

DEPARTMENT OF NATURAL SCIENCES

PHYS 1112, Exam 3
 Version 1
 Total Weight: 100 points

Section 1
 April 18, 2002

1. Check your examination for completeness prior to starting. There are a total of twelve (12) problems on twelve (12) pages.
2. Authorized references include your calculator with calculator handbook, and the Reference Data Pamphlet (provided by your instructor).
3. You will have 80 minutes to complete the examination.
4. The total weight of the examination is 100 points.
5. There are seven (7) multiple choice and five (5) calculation problems. Work 4 out of 5 calculation problems and 6 out of 7 multiple choice. Show all work; partial credit will be given for correct work shown.
6. If you have any questions during the examination, see your instructor who will be located in the classroom.
7. Start: 10:30 a.m.
 Stop: 11:50 a.m

PROBLEM	POINTS	CREDIT
1-7	35	
8	15	
9	20	
10	20	
11	20	
12	15	
TOTAL		

CIRCLE THE SINGLE BEST ANSWER FOR ALL MULTIPLE CHOICE QUESTIONS. IN MULTIPLE CHOICE QUESTIONS WHICH REQUIRE A CALCULATION SHOW WORK FOR PARTIAL CREDIT.

1. You stand two feet away from a plane mirror. How far is it from you to your image?

a. 2.00 ft.

b. 3.00 ft.

(5) c. 4.00 ft.

d. 5.00 ft.

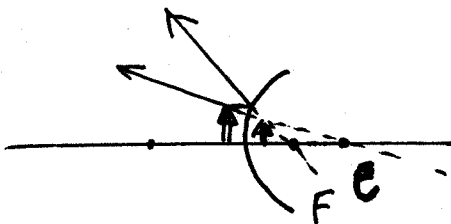
2. Which of the following best describes the image formed by a convex mirror when the object's distance from the mirror is less than the absolute value of the focal length?

a. Virtual, upright, and magnification greater than one.

b. Real, inverted, and magnification less than one.

(5) c. Virtual, upright, and magnification less than one.

d. Real, inverted, and magnification greater than one.



3. A Fraunhofer diffraction pattern is produced from a light source of 580 nm. The light goes through a single slit and onto a screen 1.00 m away. The first dark fringe is 5.00 mm from the central bright fringe. What is the slit width?

a. 0.24 mm.

(5) b. 0.12 mm.

c. 0.10 mm.

d. 0.81×10^{-5} m.

$$m\lambda = a \cdot \sin \theta$$

$$m = 1 \quad \tan \theta = \frac{y}{L}$$

$$\theta = \tan^{-1} \left(\frac{5.00 \times 10^{-3} \text{ m}}{1.00 \text{ m}} \right) = 0.286^\circ$$

$$a = \frac{\lambda}{\sin \theta} = \frac{580 \times 10^{-9}}{\sin(0.286^\circ)} =$$

$$= 116001 \times 10^{-9} \text{ m} = 0.12 \times 10^{-3} \text{ m}$$

4. The critical angle for sapphire surrounded by air is 34.4° . Calculate the polarizing angle for sapphire.

(10) a. 60.5° .

b. 59.7° .

c. 58.6° .

d. 56.3° .

$$\sin \theta_c = \frac{n_2}{n_1}$$

$$\sin \theta_c = \frac{1}{n_1} \Rightarrow n_1 = \frac{1}{\sin \theta_c}$$

$$n_1 = \frac{1}{\sin(34.4^\circ)} = 1.77$$

$$n = \tan \theta_p \quad 1.77 = \tan \theta_p$$

$$\theta_p = \tan^{-1}(1.77)$$

$$\theta_p = 60.5^\circ$$

60.5°

5. A light ray in air is incident on an air-glass boundary at an angle of 45.0° and is refracted in the glass at 30.0° with the normal. Find the index of refraction of the glass.

a. 2.13.

b. 1.74.

c. 1.23.

d. 1.41.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$1 \cdot \sin(45^\circ) = n_2 \cdot \sin(30^\circ)$$

$$n_2 = \frac{\sin(45^\circ)}{\sin(30^\circ)} = \frac{0.707}{0.5} = 1.41$$

6. One phenomenon that demonstrates the particle nature of light is:

a. Photoelectric effect.

b. Diffraction effects.

c. Interference effects.

d. Polarization effect

7. A monochromatic light source emits a wavelength of 490 nm in air. When passing through a liquid, the wavelength reduces to 429 nm. What is the liquid's index of refraction?

a. 1.26.

b. 1.49.

c. 1.14

d. 1.33.

$$n = \frac{\lambda_0}{\lambda}$$

$$n = \frac{490 \text{ nm}}{429 \text{ nm}} = 1.14$$

8. Monochromatic light of unknown wavelength from a distant source is incident on the two slits of Young's double slit experiment. The slits are separated by 0.500 mm. A screen located 6.50 m from the slits has interference pattern, in which the first and the second order bright fringes are separated by 7.70 mm. What is the wavelength of the incident light?

(15)

$$y_{\text{BRIGHT}} = \frac{\lambda L}{d} \text{ m}$$

$$y_{\text{BRIGHT } 1} = \frac{\lambda L}{d}$$

$$y_{\text{BRIGHT } 2} = \frac{2\lambda L}{d}$$

$$y_{\text{BRIGHT } 2} - y_{\text{BRIGHT } 1} = \frac{\lambda L}{d} = 7.70 \times 10^{-5} \text{ m}$$

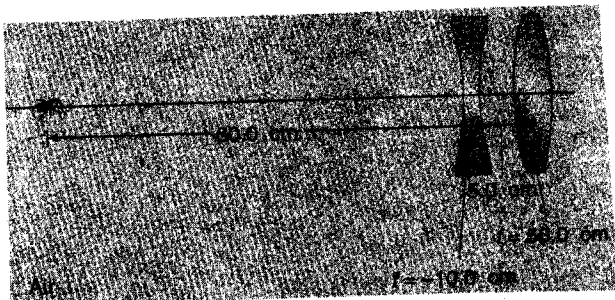
$$\lambda = \frac{d \cdot 7.70 \times 10^{-5} \text{ m}}{L} = \frac{0.5 \times 10^{-3} \cdot 7.70 \times 10^{-5}}{6.50}$$

$$= 0.592 \times 10^{-6} \text{ m} = 592 \times 10^{-9} \text{ m}$$

$$\underline{\underline{\lambda = 592 \text{ nm}}}$$

9. A black widow spider (*Latrodectus mactans*) is 60.0 cm in front of the first lens of a two-lens system as indicated in the figure.

(20)



$$f_1 = -10.0 \text{ cm}$$

$$f_2 = 50.0 \text{ cm}$$

$$p_1 = 60.0 \text{ cm}$$

- a. Find the position of the final image relative to the second lens.

$$\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{f_1} \quad \frac{1}{q_1} = \frac{1}{f_1} - \frac{1}{p_1}$$

$$\frac{1}{q_1} = \frac{1}{-10.0 \text{ cm}} - \frac{1}{60.0 \text{ cm}} = -0.1 - 0.0166 =$$

$$= -0.1166\bar{6}$$

$$\underline{\underline{q_1 = -8.57 \text{ cm}}}$$

$$p_2 = +8.57 \text{ cm} + 5.00 \text{ cm} = 13.57 \text{ cm}$$

$$\frac{1}{q_2} = \frac{1}{f_2} - \frac{1}{p_2} \quad \frac{1}{q_2} = \frac{1}{50.0 \text{ cm}} - \frac{1}{13.57 \text{ cm}}$$

$$= 0.02 - 0.0736$$

$$= -0.0536$$

$$\underline{\underline{q_2 = -18.65 \text{ cm}}}$$

- b. Determine the total magnification.

$$M = M_1 \cdot M_2$$

$$M_1 = - \frac{q_1}{p_1} = - \frac{-8.57 \text{ cm}}{60.0 \text{ cm}} = \underline{\underline{0.1428}}$$

$$M_2 = - \frac{q_2}{p_2} = - \frac{-18.65 \text{ cm}}{13.57 \text{ cm}} = \underline{\underline{1.37}}$$

$$M = (1.37)(0.1428) = \underline{\underline{0.196}}$$

- c. Is the final image upright or inverted, enlarged or reduced in size?

UPRIGHT

REDUCED

10. A lens has radii of curvature of its front and second surfaces of 20.0 cm and 25.0 cm, respectively. The lens is made from recycled physic elixir bottles with an index of refraction of 1.50. The lens is surrounded by air.

a. Find the focal length of the lens.

(20)



$$\frac{1}{f} = (n-1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\frac{1}{f} = (1.50-1) \left(\frac{1}{20.0 \text{ cm}} - \frac{1}{25.0 \text{ cm}} \right) =$$

b. Is the lens converging or diverging?

$$(0.50) (0.05 - 0.04) = 0.005$$

$$\underline{\underline{f = +200 \text{ cm}}}$$

CONVERGING

c. An uninteresting object is placed 40.0 cm from the lens (front side). Find the location of its equally uninteresting image.

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

$$\frac{1}{q} = \frac{1}{200 \text{ cm}} - \frac{1}{40 \text{ cm}} = (0.005 - 0.025) \text{ cm}^{-1}$$

$$= -0.02 \text{ cm}^{-1}$$

$$\underline{\underline{q = -50.0 \text{ cm}}}$$

d. Determine the magnification.

$$M = - \frac{q}{p} = - \frac{-50.0 \text{ cm}}{40.0 \text{ cm}}$$
$$= \underline{\underline{1.25}}$$

e. Describe the image (real or virtual, upright or inverted, enlarged or reduced?).

VIRTUAL
UPRIGHT
ENLARGED

11. A tasty lollipop is located 200 cm in front of a concave spherical mirror with a focal length of 50.0 cm.

a. Locate the image of the sucker.

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

$$\frac{1}{q} = \frac{1}{50.0 \text{ cm}} - \frac{1}{200 \text{ cm}} = 0.02 - 0.005 = 0.015$$

$$q = 66.7 \text{ cm}$$

b. Determine the magnification.

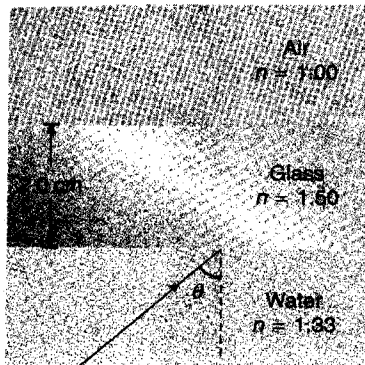
$$M = -\frac{q}{p} = -\frac{66.7 \text{ cm}}{200 \text{ cm}} = -0.333$$

c. Describe the image (real or virtual, upright or inverted, enlarged or reduced?).

REAL
INVERTED
REDUCED

12. To calm troubled waters, a sheet of glass 2.00 cm thick is placed in full contact over water as indicated in the figure.

(15)



- a. What is the critical angle for the glass-air interference?

$$\sin \theta_c = \frac{n_2}{n_1}$$

$$\sin \theta_c = \frac{1.00}{1.50} = 0.6667$$

$$\underline{\theta_c = 41.8^\circ}$$

- b. At what angle of incidence θ must light approach the water-glass surface so that the light is incident on the glass-air interface at the critical angle?

$$n_w \cdot \sin \theta = n_g \cdot \sin 41.8^\circ$$

$$\sin \theta = \frac{n_g \cdot \sin 41.8^\circ}{n_w} = \frac{1.50 \cdot \sin 41.8^\circ}{1.33}$$

$$= \underline{0.751}$$

$$\underline{\theta = 48.7^\circ}$$