INDIAN SCHOOL AL WADI AL KABIR

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| **Class: XII** | **Department: SCIENCE (PHYSICS)** | **DATE- 01-11-2025** |
| **Worksheet No:10** | **Topic: WAVE OPTICS** | **Note:**<br>**A4 FILE FORMAT** |
| **NAME OF THE STUDENT-** | **CLASS & SECTION** | **ROLL NO.** |

# MULTIPLE CHOICE QUESTIONS:

1. What is the geometric shape of the wave front that originates when a plane wave passes through a convex lens?

a. Converging spherical
b. Diverging spherical
c. Plane
d. None of the above

2. How can the fringe width increase in Young's double-slit experiment?

a. By decreasing the width of the slit
b. By reducing the separation of slits
c. By reducing the wavelength of the slits
d. By decreasing the distance between slits and the screen

3. What is the locus of all particles in a medium vibrating in the same phase called?

a. Fringe
b. Wavelet
c. Wave front
d. None of the above

4. Which of the following factors does the intensity of light depend on?

a. Frequency
b. Wavelength
c. Amplitude
d. Velocity

5. Two light sources are said to be coherent when both the sources of light emit light of

a. The same amplitude and phase
b. The same intensity and wavelength
c. The same speed
d. The same wavelength and constant phase difference

6. Which of the following is conserved when light waves interfere?

a. Intensity
b. Amplitude
c. Phase
d. None of the above

7. The idea of secondary wavelets for the. propagation of a wave was first given by
(a) Newton
(b) Huygens
(c) Maxwell
(d) Fresnel

8.Two slits in Young's double slit experiment have widths in the ratio 81 :1. The ratio of the amplitudes of light waves is
(a) 3 :1
(b) 3 : 2
(c) 9 :1
(d) 6:1

9.When interference of light takes place
(a) energy is created in the region of maximum intensity
(b) energy is destroyed in the region of maximum intensity
(c) conservation of energy holds good and energy is redistributed
(d) conservation of energy does not hold good

10. In a double slit interference pattern, the first maxima for infrared light would be
(a) at the same place as the first maxima for green light
(b) closer to the centre than the first maxima for green light
(c) farther from the centre than the first maxima for green light
(d) infrared light does not produce an interference pattern

11. To observe diffraction, the size of the obstacle
(a) should be X/2, where X is the wavelength.
(b) should be of the order of wavelength.
(c) has no relation to wavelength.
(d) should be much larger than the wavelength.

12. Which of the following effects was NOT one of the things predicted by the wave theory of light?

a. Interference
b. Refraction
c. Diffraction
d. The Photoelectric Effect

13) A narrow slit is taken and a parallel beam of moving electrons is incident normally on it. At a larger distance from the slit, a fluorescent screen is placed. Which of the following statement is true if the size of the slit is further narrowed?

a. The diffraction pattern cannot be observed on the screen
b. The angular width of the central maxima of the diffraction pattern will increase

c. The angular width of the central maxima of the diffraction pattern will decrease
d. The angular width of the central maxima of the diffraction pattern remains the same

14) How does the diffraction band of blue light look in comparison with the red light?

a. No changes
b. Diffraction pattern becomes narrower
c. Diffraction pattern becomes broader
d. Diffraction pattern disappears

15) The ratio of the amplitude of the two sources producing interference 3 : 5, the ratio of intensities at maxima and minima is

a. 25:6
b. 5:3
c. 16:1
d. 25:9

16): The colours on the soap bubble is due to

a. Interference
b. Polarization
c. Diffraction
d. Reflection

17) In Young's double-slit experiment, the phase difference between the light waves reaching the third bright fringe from the central fringe will be ($\lambda$=6000 Å)

a. Zero
b. $2\pi$
c. $4\pi$
d. $6\pi$

18) When Two waves of same amplitude add constructively, the intensity becomes _____
a) Double
b) Half
c) Four Times
d) One-Fourth

19) If instead of monochromatic light white light is used for interference of light, what would be the change in the observation?
a) The pattern will not be visible.
b) The shape of the pattern will change from hyperbolic to circular.
c) Coloured fringes will be observed with a white bright fringe at the centre.
d) The bright and dark fringes will change position.

20) One beam of coherent light travels path $P_1$ in arriving at point Q and another coherent beam travels path $P_2$ in arriving at the same point. If these two beams are to interfere destructively, the path difference $P_1 - P_2$ must be equal to
a. an odd number of half-wavelengths.
b. zero.
c. a whole number of wavelengths.

d. a whole number of half-wavelengths.

21) Two beams of coherent light travel different paths arriving at point P. If the maximum constructive interference is to occur at point P, the two beams must
   a. arrive 180° out of phase.
   b. arrive 90° out of phase.
   c. travel paths that differ by a whole number of wavelengths.
   d. travel paths that differ by an odd number of half-wavelengths.

22) Two light sources are said to be coherent if they
   a. are of the same frequency.
   b. are of the same frequency, and maintain a constant phase difference.
   c. are of the same amplitude, and maintain a constant phase difference.
   d. are of the same frequency and amplitude.

**SHORT ANSWER QUESTIONS-2 MARKS**

23) 633 nm laser light is passed through a narrow slit and a diffraction pattern is observed on a screen 6.0 m away. The distance on the screen between the centres of the first minima outside the central bright fringe is 32 mm. What is the slit width?

24) The wavelengths of visible light are from approximately 400 nm (violet) to 700 nm (red). Find the angular width of the first-order visible spectrum produced by a plane grating with 600 slits per millimetre when white light falls normally on the grating.

25) What changes are observed in a diffraction pattern if the whole apparatus is immersed in water?

26) How shall a diffraction pattern change when white light is used instead of a monochromatic light?

27) What will be the angular separation of the first order fringe from the central maximum, when a light of wavelength 500 nm is diffracted at a slit of width 0.5 mm?

28) A screen is placed 2m away from the lens to obtain the diffraction pattern in the focal plane of the lens in a single slit diffraction experiment. What will be the slit width if the first minimum lies 5 mm on either side of the central maximum when plane light waves of wavelength 4000 Å are incident on the slit?

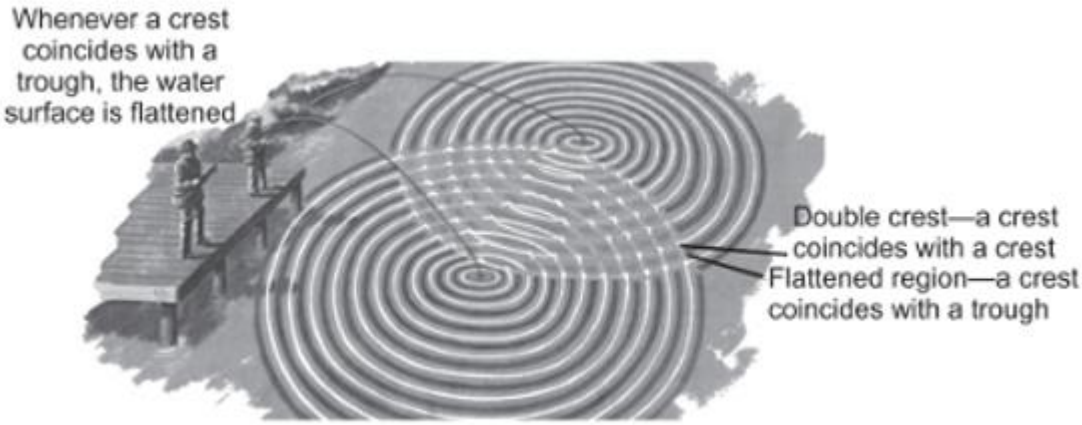
29) What is the effect on the interference fringes in a Young's double slit experiment when (i) the width of the two slits is increased (ii) the monochromatic source is replaced by a source of white light and (iii) the separation between the two slits is increased, keeping other variables constant in each case?

30)A ray of monochromatic light passes from medium (1) to medium (2). If the angle of incidence in medium (1) is $\theta$ and the corresponding angle of refraction in medium (2) is $\theta/2$, which of the two media is optically denser? Give reason.

31) How do the increasing (i) wavelength and (ii) intensity of light affect the speed of light in glass?

**CASE BASED STUDY QUESTIONS**

32) Two students were creating a series of circular waves while fishing in the water. The waves form a pattern similar to the diagram as shown. They observed that beautiful pattern of ripples which became very colourful when few drops of oil is poured on it.




Read the passage and answer the following questions

(i) Name the phenomenon involved in the activity

(A) Reflection (B) Refraction

(C) Interference (D) Polarisation

(ii)A surface over which an optical wave has a constant phase is called

(A) Wave (B) Wavefront

(C) Wavelets (D) Carrier

(iii) Which of the following is correct for light diverging from a point source?

(A)The intensity decreases in proportion to the distance squared.

(B) The wavefront is parabolic

(C) The intensity at the wavelength does not depend on the distance.

(D) The intensity increases in proportion to the distance squared.

(iv) Huygens's 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.

CASE BASED STUDY QUESTIONS.

33) According to superposition principle, the resultant displacement produced due the number of waves at a particular point is the vector sum of displacement produced by each vector at that point. The two sources of light are said to be coherent only when the phase difference between the light waves produced by them is zero or constant. The point at which two waves are in phase or if trough of one wave coincides with the trough of other or crest of one wave coincides with the crest of other then the resultant intensity produced at that point will be larger and amplitude also maximum. Such points are the points where constructive interference takes place. While there are some points where two light waves are not in phase with each other and crest of one wave coincides with the trough of other and vice versa due to which resultant intensity at that point is minimum and amplitude also get decreased. Such points are the points where destructive interference takes place.

For constructive interference, the path difference is equal to integral multiple of wavelengths and resultant intensity will be maximum at those points. While for destructive interference, the path difference is (n + 1/2) multiple of wavelengths and where resultant intensity is zero. When light is passed around the sharp edges of an obstacle it get bended and may enters into the geometrical shadow of that obstacle such a phenomenon of light is called as diffraction of light. In interference, there are equally spaced alternate bright and dark bands are possible. While in diffraction, the there is a only one bright central Maxima and around both sides of the central Maxima the intensity of the light decreases as we go away from that central Maxima.

**Q 1.) For coherent sources of light, the phase difference must be___**

a) one

b) zero

c) either zero or constant

d) 90°

**Q 2.) If the phase difference is 0, +2π, -4π then the interference should be**

a) constructive interference

b) destructive interference

c) both a and b

d) diffraction of light

**Q 3.) For destructive interference**

a) path difference is (n +1/2) times wavelength

b) phase difference is π, -3π, +5π

c) path difference is integral multiple of wavelengths

d) both a and b

Q 4.) The interference and diffraction of light explains which nature of light?

a) Particle nature of light.

**b)** Wave nature of light.

**c)** Dual nature of light.

**d)** Corpuscular nature of light.

Q 5.) How conservation of energy is possible in interference and diffraction of light?

## LONG ANSWER TYPE QUESTIONS:

**34)** Laser light of wavelength 640 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 7.2 mm. Calculate the wavelength of another source of light which produces interference fringes separated by 8.1 mm using same arrangement. Also find the minimum value of the order 'n' of bright fringe of shorter wavelength which coincides with that of the longer wavelength.

**35)** Yellow light ($\lambda = 6000Å$) illuminates a single slit of width 1 x 10-4 m. Calculate
(i) the distance between the two dark lines on either side of the central maximum, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit;
(ii) the angular spread of the first diffraction minimum.

36) A parallel beam of light of 600 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1.2 m away. It is observed that the first minimum is at a distance of 3 mm from the centre of the screen. Calculate the width of the slit.

**ASSERTION REASONING QUESTIONS**

**Directions:** These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.
(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

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

2)**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.

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

4) **Assertion:** It is necessary to have two waves of equal intensity to study interference pattern.
**Reason:** There will be an effect on clarity if the waves are of unequal intensity.

5) **Assertion:** White light falls on a double slit with one slit is covered by a green filter. The bright fringes observed are of green colour.
**Reason:** The fringes observed are coloured.

\CBSE BOARD QUESTIONS

1) a ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the same for the reflected and refracted ray?

(a) Energy carried (b) Speed
(c) Frequency (d) Wavelength

Ans. c- frequency

2) In a Young's double slit experiment, the separation between the two slits is d and distance of the screen from the slits is 1000d. If the first minima fall at a distance d from the central maximum, obtain the relation between d and λ. (2)

3)State Huygen's principle. With the help of a diagram, show how a plane wave is reflected from a surface. Hence verify the law of reflection. (3)

ASSERTION AND REASON

4)ASSERTION (A) : In Young's double slit experiment all fringes are of equal width.

REASON : The fringe width depends upon wavelength of light used, distance of screen from plane of slits(D) and slit separation(d).

5) State Huygen's principle. With the help of a diagram,show the details of passage of a plane

wave from a denser into a rarer medium. (2 marks)

6) The shape of the wavefront of the portion of the wavefront of light from a distant start intercepted by the earth is

a)Plane b) spherical c) conical d) hyperboloid

**(a)** plane

**Explanation:** Stars are very far away from earth. Near the star the shape is spherical but by the time its light reaches earth, the portion of the wavefront is plane due to increase in radius.

7) The beam of light consisting of two wavelengths, 650 nm and 520 nm, are used to obtain interference fringes in a Young's double slit experiment.

a. Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm.

b. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

ANSWER

. Here, $\lambda_1 = 650\ nm = 650 \times 10^{-9} m$

$\lambda_2 = 520\ nm = 520 \times 10^{-9} m$

Suppose, d = distance between two slits

D = Distance of screen from the slits

a. For third bright fringe, n = 3

$x = n\ \lambda_1 \cdot \frac{D}{d}$

$= 3 \times 650 \times \frac{D}{d} = 1950 \frac{D}{d}$

b. Let nth bright fringe due to wavelength 650 nm coincide with (n -1)th due to wavelength 520 nm.

Therefore, $n\ \lambda_2 = (n-1)\lambda_1$

or, $n \times 520 = (n-1) \times 650 \Rightarrow n = 5$

Hence, the least distance from the central maximum can be obtained by the relation:

$x = n\lambda_2 \frac{D}{d} = 5 \times 520 \frac{D}{d} = 2600 \frac{D}{d}\ nm$

Note: The value of d and D are not given in the question.

ANSWERS

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| 1. | **Answer:** (a) Converging Spherical<br>**Explanation:** A converging spherical wave front originates when a plane wave passes through a convex lens. |
| 2. | **Answer:** (b) By decreasing the separation of slits<br>**Explanation:** The fringe width can be increased in Young's double-slit experiment by decreasing the separation of slits. |
| 3. | **Answer:** (c) Wave front<br>**Explanation:** The locus of all particles in a medium vibrating in the same phase is called a wave front. |
| 4. | **Answer:** (c) Amplitude<br>**Explanation:** The intensity of light depends on amplitude. |
| 5. | **Answer:** (d) the same wavelength and constant phase difference<br>**Explanation:** Two light sources are said to be coherent when both light sources emit light of the same wavelength and constant phase difference. |
| 6. | **Answer:** (d) None of the above<br>**Explanation:** Intensity, amplitude, and phase are not conserved when light waves interfere. |
| 7. | Answer: b |

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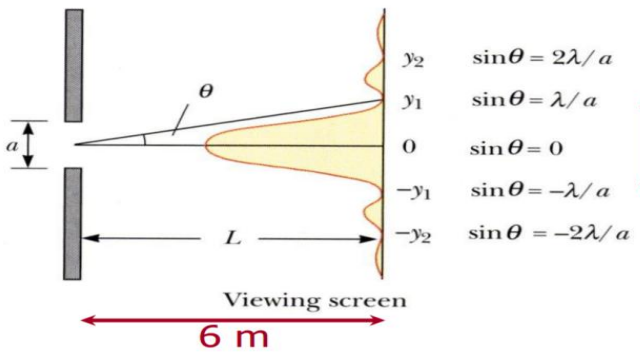
| 8. | Answer: c |
| 9. | Answer: c |
| 10. | Answer: c |
| 11. | Answer: b |
| 12. | Ans. d |
| 13. | Answer: (b) The angular width of the central maxima of the diffraction pattern will increase |
| 14. | Answer: (b) Diffraction pattern becomes narrower |
| 15. | Answer: (c) 16:1 |
| 16. | Answer: (a) Interference |
| 17. | Answer: $6\pi$ |
| 18. | Ans. C. Explanation: As we know, $I \propto A^2$. Thus, as the two waves add constructively, their amplitude becomes twice and hence the intensity becomes four times. |
| 19. | answer: c<br>Explanation: When white light is used instead of monochromatic light, all the seven constituent colors produce their interference pattern. At the center of the screen, all the wavelengths meet in phase and, therefore, a white bright fringe is formed. Then the next fringe will be formed due to violet color as the wavelength is shortest for violet color. This will be followed by indigo, blue till red color. |
| 20. | a.an odd number of half-wavelengths. |
| 21. | c. travel paths that differ by a whole number of wavelengths. |
| 22. | b. are of the same frequency, and maintain a constant phase difference. |
| | SECTION B (2 MARKS QUESTIONS) |
| 23. | $y_1 = (32\text{ mm})/2$ $\quad \tan\theta = y_1/L$ $\quad \tan\theta \approx \sin\theta \approx \theta$ for small $\theta$<br>  <br><br>$a\sin\theta = m\lambda = (1)\lambda$<br>$\sin\theta = \frac{\lambda}{a} \Rightarrow a = \frac{\lambda}{\sin\theta} \approx \frac{\lambda}{y_1/L} = \frac{L\lambda}{y_1}$<br>$a = \frac{(6.0\text{ m})(633\times10^{-9}\text{ m})}{(16\times10^{-3}\text{ m})}$<br>$a = 2.37\times10^{-4}\text{ m}$ |

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| 24. | Interference Maxima: $d \sin\theta = m\lambda$<br>$d = \frac{1}{600 \text{ slits/mm}} = 1.67 \times 10^{-6} \text{ m}$<br>First-order violet: $\sin\theta_V = m\frac{\lambda_V}{d} = \frac{(1)(400 \times 10^{-9} \text{ m})}{1.67 \times 10^{-6} \text{ m}} = 0.240$<br>$\theta_V = 13.9^\circ$<br>First-order red: $\sin\theta_R = m\frac{\lambda_R}{d} = \frac{(1)(700 \times 10^{-9} \text{ m})}{1.67 \times 10^{-6} \text{ m}} = 0.419$<br>$\theta_R = 24.8^\circ$<br>$\Delta\theta = \theta_R - \theta_V = 24.8^\circ - 13.9^\circ = 10.9^\circ$<br>  |
| 25. | Explanation: As the whole apparatus is now immersed in water, the wavelength of the light will change.<br>$\lambda' = \lambda\mu$<br>Therefore, as the refractive index of water is greater than the air, the wavelength of light will decrease.<br>Width of central maxima = $2\lambda a$<br>Therefore, as the wavelength decreases, the width of the central maxima decreases. |
| 26. | Answer:<br>Explanation: When white light is used instead of monochromatic light, then the central maximum remains white as all seven wavelengths meet there in the same phase. The first minimum and second maximum will be formed by violet color due to its shortest wavelength while the last is due to the red color as it has the longest wavelength. Thus, a colored pattern is observed.<br>However, after the first few colored bands, the clarity of the band is lost, due to overlapping. |
| 27. | Answer: b<br>Explanation: a = 0.5 mm = 0.5 X $10^{-3}$m, $\lambda$ = 5000 Å = 5 X $10^{-7}$ m.<br>Angular separation between the central maximum and the first order minimum is given by:<br>$\sin\theta = \lambda/a = 0.001$<br>$\sin\theta \approx \theta$<br>$\theta = 0.001$ radian<br>$\theta = 3.4$ minute. |
| 28. | Explanation: Given: f = 2 m, x = 5 X $10^{-3}$ m, $\lambda$ = 4 X $10^{-7}$ m, n=1<br>$\sin\theta = n\lambda/a$, we have<br>$a = n\lambda/\sin\theta$<br>= 1.6 X $10^{-4}$m<br>= 0.16 mm. |

29. (i) : Intensity of light emitted by the slits increases as the width of the slit i increased. Thus, more brighter fringes are formed at the screen on increas the width of the slits.
(ii) : Coloured fringes are formed at the screen if monochromatic light is replaced by the white light.
(iii) : Fringe width $\beta = \frac{\lambda D}{d}$
So, width of the fringes gets decreased if the distance between the slits (d) i increased and thus we get narrower fringes.

30. Given: $i = \theta$, $r = \frac{\theta}{2}$

$\because \quad \frac{\sin i}{\sin r} = \frac{n_2}{n_1}$

i.e. $\sin r < \sin i \Rightarrow n_2 > n_1$

Hence, 2nd medium is optically denser.

31. (i) $\because v \propto \lambda$; $\therefore$ speed of light increases on increasing the wavelength in glass.
(ii) There is no effect on speed of light on changing the intensity.

**CASE BASED STUDY QUESTIONS**

32. (i)(C) Interference

(ii) (B) Wavefront

(iii) (A)The intensity decreases in proportion to the distance squared.

(iv) (b) Is a geometrical method to find a wavefront.

33. (i) c) either zero or constant

(ii) a) constructive interference

(iii) d) both a and b

**(iv)** b)Wave nature of light.

**(v)** In interference and diffraction of light, there is a redistribution of light energy takes place. That means if a dark fringe with less light energy is produced then there will be also a bright fringe with high light energy will be produced in another region. Therefore, there will be no loss or gain in light energy takes place which obeys the law of conservation of energy.

**LONG ANSWER TYPE QUESTIONS:**

34. **Ans.** Distance between two bright fringes = Fringe width

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

For same values of D and $d$, we have

$$\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} \quad \text{or} \quad \frac{7.2}{8.1} = \frac{640}{\lambda_2} \quad \text{or} \quad \frac{0.8}{0.9} = \frac{640}{\lambda_2}$$

or $0.8\lambda_2 = 576 \;\therefore\; \lambda_2 = 720$ nm

Calculation of minimum value of order: for n to be minimum

$(n + 1)^{th}$ maxima of shorter wavelength should coincide with $n^{th}$ maxima of longer wavelength

coincide with $n^{th}$ maxima of longer wavelength

$(n + 1)\,640 = n \times 720$ or $640\,n + 640 = 720\,n$

or $640 = 720\,n - 640\,n$ *i.e.* $80\,n$

or $80\,n = 640$ or $n = 8$

$\therefore$ ***Minimum order of shorter wavelength***

$= (n + 1) = (8 + 1) = \mathbf{9}$

35. **Ans.** (i) Distance between two dark lines, on either side of central maxima $= 2\dfrac{\lambda D}{a}$

$$= \frac{2 \times 6000 \times 10^{-10} \times 1.5}{1 \times 10^{-4}} = 18000 \times 10^{-6}$$

$= 18 \times 10^{-3}$m $=$ **18 mm**

(ii) Angular spread of the first diffraction minimum (on either side)

$$= \theta = \frac{\lambda}{a} = \frac{6 \times 10^{-7}}{1 \times 10^{-4}} = \mathbf{6 \times 10^{-3}\ radians}$$

36.

$\lambda = 600$ nm $= 600 \times 10^{-9}$ m, $D = 1.2$ m

First minima at $x_1 = 3$ mm $= 3 \times 10^{-3}$ m

Diffraction angle for first minima :

$$\theta_1 = \frac{x_1}{D}$$

$$\theta_1 = \frac{3 \times 10^{-3} \times 10}{12} = 2.5 \times 10^{-3} \text{ rad}$$

We know, $a \sin\theta_1 = n\lambda, \quad n = 1$

$a \sin\theta_1 = n\lambda$

Since angle is very small so $\sin\theta_1 \sim \theta$

$$a = \frac{\lambda}{\theta_1} = \frac{600 \times 10^{-9}}{2.5 \times 10^{-3}}$$

$$a = \frac{6}{2.5} \times 10^{-4} \text{ m} = 2.4 \times 10^{-4} \text{ m} = 0.24 \text{ mm}$$

$\therefore$ $\boxed{a = 0.24 \text{ mm}}$

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| | ASSERTION REASONING QUESTIONS |
| 1. | Ans. b |
| 2. | Ans. a |
| 3. | Ans. a |
| 4. | Ans.(d) For interference, the waves may be of unequal intensities. |
| 5. | Ans. (c) Interference will take place in green light only |

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