https://bit.ly/2NOHacV	
Computational Biology, Bubble Sort	Gene Subsequences (LRSS)	lab1	lrss-bubble		x
Quicksort Algorithm	Gene Subsequences (LRSS)	lab2	lrss-qsort		x
Amino Acids, Codons, Genetic Homology	Substring Frequencies	lab3	freq-substr		x
Computational Earth Science	Contour Interpolation (IDW)	lab4	idw		
EXAM # 2				https://bit.ly/2oKUG6w	
Systems of Linear Equations	Cramer's Rule	q01	solve4x4-given	5	x
Linear Algebra	Determinants	q02	solve10x10-random	20	x
Number Theory, Sieves	Prime Counting Function	q03	riemann-pi	15	x
Analytic Continuation	Euler Gamma and Eta Functions	q04	gamma-eta	10	x
Continued Fractions	Generate Standard CF	q05	stdcf-biersach	15	x
Numerical Integration, CDFs	Simpson's Rule, Standard Normal	q06	stdnormal-area	10	x
Cryptanalysis, Caesar Shift Decoding	ciphertext2.txt	q07	decrypt-ciphertext	5	x
DNA Sequences, String Operations	Open Reading Frames	q08	find-orf	10	x
3D Cylindrical Coordinates	Draw Cylinder	q09	draw-cylinder	5	x
Using CERN ROOT	Known Sinusoid Frequency	q10	sinewave_7x13	5	x
				100	
Session 19 - Computational Physics				https://bit.ly/2Nshhmg	
Computational Physics, Projectile Motion	Circus Cannon	lab1	projectile-motion		x
Differential Equations	Medical Tracers: Fluorine-18 Decay	lab2	decay_fluorine18		x
Euler's Method	Radioactive Dating: Carbon-14 Decay	lab3	decay_carbon14		x
Euler-Cromer Method	Pendulum	lab4	pendulum		x
Euler-Cromer Method	Linked Pendulums	lab5	harmonograph		x
Session 20 - Monte Carlo Method				https://bit.ly/2QhPfiQ	

Monte Carlo Integration, 2D Circle PRNG	2D Circle Area	lab1	mc-circle-prng		x
Neideritter QRNG	2D Circle Area	lab2	mc-cirlce-qrng		x
Neideritter QRNG	3D Sphere Volume	lab3	mc-sphere		x
Halton QRNG	4D Hypersphere Content	lab4	mc-hypersphere		x
5D High Dimensional Hyperspheres	High Dimensional Hyperspheres	lab5	mc-highdimensional		x
Fractional Dimensional Hyperspheres	Gamma Function in Volumes	lab6	nball-volume		x
Session 21 - Fourier Transform, Signals Analysis			https://bit.ly/2Czainu		
Time vs Frequency Domains, CSV Files	Sample Complicated Wave	lab1	make-samples		x
Discrete Fourier Transform	Reconstruct Complicated Wave	lab2	fourier_discrete		x
Signals Analysis	Arecibo Signals	lab3	space-signals		x
Fourier Power Spectrum	Sunspot Cycle Analysis	lab4	sunspots		x
Session 22 - Search Algorithms, Adjacency Matrix			https://bit.ly/2NshENQ		
Binary Encoding	Create, Encode, Draw 2D Maze	lab1	maze-draw		x
Search Pattern (Depth-First)	Search 2D Maze with Breadcrumbs	lab2	maze-search		x
Adjacency Matrix	Search 2D Maze with Path Limiter	lab3	maze-search-adj		x
Session 23 - Difference Tables, Least Squares			https://bit.ly/2O2zILI		
LibreOffice Calc, Difference Tables	Steady State Average Values	lab1	<create spreadsheet>		x
Sequence Generators	Fit a Quadratic	lab2	<create spreadsheet>		x
Sequence Generators	Fit cubic	lab3	<create spreadsheet>		x
Reel-To-Reel Stopping Time	Difference Tables	lab4	<create spreadsheet>		x
Reel-To-Reel Stopping Time	Quadratic Least Squares	lab5	quadratic-regression		x
Session 24 - Dynamical Systems, Fractals			https://bit.ly/2CDPevS		
Dynamical Systems	Logistics Map	lab1	logistic-map		x
Complex Set Iteration	Mandelbrot Set	lab2	mandelbrot-set		x
Affine Transformations	Draw Sierpinski's Triangle	lab3	ifs-triangle		x
Transformation Matrices	Draw Barnsley's Fern	lab4	ifs-fern		x
Iterated Function Systems	Draw BNL	lab5	ifs-bnl		x
Iterated Function Systems	Draw Square	lab6	ifs-square		x
EXAM # 3			http://bit.ly/2IRt7SI		
Lotka–Volterra equations	Coupled Non-Linear ODEs	q01	rk4-lv	10	
Damped Oscillator	Euler-Cromer	q02	damped-pendulum	15	
Discrete Fourier Transform	High Frequency Filter	q03	dft2-filter	15	
Netownian Kinematics ($d=1/2at^2+vt$)	Quadratic Least Squares	q04	kinematics-regression	10	
Balancing Chemical Equations	Combustion Reaction of Octane	q05	octane-combustion	10	
Iterated Function System	Regular Hexagon	q06	ifs-hexagon	15	
Surface Interpolation	Interpolate Ocean Floor	q07	idw2	5	
Monte Carlo Estimation	First Sigma in Standard Normal	q08	mc-stdnormal	15	
kMeans Clustering	Eviction For Excessive Distance	q09	kmeans-3sigma	5	
				100	
Session 25 - Early Quantum Mechanics			https://bit.ly/2KrBfYS		
Hydrogen Spectral Emission Lines	Rydberg Constant	lab1	spectrum-rydberg		
Early Quantum Mechanics	Bohr Model	lab2	spectrum-bohr		

Session 26 - Boolean Algebra, Logic Gates

Boolean Algebra, Digital Logic Gates
Truth Tables
Sequential Circuits

Trace the Circuit
2-of-3 Majority Vote
Full Adder

lab1 <ppt only>
lab2 logisim
lab3 logisim

<https://bit.ly/2AJb6VX>

Session 27 - Parallel Programing Using Threads

Bin Counting
Multi-threading
Pre-emptive Threading
Mutual Exclusion Sections
Non-Atomic Operations
Atomic Operations
Thread Synchronization

Binary Search
C++ Thread Library
Race Conditions
Mutex
Algebraic Operator Pre-emption
Mutex Guards
Thread Control Blocks

lab1 data-binning
lab2 simple-threading
lab3 race-condition
lab4 mutex
lab5 nonatomic-op
lab6 thread-safety
lab7 parallel-simpsons

Session 28 - General Relativity

Orbital Mechanics, Kepler's Laws
Relativistic Correction to Gravity Law

Newtonian Dymaics
Mercury perihelion precession

lab3 kepler-newton
lab4 mecury-precession