Engineering Daily 25 [Set 04] EV

Physical Optics, Modern Physics

Total Marks: 50 **Negative Marks:** 0.25 **Time:** 1 Hour

MCQ 50 marks

1. Interference fringes of 600 nm light are formed on a screen 1.5 m away from two equal slits separated by 0.5 mm. If the intensity of the central maximum is I_0, the minimum distance from the centre at which the intensity is $\frac{I_0}{4}$ is—

(A) 0.3 mm (B) 0.9 mm (C) 1.8 mm (D) 0.6 mm

2. If the ratio of maximum to minimum intensity in the interference of two coherent waves is 9 : 1, the ratio of the intensities of the two waves is—

(A) 2 : 1 (B) 9 : 1 (C) 3 : 1 (D) 4 : 1

3. In a double-slit experiment, moving the screen 0.1 m towards the slits changes the fringe width by 5×10^{-5} m. If the slit separation is 1.2 mm, what is the wavelength of the light used?

(A) 417 nm (B) 720 nm (C) 500 nm (D) 600 nm

4. In single-slit diffraction, what wavelength of light is required to reduce the angular width of the central maximum by 20% relative to that for 500 nm light? (small angles)

(A) 625 nm (B) 600 nm (C) 400 nm (D) 100 nm

5. A process occurring on a train moving at 0.6c lasts 4 min by the train's clock. The duration of the process as measured by an observer on the platform is—

(A) 5 min (B) 3.2 min
(C) 6.67 min (D) 4 min

6. In Young's experiment, the angular separation of fringes for 550 nm light is 0.1°. What is the separation between the two slits?

(A) 0.315 mm (B) 5.5×10^{-3} mm
(C) 0.63 mm (D) 0.158 mm

7. 3% of the energy consumed by a 100 W lamp is converted into light. If the average wavelength of the light is 600 nm, how many photons are emitted per second?

(A) 9.06×10^{18} (B) 9.06×10^{15}
(C) 3.02×10^{20} (D) 3.02×10^{18}

8. Trains A and B approach each other at 0.6c and 0.8c respectively relative to the ground. When 4 min elapse on B's clock, this time as measured by an observer on A is—

(A) 6.67 min (B) 1.3 min (C) 12.3 min (D) 5 min

9. The speed of radio waves in a medium of relative magnetic permeability 1 and dielectric constant 4 is—

(A) 7.5×10^7 ms^{-1} (B) 1.5×10^8 ms^{-1}
(C) 6×10^8 ms^{-1} (D) 3×10^8 ms^{-1}

10. In a moving frame, two events occur at the same place 400 s apart. If the speed of the frame is 2.4×10^8 ms^{-1}, the spatial separation of the two events in the rest frame is—

(A) 2.67×10^{11} m (B) 5.76×10^{10} m
(C) 1.6×10^{11} m (D) 9.6×10^{10} m

11. Relative to the laboratory, two particles move in opposite directions, each at 0.5c. What is the velocity of one relative to the other?

(A) 0.8c (B) 0.5c (C) c (D) 0.75c

12. When photons of energy 3ϕ and 9ϕ are incident on a metal of work function ϕ, the ratio of the maximum speeds of the emitted electrons is—

(A) 1 : 4 (B) 1 : 2
(C) $1 : \sqrt{3}$ (D) 1 : 3

13. When the frequency of light incident on a single slit is changed from 5×10^{14} Hz to 6×10^{14} Hz, the angular width of the central maximum changes by 0.2 rad (small angles). The slit width is—

(A) 1 µm (B) 0.5 µm (C) 0.1 µm (D) 2 µm

14. Light of 589.0 nm and 589.6 nm is incident in turn on a single slit of width 0.2 mm. What is the difference between the positions of the first secondary maxima on a screen 2 m away?

(A) 6 µm (B) 3 µm (C) 4.5 µm (D) 9 µm

15. The threshold frequencies of two metals are 5.5×10^{14} Hz and 4.4×10^{14} Hz. If the stopping potentials for the same light are 1.5 V and 1.955 V respectively, the value of Planck's constant from this data is—

(A) 1.32×10^{-33} Js (B) 6.62×10^{-34} Js
(C) 7.11×10^{-34} Js (D) 1.32×10^{-34} Js

16. X-rays of wavelength 0.10 nm undergo Compton scattering from free electrons. What is the maximum kinetic energy of the scattered electron?

(A) 287 eV (B) 575 eV
(C) 294 eV (D) 12400 eV

17. In a double-slit experiment, a = 0.4 mm and D = 1.2 m. What change in the slit separation is required to keep the fringe width unchanged when the screen is moved a further 30 cm away?

(A) 0.08 mm increase (B) 0.5 mm increase
(C) 0.1 mm increase (D) 0.1 mm decrease

18. In Young's experiment, $\lambda = 6000$ Å, a = 0.25 mm and D = 1.25 m. The distance between the first and last of 9 consecutive bright fringes is—

(A) 21 mm (B) 12 mm (C) 27 mm (D) 24 mm

19. When 500 nm light is incident on a single slit of width 0.25 mm, the diffraction angle of the second minimum is—

Ⓐ 0.229° Ⓑ 0.286° Ⓒ 0.115° Ⓓ 0.458°

20. The equation of a plane electromagnetic wave travelling in a medium is $E_z = 50\cos(4.5 \times 10^8 t + 2x)\ Vm^{-1}$. The refractive index of the medium is—

Ⓐ $\frac{4}{3}$ Ⓑ 2.25 Ⓒ $\frac{3}{4}$ Ⓓ 1.5

21. If the kinetic energy of an electron moving at 0.6c is $x\,m_0c^2$, the value of x is—

Ⓐ 0.25 Ⓑ 0.36 Ⓒ 1.25 Ⓓ 0.18

22. A grating has 20000 lines in a length of 4 cm. When 5000 Å light is incident normally, the maximum order observable on the screen is—

Ⓐ 5 Ⓑ 3 Ⓒ 4 Ⓓ 2

23. In a grating, the width of each transparent part is 1.2 µm and the width of each opaque line is 0.8 µm. What is the diffraction angle of the second order for 500 nm light?

Ⓐ 30° Ⓑ 90° Ⓒ 56.4° Ⓓ 14.5°

24. Unpolarized light of intensity 120 Wm^{-2} passes through three polarizers. The axes of the second and third are inclined to that of the first at 30° and 75° respectively. The transmitted intensity is—

Ⓐ 3.02 Wm^{-2} Ⓑ 22.5 Wm^{-2}

Ⓒ 45 Wm^{-2} Ⓓ 33.75 Wm^{-2}

25. In Young's experiment using 500 nm light, a 5 µm thick plate of refractive index 1.5 is placed in front of one slit. By how many fringes will the interference pattern shift?

Ⓐ 10 Ⓑ 15 Ⓒ 5 Ⓓ 2.5

26. In a double-slit experiment, light of 450 nm and 600 nm is used together; a = 0.3 mm and D = 1.5 m. The minimum distance from the centre at which a bright fringe of 450 nm coincides with a dark fringe of 600 nm is—

Ⓐ 6 mm Ⓑ 4.5 mm Ⓒ 9 mm Ⓓ 2.25 mm

27. For a wave of frequency 250 Hz, what is the phase difference between two states of a particle separated by a time interval of 1.5×10^{-3} s?

Ⓐ $\frac{3\pi}{8}$ Ⓑ $\frac{3\pi}{4}$ Ⓒ $\frac{3\pi}{2}$ Ⓓ $\frac{\pi}{2}$

28. Two electrons move in the same direction at 0.6c and 0.8c. The magnitude of the relative velocity of one with respect to the other is—

Ⓐ 0.2c Ⓑ 0.385c Ⓒ 0.946c Ⓓ 0.13c

29. In a double-slit experiment using white light, the first bright fringes of violet (400 nm) and red light form at 1.6 mm and 2.8 mm from the centre respectively. The wavelength of the red light is—

Ⓐ 750 nm Ⓑ 700 nm Ⓒ 229 nm Ⓓ 650 nm

30. On a vehicle moving at 0.8c, 50 identical processes are completed in a total of 120 min by the vehicle's clock. By an Earth observer's reckoning, the average duration of each process is—

Ⓐ 4 min Ⓑ 2.4 min

Ⓒ 6.67 min Ⓓ 1.44 min

31. If the total energy of a particle is $\frac{5}{3}$ times its rest energy, the speed of the particle is—

Ⓐ 0.917c Ⓑ 0.75c Ⓒ 0.8c Ⓓ 0.6c

32. The intensity of a pion beam moving at 0.995c falls to half after travelling 30 m from the source. What is the proper half-life of the pion?

Ⓐ 1.01×10^{-7} s Ⓑ 1.01×10^{-6} s

Ⓒ 10^{-9} s Ⓓ 10^{-8} s

33. When 1 day elapses on a spacecraft's clock, 3 days elapse on Earth. The speed of the craft is—

Ⓐ 2×10^8 ms^{-1} Ⓑ 4.24×10^8 ms^{-1}

Ⓒ 2.45×10^8 ms^{-1} Ⓓ 2.83×10^8 ms^{-1}

34. In a double-slit experiment, a = 0.2 mm and D = 1 m . Placing a plate of refractive index 1.5 in front of one slit shifts the central bright fringe by 15 mm. The thickness of the plate is—

Ⓐ 4 µm Ⓑ 3 µm Ⓒ 6 µm Ⓓ 2 µm

35. If a particle of mass 3.2×10^{-27} kg is converted completely into energy, the energy obtained is—

Ⓐ 1.8 MeV Ⓑ 0.000006 MeV

Ⓒ 900 MeV Ⓓ 1800 MeV

36. In a grating with 5000 lines per centimetre, the diffraction angle of the second order of a monochromatic light is 30°. The wavelength of the light is—

Ⓐ 250 nm Ⓑ 433 nm Ⓒ 500 nm Ⓓ 1000 nm

37. Two microbes that double every year of their own time are sent to a star 24 light-years from Earth in a vehicle travelling at 0.96c. The number of microbes on arrival at the star is—

Ⓐ 6.7×10^7 Ⓑ 256 Ⓒ 512 Ⓓ 128

38. The wavelength range of visible light in air is 400–700 nm. In glass of refractive index 1.5, this range will be—

Ⓐ 300.8–526.3 nm Ⓑ 400–700 nm

Ⓒ 600–1050 nm Ⓓ 266.7–466.7 nm

39. An electron of rest mass 9.11×10^{-31} kg moves at 0.5c . The correct statement about its mass is—

Ⓐ Less than 9.11×10^{-31} kg

Ⓑ Greater than 9.11×10^{-31} kg

Ⓒ Equal to 9.11×10^{-31} kg

Ⓓ Zero

40. Along a diameter of a circular field of area $2500\pi\ m^2$, at what speed must a spaceship move for the area of the field to be measured as $1500\pi\ m^2$?

(A) 0.6c (B) 0.4c (C) 0.8c (D) 0.36c

41. A spaceship passes at 0.8c along a diameter of a circular field of diameter 60 m. The area of the field as measured by the astronaut is—

(A) $540\pi\ m^2$ (B) $720\pi\ m^2$

(C) $324\pi\ m^2$ (D) $900\pi\ m^2$

42. If the polarizing angle of a medium is 60°, the critical angle of that medium is—

(A) 60° (B) 54.7° (C) 30° (D) 35.3°

43. A rod of length 2 m moves at 0.9c perpendicular to its length. The length of the rod in the laboratory frame is—

(A) 0.2 m (B) 4.59 m (C) 2 m (D) 0.87 m

44. A body at rest explodes into two fragments of rest mass 1.5 kg each, which fly off in opposite directions at 0.6c. What was the rest mass of the original body?

(A) 3 kg (B) 4.69 kg

(C) 3.75 kg (D) 2.4 kg

45. In Young's experiment, the double slit is 5 cm from the single slit and the screen is 155 cm from the single slit. With 4500 Å light, 10 fringes form over a length of 1.5 cm of the screen. The separation of the double slit is—

(A) 0.45 mm (B) 4.5 mm

(C) 0.0465 mm (D) 0.465 mm

46. A rod of rest length 2.0 m is measured to be 1.96 m when moving along its length. What is the speed of the rod?

(A) $2.94 \times 10^8\ ms^{-1}$ (B) $5.97 \times 10^7\ ms^{-1}$

(C) $2.12 \times 10^7\ ms^{-1}$ (D) $6 \times 10^6\ ms^{-1}$

47. One of two 25-year-old twins travels in a vehicle at $2.4 \times 10^8\ ms^{-1}$ and returns to Earth at the age of 43. What is the age difference between them?

(A) 10.8 years (B) 30 years

(C) 18 years (D) 12 years

48. If the kinetic energy of a proton is $2m_0c^2$, what is the magnitude of its momentum?

(A) $3m_0c$ (B) $\frac{\sqrt{8}\,m_0c}{3}$

(C) $\sqrt{3}\,m_0c$ (D) $2\sqrt{2}\,m_0c$

49. The radius of the second Bohr orbit of the hydrogen atom is 2.12 Å. The de Broglie wavelength of the electron revolving in that orbit is—

(A) 13.3 Å (B) 4.24 Å

(C) 6.66 Å (D) 1.06 Å

50. Of three polarizers, the axes of the second and third are inclined to that of the first at 20° and 50° respectively. Unpolarized light passes through all three and emerges with an intensity of $30\ Wcm^{-2}$. For the same incident light, what will the emergent intensity be if the second polarizer is removed?

(A) $18.7\ Wcm^{-2}$ (B) $37.4\ Wcm^{-2}$

(C) $45.3\ Wcm^{-2}$ (D) $12.4\ Wcm^{-2}$