Exercise-1

Marked Questions can be used as Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Principle of superposition, path difference, Wavefronts, and coherence

A 1. **Sol.** we know $I \propto A^2$.

$\Rightarrow \frac{I_1}{I_2} = \frac{A_1^2}{A_2^2}$

$\Rightarrow \sqrt{\frac{4}{1}} = \frac{A_1}{A_2}$ $\Rightarrow$ $A_1 : A_2 = 2 : 1$

A 2. **Sol.** $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{4\ I} + \sqrt{I}\right)^2 = 9I$.

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{4\ I} - \sqrt{I}\right)^2 = I$.

B 1. **Sol.** Contrast indicates the ratio of maximum possible intensity on screen to the minimum possible intensity.

As $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$

so it only depends on the source intensity.

B 2. **Sol.** we know that $\beta = \frac{\lambda D}{d}$

& $\lambda_{yellow} > \lambda_{blue}$.

$\Rightarrow$ as λ decreases, so β also decreases.

B-17._ **Sol.** **(4)**

$I_R = I_0 \cos^2 \frac{\phi}{2}$

$\phi = \frac{2\pi}{\lambda}(\Delta x) = \frac{\pi}{3}$

$\because I_R = \cos^2 \frac{\pi}{6}$

$\frac{I}{I_0} = \frac{3}{4}$

B-18_
Ans. **(4)**

Sol. $w = \frac{D\lambda}{d}$

since $v = f\lambda$

since vacuum is made, λ increased fringe width increases

C-1. **Sol.** If it is performed with white light. the central point will have maxima of all the colours, hence it will look white.

$\beta = \frac{\lambda D}{d}$; as λ_v is minimum
so first maxima after white as will be that of violet.
So there will be no dark fringe as it is not possible be have minimas of all the colors at the same point.

G-1_. **Ans.** **(1)**

Sol. $d\theta = \frac{1.22\lambda}{a}$

G-2._ **Sol.** When unpolarized light passes through a Polaroid, its intensity becomes 50%.

G-3._ **Sol.** $\theta = \frac{\lambda}{a}$

$\lambda_v < \lambda_R$

$\theta_v < \theta_R$

G-4

Sol. By Brewester law reflected light will be a plane polarized light with vibrations Perpendicular to the plane of incidence

G-5._ **Sol.** $1.22\frac{\lambda}{a} = \frac{1mm}{D}$

a = 3mm, λ = 500nm

G-6._ **Sol.** $\because \theta = \frac{\lambda}{a} = \frac{R}{D}$

and $\lambda_{x\text{-Ray}} < \lambda_{visible}$

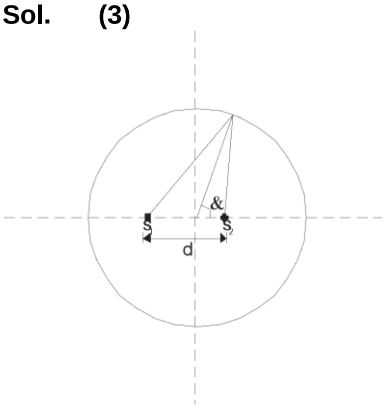
$\therefore R_{x\text{-Ray}} < 0.1$

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

3. **Sol.** **(3)**



$\Delta x = d\cos\theta = n\lambda$

$d = 2\lambda$

$\because \quad \cos\theta = \frac{n}{2}$

$n = 1$

$\cos\theta = \frac{1}{2}$

$\theta = 60°$

7. Sol. Fourth maxima will be at $y = 4\beta$.

$\Rightarrow \quad y = \frac{4\lambda D}{d}$

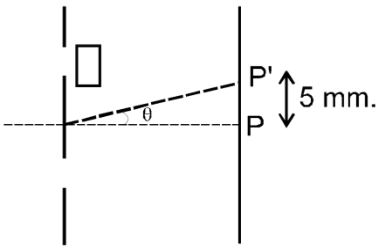
as $\lambda_{Green} > \lambda_{blue}$.

$\Rightarrow \quad \beta_{Green} > \beta_{blue}$

$\Rightarrow \quad X_{Green} > X_{blue}$

Also get $\frac{X(blue)}{X(green)} = \frac{4360}{5460}$

10. Sol.



Clearly the central maxima at P(initially) shifts to P' where PP' = 5 mm.
So now, path difference at P' must be zero.

$\Rightarrow \quad d\sin\theta = (\mu - 1)t$

$\Rightarrow \quad d\tan\theta = (\mu - 1)t$

$\mu = 1 + \frac{d.(PP')}{Dt}$; get $\mu = 1.2$

13. Sol. For strong reflection.

$2\mu t = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ ......

$\Rightarrow \quad \lambda = 4\mu t, \frac{4\mu t}{3}, \frac{4\mu t}{5}, \frac{4\mu t}{7}$ ......

$\Rightarrow$ 3000 nm. 1000 nm, 600 nm, 430 nm, 333 nm.

$\Rightarrow$ only option is 600 nm.

15. Sol. **(Easy)** The distance between nth bright fringe and $(n + 1)^{th}$ dark fringe is equal to half fringe width = $\frac{\lambda D}{2d}$

16. Sol. **(Moderate)** The intensity at distance x-from central order bright on screen is

$I = I_0 \cos^2 \frac{\pi x}{\beta}$ where I_0 = maximum intensity
β = fringe width

If $I = \frac{3}{4} I_0 \Rightarrow \cos\frac{\pi x}{\beta} = \frac{\sqrt{3}}{2} = \cos\frac{\pi}{6} \quad \therefore x = \frac{\beta}{6}$

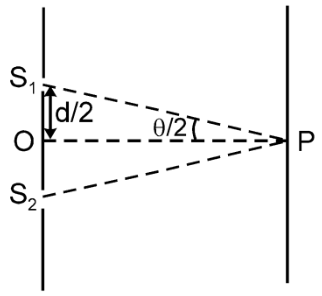
Hence the required distance $= 2 \times \frac{\beta}{6} = \frac{\beta}{3} = 0.20$ mm

$I = I_0 \cos^2 \frac{\pi x}{\beta}$

$I = \frac{3}{4} I_0 \Rightarrow \cos \frac{\pi x}{\beta} = \frac{\sqrt{3}}{2} = \cos \frac{\pi}{6} \quad \therefore x = \frac{\beta}{6}$

$= 2 \times \frac{\beta}{6} = \frac{\beta}{3} = 0.20$ mm

17. **Sol.**



In ΔS_1PO :

$\tan \frac{\theta}{2} = \frac{d/2}{D}$

As $D >> d$

$\therefore$ θ is very small.

$\Rightarrow \tan\frac{\theta}{2} \approx \frac{\theta}{2} \quad \Rightarrow \frac{\theta}{2} = \frac{d}{2D}$

$\Rightarrow \frac{D}{d} = \frac{1}{\theta} \Rightarrow$ Fringe width $= \frac{\lambda D}{d} = \frac{\lambda}{\theta}$ **Ans.**

18.

Sol. (1) Optical path difference between the waves = $(n_3 - n_2)$ t

$\therefore$ phase difference $2\pi \frac{(n_3 - n_2)t}{\lambda_{(vacuum)}} = 2\pi \frac{(n_3 - n_2)t}{n_1\lambda_1}$

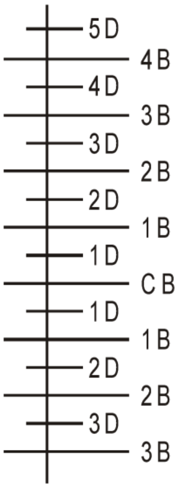
PART - II : MISCELLANEOUS QUESTIONS

A-1. **Sol.** Statement 1 is false because constructive interference can be obtained if phase difference of sources is 2π, 4π , 6π, etc.

A-2. **Sol.** **(3)** The beautiful colours are seen an acount of interference of light reflected from the upper and the lower surfaces of the thin film. As conditions for constructive & destructive interference depend upon the wavelength of light, therefore coloured interference fringes are observed.

A-3. **Sol.** If maximum intensity is observed at P then for maximum intensity to be also observed at Q, S_1 and S_2 must have phase difference of $2m\pi$ (where m is an integer).

B-1. **Ans.** (1 → r), (B → r), (C → s), (D → p)



Sol.

(Tough) By using $(\mu - 1)t = n\lambda$, we can find value of n, that is order of the fringe produced at P, if that particular strip has been placed over any of the slit. If two strips are used in conjuction (over each other), path difference due to each is added to get net path difference created. If two strips are used over different slits, their path differences are subtracted to get net path difference.

Now, $n_1 = \dfrac{(\mu_1 - 1)\ t_1}{\lambda} = 5$

$n_2 = 4.5$

and $n_3 = 0.5$

For (a), order of the fringe is 4.5 i.e. 5th dark.

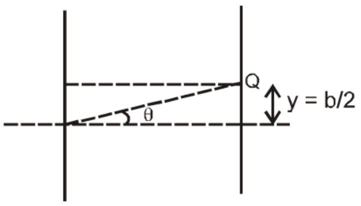
for (b), net order is 5 – 0.5 = 4.5
i.e. fifth dark.

for (c) net order is 5 – (0.5 + 4.5) = 0
i.e. it is central bright again at P.

for (d) net order is (5 + 0.5) – (4.5) = 1
i.e. first bright

C-1*. **Ans.** (1,3)

Sol.



Clearly at Q, path difference = d sinθ

$\Rightarrow$ $b \sin\theta \approx b\tan\theta \approx \dfrac{b.y}{d} = \dfrac{b^2}{2d}$

Now whenever $\dfrac{b^2}{2d}$ will be odd multiple of $\dfrac{\lambda}{2}$, those λ's will be having minima at point Q.

$\Rightarrow$ $\dfrac{b^2}{2d} = \dfrac{\lambda}{2}, \dfrac{3\lambda}{2}, \dfrac{5\lambda}{2}$ ....

$\Rightarrow$ $\lambda = \dfrac{b^2}{d}, \dfrac{b^2}{3d}, \dfrac{b^2}{5d}$ .....

C-2.* **Ans.** (2,4)

Sol $\dfrac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}=\dfrac{9}{1}$

by checking the options : $I_1 = 4$ unit. $I_2 = 1$ unit.

and $\dfrac{A_1}{A_2}=\sqrt{\dfrac{I_1}{I_2}} = 2$.

C-3.* **Sol.** $I_{max} = (\sqrt{I_1}+\sqrt{I_2})^2 = \left(\sqrt{I_1}+\sqrt{\dfrac{I}{2}}\right)^2 < 4I$

$I_{min} = \left(\sqrt{I_1}-\sqrt{\dfrac{I}{2}}\right)^2 > 0$

Exercise-3

Marked Questions can be used as Revision Questions.

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

3. **Sol.** Resolution power $\alpha \dfrac{1}{\lambda}$

$\dfrac{(RP)_1}{(RP)_2} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{5}{4}$

6. **Sol.** Brewster's law : ordinary light is completely polarised in the plane of incidence when it gets reflected from transparent, medium at a particular angle known as the angle of polarization.

$n = \tan i_p$

$\Rightarrow$ $i_p = \tan^{-1} n$

11. **Sol.** $\Delta x_1 = 0$

$\Delta\phi = 0^o$

$I_1 = I_0 + I_0 + 2I_0 \cos 0^o = 4I_0$

$\Delta x_2 = \dfrac{\lambda}{4}$

$\Delta\theta = \dfrac{2\pi}{\lambda}.\dfrac{\lambda}{4} = \left(\dfrac{\pi}{2}\right)$

$I_2 = I_0 + I_0 + 2I_0 \cos\dfrac{\pi}{2} = 2I_0$

$\dfrac{I_1}{I_2} = \dfrac{4I_0}{2I_0} = \dfrac{2}{1}$

12. **Sol.** For coherent sources :

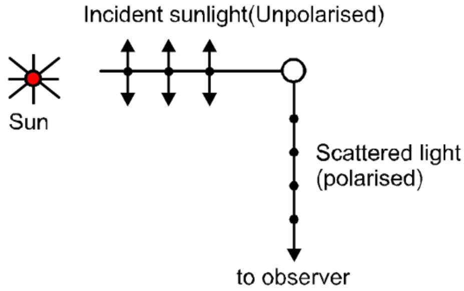
$I_1 = 4I_0$

For incoherent sources

$I_2 = 2I_0$

$\dfrac{I_0}{I_2} = \dfrac{2}{1}$.

13. **Sol.** The light from a clear blue portion of the sky shows a rise and fall of intensity when viewed through a polaroid which is rotated.



14. **Sol.** $I_m = I_0 + 4I_0 + 2\sqrt{I_0 \times 4I_0}\cos\phi$

$I_m = I_0 + 4I_0 + 4I_0 \cos\phi$

$= \frac{I_m}{9}(5 + 4\cos\phi)$

$= \frac{I_m}{9}\left(1 + 8\cos^2\phi/2\right)$

15. **Sol.** Both are true

16. **Sol.** It will be concentric circles
Ans (4)

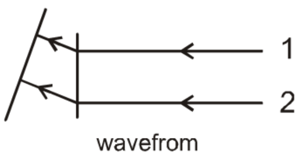
17. **Ans.** **(4)**
Sol.

$I_A \cos^2 30^0 = I_B \cos^2 60^0$

$\Rightarrow I_A = \frac{3}{4} I_B \, . \, \frac{1}{4}$

$\frac{I_A}{I_B} = \frac{1}{3}$

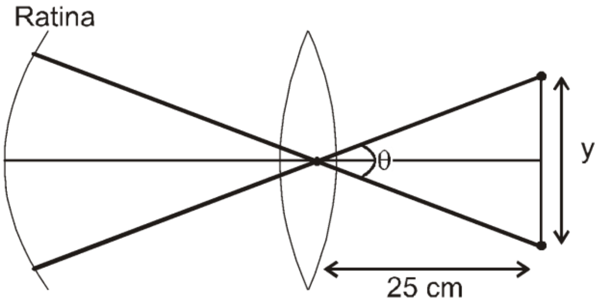
18.
Ans. **(4)**
Sol.



Ray 2 will travel faster than 1,
so beam will bend upward

19. **Ans.** **(2)**

Sol.



Resolving angle of necked eye is given by :

$\theta = 1.22\frac{\lambda}{D}$

$\frac{y}{25\times10^{-2}} = \frac{1.22\times500\times10^{-9}}{0.25\times2\times10^{-2}}$

$y = 30 \times 10^{-6}$ m = 30 μm

20. **Ans.** **(2)**

Sol. b → radius of spot.

$b = a + \frac{xL}{a}$

geometrical spread + spread due to diffraction

$\frac{db}{da} = 0$

⇒ $1 - \frac{\lambda}{a^2}L = 0$

⇒ $a^2 = L\lambda$

⇒ $a = \sqrt{L\lambda}$

$b_{min.} = \sqrt{L\lambda} + \frac{\lambda L}{\sqrt{L\lambda}}$

$b_{min.} = 2\sqrt{L\lambda}$

$b_{min.} = \sqrt{4L\lambda}$

21. **Ans.** **(3)**

Sol. $\beta_1 = \frac{\lambda D}{d} = \frac{650\times10^{-9}\times1.5}{5\times10^{-4}}$

$= 650 \times 0.3 \times 10^{-5}$

= 1.95 mm

$\beta_2 = \frac{520\times10^{-9}\times1.5}{5\times10^{-4}}$

$= 520 \times 0.3 \times 10^{-5}$

= 1.56mm

$4\beta_1 = 5\beta_2 = 7.8$ mm

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. **Sol.** Path difference due to slab should be integral multiple of λ or

$\Delta x = n\lambda$

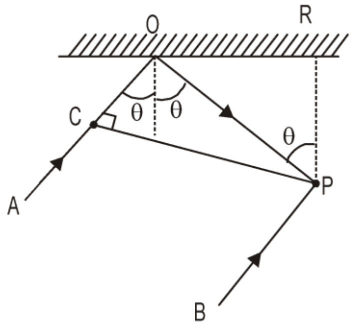
or $(\mu - 1)\, t = n\lambda$ n = 1, 2, 3, ...

or $t = \frac{n\lambda}{\mu - 1}$

For minimum value of t, n = 1

$\therefore \quad t = \frac{n\lambda}{\mu - 1} = \frac{\lambda}{1.5 - 1} = 2\lambda$

2. Sol.



PR = d

PO = d secθ

and CO = PO cos 2θ = d secθ cos 2θ

path difference between the two rays is,

$\Delta p = CO + OP + \lambda/2$

$= d \sec\theta \cos 2\theta + d\sec\theta + \lambda/2$ (one is reflected, while another is direct)

Therefore condition for constructive interference path difference should be

$\Delta p = \lambda, 2\lambda, 3\lambda$ ....

or $d \sec\theta (1 + \cos 2\theta) + \frac{\lambda}{2} = \lambda$

or $\left(\frac{d}{\cos\theta}\right)(2\cos^2\theta) = \frac{\lambda}{2}$

or $\cos\theta = \frac{\lambda}{4d}$

3. Sol. Let nth minima of 400 nm coincides with m th minima of 560 nm, then

$(2n - 1)\left(\frac{400}{2}\right) = (2m - 1)\left(\frac{560}{2}\right)$ or $\frac{2n-1}{2m-1} = \frac{7}{5} = \frac{14}{10} =$.........

i.e. 4th minima of 400 nm coincides with 3rd minima of 560 nm.

Location of this minima is,

$Y_1 = \frac{(2\times4-1)(1000)(400\times10^{-6})}{2\times0.4} = 14$ mm

Next 11th minima of 400 nm will coincide with 8th minima of 560 nm.

Location of this minima is,

$Y_2 = \frac{(2\times11-1)(1000)(400\times10^{-6})}{2\times0.1} = 42$ mm

$\therefore$ Required distance = $Y_2 - Y_1$ = 28 mm

Hence, the correct option is (D).

4. Sol. For half of maximum intensity

$2I_0 = I_0 + I_0 + 2I_0 \cos\theta$

θ (Phase difference) = $\frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}$.........

Path difference is $\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$.........$\left(\frac{2n+1}{4}\lambda\right)$

5. Sol. $2d \sin\theta = \lambda$

$d = \frac{\lambda}{2\sin\theta}$

differntiate

$\partial(d) = \frac{\lambda}{2}\partial$ (cosecθ)

$\partial(d) = \frac{\lambda}{2}(-\operatorname{cosec}\theta \quad \cot\theta)\partial\theta$

$\partial(d) = \frac{-\lambda\cos\theta}{2\sin^2\theta}\partial\theta$

as θ = increases , $\frac{\lambda\cos\theta}{2\sin^2\theta}$ decreases

Alternate solution

Sol $d = \frac{\lambda}{2\sin\theta}$

$\ell n \quad d = \ell n \quad \lambda - \ell n \quad 2 - \ell n \quad \sin\theta$

$\frac{\Delta(d)}{d} = 0 - 0 - \frac{1}{\sin\theta}\times\cos\theta(\Delta\theta)$

Fractional error |+(d)| = |cotθ Δθ|

Absoulute error Δd = (dcotθ) Δθ

$\frac{d}{2\sin\theta}\times\frac{\cos\theta}{\sin\theta}$

$\Delta d = \frac{\cos\theta}{\sin^2\theta}$

6*. **Ans. (A), (B), (C)**

Sol. $\beta = \frac{\lambda D}{d}$ $\therefore$ $\lambda_2 > \lambda_1$ so $\beta_2 > \beta_1$

No of fringes in a given width (m) = $\frac{y}{\beta} \Rightarrow m_2 < m_1$

3rd maximum of $\lambda_2 = \frac{3\lambda_2 D}{d} = \frac{1800 \quad D}{d}$

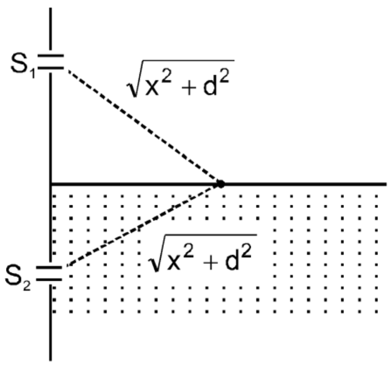
5th minimum of $\lambda_1 = \frac{9\lambda_1 D}{2d} = \frac{1800 \quad D}{d}$

So, 3rd maxima of λ_2 will meet with 5th minimum of λ_1

Angular sepration = $\frac{\lambda}{d} \Rightarrow$ Angular seperation for λ_1 will be lesser

7. **Ans. 3**

Sol.



For constructive interference $\Delta x = m\lambda$

$$\frac{4}{3}\sqrt{d^2+x^2} - \sqrt{d^2+x^2} = m\lambda$$

$$\frac{1}{3}\sqrt{d^2+x^2} = m\lambda$$

$x^2 = 9m^2\lambda^2 - d^2$

p = 3

8. Ans. (AC)

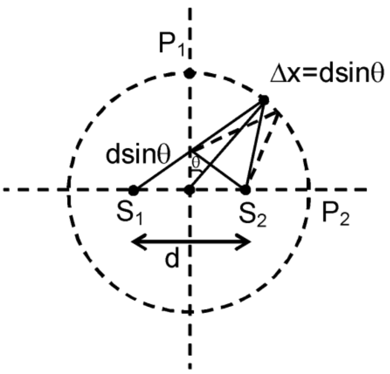
Sol. from theory fringes will be semi circular

and $\frac{d}{\lambda} = 1000 + \frac{1}{2}$

at 0 Dx = $1000\lambda + \frac{\lambda}{2}$

so at 0 it will be dark

9. Ans. (AC)



Sol.

$\lambda = 600$ nm

at P_1 $\Delta x = 0$

at P_2 $\Delta x = 1.8\text{mm} = n\lambda$

No. maximum will be $= n = \frac{\Delta x}{\lambda} = \frac{1.8\text{mm}}{600\text{nm}} = 3000$

at P_2 $\Delta x = 3000\lambda$

hence bright fringe will be formed

at P_2 3000^{th} maxima is formed

for 'D' option

$\Delta x = d\sin\theta$

$d\Delta x = d\cos\theta . d\theta$

$R\lambda = d\cos\theta . Rd\theta$

$Rd\theta = \frac{R\lambda}{d\cos\theta}$

as we move from P_1 to P_2

$\theta \uparrow \cos\theta \downarrow Rd\theta \uparrow$

Answers

EXERCISE-1

SectionM (A)

A 1.	(1)	**A 2.**	(3)	**A 3.**	(3)
A 4.	(1)				

SectionM (B)

B 1.	(3)	**B 2.**	(1)	**B 3.**	(3)	**B 4.**	(2)	**B 5.**	(4)	**B 6.**	(2)
B 7.	(1)	**B 8.**	(2)	**B 9.**	(1)	**B 10.**	(4)	**B 11.**	(4)	**B 12.**	(3)
B 13.	(4)	**B 14.**	(1)	**B 15.**	(1)	**B 16.**	(1)	**B-17.**	(D)	**B-18.**	(D)

SectionM (C)

C-1. (1)

SectionM (D)

D 1. (3) **D 2.** (2)

SectionM (E)

E 1. (2)

SectionM (F)

F 1.	(1)	**F 2.**	(2)	**F 3.**	(2)	**F 4.**	(3)	**F 5.**	(3)

SectionM (G)

G-1.	(1)	**G-2.**	(1)	**G-3.**	(2)	**G-3.**	(1)	**G-5.**	(3)	**G-6.**	(2)

EXERCISE-2

PART – 1

1.	(1)	**2.**	(2)	**3.**	(3)	**4.**	(1)	**5.**	(2)	**6.**	(1)
7.	(3)	**8.**	(4)	**9.**	(2)	**10.**	(1)	**11.**	(2)	**12.**	(1)
13.	(2)	**14.**	(4)	**15.**	(3)	**16.**	(4)	**17.**	(1)	**18.**	(1)

PART - II

SectionM (A)

A-1. (4) **A-2.** (3) **A-3.** (4)

SectionM (B)

B-1. (1 → r), (B → r), (C → s), (D → p)

SectionM (C)

C-1. (1,3) **C-2.** (2,4) **C-3.** (1,3,4)

EXERCISE – 3

PART – I

1.	(4)	**2.**	(1)	**3.**	(4)	**4.**	(4)	**5.**	(2)	**6.**	(4)
7.	(3)	**8.**	(3)	**9.**	(3)	**10.**	(4)	**11.**	(1)	**12.**	(1)
13.	(2)	**14.**	(4)	**15.**	(3)	**16.**	(4)	**17.**	(4)	**18.**	(4)
19.	(2)	**20.**	(2)	**21.**	(3)						

PART –II

1.	(A)	**2.**	(B)	**3.**	(D)	**4.**	(B)	**5.**	(D)	**6.**	(A, B, C)
7.	3	**8.**	(A,C)	**9.**	(A,C)						

Additional Problems For Self Practice (APSP)

PART-I : PRACTICE TEST PAPER

1. **Sol.** Here $\sin\theta = \dfrac{\lambda}{a}$

Where θ is half angular width of the central maximum.

A = 12 × 10^{-5} cm, λ = 6000Å = 6 × 10^{-5}cm.

∴ $\sin\theta = \dfrac{\lambda}{a} = \dfrac{6\times10^{-5}}{12\times10^{-5}} = 0.50$

or θ = 30°

2. **Sol.** In the case of Fraunhofer diffraction at a narrow rectangular aperature,

a sin θ = nλ

n = 1

∴ a sin θ = λ

sin θ = $\dfrac{x}{D}$

∴ $\dfrac{ax}{D} = \lambda$ $\lambda = \dfrac{ax}{D}$

Here a = 0.2 mm = 00.2cm

x = 5 mm = 0.5 cm

D = 2m = 200 cm

∴ $\lambda = \dfrac{0.02\times0.5}{200}$

λ = 5 × 10^{-5} cm

L = 5000Å

3. **Sol.** The first dark fringe is on either side of the central bright fringe.

Here, n = ±1, D = 2m

λ = 6000Å = 6 × 10^{-7}m

sin θ = $\dfrac{x}{D}$

a = 0.30 mm = 3 × 10^{-4} m

a sin θ = nλ

(a) x = $\dfrac{n\lambda D}{a}$ ⇒ x = ± $\left[\dfrac{1\times6\times10^{-7}\times2}{3\times10^{-4}}\right]$

x = ±4 × 10^{-3}m

The positive and negative signs correspond to the dark fringes on either side of the central bright fringe.

(b) The width of the central bright fringe,

y = 2x

= 2 × 4 × 10^{-3}

= 8 × 10^{-3} m

= 8 mm

4. **Sol.** In the case of Fraunhofer diffraction at a narrow rectangular slit,

a sin θ = nλ

Here θ gives the directions of the minimum

n = 2 , λ = ?

$a = 0.14$ mm $= 0.14 \times 10^{-3}$ m
$D = 2$ m
$x = 1.6$ cm $= 1.6 \times 10^{-2}$ m

$\sin\theta = \frac{x}{D} = \frac{n\lambda}{a}$ $\quad\therefore\quad$ $\lambda = \frac{xa}{nD}$

$= \frac{1.6\times10^{-2}\times0.14\times10^{-3}}{2\times2}$

$= 5.6 \times 10^{-7}$ m
$= 5600$Å

5. **Sol.** In the case of Fraunhofer diffraction at a narrow slit,

$a\sin\theta = n\lambda \quad\Rightarrow\quad \sin\theta = \frac{x}{D} \quad\therefore\quad \frac{ax}{D} = n\lambda$

Here width of the slit = a = ?
$x = 5$ mm $= 5 \times 10^{-3}$ m
$D = 2$m
$\lambda = 6000$Å $= 6 \times 10^{-7}$m $\quad\Rightarrow\quad n = 1$

$a = \left(\frac{n\lambda D}{x}\right) \quad\Rightarrow\quad a = \left(\frac{1\times6\times10^{-7}\times2}{5\times10^{-3}}\right)$

$\Rightarrow \quad a = 2.4 \times 10^{-4}$ m $\Rightarrow \quad a = 0.24$ mm

6. **Sol.** Here $\sin\theta = \frac{\lambda}{a}$
where θ is the half angular width of the central maximum
$a = 12 \times 10^{-5}$ cm $= 12 \times 10^{-7}$ m
$\lambda = 6000$Å $= 6 \times 10^{-7}$ m

$\sin\theta = \frac{6\times10^{-7}}{12\times10^{-7}} = 0.5$

$\theta = 30°$
Angular width of the central maximum.
$2\theta = 60°$

7. **Sol.** For minimum intensity
$a\sin\theta_n = n\lambda$

$\sin\theta_n = \frac{x_1}{f'} \quad\Rightarrow\quad n = 1$

$\frac{x_1}{f} = \frac{\lambda}{a}$

Here $\lambda = 4890$Å $= 4890 \times 10^{-10}$ m
$a = 0.5$ cm $= 5 \times 10^{-3}$ m
$f = 40$ cm $= 0.4$ m

$x_1 = \frac{f\lambda}{a}$

$x_1 = \frac{0.4\times4890\times10^{-10}}{5\times10^{-3}}$

$x_1 = 3.912 \times 10^{-5}$ m
For secondary maximum

$a \sin \theta_n = \dfrac{(2n+1)\lambda}{2}$

For the first secondary maximum

$n = 1$

$\sin \theta_n = \dfrac{x_2}{f}$

$\dfrac{x_2}{f} = \dfrac{3\lambda}{2a}$

$x_2 = \dfrac{3\lambda f}{2a}$

$x_2 = \dfrac{3 \times 4890 \times 10^{-10} \times 0.4}{2 \times 5 \times 10^{-5}}$

$x_2 = 5.868 \times 10^{-5}$ m

Difference,

$x_2 - x_1 = 5.868 \times 10^{-5} - 3.912 \times 10^{-5}$

$= 1.956 \times 10^{-5}$ m

8. **Sol.** The limit of resolution of a telescope is given by

$d\theta = \dfrac{1.22\lambda}{a}$

Here $\lambda = 5500 \times 10^{-8}$cm, a = 500 cm

$\therefore$ $d\theta = \dfrac{1.22 \times 5500 \times 10^{-8}}{500}$

$\therefore$ $d\theta = 13.42 \times 10^{-8}$ radian

Let the distance between the two point be x

$\therefore$ $d\theta = \dfrac{x}{R}$

Here $R = 3.8 \times 10^{10}$ cm

$x = R.d\theta$

$= 3.8 \times 10^{10} \times 13.42 \times 10^{-8}$

$= 50.996 \times 10^{2}$ cm

$= 50.996$ meters

9. **Sol.** Here $\lambda = 6000Å = 6 \times 10^{-5}$ cm, $\theta = 4.88 \times 10^{-6}$ radian

D = ?

$\theta = \dfrac{1.22\lambda}{\theta}$

or $D = \dfrac{1.22\lambda}{\theta} = \dfrac{1.22 \times 6 \times 10^{-5}}{4.88 \times 10^{-8}} = 15\text{cm}$

10. **Sol.** Here, $\lambda = 5.5 \times 10^{-5}$ cm

a = 0.4 cm

$d\theta = \dfrac{1.22\lambda}{a}$

Also $d\theta = \dfrac{x}{d}$

x = 1.5 mm = 0.15 cm

$\therefore \quad \frac{x}{d} = \frac{1.22\lambda}{a}$

$d = \frac{xa}{1.22\lambda}$

$d = \frac{0.15 \times 0.4}{1.22 \times 5.5 \times 10^{-5}}$ cm

d = 894.2 cm = 8.942 m

11. Sol. As $\lambda << d$; we can we $\quad \beta = \frac{\lambda D}{d}$

we get $\beta = \frac{500 \times 10^{-9} \times 1}{10^{-3}} = 0.5$ mm.

As β is not very small; hence it might so happen that till 1000th maxima, we no longer can apply $y' = 1000 \times \beta$.

Lets see if we can apply:

At 1000th maxima. Path difference is 1000 λ.

$\Rightarrow \quad 1000\,\lambda = d \sin\theta = \frac{d \times y}{\sqrt{D^2 + y^2}}$

$\Rightarrow \quad (5 \times 10^{-4})^2 = \frac{(10^{-3}\ \ m)^2\ \times y^2}{D^2 + y^2}$

$\Rightarrow \quad 0.25\, D^2 = y^2 (1 - 0.25) \quad \Rightarrow \quad y = \left(\frac{0.25}{0.75}\right)^{\frac{1}{2}} \times D$

$y = \frac{D}{\sqrt{3}} = 0.577$ m.

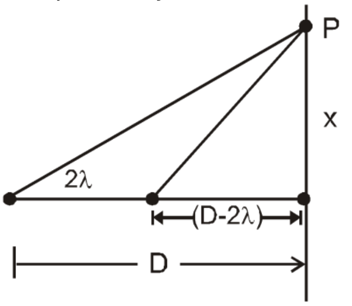
As 0.577 m. and 0.5 m. are quite distant, so we could not use $y' = 1000\,\beta$ for such a high maxima.

12. Sol. When unpolarised light passes through a polaroid, intensity of emergent light,

$i = I_0 (\cos^2 \theta)_{mean}$

$= I_0 \times \frac{1}{2} = \frac{I_0}{2}$

13. Sol. When a mica sheet is introduced in the path of one of interfering beams, the whole interference pattern is displaced by an amount $\frac{D}{d}(\mu - 1)\,t$ in the direction of introduction of sheet.



14. Sol.

$\sqrt{D^2+x^2} - \sqrt{x^2 + (D-2\lambda)^2} = \lambda$

$\sqrt{x^2 + D^2} - \lambda = \sqrt{x^2 + (D-2\lambda)^2}$

$x^2 + D^2 + \lambda^2 - 2\lambda\sqrt{x^2 + D^2} = x^2 + D^2 + 4\lambda^2 - 4\lambda D$

$2\lambda \sqrt{x^2 + D^2} = -3\lambda^2 + 4\lambda D$

$4(x^2 + D^2) = (4D - 3\lambda)^2 \approx 16\, D^2$

$x^2 + D^2 = 4\, D^2$

$x^2 = 3D^2$

$x = \sqrt{3}D$

15. **Sol.** Resultant intensity of two periodic waves is given by

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta$

where δ is the phase difference between the waves

for maximum intensity, $\delta = 2n\pi$; n = 0, 1, 2, ...etc.

Therefore, for zero order maxima, $\cos\delta = 1$

$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2} = (\sqrt{I_1} + \sqrt{I_2})^2$

For minimum intensity, $\delta = (2n - 1)\pi$;

n = 1, 2,.... etc.

Therefore, for Ist order minima, $\cos\delta = -1$

$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2} = (\sqrt{I_1} - \sqrt{I_2})^2$

Therefore,

$I_{max} + I_{min} = (\sqrt{I_1} + \sqrt{I_2})^2 + (\sqrt{I_1} - \sqrt{I_2})^2 = 2(I_1 + I_2)$

16. **Sol.** If screen is taken near by the disc, as intensity is inversely proportional to distance. It means when distance between source and screen is decreasing, so intensity increases.

17. **Sol.** When light wave passes through a transparent medium, velocity of longest wavelength v will be maximum.

18.
Sol. The wavelength of light in air is

$\lambda_a = \frac{c}{n}$ … (1)

Where c = velocity of light in vacuum

n = frequency of light

The frequency of light never change when it goes to any other medium So, wavelength of light in medium is

$\lambda_m = \frac{c}{\mu n}$ …(2)

μ = refractive index of the medium Dividing eq. (1) by eq. (2), we get

$\frac{\lambda_a}{\lambda_m} = \mu$

Hence $\mu = \frac{\lambda_a}{\lambda_m}$

19. Sol. Intensity $\propto \frac{1}{r^2}$

$\Rightarrow \frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{r_i}{r_i(1+2\%)}\right)^2$

$I_2 = I_1 (1 + 2\%)^{-2}$

Expanding by binomial theorem

$I_2 = I_1 (1 - 4\%)$

Intensity decreases by 4%

20. Sol. As velocity of light is perpendicular to the wavefront and light is travelling in vacuum along the y-axis, therefrore, the wavefront is represented by y = constant.

21. Sol. The refractive index is related to the speed of light in the two media as given below

$_1\mu_2 = \frac{\text{speed of light in first medium}}{\text{speed of light in second medium}}$

or speed of light in second medium = $\frac{\text{speed of light in first medium}}{_1\mu_2}$

$_1\mu_2$ is refractive index of second medium relative to the first medium.

Hence, we see that on passing throught another medium, speed of light changes due to which it bends.

22. Sol. The average power per unit area that is incident perpendicular to the direction of propagation is called the intensity ie,

$I = \frac{p}{4\pi r^2}$ or $I \propto \frac{1}{r^2}$

or $\frac{I_1}{I_2} = \left(\frac{I_2}{I_1}\right)^2$

Here , $r_1 = 2$ m, $r_2 = 3$ m

$\therefore \frac{I_2}{I_1} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$

23. Sol. Plane contatining the direction of vibration and wave motion is called plane of polarisation, plane of vibration is perpendicular to the direction of propagation and also perpendicular to the plane of polarisation. Therefore, angle between plane of polarisation and direction of vibration is 0°.

24.

Sol. For constructive interference, we must have

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

or $\sin\theta = \frac{n\lambda}{2d} = \frac{1 \times 0.3 \times 10^{-10}}{2 \times 0.3 \times 10^{-9}}$

= 0.05 Rad

$= \frac{0.05 \times 180}{\pi} = 2.86°$

25. Sol. In a single slit diffraction, the central fringe has maximum intensity and has width double than other fringe.

26. Sol. For possible interference maxima on the screen , the conditions is

$d \sin\theta = n\lambda$ ...(i)

Given : d = slit – width = 2λ

$\therefore$ $2\lambda \sin\theta = n\lambda$

$\Rightarrow$ $2\sin\theta = n$

The maximum value of $\sin\theta$ is 1, hence

$n = 2 \times 1 = 2$

Thus, Eq. (i) must be satisfied by 5 integrer values ie., –2, –1, 0, 1, 2. Hence, the maximum number of possible interference maxima is 5.

27. Sol. Frequency (f) = 5×10^{14} Hz

$\therefore$ Wavelength of light (λ) = $\frac{c}{f} = \frac{3\times10^{8}}{5\times10^{14}} = 6 \times 10^{-7}$

= 6000 Å

$\therefore$ Wavelength in medium of refractive index μ,

$$\lambda' = \frac{\lambda}{\mu} = \frac{6000}{1.5} = 4000 \text{ Å}$$

28. Sol. Colouring of film is due to interference

29. Sol.

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{\sqrt{\frac{25}{4}}+1}{\sqrt{\frac{25}{4}}-1}\right) = \frac{49}{9}$$

PART - II : PRACTICE QUESTIONS

10. Sol. In a longitudinal wave, the particles of the medium oscillate about their mean or equilibrium position along the direction of propagation of the wave itself. Sound waves are longitudinal in nature. In trasverse wave, the particles of the medium oscillate about their mean or equilibrium position at right angles to the direction of propagation of wave itself. Light waves being electromagnetic are transverse waves.

11. Ans. $\Delta\phi = 120^\circ = \frac{2\pi}{3}\text{rad}$

Sol. Amplitude of the resultant wave

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\Delta\phi}$$

$\therefore$ $A^2 = a_1^2 + a_2^2 + 2a_1a_2\cos\Delta\phi$

$A^2 = a_1^2 + a_2^2 + 2a_1a_2\cos\Delta\phi$

Given , A = a_1 = a_2 = a (say), then

$a^2 = 2a^2 + 2a^2 \cos\Delta\phi$

so $a^2 = 2a^2$ (1+cos) $\Delta\phi$

so 1+ cos $\Delta\phi$ = $\frac{1}{2}$

So $\cos\Delta\phi = -\frac{1}{2}$

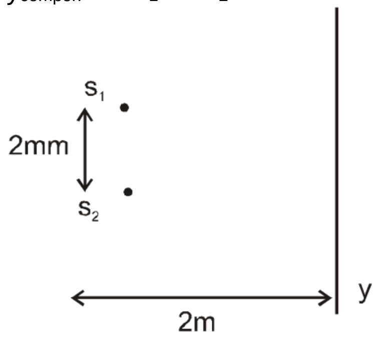
So $\Delta\phi = 120^\circ = \frac{2\pi}{3}\text{rad}$

12. **Sol.** $y = \frac{n\lambda D}{d}$

$\therefore$ $n_1 \lambda_1 = n_2 \lambda_2$

$n_1\ 12000 = n_2\ 10000$

$y_{compon} = 6\ n_1 = 5n_2$



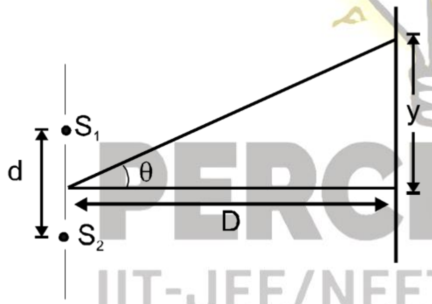
here $y_{common} = \frac{5(12000 \times 10^{-10})}{2 \times 10^{-3}}$

$= 5\ 5\ 12 \times 10^{-4}$

$= 60 \times 10^{-4}$ m

$= 6 \times 10^{-3}$ m

$= 6$ mm



13. **Sol.**

θ = $\frac{Y}{D} = \frac{n\lambda D}{dD}$

so $\theta = \frac{\lambda}{d}$

$v \uparrow \lambda \downarrow \theta \downarrow$

14. **Sol.** $d = 1\text{mm} = 10^{-3}$m

$D = 1$ mm

$\lambda = 500\text{nm} = 500 \times 10^{-9}$m

width of central maxima in single slit pattern

$= \frac{2\lambda D}{a}$

fring width in double slit exp. $\beta = \frac{\lambda D}{d}$

so required condition $\Rightarrow$ $\frac{10\lambda D}{d} = \frac{2\lambda D}{a}$

$a = \frac{d}{5} = \frac{1}{5}\times 10^{-3}\,m = 0.2$ mm

15. **Sol.** Width of central maxima = $\frac{2\lambda D}{a}$

16. **Sol.** Path difference between the extreme rays at first minima = a sinθ = λ
$a \sin(30°) = \lambda \quad \Rightarrow \quad a = 2\lambda$

Path difference between the extreme rays at first secondary maxima = $a \sin\theta' = \frac{3\lambda}{2}$

$(2\lambda)\sin\theta' = \frac{3\lambda}{2} \quad \Rightarrow \quad \theta' = \sin^{-1}\left(\frac{3}{4}\right)$

17. **Sol.** Width of - maximas $\propto \lambda$ so. ans. (b)

APSP Answers

PART – I

1.	(4)	**2.**	(1)	**3.**	(1)	**4.**	(2)	**5.**	(2)	**6.**	(3)	**7.**	(1)
8.	(1)	**9.**	(2)	**10.**	(1)	**11.**	(2)	**12.**	(2)	**13.**	(2)	**14.**	(4)
15.	(4)	**16.**	(1)	**17.**	(3)	**18.**	(1)	**19.**	(4)	**20.**	(1)	**21.**	(3)
22.	(1)	**23.**	(1)	**24.**	(3)	**25.**	(4)	**26.**	(3)	**27.**	(1)	**28.**	(2)
29.	(3)	**30.**	(4)										

PART – II

1.	(1)	**2.**	(3)	**3.**	(1)	**4.**	(4)	**5.**	(1)	**6.**	(1)	**7.**	(3)
8.	(3)	**9.**	(3)	**10.**	(2)	**11.**	$\Delta\phi = 120^\circ = \frac{2\pi}{3}\text{rad}$			**12.**	(1)	**13.**	(2)
14.	(4)	**15.**	(4)	**16.**	(1)	**17.**	(2)	**18.**	(1)				