Physics 10164 - Summer 2019 - Exam #3B

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. (25 pts) The Andromeda galaxy has a radial component of its velocity such that it is moving toward our galaxy at a speed of 301 km/sec. If light is emitted from that galaxy with a wavelength of 656.3 nm, what is the wavelength of that light we observe from the Earth? Answer with 4 SF.

Using frequency:

$$f_{src} = \frac{c}{\lambda_{src}} = 4.5711 \times 10^{14}\ Hz$$

$$f_{obs} = f_{src}\left(1 + \frac{v}{c}\right)$$

$$= 4.5711 \times 10^{14}\left(1 + \frac{3.01 \times 10^5}{3.0 \times 10^8}\right)$$

$$= 4.5757 \times 10^{14}\ Hz$$

$$\lambda_{obs} = \frac{c}{f_{obs}} = \boxed{655.6\ nm}$$

Using λ:

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \Delta\lambda = 0.7\ nm$$

$$\text{so } \lambda_{obs} = 656.3 - 0.7$$

$$= 655.6\ nm$$

2. (25 pts) When an object is placed 22 cm in front of a mirror, the resulting magnification is +2.1. Now we move the object so that both object distance and image distance change, but we are using the same mirror. What <u>object distance</u> would result in a magnification of -0.41?

$$p = 22\ cm$$

$$-\frac{q}{p} = +2.1 \Rightarrow q = -2.1p = -46.2$$

$$\frac{1}{22} - \frac{1}{46.2} = \frac{1}{f} \Rightarrow f = 42\ cm$$

$$M = -\frac{q}{p} = -0.41$$

$$q = 0.41p$$

$$\frac{1}{p} + \frac{1}{0.41p} = \frac{1}{42}$$

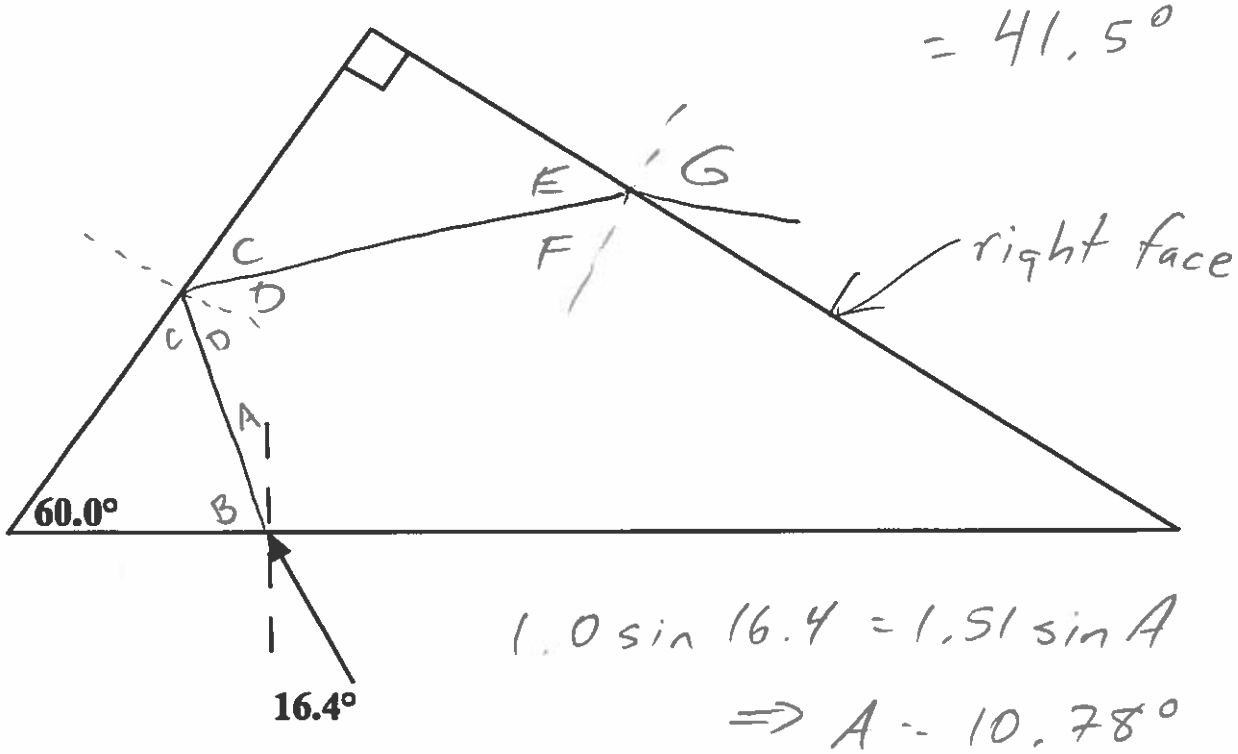
$$\frac{0.41}{0.41p} + \frac{1}{0.41p} = \frac{1}{42}$$

$$\frac{1.41}{0.41p} = \frac{1}{42} \Rightarrow \boxed{p = 140\ cm}$$

#3. (25 pts) The prism below has an index of refraction of 1.51 and is surrounded by air. Light is incident on the left face of the prism as shown. Through what face of the prism does the light exit, and what is the final angle of refraction?

$\theta_{crit} = \sin^{-1}\left(\frac{1}{1.51}\right)$

$= 41.5^\circ$



$1.0 \sin 16.4 = 1.51 \sin A$

$\Rightarrow A = 10.78^\circ$

$A + B = 90^\circ \Rightarrow B = 79.22^\circ$

$B + 60^\circ + C = 180^\circ \Rightarrow C = 40.78^\circ$

$C + D = 90^\circ \Rightarrow D = 49.22^\circ > \theta_{crit}$

so internal reflection!

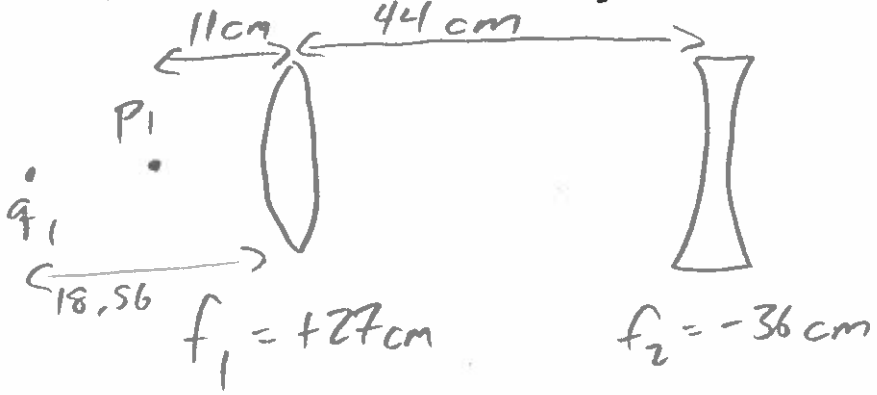
$C + 90 + E = 180^\circ \Rightarrow E = 49.22^\circ$

$E + F = 90^\circ \Rightarrow F = 40.78^\circ$

$1.51 \sin 40.78^\circ = 1.0 \sin G \Rightarrow \boxed{G = 80.5^\circ}$

4. (25 pts) A converging lens of focal length +27 cm is placed on an optical bench. Next, a diverging lens of focal length -36 cm is placed at a distance of 44 cm behind the converging lens. For an object placed 55 cm in front of the diverging lens…

a) What is the final location of the image created by the diverging lens, relative to the position of that lens?
b) What is the overall magnification of the system?



$$\frac{1}{11} + \frac{1}{q_1} = \frac{1}{27} \Rightarrow q_1 = -18.56 \text{ cm}$$

so $p_2 = 44 + 18.56 = 62.56$ (see above)

$$\frac{1}{62.56} + \frac{1}{q_2} = \frac{1}{-36} \Rightarrow q_2 = -23 \text{ cm}$$

final image = 23 cm in front of lens 2

$$M_{TOT} = \left(-\frac{-18.56}{11}\right) * \left(-\frac{-23}{62.56}\right)$$

$$= \boxed{+0.62}$$