Survey of Scientific Computing (SciComp 301) Syllabus

Topics	Lab Title	Lab #	Lab Folder	Points
Session 01 - SciComp Overview				
Defining Scientific Computing				
Course Outline & Grading				
Hello Problems 1 - 11	Pythagorean Theorem, Quadratic Formula		<paper only>	
Session 02 - Code Structure, Variables				
Amazon Cloud, Remote Desktop	Hello World!	lab1	hello-world	
Program Structure, Variables	Age in Seconds	lab2	age-converter	
For Loops, Absolute Zero	Temperature Conversion	lab3	temperature-converter	
Session 03 - Loops, Conditionals, Modulus				
If/Else, Modulus	Perfect Numbers	lab1	perfect-numbers	
While Loops	Newton's Method for Square Roots	lab2	newton-sqrt	
Vectors, Long Arithmetic	Roots of Googol	lab3	bigint-sqrt	
Nested Loops	Factoring Quadratics	lab4	factor-quadratic	
Numerical Integration	Derive Simpson's Rule	lab5	simpsons-rule	
Numerical Integration	Left-Hand Rule vs. Simpson's Rule	lab6	circle-area	
Session 04 - Vectors, Random Numbers, Timing				
Encoding, Vectors	Card Encoding	lab1	list-cards	
Boolean Data Type, Helper Data Structures	Unique Random Sequence	lab2	dealer-bogus	
Random Numbers, Instrumentation	Slow Card Dealer	lab3	dealer-slow	
Algorithmic Efficiency	Fast Card Dealer	lab4	dealer-fast	
Implementation Optimization	Primality Race	lab5	primality-race-v1	
Session 05 - 2D Graphics, Polar Coordinates				
Allegro Graphics	Draw Triangle	lab1	draw-triangle	
2D Cartesian, Solve Quadratic	Draw Rectangle	lab2	draw-rectangle	
2D Polar Coordinates	Draw Circle	lab3	draw-circle	
2D Translations and Scaling	Draw Olympic Rings	lab4	draw-rings	
Parametric Curves	Polar Sinusoids (Rose Curves)	lab5	draw-curves	
Session 06 - Statistics, Euler Line				
Statistics (Mean, Variance)	Hero Abilities	lab1	hero-abilities	
Moment of Distribution	Variance of Uniform Distribution	lab2	uniform-variance	
Experimental Mathematics	Random Straws	lab3	random-straws	
Triangle Geometry	Euler's Line	lab4	euler-line	
Session 07 - Creating a New Project				
Code Blocks Project Files	Sum of Squares	lab1	sum-squares	
stdafx.h, using namespace std;	Bubble Sort	lab2	bubble-sort	
Debug vs. Release Build	Euler's Totient	lab3	euler-totient	
Greek Geometry	Heron's Formula	lab4	herons-formula	
Range Based For Loop	Mean, Median, Mode	lab5	statistics	
Session 08 - Algorithms, Series Convergence				
Infinite Series, Convergence	Basel Problem	lab1	basel-series	
Algorithms	Euclid's GCD	lab2	euclid-gcd	
Series Estimation	Coprime Probability	lab3	coprime-probability	
Probability Theory	Birthday Paradox	lab4	birthday-paradox	

EXAM # 1

Iterative Root Finding	Heron's Method	q01	herons-method	15
Adaptive Quadrature	Dynamic Midpoint Integrator	q02	adaptive-quadrature	15
For Loops, Mod Operator, if() Statement	Sum of Multiples of 7 & 11 < 1900	q03	sum-multiples	10
Temerature Conversion	Celsius to Farenheit	q04	temperature-converter2	5
Algorithm Analysis, Run time Order	Bubble Sort vs. Quicksort	q05	qsort-median3	10
Number Theory, Random Numbers	LCM from GCD	q06	lcm-gcd	5
Vector Algebra	Vector Addition	q07	vector-addition	5
Base Conversion	Population Count	q08	hamming-weight	15
Statistical Analysis	Mean vs Median vs. Mode	q09	multi-modal	10
Group Theory, Algebraic Structure	Lattice Points in 2D Circle	q10	lattice-circle	10
				100

Session 09 - Equilibrium Simulation

Sigma Notation, Accumulator	Gaussian Sums	lab1	gauss-sum
Object Oriented Design	Jenga Cantilever 14 Construction	lab2	jenga-14
Equilibrium Simulation	Jenga Cantilever 15 Construction	lab3	jenga-15
Functional Equations	Center of Mass Equations		<ppt only>

Session 10 - Matrix Algebra, Number Theory

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

Complex Algebra	Multiplication & Exponentiation	lab1	complex-algebra
Gaussian Integers	Complex Factorization	lab2	complex-factorization
Taylor Series	Euler's Identity	lab3	euler-identity
Complex Numbers and Trigonometry	Euler's Formula	lab4	euler-formula
Analytic Continuation	Euler Gamma vs Factorial	lab5	euler-gamma
Riemann Hypothesis	Eta vs. Zeta	lab6	riemann-hypothesis

Session 12 - Continued Fractions, Chi Squared

Continued Fractions Taxonomy	Generate Standard CF	lab1	stdcf-encode
Continued Fraction Algorithms	Expand Standard CF	lab2	stdcf-decode
Period of Continued Fraction Expansion	Pell's Equation	lab3	pells-equation
Normal Distribution, Chi Squared	Pachinko Distribution	lab4	pachinko-normal

Session 13 - CERN ROOT, Nyquist Sampling

Using CERN ROOT	Known Sinusoid Frequency	lab1	nyquist_known
Nyquist Sampling	Unknown Sinusoid Frequency	lab2	nyquist_unknown
Collatz Conjecture	Stopping Time Histogram	lab3	collatz_conjecture

Session 14 - Cryptanalysis, Anagrams

Strings, Char Position (Index)	Reverse a String	lab1	reverse-string
ASCII, Frequency Histograms	gettysburg.txt	lab2	freq_histogram
Cryptography, Caesar Shift Encoding	ciphertext1.txt	lab2	freq_histogram
Cryptanalysis	Caesar Shift Decoding	lab3	caesar-decrypt
Bigram Frequency Analysis	Bigram Analysis	lab4	freq-bigrams
Boost Libraries, Permutations	Heap's Algorithm	lab5	anagrams-slow
Dictionary Sort	Lambda Expression	lab6	anagrams-fast
Search with Wildcard Matching	Compound Anagrams	lab7	anagrams-compound

Session 15 - Combinatorics, Encoding, Search

Combinatorics	Scramble Squares Analysis	lab1	factorial-recursive
Binary Encoding, Recursive Search	Scramble Squares Solution	lab2	scramble-squares

Session 16 - 3D Graphics, Vector Algebra

Sizing The World Rectangle	Draw Polynomial	lab1	draw-polynomial
Oblique Projection, Vertices, Facets	Draw Monolith	lab2	draw-monolith
3D Cartesian Coordinates	Draw Pyramid	lab3	draw-pyramid
3D Spherical Coordinates	Draw Sphere	lab4	draw-sphere
Vector Algebra, Back face Culling	Draw Sphere	lab4	draw-sphere
Surface of Revolution, Facet Shading	Draw Torus	lab5	draw-torus

Session 17 - Computational Chemistry, Clustering

Computational Chemistry, CSV Files	Balancing Ionic Equations	lab1	stoichiometry	
Data Clustering & Outlier Detection	k-Means Clustering, Cluster Eviction	lab2	kmeans	

Session 18 - Computational Biology, Earth Science

Computational Biology, Bubble Sort	Gene Subsequences (LRSS)	lab1	lrss-bubble	
Quicksort Algorithm	Gene Subsequences (LRSS)	lab2	lrss-qsort	
Amino Acids, Codons, Genetic Homology	Substring Frequencies	lab3	freq-substr	
Computational Earth Science	Contour Interpolation (IDW)	lab4	idw	

EXAM # 2

Systems of Linear Equations	Cramer's Rule	q01	solve4x4-given	5
Linear Algebra	Determinants	q02	solve10x10-random	15
Number Theory, Sieves	Prime Counting Function	q03	riemann-pi	20
Analytic Continuation	Euler Gamma and Eta Functions	q04	gamma-eta	10
Continued Fractions	Generate Standard CF	q05	stdcf-biersach	15
Numerical Integration, CDFs	Simpson's Rule, Standard Normal	q06	stdnormal-area	10
Cryptanalysis, Caesar Shift Decoding	ciphertext2.txt	q07	decrypt-ciphertext	5
DNA Sequences, String Operations	Open Reading Frames	q08	find-orf	10
3D Cylindrical Coordinates	Draw Cylinder	q09	draw-cylinder	5
Using CERN ROOT	Known Sinusoid Frequency	q10	sinewave_7x13	5
				100

Session 19 - Computational Physics

Computational Physics, Projectile Motion	Circus Cannon	lab1	projectile-motion
Differential Equations	Medical Tracers: Fluorine-18 Decay	lab2	decay_fluorine18
Euler's Method	Radioactive Dating: Carbon-14 Decay	lab3	decay_carbon14
Euler-Cromer Method	Pendulum	lab4	pendulum
Euler-Cromer Method	Linked Pendulums	lab5	harmonograph

Session 20 - Monte Carlo Method

Monte Carlo Integration, 2D Circle PRNG	2D Circle Area	lab1	mc-circle-prng
Neideritter QRNG	2D Circle Area	lab2	mc-cirlce-qrng
Neideritter QRNG	3D Sphere Volume	lab3	mc-sphere
Halton QRNG	4D Hypersphere Content	lab4	mc-hypersphere
5D High Dimensional Hyperspheres	High Dimensional Hyperspheres	lab5	mc-highdimensional
Fractional Dimensional Hyperspheres	Gamma Function in Volumes	lab6	nball-volume

Session 21 - Fourier Transform, Signals Analysis

Time vs Frequency Domains, CSV Files	Sample Complicated Wave	lab1	make-samples
Discrete Fourier Transform	Reconstruct Complicated Wave	lab2	fourier_discrete
Signals Analysis	Arecibo Signals	lab3	space_signals
Fourier Power Spectrum	Sunspot Cycle Analysis	lab4	sunspots

Session 22 - Search Algorithms, Adjacency Matrix

Binary Encoding	Create, Encode, Draw 2D Maze	lab1	maze-draw
Search Pattern (Depth-First)	Search 2D Maze with Breadcrumbs	lab2	maze-search
Adjacency Matrix	Search 2D Maze with Path Limiter	lab3	maze-search-adj

Session 23 - Difference Tables, Least Squares

LibreOffice Calc, Difference Tables	Steady State Average Values	lab1	<create spreadsheet>
Sequence Generators	Fit a Quadratic	lab2	<create spreadsheet>
Sequence Generators	Fit cubic	lab3	<create spreadsheet>
Reel-To-Reel Stopping Time	Difference Tables	lab4	<create spreadsheet>
Reel-To-Reel Stopping Time	Quadratic Least Squares	lab5	quadratic-regression

Session 24 - Dynamical Systems, Fractals

Dynamical Systems	Logistics Map	lab1	logistic-map
Complex Set Iteration	Mandelbrot Set	lab2	mandelbrot-set
Affine Transformations	Draw Sierpinski's Triangle	lab3	ifs-triangle
Transformation Matrices	Draw Barnsley's Fern	lab4	ifs-fern
Iterated Function Systems	Draw BNL	lab5	ifs-bnl
Iterated Function Systems	Draw Square	lab6	ifs-square

EXAM # 3

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	fourier_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
Data Clustering & Outlier Detection	kMeans using Manhattan Distance	q09	kmeans-eviction	5
				100

Session 25 - Early Quantum Mechanics

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	Trace the Circuit (Paper)	lab1	simple-circuit-trace
Combinatorial Circuit	Circuit Simulation (Logisim)	lab2	simple-circuit-logisim
Logisim, Truth Tables	2-of-3 Majority Vote (Logisim)	lab3	majority-vote-logisim
Sequential Circuits	Full Adder (Logisim)	lab4	full-adder-logisim

Session 27 - Parallel Programing Using Threads

Multithreading	C++ Thread Library	lab1	simple-threading
Thread Synchronization	Critical Sections and Mutexes	lab2	mutex
Preemptive Threading	Race Conditions	lab3	race-condition
Non-Atomic Operations	C++ Operators in Assembly Language	lab4	nonatomic-op
Parallel Numerical Analysis	Thread Control Blocks	lab5	parallel-simpsons