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PH2501 -- Photonics
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Study Guide 5

Weeks 5&6 11/19 – 11/30	Homework due 12/3 (Mon)

READINGS: Quimby, Chapter 10 (you can skip material on pp. 178-183 on metal-semiconductor junctions, unless you are interested)
Quimby, Chapter 11

Ch. 10: We review in this chapter the elements of solid state physics that are needed for an understanding of light sources and detectors. The concept of energy bands in a solid is introduced qualitatively by analogy with the energy levels in a molecule. The band picture of solids is extended to include the electron's momentum as well as energy, and the distinction between *direct transitions* and *indirect transitions* is made on the basis of the E(k) diagram. The pn junction is described as a means of injecting electrons into a region with *holes* (vacancies in a filled electron band) so that radiative transitions (recombination of electrons and holes) can occur. A simple model shows how the thickness of the *depletion region* of a pn junction depends on doping level and applied voltage. The *quantum well* is described, which is a thin layer of one composition sandwiched between thicker layers of a different composition on either side. The absorption and emission wavelengths for states in the quantum well are predicted using the "particle in a box" model of quantum mechanics.

Ch. 11: In this chapter the general properties of light emission from LED's (light emitting diodes) and lasers are considered. Aspects of LED emission discussed includes electrical biasing (the *load line* concept), time and frequency response (and how these are related), and the efficiency with which generated light can escape from the LED. Several distinguishing characteristics of laser light are discussed, including *lasing threshold*, directionality of the light (high *brightness*), spectral purity of the light (*monochromatic*), and faster time response compared with an LED. A number of different types of semiconductor lasers are described, including the *double heterostructure* (DH) laser, the *quantum well laser*, the *distributed feedback* (DFB) and *distributed Bragg grating* (DBG) lasers for high spectral purity, the *vertical cavity surface-emitting laser* (VCSEL) which emits from the surface rather than from the edge, and the *quantum cascade laser* (QCL), which utilizes transitions within a single band.

PROBLEMS: Ch. 10: problems 3 (neglect Auger processes), 4, 6, 10

Ch. 11: problems 3 (omit part c), 6, 7, 9, 10, 12