Multiple choice questions. Circle the correct answer. No work needs to be shown and no partial credit will be given.

(6 pts) 1. A rectangular block of glass is totally immersed in water \((n = 1.33)\). If a ray of light traveling in the glass is incident on the interface with the water at an angle with respect to the normal that is greater than \(53.1^\circ\), it is found that no light is refracted into the water. For angles with respect to the normal less than \(53.1^\circ\), some of the light is refracted into the water. What is the refractive index of the glass?

\[ b \]

(a) 2.22
(b) 1.66
(c) 1.25
(d) 1.06
(e) none of the above answers

(6 pts) 2. At an instant of time and at a particular location in space, the electric field of an electromagnetic wave is in the \(-x\)-direction and the magnetic field is in the \(+y\)-direction. What is the direction in which the wave is traveling?

\[ f \]

(a) \(+x\)
(b) \(-x\)
(c) \(+y\)
(d) \(-y\)
(e) \(+z\)
(f) \(-z\)

(6 pts) 3. Unpolarized light with intensity \(I_0\) is passed through two polarizing filters. The axis of the first filter is horizontal and the axis of the second filter makes an angle of \(36.9^\circ\) with respect to the horizontal. The intensity of the light after it has passed through the second filter is

\[ a \]

(a) \(0.32I_0\)
(b) \(0.36I_0\)
(c) \(0.40I_0\)
(d) \(0.50I_0\)
(e) \(0.80I_0\)
(f) none of the above answers
4. An object is placed 6.0 cm to the left of a concave mirror. The image formed by the mirror is 8.0 cm to the right of the mirror. The image is

(a) real and inverted
(b) real and upright
(c) virtual and inverted
d (d) virtual and upright

5. Parallel rays from a distant object are traveling in air and then are incident on the concave end of a glass rod, which has a radius of curvature of magnitude 15.0 cm. The refractive index of the glass is 1.50. The image formed by refraction at the concave surface of the rod is located

(a) 5.0 cm to the left of the vertex of the curved surface
(b) 5.0 cm to the right of the vertex of the curved surface
(c) 7.5 cm to the left of the vertex of the curved surface
d (d) 7.5 cm to the right of the vertex of the curved surface
e (e) 45.0 cm to the left of the vertex of the curved surface
(f) 45.0 cm to the right of the vertex of the curved surface
g none of the above answers

6. Two antennas, A and B, are 5.0 m apart and emit electromagnetic waves in phase. The wavelength of the waves is 2.0 m. Point P is 3.0 m from antenna A and 4.0 m from antenna B. The interference observed at P is

(a) destructive
(b) constructive

7. Without a corrective lens, a farsighted person can't focus clearly on objects that are closer to her eye than 75 cm. What is the focal length of the contact lens that will allow this person to see clearly objects that are 25 cm from her eye?

(a) +18.75 cm
(b) −18.75 cm
c (c) +37.5 cm
d −37.5 cm
e +75.0 cm
(f) −75.0 cm
g none of the above answers
(6 pts) 8. Coherent light from a laser is passed through two very narrow and closely-spaced slits. On a screen 1.5 m from the slits the distance between adjacent interference maxima near the center of the screen is 3.0 mm. If the apparatus (slits, screen and space in between) is immersed in water, the spacing on the screen between adjacent interference maxima will then be

(a) 3.0 mm
(b) greater than 3.0 mm
(c) less than 3.0 mm

(6 pts) 9. Coherent light from a laser is passed through a single slit of width 0.80 mm. On a screen 1.5 m from the slit the width of the central diffraction maximum is 8.0 mm. If the width of the slit is decreased to 0.40 mm, the width of the central maximum will then be

(a) 8.0 mm
(b) greater than 8.0 mm
(c) less than 8.0 mm

On the following problems show all your work. Partial credit will be given, if earned. Write your answers in the blanks provided.

(15 pts) 10. A flat horizontal glass plate has refractive index \( n = 1.50 \) and is \( 5.00 \times 10^{-7} \) m thick. The plate is surrounded by air. The plate is illuminated by a beam of white light that is normal to the plate. What wavelengths in air within the limits of the visible spectrum (\( \lambda = 400 \) nm to \( \lambda = 700 \) nm) will have destructive interference between light reflected from the upper and lower surfaces of the plate?

Ans. 500 nm
11. A point source of electromagnetic waves emits waves uniformly in all directions. At a distance of 10.0 m from the source the magnetic field amplitude for the waves is $4.0 \times 10^{-8}$ T. 
(Note: $c = 3.00 \times 10^8$ m/s, $\varepsilon_0 = 8.854 \times 10^{-12}$ C$^2$/N·m$^2$, $\mu_0 = 4\pi \times 10^{-7}$ T·m/A )

a) What is the electric field amplitude at this point, 10.0 m from the source? Ans. $12 \text{ V/m}$

b) What is the intensity of the wave at this point, 10.0 m from the source? Ans. $0.19 \text{ W/m}^2$

c) What is the power output of the source? Ans. $240 \text{ W}$

12. An object 2.0 mm tall is placed 20.0 cm to the left of a lens. The image formed by the lens is 3.0 mm tall and is upright.

a) Is the image to the left or to the right of the lens? Ans. To the left

b) What is the magnitude of the focal length of the lens? Ans. 60.0 cm

c) Is the lens converging (positive $f$) or diverging (negative $f$)? Ans. Converging