Physics 261, Sec. 801, Test 1: Solutions

Section A

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

Section B

1. Monochromatic light which has a wavelength of $3.0 \times 10^{-7}\,\mathrm{m}$ in vacuum passes through glass with index of refraction of $n = 2.0$.

   (a) What is the frequency of the light in vacuum? (The speed of light in vacuum in $3.0 \times 10^{8}\,\mathrm{m/s}$.) [8 points]

   (b) Is the frequency of the light the same in the glass as it is in vacuum? (Just answer "yes" or "no.") [2 points]

   (c) What is its wavelength of the light in the glass? [8 points]

   Answers:

   (a) Use $c = \lambda_v f$, where c is the speed of light in vacuum, λ_v is the wavelength in vacuum, and f is the frequency. Therefore

   $$f = \frac{c}{\lambda} = \frac{3.0 \times 10^{8}\,\mathrm{m/s}}{3.0 \times 10^{-7}\,\mathrm{m}} = \boxed{1.0 \times 10^{15}\,\mathrm{Hz}}.$$

   (b) $\boxed{\text{Yes}}$.

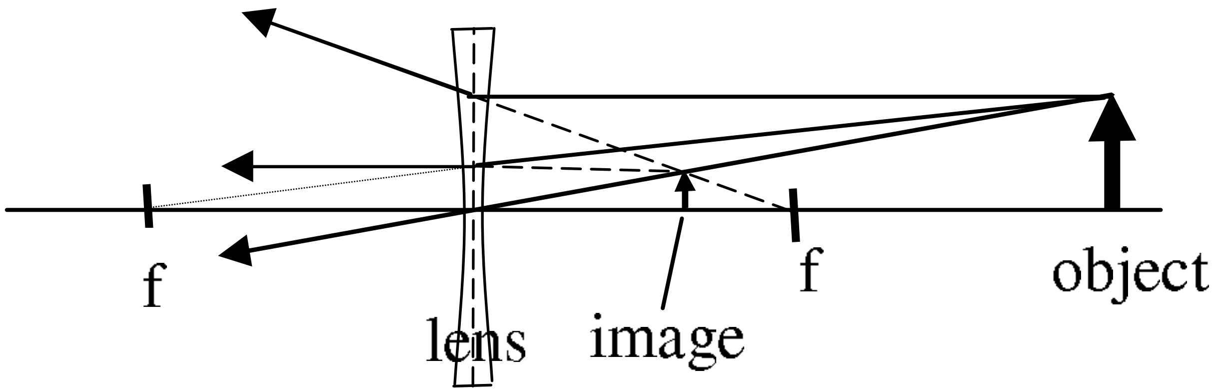
   (c) In glass, $v_g = \lambda_g f$. Dividing this equation by $c = \lambda_v f$ and cancelling the f's gives

   $$\frac{v_g}{c} = \frac{\lambda_g}{\lambda_v}.$$

   But $v_g = c/n$, where n is the index of refraction, which implies that $v_g/c = 1/n$. Substituting this into the above equation gives

   $$\frac{\lambda_g}{\lambda_v} = \frac{1}{n} \quad \Rightarrow \quad \lambda_g = \frac{\lambda_v}{n} = \frac{3.0 \times 10^{-7}\,\mathrm{m}}{2.0} = \boxed{1.5 \times 10^{-7}\,\mathrm{m}}.$$

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

(b) Use the thin lens formula which relates the object distance $d_o = 1\,\mathrm{m}$, the unknown image distance d_i and the focal length $f = -\frac{1}{2}\,\mathrm{m}$:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \quad \Rightarrow \quad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{(-\frac{1}{2}\,\mathrm{m})} - \frac{1}{1\,\mathrm{m}} = \frac{(-2-1)}{\mathrm{m}} = \frac{-3}{\mathrm{m}}$$

$$\Rightarrow \quad \boxed{d_i = -\tfrac{1}{3}\,\mathrm{m}}.$$

Note that the negative image distance indicates that image is virtual, in agreement with the diagram above.

(c)

$$M = -\frac{d_i}{d_o} = -\frac{-\frac{1}{3}\,\not{\mathrm{m}}}{1\,\not{\mathrm{m}}} = \boxed{+\frac{1}{3}}.$$

Note that this agrees with the image in the drawing — it is diminished to 1/3 its original size, and is upright.