

Answers

Module 1: Huygens Principle and Interference

A.10.1.1 (C)

Effective path length of medium of thickness t and refractive index μ is μt .

A.10.1.2 (A)

$y = A \sin \phi = A \sin \left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} \right)$. After traveling distance Δx in time $\Delta x/c$, phase angle becomes $\frac{2\pi(t + \frac{\Delta x}{c})}{T} - \frac{2\pi(x + \Delta x)}{\lambda}$. This is $\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \frac{2\pi \Delta x}{cT} - \frac{2\pi \Delta x}{\lambda} = \frac{2\pi t}{T} - \frac{2\pi x}{\lambda}$. Since $cT = \lambda$.

Note: Wavefront is a constant phase surface.

A.10.1.3 (B)

It will be spherical with the center of the sphere at F of the lens as shown in the Fig. A.10.1.1

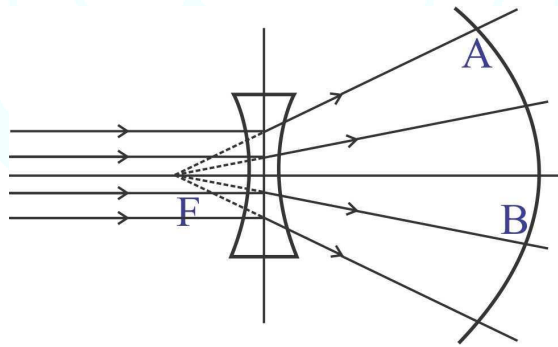


Fig. A.10.1.1

A.10.1.4 (A)

According to definition a wavefront is a constant phase surface, so the phase difference between A and B is zero.

A.10.1.5 (C)

Light originating from the focal point of a spherical mirror after reflection emerges as a parallel beam. Parallel beam propagates as a plane wavefront in this case.

A.10.1.6 (A)



Wavefront before and after reflection is the same and the wavefront is a constant wave surface.

A.10.1.7 (D)

We know that $\frac{v_{air}}{v_{med}} = 1.5$. Therefore $\frac{d_{air}/\Delta t}{d_{med}/\Delta t} = \frac{d_{air}}{d_{med}} = 1.5$. Since $d_{air} = 2 \text{ m}$, $d_{med} = \frac{2m}{1.5} = 1.333 \text{ m}$

A.10.1.8 (C)

At $t = 0$ all wavelengths emitted are having the same phase angle. By definition, a wavefront is a constant phase surface. So $\phi_{violet} = \phi_{red}$

A.10.1.9 (B) All the light starting should be at the same distance from the source. For a slit this is a cylindrical surface.

A.10.1.10 (B)

$$\mu_{water} = \frac{\lambda_{air}}{\lambda_{water}},$$

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$$\lambda_{water} = \frac{5000 \text{ \AA}}{4/3} = 3750 \text{ \AA}$$

Module 2: Young's Double slit Experiment

A.10.2.1 For distinct interference patterns we require monochromatic coherent sources. The fringe width is inversely proportional to the distance between coherent sources ($\beta = \frac{\lambda D}{d}$). If the size of source aperture is large, the diffraction effects will make interference patterns diffuse.

A.10.2.2 (C) Additional path difference due to glass plate $\Delta = t(\mu - 1)$

$$= 12500 \text{ \AA} = n\lambda = (2 + \frac{1}{2})\lambda = 2.5 \times 5000 \text{ \AA}$$

Therefore $n = 2.5 (\frac{\lambda}{2})$, the factor makes the bright fringe dark. Therefore the central bright fringe would become dark.

A.10.2.3 (C) when a wave is reflected from the surface of denser medium it undergoes an additional phase change of π .

A.10.2.4 (A) $x_n = \frac{n\lambda D}{d} \Rightarrow n = 1$ shortest wavelength would appear at smallest x .

A.10.2.5 (D) sources must emit the same wavelength to produce interference patterns.

A.10.2.6 (A), (B) Intensity is inversely proportional to the square of distance from the source.

$$\text{A.10.2.7 (A)} \quad \frac{I_1}{I_2} = \frac{16}{9}, \quad \frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \frac{4}{3}, \quad \frac{I_{\max}}{I_{\min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = 49.$$

A.10.2.8 (C) One of the two rays undergo an additional path length $\frac{\lambda}{2}$ and hence the bright band will become dark.

$$\text{A.10.2.9 (B)} \quad n\lambda_1 = (n + 1)\lambda_2 \text{ therefore } \frac{n+1}{n} = \frac{\lambda_1}{\lambda_2} = \frac{652}{520} = \frac{5}{4}. \text{ So } n_{\min} = 4.$$

A.10.2.10 (A) In Fig. A.10.2.1

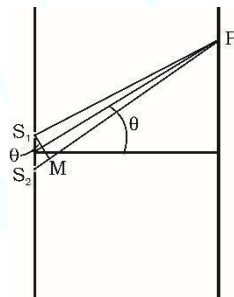


Fig. A.10.2.1

$$\angle S_2 S_1 M = \theta, \text{ hence } S_2 M = \Delta = d \sin \theta.$$

A.10.2.11 (C) Source is too far, so part of the spherical wavefront reached as a plane wavefront.

Module 3: Single Slit Diffraction

$$\text{A.10.3.1 (A)} \quad \lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{1.420 \times 10^9} \text{ m} = 0.211 \text{ m}$$

$$\theta = 1.22 \frac{\lambda}{a} = \frac{1.22 \times 0.211}{45} = 0.0057 \text{ radian}$$

$$= 0.3268 \text{ degree}$$

$$= 19.6 \text{ arc min}$$

$$\text{A.10.3.2 (C)} \quad \theta = 1.22 \frac{\lambda}{a} = \frac{1.22 \times 0.211}{50 \times 10^3} = 5.148 \times 10^{-6} \text{ rad}$$

$$= 0.0185 \text{ arc sec}$$

A.10.3.3 (C) Each wavelength will produce its own interference pattern resulting in the overlapping of interference patterns of different colors of white light resulting in a bright slit

at the center diffusing to regions of different colors.

A.10.3.4 (B) Width of the pinhole is very much less than the wavelength of light and hence no diffraction pattern so, the image is different from a geometrical image but devoid of any diffraction pattern..

A.10.3.5 (C) Condition for maxima : $d \sin(\theta) = (2n+1)\lambda/2$

$$\text{As } n = 3$$

A.10.3.6 (A) Diffraction is superposition of waves from the same source.

A.10.3.7 (B) As λ decreases, θ decreases resulting in diffraction bands becoming narrower and crowded together.

A.10.3.8 (B) and (C) slit width smaller than λ would fill the forward hemisphere with central maximum and slit width very large would show diffraction effect near the shadow of the edges of the slit.

A.10.3.9 (C) For 3rd minimum $a \sin \theta = 3\lambda$ therefore $\frac{a}{6} \sin \theta = \frac{3\lambda}{6} = \frac{\lambda}{2}$

A.10.3.10 (C) circular obstacle is a two dimensional analog of slit and therefore the central maximum will be seen at the centre of the screen opposite to the circular obstacle.



Module 4: Polarisation

A.10.4.1 (D) Transmitted intensity $I = \frac{1}{2} I_0 \cos^2 \theta \sin^2 \theta$

$$= \frac{1}{2} I_0 (1 - \sin^2 \theta) \sin^2 \theta$$

$$= \frac{1}{2} I_0 \sin^2 \theta - \frac{1}{2} I_0 \sin^4 \theta,$$

$\frac{dI}{d\theta} = 0$ for maximum or minimum intensity therefore

$$\frac{dI}{d\theta} = \frac{1}{2} I_0 2 \sin \theta \cos \theta - \frac{1}{2} I_0 (4 \sin^3 \theta \cos \theta) = 0$$

i.e. $2 \sin \theta \cos \theta (1 - 2 \sin^2 \theta) = 0,$

therefore either $\sin \theta = 0$ or $\cos \theta = 0$ or $1 - 2 \sin^2 \theta = 0$, therefore transmitted intensity is minimum for $\theta = 0, 90^\circ, 180^\circ, 270^\circ$ and maximum for $\theta = 45^\circ, 135^\circ, 225^\circ, 315^\circ$

A.10.4.2 (C) Reflected light is partially polarised and is completely plane polarised at Brewster angle, where minimum intensity will be zero, i.e. complete darkness.

A.10.4.3 (C) If light is incident at an angle other than Brewster's angle, the reflected light is partially plane polarized.

A.10.4.4 (B) Scattered sunlight is partially polarized. It is completely plane polarized when viewed along a direction at 90° with respect to the sun.

A.10.4.5 (D) By Malus law, the intensity of light after passing through polarizer is $I_1 = \frac{1}{2}I_0$ and $I_2 = I_1 \cos^2 \theta$
 $\Rightarrow I_2 = \frac{1}{2}I_0 \cos^2 \theta$

A.10.4.6 (C) By Malus law, intensity of light after passing through polarizer is $I_1 = \frac{1}{2}I_0$ and $I_2 = I_1 \cos^2 \theta \Rightarrow$
 $I_2 = \frac{1}{2}I_0 \cos^2 \theta \Rightarrow I_2 = 0$ as $\cos^2 90^\circ = 0$

A.10.4.7 (B) Using Malus law intensity after passing through first polaroid $I_1 = \frac{1}{2}I_0$, intensity after passing through in between (third) polaroid $I_{3rd} = I_1 \cos^2 \theta = \frac{1}{2}I_0 \cos^2 \theta$, intensity (I_2) after passing through last polaroid $I_2 = I_{3rd} \cos^2 (90^\circ - \theta) = \frac{1}{2}I_0 \cos^2 \theta \sin^2 \theta$

A.10.4.8 (A) When P_1 and P_2 pass axes parallel, transmitted intensity is maximum.

A.10.4.9 (A) $I_2 = I_0 \cos^2 \theta \cos^2 (\phi - \theta) = I_0 \cos^2 \phi$ when $\theta = 0$.

A.10.4.10 (B) When reflected light is completely plane polarized $i + r = 90^\circ$, therefore, $r = 37^\circ$.



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