

Physics 261: Physics for Life Sciences 2

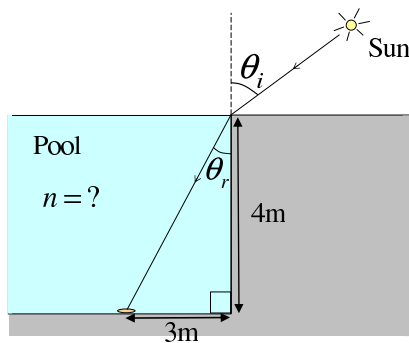
Exam 1: Solutions

Section A

1. B	5. C	9. D	13. C	17. D	21. B
2. B	6. C	10. A	14. A	18. B	22. D
3. A	7. A	11. B	15. D	19. A	23. A
4. B	8. C	12. B	16. C	20. D	

Section B

1. A coin lies at the bottom of a pool at a depth of 4 m, at a distance of 3 m from a vertical wall. Light rays from the sun that pass close to the edge of the pool illuminate the coin, as shown in the figure below. The angle of incidence and refraction of the light ray are θ_i and θ_r , respectively.



- (a) What is θ_r ? You may express your answer in terms of \sin^{-1} . (Hints: Pythagoras' theorem for right-angled triangles: Square of hypotenuse = sum of squares of two other sides. Also, $\sqrt{25} = 5$.) [10 points]
- (b) If $\sin \theta_i = \frac{4}{5}$, what is the index of refraction of the liquid? You may express your answer in terms of fraction. (Air has index of refraction of 1.) [10 points]

Answers

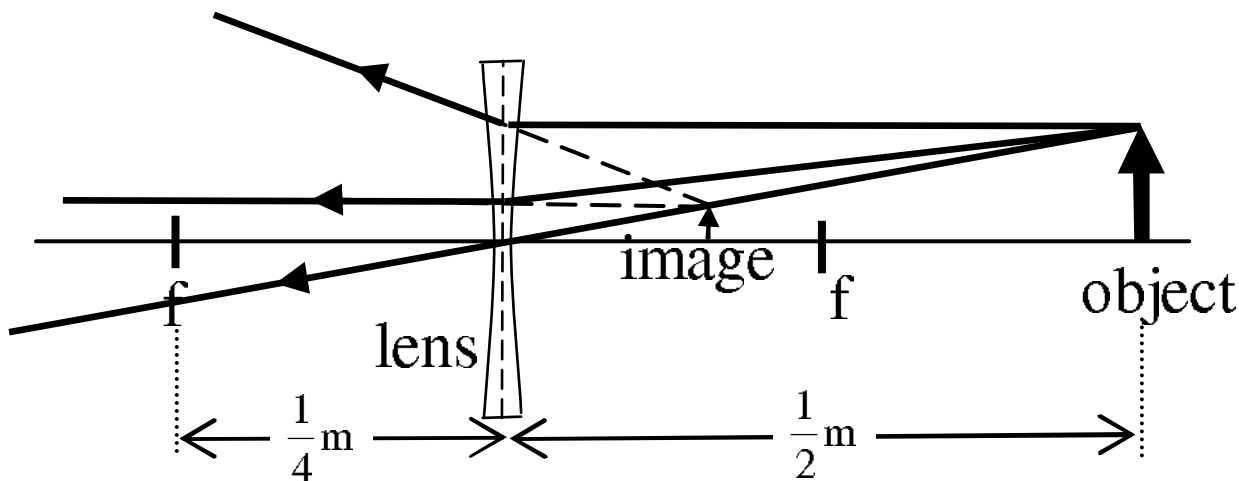
- (a) From Pythagoras' theorem, the length of the light ray in the liquid (which is the hypotenuse of the triangle created by it, the pool wall and the pool bottom) is $\sqrt{3^2 + 4^2} \text{ m} = \sqrt{25} \text{ m} = 5 \text{ m}$. Therefore, $\sin \theta_r =$

$$\text{opposite/hypotenuse} = \frac{3}{5} \Rightarrow \theta_r = \sin^{-1} \left(\frac{3}{5} \right).$$

- (b) Using Snell's law here gives $n_{\text{air}} \sin \theta_i = n_{\text{liquid}} \sin \theta_r$

$$\Rightarrow n_{\text{liquid}} = n_{\text{air}} \frac{\sin \theta_i}{\sin \theta_r} = 1 \times \frac{4/5}{3/5} = \frac{4}{3}.$$

2. The diagram below represents an object that is $\frac{1}{2}$ m away from an a concave (diverging) lens with focal length of magnitude $\frac{1}{4}$ m.



- (a) Draw the ray diagram (include at least 2 rays) for the above situation. Indicate where the image is. (If you don't have a ruler, you can use the edges of a sheet of paper to draw straight lines.) The focal points are labelled f . [11 points]
- (b) Calculate where the image should be. Include the correct sign in your answer. (Your answer can be expressed as a fraction.) [8 points]
- (c) What is the linear magnification factor of this image? (Include the correct sign.) [3 points]

Answers

(a) See ray diagram above.

(b) Here, $d_{\text{object}} = \frac{1}{2}$ m and $f = -\frac{1}{4}$ m. Therefore, using the thin lens formula,

$$\frac{1}{d_{\text{image}}} = \frac{1}{f} - \frac{1}{d_{\text{object}}} = \frac{1}{-1/4 \text{ m}} - \frac{1}{1/2 \text{ m}} = -\frac{4}{\text{m}} - \frac{2}{\text{m}} = -\frac{6}{\text{m}}$$

$$\Rightarrow \boxed{d_{\text{image}} = -\frac{1}{6} \text{ m}}.$$

(c) The linear magnification is

$$M = -\frac{d_{\text{image}}}{d_{\text{object}}} = -\frac{-\frac{1}{6} \text{ m}}{\frac{1}{2} \text{ m}} = \boxed{(+)\frac{1}{3}}.$$

Notice that this answer is consistent with the ray diagram in part (a); *i.e.*, the image is upright and $\frac{1}{3}$ the size of the object.