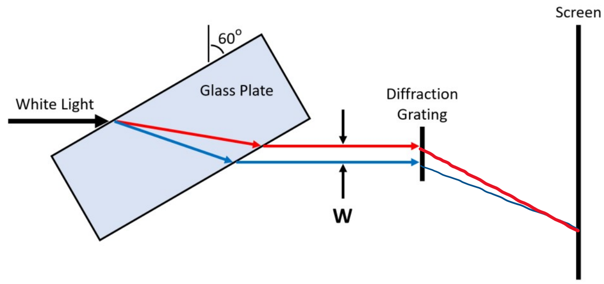
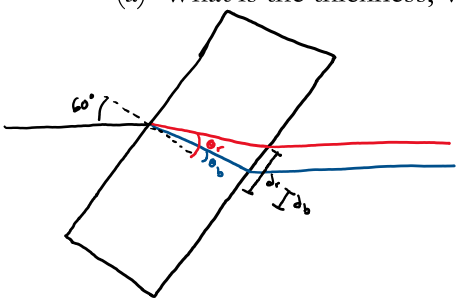
RO.L1.4 - 01

Flint glass has especially high dispersion, and is sometimes used to make glass prisms to hang outside your house that make pretty rainbows. It has an index of refraction for red light of 1.71, and an index of refraction for violet light of 1.79. White light is horizontally incident on a 4.00 cm thick plate of flint glass that is rotated 60.0° from the vertical as pictured.



(a) What is the thickness, W, of the visible light rainbow after the light exits the glass plate?

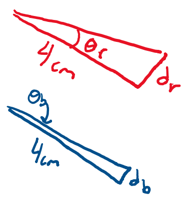


$n_a \sin 60° = n_r \sin\theta_r$

$\theta_r = 30.43°$

$n_a \sin 60° = n_b \sin\theta_b$

$\theta_b = 28.93°$



$\tan\theta_r = \frac{d}{4\,cm}$

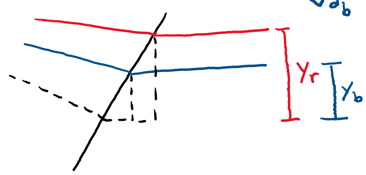
$d_r = 2.350\,cm$

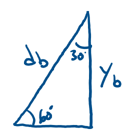
$\cos 30 = \frac{Y_r}{d_r}$

$Y_r = d_r \cos 30$

$Y_r = 2.035\,cm$

$d_b = 2.211\,cm \Rightarrow Y_b = 1.915\,cm$

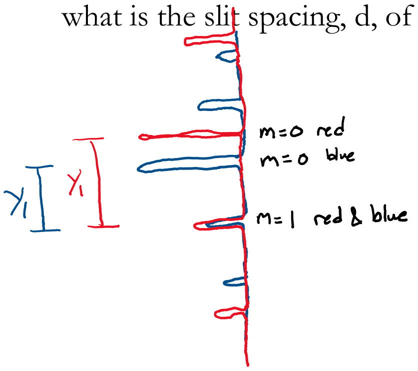




$W = Y_r - Y_b$

$W = 1.20\,mm$

(b) The rainbow is then incident on a diffraction grating. If the grating produces a bright spot of white light (at a first order maximum of both violet and red light) on a screen 50.0 cm away, what is the slit spacing, d, of the diffraction grating?



$W = Y_{1,red} - Y_{1,blue}$

$W = L\frac{\lambda_r}{d} - L\frac{\lambda_b}{d}$

$W = \frac{L}{d}(\lambda_r - \lambda_b)$

$\Rightarrow d = \frac{L}{W}(\lambda_r - \lambda_b)$

$d = \frac{.5}{1.2\times10^{-3}}(350\times10^{-7}) = 146\,\mu m = d$

$Y_1 << L$

$\Rightarrow$ small θ approx is ✓

$m\frac{\lambda}{d} = \sin\theta = \tan\theta = \frac{Y_m}{L}$

$\Rightarrow Y_1 = L\frac{\lambda}{d}$

(c) What is the distance on the screen from the white spot to the central maximum of the red light? Does the white spot occur above, below, or both above and below the center maximum?

$Y_{1,r} = L\frac{\lambda}{d} = 0.5\,\frac{700\times10^{-9}}{146\times10^{-6}} = 2.39\,mm$

white spot occurs only below b/c red light hits diff. grating above the blue light.

$Y_{1,r} > Y_{1,b}$ so red 1st order max will be even farther above the blue 1st order max than if red & blue hit diff. grat. @ same point