

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	10
For Loops, Mod Operator, if() Statement	Sum of Multiples of 7 & 11 < 1900	q03	sum-multiples	10
Temperature 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	20
Statistical Analysis	Mean vs Median vs. Mode	q09	multi-modal	10
Group Theory, Algebraic Structure	Lattice Points in 2D Circle	q10	lattice-circle	10
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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 Equation	lab4	euler-equation
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
Data Clustering & Outlier Detection

Balancing Ionic Equations
k-Means Clustering, Cluster Eviction

lab1 stoichiometry
lab2 kmeans

Session 18 - Computational Biology, Earth Science

Computational Biology, Bubble Sort
Quicksort Algorithm
Amino Acids, Codons, Genetic Homology
Computational Earth Science

Gene Subsequences (LRSS)
Gene Subsequences (LRSS)
Substring Frequencies
Contour Interpolation (IDW)

lab1 lrss-bubble
lab2 lrss-qsort
lab3 freq-substr
lab4 idw

EXAM # 2

Systems of Linear Equations
Linear Algebra
Number Theory, Sieves
Analytic Continuation
Continued Fractions
Numerical Integration, CDFs
Cryptanalysis, Caesar Shift Decoding
DNA Sequences, String Operations
3D Cylindrical Coordinates
Using CERN ROOT

Cramer's Rule
Determinants
Prime Counting Function
Euler Gamma and Eta Functions
Generate Standard CF
Simpson's Rule, Standard Normal
ciphertext2.txt
Open Reading Frames
Draw Cylinder
Known Sinusoid Frequency

q01 solve4x4-given 5
q02 solve10x10-random 20
q03 riemann-pi 15
q04 gamma-eta 10
q05 stdcf-biersach 15
q06 stdnormal-area 10
q07 decrypt-ciphertext 5
q08 find-orf 10
q09 draw-cylinder 5
q10 sinewave_7x13 5

100

Session 19 - Computational Physics

Computational Physics, Projectile Motion
Differential Equations
Euler's Method
Euler-Cromer Method
Euler-Cromer Method

Circus Cannon
Medical Tracers: Fluorine-18 Decay
Radioactive Dating: Carbon-14 Decay
Pendulum
Linked Pendulums

lab1 projectile-motion
lab2 decay_fluorine18
lab3 decay_carbon14
lab4 pendulum
lab5 harmonograph

Session 20 - Monte Carlo Method

Monte Carlo Integration, 2D Circle PRNG
Neideritter QRNG
Neideritter QRNG
Halton QRNG
5D High Dimensional Hyperspheres
Fractional Dimensional Hyperspheres

2D Circle Area
2D Circle Area
3D Sphere Volume
4D Hypersphere Content
High Dimensional Hyperspheres
Gamma Function in Volumes

lab1 mc-circle-prng
lab2 mc-cirlce-qrng
lab3 mc-sphere
lab4 mc-hypersphere
lab5 mc-highdimensional
lab6 nball-volume

Session 21 - Fourier Transform, Signals Analysis

Time vs Frequency Domains, CSV Files
Discrete Fourier Transform
Signals Analysis
Fourier Power Spectrum

Sample Complicated Wave
Reconstruct Complicated Wave
Arecibo Signals
Sunspot Cycle Analysis

lab1 make-samples
lab2 fourier_discrete
lab3 space_signals
lab4 sunspots

Session 22 - Search Algorithms, Adjacency Matrix

Binary Encoding
Search Pattern (Depth-First)
Adjacency Matrix

Create, Encode, Draw 2D Maze
Search 2D Maze with Breadcrumbs
Search 2D Maze with Path Limiter

lab1 maze-draw
lab2 maze-search
lab3 maze-search-adj

Session 23 - Difference Tables, Least Squares

LibreOffice Calc, Difference Tables
Sequence Generators
Sequence Generators
Reel-To-Reel Stopping Time
Reel-To-Reel Stopping Time

Steady State Average Values
Fit a Quadratic
Fit cubic
Difference Tables
Quadratic Least Squares

lab1 <create spreadsheet>
lab2 <create spreadsheet>
lab3 <create spreadsheet>
lab4 <create spreadsheet>
lab5 quadratic-regression

Session 24 - Dynamical Systems, Fractals

Dynamical Systems
Complex Set Iteration
Affine Transformations
Transformation Matrices
Iterated Function Systems
Iterated Function Systems

Logistics Map
Mandelbrot Set
Draw Sierpinski's Triangle
Draw Barnsley's Fern
Draw BNL
Draw Square

lab1 logistic-map
lab2 mandelbrot-set
lab3 ifs-triangle
lab4 ifs-fern
lab5 ifs-bnl
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
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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	lab1	<ppt only>
Truth Tables	2-of-3 Majority Vote	lab2	circuits-logisim
Sequential Circuits	Full Adder	lab3	circuits-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