Code Number: **A**

Aakash
Medical | IIT-JEE | Foundations
Corp. Office: Aakash Educational Services Limited, 3rd Floor, Incuspaze Campus- 2, Plot No. 13, Sector- 18, Udyog Vihar, Gurugram, Haryana - 122015

Time: 3 hrs. **Mock Test Paper for Class-XII** **Max. Marks: 70**

PHYSICS

Answers & Solutions

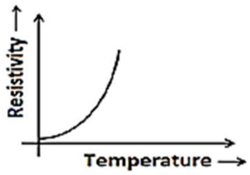
1. Answer (b)
2. Answer (d)
3. Answer (a)
4. Answer (a)
5. Answer (d)
6. Answer (b)
7. Answer (c)
8. Answer (c)
9. Answer (a)
10. Answer (b)
11. Answer (c)
12. Answer (a)
13. Answer (d)
14. Answer (d)
15. Answer (b)
16. electric dipole moment
17. magnetic flux
18. greater than
19. half of
20. photon
21. **Statement:** The electrostatic force between two stationary point charges is directly proportional to the product of the magnitude of the two charges and inversely proportional to the square of the distance between charges.

    Explanation: If q_1 and q_2 are the two point charges at rest separated by a distance 'r', then by

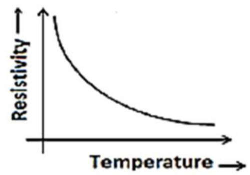
    Coulomb's law. $F \propto \frac{|q_1q_2|}{r^2} \Rightarrow F = K\frac{|q_1q_2|}{r^2}$

Where, K is proportionality constant and $K = \frac{1}{4\pi\varepsilon_0}$ for air/vacuum in SI system

OR $F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1 q_2|}{r^2}$

22. 

(i) Copper



(ii) Semiconductor

23. The total force on a moving charge in the presence of both electric field and magnetic fields is called the Lorentz force.

Expression: Lorentz force, $\vec{F} = q\left[\vec{E} + \vec{v} \times \vec{B}\right]$

24. Induced emf: $|\varepsilon| = L\frac{di}{dt}$

$\Rightarrow 20 = L\left(\frac{2-0}{0.1}\right) \Rightarrow$ Self inductance : L = 1H

25. • Infrared lamps are used in physical therapy.
- In remote switches of household electronic systems such as TV sets, video recorders, hi-fi systems.
- Infrared detectors are used in Earth satellites, both for military purposes and to observe growth of crops.
- Infrared radiation is used to maintain earth's warmth or average temperature through the greenhouse effect.

26. The power of a lens is defined as the tangent of the angle by which it converges or diverges a beam of light falling at unit distant from the optical centre.

OR

Power of a lens is the reciprocal of its focal length expressed in metre.

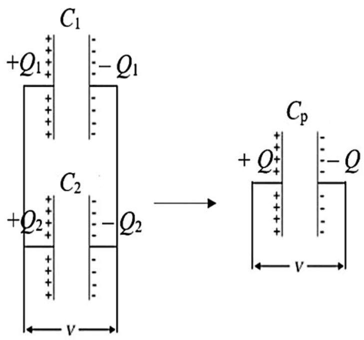
The SI unit for power of a lens is dioptre

27. • There is no chromatic aberration in a mirror.
- Using parabolic reflecting surface(mirrors), spherical aberration is also removed.
- Providing mechanical support is much less of a problem since a mirror weighs much less than a lens.

28. (i) Temperature and (ii) doping concentration.

29. • Electric field lines start from positive charge and end at negative charge.
  For a single charge, they may start or end at infinity.
- In a charge-free region, electric field lines are continuous curves without any break.
- Two field lines can never cross each other (never intersect each other).
- A tangent drawn to a field line at any point gives the direction of electric field at that point.
- Density of field lines is a measure of the strength of electric field.
- Electrostatic field lines do not form any closed loops.

30. Labelled diagram



Let 2 capacitors C_1, C_2 be connected in parallel across a voltage V.

Let C_p be the effective capacitance of the combination.

For the first capacitor, charge $= Q_1 = C_1V$

For the second capacitor, charge $= Q_2 = C_2V$

For the equivalent capacitor, charge $= Q = C_pV$

As the capacitors are in parallel, Total charge $= Q = Q_1 + Q_2$

$$\Rightarrow C_pV = C_1V + C_2V$$

$$\Rightarrow C_p = C_1 + C_2$$

31. Torque: $\tau = NIAB\sin\theta$

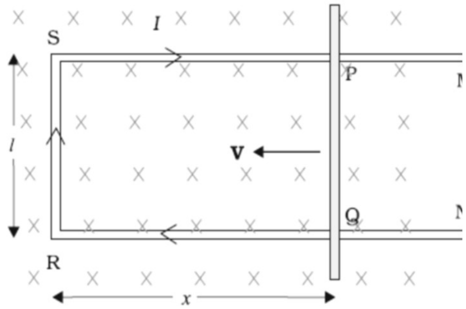
$$\tau = 50 \times 10 \times (0.1 \times 0.1) \times 0.80 \times (\sin 30°)$$

$$\tau = 2 \text{ Nm}$$

32.

Diamagnetic material	**Paramagnetic material**
These are repelled by a magnet.	These are attracted by a magnet.
The magnetic susceptibility is negative $(\chi < 0)$	The magnetic susceptibility is positive $(\chi > 0)$
The relative permeability (μ_r) less than one, $\mu_r < 1$	The relative permeability is more than one. $\mu_r > 1$
The magnetic susceptibility (or magnetisation) is independent of temperature.	The magnetic susceptibility (or magnetisation) is inversely proportional to absolute temperature.
These are weakly magnetised in the opposite direction when placed in external magnetic field.	These are weakly magnetised in the same direction when placed in an external magnetic field.

33. Labelled diagram (current direction not necessary)



Magnetic flux enclosed by the loop PQRS is $\phi_B = BA\cos 0 = BA = Blx$

Induced emf $\varepsilon = \frac{d\phi_B}{dt}$

$\varepsilon = \frac{d}{dt}(Blx) = -Bl\frac{dx}{dt} = Blv \quad (\because -dx/dt = v)$

34. • The photoelectric emission is an instantaneous process

• For a given photosensitive material, threshold frequency of incident radiation, the photoelectric current is directly proportional to the intensity of incident light.

• For a given photosensitive material and frequency of incident radiation, saturation current is found to be proportional to the intensity of incident radiation whereas the stopping potential is independent of its intensity.

• Above the threshold frequency, the stopping potential or equivalently the maximum kinetic energy of the emitted photoelectrons increases linearly with the frequency of the incident radiation but is independent of its intensity.

• For a given photosensitive material, there exists a certain minimum cut-off frequency of the incident radiation, below which no emission of photoelectrons takes place.

35. • Bohr's first postulate: An electron in an atom could revolve in certain stable orbits without the emission of radiant energy.

• Bohr's second postulate: An electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of h/2π, where h is the Planck's constant.

• Bohr's third postulate: An electron might make a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states.

36. • The nuclear force is much stronger than the Coulomb force between charges or the gravitational force.

• The nuclear force is a short-range force.

• The nuclear force does not depend on the electric charge.

• The nuclear force is a saturation of force

37. **Definition:**

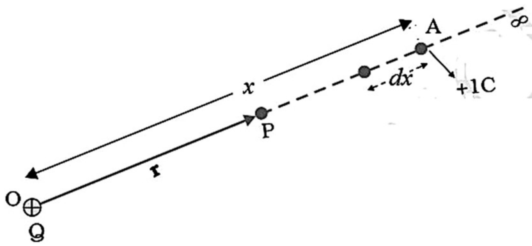
The electrostatic potential at any point in an electrostatic field is defined as the work done in carrying a unit positive charge from infinity to that point against the electrostatic force of the field.

Derivation:

Let us calculate the potential due to this charge at a point P at a distance r from Q.

Suppose a unit positive charge (+1C) is brought radially from infinity to P.

Consider an intermediate point A at a distance x from the charge. Let the unit positive charge be displaced by a small displacement dx.



The force between Q and +1C, at this point is given by: $F = \frac{1}{4\pi\varepsilon_0}\frac{Q \times 1}{x^2}$

The work done to move the unit positive charge through a distance dx is: $dW = F\,dx\,\cos\theta = -\frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}dx$

Therefore, the total work done is equal is given by: $W = \int_{\infty}^{r} dW = \int_{\infty}^{r} -\frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}dx = -\frac{Q}{4\pi\varepsilon_0}\int_{\infty}^{r}\frac{1}{x^2}dx = -\frac{Q}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_{\infty}^{r}$

$\Rightarrow W = +\frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{\infty}\right] = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

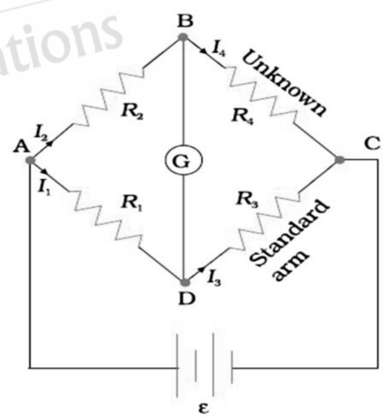
This is the work done to move the unit positive charge from infinity to point P.

By definition, it is equal to the electric potential at P.

$W = V$

$\therefore V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

38. Labelled circuit diagram with arrows for currents.



Let four resistors R_1, R_2, R_3 and R_4 be connected to form Wheatstone bridge. Let the currents through the resistors be I_1, I_2, I_3 and I_4 respectively. When the bridge is balanced, **no current flows through galvanometer** G, i.e., $I_g = 0$.

Applying Kirchhoff's junction rule to the junctions D and B when $I_g = 0$, gives $I_1 = I_3$ and $I_2 = I_4$.

Taking $I_g = 0$ and p.d. across G is 0.

Applying Kirchhoff's loop rule to loop ABDA gives,

$$-I_2R_2 + 0 + I_1R_1 = 0 \text{ .... (1)}$$

Applying Kirchhoff's loop rule to loop BCDB gives,

$$-I_4R_4 + I_3R_3 + 0 = 0$$

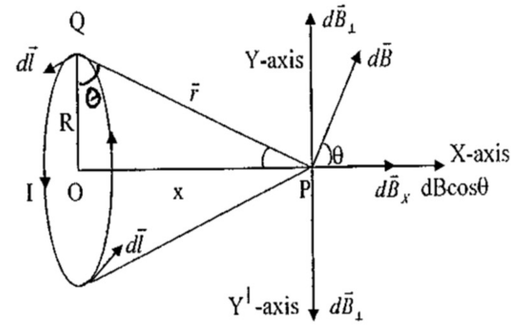
Using $I_3 = I_1$, $I_4 = I_2$, we get $I_2R_4 - I_1R_3 = 0$ .... **(2)**

From **Eq. (1)**, we get, $I_2R_2 = I_1R_1 \Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1}$ .... **(3)**

From **Eq. (2)**, we get, $I_2R_4 = I_1R_3 \Rightarrow \frac{I_1}{I_2} = \frac{R_4}{R_3}$ .... **(4)**

From **Eq.** (3) and **Eq.** (4), the **balance condition** is $\frac{R_2}{R_1} = \frac{R_4}{R_3}$

39. Diagram with arrows for current and field.



Let $\bar{I}$ be the current in the loop of radius R,
θ is angle between r and R.
The magnitude of the magnetic field dB due to $d\vec{l}$ is given by the Biot-Savart's law,

$$dB = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{I\,|d\vec{l} \times \vec{r}|}{r^3}\right) \quad \text{and} \quad r^2 = x^2 + R^2.$$

Any element $d\vec{l}$ of the loop will be perpendicular to the displacement vector $\vec{r}$ from the element to the axial point. Hence $|d\vec{l} \times \vec{r}| = r\,dl \sin 90° = r\,dl$

$$dB = \frac{\mu_0}{4\pi}\frac{I\,r\,dl}{r^3} = \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2} \quad \text{.................. (1)}$$

$d\vec{B}$ has an X-component $\mathbf{dB_x}$ and a component perpendicular to x-axis $\mathbf{dB_\perp}$. When the components **perpendicular to the X-axis** are summed over, they **cancel out**. Thus, **only the X-component (dB cosθ) remains**. The **net magnetic field** along X-axis can be obtained by summing

$dB_x = dB\cos\theta$ ……..**(2)** over the entire loop.

From equations (1) and (2), $dB_x = \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2}\cos\theta$; but $\cos\theta = \frac{R}{r}$ $\quad\therefore\ dB_x = \frac{\mu_0\, I\, dl}{4\pi}\frac{R}{r^3}$

Thus, the magnetic field at P due to the entire circular loop is $B = \sum dB_x = \sum \frac{\mu_0\, I\, dl}{4\pi}\frac{R}{r^3}$

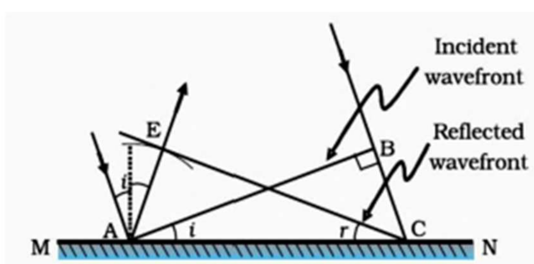
The summation of elements dl over the loop is 2πR, the circumference of the loop. i.e., $\sum dl = 2\pi R$

The magnetic field at P due to the entire circular loop is $B = \frac{\mu_0}{4\pi}\frac{2\pi I R^2}{\left(x^2+R^2\right)^{3/2}} = \frac{\mu_0 I R^2}{2\left(x^2+R^2\right)^{3/2}}$

40. **a) Huygens principle:** (i) Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. (ii)The wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.

b)

Diagram

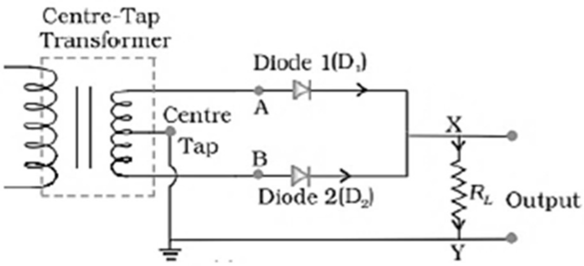


Consider a wavefront AB incident at an angle i on a reflecting surface MN.
Let v be the speed of light wave in the medium.
Let the secondary wavelets from B strike the surface MN at C in time t then $BC = vt$.
With A as centre, vt as radius draw an arc.
The tangent from C touches the arc at E.
Then $AE = vt$ and CE is the reflected wavefront.
In the figure from triangles, ABC and AEC , $\angle ABC = \angle AEC = 90^0$
$BC = AE = vt$ and AC = common side $\quad\therefore\ \Delta ABC \cong \Delta AEC$

Hence $\angle BAC = \angle ECA \Rightarrow \boldsymbol{i = r}$

41. a) The device which converts both the half cycles of AC into DC is called a full-wave rectifier.

b) Circuit diagram :



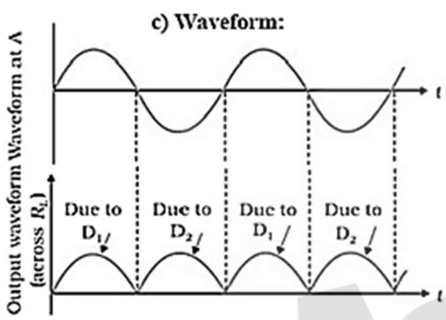
During positive half cycle of AC input the diode D_1 **is forward biased** and conducts, while D_2 reverse biased, does not conduct. So the output current flows through R_L as shown in the figure.

The output due to D_1 appears across R_L.

During negative half cycle of AC input D_2 **is forward biased** and conducts while D_1 **is reverse biased**, does not conduct. Again the current flows through R_L from X to Y as shown in the figure.

The output due to D_2 appears across R_L.

c) Waveform:



42. Charge at A, $q_A = 2\mu C = 2\times10^{-6}$ C, charge at B, $q_B = 3\mu C = 3\times10^{-6}$ C, Sides AC = BC = r = 0.2m

Electric field: $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

Electric field at C due to q_A is $E_A = \frac{9\times10^9\times2\times10^{-6}}{0.2^2} = 450\times10^3$ N/C $= 4.5\times10^5$ NC^{-1}

Electric field at C due to q_B is $E_B = \frac{9\times10^9\times 3\times10^{-6}}{0.2^2} = 675\times10^3$ N/C $= 6.75\times10^5$ NC^{-1}

Resultant electric field at the corner C is

$$E_R = \sqrt{E_A^2 + E_B^2 + 2E_AE_B\cos\theta}$$

$$= 10^5\sqrt{4.5^2 + 6.75^2 + 2\times4.5\times6.75\cos60^\circ}$$

$$= 9.81\times10^5\ \text{NC}^{-1}$$

43. Given: $\varepsilon_1 = \varepsilon_2 = \varepsilon$; $R = 2\,\Omega$ $\quad r_1 = r_2 = r$; $\quad I_s = I_p = 0.5\,A$

In series, $\varepsilon_s = \varepsilon_1 + \varepsilon_2 = 2\varepsilon$; In parallel, $\varepsilon_P = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{\varepsilon r + \varepsilon r}{r + r} = \varepsilon$

In series, $r_s = r_1 + r_2 = 2r$; In parallel, $r_p = \frac{r_1 r_2}{r_1 + r_2} = \frac{r.r}{r+r} = \frac{r}{2}$

Current: $I = \frac{\varepsilon}{R+r}$

$$I_s = I_p \quad \Rightarrow \quad \frac{2\varepsilon}{2+2r} = \frac{\varepsilon}{2+r/2} \quad \Rightarrow \quad 4 + r = 2 + 2r$$

∴ **Internal Resistance : $r = 2\,\Omega$**

$$\text{From } I_s = \frac{2\varepsilon}{2+2r} = 0.5 \quad \Rightarrow \quad 2\varepsilon = 1 + r \Rightarrow \quad 2\varepsilon = 1 + 2$$

∴ **Emf of the cell, $\varepsilon = 1.5\,V$**

44. (i) $X_L = 2\pi\nu L = 2 \times 3.14 \times 50 \times 0.2 = 62.8\,\Omega$

$$X_C = \frac{1}{2\pi\nu C} = \frac{1}{2 \times 3.14 \times 50 \times 100 \times 10^{-6}} = 31.8\,\Omega$$

Impedance: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$Z = \sqrt{100^2 + (62.8 - 31.8)^2} = \mathbf{104.7\,\Omega}$$

(ii) Current: $I = \frac{V}{Z} = \frac{220}{104.7} = \mathbf{2.1\,A}$

45. Refracting angle of the prism: $A = 60^o$. R.I. of prism is n^2 $\qquad$ R.I. of surrounding air is $n_1 = 1$

$$\frac{n_2}{n_1} = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\Rightarrow \frac{n_2}{1} = \frac{\sin\left(\frac{60^\circ + 40^\circ}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} = \frac{\sin(50^\circ)}{\sin(30^\circ)}$$

$$\Rightarrow \quad n_2 = \frac{0.766}{0.5} \quad \Rightarrow \quad n_2 = 1.532$$

When the prism is immersed in water ($n_1 = 1.33$) and let the angle of minimum deviation = D'

$$\frac{n_2}{n_1} = \frac{\sin\left(\frac{A+D'}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \Rightarrow \quad \frac{1.532}{1.33} = \frac{\sin\left(\frac{60^\circ + D'}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} \Rightarrow \quad 1.152 = \frac{\sin\left(\frac{60^\circ + D'}{2}\right)}{0.5}$$

$$\sin^{-1}(0.576) = \left(\frac{60^\circ + D'}{2}\right) \quad \Rightarrow 35^\circ 10' = \left(\frac{60^\circ + D'}{2}\right) \qquad \Rightarrow \qquad 70^\circ 20' = 60^\circ + D'$$

Angle of minimum deviation when prism is immersed in water is $D' = 10^\circ 20'$