Quiz 27.1C

Light is incident on a diffraction grating and multiple orders of the visible spectrum (400-700 nm) are reflected on a nearby screen. For one of the orders (unknown order number), the angle of reflection of blue light (400 nm) is measured to be 12.0°.

a) What will be the angle of reflection seen in the same order for red light (700 nm)? Answer with 3 SF.
b) Suppose the unknown order referred to above is m = 2. What would be the line density of this grating (in lines/cm)?
c) Given your answer to (b), how many complete orders of the visible spectrum can be observed?

a) $d \sin\theta_{blue} = m\lambda_{blue}$

$d \sin\theta_{red} = m\lambda_{red}$

$\Rightarrow \dfrac{\sin\theta_{blue}}{\sin\theta_{red}} = \dfrac{\left(\frac{m}{m}\right)\left(\frac{\lambda_{blue}}{\lambda_{red}}\right)}{\left(\frac{d}{d}\right)}$

$\Rightarrow \dfrac{\sin\theta_{blue}}{\sin\theta_{red}} = \dfrac{400}{700}$ $\Rightarrow \sin\theta_{red} = \dfrac{700}{400}\sin\theta_{blue}$

$\Rightarrow \theta_{red} = \sin^{-1}(.3638) = \boxed{21.3^\circ}$

b) Blue: $d \sin 12^\circ = 2(400\times10^{-9})$

$\Rightarrow d = 3.85\times10^{-6}\,m = 3.85\times10^{-4}\,cm$

$n = \dfrac{1}{d(cm)} = \boxed{2600\ \frac{lines}{cm}}$

Double-check (a): $d \sin\theta_{red} = m\lambda_{red}$

$(3.85\times10^{-6})\sin 21.3 = (2)(700\times10^{-9})$

$1.4\times10^{-6} = 1.4\times10^{-6}$ ✓

c) Let $\theta = 90^\circ$, $\lambda = 700\,nm$

$(3.85\times10^{-6})\sin 90 = m(700\times10^{-9})$

$m = 5.5$ $\Rightarrow \boxed{5 \text{ complete orders}}$