INDIAN SCHOOL AL WADI AL KABIR

Class: XII	Department: SCIENCE (PHYSICS) 2023-2024	DATE OF SUBMISSION-04-11-23
Worksheet No:10	Topic: WAVE OPTICS	Note: 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

Answer: (a) Converging Spherical

Explanation: A converging spherical wave front originates when a plane wave passes through a convex lens.

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

Answer: (b) By decreasing the separation of slits

Explanation: The fringe width can be increased in Young's double-slit experiment by decreasing the separation of slits.

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

Answer: (c) Wave front

Explanation: The locus of all particles in a medium vibrating in the same phase is called a wave front.

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

(a) Frequency
(b) Wavelength
(c) Amplitude
(d) Velocity

Answer: (c) Amplitude

Explanation: The intensity of light depends on amplitude.

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

Answer: (d) the same wavelength and constant phase difference

Explanation: Two light sources are said to be coherent when both light sources emit light of 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

Answer: (d) None of the above

Explanation: Intensity, amplitude, and phase are not conserved when light waves interfere.

7. The idea of secondary wavelets for the. propagation of a wave was first given by

(a) Newton
(b) Huygens
(c) Maxwell
(d) Fresnel

Answer: b

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

Answer: c

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

Answer: c

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

Answer: c

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.

Answer: b

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

Ans. d

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

Answer: (b) The angular width of the central maxima of the diffraction pattern will increase

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

Answer: (b) Diffraction pattern becomes narrower

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

Answer: (c) 16:1

16) The colours on the soap bubble is due to

(a) Interference
(b) Polarisation
(c) Diffraction
(d) Reflection

Answer: (a) Interference

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 (λ=6000 Å)

(a) Zero
(b) 2π
(c) 4π
(d) 6π

Answer: 6π

18) When Two waves of same amplitude add constructively, the becomes ______________

(a) Double
(b) Half

(c) Four Times
(d) One-Fourth
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) 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) Colored fringes will be observed with a white bright fringe at the center
(d) The bright and dark fringes will change position
answer: c
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) 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.
[a]
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.
[c]
22) Two light sources are said to be coherent if they

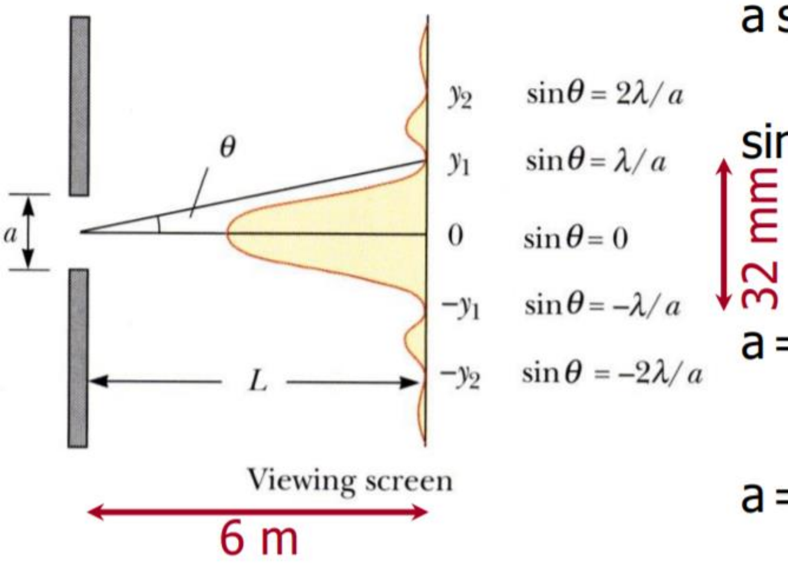
(a) are of the same frequency.
(b) are of the same frequency, and maintain a constant phase difference.
(c) are of the same amplitude, and maintain a constant phase difference.
(d) are of the same frequency and amplitude.

[b]

SHORT ANSWER QUESTIONS-2 MARKS

1) 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 centers of the first minima outside the central bright fringe is 32 mm. What is the slit width?

$y_1 = (32\ \text{mm})/2 \qquad \tan\theta = y_1/L \qquad \tan\theta \approx \sin\theta \approx \theta$ for small θ



$$a\sin\theta = m\lambda = (1)\lambda$$

$$\sin\theta = \frac{\lambda}{a} \Rightarrow a = \frac{\lambda}{\sin\theta} \approx \frac{\lambda}{y_1/L} = \frac{L\lambda}{y_1}$$

$$a = \frac{(6.0\ \text{m})(633\times10^{-9}\ \text{m})}{(16\times10^{-3}\ \text{m})}$$

$$a = 2.37\times10^{-4}\ \text{m}$$

2) 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 millimeter when white light falls normally on the grating

Interference Maxima: $d\sin\theta = m\lambda$

$$d = \frac{1}{600 \text{ slits/mm}} = 1.67\times10^{-6}\text{ m}$$

First-order violet: $\sin\theta_V = m\frac{\lambda_V}{d} = \frac{(1)(400\times10^{-9}\text{ m})}{1.67\times10^{-6}\text{ m}} = 0.240$

$$\theta_V = 13.9^\circ$$

First-order red: $\sin\theta_R = m\frac{\lambda_R}{d} = \frac{(1)(700\times10^{-9}\text{ m})}{1.67\times10^{-6}\text{ m}} = 0.419$

$$\theta_R = 24.8^\circ$$

$$\Delta\theta = \theta_R - \theta_V = 24.8^\circ - 13.9^\circ = 10.9^\circ$$

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

Explanation: As the whole apparatus is now immersed in water, the wavelength of the light will change.
λ’=λμ
Therefore, as the refractive index of water is greater than the air, the wavelength of light will decrease.
Width of central maxima = 2λa
Therefore, as the wavelength decreases, the width of the central maxima decreases.

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

Answer: c

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.

However, after the first few colored bands, the clarity of the band is lost, due to overlapping.

5) 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?

Answer: b

Explanation: a = 0.5 mm = 0.5×10^{-3}m, λ = 5000 Å = 5×10^{-7} m.

Angular separation between the central maximum and the first order minimum is given by:

$\sin\theta = \lambda/a = 0.001$

$\sin\theta \approx \theta$

$\theta = 0.001$ radian

$\theta = 3.4$ minute.

6) 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?

Answer: a

Explanation: Given: f = 2 m, x = 5×10^{-3} m, $\lambda = 4 \times 10^{-7}$ m, n=1

$\sin\theta = n\lambda/a$, we have

$a = n\lambda/\sin\theta$

$= 1.6 \times 10^{-4}$m

= 0.16 mm.

7) 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?

(i) : Intensity of light emitted by the slits increases as the width of the slit is increased. Thus, more brighter fringes are formed at the screen on increasing 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) is increased and thus we get narrower fringes.

8) A ray of monochromatic light passes from medium (1) to medium (2). If the angle of incidence in medium (1) is θ and the corresponding angle of refraction in medium (2) is θ/2, which of the two media is optically denser? Give reason.
Explanation: -

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.

9) How do the increasing (i) wavelength and (ii) intensity of light affect the speed of light in glass?
Explanation:
(i) $\because v \propto \lambda$; ∴ speed of light increases on increasing the wavelength in glass.
(ii) There is no effect on speed of light on changing the intensity.

Long answer type questions;

1) 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.

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 nth 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***

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

2) Yellow light (λ = 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.

Ans. (i) Distance between two dark lines, on either

side of central maxima $= 2\frac{\lambda D}{a}$

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

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

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

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

3) 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..

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

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

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, $a \sin \theta_1 = n\lambda, \qquad n = 1$

$a \sin \theta_1 = n\lambda$

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

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

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

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

CASE BASED STUDY QUESTIONS.

1) 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 that 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?

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

Answer key:

Q 1.) c) either zero or constant

Q 2.) a) constructive interference

Q 3.) d) both a and b

Q 4.) The phenomenon of interference of light and diffraction of light explains the wave nature light.

Q 5.) 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.

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 θ) where θ is the angle between the ray at the point of consideration and the direction of secondary wavelet.

Ans. b

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.

Ans. a

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.

Ans. a

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.

Ans.(d) For interference, the waves may be of unequal intensities.

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.

Ans. (c) Interference will take place in green light only

CBSE BOARD QUESTIONS-2022-23

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)

4) (i) Draw a labelled ray diagram showing the image formation by a refracting telescope. Define its magnifying power. Write two limitations of a refracting telescope over a reflecting telescope. (5)
(ii)The focal lengths of the objective and the eye- piece of a compound microscope are 1.0cm and 2.5 cm respectively. Find the tube length of the microscope for obtaining magnification of 300.

5) ASSERTION AND REASON
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).

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PREPARED BY Ms ANU ANNIE MATHEWS	CHECKED BY HOD SCIENCE