Solved Sample Paper

Section II of CUET (UG) is Domain specific. In this section of Physics 40 questions to be attempted out of 50.

Time : 45 minutes

1. In the case of light waves from two coherent sources S_1 and S_2, there will be constructive interference at an arbitrary point P, if the path difference $S_1P - S_2P$ is

(a) $\left(n + \frac{1}{2}\right)\lambda$ (b) $n\lambda$

(c) $\left(n - \frac{1}{2}\right)\lambda$ (d) $\frac{\lambda}{2}$

2. An object is 8 cm high. It is desired to form a real image 4 cm high at 60 cm from the mirror. The type of mirror needed with the focal length is

(a) convex mirror with focal length $f = 40$ cm
(b) convex mirror with focal length $f = 20$ cm
(c) concave mirror with focal length $f = -40$ cm
(d) concave mirror with focal length $f = -20$ cm

3. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is

(a) 802 nm (b) 823 nm
(c) 1882 nm (d) 1648 nm

4. Red, blue, green and violet colour lights are one by one made incident on a photocathode. It is observed that only one colour light produces photoelectrons. That light is

(a) red (b) blue (c) green (d) violet

5. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is

(a) Microwaves are heat waves, so always produce heating.
(b) Infra-red waves produce heating in a microwave oven.
(c) The frequency of the microwaves must match the resonant frequency of the water molecules.
(d) The frequency of the microwaves has no relation with natural frequency of water molecules

6. A ray of light is incident at an angle of incidence i, on one face of a prism of angle A (assumed to be small) and emerges normally from the opposite face. If the refractive index of the prism is μ, the angle of incidence i, is nearly equal to

(a) μA (b) $\frac{\mu A}{2}$ (c) $\frac{A}{\mu}$ (d) $\frac{A}{2\mu}$

7. The energy released by the fission of one uranium atom is 200 MeV. The number of fissions per second required to produce 3.2 W of power is

(Take 1 eV = 1.6×10^{-19} J)

(a) 10^7 (b) 10^{10} (c) 10^{15} (d) 10^{11}

8. The lowest Bohr orbit in hydrogen atom has

(a) the maximum energy (b) the least energy
(c) infinite energy (d) zero energy

9. Which of the following figure represents the electric field lines due to a combination of one positive and one negative charge?

(a) + −

(b) + −

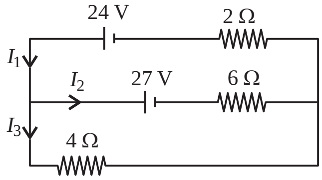
(c) +

(d) + −

10. Consider a uniform electric field in the z-direction. The potential is a constant

(a) for any x for a given z
(b) for any y for a given z
(c) on the x-y plane for a given z
(d) all of these

11. In given circuit, the value of currents I_1, I_2 and I_3 are



(a) 3 A, $\frac{-3}{2}$ A, $\frac{9}{2}$ A (b) $\frac{9}{2}$ A, 3 A, $\frac{-3}{2}$ A
(c) 5 A, 4 A, –3 A (d) 7 A, $\frac{5}{4}$ A, $\frac{9}{2}$ A

12. The magnitude of the magnetic field at the centre of the tightly wound 150 turn coil of radius 12 cm carrying a current of 2 A is
(a) 18 G (b) 19.7 G (c) 15.7 G (d) 17.7 G

13. A solenoid of cross-sectional area 2×10^{-4} m^2 and 900 turns has 0.6 Am^2 magnetic moment. Then the current flowing through it is
(a) 2.24 A (b) 2.34 m A
(c) 3.33 A (d) 3.33 m A

14. In a permanent magnet at room temperature
(a) magnetic moment of each molecule is zero
(b) The individual molecules have non-zero magnetic moment which are all perfectly aligned.
(c) domains are partially aligned
(d) domains are all perfectly aligned.

15. A magnetising field of 1500 A m^{-1} produces flux of 2.4×10^{-5} weber in a iron bar of the cross-sectional area of 0.5 cm^2. The permeability of the iron bar is
(a) 245 (b) 250 (c) 252 (d) 255

16. In the case of an inductor
(a) voltage lags the current by $\frac{\pi}{2}$
(b) voltage leads the current by $\frac{\pi}{2}$
(c) voltage leads the current by $\frac{\pi}{3}$
(d) voltage leads the current by $\frac{\pi}{4}$

17. In an electromagnetic wave in free space the root mean square value of the electric field is $E_{rms} = 6$ Vm^{-1}. The peak value of the magnetic field is
(a) 2.83×10^{-8} T (b) 0.70×10^{-8} T
(c) 4.23×10^{-8} T (d) 1.41×10^{-8} T

18. Diameter of aperture of a plano-convex lens is 6 cm and thickness at the centre is 3 mm. If the speed of light in the material of the lens is 2×10^8 m s^{-1}, the focal length of the lens is
(a) 15 cm (b) 20 cm (c) 30 cm (d) 10 cm

19. In Young's double slit experiment, the distance between two sources is 0.1 mm. The distance of the screen from the source is 20 cm. Wavelength of light used is 5460 Å. The angular position of the first dark fringe is
(a) 0.08° (b) 0.16° (c) 0.20° (d) 0.32°

20. A radioactive sample S_1 having the activity A_1 has twice the number of nuclei as another sample S_2 of activity A_2. If $A_2 = 2A_1$, then the ratio of half life of S_1 to the life of S_2 is
(a) 4 (b) 2 (c) 0.25 (d) 0.75

21. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is
(a) $\frac{5}{2}\lambda$ (b) 3λ (c) 4λ (d) 5λ

22. The constant k in Coulomb's law depends on
(a) nature of medium (b) system of units
(c) intensity of charge (d) both (a) and (b)

23. A cube of side x has a charge q at each of its vertices. The potential due to this charge array at the centre of the cube is
(a) $\frac{4q}{3\pi\varepsilon_0 x}$ (b) $\frac{4q}{\sqrt{3}\pi\varepsilon_0 x}$
(c) $\frac{3q}{4\pi\varepsilon_0 x}$ (d) $\frac{2q}{\sqrt{3}\pi\varepsilon_0 x}$

24. If voltage across a bulb rated 220 V 100 W drops by 2.5% of its rated value, the percentage of the rated value by which the power would decrease is
(a) 20% (b) 2.5% (c) 5% (d) 10%

25. The self inductance L of a solenoid of length l and area of cross-section A, with a fixed number of turns increases as
(a) both l and A increase.
(b) l decreases and A increases.
(c) l increases and A decreases.
(d) both l and A decrease.

26. Light of wavelength 600 nm is incident normally on a slit of width 0.2 mm. The angular width of central maxima in the diffraction pattern is (measured from minimum to minimum)
(a) 6×10^{-3} rad (b) 4×10^{-3} rad
(c) 2.4×10^{-3} rad (d) 4.5×10^{-3} rad

27. In a common emitter (CE) amplifier having a voltage gain A_v, the transistor used has transconductance 0.03 mho and current gain 25. If this transistor is replaced with another one with transconductance

0.02 mho and current gain 20, the voltage gain will be

(a) $\frac{2}{3}A_v$ (b) A_v (c) $\frac{3}{2}A_v$ (d) $\frac{A_v}{2}$

28. Find the energy equivalent of one atomic mass unit in joules and in MeV.

(a) 1.66×10^{-10} J, 93.15 MeV
(b) 2.5×10^{-10} J, 931.5 MeV
(c) 1.5×10^{-10} J, 931.5 MeV
(d) 3×10^{-10} J, 9.315 MeV

29. Electrons of mass m with de-Broglie wavelength λ fall on the target in an X-ray tube. The cutoff wavelength (λ_0) of the emitted X-ray is

(a) $\lambda_0 = \frac{2mc\lambda^2}{h}$ (b) $\lambda_0 = \frac{2h}{mc}$

(c) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ (d) $\lambda_0 = \lambda$

30. Two identical capacitors have the same capacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the combine system is

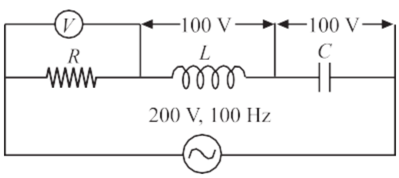
(a) $\frac{C}{4}\left(V_1^2 - V_2^2\right)$ (b) $\frac{C}{4}\left(V_1^2 + V_2^2\right)$

(c) $\frac{C}{4}(V_1 - V_2)^2$ (d) $\frac{C}{4}(V_1 + V_2)^2$

31. A current of 10 A is flowing in a wire of length 1.5 m. A force of 15 N acts on it when it is placed in a uniform magnetic field of 2 T. The angle between the magnetic field and the direction of the current is

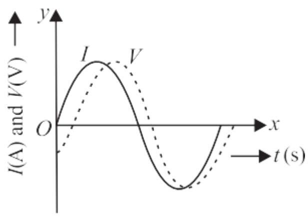
(a) 30° (b) 45° (c) 60° (d) 90°

32. In the circuit shown in figure, what will be the reading of the voltmeter?



(a) 300 V (b) 900 V (c) 200 V (d) 400 V

33. When an ac source of voltage $V = V_0 \sin 100t$ is connected across a circuit, the phase difference between the voltage V and current I in the circuit is observed to be $\pi/4$, as shown in figure. If the circuit consists possibly only of RC or RL or LC in series, find possible values of two elements.



(a) $R = 1$ kΩ, $C = 10$ μF
(b) $R = 1$ kΩ, $C = 1$ μF
(c) $R = 1$ kΩ, $L = 10$ mH
(d) $R = 10$ kΩ, $L = 10$ mH

34. A diver at a depth of 12 m in water $\left(\mu = \frac{4}{3}\right)$ sees the sky in a cone of semivertical angle

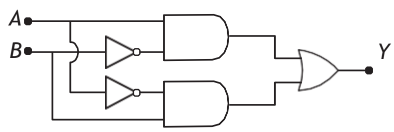
(a) $\sin^{-1}\left(\frac{4}{3}\right)$ (b) $\tan^{-1}\left(\frac{4}{3}\right)$

(c) $\sin^{-1}\left(\frac{3}{4}\right)$ (d) 90°

35. Critical angle for certain medium is $\sin^{-1}$ (0.6). The polarizing angle of that medium is

(a) $\tan^{-1}(1.5)$ (b) $\sin^{-1}(0.8)$
(c) $\tan^{-1}(1.6667)$ (d) $\tan^{-1}(0.6667)$

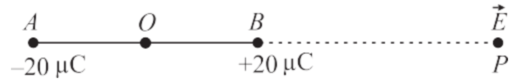
36. In the combination of the following gates the output Y can be written in terms of inputs A and B as



(a) $\overline{A \cdot B}$ (b) $A \cdot \overline{B} + \overline{A} \cdot B$

(c) $\overline{A \cdot B} + A \cdot B$ (d) $\overline{A + B}$

37. Two charges ± 20 μC are placed 10 mm apart. The electric field at point P, on the axis of the dipole 10 cm away from its centre O on the side of the positive charge is

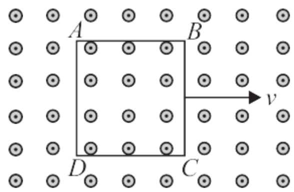


(a) 8.6×10^9 N C^{-1} (b) 4.1×10^6 N C^{-1}
(c) 3.6×10^6 N C^{-1} (d) 4.6×10^5 N C^{-1}

38. In a potentiometer of 10 wires, the balance point is obtained on the 7th wire. To shift the balance point to 9th wire, we should

(a) decrease resistance in the main circuit.
(b) increase resistance in the main circuit.
(c) decrease resistance in series with the cell whose emf is to be measured.
(d) increase resistance in series with the cell whose emf is to be determined.

39. A metallic square loop $ABCD$ is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in figure. An electric field is induced



(a) in AD, but not in BC
(b) in BC, but not in AD
(c) neither in AD nor in BC
(d) in both AD and BC

40. A loop, made of straight edges has six corners at $A(0, 0, 0)$, $B(L, 0, 0)$, $C(L, L, 0)$, $D(0, L, 0)$, $E(0, L, L)$ and $F(0, 0, L)$. A magnetic field $\vec{B} = B_0(\hat{i} + \hat{k})$ T is present in the region. The flux passing through the loop $ABCDEFA$ in that order is

(a) B_0L^2 Wb (b) $2B_0L^2$ Wb
(c) $\sqrt{2}B_0L^2$ Wb (d) $4B_0L^2$ Wb

41. The power and type of lens by which a person can see clearly the distant objects, if the person cannot see objects beyond 40 cm, are
(a) –2.5 D and concave lens
(b) –2.5 D and convex lens
(c) –3.5 D and concave lens
(d) –3.5 D and convex lens

42. In a Young's double slit experiment the intensity of light when slit is at distance λ from central is I. What will be the intensity at the distance of slit is $\frac{\lambda}{6}$?
(a) $\frac{I}{6}$ (b) $\frac{I}{12}$ (c) $\frac{3}{4}I$ (d) $\frac{I}{8}$

43. The current through the ideal diode as shown in the figure is

(a) 0 A (b) 0.02 A
(c) 0.04 A (d) 0.06 A

44. In a hydrogen like atom electron makes transition from an energy level with quantum number n to another with quantum number $(n – 1)$. If $n >> 1$, the frequency of radiation emitted is proportional to
(a) $\frac{1}{n^3}$ (b) $\frac{1}{n}$
(c) $\frac{1}{n^2}$ (d) $\frac{1}{n^{3/2}}$

45. What is the momentum of a photon having frequency 1.5×10^{13} Hz?
(a) 3.3×10^{-29} kg m/s
(b) 3.3×10^{-34} kg m/s
(c) 6.6×10^{-34} kg m/s
(d) 6.6×10^{-32} kg m/s

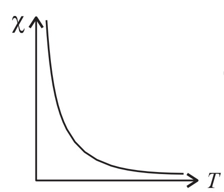
46. A uniform electric field $E = 2 \times 10^3$ N C^{-1} is acting along the positive x-axis. The flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane is
(a) 20 N C^{-1} m^2 (b) 30 N C^{-1} m^2
(c) 10 N C^{-1} m^2 (d) 40 N C^{-1} m^2

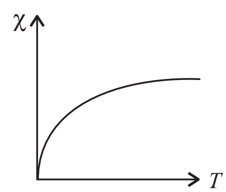
47. In a parallel plate capacitor, the capacity increases if
(a) area of the plate is decreased
(b) distance between the plates increases
(c) area of the plate is increases
(d) dielectric constant decreases.

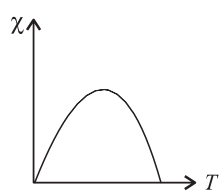
48. In the series combination of two or more than two resistances
(a) the current through each resistance is same
(b) the voltage through each resistance is same
(c) neither current nor voltage through each resistance is same
(d) both current and voltage through each resistance are same.

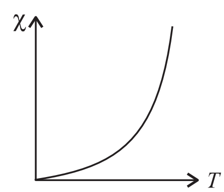
49. A galvanometer coil has a resistance of 15 Ω and the metre shows full scale deflection for a current of 4 mA. To convert the meter into a voltmeter of range 0 to 18 V, the required resistance is
(a) 5885 Ω in series
(b) 4485 Ω in series
(c) 5885 Ω in parallel
(d) 4485 Ω in parallel

50. Point out the best representation of relation between magnetic susceptibility (χ) and temperature (T) for a paramagnetic material.

(a)


(b)


(c)


(d)


ANSWER KEYS

1.	(b)	**2.**	(c)	**3.**	(b)	**4.**	(d)	**5.**	(c)	**6.**	(a)	**7.**	(d)	**8.**	(b)	**9.**	(a)	**10.**	(d)
11.	(a)	**12.**	(c)	**13.**	(c)	**14.**	(c)	**15.**	(d)	**16.**	(b)	**17.**	(a)	**18.**	(c)	**19.**	(b)	**20.**	(a)
21.	(b)	**22.**	(a)	**23.**	(b)	**24.**	(c)	**25.**	(b)	**26.**	(a)	**27.**	(a)	**28.**	(c)	**29.**	(a)	**30.**	(c)
31.	(a)	**32.**	(c)	**33.**	(a)	**34.**	(c)	**35.**	(c)	**36.**	(b)	**37.**	(a)	**38.**	(d)	**39.**	(c)	**40.**	(b)
41.	(a)	**42.**	(c)	**43.**	(b)	**44.**	(a)	**45.**	(a)	**46.**	(a)	**47.**	(c)	**48.**	(a)	**49.**	(b)	**50.**	(a)

Hints &

1. (b) : Constructive interference occurs when the path difference ($S_1P - S_2P$) is an integral multiple of λ.
or $S_1P - S_2P = n\lambda$, where $n = 0, 1, 2, 3, ...$

2. (c) : Here $I = 4$ cm, $O = 8$ cm, $v = -60$ cm

$$\text{Magnification} = \frac{\text{Size of image } (I)}{\text{Size of object } (O)} = \frac{\text{distance of image}}{\text{distance of object}}$$

$$\Rightarrow \frac{I}{O} = -\frac{v}{u}$$

$$u = \frac{O}{I}v = \frac{8}{4}(-60) = -120 \text{ cm}$$

Now, mirror formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\frac{1}{f} = \frac{1}{(-120)} + \frac{1}{(-60)} = -\frac{1}{120} - \frac{1}{60} = \frac{-1-2}{120} = \frac{-3}{120}$$

$$f = -40 \text{ cm}$$

As image is real, inverted, diminished and located between focus and centre of curvature hence the mirror is concave mirror.

3. (b) : The largest wavelength in the ultraviolet region of the hydrogen spectrum corresponds to the transition $n = 2$ to $n = 1$. That is,

$$\frac{1}{122} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) \quad ...(i)$$

The transition from $n = \infty$ to $n = 3$ will produce the smallest wavelength in infrared region of the hydrogen spectrum. So,

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{\infty}\right) \quad ...(ii)$$

Equations (i) and (ii) gives $\lambda = 823.5$ nm

4. (d) : The energy of incident light is $E = h\upsilon$
where h is the Planck's constant and υ is the frequency of incident light.

As $\upsilon_{violet} > \upsilon_{blue} > \upsilon_{green} > \upsilon_{red}$

$\therefore \quad E_{violet} > E_{blue} > E_{green} > E_{red}$

Since the incident energy is maximum for violet colour, therefore violet light produces photoelectrons.

5. (c) : In microwave oven, the frequency of the microwaves must match the resonant frequency of water molecules so that energy from the waves is transferred efficiently to the kinetic energy of the molecules.

6. (a) : As the emergent ray emerges normally from the opposite face,

$\therefore \quad e = 0, r_2 = 0$

As $r_1 + r_2 = A \quad \therefore \quad r_1 = A$

Applying Snell's law for incident ray

$1 \sin i = \mu \sin r_1 = \mu \sin A$

or $\mu = \frac{\sin i}{\sin A}$

For small angle, $\sin i \approx i$, $\sin A \approx A$

$\therefore \quad \mu = \frac{i}{A}$ or $i = \mu A$

7. (d) : Energy released per fission is

$E = 200 \text{ MeV} = 200 \times 10^6 \times 1.6 \times 10^{-19} \text{ J} = 3.2 \times 10^{-11} \text{ J}$

Power, $P = 3.2$ W

Number of fissions per second $= \frac{P}{E}$

$$= \frac{3.2 \text{ W}}{3.2 \times 10^{-11} \text{ J}} = \frac{3.2 \text{ J s}^{-1}}{3.2 \times 10^{-11} \text{ J}} = 10^{11}$$

8. (b) : The energy of n^{th} Bohr orbit in hydrogen atom is

$$E_n = -\frac{13.6}{n^2} \text{ eV}$$

For lowest orbit, $n = 1$

$\therefore \quad E_1 = -13.6$ eV

For highest orbit, $n = \infty$

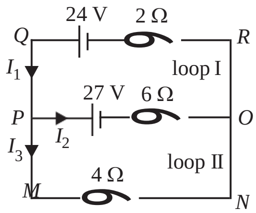
$\therefore \quad E_n = 0$ eV

Thus, the lowest Bohr orbit in hydrogen atom has the least energy.

9. **(a) :** Option (a) represents the electric field lines due to a combination of a positive and one negative charge.

10. **(d) :** As the electric field in the z-direction is uniform, equipotential surfaces are in xy plane. Hence the potential for given z is constant on x-y plane, for any x in this plane and for any y in this plane. So all are correct.

11. **(a) :**



Applying Kirchhoff's voltage law

In loop I, $-27 - 6I_2 - 2I_1 + 24 = 0$

$$6I_2 + 2I_1 = -3 \qquad \text{...(i)}$$

In loop II, $-27 - 6I_2 + 4I_3 = 0$

$$6I_2 - 4I_3 = -27 \qquad \text{...(ii)}$$

At junction P, $\quad I_1 - I_2 - I_3 = 0 \qquad$ ...(iii)

Solving equations (i), (ii) and (iii) we get

$I_1 = 3$ A, $I_2 = -3/2$ A, $I_3 = 9/2$ A.

12. **(c) :** Here, $N = 150$;

$r = 12$ cm $= 12 \times 10^{-2}$ m

$I = 2$A

$$B = \frac{\mu_0 NI}{2R} = \frac{2\pi \times 10^{-7} \times 150 \times 2}{12 \times 10^{-2}} = 1.57 \times 10^{-3} \text{ T}$$

$$= 1.57 \times 10^{-3} \text{ T} = 15.7 \times 10^{-4} \text{ T} = 15.7 \text{ G}$$

13. **(c) :** Here, $N = 900$ turns, $A = 2 \times 10^{-4}$ m^2, $m_s = 0.6$ A m^2

The magnetic moment of solenoid

$$m_s = NIA$$

The current flowing through the solenoid is

$$I = \frac{m_s}{NA} = \frac{0.6}{900 \times 2 \times 10^{-4}} = 3.33 \text{ A}$$

14. **(c) :** In a permanent magnet at room temperature, domains are partially aligned.

15. **(d) :** Here, $H = 1500$ A m^{-1}, $\phi = 2.4 \times 10^{-5}$ weber

$A = 0.5$ cm^2 $= 0.5 \times 10^{-4}$ m^2

$$\therefore \quad B = \frac{\phi}{A} = \frac{2.4 \times 10^{-5}}{0.5 \times 10^{-4}} = 4.8 \times 10^{-1} \text{ T}$$

and $\mu = \dfrac{B}{H} = \dfrac{4.8 \times 10^{-1}}{1500} = 3.2 \times 10^{-4}$

So relative permeability

$$\mu_r = \frac{\mu}{\mu_0} = \frac{3.2 \times 10^{-4}}{4\pi \times 10^{-7}} = 0.255 \times 10^{3} = 255$$

16. **(b) :** In an inductor voltage leads the current by $\dfrac{\pi}{2}$ or current lags the voltage by $\dfrac{\pi}{2}$.

17. **(a) :** Given: $E_{rms} = 6$ V m^{-1}

$$\frac{E_{rms}}{B_{rms}} = c \text{ or } B_{rms} = \frac{E_{rms}}{c}$$

$$B_{rms} = \frac{6}{3 \times 10^8} = 2 \times 10^{-8} \text{ T}$$

Since, $B_{rms} = \dfrac{B_0}{\sqrt{2}}$

where B_0 is the peak value of magnetic field.

$$\therefore B_0 = B_{rms}\sqrt{2} = 2 \times 10^{-8} \times \sqrt{2} \text{ T}$$

$$B_0 \approx 2.83 \times 10^{-8} \text{ T}$$

18. **(c) :** Here, $r = \dfrac{6}{2} = 3$ cm, $t = 3$ mm $= 0.3$ cm.

If R_2 is radius of curvature of convex surface, then $2R_2t = r^2$

$$\therefore \quad R_2 = \frac{r^2}{2t} = \frac{3 \times 3}{2 \times 0.3} = 15 \text{ cm}, R_1 = \infty$$

and $\mu = \dfrac{c}{v} = \dfrac{3 \times 10^8}{2 \times 10^8} = \dfrac{3}{2}$

As $\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$$\therefore \quad \frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{\infty} - \frac{1}{-15}\right) = \frac{1}{30} \Rightarrow f = 30 \text{ cm}$$

19. **(b) :** For first dark fringe ($n = 1$)

$$x = (2n - 1)\frac{\lambda D}{2d} = \frac{\lambda D}{2d}$$

Angular position, $\theta = \dfrac{x}{D} = \dfrac{\lambda}{2d} = \dfrac{5460 \times 10^{-10}}{2 \times 10^{-4}}$ radian

$$= 2730 \times 10^{-6} \times \frac{180}{\pi} \text{ degree} = 0.16°$$

20. **(a) :** Activity, $A = \lambda N = \dfrac{0.693}{T} N$

where T is the half life of a radioactive sample

$$\therefore \quad \frac{A_1}{A_2} = \frac{N_1}{T_1} \times \frac{T_2}{N_2}$$

$$\frac{T_1}{T_2} = \frac{A_2}{A_1} \times \frac{N_1}{N_2} = \frac{2A_1}{A_1} \times \frac{2N_2}{N_2} = \frac{4}{1}$$

21. **(b) :** According to Einstein's photoelectric equation,

$$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$\therefore$ As per question, $eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ...(i)

$\frac{eV}{4} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$ ...(ii)

From equations (i) and (ii), we get

$$\frac{hc}{2\lambda} - \frac{hc}{4\lambda} = \frac{hc}{\lambda_0} - \frac{hc}{4\lambda_0} \Rightarrow \frac{hc}{4\lambda} = \frac{3hc}{4\lambda_0} \text{ or } \lambda_0 = 3\lambda$$

22. (a) : The value of $k = \frac{1}{4\pi\varepsilon_0}$

where ε_0 is permittivity of free space

$= 8.854 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

23. (b) : The length of diagonal of the cube of each side x is $\sqrt{3x^2} = x\sqrt{3}$

$\therefore$ Distance between centre of cube and each vertex,

$r = \frac{x\sqrt{3}}{2}$

Now, potential, $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

Since cube has 8 vertices and 8 charges each of value q are present there

$$\therefore \quad V = \frac{1}{4\pi\varepsilon_0}\frac{8q}{\frac{x\sqrt{3}}{2}} = \frac{4q}{\sqrt{3}\pi\varepsilon_0 x}$$

24. (c) : Power, $P = \frac{V^2}{R}$

As the resistance of the bulb is constant

$\therefore \quad \frac{\Delta P}{P} = \frac{2\Delta V}{V}$

% decrease in power $= \frac{\Delta P}{P} \times 100 = \frac{2\Delta V}{V} \times 100$

$= 2 \times 2.5\% = 5\%$

25. (b) : The self inductance L of a solenoid of length l and area of cross section A with fixed number of turns is

$$L = \frac{\mu_0 N^2 A}{l}$$

So, L increases when l decreases and A increases.

26. (a) : Here, $\lambda = 600$ nm $= 6 \times 10^{-7}$ m

$a = 0.2$ mm $= 2 \times 10^{-4}$ m, $\theta = ?$

Angular width of central maxima,

$$\theta = \frac{2\lambda}{a} = \frac{2 \times 6 \times 10^{-7}}{2 \times 10^{-4}} = 6 \times 10^{-3} \text{ rad}$$

27. (a) : $A_v = \beta\frac{R_{out}}{R_{in}} = 25\frac{R_{out}}{R_{in}}$

$\because \quad G_m = \frac{\beta}{R_{in}} \Rightarrow R_{in} = \frac{\beta}{G_m} = \frac{25}{0.03}$

$\therefore \quad A_v = 25\frac{R_{out}}{25} \times 0.03$

Now, $A_v' = 20\frac{R_{out}}{20} \times 0.02 = \frac{2}{3}A_v$

28. (c) : Here, $m = 1$ u $= 1.6605 \times 10^{-27}$ kg

According to Einstein's mass-energy equivalence relation,

$E = mc^2$

$= (1.6605 \times 10^{-27}\text{ kg})(2.9979 \times 10^8\text{ m s}^{-1})^2$

$= 1.4924 \times 10^{-10}\text{ J} \approx 1.5 \times 10^{-10}\text{ J}$

$$E = \frac{1.4924 \times 10^{-10}}{1.602 \times 10^{-19}}\text{ eV}$$

$= 0.9315 \times 10^9$ eV $= 931.5 \times 10^6$ eV $= 931.5$ MeV

29. (a) : Kinetic energy of electrons

$$K = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m} = \frac{h^2}{2m\lambda^2}$$

So, maximum energy of photon $= K$

$$\frac{hc}{\lambda_0} = \frac{h^2}{2m\lambda^2} \quad \therefore \lambda^0 = \frac{2mc\lambda^2}{h}$$

30. (c) : Initial energy of the combined system

$$U_1 = \frac{1}{2}CV_1^2 + \frac{1}{2}CV_2^2 = \frac{C}{2}\left(V_1^2 + V_2^2\right)$$

On joining the two condensers in parallel, common potential

$$V = \frac{CV_1 + CV_2}{C + C} = \frac{V_1 + V_2}{2}$$

$\therefore$ Final energy of the combined system

$$U_2 = \frac{1}{2}(C + C)\left(\frac{V_1 + V_2}{2}\right)^2$$

Decrease in energy

$$\Delta U = U_1 - U_2 = \frac{1}{2}C\left(V_1^2 + V_2^2\right) - \frac{1}{2}(2C)\left(\frac{V_1 + V_2}{2}\right)^2$$

$$= \frac{C}{2}\left[2\left(V_1^2 + V_2^2\right) - \left(V_1 + V_2\right)^2\right]$$

$$= \frac{C}{4}\left[2V_1^2 + 2V_2^2 - V_1^2 - V_2^2 - 2V_1V_2\right] = \frac{C}{4}(V_1 - V_2)^2$$

31. (a) : As, $F = IlB\sin\theta$ or $\sin\theta = \frac{F}{IlB}$

$$\sin\theta = \frac{15}{10 \times 1.5 \times 2} = \frac{1}{2}$$

or $\theta = 30°$

32. (c) : Here, $V_L = V_C = 100$ V, $V = 200$ V

As $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

$\therefore \quad 200 = \sqrt{V_R^2 + (100-100)^2} = V_R$

or $\quad V_R = 200$ V

33. (a) : Figure given in the question shows that current I leads the voltage V by a phase angle $\pi/4$. Therefore, the circuit can be RC circuit alone.

$$\tan\phi = \frac{X_C}{R} = \frac{1}{\omega CR} \qquad \left(\because X_C = \frac{1}{\omega C}\right)$$

$$\tan\frac{\pi}{4} = \frac{1}{\omega CR}$$

$$1 = \frac{1}{\omega CR} \qquad \text{...(i)}$$

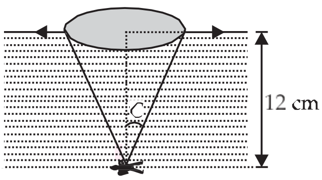
From $V = V_0 \sin 100t$, we get

$\omega = 100$ rad s^{-1}

$$\therefore \quad CR = \frac{1}{\omega} = \frac{1}{100} \qquad \text{(Using (i))}$$

When $R = 1$ k$\Omega = 10^3\ \Omega$

and $C = \dfrac{1}{10^5} = 10^{-5}$ F $= 10\ \mu$F

34. (c) : 

$$\sin C = \frac{1}{\mu}\ ;\ C = \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{3}{4}\right)$$

35. (c) : Here, critical angle, $C = \sin^{-1}(0.6)$

As, $\quad \sin C = \dfrac{1}{\mu}$

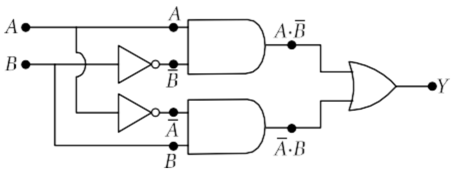
where μ is the refractive index of the medium

$$\mu = \frac{1}{\sin C} = \frac{1}{\sin(\sin^{-1}(0.6))} = \frac{1}{0.6}$$

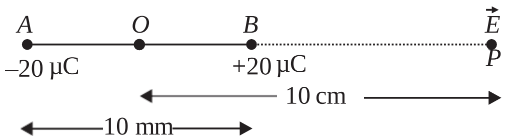
According to Brewster's law

$\mu = \tan i_p$, where i_p is the polarizing angle

$$i_p = \tan^{-1}(\mu) = \tan^{-1}\left(\frac{1}{0.6}\right) = \tan^{-1}(1.6667)$$

36. (b) : 

$$Y = (A\cdot\overline{B} + \overline{A}\cdot B)$$

37. (a) : 

Here, $q = \pm 20\ \mu$C $= \pm 20 \times 10^{-6}$ C

or $\quad 2a = 10$ mm $= 10 \times 10^{-3}$ m

$r = OP = 10$ cm $= 10 \times 10^{-2}$ m

$|p| = q \times 2a = 20 \times 10^{-6} \times 10 \times 10^{-3}$ m $= 2 \times 10^{-7}$ m

The electric field along BP, $E = \dfrac{2\vec{p}\,r}{4\pi\varepsilon_0 (r^2 - a^2)^2}$

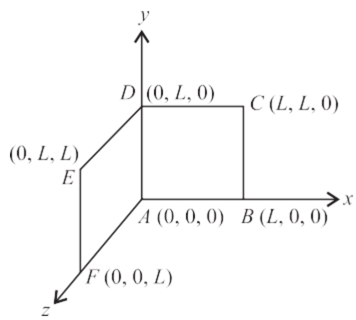
As $\quad a << r$,

$$\vec{E} = \frac{2|\vec{p}|}{4\pi\varepsilon_0 r^3} = \frac{2\times 2\times 10^{-7}\times 9\times 10^9}{(10\times 10^{-2})^3} = 3.6 \times 10^6 \text{ N C}^{-1}$$

38. (d) : To shift the balance point on higher length, the potential gradient of the wire is to be decreased. The same can be obtained by decreasing the current of the main circuit, which is possible by increasing the resistance in series of potentiometer wire.

39. (c) : The electric field/emf is induced neither in sides AD and nor in BC. Unless the metallic square loop is entering or leaving the magnetic field and the flux linked with it is changing.

40. (b) : Here, $B = B_0(\hat{i} + \hat{k})$ T



Area vector of $ABCD = L^2\hat{k}$

Area vector of $DEFA = L^2\hat{i}$

Total area vector, $\vec{A} = L^2(\hat{i} + \hat{k})$

Total magnetic flux, $\phi = \vec{B}\cdot\vec{A}$

$= B_0(\hat{i} + \hat{k})\cdot L^2(\hat{i} + \hat{k}) = B_0L^2(1+1) = 2B_0L^2$ Wb

41. (a) : Here, in this case lens used by person should form the image of distant object at a distance of 40 cm in front of it

$\therefore \quad u = -\infty,\ v = -40$ cm

and $\dfrac{1}{f} = \dfrac{1}{v} - \dfrac{1}{u}$ $\quad$ or, $\dfrac{1}{f} = \dfrac{1}{-40} - \dfrac{1}{-\infty}$

or, $\dfrac{1}{f} = \dfrac{1}{-40}$ $\quad$ or $\quad f = -40$ cm

Power $= \dfrac{100}{f} = \dfrac{100}{-40} = -2.5$ D

Negative sign shows that lens used is concave lens.

42. (c) : As, $\phi = \frac{2\pi}{\lambda}\Delta x \Rightarrow \phi = \frac{2\pi}{\lambda}\lambda = 2\pi$

$\therefore \quad I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$= I' + I' + 2I'\cos 2\pi$

$I = 2I' + 2I' = 4I'$

When $\Delta x = \frac{\lambda}{6}$, then $\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{2\pi}{6}$

$\therefore \quad I_1 = I' + I' + 2\sqrt{I'I'}\cos\frac{2\pi}{6}$

$I_1 = 2I' + 2I'(1/2)$ or $I_1 = 3I'$

$\therefore \quad \frac{I_1}{I} = \frac{3I'}{4I'} = \frac{3}{4}$ or $I_1 = \frac{3}{4}I$

43. (b) : Here, the diode is forward biased .

$\therefore$ The current through the diode is

$$I = \frac{6\text{ V} - 3\text{ V}}{150\ \Omega} = \frac{3\text{ V}}{150\ \Omega} = 0.02\text{ A}$$

44. (a) : In a hydrogen like atom, when an electron makes an transition from an energy level with n to $n - 1$, the frequency of emitted radiation is

$$\upsilon = RcZ^2\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right] = \frac{RcZ^2(2n-1)}{n^2(n-1)^2}$$

As $n >> 1$

$$\therefore \quad \upsilon = \frac{RcZ^2 2n}{n^4} = \frac{2RcZ^2}{n^3} \quad \text{or} \quad \upsilon \propto \frac{1}{n^3}$$

45. (a) : Energy of a photon, $E = h\upsilon$

Momentum of a photon, $p = \frac{E}{c} = \frac{h\upsilon}{c}$

$$p = \frac{(6.6 \times 10^{-34}\text{ J s})(1.5 \times 10^{13}\text{ Hz})}{3 \times 10^8\text{ m/s}}$$

$= 3.3 \times 10^{-29}$ kg m/s

46. (a) : Here, $E = 2 \times 10^3$ N C^{-1} is along + direction x-axis

Surface area, $s = (10\text{ cm})^2 = 10^2 \times 10^{-4}\text{ m}^2 = 10^{-2}\text{ m}^2$

when plane is parallel to yz plane, $\theta = 0°$

So $\phi = E\,s\cos\theta = 2 \times 10^3 \times 10^{-2}\cos 0° = 20$ N C^{-1} m^2

47. (c) : In a parallel plate capacitor, the capacity of capacitor

$$C = \frac{K\varepsilon_0 A}{d}$$

i.e., $C \propto A$

The capacity of capacitor increases if area of the plate is increased.

48. (a) : In series combination, current across its circuit components is always constant and in parallel combination the voltage across the circuit components is constant.

49. (b) : The galvanometer can be transformed into a voltmeter by applying a high resistance in series. If the series resistance is R, then total resistance in circuit $= (15 + R)\ \Omega$

Now $$15 + R = \frac{V}{I} = \frac{18}{4 \times 10^{-3}} = \frac{18 \times 10^3}{4} = 4.5 \times 10^3$$

$\therefore \quad R = 4500 - 15 = 4485\ \Omega$

50. (a) : According to curie's law

$$\chi = \frac{C\mu_0}{T}$$

$\Rightarrow \quad \chi \propto 1/T$

i.e., magnetic susceptibility is inversely proportional to temperature hence graph (a) is best representation of this relation.