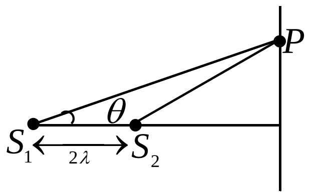
SRIGAYATRI EDUCATIONAL INSTITUTIONS
INDIA

SR MPC JEE MAINS (UT1) – QUESTION BANK
WAVE OPTICS

1. The earth is moving towards a fixed star with a velocity of $30 km s^{-1}$. An observer on the earth observes a shift of $0.58 A^0$ in the wavelength of light coming from the star. The actual wavelength of light emitted by the star is
   1) $5800 A^0$ 2) $2400 A^0$ 3) $12000 A^0$ 4) $6000 A^0$
   Ans: 1
2. Two beams of light having intensities I and 4I interfere to produce a fringe pattern on a streen. The phase difference between the beams is $\pi / 2$ at point A and π at point B. Then the difference between the resultant intensities at A and B is
   1) 2I 2) 4I 3) 5I 4) 7I
   Ans: 2
3. In young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen with path difference λ is M units. The intensity of light at a point where path difference is $\lambda / 3$, is
   1) $M / 2$ 2) $m / 4$ 3) $M / 8$ 4) $M / 16$
   Ans: 2
4. In young's double slit experiment, the slits are horizontal. The intersity at a point P as shown in figure is $3/4 I_0$, where I_0 is the maximum intensity then the value of θ is (Give the distance between the two slits S_1 and S_2 is 2λ



   1) $\cos^{-1}[1/12]$ 2) $\sin^{-1}[1/12]$ 3) $\tan^{-1}[1/12]$ 4) $\sin^{-1}[3/5]$
   Ans: 1
5. In young's double slit experiment, the 10^{th} maximum of wavelength λ_1 is at a distance y_1 from its central maximum and the 5^{th} maximum of wavelength λ_2 is at a distance y_2 from its central maximum. The ratio y_1 / y_2 will be
   1) $\frac{2\lambda_1}{\lambda_2}$ 2) $\frac{2\lambda_2}{\lambda_1}$ 3) $\frac{\lambda_1}{2\lambda_2}$ 4) $\frac{\lambda_2}{2\lambda_1}$
   Ans: 1
6. The two slits are 1mm part from each other and illuminated with a light of wavelength $5 \times 10^{-7} m$. If the distance of the screen is 1m from the slits, then the distance between third dark fringe and fifth bright fringe is
   1) 1.2mm 2) 0.75mm 3) 1.25mm 4) 0.625mm
   Ans: 3

7. In a double slit experiment, the distance between slits is increased ten times whereas their distance from screen is halved then the fringe width is

1) becomes $1/20$ 2) becomes $1/90$

3) it remains same 4) becomes $1/10$

Ans: 1

8. In a young's double slit experiment, (slit distanced) monochromatic light of wavelength λ is used and the fringe pattern observed at a distance D from the slits. The angular position of the bright fringes are

1) $\sin^{-1}\left[\frac{N\lambda}{d}\right]$ 2) $\sin^{-1}\left[\frac{(N+1/2)\lambda}{d}\right]$

3) $\sin^{-1}\left[\frac{N\lambda}{D}\right]$ 4) $\sin^{-1}\left[\frac{(N+1/2)\lambda}{D}\right]$

Ans: 1

9. On introducing a thin film in the path of one of the two interfering beam, the central fringe will shift by one fringe width. If $\mu = 1.5$, the thickness of the film is (wavelength of monochromatic light is λ)

1) 4λ 2) 3λ 3) 2λ 4) λ

Ans: 3

10. A screen is placed 50 cm from a single slit which I illuminated with light of wavelength $6000A^0$. If the distance between the first and third minima in the diffraction pattern is 3.0mm. The width of the slit is

1) $1\times10^{-4}m$ 2) $2\times10^{-4}m$ 3) $0.5\times10^{-4}m$ $4\times10^{-4}m$

Ans: 2

11. In single slit diffraction experiment, the width of the slit made double its original width. Then the central maximum of the diffraction pattern will become

1) narrower and fainter 2) narrower and brighter

3) broader and fainter 4) broader and brighter

Ans: 2

12. In young's double slit experiment the distanced between the slits S_1 and S_2 is 1mm. What should the width of each slit be, so as to obtain 10th maxima of the double slit pattern within the central maximum of the single slit pattern?

1) 0.9 mm 2) 0.8 mm 3) 0.2 mm 4) 0.6 mm

Ans: 3

13. In a fraunhofer diffraction at single slit of width of with d, incident light at wavelength $5500A^0$, the first minimum is doserved, at angle 30^0, the first secondary maximum is observed at an angle $\theta =$

1) $\sin^{-1}\left[\frac{1}{\sqrt{2}}\right]$ 2) $\sin^{-1}\left[\frac{1}{4}\right]$ 3) $\sin^{-1}\left[\frac{3}{4}\right]$ 4) $\sin^{-1}\left[\frac{\sqrt{3}}{2}\right]$

Ans: 3

14. The diameter of the pupil of human eye is about 2mm. Human eye is most sensitive to the wavelength of 555nm. The limit of resolution of human eye is
 1) 1.2 min 2) 2.4 min 3) 0.6 min 4) 0.3 min
 Ans: 1

15. A polorid is being used as an analyzer of plane polroid light. In one complete rotation of the crystal, the maximum intensities will be observed only
 1) once 2) twice 3) thrice 4) datu is inadequate
 Ans: 2

16. If θ is the polarising angle for two optical media, whose critical angles are C_1 and C_2. Then the correct relation is
 1) $\sin\theta = \frac{\sin C_2}{\sin C_1}$ 2) $\theta = \frac{\sin C_2}{\sin C_1}$ 3) $\tan\theta = \frac{\sin C_1}{\sin C_2}$ 4) $\sin\theta = \frac{\sin C_1}{\sin C_2}$
 Ans: 3

17. Unpolarised light of intensity $32Wm^{-2}$ passes through three polarisers such that transmission axis of first is crossed with third. If intensity of emerging light is $2Wm^{-2}$, what is the angle of transmission axis between the first two polarisers?
 1) 30^0 2) 45^0 3) 22.5^0 4) 60^0
 Ans: 3

18. Unpolarized light of intensity I is incident on a system of two polarizers, A followed by B. The intensity of emergent light is $\frac{I}{2}$. If a third polarizer C is placed between A and B. The intensity of emergent light is reduced to $\frac{I}{3}$. The angle between the polarizer A and C is θ. Then
 1) $\cos\theta = \left(\frac{1}{3}\right)^{1/2}$ 2) $\cos\theta = \left(\frac{2}{3}\right)^{1/4}$ 3) $\cos\theta = \left(\frac{2}{3}\right)^{1/2}$ 4) $\cos\theta = \left(\frac{1}{3}\right)^{1/4}$
 Ans: 2

19. In a YDSE arrangement comrposite lights of different wavelengths $\lambda_1 = 560nm$ and $\lambda_2 = 400nm$ are used. If $D = 1m$, $d = 0.1mm$. The distance (in mm) between two completely dark regions is
 1) 28 2) 18 3) 38 4) 20
 Ans: 1

20. The value of numerical aperture of the objective lens of a microscope is 1.25. If light of wavelength $5000A^0$ is used, the minimum separation between two points to be seen as distinct, will be
 1) $0.48\mu m$ 2) $0.12\mu m$ 3) $0.38\mu m$ 4) $0.24\mu m$
 Ans: 4

21. What speed should a galaxy move with respect to us so that sodium line at $579.0nm$ is observed at $579.6nm$?
 Ans: $310km/s$

22. Assume that light of wavelength $5000A^0$ is coming from a star. What is the limit of resolution of a telescope whose objective has a diameter of 50 inch?
Ans: 4.8×10^{-7} radians

23. In double-slit experiment using light of wavelength 500nm, the Angular width of a fringe formed on a distant screen is 0.2^0. What is the spacing between the two slits?
Ans: $1.4\times10^{-4}m$

24 For what distance is ray optics a good approximation when the aperture is 4mm wide and the wavelength is 400 nm?
Ans: 40m

25. What should the width of each slit be to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern? $\left(id\, d = 2mm\right)$
Ans: $0.4mm$

26. A beam of light consisting of two wavelengths 650nm and 520nm is used to obtain interference fringes in a young's double –slit experiment. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincider?
Ans: $1.56mm$

27. In a single slit diffraction experiment first minimum for $\lambda_1 = 660nm$ coincides with first maxima for wavelength λ_2. The value of λ_2 (in nm) is
Ans: 440

28. Light of wavelength $6328A^0$ is incident normally on a slit of width 0.2mm. The Angular width of central maximum on a screen (in degree) at distance 9m is____(Take $\pi = 3.14$)
Ans: 0.36

29. A system of three polarizers P_1, P_2, P_3 is set up such that the pass axis of P_3 is crossed with respect to that of P_1. The pass axis of P_2 is inclined at 60^0 to the pass axis of P_3. When a beam of unpolarised light of intensity I_0 is incident on P_1, the intensity of light transmitted by the three polarizes is I. The value of I_0 / I equals to
Ans: 10.7

30. The velocity of light in air is $3\times10^8 ms^{-1}$ and that in water is $2.2\times10^8 ms^{-1}$. The polarising angle of incidence is
Ans: 53.67^0

Wave Optics (Solutions)

1. $\frac{\Delta\lambda}{\lambda} = \frac{V}{C}$

$\lambda = \frac{C}{V}\Delta\lambda$

2. $I_1 = I \quad I_2 = 4I$

$\phi_1 = \frac{\pi}{2} \quad \phi_2 = \pi$

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$I_A = I + 4I = 5I$

$I_B = I + 4I - 4I = I$

$I_A - I_B = 4I$

3. $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

Path difference = λ

Phase difference = 2π

$\Delta\phi = \frac{2\pi}{\lambda}.\Delta x = \frac{2\pi}{\cancel{\lambda}}.\cancel{\lambda}$

$\phi = \Delta\phi = 2\pi$

$I_1 = I_2 = I$

$I_R = I + I + 2\sqrt{I\ I}\cos 2\pi$

$I_R = 4I = M$

$\Delta x = \frac{\lambda}{3}$

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

$I_R = I + I + 2\sqrt{I\ I}\cos\frac{2\pi}{3}$

$I_R = I = \frac{M}{4}$

4. $I=I_0\cos^2\frac{\phi}{2}$

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

$\cos^2\frac{\phi}{2}=\frac{I}{I_0}=\frac{3}{4}$

$\cos^2\frac{\phi}{2}=\frac{3}{4}\Rightarrow\cos\frac{\phi}{2}=\sqrt{\frac{3}{4}}$

$\cos\frac{\phi}{2}=\frac{\sqrt{3}}{2}\Rightarrow\phi=60^0=\frac{\pi}{3}$

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

$\frac{\not\pi}{3}=\frac{2\not\pi}{\lambda}\Delta x$

$\Delta x=\frac{\lambda}{6}$

But path difference

$\Delta x=d\cos\theta \qquad (d=2\lambda)$

$\frac{\not\lambda}{6}=2\not\lambda\cos\theta$

$\cos\theta=\frac{1}{6\times 2}=\frac{1}{12}$

$\theta=\cos^{-1}\left[\frac{1}{12}\right]$

5. $y_m=\frac{m\lambda D}{d}\ \left(m^{th}\ bright\right)$

$y_1=\frac{10\lambda_1 D}{d}\ \left(\ for\ \lambda_1\right)$

$y_2=\frac{5\lambda_2 D}{d}\ \left(\ for\ \lambda_2\right)$

$\frac{y_1}{y_2}=\frac{2\lambda_1}{\lambda_2}$

6. $\lambda = 5\times10^{-7}m \quad D = 1m$

d = 1 m m

$$y_n = \frac{n\lambda D}{d} \left(n^{th}\ Bright\right)$$

$$y_5 = \frac{5\lambda D}{d}$$

n^{th} dark $y_n = \dfrac{(2n-1)\lambda D}{2d}$

3^{rd} dark $y_3 = \dfrac{5\lambda D}{2d}$

Distance between $y_5 - y_3 = 1.25mm$

7. $\beta = \dfrac{\lambda D}{d}$

$$D^1 = \frac{D}{2} \Rightarrow d^1 = 10d$$

$$\beta^1 = \frac{\lambda D^1}{d^1} \Rightarrow \frac{\lambda D^1}{2\times10d} = \frac{\lambda D}{20d}$$

$$\beta^1 = \frac{\beta}{20}$$

8. Path difference $\Delta x = d\sin\theta = n\lambda$

$$\theta_{bright} = \sin^{-1}\left[\frac{N\lambda}{d}\right]$$

9. Path difference

$$\Delta x = (\mu - 1)t = N\lambda$$

$N = 1$

$\mu = 3/2$

$$t = \frac{N\lambda}{(\mu-1)} = \frac{1\lambda}{\frac{3}{2}-1}$$

$t = 2\lambda$

10. $y_n = \frac{n\lambda D}{d}$; $(d = a)$

$y_3 - y_1 = (3-1)\frac{\lambda D}{a} = \frac{2\lambda D}{a}$

$a = \frac{2\lambda D}{y_3 - y_1}$

11. Angular width of the central maximum is $\frac{2\lambda}{a}$

12. Angular separation between n^th bright fringe $\theta_x = \frac{y_n}{D} = \frac{n\lambda}{d}$

10^{th} bright $\theta_{10} = \frac{10\lambda}{d}$

The Angular width of the central maximum in diffraction

$2\theta_1 = \frac{2\lambda}{a}$

$\frac{10\lambda}{d} \le \frac{2\lambda}{a} \Rightarrow a \le \frac{d}{5}$

$a \le \frac{1}{5} = 0.2\text{mm}$

13. For first secondary minima

$d\sin\theta = n\lambda \quad (n=1)$

$d\sin\theta_1 = \lambda \Rightarrow d = \frac{\lambda}{\sin\theta_1}$

$(\theta_1 = 30)$

For secondary maxima

$d\sin\theta_2 = \frac{3\lambda}{2}$

$\sin\theta_2 = \frac{3\lambda}{2d} = \frac{3}{4}$

14. $d\theta = \frac{1.22\lambda}{D}$ $\quad \lambda = 555\times10^{-9}$

$D = 2\times10^{-3}$

$d\theta = 3.39\times10^{-4}\text{rad}$

$\pi \text{ rad} = 180^0 \Rightarrow 1 \text{ rad} = \dfrac{180^0}{\pi}$

$d\theta = 3.39 \times 10^{-4} \times \dfrac{180^0}{\pi}$

$1^\circ = 60'$

$d\theta = 1 \cdot 2'$

15. $I = I_0 \cos^2 \theta$

$I_f I = I_0$

$\cos\theta = \pm 1$

$\theta = 0^0, 180^0$

16. $\mu_1 \sin\theta = \mu_2 \sin(90 - \theta)$

$Tan\theta = \dfrac{\mu_2}{\mu_1}$

$\sin c_1 = \dfrac{1}{\mu_1}$

$\sin c_2 = \dfrac{1}{\mu_2}$

$Tan\theta = \dfrac{\sin c_1}{\sin c_2}$

17. $I = \dfrac{I_0}{2} \cos^2\theta \sin^2\theta$

$\sin 2\theta = \dfrac{1}{\sqrt{2}}$

$2\theta = 45^0$

$\theta = 22.5^0$

18. $I_B = I_c \cos^2\theta$

$I_c = \dfrac{I}{2} \cos^2\theta$

$I_B = \frac{I}{2}\cos^2\theta \cdot \cos^2\theta$

$I_B = \frac{I}{2}\cos^4\theta$

But $I_B = \left(\frac{I}{3}\right)$

$\frac{I}{3} = \frac{I}{2}\cos^4\theta$

$\frac{2}{3} = \cos^4\theta$

$\cos\theta = \left(\frac{2}{3}\right)^{1/4}$

19. n^{th} minima of 400nm coincides with m^{th} minima of 560nm

$y_n = y_m$

$(2n-1)\frac{400}{2} = (2m-1)\frac{560}{2}$

$\frac{2n-1}{2m-1} = \frac{7}{5}$ $\quad n = 4$, $m = 3$

$y_1 = \frac{(2n-1)\lambda D}{2d} = 14mm$

$y_2 = \frac{(2m-1)\lambda D}{2d} = 42mm$

distance $y_2 - y_1 = 28mm$

20. Numerical aperture of objective lens of microscope $= \frac{0.61\lambda}{d}$

$d = \frac{0.61\lambda}{\text{aperture}}$

$d = 0.24\mu m$

21. $\frac{\Delta\lambda}{\lambda} = \frac{v_{\text{rad}}}{c}$

$V_{\text{rad}} = \frac{\Delta\lambda}{\lambda} \times c$

$V_{\text{rad}} = 310 \text{k}m / \text{s}$

22. $2a = 50 \text{ Inch}$

$1 \text{ Inch} = 2.54 \text{c}m$

$$\Delta\theta = \frac{0.61\lambda}{a}$$

$$\Delta\theta = 4.8 \times 10^{-7} rad$$

23. $\lambda = 500\, nm$

$\theta = 0.2^{\circ}$

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

$$\text{d} = 1.4 \times 10^{-4} m$$

24. $Z_F = \dfrac{a^2}{\lambda}$

$Z_F = 40m$

25. $a\theta = \lambda \Rightarrow \theta = \dfrac{\lambda}{a}$

$$\frac{10\lambda}{d} = 2\theta$$

$$\frac{10\lambda}{d} = 2\left(\frac{\lambda}{a}\right)$$

$$a = \frac{d}{5} = \frac{2mm}{5} = 0.4mm$$

26. $n_1\lambda_1 = n_2\lambda_2$

$(n-1)\lambda_1 = n\lambda_2$

$\lambda_1 = 650nm,\ \lambda_2 = 520nm$

$n = 5$

The least distance

$$x = \frac{n\lambda_2 D}{d}$$

$$x = 1.56mm$$

27. $d\sin\theta = n\lambda\,(\text{minimum})$

$$\sin\theta_1 = \frac{\lambda_1}{d}\ \ (\text{n} = 1)$$

$$d\sin\theta = (2n+1)\frac{\lambda}{2}\ \ (\max)$$

$$\sin\theta_2 = \frac{3}{2}\frac{\lambda_2}{d}$$

The two will coincide $\theta_1 = \theta_2$

$$\lambda_2 = \frac{2}{3}\lambda_1 = 440nm$$

28. $\theta = \dfrac{2\lambda}{a}$

$$\theta = 0.36$$

29. $I_1 = \dfrac{I_0}{2}$

$$I_2 = I_1\cos^2\theta = \frac{I_0}{2}\cos^2 30^0$$

$$I_2 = \frac{I_0}{2}\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3I_0}{8}$$

$$I_3 = I_2\cos^2\theta$$

$$I_3 = \frac{3I_0}{8}\cos^2 60^0 = \frac{3I_0}{32}$$

$$\frac{I_0}{I_3} = \frac{32}{3} = 10.7$$

30. $\mu = \dfrac{\text{C}}{\text{V}}$

$$\text{Tan}\,\theta_\text{P} = \mu$$

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