Instructions: There are 6 multiple choice questions and 2 longer questions. Read the problems carefully and give the best answer based on the material presented during lecture and in the text. The multiple choice is worth 60% and the problems are worth 40%.

1. At some instant the electric field from some electromagnetic wave points in the positive z-direction (+z) and the Poynting vector points in the positive x-direction (+x). In which direction does the magnetic field point?
   (a) (+z) (b) (−z) (c) (+y) (d) (−y) (e) (−x)

2. A layer of water (n=1.333) floats on a layer of carbon tetrachloride (n=1.461). If light is traveling from the water into the carbon tetrachloride what is the critical angle at the interface (in degrees)?
   (a) 88 (b) 78 (c) 66 (d) 58 (e) the critical angle is not defined

3. An object is placed 15 cm in front of a concave mirror with a focal length of 30 cm. What is the magnification?
   (a) 1 (b) 2 (c) 1/2 (d) 1/3 (e) -2

4. A plano-convex lens has a front surface with a radius of curvature of 20 cm, and a back surface that is flat. It is made of glass, with n = 1.5. What is the focal length (in cm) of this lens?
   (a) 20 (b) 30 (c) 40 (d) 10 (e) 50

5. At a distance of 8 km from a radio transmitter the amplitude of electric field strength is measured to be 0.35 V/m. What is the total power emitted by the transmitter? (Area of a sphere is $4\pi r^2$)
   (a) $1.63 \times 10^{-4}$ W (b) $1.31 \times 10^5$ W (c) $4.66 \times 10^{-4}$ W (d) $3.74 \times 10^5$ W (e) 16.38 W

6. An electromagnetic wave of wavelength $1.2 \times 10^{-6}$ m and frequency $2.5 \times 10^{14}$ Hz travels from vacuum (n=1.00) into cubic zirconia (n=2.20). Which of the following statements most accurately describes what happens to the properties of the electromagnetic wave?
   (a) the wavelength gets shorter and the frequency gets longer
   (b) the wavelength gets longer and the frequency gets shorter
   (c) the velocity of the wave decreases and the frequency decreases
   (d) the velocity of the wave decreases and the wavelength increases
   (e) the velocity of the wave decreases and the wavelength decreases
Box your final answer. No work = No credit on this part.

Problems.

(A) A thin lens is made from material having an index of refraction of 1.65. The front surface of the lens has a radius of curvature of +12.0 cm while the back surface has a radius of curvature of -12.0 cm.

(i) What is the focal length of this lens? Is it a converging or diverging lens?

(ii) If an object is placed 18.0 cm from this lens determine the location and magnification of the image formed. Is the image real or virtual?
(B) A linearly polarized laser light of frequency $4.6 \times 10^{14}$ Hz is traveling in the positive $z$ direction. The magnetic part of the laser light has a maximum amplitude of $6.67 \times 10^{-7}$ T, and oscillates in the $y$ direction. Assume that the electric field magnitude for the laser light can be written as $E = E_{\text{max}} \sin(kz - \omega t)$

(i) What are $E_{\text{max}}$, $k$ and $\omega$ in MKS units?

(ii) What is the full Poynting vector for this wave (magnitude and direction). I want the $t$ and $z$ dependent Poynting vector, NOT the time averaged Poynting vector. Everything except $t$ and $z$ should be written out numerically.

(iii) What is the maximum radiation pressure that this laser light would exert if it were completely reflected from some surface at normal incidence?