Quantum Computation.
Textbook : Quantum Computation, A Gentle Introduction, by Rieffle and Polak.
Prerequisites:
A course in Linear Algebra is a prerequisite. A lower division undergraduate physics course that covers quantum mechanics would be desirable is not necessary.

Week 1:
The nature of reality
- Particles and Waves
- Experiments with light, lasers, flashlights and polarization
- Linear Polarization
- Circular Polarization
- Polarization and vectors

Week 2: (Exercises 2.1, 2.3,2.5, 2.6, 2.8,2.12)
Reality and Math for a Single Particle
- Complex numbers and complex vectors
- Superposition
- Vectors say something but they say too much
- Greatness is overrated. So is phase.
- Restrictions and quotient spaces
- Spheres are perfect
  - not the sphere you thought though
  - cinching the belt much too tightly
  - the Bloch sphere
- Superposition, again
- Measurements, projections, state collapse and probability
- A Quantum Key exchange

Week 3 (Exercises 3.2, 3.3, 3.8, 3.10, 3.14, 3.15)
Reality and Math for Multiple (Two) Particles
- New Vector Spaces from Old
- Cartesian products and direct sums
- The tensor product, with too much love.
  - bilinearity
  - universality
  - basis independence
  - order matters. Here's how (non-commutativity)
- Tensor geometry, demystified more than you'd like
  - decomposibility and entanglement
  - bilinearity is not linearity
  - the decomposable quadric
- Pauli Matricies
- Measurement

Week 4 (Exercises 4.2, 4.5, 4.7, 4.10, 4.16, 4.19, 4.20 plus handout)
Tensor Algebra, as if you hadn't already heard too much.

- Multilinearity
- Order matters more
- Linear Transformations, in part and in whole
- The tensor product vs any old bilinear map
- Basis free, but factors matter

Measurement and Computation

- Projections
- Probability
- Mapping unit vectors to probability
- Hermitian operators and measurement
    - eigenvalues
    - eigenvectors
    - orthonormality
    - what these have to do with projections

Week 5 (Exercises 5.2, 5.5, 5.8, 5.11, 5.12, 5.17)
Exam 1 (Chapters 1-4)
Quantum State Transformations as a Model for Computation

- Unitary Transformations
    - no cloning, because why would it?
- Quantum Gates
    - Pauli
    - Hadamard
    - Tensor products of single bit operators
    - Controlled NOT and other controlled gates
- Applications
    - Dense Coding
    - Teleportation
- Unitary transformations as circuits.

Week 6 (Exercises 6.2, 6.3, 6.5)
Quantum Computation doing Classical Computations

- Unitarity and reversibility
- Reversibility for classical computations
- Quantum circuits for arithmetic operations
    - and
    - addition
    - modular addition
    - modular multiplication
    - modular exponentiation

Week 7-8 (Exercises 7.2, 7.3, 7.5, 7.6, 7.7)
Quantum Algorithms

- Useful things to do with superposition and parallelism
- Complexity of quantum algorithms
- Examples of quantum algorithms
- Quantum subroutines
  - disentangling qbits
  - phase change for a subset of basis vectors
  - state dependent phase shift
  - state dependent single qbit amplitude shifts
- Classical quantum computations
- Models and Complexity Classes
- Quantum Fourier Transform

Week 9 (Exercises 8.2, 8.3, 8.5, 8.6, 9.2, 9.4, 9.7,9.10)
Shor's Algorithm

- Reduction to finding the period.
- Factoring
  - quantum core,
  - getting the period from the measurement
- Efficiency
- Generalizations
  - discrete logarithm
  - hidden subgroups

Grover's Algorithm

- Quantum Search
- Amplitude amplification
- Optimality
- Derandomization

Week 10 (Exercises 10.2, 10.4, 10.6)
Test 2 (State transformation, unitarity, reversibility, quantum arithmetic, quantum complexity, Shor and Grover algorithms)

Quantum Subsystems

- Quantum subsystems and mixed states
  - density operators
  - the geometry of mixed states
  - Von Neuman entropy

Week 11 (Exercises 10.10, 10.11, 10.12, 10.13, 10.16, 10.17, 10.24, 10.25)

Quantum Subsystems and Entanglement

- Classifying Entangled states
  - bipartite quantum systems
  - classifying bipartite pure states
  - quantifying entanglement in bipartite states
- Density operator formalism of measurement
- Transformations of quantum subsystems and decoherence
  - superoperators and sum decompositions
  - relation between state transformations and measurements
  - decoherence

Quantum Codes

- Examples of quantum error correction
  - correcting single qbit flips
  - correcting single qbit phase flips
  - correcting all single qbit errors

Week 12-13 (Exercises 11.1, 11.2, 11.6, 11.9, 11.11, 11.17, 11.18)

Quantum Error Correction

- Framework for Error Correction
  - classical error correcting codes
  - quantum error correcting codes
  - correctable sets of errors for classical codes vs quantum codes
  - correcting errors using classical codes vs quantum codes
  - computing on encoded quantum states
  - superpositions and mixtures of correctable errors are correctable
  - classical and quantum independent error models
- CSS Codes
  - dual classical codes
  - construction of css codes from classical codes
  - Steane code
- Stabilizer Codes
  - binary observables for quantum error correction
  - Pauli observables
  - computing on encoded stabilizer states
- CSS codes as stabilizer codes

Week 14

Review

Final Exam: comprehensive