

10.Wave Optics

Self-Assessment

Module 1: Huygens Principle and Interference

Q.10.1.1 A thin glass plate of thickness t and refractive index μ is introduced in the path of light ray of wavelength λ , then additional path length it would have to travel is

- (A) $\mu \lambda$
- (B) $\lambda (\mu - 1)$
- (C) $t(\mu - 1)$
- (D) $\mu t^2 / \lambda$

Q.10.1.2 A light of wavelength λ starting from a wavefront has phase of ϕ . After it travels further distance Δx , its phase on the wavefront will be

- (A) ϕ
- (B) $\phi + \frac{2\pi\Delta x}{\lambda}$
- (C) $\phi - \frac{2\pi\Delta x}{\lambda}$
- (D) $\frac{2\pi\Delta x}{\lambda}$

Q.10.1.3 A plane wavefront is incident on a concave lens. What will be its shape after it passes through the lens?

- (A) Plane
- (B) Spherical
- (C) cylindrical
- (D) Parabolic

Q.10.1.4 The phase difference between points A and B (Fig. Q.10.1.1)

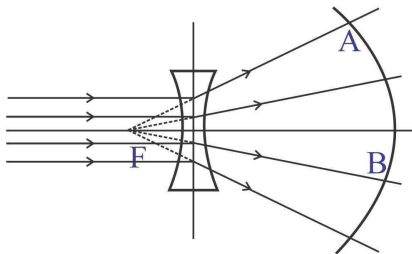


Fig. Q.10.1.1

- (A) Zero
- (B) depends on distance between A and B
- (C) depends on angle between two rays arriving at A and B
- (D) non-zero constant

Q.10.1.5 A point source of light is kept at focal point F of a concave mirror of focal length f as shown in Fig. Q.10.1.2 . Light originating at $t = 0$, after reflection from the mirror, at some later instant t , will all be on

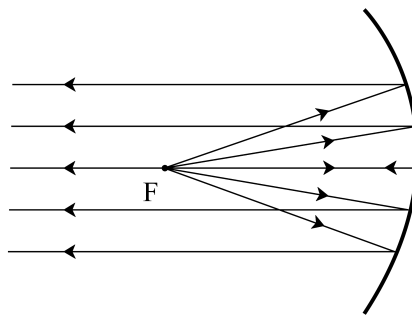


Fig. Q.10.1.2

- (A) A spherical wave front of radius $2f$ with centre at F
- (B) A spherical wave front of radius f with centre at F
- (C) A plane wavefront perpendicular to reflected beam
- (D) A parabolic wavefront with focal point at F

Q.10.1.6 A point source of light is kept at focal point F of a concave mirror of focal length f as shown in Fig. Q.10.1.3. Light originating at $t = 0$, after reflection from the mirror, at some later instant t , phase of all the points on the wavefront at time t be

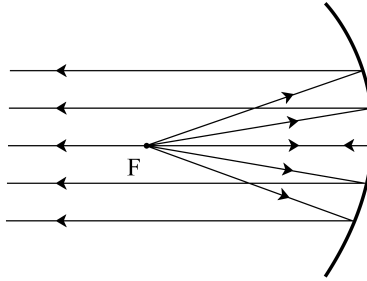


Fig. Q.10.1.3

- (A) Same as that at $t = 0$
- (B) Increased by $\frac{2\pi x}{\lambda}$, where x is the distance traveled from focal point to the wavefront
- (C) decreased by $\frac{2\pi x}{\lambda}$, where x is the distance traveled from focal point to the wavefront
- (D) different as all the rays would have traveled different distance

Q.10.1.7 A parallel beam of light is incident from air on a medium of refractive index 1.5. In a certain time interval Δt the incident wavefront advances 2 m in air. What is the distance that the refracted wavefront would advance in the medium during the same time interval Δt ?

- (A) 3.5 m
- (B) 3 m
- (C) 2 m
- (D) 1.333 m

Q.10.1.8 White light starting from a point source in air spreads as a spherical wavefront. Suppose at $t = 0$ all wavelengths emitted are having the same phase angle. Then at some later time t , their phase angle on spherical wavefront be related as

- (A) $\phi_{\text{violet}} > \phi_{\text{red}}$
- (B) $\phi_{\text{violet}} < \phi_{\text{red}}$
- (C) $\phi_{\text{violet}} = \phi_{\text{red}}$
- (D) $\frac{\phi_{\text{violet}}}{\phi_{\text{red}}} = \frac{\lambda_{\text{violet}}}{\lambda_{\text{red}}}$

Q.10.1.9 A plane wavefront passing through a thin narrow slit spreads as a

- (A) plane wavefront
- (B) cylindrical wavefront
- (C) spherical wavefront
- (D) parabolic wavefront

Q.10.1.10 A green color light of wavelength $5000 \text{ \AA}$ when passes through water (refractive index $4/3$) will have a wavelength

- (A) $3000 \text{ \AA}$
- (B) $3750 \text{ \AA}$
- (C) $5000 \text{ \AA}$
- (D) $6667 \text{ \AA}$



Module 2: Young's Double slit Experiment

Q.10.2.1 Which of the following is not a requirement for distinct interference fringes in a double slit experiment.

- (i) coherent sources
- (ii) distance between sources
- (iii) monochromatic light
- (iv) size of the source aperture

- (A) (i) and (ii)
- (B) (ii) and (iv)
- (C) (iv) only

(D) none of the (i), (ii), (iii) and (iv)

Q.10.2.2 In Young's double slit experiment using a wavelength of $5000 \text{ \AA}$, clear distinct fringes are formed on the screen. A thin transparent glass sheet ($\mu = 1.5$) of thickness 2.5 micron is introduced in front of one of the slits. What will happen to the central bright fringe? The central bright fringe

(A) remains bright, no change.

(B) becomes dark due to the shift of half a fringe.

(C) becomes dark due to the shift of 2.5 fringes.

(D) remain bright due to the shift of 5 fringes.

Q.10.2.3 Consider rays of light incident from air onto a glass slab (refractive index n) of width d , at an angle θ . The phase change that suffered by the reflected rays by the top surface of the glass slab is

(A) 0

(B) $\frac{\pi}{2}$

(C) π

(D) 2π

Q.10.2.4 When Young's double slit experiment is performed with white light, beautiful colored fringes are observed on the screen. Their interference pattern occurs with white central fringe followed by coloured fringes. The first bright coloured fringe next to central white band would be

(A) violet

(B) red

(C) orange

(D) purple

Q.10.2.5 In Young's double slit experiment for forming distinct interference patterns on the screen the two source S_1 and S_2 have to meet certain conditions. Which of the following can never be the correct condition.

- (A) Two source S_1 and S_2 must have constant phase difference.
- (B) Two source S_1 and S_2 must have the same intensities.
- (C) Two sources must be narrow.
- (D) Two source S_1 and S_2 must emit different wavelengths.

Q.10.2.6 For light diverging from a point source, given below are four characteristics :

- (i) The wavefront is spherical.
- (ii) the intensity decreases in proportion to the distance squared.
- (iii) The wave front is parabolic.
- (iv) The intensity at the wavefront does not depend on the distance.

Which among them is/are correct?

- (A) Only (i)
- (B) (i) and (ii)
- (C) Only (iii)
- (D) Only (iii) and (iv)

Q.10.2.7 In Young's double slit experiment, two slits have areas in the ratio 16:9. What will be the ratio of maximum intensity to minimum intensity in the interference pattern formed on the screen.

- (A) 49:1
- (B) 25:1
- (C) 25:7
- (D) 4:3

Q.10.2.8 In Young's double slit experiment with monochromatic light of wavelength λ , the central bright spot has intensity I_0 . One of the slit is then covered by a transparent glass sheet of thickness t and refractive index μ such that $t(\mu-1) = \frac{\lambda}{2}$. Then, centre spot will

- (A) remain bright with intensity I_0
- (B) remain bright with intensity $I_0 / 2$
- (C) become dark point
- (D) disappear and screen will have uniform brightness

Q.10.2.9 A beam of light consisting of two wavelengths, 650 nm and 520 nm is used to obtain interference fringes in a Young's double slit experiment. The bright fringes of the two wavelengths coincide (other than central bright fringe) when n^{th} bright fringe of first wavelength falls on $(n+1)^{\text{th}}$ bright fringe of the second wavelength. Then the lowest value of n is

- (A) 3
- (B) 4
- (C) 5
- (D) 6

Q.10.2.10 Fig. Q.10.2.1 shows the arrangement of Young's double slit experiment. If the distance between the slits is d , then the path difference is best estimated as

- (A) $d \sin \theta$
- (B) $d \cos \theta$
- (C) $d \tan \theta$
- (D) $d / \sin \theta$

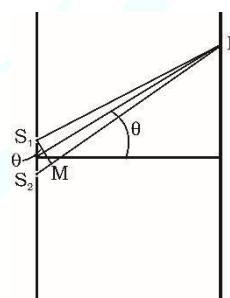


Fig. Q.10.2.1

Q.10.2.11 What is the shape of the wavefront on Mars for sunlight?

- (A) Parabolic
- (B) Spherical
- (C) Planar
- (D) Cylindrical



Module 3: Single Slit Diffraction

Q.10.3.1 Giant Metrewave Radio Telescope (GMRT) has 30 circular radio telescope dishes each of diameter 45 m spread over an area of radius 25 km. (This makes telescope of effective radius (25 km).

The size is chosen so as to observe a 1420 MHz (wavelength 21 cm) line from the H-atom. This line can be red shifted even up to 1 m due to expansion of the universe and depending on the distance of the source, which corresponds to a range of frequencies from 13 MHz to 350 MHz.

The resolution angle $\Delta\theta$ is the angular size of the object that can be observed clearly. What is the smallest angular size that this 45 m dish can resolve at 1420 MHz?

- (A) 19.6 arc min
- (B) 19.6 arc-sec
- (C) 0.32 arc min
- (D) 0.32 arc sec

Q.10.3.2 In Q.10.3.1 (GMRT) what is the smallest resolution that we achieve with effective diameters of 50 km.

- (A) 2.92×10^{-4} arc min
- (B) 17.62×10^{-3} arc sec
- (C) 0.018 arc sec
- (D) 0.018 arc min

Q.10.3.3 Consider sunlight incident on a slit of width $10^4 \lambda$. The image seen through the slit shall

- (A) be a fine sharp slit white in color.
- (B) a bright slit white at the center with no diffusing intensities at the edges.
- (C) a bright slit white at the center diffusing to regions of different colors near the edges.
- (D) only be a diffused slit white in color.

Q.10.3.4 Consider a sunlight incident on a pinhole of width $10^3 \lambda$. The image of the pinhole seen on a screen shall be

- (A) a sharp white ring.
- (B) different from a geometrical image but devoid of any diffraction pattern.
- (C) a diffused central spot, white in color.
- (D) diffused coloured region around a sharp central white spot.

Q.10.3.5 In the diffraction pattern due to a single slit, at the position of 3rd maximum the path difference between the wavelets from the opposite edges of the slit is

- (A) 3λ
- (B) $5\lambda/2$
- (C) $7\lambda/2$
- (D) 5λ

Q.10.3.6 Diffraction is the result of superposition of waves from

- (A) single source of light of finite size.
- (B) two coherent sources of light.
- (C) multiple coherent sources of light.
- (D) multiple sources of light not necessarily coherent.

Q.10.3.7 A diffraction pattern is obtained using a beam of red light. What will happen if the red light is replaced by a blue light?

- (A) no change
- (B) diffraction bands will become narrower and crowded together.
- (C) diffraction bands will become broader and farther apart.
- (D) bands disappear.

Q.10.3.8 When does the single slit diffraction occur?

- (A) The slit width is smaller than λ .
- (B) The slit width is the same as λ .
- (C) The slit width is slightly larger than λ .
- (D) The slit width is much larger than λ .

Q.10.3.9 In a single slit diffraction experiment, consider the paths A and B on the slit separated by distance $\frac{a}{6}$ where a is the width of the slit. Let P be a point on the screen such that it is on the third minimum of the diffraction pattern. Then the path difference between waves arriving at P from A and B ($\frac{a}{6} \sin \theta$) is

- (A) $\frac{\lambda}{6}$
- (B) $\frac{\lambda}{3}$
- (C) $\frac{\lambda}{2}$
- (D) 3λ

Q.10.3.10 A tiny circular obstacle is placed in the path of monochromatic light from a distant source. Then which of the following is true about diffraction patterns?

- (A) dark spot at the centre of screen in front of the centre of the obstacle.
- (B) centre will be a circular shadow with dark and bright rings.
- (C) bright spot at the centre of geometrical shadow.
- (D) total darkness on the screen.



Module 4: Polarisation

Q.10.4.1 An unpolarised light is made to pass through two crossed polarisers (transmission axis perpendicular to each other). As a result no light passes through the second polariser. A third polariser is now introduced midway between the two, which can be rotated 360° around the direction of incident light. Now the final transmitted light intensity as a function of angle of rotation of third polarizer is

- (A) constant
- (B) zero
- (C) will be maximum twice and minimum twice alternately during 360° rotation.

(D) will be maximum four times and minimum four times alternately during 360° rotation.

Q.10.4.2 Consider light reflected from the shiny surface of a table and viewed at a particular angle. A polaroid is placed in the path of reflected light and rotated about an axis along the viewing direction and passing through the center and perpendicular to the plane of the polaroid.

- (A) for a particular orientation of the polaroid, there will be darkness as observed through the polaroid irrespective of viewing angle.
- (B) The intensity of light as seen through the polaroid shall be independent of rotation of the polaroid around viewing direction.
- (C) The intensity of light as seen through the polaroid shall go through a minimum for two orientations of the polaroid. The minimum is zero for one particular viewing direction.
- (D) The intensity of light as seen through the polaroid shall go through a minimum for four orientations of the polaroid. The minimum is zero for one particular viewing direction.

Q.10.4.3 Consider a light beam incident from air to a glass slab at some angle. A polaroid is placed in the path of the reflected ray and rotated about an axis along the reflected ray and passing through the centre and perpendicular to the plane of the polaroid.

- (A) The intensity of light as seen through the polaroid shall be independent of rotation.
- (B) The intensity of transmitted light shall be zero and independent of rotation.
- (C) The intensity of light transmitted through a polaroid shall vary from maximum to minimum and minimum to maximum as the polaroid is rotated by 360° .
- (D) The intensity of light transmitted through a polaroid shall vary from maximum to zero to maximum as the polaroid is rotated by 360° for all angles of incidence.

Q.10.4.4 Sky appears blue due to scattering of sunlight by molecules of the atmosphere. Such scattered light is viewed through a polariser (not pointed directly to the sun). This polariser is now rotated around the viewing direction from 0° to 360° . Then intensity of light

- (A) remains constant.
- (B) varies from minimum (not necessarily zero) to maximum and maximum to minimum twice during 360° rotation.
- (C) varies from minimum (not necessarily zero) to maximum and maximum to zero twice during 180° rotation.
- (D) varies from zero to maximum and maximum to zero twice during 360° rotation.

Q.10.4.5 In the Fig. Q.10.4.1 transmitted intensity I_1 and I_2 are

- (A) $I_1 = I_0, I_2 = I_0 \cos^2 \theta$
- (B) $I_1 = \frac{1}{2} I_0, I_2 = \frac{1}{2} I_0 \theta$
- (C) $I_1 = I_0, I_2 = I_0 \theta$
- (D) $I_1 = \frac{1}{2} I_0, I_2 = \frac{1}{2} I_0 \cos^2 \theta$

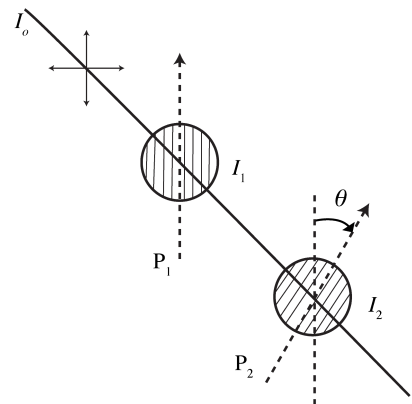


Fig. Q.10.4.1

Q.10.4.6 In the Fig. Q.10.4.2 pass axis of 2nd Polaroid is perpendicular to that of the first then, intensity I_1 and I_2 are

- (A) $I_1 = I_0, I_2 = 0$
- (B) $I_1 = \frac{1}{2} I_0, I_2 = \frac{1}{2} I_0$
- (C) $I_1 = \frac{1}{2} I_0, I_2 = 0$
- (D) $I_1 = I_0, I_2 = \frac{1}{2} I_0$

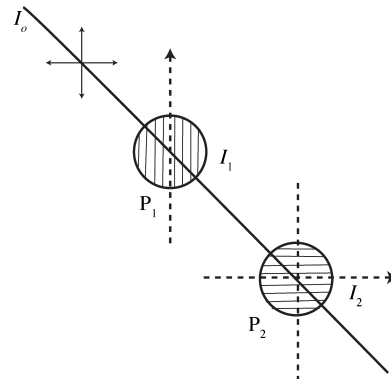


Fig. Q.10.4.2

Q.10.4.7 In the Fig. Q.10.4.3 pass axis of 2nd Polaroid is perpendicular to that of the first, a third Polaroid is introduced between the two with its pass axis is making an angle θ with that of the first then final intensity I_2 will be

- (A) Zero
- (B) $\frac{1}{2} I_0 \cos^2 \theta \sin^2 \theta$
- (C) $\frac{1}{4} I_0 \sin^2 \theta$
- (D) $I_0 \cos^2 \theta \sin^2 \theta$

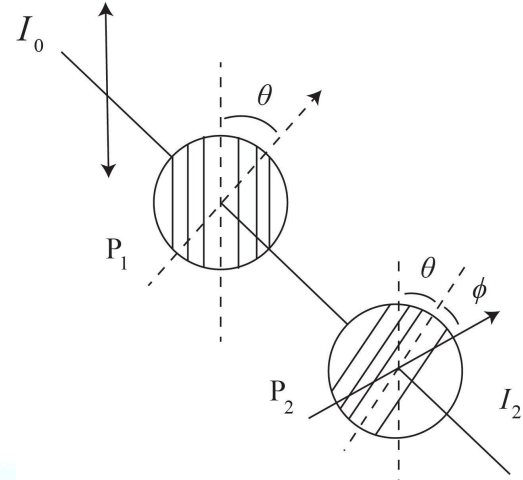


Fig. Q.10.4.3

Q.10.4.8. Two polarisers are introduced in the path of a plane polarized light of intensity I_0 as shown in Fig. Q.10.4.4. The pass axis of 1st polariser P_1 makes an angle of θ with the polarization vector of the incident wave. The pass axis of 2nd polariser P_2 makes an angle ϕ with the pass axis of 1st polariser. The final transmitted intensity I_2 will be maximum when the angle ϕ is

- (A) 0°
- (B) $90^\circ - \theta$
- (C) 45°
- (D) 90°

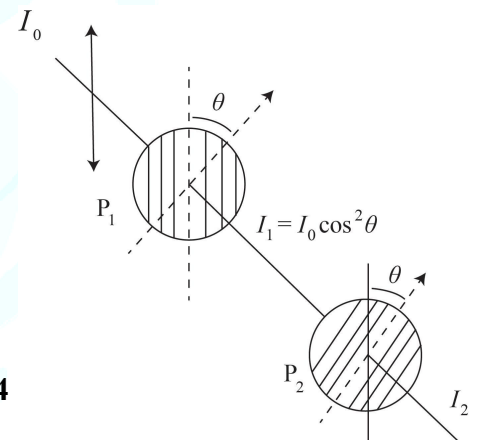
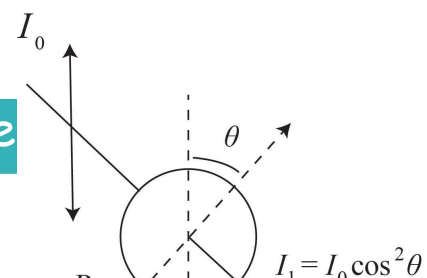


Fig. Q.10.4.4

Q.10.4.9 Two polarisers are introduced in the path of a plane polarized light of intensity I_0 as shown Fig. Q.10.4.5. The pass axis of 1st polariser P_1 makes an angle θ with the polarization vectors of the incident wave. The pass axis of 2nd polariser P_2 makes an angle ϕ with the polarization vector of the incident wave. P_1 is now rotated around the direction of propagation. The final transmitted intensity I_2 will be maximum when angle θ is



- (A) 0°
- (B) 45°
- (C) $90^\circ - \phi$
- (D) 90°

Fig. Q.10.4.5

Q.10.4.10 Consider a light beam incident from air on a water surface at an angle of incidence of 53° . The reflected light was examined using a polariser. Intensity of reflected light was found to vary from maximum to zero and zero to maximum twice as polariser was rotated through 360° . Then the angle of refraction inside water is

- (A) 0°
- (B) 37°
- (C) 53°
- (D) 90°



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