NARAYANA EDUCATIONAL INSTITUTIONS

PHYSICS :: WAVE OPTICS

1. Consider interference between two sources of intensities I and 4I. obtain intensities at points where the phase difference is $\frac{\pi}{2}$ & π?

   a) 5I b) 5I,2I c) 2I,5I d) I,5I

2. The two coherent sources of monochromatic light of wavelength λ are located at a separation λ the two sources are placed on a horizontal line and screen is placed perpendicular to the line joining the sources Find position of the farthest minima from the centre of the sources?

   a)60^0 b) 30^0 c) 45^0 d) 90^0

3. Two slits in young's interference experiment have width in the ratio 1:4 Find the ratio of intensity at the maxima and minima in their interference?

   a)27/8 b) 8/27 c) 9/1 d) 4/9

4. A beam of light consisting of two wave lengths 6500 Åand 5200 A^0 is used to obtain interference fringes in a young's double slit experiment find the distance of the third bright fringe on the screen from the central maximum for the wavelength 6500Å

   a) $1.17x10^{-3}$m b) $2.27x10^{-4}$m c) $1.87x10^{-3}$ m d) $2.20x10^{-3}$m

5. Plane microwaves are incident on a long slit having a width of 5.0cm calculate the wavelength of the microwaves if the first diffraction minimum is formed at $\theta=30^0$?

   a) 1.5cm b) 3.5cm c) 2cm d) 2.5cm

6. Light of wavelength 560nm goes through a pinhole of diameter 0.20 mm and falls on a wall at a distance of 2.00 m.what will be the radius of the central bright spot formed on the wall?

   a)0.68cm b) 1.28cm c) 0.24 cm d) 2.24 cm

7.Each of the four pairs of light waves arrives at a certain point on a screen. The waves have the same wavelength. At the arrived point,their amplitudes and phase differences are?

(a)$2a_0,6a_0$ and π rad (b) $3a_0,5a_0$ and π rad

(c) $9a_0,7a$ and 3π rad (d) $2a_0,2a_0$ and 0

The pairs which has greatest intensity is are

(a)I (b) II (C) II,III (d) I,IV

8. Light appears to travel in straight lines since

   (a) it not absorbed by the atmosphere (b) it is reflected by the atmosphere

   (c) its wavelength is very small (d) its velocity is very large

9. On a rainy day, a small oil film on water show brilliant colours this is due to

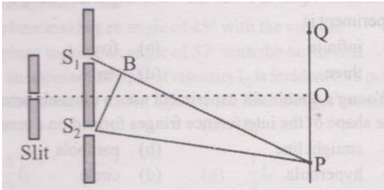
   (a)dispersion of light

   (b) interference of light

   (c) absorption of light

   (d) scattering of light

10. In the figure is shown young's double slit experiment Q is the position of the first bright fringe on the right side of O,P is the 11^{th} fringe on the other side,as measured from q. if the wavelength of the light used is $6000x10^{-10}$m,then S_1 B will be equal to



(a) 6×10^{-6}m (b) 6.6×10^{-6}m (c) 3.138×10^{-7}m (d) 3.144×10^{-7}m

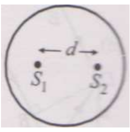
11. In young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is (separation between slits is d)

(a) $\sin^{-1}(\lambda/d)$ (b) $\sin^{-1}(\lambda/2d)$ (c) $\sin^{-1}(\lambda/3d)$ (d) $\sin^{-1}(\lambda/4d)$

12. In young's double slit experiment if the incident light consists of two wavelengths λ_1 and λ_{2}, the slit separation is d and the distance between the slit and the screen is D the maxima due to the two wave lengths will consider at a distance from the central maxima given by

(a) $\frac{\lambda_1 \lambda_2}{2Dd}$ (b) $(\lambda_1 - \lambda_2)\frac{2d}{D}$ (c) Lcm of $\lambda_1 \frac{D}{d}$ and $\lambda_2 \frac{D}{d}$ (d) HCF of $\frac{\lambda_1 D}{d}$ and $\frac{\lambda_2 D}{d}$

13. Two coherent sources separated by distance d are radiating in phase having wavelength λ.A detector moves in a big circle around the two sources in the plane of the two sources. The angular position of n=4 interference maxima is given as



(a) $\sin^{-1}\frac{n\lambda}{d}$ (b) $\cos^{-1}\frac{4\lambda}{d}$ (c) $\tan^{-1}\frac{d}{4\lambda}$ (d) $\cos^{-1}\frac{\lambda}{4d}$

14. Two polaroid's are placed in the path of unpolarized beam of intensity I_0 such that no light is emitted from the second polaroid if a third polaroid whose polarization axis makes an angle θ with the polarization axis of first polaroid, is placed between these polaroids then the intensity of light emerging from the last polaroid will be

(a) $(\frac{I_0}{8})\sin^2 2\theta$ (b) $(\frac{I_0}{4})\sin^2 2\theta$ (c) $(\frac{I_0}{2})\cos^4 2\theta$ (d) $I_0 \cos^4\theta$

15. Statement -1: No interference pattern is detected when two coherent sources are infinitely close to each other

Statement -2 : The fringe width is inversely proportional to the distance between the two sources

(a) Both statements are true and statement 2 is the correct explanation of statement 1

(b) Both statements are true but statement 2 is not the correct explanation of statement-1

(c) statement 1 is true but statement 2 is false

(d) Both are false

16. In double silt arrangement ,the source S is not symmetrically placed from the slits. It is located as shown in the figure. Find the position of the zero order maxima from the Centre of the screen. The separation between slits and screen is D(d<<D)?

(a) $(\sqrt{2}-1)$D b) $(1-\sqrt{3})$D c) $(\sqrt{3}-1)$D d) $(\sqrt{3}-\sqrt{2})$D

17. A beam of electron is used in an YDSE experiment the slit width is d when the velocity of electron is increased then

(a) no interference is observed (b) fringe width increase (c) fringe width decrease

18. In young's double –slit experiment with slit separation 0.1mm, one observes a bright fringe at angle 1/40 rad by using the light of wavelengthλ_1 . when the light of wavelength λ_2 is used a bright fringle is seen at the same angle in the same setup. Give that 1 and 2 are in the visible range (380 nmto 740 nm) ,their values are?

(a) 400 nm,500 nm (b) 625 nm,500 nm (c) 380 nm,525 nm (d) 380 nm,500nm

19. In young's double –slit experiment, the path difference, at a certain point on the screen between two interfering eaves is ($1/8^{th}$) of wavelength. The ratio of the intensity at this point to that at the centre of a bright triangle is close to

(a) 0.80 (b) 0.94 (c) 0.85 (d) 0.74

20. Calculate the limit of resolution of a telescope objective having a diameter of 200cm, if it has to detect light of wavelength 500 nm coming from a star

(a) 610 x 10^{-9} radian (b) 1525 x 10^{-9} radian
(c) 457.5 x10^{-9} radian (d) 305 x 10^{-9} radian

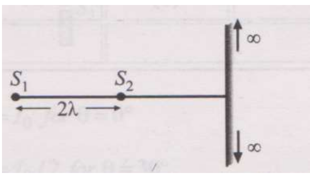
. 21. In YDSE using monochromatic light, the fringe pattern shifts by a certain distance on the screen when a

Mica sheet of refractive index 1.6 and thickness1.964 micron is introduced in the path of one of interfering waves. The mica sheet is then removed and the distance between the slits and screen is doubled. It is found that the distance between successive maxima (or minima) now is the same as the

Observed fringe shifts on the introduction of mica sheet. Caluculate the wavelength of the monochromatic light in $A^{0.}$ Is used in the experiment.

22. I n a modified YDSEthe region between screen and slits is immersed in a liquid whose refractive index varies with time as μ_t=($\frac{5}{2}$)-($\frac{R}{4}$) until it reaches a steady state value of ($\frac{5}{4}$). A glass plate of thickness 36 μm and refractive index $\frac{3}{2}$ is introduced infront of one of the slits.Find the time when it is at point O,located symmetrically on the x-axis.?

23. There are two sources kept at distances 2**λ**. A large screen is perpendicular to line joining the sources number of maxima's on the screen in this case is (**λ**=wavelength of light)



24. In an interference pattern ,at point there observe 16^{th} order maximum for λ_1 =6000 A^0 what order will be visible here if the source is replaced by light of wavelength λ_2 = 4800A^0?

25. A two slit young's experiment is done with monochromatic light of wave length 6000 A. the slits are 2mm apart and the fringes are observed on a screen placed 10cm away from the slits. Now a transparent path of thickness 0.5 mm is placed in from of one of the slits and it is found that the interference pattern shifts by 5 mm. what is the refractive index of the transparent plate to a near integer?

26 . Angular width of central maximum in the fraunhoffer diffraction pattern of a slit is measured. The slit is illuminated by light of wavelength 6000A^0 .when the slit is illuminated by light of another wavelength ,angular the angular width decreases by 30% calculate the wavelength of this light?

27. Consider the three wave represented by

Y1 = 3 sin (kx-ωt)

$Y_2 = 3 \sin (kx - \omega t + \frac{2\pi}{3})$

$Y_2 = 3 \sin(kx - \omega t + \frac{4\pi}{3})$

The amplitude of resultant of waves at $x = 0$ is

28. In double slit experiment green light (5303 A^0) falls on a double slit having a separation of 19.44m and a width of 4.05m. the number of bright fringes between the first and second diffraction minima is

29. In an interference experiment the ratio of amplitudes of coherent waves is $(a_1/a_2) = (1/3)$. The ratio of maximum and minimum intensities of fringes will be?

30. In young's double –slit experiment, the ratio of the slit's width is 4:1 the ratio of the intensity of maxima to minima, close to the central triangle on the screen, will be, value of x is?

(a) $(\sqrt{3}+1)^4.16$ (b) 9:1 (c) 25:9 (d) 4:1

KEY

1	2	3	4	5	6	7	8	9	10
b	a	c	a	d	a	d	c	b	a
11	12	13	14	15	16	17	18	19	20
c	c	b	a	a	a	c	b	c	d
21	22	23	24	25	26	27	28	29	30
5892	4	3	20	1	4200	0	5	4	9

Hints& solutions

1. We know that resultant intensity

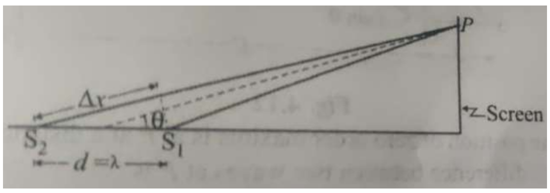
$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\emptyset$

For $\emptyset = \frac{\pi}{2}$; $I_R = I + 4I + 2\sqrt{I_1 X 4I}\ \cos\frac{\pi}{2}\ = 5I$

For $\emptyset = \pi$; $I_R = I + 4I + 2\sqrt{I X 4I}\cos \pi$

$5I - 4I = I$

2. Suspose at p the farthest minima will occur let it subtends an angle θ at the centre of the sources



The path difference $\Delta x = S_2P - S_1P$

$= d\cos\theta$

$= \boldsymbol{\lambda}\cos\theta$

The maximum path difference can be

$\Delta x_{max} = \boldsymbol{\lambda}$; when $\cos\theta=1$ or $\theta=0^0$

and minimum path difference

$\Delta x_m = 0$; when $\cos\theta=0$ or $\theta = 90^0$

Thus in between these two postions there is only one minima for which $\Delta_x=\frac{\lambda}{2}$. Thus

$\frac{\lambda}{2}= \boldsymbol{\lambda}\cos\theta$

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

$\theta = 60^0$

3.The intensity of the waves is proportional to the area of the slit. Thus $I_1/I_2=b_1 l/b_2 l=\frac{1}{4}$

If a_1 and a_2 are the amplitudes of the waves, then

$I_1/I_2=a_1^2/a_2^2=\frac{1}{4}$

$\frac{a_1}{a_2}=\frac{1}{2}$

The ratio $\frac{I_{max}}{I_{min}}=\frac{(a_1+a_2)^2}{(a_1-a_2)^2}$

$=\frac{(1+2)^2}{(1-2)^2}=\frac{9}{1}$

4. For bright fringe $y_n = \frac{n\,D\lambda}{d}$

For third bright n=3

$\therefore y_3 = \frac{3\,D\lambda}{d}$

$= 3x\frac{(120X10^{-2})X6500x10^{-10}}{2X10^{-3}}$

$=1.17X10^{-3}$ m

5. $\sin\theta = \frac{\lambda}{d}$

$\theta = 30^0$

$sin 30^0=\frac{\lambda}{5}$

$\boldsymbol{\lambda}=5X\frac{1}{2}$

2.5cm

6. $R= 1.22\frac{\lambda D}{d}$

$= \frac{1.22x(560x10^{-9})x2}{0.20X10^{-3}}$=0.68cm

7. $I_1 = (2a_0)^2 + (6a_0)^2 + 2X2a_0x6a_0\cos\pi$

16 a_0^2

$I_2 = (3a_0)^2 + (5a_0)^2 + 2X3a_0x5a_0\cos\pi$

$= 4\ a0^2 a_0$

$$I_3 = (9a_0)^2 + (7a_0)^2 + 2\times 9a_0 \times 7a_0 \cos 3\pi$$

$$= 4{a_0}^2$$

$$I_4 = (2a_0)^2 + (2a_0)^2 + 2\times 2a_0 \times 2a_0 \cos 0$$
$$= 16{a_0}^2$$

8. Its wave length is very small.

9. Interference of light .

10. Path difference ,$S_1B = \Delta x = n\lambda$.
As Pis the position of 11th fringe from Q,so from Q it will be 10

$\therefore \Delta x = n\lambda = 10x6000x10^{-10}$

$= 6x10^{-6}$ m

11.If a is the amplitude of the wave then

$(I_{max})/4 = a^2 = a^2 + a^2 + 2aa\cos\emptyset$

Or $\cos\emptyset = \frac{1}{2}$

Or $\emptyset = \frac{2\pi}{3}$

Corresponding path difference,

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

$= \frac{2\pi/3)\ X\lambda}{2\pi} = \frac{\lambda}{3}$

So d $\sin\theta = \frac{\lambda}{3}$

Or $\theta = \sin^{-1}(\frac{\lambda}{3d})$.

12. $y_n = \frac{nD\lambda_1}{d} = \frac{(n+1)D\lambda_2}{d}$

13 $\cos^{-1}\frac{4\lambda}{d}$

14. $\frac{I_0}{8} Sin^2 2\theta$

15. $\beta = \frac{D\lambda}{d}$.when d $\rightarrow$0, $\beta \rightarrow \infty$,and so fringes will not be seen over the screen

16.$\Delta x = (SS_2 + S_2P) - (SS_1 + S_1P)$

$= -(SS_1 - SS_2) + (S_2P - S_1P)$

$=-(\sqrt{2d}-d)+d\sin\theta$

For small θ, $\sin\theta=\tan\theta=y_0/d$

$\Delta x=-(\sqrt{2d}-d)+dy_0/d$

For zero order maxima, $\Delta x=0$

Or $0=-(\sqrt{2\,d}-d)+dy_0/D$

$Y_0=(\sqrt{2}-1)D$

17. $\lambda=\frac{h}{mv}$, so with the increase in velocity of the electron wavelength decreases , and so fringe width decreases

18. Path difference = $d\sin\theta=dx\theta=(0.1mm)$

(1/40)=2.5X10-3mm=2500nm

For bright fringes ,path difference =nλ

So, $2500=n\lambda 1=m\,\lambda 2$

n=4, m=5

0r $\lambda 1=2500/4=625$ nm

$\lambda 2=2500/5=500$ nm

625 nm, 500 nm

19. The phase difference between two waves is given by

(Δx)x(2π/ λ)=(λ/8) x(2π/ λ)= π/4

So, the intensity at this point is

$I=I_0\cos^2(\emptyset/2)$

$I=I_0\cos^2(\pi/8)$

$I=I_0(0.9238)^2$

$\frac{I}{I_0}=0.853$

20. The limit of resolution,

$\theta\Delta=1.22\frac{\lambda}{a}=[(1.22X500X10^{-19})/(200X10^{-2})]=3.05X10^{-7}$raddian$=305x10^{-9}$ radian

$305x10^{-9}$radian

21.The shift produced in the fringes is

$\Delta=\frac{D}{d}(\mu-1)t$

When distance between slits and screen is doubled the length width

$\beta=\frac{(2D)\lambda}{d}$

According to the given condition

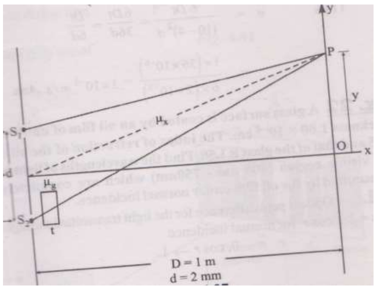
$\frac{D}{d}(\mu - 1)t = \frac{(2D)\lambda}{d}$

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

$= \frac{(1.6-1)X1.964X10^{-6}}{2}$

=5982A0

22.



The optical path difference between lights start from S_1 and S_2 μ_t

$\Delta x = [S_{2liquid}p + (\mu_g - \mu_t)t] - (s_1p)_{liquid}$

$= (s_2p - s_1p)_{liquid} + (\mu_g - \mu_t)t$

$= \mu_l = (s_2p - s_1p)_{air} + (\mu_g - \mu_t)_t$

$$\Delta x = \mu_t \alpha \frac{y}{D} + (\mu_g - \mu_l)t$$

For central maxima, $\Delta x = 0$

(or) $$0 = \mu_l \frac{dy}{D} + (\mu_g - \mu_l)t$$

Which given

$$y = \frac{-D(\mu_g - \mu_l)t}{d\mu_l}$$

$$= \frac{-D\left[\frac{3}{2} - \left(\frac{5}{2} - \frac{T}{4}\right)\right]l}{d\left[\frac{5}{2} - \frac{T}{4}\right]}$$

$$= \frac{D\left[1 - \frac{T}{4}\right]t}{d\left[\frac{5}{2} - \frac{T}{4}\right]} = \frac{D(4-T)}{d(10-T)}$$

$T = 4S$

23. $\Delta x_{\max} = 0, \Delta x_{\max} = 2\lambda$

Theoritical maximas are = 2n+1

=2x2+1=5

But on the screen there will be 3 maximas

24. The distance of n^{th} maximum from central maxima is given by

$$Y_n = n\frac{D\lambda}{d}$$

For Yn to be constant, $n\lambda = constant\ thus$

$n1\lambda1 = n2\ \lambda2$

$n2=n1\ \lambda1/\ \lambda2 =\frac{16x6000}{4800}=20$

25. Given d=2 x10-3 m,D=10x10-2m D=5x10-3 m.

The displacement of fringe pattern is given by Δ=

$\Delta=\frac{D(\mu-I)t}{d}$

Or 5x10-3 =10x10-2(μ-1)X0.5x10-3/2x10-3

$$\mu = 1.2$$

26. The angular width of central maxima is,

$$\alpha\alpha\lambda$$

For two wavelengths λ_1 and λ_2 , we have

$$\frac{\alpha_1}{\alpha_2}=\frac{\lambda_1}{\lambda_2}$$

$$\frac{\alpha}{0.70\alpha}=\frac{6000}{\lambda_2}$$

$$\lambda_2 = 4200A^0$$

27. Phase difference between every two waves is 120^0. So resultant amplitude=0

28. λg=5303 Å,d=19.44 m,a=4.05 m

For diffraction location of first minima and second minima

$Y_1=D\lambda/a$, $y_2=2D\lambda/a$

$Y_2 - y_1=(2D\lambda/a)-(D\lambda/a)=D\lambda/a$

$\beta = D\lambda/d$

$=(D\lambda/a)\ X(d/D\lambda)$

= d/a

= 19.44/4.05=5

29. $(a_1/a_2)=(1/3)$

$I_{max} = a_1+a_2$

$I_{min}=a_1-a_2$

$(I_{max}/I_{min})=[(a_1+a_2)^2/(a_1-a_2)^2)]=[(1+1/3)^2/(1-1/3)^2]=(4/2)^2=4$

30. $I_1=4I_0$

$I_2=I_0$

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

$= (2\sqrt{I_0}+\sqrt{I_0})^2$

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

$=(2\sqrt{I_0}-\sqrt{I_0})^2=9I_0$

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

$=(2\sqrt{I_0}-\sqrt{I_0})^2=I_0$

$(I_{max}/I_{min})=9/1$