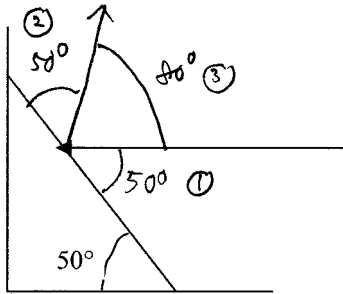


Time Allowed: 2 Hours

Each question is worth 5 points.

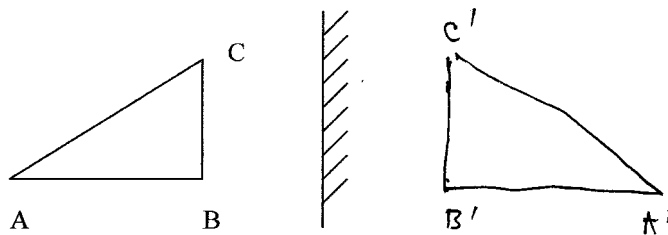
Credits are given for numerical problems only if evidence of calculation is presented.

1. The diagram shows a mirror leaning on a wall making an angle of 50° with the floor. A horizontal ray is reflected off the mirror. What is the angle made by the reflected ray with the floor?

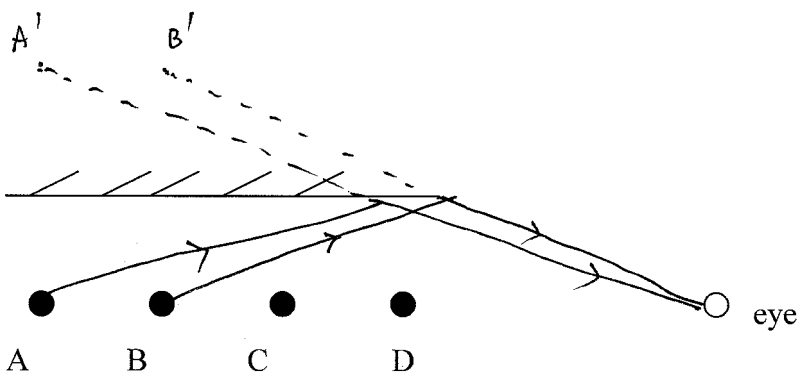


- (a) 50° (b) 60° (c) 70° (d) 80°

2. Draw the image of the triangle ABC in the mirror as shown:

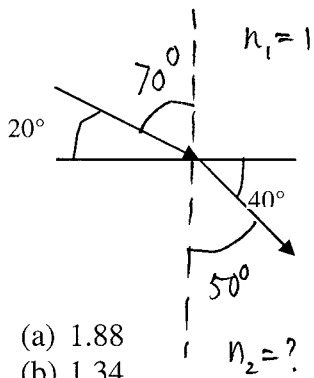


3. Determine the viewable objects when you look into the mirror from the position shown, and draw the rays that allow the object(s) to be seen.



- (a) A,B,C,D
 (b) A,B,C
 (c) A,B
 (d) A

4. The diagram below shows an incident ray from air and the refracted ray into a transparent medium. From the angles identified, determine the refractive index of the medium. (index of refraction of air = 1)



Snell's law:

$$1 \times \sin 70^\circ = n_2 \sin 50^\circ$$

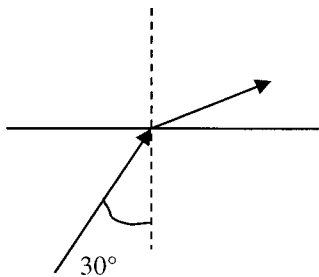
$$n_2 = \frac{\sin 70^\circ}{\sin 50^\circ} = 1.23$$

- (a) 1.88
- (b) 1.34
- (c) 1.15
- (d) 1.23

5. Which of the following statements regarding the critical angle for total internal reflection is false:

- (a) A ray is 100% reflected if its angle of incidence exceeds the critical angle.
- (b) It occurs only when the ray enters a medium of lower refractive index from one of higher refractive index.
- (c) It is equal to $\sin^{-1}(1/n)$ for rays entering air from a medium of refractive index n
- (d) It increases as n decreases for rays entering air from a medium of refractive index n

6. The diagram below shows a ray entering air from a liquid with an angle of incidence of 30° . From the very existence of such a ray, what conclusion can you draw regarding the refractive index of the liquid?



Critical angle $\theta_c > 30^\circ$ from diagram

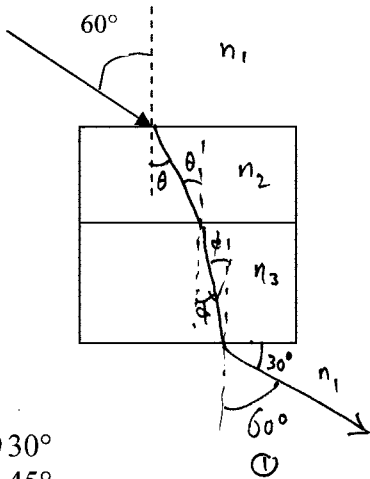
$$\sin \theta_c > \sin 30^\circ = 0.5$$

$$\text{Or } \frac{1}{n} > 0.5$$

$$n < 2$$

- (a) $n < 1$
- (b) $1 < n < 2$
- (c) $2 \leq n$
- (d) No conclusion can be drawn

7. Two slabs of plastics are stacked together to form a single slab as shown. A ray strikes the top slab at an angle of incidence of 60° as shown. The refractive indices of the top and bottom slabs are 1.5 and 2.0 respectively. What is the angle made by the ray with the bottom surface as it emerges from the slab?



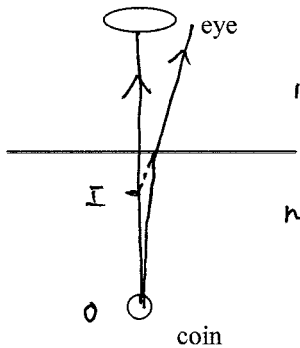
$$n_1 \sin 60^\circ = n_2 \sin \theta$$

$$n_2 \sin \theta = n_3 \sin \phi$$

$$\therefore n_1 \sin 60^\circ = n_3 \sin \phi$$

- (a) 30°
 (b) 45°
 (c) 60°
 (d) 75°

8. The diagram below shows a coin at the bottom of a 2.5m deep swimming pool. Determine how far below the water level it appears to be when viewed directly from above in air, and draw two rays showing how the coin can be seen by the eye. (The refractive index of water is 1.33).

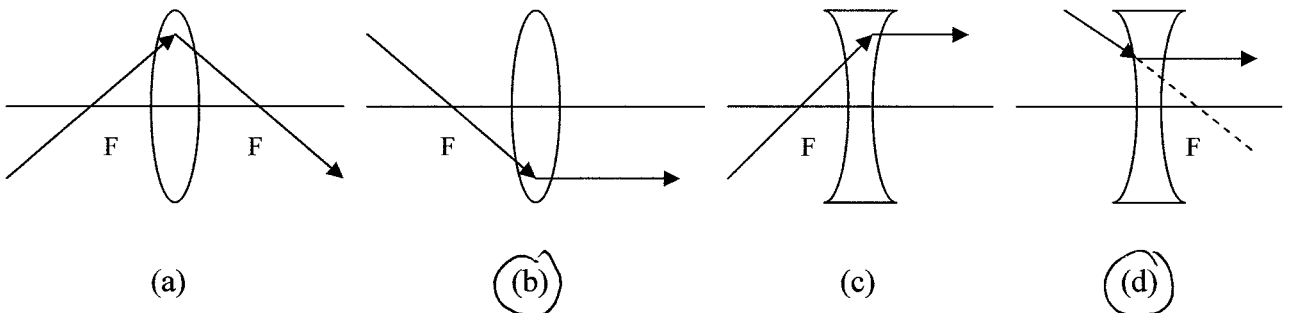


$$\text{Apparent depth} = \frac{\text{real depth}}{n}$$

$$= \frac{2.5}{1.33} = 1.9$$

- (a) 3.3m (b) 2.0m (c) 1.9m (d) 1.5m

9. The diagrams below each show a ray being refracted by a lens. The point F is a focal point. Circle the diagram(s) that are correct.



10. When an object is placed 10cm from a lens, it is found that a sharp image can be located by a screen placed 15 cm from the lens. What is the focal length of the lens and what kind of lens is it?

- (a) 6.0 cm concave
- (b) 6.0 cm convex
- (c) 30 cm convex
- (d) 30 cm concave

$$d_o = 10 \text{ cm}$$

$$d_i = +15 \text{ cm}$$

$$\frac{1}{f} = \frac{1}{10} + \frac{1}{15} = 0.1 + 0.0667 = 0.1667$$

$$f = \frac{1}{0.1667} = 6.0$$

11. Find the image distance and magnification by ray tracing on the graph paper provided with following data (NO CALCULATION ACCEPTED)

$$f = +20 \text{ cm} \quad d_o = 10 \text{ cm}$$

Answers: $d_i = -20 \text{ cm} \quad m = 2$

The next two questions refer to a person who can only see clearly objects from 15cm to 50cm.

12. What type of vision defect does he suffer from, and what is the strength of the corrective contact lens he should wear?

- (a) near sighted, +2.0 dioptre
- (b) near sighted, -2.0 dioptre
- (c) far sighted, +6.7 dioptre
- (d) far sighted, -6.7 dioptre

$$\text{Far point} = 50 \text{ cm} < \infty$$

\therefore near sighted.

With corrective lens, object at ∞ forms image at far point.

$$\therefore d_o = \infty; \quad d_i = -50 \text{ cm} \quad \therefore f = -50 \text{ cm} = -0.5 \text{ m}$$

$$\text{Strength} = \frac{1}{f} = -2.0$$

13. When he is wearing the lens, what is the closest distance he can see clearly?

- (a) 27.3 cm
- (b) 25.0 cm
- (c) 21.4 cm
- (d) 15.0 cm

Object at closest distance should form image at near point:

$$d_i = -15 \text{ cm} \quad f = -50 \text{ cm}$$

$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = -\frac{1}{50} + \frac{1}{15} = -0.02 + 0.0667 = 0.0467$$

$$d_o = \frac{1}{0.0467} = 21.4 \text{ cm}$$

14. What is the magnifying power of a telescope that enables a person to see a 50 feet tall building two miles away to be as large as a 2 inch pin held 2 feet away from the eye? (1 mile= 5280 feet)

- (a) 23.6
- (b) 17.76**
- (c) 11.9
- (d) 8.2

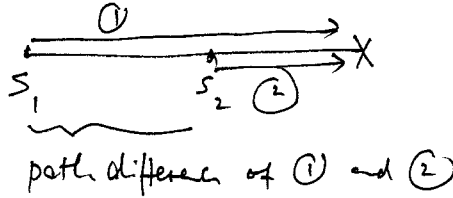
angle subtended by building $\theta = \frac{50}{2 \times 5280} = 0.004735$

angle subtended by pin $\theta' = \frac{2}{2 \times 12} = 0.08333$

$$M = \frac{\theta'}{\theta} = 17.6$$

15. A person listens to the sound of wavelength 60cm given by two loudspeakers oscillating in phase. One speaker is directly behind the other. It turns out that he hears no sound at all. Circle the possible answer(s) for the distance between the speakers.

- (a) 30 cm
- (b) 60 cm
- (c) 90 cm**
- (d) 120 cm



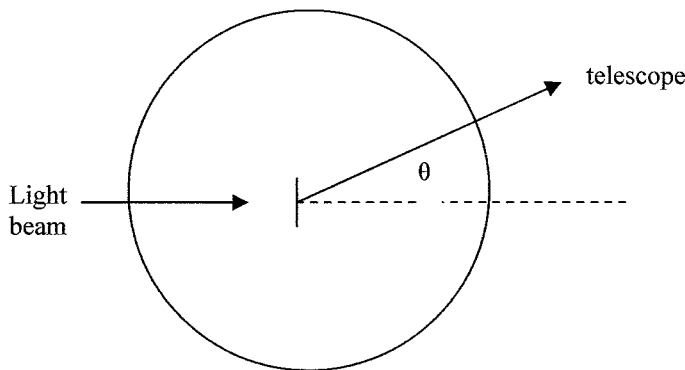
path difference = $\frac{\lambda}{2}, \frac{3\lambda}{2}$
 $= 30, 90$

16. In Young's double slit experiment, which of the following actions can produce most dark fringes within a length of 1 cm on the screen?

- (a) increase the wavelength and increase the distance between the slits
- (b) increase the wavelength and reduce the distance between the slits
- (c) reduce the wavelength and increase the distance between the slits**
- (d) reduce the wavelength and reduce the distance between the slits

The distance between fringes is narrower
 $\Delta\theta = \frac{\lambda}{d}$

17. The diagram below shows a screen with a double slit situated at the center of a circle and a monochromatic light beam incident on it from the left. A telescope can swing around the circle aiming at the screen. As the angle θ is increased from zero degree, the second time a dark fringe is seen through the telescope is when $\theta = 0.5^\circ$. If the wavelength of the light is 640nm, what must be the distance between the two slits?



The condition for dark fringe:

$$d\theta = \frac{\lambda}{2}, \frac{3\lambda}{2}, \dots$$

for the second dark fringe

$$d\theta = \frac{3\lambda}{2}$$

$$\therefore d = \frac{3\lambda}{2\theta} = \frac{3 \times 640 \times 10^{-9}}{2 \times 0.5 \times \frac{\pi}{180}}$$

$$= 1.1 \times 10^{-4} \text{ m}$$

(a) 0.037 mm

(b) 0.074 mm

(c) 0.11 mm

(d) 0.14 mm

18. Referring to the diagram in the previous question, where now the double slit screen is replaced by a diffraction grating with 900 lines per millimeter, and the wavelength of the light is unknown. It is found that the first value of θ when the light beam can be seen through the telescope is 30° . Determine the wavelength of the light.

- (a) 640 nm
 (b) 556 nm
 (c) 513 nm
 (d) 482 nm

$$d = \frac{1}{900} \text{ mm} = \frac{1}{900} \times 10^{-3} \text{ m}$$

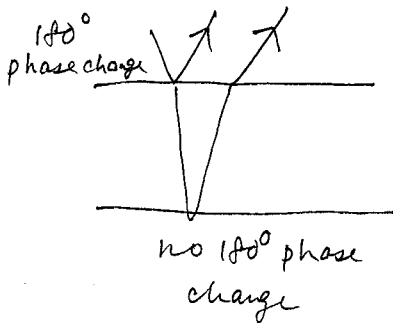
$$\lambda = d \sin \theta = \frac{1}{900} \times 10^{-3} \sin 30^\circ = 5.56 \times 10^{-7} \text{ m}$$

19. Give two reasons why the diameter of the objective lens in an astronomical telescope is made very large.

- (1) To collect more light to form brighter image
 (2) To increase the resolving power

20. When light of wavelength 520 nm shines on a soap bubble, no reflected light is seen at a certain spot. What is the minimum thickness of the soap film at this spot? (The refractive index of soap solution is 1.33)

- (a) 195 nm
 (b) 260 nm
 (c) 390 nm
 (d) 520 nm



$$2t + \frac{\lambda_f}{2} = \frac{3\lambda_f}{2}$$

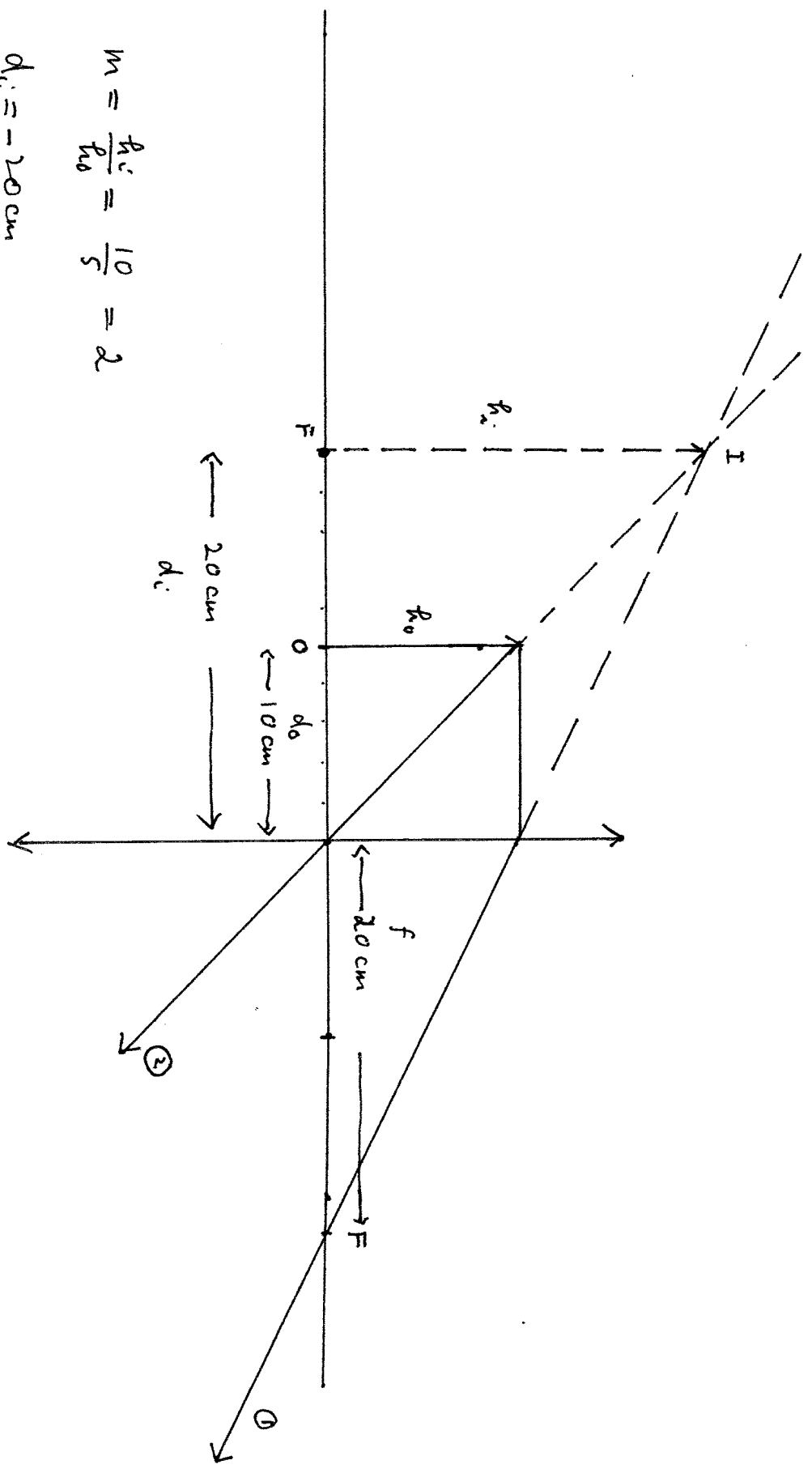
$$t = \frac{\lambda_f}{2} = \frac{520}{1.33} = 195 \text{ nm}$$

21. The speed of light in a certain transparent medium is 2.1×10^8 m/c. What is the wavelength of light in this medium if the wavelength in vacuum is 600 nm? (Speed of light in vacuum = 3.0×10^8 m/s)

- (a) 860 nm
 (b) 600 nm
 (c) 560 nm
 (d) 420 nm

$$n = \frac{c}{v} = \frac{3 \times 10^8}{2.1 \times 10^8} = 1.43$$

$$\lambda_{\text{medium}} = \frac{\lambda_{\text{vacuum}}}{n} = \frac{600}{1.43} = 420 \text{ nm}$$



$$m = \frac{h_i}{h_o} = \frac{10}{5} = 2$$

$$d_i = -20\text{ cm}$$