Interference and Diffraction

(1) Path Difference $= (n + \frac{1}{2})\lambda$ – minima

$3.30 - 3.22 = \frac{1}{2}\lambda$

$0.08 = \frac{1}{2}\lambda$

$\lambda = 0.16\text{m}$

(2) Path Difference $= n\lambda$ – maxima

$20 - 18 = \lambda$

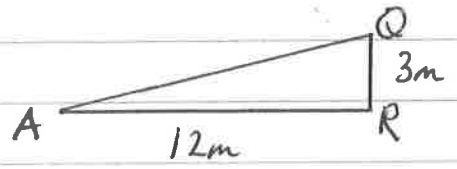
$\lambda = 2\text{ cm}$

Path Difference $= n\lambda$

$= 3 \times 2$

$= 6\text{cm}$

(3) a.

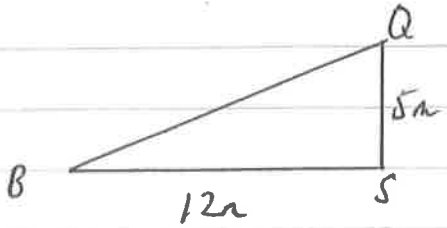


$AQ^2 = AR^2 + RQ^2$

$= 12^2 + 3^2$

$= 153$

$AQ = 12.37\text{m}$



$BQ^2 = BS^2 + SQ^2$

$= 12^2 + 5^2$

$= 169$

$BQ = 13\text{m}$

(3) b. Path Difference $= n\lambda$

$13 - 12.37 = \lambda$

$\lambda = 0.63\,m$

(3) c. $f = \frac{v}{\lambda}$

$= \frac{340}{0.63}$

$= 539.7\,Hz$

(4) a. Path Difference $= 55 - 52$

$= 3\,cm$

(4) b. Path Difference $= n\lambda$

$3 = \lambda$

$\lambda = 3\,cm$

(4) c. Path Difference $= n\lambda$

$= 2 \times 3$

$= 6\,cm$

(4) d. Path Difference $= (n + \frac{1}{2})\lambda$

$= \frac{1}{2} \times 3$

$= 1.5\,cm$

(4) e Path Difference $= (n + \frac{1}{2})\lambda$

$= (1 + \frac{1}{2}) \cdot 3$

$= 4.5\,cm$

(4) f Path Difference $= 0\,cm$

(5) Path Difference $= n\lambda$

$4.6 - 4.3 = \lambda$

$\lambda = 0.3m$

$f = \frac{v}{\lambda}$

$= \frac{330}{0.3}$

$= \underline{\underline{1100 Hz}}$

(6) Path Difference $= (n + \frac{1}{2})\lambda$

$46.6 - 42.1 = \frac{1}{2}\lambda$

$4.5 = \frac{1}{2}\lambda$

$\underline{\underline{\lambda = 9 cm}}$

(7) a. The wavelength of the microwaves could be 3 cm since the path difference (38 - 32) of 6cm results in a maximum and is multiple of 3.

b. A minimum occurs when two waves meet at a point OUT OF PHASE and INTERFERE DESTRUCTIVELY cancelling each other out.

(8) C

(9) $d = \frac{1}{4000}$ cm

$= 2.5 \times 10^{-4}$ cm

$= 2.5 \times 10^{-6}$ m

(10) $d = \frac{1}{250}$ mm

$= 4 \times 10^{-3}$ mm

$= 4 \times 10^{-6}$ m

(11)(i) $d = \frac{1}{300}$ mm

$= 3.3 \times 10^{-3}$ mm

$= 3.3 \times 10^{-6}$ m

(11)(ii) $d = \frac{1}{5000}$ cm

$= 2 \times 10^{-4}$ cm

$= 2 \times 10^{-6}$ m

(11)(iii) $d = \frac{1}{450}$ mm

$= 2.2 \times 10^{-3}$ mm

$= 2.2 \times 10^{-6}$ m

(12)

$$n\lambda = d\sin\theta$$
$$1 \times 6\times10^{-7} = d\sin 14^\circ$$
$$d = \frac{6\times10^{-7}}{0.242}$$
$$= 2.48\times10^{-6}\ m$$

(13)

$$d = \frac{1}{5900}\ cm$$
$$= 1.69\times10^{-4}\ cm$$
$$= 1.69\times10^{-6}\ m$$

$$n\lambda = d\sin\theta$$
$$\lambda = 1.69\times10^{-6}\sin 20^\circ$$
$$= 5.78\times10^{-7}\ m$$

(14)

$$n\lambda = d\sin\theta$$
$$2\times 7\times10^{-7} = 2\times10^{-6}\sin\theta$$
$$\sin\theta = \frac{14\times10^{-7}}{2\times10^{-6}}$$
$$= 0.7$$
$$\theta = 44.4^\circ$$

$$d = \frac{1}{5000}\ cm$$
$$= 2\times10^{-4}\ cm$$
$$= 2\times10^{-6}\ m$$

(15)

$$n\lambda = d\sin\theta$$
$$1\times650\times10^{-9} = 2.5\times10^{-6}\sin\theta$$
$$\sin\theta = \frac{650\times10^{-9}}{2.5\times10^{-6}}$$
$$= 0.26$$
$$\theta = 15.1^\circ$$

$$d = \frac{1}{4000}\ cm$$
$$= 2.5\times10^{-4}\ cm$$
$$= 2.5\times10^{-6}\ m$$

(16) $n\lambda = d \sin\theta$

$2 \times 500 \times 10^{-9} = d \sin 30^\circ$

$d = \dfrac{1 \times 10^{-6}}{\sin 30^\circ}$

$\underline{d = 2 \times 10^{-6}\ m}$

(17) $n\lambda = d \sin\theta$

$3 \times 6 \times 10^{-7} = d \sin 31^\circ$

$d = \dfrac{1.8 \times 10^{-6}}{\sin 31^\circ}$

$\underline{d = 3.49 \times 10^{-6}\ m}$

(18) $n\lambda = d \sin\theta_{Blue}$

$400 \times 10^{-9} = 2 \times 10^{-6} \sin\theta_{Blue}$

$\sin\theta_{Blue} = \dfrac{400 \times 10^{-9}}{2 \times 10^{-6}}$

$\underline{\theta_{Blue} = 11.5^\circ}$

$d = \dfrac{1}{5000}\ cm$

$= 2 \times 10^{-4}\ cm$

$= 2 \times 10^{-6}\ m$

$n\lambda = d \sin\theta_{Red}$

$700 \times 10^{-9} = 2 \times 10^{-6} \sin\theta_{Red}$

$\sin\theta_{Red} = \dfrac{700 \times 10^{-9}}{2 \times 10^{-6}}$

$\underline{\theta_{Red} = 20.49^\circ}$

Angle between extremes

$= 20.49^\circ - 11.5^\circ$

$\underline{= 8.99^\circ}$

(19) $d = \frac{1}{5000}\ cm = 2 \times 10^{-4}\ cm = 2 \times 10^{-6}\ m$

$n\lambda = d \sin\theta$

$n = 1 \quad \therefore \quad \lambda = d \sin\theta$

for 18.8° $\quad \lambda = 2 \times 10^{-6} \sin 18.8$

$= \underline{644.5\ nm}$

for 15.53° $\quad \lambda = 2 \times 10^{-6} \sin 15.53$

$= \underline{535.5\ nm}$

(20) $d = \frac{1}{1000}\ cm = 1 \times 10^{-5}\ m$

$n\lambda = d \sin\theta$

$n = 1 \quad \therefore \quad \lambda = d \sin\theta$

blue $\quad \lambda = 1 \times 10^{-5} \times \sin 2.5°$

$= \underline{436\ nm}$

green $\quad \lambda = 1 \times 10^{-5} \times \sin 3.1°$

$= \underline{541\ nm}$

red $\quad \lambda = 1 \times 10^{-5} \times \sin 4°$

$= \underline{698\ nm}$

(21) a. $d = \frac{1}{600}\ mm = 0.00167\ mm = 1.67 \times 10^{-6}\ m$

$$n\lambda = d \sin\theta$$
$$1 \times \lambda = 1.67 \times 10^{-6} \sin 20.5^\circ$$
$$\underline{\lambda = 585\ nm}$$

b. $d = \frac{1}{1400}\ mm = 7.14 \times 10^{-4}\ mm = 7.14 \times 10^{-7}\ m$

$$n\lambda = d \sin\theta$$
$$1 \times 585 \times 10^{-9} = 7.14 \times 10^{-7} \sin\theta$$
$$\sin\theta = \frac{5.85 \times 10^{-7}}{7.14 \times 10^{-7}}$$
$$\underline{\theta = 55^\circ}$$

(22) $d = \frac{1}{600}\ mm = 1.67 \times 10^{-6}\ m$

for first order
$$n\lambda = d \sin\theta$$
$$1 \times 5 \times 10^{-7} = 1.67 \times 10^{-6} \sin\theta$$
$$\sin\theta = \frac{5 \times 10^{-7}}{1.67 \times 10^{-6}}$$
$$\theta = 17.4^\circ$$

for second order
$$n\lambda = d \sin\theta$$
$$2 \times 5 \times 10^{-7} = 1.67 \times 10^{-6} \sin\theta$$
$$\sin\theta = \frac{1 \times 10^{-6}}{1.67 \times 10^{-6}}$$
$$\theta = 36.8^\circ$$

Angle difference $= \underline{19.4^\circ}$

(23) a. Angle to first maximum $= \frac{17.2^\circ}{2} = 8.6^\circ$

$$n\lambda = d\sin\theta$$
$$\lambda = 3.3\times10^{-6}\sin 8.6^\circ$$
$$= \underline{\underline{493\text{ nm}}}$$

b.
$$n\lambda = d\sin\theta$$
$$2\times493\times10^{-9} = 3.3\times10^{-6}\sin\theta$$
$$\sin\theta = \frac{2\times493\times10^{-9}}{3.3\times10^{-6}}$$
$$\theta = 17.4^\circ$$

∴ The angle between two second order maxima $= 2\times17.4^\circ = \underline{\underline{34.8^\circ}}$

(24)
$$\sin\theta = \frac{n\lambda}{d}$$

- The wavelength of the light could be increased.
- The slit separation could be decreased
- The screen should be moved further from the diffraction grating.

(25) a) A central white maximum and numerous visible spectra (maxima) either side of the central maximum.

b) The pattern is an interference pattern for white light caused by the diffraction of the various wavelengths passing through the grating - adding together constructively.

c) $d = \frac{1}{500}\text{ mm} = 0.002\text{ mm} = 2 \times 10^{-6}\text{ m}$

$n = 1$

$\lambda = d \sin\theta$

$\sin\theta = \frac{440 \times 10^{-9}}{2 \times 10^{-6}}$

$\theta = 12.7°$

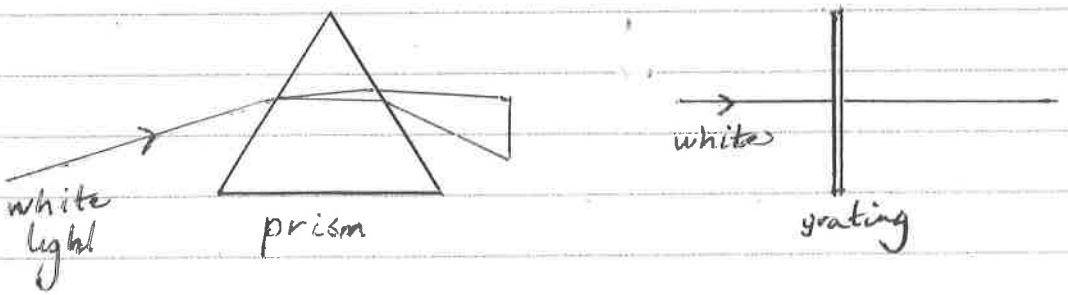
$\lambda = d \sin\theta$

$\sin\theta = \frac{730 \times 10^{-9}}{2 \times 10^{-6}}$

$\theta = 21.4°$

Angle $= 21.4° - 12.7° = \underline{\underline{8.7}}$

(26) a)



b)
- Prism produces a single spectrum where as a grating produces many spectra, with a white central maximum.
- Violet is deviated the greatest with the prism. Red is deviated the greatest with the grating.
- Prism relies upon refraction where as the grating relies upon diffraction.