

Listed below are the primary topics from OPTI 511R that also have overlap with OPTI 570, OPTI 544, and OPTI 600G. These are the main topics that will be available for questioning on the PhD Qualifying Exam.

1. postulates of quantum mechanics
2. wavefunctions – interpretation, sketching, physically acceptable wave functions, normalization, orthonormality, probability density distributions, stationary states, position and momentum representations and Fourier transforms, uncertainty relations
3. calculating expectation values and probabilities
4. superpositions of energy eigenstates, and their time dependence
5. free-particle wave functions and wave packets
6. infinite square well – energy eigenfunctions and eigenvalues
7. harmonic oscillator (energy eigenfunctions and eigenvalues, raising and lowering operators)
8. hydrogen atom (spinless electron and proton model) – Coulomb potential, energy levels and energy eigenvalues, spherical harmonics and electron orbital angular momentum, quantum numbers, kets that indicate the quantum numbers of energy eigenstates
9. 2-level systems, spin-1/2 problem – spin-1/2 particle in a magnetic field, Stern-Gerlach
10. Rabi oscillations
11. basics of light-matter interaction – Electric dipole interaction, single-photon transitions especially between hydrogen atom energy eigenstates, dipole matrix elements, selection rules
12. basics of laser physics – 3 and 4 level systems, population rate equations (in terms of atomic densities, but not density matrix elements), gain and absorption, round trip gain and loss for cw lasing (NOT modelocked or Q switched operation of lasers)
13. photon number states, photon annihilation and creation operators
14. optical resonators – longitudinal and transverse modes, Hermite-Gaussian modes of curved-mirror optical resonators, stability of two-mirror optical resonators, Fabry-Perot resonators, free spectral range