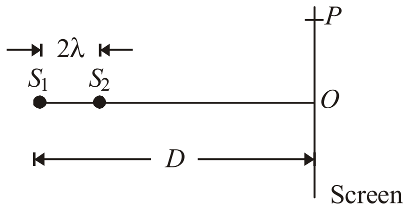
Chapter 16

WAVE OPTICS

A SINGLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

1. Two sources S_1 and S_2 emitting coherent light waves of wavelength λ in the same phase are situated as shown. The distance OP, so that the light intensity detected at P is equal to that at O is



(a) $D\sqrt{2}$ (b) $D/2$

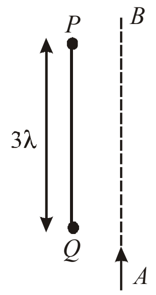
(c) $D\sqrt{3}$ (d) $D/\sqrt{3}$

2. 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

(a) unchanged. (b) halved.

(c) doubled (d) quadrupled

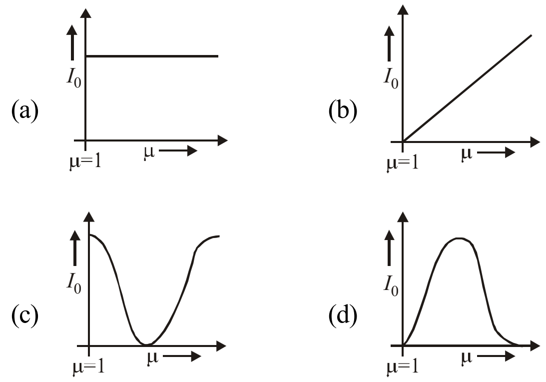
3. Two coherent light sources each of wavelength λ are separated by a distance 3λ. The maximum number of minima formed on line AB which runs from $-\infty$ to $+\infty$ is



(a) 2 (b) 4

(c) 6 (d) 8

4. In a *YDSE* experiment if a slab whose refraction 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 ($\mu \geq 1$). [Assume slits of equal width and there is no absorption by slab; mid point of screen is the point where waves interfere with zero phase difference in absence of slab]



5. 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 $3I$

6. In Fresnel's biprism experiment the width of 10 fringes is 2cm which are formed at a distance of two 2 meter from the slit. If the wavelength of light is 5100 Å then the distance between two coherent sources will be

(a) 5.1×10^{-4} m (b) 5.1×10^{4} cm.

(c) 5.1×10^{-4} mm (d) 10.1×10^{-4} cm

7. A beam of light of wave length 600 nm from a distance source falls on a single slit 1 mm wide and a resulting diffraction pattern is observed on a screen 2m away. The distance between the first dark fringes on either side of central bright fringe is

(a) 1.2 cm (b) 1.2 mm

(c) 2.4 cm (d) 2.4 mm

8. When a plastic thin film of refractive index 1.45 is placed in the path of one of the interfering waves then the central fringe is displaced through width of five fringes. The thickness of the film, if the wavelength of light is 05890Å, will be

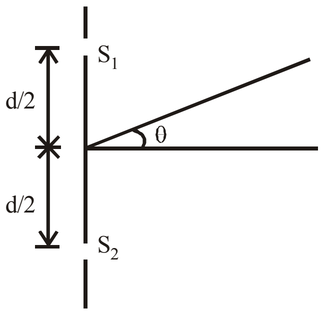
(a) 6.544×10^{-4} cm (b) 6.544×10^{-4} m

(c) 6.54×10^{-4} cm (d) 6.5×10^{-4} cm

MARK YOUR RESPONSE					
	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ		

9. The equation of two light waves are
$y_1 = 6 \cos\omega t,\ y_2 = 8 \cos(\omega t + f)$.
The ratio of maximum to minimum intensities produced by the superposition of these waves will be
(a) 49 : 1 (b) 1 : 49
(c) 1 : 7 (d) 7 : 1

10. 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 = 150.0 m. The intensity $I(\theta)$ is measured as a function of θ, where θ is defined as shown. If I_0 is the maximum intensity, then $I(\theta)$ for $0 \le \theta \le 90$ is given by



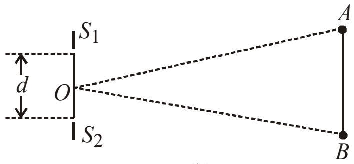
(a) $I(\theta) = I_0/2\ for\ \theta\ \ 30$
(b) $I(\theta) = I_0/4\ for\ \theta\ \ 90$
(c) $I(\theta) = I_0\ for\ \theta\ \ 0$
(d) $I(\theta)$ is constant for all values of θ.

11. Interference fringes were produced using white light in a double slit arrangement. When a mica sheet of uniform thickness of refractive index 1.6 (relative to air) is placed in the path of light from one of the slits, the central fringe moves through some a distance. This distance is equal to the width of 30 interfernece bands if light of wavelength 4800 Å is used. The thickness (in 1 μm) of mica is
(a) 90 (b) 12
(c) 14 (d) 24

12. In Young's experiment the wavelength of red light is 7.5×10^{-5} cm and that of blue light 5.0×10^{-5} cm. The value of n for which $(n+1)^{th}$ the blue bright band coincides with n^{th} red band is
(a) 8 (b) 4
(c) 2 (d) 1

13. Consider Fraunhoffer diffraction pattern obtained with a single slit illuminated at normal incidence. At the angular position of the first diffraction minimum the phase difference (in radians) between the wavelets from the opposite edges of the slit is
(a) $\pi/4$ (b) $\pi/2$
(c) 2π (d) π

14. Figure shows two coherent sources $S_1 - S_2$ vibrating in same phase. AB is an irregular wire lying at a far distance from the sources S_1 and S_2. Let $\frac{\lambda}{d}\ \ 10^{-3}$.
$\angle BOA\ \ 0.12$. How many bright spots will be seen on the wire, including points A and B.



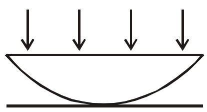
(a) 2 (b) 3
(c) 4 (d) more than 4

15. Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. If yellow light is replaced by X– rays, then the observed pattern will reveal,
(a) that the central maximum is narrower
(b) more number of fringes
(c) less number of fringes
(d) no diffraction pattern

16. Two slits separated by a distance of 1 mm are illuminated with red light of wavelength 6.5×10^{-7} m. The interference fringes are observed on a screen placed 1 m from the silts. The distance of the third dark fringe from the central fringe will be equal to :
(a) 0.65 mm (b) 1.30 mm
(c) 1.62 mm (d) 1.95 mm

17. A diffraction grating 1 cm wide has 1000 lines and is used to third order. Find the difference between the diffraction angles for 400 nm and 600 nm light.
(a) 2° (b) 3.4°
(c) 4° (d) 6°

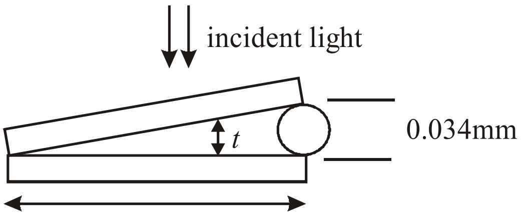
18. A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat glass plate as shown in figure. The observed interference fringes from this combination shall be



(a) straight
(b) circular
(c) equally spaced
(d) having fringe spacing which increases as we go outwards

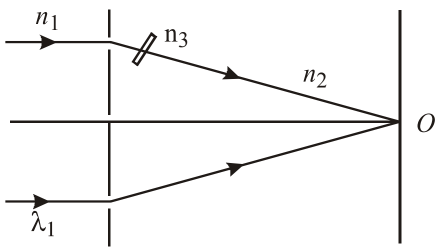
MARK YOUR RESPONSE					
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ
	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ

19. A broad source of light ($l = 680$ nm) illuminates normally two glass plates 120 mm long that touch at one end and are separated by a wire 0.034 mm in diameter at the other end. The total number of bright fringes that appear over the 120 mm distance is –



(a) 50 (b) 100
(c) 200 (d) 400

20. In the figure shown in a *YDSE*, a parallel beam of light is incident on the slits 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 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 slit) is



(a) $\dfrac{2\pi}{n_1\lambda_1}(n_3 - n_2)\,t$ (b) $\dfrac{2\pi}{\lambda_1}(n_3 - n_2)\,t$

(c) $\dfrac{2\pi n_1}{n_2\lambda_1}\left(\dfrac{n_3}{n_2} - 1\right)t$ (d) $\dfrac{2\pi n_1}{\lambda_1}(n_3 - n_2)\,t$

21. 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

(a) the intensities of both the maxima and the minima increase
(b) the intensity of the maxima increases and the minima has zero intensity
(c) the intensity of the maxima decreases and that of the minima increases
(d) the intensity of the maxima decreases and the minima has zero intensity

22. A beam of light consisting of two wavelength 6500A° & 5200A° is used to obtain interference fringes in a young's double slit experiment. The distance between the slits is 2.0 mm and the distance between the plane of the slits and the screen is 120 cm. What is the least distance from the central maximum where the bright fringes due to both the wave length coincide ?

(a) 0.156 cm (b) 0.152 cm
(c) 0.17 cm (d) 0.16 cm

23. A thin sheet of mica (12×10^{-7} m thick) is placed in the path of one of the interfering beams in a biprism arrangement. It is found that the central bright band shifts a distance equal to the width of a bright fringe. The refractive index of mica (Given $\lambda = 6 \times 10^{-7}$ m) is

(a) 1.0 (b) 1.5
(c) 1.75 (d) 1.25

24. Two beams of light having intensities I and $4I$ interfere to produce a fringe pattern on a screen. The phase difference between the beams is $\pi/2$ at point A and π at point B. Then the difference between the resultant intensities at A and B is

(a) $2I$ (b) $4I$
(c) $5I$ (d) $7I$

25. From a medium of index of refraction n_1, monochromatic light of wavelength λ is incident normally on a thin film of uniform thickness L (where $L > 0.1\lambda$) and index of refraction n_2. The light transmitted by the film travels into a medium with refractive index n_3. The value of minimum film thickness when maximum light is transmitted if ($n_1 \quad n_2 \quad n_3$) is

(a) $\dfrac{n_1\lambda}{2n_2}$ (b) $\dfrac{n_1\lambda}{4n_2}$

(c) $\dfrac{\lambda}{4n_2}$ (d) $\dfrac{\lambda}{2n_2}$

26. Interference fringes were produced in Young's double slit experiment using light of wave length 5000 Å. When a film of material 2.5×10^{-3} cm thick was placed over one of the slits, the fringe pattern shifted by a distance equal to 20 fringe width. The refractive index of the material of the film is -

(a) 1.25 (b) 1.33
(c) 1.4 (d) 1.5

MARK YOUR RESPONSE					
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ		

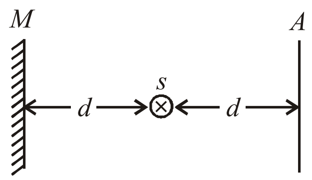
27. In a Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength of light is changed to 400 nm, number of fringes observed in the same segment of the screen is given by

(a) 12 (b) 18
(c) 24 (d) 30

28. A plastic sheet (refractive index = 1.6) covers one slit of a double slit arrangement meant for the Young's experiment. When the double slit is illuminated by monochromatic light (wavelength in air = 6600 Å), the centre of the screen appears dark rather than bright. The minimum thickness of the plastic sheet to be used for this to happen is:

(a) 3300 Å (b) 6600 Å
(c) 2062 Å (d) 5500 Å

29. The intensity of a point source of light, S, placed at a distance d in front of a screen A, is I_0 at the center of the screen. Find the light intensity at the center of the screen if a completely reflecting plane mirror M is placed at a distance d behind the source, as shown in figure.



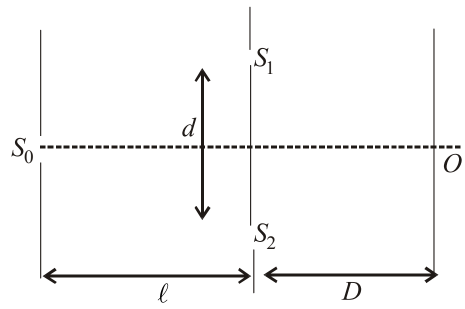
(a) $\frac{27 I_0}{9}$ (b) $\frac{25 I_0}{9}$

(c) $\frac{17 I_0}{9}$ (d) $\frac{10 I_0}{9}$

30. 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 (wave-lenght λ), the intensity at the position where the central maximum occurred previously remains unchanged. The minimum thickness of the glass-plate is

(a) 2λ (b) $2\lambda/3$
(c) $\lambda/3$ (d) λ

31. The figure shows a schematic diagram for Young's double slit experiment. Given $d \quad \ell, d \quad D, \lambda / D \quad 1$. Which of the following is a right statement about the wavelength of light used?

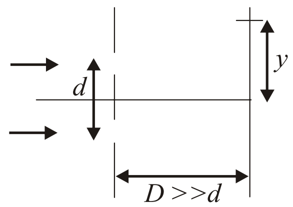


(a) Larger the wavelength, larger will be the fringe width.
(b) If white light is used, violet colour forms its first maxima closest to the central maxima.
(c) The central maxima of all wavelength coincide.
(d) All of the above

32. Monochromatic light of wavelength 400 nm and 560 nm are incident simultaneously and normally on double slits apparatus whose slits separation is 0.1 mm and screen distance is 1m. Distance between areas of total darkness will be

(a) 4mm (b) 5.6mm
(c) 14mm (d) 28mm

33. Consider the YDSE arrangement shown in figure. If $d = 10\lambda$ then position of 8th maxima is



(a) $y = \frac{D}{10}$ (b) $y = \frac{D}{3}$

(c) $y = \frac{4}{5}D$ (d) $y = \frac{4D}{3}$

34. In a Young's double slit experiment, the fringes are displaced by a distance x when a glass plate of refractive index 1.5 is introduced in the path of one of the beams. When this plate is replaced by another plate of same thickness, the shift of fringes is (3/2) x. The refractive index of second plate is

(a) 1.75 (b) 1.50
(c) 1.25 (d) 1.00

MARK YOUR RESPONSE					
	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ
	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ	34. ⓐⓑⓒⓓ		

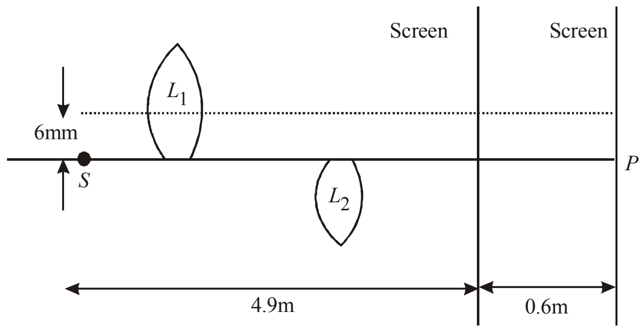
35. In Young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is

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

36. A Young's double slit experiment is conducted in a liquid of refractive index μ_1 and a glass plate of thickness t and refractive index μ_2 is placed in path of one slit. The magnitude of the optical path difference at centre of screen will be

(a) $\left|\left(\frac{\mu_2}{\mu_1}-1\right)t\right|$ (b) $\left|\left(\frac{\mu_1}{\mu_2}-1\right)t\right|$
(c) $|(\mu_2-\mu_1)t|$ (d) $|(\mu_2-1)t|$

37. A thin convex lens of focal length $f = 0.6$m is a cut into two unequal parts L_1 and L_2. One part is shifted along the cutting plane axis as shown in figure. A monochromatic line source S, perpendicular to the plane of paper, emitting light of wavelength $\lambda = 600$nm, is placed on the cutting plane axis. A screen with slits where the images of S is formed by these two pieces of the lens separately is placed perpendicular to the optical axis from the source at 4.9m. There is an another screen placed at distance 0.6m normal to optical axis where fringes are observed due to interference of the light passes through the holes. Find the position of central maximum from P. [Dotted line represent the principal axis of lens L_1]



(a) 24.5mm. (b) 12.5mm.
(c) 18.5mm. (d) 6.5mm.

38. A physics professor wants to find the diameter of a human hair by placing it between two flat glass plates, illuminating the plates with light of vaccum wavelength λ = 552nm and counting the number of bright fringes produced along the plates. The Professor find 125 bright fringes between the edge of the plates and the hair. What is the diameter of the hair?

(a) 525×10^{-9}m (b) 344×10^{-3}m
(c) 3.44×10^{-5}m (d) none of the above

39. The sky is blue because

(a) most polluting gases and dust particles in the air are bluish in colour and lend their colour to that of the sky.
(b) air molecules absorb red light more efficiently than they do blue light because of their electron orbitals.
(c) tiny particles in the air are more efficient at scattering short wavelength light than they are at scattering long wavelength light.
(d) air molecules absorb blue light more efficiently than they do red light because of their electron orbitals

40. At night approximately 500 photons per second must enter an unaided human eye for an object to be seen. A light bulb emits about 5.00×10^{18} photons per second uniformly in all directions. The radius of the pupil of the eye is about 4×10^{-3} meters. What is the maximum distance from which the bulb could be seen ?

(a) 2.0×10^4m (b) 2.0×10^5m
(c) 2.0×10^2m (d) 5.0×10^3m

41. A certain region of a soap bubble reflects red light of vaccum wavelength λ = 650nm. What is the minimum thickness that this region of the soap bubble could have? Take the index of reflection of the soap film to be 1.41.

(a) 1.2×10^{-7}m (b) 650×10^{-9}m
(c) 120×10^{7}m (d) 650×10^{5}m

42. A double slit arrangement produces fringes for λ = 5890 Å that are 0.4° apart. What is the angular width if the entire arrangement is immersed in water ? ($\mu_w = 4/3$)

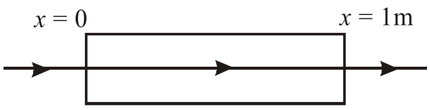
(a) 0.3° (b) 2.3°
(c) 0.8° (d) 1.3°

43. Screen S is illuminated by two points source A and B. Another source C sends a parallel beam of light towards the point P on the screen. Line AP is normal to the screen and line AP, BP and CP are in one plane. The distance AP, BP and CP are 3m, 1.5m and 1.5m respectively. The radiant powers of source A and B are 90 and 180W respectively and the beam from C is of the intensity 20W/m^2. Calculate the intensity at P on the screen.

(a) $14\frac{W}{m^2}$ (b) $10\frac{W}{m^2}$
(c) $10\frac{m^2}{W}$ (d) $14\frac{m^2}{W}$

MARK YOUR RESPONSE					
	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ	39. ⓐⓑⓒⓓ
	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ	

44. A ray of light travels through a slab as shown.



The refractive index of the material of the slab varies as $\mu = 1.2 + \frac{x^2}{2}$, where $0 \le x \le 1$m. What is the equivalent optical path of the glass slab ?

(a) 1.212 m (b) 1.367 m
(c) 0.123 m (d) 2.124 m

45. White light used to illuminate the two slits in Young's double slit experiment. The separation between the slits is d and the distance between the screen and the slit is D (>>d). At a point on the screen in front of one of the slits, certain wavelengths are missing. The missing wavelengths are

(a) $\lambda \quad \frac{d^2}{(2n \quad 1)D}$ (b) $\lambda \quad \frac{(2n \quad 1)d^2}{D}$

(c) $\lambda \quad \frac{d^2}{(n \quad 1)D}$ (d) $\lambda \quad \frac{(n \quad 1)D}{d^2}$

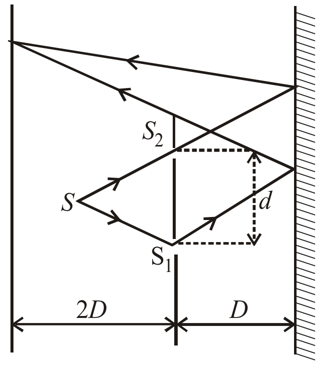
46. Young's double slit experiment is made in a liquid. The 10^{th} bright fringe lies in liquid where 6^{th} dark fringe lies in vacuum. The refractive index of the liquid is approximately

(a) 1.8 (b) 1.5
(c) 1.3 (d) 1.6

47. The wavelength of visible light in air can be

(a) 5 nm (b) 5 mm
(c) 50 μm (d) 500 nm

48. A double slit, $S_1 - S_2$ is illuminated by a light source S emitting light of wavelength λ. The slits are separated by a distance d. A plane mirror is placed at a distance D in front of the slits and a screen is placed at a distance 2D behind the slits. The screen receives light reflected only by the plane mirror. The fringe-width of the interference pattern on the screen is



(a) $\frac{D\lambda}{d}$ (b) $\frac{2D\lambda}{d}$

(c) $\frac{3D\lambda}{d}$ (d) $\frac{4D\lambda}{d}$

49. A possible means for making an airplane invisible to radar is to coat the plane with an antireflective polymer. Radar waves have a wavelength of 3.00 cm and the index of refraction of the polymer is $n = 1.50$. How thick would you make the coating?

(a) 1.50 cm (b) 3.00 cm
(c) 0.50 cm (d) None of these

50. In a two-slit experiment, with monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in fringe width is 10^{-3} m. Then the wavelength of light used is (given that distance between the slits is 0.03 mm)

(a) 4000 Å (b) 4500 Å
(c) 5000 Å (d) 6000 Å

51. Specific rotation of sugar solution is 0.5 deg m^2/kg. 200 kgm^{-3} of impure sugar solution is taken in sample polarimeter tube of length 20 cm and optical rotation is found to be 19º. The percentage of purity of sugar is

(a) 20% (b) 80%
(c) 95% (d) 89%

52. If white light is used in the Newton's rings experiment, the colour observed in the reflected light is complementary to that observed in the transmitted light through the same point. This is due to

(a) 90º change of phase in one of the reflected waves
(b) 180º change of phase in one of the reflected waves
(c) 145º change of phase in one of the reflected waves
(d) 45° change of phase in one of the reflected waves

MARK YOUR RESPONSE					
	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ	46. ⓐⓑⓒⓓ	47. ⓐⓑⓒⓓ	48. ⓐⓑⓒⓓ
	49. ⓐⓑⓒⓓ	50. ⓐⓑⓒⓓ	51. ⓐⓑⓒⓓ	52. ⓐⓑⓒⓓ	

53. An unpolarised beam of intensity I_0 is incident on a pair of nicols making an angle of 60° with each other. The intensity of light emerging from the pair is

(a) I_0 (b) $I_0/2$
(c) $I_0/4$ (d) $I_0/8$

54. The width of the diffraction band varies

(a) inversely as the wavelength
(b) directly as the width of the slit
(c) directly as the distance between the slit and the screen
(d) inversely as the size of the source from which the slit is illuminated

55. When unpolarised light beam is incident from air onto glass ($n = 1.5$) at the polarising angle :

(a) reflected beam is polarised 100 percent
(b) reflected and refracted beams are partially polarised
(c) the reason for (a) is that almost all the light is reflected
(d) all of the above

56. As a result of interference of two coherent sources of light energy is :

(a) redistributed and the distribution does not vary with time
(b) increased
(c) redistributed and that distribution changes with time
(d) decreased

57. Waves that can not be polarised are :

(a) electromagnetic waves
(b) light waves
(c) longitudinal waves
(d) transverse waves

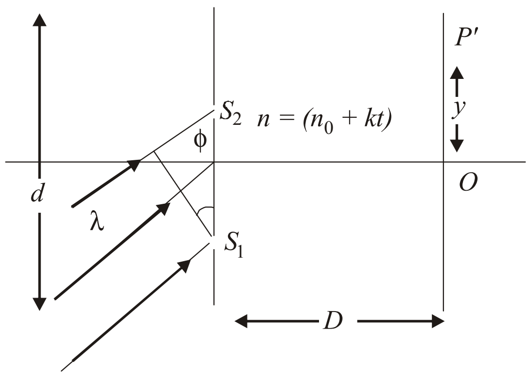
MARK YOUR RESPONSE	53. ⓐⓑⓒⓓ	54. ⓐⓑⓒⓓ	55. ⓐⓑⓒⓓ	56. ⓐⓑⓒⓓ	57. ⓐⓑⓒⓓ

B COMPREHENSION TYPE

This section contains groups of questions. Each group is followed by some multiple choice questions based on a paragraph. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

PASSAGE-1

For the Young's double slit experiment a monochromatic source light is used whose wavelength is λ strikes on the slits, separated by distance d as shown in the figure.



1. The y co-ordinates of central maxima at any time t is

(a) $\dfrac{D\sin\phi}{n_0 \quad kt}$ (b) $\dfrac{D\cos\phi}{n_0 \quad kt}$

(c) $\dfrac{D\sin\phi}{n_0 \quad kt^{\,2}}$ (d) $\dfrac{D\cos\phi}{n_0 \quad kt^{\,2}}$

2. The velocity of central maxima at any time t as a function of time t is

(a) $\dfrac{-2kD\sin\phi}{(n_0 \quad kt)^2}$ (b) $\dfrac{-kD\sin\phi}{(n_0 \quad kt)^2}$

(c) $\dfrac{-2kD\sin\phi}{(n_0 \quad kt)}$ (d) $\dfrac{-kD\sin\phi}{(n_0 \quad kt)}$

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ			

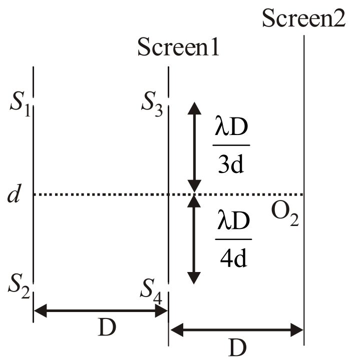
3. If a glass plate of small thickness b is placed in front of S_1. How should its refractive index vary with time so that central maxima is formed at O.

(a) $n_0 \quad kt \quad \frac{2d\sin\phi}{b}$ (b) $n_0 \quad kt - \frac{2d\sin\phi}{b}$

(c) $n_0 \quad kt - \frac{d\sin\phi}{b}$ (d) $n_0 \quad kt \quad \frac{d\sin\phi}{b}$

PASSAGE-2

In YDSE two slits S_1 and S_2 are giving light of wavelength λ and intensity I_0 and are in the same phase. Two pin holes S_3 and S_4 are made in screen 1 as shown in figure.



4. The ratio of intensity at S_3 and S_4 will be

(a) $\frac{1}{2}$

(b) 2

(c) 1

(d) ∞.

5. The ratio of maximum and minimum intensity on screen 2 is

(a) $\left(\frac{\sqrt{2} \quad 1}{\sqrt{2}-1}\right)$ (b) $\left(\frac{\sqrt{2} \quad 1}{\sqrt{2}-1}\right)^2$

(c) $\frac{4}{1}$ (d) $\left(\frac{2-\sqrt{2}}{2 \quad \sqrt{2}}\right)$.

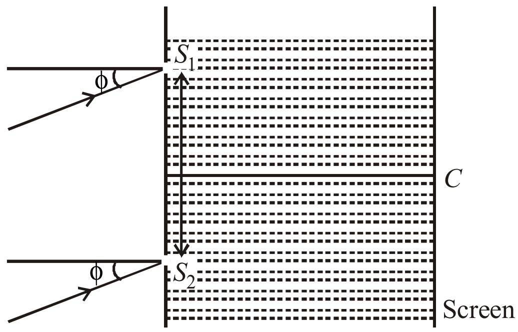
6. The intensity of light at a point eqidistant from S_3 and S_4 on screen 2 is

(a) $3I_0$ (b) $9I_0$

(c) $(3 \quad \sqrt{6})I_0$ (d) zero.

PASSAGE-3

In a Young's double slit experiment a parallel beam containing wavelengths λ_1 = 4000 Å and λ_2 = 5600 Å incident at an angle ϕ = 30° on a diaphragm having narrow slits at a separation d = 2mm. The screen is place at a distance D = 40cm. from slits. A mica slab of thickness t = 5mm is placed in front of one of the slits and whole the apparatus is submerged in water. If the central bright fringe is observed at C, which is equidistant from both the slits then



7. The refractive index of the slab is

(a) 1.6 (b) 1.2

(c) 2.6 (d) 3.65

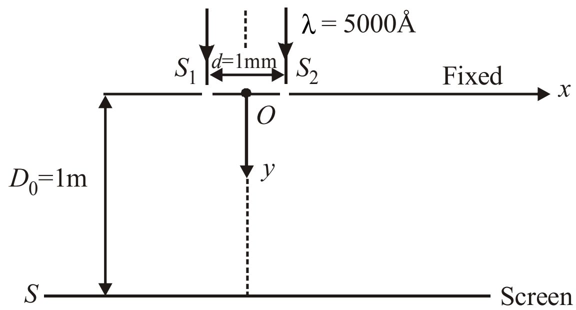
8. The distance of the first black line from C is

(a) 120 μm (b) 105 μm

(c) 210 μm (d) 180 μm

PASSAGE- 4

In the figure shown light of wavelength λ = 5000 Å is incident on the slits (in a horizontal fixed plane) S_1 and S_2 separated by distance d = 1 mm. A horizontal screen S is released from rest from initial distance D_0 = 1m from the plane of the slits. Taking origin at O and positive x and y axis as shown, (Use g = 10 m/s^2)



MARK YOUR RESPONSE	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ
	8. ⓐⓑⓒⓓ				

9. Velocity of central maxima in vector form at $t = 2$ sec. is
(a) $20\hat{j}\ m/s$ (b) $5\hat{j}\ m/s$
(c) $10\,\hat{j}\ m/s$ (d) $25\,\hat{j}\ m/s$

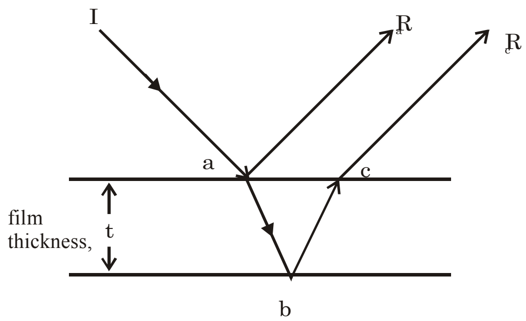
10. Acceleration of central maxima in vector form at $t = 2$ sec. is
(a) $5\,\hat{j}\ m/s^2$ (b) $15\,\hat{j}\ m/s^2$
(c) $10\,\hat{j}\ m/s^2$ (d) $20\,\hat{j}\ m/s^2$

11. Relative acceleration of second maxima with respect to first minima, on the same side of central maxima is
(a) $2.5\times10^{-3}\ m/s^2\ \hat{i}$ (b) $7.5\times10^{-3}\ m/s^2\ \hat{j}$
(c) $5.5\times10^{-3}\ m/s^2\ \hat{i}$ (d) $7.5\times10^{-3}\ m/s^2\ \hat{i}$

PASSAGE- 5

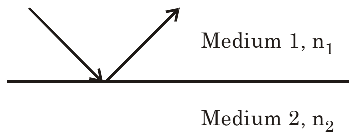
Thin films, including soap bubbles and oil sticks, show patterns of alternating dark and bright regions resulting from interference among the reflected light waves. If two waves are in phase their crest and troughs will coincide. The interference will be constructive and the amplitude of either constituent wave . If the two waves are out of phase by 1/2 a wavelength (180°), the crests of one wave will coincide with the troughs of the other wave. The interference will be destructive and the amplitude of the resultant wave will be less than that of either constituent wave.
At the interface between two transparent media, some light is reflected and some light is refracted.

1. When incident light, I, reaches the surface at point a, some of the light is reflected as ray R_a and some is refracted following the path ab to the back of the film.
2. At point b some of the light is refracted out of the film and part is reflected back through the film along path bc. At point c some of the light is reflected back into the film and part is reflected out of the film as ray R_c



R_a and R_c are parallel . However, R_c has traveled the extra distance within the film of abc. If the angle of incidence is small, then abc is approximately twice the film's thickness. If R_a and R_c are in phase, they will undergo constructive interference and the region ac will be bright . If R_a and R_c are out of phase, they will undergo destructive interference and the region ac will be dark.
The thickness of the film and the refractive indices of the media at each interface determine the final phase relationship between R_a and R_c

I. Refraction at an interface never changes the phase of the wave.
II. For reflection at the interface between two media 1 and 2. If $n_1 < n_2$ the reflected wave will change phase. If $n_1 > n_2$ the reflected wave will not undergo a phase change.



For reference. $n_{air} = 1.00$

III. If the waves are in phase after reflection at all interfaces, then the effects of path length in the film are :
Constructive interference occurs when $2t = m\lambda/n$ m = 0, 1, 2, 3, ...
Destructive interference occurs when
$2t \quad (m \quad \frac{1}{2})\lambda/n$ m = 0, 1, 2, 3,...
If the wave are 180° out of phase after reflection at all interfaces then the effects of path length in the film are :
Constructive interference occurs when
$2t \quad (m \quad 1/2)\lambda/n$ m = 0, 1, 2, 3 ......
Destructive interference occurs when
$2t = m\lambda/n$ m = 0, 1, 2, 3, ...

12. A thin film with index of refraction 1.50 coats a glass lens with index of refraction 1.80. What is the minimum thickness of the thin film that will strongly reflect light with wavelength 600 nm?
(a) 150 nm (b) 200 nm
(c) 300 nm (d) 450 nm

13. A thin film with index of refraction 1.33 coats a glass lens with index of refraction 1.50. Which of the following choices is the smallest film thicknesses that will not reflect light with wavelength 640 nm?
(a) 160 nm (b) 240 nm
(c) 360 nm (d) 480 nm

14. A soap film of thickness t is surrounded by air and is illuminated at near normal incidence by monochromatic light with wavelength λ in the film. With respect to the wavelength of the monochromatic light in the film, what film thickness will produce maximum constructive interference?
(a) $\frac{1}{4}\lambda$ (b) $\frac{1}{2}\lambda$
(c) 1λ (d) 2λ

MARK YOUR RESPONSE					
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ
	14. ⓐⓑⓒⓓ				

15. The average human eye sees colors with wavelengths between - 430 nm to 680 nm. For what visible wavelength(s) will a 350-nm thick $n = 1.35$ soap film produce maximum destructive interference?

(a) 945 nm (b) 473 nm
(c) 315 nm (d) None of these

16. A 600 nm light is perpendicularly incident on a soap film suspended in air. The film is 1.00 μm thick with $n = 1.35$. Which statement most accurately describes the interference of the light reflected by the two surfaces of the film?

(a) The waves are close to destructive interference
(b) The waves are close to constructive interference
(c) The waves show complete destructive interference
(d) The waves show complete constructive interference

17. A thin film of liquid polymer n = 1.25 coats a slab of Pyrex, n = 1.50. White light is incident perpendicularly to the film. In the reflections full destructive interference occurs for λ 600 nm and full constructive interference occurs for λ = 700 nm. What is the thickness of the polymer film?

(a) 120 nm (b) 280 nm
(c) 460 nm (d) 840 nm

MARK YOUR RESPONSE	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ		

C REASONING TYPE

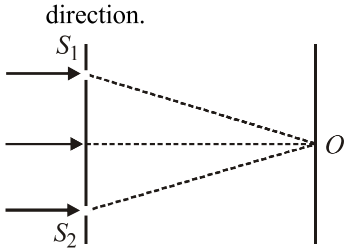
In the following questions two Statements (1 and 2) are provided. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct. Mark your responses from the following options:

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.
(b) Both Statement-1 and Statement-2 are true and Statement-2 is not the correct explanation of Statement-1.
(c) Statement-1 is true but Statement-2 is false.
(d) Statement-1 is false but Statement-2 is true.

INSTRUCTIONS : In the following questions an Statement –1 is given followed by a Statement – 2. Mark your responses from the following options.

(a) Both Statement - 1 and Statement - 2 are true and Statement - 2 is the correct explanation of 'Statement - 1'
(b) Both Statement - 1 and Statement - 2 are true and Statement - 2 is not the correct explanation of 'Statement - 1'
(c) Statement - 1 is true but Statement - 2 is false
(d) Statement - 1 is false but Statement - 2 is true

1. **Statement - 1 :** 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 - 2 : If path difference at *O* increases y-coordinate of central bright fringe will change.

2. **Statement - 1 :** In standard *YDSE* set up with visible light, the position on screen where phase difference is zero appears bright.

Statement - 2 : In *YDSE* set up magnitude of electromagnetic field at central bright fringe is not varying with time.

3. **Statement - 1 :** Radio waves can be polarised.

Statement - 2 : Sound waves in air are longitudinal in nature.

4. **Statement - 1 :** Newton's rings are formed in the reflected system when the space between the lens and the glass plate is filled with a liquid of refracitve index greater than that of glass, the central spot of the pattern is bright.

Statement - 2 : This is because the reflection in these cases will be from a denser to rarer medium and the two interfering rays are reflected under similar conditions.

5. **Statement - 1 :** Corpuscular theory fails in explaining the velocities of light in air and water.

Statement - 2 : According to corpuscular theory, light should travel faster in denser medium than in rarer medium.

6. **Statement - 1 :** In Young's experiment, the fringe width for dark fringes is equal to that for white fringes.

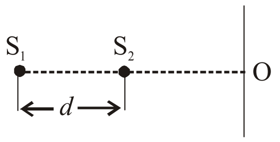
Statement - 2 : In Young's double slit experiment the fringes are performed with a source of white light, then only black and bright fringes are observed.

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ				

D MULTIPLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONE OR MORE is/are correct.

1. Two point monochromatic and coherent sources of light of wavelength λ are placed on the *d*otted line in front of an infinite 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.



(a) if d is $\frac{3\lambda}{2}$, at O minima will be observed

(b) if d is $\frac{11\lambda}{6}$, then intensity at O will be $\frac{3}{4}$ of maximum intensity

(c) If d is 3λ, O will be a maxima

(d) if d is $\frac{7\lambda}{6}$, the intensity at O will be $\frac{3}{4}$ of maximum intensity

2. 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

(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 units respectively

(c) the amplitude ratio is 3

(d) the amplitude ratio is 2

3. Young's double slit experiment is conducted with a slit separation of 0.5 mm, with the distance between the slit and screen being 1 m. The wavelength of light used is 5000 Å. The size of fringes formed on the screen if a parallel beam of light is incident, making an angle of 1/100 radian with the x normal to the plane of the double slit is

(a) 1 m (b) 1 mm
(c) < 1 mm (d) > 1 mm

4. 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) $\lambda \ \frac{b^2}{d}$ (b) $\lambda \ \frac{2b^2}{d}$

(c) $\lambda \ \frac{b^2}{3d}$ (d) $\lambda \ \frac{2b^2}{3d}$

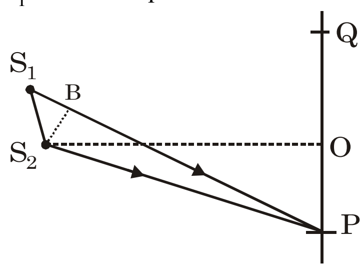
5. Two beams of light having intensities I and $4I$ interfere to produce a fringe pattern on a screen. The phase difference between the beam is $\pi/2$ at a point A and π at point B. Then the difference between resultant intensities at A and B is.

(a) $2I$ (b) $4I$
(c) $5I$ (d) $7I$

6. In Young's double slit experiment, if distance between the slits is doubled, then to keep fringe width unchanged

(a) wavelength should be double
(b) distance between screen and slits should be doubled
(c) both should remain constant
(d) none of the above

7. In figure, Young's double slit experiment., Q is the position of the first bright fringe on the right side of O. P is the 11th fringe on the other side, as measured from Q. If λ = 6000 Å, then S_1B will be equal to



(Fig. 15.2)

(a) 6×10^{-6} m (b) 6.6×10^{-6} m
(c) 3.318×10^{-7} m (d) 3.144×10^{-7} m

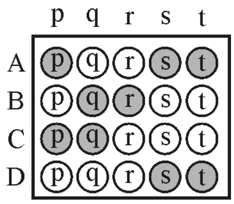
8. Which of the following are essential for producing interference in Young's double slit experiment ?

(a) Constant phase (b) Same wavelength
(c) Same amplitude (d) Same intensity

MARK YOUR RESPONSE					
	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ		

E MATRIX-MATCH TYPE

Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labeled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column -I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:
If the correct matches are A–p, s and t; B–q and r; C–p and q; and D–s and t; then the correct darkening of bubbles will look like the given.



1. **Column I** — **Column II**

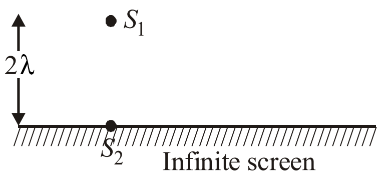
(A) Young's double slit experiment uses — (p) Incoherent sources
(B) Sources of variable phase difference — (q) Coherent source
(C) A point on a wavefront behaves as a light source — (r) Superposition principle
(D) Net displacement is vector sum of individual displacements — (s) Huygen's principle

2. **Column - I** — **Column - II**

(A) If Young's double slit experiment is performed in water instead of air then the fringe pattern will — (p) equal
(B) A plane wave front is incident normally on a circular operature and diffraction pattern is obtained on the screen on another side of aperture. On displacing the screen towards operture, the number of HPZ exposed through the aperture is — (q) more
(C) If the wavelength of a wave is large than the degree of diffraction observed — (r) increase
(D) For best contrast between maxima and minima in the interference pattern of Young's double slit experiment the intensity of light emerging out of the two slits should — (s) shrink

3. S_1 and S_2 in column I represent coherent point sources, S represents a point source.
λ = wavelength of light emitted by the sources.

Column I — **Column II**

(A)


(p) Number of maxima = 2

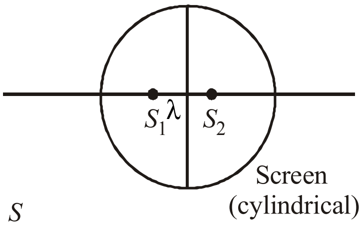
MARK YOUR RESPONSE

1.

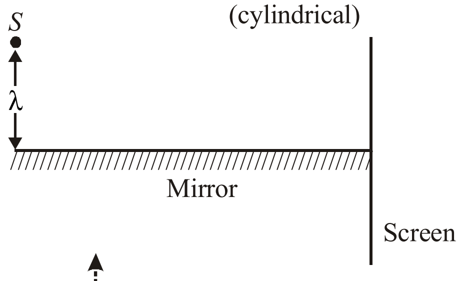
	p	q	r	s
A	(p)	(q)	(r)	(s)
B	(p)	(q)	(r)	(s)
C	(p)	(q)	(r)	(s)
D	(p)	(q)	(r)	(s)

2.

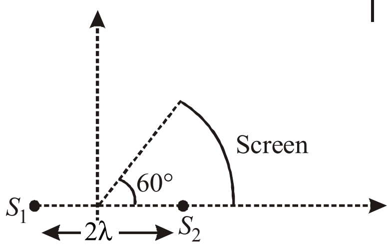
	p	q	r	s
A	(p)	(q)	(r)	(s)
B	(p)	(q)	(r)	(s)
C	(p)	(q)	(r)	(s)
D	(p)	(q)	(r)	(s)

(B) 

(q) Number of minima = 2

(C) 

(r) Number of maxima = 4

(D) 

(s) Number of minima = 4

(t) Number of maxima = 7

4. **Column - I** **Column - II**

(A) The fringe width for red colour as compared to that for violet colour is approximately — (p) half

(B) In a Young's double slit experiment, the distance between the slits is halved and the distance between slit and screen is doubled then the fringe width will become — (q) double

(C) If the distance of a surface from light source is doubled then the illuminance will become — (r) quarter times

(D) Light from a lamp is falling normally on a small surface. If the surface is tilted to 60° from this position, then the illuminance of the surface will become — (s) four times

MARK YOUR RESPONSE

3.

	p	q	r	s	t
A	p	q	r	s	t
B	p	q	r	s	t
C	p	q	r	s	t
D	p	q	r	s	t

4.

	p	q	r	s
A	p	q	r	s
B	p	q	r	s
C	p	q	r	s
D	p	q	r	s

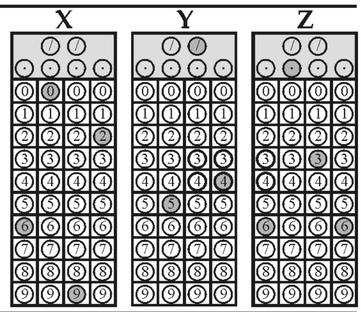
F NUMERIC/INTEGER ANSWER TYPE

The answer to each of the questions is either numeric (eg. 304, 40, 3010, 3 etc.) or a fraction (2/3, 23/7) or a decimal (2.35, 0.546).

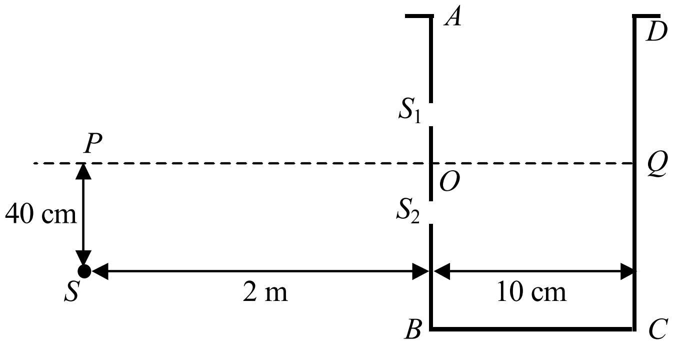
The appropriate bubbles below the respective question numbers in the response grid have to be darkened.

For example, if the correct answers to question X, Y & Z are 6092, 5/4 & 6.36 respectively then the correct darkening of bubbles will look like the following.

For single digit integer answer darken the extreme right bubble only.

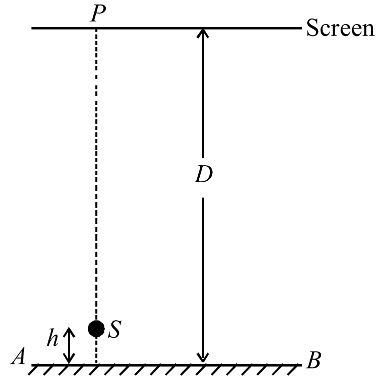


1. A vessel $ABCD$ of 10 cm width has two small slits S_1 and S_2 sealed with identical glass plates of equal thickness. The distance between the slits is 0.8 mm. POQ is the line perpendicular to the plane AB and passing through O, the middle point of S_1 and S_2. A monochromatic light source is kept at S, 40 cm below P and 2 m from the vessel, to illuminate the slits as shown in the figure below. Calculate the position of the central bright fringe (in cm) on the other wall CD with respect to the line OQ.



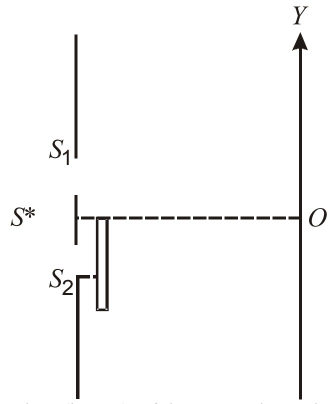
2. In $YDSE$ a light containing two wavelengths 500 nm and 700 nm are used. Find the minimum distance (in mm) where maxima of two wavelengths coincide. Given $D/d = 10^3$, where D is the distance between the slits and the screen and d is the distance between the slits.

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



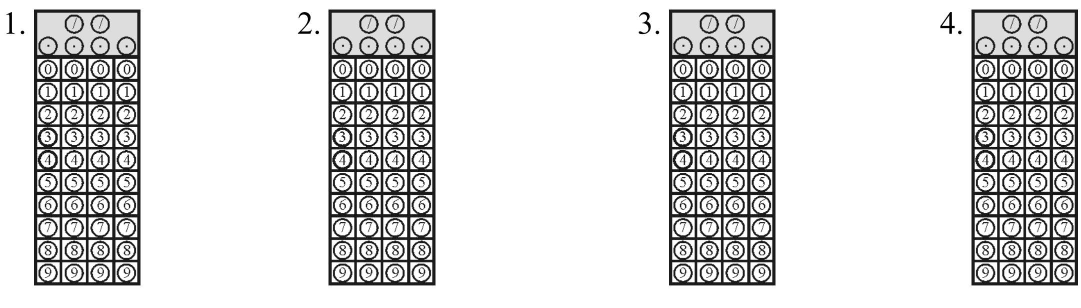
Calculate the ratio of the minimum to the maximum intensities in the interference fringes formed near the point P (shown in the figure).

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



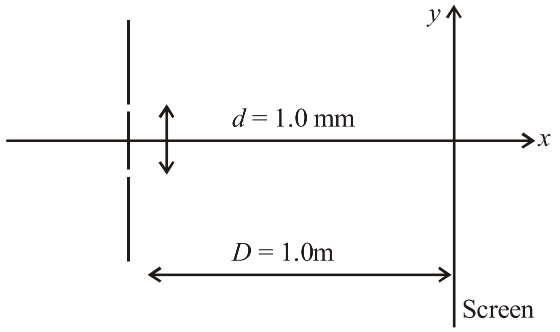
Find the location (in µm) of the central maximum (bright fringe

MARK YOUR RESPONSE



with zero path difference) on the y-axis.
[All wavelengths in this problem are for the given medium of refractive index 4/3. Ignore dispersion]

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

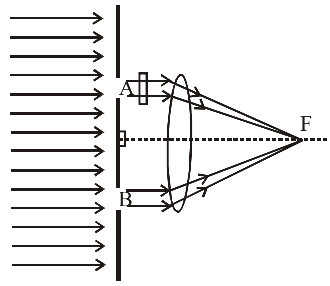


If the incident beam falls normally on the double slit apparatus, find the sum of the magnitudes (in m) of the y-coordinates of all the interference minima on the screen.

6. 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 (in μm) of the plate.

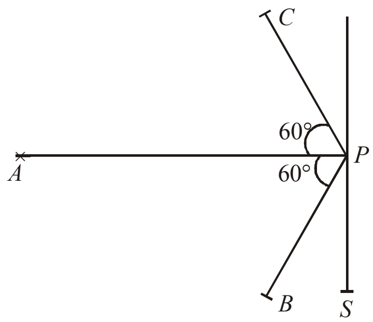
7. In Young's experiment, the upper slit is covered by a thin glass plate of refractive index 1.4 while the lower slit is covered by another glass plate, having the same thickness as the first one but having refractive index 1.7. Interference pattern is observed using light of wavelength 5400 Å. It is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

8. In a modified Young's double slit experiment, a monochromatic uniform and parallel beam of light of wavelength 6000 Å and intensity $(10/\pi)$ W m^{-2} is incident normally on two circular 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 fig.



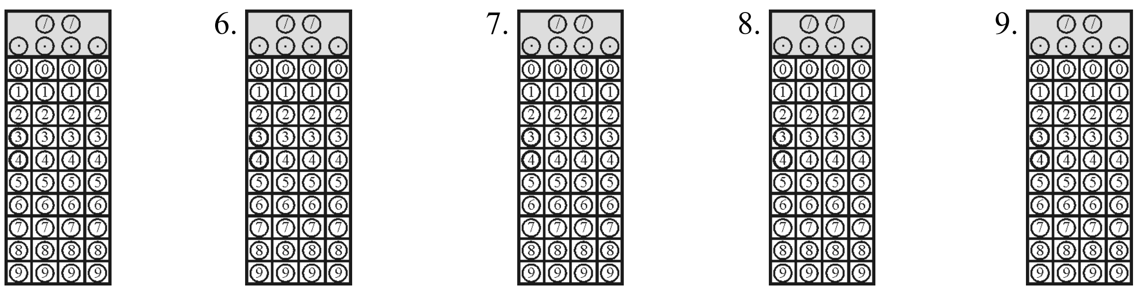
Calculate the power (in micro-watt) received at the focal spot F of the lens.
The lens is symmetrically placed with respect to the apertures. Assume that 10% of the power received by each aperture goes in the original direction and is brought to the focal spot.

9. 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 distance AP, BP and CP are in one plane. The distance AP, BP and CP are 3 m, 1.5 m and 1.5 m respectively. The radiant powers of sources A and B are 90 watts and 180 watts respectively. The beam from C is of intensity 20 watt/m^2. Calculate the intensity (in W/m^2) at P on the screen.



MARK YOUR RESPONSE

5. 6. 7. 8. 9.



Answerkey

A SINGLE CORRECT CHOICE TYPE

1	(c)	**11**	(d)	**21**	(a)	**31**	(d)	**41**	(a)	**51**	(c)
2	(d)	**12**	(c)	**22**	(a)	**32**	(d)	**42**	(a)	**52**	(b)
3	(c)	**13**	(c)	**23**	(b)	**33**	(d)	**43**	(a)	**53**	(c)
4	(c)	**14**	(b)	**24**	(b)	**34**	(a)	**44**	(b)	**54**	(c)
5	(c)	**15**	(d)	**25**	(b)	**35**	(c)	**45**	(a)	**55**	(a)
6	(a)	**16**	(c)	**26**	(c)	**36**	(a)	**46**	(a)	**56**	(a)
7	(d)	**17**	(d)	**27**	(b)	**37**	(a)	**47**	(d)	**57**	(c)
8	(a)	**18**	(a)	**28**	(d)	**38**	(c)	**48**	(d)		
9	(a)	**19**	(b)	**29**	(d)	**39**	(c)	**49**	(c)		
10	(c)	**20**	(a)	**30**	(a)	**40**	(b)	**50**	(d)		

B COMPREHENSION TYPE

1	(a)	**5**	(b)	**9**	(a)	**13**	(c)	**17**	(d)
2	(b)	**6**	(c)	**10**	(c)	**14**	(a)		
3	(c)	**7**	(a)	**11**	(d)	**15**	(b)		
4	(a)	**8**	(c)	**12**	(b)	**16**	(d)		

C REASONING TYPE

1	(d)	**3**	(b)	**5**	(a)
2	(c)	**4**	(a)	**6**	(c)

D MULTIPLE CORRECT CHOICE TYPE

1	(a, b, c, d)	**3**	(b)	**5**	(b)	**7**	(a)
2	(b, d)	**4**	(a, c)	**6**	(a, b)	**8**	(a, b)

E MATRIX-MATCH TYPE

1. **A-q, r, s; B-p; C-s; D-r**

2. **A-s; B-r; C-q; D-p**

3. **A-p, q; B-r, s; C-s, t; D-p**

4. **A-q; B-s; C-r; D-p**

F NUMERIC/INTEGER ANSWER TYPE

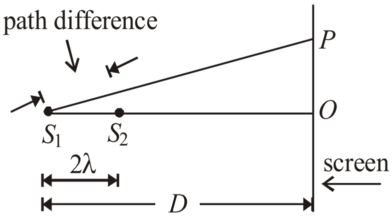
1	2	**2**	3.5	**3**	0.06	**4**	4330
5	2.78	**6**	7	**7**	9.3	**8**	7
9	13.9						

Solutions

A SINGLE CORRECT CHOICE TYPE

1. **(c)** Referring to the figure, the path difference between the two waves starting from S_1 and S_2 turns out to be $(2\lambda\cos\theta) = n\lambda$ where n is taken as 1 to get the point of maximum intensity which is the same as a point O. Therefore, the above relation gives $\cos\theta = 1/2$ so that $\theta = 60°$

and $\tan\theta = PO/D = \sqrt{3}$, giving $PO = D\sqrt{3}$.



2. **(d)** The fringe width in Young's double slit experiment is

$$\beta \quad \frac{\lambda D}{d}$$

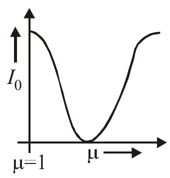
where λ is the wavelength of light used. D is the distance between slit and screen. d is the distance between the slit.

$$\beta' \quad \frac{\lambda(2D)}{d/2} \quad 4\frac{\lambda D}{d} \quad 4\beta$$

3. **(c)** There can be three minima from central point to ∞ corresponding to $\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ path differences.

$\therefore$ total number of minima $= 2n_{max} = 6$.

4. **(c)** In absence of film or for $m = 0$ intensity is maximum at screen. As the value of m is increased, intensity shall decrease and then increase alternately. Hence the correct variation is.



5. **(c)** Let $I_1 = I$ and $I_2 = 4I$

$$I_{max} \quad \sqrt{I_1} \quad \sqrt{I_2}^{\,2} \quad \sqrt{I} \quad \sqrt{4I}^{\,2} \quad 3\sqrt{I}^{\,2} \quad 9I$$

$$I_{min} = \sqrt{I_1} - \sqrt{I_2}^{\,2} = \sqrt{I} - \sqrt{4I}^{\,2} \quad I$$

6. **(a)** $d \quad \frac{D\lambda}{\beta}$ ....(1)

According to question, $\lambda = 5100 \times 10^{-10}$ m

$\beta = \frac{2}{10} \times 10^{-2}$ m ....(2)

$D = 2$m, $d = ?$

From eqs. (1) and (2)

$$d \quad \frac{2 \times 51 \times 10^{-8}}{2 \times 10^{-3}} = 5.1 \times 10^{-4}\text{ m}$$

7. **(d)** The distance between the first dark fringe on either side of the central maximum = width of central maximum

$$= \frac{2D\lambda}{a} \quad \frac{2 \times 2 \times 600 \times 10^{-9}}{10^{-3}} = 2.4 \times 10^{-3}\text{ m} = 2.4\text{ mm}$$

8. **(a)** $\therefore X_0 = \frac{\beta}{\lambda}(\mu - 1)t \Rightarrow 5\beta \quad \frac{\beta(0.45)t}{5890 \times 10^{-10}}$

$$\therefore t \quad \frac{5 \times 5890 \times 10^{-10}}{0.45} = 6.544 \times 10^{-4}\text{ cm}$$

9. **(a)** $a_1 = 6$ units, $a_2 = 8$ units

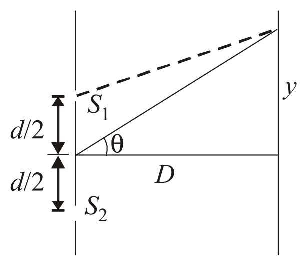
$$\frac{I_{max}}{I_{min}} \quad \frac{\left[\frac{a_1}{a_2} \quad 1\right]^2}{\left[\frac{a_1}{a_2} - 1\right]^2} \quad \frac{\left[\frac{6}{8} \quad 1\right]^2}{\left[\frac{6}{8} - 1\right]^2} \Rightarrow \frac{I_{max}}{I_{min}} \quad \frac{49}{1}$$

10. **(c)** We know that

$$I(\theta) = I_0 \cos^2\frac{\delta}{2} \text{ where } \delta = \frac{2\pi}{\lambda} \times \frac{dy}{D} \quad \frac{2\pi d\tan\theta}{\lambda}$$

$$I(\theta) \quad I_0\cos^2\left(\frac{\pi d\tan\theta}{\lambda}\right) \quad I_0\cos^2\left(\frac{\pi \times 150 \times \tan\theta}{3 \times 10^8/10^6}\right)$$

$$= I_0\cos^2\left(\frac{\pi}{2}\tan\theta\right)$$



For $\theta = 30°; I(\theta) = I_o \cos^2\left(\frac{\pi}{2\sqrt{3}}\right)$

For $\theta = 90°$; $I(\theta) = I_o \cos^2(\infty)$

For $\theta = 0°$

$I(\theta) = I_0$

$I(\theta)$ is not constant.

11. **(d)** Shift of fringe pattern = $(\mu - 1)\frac{tD}{d}$

$$\therefore \quad \frac{30D\,(4800\times10^{-10})}{d} \quad (0.6)t\frac{D}{d}$$

$$30\times4800\times10^{-10} \quad 0.6t$$

$$t \quad \frac{30\times4800\times10^{-10}}{0.6} \quad \frac{1.44\times10^{-5}}{0.6} \quad 24\times10^{-6}$$

12. **(c)** $n_1\lambda_1 = n_2\lambda_2$ for bright fringe

$n(7.5\times10^{-5}) = (n+1)(5\times10^{-5})$

$$n \quad \frac{5.0\times10^{-5}}{2.5\times10^{-5}} = 2.$$

13. **(c)** Path difference between the opposite edges is λ.
For a phase difference of 2π we get a path diff. of λ.

14. **(b)** Angular width = $\frac{\lambda}{d} \quad 10^{-3}$ (given)

$\therefore$ No. of fringes within 0.12° will be

$$n = \frac{0.12\times2\pi}{360\times10^{-3}} \cong [2.09]$$

$\therefore$ The number of bright spots will be three

15. **(d)** For diffraction pattern to be observed, the dimension of slit should be comparable to the wave length of light.

16. **(c)** Given $d = 1$mm, $\lambda = 6.5\times10^{-7}$m, $D = 1$m.

For n^{th} dark fringe $y_n = \left(\frac{2n-1}{2}\right)\frac{D\lambda}{d}$

For third fringe,

$$y_3 = \left(\frac{2\times3-1}{2}\right)\times\frac{1\times6.5\times10^{-7}}{1\times10^{-3}} = 1.625\text{ mm.}$$

17. **(d)** We have, $\frac{d\theta}{d\lambda} \quad \frac{n}{(a+b)\cos\theta}$

The angular separation for IIIrd order is given by

$$d\theta \quad \frac{3.d\lambda}{(a+b)\sqrt{1-\sin^2\theta}}$$

We also have for IIIrd order

$(a+b)\sin\theta = 3\lambda$

$$\sin\theta \quad \frac{3\lambda}{(a \quad b)}$$

So, $d\theta = \frac{3.d\lambda}{(a \quad b)\sqrt{1-\frac{9\lambda^2}{(a \quad b)^2}}} \rightarrow$

Here, $\lambda = 400\times10^{-9}$, $d\lambda = 200\times10^{-9}$.

$$(a \quad b) \quad \frac{1\times10^{-2}}{1000} \quad 1\times10^{-5}\text{ m/line}$$

$$\text{So, } d\theta = \frac{3\times200\times10^{-9}}{1\times10^{-5}\sqrt{1-\frac{9\times4\times4\times10^{-14}}{1\times10^{-10}}}} \approx 6$$

18. **(a)** Locus of equal path difference are lines running parallel to axis of the cylinder. Hence straight fringes will be observed.

19. **(b)** Constructive interference happens when $2t = (m - 1/2)\lambda$. The minimum value for m = is $m = 1$, the maximum value is the integer portion of

$$\frac{2d}{\lambda} \quad \frac{1}{2} \quad \frac{2\times0.034\times10^{-3}}{680\times10^{-9}} \quad \frac{1}{2} \quad 100.5$$

$m_{max} = 100$

20. **(a)** Optical path difference between the waves $= (n_3 - n_2)\,t$

$$\therefore \text{ Phase difference} = 2\pi\frac{(n_3-n_2)\,t}{\lambda_{(Vacuum)}} = 2\pi\frac{(n_3-n_2)\,t}{n_1\lambda_1}$$

21. **(a)** When slits are of equal width.

$I_{max} \quad (a+a)^2\,(=4a^2)$

$I_{min} \quad (a-a)^2\,(=0)$

When one slit's width is twice that of other

$$\frac{I_1}{I_2} \quad \frac{W_1}{W_2} \quad \frac{a^2}{b^2} \Rightarrow \frac{W}{2W} \quad \frac{a^2}{b^2} \Rightarrow b \quad \sqrt{2}a$$

$\therefore \quad I_{max} \quad (a+\sqrt{2}a)^2 = (5.8\,a^2)$

$I_{min} \quad (\sqrt{2}a - a)^2 = (= 0.17\,a^2)$

22. **(a)** Suppose the m^{th} bright fringe of 6500 Å coincides with the n^{th} bright fringe of 5200A°.

$$X_n \quad \frac{m\lambda_1 D}{d} \quad \frac{n\lambda_2 D}{d}$$

$$\Rightarrow \quad \frac{m\times6500\times D}{d} = \frac{n\times5200\times D}{d}$$

$$\Rightarrow \quad \frac{m}{n} \quad \frac{5200}{6500} \quad \frac{4}{5}$$

$\therefore$ distance y is $y \quad \frac{m\lambda_1 D}{d} \Rightarrow y = 0.156$ cm.

23. **(b)** When a mica sheet of thickness t and refractive index μ is introduced in the path of one of the interfering beams in a biprism arrangement, the shift in interference pattern is given by

$$y' = \frac{W}{\lambda}(\mu - 1)t$$

According to question,
Given $y' = W$
$\lambda = 6 \times 10^{-7}$m
$t = 12 \times 10^{-7}$ m

So, $y' = W = \dfrac{W}{\lambda}(\mu - 1)t$

$\lambda = (\mu - 1)\, t$

$\mu \quad \dfrac{\lambda}{t} \quad 1$

$\mu \quad \dfrac{6 \times 10^{-7}}{12 \times 10^{-7}} \quad 1 \quad 0.5 \quad 1 \quad 1.5$

24. **(b)** $I \quad I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$ ...(1)

Applying eq. (1) when phase difference is $\pi/2$

$I_{\pi/2} \quad I + 4I \Rightarrow I_{\pi/2} \quad 5I$

Again applying eq. (1) when d phase difference is π

$I_\pi \quad I \quad 4I \quad 2\sqrt{I}\sqrt{4I}\cos\pi$

$\therefore \quad I_\pi \quad I$

$\therefore \quad I_{\pi/2} - I_\pi \quad 4I$

25. **(b)** Equation of path difference form maxima in transmission (or weak reflection)

$\Delta P_{opt} \quad 2n_2 L \quad \dfrac{\lambda_{vacuum}}{2}, \dfrac{3\lambda_{vacuum}}{2}$.......

$\Rightarrow \quad 2\left(\dfrac{n_2}{n_1}\right)L = \dfrac{\lambda}{2}, \dfrac{3\lambda}{2}, ... \Rightarrow L \quad \dfrac{\lambda}{4n_2}$

(notice that λ = wavelength in medium is related to λ_{vacuum} as, $\lambda_{vacuum} = n_1\lambda$)

26. **(c)** $n \quad \dfrac{(\mu - 1)tD}{d}$ but $\beta = \dfrac{\lambda D}{d} \Rightarrow \dfrac{D}{d} \quad \dfrac{\beta}{\lambda}$

$n = (\mu - 1)t\beta/\lambda$

$20\beta = (\mu - 1)\, 2.5 \times 10^{-3}\, (\beta/5000 \times 10^{-8})$

$\mu - 1 \quad \dfrac{20 \times 5000 \times 10^{-8}}{2.5 \times 10^{-3}} \Rightarrow \mu = 1.4$

27. **(b)** In Young's double slit experiment, fringe width $\dfrac{\lambda D}{d}$

Given that, twelve fringes of wavelength λ_1 occupy a segment of screen

$x_2 - x_1 \quad 12\dfrac{\lambda_1 D}{d}$ ...(i)

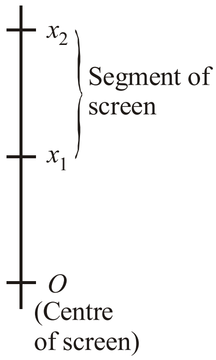
Where $\lambda_1 = 600$ nm

Also, k fringes of wavelength λ_2 occupy the same segment of screen.

$\therefore \; x_2 - x_1 \quad k\dfrac{\lambda_2 D}{d}$ ...(ii)

where, $\lambda_2 = 400$ nm

From (i) and (ii), we get



$\dfrac{12\lambda_1 D}{d} \quad \dfrac{k\lambda_2 D}{d}$

$\therefore \quad k \quad \dfrac{12 \times 600}{400} \quad 18$

28. **(d)** The path difference produced by a sheet

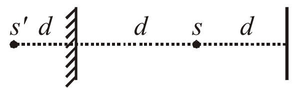
$\Delta = (\mu - 1)t$

According to the given condition (for minimum thickness)

$(\mu - 1)\, t = \dfrac{\lambda}{2}$

$\therefore \quad t = \dfrac{\lambda}{2(\mu - 1)} \quad \dfrac{6600 \times 10^{-10}}{2(1.6 - 1)} = 5500$ Å.

29. **(d)** $E_1 = I_0 = \dfrac{L}{d^2}$, without mirror



and $E_2 = \dfrac{L}{d^2} \quad \dfrac{L}{(3d)^2}$

$\dfrac{L}{d^2}\left[1 \quad \dfrac{1}{9}\right] \quad \dfrac{10 I_0}{9}$ with mirror.

30. **(a)** Path difference = $(\mu - 1)$ t = nλ;

For minimum t, $n = 1$;

$\therefore \quad t = 2\lambda$

31. **(d)** $\beta = \lambda D / d \Rightarrow \beta \propto \lambda$

The position of the central maxima is independent of wavelength used.

$y_n \quad \dfrac{n\lambda D}{d} \qquad \therefore y_n \propto \lambda$

32. **(d)** At the area of total darkness minima will occur for both the wavelengths.

$\therefore \quad \dfrac{(2n \quad 1)}{2}\lambda_1 = \dfrac{(2m \quad 1)}{2}\lambda_2$

$\Rightarrow \quad (2n + 1)\lambda_1 = (2m + 1)\,\lambda_2$

or $\frac{(2n \quad 1)}{(2m \quad 1)} \quad \frac{560}{400} \quad \frac{7}{5}$ or $10n = 14m + 2$

by inspection for $m = 2$, $n = 3$ and for $m = 7$, $n = 10$, the distance between them will be the distance between such points.

i.e., $\Delta s \quad \frac{D\lambda_1}{d}\left\{\frac{(2n_2+1)-(2n_1 \quad 1)}{2}\right\}$

put $n_2 = 10, n_1 = 3$

On solving we get, $\Delta s = 28\text{mm}$.

33. (d) For maxima $d\sin\theta = n\lambda$

$\sin\theta \quad \frac{n\lambda}{d} \quad \frac{8\lambda}{10\lambda} \Rightarrow \sin\theta \quad \frac{4}{5} \Rightarrow \tan\theta \quad \frac{4}{3}$

Also $\tan\theta \quad \frac{y}{D}$

$\therefore y = \frac{4D}{3}$

34. (a) Using relation, $y_0 = \frac{D}{d}(\mu - 1)t$

We have,

$\frac{z}{\frac{3}{2}z} \quad \frac{(1.5-1)}{(\mu-1)} \quad \Rightarrow \quad \frac{2}{3} \quad \frac{1}{2(\mu-1)}$

$\frac{1}{\mu-1} \quad \frac{4}{3} \quad \Rightarrow \quad \mu - 1 = \frac{3}{4}$

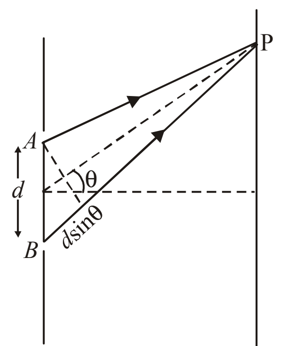
$\mu = \frac{7}{4} \quad 1.75$

35. **(c)** Let P be the point on the central maxima whose intensity is one fourth of the maximum intensity .

For interference we know that

$I \quad I_1 \quad I_2 \quad 2\sqrt{I_1 I_2}\cos\phi$

where I is the intensity at P and I_1, I_2 are the intensities of light originating from A and B respectively and ϕ is the phase difference at P.



In $YDSE, I_1 = I_2 = I$ and $I_{max} = 4I$

we are concentrating at a point where the intensity is one fourth of the maximum intensity.

$\therefore \quad I = I + I + 2I\cos\phi$

$\Rightarrow \quad -\frac{1}{2} = \cos\phi \quad \Rightarrow \quad \phi \quad \frac{2\pi}{3}$

We take the least value of the angle as the point is in central maxima]

For a phase difference of 2π, the path difference is λ

For a phase difference of $\frac{2\pi}{3}$, the path difference is

$\frac{\lambda}{2\pi} \times \frac{2\pi}{3} \quad \frac{\lambda}{3}$

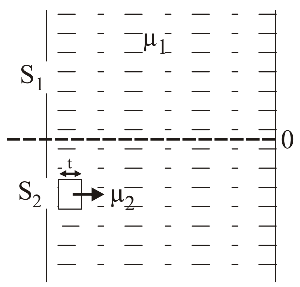
But the path difference (in terms of P and Q) is $d\sin\theta$ as shown in figure.

$\therefore \quad d\sin\theta \quad \frac{\lambda}{3}$

$\Rightarrow \quad \sin\theta \quad \frac{\lambda}{3d}$

$\Rightarrow \quad \theta \quad \sin^{-1}\left(\frac{\lambda}{3d}\right)$

36. (a) $\mu_1 S_1O - \mu_1 S_2O + \mu_1 t - \mu_2 t = 0$

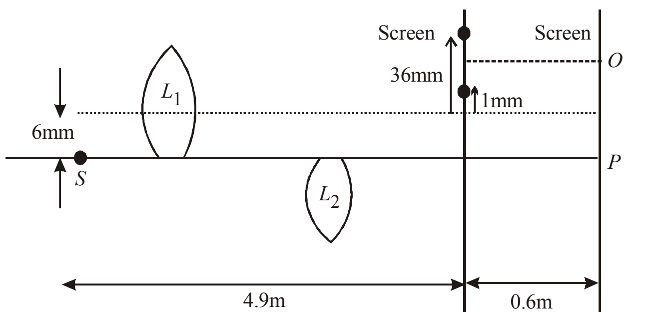


$\mu_1 (S_1O - S_2O) = (\mu_2 - \mu_1)t$

$(S_1O - S_2O) = \left|\left(\frac{\mu_2}{\mu_1} - 1\right)t\right|$

37. **(a)** Let x = distance between lenses, D is distance between the source and first screen. As images of the source due to both pieces of lens are observed on the screen, from displacement method.

$x = \sqrt{D(D-4f)} = \sqrt{4.9(4.9-2.4)} \quad 3.5m$



Let m_1 and m_2 are the magnification by the lenses L_1

and L_2,

$$m_1 = -\frac{D \quad x}{D-x} = -6,\ m_2 = -\frac{1}{6}$$

Let S_1 is image formed by L_1 of S and h_1 is height of S_1 from P'

$\Rightarrow h_1 = m_1 h = 36\text{mm}$

Let S_2 is image formed by L_2 of S and h_2 is height of S_2 from P'

$\Rightarrow h_2 = m_2 h = 1.0$ mm

Distance between S_1 and S_2 (d)

$= h_1 - h_2 = 36.0 - 1.0 = 35.0$ mm

Position of central maximum O from P is

$$6 + 1 + \frac{35}{2} = 24.5\text{mm}.$$

38. (c) The reflections from the boundaries will cause a net 180º phase shift.

The condition for bright fringes is $2t = (m + ½)\ \lambda_{film}$

Now, m = 124 since there is a bright fringe for m = 0 and

$$\lambda_{film} \quad \frac{\lambda}{n}$$

$$t \quad \frac{\left(m+\frac{1}{2}\right)\lambda_{film}}{2} \quad \frac{\left(m+\frac{1}{2}\right)\lambda}{2n}$$

$$= \frac{\left(124+\frac{1}{2}\right)(552\times10^{-9}m)}{2\times(1.00)} = 3.44\times10^{-5}m$$

39. (c) The sky is blue because tiny particles in the air are more efficient at scattering short wavelength light than they are at scattering long wavelength light.

40. (b) Photons per area per second at a distance r are $5.00 \times 10^{18}/4\pi r^2$. Photons per second entering the eye, radius R is then this times πR^2. Set this product equal to 500 per second and solve for r.

41. (a) There is air on both sides of the soap film.

$\therefore$ the reflections of the light produce a net 180º phase shift.

The condition for bright fringes is

$$2t \quad (m \quad ½)\lambda_{film}$$

$$t \quad \frac{m + ½ \ \ \lambda_{film}}{2} \quad \frac{m + ½ \ \ \lambda}{2n}$$

$$= \frac{(½)(650\times10^{-9}m)}{2(1.41)} = 1.2\times10^{-7}m$$

42. (a) Let θ be the angular width in water. We know angular width $= \frac{\lambda}{d}$

$\Rightarrow$ Angular width $\quad \lambda$

$$\frac{\theta}{0.4°} \quad \frac{\lambda_w}{\lambda_a} \qquad ......(1)$$

Now, ${}_a\mu_w = \frac{\lambda_a}{\lambda_w} \Rightarrow \frac{\lambda_a}{\lambda_w} \quad \frac{4}{3}$

Hence from eq. (1), we have

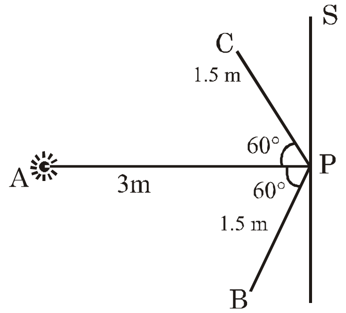
$$\frac{\theta}{0.4} = \frac{3}{4} \Rightarrow \theta \quad 0.3$$

43. (a) As A and B are point sources,

$$\therefore\ I \quad \frac{L \cos\theta}{r^2} \quad \frac{\phi \cos\theta}{4\pi r^2} \quad (\text{as } \phi = 4\pi L)$$

$$\therefore\ I_A \quad \frac{90 \cos 0°}{4\pi\times(3)^2} \quad \frac{10}{4\pi}\frac{W}{m^2};$$

$$I_B \quad \frac{180\times\cos 60°}{4\pi\,(1.5)^2} \quad \frac{10}{\pi}\frac{W}{m^2}$$



As source C gives a parallel beam of light,

$$I_C \quad I_0 \cos\theta \quad 20\times\cos 60° \quad 10\,\frac{W}{m^2}$$

$$I \quad I_A \quad I_B \quad I_C \quad \frac{10}{4\pi} \quad \frac{10}{\pi} \quad 10$$

$$= 10\left[\frac{5 \quad 4\pi}{4\pi}\right] \simeq 14\frac{W}{m^2}$$

44. (b) Equivalent optical path length

$$= \int_0^1 \mu\, dx \quad \int_0^1 \left(1.2 \quad \frac{x^2}{2}\right) dx \quad \frac{8.2}{6} \quad 1.367\text{m}$$

45. (a) n^{th} minimum has a distance from the centre =

$$x \quad (2n \quad 1)\frac{1}{2}\frac{\lambda D}{d}$$

For a point on the screen directly in front of one of the slits, x = d/2

$\therefore$ for minimum intensity in front of one of the slits =

$$\frac{d}{2} \quad (2n \quad 1)\frac{\lambda}{2}\frac{D}{d}$$

$$\therefore\ \lambda \quad \frac{d^2}{(2n \quad 1)D}$$

46. (a) Fringe width $\omega = \frac{\lambda D}{d}$.

When the apparatus is immersed in a liquid, then λ will decrease μ times and hence ω is reduced μ (refractive index) times.

$10\omega' = (5.5)\,\omega$

or $10\lambda'\left(\frac{D}{d}\right) \quad (5.5)\frac{\lambda D}{d}$ or $\frac{\lambda}{\lambda'} \quad \frac{10}{5.5} \quad \mu$

or $\mu = 1.8$

47. **(d)** $350\,\text{nm} < \lambda < 750\,\text{nm}$

48. **(d)** Due to reflection virtual source will be formed at distance D from mirror.

The effective distance of the screen = 2D + 2D = 4D

$\therefore$ Fringe width = $\frac{4D\lambda}{d}$

49. **(c)** Treating the anti-reflectance coating like a camera-lens coating, one can obtain for its thickness t:

$$2t \quad \left(m \quad \frac{1}{2}\right)\frac{\lambda}{n}, m \quad 0, \quad 1, \quad 2, ... \qquad ....(1)$$

Condition (1) is the condition for the destructive interference for the normally incident and reflected electromagnetic wave.

The minimum thickness of the coat refers to $m = 0$. This gives for the thickness:

$$t \quad \frac{\lambda}{4n} \quad \frac{3.00}{4\,(1.5)}\text{cm} \quad 0.500 \text{ cm.}$$

This anti-reflectance coating could be easily countered by changing the wavelength of the radar to 1.50 cm now creating maximum reflection.

50. **(d)** The fringe-width (β) is given by

$$\beta = \frac{\lambda D}{d}$$

When the screen is displaced by distance ΔD then the fringe-width is changed by.

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

$$\Rightarrow \qquad \lambda = \frac{(\Delta\beta)\,d}{\Delta D}$$

Here, $\Delta\beta = 10^{-3}$ m

$d = 0.03$ mm

$= 3 \times 10^{-5}$ m

$\Delta D = 5 \times 10^{-2}$ m

$$\therefore \qquad \lambda = \frac{10^{-3} \times 3 \times 10^{-5}}{5 \times 10^{-2}}$$

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

$= (6 \times 10^{-7} \times 10^{10})$ Å

$= 6000$ Å.

51. **(c)** If S, l and θ be the specific rotation of sugar solution, polarimeter tube length and optical rotation respectively, then the strength of solution is given by

$$c = \frac{\theta}{l \times S}$$

Here, $\theta = 19^{\circ}$

$l = 20\text{ cm} = 0.20$ m

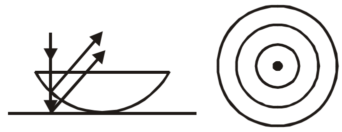
$S = 0.5$ deg m^2/kg

$$\therefore \qquad c = \frac{19}{0.20 \times 0.5} = 190\,\text{kgm}^{-3}$$

Thus, 200 kgm^{-3} impure sugar solution contains 190 kg-m^{-3} pure sugar.

$\therefore$ Purity of sugar $= \left(\frac{190}{200} \times 100\right)\% = 95\%$.

52. **(b)** When a ray of light is incident on a plano convex lens placed on a glass plate, it reflects at two surfaces. These two reflected rays interfere and produce dark and bright rings which are known as Newton's rings.



The ray reflected at the upper surface of the air-film suffers no phase change but the ray reflected internally at the lower surface suffers a phase change of 180º.

53. **(c)** According to Malus' law

$I = I_0 \cos^2\theta$

$= I_0 (\cos^2 60^{\circ})$

$= I_0 \times \left(\frac{1}{2}\right)^2$

$= \frac{I_0}{4}$.

54. **(c)** The width of the diffraction band is given by

$$\beta = \frac{\lambda D}{d}$$

$\Rightarrow \qquad \beta \quad \lambda$

$\beta \quad$ D

and $\quad \beta \quad \frac{1}{d}$.

55. **(a)** When unpolarised light beam is incident from air onto glass at the polarising angle, reflected beam is completely polarised.

56. **(a)** In the phenomenon of interference the light energy is redistributed and the distribution does not vary with time.

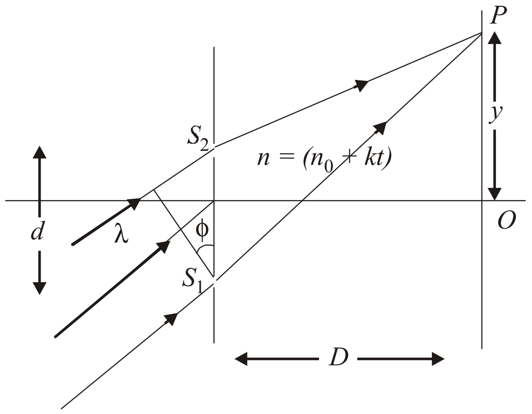
57. **(c)** Longitudinal waves cannot be polarised.

B COMPREHENSION TYPE

1. (a) $S_1P - S_2P \quad \frac{dy}{D}$

$$\Delta x = (n_0 + kt)\ \frac{dy}{D} - d\sin\phi \quad 0$$

For central maxima.



$$\therefore y \quad \frac{D\sin\phi}{n_0 \quad kt}$$ (y -coordinates of central maximum).

2. (b) $\frac{dy}{dt} \quad \frac{-kD\sin\phi}{(n_0 \quad kt)^2}$ = velocity of central maximum.

3. (c) For central maxima to be formed at O

$$n'\left(\frac{n}{n'} - 1\right)b = d\sin\phi$$

Here $n' = n_0 + kt$, n = refractive index of plate.

$$n \quad n_0 \quad kt \quad \frac{d\sin\phi}{b}$$

4. (a) For screen 1

$$\Delta x = d\sin\theta \quad d\left(\frac{y}{D}\right)$$

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

$$I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$$

Solving

For S_3

$$\phi_3 = \frac{2\pi}{3} \text{ and } I_3 = I_0$$

For S_4

$$\phi_4 = \frac{\pi}{2} \text{ and } I_4 = 2I_0$$

$$\frac{I_3}{I_4} \quad \frac{1}{2}.$$

5. (b) $\frac{I_{max}}{I_{min}} \quad \left(\frac{\sqrt{I_3} \quad \sqrt{I_4}}{\sqrt{I_3} - \sqrt{I_4}}\right) \quad \frac{(1 \quad \sqrt{2})^2}{(1-\sqrt{2})^2}$

6. (c) $\Delta\phi = \phi_3 - \phi_4 = 30°$

$\therefore \quad I_R = I_3 + I_4 + 2\sqrt{I_3 I_4}\cos(\Delta\phi) = (3 \quad \sqrt{6})I_0.$

7. (a), 8. (c).

Total phase difference at C,

$\Delta\phi = kd\sin\phi - kt(\mu' - 1)$ for centre maxima at C, $\Delta\phi = 0$

$$t \quad \frac{d\sin\phi}{(\mu' - 1)} \Rightarrow \frac{2\times10^{-3}\times\sin 30}{(\mu' - 1)} = 5\times10^{-3}$$

$\mu' = 1.2$

$\Rightarrow \quad \mu = 1.2 \times (4/3) = 1.6$

Hence refractive index of mica slab = 1.6

A black line is formed at the position where dark fringe are formed for both the wavelength.

The distance of first black line from centre bright line

$$y \quad \frac{(2n-1)\lambda D}{2d} \qquad \text{...........(1)}$$

For black line, $\frac{(2n_1 - 1)\lambda_1' D}{2d} \quad \frac{(2n_2 - 1)\lambda_2' D}{2d}$

$\frac{(2n_1 - 1)}{(2n_2 - 1)} \quad \frac{\lambda_2'}{\lambda_1'}$, where $\lambda_1' = \frac{\lambda_1}{\mu_w}$ and $\lambda_2' \quad \frac{\lambda_2}{\mu_w}$

$$\frac{(2n_1 - 1)}{(2n_2 - 1)} \quad \frac{7}{5}$$

For minimum value, $n_1 = 4$ and $n_2 = 3$

Hence distance of first black line

$$y \quad \frac{(2\times4-1)\,4000\times10^{-10}\times40\times10^{-2}\times3}{2\times2\times10^{-3}\times4}$$

$= 2.1 \times 10^{-4}\,\text{m} = 210\,\mu\text{m}$

9. (a), 10. (c), 11. (d).

Velocity and acceleration of central maximum = velocity and acceleration of screen

[$\because$ it does not move to the left or right on the screen]

$v_{screen} = 0 + gt = 20$ m/s

$\therefore \quad \vec{v}_s \quad 20\hat{j}$ m/s (in vector form) and $\vec{a}_s \quad 10\,\hat{j}$ m/s^2

$D \quad D_0 \quad \frac{1}{2}gt^2$ [where D in distance of screen at a time t along y-axis]

Position vector of 2nd maximum is given by

$$\vec{r}_x \quad 2\frac{\lambda D}{d}\hat{i} \quad D\hat{j}$$

Position vector of 1st minimum is given by

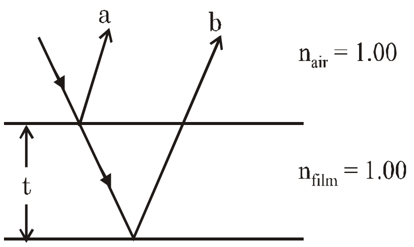
$$\vec{r}_n \quad \frac{1}{2}\frac{\lambda D}{d}\hat{i} \quad D\hat{j}$$

Relative position vector of 2nd maximum with respect to 1st minimum is given by $\vec{r} \quad \frac{3}{2}\frac{\lambda D}{d}\hat{i}$

Differentiating with respect to time,

$$\vec{a} \quad \frac{d^2\vec{r}}{dt^2} \quad \frac{3}{2}\frac{\lambda g}{d}\hat{i} \qquad 7.5\times10^{-3}\ m/s^2\ \hat{i}$$

12. (b) $n_{air} \quad n_{film} \quad n_{glass}$. Reflection with phase change of $\lambda/2$ occurs for ray a at the air-film interface and for ray b at the film-glass interface. Therefore, reflections alone keep both rays in phase.



Constructive interference then depends on making the path length difference, 2t, within the film a multiple of λ.

$2t \quad m\lambda/n \quad t \quad m(600\text{ nm})/2(1.50) \quad m200\text{ nm}$

For m = 1,t = 200 nm

13. (c) The ratio of the refractive indices is $n_{air} \quad n_{film} \quad n_{glass}$. Reflections at the interfaces do not produce a net phase difference between rays a and b. (See diagram from Answer above.) Destructive interference requires that the optical path length through the film, 2t, be an odd multiple of $\lambda/2$:

$2t \quad (m \quad 1/2)\lambda/n$

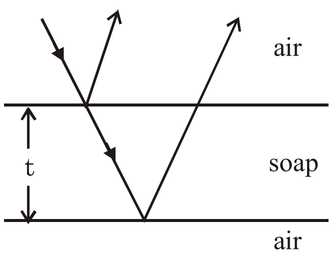
$t \quad (m \quad 1/2)(640nm)/2(1.33)$

$\Rightarrow t \quad (m \quad 1/2)240\ nm$

For m = 0, t = 120 nm which is not one of the choices.
For m = 1,t = 360 nm.

14. (a) It isn't necessary to know if

$n_{air} \quad n_{film} \quad n_{glass}$



Either ray a or ray b will undergo a phase change during reflection. Therefore the two rays will be out of phase.

For constructive interference to occur, the optical path difference must provide a 180º phase change for ray b. This happens if 2t is an odd multiple of $\lambda/2$. Since 2t = $\lambda/2$, t = $\lambda/4$.

15. (b) Choices (a) and (c) are eliminated immediately since they are outside the visible range. For soap $n_{air} > n_{soap}$. The reflected wave, ray_a undergoes a phase change at the air-soapy water interface. Ray R_b doesn't change phase at the soapy water-air interface. Based on interface reflections, the two rays are out of phase. To maintain this, the optical path difference, 2t, must not produce a phase change in R_b. Therefore the path must be an integer multiple of λ.

$2t \quad m\lambda/n$

$\lambda \quad 2tn/m \quad 2(350\ nm)(1.35)/m \quad 945\ nm/m$

For m = 1, λ = 945 nm
For m = 2, λ = 473 nm [this is choice (b)]
For m = 3, λ = 315nm
Choice (b), λ = 473 nm, is the only choice in the visible range.

16. (d) Again, ray R_a is reflected with phase change and ray R_b isn't. For the two reflected waves to interact:
2t = Mλ/n where M is either m or m + 1/2
M = 2tn/λ = $2(1.00 \times 10^{-6}$ m)(1.35)/600 x 10^{-9} nm = 4.5
M = m + 1/2 for m = 4. This describes the complete constructive interaction.

17. (d) Both rays R_a and R_b are reflected with a change of phase. Therefore the net change of phase with reflection is zero. For constructive interference, 2t = mλ/n and for destructive interference 2t = (m + 1/2)λ/n.
t = (m + 1/2)(600 nm)/2(1.25) = m700/2 (1.25)
600m + 300 = 700m, 300 = 100 m, m = 3
Solve either equation for t :
t = 3(700 nm)/2(1.25) = 840 nm

C REASONING TYPE

1. **(d)** Filling liquid will increase the optical path length by same amount.
$\therefore$ *CBF* will not shift.

2. **(c)** When $\Delta x = 0$
for any λ the interference will be constructive.

3. **(b)** Radio waves are electromagnetic so it is transverse in nature. It can be polarised. Sound wave is longitudinal in nature which can never be polarised. These two statements are uncorrelated.

4. **(a)** Newton's rings are formed in reflected system and if the refractive index of the first medium is more than the second medium, there is no reversal of phase in reflected ray so, central fringe remains bright.

5. **(a)** Corpuscular theory fails to explain the velocityof light in air and water because it predicted light to have more velocity in denser medium where as the fact is just the

6. **(c)** In Young's experiments, fringe width of dark and white fringes are equal. If white light is used as source, coloured fringes are observed representing bright band of different colours.

D MULTIPLE CORRECT CHOICE TYPE

1. **(a, b, c, d)**

For maxima $d = n\lambda$.

For minima $d = (n + 1/2)\lambda$

For intensity $\frac{3}{4}$ th of maximum $d \quad \left(n \quad \frac{1}{3}\right)\frac{\lambda}{2}$

2. **(b, d)** $\frac{I_{max}}{I_{min}} \quad \frac{\left(\sqrt{I_1} \quad \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} \quad \frac{9}{1}$

$\Rightarrow \frac{\sqrt{I_1} \quad \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}} \quad \frac{3}{1} \quad \Rightarrow \quad 4\sqrt{I_2} \quad 2\sqrt{I_1}$

$\Rightarrow \sqrt{\frac{I_1}{I_2}} \quad \frac{4}{2} \quad \Rightarrow \quad \frac{I_1}{I_2} \quad 4 \quad \frac{a^2}{b^2}$

$\Rightarrow \frac{a}{b} \quad 2$

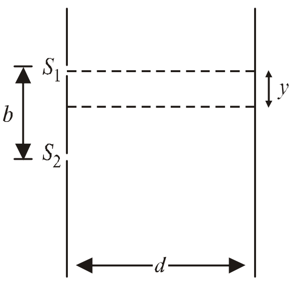
3. **(b)** The fringe width does not depend on the angle made by beam, for small angles.

4. **(a, c)** Here $y = (2n-1)\frac{\lambda}{2}\frac{D}{d} = (2n-1)\frac{\lambda}{2}\frac{d}{b}$

$(\because d = b \text{ and } D = d)$

But $y \quad \frac{b}{2}$

$\therefore \quad \frac{b}{2} = (2n-1)\frac{\lambda}{2}\frac{d}{b}$



$\Rightarrow \lambda \quad \frac{b^2}{(2n-1)d}$ when n = 1, 2

$\lambda \quad \frac{b^2}{d}, \frac{b^2}{3d}, \ldots$

5. **(b)** $I(\phi) = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

Here, $I_1 = 1$ and $I_2 = 4l$

At point A, $\phi = \pi/2$

$\therefore \quad I_A = I + 4I = 5I$

At point B, $\phi = \pi/2$

$\therefore \quad I_B = I + 4I - 4I = I$

$\therefore \quad I_A - I_B = 4I$

6. **(a, b)** As $\beta \quad \frac{\lambda D}{d} \quad \therefore \beta' \quad \frac{\lambda' D'}{d'}$

If $d' = 2d$, we get

$\beta' \quad \frac{\lambda' D'}{2d}$

To keep β ' and β equal either λ is to be made double or D is to made double.

7. **(a)** Path difference between first and 11th bright fringe $= S_1B$ (10 bright fringes) $= 10\,\lambda = 10 \times (6000 \times 10^{-7})\text{m} = 6 \times 10^{-6}$ m

8. **(a, b)** If two waves have a constant phase difference and have same wavelengths, then they produce coherence.

E MATRIX-MATCH TYPE

1. **A-q, r, s; B-p; C-s; D-r**
2. **A-s; B-r; C-q; D-p**
3. **A-p, q; B-r, s; C-s, t; D-p**

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

For maximas $\Delta x = n\lambda$

$D^2 + (2\lambda)^2 = (D + n\lambda)^2$

$4\lambda^2 = n^2\lambda^2 + 2Dn\lambda$

Only two possible values of n, $n = 1$,

$D \quad \frac{3\lambda}{2}$; $n = 2$, $D = 0$

Similarly, for minimas, $\Delta x = (2n-1)\frac{\lambda}{2}$

(B) For maxima, $\Delta x = n\lambda$

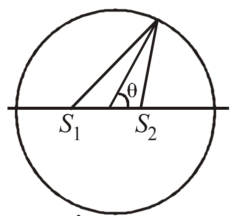
$\cos\theta = n$,

Possible values of $n = 0, 1$

$\cos\theta = 0, \Rightarrow \theta = 90°, 270°$

$\cos\theta = 1, \Rightarrow \theta = 0°, 360°$

$\therefore$ Number of maximas = 4



Similarly for minimas, $\Delta x = (2n-1)\frac{\lambda}{2}$

(C) Virtual image of S will act as another source

$\Delta x = d\sin\theta$, $d = 2\lambda$

For maximas, $n\lambda = 2\lambda\sin\theta \Rightarrow \sin\theta \quad \frac{n}{2}$

$n = 0, 1, 2,$

$\theta = 0, 30°, 90°, 150°$

Total maximas possible = 7 (centre + 3 up + 3 down)

(D) $\Delta x = 2\lambda \cos\theta$; $\theta \le 60°$

For maximas, $\Delta x = n\lambda \Rightarrow \cos\theta \quad \frac{n}{2}$; $n = 0, 1, 2, \theta \ne 90°$, $\theta = 60°, \theta = 0°$

Total maximas two, For minima, $\Delta x = (2n-1)\frac{\lambda}{2}$;

$\cos\theta \quad \frac{2n-1}{4}$

$n = 1,\ \cos\theta = \frac{1}{4}$; $\theta \quad 60$; $n = 2$,

$\cos\theta = \frac{3}{4}$; $\theta \quad 60$; No. of possible minimas = 1.

4. A-q; B-s; C-r; D-p

F NUMERIC/INTEGER ANSWER TYPE

1. 2

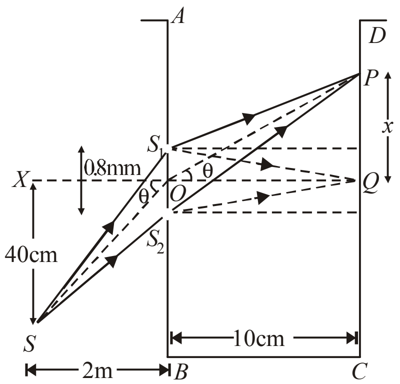
The phase difference between two waves arriving at a common point consists of two parts

(i) initial phase difference ϕ_0

(ii) phase difference (ϕ') due to path difference

$\phi = \frac{2\pi}{\lambda} p$ where p = path difference

$\therefore \quad \phi = \phi_0 + \phi' = \phi_0 + \frac{2\pi}{\lambda} p$



Here S to P, since the source is same, $\phi_0 = 0$

$\therefore \quad \phi = \frac{2\pi}{\lambda} p$. If $p = 0$ then $\phi = 0$ then there will be central maxima.

In ΔOXS, $\tan\theta \quad \frac{40}{200} \quad \frac{1}{5}$ ... (i)

In ΔPOQ, $\tan\theta \quad \frac{x}{10}$ ... (ii)

$\therefore$ From (i) and (ii), $\frac{1}{5} \quad \frac{x}{10}$

$\therefore \quad x =$ **2 cm**

2. 3.5

At the place where maxima for both the wavelengths coincide, y will be same for both the maxima, i.e.,

$$\frac{n_1\lambda_1 D}{d} \quad \frac{n_2\lambda_2 D}{d} \Rightarrow \frac{n_1}{n_2} \quad \frac{\lambda_2}{\lambda_1} \quad \frac{700}{500} \quad \frac{7}{5}$$

$\therefore$ Minimum distance of maxima of the two wavelengths from central fringe is

$= 5 \times 700 \times 10^{-9} \times 10^3 =$ **3.5 mm.**

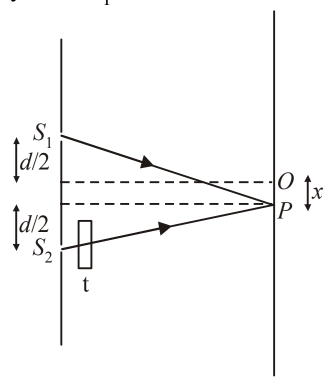
3. 0.06

$$\frac{I_{min}}{I_{max}} \quad \left(\frac{\sqrt{I} - \sqrt{0.36I}}{\sqrt{I} \quad \sqrt{0.36I}}\right)^2 \quad \left(\frac{0.4}{1.6}\right)^2 \quad \frac{1}{16} = \mathbf{0.06}$$

[$\because$ If intensity of light falling on P directly from S is I, then the intensity of light falling at P after reflection from AB is $0.36I$]

4. 4330

Let the central maxima is obtained at a distance x below O. [This is because a glass sheet is present in front of S_2 which increases its path length to the screen. Therefore the path length of ray from S_1 to the screen should also increase].



For central maxima

$S_1P = S_2P$

$$\left[D^2 \quad \left(\frac{d}{2} \quad x\right)^2\right]^{1/2} \quad \left[D^2 \quad \left(\frac{d}{2} \quad x\right)^2\right]^{1/2} \quad \left(\frac{\mu_g}{\mu_m} - 1\right)t$$

where $\left(\frac{\mu_g}{\mu_m} - 1\right)t$ = path ifference due to glass sheet.

$$\therefore \quad D\left[1 \quad \left(\frac{\frac{d}{2} + x}{D}\right)^2\right]^{1/2} \quad D\left[1 \quad \left(\frac{\frac{d}{2} - x}{D}\right)^2\right]^{1/2} \quad \left(\frac{\mu_g}{\mu_m} - 1\right)t$$

$$\Rightarrow \quad D\left[1 + \left(\frac{\frac{d}{2} + x}{D}\right)^2\right]^{1/2} - D\left[1 \quad \left(\frac{\frac{d}{2} - x}{D}\right)^2\right]^{1/2} \quad \left(\frac{\mu_g}{\mu_m} - 1\right)t$$

$$\Rightarrow D\left[1+\frac{1}{2}\frac{\frac{d^2}{4}\quad x^2\quad xd}{D^2}-1-\frac{1}{2}\times\frac{\frac{d^2}{4}\quad x^2-xd}{D^2}\right]$$

$$=\left(\frac{\mu_g}{\mu_m}-1\right)t$$

$$\Rightarrow \frac{xd}{D}=\left(\frac{\mu_g}{\mu_m}-1\right)t$$

$$\Rightarrow x=\left(\frac{\mu_g}{\mu_m}-1\right)t\times\frac{D}{d}=\left(\frac{1.5}{4/3}-1\right)\times\frac{(10.4\times10^{-6})(1.5)}{0.45\times10^{-3}}$$

$$=4.33\times10^{-3}\text{ m}=\mathbf{4330\ \mu m}$$

5. 2.78

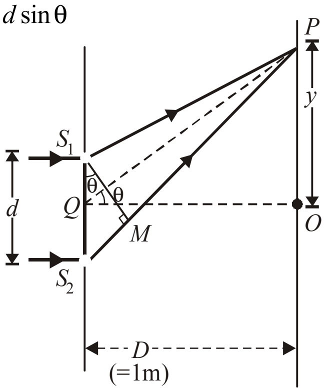
The path difference from the ray starting from S_1 and S_2 and reaching a point P will be

$$\Delta x = S_2P - S_1P \approx S_2M$$

From ΔS_1S_2M

$$\sin\theta\quad \frac{S_2M}{S_1S_2}\Rightarrow S_2M = d\sin\theta$$

$$\therefore\quad \Delta x = d\sin\theta$$



We know that the path difference for minimum intensity is

$(2m-1)\,\frac{\lambda}{2}$ where m = 1, 2, 3...

$$\therefore\quad d\sin\theta = (2m-1)\,\frac{\lambda}{2}$$

$$\Rightarrow\quad \sin\theta\quad \frac{(2m-1)\lambda}{2d}\quad \frac{(2m-1)0.5}{2\times1.0}\quad \frac{2m-1}{4}$$

Also $-1\le\sin\theta\le1$. Therefore possible values of m are ±1, $+2, 0$

From ΔPOQ

$$y = D\ \tan\theta\quad \frac{D\sin\theta}{\sqrt{1-\sin^2\theta}}\qquad \text{... (i)}$$

Positions of minima

For $m=+1,\ \sin\theta\quad \frac{1}{4}$

$$\therefore\quad y=\frac{1\times\frac{1}{4}}{\sqrt{1-\left(\frac{1}{4}\right)^2}}=\frac{1}{\sqrt{15}}\quad 0.26\text{ m}$$

$m=-1,\ \sin\theta=-\frac{3}{4}$

$$\therefore\quad y=\frac{1\left(-\frac{3}{4}\right)}{\sqrt{1-\left(-\frac{3}{4}\right)^2}}=-\frac{3}{\sqrt{7}}=-1.13\text{ m}$$

$m=+2,\ \sin\theta\quad \frac{3}{4}$

$\therefore\quad y=+1.13$ m

$m=0,\ \sin\theta=-\frac{1}{4}\qquad \therefore\quad y=-0.26$ m

$\therefore$ Required sum $=|0.26|+|-1.13|+|1.13|+|-0.26|=$ **2.78**

6. 7

For Red Light

The shifts of fringes due to glass plate $=\frac{Dt(\mu-1)}{d}$

where t is the thickness of the plate.

This shift is equal to 5ω where ω is the fringe width

$$\frac{Dt(\mu-1)}{d}=5\omega\Rightarrow\frac{Dt(\mu-1)}{d}=\frac{5\lambda_R D}{d}$$

$$t=\frac{5\lambda}{(\mu-1)}\quad\frac{5\times7\times10^{-7}}{1.5-1}=7\times10^{-6}\text{ m}=\mathbf{7\mu m}$$

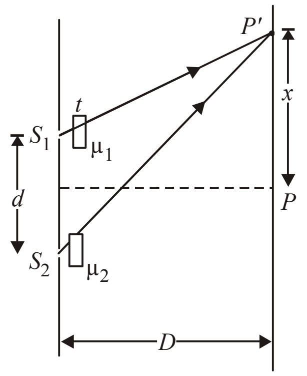
7. 9.3

The time taken by the ray to reach P' from S_1

$$=\frac{d_{air}}{V_{air}}\quad\frac{d_{plate}}{v_{plate}}=\frac{S_1P'-t}{c}\quad\frac{t}{c/\mu_1}=\frac{S_1P'-t\quad t\mu_1}{c}$$

Effective path travelled $=S_1P'-t+t\mu_1$

where c is the speed of light in air.



Similarly, the time taken by the ray to reach P' from S_2

$$=\frac{S_2P'-t\quad t\mu_2}{c}$$

Effective path travelled $= S_2P' - t + t\mu_2$

$\therefore$ Path difference $= S_2P' - t + t\mu_2 - S_1P' + t - t\mu_1$

Also when there were no plates infront of the slits.

$$= S_2P' - S_1P' = \frac{xd}{D}$$

$$S_2P' - S_1P' = \frac{xd}{D}$$

$\therefore$ Path difference $= \dfrac{xd}{D} + t(\mu_2 - \mu_1)$

For the point P, $x = 0$

$\therefore$ Path difference $= t(\mu_2 - \mu_1) = t(1.7 - 1.4) = 0.3\,t$... (i)

But the point P lies between the 5th maximum and 6th minimum (given).

Therefore the path difference $= 5\lambda + D$ ...(ii)

Equating equations (i) and (ii), we get

$0.3t = 5\lambda + \Delta$ ...(iii)

The path difference Δ can be determined from the given intensity at P, which is $\dfrac{I}{I_0} \quad \dfrac{3}{4}$.

The expression I / I_0 in terms of Δ is

$$\frac{I}{I_0} \quad \cos^2\left(\frac{\pi\Delta}{\lambda}\right)$$

For $I / I_0 = 3/4$, we get $\cos\left(\dfrac{\pi\Delta}{\lambda}\right) \quad \dfrac{\sqrt{3}}{2}$

or $\dfrac{\pi\Delta}{\lambda} \quad \dfrac{\pi}{6}$ or $\Delta = \dfrac{\lambda}{6}$

Hence, the thickness of the glass plates (Eq. 3) is

$0.3\,t = 5\lambda + \lambda/6$

or $t = \left(\dfrac{1}{0.3}\right)\left(\dfrac{31}{6}\lambda\right) = \left(\dfrac{1}{0.3}\right)\left(\dfrac{31}{6}\times 54000Å\right)$

$= 9.3 \times 10^4$ Å $= 9.3 \times 10^{-6}$ m $=$ **9.3 μm**

Alternatively :

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

Given that 5th maxima lies below P and 6th minima lies above P, therefore the path difference should lie between 5λ and $5\lambda + \lambda/2$. Let $Dx = 5\lambda + \Delta$ where $\Delta < \lambda/2$.

The phase difference $\phi = \dfrac{2\pi}{\lambda}\Delta x = \dfrac{2\pi}{\lambda}(5\lambda + \Delta)$

We know that $I(\phi) = I_{max}\cos^2\left(\dfrac{\phi}{2}\right)$

$$\Rightarrow \frac{3}{4}I_{\max} \quad I_{\max}\cos^2\frac{\phi}{2} \Rightarrow \frac{\phi}{2} \quad 30 \quad \frac{\pi}{6}$$

$$\Rightarrow \frac{2\pi}{6} = \frac{2\pi}{\lambda}(5\lambda + \Delta) \Rightarrow \Delta x = \frac{\lambda}{6} = 0.3\,t$$

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

8. 7

The power transmitted through

$$A = \left[10\%\text{ of}\left(\frac{10}{\pi}\right)\right]\times\pi(0.001)^2$$

$$= \frac{10}{100}\times\frac{10}{\pi}\times\pi\times(0.001)^2 = 10^{-6}\text{ W}$$

The power transmitted through

$$B = \left[10\%\text{ of}\left(\frac{10}{\pi}\right)\right]\times\pi\times(0.002)^2$$

$$= \frac{10}{100}\times\frac{10}{\pi}\times\pi\times(0.002)^2 = 4\times10^{-6}\text{ W}$$

Let $\Delta\phi$ be the phase difference introduced by film

$\therefore \quad \Delta\phi = \dfrac{2\pi}{\lambda}$ (path difference introduced by the film)

$$= \frac{2\pi}{\lambda}\times(\mu - 1)t \quad \frac{2\pi}{6000\times10^{-10}}[1.5 - 1]\times2000\times10^{-10}$$

$$= \frac{\pi}{3}\text{ radian}$$

The power received at F

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

$$= 10^{-6} + 4\times10^{-6} + 2\sqrt{10^{-6}\times4\times10^{-6}}\cos\frac{\pi}{3}$$

$= 7\times10^{-6}$ W $=$ **7 μW**

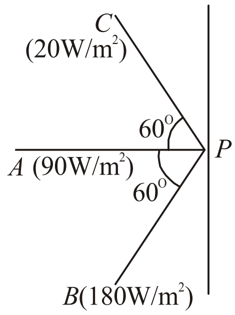
9. 13.9

The total intensity at point P will be

$$= I_A + I_B + I_C$$

$$I_A \quad \frac{(\text{Illuminating power})\times\cos\theta}{4\pi r^2} \quad \frac{90\times\cos 0}{4\pi\times3^2}$$

$$\frac{10}{4\pi}\text{ watt / m}^2$$



$$I_B \quad \frac{180\times\cos 60}{4\pi\times(1.5)^2} \quad \frac{10}{\pi}\text{ watt / m}^2$$

$$I_C = 20\cos 60° = 10$$

$\therefore \quad I_p \quad \dfrac{10}{4\pi} \quad \dfrac{10}{\pi} \quad 10 \quad$ **13.9W/m²**