11. Interference and Diffraction

Shortcuts, Important Results & Formulae

- Superposition of waves (Interference of two light waves) : Conditions for
  a) Bright band or bright point (constructive interference) :
     i) Path difference is even multiple of $\frac{\lambda}{2}$
     ii) Phase difference is even multiple of 'π'.
  b) Dark band or dark point (destructive interference) :
     i) Path difference is odd multiple of $\frac{\lambda}{2}$.
     ii) Phase difference is odd multiple of 'π'.

- For Young's experiment or biprism experiment in which interference is obtained by using light of wavelength 'λ' from two coherent sources (slits) apart "d" and is observed on a screen (in focal plane of eyepiece) at a distance 'D' from slits.
  a) Bright band or bright fringe :
     i) Path difference $\Delta = \frac{xd}{D} = 2n\left(\frac{\lambda}{2}\right) = n\lambda$, where, n = 0, 1, 2, 3, ...
     ii) Phase difference = $\delta = 2n\pi$, where n = 0,1, 2, ...
     iii) The number 'n' indicate the order of fringe or band.
     iv) n = 0, correspond to central bright band. For it, $\Delta = 0$ and $\delta = 0$
     v) If a heterogeneous source of light is used, central bright band will be white while all other bands will be coloured.
     vi) If central bright band is considered as the origin, then the distance "x_n" of n^{th} bright band from central bright band is given by

$$x_n = \left(\frac{nD}{d}\right)\lambda = nX, \text{ where } n = 0,1,2,.....; \text{ and } X = \text{band width.}$$

  b) Dark band or dark fringe :
     i) path difference $= \Delta = \frac{xd}{D} = \left(n-\frac{1}{2}\right)\lambda$, where n = 1, 2, 3, ...
     ii) phase difference = $\delta = (2n-1)\pi$, where n = 1, 2, ...
     iii) The number 'n' indicate the order of the fringe or band.
     iv) Note that zeroth order (n = 0) dark band does not exist. Hence the condition is as written in b(i).
     v) The distance x_n of the n^{th} dark band from central bright band is given by

$$x_n = \frac{D}{d}\left(n-\frac{1}{2}\right)\lambda = \left(n-\frac{1}{2}\right)X,$$

     where, n = 1, 2, 3, ...; and X = band width

  c) Band width or fringe width :
     i) The value of band width for dark bands and bright bands is the same. Hence the interference fringes are equidistant and are called fringes of equal thickness.
     ii) Band width 'X' : or 'β' :

$$X = \frac{\lambda D}{d} \quad \therefore X \propto \lambda \quad \therefore X \propto D \quad \therefore X \propto \frac{1}{d}$$

     where, D = distance between the slits and the screen or the focal plane of the eye piece, d = distance between two coherent sources (slits).

- Biprism experiment :

  i) Band width = $X = \frac{\lambda D}{d}$

  ii) Distance between two coherent sources :

  $d = \sqrt{d_1 d_2}$

  where, d_1 = distance between magnified images of two virtual sources

  d_2 = distance between diminished images of two virtual sources

  iii) Determination of d_1 and d_2 using conjugate foci method.

  a) By magnification :

  $$\frac{\text{Size of image}}{\text{Size of object}} = \frac{\text{Image distance}}{\text{Object distance}}$$

  $\therefore \quad \frac{d_1}{d} = \frac{v}{u}$ ... for magnified images.

  $\frac{d_2}{d} = \frac{v'}{u'}$ ... for diminished images.

  b) By property of conjugate foci :

  $v = u'$ and $u = v'$

  $\therefore \quad d = \sqrt{d_1 d_2}$

  c) For convex lens : $\frac{1}{u} - \frac{1}{v} = \frac{1}{f}$

  iv) $\therefore \quad X = \frac{\lambda D}{\sqrt{d_1 d_2}}$

Multiple Choice Questions

1. If the ratio of amplitudes of two waves is 4 : 3. Then, the ratio of maximum and minimum intensities will be **[MH-CET 2000]**

(A) 16 : 18 (B) 18 : 16 (C) 49 : 1 (D) 1 : 49

2. In a double slit experiment, the distance between slits is increased 10 times whereas their distance from screen is halved, then what is the fringes width? **[MH-CET 2000]**

(A) It remains same (B) Becomes $\frac{1}{10}$ (C) Becomes $\frac{1}{20}$ (D) Becomes $\frac{1}{90}$

3. If the ratio of amplitude of waves is 2 : 1, then the ratio of maximum and minimum intensity is **[MH-CET 2001]**

(A) 9 :1 (B) 1 : 9 (C) 4 : 1 (D) 1 : 4

4. If a torch is used in place of monochromatic light in Young's experiment, what will happen? **[MH-CET 2001]**

(A) Fringe will appear for a moment then it will disappear
(B) Fringes will occur as from monochromatic light
(C) Only bright fringes will appear
(D) No fringes will appear

5. In Young's double slit experiment carried out with light of wavelength $\lambda = 5000$ Å, the distance between the slits is 0.2 mm and screen is 2.0 m away from the slits. The central maxima is at n = 0. The third maximum will be at a distance x(from central maxima) equal to

(A) 5 cm (B) 0.5 cm (C) 1.67 cm (D) 1.5 cm **[MH-CET 2002]**

6. In Young's double slit experiment, a minimum is obtained when the phase difference of superimposing waves is [MHT-CET 2004]
(A) zero (B) $(2n-1)\pi$ (C) $n\pi$, (D) $(n+1)\pi$

7. The path difference produced by two waves is 3.75 μm and the wavelength is 5000 Å. The point is [MHT-CET 2005]
(A) uncertain (B) dark (C) partially bright (D) bright

8. In Young's double slit experiment, the distance between the slits is 1 mm and screen is 25 cm away from the slits. If the wavelength of light is 6000 Å, the fringe width on the screen is [MHT-CET 2005]
(A) 0.15 mm (B) 0.30 mm (C) 0.24 mm (D) 0.12 mm

9. In Young's experiment when sodium light of wavelength 5893 Å is used, then 62 fringes are seen in the field of view. Instead, if violet light of wavelength 4358 Å is used, then the number of fringes that will be seen in the field of view will be [MHT-CET 2006]
(A) 54 (B) 64 (C) 74 (D) 84

10. In a Fresnel biprism experiment, the two position of lens gives separation between the slits as 16 cm and 9 cm, respectively. What is the actual distance of separation? [MHT-CET 2006]
(A) 12.5 cm (B) 12 cm (C) 13 cm (D) 14 cm

11. If Young's double slit experiment, is performed in water [MHT-CET 2007]
(A) the fringe width will decrease (B) the fringe width will increase
(C) the fringe width will remain unchanged (D) there will be no change

12. When exposed to sunlight, thin films of oil on water often exhibit brilliant colours due to the phenomenon of [MHT-CET 2007]
(A) interference (B) diffraction (C) dispersion (D) polarisation

13. In an interference experiment, the spacing between successive maxima or minima is [MHT-CET 2008]
(A) $\lambda d/D$ (B) $\lambda D/d$ (C) dD/λ (D) $\lambda d/4D$

14. If fringe width is 0.4 mm, the distance between fifth bright and third dark band on same side is [MHT-CET 2009]
(A) 1 mm (B) 2 mm (C) 3 mm (D) 4 mm

15. If the aperture of a telescope is decreased, the resolving power will [MHT-CET 2010]
(A) increase (B) decrease (C) remain same (D) zero

16. In an interference experiment, third bright fringe is obtained at a point on the screen with a light of 700 nm. What should be the wavelength of the light source in order to obtain 5th bright fringe at the same point ? [MHT-CET 2010]
(A) 500 nm (B) 630 nm (C) 750 nm (D) 420 nm

17. In a single slit diffraction pattern intensity and width of fringes are [MHT-CET 2011]
(A) unequal width (B) equal width
(C) equal width and equal intensity (D) unequal width and unequal intensity

18. In Young's double slit experiment if the slit widths are in the ratio 1 : 9. The ratio of the intensity at minima to that at maxima will be [MHT-CET 2011]
(A) 1 (B) $\frac{1}{9}$ (C) $\frac{1}{4}$ (D) $\frac{1}{3}$

19. A plane wavefront of wavelength λ is incident on a single silt of width b. What is the angular width for secondary maximum? [MHT-CET 2011]
(A) $\frac{\lambda}{2b}$ (B) $\frac{\lambda}{b}$ (C) $\frac{2\lambda}{b}$ (D) $\frac{b}{\lambda}$

20. Two coherent sources of intensity ratio α interfere. In interference pattern $\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$ is equal to **[MHT-CET 2014]**

(A) $\frac{2\alpha}{1+\alpha}$ (B) $\frac{2\sqrt{\alpha}}{1+\alpha}$ (C) $\frac{2\alpha}{1+\sqrt{\alpha}}$ (D) $\frac{1+\alpha}{2\alpha}$

21. The distance of a point on the screen from two slits in biprism experiment is 1.8×10^{-5} m and 1.23×10^{-5} m. If wavelength of light used is 6000 Å, the fringe formed at that point is **[MHT-CET 2015]**

(A) 10^{th} bright (B) 10^{th} dark (C) 9^{th} bright (D) 9^{th} dark

22. Two coherent monochromatic light beams of intensities '4 I' and '9 I' are superimposed The maximum and minimum possible intensities in the resulting beam are **[MHT-CET 2015]**

(A) 3 I and 2 I (B) 9 I and 5 I (C) 16 I and 3 I (D) 25 I and I

23. In Young's double slit experiment, the ratio of intensities of bright and dark bands is 16 which means **[MHT-CET 2015]**

(A) the ratio of their amplitudes is 5
(B) intensities of individual sources are 25 and 9 units respectively
(C) the ratio of their amplitudes is 4
(D) intensities of individual sources are 4 and 3 units respectively

24. Interference fringes are produced on a screen by using two light sources of intensities 'I' and '9I'. The phase difference between the beams is $\frac{\pi}{2}$ at point P and π at point Q on the screen. The difference between the resultant intensities at point P and Q is **[MHT-CET 2016]**

(A) 2 I (B) 4 I (C) 6 I (D) 8 I

25. Two coherent sources 'P' and 'Q' produce interference at point 'A' on the screen where there is a dark band which is formed between 4th bright band and 5th bright band. Wavelength of light used is 6000A. The path difference between PA and QA is **[MHT-CET 2016]**

(A) 1.4×10^{-4} cm (B) 2.7×10^{-4} cm (C) 4.5×10^{-4} cm (D) 6.2×10^{-4} cm

26. Resolving power of telescope increases when **[MHT-CET 2016]**

(A) wavelength of light decreases (B) wavelength of light increases
(C) focal length of eye-piece increases (D) focal length of eye-piece decreases

27. In Fraunhofer diffraction pattern, slit width is 0.2 mm and screen is at 2 m away from the lens. If wavelength of light used is 5000 Å then the distance between the first minimum on either side of the central maximum is (θ is small and measured in radian) **[MHT-CET 2017]**

(A) 10^{-1} m (B) 10^{-2} m (C) 2×10^{-2} m (D) 2×10^{-1} m

28. Two identical light waves having phase difference 'ϕ' propagate in same direction. When they superpose, the intensity of resultant wave is proportional to **[MHT-CET 2017]**

(A) $\cos^2\phi$ (B) $\cos^2\frac{\phi}{2}$ (C) $\cos^2\frac{\phi}{3}$ (D) $\cos^2\frac{\phi}{4}$

29. In Young's double slit experiment, in an interference pattern second minimum is observed exactly in front of one slit. The distance between the two coherent sources is 'd' and the distance between source and screen is 'D'. The wavelength of light source used is **[MHT-CET 2017]**

(A) $\frac{d^2}{D}$ (B) $\frac{d^2}{2D}$ (C) $\frac{d^2}{3D}$ (D) $\frac{d^2}{4D}$

30. Two light waves of intensities 'I_1' and 'I_2' having same frequency pass through same medium at a time in same direction and interfere. The sum of the minimum and maximum intensities is [MHT-CET 2018]

(A) $(I_1 + I_2)$ (B) $2(I_1 + I_2)$ (C) $\left(\sqrt{I_1} + \sqrt{I_2}\right)$ (D) $\left(\sqrt{I_1} - \sqrt{I_2}\right)$

31. If numerical aperture of a microscope is increased then its [MHT-CET 2018]

(A) resolving power remains constant (B) resolving power becomes zero
(C) limit of resolution is decreased (D) limit of resolution is increased

32. The luminous border that surrounds the profile of a mountain just before sun rises behind it, is an example of [MHT-CET 2019]

(A) interference (B) dispersion
(C) total internal reflection (D) diffraction

33. Light of wavelength 'λ' is incident on a single slit of width 'a' and the distance between slit and screen is 'D'. In diffraction pattern, if slit width is equal to the width of the central maximum then 'D' is equal to [MHT-CET 2019]

(A) a^2/λ (B) $a^2/2\lambda$ (C) $a/2\lambda$ (D) a/λ

34. The magnifying power of a telescope is nine. When it is adjusted for parallel rays, the distance between the objective and eyepiece is 20 cm. The focal length of objective and eyepiece are respectively [MHT-CET 2019]

(A) 10 cm, 10 cm (B) 15 cm, 5 cm (C) 18 cm, 2 cm (D) 11 cm, 9 cm

35. The phenomenon of interference is based on [MHT-CET 2019]

(A) quantum nature of light (B) conservation of energy
(C) conservation of momentum (D) conservation of charge

36. In Young's double slit experiment fifth dark fringe is formed opposite to one of the slit. If 'D' is the distance between the slits and the screen and 'd' is the separation between the slits then the wavelength of light used is [MHT-CET 2019]

(A) $\frac{d^2}{9D}$ (B) $\frac{d^2}{5D}$ (C) $\frac{d^2}{6D}$ (D) $\frac{d^2}{15D}$

37. For destructive interference to take place between two monochromatic light waves of wavelength 'λ', the path difference should be, (where n = 1, 2, 3, ...) [MHT-CET 2019]

(A) $(2n - 1)\lambda/4$ (B) $n\lambda$ (C) $(2n - 1)\lambda/2$ (D) $(2n + 1)\lambda/2$

38. A slit of width 'd' is illuminated by monochromatic light of wavelength 4714 Å. Then the value of 'a' for which first maximum falls at 45° is [$\sin 45° = \cos 45° = \frac{1}{\sqrt{2}} = 0.7071$]

(A) 10^4 Å (B) 10^5 Å (C) 10^6 Å (D) 10^8 Å [MHT-CET 2019]

39. If the two slits in Young's double slit experiment have width ratio 9 : 1, the ratio of maximum to minimum intensity in the interference pattern is [MHT-CET 2019]

(A) 1 : 4 (B) 4 : 1 (C) 2 : 1 (D) 1 : 2

40. In an interference pattern, fringe width 'X' is obtained with a source of light of wavelength 'λ_1', With the same experimental set up, the source is replaced by a light of wavelength 'λ_2', the fringe width obtained is $\left(\frac{1}{6}\right)^{th}$ of the distance between the two coherent monochromatic sources 'd'. The ratio $\frac{\lambda_1}{\lambda_2}$ will be [MHT-CET 2019]

(A) $\frac{6X}{d}$ (B) $\frac{4X}{d}$ (C) $\frac{X}{6d}$ (D) $\frac{2X}{d}$

41. In Young's double slit experiment, instead of taking slits of equal widths, one slit is made twice as wide as the other. Then in the interference pattern **[MHT-CET 2019]**

(A) the intensity of maxima decreases and the minima has zero intensity decreases

(B) the intensities of both the maxima and minima increase

(C) the intensity of maxima decreases and that of minima decreases

(D) the intensity of maxima increases and the minima has zero intensity

42. A telescope has large diameter of the objective. Then its resolving power is **[MHT-CET 2019]**

(A) independent of the diameter of the objective (B) low

(C) high (D) zero