

We strongly recommend that you read about a topic before it is covered in lectures.

Lecture Date	Topics Covered	Reading from Giancoli
#29 Fri 4/26	Snell's law - Refraction - Total Reflection Dispersion - Prisms - Huygen's Principle The Illusion of Color - The weird Benham Top Edwin Land's famous demo	Sect. 33-5, 33-6 & 33-7 Chapter 35 through Sect. 35-2
#30 Mon 4/29	Polarizers - Malus's law Brewster angle Polarization by reflection and scattering Why is the sky blue, why are sunsets red? <i>the sun will set in 26-100!</i>	Handout Optics Kits Sect. 36-11 & 36-12 <i>Take Notes!</i>
#31 Wed 5/1	<i>Rainbows (take notes)</i> <i>A modest rainbow will appear in 26-100!</i> Supernumerary bows - Fog bows Polarization of the bows Halo's around the sun and the moon - mock suns	<i>Bring a friend, this lecture may also be appreciated by non 8.02 "experts".</i> Sect. 33-6

Due before 4 PM, Wednesday, May 1 in 4-339B.

Problem 9.1

Wavelength of radio waves.

Giancoli 32-37.

Problem 9.2

Traveling Electromagnetic Waves.

Consider three examples of a plane, monochromatic, electromagnetic wave traveling in a homogeneous medium. The electric field vector is given in each case by

$$\text{case (1)} \quad E_x = 0 ; E_y = 0 \\ E_z = -25 \sin(1.57x + 4.71 \times 10^8 t)$$

$$\text{case (2)} \quad E_x = 0 ; E_z = 0 \\ E_y = 50 \cos(3.14x - 9.42 \times 10^8 t)$$

$$\text{case (3)} \quad E_x = 0 ; E_y = 0 \\ E_z = 40 \cos(6.28x + 1.34 \times 10^9 t)$$

where $|\vec{E}|$ is measured in V/m, t in sec, and x in m. For each case, answer the following questions:

- What is the propagation direction of the wave?
- What is the wavelength? What is the wave number?
- What is the frequency of the wave in Hz?
- What is its speed?

- (e) What is the index of refraction of the three media?
- (f) What are the corresponding equations for the magnetic field, \vec{B}
- (g) For case (3), what is the time-averaged Poynting vector (magnitude and direction) for the position $x = y = z = -3$, and what for $x = 5, y = z = -3$?

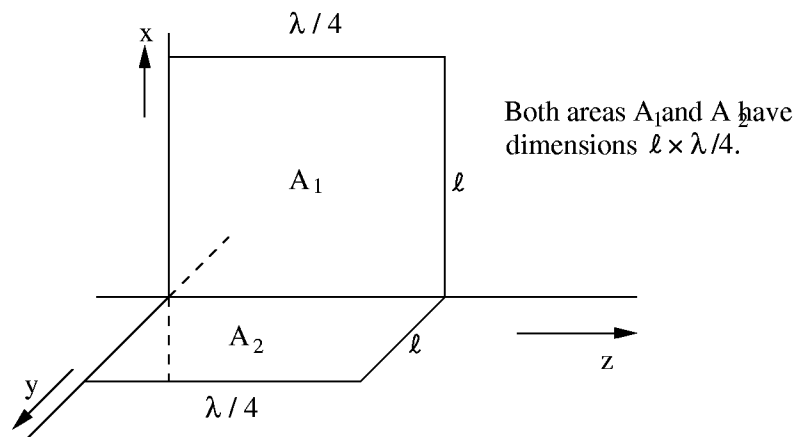
Problem 9.3 *E-M Waves - Maxwell's Equations, and the "speed of light".*

We discussed in lectures that traveling Electromagnetic waves in vacuum of the form

$$\vec{E} = E_o \hat{x} \cos(kz - \omega t), \vec{B} = B_o \hat{y} \cos(kz - \omega t)$$

satisfy *all* 4 Maxwell's equations. In lectures, I showed that an application of the generalized Ampere's Law (closed loop surrounding area A_2 , see below), leads to: $B_o = \epsilon_o \mu_o c E_o$, and I mentioned that independently it follows from an application of Faraday's Law that $B_o = E_o/c$. Combining these two results then leads to the fantastic result that the "speed of light" in vacuum $c = 1/(\epsilon_o \mu_o)^{0.5}$. I want you to show that Faraday's Law indeed leads to the result $B_o = E_o/c$. You can show this by choosing a similar special area as we did in lectures:

Apply Faraday's Law, $\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\phi_B}{dt}$, by choosing an area A_1 , shown below, and calculate separately $d\phi_B/dt$ and $\oint \vec{E} \cdot d\vec{\ell}$.



Problem 9.4

A Standing Electromagnetic Wave.

A wave solution to Maxwell's Equations is given by $\vec{E} = E_o \hat{x} \cos(2\sqrt{3}z) \cos(7.0 \times 10^{10}t)$ where z is measured in centimeters and t in seconds.

- (a) What is the wavelength and the frequency (in Hz) of the wave?
- (b) What is the index of refraction, n , of the medium?
- (c) Give the expression for the associated magnetic field, \vec{B} , in terms of E_o, z and t .
- (d) What is the time-averaged Poynting vector for $x = y = 3, z = \sqrt{3}$?

Note: Part (c) is not as easy as it may seem. Your solution must satisfy all Maxwell's equations.

Problem 9.5

Polarization of Electromagnetic Radiation.

- (a) Describe the polarization state of the plane E-M waves represented by the following equations for the electric field $\vec{E}(x, t)$ ($E_x = 0$ in all three cases):

(1) $E_y = E_0 \sin(kx - \omega t)$, $E_z = 4E_0 \sin(kx - \omega t)$

(2) $E_y = -E_0 \cos(kx + \omega t)$, $E_z = E_0 \sin(kx + \omega t)$

(3) $E_y = 2E_0 \cos(kx - \omega t + \frac{\pi}{2})$, $E_z = -2E_0 \sin(kx - \omega t)$

- (b) In each case, give the corresponding equations for the magnetic field, \vec{B} . Assume $\omega/k = c$.

Problem 9.6

Radiation pressure due to the Sun.

Giancoli 32-29.

Problem 9.7

Snell's law in action \Rightarrow Dispersion!

Giancoli 33-46.

Problem 9.8

Snell's law in action \Rightarrow Fiber optics!

Giancoli 33-53.