

Assessment:

- Assignments: 32% (4 assignment at 8% each)
- Term Paper: 20% (Computational and Theoretical Calculation)
- Literature Review: 23% (Review and Summary of key papers in the field)
- Final Take-Home Exam: 25% (Comprehensive Exam, assigned at start of exam period)

Tentative Syllabus:

Weeks 1-2: Review of Quantum Mechanics

- Schrödinger, Heisenberg, and Interaction Pictures
- The Density Matrix and Mixed states
- The Lindblad approach to open systems

Week 3: Review of Linear Optics

- The wave equation and slowly varying envelope approximation
- The classical theory of dispersion

Week 4: Key Elements on Nonlinear Optics

- The nonlinear polarization
- Exploiting symmetries
- Application: frequency conversion & entanglement generation

Weeks 5-7: Semi-classical Light-Atom Interactions: The two level atom

- Light-atom Hamiltonian
- the Rotating wave approximation
- Avoided crossings/dressed states
- Quantum treatment of optical susceptibility

Weeks 8-9: Fully Quantum Treatment of Light-Matter Interactions

- Formal Quantization
- The Jaynes-Cummings model
- Cavity QED

Week 10-11: Quantum Atom Optics in Multilevel Systems

- Electromagnetically Induced Transparency
- Dark state polaritons & Quantum memory
- Four Wave Mixing

Weeks 12-13: Quantum Optical Computing

- Single photon qubits
- Quantum Cryptography (BB-84)
- Teleportation/Cloning
- The KLM Protocol