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(தகவல்பொறிகள் குறிப்பிட்டுக்கொள்ள்கூற்றுகள்!)

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**UNIT 1 ELECTROSTATICS**  

***** ONE MARK QUESTIONS WITH SOLUTIONS *****

<table>
<thead>
<tr>
<th>S.NO</th>
<th>MARK QUESTIONS</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| 1.   | Two identical point charges of magnitude \(-q\) are fixed as shown in the figure below. A third charge \(+q\) is placed midway between the two charges at the point \(P\). Suppose this charge \(+q\) is displaced a small distance from the point \(P\) in the directions indicated by the arrows, in which direction(s) will \(+q\) be stable with respect to the displacement? | Angle between \(B_1\) and \(B_2\) is \(90^\circ\)  
\[ V = \frac{1}{4\pi\varepsilon_0} \frac{P \cos \theta}{r^2} = \frac{1}{4\pi\varepsilon_0} \frac{P \cos 90^\circ}{r^2} = 0 \]  
\[ W = V \cdot q = 0 \]  
\(+q\) is stable along \(B_1\) and \(B_2\)  
**ANSWER:** (b) \(B_1\) and \(B_2\) |
| (a)A\(_1\) and A\(_2\)  
(b) B\(_1\) and B\(_2\)  
(c) both directions  
(d) No stable |  
\[ (a) \]  
\[ (b) \]  
\[ (c) \]  
\[ (d) \] |
| 2.   | Which charge configuration produces a uniform electric field?  
(a) point Charge  
(b) infinite uniform line charge  
(c) uniformly charged infinite plane  
(d) uniformly charged spherical shell |  
**ANSWER:** (d) uniformly charged spherical shell |
| 3.   | What is the ratio of the charges \(\frac{q_1}{q_2}\) for the following electric field line pattern?  
\[ (a) \frac{1}{5} \]  
\[ (b) \frac{25}{11} \]  
\[ (c) 5 \]  
\[ (d) \frac{11}{25} \] |  
\[ q_1 = 11 \]  
\[ q_2 = 25 \]  
\[ \frac{\text{No. of lines entering } (q_1)}{\text{No. of lines leaving } (q_2)} = \left| \frac{q_1}{q_2} \right| \]  
\[ \left| \frac{11}{25} \right| \]  
**ANSWER:** (d) \(\frac{11}{25}\) |
| 4.   | An electric dipole is placed at an alignment angle of \(30^\circ\) with an electric field of \(2 \times 10^5 \text{ N C}^{-1}\). It experiences a torque equal to \(8 \text{ Nm}\). The charge on the dipole if the dipole length is \(1 \text{ cm}\) is  
(a) 4 mC  
(b) 8 mC  
(c) 5 mC  
(d) 7 mC |  
\[ \tau = pE \sin \theta = (2qa)E \sin \theta \]  
\[ q = \frac{\tau}{2aE \sin \theta} \]  
\[ q = \frac{8}{2 \times 10^5 \times 10^{-2} \times \sin 30^\circ} \]  
\[ q = 8 \times 10^{-3} \text{ C} \]  
**ANSWER:** (b) 8 mC |
5. Four Gaussian surfaces are given below with charges inside each Gaussian surface. Rank the electric flux through each Gaussian surface in increasing order.

(a) D < C < B < A  
(b) A < B = C < D  
(c) C < A = B < D  
(d) D > C > B > A

Net charge A=3q-q=2q,  
Net charge B=2q-q=q  
Net charge C=-q+q=0,  
Net charge D=-q

\[ \Phi = \frac{q}{\varepsilon_0} \]

\[ \Phi \propto q \]

**ANSWER:** d) D>C>B>A

6. The total electric flux for the following closed surface which is kept inside water.

\[ \Phi = \frac{q}{\varepsilon_0} \]

\[ \frac{q}{40\varepsilon_0} \]

\[ \frac{q}{80\varepsilon_0} \]

\[ \frac{q}{160\varepsilon_0} \]

Net charge Q=-q+q+2q=2q

\[ \Phi = \frac{q}{\varepsilon_0} = \frac{2q}{80\varepsilon_0} = \frac{q}{40\varepsilon_0} \]

**ANSWER:** b) \[ \frac{q}{40\varepsilon_0} \]

7. Two identical conducting balls having positive charges \( q_1 \) and \( q_2 \) are separated by a center to center distance \( r \). If they are made to touch each other and then separated to the same distance, the force between them will be

a) less than before
b) same as before
(c) more than before
(d) zero

**When before contact**

According to the Coulomb’s law, \[ F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \]

**After contact**

when the charged spheres A and B are bought in contact, each sphere will attain equal charge \( q \)

\[ q = \frac{q_1 + q_2}{2} \]

The force of repulsion between them at same distance \( r \)

\[ F' = \frac{1}{4\pi\varepsilon_0} \left( \frac{q_1 + q_2}{2} \right)^2 \]

when compare \( F \) and \( F' \)

\[ \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0} \left( \frac{q_1 + q_2}{2} \right)^2 \]

\[ q_1 q_2 \leq \left( \frac{q_1 + q_2}{2} \right)^2 \]

\[ F \leq F' \]
8. Rank the electrostatic potential energies for the given system of charges in increasing order.

<table>
<thead>
<tr>
<th>Option</th>
<th>Potential Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>1 = 4 &lt; 2 &lt; 3</td>
</tr>
<tr>
<td>(b)</td>
<td>2 = 4 &lt; 3 &lt; 1</td>
</tr>
<tr>
<td>(c)</td>
<td>2 = 3 &lt; 1 &lt; 4</td>
</tr>
<tr>
<td>(d)</td>
<td>3 &lt; 1 &lt; 2 &lt; 4</td>
</tr>
</tbody>
</table>

**Answer:** a) 1 = 4 < 2 < 3

---

9. An electric field \( \overrightarrow{E} = 10 x \hat{î} \) exists in a certain region of space. Then the potential difference \( V = V_0 - V_A \) where \( V_0 \) is the potential at the origin and \( V_A \) is the potential at \( x = 2 \) m is:

(a) 10 J  
(b) -20 J  
(c) +20 J  
(d) -10 J

**Answer:** (c) 20 J

---

10. A thin conducting spherical shell of radius \( R \) has a charge \( Q \) which is uniformly distributed on its surface. The correct plot for electrostatic potential due to this spherical shell is

- **Option (a):** Incorrect
- **Option (b):** Correct
- **Option (c):** Incorrect
- **Option (d):** Incorrect

**Answer:** (b)

---

11. Two points \( A \) and \( B \) are maintained at a potential of 7 V and -4 V respectively. The work done in moving 50 electrons from \( A \) to \( B \) is

(a) \( 8.80 \times 10^{-17} \) J  
(b) \( -8.80 \times 10^{-17} \) J  
(c) \( 4.40 \times 10^{-17} \) J  
(d) \( 5.80 \times 10^{-17} \) J

**Answer:** (a) \( 8.80 \times 10^{-17} \) J

---

12. If voltage applied on a capacitor is increased from \( V \) to \( 2V \), choose the correct conclusion.

(a) \( Q \) remains the same, \( C \) is doubled  
(b) \( Q \) is doubled, \( C \) doubled  
(c) \( C \) remains same, \( Q \) doubled  
(d) Both \( Q \) and \( C \) remain same

**Answer:**

1) \( Q \propto V \)
   - Charge depends on potential
   - If \( V \) is doubled, \( Q \) also doubled
2) \( C = \frac{\varepsilon_0 A}{d} \)
   - Capacitance is independent of \( C \) and \( V \)
13. A parallel plate capacitor stores a charge \( Q \) at a voltage \( V \). Suppose the area of the parallel plate capacitor and the distance between the plates are each doubled then which is the quantity that will change?

\[
\begin{align*}
A &\rightarrow 2A, \ d \rightarrow 2d \\
C &= \frac{\varepsilon_0 A}{d} \\
Q &\propto V \\
V &= \frac{Q}{C} = \frac{Qd}{\varepsilon_0 A} \\
U_E &= \frac{1}{2} \varepsilon_0 E^2 Ad
\end{align*}
\]

\[
\begin{align*}
C' &= \frac{\varepsilon_0 2A}{2d} - \frac{\varepsilon_0 A}{d} \\
V' &= \frac{Q2d}{\varepsilon_0 2A} = \frac{Qd}{\varepsilon_0 A} \\
U_{E'} &= \frac{1}{2} \varepsilon_0 E^2 2A2d \\
&= 4 \frac{1}{2} \varepsilon_0 E^2 Ad
\end{align*}
\]

\[
\begin{align*}
C &= C' \\
Q &\text{ same} \\
V &= V'
\end{align*}
\]

**ANSWER**
d) Energy density only changed

14. Three capacitors are connected in triangle as shown in the figure. The equivalent capacitance between the points A and C is

- (a) 1\( \mu \)F
- (b) 2\( \mu \)F
- (c) 3\( \mu \)F
- (d) 1/4\( \mu \)F

Step: 1

**Equivalent capacitance are connected in series**

\[
\begin{align*}
C_S &= \frac{C}{n} = \frac{2}{2} = 1 \mu F
\end{align*}
\]

Step: 2

**Equivalent capacitance are connected in parallel**

\[
\begin{align*}
P &= nC_S = 2 \times 1 = 2 \mu F
\end{align*}
\]

**ANS:** (b) 2\( \mu \)F

15. Two metallic spheres of radii 1 cm and 3 cm are given charges of \(-1 \times 10^{-2} \) C and \(5 \times 10^{-2} \) C respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is

- (a) 3 \( \times \) 10\(^{-2} \) C
- (b) 4 \( \times \) 10\(^{-2} \) C
- (c) 1 \( \times \) 10\(^{-2} \) C
- (d) 2 \( \times \) 10\(^{-2} \) C

\[
\begin{align*}
V &= \frac{KQ}{r} \\
V_1 &= \frac{KQ_1}{3} ; \quad V_2 = \frac{KQ_2}{1} ; \\
V_1 &= V_2 \\
\frac{KQ_1}{3} &= \frac{KQ_2}{1} ; \\
3Q_2 &= Q_1 \quad ----1
\end{align*}
\]

Two charges connected externally

\[
\begin{align*}
Q_1 + Q_2 = (5-1) \times 10^{-2} = 4 \times 10^{-2} \text{C} \\
Q_1 + Q_2 = 4 \times 10^{-2} \text{C} \quad ----2
\end{align*}
\]

Sub eq 1 in eq 2

\[
\begin{align*}
3Q_2 + Q_2 &= 4 \times 10^{-2} \text{C} ; \quad 4Q_2 = 4 \times 10^{-2} \text{C} ; \\
Q_2 &= 10^{-2} \text{C} \quad ----3
\end{align*}
\]
### UNIT-2 CURRENT ELECTRICITY

<table>
<thead>
<tr>
<th>S.NO</th>
<th>QUESTIONS</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>The following graph shows current versus voltage values of some unknown Conductor. What is the resistance of this conductor? (a) 2 ohm (b) 4 ohm (c) 8 ohm (d) 1 ohm</td>
<td>[ R = \frac{dV}{di} ] [ = \frac{4 - 0}{2 - 0} = 2 ] [ \text{ANSWER: (a) 2 ohm} ]</td>
</tr>
<tr>
<td>2)</td>
<td>A wire of resistance 2 ohms per meter is bent to form a circle of radius 1 m. The equivalent resistance between its two diametrically opposite points, A and B as shown in the figure is ( \pi \Omega ) a) ( \frac{\pi}{2} \Omega ) b) ( 2 \pi \Omega ) c) ( \frac{\pi}{4} \Omega )</td>
<td>( L = 2\pi R = 2\pi \times 1 = 2\pi ) Total resistance ( R = 2\pi \times 2 = 4\pi \Omega ) Resistance in each part = ( \frac{2\pi}{2} = 2\pi \Omega ) Equivalent resistance are connected in parallel ( R_p = \frac{R}{n} ) ( R_p = \pi \Omega ) [ \text{ANSWER: a) } \pi \Omega ]</td>
</tr>
<tr>
<td>3)</td>
<td>A toaster operating at 240 V has a resistance of 120 Ω. The power is a) 400 W b) 2 W c) 480 W d) 240 W</td>
<td>[ P = \frac{V^2}{R} ] [ = \frac{240 \times 240}{120} ] [ P = 480 \text{W} ] [ \text{ANSWER: c) 480 W} ]</td>
</tr>
<tr>
<td>4)</td>
<td>A carbon resistor of ((47 \pm 4.7) \text{ kΩ}) to be marked with rings of different colours for its identification. The colour code sequence will be a) Yellow – Green – Violet – Gold b) Yellow – Violet – Orange – Silver c) Violet – Yellow – Orange – Silver d) Green – Orange – Violet – Gold</td>
<td>Yellow – Violet – Orange – Silver ((47 \times 10^3) \pm 10% = 47000 \pm 4700 \text{ ohm}) Tolerance in % = ((47000 \times 10%) = 47000 \times 0.1 = 4700 \text{ ohm} ) or ((47 \pm 4.7)1000 \text{ ohm}) [ \text{ANSWER: b) Yellow – Violet – Orange – Silver} ]</td>
</tr>
<tr>
<td>5)</td>
<td>What is the value of resistance of the following resistor? (a) 100 kΩ (b) 10 kΩ (c) 1 kΩ (d) 1000 kΩ</td>
<td>Brown: 1 Black: 0 Yellow: (10^4) or 10000 Value of resistance : (10 \times 10^4) [ \text{ANSWER: (a) 100 kΩ} ]</td>
</tr>
<tr>
<td>6)</td>
<td>Two wires of A and B with circular cross section made</td>
<td>( R_A = 3 R_B )</td>
</tr>
</tbody>
</table>
up of the same material with equal lengths. Suppose $R_A = 3 R_B$, then what is the ratio of radius of wire $A$ to that of $B$?

(a) 3  (b) $\sqrt{3}$  (c) $\frac{1}{\sqrt{3}}$  (d) $\frac{1}{3}$

$R \propto \frac{l}{A}$; length are common

$$\frac{R_A}{R_B} = \frac{\pi r_A^2}{\pi r_B^2}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{R_B}{R_A}}$$

$$= \sqrt{\frac{R_B}{3R_B}} = \frac{1}{\sqrt{3}}$$

**ANSWER:** c) $\frac{1}{\sqrt{3}}$

7) A wire connected to a power supply of 230 V has power dissipation $P_1$. Suppose the wire is cut into two equal pieces and connected parallel to the same power supply. In this case power dissipation is $P_2$. The ratio $\frac{P_2}{P_1}$ is

(a) 1  (b) 2  (c) 3  (d) 4

Before cutting the wire, resistance - $R$
After cutting the wire, resistance of each pieces - $\frac{R}{2}$
Two equal pieces are connected parallel is

$$R_P = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_P = \frac{R}{2} \times \frac{R}{2} = \frac{R^2}{4}$$

Power $P = \frac{V^2}{R}$
potential is common
ratio $\frac{P_2}{P_1} = \frac{R}{R_P} = \frac{R}{\frac{R}{4}} = 4$

**ANSWER:** : (d) 4

8) In India electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60W bulb for use in India is $R$, the resistance of a 60W bulb for use in USA will be

(a) $R$  (b) $2R$  (c) $\frac{R}{4}$  (d) $\frac{R}{2}$

Power $P = \frac{V^2}{R}$

For india $P_1 = \frac{V_1^2}{R_1}$

For USA $P_2 = \frac{V_2^2}{R_2}$

$P_1 = P_2$

$$\frac{V_1^2}{R_1} = \frac{V_2^2}{R_2}$$

$$R_2 = \frac{V_2^2}{V_1^2} \times R$$

$$= \frac{110 \times 110 \times R}{220 \times 220} = \frac{R}{4}$$

**ANSWER:** : (c) $\frac{R}{4}$

9) In a large building, there are 15 bulbs of 40W, 5 bulbs of 100W, 5 fans of 80W and 1 heater of 1kW are connected. Total power consumed $P$

$$= (15 \times 40) + (5 \times 100) + (5 \times 80) + (1 \times 100)$$
<table>
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<tr>
<th>Question</th>
<th>Description</th>
<th>Options</th>
<th>Answer</th>
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</thead>
<tbody>
<tr>
<td>10)</td>
<td>There is a current of 1.0 A in the circuit shown below. What is the resistance of P?</td>
<td>a) 1.5 Ω b) 2.5 Ω c) 3.5 Ω d) 4.5 Ω</td>
<td>b) 0.5 Ω</td>
</tr>
<tr>
<td>11)</td>
<td>What is the current out of the battery?</td>
<td>a) 1A b) 2A c) 3A d) 4A</td>
<td>a) 1A</td>
</tr>
<tr>
<td>12)</td>
<td>The temperature coefficient of resistance of a wire is 0.00125 per °C. At 300 K, its resistance is 1 Ω. The resistance of the wire will be 2 Ω at</td>
<td>a) 1154 K b) 1100 K c) 1400 K d) 1127 K</td>
<td>b) 1100 K</td>
</tr>
<tr>
<td>13)</td>
<td>The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is</td>
<td>a) 0.2 Ω b) 0.5 Ω c) 0.8 Ω d) 1.0 Ω</td>
<td>b) 0.5 Ω</td>
</tr>
<tr>
<td>14)</td>
<td>A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of</td>
<td></td>
<td>For copper, Temperature cooled</td>
</tr>
</tbody>
</table>

For conductors, resistivity is directly proportional to temperature, \( \rho \propto T \).
c) copper increases and germanium decreases  
d) copper decreases and germanium increases

15) In Joule’s heating law, when R and t are constant, if the H is taken along the y axis and l² along the x axis, the graph is a) straight line  b) parabola  c) circle  d) ellipse

ANSWER: a) straight line

B = \oint dB = \frac{\mu_0}{4\pi} \frac{I dl \sin \theta}{r^2}

B = \frac{\mu_0}{4\pi} \frac{l}{r^2} \int dl \quad (\theta = 90^\circ)

B = \frac{\mu_0}{4\pi} \frac{l}{r^2} \int \pi r^2 = \frac{\mu_0 l}{4r}

ANSWER : a) \frac{\mu_0 l}{4r} \bigotimes

Velocity = \frac{\text{displacement}}{\text{time}} = \frac{l}{t}

\frac{E}{B} = \frac{l}{t} \quad [E = \frac{\sigma}{\varepsilon_0}]

t = \frac{B x l}{E} = \frac{B \varepsilon_0 x l}{\sigma}

t = \frac{\varepsilon_0 l B}{\sigma}

ANSWER: d) \varepsilon_0 \frac{l B}{\sigma}

The force experienced by a particle having mass m and charge q accelerated through a potential difference V when it is kept under perpendicular magnetic field is \vec{B}
4) A circular coil of radius 5 cm and 50 turns carries a current of 3 ampere. The magnetic dipole moment of the coil is
(a) 1.0 amp – m²  (b) 1.2 amp – m²
(c) 0.5 amp – m²  (d) 0.8 amp – m²

ANSWER: (b) 1.2 amp – m²

5) A thin insulated wire forms a plane spiral of N = 100 tight turns carrying a current I = 8 mA (milli ampere).
The radii of inside and outside turns are a = 50 mm and b = 100 mm respectively. The magnetic induction at the center of the spiral is
(a) 5 µT  (b) 7 µT  (c) 8 µT  (d) 10 µT

The magnetic induction
\[ B = \frac{\mu_0 NI}{2\pi} \int_a^b \frac{dx}{x} = \frac{\mu_0 NI}{2\pi} \ln \left( \frac{b}{a} \right) \]

n = \frac{N}{b-a}

\[ B = \frac{\mu_0 NI}{2x} \int_a^b \frac{dx}{x} = \frac{\mu_0 NI}{2x} \ln \left( \frac{b}{a} \right) \]

\[ B = \frac{4\pi \times 10^{-7} \times 100 \times 8 \times 10^{-3} \times 2.303 \times 10^{-2}}{2 \times 10^{-7} \times 10^{-2}} \]

\[ = 6.96 \times 10^{-6} \text{ T} = 7 \mu \text{T} \]

ANSWER: (b) 7 µT

6) Three wires of equal lengths are bent in the form of loops. One of the loops is circle, another is a semi-circle and the third one is a square. They are placed in a uniform magnetic field and same electric current is passed through them. Which of the following loop configuration will experience greater torque?
(a) circle  (b) semi-circle  (c) square (d) all of them

Torque \( \propto \) Area ; \( \propto \) A

Area of circle > Area of square >
Area of semi-circle

\[ \pi r^2 > r^2 > \frac{1}{2} \pi r^2 \]

(\( \propto \) circle > \( \propto \) square > \( \propto \) semi circle)

ANSWER: a) circle

7) Two identical coils, each with N turns and radius R are placed coaxially at a distance R as shown in the figure. If I is the current passing through the loops in the same direction, then the magnetic field at a point P which is at exactly at \( \frac{R}{2} \) distance between two coils is

\[ B_1 = \frac{\mu_0 NI }{2} \left( \frac{R^2}{(R^2 + z^2)^{3/2}} \right) \]

\[ \text{for } z = \frac{R}{2} \]

\[ B_1 = \frac{\mu_0 NI }{2} \left( \frac{R^2}{(R^2 + \frac{R^2}{4})^{3/2}} \right) \]

\[ = \frac{\mu_0 NI }{2} \left( \frac{R^2}{(\frac{5R^2}{4})^{3/2}} \right) \]

\[ = \frac{\mu_0 NI }{2} \left( \frac{R^2}{(\frac{5R^2}{4})} \right)^{3/2} \]
8) A wire of length l carries a current I along the Y direction and magnetic field is given by \( \vec{B} = \frac{B}{\sqrt{3}} (\hat{i} + \hat{j} + \hat{k}) \) The magnitude of Lorentz force acting on the wire is

\[
\begin{align*}
\text{a) } & \sqrt{\frac{2}{3}} BIl \quad \text{b) } \sqrt{\frac{1}{3}} BIl \\
\text{c) } & \sqrt{2} BIl \quad \text{d) } \sqrt{\frac{1}{3}} BIl
\end{align*}
\]

9) A bar magnet of length l and magnetic moment M is bent in the form of an arc as shown in figure. The new magnetic dipole moment will be

- (a) \( M \)
- (b) \( \frac{3}{\pi} M \)
- (c) \( \frac{2}{\pi} M \)
- (d) \( \frac{1}{2} M \)

For straight magnet, magnetic moment \( M = q_m l \)

For new magnet, magnetic moment \( M' = q_m l' \)

\[ l' = 2r \sin 30^\circ = r \]

arc length = radius \( r \) \( \theta \)

\[ l = r \theta \]

\[ r = \frac{3l}{\pi} \]

For new magnet, magnetic moment

\[ M' = q_m l' = \frac{3q_ml}{\pi} = \frac{3M}{\pi} \]

ANSWER: (b) \( \frac{3}{\pi} M \)

10) A non-conducting charged ring of charge q, mass m and radius r is rotated with constant angular speed \( \omega \). Find the ratio of its magnetic moment with angular momentum is

\[
\mu_L = \frac{q\omega}{2\pi} \frac{mr^2}{T} \]

ANSWER: \( \frac{q\omega}{2\pi} \frac{mr^2}{T} \)
11) The BH curve for a ferromagnetic material is shown in the figure. The material is placed inside a long solenoid which contains 1000 turns/cm. The current that should be passed in the solenoid to demagnetize the ferromagnetic completely is:

<table>
<thead>
<tr>
<th>a) $\frac{q}{m}$</th>
<th>b) $\frac{2q}{m}$</th>
<th>c) $\frac{q}{2m}$</th>
<th>d) $\frac{q}{4m}$</th>
</tr>
</thead>
</table>

Angular momentum $L = m r^2 \omega$

\[ \frac{\mu_0}{L} \frac{q \omega \pi r^2}{2 \pi m r^2 \omega} = \frac{q}{2m} \]  

**ANSWER:** c) $\frac{q}{2m}$

n=1000 turns/cm, H=150 (graph)

\[ I = \frac{H}{n} = \frac{150}{10^5} = 150 \times 10^{-5} \]

\[ I = 1.50 \times 10^{-3} \text{ A} \]

**ANSWER:** (c) 1.50 mA

---

12) Two short bar magnets have magnetic moments 1.20 Am$^2$ and 1.00 Am$^2$ respectively. They are kept on a horizontal table parallel to each other with their north poles pointing towards the south. They have a common magnetic equator and are separated by a distance of 20.0 cm. The value of the resultant horizontal magnetic induction at the mid-point O of the line joining their centers is (Horizontal components of Earth’s magnetic induction is $3.6 \times 10^{-5}$ Wb m$^{-2}$)

- (a) $3.60 \times 10^{-5}$ Wb m$^{-2}$
- (b) $3.5 \times 10^{-5}$ Wb m$^{-2}$
- (c) $2.56 \times 10^{-4}$ Wb m$^{-2}$
- (d) $2.2 \times 10^{-4}$ Wb m$^{-2}$

**Resultant magnetic field**

\[ B = B_1 + B_2 + B_H \]

\[ B = \frac{\mu_0}{4\pi r^3} (P_{m1} + P_{m2}) + B_H \]

\[ B = \frac{4\pi x 10^{-7}}{4\pi x 10^{-3}} (1.2 + 1) + 3.6 \times 10^{-5} \]

\[ 2.2 \times 10^{-4} + 0.36 \times 10^{-4} \]

\[ B = 2.56 \times 10^{-4} \text{ Wb m}^{-2} \]

**ANSWER:** (c) $2.56 \times 10^{-4}$ Wb m$^{-2}$

---

13) The vertical component of Earth’s magnetic field at a place is equal to the horizontal component. What is the value of angle of dip at this place?

| a) $30^\circ$ | b) $45^\circ$ | c) $60^\circ$ | d) $90^\circ$ |

**ANSWER:** (b) 45$^\circ$

\[ B_v = B_H \]

\[ \tan \theta = \frac{B_v}{B_H} = 1 \]

\[ \theta = \tan^{-1}(1) = 45^\circ \]

**ANSWER:** (b) 45$^\circ$

---

14) A flat dielectric disc of radius $R$ carries an excess charge on its surface. The surface charge density is $\sigma$. The disc rotates about an axis perpendicular to its plane passing through the center with angular velocity $\omega$. Find the magnitude of the torque on the disc if it is placed in a constant magnetic field $B$.

**Total charge on the disc**

\[ Q = \sigma A = \sigma 2\pi r dr \]

**Time period**

\[ T = \frac{2\pi}{\omega} \]

**Current in the ring**

\[ dl = \frac{dq}{T} \]
uniform magnetic field whose strength is B which is directed perpendicular to the axis of rotation
(a) $\frac{1}{4}\sigma \omega \pi BR$  
(b) $\frac{1}{4}\sigma \omega \pi BR^2$  
(c) $\frac{1}{4}\sigma \omega \pi BR^3$  
(d) $\frac{1}{4}\sigma \omega \pi BR^4$

\[
dl = \frac{\sigma 2\pi rdr \omega}{2\pi} = \sigma \omega r dr
\]
magnetic moment of the ring dM 
= dl $\pi r^2$

\[M = \int_0^R \pi \sigma \omega r^3 dr = \frac{\pi}{4} \sigma R^4 \omega
\]

\[M = \frac{1}{4} QR^2 \omega \quad (Q = \sigma \pi R^2)
\]

\[\tau = P_m B \sin \theta ; \quad \theta = 90^\circ
\]

\[\tau = P_m B R \frac{1}{4} \sigma AR^2 \omega \theta
\]

\[\tau = \frac{1}{4} \sigma \pi R^2 R^2 \omega
\]

**ANSWER:** (d) $\frac{1}{4}\sigma \omega \pi BR^4$

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<tbody>
<tr>
<td>1</td>
<td>A simple pendulum with charged bob is oscillating with time period T and let $\theta$ be the angular displacement. If the uniform magnetic field is switched ON in a direction perpendicular to the plane of oscillation then (a) time period will decrease but $\theta$ will remain constant (b) time period remain constant but $\theta$ will decrease (c) both T and $\theta$ will remain the same (d) both T and $\theta$ will decrease</td>
<td>Magnetic field is perpendicular to the plane of oscillation, there is no work. so both T and $\theta$ will remain the same <strong>ANSWER:</strong> (C) both T and $\theta$ will remain the same</td>
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**UNIT -04 ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT**

<table>
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| 1 | An electron moves on a straight line path XY as shown in the figure. The coil abcd is adjacent to the path of the electron. What will be the direction of current, if any, induced in the coil? a)The current will reverse its direction as the electron goes past the coil (b) No current will be induced (c) abcd (d) adcb | 1. When electron moves towards the loop flux increases , induced current flows in anticlockwise direction(abcd) 2. When electron moves away flux decrease, induced current flows clock wise direction.(dcba). **ANSWER**:
 a) The current will reverse its direction as the electron goes past the coil |

Send Your Questions & Answer Keys to our email id - padasalai.net@gmail.com
2) A thin semi-circular conducting ring (PQR) of radius \( r \) is falling with its plane vertical in a horizontal magnetic field \( B \), as shown in the figure. The potential difference developed across the ring when its speed \( v \), is

- (a) Zero
- (b) \( \frac{B v r^2}{2} \)
- (c) \( \pi r B v \)
- (d) \( 2 r B v \)

\[ \text{ANSWER: } \]
\[ d) 2 r B v \text{ and } R \text{ is at higher potential} \]

3) The flux linked with a coil at any instant \( t \) is given by

\[ \Phi_B = 10t^2 - 50t + 250t \]. The induced emf at \( t = 3s \) is

- (a) -190 V
- (b) -10 V
- (c) 10 V
- (d) 190 V

\[ \text{ANSWER: } (b) -10 V \]

4) When the current changes from +2A to -2A in 0.05 s, an emf of 8 V is induced in a coil. The coefficient of self-induction of the coil is

- (a) 0.2 H
- (b) 0.4 H
- (c) 0.8 H
- (d) 0.1 H

\[ \text{ANSWER: } (d) 0.1 H \]

5) The current \( i \) flowing in a coil varies with time as shown in the figure. The variation of induced emf with time would be

\[ \text{ANSWER: } \]

6) A circular coil with a cross-sectional area of 4 cm\(^2\) has 10 turns. It is placed at the centre of a long solenoid that has 15 turns/cm and a cross-sectional area of 10 cm\(^2\). The axis of the coil coincides with the axis of the solenoid. What is their mutual inductance?

- (a) 7.54 \( \mu \)H
- (b) 8.54 \( \mu \)H
- (c) 9.54 \( \mu \)H
- (d) 10.54 \( \mu \)H

\[ \text{ANSWER: } (a) 7.54 \text{ \( \mu \)H} \]
<table>
<thead>
<tr>
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<tr>
<td>7)</td>
<td>In a transformer, the number of turns in the primary and the secondary are 410 and 1230 respectively. If the current in primary is 6A, then that in the secondary coil is (a) 2 A (b) 18 A (c) 12 A (d) 1 A</td>
<td>$\frac{i_p}{i_s} = \frac{N_s}{N_p}$ =&gt; $i_s = \frac{i_p \times N_s}{N_p} = \frac{410 \times 6}{1230} = 2A$&lt;br&gt;<strong>ANSWER</strong>: (a) 2 A</td>
</tr>
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<td>8)</td>
<td>A step-down transformer reduces the supply voltage from 220 V to 11 V and increase the current from 6 A to 100 A. Then its efficiency is (a) 1.2 (b) 0.83 (c) 0.12 (d) 0.9</td>
<td>$\eta = \frac{E_sI_s}{E_pI_p} = \frac{11 \times 100}{220 \times 6} = 0.83$&lt;br&gt;<strong>ANSWER</strong>: (b) 0.83</td>
</tr>
<tr>
<td>9)</td>
<td>In an electrical circuit, R, L, C and AC voltage source are all connected in series. When L is removed from the circuit, the phase difference between the voltage and current in the circuit is $\frac{\pi}{3}$. Instead, if C is removed from the circuit, the phase difference is again $\frac{\pi}{3}$. The power factor of the circuit is (a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$ (c) 1 (d) $\frac{\sqrt{3}}{2}$</td>
<td>Phase by removing the inductor = Phase by removing the capacitor&lt;br&gt;$X_L = X_C$;&lt;br&gt;power factor $\cos \phi = \frac{R}{Z} = \frac{R}{R} = 1$&lt;br&gt;$Z = R$&lt;br&gt;<strong>ANSWER</strong>: (c) 1</td>
</tr>
<tr>
<td>10)</td>
<td>In a series RL circuit, the resistance and inductive reactance are the same. Then the phase difference between the voltage and current in the circuit is (a) $\frac{\pi}{4}$ (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{6}$ (d) 0</td>
<td>$R = X_L$ =&gt; $\tan \phi = \frac{X_L}{R} = 1$&lt;br&gt;$\Phi = \tan^{-1}(1) = 45 = \frac{\pi}{4}$&lt;br&gt;<strong>ANSWER</strong>: (a) $\frac{\pi}{4}$</td>
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<td>11)</td>
<td>In a series resonant RLC circuit, the voltage across 100 $\Omega$ resistor is 40 V. The resonant frequency $\omega$ is 250 rad/s. If the value of C is 4 $\mu$F, then the voltage across L is (a) 600 V (b) 4000 V (c) 400 V (d) 1 V</td>
<td>At resonance $X_L = X_C$&lt;br&gt;$X_L = L\omega_r = \frac{1}{\omega C} = \frac{1}{4 \times 10^{-6} \times 250}$&lt;br&gt;$X_L = 10^3 \Omega$&lt;br&gt;$I = \frac{V}{R} = \frac{40}{100} = 0.4A$&lt;br&gt;Voltage across $L = IX_L$&lt;br&gt;$= 0.4 \times 10^3 \times 400V$&lt;br&gt;<strong>ANSWER</strong>: (c) 400 V</td>
</tr>
<tr>
<td>12)</td>
<td>An inductor 20 mH, a capacitor 50 $\mu$F and a resistor 40$\Omega$ are connected in series across a source of emf $V = 10 \sin 340t$. The power loss in AC circuit is (a) 0.76 W (b) 0.89 W (c) 0.46 W (d) 0.67 W</td>
<td>$X_L = L\omega = 20 \times 10^{-3} \times 340 = 6.8 \Omega$&lt;br&gt;$V_{rms} = \frac{V_0}{\sqrt{2}} = 10 \times 0.707 = 7.07$&lt;br&gt;$X_C = \frac{1}{\omega C} = \frac{1}{50 \times 10^{-6} \times 340} = 58.8 \Omega$&lt;br&gt;$X_L - X_C = 58.8 - 6.8 = 52 \Omega$</td>
</tr>
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</table>
13) The instantaneous values of alternating current and voltage in a circuit are \( i = \frac{1}{\sqrt{2}} \sin(100\pi t) \text{A} \) and \( v = \frac{1}{\sqrt{2}} \sin(100\pi t + \frac{\pi}{3}) \text{V} \). The average power in watts consumed in the circuit is

- (a) \( \frac{1}{4} \)
- (b) \( \frac{\sqrt{3}}{4} \)
- (c) \( \frac{1}{2} \)
- (d) \( \frac{1}{8} \)

**ANSWER:** (d) \( \frac{1}{8} \)

14) In an oscillating LC circuit, the maximum charge on the capacitor is \( Q \). The charge on the capacitor when the energy is stored equally between the electric and magnetic fields is

- (a) \( \frac{Q}{2} \)
- (b) \( \frac{Q}{\sqrt{3}} \)
- (c) \( \frac{Q}{\sqrt{2}} \)
- (d) \( Q \)

**ANSWER:** (c) \( \frac{Q}{\sqrt{2}} \)

15) \( \frac{20}{\pi^2} \) H inductor is connected to a capacitor of capacitance \( C \). The value of \( C \) in order to impart maximum power at 50 Hz is

- (a) 50 \( \mu \text{F} \)
- (b) 0.5 \( \mu \text{F} \)
- (c) 500 \( \mu \text{F} \)
- (d) 5 \( \mu \text{F} \)

**ANSWER:** (d) 5 \( \mu \text{F} \)

### UNIT 05- ELECTROMAGNETIC WAVES

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<tbody>
<tr>
<td>1)</td>
<td>The dimension of ( \frac{1}{\mu_0 \varepsilon_0} ) is ________</td>
<td>( c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \Rightarrow c^2 = \frac{1}{\mu_0 \varepsilon_0} )</td>
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<tr>
<td></td>
<td>a) ([LT^{-1}])  b) ([L^2 T^{-2}])  c) ([L^{-1} T])  d) ([L^{-2} T^{-2}])</td>
<td>( c^2 = [LT^{-1}]^2 = [L^2 T^{-2}] )</td>
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<tr>
<td></td>
<td><strong>ANSWER:</strong> b) ([L^2 T^{-2}])</td>
<td></td>
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<tr>
<td>2)</td>
<td>If the amplitude of the magnetic field is ( 3 \times 10^{-6} \text{T} ) then</td>
<td>( c = \frac{E}{B} \Rightarrow E = Bxc = 3 \times 10^{-6} \times 3 \times 10^8 )</td>
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</table>
3) Which of the following electromagnetic radiation is used for viewing objects through fog
(a) microwave (b) gamma rays (c) X-rays (d) infrared

**ANSWER:** (d) infrared

4) Which of the following are false for electromagnetic waves
(a) transverse (b) non mechanical waves (c) longitudinal (d) produced by accelerating charges

**ANSWER:** (c) longitudinal

5) Consider an oscillator which has a charged particle and oscillates about its mean position with a frequency of 300 MHz. The wavelength of electromagnetic waves produced by this oscillator is
(a) 1 m (b) 10 m (c) 100 m (d) 1000 m

\[ \lambda = \frac{c}{\nu} \]

\[ \nu = 3 \times 10^8 \, \text{m/s} \]

\[ \lambda = \frac{3 \times 10^8}{3 \times 10^8} = 1 \text{ m} \]

**ANSWER:** (a) 1 m

6) The electric and the magnetic field, associated with an electromagnetic wave, propagating along X axis can be represented by
(a) \( \vec{E} = E_0 \hat{j} \) and \( \vec{B} = B_0 \hat{k} \) (b) \( \vec{E} = E_0 \hat{k} \) and \( \vec{B} = B_0 \hat{j} \)
(c) \( \vec{E} = E_0 \hat{i} \) and \( \vec{B} = B_0 \hat{j} \) (d) \( \vec{E} = E_0 \hat{j} \) and \( \vec{B} = B_0 \hat{i} \)

**ANSWER:** (a) \( \vec{E} = E_0 \hat{j} \) and \( \vec{B} = B_0 \hat{k} \)

7) In an electromagnetic wave in free space the rms value of the electric field is 3 V m\(^{-1}\).

The peak value of the magnetic field is
(a) \( 1.414 \times 10^{-8} \) T (b) \( 1.0 \times 10^{-8} \) T
(c) \( 2.828 \times 10^{-8} \) T (d) \( 2.0 \times 10^{-8} \) T

\[ B_{\text{rms}} = \frac{B_0}{\sqrt{2}} \]

\[ c = \frac{E_{\text{rms}}}{B_{\text{rms}}} \]

\[ B_{\text{rms}} = \frac{E_{\text{rms}}}{c} \]

\[ B_0 = \frac{E_{\text{rms}}}{c} \sqrt{2} \]

\[ \frac{3}{3 \times 10^8} \times 1.414 \]

\[ = 1.414 \times 10^{-8} \] T

**ANSWER:** (a) \( 1.414 \times 10^{-8} \) T

8) During the propagation of electromagnetic waves in a medium:
(a) electric energy density is double of the magnetic energy density
(b) electric energy density is half of the magnetic energy density
(c) electric energy density is equal to the magnetic energy density

**Magnetic energy**

\[ u_B = \frac{B^2}{2\mu_0} \]

**Electric energy**

\[ u_E = \frac{1}{2} \varepsilon_0 E^2 \]

\[ u_E = \frac{1}{2} \varepsilon_0 (Bc)^2 \]

\[ u_E = \frac{1}{2} \varepsilon_0 B^2 c^2 = \frac{1}{2} \varepsilon_0 B^2 x c^2 \]

\[ c^2 = \frac{1}{\mu_0 \varepsilon_0} \]
9) If the magnetic monopole exists, then which of the Maxwell’s equation to be modified?.

\( \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\varepsilon_0} \)  
\( \oint \vec{E} \cdot d\vec{A} = 0 \)
\( \oint \vec{E} \cdot d\vec{A} = \mu_0 I_{\text{enclosed}} + \varepsilon_0 \frac{d}{dt} \int \vec{E} \cdot d\vec{A} \)
\( \oint \vec{E} \cdot d\vec{A} = \frac{d}{dt} \phi_B \)

**ANSWER :** (b) \( \oint \vec{E} \cdot d\vec{A} = 0 \)

The magnetic lines of force form a continuous closed path.
No isolated magnetic monopole exists. Total magnetic flux=0
\( \oint \vec{E} \cdot d\vec{A} = 0 \)

10) A radiation of energy \( E \) falls normally on a perfectly reflecting surface. The momentum transferred to the surface is

\[ \begin{align*}
(a) & \quad \frac{E}{c} \\
(b) & \quad 2\frac{E}{c} \\
(c) & \quad E/c \\
(d) & \quad \frac{E^2}{2c^2}
\end{align*} \]

**ANSWER :** (b) \( 2\frac{E}{c} \)

Change in momentum \( p = p_f - p_i \)
\[ p = \frac{E}{c} - \left( -\frac{E}{c} \right) = \frac{E}{c} + \frac{E}{c} = 2\frac{E}{c} \]

11) Which of the following is an electromagnetic wave?

(a) \( \alpha \) - rays   (b) \( \beta \) - rays   (c) \( \gamma \) - rays   (d) all of them

\( \alpha \) - rays : helium nucleus, \( \beta \) - rays - electron, \( \gamma \) - rays- electromagnetic wave

**ANSWER :** (c) \( \gamma \) - rays

12) Which one of them is used to produce a propagating electromagnetic wave?

(a) an accelerating charge
(b) a charge moving at constant velocity
(c) a stationary charge
(d) an uncharged particle

**ANSWER :**
(a) an accelerating charge

13) Let \( \vec{E} = E_0 \sin[10^6 x - \omega t] \) be the electric field of plane electromagnetic wave, the value of \( \omega \) is

\[ \begin{align*}
(a) & \quad 0.3 \times 10^{-14} \text{ rad s}^{-1} \\
(b) & \quad 3 \times 10^{-14} \text{ rad s}^{-1} \\
(c) & \quad 0.3 \times 10^{14} \text{ rad s}^{-1} \\
(d) & \quad 3 \times 10^{14} \text{ rad s}^{-1}
\end{align*} \]

\[ \begin{align*}
\vec{E} & = E_0 \sin[kx - \omega t] \quad \rightarrow (1) \\
\vec{E} & = E_0 \sin[10^6 x - \omega t] \quad \rightarrow (2)
\end{align*} \]

\[ \begin{align*}
\text{From eqn (1) and (2)} \\
k & = 10^6 \\
k & = \frac{\omega}{c} \\
\omega & = kxc = 10^6 \times 3 \times 10^8 \\
\omega & = 3 \times 10^{14} \text{ rad s}^{-1}
\end{align*} \]
14) Which of the following is NOT true for electromagnetic waves?
   (a) it transport energy  
   (b) it transport momentum  
   (c) it transport angular momentum  
   (d) in vacuum, it travels with different speeds which depend on their frequency

   **ANSWER:** (d) \( 3 \times 10^{14} \text{ rad s}^{-1} \)

1) In vacuum, it travels with different speeds which depend on their frequency

2) Velocity of electromagnetic wave (light) is constant in vacuum.

   **ANSWER:** (d) in vacuum, it travels with different speeds which depend on their frequency

15) The electric and magnetic fields of an electromagnetic wave are
   (a) in phase and perpendicular to each other  
   (b) out of phase and not perpendicular to each other  
   (c) in phase and not perpendicular to each other  
   (d) out of phase and perpendicular to each other.

   **ANSWER:** (a) in phase and perpendicular to each other