Physics 212E – Chowdary
Classical and Modern Physics
Spring 2005

Objectives for Unit II: Light and Waves

By the end of this unit, students should be able to:

2.0 (Continuing objectives) Relate concepts related to light, waves, and interference to "everyday" situations and discuss various applications of the concepts to practical problems in various fields of science, medicine and engineering.

2.1 Describe qualitatively the four Maxwell equations, the physical situations they model, and how electric and magnetic fields combine to create electromagnetic (EM) radiation.

2.2 Using sketches of oscillating charges, explain how the electric and magnetic fields of electromagnetic radiation are generated by moving charges in an antenna and determine the effects of different orientations of a receiving antenna.

2.3 Determine the relationship between the directions and magnitudes of the electric and magnetic fields in a harmonic plane EM wave.

2.4 Given a specific expression for the electric (or magnetic field) in a harmonic plane EM wave, obtain the direction of propagation of the EM wave, and determine the expression for the corresponding magnetic (or electric) field.

2.5 Relate the index of refraction of a material to the speed of light in the material and the speed of light in vacuum.

2.6 Relate wavelength to wave number, frequency to angular frequency, and determine wave speed.

2.7 Given a specific expression for a traveling transverse or longitudinal harmonic wave, determine amplitude, angular frequency, frequency, wave number, wavelength, period, wave speed, and direction of propagation. Also determine the transverse speed of the wave.

2.8 Check whether a specific wave function of position and time satisfies the wave equation.

2.9 Describe qualitatively the following effects for waves encountering barriers: a) inversion on reflection, and b) diffraction around the edges.

2.10 Use the method of phasors to calculate the resultant amplitude of two or more harmonic waves with given amplitudes and phase differences.

2.11 Calculate the beat period and frequency for two signals differing slightly in frequency.

2.12 Determine the path length difference from geometry and the phase difference from wavelength and path length difference for two source superposition.

2.13 Understand the connection between traveling waves and standing waves in the same medium. For standing wave modes on strings or in air columns in pipes: sketch the wave pattern, identify nodes and antinodes, and determine wavelength, wave number, frequency or wave speed.

2.14 Explain why different instruments playing notes of the same pitch may nevertheless sound quite different.

2.15 For interference problems, combine phase difference from path length difference and phase difference due to reflection. Use this total phase difference and the method of phasors to determine the total amplitude in thin film, two-source, or multiple source interference situations.

2.16 Calculate the new wavelength as light enters a thin film and calculate the wavelengths or colors of light that are most strongly reflected for a given film thickness.

2.17 For films of varying thickness, relate the thickness variations to patterns of bright and dark fringes.

2.18 Use the method of phasors to locate maxima and minima in a two-slit interference problem, multiple-slit interference patterns, or for diffraction gratings.

2.19 For single slit diffraction, use phasors to relate wavelength and slit width to locations of minima and side maxima.

2.20 Explain how diffraction effects limit the size of objects that can be resolved. Use Rayleigh's criterion for circular apertures to calculate resolving angles or separations between closely spaced point sources.

2.21 Use Snell's law to determine angles or indices of refraction for light rays crossing a surface. Connect the law of refraction to the idea of total internal reflection.

2.22 Be able to relate the concepts of re-radiation to scattering and polarization and determine the polarization of an EM wave transmitted through a medium. Understand polarizing filters in terms of classical EM radiation.

2.23 Use the ideas of refraction, scattering, and dispersion to explain rainbows, the color of the sky, and the color of sunrise / sunset.

2.24 Calculate any of these photon properties, given one of the others: energy, momentum, frequency, or wavelength. Also relate light intensity, area of illumination, and number of photons / sec.

2.25 Describe the evidence for the particle nature of light in the photoelectric effect and the Compton effect, and relate this to the concept of wave-particle duality.

2.26 Using Einstein's photoelectric equation, determine the ejected electron's maximum kinetic energy or speed, the light frequency, the threshold frequency or wavelength, or the work function.

2.27 Describe the evidence for the wave nature of particles in the double-slit experiment and in diffraction experiments. Calculate the de Broglie wavelength for nonrelativistic particles.