One Two Academy | Wave Optics

Maximum Marks : 25 **PHYSICS** **Time: 50 Minutes**

Choose the correct answer :- **3x1=3**

1. In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to,

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

2. Light transmitted by Nicol prism is,

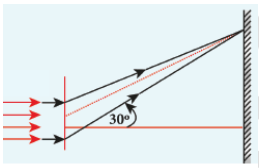
(a) partially polarised (b) unpolarised
(c) plane polarised (d) elliptically polarised

3. Which of the following condition is incorrect for the two coherent light sources?

(a) same phase (b) same frequency
(c) same wavelength (d) same polarization

Answer the following :- **3x2=6**

4. State Huygens' principle.
5. Define Fresnel's distance .
6. A monochromatic light of wavelength 5000 Å passes through a single slit producing diffraction pattern for the central maximum as shown in the figure. Determine the width of the slit.



Answer any two of the following:- **2x3=6**

7. What are polariser and analyser? Give its diagram.
8. State and obtain Malus' law.
9. A microscope has an objective and eyepiece of focal lengths 5 cm and 50 cm respectively with tube length 30 cm. Find the magnification of the microscope in the (a) near point and (b) normal focusing.

Answer the following :- **2x5=10**

10. (a) Explain the Young's double slit experimental setup and obtain the equation for path difference.

(OR)

(b) Prove law of refraction using Huygens' principle.

11. i) Discuss about pile of plates.

ii. In Young's double slit experiment, 62 fringes are seen on a screen for sodium light of wavelength 5893Å . If violet light of wavelength 4359 Å is used in place of sodium light, how many fringes will be seen?

ALL THE BEST

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Answer key attached in next page!!!

This page is to prevent seeing answer key

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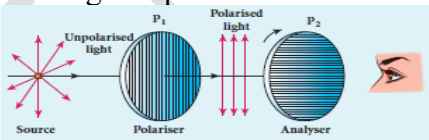
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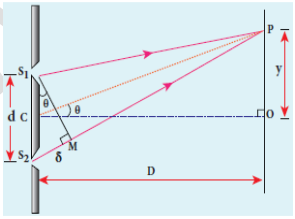
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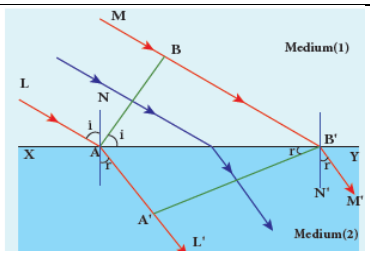
ANSWER KEY

Q NO	ANSWERS	MARKS
1.	(A) 2D	**1**
2.	(C) plane polarised	**1**
3.	(D) same polarization	**1**
4.	According to Huygens principle, each point on the wavefront behaves as the source of secondary wavelets spreading out in all directions with the speed of the wave. These are called as secondary wavelets. The envelope to all these wavelets gives the position and shape of the new wavefront at a later time.	**2**
5.	Fresnel's distance is the distance upto which the ray optics is obeyed and beyond which the ray optics is not obeyed; but, the wave optics becomes significant. $$z = \frac{a^2}{2\lambda}$$	**2**
6.	$a \sin\theta = n\lambda$ n=1, $a = \frac{\lambda}{\sin\theta}$ $a = 0.001 \times 10^{-3} m = 0.001\ mm$	**2**
7.	The Polaroid (here $P1$) which polarises the light passing through it is called a *polariser*. The polaroid (here $P2$) which is used to examine whether a light is polarised or not is called an *analyser*. 	**3**
8.	When a beam of plane polarised light of intensity I_0 is incident on an analyser, the intensity of light I transmitted from the analyser varies directly as the square of the cosine of the angle θ between the transmission axes of polariser and analyser. This is known as Malus' law. $$I = I_0 \cos^2\theta$$ The proof of Malus' law is as follows. Let us consider that the transmission axes of the polariser and the analyser are inclined by an angle θ . Let $I0$ be the intensity and a be the amplitude of the electric vector transmitted by the polariser. The amplitude a of the incident light has two rectangular components, $a\cos\theta$ and $a\sin\theta$ which are the parallel and perpendicular components to the axis of transmission of the analyser. Only the component $a\cos\theta$ will be transmitted by the analyser. The intensity of light transmitted from the	**3**

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	analyser is proportional to the square of the component of the amplitude transmitted by the analyser. $I \propto (a\cos\theta)^2$ $I = k(a\cos\theta)^2 \rightarrow \quad I = I_0\cos^2\theta$	
9.	a) The total magnification m in near point focusing is, $m = m_0 m_e = \left(\frac{L}{f_0}\right)\left(1+\frac{D}{f_e}\right) \Longrightarrow \quad m = 9$ b) The total magnification m in normal focusing is, $m = m_0 m_e = \left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right) \Longrightarrow \mathrm{m} = 3$	**3**
10. a	Thomas Young, a British Physicist in 1801 used an opaque screen with two small openings called double slit S_1 and S_2 kept equidistance from a source S . The width of each slit is about 0.03 mm and they are separated by a distance of about 0.3 mm. As S_1 and S_2 are equidistant from S the same wavefront is cut by S_1 and S_2. The light waves at S_1 and S_2 are in-phase. So, S_1 and S_2 act as coherent sources which is the requirement for obtaining interference pattern. Wavefronts from S_1 and S_2 spread out and overlap on the other side of the double slit. When a screen is placed at a distance of about 1 m from the slits, alternate bright and dark fringes which are equally spaced appear on the screen. These are called interference fringes (or) bands. Using an eyepiece, the fringes can be seen directly. At the center point O on the screen, the waves from S_1 and S_2 travel equal distances and arrive in-phase. These two waves constructively interfere and a bright fringe is observed at O. This is called central bright fringe. When one of the slits is closed, the fringes disappear and there is uniform illumination on the screen. This shows clearly that the bands are due to interference.  *Equation for path difference :* Let d be the distance between the double slits S_1 and S_2 which act as coherent sources of wavelength λ. A screen is placed parallel to the double slit at a distance D from it. The mid-point of $S1$ and $S2$ is C and the mid-point of the screen O is equidistant from S_1 and S_2. P is any point at a distance y from O. The waves from S_1 and S_2 meet at P either in-phase or out-of-phase depending upon the path difference between the two waves. The path difference δ between the light waves from $S1$ and $S2$ to the point P is, $\delta = S_2P - S_1P = S_2P - MP$ In right angle triangle ΔS_1S_2M, the path difference, $S_2M = d\sin\theta$, $\delta = d\sin\theta \quad \rightarrow \quad \tan\theta = y/D \quad \rightarrow \quad \delta = d\,y/D$	**5**

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10. b	 $t = \frac{BB'}{v_1} = \frac{AA'}{v_2} (or) \frac{BB'}{AA'} = \frac{v_1}{v_2}$ (i) The incident rays, the refracted rays and the normal are in the same plane. (ii) Angle of incidence, $i = \angle NAL = 90^o - \angle NAB = \angle BAB'$ Angle of refraction, $r = \angle N'B'M' = 90^o - \angle N'B'A' = \angle A'B'A$ For the two right angle triangles $\Delta ABB'$ and $\Delta AA'B'$, $$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{v_1}{v_2} \times \frac{c}{c} = \frac{\frac{c}{v_2}}{\frac{c}{v_1}}$$ c/v = n , $$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$	**5**
11	i) Pile of plates makes use of Brewster's law to convert the partially polarised refracted light into plane polarised light. It consists of several glass plates kept one behind the other at an angle 90° – i_p with the horizontal surface. This arrangement ensures that the parallel light falls on these plates at i_p. When this unpolarised light passes successively through these plates, the few parallel vibrations to the surface which may be present in the refracted light, get a chance for further reflections at the succeeding plates. Thus, both the reflected and the refracted lights are found to be plane polarised. ii) $n_1\lambda_1 = n_2\lambda_2$ $n_2 \approx 83.818$ $n_2 = 84$ 84 fringes can be seen.	**5**

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