

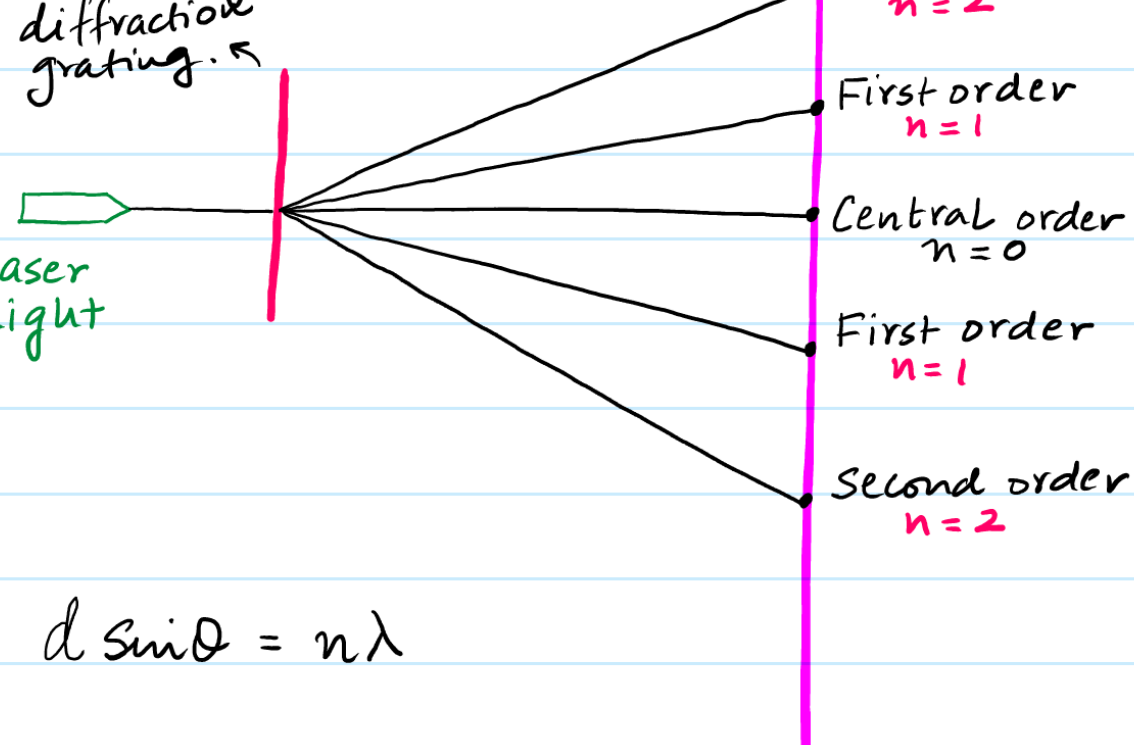
CONCEPT OF DIFFRACTION GRATING

29 January 2021 14:59

- A diffracting grating is an optical instrument constructed either using glass or Plastic
- This instrument has many microscopic slits on it, so that when light is allowed to fall on this instrument (diffraction grating), diffraction occurs, causing the light to spread.
- If a screen is positioned in the background (as shown on the next slide), then the spreading of light can be displayed on the screen.
- The angle through which the light spread is denoted as  $\theta$  (it is generally measured from the central line). This angle  $\theta$  can be worked out using the equation

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

where  $\lambda$  = wavelength of light  
 $\theta$  = angle through which the light diffracts  
 $n$  denotes the number of order i.e.  $n = 1, 2, 3, 4, 5$  etc &  
 $d$  is a constant known as the grating spacing. (This constant value is provided by the manufacturer in unit of m)



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

Q: A certain diffraction grating has a grating spacing ( $d$ ) =  $2.0 \times 10^{-6}$  m. Light of wavelength ( $\lambda$ ) = 450 nm is allowed to fall onto the grating

(i) find angle for 1st order

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

$$(2 \times 10^{-6}) \sin \theta = (1)(450 \times 10^{-9})$$

$$\theta = 13^\circ$$

(ii) find angle for 2nd order

$$(2 \times 10^{-6}) \sin \theta = (2)(450 \times 10^{-9})$$

$$\theta = 26.7^\circ$$

(iii) find angle for 3rd order

$$(2 \times 10^{-6}) \sin \theta = (3)(450 \times 10^{-9})$$

$$\theta = 42.5^\circ$$

(iv) find angle for 4th order

$$(2 \times 10^{-6}) \sin \theta = (4)(450 \times 10^{-9})$$

$$\theta = 64.2^\circ$$

(v) find angle for 5th order

$$(2 \times 10^{-6}) \sin \theta = (5)(450 \times 10^{-9})$$

$$\theta = \text{error}$$

Conclusion max orders = 4.

Total # of order = 9  
 general formula =  $(2n + 1)$

\* What if we are asked to directly find the max orders?

$$\theta < 90^\circ \quad \sin 90 = 1$$

$$\sin \theta < 1 \rightarrow \text{①}$$

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

$$\sin \theta = \frac{n \lambda}{d} \rightarrow \text{②}$$

replace ② into eq ① to get a formula which "directly" gives you max order

Eq. formula  $\frac{n \lambda}{d} < 1$

$$\frac{n(450 \times 10^{-9})}{(2.0 \times 10^{-6})} < 1$$

$$n < 4.44 \therefore n = 4$$

Q: The experiment is now repeated using a different light whose wavelength  $\lambda = 620$  nm

(i) find angle for 1st order

$$(2.0 \times 10^{-6}) \sin \theta = (1)(620 \times 10^{-9})$$

$$\theta = 18.1^\circ$$

(ii) find angle for 2nd order

$$(2.0 \times 10^{-6}) \sin \theta = (2)(620 \times 10^{-9})$$

$$\theta = 38.3^\circ$$

(iii) find angle for 3rd order

$$(2.0 \times 10^{-6}) \sin \theta = (3)(620 \times 10^{-9})$$

$$\theta = 68.4^\circ$$

(iv) find angle for 4th order

$$\theta = \text{error}$$

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

$\sin \theta \propto \lambda$  as  $\lambda \uparrow$ , the angle  $\theta$  will also  $\uparrow$ .

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

$n \propto \frac{1}{\lambda}$  as  $\lambda \uparrow$ , the

number of orders will  $\downarrow$

Q: Cal. the angular separation in the 1st order for the two wavelengths ( $\lambda = 450$  nm &  $\lambda = 620$  nm)

$$\theta_1 = 13^\circ \quad \theta_1 = 18.1^\circ$$

angular separation =  $5.1^\circ$   
 [difference b/w the angles in a particular order]

Q: angular separation in the 2nd order

$$\theta_2 = 26.7^\circ \quad \theta_2 = 38.3^\circ$$

angular separation =  $11.6^\circ$

Q: angular separation in the 3rd order

$$\theta_3 = 42.5^\circ \quad \theta_3 = 68.4^\circ$$

angular separation =  $25.9^\circ$

Q: angular separation in the 4th order

$$\theta_4 = 64.2^\circ \quad \theta_4 = \text{error}$$

not possible.

Conclusion: Angular separation INCREASES as the number of orders increase

$\therefore$  we can conclude that MAXIMUM ANGULAR SEPARATION WILL ALWAYS ARISE IN THE HIGHEST ORDER.