Physics 202 MWF10:20 Spring 2009 (Ford)
Exam III Chapts. 22–25 in Young/Geller

Name (printed) Version 1

Name (signature as on ID) Key

Lab Section

Circle the correct answer. No work need be shown and no partial credit will be given.

(5 pts) 1. The power radiated by a star is 8.0×10^{30} W. What is the intensity of the radiation from this star at a distance of 1.0×10^{12} m from the star?

(a) 8.0×10^{18} W/m^2
(b) 8.0×10^{6} W/m^2
(c) 2.5×10^{6} W/m^2
d (d) 6.4×10^{5} W/m^2
(e) 3.2×10^{5} W/m^2
(f) none of the above answers

$$I = \frac{P}{A} = \frac{P}{4\pi r^2} = \frac{8 \times 10^{30}\ \text{W}}{4\pi (1 \times 10^{12}\ \text{m})^2}$$

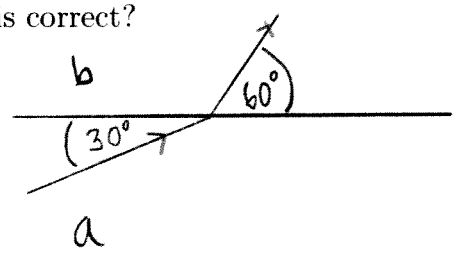
$$I = 6.4 \times 10^{5}\ \text{W/m}^2$$

(5 pts) 2. Light that is initially unpolarized and with initial intensity I_0 passes through two polarizing filters. The angle between the polarizing axis of the first and second filter is 45°. What is the intensity of the light after it has passed through the second filter?

(a) zero
(b) $0.71 I_0$
(c) $0.50 I_0$
d (d) $0.25 I_0$
(e) I_0
(f) none of the above answers

$$I = \left(\frac{1}{2} I_0\right)(\cos 45^\circ)^2 = 0.25\, I_0$$

(5 pts) 3. A ray of light traveling in material a strikes the interface between materials a and b and refracts into material b. In material a the light makes an angle of 30° with respect to the surface of material a and in material b it makes an angle of 60° with respect to the surface of material b. Which of the following statements is correct?



(a) The light travels faster in material b than in material a.
b (b) The light travels slower in material b than in material a.
(c) The speed of the light is the same in both materials.

Bent toward normal $\Rightarrow$ $n_b > n_a$

$v = \frac{c}{n}$, so slower in b

(5 pts) 4. Light traveling in benzene ($n = 1.50$) is incident on the flat surface of a piece of plastic. It is found that if the light in the benzene is incident at an angle with respect to the normal to the surface of the plastic that is greater than 60°, none of the light passes into the plastic. What is refractive index of the plastic?

b (a) 0.77
(b) 1.30
(c) 1.50
(d) 1.60
(e) 1.73
(f) 3.00
(g) none of the above answers

$\theta_{crit} = 60°$

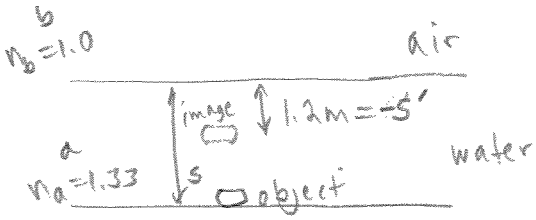
$n_a \sin\theta_a = n_b \sin\theta_b$

$(1.50)(\sin 60°) = n_b \sin 90°$

$n_b = 1.30$

(5 pts) 5. A person in the air above the water in a swimming pool looks straight down into the water ($n = 1.33$) at a diamond ring that lies on the bottom of the pool. If the image of the ring is 1.20 m below the surface of the water, what is the depth of the water (the distance from the surface of the water to the bottom of the pool)?

d (a) 0.60 m
(b) 0.90 m
(c) 1.20 m
(d) 1.60 m
(e) 2.40 m
(f) none of the above answers



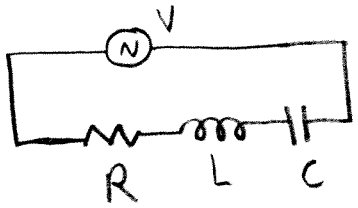
$\frac{n_a}{s} + \frac{n_b}{s'} = \frac{n_b - n_a}{R}$ (R → ∞, so $= 0$)

$s = -\frac{n_a}{n_b} s'$

$s = \frac{1.33}{1.0}(-1.2\text{m}) = 1.60\text{m}$

(5 pts) 6. Consider the RCL series circuit shown in the sketch. $R = 200\ \Omega$, $L = 0.20$ H, and $C = 5.0 \times 10^{-6}$ F. The source has voltage amplitude 400 V. When the source is operated at the resonance frequency of the circuit, what is the current amplitude in the circuit?

(a) zero
(b) 0.5 A
(c) 1.0 A
d (d) 2.0 A
(e) 4.0 A
(f) none of the above answers



$Z = R$

$I = \frac{V}{Z} = \frac{400\text{V}}{200\Omega} = 2\text{A}$

Show all your work. Partial credit will be given if earned. Write your answers in the blanks provided.

(18 pts) 7. An upright object that is 2.0 mm tall is placed to the left of a spherical mirror and the mirror produces an image that is 60 cm to the left of the mirror and that is 4.0 mm tall.

a) Is the image real or virtual?

same side as object so is real

Ans. real

b) Is the image upright or inverted?

$s' > 0$, $m = -\frac{s'}{s}$ so $m < 0$ and image is inverted

Ans. inverted

c) What is the focal length of the mirror?

Ans. 20 cm

$m = -2.0$

$m = -\frac{s'}{s} = -2$ so $s' = 2s$

$s' = 60\,cm$, $s = 30\,cm$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$, $f = \frac{ss'}{s+s'} = \frac{(30\,cm)(60\,cm)}{30\,cm + 60\,cm} = 20\,cm$

d) Is the focal length of the mirror positive or negative?

Ans. positive

(16 pts) 8.

a) An eye has a near point of 60 cm. What is the focal length of the contact lens that allows the eye to see objects clearly that are 25 cm from the eye? Is the focal length positive or negative?

Ans. $f =$ +42.9 cm

positive or negative? positive

$s = 25$ cm

$s' = -60$ cm

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

$f = \frac{ss'}{s+s'} = \frac{(25\text{ cm})(-60\text{ cm})}{25\text{ cm} + (-60\text{ cm})} = +42.9\text{ cm}$

b) An eye has a far point of ~~20~~ 200 cm. What is the focal length of the contact lens that allows the eye to see objects clearly that are very far from the eye? Is the focal length positive or negative?

Ans. $f =$ -200 cm

positive or negative? negative

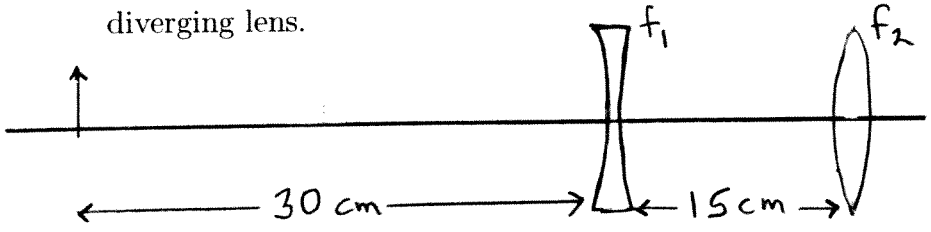
$s = \infty$

$s' = -200$ cm

$\frac{1}{s}^{0} + \frac{1}{s'} = \frac{1}{f}$

$f = s' = -200$ cm

(18 pts) 9. A small object that is 2 mm tall is placed 30 cm to the left of a diverging lens that has $f_1 = -10$ cm. A converging lens with $f_2 = +10$ cm is 15 cm to the right of the diverging lens.



$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

$s' = \frac{sf}{s-f}$

a) Is the final image real or inverted?

$s_1' = \frac{s_1 f_1}{s_1 - f_1} = \frac{(30)(-10)}{30-(-10)} = -7.5$ cm

Ans. real

7.5 cm to left of lens #1 so 22.5 cm to left of lens #2

$s_2' = \frac{s_2 f_2}{s_2 - f_2} = \frac{(22.5)(10)}{22.5-10} = 18.0$ cm

b) How far is the final image from the converging lens?

Ans. 18.0 cm

c) What is the height of the final image?

$m_1 = -\frac{s_1'}{s_1} = -\frac{-7.5}{30} = +0.25$

$m_2 = -\frac{s_2'}{s_2} = -\frac{18}{22.5} = -0.80$

$m = m_1 m_2 = (+0.25)(-0.80) = -0.20$

Ans. 0.40 mm

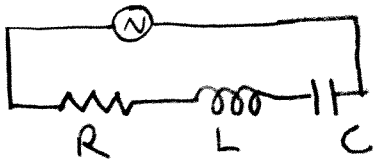
$|y'| = |m| y = 0.40$ mm

d) Is the final image upright or inverted?

Ans. inverted

$m < 0$ so final image is inverted

(18 pts) 10. Consider the RCL series circuit shown in the sketch. $R = 300\ \Omega$. At the frequency of the source, the inductor has reactance $X_L = 900\ \Omega$ and the capacitor has reactance $500\ \Omega$. The amplitude of the voltage across the inductor is 450 V.



a) What is the amplitude of the voltage across the resistor?

$I = \frac{V_L}{X_L} = \frac{450\,V}{900\,\Omega} = 0.5\,A$

$V_R = IR = (0.5)(300) = 150\,V$

Ans. 150 V

b) What is the amplitude of the voltage across the capacitor?

$V_C = IX_C = (0.5)(500) = 250\,V$

Ans. 250 V

c) What is the rate at which the source is delivering electrical energy to the circuit?

$P = I_{rms}^2 R = \frac{1}{2} I^2 R = \frac{1}{2}(0.5\,A)^2(300\,\Omega)$

$P = 37.5\,W$

Ans. 37.5 W

d) Does the source voltage lag or lead the current in the circuit?

$X_L > X_C$ so source voltage leads current

Ans. leads