Solution

CET25P10 WAVE OPTICS

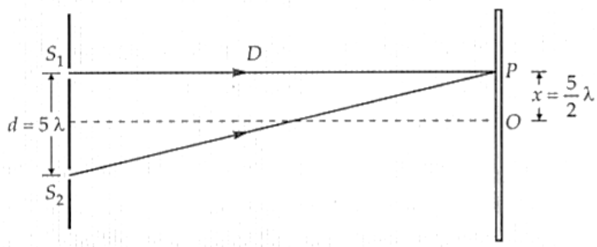
Class 12 - Physics

1.
(d) five
Explanation: According to the condition for interference maxima,
d sinθ = n λ
Here, d = 2 λ
$\therefore$ 2 λsinθ = n λ
or n = 2 sinθ
For number of interference maxima to be maximum
sinθ = 1
$\therefore$ n = 2 $\times$ 1 = 2
The interference maxima will occur, when
n = 0, $\pm$ 1 and $\pm$ 2
Hence, the maximum number of possible interference maxima = 5

2. **(a)** diffraction
Explanation: The phenomenon of bending of waves around corners of obstacle without a change in medium is known as diffraction.

3.
(b) 2(I_1 + I_2)
Explanation: Other factors such ω o and v remain the same,
I = A^2 $\times$ constant K or $A = \sqrt{\frac{I}{K}}$
On superposition $A_{max.}$ = A_1 + A_2 and $A_{min.}$ = A_1 - A_2
$\therefore \quad A_{\max}^2 = A_1^2 + A_2^2 + 2A_1A_2$
or $\frac{I_{\max}}{K} = \frac{I_1}{K} + \frac{I_2}{K} + \frac{2\sqrt{I_1I_2}}{K}$
$A_{\text{nin.}}^2 = A_1^2 + A_2^2 - 2A_1A_2$
or $\frac{I_{\min}}{K} = \frac{I_1}{K} + \frac{I_2}{K} - \frac{2\sqrt{I_1I_2}}{K}$
$\therefore$ $I_{max.}$ + $I_{min.}$ = 2(I_1 + I_2)

4.
(b) $\frac{I_0}{2}$
Explanation:



Path difference, p = $\frac{xd}{D} = \frac{\frac{d}{2} \times d}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$
Phase difference, $\phi = \frac{2\pi p}{\lambda} = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$
I_{max} = I_0
I = I_0 $\cos^2 \frac{\phi}{2}$ = I_0 $\cos^2 \frac{\pi}{4} = \frac{I_0}{2}$

5.
(d) The fringe width will decrease
Explanation: The fringe width is given by

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

Therefore, when blue light (light of lesser wavelength) is used, the fringe width will decrease.

6.

(c) $\frac{49}{9}$

Explanation: Here amplitude ratio $= \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{25}{4}} = \frac{5}{2}$

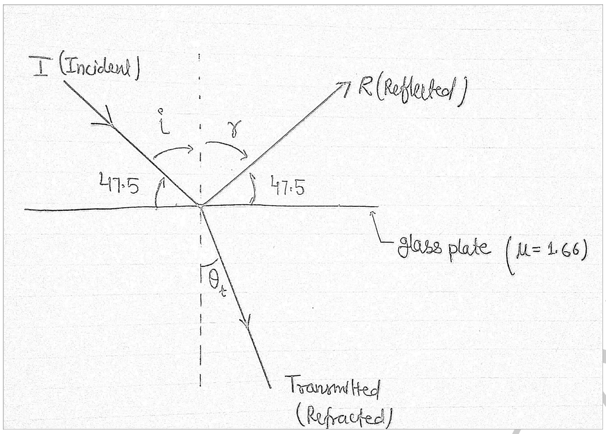
Thus, $\frac{I_{max}}{I_{min}} = \frac{(5/2+1)^2}{5/2-1)^2} = (\frac{7}{3})^2 = \frac{49}{9}$

7.

(c) a few coloured bands and then uniform illumination

Explanation: a few coloured bands and then uniform illumination

8. **(a)** 66.0°

Explanation: 

Let x is the angle between the refracted beam and the surface of the glass.

From diagram, we have

i + 47.5° = 90°

i = 42.5^o

Since, i = r [law of reflection]

i = r = 42.5^o

Using snell 's law, we get

$n_1 sin\theta_1 = n_2 sin\theta_2$

$\theta_2 = sin^{-1}(\frac{1\times\sin(42.5)}{1.66}) = 24^o$

So, $\theta_t = \theta_2$ = 24^o

But, $x + \theta_t = 90^\circ$

$\implies x = 66^\circ$

9. **(a)** $\sin^{-1}\left(\frac{\lambda}{3d}\right)$

Explanation: $I = I_{max} cos^2(\phi/2)$

$\frac{I_{max}}{4} = I_{max} cos^2(\phi/2)$

$cos(\phi/2) = 1/2$

or, $\frac{\phi}{2} = \frac{\pi}{3}$

Therefore,$\phi = \frac{2\pi}{3}$

Also, $\phi = \frac{2\pi}{\lambda}.\Delta x$

So, $\frac{2\pi}{3} = \frac{2\pi}{\lambda}\Delta x \Rightarrow \Delta x = \frac{\lambda}{3}$

where, $\Delta x = d sin\theta$

Substituting we get,

$sin\theta = \frac{\lambda}{3d}$

or, $\theta = sin^{-1}(\frac{\lambda}{3d})$

10.

(d) increases by (μ - 1)t

Explanation: increases by (μ - 1)t

11.

(c) $\frac{k}{2}$

Explanation: Path difference λ implies a maximum, so I_{max} = k

I = I_{max} $\cos^2 \frac{\phi}{2}$ = k $\cos^2 \left(\frac{1}{2} \cdot \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}\right)$

= k $\cos^2 \frac{\pi}{4}$ = k$\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{k}{2}$

12.

(d) $\frac{I}{4}$

Explanation: I = $\left(\sqrt{I_0} + \sqrt{I_0}\right)^2$ = $4I_0$

When one slit is closed

I' = I_0 = $\frac{I}{4}$

13. **(a)** Only the central fringe is white and all the other fringes are coloured

Explanation: Only the central fringe is white and all the other fringes are coloured

14.

(d) 1.9 mm

Explanation: Angular width of a fringe, $\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

For same λ, $\frac{\theta_1}{\theta_2} = \frac{d_2}{d_1}$

$\therefore$ d_2 = $\frac{\theta_1}{\theta_2} \times$ d_1 = $\frac{0.20}{0.21} \times$ 2 mm = 1.90 mm

15.

(d) same frequency, phase and amplitude

Explanation: same frequency, phase and amplitude

16.

(d) $\frac{2\sqrt{n}}{n+1}$

Explanation: Here n = $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} \Rightarrow \frac{a_1}{a_2} = \sqrt{n}$

$\frac{I_{\max}-I_{\min}}{I_{\max}+I_{\min}} = \frac{k(a_1+a_2)^2-k(a_1-a_2)^2}{k(a_1+a_2)^2+k(a_1-a_2)^2}$

$= \frac{4a_1a_2}{2(a_1^2+a_2^2)} = \frac{2\left(\frac{a_1}{a_2}\right)}{\left[\frac{a_1^2}{a_2^2}+1\right]} = \frac{2\sqrt{n}}{n+1}$

17. **(a)** 1.2 mm

Explanation: $\beta = \frac{D\lambda}{d} \Rightarrow \beta \propto \lambda$

$\therefore \frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1}$

$\Rightarrow \quad \beta_2 = \frac{\lambda_2}{\lambda_1} \cdot \beta_1 = \frac{6000}{5000} \times$ 1 mm = 1.2 mm

18. **(a)** 4200 $\overset{\circ}{A}$

Explanation: 2 $\theta_1 = \frac{2\lambda_1}{a}$

2 θ_2 = 0.7 $\times$ 2 $\theta_1 = \frac{2\lambda_2}{a}$

λ_2 = 0.7 λ_1 = 0.7 $\times$ 6000 $\overset{\circ}{A}$

= 4200 $\overset{\circ}{A}$

19.

(b) there shall be no interference fringes

Explanation: For sustained interference, the source must be coherent and should emit the light of same frequency.

In the Young Double Slit experiment, one hole is covered with red and other with blue, which has different frequency, so no interference takes place.

20.

(d) 460 nm

Explanation: 460 nm

21.

(d) photoelectric effect.

Explanation: Wave nature of light cannot explain the photoelectric effect. Particle nature of light can only explain it.

22.

(d) Huygens

Explanation: Huygens principle states that every point on a wavefront is a source of secondary wavelets. These wavelets spread out in the forward **direction**, at the same speed as the source wave. The new wavefront is a line tangent to all of the wavelets.

23.

(c) interference, in which width of the fringe will be slightly increased

Explanation: Strictly speaking, the refractive index of air is $1 \cdot 00029$ and that of vacuum is 1. Therefore, on evacuating the chamber, the wavelength of the light used will increase slightly. Since $\beta \propto \lambda$, the fringe width will increase slightly.

24.

(b) 0.15 cm

Explanation: Distance of first minimum from the centre of the screen,

x = $\frac{\lambda D}{a} = \frac{\lambda f}{a}$ [D = f]

$= \frac{5\times10^{-5}\times60}{0.02}$ cm = 0.15 cm

25. **(a)** 2 I_0

Explanation: For two incoherent sources, the resultant intensity at every point is just twice of the two individual intensities.

26. **(a)** 9 I and I

Explanation: 9 I and I

27.

(b) 2.4 mm

Explanation: Distance between the first-order dark fringes

= Width of central maximum

$= \frac{2D\lambda}{a} = \frac{2\times2\times600\times10^{-9}}{1\times10^{-3}}$ m

= 24 $\times$ 10^{-4} m = 2.4 mm

28.

(d) 0.2 mm

Explanation: $\beta = \frac{D\lambda}{d} = \frac{2\times500\times10^{-9}}{5\times10^{-3}}$ m

= 0.2 $\times$ 10^{-3} m = 0.2 mm

29. **(a)** 5600 $\overset{\circ}{A}$

Explanation: The distance of the second secondary maximum from the centre of the screen is

$x_2' = \frac{5}{2}\frac{D\lambda}{a}$

$\lambda = \frac{2ax_2'}{5D} = \frac{2\times0.7\times10^{-3}\times2\times10^{-3}}{5\times1}$ m

$= \frac{28}{5}\times$ 10^{-7} m

= 5600 $\overset{\circ}{A}$

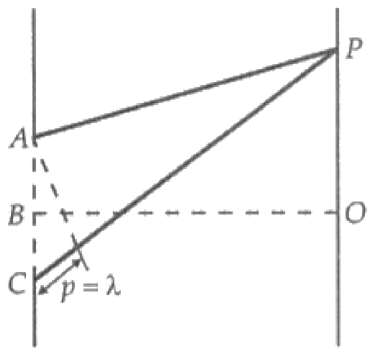
30.

(c) π radian

Explanation:

For the first minimum, the path difference between A and C is λ, so the path difference between A and B is $\frac{\lambda}{2}$.

Hence, the phase difference is π.



31.
(d) 3.00
Explanation: Velocity of light in the medium,
$v_{med} = v\lambda = 2 \times 10^{14} \times 5000 \times 10^{-10} = 10^8\ ms^{-1}$
$\mu = \frac{v_{vac}}{v_{med}} = \frac{3\times10^8}{10^8} = 3$

32.
(d) I_0
Explanation: The intensity of the central maximum is independent of the slit width. However, the slit width affects the width of the central maximum. The wider the slit is, the narrower is the central diffraction maximum.

33.
(c) 0.03 mm
Explanation: Angular fringe width,
$\theta_0 = \frac{\beta}{D} = \frac{D\lambda}{d} \cdot \frac{1}{D} = \frac{\lambda}{d}$
But $\theta_0 = 1^o = \frac{\pi}{180}$ rad, $\lambda = 6 \times 10^{-7}$ m
$\therefore$ d = $\frac{\lambda}{\theta_0} = \frac{6\times10^{-7}}{\frac{180}{\pi}}$ = 3.44×10^{-5} m
= 0.03 mm

34.
(c) $\frac{R}{2}$
Explanation: $\frac{R}{2}$

35. **(a)** 4.5×10^{-3} rad
Explanation: The angular width of central maximum,
$2\,\theta = \frac{2\lambda}{a} = \frac{2\times900\times10^{-9}}{0.4\times10^{-3}}$ rad
= 4.5×10^{-3} rad

36.
(c) $\sin^{-1}\left(\frac{3}{4}\right)$
Explanation: The condition for first minimum is
a $\sin\theta = \lambda$
$\Rightarrow$ a $\sin 30^o = \lambda$
$\Rightarrow$ a = 2λ
The condition for first secondary maximum is
a $\sin\theta_1 = \frac{3\lambda}{2}$
$\Rightarrow \sin\theta_1 = \frac{3\lambda}{2a} = \frac{3\lambda}{2\times2\lambda} = \frac{3}{4}$
$\therefore \theta_1 = \sin^{-1}\left(\frac{3}{4}\right)$

37. **(a)** 2
Explanation: At the centre of a bright fringe,
$I_0 = I + I + 2\sqrt{II}\cos 0^o = 4I$

At a point distant $\frac{\beta}{4}$ (or $\phi = \frac{2\pi}{4} = \frac{\pi}{2}$) intensity is
I' = I + I + $2\sqrt{II}$ cos $\frac{\pi}{2}$ = 2I
$\frac{I_0}{I'} = \frac{4I}{2I}$ = 2

38.

(c) 1.5

Explanation: 1.5

39.

(d) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\pi$

Explanation: The ray reflected by the top surface of the glass and the bottom surface is:-
$\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\pi$

40.

(c) origin of spectra

Explanation: Huygen’s construction of wavefront does not explain the phenomena of origin of spectra.

41. **(a)** all of these

Explanation: Interference occurs in all types of waves.

42.

(b) size of obstacle should be comparable to the wavelength of the wave

Explanation: size of obstacle should be comparable to the wavelength of the wave

43.

(c) same frequency, phase and amplitude

Explanation: Two waves are coherent if they have the same frequency and constant phase difference but amplitude may or may not be the same.

44.

(d) $\frac{(2n+1)\lambda}{2}$

Explanation: For destructive interference, the path difference should be an odd multiple of $\frac{\lambda}{2}$.

45.

(c) 2 : 1

Explanation: In case of coherent sources, interference occurs. Intensity at the midpoint is

I_{max} = k(a + a)^2 = k $\times$ 4a^2

In case of incoherent sources, interference does not occur.
Intensity at the midpoint is

I = I_1 + I_2 = ka^2 + ka^2 = k $\times$ 2a^2

$\therefore \frac{I_{\max}}{I} = \frac{4}{2}$ = 2 : 1

46.

(c) its wavelength is very small

Explanation: Light appears to travel in a straight line because diffraction (or deviation from the path) is least in light. Diffraction is least because -of small wavelength of light. So small wave length of light causes the light to travel almost in straight line.

47.

(b) shift upward by nearly two fringes

Explanation: Displacement of the central bright fringe,
$\Delta x = \frac{\beta}{\lambda}$ (μ - 1)t
$= \frac{\beta(1.5-1)\times 2\times 10^{-6}}{500\times 10^{-9}} = 2\beta$, upward

48.

(d) $\frac{9}{4}$

Explanation: r = $\sqrt{\frac{w_1}{w_2}} = \sqrt{\frac{1}{25}} = \frac{1}{5}$

$\frac{I_{\max}}{I_{\min}} = \frac{\left(1+\frac{1}{5}\right)^2}{\left(1-\frac{1}{5}\right)^2}$ = 9 : 4

49.

(c) 1.63 mm

Explanation: Position of fifth bright fringe,

$x_5 = \frac{5D\lambda}{d}$

Position of third dark fringe,

x_3' = (2 × 3 - 1) $\frac{D\lambda}{2d} = \frac{5D\lambda}{2d}$

Required distance,

$x_5 - x_3' = \left(5 - \frac{5}{2}\right) \frac{D\lambda}{d} = \frac{5}{2} \frac{D\lambda}{d}$

$= \frac{5\times1\times6.5\times10^{-7}}{2\times1\times10^{-3}}$ = 1.625 × 10^{-3} m

$\approx$ 1.63 mm

50.

(b) cos $\theta = \frac{3\lambda}{4d}$

Explanation: cos $\theta = \frac{3\lambda}{4d}$

51.

(d) 306 km/s

Explanation: λ = 589 nm

Δλ = 589.6 − 589.0 = 0.6 nm

Use the equation, $\triangle\lambda = \frac{v}{c} \times \lambda$, we have

$v = \frac{0.6\times10^{-9}}{589\times10^{-9}} \times 3 \times 10^8 m/s$

$= 3.06 \times 10^5 m/s$

$= 306 km/s$

52.

(d) Prism

Explanation: A prism cannot be used to produce two coherent sources of light.

53.

(c) diffraction bands become narrower and crowded together

Explanation: Directions of various minima in a diffraction pattern are given by

$\theta_n = \frac{n\lambda}{a}$

When red light is replaced by blue light $(\lambda_B < \lambda_R)$ the diffraction bands become narrower and crowded together.

54.

(b) distance between slit and screen

Explanation: Angular width of central maximum,

$\theta_0 = \frac{\beta_0}{D} = \frac{2D\lambda}{a} \frac{1}{D} = \frac{2\lambda}{a}$

Clearly, θ_0 does not depend on the distance D between the slit and screen.

55.

(d) both light and sound waves

Explanation: Interference is possible both in light and sound waves.

56.

(b) spherical

Explanation: When light diverges from a point source, it moves in the form of the diverging spherical wavefront.

57.

(b) not possible at all

Explanation: not possible at all

58. **(a)** Frequency

Explanation: Frequency

59. **(a)** wave

Explanation: According to Huygens' principle, light travels in the form of a longitudinal wave.

60. **(a)** The fringes shrink

Explanation: The fringes shrink

61.

(d) 0.5 mm

Explanation: We know that fringe width, $\beta = \frac{\lambda D}{d}$

$= \frac{5\times10^{-7}\times1}{10^{-3}}$ = 5×10^{-4} m $= 0.5\ mm$

62.

(d) $\frac{\mu t}{c}$

Explanation: Speed of light in glass plate, v = $\frac{c}{\mu}$

Time taken light to traverse thickness t of the glass plate,

$= \frac{t}{\frac{c}{\mu}} = \frac{\mu t}{c}$

63.

(d) 0.2 mm

Explanation: Angular width of a maximum in double-slit pattern = $\frac{\beta}{D} = \frac{\lambda}{d}$

Angular width of central maximum in single slit pattern = $\frac{2\lambda}{a}$

Given, $10 \times \frac{\lambda}{d} = \frac{2\lambda}{a}$

$\Rightarrow$ a = $\frac{1}{5}$d = $\frac{1}{5}\times$ 1 mm = 0.2 mm

64.

(d) 2 : 1

Explanation: $\frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{4}{1} \quad \therefore \frac{a}{b} = \frac{2}{1}$

65.

(b) are longitudinal waves and require a medium to travel.

Explanation: According to Huygens, light waves are longitudinal waves and require a material medium to travel. For this reason Huygens assumed the existence of a hypothetical medium called luminiferous aether.

66.

(b) Polarisation

Explanation: Sound waves, being longitudinal cannot be polarised. Light waves can be polarised because they are transverse.

67.

(d) the fringe width remains the same but the pattern shifts

Explanation: When a thin film of mica is inserted in the path of one beam, the entire fringe pattern shifts towards the side in which the film is inserted.

68.

(c) they are not monochromatic

Explanation: When two waves of same frequency, same wavelength and same velocity move in the same direction, their superposition results in the interference. The two beams are monochromatic.

69.

(d) amplitude

Explanation: As we know that,

I $\propto$ a^2

70.

(b) 1/3 times

Explanation: $\beta \propto \frac{1}{d}$

If d becomes thrice, then β becomes 1/3 times.

71.

(d) coherent waves of a single wavelength

Explanation: A laser beam is coherent because it contains coherent waves of a single wavelength.

72.

(b) 0

Explanation: Wavefront is the locus of all points those are in same phase.

73. **(a)** 549 nm

Explanation: $\mu = \frac{v_1}{v_2}$

Also, $\mu = \frac{\lambda_1}{\lambda_2}$

This gives $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

Putting the values of $v_1 = 1.94 \times 10^8, v_2 = 3 \times 10^8 and\, \lambda_1 = 355nm$, we get

$\lambda_2 = 549nm$

74.

(b) $\sin^{-1} \frac{3}{4}$

Explanation: For first minimum,

d $\sin \theta = \lambda$

d $\sin 30^o = 5500 \overset{\circ}{A}$

d = $\frac{5500}{0.5} \overset{\circ}{A} = 11000 \overset{\circ}{A}$

For first secondary maximum,

d $\sin \theta' = \frac{3\lambda}{2}$

$\sin \theta' = \frac{3 \times 5500}{2 \times 11000} = \frac{3}{4}$

$\therefore \theta' = \sin^{-1} \frac{3}{4}$

75. **(a)** plane

Explanation: When the point source or linear source of light is a very large distance, a small portion of the spherical or cylindrical wavefront appears to be plane. Such a wavefront is plane wavefront.