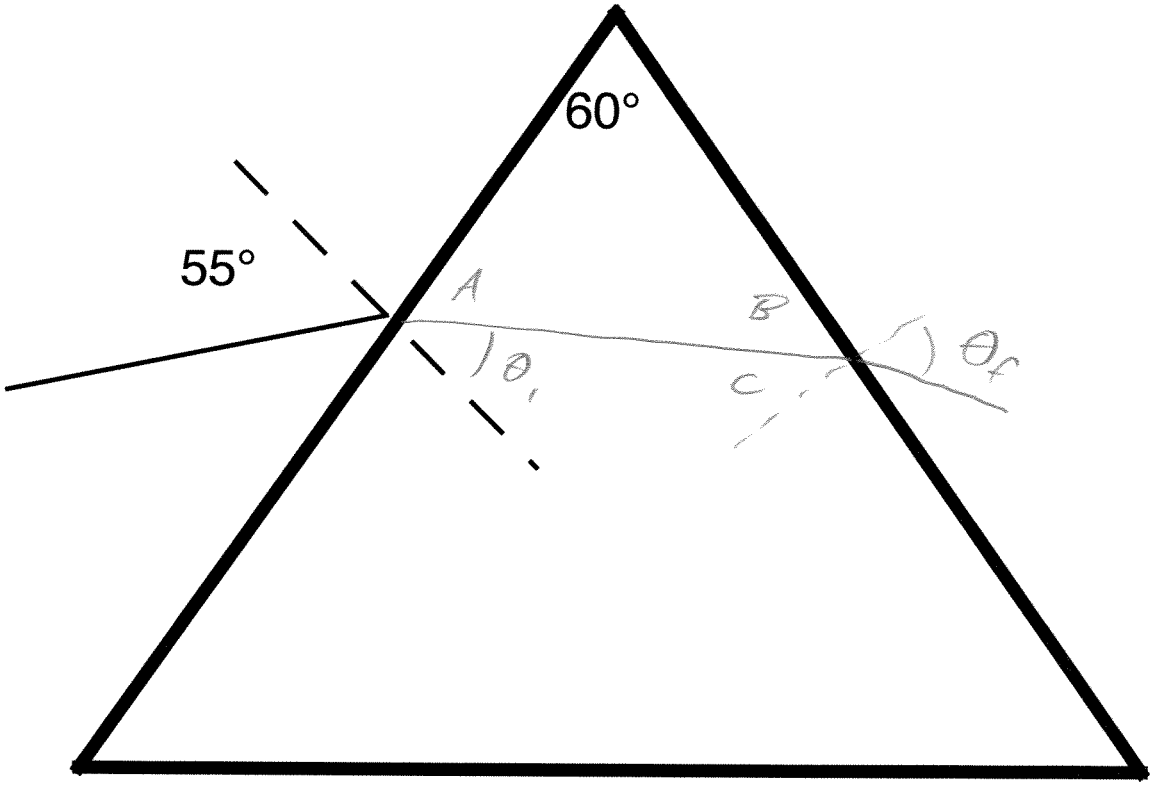
Physics 10164 - Exam 4B

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. (25 pts) The prism below is surrounded by air. The index of refraction for blue light is 1.64. For red light, n = 1.59. What is the angular dispersion of the visible spectrum, from blue to red, of the light exiting the prism?



Blue

$1.0 \sin 55° = 1.64 \sin \theta_1$

$\theta_1 = 30°$

$A = 60°$

$B = 180 - 60 - 60 = 60$

$C = 30°$

$1.64 \sin 30° = 1.0 \sin \theta_f$

$\theta_f = 55.1°$

Red

$1.0 \sin 55° = 1.59 \sin \theta_1$

$\theta_1 = 31°$

$A = 59°$

$B = 180 - 59 - 60 = 61°$

$C = 29°$

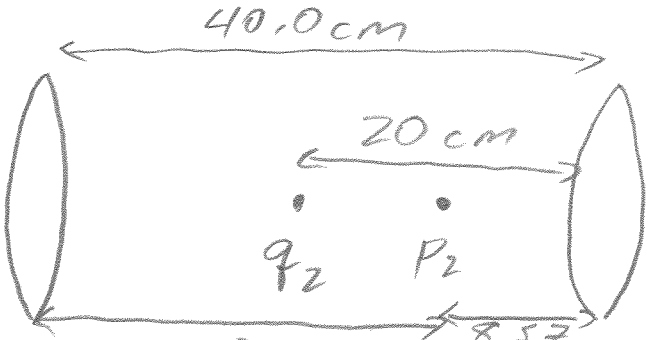
$1.59 \sin 29° = 1.0 \sin \theta_f$

$\theta_f = 50.4°$

$\Delta\theta = 4.7°$

2. (25 pts) Two converging lenses have focal lengths of 25.0 cm (left) and 15.0 cm (right). The lenses are placed 40.0 cm apart. The final image is located halfway between the two lenses.

a) What must be the original position of the object relative to the left lens?
b) What is the total magnification of the final image?
c) Is the final image upright or inverted?



Lens 2: $\frac{1}{p_2} + \frac{1}{-20} = \frac{1}{15}$

$\frac{1}{p_2} = \frac{1}{15} + \frac{1}{20} = \frac{4}{60} + \frac{3}{60} = \frac{7}{60}$

$p_2 = 8.57$

$M_2 = -\frac{q_2}{p_2} = +2.33$

Lens 1: $q_1 = 40 - 8.57 = +31.43$

$\frac{1}{p_1} + \frac{1}{+31.43} = \frac{1}{25}$

$\frac{1}{p_1} = \frac{1}{25} - \frac{1}{31.43} = .00818$

$p_1 = 122\,cm$ (in front)

$M_1 = -\frac{q_1}{p_1} = -\frac{31.43}{122} = -0.258$

b) $M_{TOT} = M_1 * M_2 = (2.33)(-.258) = -0.600$

c) $M < 0$, so inverted

3. (25 pts) A laser with a wavelength of 532 nm is used to calibrate a diffraction grating. The first-order maximum occurs at an angle of 17.0°.

a) How many lines/cm make up the diffraction grating?
b) How many orders of the laser light are visible in reflection?

a) $d \sin\theta = \lambda$

$$d = \frac{532 \times 10^{-9}\ m}{\sin 17^\circ} = 1.82 \times 10^{-6}$$

$$\frac{1}{d} = 5.5 \times 10^{5}\ \text{lines/m} \quad \text{or} \quad 5500\ \text{lines/cm}$$

b) Let $\theta = 90^\circ$, solve for n

$$d \sin 90 = nd$$

$$n = \frac{1.82 \times 10^{-6}}{532 \times 10^{-9}} = 3.4$$

3 complete orders visible

4. (25 pts) Light of wavelength 550 nm falls on a 0.250-mm wide slit and forms a pattern on the screen 2.5 meters away.

a) Find the position of the first dark band (in cm) relative to the center of the pattern.
b) Find the width (in cm) of the central maximum of the pattern.

a) $a \sin\theta = \lambda$

$$\frac{a y}{L} = \lambda$$

$$y = \frac{\lambda L}{a} = \frac{(550 \times 10^{-9})(2.5)}{.25 \times 10^{-3}}$$

$$= 5.5 \times 10^{-3} m$$

or 0.55 cm

b) width $= 2y =$ 1.1 cm