Wave Optics

JEE Main/Boards

Exercise 1

Q.1 State the essential condition for diffraction of light to occur. The light of wavelength 600mn is incident normally on a slit of width 3mm. Calculate the linear width of central maximum on a screen kept 3m away from the slit.

Q.2 (a) State the postulates of Huygens's wave theory. (b) Draw the type of wave front that correspond to a beam of light (i) coming from a very far-off source and (ii) diverging from a point source.

Q.3 In a single slit diffraction pattern, how does the angular width of central maximum change, when (i) slit width is decreased (ii) distance between the slit and screen in increased and (iii) light of smaller visible wavelength is used? Justify your answer in each case.

Q.4 Derive Snell's law of refraction using Huygens's wave theory.

Q.5 Explain with reason, how the resolving power of a compound microscope will change when (i) frequency of the incident light on the objective lens in increased, (ii) focal length of the objective lens is increased, and (iii) aperture of the objective lens is increased.

Q.6 What is a wavefront? What is the geometrical shape of a wave front of light emerging out of a convex lens, when point source is placed at its focus? Using Huygens's principles show that, for a parallel beam incident on a reflecting surface, the angle of reflection is equal to the angle of incidence.

Q.7 Two slits in Young's double slit experiment are illuminated by two different lamps emitting light of the same wavelength. Will you observe the interference pattern? Justify your answer.

Find the ratio of intensities at two points on a screen in Young's double slit experiment, when waves from the two slits have path difference of (i) 0 (ii) $\lambda/4$

Q.8 Two narrow slits are illumination by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? Draw intensity pattern obtained in the two cases. Also write two difference between the patterns obtained in the above two cases.

Q.9 Using Huygens's Principle, draw a diagram to show propagation of a wave-front originating from a monochromatic point source. Describe diffraction of light due to a single slit. Explain formation of a pattern of fringes obtained on the screen and plot showing variation of intensity with angle θ in single slit diffraction.

Q.10 What are coherent sources of light? State two conditions for two light sources to be coherent. Derive a mathematical expression for the width of interference fringes obtained in Young's double slit.

Q.11 Define resolving power of a compound microscope. How does the resolving power of a compound microscope change when

(i) refractive index of the medium between the object and objective lens increases?

(ii) wavelength of the radiation used in increased?

Q.12 State one feature by which the phenomenon of interference can be distinguished from that of diffraction. A parallel beam of light of wavelength 600nm is incident normally on a slit of width 'a'. If the distance between the slits and the screen is 0.8 m and the distance of 2^{nd} order minimum from the centre of the screen is 15 mm. Calculate the width of the slit.

Q.13 How would the angular separation of interference fringes in Young's double slit experiment change when the distance between the slits and screen is doubled?

Q.14 Define the term 'linearly polarized light'. When does the intensity of transmitted light become maximum, when a polaroid sheet is rotated between two crossed polaroids?

Q.15 In Young's double slit experiment, monochromatic light of wave length 630nm illuminates the pair of slits and produce an interference pattern in which two consecutive bright fringes are separated by 8.1mm. Another source of monochromatic light produces the interference pattern in which the two consecutive bright fringes are separated by 7.2 mm. Find the wavelength of light from the second source. What is the effect on the interference fringes if the monochromatic source is replaces by a source of white light?

Q.16 (a) In a single slit diffraction experiment, a slit of width 'd' is illuminated by red light of wavelength 650nm. For what value of 'd' will

(i) the first minimum fall at an angle of diffraction of $30°$, and

(ii) the first maximum fall at an angle of diffraction of $30°$?

(b) Why does the intensity of the secondary maximum becomes less as compared to the central maximum?

Q.17 When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a decrease in the energy carried by the light wave? Justify your answer.

Q.18 In Young's double slit experiment, the two slits 0.12 mm apart are illuminated by monochromatic light of wavelength 420 nm. The screen is 1.0 m away from the slits.

(a) Find the distance of the second (i) bright fringes, (ii) dark fringes from the central maximum.

(b) How will the fringes pattern change if the screen is moved away from the slits?

Q.19 How does an unpolarised light get polarized when passes through a polaroid?

Two polaroids are set in crossed position. A third Polaroid is placed between the two making an angle θ with the pass axis of the first Polaroid. Write the expression for the intensity of light transmitted from the second Polaroid. In what orientations will the transmitted intensity be (i) minimum and (ii) maximum?

Q.20 How does the angular separation between fringes in single-slit diffraction experiment change when the distance of separation between the slit and screen is doubled?

Q.21 For the same value of angle of incidence, the angle of refraction in three media A, B and C are $15°$, $25°$ and $35°$ respectively. In which medium would the velocity of light be minimum?

Q.22 (a) In Young's double slit experiment, derive the condition for (i) constructive interference and (ii) destructive interference at a point in the screen.

(b) A beam of light consisting of two wavelengths, 800nm and 600nm is used to obtain in the interference fringes in a Young's double slit experiment on a screen placed 1.4 m away. If the two slits are separated by 0.28 mm, calculate the least distance from the central bright maximum where the bright fringes of the two wavelengths coincide.

Q.23 (a) How does an unpolarized light incident on light on polaroid get polarized?

Describe briefly, with the help of a necessary diagram, the polarization of light by reflecting from a transparent medium.

(b) Two polaroids 'A' and 'B' are kept in crossed position. How should a third polaroid 'C' be placed between them so that the intensity of polarized light transmitted by polaroid B reduce to 1/8th of the intensity of unpolarized light incident on A?

Q.24 Two sources of intensity I_1 and I_2 undergo interference in Young's double slit experiment. Show that $\frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2$

Where a_1 and a_2 are the amplitudes of disturbance for two sources S_1 and S_2.

Q.25 Two coherent waves of equal amplitude produce interference pattern in Young's double slit experiment. What is the ratio of intensity at a point where phase different is $\pi/2$ to intensity at centre.

Exercise 2

Single Correct Choice Type

Q.1 Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are:

(A) 5I and I (B) 5I and 3I

(C) 9I and I (D) 9I and 3I

Q.2 When light is refracted into a denser medium,

(A) Its wavelength and frequency both increase

(B) Its wavelength increase but frequency remains unchanged

(C) Its wavelength decreases but frequency remain unchanged

(D) It wavelength and frequency both decrease.

Q.3 In YDSE how many maxima can be obtained on the screen if wavelength of light used is 200nm and d=700nm:

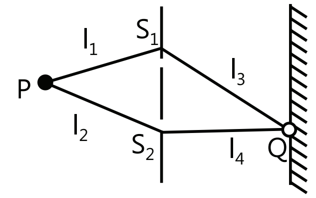
(A) 12 (B) 7

(C) 18 (D) None of these

Q.4 In Young's double slit experiment, the wavelength of red light is 7800Å and that of blue is 5200 Å. The value of n for which n^{th} bright band due to red light coincides with $(n+1)^{th}$ bright band due to blue light is:

(A) 1 (B) 2 (C) 3 (D) 4

Q.5 Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P. If, as shown in the diagram above, the light is then allowed to fall on a screen, and if n is a positive integer, the condition for destructive interference at Q is



(A) $(l_1 - l_2) = (2n+1)\lambda/2$

(B) $(l_3 - l_4) = (2n+1)\lambda/2$

(C) $(l_1 + l_2) - (l_3 + l_4) = n\lambda$

(D) $(l_1 + l_3) - (l_2 + l_4) = (2n+1)\lambda/2$

Q.6 In a young's double slit experiment, a small detector measures an intensity of illumination of I units at the centre of the fringe pattern. If one of the two (identical) slits is now covered, the measured intensity will be

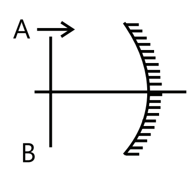
(A) 2I (B) I (C) I/4 (D) I/2

Q.7 In a Young's double slit experiment D equals the distance of screen and d is the separation between the slit. The distance of the nearest point to the central maximum where the intensity is same as that due to a single slit, is equal to

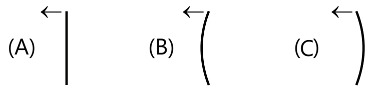
(A) $\frac{D\lambda}{d}$ (B) $\frac{D\lambda}{2d}$

(C) $\frac{D\lambda}{3d}$ (D) $\frac{2D\lambda}{d}$

Q.8 A plane wavefront AB is incident on a concave mirror as shown.

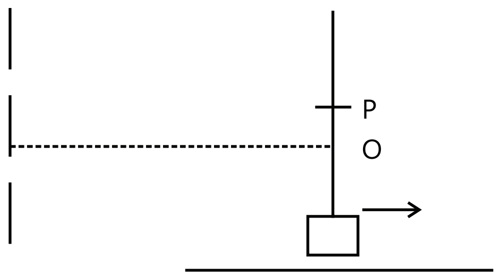


Then, the wavefront just after reflection is



(D) None of the above

Q.9 In a Young's double slit experiment, first maxima is observed at a fixed point P on the screen. Now the screen is continuously moved away from the plane of slits. The ratio of intensity at point P to the intensity at point O (center of the screen)



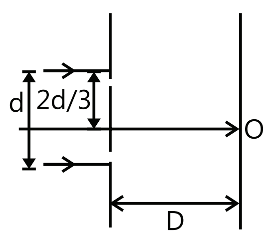
(A) Remains constant

(B) Keeps on decreasing

(C) First decrease and then increases

(D) First decreases and then becomes constant

Q.10 In the figure shown if a parallel beam of white light is incident on the plane of the slits then the distance of the white spot on the screen from O is [Assumed d<<D λ <<d]



(A) 0 (B) d/2

(C) d/3 (D) d/6

Q.11 In Young's double slit arrangement, water is filled in the space between screen and slits. Then:

(A) Fringe pattern shifts upwards but fringes width remain unchanged.

(B) Fringe width decreases and central bright fringe shift upwards.

(C) Fringe width increases and central bright fringe does not shift.

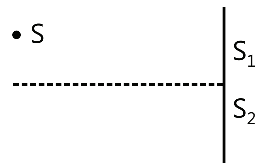
(D) Fringe width decreases and central bright fringe does not shift.

Q.12 Light of wavelength λ in air enters a medium of refractive index μ. Two points in this medium, lying along the path of this light, are at a distance x apart. The phase difference between these points is:

(A) $\frac{2\pi\mu x}{\lambda}$ (B) $\frac{2\pi x}{\mu\lambda}$

(C) $\frac{2\pi(\mu-1)x}{\lambda}$ (D) $\frac{2\pi x}{(\mu-1)\lambda}$

Q.13 In YDSE, the source placed symmetrically with respect to the slit is now moved parallel to the plane of the slits so that it is closer to the upper slit, as shown. Then,



(A) The fringe width will remain and fringe pattern will shift down

(B) The fringe width will remain same but fringe pattern will shift up

(C) The fringe width will decrease and fringe pattern will shift down

(D) The fringe width will remain same but fringe pattern will shift down

Q.14 In a YDSE with two identical slits, when the upper slit is covered with a thin, perfectly transparent sheet of mica, the intensity at the centre of screen recs to 75% of the initial value. Second minima is observed to the above this point and third maxima below it. Which of the following can not be a possible value of phase difference caused by the mica sheet.

(A) $\frac{\pi}{3}$ (B) $\frac{13\pi}{3}$

(C) $\frac{17\pi}{3}$ (D) $\frac{11\pi}{3}$

Q.15 Two monochromatic and coherent point sources of light are placed at a certain distance from each other in the horizontal plane. The locus of all those points in the horizontal plane which have constructive interference will be:

(A) A hyperbola

(B) Family of hyperbolas

(C) Family of straight lines

(D) Family of parabolas

Q.16 A circular planar wire loop is dipped in a soap solution and after taking it out, held with its plane vertical in air. Assuming thickness of film at the top to be very small, as sunlight falls on the soap film, & observer receive reflected light

(A) The top portion appears dark while the first colour to be observed as one moves down is red

(B) The top portion appears violet while the first colour to be observed as one moves down is indigo

(C) The top portion appears dark while the first colour to be observed as one moves down is violet

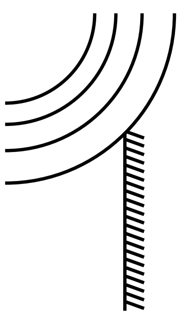
(D) The top portion appears dark while the first colour to be observed as one moves down is depends on the refractive index of the soap solution.

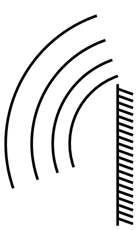
Q.17 A thin film of thickness t and index of refraction 1.33 coats a glass with index of refraction 1.50. What is the least thickness t that will strongly reflect light with wavelength 600nm incident normally?

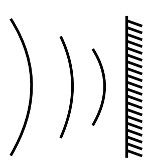
(A) 225nm (B) 300nm

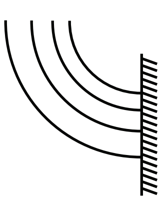
(C) 400nm (D) 450nm

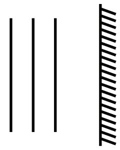
Q.18 Spherical wave fronts shown in figure, strike a plane mirror. Reflected wavefronts will be as shown in



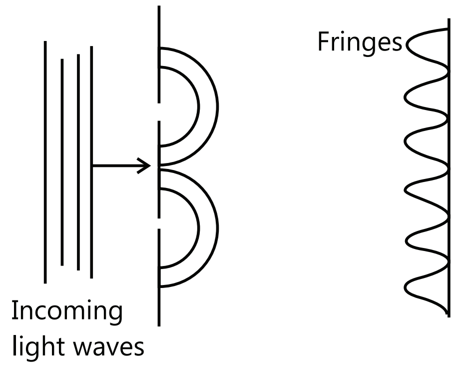
(A) 

(B) 

(C) 

(D) 

Q.19 In a Young's double slit experiment, green light is incident on the two slits. The interference pattern is observed on a screen. Which of the following changes would cause the observed fringes to be more closely spaced?



(A) Reducing the separation between the slits

(B) Using blue light instead of green light

(C) Used red light instead of green light

(D) Moving the light source further away from the slits.

Q.20 In the previous question, films of thickness t_A and t_B and refractive indices μ_A and μ_B, are placed in front of A and B respectively. If $\mu_A t_A = \mu_B t_B$, the central maximum will:

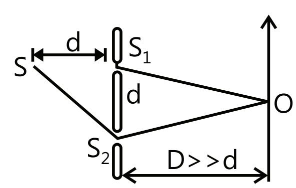
(A) Not shift

(B) Shift towards A

(C) Shift towards B

(D) Option (B), if $t_B > t_A$; option (C) if $t_B < t_A$

Q.21 To make the central fringe at the centre O, a mica sheet of refractive index 1.5 is introduced. Choose the correct statement(s).



(A) The thickness of sheet is $2(\sqrt{2}-1)d$ in front of S_1.

(B) The thickness of sheet is $(\sqrt{2}-1)d$ in front of S_2.

(C) The thickness of sheet is $2\sqrt{2}$ in front of S_1

(D) The thickness of sheet is $(2\sqrt{2}-1)d$ in front of S_1.

Previous Years' Questions

Q.1 In Young's double slit experiment, the separation between the slits is halved and the distance between the slits and the screen is doubled. The fringe width is ***(1981)***

(A) Unchanged (B) Halved

(C) Doubled (D) Quadrupled

Q.2 Two coherent monochromatic light beams of intensities I and 4I are superimposed. The maximum and minimum possible intensities in the resulting beam are ***(1988)***

(A) 5I and I (B) 5I and 3I

(C) 9I and I (D) 9I and 3I

Q.3 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. ***(2000)***

(A) The intensities of both the maxima and the minima increase

(B) The intensity of the maxima increases and the minima has zero

(C) The intensity of the maxima decreases and that minima increases.

(D) The intensity of the maxima decreases and the minima has zero.

Q.4 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 resultant intensities at A and B is ***(2001)***

(A) 2I (B) 4I

(C) 5I (D) 7I

Q.5 In a YDSE bi-chromatic light of wavelengths 400nm and 560nm is used. The distance between the slits is 0.1mm 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 ***(2004)***

(A) 4mm (B) 5.6mm

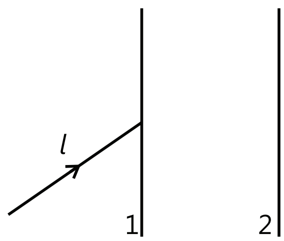
(C) 14mm (D) 28mm

Q.6 In Young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is ***(2005)***

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

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

Q.7 A narrow monochromatic beam of light intensity I is incident on a glass plate as shown in figure. Another identical glass plate is kept close to the first one-and parallel to it. Each glass plate reflects 25 per cent of the light incident on it transmits the remaining. Find the ratio of the minimum and maximum intensities in the interference pattern formed by the two beams obtained after one reflection at each plate. ***(1990)***



Q.8 Angular width of central maximum in the Fraunhofer diffraction pattern of a slit is measured. The slit is illuminated by light of wavelength 6000 Å . When the slit is illuminated by light of another wavelength, the angular width decreases by 30%. Calculate the wavelength of this light. The same decrease in the angular width of central maximum is obtained when the original apparatus is immersed in a liquid. Find refractive index of the liquid. ***(1996)***

Q.9 A double slit apparatus is immersed in a liquid of refractive index 1.33. it has slit separation of 1mm and distance between the plane of slits and screen is 1.33m. The slits are illuminated by a parallel beam of light whose wavelength in air is 6300 Å . ***(1996)***

(a) Calculate the fringes 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 minimum as the axis.

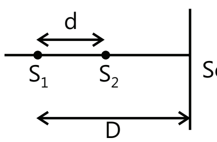
Q.10 In a Young's double slit experiment, two wavelengths of 500nm and 700nm were used. What is the minimum distance from the central maximum where their maximas coincide again? Take $D/d = 10^3$. Symbols have their usual meanings. ***(2004)***

Q.11 A beam of unpolarised light of intensity I_0 is passed through a polaroid A and then through another polaroid B which is oriented so that its principal plane makes an angle of $45°$ relative to that of A. The intensity of the emergent light is: ***(2013)***

(A) $I_0/2$ (B) $I_0/4$

(C) $I_0/8$ (D) I_0

Q.12 Two coherent point sources S_1 and S_2 are separated by a small distance 'd' as shown. The fringes obtained on the screen will be: ***(2013)***



(A) Straight lines (B) Semi-circles

(C) Concentric circles (D) Points

Q.13 Two beams, A and B, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam A has maximum intensity (and beam B has zero intensity), a rotation of Polaroid through $30°$ makes the two beams appear equally bright. If the initial intensities of the two beams are I_A and I_B respectively, then I_A/I_B equals: ***(2014)***

(A) 1 (B) 1/3

(C) 3 (D) 3/2

Q.14 The box of pin hole camera, of length L, has a hole of radius a. It is assumed that when the hole is illuminated by a parallel beam of light of wavelength λ the spread of the spot (obtained on the opposite wall of the camera) is the sum of its geometrical spread and the spread due to diffraction. The spot would then have its minimum size $\left(\text{say } b_{min}\right)$ when: ***(2016)***

(A) $a=\sqrt{\lambda L}$ and $b_{min}=\left(\dfrac{2\lambda^2}{L}\right)$

(B) $a=\sqrt{\lambda L}$ and $b_{min}=\sqrt{4\lambda L}$

(C) $a=\dfrac{\lambda^2}{L}$ and $b_{min}=\sqrt{4\lambda L}$

(D) $a=\dfrac{\lambda^2}{L}$ and $b_{min}=\left(\dfrac{2\lambda^2}{L}\right)$

JEE Advanced/Boards

Exercise 1

Q.1 Two coherent waves are described by the expressions.

$$E_1=E_0\sin\left(\frac{2\pi x_1}{\lambda}-2\pi ft+\frac{\pi}{6}\right)$$

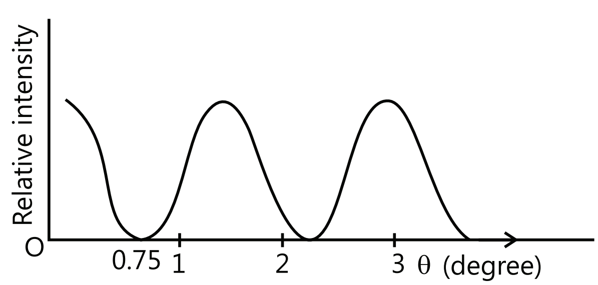
$$E_1=E_0\sin\left(\frac{2\pi x_2}{\lambda}-2\pi ft+\frac{\pi}{8}\right)$$

Determine the relationship between x_1 and x_2 that produces constructive interference when the two waves are superposed.

Q.2 In a Young's double slit experiment for interference of light, the slits are 0.2 cm apart and are illuminated by yellow light $(\lambda = 600\text{nm})$. What would be the fringe width on a screen placed 1m from the plane of slits if the whole system is immersed in water of index 4/3?

Q.3 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 100cm from the slit. It is found that the 9th bright fringe is at a distance of 7.5mm from the second dark fringe from the centre of the fringe pattern on same side. Find the wavelength of the light used.

Q.4 Light of wavelength 520nm passing through a double slit, produce interference pattern of relative intensity versus deflection angle θ as shown in the figure. Find the separation d between the slits.



Q.5 In a YDSE apparatus, d=1mm, $\lambda = 600\text{nm}$ and D=1m. The slits individually produce same intensity on the screen. Find the minimum distance between two points on the screen having 75% intensity of the maximum intensity.

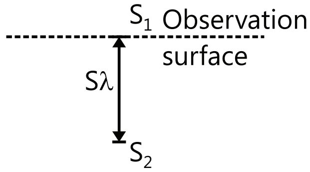
Q.6 The distance between two slits is a YDSE apparatus is 3mm. The distance of the screen from the slits is 1 m. Microwaves of wavelength 1mm are incident on the plane of the slits normally. Find the distance of the first maxima on the screen from the central maxima. Also find the total number of maxima on the screen.

Q.7 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 4800Å, find their thickness.

Q.8 A monochromatic light of $\lambda = 5000\text{Å}$ 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 1m from the slits. A thin glass plate of thickness 1.5×10^{-6} m & refractive index $\mu = 1.5$ 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 internal shift of the central maximum.

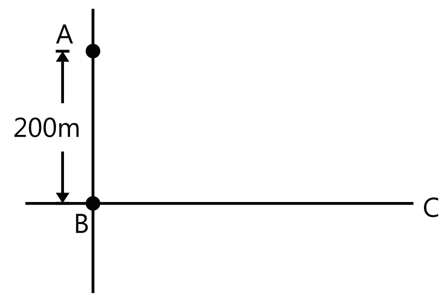
Q.9 One radio transmitter A operating at 60.0 MHz is 10.0 m from another similar transmitter B that is 180° out of the phase with transmitter. A. How far must an observe move from transmitter A toward transmitter B along the line connecting A and B to reach the nearest point where the two beams are in phase?

Q.10 Two microwaves coherent point sources emitting waves of wavelength λ are placed at 5λ distance apart. The interference is being observed on a flat non-reflecting surface along a line passing through one source, in a direction perpendicular to the line joining the two sources (refer figure).

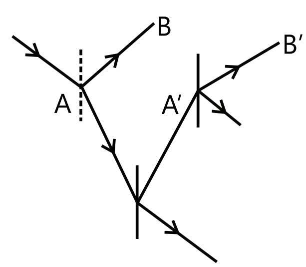


Considering λ as 4mm, calculate the position of maxima and draw shape of interference pattern. Take initial phase difference between the two sources to be zero.

Q.11 Two radio antennas radiating wave in phase are located at points A and B , 200m apart (Figure). The radio waves have a frequency of 5.80MHz. A radio receiver is moved out from point B along a line perpendicular to the line connecting A and B (line BC shown in figure). At what distance from B will there be destructive interference?



Q.12 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} .



[Neglect the absorption of light]

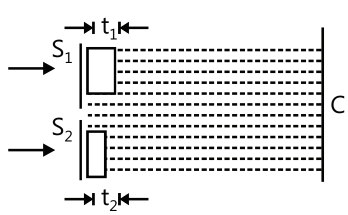
Q.13 If the slits of the double slit were moved symmetrically apart with relative velocity v, calculate the number of fringes passing per unit time at a distance x from the centre of the fringes system formed on a screen y distance away from the double slits if wavelength of light is λ. Assume y>>d & d>>λ.

Q.14 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?

Q.15 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 shift to a position initially occupied by the 6th bright fringe due to red light without the plate. Find the refractive index of glass for the green light. Also estimate the change in fringe width due to the change in wavelength.

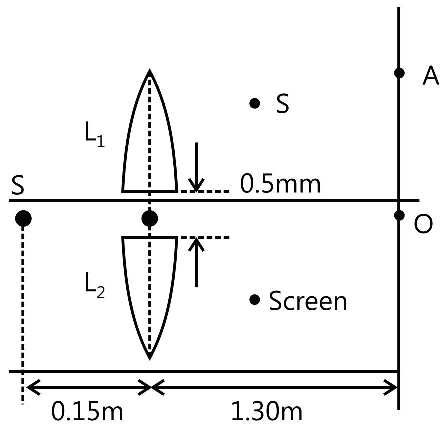
Q.16 In a Young's experiment, the upper slit is covered by a thin glass plate of refractive index 1.4 while the lower slit is covered by another glass plate having the same thickness as the first one but having refractive index 1.7. Interference pattern is observed using light of wavelength 5400 Å . 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 ¾ the original intensity. It is further observed that what used to be the 5th maximum earlier, lies below (Absorption of light by glass plate may be neglected).

Q.17 A screen is at a distance D=80cm from a diaphragm having two narrow slits S_1 is 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_1 S_2. (Refractive index of water, μ_w =4/3)



Q.18 In the figure shown S is a monochromatic point source emitting light of wavelength=500nm. A thin lens of circular shape and focal length 0.10 m is cut into 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 the S to L_1 and L_2 is 0.15m, while that from L_1 and L_2 to O is 1.30m. The screen at O is normal SO.

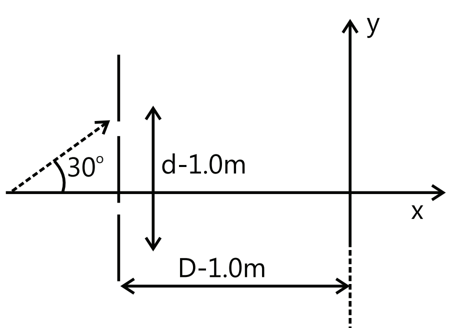
(i) If the third intensity maximum occurs at the point A on the screen, find the distance OA.



(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?

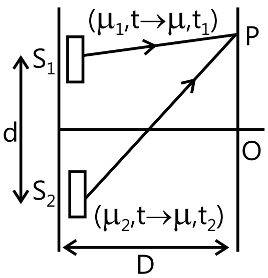
Q.19 A coherent parallel beam of microwave of wavelength $\lambda = 0.5$ mm falls on a Young's double slit apparatus. The separation between the slits is 1.0 mm. The intensity of microwaves in measured on screen placed parallel to the plane of the slits at a distance of 1.0m from it, as shown in the 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.

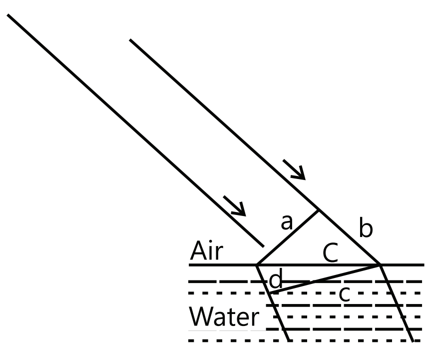
Q.20 In a YDSE with visible monochromatic light two thin transparent sheets are used in front of the slits S_1 and S_2 with μ_1 =1.6 and μ_2 =1.4 respectively. If both sheets have thickness t, the central maximum is observed at a distance of 5mm from centre O. Now the sheets are replaced by two sheets of same material refractive index $\frac{\mu_1 + \mu_2}{2}$ but having thickness t_1 & t_2 such that $t = \frac{t_1 + t_2}{2}$. Now central maximum is observed at distance of 8mm from centre O on the same side as before. Find the thickness t_1 (in μm) [Given: d=1mm. D=1m].



Exercise 2

Single Correct Choice Type

Q.1 Figure shows plane waves refracted from air to water using Huygens's principle a, b, c, d, e are lengths on the diagram. The refractive index of water w.r.t. air is the ratio:



(A) a/e (B) b/e (C) b/d (D) d/b

Q.2 In a YDSE, the central bright fringe can be identified:

(A) As it has greater intensity than the other bright fringes.

(B) As it is wider than the other bright fringes.

(C) As it is narrower than the other bright fringes.

(D) By using white light instead of single wavelength light.

Q.3 In Young's double slit experiment, the two slits act as coherent sources of equal amplitude A and wavelength λ. In another experiment with the same setup the two slits are sources of equal amplitude A and wavelength λ but are incoherent. The ratio of the average intensity of light at the midpoint of the screen in the first case to that in the second case is

(A) 1:1 (B) 2:1

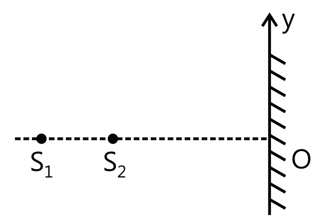
(C) 4:1 (D) None of these

Q.4 Two point monochromatic and coherent sources of light wavelength λ are placed on the dotted line in front of a large screen. The source emit waves in phase with each other. The distance between S_1 and S_2 is 'd' while their distance from the screen is much larger. Then,

(1) If $d = 7\lambda/2$, O will be a minima

(2) If $d = 4.3\lambda$, there will be a total of 8 minima on y axis.

(3) If $d = 7\lambda$, O will be a maxima.



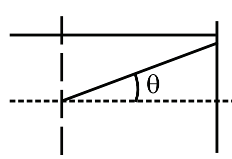
(4) If $d = \lambda$, there will be only one maxima on the screen.

Which is the set of correct statement

(A) 1, 2, & 3 (B) 2, 3 & 4

(C) 1, 2, 3 & 4 (D) 1, 3 & 4

Q.5 Two slits are separated by 0.3 mm. A beam of 500nm light strikes the slits producing an interference pattern. The number of maxima observed in the angular range- $0° < \theta < 30°$.

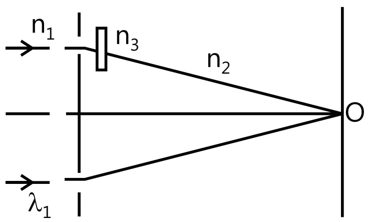


(A) 300 (B) 150 (C) 599 (D) 601

Q.6 In the above question of the light incident is monochromatic and point O is a maxima, then the wavelength of the light incident cannot be

(A) $\frac{d^2}{3D}$ (B) $\frac{d^2}{6D}$ (C) $\frac{d^2}{12D}$ (D) $\frac{d^2}{18D}$

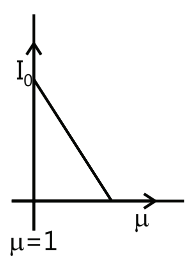
Q.7 In the figure shown in YDSE, a parallel beam of light is incident on the slit from a medium of refractive index n_1. The wavelength of light in this medium is λ_1. A transparent slab of thickness 't' and refractive index n_3 is put infront of one slit. The medium between the screen and the plane of the slits is n_2. The phase difference between the light waves reaching point 'O' (symmetrical, relative to the slits) is:

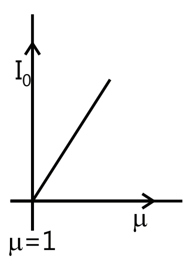


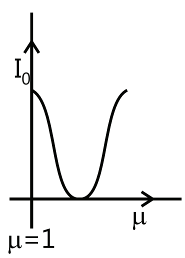
(A) $\frac{2\pi}{n_1\lambda_1}(n_3 - n_2)t$ (B) $\frac{2\pi}{\lambda_1}(n_3 - n_2)t$

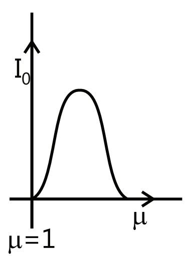
(C) $\frac{2\pi n_1}{n_2\lambda_1}\left(\frac{n_3}{n_2} - 1\right)t$ (D) $\frac{2\pi n_1}{\lambda_1}(n_3 - n_1)t$

Q.8 In A YDSE experiment if a slab whose refractive index can be varied is placed in front of one of the slits then the variation of resultant intensity at mid-point of screen with 'μ' will be best represented by $(\mu \geq 1)$. [Assumes slits of equal width and there is no absorption by slab]

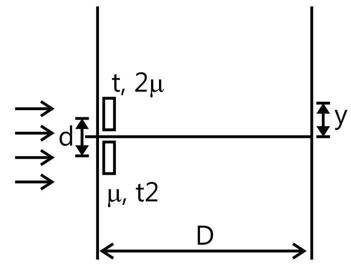
(A)


(B)


(C)


(D)


Q.9 In the YDSE shown the two slits are covered with thin sheets having thickness t & 2t and refractive index 2μ and μ. Find the position (y) of central maxima



(A) Zero (B) $\frac{tD}{d}$

(C) $-\frac{tD}{d}$ (D) None

Multiple Correct Choice Type

Q.10 In a YDSE apparatus, if we use white light then:

(A) The fringe next to the central will be red

(B) The central fringe will be white

(C) The fringe next to the central will be violet

(D) There will not be a completely dark fringe.

Q.11 If one of the slits of a standard YDSE apparatus is covered by a thin parallel sided glass slab so that it transmit only one half of the light intensity of the other, then:

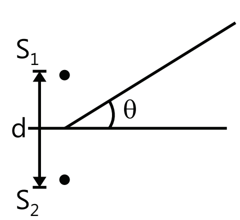
(A) The fringe pattern will get shifted towards the covered slit

(B) The fringe pattern will get shifted away from the covered slit

(C) The bright fringes will be less bright and the dark ones will be more bright

(D) The fringe width will remain unchanged.

Q.12 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=150.0m. The intensity $I(\theta)$ is measured as a function of θ at a large distance from S_1 & S_2, where θ is defined as shown if I_0 is the maximum intensity then



$I(\theta)$ for $0 \le \theta \le 90°$ is given by:

(A) $I(\theta) = \frac{I_0}{2}$ for $\theta = 30°$

(B) $I(\theta) = \frac{I_0}{4}$ for $\theta = 90°$

(C) $I(\theta) = I_0$ for $\theta = 0°$

(D) $I(\theta)$ is constant for all values of θ

Q.13 To observe a sustained interference pattern formed by two light waves, it is not necessary that they must have:

(A) The same frequency

(B) Same amplitude

(C) A constant phase difference

(D) The same intensity

Q.14 If the source of light used in a Young's Double Slit Experiment is changed from red to blue, then

(A) The fringes will become brighter

(B) Consecutive fringes will come closer

(C) The number of maxima formed on the screen increases

(D) The central bright fringe will become a dark fringe.

Q.15 In a Young's double-slit experiment, let A and B be the two slits. A thin film of thickness t and refractive index μ is placed in front of A. Let β =fringe width. The central maximum will shift:

(A) towards A (B) towards B

(C) by $t(\mu - 1)\frac{\beta}{\lambda}$ (D) by $\mu t\frac{\beta}{\lambda}$

Q.16 In a standard YDSE apparatus a thin film $(\mu = 1.5, t - 2.1\mu m)$ is placed in front of upper slit. How far above or below the centre point of the screen are two nearest maxima located? Take D=1m, d=1 mm, $\lambda = 4500Å$.(Symbols have usual meaning)

(A) 1.5mm (B) 0.6mm

(C) 0.15mm (D) 0.3mm

Assertion Reasoning Type

(A) Statement-I is true, statement-II is true and statement-II is correct explanation for statement-I

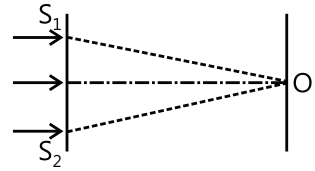
(B) Statement-I is true, statement-II is true and statement-II is NOT the correct explanation for statement-I

(C) Statement-I is true, statement-II is false

(D) Statement-I is false, statement-II is true

Q.17 Statement-I: In YDSE, as shown in figure, central bright fringe is formed at O. If a liquid is filled between plane of slits and screen, the central bright fringe is shifted in upward direction.

Statement-II: If path difference at O increases y-coordinate of central bright fringe will change.



Q.18 Statement-I: In glass, red light travels faster than blue light.

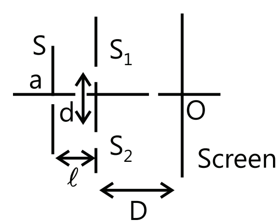
Statement-II: Red light has a wavelength longer than blue.

Q.19 Statement-I: In standard YDSE set up with visible light, the position on screen where phase difference is zero appears bright

Statement-II: In YDSE set up magnitude of electromagnetic field at central bright fringe is not varying with time.

Comprehension Type

The figure shows a schematic diagram showing the arrangement of Young's Double Slit Experiment:



Q.20 Choose the correct statement(s) related to the wavelength of light used

(A) Larger the wavelength of light larger the fringe width

(B) The position of central maxima depends on the wavelength of light used

(C) If white light is used in YDSE, then the violet forms its first maxima closest to the central maxima

(D) The central maxima of all the wavelength coincide

Q.21 If the distance D is varied, then choose the correct statement(s)

(A) The angular fringe width does not change

(B) The fringe width change in direct proportion

(C) The change in fringe width is same for all wavelengths

(D) The position of central maxima remains unhanged

Q.22 If the distance d is varied, then identify the correct statement

(A) The angular width does not change

(B) The fringe width changes in inverse proportion

(C) The positions of all maxima change

(D) The positions of all minima change

Previous Years' Questions

Q.1 A narrow slit of width 1mm is illuminated by monochromatic light of wavelength 600nm. The distance between the first minima on either side of a screen at a distance of 2 m is. ***(1994)***

(A) 1.2 cm (B) 1.2 mm

(C) 2.4 cm (D) 2.4 mm

Q.2 A parallel monochromatic beam of light is incident normally on a narrow slit. A diffraction pattern is formed on a screen placed perpendicular to the direction of the incident beam. At the first minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of the slit is ***(1998)***

(A) Zero (B) $\pi/2$

(C) π (D) 2π

Q.3 In a Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600nm is used. If the wavelength of light is changed to 400nm, number of fringes observed in the same segment of the screen is given by ***(2001)***

(A) 12 (B) 18

(C) 24 (D) 30

Q.4 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 remain unchanged. The minimum thickness of the glass-plate is ***(2002)***

(A) 2λ (B) $\frac{2\lambda}{3}$

(C) $\frac{\lambda}{3}$ (D) λ

Q.5 The phases of the light wave at c, d, e and f are ϕ_c, ϕ_d, ϕ_e and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$ ***(2007)***

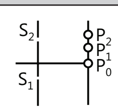
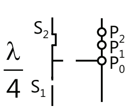
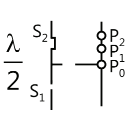
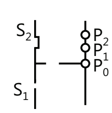
(A) ϕ_c cannot be equal to ϕ_d

(B) ϕ_d cannot be equal to ϕ_e

(C) $(\phi_d - \phi_f)$ is equal to $(\phi_c - \phi_e)$

(D) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$

Q.6 Shows four situations of standard Young's doubles slit arrangement with the screen placed away from the slits S_1 and S_2. In each of these cases $S_1P_0 = S_2P_0, S_1P_1 - S_2P_1 = \frac{\lambda}{4}$ and $S_1P_2 - S_2P_2 = \frac{\lambda}{3}$, where λ is the wavelength of the light used. In the cases B, C and D, a transparent sheet of refractive index μ and thickness t is pasted on slit S_2. The thickness of the sheets are different in different cases. The phase difference between the light waves reaching a point P on the screen from the two slits is donated by $\delta(P)$ and the intensity by I (P). Match each situation given in Column I with the statement(s) in Column II valid that situation. ***(2009)***

Column I	**Column II**
(A) 	(p) $\delta(P_0) = 0$
(B) $(\mu - 1)t = \frac{\lambda}{4}$ 	(q) $\delta(P_1) = 0$
(C) $(\mu - 1)t = \frac{\lambda}{2}$ 	(r) $I(P_1) = 0$
(D) $(\mu - 1)t = \frac{3\lambda}{4}$ 	(s) $I(P_0) > I(P_1)$
	(t) $I(P_2) > I(P_1)$

Q.7 In the Young's double slit experiment, the interference pattern is found to have an intensity ratio between the bright and dark fringes as 9. This implies that ***(1982)***

(A) The intensities at the screen due to the two slits are 5 units and 4 units respectively.

(B) The intensities at the screen due to the two slits are 4 units and 1 unit respectively

(C) The amplitude ratio is 3

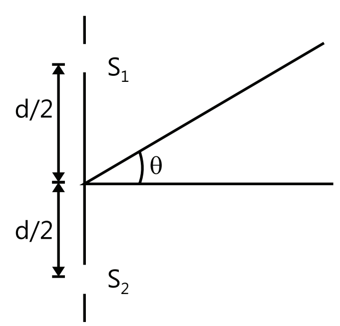
(D) The amplitude ratio is 2

Q.8 White light is used to illuminate the two slits in a Young's double slit experiment. The separation between the slits is b and the screen is at a distance d (>>b) from the slits. At a point on the screen directly in front of one of the slits, certain wavelengths are missing. Some of these missing wavelengths are

(A) $\lambda = b^2/d$ (B) $\lambda = 2b^2/d$

(C) $\lambda = b^2/3d$ (D) $\lambda = 2b^2/3d$

Q.9 In an interference arrangement similar to Young's double-slit experiment, the slits S_1 and 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=150.0m. The intensity I (θ) is measured as a function of θ where θ is defined as shown. If I_0 is the maximum intensity then I



(θ) for $0 \le \theta \le 90°$ is given by ***(1995)***

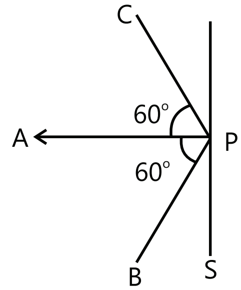
(A) $I(\theta) = I_0/2$ for $\theta = 30°$

(B) $I(\theta) = I_0/4$ for $\theta = 90°$

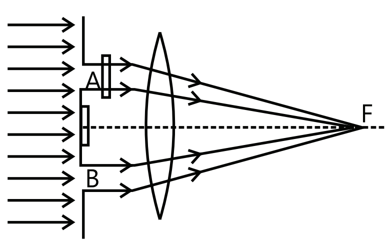
(C) $I(\theta) = I_0$ for $\theta = 0°$

(D) $I(\theta)$ = is constant for all values of θ

Q.10 Screen S is illuminated by two point sources A and B. Another source C sends a parallel beam of light towards point P on the screen (see figure). Line AP is normal to the screen and the lines AP, BP and CP are in one plane. The radiant powers of sources A and B are 90 W and 180 W respectively. The beam from C is of intensity $20\,W/m^2$. Calculate intensity at P on the screen.



Q.11 In a modified Young's double slit experiment, a monochromatic uniform and parallel beam of light of wavelength 6000 Å and intensity $(10/\pi)$ Wm^2 is incident normally on two apertures A and B of radii 0.001 m and 0.002 m respectively. A perfectly transparent film of thickness 2000 Å and refractive index 1.5 for the wavelength of 6000 Å is placed in front of aperture A (see figure). Calculate the power (in W) received at the focal spot F of the lens. The lens is symmetrically placed with respect to the apertures. Assume that 10% of the power received by each aperture goes in the original direction and is brought to the focal spot. ***(1989)***



Q.12 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 shift by 10^{-3} m to the position previously occupied by the 5th bright fringe. Find the thickness of the plate. When the sources 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 green light. Also estimate the change in fringe width due to change in wavelength. ***(1997)***

Q.13 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) fall before the glass plates were inserted, now has $\frac{3}{4}$ the original intensity. It is further observed that what used to be the fifth maximum earlier lies below the point P while the sixth minima lies above P. Calculate the thickness of glass plate. (Absorption of light by glass plate may be neglected). ***(1997)***

Q.14 In the Young's double slit experiment using a monochromatic light of wavelength λ, the path difference (in terms of an integer n) corresponding to any point having half the peak intensity is ***(2013)***

(A) $(2n+1)\frac{\lambda}{2}$ (B) $(2n+1)\frac{\lambda}{4}$

(C) $(2n+1)\frac{\lambda}{8}$ (D) $(2n+1)\frac{\lambda}{16}$

Q.15 A light source, which emits two wavelengths $\lambda_1 = 400$ mm and $\lambda_2 = 600$ nm, is used in a Young's double slit experiment. If recorded fringe widths for λ_1 and λ_2 are β_1 and β_2 and the number of fringes for them within a distance y on one side of the central maximum are m_1 and m_2, respectively, then ***(2014)***

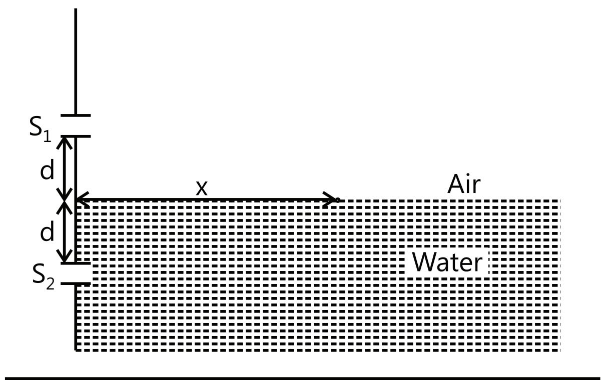
(A) $\beta_2 > \beta_1$

(B) $m_1 > m_2$

(C) From the central maximum, 3rd maximum of λ_2 overlaps with 5th minimum of λ_1

(D) The angular separation of fringes for λ_1 is greater than λ_2

Q.16 A Young's double slit interference arrangement with slits S_1 and S_2 is immersed in water (refractive index = 4/3) as shown in the figure. The positions of maxima on the surface of water are given by $x^2 = p^2m^2\lambda^2 - d^2$, where λ is the wavelength of light in air (refractive index = 1), 2d is the separation between the slits and m is an integer. The value of p is ***(2015)***



MASTERJEE Essential Questions

JEE Main/Boards

Exercise 1

Q. 12 Q.15 Q.16

Q.18 Q.22 Q.23

Exercise 2

Q.4 Q.5 Q.8

Q.15 Q.16

Previous Years' Questions

Q.5 Q.7 Q.8

Q.9

JEE Advanced/Boards

Exercise 1

Q.2 Q.3 Q.8

Q.12 Q.15

Exercise 2

Q.4 Q.7

Previous Years' Questions

Q.3 Q.9

Answer Key

JEE Main /Boards

Exercise 1

Q.1 1.2×10^{-3}

Q.3 (i) Angular width increases (ii) no change (iii) angular width increases

Q.5 (i) Resolving power increases (ii) remains unchanged (iii) resolving power increases

Q.7 No, Ratio=2:1

Q.9 Intensity becomes $\frac{I_0}{4}$

Q.12 6.4×10^{-4} mm

Q.13 Fringe width becomes twice

Q.15 560nm, when the monochromatic source is replaced by a source of white light; the fringe width would change.

Q.16 (a) (i) 1300nm; (ii) 1950nm

(b) Intensity of secondary maximum is lesser as compared to central maxima

Q.17 No, Energy carried by a wave depends on the amplitude of the wave, not on the speed of wave propagation.

Q.18 (a) (i) 0.007m, (ii) 0.00525m (b) If screen is moved away from the slits fringe pattern will shrink.

Q.25 $\frac{1}{2}$

Exercise 2

Single Correct Question

Q.1 C	**Q.2** C	**Q.3** B	**Q.4** B	**Q.5** D	**Q.6** C
Q.7 C	**Q.8** C	**Q.9** C	**Q.10** D	**Q.11** D	**Q.12** A
Q.13 D	**Q.14** A	**Q.15** B	**Q.16** C	**Q.17** A	**Q.18** C
Q.19 B	**Q.20** D	**Q.21** A			

Previous Years' Questions

Q.1 D **Q.2** C **Q.3** A **Q.4** B **Q.5** D **Q.6** C

Q.7 $1/49$ **Q.8** (a) 4200 Angstrom, (b) 1.4 **Q.9** (a) 0.63mm, (b) 1.579 μm **Q.10** 3.5mm

Q.11 B **Q.12** C **Q.13** B **Q.14** B

JEE Advanced/Boards

Exercise 1

Q.1 $\left(n-\frac{1}{48}\right)\lambda = x_1 - x_2$

Q.2 0.225mm

Q.3 5000 Å

Q.4 1.99×10^{-2} mm

Q.5 0.2 mm

Q.6 35.35 cm app., 5

Q.7 8 μm

Q.8 0, 1.5mm

Q.9 1.25m

Q.10 48, 21, $\frac{32}{3},\frac{9}{2}$,0 m.m

Q.11 760m, 21.8m, 89.4m, 19.6m

Q.12 81:1

Q.13 $\frac{x}{\lambda y}v$

Q.14 $I_0 = I\sec^2\left[\frac{\pi(\mu-1)t}{\lambda}\right]$

Q.15 7 μm, 1.6, $\frac{400}{7}$ μm (decrease)

Q.16 9.3 μm

Q.17 3/4

Q.18 (i) 1 mm (ii) increase

Q.19 (a) $\frac{1}{\sqrt{15}}, \frac{3}{4}$; (b) No shift

Q.20 33

Exercise 2

Single Correct Choice Type

Q.1 C **Q.2** D **Q.3** B **Q.4** C **Q.5** C **Q.6** A
Q.7 A **Q.8** C **Q.9** B

Multiple Correct Choice Type

Q.10 B, C, D **Q.11** A, C, D **Q.12** A, C **Q.13** B, D **Q.14** B, C **Q.15** A, C
Q.16 C, D

Assertion Reasoning Type

Q.17 D **Q.18** A **Q.19** C

Comprehension Type

Q.20 A, C, D **Q.21** A, B, D **Q.22** B, D

Previous Years' Questions

Q.1 D **Q.2** D **Q.3** B **Q.4** A **Q.5** C

Q.6 A $\rightarrow$ p, s; B $\rightarrow$ q; C $\rightarrow$ t; D $\rightarrow$ s **Q.7** B, D **Q.8** A, C **Q.9** A, C

Q.10 13.97 W/m^2 **Q.11** 7×10^{-6} W **Q.12** (a) 7×10^{-6} m ; (b) 1.6; (c) -5.71×10^{-5} m

Q.13 9.3 μm **Q.14** B **Q.15** A, B, C **Q.16** 3

Solutions

JEE Main/Boards

Exercise 1

Sol 1: Size of obstacle must be comparable to wavelength of light width = $\frac{2\lambda D}{d}$

= $\frac{2\times6\times10^{-9}\times3\times10^{2}}{3\times10^{-3}}$ = 1.2×10^{-3} m.

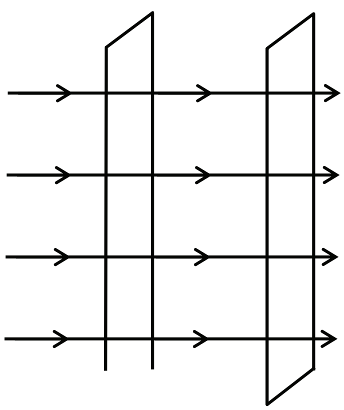
Sol 2: (a) Wave front is the locus of all particles of the medium which vibrate in same phase and where disturbances reach at the same point of time.

Consider all the point on a primary wave front to be sources of light, which emit disturbances known as secondary disturbances.

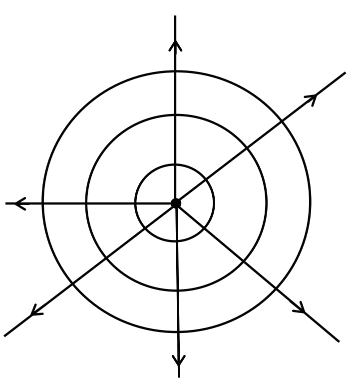
Tangent envelope to all secondary wavelets gives the position of new wave front.

(b)

(i)



(ii)



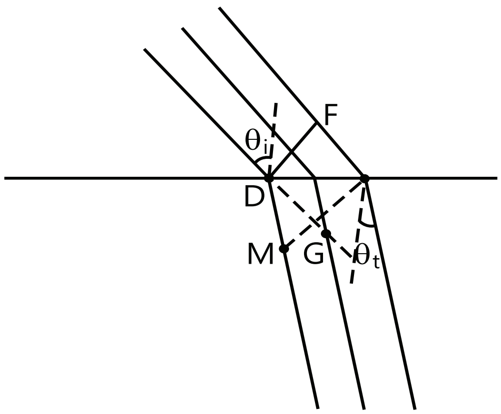
Sol 3: $\theta \propto \frac{\lambda}{d}$

(i) If d decrease, θ increases

(ii) Doesn't depend on D

(iii) If λ decreases, θ decreases

Sol 4: According to Huygens theory each point on the leading surface of a wave disturbance may be regarded as a secondary source of spherical wave, which themselves progress with the speed of light in the medium & whose envelope at later times constitutes the new wave front.



$$DM = V_t t = V_t\left(\frac{DG}{V_i}\right)$$

$$DM = \left(\frac{n_i}{n_t}\right)DG$$

$$\Rightarrow \frac{n_i}{n_t} = \frac{\sin\theta_t}{\sin\theta_i}$$

Sol 5: R. P. = $\frac{D}{1.22\lambda}$

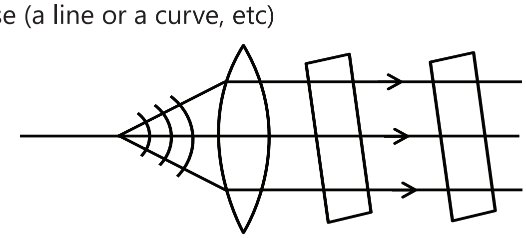
(i) If f increases, λ decreases

R. P. increases

(ii) R. P. doesn't depend on f.

(iii) If D increases, R. P increases

Sol 6: Wave front is the locus of points having the same phase (a line or a curve, etc)



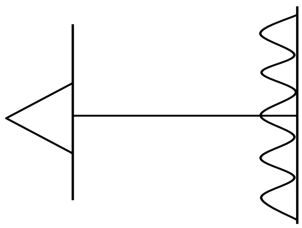
Sol 7: If the wavelength of both the sources is same, then interference may not be possible as even phase difference must be constant

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

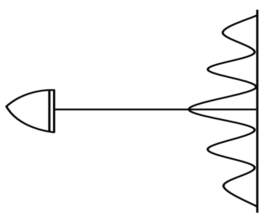
(i) $\theta = 0; I_1 = 4I_0;$

(ii) $\theta = 90° \; \frac{I_1}{I_2} = 2; I_2 = 2I_0$

Sol 8: With 2 slits → interference pattern



With 1 slit → diffraction pattern

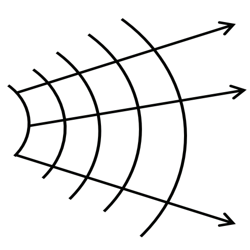


In first case, the maximum intensity is constant as we go from centre.

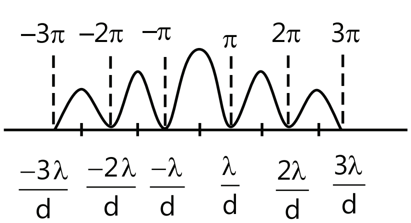
In second case, the intensities at maximum decrease as we go from centre.

In first case, the fringe length is fixed. In second case, the fringe angle is fixed.

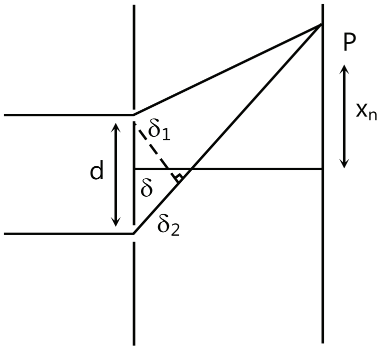
Sol 9:



In diffraction pattern



Sol 10: Two sources are said to be coherent if their frequencies are equal and they have a constant phase difference. Two independent sources of light cannot be coherent



$S_2P - S_1P = \frac{x_n d}{D}$

$\left[\because \frac{\delta}{d} = \frac{x_n}{D}\right]$

If $\frac{x_n d}{D} = n\lambda$

we will observe maximum intensity

If $\frac{x_n d}{\lambda} = (2n+1)\frac{\lambda}{2}$

we will observe minimum intensity.

Sol 11: Resolving power of an instrument is its capacity to resolve 2 points which are close together

(i) It doesn't depend on μ of the medium

(ii) It's inversely proportional to λ of light.

Sol 12: Difference between interference and diffraction: Interference is due to superposition of two distinct waves coming from two coherent sources. Diffraction is produced as a result of superposition of the secondary wavelets coming from different parts of the same wavefront.

Numerical: Here, $\lambda = 600\,\text{nm} = 600\times10^{-19} = 6\times10^{-7}\,\text{m}$

$D = 0.8\,\text{m},\ x = 15\,\text{mm} = 15\times10^{-3}\,\text{m}$

$n = 2, a = ?$

$\because\ a\frac{x}{D} = n\lambda$

$a = \frac{n\lambda D}{x} = \frac{2\times6\times10^{-7}\times0.8}{15\times10^{-3}} = 6.4\times10^{-5}\,\text{m}$

Sol 13: Angular separation of interference fringes in YDSE depends only on λ, d but not on D.

Sol 14: Linearly polarised light is light in which all the electric field of all the photons are confined to 1 direction perpendicular to direction of wave.

$I = I_0\cos^2\theta$

$I \propto \cos^2\theta$

$\theta = 180°$

Sol 15: $\beta = \dfrac{\lambda D}{d}$

$\Rightarrow \beta\ \alpha\ \lambda;\quad \dfrac{\beta_1}{\beta_2} = \dfrac{\lambda_1}{\lambda_2}$

If white light is used, there will no complete darkness as all colours will not be out of phase at a single point centre will be brightest as all colours will be in phase at that point.

Sol 16: First maxima $\to \theta = \dfrac{3\lambda}{2d}$

First minima $\to \theta = \dfrac{\lambda}{d}$

Sol 17: $E = h\nu = \dfrac{hc}{\lambda}$. c value decrease & λ also decreases maintaining the frequency constant. So E is constant.

Sol 18: $\beta = \dfrac{\lambda D}{d}$

(a) (i) 2^{nd} bright : $y = 2\beta$

(ii) 1^{st} dark : $y = \dfrac{\beta}{2}$

(b) If D increases

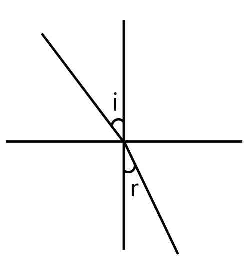
β decreases, so fringe width increases.

Sol 19: The centre reflects the components perpendicular to the direction

$I = I_0\cos^2\theta$

Sol 20: In single slit diffraction angular fringe width depends only of λ, d but not on D.

Sol 21:



$\mu = \dfrac{\sin i}{\sin r}$

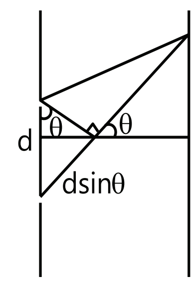
$C = \dfrac{C_0}{\mu}$ as $C \propto \dfrac{1}{\mu}$

$\Rightarrow C \propto \sin r.$

Minimum for r = 15°.

Sol 22: (a) $d\sin\theta = n\lambda$ (for constructive)

$d\sin\theta = \left(n + \dfrac{1}{2}\right)\lambda$ (for destructive)



(b) $\beta_1 = \dfrac{\lambda_1 D}{d}$

$= \dfrac{8\times10^{-7}\times1.4}{2.8\times10^{-4}} = 4 \times 10^{-3}\ m = 4\ mm$

$\beta_2 = \dfrac{\lambda_2 D}{d} = \dfrac{6\times10^{-7}\times1.4}{2.8\times10^{-4}} = 3\ mm.$

$3\beta_1 = 4\beta_2$

3^{rd} bright of 1^{st} light = 4^{th} bright of 2^{nd} light

Sol 23: (a) The transparent medium allows components of E only in 1 direction & reflects all its perpendicular components.

(b) As A & B are crossed, $I_0 = \to \dfrac{I_0}{2}$

& $\dfrac{I_0}{2}\cos^2\theta = \dfrac{I_0}{8}$

Sol 24: $I_{min} = I_1 + I_2 + 2\sqrt{I_1 I_2}.\cos\phi$ & $I = a^2$

$I_{max} = a_1^2 + a_2^2 + 2a_1a_2(1) = (a_1 + a_2)^2$

$I_{min} = a_1^2 + a_2^2 + 2a_1a_2(-1) = (a_1 - a_2)^2$

Sol 25: $I_0 = 4I_1$

$I'_0 = I_1 + I_1 + 2I_1\cos90° = 2I_1 = \dfrac{I_0}{2}$

Exercise 2

Single Correct Choice Type

Sol 1: (C) $I = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

$I_{max} \rightarrow \cos\phi = 1$

$I = 9I$

$I_{min} \rightarrow \cos\phi = -1$

$I_{min} = I$

Sol 2: (C) $\gamma = \dfrac{c}{\lambda}$

In denser medium, c decreases but frequency remains the same.

$\therefore$ λ also decreases

Sol 3: (B) Maximum path difference = 100 nm = 3.5 λ

So, we can get pd of $-3\lambda, -2\lambda, \ldots, 3\lambda$.

i.e. 7 maxima.

Sol 4: (B) $\dfrac{n\lambda_1 D}{d} = \dfrac{(n+1)\lambda_2 D}{d}$

n(2200) = (n + 1)(5200)

$\Rightarrow 3n = 2(n + 1)$

$\Rightarrow n = 2$

Sol 5: (D) $(l_1 + l_3) - (l_2 + l_4) = \dfrac{(2n+1)\lambda}{2}$

$\downarrow$ path by S_1 $\downarrow$ path by S_2

Sol 6: (C) Let intensity due to single slit by I_1. By two slits we get I.

$\Rightarrow I = I_1 + I_2 + 2\sqrt{I_1I_2}\cos(\phi)$

and $\phi = 0°$ at centre.

$\Rightarrow I = 4I_1$

$\Rightarrow I_1 = \dfrac{I}{4}$

Sol 7: (C) Let I be intensity due to single slit.

$I = I + I + 2\sqrt{I.I}\cos\phi$

$\Rightarrow \cos\phi = \dfrac{-I}{2I} = \dfrac{-1}{2}$

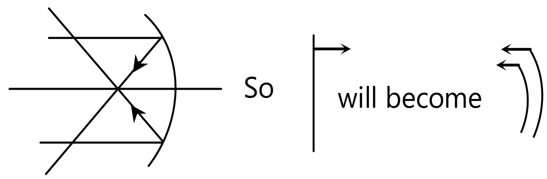
$\Rightarrow \phi = 120°$

Phase difference = $\dfrac{2\pi}{3}$

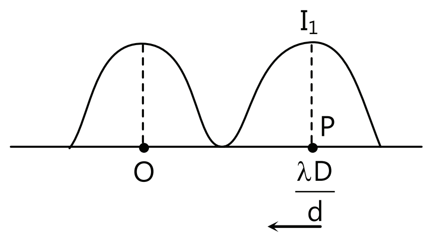
for $2\pi \rightarrow \dfrac{\lambda D}{d}$

for $\dfrac{2\pi}{3} \rightarrow \dfrac{\lambda D}{3d}$

Sol 8: (C)



Sol 9: (C)

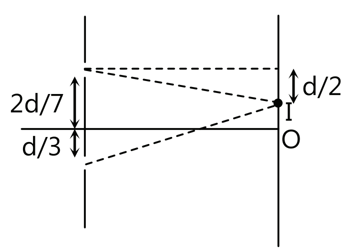


as D increases

I_1 moves away from O.

$\therefore$ I first decreases, then increases.

Sol 10: (D)



$OI = \dfrac{2d}{3} - \dfrac{d}{2} = \dfrac{d}{6}$

$\dfrac{d}{6} = \dfrac{n\lambda D}{d}$

$\Rightarrow \lambda = \dfrac{d^2}{6nD}$

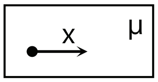
So $\dfrac{d^2}{3D}$ is not possible.

Sol 11: (D) $\beta = \dfrac{2\lambda D}{d}$

as c decreases, λ also decreases

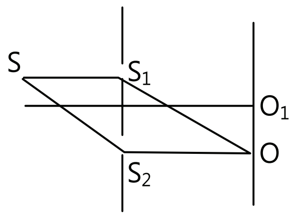
so β decreases but there won't be any shift.

Sol 12: (A) d = μx



phase difference = $\frac{\mu x}{\frac{\lambda}{2\pi}} = \frac{2\pi\mu x}{\lambda}$

Sol 13: (D)



Fringe width will not change it depends only on λ, d, D.

To get Pd = 0, $S_1O > S_2O$.

So O will be below O_1 pattern will shift downwards.

Sol 14: (A) $I_{max} = 4I_0$

75% of $I_{max} = 3I_0$

$3I_0 = I_0 + I_0 + 2I_0.\cos\phi$

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

$\Rightarrow \phi = 2n\pi \pm 60°$

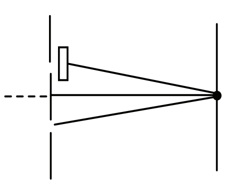
It's between

3π 6π

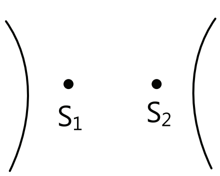
↓ ↓

2nd minima 3rd maxima

only $\frac{\pi}{3}$ is not possible in the options



Sol 15: (B)

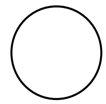


$S_1P - S_2P = n\lambda$

Family of hyperbolas with n as variable.

Sol 16: (C) First coloured to be received is violet. As frequency of violet is high, λ_{red} is high and

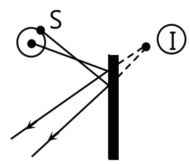
$\mu_{red} > \mu_{violet}$



Sol 17: (A) $\frac{\lambda}{2} = 1.33\ t$

$\Rightarrow t = \frac{300}{1.33} = 225$ nm

Sol 18: (C) Image will coincide with S but on opposite side.



Sol 19: (B) They will get closer, if we use light of lower λ.

i.e. using blue light.

If 'd' decreases, β increases

β doesn't depend on distance between source and slits.

Sol 20: (D) $P_1 = \mu_A t_A + t_B$

$P_2 = t_A + \mu_B t_B$

$Pd = t_A.t_B$

If $t_A > t_B \rightarrow$ towards B

[same as in previous question]

If $t_B < t_A \rightarrow$ towards A

Sol 21: (A) If we put mica sheet in front of S_1.

$(\sqrt{2} - 1)d = (\mu - 1)t$

$\Rightarrow t = 2(\sqrt{2} - 1)d$

In front of S_2

$(\sqrt{2} - 1)d + (\mu - 1)t = n\lambda$.

Previous Years' Questions

Sol 1: (D) $\omega = \dfrac{\lambda D}{d}$

d is halved and D is doubled

$\therefore$ Fringe width ω will become four times.

Sol 2: (C) $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 = (\sqrt{4I} + \sqrt{I})^2 = 9I$

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

Sol 3: (A) In interference we know that

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

Under normal conditions (when the widths of both the slits are equal)

$I_1 \approx I_2 = I$ (say)

$\therefore I_{max} = 4I$ and $I_{min} = 0$

When the width of one of the slits is increased. Intensity due to that slit would increase, while that of the other will remain same. So, let :

$I_1 = I$ and $I_2 = \eta I$ $(\eta > 1)$

Then, $I_{max} = I(1 + \sqrt{\eta})^2 > 4I$

And $I_{min} = I(\sqrt{\eta} - 1)^2 > 0$

$\therefore$ Intensity of both maxima and minima is increased.

Sol 4: (B) $I(\phi) = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$ ...(i)

Here, $I_1 = I$ and $I_2 = 4I$

At point A, $\phi = \dfrac{\pi}{2}$ $\therefore I_A = I + 4I = 5I$

At point B, $\phi = \pi$ $\therefore$ IB = I + 4I – 4I = I

$\therefore I_A - I_B = 4I$

Note: Equation (i) for resultant intensity can be applied only when the sources are coherent. In the question it is given that the rays interfere. Interference takes place only when the sources are coherent. That is why we applied equation number (i). When the sources are incoherent, the resultant intensity is given by $I = I_2 + I_2$

Sol 5: (D) Let *n*th 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 $\dfrac{2n-1}{2m-1} = \dfrac{7}{5} = \dfrac{14}{10} = \ldots$

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

Location of this minima is,

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

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

Location of this minima is,

$$Y_1 = \frac{(2\times11-1)(1000)(400\times10^{-6})}{2\times0.1} = 42 \text{ mm}$$

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

Sol 6: (C) $I = I_{max}\cos^2\left(\dfrac{\phi}{2}\right)$

$\therefore \dfrac{I_{max}}{4} = I_{max}\cos^2\dfrac{\phi}{2}$

$\cos\dfrac{\phi}{2} = \dfrac{1}{2}$

or $\dfrac{\phi}{2} = \dfrac{\pi}{3}$

$\therefore \phi = \dfrac{2\pi}{3} = \left(\dfrac{2\pi}{\lambda}\right)\Delta x$ ... (i)

where $\Delta x = d\sin\theta$

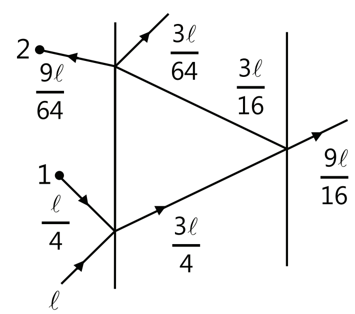
Substituting in Eq. (i), we get

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

or $\theta = \sin^{-1}\left(\dfrac{\lambda}{3d}\right)$

Sol 7: Each plate reflects 25% and transmits 75%.

Incident beam has an intensity I. This beam undergoes multiple reflections and refractions. The corresponding intensity after each reflection and refraction (transmission) are shown in figure.



Interference pattern is to take place between rays 1 and 2.

$I_1 = I/4$ and $I_2 = 9I/64$

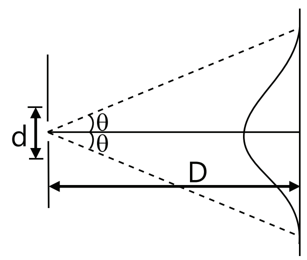
$$\therefore \frac{I_{min}}{I_{max}} = \left(\frac{\sqrt{I_1}-\sqrt{I_2}}{\sqrt{I_1}+\sqrt{I_2}}\right)^2 = \frac{1}{49}$$

Sol 8: Given $\lambda = 6000$ Å

Let b be the width of slit and D the distance between screen and slit.

First minima is obtained at $b \sin\theta = \lambda$

or $b\theta = \lambda$ as $\sin\theta = \theta$



or$\theta = \frac{\lambda}{b}$ Angular width of first maxima = 2θ

$= \frac{2\lambda}{b} \propto l$

Angular width will decrease by 30% when λ is also decreased by 30%.

Therefore, new wavelength

$$\lambda' = \left\{(6000) - \left(\frac{30}{100}\right)6000\right\} \text{ Å}$$

$\lambda' = 4200$ Å

(b) When the apparatus is immersed in a liquid of refractive index μ, the wavelength is decreased μ times. Therefore,

$$4200 \text{ Å} = \frac{6000\text{Å}}{\mu}$$

$\therefore \mu = \frac{6000}{4200}$ or $\mu = 1.429 \approx 1.43$

Sol 9: Given, $\mu = 1.33$, d = 1 mm, D = 1.33 m,

$\lambda = 6300$ Å

(a) Wavelength of light in the given liquid:

$$\lambda' = \frac{\lambda}{\mu} = \frac{6300}{1.33} \text{ Å} = 4737 \text{ Å} = 4737 \times 10^{-10} \text{ m}$$

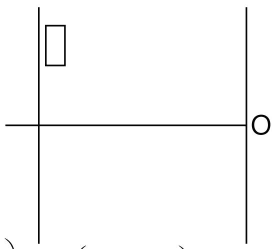
$\therefore$ Fringe width, $\omega = \frac{\lambda' D}{d}$

$$\omega = \frac{(4737\times10^{-10}\text{m})(1.33\text{m})}{(1\times10^{-3}\text{m})} = 6.3\times10^{-4} \text{ m}$$

$\omega = 0.63$ mm

(b) Let t be the thickness of the glass slab

Path difference due to glass slab at centre O.



$$\Delta x = \left(\frac{\mu_{glass}}{\mu_{liquid}} - 1\right) t = \left(\frac{1.53}{1.33} - 1\right) t$$

or $\Delta x = 0.15t$

Now, for the intensity to be minimum at O, this path difference should be equal to $\frac{\lambda'}{2}$

$\therefore \Delta x = \frac{\lambda'}{2}$

or $0.15\, t = \frac{4737}{2}$ Å

$\therefore t = 15790$ Å

or $t = 1.579\ \mu$m

Sol 10: Let n_1 bright fringe corresponding to wavelength $\lambda_1 = 500$ nm coincides with n_2 bright fringe corresponding to wavelength $\lambda_2 = 700$ nm.

$$\therefore \quad n_1 \frac{\lambda_1 D}{d} = n_2 \frac{\lambda_2 D}{d}$$

$$\text{or} \quad \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{7}{5}$$

This implies that 7^{th} maxima of λ_1 coincides with 5^{th} maxima of λ_2. Similarly 14^{th} maxima of λ_1 will coincide with 10^{th} maxima of λ_2 and so an.

$\therefore$ Minimum distance $= \frac{n_1\lambda_1 D}{d} = 7\times5\times10^{-7}\times10^{3}$

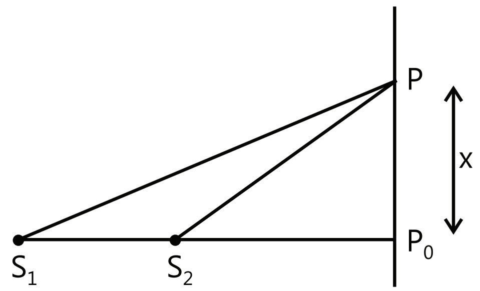
$= 3.5 \times 10^{-3}$ m = 3.5 mm

Sol 11: (B) Intensity of light transmitted by $A = \frac{I_0}{2}$

According to Malus law, the intensity of light transmitted by B

$$= \frac{I_0}{2}\cos^2\theta = \frac{I_0}{2}\cos^2(45°) = \frac{I_0}{4}$$

Sol 12: (C) Consider a point P on the screen. The path difference between the waves from S_1 and S_2 on reaching P is $\left(S_2P - S_1P\right)$. This path difference is constant for every point on a circle of radius x with P_0 as the centre. Hence the figures will be concentric circles with common centre at P_0.



Note that S_1 and S_2 are point sources and (not slit sources as in Young's experiment).

Sol 13: (B)

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

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

Sol 14: (B) We know that

Geometrical spread = a

and diffraction spread = $\frac{\lambda L}{a}$

So spot size(b) = $a + \frac{\lambda L}{a}$

For minimum spot size $a = \frac{\lambda L}{a} \Rightarrow a = \sqrt{\lambda L}$

and $b_{min} = \sqrt{\lambda L} + \sqrt{\lambda L} = \sqrt{4\lambda L}$

JEE Advanced/Boards

Exercise 1

Sol 1: For constructing interference

$\phi = 2x\pi$

$$\frac{2\pi(x_1 - x_2)}{\lambda} = \frac{\pi}{8} - \frac{\pi}{6} + 2n\pi$$

$$\Rightarrow (x_1 - x_2) = \left(n - \frac{1}{48}\right)\lambda.$$

Sol 2: $\beta = \frac{\lambda D}{d}$; $\lambda = \frac{\lambda_0}{\mu}$

$$\therefore \beta = \frac{6\times10^{-7}}{4}\times3\times\frac{1}{2\times10^{-3}} = 2.25 \times 10^{-4} \text{ m.}$$

Sol 3: 9^{th} Bright fringe = $\frac{9\lambda D}{d}$

2^{nd} dark fringe = $\frac{1.5\lambda D}{d}$

$7.5 \times 10^{-3} = \frac{\lambda\times1}{5\times10^{-4}}(9 - 1.5)$

$\Rightarrow \lambda = 5 \times 10^{-7}$ m = 5000 Å.

Sol 4: Pd = d sin θ

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

$d \times 0.75 \frac{\pi}{180°} = 2.6 \times 10^{-7}$

$\Rightarrow d = 2 \times 10^{-2}$ mm.

Sol 5: $I_{max} = 4I_0$

75% of $I_{max} = 3I_0$

$3I_0 = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi$

$\Rightarrow \cos\phi = \frac{1}{2}$

$\phi = 60°, -60°, 120°$

$360 \to \frac{\lambda D}{d}$

$120° \to \frac{\lambda D}{3d}$ = 0.2 mm.

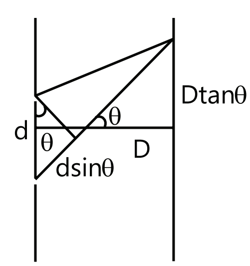
Sol 6: Possible pd for maxima $\to -2\lambda_1 \ldots\ldots 2\lambda$

i. e. 5

d sin θ = λ for 1^{st} maxima

$\Rightarrow 3 \sin\theta = 1$

$\sin\theta = \frac{1}{3}$



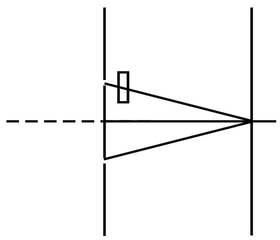
$\Rightarrow \tan\theta = \frac{1}{\sqrt{8}}$

y = tan θ = 0. 353 m.

Sol 7: $(\mu_1 - \mu_2)$ t = Pd = 5λ

$$t = \frac{5\times(48\times10^{-8})}{0.3} = 8\,\mu m$$

Sol 8: $I_0 = 4I_1$



Pd = (y – 1) t

= 0. 5 × 1. 5 × 10^{-6}

= 7.5 × 10^{-7} m

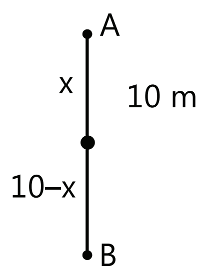
λ = 5 × 10^{-7} m

Pd = 1. 5 λ

∴ $I_0 = 0$

Shift = 1.5 $\frac{\lambda D}{d} = 1.5$ mm

Sol 9: $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{6\times10^7} = 5m$



Δp must be $\frac{\lambda}{2}$

10 – x – x = $\frac{\lambda}{2}$ (2n + 1)

10 – 2x = 2.5 or 7.5

to get minimum x

10 – 2x = 7.5

$$x = \frac{10-7.5}{2} = 1.25m$$

Sol 10: $\sqrt{25\lambda^2 + d^2} - d = n\lambda$

Possible values of

n = 5, 4, …. . 1

for each value of d, we will get a circle with S_1 as center.

Sol 11: | AB – BC | = $(2n+1)\frac{\lambda}{2}$

AB = 200 m

$$\lambda = \frac{c}{\nu} = \frac{3\times10^8}{5.8\times10^6}$$

Sol 12: $I_{A'B'} = \frac{4}{5}\times\frac{4}{5}I = \frac{16}{25}I$

$$\frac{I_{max}}{I_{min}} = \frac{1+\frac{16}{25}+2\sqrt{\frac{16}{25}}}{1+\frac{16}{2\sqrt{5}}-2\sqrt{\frac{16}{25}}} = 81:1$$

Sol 13: $n = \frac{x}{\beta}$

$$n = \frac{xd}{\lambda D}$$

$$\frac{dn}{dt} = \frac{x}{\lambda D}\frac{d(d)}{dt} = \frac{xv}{\lambda y}$$

Sol 14: Let intensity of individual slit be I_1

$I_0 = 4I_1$

with glass plate

$$\phi = 2\pi \times \frac{(\mu-1)t}{\lambda}$$

$I = 2I_1 + 2I_1 \cos\phi$

$$I = \frac{I_0}{2}(1 + \cos\phi)$$

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

Sol 15: $\phi_1 = \frac{(\mu-1)t}{\lambda r}\times 2\pi$; $10^{-3} = 5\beta_1 = \frac{5\lambda_r D}{d}$

and φ = 10π

$$\phi_2 = \frac{(\mu-1)t}{\lambda_g}\times 2\pi$$

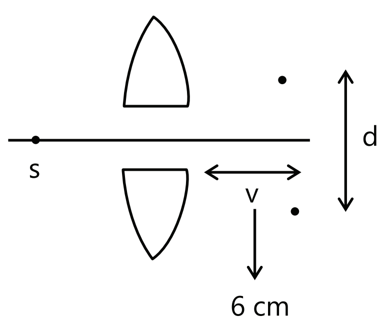
$\Delta y_c = 6\beta_1$

Sol 16: Pd = $(\mu_1 - \mu_2)$ t

$$I_1 = \frac{3}{4} I_{max}$$

⇒ φ = 60° or – 60° ± 2 nπ

φ must lie between 10π, 11π.



Sol 17: $\phi = \frac{(\mu_2 - \mu_1)(t_2 - t_1)}{\lambda_0} \times 2\pi$

$I_c = 2I_0 + 2I_0 \cos\phi$

$I_{max} = 4I_0$.

Sol 18: S will have 2 images which will act as sources and is similar to YDSE

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

f = 10 cm

u = – 15 cm

$\frac{1}{v} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$

$d = 0.5 \times \frac{v}{u} = 1\text{mm}$

Sol 19: Minima possible when

(a) $Pd = (2n + 1)\frac{\lambda}{2}$

i. e. – 0.75, – 0.25, 0.25, 0.75

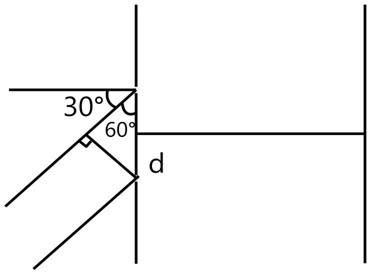
$d \sin\theta = pd$

$y = D \tan\theta$

$\sin\theta = \frac{0.25}{1}, \frac{0.75}{1} \Rightarrow \frac{1}{4}, \frac{3}{4}$

$\Rightarrow \tan\theta = \frac{1}{\sqrt{15}}, \frac{3}{4}$

(b) We need to find the initial Pd



$Pd = d \sin 30° = \frac{d}{2} = 0.5\text{ mm} = \lambda$

So, there will be no shift.

Sol 20: Let $\beta = \frac{\lambda D}{d}$

$\frac{5}{\beta} = \frac{Pd}{\lambda}$ $Pd = (\mu_1 - \mu_2)t$

$\frac{8}{\beta} = \frac{(\mu - 1)(t_2 - t_1)}{\lambda}$

Exercise 2

Single Correct Choice Type

Sol 1: (C) $\frac{b}{V_{air}} = \frac{d}{V_{water}}$

$\Rightarrow \frac{b}{d} = \frac{V_{air}}{V_{water}} = \frac{\mu_{water}}{\mu_{air}}$

Sol 2: (D) For monochromatic light, I_{max} and fringe width is constant.

so, we use white light to determine central maximum.

Sol 3: (B) Case-I $\rightarrow I_1 = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos(0°) = 4I_0$

Case-II $\rightarrow I_2 = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos(90°) = 2I_0$

$\frac{I_1}{I_2} = 2$

Sol 4: (C) At O, $Pd = S_1S_2 = d$

if $d = \frac{(2n+1)\lambda}{2} \rightarrow 0 \rightarrow$ minima

$d = n\lambda \rightarrow 0 \rightarrow$ maxima

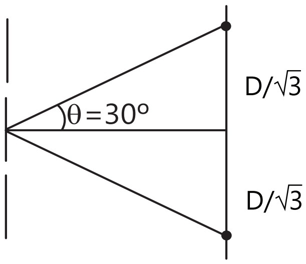
if $d = 4.3\lambda$,

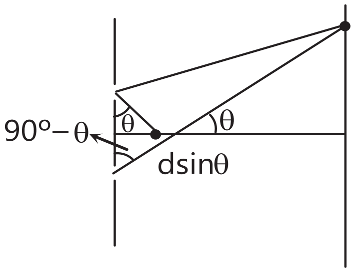
Possible minima

$\rightarrow -3.5\lambda, -2.5\lambda, ... 3.5\lambda$.

i.e. 8 points.

Sol 5: (C)





Pd = d sinθ

$= \frac{d}{2} = \frac{3}{2} \times 10^{-4}$ m

$= \frac{3}{10} \times 5 \times 10^{-7} \times 10^{3}$ m = 300 λ

So, possible maxima

–299λ, –298λ, ... 299λ

i.e. 599 maxima

Sol 6: (A) In the YDSE experiment, $\Delta x = \frac{yd}{D}$,

for the maxima, $\Delta x = n\lambda \Rightarrow \frac{yd}{D} = n\lambda$

$\Rightarrow y = \frac{n\lambda D}{d}$. In the question, $y = \frac{d}{6}$.

Then, $\frac{d}{6} = \frac{n\lambda D}{d} \Rightarrow \lambda = \frac{d^2}{6nD}$ where, n = 1, 2 , 3 , 4....

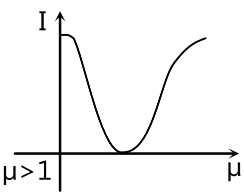
Sol 7: (A) Pd = $n_3t - n_2t$

$\phi = \frac{(n_3t - n_2t)}{\lambda_0} \times 2n = \frac{2\pi}{n_1\lambda_1}(n_3 - n_2)t$

Sol 8: (C) Pd = (μ – 1) t

$\phi = \frac{(\mu - 1)t}{\lambda} \times 2\pi$

$I = I_0 + I_0 + 2I_0\cos\phi$



Sol 9: (B) Pd = 2μt + t – μ(2t)

Pd = t

$\frac{y}{Pd} = \frac{D}{d} \Rightarrow y = \frac{Dt}{d}$

Multiple Correct Choice Type

Sol 10: (B, C, D) Central fringe will white as phase difference = 0 for all colours.

We can't get completely dark fringe as all colours will not have phase difference = 0 at a single point.

Sol 11: (A, C, D) $I_{max} = I_1 + kI_1 + 2\sqrt{k}\, I_1\cos\phi$; ($\cos\phi \rightarrow 1$)

$= I_1(1 + k + 2\sqrt{k})$ and k < 1

$I_{min} = I_1(1 + k - 2\sqrt{k})$

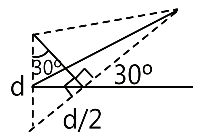
so $I_{max} < I_0$ and $I_{min} > 0$

β doesn't change.

Fringes will shift towards covered slit.

Sol 12: (A, C) $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{10^6}$ = 300 m

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



$I_1 = I_1 + I_2 + 2\sqrt{I_1I_2}\cos(0°)$

$I_0 = 4I_1$

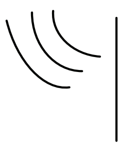
If θ = 90° ; $\phi = \frac{\lambda}{2}$; I = 0

If θ = 30°; $\Delta Pd = \frac{d}{2} = \frac{\lambda}{4}$; φ = 90°

$I = 2I_1 = \frac{I_0}{2}$

Sol 13: (B, D) They must have same frequency and constant φ.

They need not have same A_1I.



Sol 14: (B, C) $\lambda_{red} > \lambda_{blue}$

$\therefore \beta_{red} > \beta_{blue}$

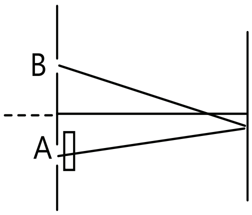
Fringe length decreases.

So, no. of maxima increases.

Sol 15: (A, C) Central maxima will shift towards A as (μ – 1)t is added before A.

Δx = (μ – 1)t

$\Delta y = \frac{(\mu - 1)t}{\lambda} \times \beta$.



Sol 16: (C, D) $\beta = \frac{2\lambda D}{d} = \frac{2\times 4.5\times 10^{-7}}{10^{-3}} = 9 \times 10^{-4}$ m

$\frac{\lambda D}{d} = 4.5 \times 10^{-4}$ m.

$Pd = (\mu - 1)t = 0.5 \times 2.1 \times 10^{-6}$

$\phi = \frac{Pd}{\lambda}$

$= \frac{10.5\times 10^{-7}}{4.5\times 10^{-7}} = 2 + \frac{1}{3}$

So $\frac{\lambda d}{3D}, \frac{2\lambda d}{3D}$

Assertion Reasoning Type

Sol 17: (D) Statement-I is false as path difference will be zero.

$P_{S_1} = \mu S_1O$

$P_{S_2} = \mu S_2O$

$Pd = 0$

Sol 18: (A) $\nu = \frac{c}{\lambda}$; $\lambda_{red} > \lambda_{blue}$

And $\mu_{red} > \mu_{blue}$

So, light speed of red > light speed of blue.

Sol 19: (C) Electromagnetic field at a point depends also on time.

It's magnitude depends with time

So statement-II is false.

Comprehension Type

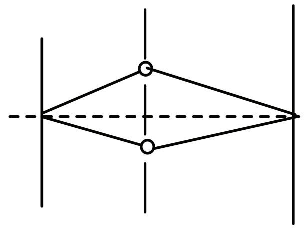
Sol 20: (A, C, D) $\beta = \frac{2\lambda d}{D}$

So $\beta \propto \lambda$

Central maxima is always at O in this case.

$\lambda_{violet} < \lambda_{red}$, λ_{violet} is minimum in visible region.

So, violet maxima is closest.



Sol 21: (A, B, D) $\beta \propto \frac{1}{D}$

Angular fringe width doesn't depend on D.

Central fringe doesn't change from O.

Sol 22: (B, D) β_x angular fringe width depends on 'd'

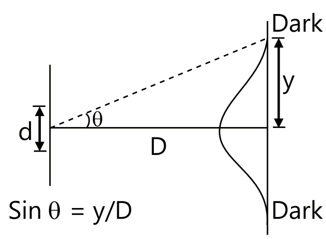
Position of central maxima doesn't change.

Rest all maxima, minima positions change.

Previous Years' Questions

Sol 1: (D) For first dark fring on either side $d \sin\theta = \lambda$ or $\frac{dy}{D} = \lambda \therefore y = \frac{yD}{d}$

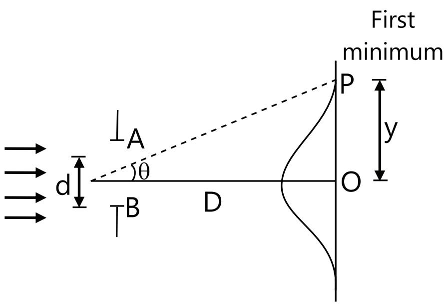
Therefore distance between two dark fringes on either side $= 2y = \frac{2yD}{d}$



Substituting that values, we have

$$\text{Distance} = \frac{2(600\times 10^{-6}\text{mm})(2\times 10^{3}\text{mm})}{(1.0\text{mm})} = 2.4 \text{ mm}$$

Sol 2: (D) At First minima, b sin θ = λ



or $b\theta = \lambda$ or $b\left(\frac{y}{D}\right) = l$

or $y = \frac{\lambda D}{b}$ or $\frac{\lambda b}{D} = \lambda$ ...(i)

Now, at P (First minima) path difference between the rays reaching from two edges (A and B) will be

$\Delta x = \frac{\lambda b}{D}$ (Compare with $\Delta x = \frac{\lambda b}{D}$ in YDSE)

or $\Delta x = \lambda$[From eq. (i)]

Corresponding phase difference (ϕ) will be

$\phi = \left(\frac{2\pi}{\lambda}\right).\Delta x$, $\phi = \frac{2\pi}{\lambda}.\lambda = 2\pi$

Sol 3: (B) Fringe width, $\omega = \frac{\lambda D}{d} \propto l$

When the wavelength is decreased from 600 nm to 400 nm, fringe width will also decrease by a factor of $\frac{4}{6}$ or $\frac{2}{3}$ or the number of fringes in the same segment will increase by a factor of 3/2.

Therefore, number of fringes observed in the same segment = $12 \times \frac{3}{2} = 18$

Note: since $\omega \propto \lambda$, if YDSE apparatus is immersed in a liquid of refractive index μ, the wavelength λ, and thus the fringe width will decrease μ times.

Sol 4: (A) Path dirrerence due to slab should be integeral 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

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

Sol 5: (C) All points on a wavefront are at the same phase.

$\therefore \phi_d = \phi_c$ and $\phi_f = \phi_e$

$\therefore \phi_d - \phi_f = \phi_c - \phi_e$

Sol 6: (A) → (p, s) → Intensity at P_0 is maximum. It will continuously decrease from P_0 towards P_2.

(B) → (q) → Path difference due to slap will be compensated by geometrical path difference. Hence $\delta(P_1) = 0$

(C) → (t) → $\delta(P_1) = \frac{\lambda}{2}$, $\delta(P_1) = \frac{\lambda}{2} - \frac{\lambda}{4} = \frac{\lambda}{4}$ and $\delta(P_2) = \frac{\lambda}{2} - \frac{\lambda}{3} = \frac{\lambda}{6}$. When path difference increases from 0 to $\frac{\lambda}{2}$, intensity will decrease from maximum to zero.

Hence in this case, $I(P_2) > I(P_1) > I(P_0)$

(D) → (r) → Intensity is zero at P_1

Sol 7: (B, D) $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} = \left(\frac{\sqrt{I_1 / I_2} + 1}{\sqrt{I_1 / I_2} - 1}\right)^2 = 9$ (Given)

Solving this, we have $\frac{I_1}{I_2} = 4$

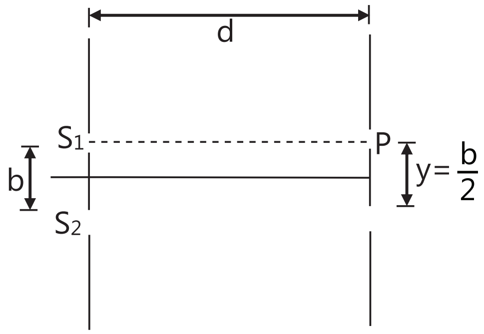
But $I \propto A^2 \therefore \frac{A_1}{A_2} = 2$

Sol 8: (A, C) At P (directly infrom of S_1) $y = \frac{b}{2}$

∴ Path difference,

$\Delta X = S_2P - S_1P = \frac{y.(b)}{d}$

$= \frac{\left(\frac{b}{2}\right)(b)}{d} = \frac{b^2}{2d}$



Those wavelengths will be missing for which

$\Delta X = \frac{\lambda_1}{2}, \frac{3\lambda_2}{2}, \frac{5\lambda_3}{2} ...$

$\therefore \lambda_1 = 2\Delta x = \frac{b^2}{d}\ \lambda_2 = \frac{2\Delta x}{3} = \frac{b^2}{3d}$

$\lambda_3 = \frac{2\Delta x}{5} = \frac{b^2}{5d}$

Sol 9: (A, C) The intensity of light is $I(\theta) = I_0 \cos^2\left(\frac{\delta}{2}\right)$

where $\delta = \frac{2\pi}{\lambda}(\Delta\pi) = \left(\frac{2\pi}{\lambda}\right)(d \sin\theta)$

(a) for $\theta = 30^o$

$\lambda = \frac{c}{v} = \frac{3\times10^8}{10^6}$ =300 m and d = 150 m

$\delta = \left(\frac{2\pi}{300}\right)(150)\left(\frac{1}{2}\right) = \frac{\pi}{2}$

$\therefore \frac{\delta}{2} = \frac{\pi}{4}$

$\therefore I(\theta) = I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$ [option (a)]

(b) For $\theta = 90^o$

$\delta = \left(\frac{2\pi}{300}\right)(150)\ (1) = p$

or $\frac{\delta}{2} = \frac{\pi}{2}$ and $I(\theta) = 0$

(c) For $\theta = 0^o$, $\delta = 0$ or $\frac{\delta}{2} = 0$

$\therefore I(\theta) = I_0$ [option (c)]

Sol 10: Resultant intensity at P

$I_p = I_A + I_B + I_C$

$= \frac{P_A}{4\pi(PA)^2} + \frac{P_B}{4\pi(PB)^2}\cos 60^o + I_C \cos 60^o$

$= \frac{90}{4\pi(3)^2} + \frac{180}{4\pi(1.5)^2}\cos60^o + 20\cos 60^o$

= 0.79 + 3.18 + 10

= 13.97 W/m^2

Sol 11: Power received by aperture A,

$P_A = I(\pi r_A^2) = \frac{10}{\pi}(\pi)(0.001)^2 = 10^{-5}$ W

Power received by aperture B,

$P_B = I(\pi r_B^2) = \frac{10}{\pi}(\pi)(0.002)^2 = 4\times10^{-5}$ W

Only 10% of P_A and P_B goes to the original direction

Hence, 10% of $P_A = 10^{-6} = P_1$ (say)

and 10% of $P_B = 4 \times 10^{-6} = P_2$ (say)

Path difference created by slab

$\Delta x = (\mu - 1)t = (1.5 - 1)(2000) = 1000$Å

Corresponding phase difference,

$\phi = \frac{2\pi}{\lambda}.\Delta x = \frac{2\pi}{6000} \times 1000 = \frac{\pi}{3}$

Now, resultant power at the focal point

$P = P_1 + P_2 + 2\sqrt{P_1P_2}\cos\phi$

$= 10^{-6}+4\times10^{-6}+2\sqrt{(10^{-6})(4\times10^{-6})}\cos\frac{\pi}{3}$

$= 7 \times 10^{-6}$ W

Sol 12: (a) Path difference due to the glass slab,

$\Delta x = (\mu - 1)t = (1.5 - 1)t = 0.5t$

Due to this slab, 5 red fringes have been shifted upwards.

Therefore, $\Delta x = 5\lambda_{red}$ or $0.5t = (5)(7 \times 10^{-7}$m)

$\therefore t$ = thickness of glass slab $=7\times10^{-6}$m

(b) Let μ' be the refractive index for green light then

$\Delta x' = (\mu' - 1)$

Now the shifting is of 6 fringes of red light. Therefore,

$\Delta x' = 6\lambda_{red}$

$\therefore (\mu' - 1)t = 6\lambda_{red}$

$\therefore (\mu' - 1) = \frac{(6)(7\times10^{-7})}{7\times10^{-6}} = 0.6$

$\therefore \mu' = 1.6$

(c) In part (a), shifting of 5 bright fringes was equal to 10^{-3} m. Which implies that

$5\omega_{red} = 10^{-3}$ m

(Here ω = Fringe width)

$\therefore \omega_{red} = \frac{10^{-3}}{5}$ m $= 0.2 \times 10^{-3}$ m

Now since $\omega = \frac{\lambda D}{d}$ or $\omega \propto l$

$\therefore \frac{\omega_{green}}{\omega_{red}} = \frac{\lambda_{green}}{\lambda_{red}}$

$\therefore \omega_{green} = \omega_{red}\frac{\lambda_{green}}{\lambda_{red}} = (0.2\times10^{-3})\left(\frac{5\times10^{-7}}{7\times10^{-7}}\right)$

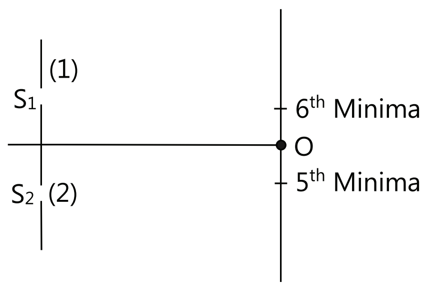
$\omega_{green} = 0.143 \times 10^{-3}$ m

$\therefore \Delta\omega = \omega_{green} - \omega_{red} = (0.143 - 0.2) \times 10^{-3}$m

$\Delta\omega = -5.71 \times 10^{-5}$ m

Sol 13: $\mu_1 = 1.4$ and $\mu_2 = 1.7$ and let t be the thickness of each glass plates.

Path difference at O, due to insertion of glass plates will be



$\Delta x = (\mu_2 - \mu_1)t = (1.7 - 1.4)t = 0.3t$ ...(i)

Now, since 5th maxima (earlier) lies below O and 6th minima lies above O.

This path difference should lie between 5λ and $5\lambda + \frac{\lambda}{2}$

So, let $\Delta x = 5\lambda + \Delta$ ...(ii)

Where $\Delta < \frac{\lambda}{2}$

Due to the path difference Δx, the phase difference at O will

$\phi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{\lambda}(5\lambda + \Delta)$

$= (10\pi + \frac{2\pi}{\lambda}.\Delta)$ ...(iii)

Intensity at O is given $\frac{3}{4}I_{max}$ and since

$I(\phi) = I_{max}\cos^2\left(\frac{\phi}{2}\right)$

$\therefore \frac{3}{4}I_{max} = I_{max}\cos^2\left(\frac{\phi}{2}\right)$

or $\frac{3}{4} = \cos^2\left(\frac{\phi}{2}\right)$ ...(iv)

From Equation (iii) and (iv), we find that

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

i.e., $\Delta x = 5\lambda + + \frac{\lambda}{6} = \frac{31}{6}\lambda = 0.3t$

$\therefore t = \frac{31\lambda}{6(0.3)} = \frac{(31)(5400\times10^{-10})}{1.8}$

or $t = 9.3 \times 10^{-6}$ m $= 9.3$ μm

Sol 14: (B) $\frac{I_{max}}{2} = I_m\cos^2\left(\frac{\phi}{2}\right)$

$\Rightarrow \cos\left(\frac{\phi}{2}\right) = \frac{1}{\sqrt{2}}$

$\Rightarrow \frac{\phi}{2} = \frac{\pi}{4}$

$\Rightarrow \phi = \frac{\pi}{2}(2n+1)$

$\Rightarrow \Delta x = \frac{\lambda}{2\pi}\phi = \frac{\lambda}{2\pi}\times\frac{\pi}{2}(2n+1) = \frac{\lambda}{4}(2n+1)$

Sol 15: (A, B, C) $\beta = \frac{D\lambda}{d}$

$\because \lambda_2 > \lambda_1 \Rightarrow \beta_2 > \beta_1$

Also $m_1\beta_1 = m_2\beta_2 \Rightarrow m_1 > m_2$

Also $3\left(\frac{D}{d}\right)(600\text{ nm}) = (2\times5-1)\left(\frac{D}{2d}\right)400$ nm

Angular width $\theta = \frac{\lambda}{d}$

Sol 16: For maxima,

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

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

$\therefore p = 3$