Engineering Daily 25 [Home Practice] EV

Physical Optics, Modern Physics

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

MCQ 50 marks

1. Unpolarized light of intensity 80 Wm^{-2} passes through two polarizers in succession. For the transmitted intensity to be 15 Wm^{-2}, what must be the angle between the axes of the polarizers?

(A) 64.3° (B) 52.2° (C) 68° (D) 37.8°

2. The relativistic momentum of a proton moving at 0.8c is—

(A) $0.8m_0c$ (B) $\frac{4}{3}m_0c$

(C) $\frac{5}{3}m_0c$ (D) $\frac{3}{4}m_0c$

3. In a double-slit experiment the fringe width is 1.2 mm. If the slit separation is doubled and the screen distance is halved, the new fringe width is—

(A) 0.3 mm (B) 1.2 mm (C) 4.8 mm (D) 0.6 mm

4. A 20-year-old astronaut travels in a vehicle at 2.4×10^8 ms^{-1} and returns after 30 years by Earth's reckoning. The astronaut's age on return is—

(A) 50 years (B) 44 years

(C) 38 years (D) 70 years

5. A closed container holds 2 moles of a monatomic ideal gas, and its temperature is lowered by 50 K. The decrease in the mass of the gas is— ($R = 8.314\ Jmol^{-1}K^{-1}$)

(A) 4.16×10^{-6} kg (B) 2.31×10^{-14} kg

(C) 1.39×10^{-14} kg (D) 6.93×10^{-15} kg

6. The mass of a metre scale moving along its length is 2.5 times its rest mass. The length of the scale while in motion is—

(A) 0.6 m (B) 0.16 m (C) 2.5 m (D) 0.4 m

7. Light of 600 nm is incident normally on a single slit of width 0.2 mm. The angular separation between the first minima on the two sides of the central maximum is—

(A) 0.172° (B) 0.688°

(C) 0.516° (D) 0.344°

8. Light of 500 nm is incident on a single slit of width 0.1 mm, and a screen is placed at the focal plane of a lens of focal length 40 cm. What is the distance of the first minimum from the centre?

(A) 4 mm (B) 2 mm (C) 1 mm (D) 0.2 mm

9. Unpolarized light of intensity I_0 passes through 6 polarizers placed in succession, each with its axis inclined at 15° to the previous one. The intensity emerging from the last polarizer is—

(A) $0.42I_0$ (B) $0.354I_0$

(C) $0.707I_0$ (D) $0.33I_0$

10. In its own frame, a rod of length 2 m lies at rest at an angle of 60° to the x-axis. What angle with the x-axis will be measured for the rod from a frame moving along the x-axis at 0.8c?

(A) 60° (B) 70.9° (C) 46.1° (D) 36°

11. Placing a plate of refractive index 1.5 in front of one slit of a double slit shifts the central fringe by 5 fringes. If the shift with another plate of the same thickness is 7 fringes, what is the refractive index of the second plate?

(A) 1.7 (B) 2.1 (C) 1.4 (D) 1.6

12. In a double-slit experiment, the distance between the centres of the two slits is 1.2 mm and the width of each slit is 0.3 mm. The number of interference bright fringes observable within the central diffraction maximum of a single slit is—

(A) 4 (B) 9 (C) 7 (D) 8

13. In the rest frame, two events occur 9×10^8 m apart and 5 s apart in time. At what speed along the x-axis must a frame move for the time interval between the events to be measured as 4 s?

(A) 0.6c (B) 0.2c (C) 0.36c (D) 0.8c

14. Two trains of proper length 100 m approach each other, each at 0.6c relative to the ground. How long does the other train take to pass completely by an observer on one of the trains, as that observer measures it?

(A) 2.78×10^{-7} s (B) 1.78×10^{-7} s

(C) 2.22×10^{-7} s (D) 3.78×10^{-7} s

15. A radio station broadcasts uniformly in all directions. The intensity at a distance of 30 km is how many times the intensity at 10 km?

(A) 3 (B) $\frac{1}{3}$ (C) $\frac{1}{9}$ (D) $\frac{1}{27}$

16. For $v \ll c$, the relativistic velocity addition formula $u = \frac{u'+v}{1+\frac{u'v}{c^2}}$ reduces to—

(A) $u = u' - v$ (B) $u = \frac{u'v}{c}$

(C) $u = u' + v$ (D) $u = c$

17. If the moving length of a rocket is one-quarter of its rest length, the speed of the rocket is—

(A) $\frac{\sqrt{3}}{2}c$ (B) $\frac{15}{16}c$

(C) $\frac{3}{4}c$ (D) $\frac{\sqrt{15}}{4}c$

18. In Young's experiment in air, the fringe width is 0.9 mm. If the whole setup is immersed in water of refractive index $\frac{4}{3}$, the fringe width becomes—

(A) 0.506 mm (B) 1.2 mm

(C) 0.9 mm (D) 0.675 mm

19. The moving mass of an electron moving at 0.8c is— ($m_0 = 9.11 \times 10^{-31}$ kg)

(A) 1.52×10^{-30} kg (B) 5.47×10^{-31} kg

(C) 2.53×10^{-30} kg (D) 1.14×10^{-30} kg

20. An aeroplane moves at 600 ms^{-1}. After how much time by the Earth's clock will the aeroplane's clock fall behind by 1 μs?

(A) 5×10^5 s (B) 2.5×10^5 s

(C) 10^6 s (D) 1500 s

21. In free space, the electric field of an electromagnetic wave is $E = 2 \times 10^{-4} \sin(9.42 \times 10^{14}t - 3.14 \times 10^6 x)$ Vm^{-1}. The wavelength and frequency are, respectively—

(A) 2 μm, 9.42×10^{14} Hz (B) 0.32 μm, 1.5×10^{14} Hz

(C) 1 μm, 3×10^{14} Hz (D) 2 μm, 1.5×10^{14} Hz

22. In a double-slit experiment, the fringe width for light of frequency 4.5×10^{14} Hz is 0.5 mm. If light of frequency 7.5×10^{14} Hz is used, the decrease in fringe width is—

(A) 0.2 mm (B) 0.3 mm

(C) 0.33 mm (D) 0.83 mm

23. A filter is placed in front of one of two slits of equal intensity, reducing the intensity of the light from that slit to 64% of its former value. The new ratio of maximum to minimum intensity in the interference pattern is—

(A) 25 : 16 (B) 81 : 1 (C) 9 : 1 (D) 41 : 9

24. In a grating, the second-order diffraction angle for 600 nm light is 25°. The number of lines per centimetre is—

(A) 7044 (B) 352200 (C) 3522 (D) 7553

25. Sunlight reflected from a glass surface of refractive index 1.5 is completely polarized. At what angle to the glass surface does the sun's ray strike it?

(A) 56.3° (B) 33.7° (C) 41.8° (D) 48.2°

26. One light-year in air is 9.46×10^{12} km. The distance light travels in one year in glass of refractive index 1.6 is—

(A) 9.46×10^{12} km (B) 5.91×10^{12} km

(C) 3.7×10^{12} km (D) 1.51×10^{13} km

27. In Young's experiment with 500 nm light, 10 fringes are formed over 3 cm of a screen 2.4 m away. The distance between the two slits is—

(A) 0.04 mm (B) 0.4 mm

(C) 0.36 mm (D) 4 mm

28. A molecule absorbs a photon of wavelength 150 nm and emits two photons. If one of them has wavelength 200 nm, the wavelength of the other is—

(A) 50 nm (B) 350 nm

(C) 85.7 nm (D) 600 nm

29. In free space, if the amplitude of the magnetic field of an electromagnetic wave is 3×10^{-6} T, the average intensity of the wave is—

(A) 1070 Wm^{-2} (B) 2150 Wm^{-2}

(C) 3.58×10^{-6} Wm^{-2} (D) 2.7×10^{-3} Wm^{-2}

30. A photon of energy 3.6 eV is incident on a metal surface of work function 3.0 eV. The impulse required to stop the electron emitted with maximum kinetic energy is—

(A) 4.18×10^{-25} $kgms^{-1}$ (B) 2.96×10^{-25} $kgms^{-1}$

(C) 9.6×10^{-20} $kgms^{-1}$ (D) 1.02×10^{-24} $kgms^{-1}$

31. A grating has 7000 lines per centimetre. What is the angular separation between the second-order lines of sodium at 589.0 nm and 589.6 nm?

(A) 0.043° (B) 0.085°

(C) 0.048° (D) 0.26°

32. In Young's experiment, the slit separation is 0.25 mm and the screen distance is 1.2 m. If the fourth bright fringe forms 9.6 mm from the central bright fringe, what is the wavelength of the light?

(A) 500 nm (B) 571 nm (C) 625 nm (D) 400 nm

33. A gamma photon of wavelength 0.010 nm is scattered through 60° by a free electron. The energy of the scattered photon is—

(A) 124.2 keV (B) 99.99 keV

(C) 83.67 keV (D) 110.8 keV

34. If the kinetic energy of a proton is 80% of its total energy, the speed of the proton is—

(A) $\frac{\sqrt{24}}{5}c$ (B) $\frac{4}{5}c$ (C) $\frac{3}{5}c$ (D) $\frac{\sqrt{21}}{5}c$

35. What potential difference is required to accelerate an electron from rest to 0.6c? (E_0 = 0.511 MeV)

(A) 128 kV (B) 307 kV (C) 92 kV (D) 639 kV

36. In the graph of eV_s versus $\frac{1}{\lambda}$ for three metals, the intercepts on the $\frac{1}{\lambda}$ axis are 0.002, 0.003 and 0.005 nm^{-1} respectively. The ratio of the work functions of the three metals is—

(A) 4 : 9 : 25 (B) 15 : 10 : 6

(C) 2 : 3 : 5 (D) 5 : 3 : 2

37. A metre stick passes an observer at 0.6c along its length. In the observer's frame, the time of passage is —

(A) 5.56 ns (B) 3.33 ns

(C) 2.67 ns (D) 4.44 ns

38. A radioactive sample has a half-life of 5 years on Earth. If the sample is in a vehicle moving at 0.8c, what is its half-life as measured by an observer on Earth?

(A) 3 years (B) 5 years

(C) 8.33 years (D) 13.9 years

39. What will a passenger in a spaceship moving at nearly the speed of light observe about the rate of time on their own wristwatch, in their own frame?

(A) Slower (B) Faster

(C) Stopped (D) Unchanged

40. In a double-slit experiment with light of frequency 4×10^{14} Hz, the separation of two consecutive bright fringes on a screen 2 m away is 1.5 mm. What will the fringe width be if the screen is moved a further 40 cm away from the slits?

(A) 0.3 mm (B) 2.1 mm (C) 1.2 mm (D) 1.8 mm

41. As the speed of a particle approaches the speed of light, its relativistic mass—

(A) Tends to zero

(B) Remains unchanged

(C) Remains limited to twice the rest mass

(D) Tends to infinity

42. At what speed will the relativistic mass of an electron equal the rest mass of a proton? ($m_e = 9.11 \times 10^{-31}$ kg, $m_p = 1.67 \times 10^{-27}$ kg)

(A) $(1 - 5.46 \times 10^{-4})c$ (B) $(1 - 2.73 \times 10^{-4})c$

(C) $(1 - 1.49 \times 10^{-7})c$ (D) c

43. A soap film of refractive index 1.25 in air is illuminated normally with 500 nm light. The second smallest non-zero thickness for which the film appears dark in reflected light is—

(A) 400 nm (B) 200 nm (C) 300 nm (D) 100 nm

44. For a particle moving at $v = \sqrt{0.96}\,c$, the relativistic mass is how many times the rest mass?

(A) 4 (B) 1.02 (C) 5 (D) 25

45. A vehicle moves at 0.5c relative to the Earth. A rocket is thrown backward from it at 0.8c relative to the vehicle. The velocity of the rocket relative to the Earth is—

(A) 0.3c, opposite to the vehicle's motion

(B) 0.5c, along the vehicle's motion

(C) 0.5c, opposite to the vehicle's motion

(D) 0.93c, opposite to the vehicle's motion

46. The photon energy of the light used in Young's experiment is 2.5 eV. Each slit is 0.2 mm from the midpoint between the slits, and the screen is 1.6 m away. The distance of the third bright fringe from the centre is—

(A) 11.9 mm (B) 2.98 mm

(C) 4.97 mm (D) 5.96 mm

47. In Young's experiment with 5880 Å light, placing a 1.2 μm thick plate in front of one slit shifts the central bright fringe by exactly one fringe width. The refractive index of the plate is—

(A) 0.49 (B) 1.25 (C) 1.49 (D) 1.98

48. In Young's experiment with 500 nm light, at the point on the screen where the path difference is 2.25 μm, there will be—

(A) The fourth dark fringe

(B) The fifth dark fringe

(C) The fifth bright fringe

(D) The fourth bright fringe

49. The threshold wavelength of a metal is 2500 Å. Light of what frequency, when incident, produces photoelectrons of maximum energy that can just ionize a hydrogen atom in the ground state?

(A) 1.2×10^{15} Hz (B) 3.28×10^{15} Hz

(C) 2.02×10^{15} Hz (D) 4.48×10^{15} Hz

50. For an electromagnetic wave, $\vec{E} = 300 \sin(kx - \omega t)\,\hat{j}\ \mathrm{Vm^{-1}}$ and $\vec{B} = 10^{-6} \sin(kx - \omega t)\,\hat{k}$ T. The Poynting vector of the wave is—

(A) $238.7 \sin^2(kx - \omega t)\,\hat{i}\ \mathrm{Wm^{-2}}$

(B) $238.7 \sin^2(kx - \omega t)\,(-\hat{i})\ \mathrm{Wm^{-2}}$

(C) $3 \times 10^{-4} \sin^2(kx - \omega t)\,\hat{i}\ \mathrm{Wm^{-2}}$

(D) $119.4 \sin^2(kx - \omega t)\,\hat{k}\ \mathrm{Wm^{-2}}$