# Physics 10164 – Exam 4D

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. <u>Clearly indicate your answer with a circle or a box</u> and remember to include correct <u>units</u> and <u>significant figures</u>.

1. (25 pts) Light is incident on a glass cube with n = 1.56. From which face does the light emerge (top, right, bottom or left) and with what angle of refraction?

$$\theta_c = \sin^{-1}\left(\frac{1}{1.56}\right) = 39.87°$$

$$1.0 \sin 75° = 1.56 \sin \theta_1$$

$$\theta_1 = 38.3°$$
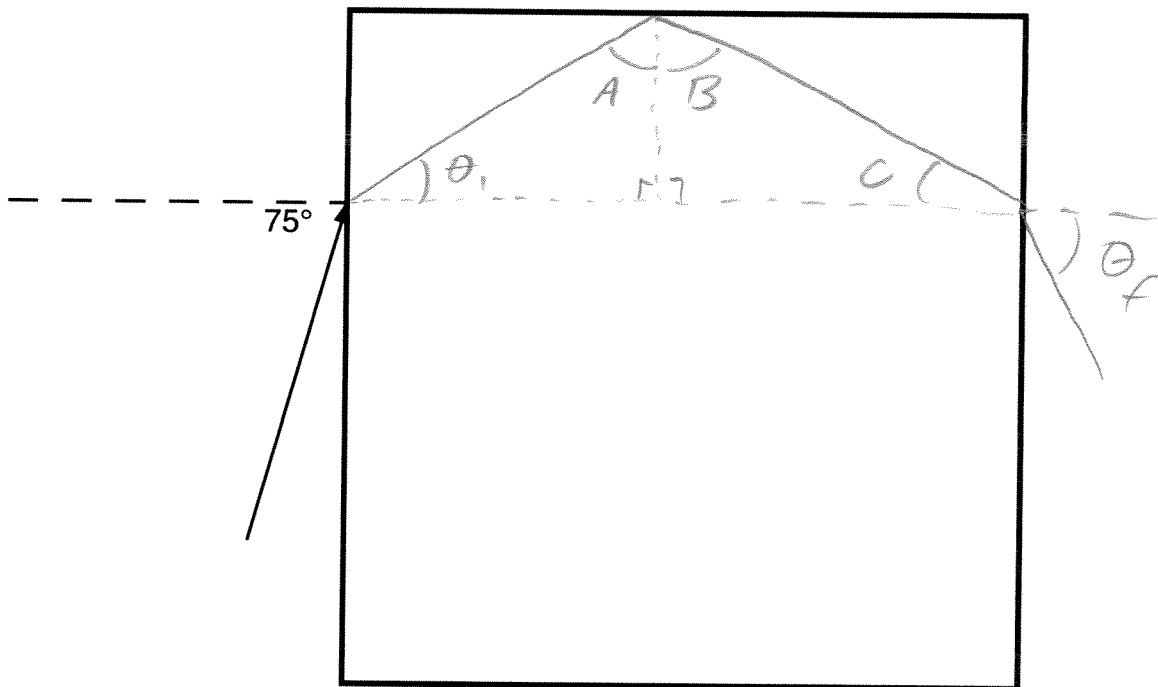
$$A = 90 - \theta_1 = 51.7° > \theta_c \text{ , so internal reflection}$$

$$B = 51.7° \text{ (law of reflection)}$$

$$C = 90 - B = 38.3°$$

$$1.56 \sin 38.3° = 1.0 \sin \theta_f \quad \boxed{\theta_f = 75°}$$

2. (25 pts) An object 82 cm in front of a mirror produces an image 22 cm in front of the mirror. How close to the mirror must the object be in order to form an upright image twice the object's actual size?

$$\frac{1}{82} + \frac{1}{22} = \frac{1}{f}$$

$$.0576 = \frac{1}{f}$$

$$f = 17.3 \text{ cm}$$

$$M = -\frac{q}{p} = +2.0$$

$$q = -2p$$

$$\frac{1}{p} - \frac{1}{2p} = \frac{1}{f}$$

$$\frac{2}{2p} - \frac{1}{2p} = \frac{1}{f}$$

$$\frac{1}{2p} = \frac{1}{f}$$

$$f = 2p$$

$$p = \frac{17.3}{2} = 8.7 \text{ cm}$$

3. (25 pts) Visible light (blue = 400 nm --> red = 700 nm) is
   incident normally on a diffraction grating. The red end of
   the 2nd order maximum of the diffraction pattern is located at
   an angle of 34°.

a) What is the number of lines per centimeter for the grating?
b) How much complete orders of the visible spectrum can be
   observed for this grating?

a)

$$d \sin \theta = n\lambda$$

$$d \sin 34° = 2(700 \times 10^{-9})$$

$$d = 2.5 \times 10^{-6} \, m = 2.5 \times 10^{-4} \, cm$$

$$\frac{\# \, lines}{cm} = \frac{1}{d} = \boxed{4000 \, lines/cm}$$
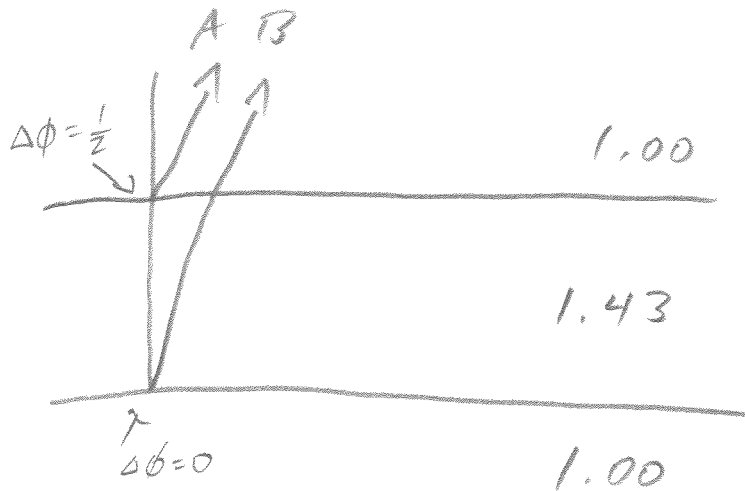
b) Set $\theta = 90°$, solve for n

$$(2.5 \times 10^{-6}) \sin 90° = n(700 \times 10^{-9})$$

↑
red has bigger angle
so will be cut off first

$$n = 3.57$$

$$\boxed{3 \ orders}$$

4. (25 pts) A thin film of soap (n = 1.43) of thickness 350 nm is viewed under white light at near normal incidence. What wavelength of visible light (400 nm – 700 nm) is most strongly reflected by the film when surrounded by air?

$\Delta\phi = \frac{1}{2}$

1.00

1.43

$\Delta\phi = 0$

1.00

strongly reflected = C. I.

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

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

$\phi_B - \phi_A = 0, 1, 2, 3$

$\frac{2tn}{\lambda_0} - \frac{1}{2} = 0 \implies \frac{2tn}{\lambda_0} = \frac{1}{2} \quad \lambda_0 = 4tn = 2002 \quad \times$

$\frac{2tn}{\lambda_0} - \frac{1}{2} = 1 \implies \frac{2tn}{\lambda_0} = \frac{3}{2} \implies \lambda_0 = \frac{4tn}{3} = \boxed{667 \text{ nm}} \checkmark$

$\frac{2tn}{\lambda_0} - \frac{1}{2} = 2 \implies \frac{2tn}{\lambda_0} = \frac{5}{2} \implies \lambda_0 = \frac{4tn}{5} = \boxed{400 \text{ nm}} \checkmark$

$\frac{2tn}{\lambda_0} - \frac{1}{2} = 3 \implies \frac{2tn}{\lambda_0} = \frac{7}{2} \implies \lambda_0 = \frac{4tn}{7} = 286 \text{ nm} \times$