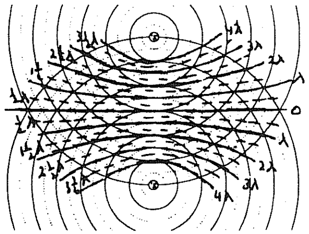
1.



—— Maximum amplitude

Path difference $= m\lambda$

where $m = 0, 1, 2, 3, \ldots$

------ Minimum amplitude

Path difference $= (m + \tfrac{1}{2})\lambda$

where $m = 0, 1, 2, 3 \ldots$

2. (1) The path difference to B from sources A & C

$= 38\,m - 22\,m$

$= 16\,m$

$= 4\lambda$. ∴ constructive interference at B.

(2) The path difference from sources A & B to C

$= 60\,m - 22\,m$

$= 38\,m = 9\tfrac{1}{2}\lambda$.

∴ destructive interference at C.

3.

Path difference from sources A & B to P is: $6.49 - 2.47\,m$

$= 4.02\,m = 3\lambda$

∴ Sound will reinforce at P and a loud sound will be heard.

Path difference from sources A & B to Q $= (7.05 - 3.70)$ m

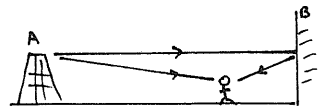
$= 3.35$ m

$= 2.5 \times 1.34 = 2.5\lambda$

∴ waves will annul at Q.

∴ no sound is heard.

4.



$f = 891\,kHz = 8.91 \times 10^5\,Hz$.

Using $c = f\lambda$, $\lambda = c/f$

$\therefore \lambda = \dfrac{3.00 \times 10^8}{8.91 \times 10^5} = 336.7\,m$

The path difference between the two waves to the radio

$= 2 \times 252.5\,m = 505\,m$.

Now, $505/336.7 = 1\tfrac{1}{2}\lambda$.

∴ The direct wave, and the reflected wave will annul

∴ Poor reception.

5. $d = 0.15\,mm = 1.5 \times 10^{-4}\,m$.

$\lambda = 540\,nm = 5.40 \times 10^{-7}\,m$

$L = 20\,cm = 0.2\,m$.

(1) for the 3rd minimum

$OPD = d\sin\theta = \tfrac{5}{2}\lambda$

$\therefore \sin\theta = \dfrac{\tfrac{5}{2}\lambda}{d}$

$\therefore \sin\theta = \dfrac{\tfrac{5}{2} \times 5.4 \times 10^{-7}}{1.5 \times 10^{-4}}$

$\theta = 0.52°$

5. (2) For the 5th maximum

$d\sin\theta = 5\lambda$

$\therefore \sin\theta = \dfrac{5 \times 5.4 \times 10^{-7}}{1.5 \times 10^{-4}}$

$\theta = 1.03°$

(3) $\Delta y = \dfrac{\lambda L}{d}$

$= \dfrac{5.40 \times 10^{-7} \times 0.2}{1.5 \times 10^{-4}}$

$= 0.72\,mm$

(4) distance will equal $4\tfrac{1}{2}$ fringe separations

ie O B_1 B_2 B_3 B_4 B_5

$\therefore d = 4\tfrac{1}{2} \times 0.72$

$d = 3.24\,mm$

6. Blue, Green, Red.

as $\lambda_B < \lambda_G < \lambda_{Red}$.

& $\Delta y = \dfrac{\lambda L}{d}$

$\therefore \Delta y \propto \lambda$

7. $d = 3.4 \times 10^{-4}\,m$.

$L = 0.3\,m$.

(1) $8\Delta y = 3.7\,mm$

$\therefore \Delta y = 3.7/8 = 4.625 \times 10^{-4}\,m$

(2) $\Delta y = \dfrac{\lambda L}{d}$

$\therefore \lambda = \dfrac{d\,\Delta y}{L}$

$= \dfrac{3.4 \times 10^{-4} \times 4.625 \times 10^{-4}}{0.3}$

$\lambda = 5.24 \times 10^{-7}\,m$

ie $\lambda = 524\,nm$.

8. (1) $\lambda = 693\,nm = 6.93 \times 10^{-7}\,m$

$L = 3.5\,m$

$\underbrace{B_3\ B_2\ B_1\ O\ B_1\ B_2\ B_3}_{6\Delta y}$

$\therefore 6\Delta y = 4.0\,cm$

$\therefore \Delta y = 4/6 = 0.667\,cm$

$\Delta y = 6.67 \times 10^{-3}\,m$.

(2) $\Delta y = \dfrac{\lambda L}{d}$

$\therefore d = \dfrac{\lambda L}{\Delta y}$

$\therefore d = \dfrac{6.93 \times 10^{-7} \times 3.5}{6.667 \times 10^{-3}}$

$\therefore d = 0.36\,mm$.

9. $\Delta y = \dfrac{\lambda L}{d}$

$\therefore \Delta y \propto 1/d$

∴ as the separation 'd' increases the distance between adjacent fringes decreases.

ie the pattern "contracts".

10. $\lambda_B = 440\,nm = 4.4 \times 10^{-7}\,m$.

$\lambda_G = 540\,nm = 5.4 \times 10^{-7}\,m$.

(1) $m\lambda = d\sin\theta$ $(m=1)$

$\therefore \dfrac{1\lambda}{\sin\theta} = d$

$\therefore d = \dfrac{5.40 \times 10^{-7}}{\sin 4.2°}$

$\therefore d = 7.37 \times 10^{-6}\,m$.

(2) $m = 2$. Green

$\sin\theta = 2\lambda/d$

$= \dfrac{2 \times 5.4 \times 10^{-7}}{7.37 \times 10^{-6}}$

$\theta = 8.42°$.

Blue: $\sin\theta = \dfrac{2\times 4.40\times10^{-7}}{7.37\times10^{-6}}$

$\therefore \theta_B = \underline{6.85°}$

$\therefore$ angular separation $= \underline{1.56°}$

11. $\lambda_1 = 460\text{ nm.} = 4.60\times10^{-7}\text{ m.}$

$\lambda_2 = ?$

The 2 fringes in question have the same angular position.

$\therefore$ for λ_1 $d\sin\theta = 6\lambda_1$

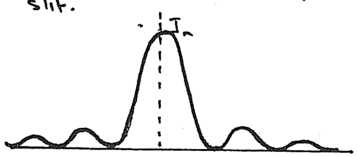
for λ_2 $d\sin\theta = 3\tfrac{1}{2}\lambda_2$

$\therefore 6\lambda_1 = \tfrac{7}{2}\lambda_2$

$\therefore \lambda_2 = \tfrac{12}{7}\lambda_1$

$\therefore \lambda_2 = \underline{789\text{ nm}}$

12. If one slit is blocked we no longer see two-slit interference. We will now see a single slit diffraction pattern centred on the open slit.



13. $d = \dfrac{1}{4500}\text{ cm} = 2.222\times10^{-6}\text{ m}$

$\lambda = 523\text{ nm} = 5.23\times10^{-7}\text{ m}$

(1) 2nd order maximum

$d\sin\theta = 2\lambda$

$\therefore \sin\theta = \dfrac{2\lambda}{d}$

$\therefore \sin\theta = \dfrac{2\times 5.23\times10^{-7}}{2.22\times10^{-6}}$

$\therefore \underline{\theta = 28.1°}$

(2) Maximum angular displacement $= 90°$

$\therefore \sin 90° = \dfrac{m\lambda}{d}.$

$\therefore \dfrac{1\times d}{\lambda} = m$

$\therefore m = \dfrac{1\times 2.22\times10^{-6}}{5.23\times10^{-7}}$

$\therefore m = 4.2$

$\therefore$ See 4 orders on each side of the central max.

$\therefore$ 9 fringes

ie 9 beams.

14. $\lambda_1 = 5.89\times10^{-7}\text{ m}$

$\lambda_2 = 5.896\times10^{-7}\text{ m.}$

$d = \dfrac{1}{6000}\text{ cm} = 1.6667\times10^{-6}\text{ m.}$

(1) $d\sin\theta_1 = 3\lambda_1$

$\therefore \sin\theta_1 = \dfrac{3\times5.89\times10^{-7}}{1.6667\times10^{-6}}$

$\therefore \theta_1 > 90°$

$\therefore$ no third order exists

(2) Highest order maximum is therefore $m=2$.

[$m = d/\lambda = \dfrac{1.6667\times10}{5.89\times10^{-7}}$

$\therefore m = 2.8$

$\therefore$ 2nd order only]

15. $d = \dfrac{1}{5000}\text{ cm} = 2.0\times10^{-6}\text{ m}$

for the $m=3$, $\theta = 40.6°$

$\therefore d\sin\theta = 3\lambda$

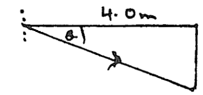
$\lambda = \dfrac{d\sin\theta}{3}$

$\therefore \lambda = \dfrac{2.0\times10^{-6}\times\sin 40.6°}{3}$

$\therefore \lambda = 4.34\times10^{-7}\text{ m}$

$\underline{\lambda = 434\text{ nm}}$

16. $d = \dfrac{1}{5000}\text{ cm} = 2.0\times10^{-6}\text{ m}$



(1) $\tan\theta = \dfrac{1.085}{4.0}$

$\underline{\theta = 15.2°}$

(2) $m\lambda = d\sin\theta$ $(m=1)$

$\therefore \lambda = d\sin\theta$

$\therefore \lambda = 2\times10^{-6}\times\sin 15.2°$

$\therefore \lambda = 5.24\times10^{-7}\text{ m}$

$\underline{\lambda = 524\text{ nm}}$

17. $\lambda_B = 4.75\times10^{-7}\text{ m}$

$\lambda_R = 6.95\times10^{-7}\text{ m}$

2nd order Red: $2\lambda = d\sin\theta$

$\therefore \sin\theta = 2\lambda/d$

$\sin\theta = \dfrac{2\times6.95\times10^{-7}}{d}$ ... (1)

3rd order Blue:

$3\lambda = d\sin\theta$

$\therefore \sin\theta = 3\lambda/d$

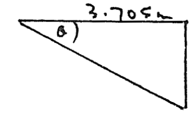
$= \dfrac{3\times4.75\times10^{-7}}{d}$

$= \dfrac{1.425\times10^{-7}}{d}$ .... (2)

$\therefore$ The 3rd order Blue reinforces at a larger angle than the 2nd red

$\therefore$ The 2nd & 3rd orders do not overlap.

18. $\lambda = 6.328\times10^{-7}\text{ m.}$



(1) $\tan\theta = \dfrac{1.672}{3.705}$

$\underline{\theta = 24.3°}$

(2) $1\lambda = d\sin\theta$

$\therefore d = \dfrac{1\lambda}{\sin\theta}$

$= \dfrac{6.328\times10^{-7}}{\sin 24.3}$

$= 1.5384\times10^{-6}\text{ m}$

$\therefore$ # lines $= 1/d = \dfrac{1}{1.5384\times10^{-6}}$

$\therefore$ # lines $= 6.50\times10^{5}$ /m.

$\therefore$ # lines $= 6500$ /cm.

19. $d = \dfrac{1}{3.15\times10^{3}}$

$= 3.175\times10^{-6}\text{ m.}$

Now, $m\lambda = d\sin\theta$

$(m=5)$

$\therefore 5\lambda = d\sin\theta$

$\therefore \sin\theta = \dfrac{5\lambda}{d}$

max. value of $\sin\theta = 1$.

$\therefore \dfrac{5\lambda}{d} < 1$

$\therefore \lambda < d/5$

$\therefore \lambda < \dfrac{3.175\times10^{-6}}{5}$

$\therefore \lambda < 6.35\times10^{-7}\text{ m}$

ie $\lambda < 635\text{ nm.}$

20. (1) globes are not coherent

(2) multiple reflections occur off walls $\therefore$ not a double slit interference but many slit pattern.

$\therefore$ (3) an infinite mix of patterns

also (4) fringe separation too small to see.

21. (1) Diffracted beams must be able to overlap to produce an interference pattern. ∴ 'L' needs to be large.

Also $\Delta y = \frac{\lambda L}{d}$

ie $\Delta y \propto L$. ∴ to see a pattern & to measure a fringe separation, the L needs to be relatively large.

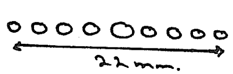
(2) $\Delta y \propto \frac{1}{d}$.

∴ To observe a 'fringe' d needs to be small. Also, if 'd' is small the coherent beams will diffract more & ∴ will overlap over a bigger area ∴ more observable.

(3) $\Delta y \propto L$ ∴ if the screen is moved closer the fringe separation will be smaller ∴ harder to measure

(4)

(a)



The distance measured is 22mm.

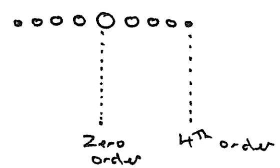
This 22mm encompasses 8 fringe separations, Δy.

$\therefore 22 = 8\Delta y$

$\therefore \Delta y = 22/8 = \underline{2.75\text{mm}}$

* Note: it is more accurate to measure the whole pattern and divide by 8 in this case, than to measure one Δy value.

(b)



OPD for 4th order is 4λ.

22. Use the ruler on the photo to measure the distance between a large number of reinforcement - say 5 or 10.

Distance between 6 reinforcements is about 10 mm.

$\therefore \Delta y = 10/5 = 2\text{mm}.$

(remember, 6 reinforcements encompass 5 fringe separations.)

1. $E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3\times10^{8}}{5.9\times10^{-7}}$

$\therefore \underline{E = 3.2\times10^{-19}\text{ J.}}$

2. $E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{0.91\times10^{-7}}$

$= \underline{2.2\times10^{-18}\text{ J.}}$

3. $p = \frac{E}{c} = \frac{13.6\times1.6\times10^{-19}}{3\times10^{8}}$

$= \underline{7.2\times10^{-27}\text{ sN.}}$

4. $p = \frac{h}{\lambda} \therefore \lambda = \frac{h}{p}$

$\therefore \lambda = \frac{6.63\times10^{-34}}{2.3\times10^{-21}} = \underline{2.9\times10^{-13}\text{ m}}$

$c = f\lambda \therefore f = c/\lambda$

$\therefore f = \frac{3.0\times10^{8}}{2.9\times10^{-13}}$

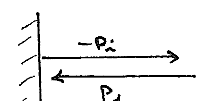
$\underline{f = 1.03\times10^{21}\text{ Hz.}}$

$E_\lambda = hf = 6.63\times10^{-34}\times1.03\times10^{21}$

$\underline{E_\lambda = 6.9\times10^{-13}\text{ J} = 4.3\text{ MeV}}$

5. $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{0.45\times10^{-7}}$

$= \underline{1.47\times10^{-26}\text{ sN.}}$



$\therefore \Delta p = -2p_i$

$\therefore \Delta p = -2p_i$

$= 2.94\times10^{-26}\text{ sN}$

away from the wall.

6. Red ←——→ violet

$\lambda = 750\text{ nm}$ $\lambda = 400\text{ nm}$

Red $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{7.5\times10^{-7}}$

$\underline{p = 8.8\times10^{-28}\text{ sN.}}$

Violet $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{4.0\times10^{-7}}$

$\underline{p = 1.66\times10^{-27}\text{ sN.}}$

7. (1) $c = f\lambda \therefore \lambda = \frac{c}{f}$

$\lambda = \frac{3.0\times10^{8}}{7.0\times10^{14}} = \underline{4.3\times10^{-7}\text{ m}}$

(2) $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{4.3\times10^{-7}}$

$\underline{p = 1.54\times10^{-27}\text{ sN.}}$

(3) $p_i = p_f \therefore p_f = p_e$

$\therefore p_e = 1.54\times10^{-27} = mV$

$\therefore V = \frac{1.54\times10^{-27}}{9.11\times10^{-31}}$

$\underline{V = 1.7\times10^{3}\text{ ms}^{-1}.}$

8. Intensity is proportional to the number of photons passing through a given area.

ie Higher intensity means more photons.

9. 60 Watts = 60 joules/sec.

E_λ of red photon $= \frac{hc}{\lambda}$

$\therefore E_\lambda = 2.8\times10^{-19}\text{ J.}$

∴ Number of photons = total energy ÷ energy of photon

$= \frac{60}{2.8\times10^{-19}} = 2.14\times10^{20}$ per sec.