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STUDY PACKAGE

Subject : PHYSICS

Topic : WAVE OPTICS

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1. Theory
2. Short Revision
3. Exercise (Ex. 1 + 5 = 6)
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SHORT REVISION

1. If two coherent waves with intensity I_1 and I_2 are superimposed with a phase difference of ϕ, the resulting wave intensity is

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

(i) For maxima, optical path difference = $n\lambda$ [optical path = μ (geometrical path)]

(ii) For minima, optical path difference = $(n - \frac{1}{2})\lambda$ or $(n + \frac{1}{2})\lambda$

(iii) Phase difference $\phi = \frac{2\pi}{\lambda}$(optical path difference)

2. The phase difference between two waves at a point will depend upon

(i) the difference in path lengths of two waves from their respective sources.(geometrical path difference)

(ii) the refractive index of the medium (media)

(iii) phase difference at source (if any).

(iv) In case, the waves suffer reflection, the reflected wave differs in phase by π with respect to the incident wave if the incidence occurs in rarer medium. There would be no phase difference if incidence occures in denser medium.

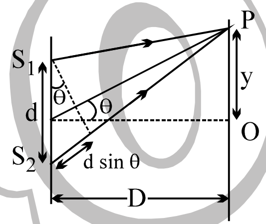
3. Young's Double Slit Experiment

(i) If d << D

$\Delta x = S_2P - S_1P = d\sin\theta$

If $\lambda \ll d$ then $\sin\theta \approx \theta \approx \tan\theta$ as when P is close to D so θ is small.

$\Delta x = \frac{dy}{D}$



(ii) For maxima $\frac{dy}{D} = n\lambda$

or $y = 0, \pm\frac{D\lambda}{d}, \pm\frac{2D\lambda}{d}, \pm$

(iii) For minima $\frac{dy}{D} = [n + (1/2)]\lambda$

or $y = \pm\frac{D\lambda}{2d}, \pm\frac{3D\lambda}{2d}$, ±, so on

(iv) Fringe width, $\beta = \frac{\lambda D}{d}$

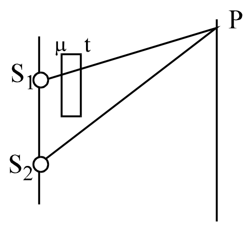
4. Displacement of fringe Pattern

When a film of thickness 't' and refractive index 'μ' is introduced in the path of one of the source's of light, then fringe shift occurs as the optical path difference changes.

Optical path difference at P.

$\Delta x = S_2P - [S_1P + \mu t - t]$

$= S_2P - S_1P\ (\mu - 1)t = y.(d/D) - (\mu - 1)t$

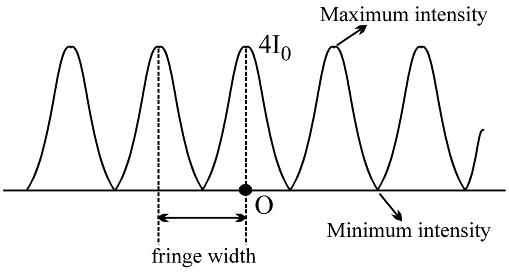


⇒ The fringe shift is given by $\Delta y = \dfrac{D(\mu - 1)t}{d}$

5. Intensity Variation on Screen

If I_0 is the intensity of light beam coming from each slit, the resultant intensity at a point where they have a phase difference of ϕ is

$$I = 4I_0 \cos^2 \frac{\phi}{2}, \text{ where } \phi = \frac{2\pi(d \sin\theta)}{\lambda}$$



6. Interference at thin film

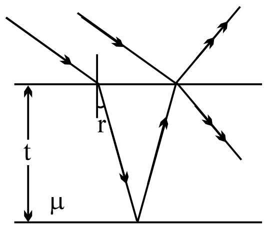
optical path difference $= 2\mu t \cos r$

$= 2\mu t$ (in case of near normal incidence)

For interference in reflected light

(i) Condition of minima $2\mu t \cos r = n\lambda$

(ii) Condition of maxima $2\mu t \cos r = \left(n + \frac{1}{2}\right)\lambda$



EXERCISE – I

Q.1 In a Young's double slit experiment for interference of light, the slits are 0.2 cm apart and are illuminated by yellow light (λ = 600 nm). What would be the fringe width on a screen placed 1 m from the plane of slits if the whole system is immersed in water of index 4/3?

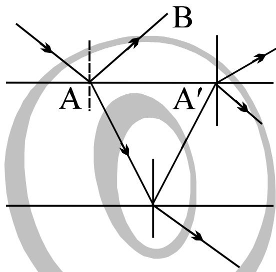
Q.2 In Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength of the light is changed to 400 nm, find the number of fringes observed in the same segment.

Q.3 In the ideal double slit experiment, when a glass plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wavelength λ), the intensity at the position where the central maximum occurred previously remains unchanged. find the minimum thickness of the glass plate.

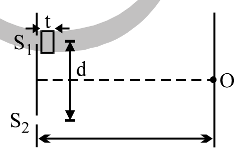
Q.4 One slit of a double slit experiment is covered by a thin glass plate of refractive index 1.4 and the other by a thin glass plate of refractive index 1.7. The point on the screen, where central bright fringe was formed before the introduction of the glass sheets, is now occupied by the 5^{th} bright fringe. Assuming that both the glass plates have same thickness and wavelength of light used is 4800 Å, find their thickness.

Q.5 Three identical monochromatic points sources of light emit light of wavelength λ coherently and in phase with each other. They are placed on the x-axis at the points x = – d, 0 and d. find the minimum value of d/λ for which there is destructive interference with almost zero resultant intensity at points on the x-axis having x > > d.

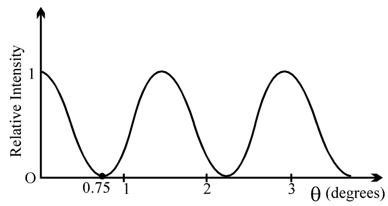
Q.6 A ray of light of intensity I is incident on a parallel glass-slab at a point A as shown in figure. It undergoes partial reflection and refraction. At each reflection 20% of incident energy is reflected. The rays AB and A′ B′ undergo interference. Find the ratio I_{max}/I_{min}.



Q.7 The figure shows the Young's double slit experiment with a mica sheet of thickness t and refractive index μ, introduced in front of S_1. If the mica-sheet is removed from earlier position and placed in front of S_2 find the number of fringes crossing O.



Q.8 Light of wavelength 520 nm passing through a double slit, produces interference pattern of relative intensity versus deflection angle θ as shown in the figure. find the separation d between the slits.



Q.9 In Young's double slit experiment the slits are 0.5 mm apart and the interference is observed on a screen at a distance of 100 cm from the slit. It is found that the 9th bright fringe is at a distance of 7.5 mm from the second dark fringe from the centre of the fringe pattern on same side. Find the wavelength of the light used.

Q.10 In a YDSE apparatus, d = 1mm, λ = 600nm and D = 1m. The slits produce same intensity on the screen. Find the minimum distance between two points on the screen having 75% intensity of the maximum intensity.

Q.11 The distance between two slits in a YDSE apparatus is 3mm. The distance of the screen from the slits is 1m. Microwaves of wavelength 1 mm are incident on the plane of the slits normally. Find the distance of the first maxima on the screen from the central maxima.

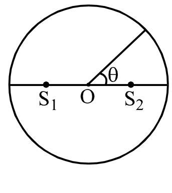
Q.12 The central fringe of the interference pattern produced by the light of wavelength 6000 Å is found to shift to the position of 4^{th} bright fringe after a glass sheet of refractive index 1.5 is introduced. Find the thickness of glass sheet.

Q.13 A lens (μ =1.5) is coated with a thin film of refractive index 1.2 in order to reduce the reflection from its surface at λ = 4800 Å. Find the minimum thickness of the film which will minimize the intensity of the reflected light.

Q.14 A long narrow horizontal slit lies 1mm above a plane mirror. The interference pattern produced by the slit and its image is viewed on a screen distant 1m from the slit. The wavelength of light is 600nm. Find the distance of first maximum above the mirror.

Q.15 A broad source of light of wavelength 680nm illuminates normally two glass plates 120mm long that meet at one end and are separated by a wire 0.048 mm in diameter at the other end. Find the number of bright fringes formed over the 120mm distance.

Q.16 Two coherent sources S_1 and S_2 separated by distance 2λ emit light of wavelength λ in phase as shown in figure. A circular wire of radius 100λ is placed in such a way that S_1S_2 lies in its plane and the midpoint of S_1S_2 is at the centre of wire. Find the angular positions θ on the wire for which intensity reduces to half of its maximum value.



Q.17 In a biprism experiment with sodium light, bands of width 0.0195 cm are observed at 100 cm from slit. On introducing a convex lens 30 cm away from the slit between biprism and screen, two images of the slit are seen 0.7 cm apart at 100 cm distance from the slit. Calculate the wavelength of sodium light.

Q.18 In a two – slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in fringe width is 3×10^{-5}. If the distance between the slits is 10^{-3} m, calculate the wavelength of the light used.

Q.19 A monochromatic light of λ = 5000 Å is incident on two slits separated by a distance of 5×10^{-4} m. The interference pattern is seen on a screen placed at a distance of 1 m from the slits. A thin glass plate of thickness 1.5×10^{-6} m & refractive index μ = 1.5 is placed between one of the slits & the screen. Find the intensity at the centre of the screen, if the intensity there is I_0 in the absence of the plate. Also find the lateral shift of the central maximum.

<u>List of recommended questions from I.E. Irodov.</u>

5.65, 5.67, 5.69, 5.70, 5.71(a) & (b), 5.72, 5.74 to 77, 5.79, 5.80

EXERCISE – II

Q.1 If the slits of the double slit were moved symmetrically apart with relative velocity v, calculate the rate at which fringes pass a point at a distance x from the centre of the fringe system formed on a screen y distance away from the double slits if wavelength of light is λ. Assume y >> d & d >> λ.

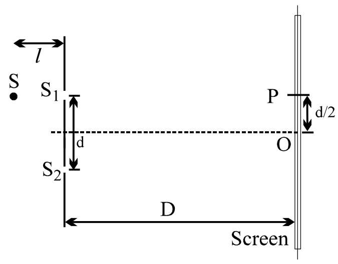
Q.2(a) A thin glass plate of thickness t and refractive index μ is inserted between screen & one of the slits in a Young's experiment. If the intensity at the centre of the screen is I, what was the intensity at the same point prior to the introduction of the sheet.

(b) One slit of a Young's experiment is covered by a glass plate (μ_1 = 1.4) and the other by another glass plate (μ_2 = 1.7) of the same thickness. The point of central maxima on the screen, before the plates were introduced is now occupied by the third bright fringe. Find the thickness of the plates, the wavelength of light used is 4000 Å.

Q.3 A source S is kept directly behind the slit S_1 in a double-slit apparatus. What will be the phase difference at P if a liquid of refraction index μ is filled; (wavelength of light in air is λ due to the source, assume l >> d, D >> d).

(i) between the screen and the slits.

(ii) between the slits & the source S. In this case find the minimum distance between the points on the screen where the intensity is half the maximum intensity on the screen.



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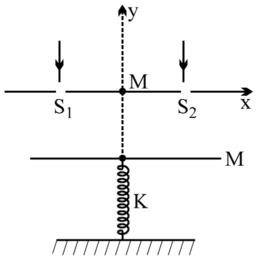
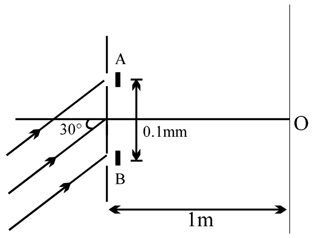
Q.4 Two slits S_1 & S_2 on the x – axis & symmetric with respect to y-axis are illuminated by a parallel monochromatic light beam of wavelength λ . The distance between the slits is d (>> λ). Point M is the mid point of the line S_1S_2 & this point is considered as the origin. The slits are in horizontal plane. The interference pattern is observed on a horizontal plate (acting as screen) of mass M, which is attached toone end of a vertical spring of spring constant K. The other end of the spring is fixed to ground. At t = 0 the plate is at a distance D(>>d) below the plane of slits & the spring is in its natural length. The plate is left from rest from its initial position . Find the x & y co-ordinates of the nth maxima on the plate as a function of time. Assume that spring is light & plate always remains horizontal.



Q.5 In a YDSE a parallel beam of light of wavelength 6000 Å is incident on slits at angle of incidence 30º. A & B are two thin transparent films each of refractive index 1.5. Thickness of A is 20.4 μm. Light coming through A & B have intensities I & 4I respectively on the screen. Intensity at point O which is symmetric relative to the slits is 3 I . The central maxima is above O.



(a) What is the maximum thickness of B to do so. Assuming thickness of B to be that found in part (a) answer the following parts.

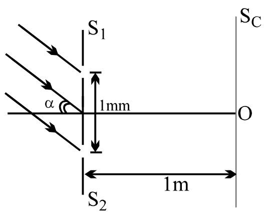
(b) Find fringe width, maximum intensity & minimum intensity on screen.

(c) Distance of nearest minima from O.

(d) Intensity at 5 cm on either side of O.

Q.6 In a YDSE experiment, the distance between the slits & the screen is 100 cm . For a certain distance between the slits, an interference pattern is observed on the screen with the fringe width 0.25 mm. When the distance between the slits is increased by Δd = 1.2 mm, the fringe width decreased to n = 2/3 of the original value. In the final position, a thin glass plate of refractive index 1.5 is kept in front of one of the slits & the shift of central maximum is observed to be 20 fringe width. Find the thickness of the plate & wavelength of the incident light.

Q.7 A plane wave of mono chromatic light of wavelength 6000Å is incident on the plane of two slits s_1 and s_2 at angle of incidence $\alpha = (1.8/\pi)^0$. The widths of s_1 and s_2 are w and 2w respectively. A thin transparent film of thickness 4μm and R.I. 3/2 is placed infront of s_1. It absorbs 50% light energy and transmits the remaining. The interference is observed on the screen. Point O is equidistant from s_1 and s_2. If the maximum intensity on the screen is I then find



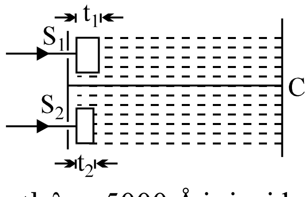
(i) intensity at 0 (ii) Minimum intensity

(iii) fringe width (iv) Distance of nearest maxima from 0

(v) Distance of central maxima from 0. (vi) intensity at 4mm from 0 upwards.

Q.8 A central portion with a width of d = 0.5 mm is cut out of a convergent lens having a focal length of 20 cm. Both halves are tightly fitted against each other and a point source of monochromatic light (A = 2500Å) is placed in front of the lens at a distance 10 cm. Find the maximum possible number of interference bands that can be observed on the screen.

Q.9 A screen is at a distance D = 80 cm from a diaphragm having two narrow slits S_1 and S_2 which are d = 2 mm apart. Slit S_1 is covered by a transparent sheet of thickness t_1 = 2.5 μm and S_2 by another sheet of thickness t_2 = 1.25 μm as shown in figure. Both sheets are made of same material having refractive index μ = 1.40. Water is filled in space between diaphragm and screen. A monochromatic light beam of wavelength λ = 5000 Å is incident normally on the diaphragm. Assuming intensity of beam to be uniform and slits of equal width, calculate ratio of intensity at C to maximum intensity of interference pattern obtained on the screen, where C is foot of perpendicular bisector of S_1S_2. (Refractive index of water, μ_w = 4/3)



Q.10 In a Young's double slit experiment a parallel light beam containing wavelength λ_1 = 4000Å and λ_2 = 5600Å is incident on a diaphragm having two narrow slits. Separation between the slits is d = 2 mm. If distance between diaphragm and screen is D = 40 cm, calculate :

(i) distance of first black line from central bright fringe.

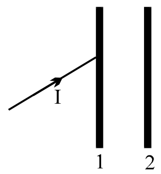
(ii) distance between two consecutive black lines.

Q.11 A plastic film with index of refraction 1.80 is put on the surface of a car window to increase the reflectivity and thereby to keep the interior of the car cooler. The window glass has index of refraction 1.60.

(a) What minimum thickness is required if light of wavelength 600 nm in air reflected from the two sides of the film is to interfere constructively?

(b) It is found to be difficult in manufacture and install coatings as thin as calculated in part (a) What is the next greatest thickness for which there will also be constructive interference?

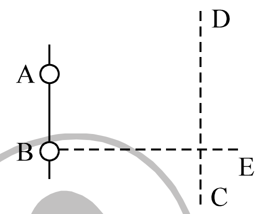
Q.12 A narrow monochromatic beam of light of intensity I is incident on a glass plate as shown in figure. Another identical glass plate is kept close to the first one & parallel to it . Each glass plaate reflects 25 % of the light incident on it & transmits the remaining . Find the ratio of the minimum & the maximum intensities in the interference pattern formed by the two beams obtained after one reflection at each plate.



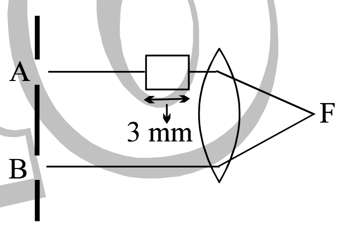
Q.13 Two coherent monochromatic sources A and B emit light of wavelength λ. The distance between A and B is d = 4λ.

(i) If a light detector is moved along a line CD parallel to AB, what is the maximum number of minima observed ?

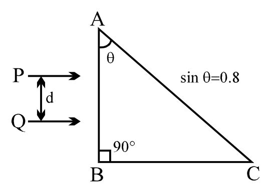
(ii) If the detector is moved along a line BE perpendicular to AB and passing through B, what is the number of maxima observed ?



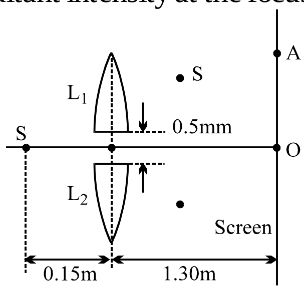
Q.14 Two identical monochromatic light sources A and B intensity10^{-15}W/m^2 produce wavelength of light 4000 $\sqrt{3}$ Å. A glass of thickness 3mm is placed in the path of the ray as shown in fig. The glass has a variable refractive index $n = 1 + \sqrt{x}$ where x (in mm) is distance of plate from left to right.Calculate resultant intensity at focal point F of the lens.



Q.15 Two parallel beams of light P & Q (separation d) each containing radiations of wavelengths 4000 Å & 5000 Å (which are mutually coherent in each wavelength separately) are incident normally on a prism as shown in figure. The refractive index of the prism as a function of wavelength is given by the relation, $\mu(\lambda) = 1.20 + \frac{b}{\lambda^2}$, where λ is in Å & b is a positive constant. The value of b is such that the condition for total reflection at the face AC is just satisfied for one wavelength & is not satisfied for the other, find the value of b. A convergent lens is used to bring these transmitted beams into focus. If the intensities of the upper & the lower beams immediately after transmission from the face AC, are 4I & I respectively, find the resultant intensity at the focus.



Q.16 In the figure shown S is a monochromatic point source emitting light of wavelength = 500 nm . A thin lens of circular shape and focal length 0.10 m is cut into two identical halves L_1 and L_2 by a plane passing through a diameter . The two halves are placed symmetrically about the central axis SO with a gap of 0.5 mm . The distance along the axis from S to L_1 and L_2 is 0.15 m, while that from L_1 & L_2 to O is 1.30 m . The screen at O is normal to SO .

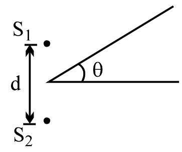


(i) If the third intensity maximum occurs at the point A on the screen, find the distance OA.

(ii) If the gap between L_1 & L_2 is reduced from its original value of 0.5 mm, will the distance OA increase, decrease or remain the same ?

EXERCISE – III

Q.1 In an interference arrangement similar to Young's double- slit experiment, the slits S_1 & S_2 are illuminated with coherent microwave sources, each of frequency 10^6 Hz. The sources are synchronized to have zero phase difference. The slits are separated by a distance d = 150.0 m . The intensity $I(\theta)$ is measured as a function of θ, where θ is defined as shown . If I_0 is the maximum intensity then $I(\theta)$ for $0 \le \theta \le 90^\circ$ is given by : [JEE '95]



(A) $I(\theta) = \frac{I_0}{2}$ for $\theta = 30^\circ$ (B) $I(\theta) = \frac{I_0}{4}$ for $\theta = 90^\circ$

(C) $I(\theta) = I_0$ for $\theta = 0^\circ$ (D) $I(\theta)$ is constant for all values of θ .

Q.2 In YDSE the separation between slits is 2×10^{-3} m where as the distance of screen from the plane of slits is 2.5 m . A light of wavelengths in the range 2000 – 8000 Å is allowed to fall on the slits . Find the wavelength in the visible region that will have maximum intensity on the screen at 10^{-3} m from the central maxima. Also find the wavelengths that will have maximum intensity at that point of screen in the infra – red as well in the ultra-violet region. [REE '96]

Q.3 A double – slit apparatus is immersed in a liquid of refractive index 1.33 . It has slit separation of 1 mm & distance between the plane of the slits & screen is 1.33 m . The slits are illuminated by a parallel beam of light whose wavelength in air is 6300 Å .

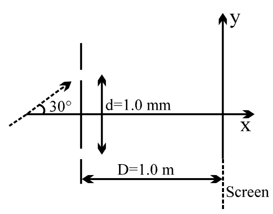
(a) Calculate the fringe width .

(b) One of the slits of the apparatus is covered by a thin glass sheet of refractive index 1.53 . Find the smallest thickness of the sheet to bring the adjacent minima on the axis.

Q.4 In Young's experiment, the source is red light of wavelength 7×10^{-7} m . When a thin glass plate of refractive index 1.5 at this wavelength is put in the path of one of the interfering beams, the central bright fringe shifts by 10^{-3} m to the position previously occupied by the 5th bright fringe . Find the thickness of the plate . When the source is now changed to green light of wavelength 5×10^{-7} m, the central fringe shifts to a position initially occupied by the 6th bright fringe due to red light . Find the refractive index of glass for the green light . Also estimate the change in fringe width due to the change in wavelength. [JEE '97(I)]

Q.5 In a Young's experiment, the upper slit is covered by a thin glass plate of refractive index 1.4 while the lower slit is covered by another glass plate having the same thickness as the first one but having refractive index 1.7 . Interference pattern is observed using light of wavelength 5400 Å . It is found that the point P on the screen where the central maximum (n = 0) fell before the glass plates were inserted now has 3/4 the original intensity . It is further observed that what used to be the 5th maximum earlier, lies below the point P while the 6th minimum lies above P. Calculate the thickness of the glass plate. (Absorption of light by glass plate may be neglected) . [JEE '97 (II)]

Q.6 A coherent parallel beam of microwaves of wavelength $\lambda = 0.5$ mm falls on a Young's double slit apparatus. The separation between the slits is 1.0 mm. The intensity of microwaves is measured on screen placed parallel to the plane of the slits at a distance of 1.0 m from it, as shown in the figure.



(a) If the incident beam falls normally on the double slit apparatus, find the y – coordinates of all the interference minima on the screen .

(b) If the incident beam makes an angle of 30° with the x – axis (as in the dotted arrow shown in the figure), find the y – coordinates of the first minima on either side of the central maximum. [JEE '98]

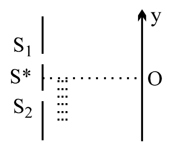
Q.7 In a Young's double slit arrangement, a source of wavelength 6000 Å is used. The screen is placed 1 m from the slits . Fringes formed on the screen, are observed by a student sitting close to the slits. The student's eye can distinguish two neighbouring fringes if they subtend an angle more than 1 minute of arc. Calculate the maximum distance between the slits so that the fringes are clearly visible. Using this information calculate the position of 3rd bright & 5th dark fringe from the centre of the screen. [REE '98]

Q.8 A young's double slit experiment is performed using light of wavelength λ = 5000Å, which emerges in phase from two slits a distance $d = 3 \times 10^{-7}$m apart. A transparent sheet of thickness $t = 1.5 \times 10^{-7}$m is placed over one of the slits. The refractive index of the material of this sheet is $\mu = 1.17$. Where does the central maximum of the interference pattern now appear? [REE '99]

Q.9 As a wave propagates,
(A) the wave intensity remains constant for a plane wave
(B) the wave intensity decreases as the inverse of the distance from the source for a spherical wave
(C) the wave intensity decreases as the inverse square of the distance from the source for a spherical wave
(D) total intensity of the spherical wave over the spherical surface centered at the source remains same at all times. [JEE '99]

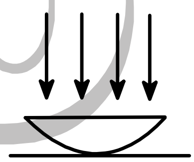
Q.10 In a wave motion $y = a \sin(kx-\omega t)$, y can represent [JEE '99]
(A) electric field (B) magnetic field (C) displacement (D) pressure

Q.11 The Young's double slit experiment is done in a medium of refractive index 4/3. A light of 600 nm wavelength is falling on the slits having 0.45 mm separation. The lower slit S_2 is covered by a thin glass sheet of thickness 10.4 μm and refractive index 1.5. The interference pattern is observed on a screen placed 1.5 m from the slits as shown [JEE'99]



(a) Find the location of the central maximum (bright fringe with zero path difference) on the y-axis.
(b) Find the light intensity at point O relative to the maximum fringe intensity.
(c) Now, if 600 nm light is replaced by white light of range 400 to 700 nm, find the wavelengths of the light that form maxima exactly at point O .
[All wavelengths in this problem are for the given medium of refractive index 4/3. Ignore dispersion]

Q.12 A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat glass plate as shown. The observed interference fringes from this combination shall be [JEE '99]



(A) straight
(B) circular
(C) equally spaced
(D) having fringe spacing which increases as we go outwards.

Q.13 In a double slit experiment, instead of taking slits of equal widths, one slit is made twice as wide as the other. Then, in the interference pattern [JEE '(Scr.) 2000]
(A) the intensities of both the maxima and the minima increase.
(B) the intensity of the maxima increases and the minima has zero intensity.
(C) the intensity of the maxima decreases and that of the minima increases.
(D) the intensity of the maxima decreases and the minima has zero intensity.

Q.14 A glass plate of refractive index 1.5 is coated with a thin layer of thickness t and refractive index 1.8. Light of wavelength λ travelling in air is incident normally on the layer . It is partly reflected at the upper and the lower surfaces of the layer and the two reflected rays interfere. Write the condition for their constructive interference. If λ = 648 nm, obtain the least value of t for which the rays interfere constructively. [JEE '2000]

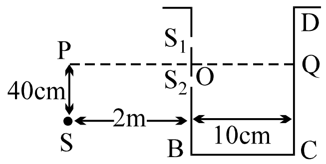
Q.15 Two coherent light sources A and B with separation 2λ are placed on the x−axis symmetrically about the origin. They emit light of wavelength λ. Obtain the positions of maxima on a circle of large radius lying in the xy-plane and with centre at the origin. [REE '2000]

Q.16 Two beams of light having intensities I and 4I interfere to produce a fringe pattern on a screen. 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 [JEE (Scr.) 2001]
(A) 2I (B) 4I (C) 5I (D) 7I

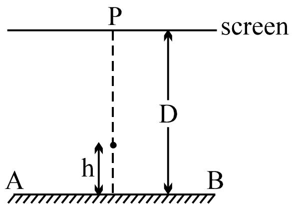
Q.17 In a young double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength of light is changed to 400 nm, number of fringes observed in the same segment of the screen is given by [JEE (Scr.) 2001]

(A) 12 (B) 18 (C) 24 (D) 30

Q.18 A vessel ABCD of 10 cm width has two small slits S_1 and S_2 sealed with identical glass plates of equal thickness. The distance between the slits is 0.8 mm. POQ is the line perpendicular to the plane AB and passing through O, the middle point of S_1 and S_2. A monochromatic light source is kept at S, 40 cm below P and 2 m from the vessel, to illuminate the slits as shown in the figure below. Calculate the position of the central bright fringe on the other wall CD with respect to the line OQ. Now, a liquid is poured into the vessel and filled up to OQ. The central bright fringe is found to be at Q. Calculate the refractive index of the liquid. [JEE'2001]



Q.19 A point source S emitting light of wavelength 600 nm is placed at a very small height h above the flat reflecting surface AB (see figure). The intensity of the reflected light is 36% of the incident intensity. Interference fringes are observed on a screen placed parallel to the reflecting surface at a very large distance D from it. [JEE'2002]

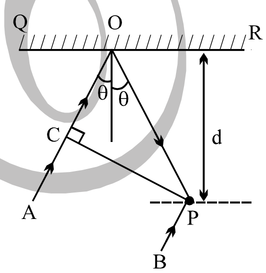


(a) What is the shape of the interference fringes on the screen?

(b) Calculate the ratio of the minimum to the maximum intensities in the interference fringes formed near the point P (shown in the figure).

(c) If the intensities at point P corresponds to a maximum, calculate the minimum distance through which the reflecting surface AB should be shifted so that the intensity at P again becomes maximum.

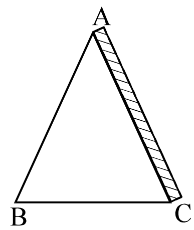
Q.20 In the adjacent diagram, CP represents a wavefront and AO and BP, the corresponding two rays. Find the condition on θ for constructive interference at P between the ray BP and reflected ray OP. [JEE (Scr.) 2003]



(A) $\cos\theta = \frac{3\lambda}{2d}$ (B) $\cos\theta = \frac{\lambda}{4d}$

(C) $\sec\theta - \cos\theta = \frac{\lambda}{d}$ (D) $\sec\theta - \cos\theta = \frac{4\lambda}{d}$

Q.21 A prism ($\mu_P = \sqrt{3}$) has an angle of prism A = 30°. A thin film (μ_f = 2.2) is coated on face AC as shown in the figure. Light of wavelength 550 nm is incident on the face AB at 60° angle of incidence. Find [JEE' 2003]



(i) the angle of its emergence from the face AC and

(ii) the minimum thickness (in nm) of the film for which the emerging light is of maximum possible intensity.

Q.22 In a YDSE bi-chromatic light of wavelengths 400 nm and 560 nm are used. The distance between the slits is 0.1 mm and the distance between the plane of the slits and the screen is 1 m. The minimum distance between two successive regions of complete darkness is [JEE' 2004 (Scr)]

(A) 4 mm (B) 5.6 mm (B) 14 mm (D) 28 mm

Q.23 In a Young's double slit experiment, two wavelengths of 500 nm and 700 nm were used. What is the minimum distance from the central maximum where their maximas coincide again? Take $D/d = 10^3$. Symbols have their usual meanings. [JEE 2004]

Q.24 In Young's double slit experiment maximum intensity is I than the angular position where the intensity becomes $\frac{I}{4}$ is: [JEE' 2005 (Scr)]

(A) $\sin^{-1}\left(\frac{\lambda}{d}\right)$ (B) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$ (C) $\sin^{-1}\left(\frac{\lambda}{2d}\right)$ (D) $\sin^{-1}\left(\frac{\lambda}{4d}\right)$

Q.25 In Young's double slit experiment an electron beam is used to form a fringe pattern instead of light. If speed of the electrons is increased then the fringe width will : [JEE' 2005 (Scr)]

(A) increase (B) decrease
(C) remains same (D) no fringe pattern will be formed

ANSWER KEY

EXERCISE – I

Q.1 0.225 mm **Q.2** 18 **Q.3** 2λ **Q.4** 8 μm

Q.5 1/3 **Q.6** 81 : 1 **Q.7** $\frac{2(\mu-1)t}{\lambda}$ **Q.8** 1.98×10^{-2} mm

Q.9 5000Å **Q.10** 0.2 mm **Q.11** 35.35 cm

Q.12 4.8 μm **Q.13** $(25/24)\times10^{-7}$ m **Q.14** 0.15 mm **Q.15** 141

Q.16 $\pm \cos^{-1}\left(\frac{2n+1}{8}\right)$, n = 0, 1, 2, 3 & $\pi \pm \cos^{-1}\left(\frac{2n+1}{8}\right)$ n = 0, 1, 2, 3

Q.17 λ = 5850 Å **Q.18** 6000 Å **Q.19** 0, 1.5 mm

EXERCISE – II

Q.1 $\frac{x}{\lambda y}v$

Q.2 (a) $I_0 = I\sec^2\left[\frac{\pi(\mu-1)t}{\lambda}\right]$, (b) 4 μm

Q.3 (i) $\Delta\phi = \left(\frac{1}{l}+\frac{\mu}{D}\right)\frac{\pi d^2}{\lambda}$ (ii) $\Delta\phi = \left(\frac{\mu}{l}+\frac{1}{D}\right)\frac{\pi d^2}{\lambda}$; $D_{min} = \frac{\beta}{2} = \frac{\lambda D}{2d}$;

Q.4 X - coordinate = $\frac{n\lambda D'}{d}$; Y–coordinate = – D', Where D' = D + Mg/K (1– cosωt)

Q.5 (a) t_B = 120 μm (b) β = 6mm; I_{max} = 9I, I_{min} = I (c) β/6 = 1mm (d) I (at 5cm above 0) = 9I, I (at 5 cm below 0) = 3I

Q.6 λ = 600 nm, t = 24 μm

Q.7 (i) I/3, (ii) I/9, (iii) 0.6 mm, (iv) 0.2mm downwards , (v) 8mm down, (vi) I

Q.8 5 **Q.9** 3/4 **Q.10** (i) 280 μm, (ii) 560 μm

Q.11 (a) 8.33×10^{-8} m, (b) 2.5×10^{-7} m **Q.12** 1 : 49 **Q.13** (i) 8, (ii) 4

Q.14 4×10^{-15} W/m^2 **Q.15** 8.0×10^5 Å^2 , 9 I **Q.16 (i)** 1 mm **(ii)** increase

EXERCISE – III

Q.1 A, C **Q.2** 4000 Å, 8000 Å , $\frac{8000}{3}$ Å , 2000 Å **Q.3** 0.63 mm, 1.575 μm

Q.4 7 μm , 1.6 , $\frac{400}{7}$ μm (decrease) **Q.5** 9.3 μm

Q.6 (a) $\pm\frac{1}{\sqrt{15}}$, $\pm\frac{3}{\sqrt{7}}$ **(b)** $+\frac{1}{\sqrt{15}}$, $\frac{3}{\sqrt{7}}$ **Q.7** $\frac{6.48}{\pi}$; $\frac{\pi}{3.6}$ mm , $\frac{\pi}{2.4}$ mm

Q.8 y = 0.085 D ; D = distance between screen & slits **Q.9** A, C, D

Q.10 A, B, C **Q.11 (a)** y = – 13/3 mm, **(b)** intensity at O = $0.75I_{max}$ **(c)** 650 nm, 433.33 nm

Q.12 A **Q.13** A **Q.14** t = $\frac{\lambda}{7.2}$, $\frac{3\lambda}{7.2}$, ... ; $t_{minimum} = \frac{\lambda}{7.2}$ = 90 nm

Q.15 (0, – R), $\left(\frac{R}{2}, -\frac{R\sqrt{3}}{2}\right)$, (R, 0), $\left(\frac{R}{2}, \frac{R\sqrt{3}}{2}\right)$, (0, R) $\left(-\frac{R}{2}, \frac{R\sqrt{3}}{2}\right)$, (– R, 0) $\left(-\frac{R}{2}, -\frac{R\sqrt{3}}{2}\right)$

Q.16 B **Q.17** B **Q.18** (i) y = 2 cm, (ii) μ = 1.0016

Q.19 (a) circular, (b) 16, (c) 3000Å **Q.20** B **Q.21** 0, 125 nm

Q.22 D **Q.23** 3.5 mm **Q.24** B **Q.25** B