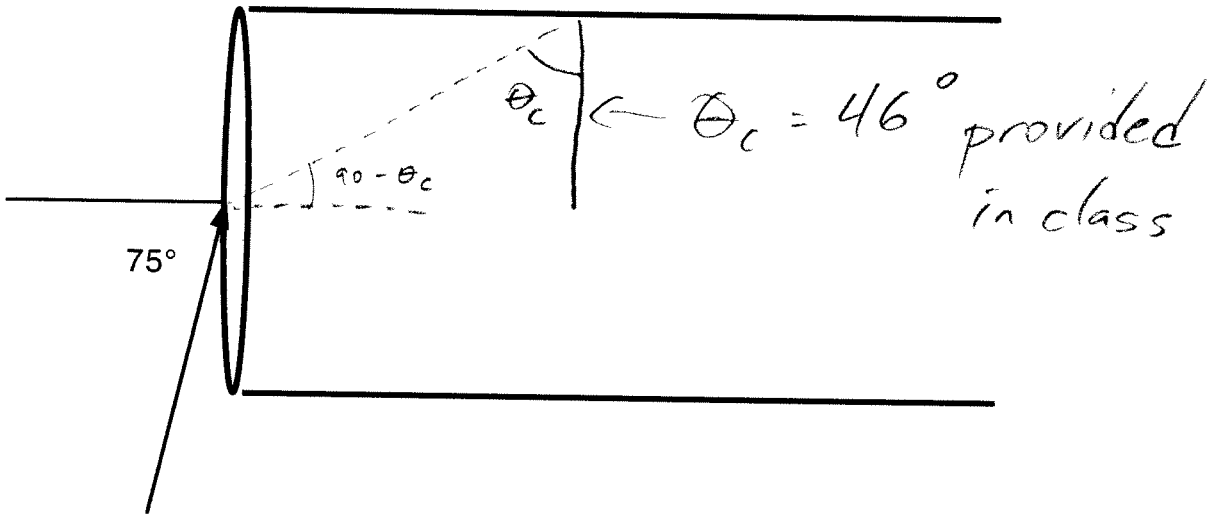
Physics 10164 - Exam 4

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. (20 pts) Light that enters a fiber-optic cable with an angle of incidence of 75 degrees or less is trapped in the cable by internal reflection. If light enters the cable at an angle of incidence greater than 75 degrees, the light escapes. The cable is surrounded by air and rectangular, as shown below. What is the index of refraction of the cable?



$\theta_c = 46^\circ$ provided in class

$$1.0 \sin 75^\circ = n \sin(90 - \theta_c)$$

$$\theta_c = \sin^{-1}\left(\frac{1}{n}\right)$$

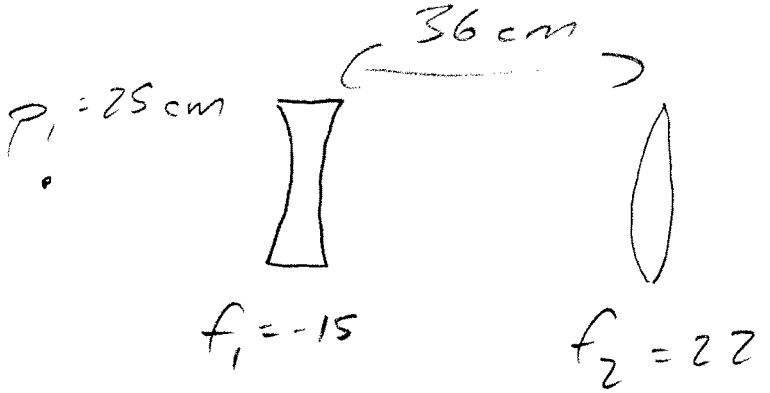
$$\boxed{n = 1.39}$$

2. (30 pts) A 12-cm tall object is placed 25 cm in front of a diverging lens with a focal length f = -15 cm. A converging lens with focal length 22 cm is placed at a distance of 36 cm behind the first diverging lens.

What is the location of the final image with respect to the 2nd (converging lens)?

What is the height of the image, in cm?

Is the final image upright or inverted?



$$\frac{1}{25} + \frac{1}{q_1} = \frac{1}{-15} \qquad q_1 = -9.38$$

$$p_2 = 36 + 9.38 = 45.38$$

$$\frac{1}{45.4} + \frac{1}{q_2} = \frac{1}{22}$$

$q_2 = 42.7$ cm behind lens 2

$$M_1 = -\frac{q_1}{p_1} = -\frac{-9.38}{25} = 0.375$$

inverted

$$M_{TOT} = -0.353$$

$$M_2 = -\frac{q_2}{p_2} = -\frac{42.7}{45.38} = -0.94$$

$$y_{image} = (.35)(12) = 4.2 \text{ cm}$$

3. (20 pts) Light of wavelength 643 nm is incident on two slits separated by 0.40 mm. The interference pattern appears on a screen 3.0 meters away from the slits. At a location y = 12 mm from the center of the pattern, is there a bright band or a dark band? Justify your answer.

Let phase difference $\frac{dy}{L} = m\lambda$, solve for m

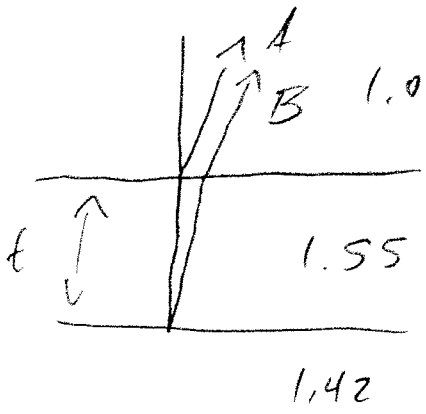
$$m = \frac{dy}{L\lambda} = \frac{(.40\times10^{-3})(.012)}{(3.0)(643\times10^{-9})}$$

$$= 2.5$$

So phase diff $= 2.5\lambda$

dark

4. (30 pts) Light is incident on a pair of glasses (n = 1.55) with an anti-reflective coating (n = 1.42) with a thickness of 220 nm. What wavelength or wavelengths of light in the visible part of the spectrum (between 400 nm and 700 nm) do not reflect back effectively?



$$\delta_A = \frac{1}{2}$$

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

$$\delta_B - \delta_A = \frac{2tn}{\lambda_0} - \frac{1}{2} = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$$

For $\frac{1}{2}$ ... $\frac{2tn}{\lambda_0} = 1$ $\quad \lambda_0 = 2tn$

$= 2(220)(1.42)$

$= \boxed{625\ nm}$

For $\frac{3}{2}$, ... $\frac{2tn}{\lambda_0} = 2$ $\quad \lambda_0 = tn$

$= 312\ nm$