PHYSICS
Q N A- WAVE-OPTICS
02 CBSE

PHYSICS-CBSE-XII

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WAVE OPTICS

Multiple Choice Questions (MCQs)

DIRECTIONS : *This section contains multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which only one is correct.*

1. Wavefront is the locus of all points, where the particles of the medium vibrate with the same ________ .
(a) phase (b) amplitude
(c) frequency (d) period

2. Shape of wavefront in case of
I. light diverging from a point source is spherical.
II. light emerging out of a convex lens when a point source is placed at its focus is plane.
III. the portion of the wavefront of light from a distant star intercepted by the Earth is plane.
Which of the above statements are true/false?
(a) T, T, F (b) F, T, T
(c) T, F, T (d) T, T, T

3. Huygens concept of secondary wave
(a) allows us to find the focal length of a thick lens
(b) is a geometrical method to find a wavefront
(c) is used to determine the velocity of light
(d) is used to explain polarisation

4. Who gave the idea of secondary wavelets for the propagation of a wave.
(a) Newton (b) Huygen
(c) Maxwell (d) Fresnel

5. Huygens wave theory allows us to know
(a) The wavelength of the wave
(b) The velocity of the wave
(c) The amplitude of the wave
(d) The propagation of wavefronts

6. The fringe width in a Young's double slit experiment can be increased if we decrease
(a) width of slits
(b) separation of slits
(c) wavelength of light used
(d) distance between slits and screen

7. 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) 5 I and 3I
(c) 9 I and I (d) 9 I and 3I

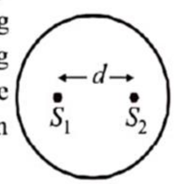
8. Distance between screen and source is decreased by 25%. Then the percentage change in fringe width is.
(a) 20% (b) 31% (c) 75% (d) 25%

9. In Young's double slit experiment, angular width of fringes is 0.20° for sodium light of wavelength 5890 Å. If complete system is dipped in water, then angular width of fringes becomes.
(a) 0.11° (b) 0.15° (c) 0.22° (d) 0.30°

10. The path difference between two interfering waves at a point on screen is 171.5 times the wavelength. If the path difference is 0.01029 cm. Find the wavelength.
(a) 6000×10^{-10} cm (b) 6000 Å
(c) 6000×10^{-8} mm (d) None of these

11. The colour of bright fringe nearest to central achromatic fringe in the interference pattern with white light will be
(a) violet (b) red (c) green (d) yellow

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



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

(c) $\tan^{-1}\dfrac{d}{4\lambda}$ (d) $\cos^{-1}\dfrac{\lambda}{4d}$

13. True/false statements are
Diffraction is a characteristic which is exhibited by
I. Matter waves II. Water waves
III. Sound waves IV. Light waves
(a) T, T, F, F (b) T, T, T, F
(c) F, F, T, T (d) T, T, T, T

14. If the width of the slit in single slit diffraction experiment is doubled, then the central maximum of diffraction pattern becomes
(a) broader and brighter
(b) sharper and brighter
(c) sharper and fainter
(d) broader adn fainter.

15. The condition for observing Fraunhoffer diffraction from a single slit is that the light wavefront incident on the slit should be
(a) spherical (b) cylindrical
(c) plane (d) elliptical

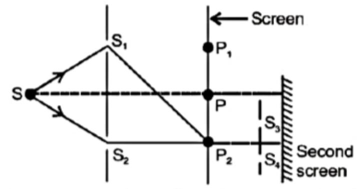
16. The phenomenon of diffraction can be treated as interference phenomenon if the number of coherent sources is
(a) one (b) two
(c) zero (d) infinity

17. Consider sunlight incident on a slit of width 10^4 Å. The image seen through the slit shall
(a) be a fine sharp slit white in colour at the centre
(b) a bright slit white at the centre diffusing to zero intensities at the edges
(c) a bright slit white at the centre diffusing to regions of different colours
(d) only be a diffused slit white in colour

18. Consider a ray of light incident from air onto a slab of glass (refractive index n) of width d, at an angle θ. The phase difference between the ray reflected bv the top surface of the glass and the bottom surface is
(a) $\frac{2\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\pi$
(b) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}$
(c) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\frac{\pi}{2}$
(d) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+2\pi$

19. In a Young's double-slit experiment, the source is white light. One of the holes is covered by a red filter and another by a blue filter. In this case,
(a) there shall be alternate interference patterns of red and blue
(b) there shall be an interference pattern for red distinct from that for blue
(c) there shall be no interference fringes
(d) there shall be an interference pattern for red mixing with one for blue

20. Figure shows a standard two slit arrangement witn slits S_1, S_2, P_1, P_2 are the two minima points on either side of P (figure).



At P_2 on the screen, there is a hole and behind P_2 is a second 2-slit arrangement with slits S_3, S_4 and a second screen behind them.
(a) There would be no interference pattern on the second screen but it would be lighted
(b) The second screen would be totally dark
(c) There would be a single bright point on the second screen
(d) There would be a regular two slit pattern on the second screen

21. The phenomena which is not explained by Huygen's construction of wavefront is
(a) reflection (b) diffraction
(c) refraction (d) origin of spectra

22. In Young's double slit experiment, one slit is covered with red filter and another slit is covered by green filter, then interference pattern will be
(a) red (b) green
(c) yellow (d) invisible

23. Larger aperture of objective lens in an astronomical telescope
(a) increases the resolving power of telescope.
(b) decreases the brightness of the image.
(c) increases the size of the image.
(d) decreases the length of the telescope.

24. The condition for obtaining secondary maxima in the diffraction pattern due to single slit is
(a) $a\sin\theta = n\lambda$ (b) $a\sin\theta = (2n-1)\frac{\lambda}{2}$
(c) $a\sin\theta = (2n-1)\lambda$ (d) $a\sin\theta = \frac{n\lambda}{2}$

25. According to Huygens, medium through which light waves travel is
(a) vacuum only (b) luminiferous ether
(c) liquid only (d) solid only

26. Wave normal is a direction which is
(a) normal at every point on the wavefront.
(b) tangential to every point on the wavefront.
(c) directed at every point of the wavefront.
(d) independent of wavefront.

27. According to Huygen's construction which of the following wavefront does not exists?
(a) forward wavefront (b) backward wavefront
(c) cylindrical wavefront (d) can not be predicted

28. Light waves travel in vacuum along the y-axis. Which of the following may represent the wave-front?
(a) $x = \text{constant}$ (b) $y = \text{constant}$
(c) $z = \text{constant}$ (d) $x + y + z = \text{constant}$

29. According to Huygen's construction, tangential envelope which touches all the secondary spheres is the position of
(a) original wavefront (b) secondary wavefront
(c) geometrical wavefront (d) extended wavefront

30. The phase difference between incident wave and reflected wave is 180° when light ray
(a) enters into glass from air
(b) enters into air from glass
(c) enters into glass from diamond
(d) enters into water from glass

31. In interference pattern, the energy is:
(a) created at the maximum
(b) destroyed at the minimum
(c) conserved but redisturbed
(d) None of the above

32. Interference was observed in interference chamber where air was present, now the chamber is evacuated, and if the same light is used, a careful observer will see
(a) no interference
(b) interference with brighter bands
(c) interference with dark bands
(d) interference fringe with larger width

33. In which of the following is the interference due to the division of wave front ?
(a) Young's double slit experiment
(b) Fresnel's biprism experiment
(c) Lloyd's mirror experiment
(d) Demonstration colours of thin film

34. Two identical light sources S_1 and S_2 emit light of same wavelength λ. These light rays will exhibit interference if
(a) their phase difference remain constant
(b) their phases are distributed randomly
(c) their light intensities remain constant
(d) their light intensities change randomly

35. Which one of the following statements is correct ?
(a) Monochromatic light is never coherent.
(b) Monochromatic light is always coherent.
(c) Two independent monochromatic sources are coherent.
(d) Coherent light is always monochromatic.

36. Coherence is a measure of
(a) capability of producing interference by wave
(b) waves being diffracted
(c) waves being reflected
(d) waves being refracted

37. Which of the following, cannot produce two coherent sources?
(a) Lloyd's mirror (b) Fresnel biprism
(c) Young's double slit (d) Prism

38. If in an interference pattern, I_{max} represents the intensity maximum value and I_{min} represents the intensity minimum value, then the fringe visibility is defined as:
(a) $V = \frac{I_{max}}{I_{min}}$ (b) $V = \frac{I_{max} + I_{min}}{I_{max} - I_{min}}$
(c) $V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ (d) $V = \frac{\sqrt{I_{max}} - \sqrt{I_{min}}}{\sqrt{I_{max}} + \sqrt{I_{min}}}$

39. The contrast in the fringes in an interference pattern depends on
(a) fringe width
(b) wavelength
(c) intensity ratio of the sources
(d) distance between the slits

40. Ratio of intensities of two waves are given by 4 : 1. Then the ratio of the amplitudes of the two waves is
(a) 2 : 1 (b) 1 : 2 (c) 4 : 1 (d) 1 : 4

41. The ratio of intensities of two waves is 9 : 1. They are producing interference. The ratio of maximum and minimum intensities will be
(a) 10 : 8 (b) 9 : 1 (c) 4 : 1 (d) 2 : 1

42. A beam of electron is used in an YDSE experiment. The slit width is d. If the velocity of electron is increased, then
(a) no interference is observed
(b) fringe width increases
(c) fringe width decreases
(d) fringe width remains same

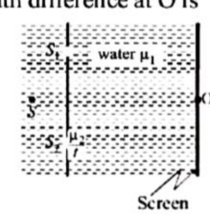
43. The maximum number of possible interference maxima for slit- separation equal to twice the wavelength in Young's double-slit experiment is
(a) infinite (b) five (c) three (d) zero

44. If yellow light emitted by sodium lamp in Young's double slit experiment is replaced by a monochromatic blue light of the same intensity
(a) fringe width will decrease
(b) finge width will increase
(c) fringe width will remain unchanged
(d) fringes will become less intense

45. The Young's double slit experiment is performed with blue and with green light of wavelengths 4360Å and 5460Å respectively. If x is the distance of 4th maxima from the central one, then
(a) x (blue) = x (green) (b) x (blue) > x (green)
(c) x (blue) < x (green) (d) $\frac{x(\text{blue})}{x(\text{green})} = \frac{5460}{4360}$

46. In double slit experiment, the angular width of the fringes is 0.20° for the sodium light $(\lambda = 5890\text{Å})$. In order to increase the angular width of the fringes by 10%, the necessary change in wavelength is
(a) zero (b) increased by 6479 Å
(c) decreased by 589 Å (d) increased by 589 Å

47. A YDSE is conducted in water (μ_1) as shown in figure. A glass plate of thickness t and refractive index μ_2 is placed in the path of S_2. The optical path difference at O is



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

48. In a Young's double-slit experiment the fringe width is 0.2 mm. If the wavelength of light used is increased by 10% and the separation between the slits is also increased by 10%, then the fringe width will be
(a) 0.20 mm (b) 0.401 mm
(c) 0.242 mm (d) 0.165 mm

49. In a Young's double slit experiment, the intensity at a point where the path difference $\frac{\lambda}{6}$ (λ is wavelength of the light) is I. If I_0 denotes the maximum intensity, then $\frac{I}{I_0}$ is
(a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{3}{4}$

50. In an experiment the two slits are 0.5 mm apart and the fringes are observed to 100 cm from the plane of the slits. The distance of the 11th bright fringe from the Ist bright fringe is 9.72 mm. Calculate the wavelength used.
(a) 4.85×10^{-5} cm (b) 4.85×10^{-5} m
(c) 4.86×10^{-7} m (d) 4.86×10^{-5} cm

51. S is the size of the slit, d is the separation between the slits and D is the distance where Young's double slit interference pattern is being observed. If λ be the wavelength of light, then for sharp fringes, the essential condition is:
(a) $\frac{S}{D} < \frac{\lambda}{d}$ (b) $\frac{S}{D} > \frac{\lambda}{d}$ (c) $S\lambda < dD$ (d) $SD > \lambda d$

52. The first maxima is closest of _______ colour
(a) violet (b) red
(c) blue (d) green

53. 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) 4500 Å (b) 5000 Å (c) 5500 Å (d) 6000 Å.

54. In a double slit experiment, the screen is placed at a distance of 1.25 m from the slits. When the apparatus is immersed in water ($\mu_w = 4/3$), the angular width of a fringe is found to be 0.2°. When the experiment is performed in air with same set up, the angular width of the fringe is
(a) 0.4° (b) 0.27° (c) 0.35° (d) 0.15°

55. At two points P and Q on screen in Young's double slit experiment, waves from slits S_1 and S_2 have a path difference of 0 and $\frac{\lambda}{4}$, respectively. The ratio of intensities at P and Q will be :
(a) 2 : 1 (b) $\sqrt{2}$: 1 (c) 4 : 1 (d) 3 : 2

56. In Young's expt., the distance between two slits is $\frac{d}{3}$ and the distance between the screen and the slits is 3 D. The number of fringes in $\frac{1}{3}$m on the screen, formed by monochromatic light of wavelength 3λ, will be
(a) $\frac{d}{9D\lambda}$ (b) $\frac{d}{27D\lambda}$ (c) $\frac{d}{81D\lambda}$ (d) $\frac{d}{D\lambda}$

57. The diffraction effects in a microscopic specimen become important when the separation between two points is
(a) much greater than the wavelength of light used
(b) much less than the wavelength of light used
(c) comparable to the wavelength of light used
(d) independent of the wavelength of light used

58. Conditions of diffraction is
(a) $\frac{a}{\lambda} = 1$ (b) $\frac{a}{\lambda} >> 1$
(c) $\frac{a}{\lambda} << 1$ (d) None of these

59. A diffraction pattern is being formed at the screen. Firstly yellow light was used for it. If yellow light is replaced by the X-rays, then the central maxima
(a) becomes wider (b) becomes narrower
(c) no change (d) None of these

60. Angular width (β) of central maxima of a diffraction pattern of a single slit does not depend upon
(a) distance between slit and source
(b) wavelength of the light used
(c) width of slit
(d) frequency of light used

61. If we observe the single slit Fraunhofer diffraction with wavelength λ and slit width b, the width of the central maxima is 2θ. On decreasing the slit width for the same λ
(a) θ increases
(b) θ remains unchanged
(c) θ decreases
(d) θ increases or decreases depending on the intensity of light

62. In a single slit diffraction experiment, the width of the slit is made double its original width. Then the central maxima of the diffraction pattern will become
(a) narrower and fainter (b) narrower and brighter
(c) broader and fainter (d) broader and brighter

Case/Passage Based Questions

DIRECTIONS : *Study the given Case/Passage and answer the following questions.*

Case/Passage-I

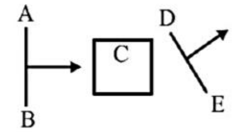
Huygen proposed the wave theory of light. According to his theory

(i) Each point of the wavefront is the source of a secondary disturbance and secondary wavelets emanating from these points spread out in all directions with the speed of the wave.

(ii) The new position of the wavefront at a later time is a common tangent drawn to all these spheres.

63. A plane wave passes through a convex lens. The geometrical shape of the wavefront that emerges is
(a) plane (b) diverging spherical
(c) converging spherical (d) None of these

64. A wavefront AB passing through a system C emerges as DE. The system C could be



(a) a slit
(b) a biprism
(c) a prism
(d) a glass slab

65. Newton's corpuscular theory could not explain the phenomenon for
(a) reflection (b) refraction
(c) diffraction (d) rectilinear propagation

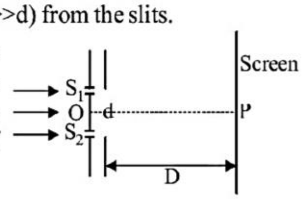
66. Wave normal is a direction which is
(a) normal at every point on the wavefront.
(b) tangential to every point on the wavefront.
(c) directed at every point of the wavefront.
(d) independent of wavefront.

67. The shape of wavefront produced by linear light source is:
(a) parabolic (b) cylinderical
(c) elliptical (d) spherical

Case/Passage-II

A student is performing Young's double slit experiment. There are two slits S_1 and S_2. Separation between them is d. There is large screen at a distance D(D >>d) from the slits.

The set-up is shown in the following figure. A parallel beam of light is incident upon it. A monochromatic light of wavelength λ is used.



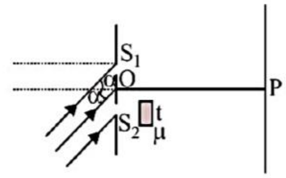
The initial phase difference between the two slits which behaves as two coherent sources of light is zero.

The intensity of light waves on the screen coming out of S_1 and S_2 are same and is I_0. In this situation, the principal maximum is formed at the point P. At the point on screen where principal maximum is formed, phase difference between two interfering waves will be zero.

68. Initially the distance of third minima from principal maxima will be
(a) $\frac{3}{2}\frac{\lambda D}{d}$ (b) $\frac{3\lambda D}{d}$ (c) $\frac{5}{4}\frac{\lambda D}{d}$ (d) $\frac{5}{2}\frac{\lambda D}{d}$

69. A glass slab of thickness t and refractive index μ is introduced before S_2, now P does not remain the point of principal maximum. Suppose principal maximum forms at a point P' on screen. Then PP' is equal to
(a) $\frac{tD(\mu-1)}{d}$ (b) $\frac{tD(\mu-1)}{2d}$
(c) $\frac{D(\mu-1)}{t}$ (d) $\frac{D(\mu-1)}{d}$

70. Use the statement given in previous question. Now parallel beam is incident at an angle α w.r.t. line OP, such that principal maximum again comes at point P. The figure is shown. The value of α is



(a) $\sin^{-1}\frac{t(\mu-1)}{d}$
(b) $\cos^{-1}\frac{t(\mu-1)}{d}$
(c) $\sin^{-1}\frac{t(\mu-1)D}{d}$
(d) $\sin^{-1}\frac{tD}{d}$

71. A slit of width a is illuminated by white light. The first minimum for red light (λ = 6500 Å) will fall at θ = 30° when a will be
(a) 3250 Å (b) 6.5×10^{-4} cm
(c) 1.3 micron (d) 2.6×10^{-4} cm

72. In Young's double slit experiment, the source S and two slits A and B are lying in a horizontal plane. The slit A is above slit B. the fringes are obtained on a vertical screen K. The optical path from S to B is increased by putting a transparent material of higher refractive index. The path from S to A remains unchanged. As a result of this the fringe pattern moves somewhat
(a) upwards
(b) downwards
(c) towards left horizontally
(d) towards right horizontally

Case/Passage-III

All types of waves, be it sound waves, light waves, water waves exhibit the phenomenon of diffraction. The size of the obstacle or opening should be comparable to the wavelength of the wave for the diffraction to be pronounced. Since the wavelength of light is much smaller than the dimensions of most obstacles; the diffraction of light is not easily observed. Sound waves having larger wavelength can be easily diffracted.

73. Wave(s) exhibit diffraction is/are
(a) light (b) water
(c) sound (d) all of the above

74. The diffraction effects in a microscopic specimen become important when the separation between two points is
(a) much greater than the wavelength of light used.
(b) much less than the wavelength of light used.
(c) comparable to the wavelength of light used.
(d) independent of the wavelength of light used.

75. The phenomenon of diffraction can be treated as interference phenomenon if the number of coherent sources is
(a) one (b) two (c) zero (d) infinity

76. Which of the following statements are true about the diffraction pattern?
I. It has a central bright maxima of twice the width of other maxima.
II. The first null occurs at an angle $\lambda/2a$.
III. The intensity of maxima falls as we move away from the central maxima.
IV. The bands are of decreasing width.
(a) II and III (b) I and II
(c) I, III and IV (d) I and III

77. 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

Case/Passage-IV

When two coherent sources interact with each other, there will be production of alternate bright and dark fringes on the screen. Young's double-slit experiment demonstrates the idea of making two coherent sources. For better visibility, one has to choose proper amplitude for the sources. The phenomena is good enough to satisfy the conservation of energy principle. The pattern formed in YDSE is of uniform thickness and is nicely placed on a long distance screen.

78. Law of conservation of energy is satisfied because
(a) equal loss and gain in intensity is observed
(b) all bright fringes are equally bright
(c) all dark fringes are of zero brightness
(d) the average intensity on screen is equal to the sum of intensities of the two sources

79. For better visibility of fringe pattern, which of the following is incorrect ?
(a) amplitudes of the sources are aqual
(b) the width of the slits should not be equal
(c) dark should be the darkest and bright should be the brightest
(d) the widths should be same

80. The best combination of independent sources to produce sustained pattern among the following is
$Y_1 = a \sin \omega t$ $\quad$ $Y_2 = a \cos \omega t$
$Y_3 = a \sin\left(\omega t + \frac{\pi}{4}\right)$ $\quad$ $Y_4 = 2a \sin(\omega t + \pi)$
(a) Y_1, Y_2 only $\quad$ (b) Y_2, Y_3 only
(c) Y_3, Y_4 only $\quad$ (d) none of these

81. In Young's interference experiment, if the slits are of unequal width, then
(a) no fringes will be formed
(b) the positions of minimum intensity will not be completely dark
(c) bright fringe as displaced from the original central position
(d) distance between two consecutive dark fringes will not be equal to the distance between two consecutive bright fringes

82. In Young's interference experiment, the central bright fringe can be identified due to the fact that it
(a) has greater intensity than other fringes which are bright
(b) is wider than the other bright fringes
(c) is narrower than the other bright fringes
(d) can be obtained by using white light instead of monochromatic light

Assertion & Reason

DIRECTIONS : *Each of these questions contains an assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*
(a) If both **Assertion** and **Reason** are **correct** and the Reason is the **correct explanation** of the Assertion.
(b) If both **Assertion** and **Reason** are correct but Reason is **not the correct explanation** of the Assertion.
(c) If the **Assertion** is **correct** but **Reason** is **incorrect**.
(d) If the **Assertion** is **incorrect** but the **Reason** is **correct**.

83. Assertion : According to Huygen's principle, no backward wave-front is possible.
Reason : Amplitude of secondary wavelet is proportional to $(1 + \cos \theta)$ where θ is the angle between the ray at the point of consideration and the direction of secondary wavelet.

84. Assertion : When a light waves travels from a rarer to a denser medium, it loses speed. The reduction in speed imply a reduction in energy carried by the light wave.
Reason : The energy of a wave is proportional to velocity of wave.

85. Assertion : Thin film such as soap bubble or a thin layer of oil on water show beautiful colours when illuminated by white light.
Reason : It happens due to the interference of light reflected from upper and lower face of the thin film.

86. Assertion : No interference pattern is detected when two coherent sources are extremely close to each other.
Reason : The fringe width is inversely proportional to the distance between the two sources.

87. Assertion : In Young's experiment, the fringe width for dark fringes is different from that for white fringes.
Reason : In Young's double slit experiment the fringes are performed with a source of white light, then only black and bright fringes are observed.

88. Assertion : In YDSE, if $I_1 = 9I_0$ and $I_2 = 4I_0$ then $\frac{I_{max}}{I_{min}} = 25$.
Reason : In YDSE $I_{max} = \frac{1}{2}(\sqrt{I_1} + \sqrt{I_2})^2$ and $I_{min} = \frac{1}{2}(\sqrt{I_1} - \sqrt{I_2})^2$.

89. Assertion : In YDSE number of bright fringe or dark fringe can not be unlimited.
Reason : In YDSE path difference between the superposing waves can not be more than the distance between the slits.

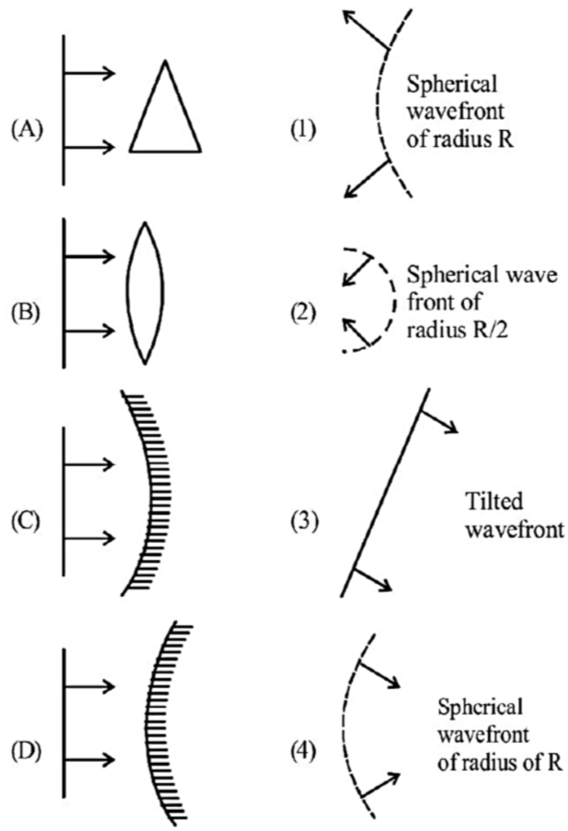
90. Assertion : Coloured spectrum is seen when we look through a muslin cloth.
Reason : It is due the diffraction of white light on passing through fine slits.

Match the Following

DIRECTIONS : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in column-I have to be matched with statements (1, 2, 3, 4) in column-II.*

91. Match Plane wave incident on different surfaces. In column I with the emergent wavefront in Column II.

Column I **Column II**



(a) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(b) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(c) (A) → (2); (B) → (4); (C) → (3); (D) → (1)
(d) (A) → (4); (B) → (2); (C) → (1); (D) → (3)

Fill in the Blanks

DIRECTIONS : *Complete the following statements with an appropriate word / term to be filled in the blank space(s).*

92. Wavelength of light of frequency 100 Hz is _______.

93. The wavefronts of a light wave travelling in vacuum are given by $x + y + z = c$. The angle made by the direction of propagation of light with the X-axis is _______.

94. The colour of bright fringe nearest to central achromatic fringe in the interference pattern with white light will be _______.

95. Sodium light $(\lambda = 6 \times 10^{-7}\,\text{m})$ is used to produce interference pattern. The observed fringe width is 0.12 mm. The angle between two interfering wave trains, is _______ rad.

96. With a monochromatic light, the fringe-width obtained in a Young's double slit experiment is 0.133 cm. The whole set-up is immersed in water of refractive index 1.33, then the new fringe-width is _______ cm.

97. The condition for observing Fraunhoffer diffraction from a single slit is that the light wavefront incident on the slit should be _______.

True / False

DIRECTIONS : *Read the following statements and write your answer as true or false.*

98. Diffraction takes place for all types of waves mechanical or non-mechanical, transverse or longitudinal.

99. Diffraction's effect are perceptible only if wavelength of wave is comparable to dimensions of diffracting device.

100. In YDSE, if a thin film is introduced in front of the upper slit, then the fringe pattern shifts in the downward direction.

101. In YDSE if the slit widths are unequal, the minima will be completely dark.

ANSWER KEY & SOLUTIONS

1. (a) Wavefront is the locus of all points, where the particles of the medium vibrate with the same phase.
2. (d) The shape of the wavefront in case of light diverging from a point source is spherical and shape of the wavefront in case of a light emerging out of a convex lens when a point source is placed at its focus is a parallel grid.
3. (b) Huygen's principle gives us a geometrical method of tracing a wavefront.
4. (b) The idea of secondary wavelets is given by huygen.
5. (d) Huygen's theory explains propagation of wavefronts.
6. (b) Fringe width, $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \frac{1}{d}$

   where d = distance between slits
7. (c) $I_{max} = I + 4I + 2\sqrt{I \times 4I} = 9I$,

   and $I_{min} = I + 4I - 2\sqrt{I \times 4I} = I$.
8. (d) $\beta = \frac{D\lambda}{d}$ so $\beta \propto D$
9. (b) Angular fringe width, $\theta = \frac{\lambda}{d}$

   $\therefore \theta \propto \lambda$

   so, $\theta_w = \frac{\theta_{air}}{\mu_{water}} = \frac{0.20}{4/3} = 0.15°$
10. (b) Path difference $= 171.5\lambda = \frac{343}{2}\lambda$

    = odd multiple of half wavelength.

    It means dark fringe is observed.

    According to question, $0.01029 = \frac{343}{2}\lambda$

    $\Rightarrow \lambda = \frac{0.01029 \times 2}{343} = 6 \times 10^{-5}$ cm $\Rightarrow \lambda = 6000$ Å
11. (a) As $\beta = \frac{\lambda D}{d} \therefore \beta \propto \lambda$.

    As λ for violet is least, therefore, fringe nearest to central achromatic fringe will be violet.
12. (b) The path difference at a point P on the circle is given by, $\Delta x = d \cos \theta$ ...(i)

    for maxima at P

    $\Delta x = n\lambda$ ...(ii)

    from equations (i) and (ii)

    $n\lambda = d \cos \theta \Rightarrow \theta = \cos^{-1}\left[\frac{n\lambda}{d}\right]$

    $\theta = \cos^{-1}\left[\frac{4\lambda}{d}\right]$
13. (d) Diffraction is a general characteristics exhibited by all types of waves.
14. (b) Width of central maximum in diffraction pattern due to single slit $= \frac{2\lambda D}{d}$ where λ is the wavelength, D is the distance between screen and slit and a is the slit width. As the slit width a increases, width of central maximum becomes sharper or narrower. As same energy is distributed over a smaller area. therefore central maximum becomes brigther.
15. (c) Because both source & screen are effectively at infinite distance from the diffractive device.
16. (d) Diffraction on a single slit is equivalent to interference of light from infinite number of coherent sources contained in the slit.
17. (a) As given that the width of the slit $= 10^4$ Å $= 10000$ Å $= 10^4 \times 10^{-10}$ m $= 10^{-6}$ m $= 1$ μm

    Wavelength of visible sunlight varies from 4000 Å to 8000 Å. Thus the width of slit is 10000 Å comparable to that of wavelength visible light i.e., 8000 Å. So diffraction occurs with maxima at centre. Hence at the centre all colours appear i.e., mixing of colours form white patch at the centre.
18. (a) Let, us consider the diagram, the ray (P) is incident at an angle θ and gets reflected in the direction P' and refracted in the direction P' through O'. Due to reflection from the glass medium there is a phase change of π. The time difference between two refracted ray OP' and O'P'' is equal to the time taken by ray to travel along OO'.

    $\Delta t = \frac{OO'}{V_g} = \frac{d/\cos r}{c/n} = \frac{nd}{c \cos r}$

    From Snell's law, $n = \frac{\sin \theta}{\sin r}$

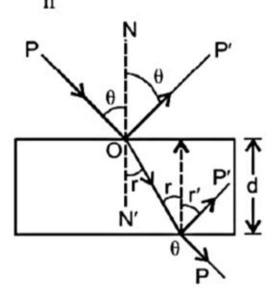
    $\sin r = \frac{\sin \theta}{n}$

    As we know that, $\cos r = \sqrt{1 - \sin^2 r}$,

    so by putting sin r value in that relation.

    So, $\cos r = \sqrt{1 - \sin^2 r}$

    $\cos r = \sqrt{1 - \frac{\sin^2 \theta}{n^2}}$



$\therefore \quad \Delta t = \frac{nd}{c\left(1 - \frac{\sin^2 \theta}{n^2}\right)^{1/2}} = \frac{nd}{c}\left(1 - \frac{\sin^2 \theta}{n^2}\right)^{-1/2}$

Phase difference $= \Delta\phi = \frac{2\pi}{T} \times \Delta t = \frac{2\pi d}{\frac{1}{\nu} \cdot \nu\lambda}\left(1 - \frac{\sin^2 \theta}{n^2}\right)^{-1/2}$

$$\Delta\phi = \frac{2\pi d}{\lambda}\left[1-\frac{\sin^2\theta}{n^2}\right]^{-1/2}$$

$\therefore$ Hence the net phase difference $= \Delta\phi + \pi$

$$= \frac{2\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{+1/2} + \pi$$

19. **(c)** For sustained interference pattern to be formed on the screen, the sources must be coherent and emits lights of same frequency and wavelength.
In a Young's double-slit experiment, when one of the holes is covered by a red filter and another by a blue filter. In this case due to filteration only red and blue lights are present which has different frequency. In this monochromatic light is used for the formation of fringes on the screen. So, in that case there shall be no interference fringes.

20. **(d)** Consider the given figure there is a hole at point P_2. By Huygen's principle, wave will propagates from the sources S_1 and S_2. Each point on the screen will acts as sources of secondary wavelets.
Wavefront starting from P_2 reaches at S_3 and S_4 which will again act as two monochromatic or coherent sources.
Hence, there will be always a regular two slit pattern on the second screen.

21. **(d)** The Huygen's construction of wavefront does not explain the phenomena of origin of spectra.

22. **(d)** Interference pattern will be invisible, because red and green are complimentary colours.

23. **(a)** **24.** **(d)** **25.** **(b)** **26.** **(a)** **27.** **(b)**

28. **(b)** If a plane wave of light travelling along the y-direciton electric field may be along any direction in x-z plane (i.e. y = c), hence wavefront represented by y = c.

29. **(b)**

30. **(a)** When light reflects from denser surface phase change of π occurs.

31. **(c)** In interference pattern, the energy is conserved but redisturbed.

32. **(d)** **33.** **(b)**

34. **(a)** For interference phase difference must be constant.

35. **(d)** Coherent light is always monochromatic.

36. **(a)** Coherence is a measure of capability of producing interference by waves.

37. **(d)** A prism cannot produce coherent sources.

38. **(c)** **39.** **(c)**

40. **(a)** $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{4}{1} \quad \therefore \frac{a_1}{a_2} = \frac{2}{1}$

41. **(c)** $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{9}{1}$ or $\frac{a_1}{a_2} = \frac{3}{1}$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(3+1)^2}{(3-1)^2} = \frac{16}{4} = \frac{4}{1}$$

42. **(c)** $\lambda = \frac{h}{P} = \frac{h}{mv}$, so with the increase in velocity of electron, wavelength decreases, and so fringe width decreases.

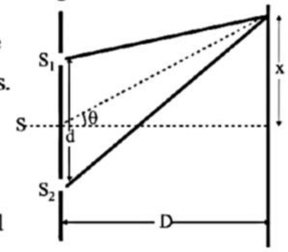
43. **(b)** $\Delta x_{max} = 2\lambda$.
So there are five maxima.
These are for $\Delta x = 0, \pm\lambda, \pm 2\lambda$.

44. **(a)** As $\beta = \frac{\lambda D}{d}$ and $\lambda_b < \lambda_y$,
$\therefore$ fringe width β will decrease

45. **(c)** Distance of nth maxima, $x = n\lambda\frac{D}{d} \propto \lambda$
As $\lambda_b < \lambda_g \therefore x_{blue} < x_{green}$

46. **(d)** Let λ be wavelength of monochromatic light incident on slit S, then angular distance between two consecutive fringes, that is the angular fringe width is

$\theta = \frac{\lambda}{d}$ where d is distance between coherent sources.



Given, $\frac{\Delta\theta}{\theta} = \frac{10}{100}$

So, from eq. (1),

$$\frac{\Delta\lambda}{\lambda} = \frac{\Delta\theta}{\theta} = \frac{10}{100} = 0.1$$

$\Rightarrow \Delta\lambda = 0.1\lambda = 0.1 \times 5890Å = 589Å$ (increases)

Note: Since, $\theta \propto \lambda$, as θ increases, λ increases.

47. **(d)** Optical path difference $\Delta x = (\mu_2 - \mu_1)t$.

48. **(a)** $\beta = \frac{D\lambda}{d}$

and $\beta' = \frac{D \times 1.1\lambda}{1.1d} = \frac{D\lambda}{d} = \beta = 0.2$ mm.

49. **(d)**

50. **(d)** Given $d = 0.5$ mm $= 5 \times 10^{-2}$ cm
$D = 100$ cm.
$X_n = X_{11} - X_1 = 9.72$ mm.

$$\therefore \quad X_n = \frac{n\lambda D}{d}$$

$$\Rightarrow \lambda = \frac{X_n d}{nD} = \frac{0.972 \times 5 \times 10^{-2}}{10 \times 100} = 4.86 \times 10^{-5} \text{ cm.}$$

51. **(d)** **52.** **(a)** **53.** **(d)**

54. **(b)** Here, $D = 1.25$m, $\mu_w = 4/3$, $\theta_w = 0.2°$

$$\mu_w = \frac{\lambda_a}{\lambda_w} = \frac{4}{3} \quad \text{...(i)}$$

Angular width $\theta_a = \frac{\beta}{D} = \frac{(\lambda_a D/d)}{D} = \frac{\lambda_a}{d}$

As d remains the same

$$\therefore \frac{\theta_a}{\theta_w} = \frac{\lambda_a}{\lambda_w} \text{ or } \theta_a = \theta_w \times \frac{\lambda_a}{\lambda_w} = 0.2° \times \frac{4}{3} = 0.27°$$

55. **(a)**

56. **(c)** $\beta = \frac{\lambda' D'}{d'} = \frac{3\lambda 3D}{d/3} = 27\frac{\lambda D}{d}$.

No. of fringes $= \frac{1/3}{\beta} = \frac{d}{81\lambda D}$.

57. **(c)** When the wavelength of light used is comparable with the separation between two points, the image of the object will be a ϕ diffraction pattern whose size will be

$$\theta = \frac{1.22\lambda}{D}$$

where λ = wavelength of light used
D = diameter of the objective
Two objects whose images are closer than this distance, will not be resolved.

58. **(a)**

59. **(b)** In diffraction, width of central maxima $\propto \lambda$.
$\therefore$ Wavelength of X rays is less than that of yellow light, so the width decreases.

60. **(a)** For single slit diffraction pattern $e \sin\theta = \lambda$ Angular width, e = slit width

$\therefore \quad \theta = \sin^{-1}\left(\frac{\lambda}{e}\right)$

It is independent of distance between source and slit.

61. **(a)** We know that for maxima $b \sin\theta = (2n+1)\frac{\lambda}{2}$

or $\sin\theta = \frac{2n+1}{2}\left(\frac{\lambda}{b}\right)$

So on decreasing the slit width, 'b', keeping λ same, $\sin\theta$ and hence θ increases.

62. **(b)** The width of the central maximum is given by

$$\beta = \frac{2\lambda D}{d} \Rightarrow \text{If } d \to 2d, \text{ then } \beta \text{ decreases.}$$

Also, intensity $I = I_0\left[\frac{\sin\alpha}{\alpha}\right]^2$ where $\alpha = \frac{\pi d \sin\theta}{\lambda}$

$\therefore$ I increases as d increases
$\therefore$ The central maximum will become narrower and brighter.

63. **(c)** Converging spherical

64. **(c)** A slit would give divergent; a biprism would give double; a glass slab would give a parallel wavefront. Edge is downward.

65. **(c)** Newtons coupuscular theory is based on the assumption that light is made up of particles. It cannot explain diffraction which is based on wave nature of light.

66. **(a)**

67. **(b)** Line source produce cylindrical wavefront.

68. **(a)** Distance of third minima from principal maxima $= \frac{3}{2}\frac{D}{d}\lambda$

69. **(b)** **70.** **(a)**

71 **(c)** The position of n^{th} dark fringe in Fraunhoffer Diffraction from a single slit is $a \sin\theta = n\lambda$

$$a = \frac{n\lambda}{\sin\theta} = \frac{1 \times 6.5 \times 10^{-7}}{\sin 30^o}, \text{(for first min. n = 1)}$$

$$= \frac{6.5 \times 10^{-7}}{1/2} = 13 \times 10^{-7}\,m = 1.3\,\mu m.$$

72. **(b)** As optical path SB of lower slit is increased, therefore, fringe pattern shifts somewhat downwards.

73. **(d)**

74. **(c)** When the wavelength of light used is comparable with the separation between two points, the image of the object will be a ϕ diffraction pattern whose size will be

$$\theta = \frac{1.22\lambda}{D}$$

where λ = wavelength of light used
D = diameter of the objective
Two objects whose images are closer than this distance, will not be resolved.

75. **(d)** **76.** **(d)**

77. **(d)** For diffraction pattern to be observed, the dimension of slit should be comparable to the wave length of rays. The wavelength of X-rays (1 – 100 Å) is less than 0.6 mm.

78. **(d)** $I_{av} = \frac{I_{max.} + I_{min.}}{2}$

$$= \frac{(A_1 + A_2)^2 + (A_1 - A_2)^2}{2} = A_1^2 + A_2^2 = I_1 + I_2$$

$I_{av} = I_1 + I_2$

Neither loss nor gain of energy is observed, but only redistribution of energy takes place.

79 **(b)** If $A_1 = A = a, I_{max} = 4a^2, I_{min} = 0$. So, visibility is the best. Choice (a) is correct.
Since $I_{min} = 0$, choice (c) is also correct.
Width decides intensity and thereby the amplitude. So, choice (d) is correct making (b) wrong.

80. **(d)** Sources are independent. They cannot form a coherent source since ϕ cannot be constant with time.

81. **(b)** When slits are of unequal width, then intensity of sources S_1 and S_2 is not equal. So, position of minimum intensity will not be completely dark.

82. **(d)** Because white light will give a general illumination at the central maxima.

83. **(b)** **84.** **(d)**

85. **(a)** Both top and bottom surfaces of this oil film can reflect light. If path difference between two light rays is an integral multiple of λ, there will be constructive interference.

86. **(a)** $\beta = \frac{D\lambda}{d}$. When $d \to 0$, $\beta \to \infty$, and so fringes will not be seen over the screen.

87. **(d)** **88.** **(c)** **89.** **(a)**

90. **(a)** When white light is passed through a fine hole of muslin cloth in diffraction occurs resulting coloured spectrum.

91. **(b)** (A)→ (3); (B)→ (4); (C)→ (2); (D) → 1

92. (3×10^6m) Frequency (n) = 100 Hz

$$v = n\lambda \Rightarrow \lambda = \frac{3 \times 10^8}{100} \quad \lambda = 3 \times 10^6\,m.$$

[where, velocity (v) = 3×10^8 m/s of light]

93. Huyghen's principle gives us a geometrical method of tracing a wavefront.

94. As $\beta = \frac{\lambda D}{d} \therefore \beta \propto \lambda$.

95. (5×10^{-3}) The fringe width is given by, $\beta = \frac{\lambda D}{d}$

The angular width of fringe is given by

$$\frac{d}{D} = \frac{\lambda}{\beta} = \frac{6 \times 10^{-7}}{0.12 \times 10^{-3}} = 5 \times 10^{-3}\text{ rad.}$$

96. (0.1) $\beta' = \frac{\beta}{\mu} = \frac{0.133}{1.33} = 0.1$ cm

97. (Both source & screen are effectively at infinite distance from the diffractive device)

98. (True) **99.** (True) **100.** (False) **101.** (True)