Physics 10164 - Exam 4A

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.

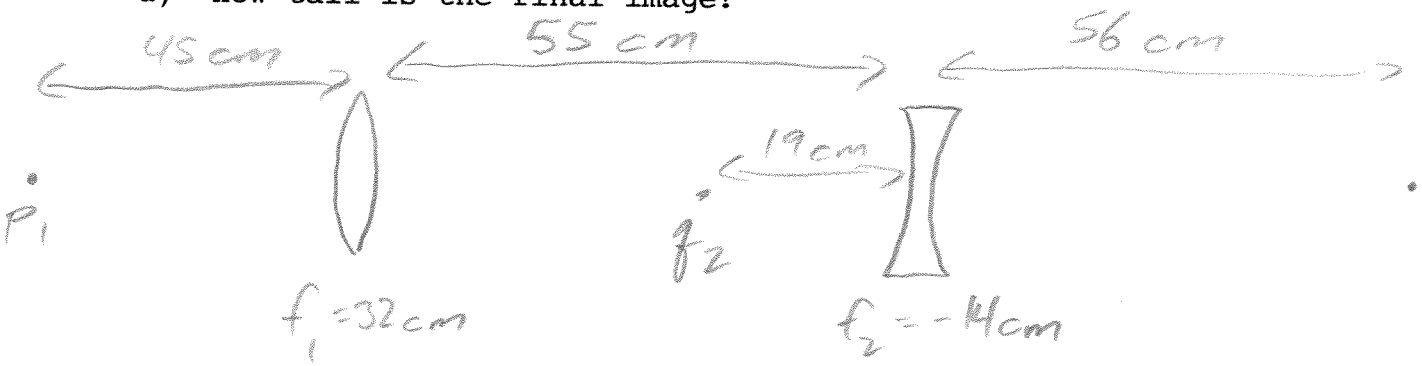
1. (30 pts) A 25-cm high object is located 45 cm in front of a converging lens of focal length 32 cm. 55 cm behind the converging lens is a diverging lens of focal length -14 cm.

a) Determine the location of the final image formed.

b) Is the final image real or virtual?

c) Is the final image upright or inverted?

d) How tall is the final image?



$$\frac{1}{q_1} = \frac{1}{f_1} - \frac{1}{p_1} = \frac{1}{32} - \frac{1}{45}$$

$$q_1 = 110.8 \text{ cm},$$

so $p_2 = -55.8$ cm

$$\frac{1}{q_2} = \frac{1}{f_2} - \frac{1}{p_2} = -\frac{1}{14} + \frac{1}{55.8} = -.0535$$

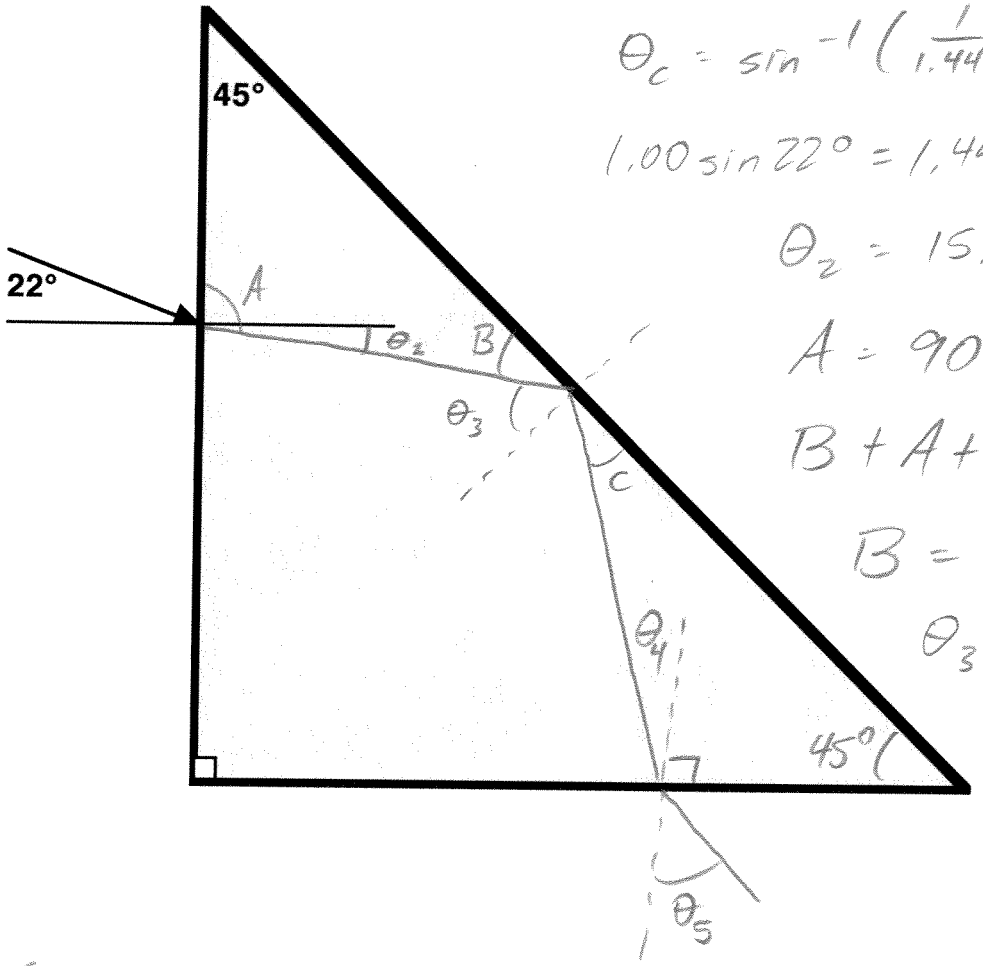
$$q_2 = -18.7 \quad \boxed{19 \text{ cm in front of lens 2}}$$

b) q - $\boxed{\text{virtual}}$

c) $M = \left(-\frac{q_1}{p_1}\right)*\left(-\frac{q_2}{p_2}\right) = \left(-\frac{110.8}{45}\right)*\left(-\frac{-18.7}{-55.8}\right) = 0.825$ $\boxed{\text{upright}}$

d) $y_i = |M| y_0 = (.825)(25) = \boxed{21 \text{ cm}}$

2. (30 pts) Light is incident on the 45-45-90 prism below at an angle of 22° as shown. The prism has an index of refraction of 1.44 and is surrounded by air. Show on the diagram below where the light exits the prism and calculate the angle of refraction after it exits. Show your work and clearly label all angles.



$\theta_c = \sin^{-1}\left(\frac{1}{1.44}\right) = 44°$

$1.00 \sin 22° = 1.44 \sin \theta_2$

$\theta_2 = 15.1°$

$A = 90 + \theta_2 = 105.1°$

$B + A + 45 = 180°$

$B = 30°$

$\theta_3 = 90 - B$

$= 60°$

Since $\theta_3 = 60° > \theta_c$, light reflects

$C = 30°$

$C + 45° + 90° + \theta_4 = 180$

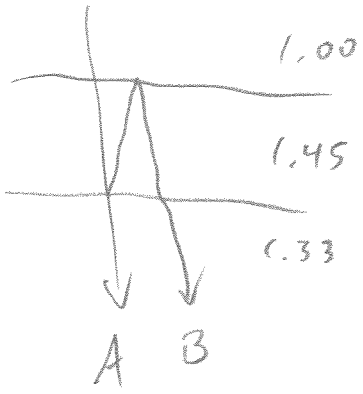
$\theta_4 = 180 - 90 - 45 - 30 = 15°$

$1.44 \sin 15° = 1.00 \sin \theta_5$

$\boxed{\theta_5 = 22°}$

3. (40 pts) White light passes through a 540-nm film of oil (n = 1.45) on top of water (n = 1.33). Determine all wavelengths of visible light (ranging from 400-700 nm) will strongly transmit through the film and into the water.

Remember to show all work, including calculations of phase shifts for different beams of light.



$\phi_A = 0$

$\phi_B = 0 + 0 + \frac{2tn}{\lambda_0}$

$\phi_B - \phi_A = 0, 1, 2, \ldots$

$\frac{2tn}{\lambda_0} = 0$ X

$\frac{2tn}{\lambda_0} = 1 \Rightarrow \lambda_0 = 2tn = 1566\ nm$ X

$\frac{2tn}{\lambda_0} = 2 \Rightarrow \lambda_0 = \frac{2tn}{2} = 783\ nm$ X

$\frac{2tn}{\lambda_0} = 3 \Rightarrow \lambda_0 = \frac{2tn}{3} = 522\ nm$

$\frac{2tn}{\lambda_0} = 4 \Rightarrow \lambda_0 = \frac{2tn}{4} = 392\ nm$ X