

SIMG-303-20033      Homework #3  
Due W, 3/31/2004

**First Midterm Exam is Scheduled for Monday, 4/5/2004**

0. Read the sections in Hecht on *Electromagnetic Theory, Photons, and Light* (§3) and the sections on *Superposition of Waves* (§7). You might also want to skim (start to read) the chapter on *The Propagation of Light* (§4, particularly the section on *the Electromagnetic Approach*).
1. A pulse of light from a sodium lamp with  $\lambda = 589$  nm passes through a tank of glycerine that is 20 m long in time  $t_1$ . When the same tank is filled with carbon disulfide, the time required for the pulse of light to traverse the tank is  $t_2$ . The refractive indices of the two media are  $n_1 = 1.47$  and  $n_2 = 1.63$ .
  - (a) Determine the propagation times and the time difference  $t_1 - t_2$ .
  - (b) If one pulse of light with the same wavelength is divided in two and passed through two tanks, one with glycerine and one with carbon disulfide, describe the pulses at the output ends of the tanks.
2. Determine  $k_0$  and  $\omega_0$  for light with  $\lambda = 600$  nm in two situations:
  - (a) in vacuum
  - (b) in glass with  $n = 1.5$ .
3. The phase velocity of waves in some medium is proportional to  $\omega^{+\frac{1}{4}}$ . Find an expression for the modulation velocity and determine whether the waves exhibit normal or anomalous dispersion.
4. The variation in refractive index with wavelength for a transparent material (such as glass) may be approximately expressed in terms of an empirical equation (*Cauchy's equation*)

$$n[\lambda_0] = A + \frac{B}{\lambda_0^2}$$

where  $A$  and  $B$  are constants derived from experimental measurements and  $\lambda_0$  is the vacuum wavelength of the incident light.

- (a) What are the dimensions (units) of  $A$  and  $B$ ?
- (b) Find an expression for the group velocity for  $\lambda_0 = 500$  nm in glass with:

$$n[\lambda_0] = 1.5 + \frac{3 \times 10^{+4}}{\lambda_0^2}$$

where  $\lambda_0$  is measured in nm.

5. The refractive index of a certain hypothetical material is found to vary as the reciprocal of the vacuum wavelength. Find an expression for the group velocity in terms of the phase velocity.