Quantum Optics

Program

1.- *Introduction*
       Maxwell's Electromagnetic Theory. The Old Quantum Theory. Quantum Mechanics. Dirac's Radiation Theory. Interference of a single photon. Wave-particle duality (discussion). Reduction of the wave packet.

Paper: Frisch, O.R. "Take a Photon", Contemp. Phys. 7 (1965), 45-53

Interesting reading: Einstein, A "On the quantum theory of radiation" Phys. Z. 18 (1921), 121

2.- *Quantization of the Electromagnetic field*
       Cavity Modes. Quantization of a single mode field. Field and vector potential operators. Fluctuations. Multimode fields. Zero point energy and vacuum fluctuations.

Paper: Clauser, J. F. "Experimental distinction between the quantum and classical filed theoretic predictions for the photoelectric effect" Phys. Rev. D 9 (1974), 853-860

Interesting reading : Power, E.A. "Zero point energy and the Lamb shift" Am. J. Phys. 34 (1966), 516-518

3.- *Photon Interference.*
Dirac's conjecture. Single photon interference. Two-photon interference: Does it exist?. Classical and quantum coherence functions. Second order correlation for single mode radiation. Bunching and anti-bunching.

Paper: Magyar, G. and Mandel, L. "Interference fringes produced by superposition of two independent maser light beams" Nature 198 (1963), 255-256

Interesting reading:
a) Loudon, R. "Photon bunching and antibunching" Phys. Bull. 27 (1976) 21-23
b) Hanbury-Brown, R and Twiss, R.Q. "Correlation between photons in two coherent beams of light" Nature 177 (1956), 1449-1450
c) Pfleegor, R.L. and Mandel L. "Interference effects at the single photon level" Phys. Lett. 24A (1967), 766-767

4.- *Everything you need to know about modern quantum optics*
       Bell's inequalities and nonlocality. Entangled states and teleportation. Squeezing and error free measurements. Q-bits and Optical Quantum computers. Quantum data encryption and secret communications. Quantum structures.

5.- Quantum Theory of the Radiation-Matter Interaction
   The two-level atom hamiltonian. The field-atom interaction hamiltonian in the dipole approximation. Atomic operators and ther dynamical equations. Thermal bath hamiltonian. The quantum fluctuation-dissipation theorem. Langevin equations.

Reading: Haken, H. Handbuch der Physik, VolXXV Chapter

6.- Quantum and semiclassical theory of radiation-matter interaction
   Quantum theory of lasers. Semiclassical approximation. Maxwell -Bloch equations. Single mode and multimode models. Absorbers, amplifiers and lasers.Homogeneous and inhomogeneous broadened lasers.

7.- Laser Dynamics
   Lorenz-Haken model of lasers. Laser threshold. Second laser threshold. Nonlinear dynamics of lasers. Gas, solid state and semiconductor lasers. Classification of lasers according their dynamical behavior. Chaos in lasers

8;- Dynamical analysis of laser systems
   Modulates laser. Laser with saturable absorber. Laser with injected signal. Laser with optical feedback. Mode-locked lasers. Q-swithched lasers. …..