Physics 10164 - Exam 4B

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (30 pts) A 12-cm high object is located in front of a converging lens of focal length 24 cm. The lens forms an inverted 9.0-cm high image.

a) Is the image real or virtual? Justify your answer.

b) How far in front of the lens is the object?

$p = ?$ (positive)

$M = -\frac{q}{12} = -0.75$ ($\leftarrow y_i$, $\leftarrow y_o$)

↑ inverted

Since $M = -\frac{q}{p}$ and $p = +$, q must $= +$ since M is negative

a) q is real

b) $f = +24\,cm$

$-\frac{q}{p} = -0.75 \qquad q = 0.75p$

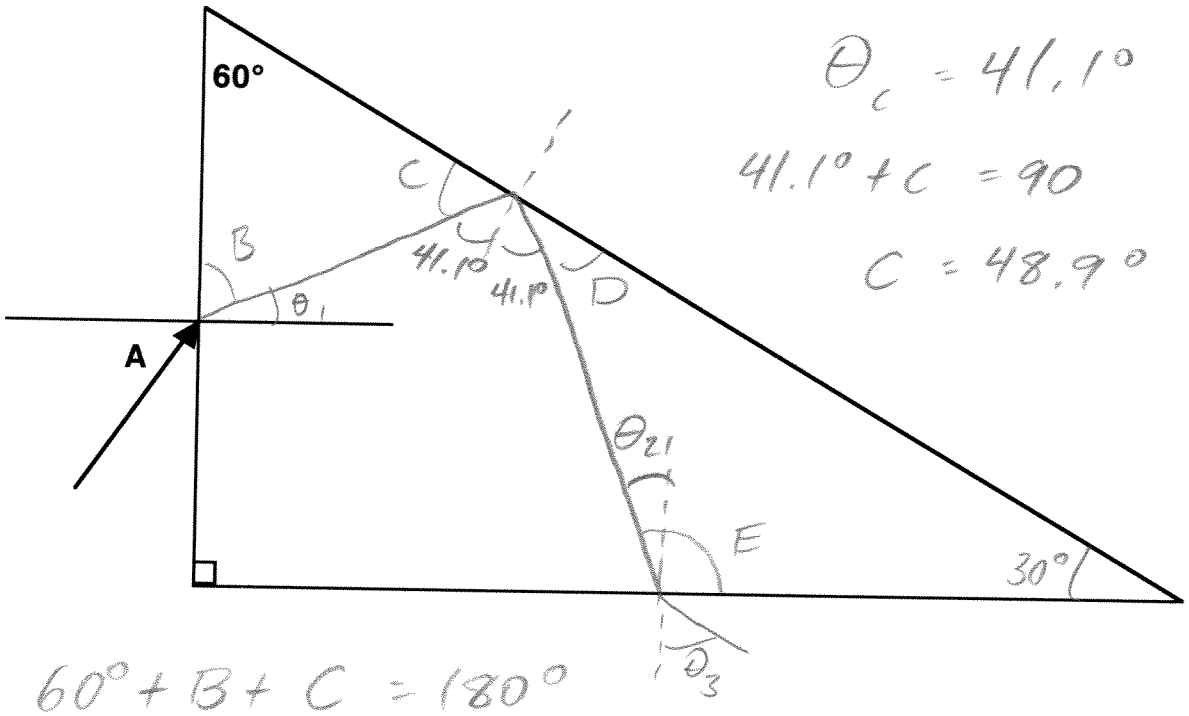
$\frac{1}{p} + \frac{1}{0.75p} = \frac{1}{24}$

$\frac{0.75}{0.75p} + \frac{1}{0.75p} = \frac{1}{24} \Rightarrow \frac{1.75}{.75p} = \frac{1}{24} \Rightarrow 0.75p = 42$

$p = 56\,cm$

2. (40 pts) Light is incident on the 30-60-90 prism below at an angle A as shown. The prism has an index of refraction of 1.52 and is surrounded by air. Light reflects off the hypotenuse of the prism at the critical angle and exits out of the bottom surface.

Find the initial angle of incidence A and the final angle of refraction upon exiting the prism. Show all work and clearly label all calculated angles. Angle A is not necessarily drawn to scale (it could be anywhere from 1 to 89 degrees).



$\theta_c = 41.1°$

$41.1° + C = 90$

$C = 48.9°$

$60° + B + C = 180°$

$B = 180 - 60 - 48.9 = 71.1°$

$B + \theta_1 = 90°$ $\quad \theta_1 = 18.9°$

$1.0 \sin A = 1.52 \sin 18.9°$

a) $A = 29.495 = \boxed{29°}$

b) $41.1° + D = 90$ $\quad D = 48.9°$

$D + E + 30 = 180$ $\quad E = 180 - 30 - 48.9 = 101.1$

$\theta_2 = E - 90° = 11.1°$

$1.52 \sin 11.1° = 1.0 \sin \theta_3$ $\quad \boxed{\theta_3 = 17°}$

3. (30 pts) A diffraction grating has 2500 lines/cm, and white light incident from the normal reflects off the grating.

a) What is the angular separation between blue (400 nm) and red (700 nm) light in the 2nd order spectrum?

b) How many orders of the complete visible spectrum (400 nm - 700 nm) are visible?

2500 lines/cm = 250,000 lines/m

$d = \frac{1}{250{,}000} = 4 \times 10^{-6}\ m$

2nd order $d \sin\theta = 2\lambda$

$\theta = \sin^{-1}\left(\frac{2\lambda}{d}\right)$

a) $\lambda = 400nm \quad \theta = \sin^{-1}(0.2) = 11.5°$

$\lambda = 700nm \quad \theta = \sin^{-1}(0.35) = 20.5°$

$\Delta\theta = 9.0°$

b) $d \sin 90 = m\lambda$

Find m for largest λ (700 nm)

$m = \frac{d \sin 90}{\lambda} = \frac{(4 \times 10^{-6})}{(700 \times 10^{-9})} = 5.71$

m = 5 complete orders