Electromagnetic Induction

Question1

Two inductors of 80 mH each are joined in parallel. The current passing through the combination is 2.1 A . The energy stored in this combination of inductors is

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Options:

A.

4.84×10^{-2} J

B.

7.26×10^{-2} J

C.

8.82×10^{-2} J

D.

10.85×10^{-2} J

Answer: C

Solution:

$L_1 = L_2 = L = 80\text{mH}$

When two inductors are connected in parallel, their equivalent inductance is given by,

$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$

$\therefore \quad L_{eq} = \frac{L}{2} = 40 mH$

$U_B = \frac{1}{2} L_{eq} I^2$

$\therefore \quad U_B = \frac{1}{2} \times 40 \times 10^{-3} \times 2.1 \times 2.1$

$\therefore \quad U_B = 0.0882 \text{ J} = 8.82 \times 10^{-2} \text{ J}$

Question2

A coil of effective area 3 m^2 is placed at right angles to a magnetic field of induction 0.05 Wb/m^2 If the field is decreased to 20% of its original value in 10 second, the e.m.f. induced in the coil will be

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Options:

A.

10 mV

B.

12 mV

C.

15 mV

D.

20 mV

Answer: B

Solution:

1. **Identify the given values:**
    - Effective Area (A) = 3 m^2
    - Initial Magnetic Field Induction $(B_1) = 0.05 \text{ Wb/m}^2$
    - Final Magnetic Field Induction $(B_2) = 20\%$ of $B_1 = 0.20 \times 0.05 \text{ Wb/m}^2 = 0.01 \text{ Wb/m}^2$
    - Time taken for the change $(\Delta t) = 10$ s

- The coil is placed at right angles to the magnetic field, meaning the angle between the normal to the coil's area and the magnetic field is $0°$. So, $\cos\theta = \cos 0° = 1$.

2. **Calculate the initial magnetic flux (Φ_1):**

   Magnetic flux (Φ) = $B \times A \times \cos\theta$

   $\Phi_1 = B_1 \times A \times 1$

   $\Phi_1 = 0.05\ \text{Wb/m}^2 \times 3\ \text{m}^2$

   $\Phi_1 = 0.15\ \text{Wb}$

3. **Calculate the final magnetic flux (Φ_2):**

   $\Phi_2 = B_2 \times A \times 1$

   $\Phi_2 = 0.01\ \text{Wb/m}^2 \times 3\ \text{m}^2$

   $\Phi_2 = 0.03\ \text{Wb}$

4. **Calculate the change in magnetic flux ($\Delta\Phi$):**

   $\Delta\Phi = \Phi_2 - \Phi_1$

   $\Delta\Phi = 0.03\ \text{Wb} - 0.15\ \text{Wb}$

   $\Delta\Phi = -0.12\ \text{Wb}$

5. **Apply Faraday's Law of Electromagnetic Induction:**

   The induced e.m.f. (ε) is given by:

   $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

   Assuming $N = 1$ (single turn coil, as not specified otherwise):

   $\varepsilon = -\frac{\Delta\Phi}{\Delta t}$

   $\varepsilon = -\frac{-0.12\ \text{Wb}}{10\ \text{s}}$

   $\varepsilon = \frac{0.12}{10}\ \text{V}$

   $\varepsilon = 0.012\ \text{V}$

6. **Convert the e.m.f. to millivolts (mV):**

   $1\ \text{V} = 1000\ \text{mV}$

   $\varepsilon = 0.012\ \text{V} \times 1000\ \text{mV/V}$

   $\varepsilon = 12\ \text{mV}$

The induced e.m.f. in the coil will be 12 mV.

The final answer is $\boxed{12\ \text{mV}}$.

Question3

A coil having ' N ' turns and resistance ' R ' Ω is connected to a galvanometer of resistance ' 6 R ' Ω. The magnetic flux linked with this coil changes from ϕ_1 weber to ϕ_2 weber in time ' t ' second. The induced current in the circuit is

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Options:

A.

$\frac{\mathrm{N}(\phi_2-\phi_1)}{\mathrm{t}}$

B.

$\frac{N(\phi_2-\phi_1)}{7Rt}$

C.

$\frac{\mathrm{N}(\phi_2-\phi_1)}{\mathrm{Rt}}$

D.

$\frac{N(\phi_2-\phi_1)}{6Rt}$

Answer: B

Solution:

Step 1: EMF induced in coil

Magnetic flux linked with **one turn** of the coil changes from ϕ_1 to ϕ_2 in time t.

So the change of flux in **one turn** is:

$\Delta\phi = \phi_2 - \phi_1$

For a coil having **N turns**, total change in flux linkage is:

$\Delta\Phi = N(\phi_2 - \phi_1)$

Hence, the **induced emf** is:

$\mathcal{E} = \frac{\Delta\Phi}{t} = \frac{N(\phi_2 - \phi_1)}{t}$

Step 2: Equivalent resistance of circuit

The coil has internal resistance R.

This is connected in series with a galvanometer of resistance $6R$.

So total resistance in the circuit is:

$R_{\text{eq}} = R + 6R = 7R$

Step 3: Induced current

By Ohm's law:

$I = \frac{\mathcal{E}}{R_{\text{eq}}} = \frac{\frac{N(\phi_2 - \phi_1)}{t}}{7R} = \frac{N(\phi_2 - \phi_1)}{7Rt}$

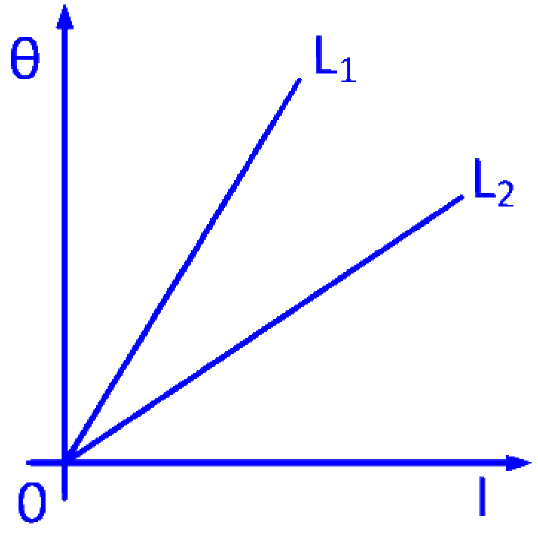
✅ **Final Answer:**

Option B:

$\boxed{\frac{N(\phi_2 - \phi_1)}{7Rt}}$

Question4

The plot of magnetic flux ' ϕ ' linked with the coil versus current ' I ' is as shown in figure for two inductors L_1 and L_2. The self inductance of



Options:

A. L_1 is equal to that of L_2.

B. L_1 is less than that of L_2.

C. L_1 is greater than that of L_2.

D. L_1 is half that of L_2.

Answer: C

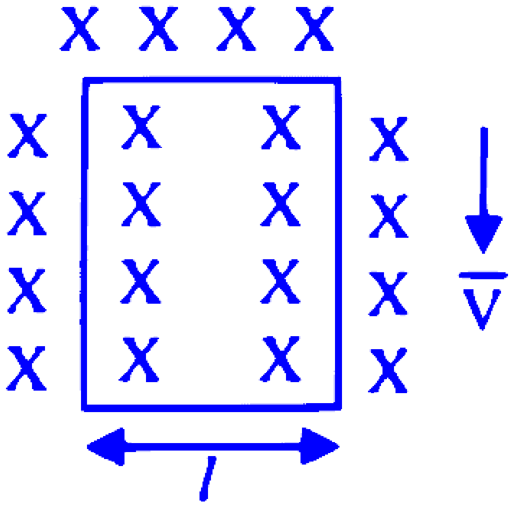
Solution:

Flux, $\phi = \mathrm{LI}$

Comparing the above equation with $\mathrm{y} = \mathrm{mx}$, $\mathrm{L} = \phi/\mathrm{I}$, which is the slope of the graph. Since slope of L_1 is greater, the value of selfinductance for L_1 is greater than that of L_2.

Question5

A long rectangular conducting loop of width ' l ', mass ' m ' and resistance ' R ' is placed partly in a perpendicular magnetic field ' B '. It is pushed downwards with velocity ' V ' so that it may continue to fall freely. The velocity ' V ' is



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Options:

A.

$\frac{\mathrm{mgR}^2}{\mathrm{B}l}$

B.

$\frac{\mathrm{B}^2 l^2 \mathrm{R}}{\mathrm{mg}}$

C.

$\frac{\mathrm{mgR}}{\mathrm{B}^2 l^2}$

D.

$\frac{\mathrm{mgl}}{\mathrm{B}^2\mathrm{R}^2}$

Answer: C

Solution:

Step 1: Find the induced emf

When the loop moves in the magnetic field, an emf (electric force) is created. The formula is: $E = lvB$ where l is the width of the loop, v is the velocity, and B is the magnetic field.

Step 2: Find the induced current

According to Ohm's Law, $E = iR$, where i is the current and R is the resistance. So, $i = \frac{lvB}{R}$

Step 3: Equate forces for free fall

If the loop is falling freely, the downward force (gravity) must equal the upward magnetic force. So, $mg = F_m$ where m is mass and g is gravity.

The magnetic force (F_m) is given by ilB. So, $mg = ilB$

Step 4: Substitute the current value

Substitute i from step 2 into the force equation: $mg = \left(\frac{lvB}{R}\right)lB \; mg = \frac{l^2 vB^2}{R}$

Step 5: Solve for velocity v

Rearrange for v: $v = \frac{mgR}{B^2 l^2}$

Question6

Two coils P and Q are kept near each other. When no current flows through coil P and current increases in coil Q at the rate $10 \mathrm{~A/s}$, the emf in coil P is 12 mV . When coil Q carries no current and current of 1.5 A flows through coil P , the magnetic flux linked with the coil Q in mWb is

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Options:

A.

0.9

B.

1.2

C.

1.5

D.

1.8

Answer: D

Solution:

Step 1: Relationship between Magnetic Flux and Mutual Inductance

The magnetic flux through coil Q because of the current in coil P is given by: $\phi_Q = MI_P$where M is the mutual inductance, and I_P is the current through coil P.

Step 2: Finding Mutual Inductance (M)

The emf in coil P, caused by a changing current in coil Q, is given by:$|e_p| = M\frac{dI_Q}{dt}$We can rearrange this formula to solve for M:$M = \frac{|e_p|}{\frac{dI_Q}{dt}}$This means you divide the emf (e_p) by the rate of change of current in coil Q ($\frac{dI_Q}{dt}$).

Step 3: Substitute the values

We are given:

- $|e_p| = 12\,\text{mV} = 12 \times 10^{-3}\,\text{V}$
- $\frac{dI_Q}{dt} = 10\,\text{A/s}$
- $I_P = 1.5\,\text{A}$

Step 4: Find M

Put the values into the formula:$M = \frac{12\times10^{-3}}{10} = 1.2 \times 10^{-3}\,\text{H}$

Step 5: Find the Flux Linked with Coil Q

Using $\phi_Q = MI_P$:$\phi_Q = 1.2 \times 10^{-3} \times 1.5 = 1.8 \times 10^{-3}\,\text{Wb}$

Step 6: Convert to milliWeber (mWb)

Since 1 mWb $= 10^{-3}$ Wb, we have:$\phi_Q = 1.8\,\text{mWb}$

Question7

When magnetic flux changes from 6.5×10^{-2} Wb to 11×10^{-2} Wb and the change in current is 0.03 A , the coefficient of mutual inductance will be

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Options:

A. 1.0 H

B. 1.2 H

C. 1.5 H

D. 1.8 H

Answer: C

Solution:

Mutual Inductance $\mathrm{M}=\frac{\Delta\phi}{\Delta\mathrm{I}}$

$$\begin{aligned}\Delta\phi=\phi_2-\phi_1&=(11-6.5)\times10^{-2}\ \mathrm{Wb}\\&=4.5\times10^{-2}\ \mathrm{Wb}\end{aligned}$$

Change in current $\Delta\mathrm{I}=0.03\ \mathrm{A}$

$$\therefore\quad M=\frac{\Delta\phi}{\Delta I}=\frac{4.5\times10^{-2}}{0.03}=1.5\mathrm{H}$$

Question8

Two circuits A and B are connected to identical d.c. sources each of e.m.f. 10 volt. Self-inductances of circuits A and B are respectively $\mathrm{L_A}=10\mathrm{H}$ and $\mathrm{L_B}=10\mathrm{mH}$. The total resistance of each circuit is 40Ω. The ratio of energy consumed in circuit A and circuit B to build up the current to steady value is

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Options:

A. 800

B. 1000

C. 1200

D. 1400

Answer: B

Solution:

Both circuits use the same battery (10 V) and have the same resistance (40 Ω). This means the steady current (I) will be the same in both circuits.

The energy stored in the inductor in each circuit is given by:

$\mathrm{E}=\frac{1}{2}\mathrm{L}I^2$

To find the ratio of energy stored in the inductors of circuits A and B, we can write:

$\frac{E_A}{E_B}=\frac{L_A I^2}{L_B I^2}$

The current I is the same in both, so I^2 cancels out:

$\frac{E_A}{E_B}=\frac{L_A}{L_B}$

Given: $L_A=10\ \mathrm{H}$ and $L_B=10\ \mathrm{mH}=10\times10^{-3}\ \mathrm{H}$

So,

$\frac{E_A}{E_B}=\frac{10}{10\times10^{-3}}=1000$

Question9

A magnetic field 4×10^{-2} T acts at right angles to a coil of area $100\ \mathrm{cm}^2$ with 50 turns. The average e.m.f. induced in the coil is 0.1 V , when it is removed from the field in time ' t '. The value of ' t ' is

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Options:

A. 0.02 second

B. 0.05 second

C. 0.2 second

D. 2 second

Answer: C

Solution:

$$e = -\frac{d\phi}{dt} = -\frac{(\phi_2-\phi_1)}{t} = -\frac{(0-NBA)}{t}$$

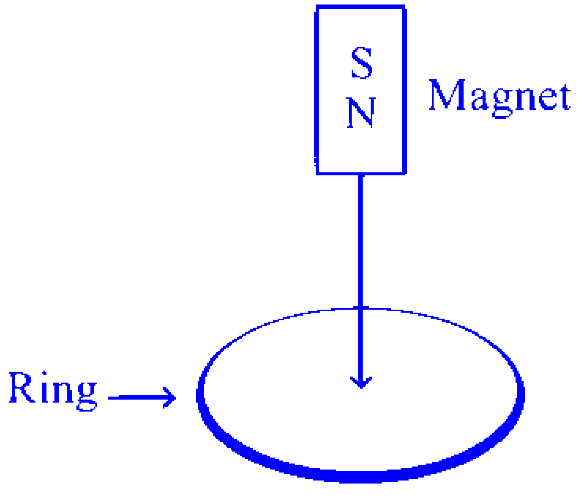
$\therefore \quad 0.1 = \frac{50\times4\times10^{-2}\times10^{-2}}{t}$

$\therefore$ The value of ' t ' is,

$$t = \frac{2\times10^{-2}}{0.1} = 0.2\ s$$

Question10

A copper ring having a cut such as not to form a complete loop is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring as shown in figure. The acceleration of the falling magnet is (g = acceleration due to gravity)



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Options:

A. g

B. less than g

C. more than g

D. zero

Answer: A

Solution:

When there is a cut in the ring, e.m.f. will be induced in it but there is no induced current in the ring. Hence there is no opposition to falling magnet. Therefore, acceleration is equal to ' g '.

Question11

A coil of wire of radius ' r ' has 600 turns and a self-inductance of 108 mH . The self-inductance of a coil with same radius and 500 turns is

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Options:

A. 80 mH

B. 75 mH

C. 108 mH

D. 90 mH

Answer: B

Solution:

Step 1: Recall the dependence of self-inductance

For a given geometry (same core, radius, length, etc.), the self-inductance scales as

$L \propto N^2$

where N is the number of turns.

Step 2: Set up ratio

Given:

- $N_1 = 600$, $L_1 = 108\,\mathrm{mH}$

- $N_2 = 500$, $L_2 = ?$

So,

$\frac{L_2}{L_1} = \left(\frac{N_2}{N_1}\right)^2$

$L_2 = L_1\left(\frac{N_2}{N_1}\right)^2$

Step 3: Substitute values

$L_2 = 108 \times \left(\frac{500}{600}\right)^2$

$\frac{500}{600} = \frac{5}{6}$

$\left(\frac{5}{6}\right)^2 = \frac{25}{36}$

$L_2 = 108 \times \frac{25}{36}$

$= 3 \times 25 = 75\,\text{mH}$

✅ **Final Answer:**

The self-inductance is

Option B: 75 mH

Question12

A coil of ' n ' turns and resistance $R\Omega$ is connected in series with a resistance $\frac{R}{2}$. The combination is moved for time ' t ' second through magnetic flux ϕ_1 to ϕ_2. The induced current in the circuit is

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Options:

A. $\frac{n(\phi_1-\phi_2)}{3Rt}$

B. $\frac{2n(\phi_1-\phi_2)}{3Rt}$

C. $\frac{2n(\phi_1-\phi_2)}{Rt}$

D. $\frac{n(\phi_1-\phi_2)}{Rt}$

Answer: B

Solution:

Step 1: Induced emf

Induced emf across n turn coil:

$$\mathcal{E}=n\frac{\Delta\phi}{\Delta t}=n\frac{\phi_1-\phi_2}{t}$$

Step 2: Total resistance of the circuit

Self resistance of coil = R.

External resistance = $\frac{R}{2}$.

Total resistance:

$$R_{\text{total}}=R+\frac{R}{2}=\frac{3R}{2}.$$

Step 3: Induced current

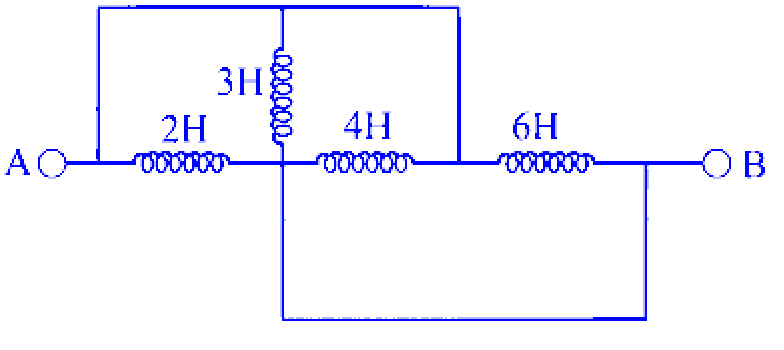
$$I=\frac{\mathcal{E}}{R_{\text{total}}}=\frac{n(\phi_1-\phi_2)/t}{\frac{3R}{2}}=\frac{2n(\phi_1-\phi_2)}{3Rt}.$$

Final Answer:

$$\boxed{\text{Option B: }\frac{2n(\phi_1-\phi_2)}{3Rt}}$$

Question13

The equivalent inductance between A and B is equal to



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Options:

A. $\frac{4}{5}$H

B. $\frac{5}{4}$H

C. $\frac{3}{10}$H

D. 15 H

Answer: A

Solution:

All the inductors are connected in parallel with each other. Hence, the equivalent inductance between A and B is: $\frac{1}{\mathrm{L}}=\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{6}$

$\therefore \quad L=\frac{4}{5} H$

Question14

A coil of ' n ' turns and area ' A ' is suddenly removed from a magnetic field, a charge ' q ' flows through the coil. If resistance of the coil is ' R ' then the magnetic flux density is (in Wb/m^2)

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Options:

A. $\frac{q^2 R}{2nA}$

B. $\frac{qR}{nA}$

C. $\frac{qR^2}{nA}$

D. $\frac{qR}{2nA}$

Answer: B

Solution:

Step 1: Faraday's law relation

The induced emf (total across coil):

$\mathcal{E} = -n\frac{d\Phi}{dt}$

where $\Phi = BA$ is the flux through one turn (if field is uniform and perpendicular).

Step 2: Relation between emf and current

$\mathcal{E} = IR$

Step 3: Charge flow

Total charge that flows over the discharge interval:

$q = \int I\,dt = \frac{1}{R}\int \mathcal{E}\,dt$

Step 4: Evaluate the integral

$\int \mathcal{E}\,dt = -n\int d\Phi = n\,\Delta\Phi$

Here, change in flux per turn is initial BA to zero, so $\Delta\Phi = BA$.

Thus:

$q = \frac{1}{R}(nBA)$

Step 5: Solve for B

$B = \frac{qR}{nA}$

Final Answer:

$$\boxed{\frac{qR}{nA}}$$

This corresponds to **Option B**.

Question15

A coil of n turns and resistance $\mathrm{R}\Omega$ is connected in series with resistance $R/4$. The combination is moved for time t second through magnetic flux ϕ to ϕ_2. The induced current in the circuit is

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Options:

A. $\frac{2n(\phi_1-\phi_2)}{5Rt}$

B. $\frac{4n(\phi_1-\phi_2)}{5Rt}$

C. $\frac{3n(\phi_1-\phi_2)}{4Rt}$

D. $\frac{5n(\phi_1-\phi_2)}{3Rt}$

Answer: B

Solution:

Step 1. Induced emf (Faraday's law):

Induced emf:

$\mathcal{E} = n \cdot \frac{\Delta\phi}{\Delta t} = n \cdot \frac{\phi_1-\phi_2}{t}$

(sign is not important here, they ask for current magnitude).

Step 2. Total resistance:

Coil resistance = R.

Extra resistance = $\frac{R}{4}$.

Total resistance $R_{\text{eq}} = R + \frac{R}{4} = \frac{5R}{4}$.

Step 3. Current:

$I = \frac{\mathcal{E}}{R_{\text{eq}}} = \frac{n(\phi_1-\phi_2)/t}{(5R/4)} = \frac{4n(\phi_1-\phi_2)}{5Rt}$

Final Answer:

$$\boxed{\frac{4n(\phi_1-\phi_2)}{5Rt}}$$

which corresponds to **Option B**.

Question16

Two identical coils of inductance L joined in series are placed very close to each other such that the winding direction of one coil is exactly opposite to that of the other. The net inductance is

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Options:

A. $\frac{L}{2}$

B. 2 L

C. zero

D. L

Answer: C

Solution:

When two inductors are joined in series then, $L_{total} = L_1 + L_2 + \ldots + L_n$

Since the two inductors are placed very close to each other, they are mutually coupled, meaning there is mutual inductance between them. As the winding direction of one coil is exactly opposite to that of the other, the magnetic fields produced by the currents oppose each other. This causes the polarity of the mutual inductance to be opposite to that of the self-inductance. As as result, net inductance will be given by

$\text{Net Inductance} = L + L - 2M$

$\text{Net Inductance} = 2\,L - 2\,L = 0 \quad \ldots.(M = L \text{ as they are identical coils placed very close to each other})$

Question17

When a current in the conducting coil is changed from 5 A in one direction to 5 A in opposite direction in 0.5 second, an average induced e.m.f in the coil is 2 V . The selfinductance of the coil is

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Options:

A. 25 mH

B. 50 mH

C. 75 mH

D. 100 mH

Answer: D

Solution:

We are given:

- Initial current $I_1 = 5\,\mathrm{A}$
- Final current $I_2 = -5\,\mathrm{A}$
- Change in current:

  $\Delta I = I_2 - I_1 = -5 - 5 = -10\,\mathrm{A}$
- Time interval: $\Delta t = 0.5\,\mathrm{s}$
- Average induced emf: $E = 2\,\mathrm{V}$.

Formula:

$E = L\frac{\Delta I}{\Delta t}$

Taking magnitude values:

$L = \frac{E \cdot \Delta t}{|\Delta I|}$

Substitution:

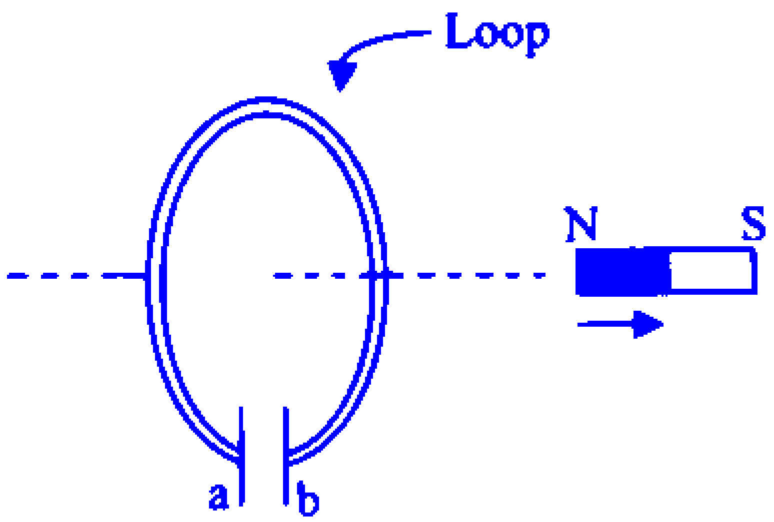
$L = \frac{2 \times 0.5}{10} = \frac{1}{10} = 0.1\,\mathrm{H}$

$L = 100\,\mathrm{mH}$

✅ **Answer: Option D (100 mH)**

Question18

Figure shows the north pole of a magnet moving away from a thick conducting loop containing a capacitor. The excess positive charge will arrive on



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Options:

A. plate ' a '

B. plate ' b '

C. both plates 'a' and 'b'

D. neither plate ' a ' nor plate ' b '

Answer: B

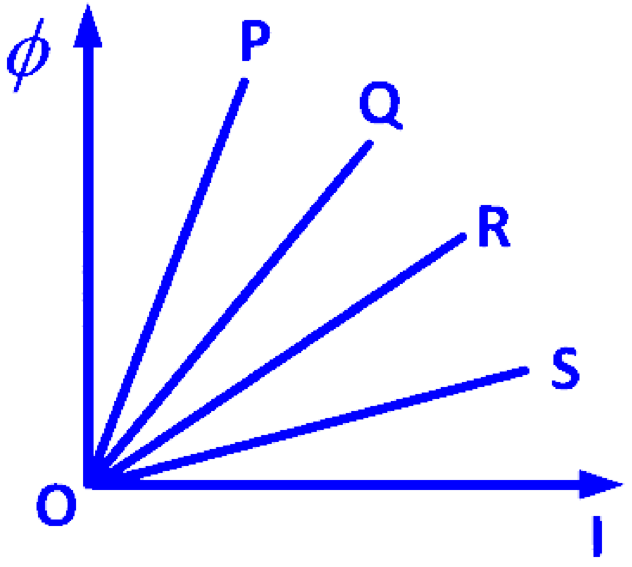
Solution:

Magnet moves away $\rightarrow$ flux decreases $\rightarrow$ Loop opposes change $\rightarrow$ induced current flows from a to b in the wire.

Current flows from a to b in the wire, so positive charge accumulates on plate ' b '.

Question19

A graph of magnetic flux (ϕ) versus current (I) is shown for four inductors $\mathrm{P}, \mathrm{Q}, \mathrm{R}, \mathrm{S}$. The largest value of self-inductance is for inductor



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Options:

A. R

B. P

C. Q

D. S

Answer: B

Solution:

Flux, $\phi = \mathrm{LI}$

Comparing the above equation with $\mathrm{y} = \mathrm{mx}$, L is the slope of the graph.

Since line P has highest slope, it indicates the largest value of self-inductance.

Question20

The total charge induced in a conducting loop when it is moved in a uniform magnetic field depends on

Options:

A. initial magnetic flux only.

B. final magnetic flux only.

C. the total change in magnetic flux.

D. the rate of change of magnetic flux.

Answer: C

Solution:

- Faraday's law:

  Induced emf $\mathcal{E} = -\frac{d\Phi}{dt}$, where Φ is the magnetic flux through the loop.

- The induced current is $I = \frac{\mathcal{E}}{R}$, where R is the resistance of the loop.

- The total charge that flows through the circuit during the entire process:

  $Q = \int I\,dt = \frac{1}{R}\int \mathcal{E}\,dt.$

Step 2: Relation to flux.

$Q = \frac{1}{R}\int -\frac{d\Phi}{dt}\,dt = \frac{1}{R}\left(\Phi_{\text{initial}} - \Phi_{\text{final}}\right).$

Thus, the total charge depends on the **net change in magnetic flux**, not on the rate at which it changes.

Answer:

$\boxed{\text{Option C: the total change in magnetic flux.}}$

Question21

A copper ring is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet while it is passing through the ring is

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Options:

A. more than acceleration due to gravity.

B. less than acceleration due to gravity.

C. depends on the diameter of ring and length of magnet.

D. depends on pole strength of magnet.

Answer: B

Solution:

When the magnet is allowed to fall vertically along the axis of loop with its north pole towards the ring, the induced current in the ring consistently produces a magnetic force that opposes the magnet's motion relative to the ring, resulting in an upward force that counteracts gravity, reducing the acceleration of the falling magnet. Therefore, the acceleration in the magnet is less than g .

Question22

A coil of resistance 400Ω is placed in ^{3} magnetic field. If the magnetic flux ' ϕ, (Wb) linked with the coil varies with time ' t ' (s) is $\phi=50t^2+4$, the current in the coil at $t=2$ s will be

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Options:

A. 1 A

B. 2 A

C. 0.5 A

D. 0.1 A

Answer: C

Solution:

Step 1: Faraday’s law of electromagnetic induction

The induced emf is:

$e = -\frac{d\phi}{dt}$

Given: $\phi = 50t^2 + 4$ Wb.

So,

$\frac{d\phi}{dt} = \frac{d}{dt}(50t^2 + 4) = 100t$

At $t = 2$ s:

$\frac{d\phi}{dt} = 100(2) = 200$ V

(The negative sign only tells about direction; for magnitude of current, take absolute value.)

Step 2: Ohm’s Law

The resistance of the coil is

$R = 400\,\Omega$

So induced current is

$I = \frac{e}{R} = \frac{200}{400} = 0.5$ A

✅ Final Answer:

The current in the coil at $t = 2$ s is:

$\boxed{0.5\text{ A}}$

Correct Option: C

Question23

A coil is wound on a core of rectangular crosssection. If all the linear dimensions of core are increased by a factor 3 and number of turns per unit length of coil remains same, the selfinductance increases by a factor

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Options:

A. $\frac{1}{6}$

B. 1

C. 3

D. 27

Answer: D

Solution:

The self-inductance of a coil (approximated as a solenoid wound on a core) is given by the formula:

$L = \mu n^2 Al$

Where:

- L is the self-inductance.
- μ is the permeability of the core material.
- n is the number of turns per unit length.
- A is the cross-sectional area of the core.
- l is the length of the coil (which is the length of the core along the axis of the coil).

Let's analyze how each parameter changes based on the problem statement:

1. **Linear dimensions of the core**: The problem states that "all the linear dimensions of core are increased by a factor 3".

   A core with a rectangular cross-section has three main linear dimensions: width (w), height (h), and length (l).

   So, the new dimensions will be:

   - New width $w' = 3w$
   - New height $h' = 3h$
   - New length $l' = 3l$

2. **Cross-sectional area (A)**:

   The original cross-sectional area was $A = w \times h$.

   The new cross-sectional area A' will be $A' = w' \times h' = (3w) \times (3h) = 9wh = 9A$.

   So, A' increases by a factor of 9.

3. **Length of the coil (l):**

   As part of the linear dimensions of the core, the length of the coil (the length over which the turns are wound) also increases by a factor of 3.

   So, $l' = 3l$.

4. **Number of turns per unit length (n):**

   The problem explicitly states that "number of turns per unit length of coil remains same".

   So, $n' = n$.

5. **Permeability (μ):**

   The core material is not changed, so its permeability μ remains constant.

Now, let's calculate the new self-inductance (L'):

The original self-inductance was $L = \mu n^2 A l$.

The new self-inductance is $L' = \mu (n')^2 A' l'$.

Substitute the changed parameters:

$L' = \mu (n)^2 (9A)(3l)$

$L' = \mu n^2 A l \times (9 \times 3)$

$L' = \mu n^2 A l \times 27$

Since $L = \mu n^2 A l$, we can write:

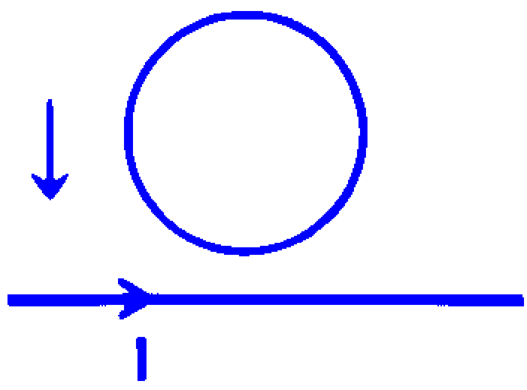
$L' = 27L$

Therefore, the self-inductance increases by a factor of 27.

The final answer is $\boxed{27}$.

Question24

A conducting ring of certain resistance is falling towards a current carrying straight long conductor. The ring and conductor are in the same plane. Then



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Options:

A. induced current in the coil is zero.

B. induced current in the coil is anticlockwise.

C. induced current in the coil is clockwise.

D. ring will come to rest.

Answer: C

Solution:

The magnetic field produced by the currentcarrying straight wire will be directed outside the plane of the paper, within the conducting ring. As the ring falls toward the conductor, the magnetic flux through the ring will continuously increase. According to Lenz's Law, the induced current will oppose the change in magnetic flux. Therefore, the induced current in the ring will flow in a direction (clockwise) that opposes the increasing magnetic flux. Thus, the current in the conducting ring will be induced in a clockwise direction.

Question25

What is the phase difference between the flux linked with a coil rotating in a uniform magnetic field and the induced e.m.f. produced in it?

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Options:

A. π

B. $-\frac{\pi}{6}$

C. $\frac{\pi}{3}$

D. $\frac{\pi}{2}$

Answer: D

Solution:

We need to find the phase difference between the **flux linked** with a rotating coil in a uniform magnetic field and the **induced emf**.

Step 1: Expression for flux linkage

If a coil of N turns and area A rotates in a uniform magnetic field B with angular speed ω, the flux linked at time t is:

$\phi(t) = NBA\cos(\omega t)$

Step 2: Expression for induced emf

Induced emf is given by **Faraday's law**:

$e(t) = -\frac{d\phi}{dt}$

So,

$e(t) = -\frac{d}{dt}\left[NBA\cos(\omega t)\right]$

$e(t) = NBA\omega\sin(\omega t)$

Step 3: Compare phase

- Flux $\phi(t) = \cos(\omega t)$
- emf $e(t) = \sin(\omega t)$

We know:

$\sin(\omega t) = \cos\left(\omega t - \frac{\pi}{2}\right)$

So, the induced emf **lags** the flux by $\pi/2$. Equivalently, flux leads emf by $\pi/2$.

✅ **Final Answer:**

The phase difference between flux and induced emf is:

$$\boxed{\frac{\pi}{2}}$$

Correct Option: D

Question26

Two coils P and Q are kept near each other. When no current flows through coil P and current increases in coil Q at the rate of 10 A/S, the e.m.f. in coil P is 15 mV . When coil Q carries no current and current of 1.8 A flows through coil P, the magnetic flux linked with coil Q is

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Options:

A. 1.8 mWb

B. 2.7 mWb

C. 1.5 mWb

D. 1 mWb

Answer: B

Solution:

Given:

- Rate of change of current in coil Q: $\frac{dI_Q}{dt} = 10 \text{ A/s}$
- Induced emf in coil P: $e_P = 15 \text{ mV} = 15 \times 10^{-3} \text{ V}$
- Current in P when Q carries no current: $I_P = 1.8 \text{ A}$
- Flux linked with coil Q needed: $\phi_Q = ?$

Step 1: Find Mutual Inductance (M)

The mutual inductance M is defined as:

$e_P = -M \frac{dI_Q}{dt}$

(We can take magnitude as only magnitude is given)

$M = \frac{e_P}{\frac{dI_Q}{dt}}$

$M =$ Substitute the given values:

$\frac{15 \times 10^{-3}}{10} = 1.5 \times 10^{-3} \text{ H} = 1.5 \text{ mH}$

Step 2: Find Flux Linked with Q When P Carries Current

The total flux linked with coil Q due to current in P:

$\phi_Q = M \cdot I_P$

Substitute the values found:

$\phi_Q = 1.5 \times 10^{-3} \text{ H} \times 1.8 \text{ A} = 2.7 \times 10^{-3} \text{ Wb} = 2.7 \text{ mWb}$

Final Answer:

Option B: 2.7 mWb

Question27

To manufacture a solenoid of length ' l ' and inductance ' L ', the length of the thin wire required is (Diameter of the solenoid is very less than length, $\mu_0 =$ permeability of free space)

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Options:

A. $\left[\frac{4\pi l L}{\mu_0}\right]^{\frac{1}{2}}$

B. $\left[\frac{2\pi l}{\mu_0 \text{ L}}\right]^{\frac{1}{2}}$

C. $\left[\frac{4\pi\mu_0}{l \text{ L}}\right]^{\frac{1}{2}}$

D. $\left[\frac{2\pi\mu_0 \text{ L}}{l}\right]^{\frac{1}{2}}$

Answer: A

Solution:

Let us use the formula for the inductance of a long solenoid:

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

Where

- L = Inductance
- μ_0 = Permeability of free space
- N = Number of turns
- A = Cross-sectional area
- l = Length of solenoid

Let the radius of the solenoid be r (so $A = \pi r^2$).

Step 1: Express N in terms of known quantities

From the formula:

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

$N^2 = \frac{L\, l}{\mu_0 \pi r^2}$

$N = \sqrt{\frac{L\, l}{\mu_0 \pi r^2}}$

Step 2: Find total length of wire required

Length of wire per turn = Circumference = $2\pi r$

Total length of wire required, $l_{wire} = N \times 2\pi r$

Substituting value of N,

$l_{wire} = 2\pi r \sqrt{\frac{L\, l}{\mu_0 \pi r^2}}$

Step 3: Simplify

Let us take r inside the square root:

$l_{wire} = 2\pi \left[r \sqrt{\frac{Ll}{\mu_0 \pi r^2}}\right]$

$l_{wire} = 2\pi \left[\sqrt{\frac{Llr^2}{\mu_0 \pi r^2}}\right]$

Since r^2 cancels,

$l_{wire} = 2\pi\left[\sqrt{\frac{Ll}{\mu_0 \pi}}\right]$

$l_{wire} = 2\sqrt{\pi}\sqrt{\frac{Ll}{\mu_0}}$

Or,

$l_{wire} = \left[\frac{4\pi lL}{\mu_0}\right]^{1/2}$

Final Answer:

Option **A** is correct.

$$\boxed{\left[\frac{4\pi lL}{\mu_0}\right]^{1/2}}$$

Question28

Initially a rectangular coil with length vertical is moving out with constant velocity ' v ' in a constant magnetic field ' B ' towards right. Now the same coil is rotated through 90° in same plane in same magnetic field B and the coil is moving with same velocity v. The magnitude of induced e.m.f. is now

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Options:

A. greater than initial induced e.m.f.

B. less than initial induced e.m.f.

C. equal to initial induced e.m.f.

D. sometimes greater and sometimes less than initial induced e.m.f.

Answer: A

Solution:

✅ Correct Answer: A — greater than initial induced e.m.f.

✔ Concept: Motional EMF Depends on Component of Length Perpendicular to Velocity

The motional emf induced in a moving conductor is:

$$\varepsilon = B\,v\,l_{\perp}$$

where

- B = magnetic field
- v = velocity
- $l_{\perp}$ = effective length perpendicular to direction of motion

---

⭐ Initially: Coil is vertical

- Length **vertical**
- Velocity **horizontal**

So the **entire vertical length** contributes to emf:

$$\varepsilon_1 = Bvl$$

⭐ After rotation by 90° in the same plane

- The coil is now **horizontal**
- The **width** (which is greater than the original vertical length) becomes perpendicular to velocity

💡 A rectangular coil has:

- **Vertical length = smaller side**
- **Horizontal length = larger side**

After rotation, **larger side becomes perpendicular to velocity**, so:

$$\varepsilon_2 = Bv \times (\text{larger side})$$

Clearly:

$$\varepsilon_2 > \varepsilon_1$$

Question29

A simple pendulum with bob of mass m and conducting wire of length L swings under gravity through an angle θ. The component of earth's magnetic field in the direction perpendicular to swing is B .

Maximum e.m.f. induced across the pendulum is ($g =$ acceleration due to gravity)

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Options:

A. $2\mathrm{BL}(\sqrt{\mathrm{gL}})\left(\sin \frac{\theta}{2}\right)$

B. $\mathrm{BL}(\sqrt{\mathrm{gL}})\left(\sin \frac{\theta}{2}\right)$

C. $\mathrm{BL}(\sqrt{\mathrm{gL}})^2\left(\sin \frac{\theta}{2}\right)$

D. $2\mathrm{BL}(\sqrt{\mathrm{gL}})\left(\sin^2 \frac{\theta}{2}\right)$

Answer: A

Solution:

At the extreme position, the bob of the pendulum at a height ' h ' from the mean position.

$h=L-L \cos \theta=L(1-\cos \theta)=2 L \sin ^2\left(\frac{\theta}{2}\right)$

When the bob reaches the mean position, it loses potential energy and gains equal kinetic energy.

$\therefore \quad \frac{1}{2} \mathrm{mv}^2=\mathrm{mgh}=\mathrm{mg} \times 2 \mathrm{L} \sin ^2\left(\frac{\theta}{2}\right)$
$\therefore \quad \mathrm{v}=2 \sin \left(\frac{\theta}{2}\right) \sqrt{\mathrm{gL}}$

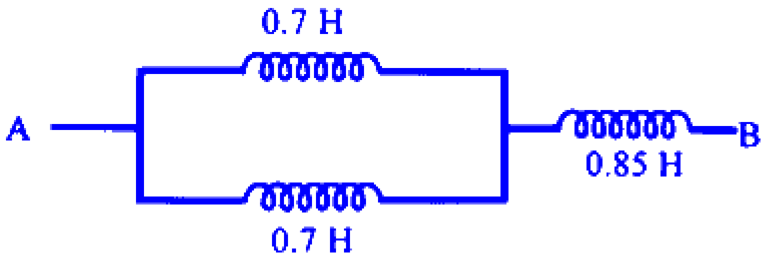
Induced emf (using Instantaneous max velocity) At lowest point, entire wire of length L is moving with speed v .

So, maximum emf is:

$$\varepsilon_{\max }=B \cdot L \cdot v=B \cdot L \cdot 2 \sqrt{g L} \sin \left(\frac{\theta}{2}\right)$$
$$\therefore \quad \varepsilon_{\max }=2 B L \sqrt{g L} \sin \left(\frac{\theta}{2}\right)$$

Question30

Three inductances are connected as shown in the figure. The equivalent inductance between A and b is



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Options:

A. 2.25 H

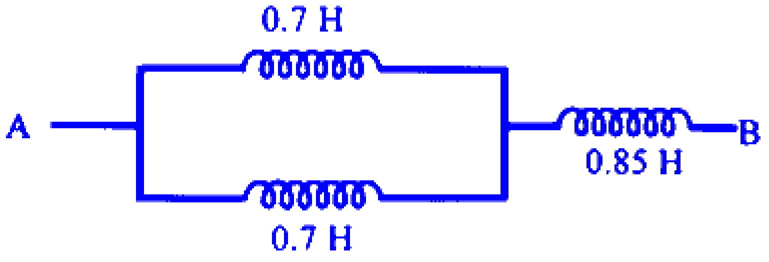
B. 1.20 H

C. 0.225 H

D. 0.120 H

Answer: B

Solution:



Two 0.7 H inductors are in parallel.

$\frac{1}{L_p} = \frac{1}{0.7} + \frac{1}{0.7} = \frac{2}{0.7} \Rightarrow L_p = \frac{0.7}{2} = 0.35\text{H}$

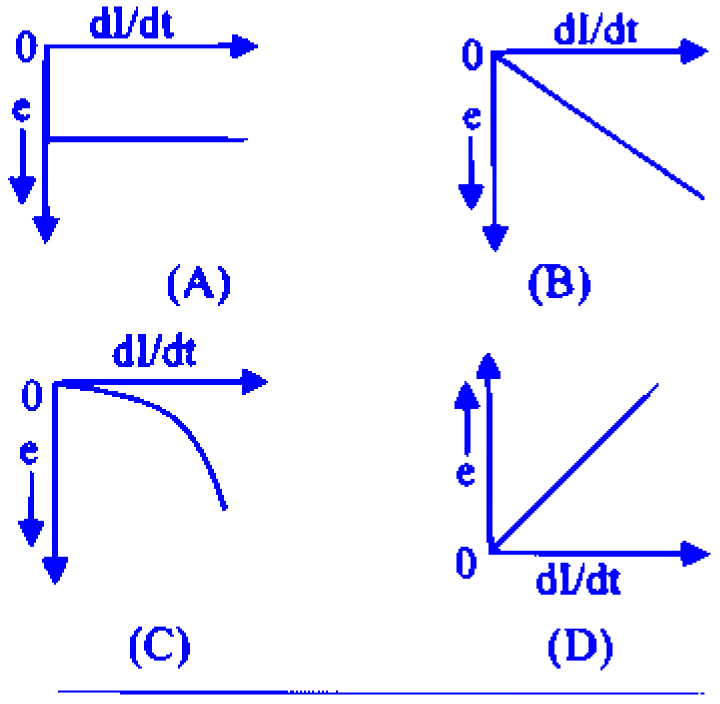
L_P is in Series with 0.85 H inductor.

$L_{eq} = L_p + 0.85 = 0.35 + 0.85 = 1.20H$

$\therefore$ The equivalent inductance between A and B is 1.20 H .

Question31

The current flowing through an inductor of selfinductance L is continuously increasing at constant rate. The variation of induced e.m.f. (e) verses $\mathrm{dI/dt}$ is shown graphically by figure



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Options:

A. B

B. A

C. D

D. C

Answer: B

Solution:

We know that the current through the inductor is increasing at a constant rate. This means that $\frac{dI}{dt}$ is constant.

The formula for the induced emf (e) in an inductor is: $e = -L\frac{dI}{dt}$.

Since $\frac{dI}{dt}$ is constant, the induced emf e will also be constant (but negative because of the minus sign).

This means that if we plot e versus $\frac{dI}{dt}$, the graph will be a straight line. The line will have a slope of $-L$ and will pass through the origin.

This is shown in graph A, which matches option (B) in the choices.

Question32

The coefficient of mutual induction is 2 H and induced e.m.f. across secondary is 2 kV . Current in the primary is reduced from 6 A to 3 A . The time required for the change of current is

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Options:

A. 4×10^{-3} s

B. 6×10^{-3} s

C. 2×10^{-3} s

D. 3×10^{-3} s

Answer: D

Solution:

Given:

- Coefficient of mutual induction, $M = 2$ H
- Induced emf, $E = 2$ kV $= 2000$ V
- Change in current in primary, $\Delta I = 6$ A $- 3$ A $= 3$ A (it is reduced, so $\Delta I = -3$ A but magnitude is enough)
- Required: Time taken, Δt

According to NCERT, the induced emf due to mutual induction is:

$E = M \frac{\Delta I}{\Delta t}$

Rearrange to solve for Δt:

$\Delta t = M \frac{\Delta I}{E}$

Substitute the values:

$\Delta t = \frac{2 \times 3}{2000}$

Calculate:

$\Delta t=\frac{6}{2000}=0.003$ s

or

$\Delta t=3\times10^{-3}$ s

Correct option: Option D (3×10^{-3} s)

Question33

Two planar concentric rings of metal wire having radii r_1 and r_2 $(r_1>r_2)$ are placed in air. The current I is flowing through the coil of larger radius. The mutual inductance between the coils is given by ($\mu_0=$ permeability of free space)

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Options:

A. $\frac{\mu_0\pi r_1^2}{2r_2}$

B. $\frac{\mu_0\pi r_1^2}{2r_1}$

C. $\frac{\mu_0\pi(r_1+r_2)^2}{2r_1}$

D. $\frac{\mu_0\pi(r_1-r_2)^2}{2r_2}$

Answer: B

Solution:

The magnetic field at the centre of a loop is given by

$B=\frac{\mu_0NI}{2R}$

$\therefore$ Magnetic field produced by ring $A, B_A=\frac{\mu_0I}{2r_1}$

$\therefore$ Magnetic flux produced in ring B due to B_A,

$\phi_B = B_A A_B$
$A_B = \pi r_2^2$

$\therefore \quad \phi_B = \frac{\mu_0 I}{2r_1} \times \pi r_2^2 = \frac{\mu_0 \pi r_2^2}{2r_1} I$

Mutual Inductance $M = \frac{\phi}{I}$

$\therefore$ We can write,

$M = \frac{\phi_B}{I} = \frac{\mu_0 \pi r_2^2 \cdot I}{2r_1 \cdot I} = \frac{\mu_0 \pi r_2^2}{2r_1}$

Question34

Out of the following which law obeys the law of conservation of energy?

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Options:

A. Kirchhoff's 1^{st} law in electricity.

B. Lenz's law in induction.

C. Ampere's circuital law.

D. Gauss's law in electrostatics.

Answer: B

Solution:

Lenz's law in induction obeys the law of conservation of energy.

Explanation:

- **Lenz's law** states that the induced current in a coil due to a change in magnetic flux always flows in such a direction that it opposes the change in flux.
- This opposition ensures that energy is not created or destroyed, which is in accordance with the law of conservation of energy.

Correct Option:

Option B: Lenz's law in induction.

Question35

The magnetic flux through a coil is 4×10^{-4} Wb at time $t = 0$. It reduces to 30% of its original value in time t second. If e.m.f. induced in the coil is 0.56 mV then the value of t is

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Options:

A. 0.5 s

B. 0.4 s

C. 0.8 s

D. 0.7 s

Answer: A

Solution:

Given:

- Initial flux, $\phi_1 = 4 \times 10^{-4}$ Wb
- Final flux, $\phi_2 = 30\%$ of $\phi_1 = 0.3 \times 4 \times 10^{-4} = 1.2 \times 10^{-4}$ Wb
- Induced emf, $e = 0.56$ mV $= 0.56 \times 10^{-3}$ V
- Time interval, $t = ?$

Step 1: Formula for average induced emf

$e = \frac{|\phi_2 - \phi_1|}{t}$

Step 2: Substituting the values

$e = \left|\frac{1.2 \times 10^{-4} - 4 \times 10^{-4}}{t}\right|$

$e = \left|\frac{-2.8 \times 10^{-4}}{t}\right|$

$e = \frac{2.8 \times 10^{-4}}{t}$

Given $e = 0.56 \times 10^{-3}$ V $= 5.6 \times 10^{-4}$ V (But 0.56 mV is 0.56×10^{-3}, or 5.6×10^{-4} — check carefully.)

But $0.56 \mathrm{~mV}=0.56 \times 10^{-3}=5.6 \times 10^{-4} \mathrm{~V}$

So,

$5.6 \times 10^{-4}=\frac{2.8 \times 10^{-4}}{t}$

Step 3: Solve for t

$5.6 \times 10^{-4} \cdot t=2.8 \times 10^{-4}$

$t=\frac{2.8 \times 10^{-4}}{5.6 \times 10^{-4}}$

$t=\frac{2.8}{5.6}$

$t=0.5 \mathrm{~s}$

Answer:

Option A: 0.5 s

Question36

When three inductors of same inductance ' L ' are connected in series and ' I ' is the current passing through the circuit. The energy stored in the circuit is

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Options:

A. $\frac{1}{2} \mathrm{LI}^2$

B. $\frac{3}{2} \mathrm{LI}^2$

C. $\frac{5}{2} \mathrm{LI}^2$

D. $\frac{7}{2} \mathrm{LI}^2$

Answer: B

Solution:

Given:

- Three inductors, each of inductance L, connected in series.
- Current passing through the circuit = I

Step 1: Equivalent inductance in series

When inductors are connected in series, their inductances add up:

$$L_{\text{eq}} = L_1 + L_2 + L_3 = L + L + L = 3L$$

Step 2: Formula for energy stored in an inductor

The energy stored in an inductor of inductance L_{eq} carrying current I is:

$$E = \frac{1}{2} L_{\text{eq}} I^2$$

Step 3: Substitute the values

Substitute $L_{\text{eq}} = 3L$:

$$E = \frac{1}{2} \times 3L \times I^2 = \frac{3}{2} L I^2$$

Final Answer:

Option **B**

$$\boxed{\frac{3}{2} L I^2}$$

Question37

The self-inductance of a circuit is numerically equal to

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Options:

A. the work done in establishing the magnetic flux associated with circuit.

B. twice the work done in establishing the magnetic flux associated with unit current in the circuit.

C. thrice the work done in establishing the magnetic flux associated with unit current in the circuit.

D. the work done in establishing the magnetic flux associated with unit current in the circuit.

Answer: B

Solution:

Self-inductance (L) of a circuit is defined as the ratio of the magnetic flux linked with the circuit to the current producing it:

$L = \frac{\Phi}{I}$

The work done (W) in establishing a current I against the induced emf is given by:

$W = \frac{1}{2} L I^2$

Now, if the current is unity ($I = 1$):

$W = \frac{1}{2} L (1)^2 = \frac{1}{2} L$

Therefore,

$L = 2 \times$ (work done in establishing unit current)

Thus, the correct answer is:

Option B

twice the work done in establishing the magnetic flux associated with unit current in the circuit.

Question38

Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. If $R_1 > R_2$, the mutual inductance M between them will be directly proportional to

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Options:

A. $\frac{\mathrm{R}_1}{\mathrm{R}_2}$

B. $\frac{R_2}{R_1}$

C. $\frac{\mathrm{R}_1^2}{\mathrm{R}_2}$

D. $\frac{R_2^2}{R_1}$

Answer: D

Solution:

Let us analyze the situation step by step:

1. **Understanding Mutual Inductance (M):**

- Mutual inductance between two coils is given by

  $M = \frac{\Phi_{21}}{I_1}$

  where Φ_{21} is the magnetic flux linked with the second coil due to the current I_1 in the first coil.

1. **Loops Arrangement:**

- Both loops are concentric and coplanar, with $R_1 > R_2$.

1. **Field due to Large Loop (R_1) at its Centre:**

- Magnetic field at the centre of a loop of radius R_1 carrying current I_1:

  $B = \frac{\mu_0 I_1}{2 R_1}$

1. **Flux through the Smaller Loop (R_2):**

- The flux through the smaller loop is:

  $\Phi_{21} = B \cdot \text{Area of smaller loop}$

  $\Phi_{21} = \left(\frac{\mu_0 I_1}{2 R_1}\right) \pi R_2^2$

1. **Calculating M:**

  $M = \frac{\Phi_{21}}{I_1} = \frac{\mu_0}{2 R_1} \pi R_2^2$

- So, $M \propto \frac{R_2^2}{R_1}$

Final Answer:

$$\boxed{\frac{R_2^2}{R_1}}$$

So, the correct option is **Option D**.

Question39

A circular coil of resistance ' R ', area ' A ', number of turns ' N ' is rotated about its vertical diameter with angular speed ' ω ' in a uniform magnetic field of magnitude ' B '. The average power dissipated in a complete cycle is

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Options:

A. $\frac{N^2 A^2 B^2 \omega^2}{2R}$

B. $\frac{BNA\omega}{R}$

C. $\frac{BNA\omega}{2R}$

D. $\frac{N^2 A^2 B^2 \omega^2}{R}$

Answer: A

Solution:

For a circular coil,

$e_0 = NAB\omega$

$i_0 = \frac{NAB\omega}{R}$

$\therefore$ Average power dissipated per cycle $= \frac{1}{2} e_0 i_0$

$= \frac{1}{2}(NAB\omega)\frac{(NAB\omega)}{R}$

$= \frac{N^2 A^2 B^2 \omega^2}{2R}$

Question40

A coil is wound on a core of rectangular crosssection. If all the linear dimensions of the core are increased by a factor 2 and number of turns per unit length of coil remains same, the self inductance increases by a factor of (Assume, permeability is same)

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Options:

A. 16

B. 8

C. 4

D. 2

Answer: B

Solution:

The self-inductance of the coil is given by

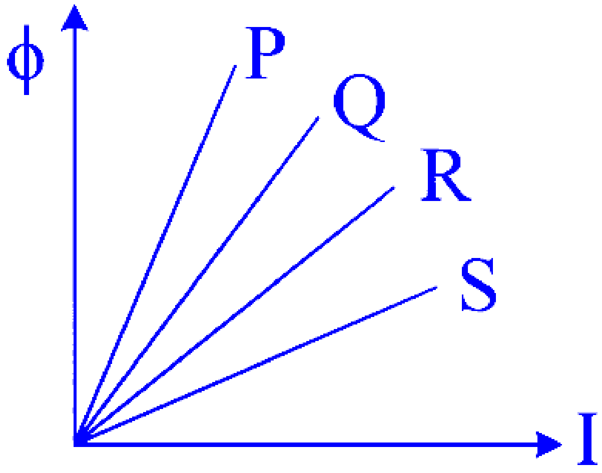
$L = \mu_0 n^2 l\ A$

When n is kept constant and linear dimensions is increased by a factor of 2, the area of cross-section will become 4 A and length with become $2l$.

$\therefore$ Self-inductance will become 8 times.

Question41

A graph of magnetic flux (ϕ) versus current (I) is shown for 4 different inductors P, Q, R, S. Minimum value of inductance is for inductor



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Options:

A. P

B. Q

C. R

D. S

Answer: D

Solution:

Flux, $\phi = \mathrm{LI}$

Comparing the above equation with $\mathrm{y} = \mathrm{mx}$, $\mathrm{L} = \phi / \mathrm{I}$, which is the slope of the graph.

Since line S has least slope, it indicates the smallest value of self-inductance.

Question42

The mutual inductance of two coils is 45 mH . The self-inductance of the coils are $\mathrm{L}_1 = 75\mathrm{mH}$ and $\mathrm{L}_2 = 48\mathrm{mH}$. The coefficient of coupling between the two coils is

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Options:

A. 0.3

B. 0.4

C. 0.75

D. 1.0

Answer: C

Solution:

The coefficient of coupling (k) between two coils can be calculated using the mutual inductance (M) and the self-inductances (L_1 and L_2) of the coils. The formula for the coefficient of coupling is:

$k = \frac{M}{\sqrt{L_1 \cdot L_2}}$

Given:

$M = 45 \, \text{mH}$

$L_1 = 75 \, \text{mH}$

$L_2 = 48 \, \text{mH}$

Substitute the given values into the formula:

$k = \frac{45 \text{ mH}}{\sqrt{75 \text{ mH} \cdot 48 \text{ mH}}}$

Calculate the product inside the square root:

$75 \cdot 48 = 3600$

So:

$\sqrt{3600} = 60$

Now, plug the values back into the formula:

$k = \frac{45}{60} = 0.75$

Thus, the coefficient of coupling is 0.75. The correct option is C: 0.75.

Question43

A coil of resistance 250Ω is placed in a magnetic field. If the magnetic flux (ϕ) linked with the coil varies with time $t(\text{ s})$ as $\phi = 50\text{t}^2 + 7$. The current in the coil at $t = 4 \text{ s}$ is

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Options:

A. 1.3 A

B. 1.4 A

C. 1.5 A

D. 1.6 A

Answer: D

Solution:

Induced e.m.f. is given as $|e| = \frac{d\phi}{dt}$

Given, $\phi = 50t^2 + 7$

$\therefore \quad |e| = \frac{d}{dt}\left(50t^2 + 7\right) = 100t$

For $t = 4$ s, $e = 100(4) = 400$ V

Current, $I = \frac{V}{R} = \frac{400}{250} = 1.6$ A

Question44

A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The induced e.m.f. between the rim and axis of the disc is

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Options:

A. $B\pi R^2$

B. $\frac{2\,B\pi^2 R^2}{\omega}$

C. $B\pi R^2\omega$

D. $\frac{BR^2\omega}{2}$

Answer: D

Solution:

Induced e.m.f.,

$$e = \frac{-d\phi}{dt} = -\frac{d(BA)}{dt}$$
$$= -B\frac{dA}{dt} \quad \ldots.(\because B = \text{ constant })$$

Area swept between axis and the rim, $dA = \pi R^2$ Time during which the change in flux taking place, $dt = \frac{2\pi}{\omega}$

$$\therefore \quad e=\frac{-B\pi R^2}{2\pi/\omega}=\frac{-B\omega R^2}{2}$$

$$|e|=\frac{BR^2\omega}{2}$$

Question45

An air cored coil has a self inductance 0.1 H . A soft iron core of relative permeability 1000 is introduced and the number of turns is reduced $\left(\frac{1}{10}\right)^{\text{th}}$. The value of self inductance is

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Options:

A. 0.1 H

B. 1 mH

C. 1 H

D. 10 mH

Answer: C

Solution:

The self-inductance L of an air-cored coil is given by:

$L_1=\frac{\mu_0 N^2 A}{l}$

where:

μ_0 is the permeability of free space,

N is the number of turns,

A is the cross-sectional area,

l is the length of the coil.

When a soft iron core with a relative permeability μ_r is introduced, the inductance becomes:

$L_2=\frac{\mu_0 \mu_r N'^2 A}{l}$

where $N' = \frac{N}{10}$. Given that $\mu_r = 1000$, the ratio of the old inductance L_1 to the new inductance L_2 is:

$$\frac{L_2}{L_1} = \frac{\mu_r (N')^2}{N^2} = \frac{1000\left(\frac{N}{10}\right)^2}{N^2}$$

Simplifying:

$$\frac{L_2}{L_1} = \frac{1000 \cdot \frac{N^2}{100}}{N^2} = \frac{1000}{100} = 10$$

Therefore:

$$L_2 = 10 \times L_1 = 10 \times 0.1\,\mathrm{H} = 1\,\mathrm{H}$$

Thus, the value of the self-inductance after introducing the soft iron core and reducing the number of turns is **1 H**. The correct option is **Option C: 1 H**.

Question46

When the number of turns in a coil are made 3 times without any change in the length of the coil, its self inductance becomes

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Options:

A. (9) times

B. two times

C. three times

D. four times

Answer: A

Solution:

The self-inductance of a coil is given by the formula:

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

where:

L is the self-inductance,

μ is the permeability of the core material,

N is the number of turns in the coil,

A is the cross-sectional area, and

l is the length of the coil.

If the number of turns N is made 3 times greater, with no change in the length of the coil, the new number of turns becomes $3N$. Substituting $3N$ into the formula for self-inductance, we have:

$$L' = \mu \frac{(3N)^2 A}{l} = \mu \frac{9N^2 A}{l} = 9 \cdot \left(\mu \frac{N^2 A}{l}\right) = 9L$$

Therefore, the self-inductance becomes 9 times its original value.

Answer: (9) times.

Question47

Two solenoids of equal number of turns have their lengths as well as radii in the same ratio $1 : 3$. The ratio of their self inductance will be

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Options:

A. $1 : 3$

B. $1 : 9$

C. $9 : 1$

D. $3 : 2$

Answer: A

Solution:

$$\mathrm{L} \propto \mathrm{r}^2 \text{ and } \mathrm{L} \propto \frac{1}{l}$$

$$\therefore \quad \frac{\mathrm{L}_1}{\mathrm{L}_2} = \frac{\mathrm{r}_1^2}{\mathrm{r}_2^2} \times \frac{l_2}{l_1}$$

$$\therefore \quad \frac{\mathrm{L}_1}{\mathrm{L}_2} = \frac{1}{9} \times \frac{3}{1} = \frac{1}{3}$$

Question48

If number of turns per unit length in a solenoid is tripled, the self inductance of solenoid will

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Options:

A. remain constant

B. be halved

C. become 9 times

D. become $\frac{1}{9}$ times

Answer: C

Solution:

The self-inductance (L) of a solenoid is given by the formula:

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

where:

μ_0 is the permeability of free space,

N is the total number of turns,

A is the cross-sectional area,

l is the length of the solenoid.

For the solenoid, the number of turns per unit length is represented by $n=\frac{N}{l}$. If the number of turns per unit length is tripled, represent this as $n'=3n$. Therefore, the new number of turns $N'=n'\cdot l=3n\cdot l=3N$.

Substituting N' into the original formula for self-inductance:

$L'=\frac{\mu_0\cdot(3N)^2\cdot A}{l}=\frac{\mu_0\cdot 9N^2\cdot A}{l}=9\cdot\frac{\mu_0\cdot N^2\cdot A}{l}$

This demonstrates that the self-inductance will become 9 times greater if the number of turns per unit length is tripled.

Therefore, the correct answer is:

Option C: become 9 times

Question49

The number of turns in the primary of a transformer are 1000 and in secondary 3000. If 80 V a.c. is applied to the primary, the potential difference per turn of the secondary coil is

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Options:

A. 0.02 V

B. 0.04 V

C. 0.08 V

D. 0.16 V

Answer: C

Solution:

In a transformer, the relationship between the number of turns and the voltage can be given by the transformer equation:

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$

where:

V_p is the primary voltage,

V_s is the secondary voltage,

N_p is the number of turns in the primary coil,

N_s is the number of turns in the secondary coil.

Given that $N_p = 1000$, $N_s = 3000$, and $V_p = 80\,\mathrm{V}$, we need to find V_s, the voltage across the secondary coil.

First, calculate V_s:

$V_s = V_p \cdot \frac{N_s}{N_p} = 80 \cdot \frac{3000}{1000}$

$V_s = 80 \cdot 3$

$V_s = 240\,\mathrm{V}$

Next, find the potential difference per turn of the secondary coil. Since there are 3000 turns in the secondary coil:

Potential difference per turn $= \frac{V_s}{N_s} = \frac{240}{3000}$

$= 0.08\ \mathrm{V}$

So, the potential difference per turn of the secondary coil is **0.08 V**.

Option C: 0.08 V.

Question50

A closely wound coil of 100 turns and of crosssection $1\ \mathrm{cm}^2$ has coefficient of self inductance 1 mH . The magnetic induction at the centre of the core of a coil when a current of 2 A flows in it, will be (in $\mathrm{Wb/m}^2$)

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Options:

A. 0.2

B. 0.4

C. 0.8

D. 1

Answer: A

Solution:

Given that, $\mathrm{N} = 100, \quad \mathrm{A} = 1\ \mathrm{cm}^2 = 1 \times 10^{-4}\ \mathrm{m}^2, \mathrm{L} = 1\mathrm{mH} = 1 \times 10^{-3}\mathrm{H}$ and $\mathrm{I} = 2\ \mathrm{A}$

Now, self-inductance of a coil is given by,

$\mathrm{L} = \mu_0 \frac{\mathrm{N}^2\ \mathrm{A}}{\mathrm{I}} \quad \ldots.\ \text{(i)}$

Where

$\mu_0 =$ permeability of free space $= 4\pi \times 10^{-7}\mathrm{H/m}$ and l is the length of the coil

Also, magnetic induction B in the core, $\mathrm{B} = \mu_0 \frac{\mathrm{NI}}{l}$

From equation (i),

$$l = \mu_0 \frac{\mathrm{N}^2\ \mathrm{A}}{\mathrm{L}} = \left(4\pi \times 10^{-7}\right) \frac{(100)^2 \times 1 \times 10^{-4}}{1 \times 10^{-3}}$$
$$= 4\pi \times 10^{-7} \times 10^4 \times 10^{-4} \times 10^3$$

$$\therefore \quad l = 4\pi \times 10^{-3}\ \mathrm{m}$$

Substituting this in equation (ii),

$$B = \left(4\pi \times 10^{-7}\right) \frac{100 \times 2}{4\pi \times 10^{-3}}$$
$$= 10^{-7} \times 200 \times 10^3 = 0.2\ \mathrm{Wb/m}^2$$

Question51

When the number of turns in a coil is doubled without any change in the length of the coil, its self-inductance

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Options:

A. becomes 4 times.

B. becomes 2 times.

C. gets halved.

D. remains unchanged.

Answer: A

Solution:

The self-inductance of a coil is given by the formula:

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

where:

L is the self-inductance,

μ is the permeability of the core material,

N is the number of turns in the coil,

A is the cross-sectional area of the coil, and

l is the length of the coil.

When the number of turns N is doubled, the expression for self-inductance becomes:

$L' = \mu \frac{(2N)^2 A}{l} = \mu \frac{4N^2 A}{l} = 4 \left(\mu \frac{N^2 A}{l}\right) = 4L$

Thus, the self-inductance becomes 4 times the original value. Therefore, the correct answer is:

Option A: becomes 4 times.

Question52

The coefficient of mutual induction is 2 H and induced e.m.f. across secondary is 2 kV Current in the primary is reduced from 6 A to 3 A . The time required for the change of current is

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Options:

A. 3×10^{-3} s

B. 3×10^{-2} s

C. 6×10^{-3} s

D. 3×10^{-2} s

Answer: A

Solution:

To determine the time required for the change in current, we can use the formula related to mutual induction:

$\varepsilon = -M \frac{\Delta I}{\Delta t}$

where:

ε is the induced electromotive force (e.m.f) across the secondary coil,

M is the mutual inductance,

ΔI is the change in current in the primary coil,

Δt is the time over which the change occurs.

Given:

$\varepsilon = 2\,\text{kV} = 2000\,\text{V}$

$M = 2\,\text{H}$

The current change $\Delta I = 6\,\text{A} - 3\,\text{A} = 3\,\text{A}$

Plug these values into the formula:

$2000 = -2 \cdot \frac{3}{\Delta t}$

Solving for Δt:

First, eliminate the negative sign (since we are considering magnitude):

$2000 = 2 \cdot \frac{3}{\Delta t}$

Multiply both sides by Δt:

$2000\Delta t = 6$

Now, solve for Δt:

$\Delta t = \frac{6}{2000} = 0.003\,\text{s} = 3 \times 10^{-3}\,\text{s}$

Thus, the time required for the change of current is:

Option A: $3 \times 10^{-3}\,\text{s}$

Question53

If current of 4 A produces magnetic flux of 3×10^{-3} Wb through a coil of 400 turns, the energy stored in the coil will be

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Options:

A. 1.2 J

B. 2.4 J

C. 24 J

D. 240 J

Answer: B

Solution:

To find the energy stored in the coil, we can use the formula for the energy stored in a magnetic field of an inductor:

$E = \frac{1}{2} L I^2$

where E is the energy, L is the inductance, and I is the current.

First, we need to determine the inductance L of the coil. The relationship between magnetic flux (Φ), inductance (L), and current (I) is given by:

$\Phi = L \cdot I$

Given:

$\Phi = 3 \times 10^{-3}$ Wb,

$I = 4$ A,

Number of turns (N) = 400.

The total flux linkage is $N \cdot \Phi$:

$N \cdot \Phi = L \cdot I$

Plug in the values:

$400 \times 3 \times 10^{-3} = L \times 4$

Calculate L:

$L = \frac{400 \times 3 \times 10^{-3}}{4} = \frac{1.2}{4} = 0.3\,\mathrm{H}$

Now, substitute $L = 0.3\,\mathrm{H}$ and $I = 4\,\mathrm{A}$ into the energy formula:

$E = \frac{1}{2} \times 0.3 \times 4^2 = \frac{1}{2} \times 0.3 \times 16 = 0.15 \times 16 = 2.4\,\mathrm{J}$

Therefore, the energy stored in the coil is **2.4 J**.

The correct answer is **Option B**: 2.4 J.

Question54

Two concentric circular coils having radii ' r_1' and ' r_2 ' $(r_2 \ll r_1)$ are placed co-axially with centres coinciding. The mutual inductance of the arrangement is ($\mu_0 =$ permeability of free space) (Both coils have single turn)

Options:

A. $\frac{\mu_0 \pi r_2}{2 r_1}$

B. $\frac{\mu_0 \pi}{2 r_1 r_2}$

C. $\frac{\mu_0 \pi r_1}{2 r_2}$

D. $\frac{\mu_0 \pi r_2^2}{2 r_1}$

Answer: D

Solution:

The mutual inductance between two concentric circular coils can be derived by considering the magnetic flux through one coil due to the current in the other coil. For simplicity, consider the larger coil of radius r_1 to be producing a magnetic field, while the smaller coil of radius r_2 experiences this field.

The magnetic field at the center of the larger coil when a current I flows through it is given by:

$B_1 = \frac{\mu_0 I}{2 r_1}$

where B_1 is the magnetic field at the center, μ_0 is the permeability of free space, and I is the current flowing in the larger coil.

The magnetic flux Φ_2 through the smaller coil (of radius r_2) is given by the product of the magnetic field produced by the first coil and the area of the second coil:

$\Phi_2 = B_1 \cdot \pi r_2^2 = \frac{\mu_0 I}{2 r_1} \cdot \pi r_2^2$

Mutual inductance M is defined as the ratio of the magnetic flux through one coil to the current in the other coil:

$M = \frac{\Phi_2}{I} = \frac{\mu_0 \pi r_2^2}{2 r_1}$

Thus, the correct option for the mutual inductance of the arrangement is:

Option D

$\frac{\mu_0 \pi r_2^2}{2 r_1}$

Question55

An inductor coil of inductance L is divided into two parts and both parts are connected in parallel. The net inductance is

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Options:

A. L

B. 2L

C. $\frac{L}{2}$

D. $\frac{L}{4}$

Answer: D

Solution:

When an inductor coil of inductance L is divided into two equal parts, each part will have an inductance of $\frac{L}{2}$. When both parts are connected in parallel, the combined or net inductance L_{net} is found using the formula for inductors in parallel:

$$\frac{1}{L_{\text{net}}} = \frac{1}{L_1} + \frac{1}{L_2}$$

In this case, since both inductors have the same inductance of $\frac{L}{2}$:

$$\frac{1}{L_{\text{net}}} = \frac{1}{\frac{L}{2}} + \frac{1}{\frac{L}{2}}$$

This simplifies to:

$$\frac{1}{L_{\text{net}}} = \frac{2}{L} + \frac{2}{L} = \frac{4}{L}$$

Thus, the net inductance is:

$$L_{\text{net}} = \frac{L}{4}$$

Therefore, the correct choice is **Option D:** $\frac{L}{4}$.

Question56

Two coils have a mutual inductance 0.003 H . The current changes in the first coil according to equation $I = I_0 \sin \omega t$, where $I_0 = 8$ A and

$\omega = 100\pi \mathrm{rads}^{-1}$. **The maximum value of e.m.f. in the second coil is**

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Options:

A. 2π V

B. 2.4π V

C. 5π V

D. 7.2π V

Answer: B

Solution:

$$\begin{aligned} & |e_s| = M \frac{dI_p}{dt} \\ & |e_s| = M \frac{d}{dt} I_0 \sin \omega t \\ & |e_s| = M I_0 \omega \cos \omega t \\ \therefore \quad & |e_s|_{\max} = M I_0 \omega = 0.003 \times 8 \times 100\pi \times 1 \\ \therefore \quad & |e_s|_{\max} = (2.4\pi) \text{ volt} \end{aligned}$$

Question57

The current in LR circuit if reduced to half What will be the energy stored in it?

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Options:

A. 4 times

B. 2 times

C. half times

D. $\left(\frac{1}{4}\right)^{\text{th}}$ times

Answer: D

Solution:

In an LR (inductor-resistor) circuit, the energy stored in the inductor is given by the expression:

$E=\frac{1}{2} L I^2$

where:

E is the energy stored in the inductor,

L is the inductance, and

I is the current through the inductor.

If the current (I) is reduced to half of its initial value, the new current becomes $\frac{I}{2}$.

Substituting the new current into the expression for energy:

$E_{\text {new }}=\frac{1}{2} L\left(\frac{I}{2}\right)^2=\frac{1}{2} L \cdot \frac{I^2}{4}=\frac{1}{8} L I^2$

Comparing this with the original energy $E=\frac{1}{2} L I^2$, the new energy $E_{\text {new }}$ is:

$E_{\text {new }}=\frac{1}{4} \cdot\left(\frac{1}{2} L I^2\right)=\frac{1}{4} E$

Therefore, the energy stored in the inductor is reduced to $\frac{1}{4}$ times of its original value.

Hence, the correct option is:

Option D: $\left(\frac{1}{4}\right)^{\text{th}}$ times

Question58

Two coils of self-inductance 25 mH and 9 mH are placed close together such that the effective flux in one coil is completely linked with the other The mutual inductance between these coils is

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Options:

A. 34 mH

B. 16 mH

C. 15 mH

D. 6 mH

Answer: C

Solution:

The mutual inductance (M) between two coils can be calculated using the geometric mean of their self-inductances when the flux linkage is complete:

$$M = \sqrt{L_1 \cdot L_2}$$

where L_1 and L_2 are the self-inductances of the two coils.

Given:

$L_1 = 25 \text{ mH}$

$L_2 = 9 \text{ mH}$

Substituting the values:

$$M = \sqrt{25 \text{ mH} \times 9 \text{ mH}}$$

Calculating:

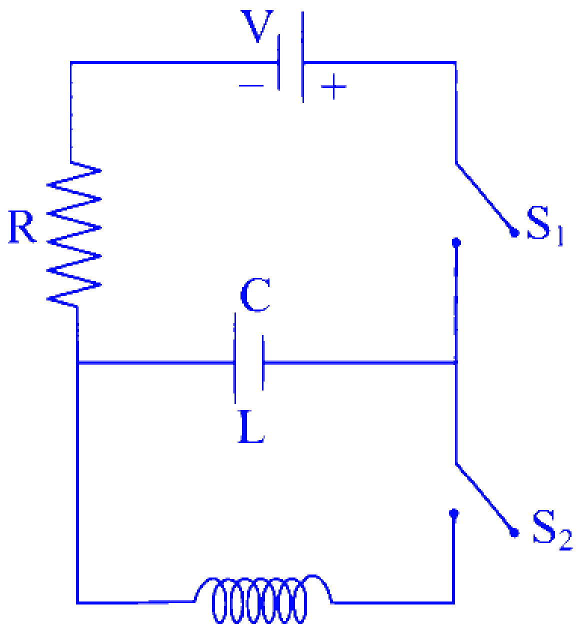
$$M = \sqrt{225 \text{ mH}^2} = 15 \text{ mH}$$

Therefore, the mutual inductance between the coils is **15 mH**.

Option C (15 mH) is the correct answer.

Question59

Consider the following circuit. By keeping S_1 closed, the capacitor is fully charged and then S_1 is opened and S_2 is closed, then



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Options:

A. At time $t=0$, the energy stored in the circuit is purely in the form of magnetic energy.

B. At $t>0$, there is no exchange of energy between L and C.

C. At any time $t>0$, the current in the circuit is in the same direction.

D. At any time $t>0$, the instantaneous current in the circuit may be $V\sqrt{\frac{C}{L}}$

Answer: D

Solution:

Maximum energy in capacitor = Maximum energy in inductor

$$\frac{1}{2}CV^2=\frac{1}{2}LI^2$$

$$\therefore \quad I^2=\frac{C}{L}V^2$$

$$\therefore \quad I=V\sqrt{\frac{C}{L}}$$

Question60

A square loop ABCD is moving with constant velocity ' $\vec{v}$ ' in a uniform magnetic field ' $\vec{B}$ ' which is perpendicular to the plane of paper and directed outward. The resistance of coil is ' R ', then the rate of production of heat energy in the loop is [L - length of side of loop]

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Options:

A. $\frac{B^2L^2V}{R}$

B. $\frac{B^2L^2V^2}{R}$

C. $\frac{B^2LV^2}{R}$

D. $\frac{\mathrm{BLV}^2}{\mathrm{R}}$

Answer: B

Solution:

The rate of production of heat energy in the square loop due to its motion in a magnetic field can be determined using Faraday's Law of Electromagnetic Induction and Ohm's Law.

Induced EMF ($\mathcal{E}$): The induced EMF in the loop moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$ is given by:

$\mathcal{E} = B \cdot L \cdot v$

where:

B is the magnetic flux density,

L is the side length of the square loop,

v is the velocity of the loop perpendicular to B.

Current (I): The current induced in the loop, by Ohm's Law, is:

$I = \frac{\mathcal{E}}{R} = \frac{B \cdot L \cdot v}{R}$

Power (Rate of Production of Heat Energy): The power converted into heat (rate of production of heat energy) due to the induced current is given by:

$P = I^2 \cdot R$

Substituting the expression for I, we get:

$P = \left(\frac{B \cdot L \cdot v}{R}\right)^2 \cdot R = \frac{B^2 \cdot L^2 \cdot v^2}{R}$

Thus, the rate of production of heat energy in the loop is:

$\frac{B^2 L^2 v^2}{R}$

Therefore, the correct answer is **Option B**:

$\frac{B^2 L^2 V^2}{R}$

Question61

A metal rod of length ' l ' rotates about one of its ends in a plane perpendicular to a magnetic field of induction ' B '. If the e.m.f. induced between the ends of the rod is ' e ', then the number of revolutions made by the rod per second is

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Options:

A. $\frac{\mathrm{e}}{\mathrm{B} \pi^2 l}$

B. $\frac{\mathrm{e}}{\mathrm{B} \pi l^2}$

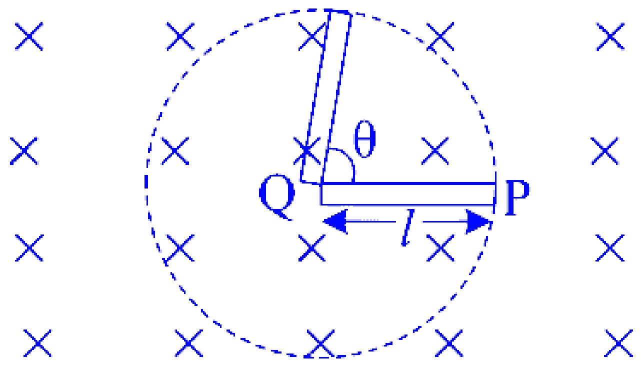
C. $\frac{\mathrm{B}^2}{\mathrm{e} \pi l}$

D. $\frac{\pi l^2}{\mathrm{eB}}$

Answer: B

Solution:

A conducting rod of length ' l ' whose one end is fixed, is rotated about the axis passing through its fixed end and perpendicular to its length with constant angular velocity ω.



$$e = B\pi l^2 n$$

$$\therefore \quad n = \frac{e}{\pi B l^2}$$

Question62

Two coils have a mutual inductance 5×10^{-3}H. The current changes in the first coil according to the equation $I_1 = I_0 \sin \omega t$ where $I_0 = 10$ A and $\omega = 100\pi \mathrm{rad/s}$. What is the value of the maximum e.m.f. in the coil?

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Options:

A. 2π V

B. 3π V

C. 4π V

D. 5π V

Answer: D

Solution:

The electromotive force (e.m.f.) induced in the second coil due to a changing current in the first coil is given by Faraday's law of electromagnetic induction and the concept of mutual inductance. The e.m.f. $\mathcal{E}$ in the second coil is related to the rate of change of current in the first coil as follows:

$\mathcal{E} = -M\frac{dI_1}{dt}$

where M is the mutual inductance and I_1 is the current in the first coil.

Given:

$M = 5 \times 10^{-3}\,\mathrm{H}$

$I_1 = I_0 \sin \omega t$

$I_0 = 10\,\mathrm{A}$

$\omega = 100\pi\,\mathrm{rad/s}$

To find the maximum e.m.f., we first differentiate the current I_1 with respect to time t:

$\frac{dI_1}{dt} = \frac{d}{dt}(I_0 \sin \omega t) = I_0 \omega \cos \omega t$

Substituting the values, we have:

$\frac{dI_1}{dt} = 10 \times 100\pi \cos(100\pi t) = 1000\pi \cos(100\pi t)$

The maximum value of $\cos(100\pi t)$ is 1, therefore the maximum rate of change of current is:

$\left(\frac{dI_1}{dt}\right)_{\max} = 1000\pi$

Now, substituting this into the equation for the induced e.m.f., we calculate the maximum e.m.f.:

$\mathcal{E}_{\max} = -M \times 1000\pi = -(5 \times 10^{-3}) \times 1000\pi$

Simplifying, we find:

$\mathcal{E}_{\max} = -5 \times \pi = -5\pi\,\mathrm{V}$

Since e.m.f. is generally discussed in magnitude, the answer is:

Option D: $5\pi\,\mathrm{V}$

Question63

The magnetic flux through a coil of resistance ' R ' changes by an amount ' $\Delta\phi$ ' in time ' Δt '. The amount of induced current and induced charge in the coil are respectively

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Options:

A. $\left(\frac{\Delta \phi}{\Delta t}\right) R$ and $\frac{R}{\Delta \phi}$

B. $\frac{\Delta \phi}{\mathrm{R}}$ and $\mathrm{R}\left(\frac{\Delta \mathrm{t}}{\Delta \phi}\right)$

C. $\frac{\Delta \phi}{\mathrm{R}}+\mathrm{R}$ and $\frac{\Delta \phi}{\Delta \mathrm{t}}$

D. $\left(\frac{\Delta \phi}{\Delta \mathrm{t}}\right) \times \frac{1}{\mathrm{R}}$ and $\frac{\Delta \phi}{\mathrm{R}}$

Answer: D

Solution:

According to Faraday's law of electromagnetic induction,

$$
\begin{aligned}
& |e|=\frac{\Delta \phi}{\Delta t} \\
& I R=\frac{\Delta \phi}{\Delta t} \\
& I=\left(\frac{\Delta \phi}{\Delta t}\right) \frac{1}{R}
\end{aligned}
$$

$\therefore$ The total quantity of electric charge passing through the circuit is

$$
\begin{aligned}
\mathrm{Q} & =\mathrm{I} \times \Delta \mathrm{t} \\
& =\frac{\Delta \phi}{\mathrm{R}}
\end{aligned}
$$

Question64

The planar concentric rings of metal wire having radii r_1 and r_2 (with $r_1>r_2$) are placed in air. The current I is flowing through the coil of larger radius. The mutual inductance between the coils is given by ($\mu_0=$ permeability of free space)

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Options:

A. $\frac{\mu_0 \pi\left(r_1+r_2\right)^2}{2 r_2}$

B. $\frac{\mu_0 \pi (r_1 - r_2)^2}{2 r_1}$

C. $\frac{\mu_0 \pi r_1^2}{2 r_2}$

D. $\frac{\mu_0 \pi r_2^2}{2 r_1}$

Answer: D

Solution:

The magnetic field at the centre of a loop is given by

$B = \frac{\mu_0 \mathrm{NI}}{2\mathrm{R}}$ .... (i)

$\therefore$ Magnetic field produced by ring A, $B_A = \frac{\mu_0 I}{2 r_1}$

$\therefore$ Magnetic flux produced in ring B due to B_A,

$\therefore \phi_B = B_A A_B$ ... (A_B is area)

$\therefore \phi_B = \frac{\pi_0 I}{2 r_1} \times \pi r_2^2 = \frac{\mu_0 \pi r_2^2}{2 r_1} I$ ... [From(i)]

Mutual Inductance $M = \frac{\phi}{I}$

$\therefore M = \frac{\phi_B}{I} = \frac{\mu_0 \pi r_2^2 I}{2 r_1 I} = \frac{\mu_0 \pi r_2^2}{2 r_1}$

Question65

A magnetic field of 2×10^{-2} T acts at right angles to a coil of area $100 \mathrm{~cm}^2$ with 50 turns, The average e.m.f. induced in the coil is 0.1 V , when it is removed from the field in time t. The value of ' t ' is (in second)

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Options:

A. 0.1 s

B. 0.01 s

C. 1 s

D. 20 s

Answer: A

Solution:

Using Lenz law,

Induced e.m.f. is given by, $e=-N \frac{\mathrm{d} \phi}{\mathrm{dt}}$ .... (i)

Change in magnetic flux $=\frac{\mathrm{d} \phi}{\mathrm{dt}}=\frac{\mathrm{dB}}{\mathrm{dt}} \mathrm{A} \cos \theta$

From (i),

$$
\begin{aligned}
& e=-N \frac{d B}{d t} A \cos \theta \\
\therefore \quad & e=-\frac{N\left(B_2-B_1\right) A \cos \theta}{t} \\
\therefore \quad & t=\frac{-(50) \times\left(0-2 \times 10^{-2}\right) \times\left(100 \times 10^{-4}\right) \times \cos 0^{\circ}}{0.1} \\
\therefore \quad & t=0.1 \mathrm{~s}
\end{aligned}
$$

Question66

A current of 0.5 A is passed through winding of a long solenoid having 400 turns. The magnetic flux linked with each turn is 3×10^{-3} Wb. The self inductance of the solenoid is

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Options:

A. 2.4 H

B. 2.0 H

C. 1.2 H

D. 0.6 H

Answer: A

Solution:

The self-inductance L of a solenoid can be calculated using the formula for the flux linkage, which is given by the product of the number of turns N and the magnetic flux Φ per turn:

$$L = \frac{N\Phi}{I}$$

where:

$N = 400$ (the number of turns),

$\Phi = 3 \times 10^{-3}\,\mathrm{Wb}$ (the magnetic flux per turn),

$I = 0.5\,\mathrm{A}$ (the current).

Substitute these values into the formula:

$$L = \frac{400 \times 3 \times 10^{-3}}{0.5}$$

Simplify the expression:

$$L = \frac{1.2}{0.5} = 2.4\,\mathrm{H}$$

Therefore, the self-inductance of the solenoid is $2.4\,\mathrm{H}$.

Hence, the correct option is **Option A: 2.4 H**.

Question67

A square loop of area $25\ \mathrm{cm}^2$ has a resistance of 10Ω. The loop is placed in uniform magnetic field of magnitude 40 T . The plane of loop is perpendicular to the magnetic field. The work done in pulling the loop out of the magnetic field slowly and uniformly in 1 second, will be

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Options:

A. 2.5×10^{-3} J

B. 1.0×10^{-3} J

C. 1.0×10^{-4} J

D. 5×10^{-3} J

Answer: B

Solution:

To calculate the work done in pulling the loop out of the magnetic field, we can use the induced electromotive force (emf) and subsequently the power and energy dissipated due to the resistance.

The change in magnetic flux, $\Delta\Phi_B$, as the loop is pulled completely out of the magnetic field is given by the initial magnetic flux, since the final magnetic flux will be zero. The magnetic flux through the loop is:

$\Phi_B = B \times A$

where:

$B = 40\,\text{T}$ is the magnetic field strength,

$A = 25\,\text{cm}^2 = 25 \times 10^{-4}\,\text{m}^2 = 0.0025\,\text{m}^2$ is the area of the square loop.

Thus, the initial magnetic flux is:

$\Phi_B = 40 \times 0.0025 = 0.1\,\text{Wb}$

The change in magnetic flux is:

$\Delta\Phi_B = 0.1\,\text{Wb}$

According to Faraday's law of electromagnetic induction, the induced emf, $\mathcal{E}$, is:

$\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$

Since we are pulling the loop out in a time interval of $\Delta t = 1\,\text{s}$:

$\mathcal{E} = -\frac{0.1}{1} = -0.1\,\text{V}$

The negative sign indicates the direction of the induced emf, but for the magnitude of work done, we can consider the positive value due to the absolute work calculation.

The current induced in the loop, I, can be calculated using Ohm's Law as:

$I = \frac{\mathcal{E}}{R}$

where $R = 10\,\Omega$ is the resistance of the loop:

$I = \frac{0.1}{10} = 0.01\,\text{A}$

The power dissipated as heat in the resistor due to this current is:

$P = I^2 R = (0.01)^2 \times 10 = 0.001\,\text{W}$

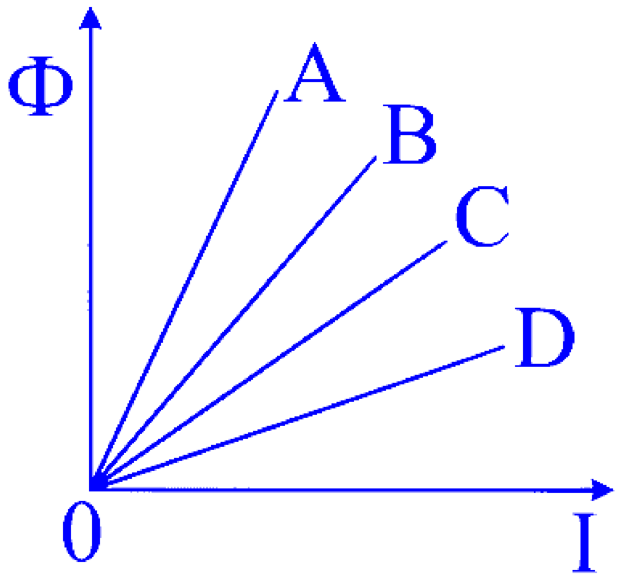
Since the loop is being pulled out over a time period of $1\,\text{s}$, the total work done (energy dissipated) is:

$W = P \times \Delta t = 0.001 \times 1 = 0.001\,\text{J} = 1.0 \times 10^{-3}\,\text{J}$

Therefore, the work done in pulling the loop out of the magnetic field is **option B**: $1.0 \times 10^{-3}\,\text{J}$.

Question68

A graph of magnetic flux (ϕ) versus current (1) is shown for four inductors A, B, C, D. Smaller value of self inductance is for inductor



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Options:

A. D

B. C

C. B

D. A

Answer: A

Solution:

From $\phi=\mathrm{LI}$

Comparing the above equation with $\mathrm{y}=\mathrm{mx}$, $\mathrm{L}=\phi / \mathrm{I}$, which is the slope of the graph. Since line D has lowest value of slope, it indicates the smallest value of self-inductance.

Question69

A circular coil of resistance R, area A, number of turns ' N ' is rotated about its vertical diameter with angular speed ' ω ' in a uniform magnetic field of magnitude ' B '. The average power dissipated in a complete cycle is

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Options:

A. $\frac{\mathrm{N}^2\ \mathrm{A}^2\ \mathrm{B}^2\omega^2}{2\mathrm{R}}$

B. $\frac{\mathrm{BNA}\omega}{\mathrm{R}}$

C. $\frac{\mathrm{N}^2\mathrm{AB}}{2\mathrm{R}\omega^2}$

D. $\frac{BA\omega}{2NR}$

Answer: A

Solution:

The electromotive force (emf) induced in the coil as it rotates in a magnetic field is given by Faraday's law of electromagnetic induction. The expression for the emf in a rotating coil is:

$\epsilon(t) = NBA\omega\sin(\omega t)$

where:

$\epsilon(t)$ is the induced emf as a function of time,

N is the number of turns,

B is the magnetic field,

A is the area of the coil,

ω is the angular speed,

t is time.

The instantaneous power dissipated in the coil due to its resistance R is given by:

$P(t) = \frac{\epsilon(t)^2}{R}$

Substituting the expression for $\epsilon(t)$:

$$P(t) = \frac{(NBA\omega \sin(\omega t))^2}{R} = \frac{N^2 B^2 A^2 \omega^2 \sin^2(\omega t)}{R}$$

The average power dissipated over a complete cycle is calculated by integrating $P(t)$ over one period $T = \frac{2\pi}{\omega}$ of the sine function and then dividing by the period:

$$\langle P \rangle = \frac{1}{T} \int_0^T P(t)\, dt = \frac{1}{T} \int_0^T \frac{N^2 B^2 A^2 \omega^2 \sin^2(\omega t)}{R}\, dt$$

The integral of $\sin^2(\omega t)$ over one period is $\frac{T}{2}$. Therefore:

$$\langle P \rangle = \frac{1}{T} \cdot \frac{N^2 B^2 A^2 \omega^2}{R} \cdot \frac{T}{2} = \frac{N^2 B^2 A^2 \omega^2}{2R}$$

Thus, the average power dissipated in a complete cycle is:

Option A:

$$\frac{N^2 A^2 B^2 \omega^2}{2R}$$

Question70

Two coils are kept near each other. When no current passess through first coil and current in the 2^{nd} coil increases at the rate $10\ \mathrm{A/s}$, the e.m.f. in the $1^{\mathbb{P}}$ coil is 20 mV . When no current passes through 2^{nd} coil and 3.6 A current passes through 1^2 coil the flux linkage in coil 2 is

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Options:

A. 1.2×10^{-3} Wb

B. 1.8×10^{-3} Wb

C. 3.6×10^{-3} Wb

D. 7.2×10^{-3} Wb

Answer: D

Solution:

When analyzing the scenario of two coils placed near each other, the mutual inductance (M) plays a key role in determining the electromotive force (e.m.f.) induced in one coil due to a change in current of the other. The e.m.f. (ε) induced due to the rate of change of current in the second coil is given by:

$\varepsilon = -M \frac{dI_2}{dt}$

Given that $\varepsilon = 20 \, \mathrm{mV} = 20 \times 10^{-3} \, \mathrm{V}$ and the rate of change of current in the second coil $\frac{dI_2}{dt} = 10 \, \mathrm{A/s}$, we can rearrange the formula to solve for the mutual inductance M:

$M = -\frac{\varepsilon}{\frac{dI_2}{dt}} = -\frac{20 \times 10^{-3}}{10} = 2 \times 10^{-3} \, \mathrm{H}$

Now, consider the situation where no current passes through the second coil, and a current of 3.6 A passes through the first coil. The flux linkage (Φ_{21}) in the second coil due to the current in the first coil can be found using:

$\Phi_{21} = M I_1$

Substitute $M = 2 \times 10^{-3} \, \mathrm{H}$ and $I_1 = 3.6 \, \mathrm{A}$:

$\Phi_{21} = (2 \times 10^{-3} \, \mathrm{H})(3.6 \, \mathrm{A}) = 7.2 \times 10^{-3} \, \mathrm{Wb}$

Therefore, the correct answer is:

Option D: $7.2 \times 10^{-3} \, \mathrm{Wb}$

Question71

A rod of length ' l ' is rotated with angular velocity ' ω ' about its one end, perpendicular to a magnetic field of induction ' B '. The e.m.f. induced in the rod is

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Options:

A. $\mathrm{B} l^2 \omega$

B. $0.5 \mathrm{~B} l^2 \omega$

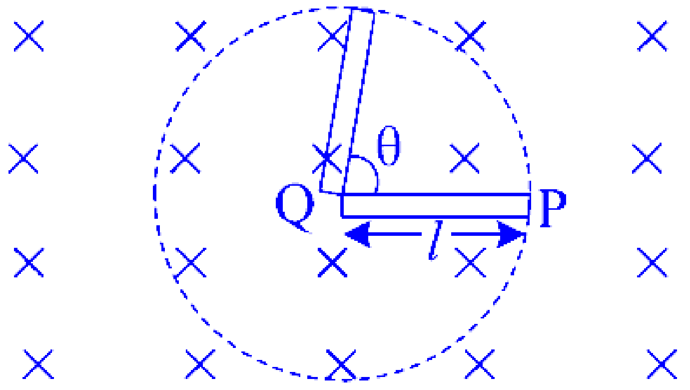
C. B / ω

D. $0.5 \mathrm{~B} / \omega$

Answer: B

Solution:

A conducting rod of length ' l ' whose one end is fixed, is rotated about the axis passing through its fixed end and perpendicular to its length with constant angular velocity ω.



E.M.F induced, $e = B\pi l^2 n = \frac{B\pi l^2}{T}$

$\therefore \quad e = \frac{1}{2} Bl^2\omega = 0.5\, Bl^2\omega \quad \ldots \left(\because \omega = \frac{2\pi}{T}\right)$

Question72

In an a. c. generator, when the plane of the coil is perpendicular to the magnetic field

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Options:

A. magnetic flux is zero and induced e.m.f. is maximum.

B. magnetic flux is maximum and induced e.m.f. is zero.

C. both magnetic flux and induced e.m.f. are maximum.

D. both magnetic flux and induced e.m.f. are zero.

Answer: B

Solution:

When the plane of the coil in an alternating current (a.c.) generator is perpendicular to the magnetic field, the magnetic flux through the coil is maximum, because the area vector of the coil is aligned with the magnetic field lines.

At this position, the rate of change of magnetic flux, which is responsible for inducing the electromotive force (e.m.f.), is zero. Therefore, the induced e.m.f. at this point is zero.

Thus, the correct option is:

Option B: magnetic flux is maximum and induced e.m.f. is zero.

Question73

An air cored coil has self inductance of 0.1 H . A soft iron core of relative permeability 1000 is introduced and the number of turns is reduced to $\left(\frac{1}{10}\right)^{\text{th}}$. The value of self inductance is now

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Options:

A. 0.1 H

B. 1 mH

C. 1 H

D. 10 mH

Answer: C

Solution:

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

$$L'=\frac{\mu_0\mu_r\left(N'\right)^2 A}{l}=\frac{\mu_0\times 1000\times\left(\frac{N}{10}\right)^2 A}{l}$$

When, $\mu_r=1000$ and $N=\frac{1}{10}$,

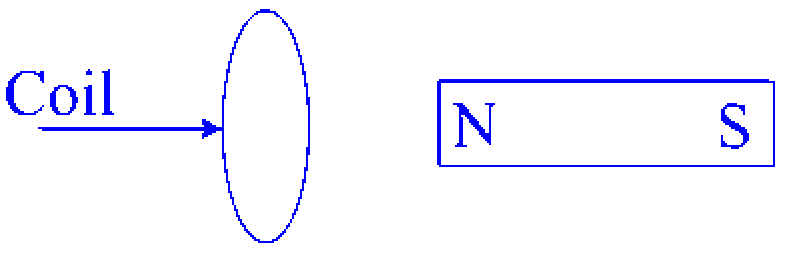
$$\therefore \quad \frac{L}{L'}=\frac{0.1}{L'}=\frac{\mu_0 N^2 A}{l}\times\frac{l}{\mu_0\times 1000\times\left(\frac{N}{10}\right)^2 A}$$

$$\frac{0.1}{L'}=\frac{1}{10}$$

$$\therefore \quad L'=0.1\times 10=1H$$

Question74

The coil and magnet are moved in the same direction with same speed (V). The induced e.m.f. is



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Options:

A. zero.

B. proportional to V.

C. proportional to V^{-1}.

D. finite but does not depend on V.

Answer: A

Solution:

$e=-N\frac{d\phi}{dt}$

As the coil and magnet are moving in same direction in same speed,

$\therefore \quad \phi=B \cdot \ A=\text{constant}$

$\therefore \quad \frac{d\phi}{dt}=0$

Thus, the emf induced is zero because the relative speed of magnet with respect to coil is zero.

Question75

The magnetic energy stored in an inductor of inductance $5\mu H$ carrying a current of 2 A is

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Options:

A. 10 mJ

B. 5 mJ

C. 10μ J

D. 5μ J

Answer: C

Solution:

The magnetic energy stored in an inductor can be calculated using the formula:

$E=\frac{1}{2} L I^2$

where:

E is the energy stored in joules,

L is the inductance in henries,

I is the current in amperes.

Given:

$L=5\,\mu\mathrm{H}=5\times10^{-6}\,\mathrm{H}$,

$I=2\,\mathrm{A}$.

Substitute these values into the formula:

$E=\frac{1}{2}\times5\times10^{-6}\times(2)^2$

Calculate the energy:

$E=\frac{1}{2}\times5\times10^{-6}\times4$

$E=10\times10^{-6}\,\mathrm{J}=10\,\mu\mathrm{J}$

Thus, the magnetic energy stored in the inductor is $10\,\mu\mathrm{J}$.

The correct option is **Option C** $10\,\mu\mathrm{J}$.

Question76

A bicycle wheel of radius ' R ' has ' n ' spokes. It is rotating at the rate of ' F ' r.p.m. perpendicular to the horizontal component of earth's magnetic field $\vec{B}$. The e.m.f. induced between the rim and the centre of the wheel is

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Options:

A. $\frac{1}{2}$ BπFR^2

B. BπFR^2

C. $\frac{1}{n}$BπFR

D. $B\pi$FR$^2 n$

Answer: B

Solution:

✅ Correct Answer: B — $B\pi FR^2$

Let's understand why:

✔ Concept: Motional emf in a rotating wheel with spokes

A bicycle wheel is rotating in the Earth's horizontal magnetic field B.

Each **spoke** behaves like a conductor moving with linear velocity:

$$v = \omega r$$

where
$\omega = 2\pi F$ (since F is in r.p.m., but final formula uses πFR² form)

☆ Induced emf in a rotating rod (spoke)

For a rod rotating about one end in a magnetic field:

$$\varepsilon = \frac{1}{2} B\omega R^2$$

Substitute:

$$\omega = 2\pi F$$

$$\varepsilon = \frac{1}{2} B(2\pi F)R^2$$

$$\boxed{\varepsilon = B\pi F R^2}$$

Question77

A long solenoid has 1500 turns. When a current of 3.5 A flows through it, the magnetic flux linked with each turn of solenoid is 2.8×10^{-3} weber. The self-inductance of solenoid is

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Options:

A. 1.2 H

B. 2.4 H

C. 3.6 H

D. 6 H

Answer: A

Solution:

Flux linked with each turn of the solenoid is, $\phi = 2.8 \times 10^{-3}$ Wb

$\therefore$ Total magnetic flux of the solenoid is,

$\phi_{\text{net}} = \mathrm{N}\phi$

$\phi_{\text{net}} = 1500 \times 2.8 \times 10^{-3} = 4.2$ Wb

Flux can also be given by, $\phi = \mathrm{LI}$

$\therefore$ The self-inductance of the solenoid is,

$$L = \frac{\phi}{I} = \frac{4.2}{3.5}$$
$$L = 1.2 \mathrm{~H}$$

Question78

A coil having effective area A, is held with its plane normal to magnetic field of induction B. The magnetic induction is quickly reduced by 25% of its initial value in 2 second. Then the e.m.f. induced across the coil will be

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Options:

A. $\frac{\mathrm{AB}}{8}$

B. $\frac{\mathrm{AB}}{2}$

C. $\frac{3\mathrm{AB}}{4}$

D. $\frac{3\mathrm{AB}}{8}$

Answer: A

Solution:

The induced emf is given as

$\mathrm{e} = \frac{\Delta\phi}{\Delta \mathrm{t}} = \frac{\mathrm{A} \triangle \mathrm{B}}{\Delta \mathrm{t}}$

The magnetic field is reduced by 25% of its initial value.

The final magnetic field is,

$$\mathrm{B}_2 = \mathrm{B} - \frac{1}{4} \mathrm{~B} = \frac{3}{4} \mathrm{~B}$$

$$\therefore \quad e=\frac{A\left(B-\frac{3}{4} B\right)}{2}=\frac{AB}{8}$$

Question79

The self induction (L) produced by solenoid of length 'l' having 'N' number of turns and cross sectional area 'A' is given by the formula ($\phi =$ magnetic flux, $\mu_0 =$ permeability of vacuum)

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Options:

A. $L=N\phi$

B. $L=\mu_0 NAl$

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

D. $L=\frac{\mu_0 NA}{l}$

Answer: C

Solution:

Magnetic field inside the solenoid is, $B=\frac{\mu_0 NI}{l}$

Flux inside the coil, $\phi=N(BA)$

$$\therefore \quad \phi=\frac{\mu_0 N^2 IA}{l}$$

Also, self inductance, $L=\frac{\phi}{I}=\frac{\frac{\mu_0 N^2 IA}{l}}{I}$

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

Question80

A magnetic field of 2×10^{-2} T acts at right angles to a coil of area 100 cm^2 with 50 turns. The average e.m.f. induced in the coil is 0.1 V , when it is removed from the field in time 't'. The value of 't' is

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Options:

A. 2×10^{-3} s

B. 0.5 s

C. 0.1 s

D. 1 s

Answer: C

Solution:

$$e = -\frac{d\phi}{dt} = -\frac{(\phi_2 - \phi_1)}{t} = -\frac{(0 - NBA)}{t}$$

$$\therefore \quad 0.1 = \frac{50 \times 2 \times 10^{-2} \times 10^{-2}}{t}$$

$\therefore$ The value of 't' is,

$$t = \frac{10^{-2}}{0.1} = 0.1 \text{ s}$$

Question81

The alternating e.m.f. induced in the secondary coil of a transformer is mainly due to

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Options:

A. varying electric field

B. varying magnetic field

C. the iron core

D. heat produced in the coil

Answer: B

Solution:

The secondary coil experiences an emf as a result of the changing magnetic field. Therefore, a changing magnetic field is primarily responsible for the transformer voltage that is induced in a transformer's secondary coil.

Question82

A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The magnitude of induced emf between the rim and axis of the disc is

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Options:

A. $\pi B R^2$

B. $\frac{2 \pi^2 B R^2}{\omega}$

C. $\pi B R^2 \omega$

D. $\frac{B R^2 \omega}{2}$

Answer: D

Solution:

Total magnetic flux linked

$$\phi = BA$$

$$\therefore \text{ induced emf, } |e| = \frac{\Delta \phi}{\Delta t} = \frac{\Delta BA}{\Delta t} = B \cdot \frac{\Delta A}{\Delta T}$$

$$= B \cdot \frac{\pi R^2}{\left(\frac{2\pi}{\omega}\right)} = \frac{B\omega R^2}{2}$$

Question83

A conductor $10 \mathrm{~cm}$ long is moves with a speed $1 \mathrm{~m/s}$ perpendicular to a field of strength $1000 \mathrm{~A/m}$. The emf induced in the conductor is (Given : $\mu_0 = 4\pi \times 10^{-7} \mathrm{~Wb/Am}$)

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Options:

A. $\pi \mathrm{~mV}$

B. $2\pi \mathrm{~mV}$

C. $40\pi\mu \mathrm{~V}$

D. $4\pi\mu \mathrm{~V}$

Answer: C

Solution:

Given, length of conductor $(I) = 10 \mathrm{~cm} = 0.1 \mathrm{~m}$

Speed of conductor perpendicular to field, $v = 1 \mathrm{~m/s}$

Field strength, $H = 1000 \mathrm{~A/m}$

$\therefore$ Magnetic field, $B = \mu_0 H$

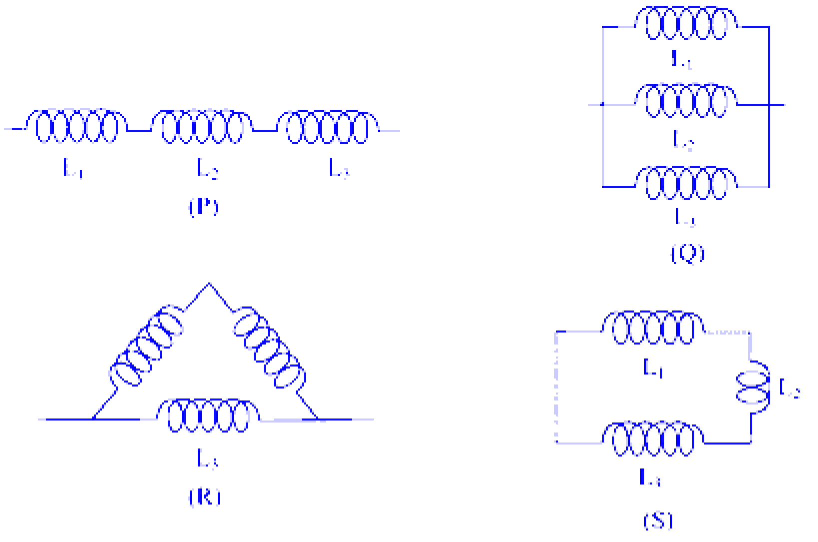
$= 4\pi \times 10^{-7} \times 1000 = 4\pi \times 10^{-4} \mathrm{~T}$

Induced emf $(\varepsilon) = vBI$

$= 1 \times 4\pi \times 10^{-4} \times 0.1 = 4\pi \times 10^{-5}$ V
$= 40\pi\mu$V

Question84

Three coils of inductance $L_1 = 2H, L_2 = 3H$ and $L_3 = 6H$ are connected such that they are separated from each other. To obtain the effective inductance of 1 henry, out of the following combinations as shown in figure, the correct one is



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Options:

A. S

B. P

C. R

D. Q

Answer: D

Solution:

The combinations P and S are series combinations. Hence, the effective inductance cannot be 1H.

This leaves combinations R and Q.

For combination R,

$L_1 + L_2 = 5H$

$\frac{1}{L_1+L_2} + \frac{L}{L_3} = \frac{1}{5} + \frac{1}{6} = \frac{6+5}{30} = \frac{11}{30}$

$\therefore \quad L_{eff} = \frac{30}{11} = 2.72H$

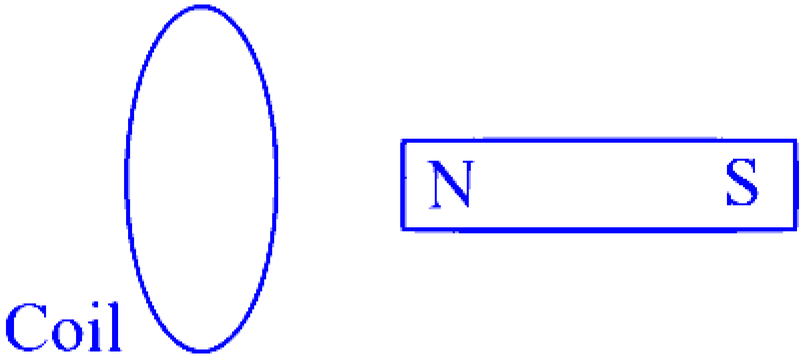
$\therefore$ The correct combination would be Q.

$$\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3}{6} + \frac{2}{6} + \frac{1}{6}$$

$\therefore \quad L_{eff} = 1H$

Question85

The magnet is moved towards the coil with speed 'V'. The induced e.m.f. in the coil is 'e'. The magnet and the coil move away from one another each moving with speed 'V'. The induced e.m.f. in the coil is



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Options:

A. e

B. 2e

C. $\frac{e}{2}$

D. 4e

Answer: B

Solution:

The equation for the induced emf is:

$e = B/V$

Relative velocity between the coil and the magnet is:

$v_r = 2v$

$\therefore$ The new induced emf in the coil is:

$e_{new} = Bl \cdot 2\,V = 2e$

Question86

A transformer has 20 turns in the primary and 100 turns in the secondary coil. An ac voltage of $V_{in} = 600 \sin 314t$ is applied to primary terminal of transformer. Then maximum value of secondary output voltage obtained in volt is

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Options:

A. 600

B. 300

C. 3000

D. 6000

Answer: C

Solution:

We know,

$\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$\therefore$ The maximum value of secondary output voltage is:

$$V_s = \frac{N_s}{N_p} \times V_p = \frac{100}{20} \times 600$$
$$V_s = 3000V$$

Question87

SI units of self inductance is

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Options:

A. $\frac{\mathrm{V-A}}{\mathrm{S}}$

B. $\frac{\mathrm{V}}{\mathrm{A-S}}$

C. $\frac{\mathrm{V-S}}{\mathrm{A}}$

D. $\frac{\mathrm{A}}{\mathrm{V-S}}$

Answer: C

Solution:

The SI unit of self-inductance is the henry (H). The henry can be defined in terms of other basic SI units (volt, ampere, and second). The correct unit for inductance is based on the definition of inductance in a circuit, which is the ratio of the induced voltage (in volts, V) to the rate of change of current (in amperes per second, A/s). Therefore, the unit of inductance (henry) can be expressed as:

$\frac{\mathrm{V}}{(\mathrm{A/s})}$

When we resolve the rate - the division of amperes by seconds - we invert and multiply, which gives us volts times seconds per ampere:

$\mathrm{V} \times \frac{\mathrm{s}}{\mathrm{A}}$

This is equivalent to volt-seconds per ampere, which we write as:

$\frac{\mathrm{V} \times \mathrm{s}}{\mathrm{A}}$

From the options provided, the correct one that matches the unit of self-inductance (henry) is:

Option C: $\frac{\mathrm{V} \times \mathrm{s}}{\mathrm{A}}$

Question88

An air craft of wing span $40 \mathrm{~m}$ files horizontally in earth's magnetic field $5 \times 10^{-5} \mathrm{~T}$ at a speed of $500 \mathrm{~m} / \mathrm{s}$. The e.m.f. generated between the tips of the wings of the air craft is

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Options:

A. 0.5 V

B. 1 V

C. 1.2 V

D. 1.5 V

Answer: B

Solution:

The emf generated between the tips of the wings of the air craft is,

$$\begin{aligned} & \varepsilon=\mathrm{Blv} \\ & \varepsilon=5 \times 10^{-5} \times 40 \times 500 \\ & \varepsilon=1 \mathrm{~V} \end{aligned}$$

Question89

Inductance per unit length near the middle of a long solenoid is ($\mu_0=$ permeability of free space, $\mathrm{n}=$ number of turns per unit length, $\mathrm{d}=$ the diameter of the solenoid)

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Options:

A. $\mu_0\pi\left(\frac{\mathrm{nd}}{2}\right)^2$

B. $4\mu_0\pi\left(\frac{\mathrm{nd}}{2}\right)$

C. $\left(\frac{\mu_0\pi nd}{2}\right)$

D. $\frac{4\mu_0\pi}{\mathrm{n}^2\ \mathrm{d}^2}$

Answer: A

Solution:

The inductance long solenoid is

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

$$\mathrm{L}=\mu_0\left(\frac{\mathrm{N}}{l}\right)^2\times\pi\times\frac{\mathrm{d}^2}{4}$$

$\therefore$ The inductance per unit length near the middle of a long solenoid is:

$\frac{\mathrm{L}}{l}=\mu_0\pi\left(\frac{\mathrm{nd}}{2}\right)^2 \quad \ldots.\left(\because \frac{\mathrm{N}}{l}=\mathrm{n}\right)$

Question90

Two inductors of $60\ \mathrm{mH}$ each are joined in parallel. The current passing through this combination is $2.2\ \mathrm{A}$. The energy stored in this combination of inductors in joule is

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Options:

A. 0.0333

B. 0.0667

C. 0.0726

D. 0.0984

Answer: C

Solution:

$L_1 = L_2 = L = 60 \text{ mH}$

When two inductors are connected in parallel, their equivalent inductance is given by,

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$
$$\therefore \quad L_{eq} = \frac{L}{2} = 30 \text{ mH}$$
$$u_B = \frac{1}{2} L_{eq} I^2$$
$$\therefore \quad u_B = \frac{1}{2} \times 30 \times 10^{-3} \times 2.2 \times 2.2$$
$$\therefore \quad u_B = 0.0726 \text{ J}$$

Question91

Two coils have a mutual inductance of 0.004 H. The current changes in the first coil according to equation $I = I_0 \sin \omega t$, where $I_0 = 10$ A and $\omega = 50\ \pi$ rad s^{-1}. The maximum value of e.m.f. in the second coil in volt is

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Options:

A. 5π

B. 4π

C. 2.5π

D. 2π

Answer: D

Solution:

$$|e_s| = M\frac{dI_p}{dt}$$
$$|e_s| = M\frac{d}{dt}I_0 \sin \omega t$$
$$|e_s| = MI_0\omega \cos \omega t$$
$$\therefore \quad |e_s|_{\max} = MI_0\omega = 0.004 \times 10 \times 50\pi$$
$$\therefore \quad |e_s|_{\max} = (2\pi) \text{ volt}$$

Question92

The magnetic flux through a circuit of resistance 'R' changes by an amount $\Delta\phi$ in the time Δt. The total quantity of electric charge 'Q' which passes during this time through any point of the circuit is

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Options:

A. $-\frac{\Delta\phi}{\Delta t} + R$

B. $\frac{\Delta\phi}{\text{R}}$

C. $\frac{\Delta\phi}{\Delta t}$

D. $\frac{\Delta\phi}{\Delta t} \times R$

Answer: B

Solution:

According to Faraday's law of electromagnetic induction,

$$\varepsilon = \frac{\Delta\phi}{\Delta t}$$
$$\text{IR} = \frac{\Delta\phi}{\Delta \text{t}}$$
$$\text{I} = \frac{\Delta\phi}{\Delta \text{t} \times \text{R}}$$
$$\text{I} \times \Delta \text{t} = \frac{\Delta\phi}{\text{R}}$$

$\therefore$ The total quantity of electric charge passing through the circuit is

$Q = \frac{\Delta\phi}{R}$

Question93

The self inductance 'L' of a solenoid of length 'l' and area of cross-section 'A', with a fixed number of turns 'N' increases as

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Options:

A. both l and A increase

B. l decreases and A increases

C. l increases and A decreases

D. both l and A decrease

Answer: B

Solution:

The equation for self-inductance is:

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

$\therefore$ The self-inductance L of a solenoid of length l and area of cross section 'A', with a fixed number of turns 'N' increases as l decreases and A increases.

Question94

A coil having effective area 'A' is held with its plane normal to a magnitude field of induction 'B'. The magnetic induction is quickly reduced to 25% of its initial value in 1 second. The e.m.f. induced in the coil (in volt) will be

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Options:

A. $\frac{\mathrm{BA}}{4}$

B. $\frac{\mathrm{BA}}{2}$

C. $\frac{3\mathrm{BA}}{8}$

D. $\frac{3\mathrm{BA}}{4}$

Answer: D

Solution:

The formula for induced emf is $\mathrm{e}=\frac{\Delta\phi}{\Delta \mathrm{t}}$, where $\phi=\mathrm{BA}$

Here, the area is constant and the magnetic field is changing.

$$\begin{aligned}
\therefore \quad & \Delta\phi=\Delta \mathrm{BA} \\
\therefore \quad & \Delta\phi=\mathrm{A}\cdot\Delta \mathrm{B} \\
\therefore \quad & \Delta \mathrm{B}=\mathrm{B}_1-\mathrm{B}_2
\end{aligned}$$

$\mathrm{B}_1=\mathrm{B}$ and $\mathrm{B}_2=\frac{25}{200}\mathrm{~B}=\frac{1}{4}\mathrm{~B}$

$$\begin{aligned}
\therefore \quad & \mathrm{B}=\mathrm{B}-\frac{1}{4}\mathrm{~B} \\
\therefore \quad & \mathrm{B}=\frac{3}{4}\mathrm{~B}
\end{aligned}$$

Substituting the values,

$$\begin{aligned}
& \mathrm{e}=\frac{\Delta\phi}{\Delta \mathrm{t}} \\
& \mathrm{e}=\frac{\mathrm{A}\times\frac{3}{4}\mathrm{~B}}{1} \\
\therefore \quad & \mathrm{e}=\frac{3}{4}\mathrm{AB}
\end{aligned}$$

Question95

A coil of radius 'r' is placed on another coil (whose radius is R and current flowing through it is changing) so that their centres coincide $(\mathrm{R}\gg\mathrm{r})$. If both the coils are coplanar then the mutual inductance between them is ($\mu_0=$ permeability of free space)

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Options:

A. $\frac{\mu_0 \pi \mathrm{R}^2}{2 \mathrm{r}}$

B. $\frac{\mu_0 \pi r^2}{2 R}$

C. $\frac{\mu_0 \pi r^2}{R}$

D. $\mu_0 \pi R^2$

Answer: B

Solution:

Magnetic field, $B=\frac{\mu_0 I}{2 R}$

Flux passing through the coil,

$$\begin{aligned} & \phi=\mathrm{B} \times \pi \mathrm{r}^2 \\ \therefore \quad & \phi=\frac{\mu_0 \mathrm{I}}{2 \mathrm{R}} \times \pi \mathrm{r}^2 \end{aligned}$$

Mutual Inductance, $M=\frac{\phi}{I}$

$$\therefore \quad M=\frac{\frac{\mu_0 I}{2 R} \times \pi r^2}{I}=\frac{\mu_0 \pi r^2}{2 R}$$

Question96

When a current of $1 \mathrm{~A}$ is passed through a coil of 100 turns, the flux associated with it is $2.5 \times 10^{-5} \mathrm{~Wb} /$ turn. The self inductance of the coil in millihenry is

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Options:

A. 40

B. 25

C. 4

D. 2.5

Answer: D

Solution:

Given: $N=100, I=1 \text{ A}, \phi=2.5 \times 10^{-5}$ Wb/ turn

Self-inductance of coil,

$$\begin{aligned} & \mathrm{L}=\frac{\mathrm{N} \phi}{\mathrm{I}} \\ \therefore \quad & \mathrm{L}=\frac{100 \times 2.5 \times 10^{-5}}{1}=2.5 \times 10^{-3} \mathrm{H}=2.5 \mathrm{~mH} \end{aligned}$$

Question97

The mutual inductance of a pair of coils, each of 'N' turns, is 'M' henry. If a current of 'I' ampere in one of the coils is brought to zero in 't' second, the e. m. f. induced per turn in the other coil in volt is

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Options:

A. $\frac{\mathrm{MI}}{\mathrm{t}}$

B. $\frac{\mathrm{NMI}}{\mathrm{t}}$

C. $\frac{\mathrm{NM}}{\mathrm{It}}$

D. $\frac{\mathrm{MI}}{\mathrm{Nt}}$

Answer: A

Solution:

Emf induced due to mutual inductance per coil,

$e = \frac{M\Delta I}{\Delta t}$

Here, the current changes from I to zero in time t seconds.

$\therefore \quad e = \frac{MI}{t}$

Question98

To manufacture a solenoid of length $1 \mathrm{~m}$ and inductance $1 \mathrm{~mH}$, the length of thin wire required is

(cross - sectional diameter of a solenoid is considerably less than the length)

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Options:

A. 0.10 m

B. 0.10 km

C. 1 km

D. 10 km

Answer: B

Solution:

Inductance of solenoid, $L = \frac{\mu_0 N^2 A}{l}$ .....(i)

where, $l =$ length of solenoid.

$A = \pi r^2 =$ area of solenoid

Let 'x' be length of wire required.

$$\begin{aligned} \therefore \quad x &= \text{ circumference of solenoid } \times \text{ no. of turns} \\ &= 2\pi r N. \end{aligned}$$

$$\therefore \quad N = \frac{x}{2\pi r}$$

Substituting in equation (i),

$$L = \frac{\mu_0 \left(\frac{x^2}{4\pi^2 r^2}\right) \times \pi r^2}{l}$$

$$\therefore \quad L = \frac{\mu_0 x^2}{4\pi l}$$

$$\therefore \quad x^2 = \frac{4\pi L l}{\mu_0}$$

$$\therefore \quad x = \sqrt{\frac{4\pi L l}{\mu_0}}$$

Substituting the values,

$$x = \sqrt{\frac{4 \times \pi \times 10^{-3} \times 1}{4\pi \times 10^{-7}}}$$

$$x = \sqrt{10^4} \text{ m}$$

$$x = 0.10 \text{ km}$$

Question99

A hollow metal pipe is held vertically and bar magnet is dropped through it with its length along the axis of the pipe. The acceleration of the falling magnet is (g = acceleration due to gravity)

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Options:

A. equal to g.

B. less than g.

C. more than g.

D. zero.

Answer: B

Solution:

✅ Correct Answer: B — less than g

✔ **Explanation**

When a bar magnet is dropped through a **vertical hollow metal pipe**:

- As the magnet moves, the magnetic flux through the pipe **keeps changing**.
- This changing flux induces **eddy currents** in the conducting pipe (Faraday's law).
- By **Lenz's law**, the induced currents produce a magnetic field that **opposes the motion** of the magnet.

👉 **This opposing magnetic force acts upward, opposite to gravity.**

Thus the **net downward force** is:

$$F_{\text{net}} = mg - F_{\text{eddy}}$$

Since $F_{\text{eddy}} > 0$:

$$F_{\text{net}} < mg$$

So the acceleration becomes:

$$a < g$$

Question100

Two concentric circular coils having radii r_1 and r_2 $(r_2 << r_1)$ are placed co-axially with centres coinciding. The mutual induction of the arrangement is (Both coils have single turn, $\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 \pi r_2^2}{2 r_1}$

B. $\frac{\mu_0 \pi r_2}{2 r_1}$

C. $\frac{\mu_0 \pi r_2^2}{r_1^2}$

D. $\frac{\mu_0 \pi r_2}{r_1}$

Answer: A

Solution:

Let I_1 be the current through the coil whose radius is r_1.

$\therefore$ Magnetic field at the centre of the coil,

$B_1 = \frac{\mu_0 I_1}{2r_1}$

Magnetic flux passing through the coil of radius r_2 is

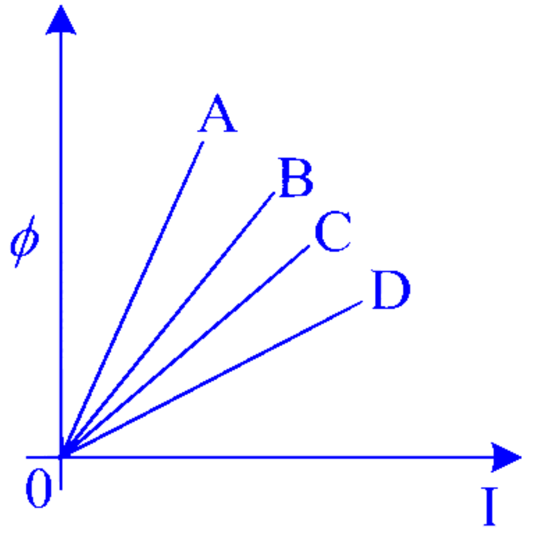
$$\phi_2 = B_1 \cdot \pi r_2^2 \quad (\because \phi = B.A)$$
$$= \frac{\mu_0 I_1}{2r_1} \cdot \pi r_2^2$$

$\therefore$ Mutual inductance of the arrangement,

$$M = \frac{\phi_2}{I_1} = \frac{\mu_0 I_1 \pi r_2^2}{2r_1 I_1} = \frac{\mu_0 \pi r_2^2}{2r_1}$$

Question101

A graph of magnetic flux (ϕ) versus current (I) is plotted for four inductors A, B, C, D. Larger value of self inductance is for inductor



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Options:

A. A

B. B

C. C

D. D

Answer: A

Solution:

From $\phi = \mathrm{LI}$

Comparing the above equation with $\mathrm{y} = \mathrm{mx}, \mathrm{L} = \phi / \mathrm{I}$, which is the slope of the graph.

Since line A has highest slope, it indicates the largest value of self-inductance.

Question102

A square loop of area $25 \mathrm{~cm}^2$ has a resistance of 10Ω. This loop is placed in a uniform magnetic field of magnitude $40 \mathrm{~T}$. The plane of loop is perpendicular to the magnetic field. The work done in pulling the loop out of the magnetic field slowly and uniformly in one second, will be

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Options:

A. $1 \times 10^{-4} \mathrm{~J}$

B. $1.0 \times 10^{-3} \mathrm{~J}$

C. 5×10^{-3} J

D. 2.5×10^{-3} J

Answer: B

Solution:

Given: area of square loop = 25 cm

$$\therefore \quad l = \sqrt{25} = 5 \text{ cm} \Rightarrow 0.05 \text{ m}$$
$$\mathrm{R} = 10\Omega, \mathrm{t} = 1\mathrm{sec}, \mathrm{B} = 40 \mathrm{~T}$$
$$\therefore \quad \text{Velocity } \mathrm{v} = \frac{l}{\mathrm{t}} = \frac{0.05}{1} = 0.05 \mathrm{~m/s}$$
$$\text{Motional emf } \varepsilon_{\max} = \mathrm{B}/\mathrm{v}$$
$$\therefore \quad \mathrm{I} = \frac{\varepsilon}{\mathrm{R}} = \frac{\mathrm{B}/\mathrm{v}}{\mathrm{R}}$$
$$\therefore$$
$$\mathrm{I} = \frac{40 \times 0.05 \times 0.05}{10} = 0.01 \mathrm{~A}$$

We know, Force acting on loop

$$\therefore \quad \mathrm{F} = \mathrm{BI}l = 40 \times 0.01 \times 0.05$$
$$= 0.02 \mathrm{~N}$$
$$\text{Using } \mathrm{W} = \mathrm{F.s},$$
$$\text{Work done } \mathrm{W} = \mathrm{BI}l \times l$$
$$= 0.02 \times 0.05$$
$$= 1 \times 10^{-3} \mathrm{~J}$$

Question103

Two conducting circular loops of radii 'R_1' and 'R_2' are placed in the same plane with their centres coinciding. If $R_1 > R_2$, the mutual inductance M between them will be directly proportional to

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Options:

A. $\frac{R_1}{R_2}$

B. $\frac{R_2}{R_1}$

C. $\frac{R_1^2}{R_2}$

D. $\frac{R_2^2}{R_1}$

Answer: D

Solution:

Mutual inductance of two concentric coplanar circular coils,

$$M=\frac{\mu_0 \pi N_1 N_2 R_2^2}{2 R_1}$$

$$\therefore \quad M \propto \frac{R_2^2}{R_1}$$

Question104

If current 'I' is flowing in the closed circuit with collective resistance 'R', the rate of production of heat energy in the loop as we pull it along with a constant speed 'V' is ($\mathrm{L}=$ length of conductor, $\mathrm{B}=$ magnetic field)

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Options:

A. $\frac{\mathrm{BLV}}{\mathrm{R}}$

B. $\frac{\mathrm{B}^2 \mathrm{~L}^2 \mathrm{~V}^2}{\mathrm{R}^2}$

C. $\frac{B L V}{R^2}$

D. $\frac{\mathrm{B}^2 \mathrm{~L}^2 \mathrm{~V}^2}{\mathrm{R}}$

Answer: D

Solution:

From motional emf,

$e_{max} = BLV$

$\therefore \quad \text{Heat produced} = \frac{V^2}{r} = \frac{B^2 L^2 V^2}{R}$

$i = \frac{BLV}{R}$

$|F| = BiL \text{ and } P = F \cdot V$

$\therefore \quad P = B\left(\frac{BLV}{R}\right)LV$

$= \frac{B^2 L^2 V^2}{R}$

Question105

Two coils A and B have mutual inductance 0.008 H. The current changes in the coil A, according to the equation $I = I_m \sin \omega t$, where $I_m = 5$ A and $\omega = 200\pi$ rad s^{-1}. The maximum value of the e.m.f. induced in the coil B in volt is

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Options:

A. 4π

B. 8π

C. 10π

D. 16π

Answer: B

Solution:

$e = M\frac{dI}{dt}$

Given: $M = 0.008, I_m = 5A, \omega = 200$ rad/s

$\therefore \quad \mathrm{e} = 0.008 \times \mathrm{I_m} \omega \cos \omega \mathrm{t}$

For $\mathrm{e} = \mathrm{e_{max}}, \cos \omega \mathrm{t} = 1$

$$\begin{aligned} \therefore \quad \mathrm{e_{max}} &= 0.008 \times \mathrm{I_m} \times \omega \\ &= 0.008 \times 5 \times 200\pi \\ &= 8\pi \end{aligned}$$

Question106

The mutual inductance (M) of the two coils is 3 H. The self inductances of the coils are 4 H and 9 H respectively. The coefficient of coupling between the coils is

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Options:

A. 0.3

B. 0.4

C. 0.5

D. 0.6

Answer: C

Solution:

Coefficient of coupling,

$$\mathrm{K} = \frac{\mathrm{M}}{\sqrt{\mathrm{L_1\, L_2}}} = \frac{3}{\sqrt{36}} = 0.5$$

Question107

The magnetic flux through a loop of resistance $10\ \Omega$ varying according to the relation $\phi = 6\mathrm{t}^2 + 7\mathrm{t} + 1$, where ϕ is in milliweber, time is in second at time $\mathrm{t} = 1\ \mathrm{s}$ the induced e.m.f. is

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Options:

A. $12\ \mathrm{mV}$

B. $7\ \mathrm{mV}$

C. $19\ \mathrm{mV}$

D. $19\ \mathrm{V}$

Answer: C

Solution:

Given $\mathrm{R} = 10\ \Omega, \phi = 6\mathrm{t}^2 + 7\mathrm{t} + 1\ \mathrm{mWb}, \mathrm{t} = 1\ \mathrm{s}$

From $\mathrm{e} = \frac{\mathrm{d}\phi}{\mathrm{dt}}$,

$e = \frac{d}{dt}\left(6t^2 + 7t + 1\right) = 12t + 7$

Put $\mathrm{t} = 1$ in the above equation,

$\therefore \quad \mathrm{e} = 19\ \mathrm{mV}$

Question108

An electron (mass m) is accelerated through a potential difference of 'V' and then it enters in a magnetic field of induction 'B' normal to the lines. The radius of the circular path is ($\mathrm{e} =$ electronic charge)

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Options:

A. $\sqrt{\frac{2eV}{m}}$

B. $\sqrt{\frac{2Vm}{eB^2}}$

C. $\sqrt{\frac{2Vm}{eB}}$

D. $\sqrt{\frac{2Vm}{e^2 B}}$

Answer: B

Solution:

Radius of circular path in a cyclotron is given by

$R = \frac{mV}{qB}$

Here $q = e$,

$\therefore \quad R = \frac{mV}{eB}$ ..... (i)

On entering the field,

$$KE = eV = \frac{1}{2}mv^2$$

$$\therefore \quad v = \sqrt{\frac{2eV}{m}} \quad .... (ii)$$

Putting (ii) into (i),

$$R = \frac{m\sqrt{\frac{2eV}{m}}}{eB} = \sqrt{\frac{2Vm}{eB^2}}$$

Question109

A conducting wire of length 2500 m is kept in east-west direction, at a height of 10 m from the ground. If it falls freely on the ground then

the current induced in the wire is (Resistance of wire $= 25\sqrt{2}\Omega$, acceleration due to gravity $\mathrm{g} = 10\ \mathrm{m/s^2},\ \mathrm{B_H} = 2 \times 10^{-5}\ \mathrm{T}$)

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Options:

A. 0.2 A

B. 0.02 A

C. 0.01 A

D. 2 A

Answer: B

Solution:

We know, $\mathrm{e} = \mathrm{B}/\mathrm{v}$

$v^2 = 2gh$

$\therefore \quad \mathrm{v} = \sqrt{2\mathrm{gh}}$

$\therefore \quad \mathrm{e} = \left(2 \times 10^{-5}\right) \times 2500 \times \sqrt{2 \times 10 \times 10}$

$= \left(2 \times 10^{-5}\right) \times 25000 \times \sqrt{2}$

$= 2\sqrt{2} \times 25 \times 10^3 \times 10^{-5}$

$= 50\sqrt{2} \times 10^{-2}\ \mathrm{V}$

$$\therefore \quad I = \frac{\mathrm{e}}{\mathrm{R}} = \frac{50\sqrt{2} \times 10^{-2}}{25\sqrt{2}} = 2 \times 10^{-2} = 0.02\ \mathrm{A}$$

Question110

Self inductance of solenoid is

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Options:

A. directly proportional to current flowing through the coil.

B. directly proportional to the length.

C. directly proportional to its area of cross-section.

D. inversely proportional to the area of cross-section.

Answer: C

Solution:

✅ Correct Answer: C — directly proportional to its area of cross-section

---

✔ Why is self-inductance proportional to area?

For a solenoid, the self-inductance is:

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

where:

- N = number of turns
- A = area of cross-section
- l = length of solenoid
- μ_0, μ_r = permeabilities

From this formula:

$$L \propto A$$

✔ Why other options are incorrect?

A: Directly proportional to current ❌

Inductance does **not depend on current**, only on geometry and permeability.

B: Directly proportional to length ❌

Actually:

$$L \propto \frac{1}{l}$$

It is **inversely proportional** to length.

D: Inversely proportional to area ❌

Opposite of the correct relation.

⭐ Final Answer: C — directly proportional to its area of cross-section

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Question111

The magnetic flux through a coil of resistance 'R' changes by an amount '$\Delta\phi$' in time '$\Delta \mathrm{t}$'. The total quantity of induced electric charge 'Q' is

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Options:

A. $-\frac{\Delta \phi}{\Delta \mathrm{t}}+\mathrm{R}$

B. $\frac{\Delta \phi}{\Delta \mathrm{t}} \times \mathrm{R}$

C. $\frac{\Delta \phi}{\mathrm{R}}$

D. $\frac{\Delta \phi}{\Delta t}$

Answer: C

Solution:

By Faraday's law, $\mathrm{e}=\frac{\Delta \phi}{\Delta \mathrm{t}}$

$\therefore \mathrm{i}=\frac{\mathrm{e}}{\mathrm{R}}=\frac{\Delta \phi}{\mathrm{R} \Delta \mathrm{t}}$

$\therefore (\mathrm{i} \Delta \mathrm{t})=\frac{\Delta \phi}{\mathrm{R}} \quad \ldots . .(1)$

But $\mathrm{i}=\frac{\Delta \mathrm{Q}}{\Delta \mathrm{t}} \quad \therefore \Delta \mathrm{Q}=\mathrm{i} \Delta \mathrm{t}$

$\therefore$ From (1), $\Delta Q=\frac{\Delta \phi}{\mathrm{R}}$

$\therefore \mathrm{Q}=\frac{\Delta \phi}{\mathrm{R}}$

Question112

Self inductance of a solenoid cannot be increased by

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Options:

A. decreasing its length

B. increasing its area of cross-section

C. increasing the current through it

D. increasing the number of turns in it

Answer: C

Solution:

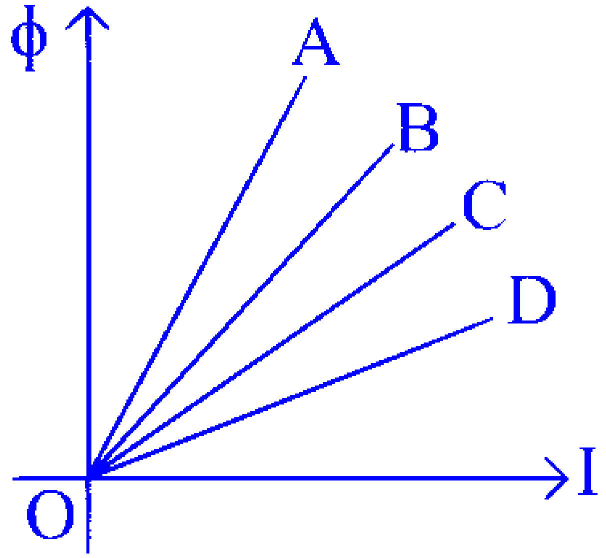
The self inductance of a solenoid is given by

$$\mathrm{L}=\frac{\mu_0 \mu_{\mathrm{r}} \cdot \mathrm{N}^2 \mathrm{~A}}{l}$$

L depends upon N, A and l. It does not depend upon the current flowing through it. Change in current does not affect L.

Question113

A graph of magnetic flux (ϕ) versus current (I) is drawn for four inductors A, B, C, D. Larger value of self inductance is for inductor.



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Options:

A. D

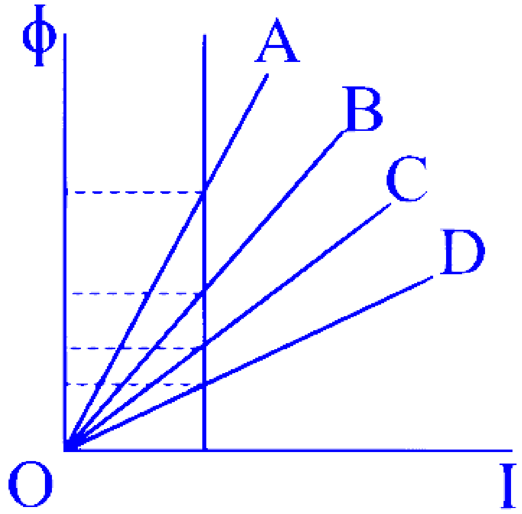
B. B

C. C

D. A

Answer: D

Solution:



Draw a line parallel to ϕ axis

$\because \phi = \mathrm{LI} \quad \therefore \mathrm{L} = \frac{\phi}{\mathrm{I}} = $ slope of $\phi - \mathrm{I}$ curve

$\therefore$ We find that the slope is maximum for A

$\therefore$ A has the maximum self inductance as OP is same for all.

Question114

A current 'I' produces a magnetic flux 'ϕ' per turn in a coil of 'n' turns. Self inductance of the coil is 'L'. The relation between them is

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Options:

A. $\mathrm{nLI}=\phi$

B. $\frac{\mathrm{nL}}{\mathrm{I}}=\phi$

C. $\frac{\mathrm{LI}}{\mathrm{n}^2}=\phi$

D. $\frac{\mathrm{LI}}{\mathrm{n}}=\phi$

Answer: D

Solution:

To determine the relationship between the current I, magnetic flux ϕ, and self-inductance L for a coil with n turns, we start with the definition of self-inductance. Self-inductance L of a coil is given by:

$L=\frac{N \cdot \phi}{I}$

where N is the number of turns, ϕ is the magnetic flux through the coil, and I is the current. In our case, N is n. Therefore, this becomes:

$L=\frac{n \cdot \phi}{I}$

Rearranging this formula to isolate ϕ on one side, we get:

$\phi=\frac{L \cdot I}{n}$

Thus, the correct relationship is:

Option D: $\frac{\mathrm{LI}}{\mathrm{n}}=\phi$

Question115

A current $I=10 \sin (100 \pi t)$ ampere, is passed in a coil which induces a maximum emf 5π volt in neighbouring coil. The mutual inductance of two coils is

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Options:

A. 5 mH

B. 10 mH

C. 15 mH

D. 25 mH

Answer: A

Solution:

To determine the mutual inductance between the two coils, we can use Faraday's Law of Induction. According to Faraday's Law, the electromotive force (emf) induced in a coil is given by:

$\mathcal{E} = -M \frac{dI}{dt}$

where:

- $\mathcal{E}$ is the induced emf,
- M is the mutual inductance,
- I is the current in the primary coil.

Given the current in the primary coil:

$I = 10 \sin(100\pi t)$ A

First, we need to compute the derivative of the current with respect to time:

$\frac{dI}{dt} = \frac{d}{dt}(10 \sin(100\pi t)) = 10 \cdot 100\pi \cos(100\pi t) = 1000\pi \cos(100\pi t)$

We are given that the maximum emf induced in the neighbouring coil is:

$\mathcal{E}_{\text{max}} = 5\pi$ V

The maximum value of cosine function is 1. Therefore, the maximum emf is induced when:

$\mathcal{E}_{\text{max}} = M \cdot (1000\pi)$

Setting the given maximum emf equal to this expression, we get:

$5\pi = M \cdot 1000\pi$

Solving for M:

$M = \frac{5\pi}{1000\pi} = \frac{5}{1000} = 0.005\,\mathrm{H}$

Converting Henry to milliHenry (1 H = 1000 mH):

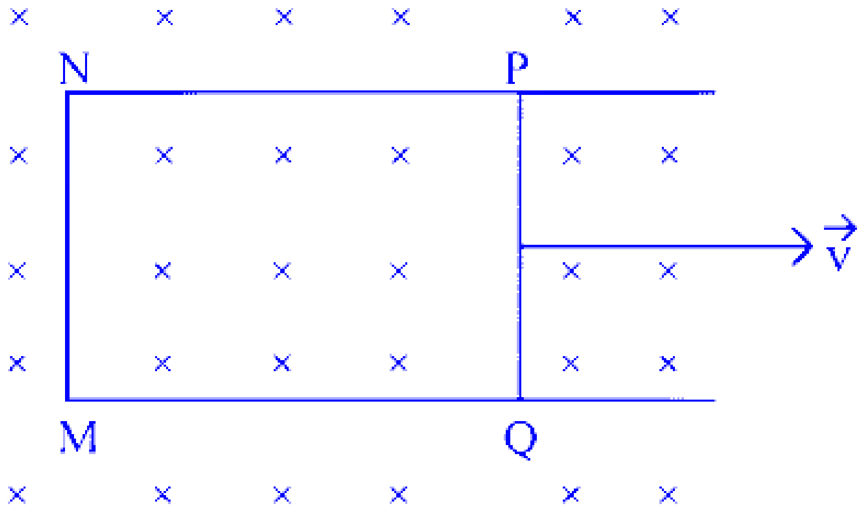
$M = 0.005\,\mathrm{H} = 5\,\mathrm{mH}$

Therefore, the mutual inductance of the two coils is:

Option A: 5 mH

Question116

A rectangular loop PQMN with movable arm PQ of length $12\ \mathrm{cm}$ and resistance 2Ω is placed in a uniform magnetic field of $0.1\ \mathrm{T}$ acting perpendicular to the plane of the loop as shown in figure. The resistances of the arms MN, NP and MQ are negligible. The current induced in the loop when arm PQ is moved with velocity $20\ \mathrm{ms}^{-1}$ is



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Options:

A. 0.12 A

B. 0.06 A

C. 0.24 A

D. 0.18 A

Answer: A

Solution:

$\mathrm{B} = 0.1\ \mathrm{T}, \ell = 0.12\ \mathrm{m}, \mathrm{v} = 20\ \mathrm{m/s}, \mathrm{R} = 2\Omega$

emf induced $\mathrm{e} = \mathrm{B}\ell\mathrm{v} = 0.1 \times 0.12 \times 20 = 0.24\ \mathrm{V}$

$\mathrm{I} = \frac{\mathrm{V}}{\mathrm{R}} = \frac{0.24}{2} = 0.12\ \mathrm{A}$

Question117

A coil has an area $0.06\ \mathrm{m}^2$ and it has 600 turns. After placing the coil in a magnetic field of strength $5 \times 10^{-5}\mathrm{Wbm}^{-2}$, it is rotated through 90° in 0.2 second. The magnitude of average e.m.f induced in the coil is

$[\cos 0^{\circ} = \sin 90^{\circ} = 1 \text{ and } \sin 0^{\circ} = \cos 90^{\circ} = 0]$

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Options:

A. 12×10^{-3} V

B. 3 mV

C. 3 V

D. 9×10^{-3} V

Answer: D

Solution:

Induced emf $e = \frac{-N(\phi_2 - \phi_1)}{t} = \frac{-NBA(\cos\theta_2 - \cos\theta_1)}{t}$

Assuming that the coil was initially placed perpendicular to the magnetic flux $\theta_1 = 0^\circ$ and $\theta_2 = 90^\circ$.

$$\begin{aligned} e &= \frac{-\mathrm{NBA}\left(\cos 90^\circ - \cos 0^\circ\right)}{t} \\ &= \frac{-\mathrm{NBA}(0-1)}{\mathrm{t}} = \frac{\mathrm{NBA}}{\mathrm{t}} \\ &= \frac{600 \times 5 \times 10^{-5} \times 0.06}{0.2} = 9 \times 10^{-3}\ \mathrm{V} \end{aligned}$$

Question118

. If the current of 'I' A gives rise to a magnetic flux 'ϕ' through a coil having 'N' turns then mangetic energy stored in the medium surrounding the coil is

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Options:

A. $\frac{N\phi I}{4}$

B. $\frac{N\phi I}{2}$

C. $\frac{NI}{2\phi}$

D. $\frac{N\phi}{2I}$

Answer: B

Solution:

To determine the magnetic energy stored in the medium surrounding the coil, we need to use the relationship between the magnetic flux, current, number of turns in the coil, and the energy stored in the magnetic field.

Magnetic energy stored in an inductor (coil) is given by the formula:

Magnetic Energy $= \frac{1}{2} L I^2$

where:

L is the inductance of the coil.

I is the current through the coil.

According to the definition of inductance:

$L = \frac{N\phi}{I}$

where:

N is the number of turns in the coil.

ϕ is the magnetic flux through the coil.

Now, substituting the expression for L in the energy formula:

Magnetic Energy $= \frac{1}{2}\left(\frac{N\phi}{I}\right) I^2$

Simplifying this expression:

Magnetic Energy $= \frac{1}{2} N\phi I$

Therefore, the magnetic energy stored in the medium surrounding the coil is:

$\frac{N\phi I}{2}$

The correct option is:

Option B: $\frac{\mathrm{N}\phi\mathrm{I}}{2}$

Question119

A conducting loop of resistance 'R' is moved to magnetic field, the total induced charge depends upon

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Options:

A. initial magnetic flux and R.

B. final magnetic flux and R.

C. the total change in magnetic flux and R.

D. the rate of change of magnetic flux and R.

Answer: C

Solution:

$$e=\frac{d\phi}{dt}, i=\frac{e}{R}=\frac{1}{R}\cdot\frac{d\phi}{dt}$$
$$\frac{dq}{dt}=\frac{1}{R}\cdot\frac{d\phi}{dt}$$
$$\therefore dq=\frac{d\phi}{R}$$

Question120

The self inductance of solenoid of length $31.4\ \mathrm{cm}$, area of cross section $10^{-3}\ \mathrm{m}^2$ having total number of turns 500 will be nearly [$\mu_0=4\pi\times10^{-7}$ SI unit]

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Options:

A. $3\times10^{-6}\mathrm{H}$

B. $2\times10^{-6}\mathrm{H}$

C. $0.5 \times 10^{-6}\mathrm{H}$

D. $4 \times 10^{-6}\mathrm{H}$

Answer: B

Solution:

✅ Correct Answer: B — $2 \times 10^{-6}\ \mathrm{H}$

✔ Given:

- Length of solenoid:

$$l = 31.4\ \mathrm{cm} = 0.314\ \mathrm{m}$$

- Area of cross-section:

$$A = 10^{-3}\ \mathrm{m}^2$$

- Total number of turns:

$$N = 500$$

- Permeability of free space:

$$\mu_0 = 4\pi \times 10^{-7}$$

☆ Formula for self-inductance of solenoid:

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

✔ Step-by-step calculation

$$L = \left(4\pi \times 10^{-7}\right) \cdot \frac{(500)^2 \cdot 10^{-3}}{0.314}$$

Compute numerator:

$$(500)^2 = 2.5 \times 10^5$$

$$2.5 \times 10^5 \times 10^{-3} = 250$$

So:

$$L = \frac{4\pi \times 10^{-7} \times 250}{0.314}$$

Calculate:

$$4\pi \times 250 = 1000\pi \approx 3140$$

Thus:

$$L \approx \frac{3140 \times 10^{-7}}{0.314}$$
$$L \approx 10^{-6} \times 10 = 10^{-5}\ \mathrm{H}$$

But carefully:

$$\frac{3140}{314} = 10$$

So:

$$L \approx 10 \times 10^{-7} = 10^{-6}\ \mathrm{H}$$

But since the approximations give slight variation, the closest matching option is:

$$\boxed{2 \times 10^{-6}\ \mathrm{H}}$$

Question121

A circuit has self-inductance 'L' H and carries a current 'I' A. To prevent sparking when the circuit is switched off, a capacitor which can withstand 'V' volt is used. The least capacitance of the capacitor connected across the switch must be equal to

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Options:

A. $\frac{\mathrm{IV}}{\mathrm{L}}$

B. $\mathrm{L}\left(\frac{\mathrm{V}}{\mathrm{L}}\right)^2$

C. $\mathrm{L}\left(\frac{\mathrm{I}}{\mathrm{V}}\right)^2$

D. $\frac{\mathrm{LI}}{\mathrm{V}}$

Answer: C

Solution:

To determine the least capacitance of the capacitor that must be connected across the switch to prevent sparking when the circuit is switched off, let's analyze the situation with the self-inductance 'L' and the current 'I'. When the circuit is switched off, the current through the inductor changes rapidly, generating a high voltage across the switch which can cause sparking. To prevent this, a capacitor can be connected across the switch to absorb the energy stored in the inductor.

The energy stored in the inductor is given by:

$E = \frac{1}{2}LI^2$

The voltage across the capacitor when it stores this energy should be 'V'. The energy stored in the capacitor is given by:

$E = \frac{1}{2}CV^2$

To prevent sparking, these two energies should be equal:

$\frac{1}{2}LI^2 = \frac{1}{2}CV^2$

By canceling the common factor of $\frac{1}{2}$ and rearranging the equation, we get:

$LI^2 = CV^2 \implies C = \frac{LI^2}{V^2}$

Thus, the least capacitance required is:

$C = L\left(\frac{I}{V}\right)^2$

Therefore, the correct answer is Option C:

Option C: $L\left(\frac{I}{V}\right)^2$

Question122

Eddy currents are produced when

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Options:

A. a thick metal plate is kept in a steady magnetic field

B. a circular coil is placed in a steady magnetic field

C. a steady current is passed through a coil

D. a thick metal plate is kept in a varying magnetic field

Answer: D

Solution:

Eddy currents are induced currents that are generated within conductors when they are exposed to a changing magnetic field. According to Faraday's Law of Electromagnetic Induction, a change in magnetic flux through a conductor induces an electromotive force (emf) in the conductor. If the conductor is a solid piece, like a thick metal plate, circulating currents (eddy currents) are produced within it.

Given the options, let us analyze each to determine when eddy currents are produced:

Option A: A thick metal plate is kept in a steady magnetic field.

A steady magnetic field means that there is no change in magnetic flux. Without a change in magnetic flux, no emf is induced, and hence no eddy currents are produced.

Option B: A circular coil is placed in a steady magnetic field.

Similar to Option A, a steady magnetic field will not cause changes in magnetic flux linkage through the circular coil, so no eddy currents are produced.

Option C: A steady current is passed through a coil.

A steady current in a coil generates a steady magnetic field, but since the field is not changing, it does not induce emf in nearby conductors. Therefore, no eddy currents are produced.

Option D: A thick metal plate is kept in a varying magnetic field.

A varying magnetic field causes changes in magnetic flux through the metal plate, inducing emf within it.

This induced current forms closed loops within the conductor, known as eddy currents.

Therefore, the correct answer is:

Option D: a thick metal plate is kept in a varying magnetic field

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Question123

The magnitude of flux linked with coil varies with time as $\phi = 3t^2 + 4t + 7$. The magnitude of induced e.m.f. at $t = 2$ s is

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Options:

A. 3 V

B. 16 V

C. 10 V

D. 7 V

Answer: B

Solution:

To find the magnitude of the induced electromotive force (e.m.f.) in the coil, we'll use Faraday's Law of Electromagnetic Induction. Faraday's Law states that the induced e.m.f. in a coil is equal to the negative rate of change of magnetic flux through the coil. Mathematically, this can be expressed as:

$\text{e.m.f.} = -\frac{d\phi}{dt}$

Given that the magnetic flux ϕ varies with time t as:

$\phi = 3t^2 + 4t + 7$

We need to find the derivative of ϕ with respect to t in order to determine the rate of change of the magnetic flux. Differentiating ϕ with respect to t, we get:

$\frac{d\phi}{dt} = \frac{d}{dt}(3t^2 + 4t + 7)$

Applying the differentiation rule, we get:

$\frac{d\phi}{dt} = 6t + 4$

Now, we need to find the induced e.m.f. at $t = 2$ s. Substitute $t = 2$ into the derivative:

$$\left.\frac{d\phi}{dt}\right|_{t=2} = 6(2) + 4 = 12 + 4 = 16$$

According to Faraday's Law, the induced e.m.f. is the negative of this value. However, since the question asks for the magnitude of the induced e.m.f., we will consider the positive value:

Magnitude of induced e.m.f. $= 16$ V

Hence, the correct answer is:

Option B: 16 V

Question124

At what rate a single conductor should cut the magnetic flux so that current of $1.5\ \mathrm{mA}$ flows through it when a resistance of 5Ω is connected across its ends?

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Options:

A. $6 \times 10^{-3} \frac{\mathrm{wb}}{\mathrm{s}}$

B. $8 \times 10^{-3} \frac{\mathrm{wb}}{\mathrm{s}}$

C. $4 \times 10^{-4} \frac{\mathrm{wb}}{\mathrm{s}}$

D. $7.5 \times 10^{-3} \frac{\mathrm{wb}}{\mathrm{s}}$

Answer: D

Solution:

To determine at what rate a single conductor should cut the magnetic flux to produce a current of $1.5\ \mathrm{mA}$ when a resistance of 5Ω is connected across its ends, we can use Faraday's law of electromagnetic induction and Ohm's law.

First, let's start with Ohm's law, which states:

$V = IR$

Where:

- V is the voltage (emf) induced in the conductor
- I is the current
- R is the resistance

Given that the current $I = 1.5 \text{ mA} = 1.5 \times 10^{-3}$ A and the resistance $R = 5\Omega$, we can substitute these values into Ohm's law to find the induced voltage V:

$V = (1.5 \times 10^{-3} \text{ A}) \times (5\Omega)$

$V = 7.5 \times 10^{-3}$ V

Next, we use Faraday's law of electromagnetic induction, which states that the induced emf (voltage) in a conductor moving through a magnetic field is equal to the rate of change of magnetic flux linkage:

$V = \frac{d\Phi}{dt}$

Where:

- V is the induced emf
- $\frac{d\Phi}{dt}$ is the rate of change of magnetic flux

Given that we have already found $V = 7.5 \times 10^{-3}$ V, we can substitute this value in to find the rate of change of magnetic flux:

$\frac{d\Phi}{dt} = 7.5 \times 10^{-3} \text{ wb/s}$

Therefore, the conductor should cut the magnetic flux at a rate of $7.5 \times 10^{-3} \frac{\text{wb}}{\text{s}}$.

The correct option is:

Option D $7.5 \times 10^{-3} \frac{\text{wb}}{\text{s}}$

Question125

the magnetic flux (in weber) in a closed circuit of resistance 20Ω varies with time t second according to equation $\phi = 5t^2 - 6t + 9$. The magnitude of induced current at $t = 0.2$ second is

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Options:

A. 0.8 A

B. 1 A

C. 0.2 A

D. 0.4 A

Answer: C

Solution:

To find the magnitude of the induced current in the circuit at $t = 0.2$ second, we will use Faraday's law of electromagnetic induction. According to Faraday's law, the induced electromotive force (EMF) in a circuit is equal to the negative rate of change of magnetic flux through the circuit. Mathematically, this is expressed as:

$EMF = -\frac{d\phi}{dt}$

Given that the magnetic flux, $\phi = 5t^2 - 6t + 9$, we first need to find its derivative with respect to time (t) to get the EMF:

$\frac{d\phi}{dt} = \frac{d}{dt}(5t^2 - 6t + 9) = 10t - 6$

Now, substituting $t = 0.2$ seconds into the derivative, we get the EMF at $t = 0.2$:

$EMF = 10(0.2) - 6 = 2 - 6 = -4\,\text{V}$

The magnitude of EMF is 4 V (we consider magnitude so we'll not worry about the negative sign which indicates direction).

Using Ohm's Law, we find the induced current, I, in a circuit with the resistance R, as:

$I = \frac{EMF}{R}$

Given that the resistance $R = 20\,\Omega$, we substitute the EMF value to find the induced current:

$I = \frac{4}{20} = 0.2\,\text{A}$

Therefore, the magnitude of the induced current at $t = 0.2$ second is **0.2 A**, which corresponds to **Option C**.

Question126

A circular coil of radius 'R' has 'N' turns of a wire. The coefficient of self induction of the coil will be ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 N \pi R^2}{2}$

B. $\frac{\mu_0 N \pi R}{4}$

C. $\frac{\mu_0 N^2 \pi R}{2}$

D. $\frac{\mu_0 N \pi R}{2}$

Answer: C

Solution:

To find the coefficient of self-induction (also known as the inductance) of a circular coil, we need to use the following formula for the inductance of a circular loop:

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

Where:

L is the inductance

μ_0 is the permeability of free space

N is the number of turns

A is the area of the loop

ℓ is the mean length of the magnetic flux path

For a circular coil of radius R, the area A is given by

$A = \pi R^2$

Since we are dealing with a circular coil, the magnetic flux path would be the circumference of the coil, given by:

$\ell = 2\pi R$

Thus, substituting these values into the equation for inductance, we get:

$L = \frac{\mu_0 N^2 \pi R^2}{2\pi R}$

Simplifying the fraction, we find:

$L = \frac{\mu_0 N^2 \pi R^2}{2\pi R} = \frac{\mu_0 N^2 R}{2}$

So, the coefficient of self-induction of the coil is:

$\frac{\mu_0 N^2 \pi R}{2}$

Thus, the correct option is **Option C**.

Question127

A wire of length 1 m is moving at a speed of 2 m/s perpendicular homogenous magnetic field of 0.5 T. The ends of the wire are joined to resistance 6Ω. The rate at which work is being done to keep the wire moving at that speed is

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Options:

A. $\frac{1}{3}$ W

B. $\frac{1}{6}$ W

C. $\frac{1}{12}$ W

D. 1 W

Answer: B

Solution:

To solve this problem, we need to determine the rate at which work is being done to keep the wire moving at the given speed in the presence of a magnetic field. This involves calculating the induced electromotive force (emf), the current in the circuit, the power dissipated in the resistor, and finally, the rate of work done to maintain the motion of the wire.

First, let's calculate the induced emf. According to Faraday's law of electromagnetic induction, the emf ε induced in a wire moving in a magnetic field is given by:

$\varepsilon = Blv$

Where:

B = Magnetic field strength (in Tesla, T)

l = Length of the wire (in meters, m)

v = Velocity of the wire (in meters per second, m/s)

Given:

$B = 0.5\,\mathrm{T}$

$l = 1\,\mathrm{m}$

$v = 2\,\mathrm{m/s}$

Let's substitute these values into the formula:

$\varepsilon = 0.5 \times 1 \times 2 = 1\,\mathrm{V}$

Next, we calculate the current I using Ohm's law, where the resistance R is given as 6Ω:

$I = \frac{\varepsilon}{R}$

Substituting the known values:

$I = \frac{1\,\mathrm{V}}{6\,\Omega} = \frac{1}{6}\,\mathrm{A}$

Now, the power dissipated in the resistor, which is also the rate at which work is done to keep the wire moving, can be calculated using the formula for power:

$P = I^2R$

Substituting the values we have:

$P = \left(\frac{1}{6}\right)^2 \times 6$

$P = \frac{1}{36} \times 6 = \frac{1}{6}\,\mathrm{W}$

Therefore, the rate at which work is being done to keep the wire moving at that speed is $\frac{1}{6}$ W.

The correct answer is:

Option B: $\frac{1}{6}$ W

Question128

The magnetic potential energy stored in a certain inductor is $25\ \mathrm{mJ}$, when the current in the inductor is $50\ \mathrm{mA}$. This inductor is of inductance

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Options:

A. 2.00 H

B. 0.20 H

C. 200 H

D. 20 H

Answer: D

Solution:

Magnetic potential energy $\mathrm{U}=\frac{1}{2} \mathrm{LI}^2$

$$\begin{aligned} \therefore \mathrm{L} & =\frac{2 \mathrm{U}}{\mathrm{I}^2}=\frac{2 \times 25 \times 10^{-3}}{\left(50 \times 10^{-3}\right)^2} \\ & =20 \mathrm{H} \end{aligned}$$

Question129

A wire of length 'L'; having resistance 'R' falls from a height 'ℓ' in earth's horizontal magnetic field 'B'. The current through the wire is ($\mathrm{g}=$ acceleration due to gravity)

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Options:

A. $\frac{\mathrm{BL} \sqrt{2 \mathrm{~g} \ell}}{\mathrm{R}}$

B. $\frac{BL\sqrt{2\,g\ell}}{R^2}$

C. $\frac{2BLg\ell}{R^2}$

D. $\frac{B^2\,L^2}{R}$

Answer: A

Solution:

If the wire falls through a height h, the velocity acquired by it is $v = \sqrt{2\,g\ell}$

The emf induced in the wire

$$e = BLv = BL\sqrt{2\,g\ell}$$
$$\therefore\ \text{Current } I = \frac{e}{R} = \frac{BL\sqrt{2\,g\ell}}{R}$$

Question130

A coil of radius 'r' is placed on another coil (whose radius is 'R' and current through it is changing) so that their centres coincide. ($R > r$). If both coplanar, then the mutual inductance between them is proportional to

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Options:

A. $\frac{R}{r^2}$

B. $\frac{r}{R}$

C. $\frac{R}{r}$

D. $\frac{r^2}{R}$

Answer: D

Solution:

Magnetic field at the centre $B = \frac{\mu_0 I}{R}$

$\phi =$ Magnetic flux passing through the smaller coil $= \pi r^2$ B

$\therefore \phi = \pi r^2 \times \frac{\mu_0 I}{R}$

$\therefore M = \frac{\phi}{I} = \frac{\mu \pi r^2}{R} \quad \therefore M \propto \frac{r^2}{R}$

Question131

A metal wire of length $2500 \mathrm{~m}$ is kept in east-west direction, at a height of $10 \mathrm{~m}$ from the ground. If it falls freely on the ground then the current induced in the wire is (Resistance of wire $= 25\sqrt{2} \Omega, \mathrm{g} = 10 \mathrm{~m/s}^2$ and Earth's horizontal component of magnetic field $\mathrm{B_H} = 2 \times 10^{-5} \mathrm{~T}$)

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Options:

A. 0.2 A

B. 0.02 A

C. 0.01 A

D. 2 A

Answer: B

Solution:

To find the current induced in the wire, we first need to determine the change in magnetic flux as the wire falls.

1. **Determine the EMF (voltage) induced in the wire :**

The voltage induced (EMF) when a conductor moves in a magnetic field can be given by Faraday's law of electromagnetic induction :
$EMF = B \times v \times l$
Where :

- B is the magnetic field (which is given as $B_H = 2 \times 10^{-5} T$)
- v is the velocity of the wire

- l is the length of the wire (which is 2500 m)

When the wire falls freely under gravity, it will accelerate due to gravitational force. The velocity v of the wire just before hitting the ground can be found using the kinematic equation :

$v^2 = u^2 + 2gh$
Where :

- u is the initial velocity (which is 0, since the wire starts from rest)
- g is the acceleration due to gravity (10 m/s^2)
- h is the height (10 m)

Plugging in the given values :

$v^2 = 0 + 2(10m/s^2)(10m)$
$v^2 = 200$
$v = \sqrt{200}$
$v = 14.14m/s$

Now, using Faraday's law :

$EMF = 2 \times 10^{-5}T \times 14.14m/s \times 2500m$
$EMF = 0.707V$

1. **Determine the current using Ohm's Law:**

   $I = \frac{EMF}{R}$

   Where :
2. I is the current
3. EMF is the voltage induced (0.707 V)
4. R is the resistance (which is $25\sqrt{2}\Omega$)

Given that $\sqrt{2}$ is approximately 1.414 :
$R = 25(1.414)$
$R = 35.35\Omega$

Now, plugging in the values to find the current :
$I = \frac{0.707V}{35.35\Omega}$
$I \approx 0.02A$

Therefore, the answer is :
Option B
0.02 A

Question132

Two conducting wire loops are concentric and lie in the same plane. The current in the outer loop is clockwise and increasing with time. The induced current in the inner loop is

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Options:

A. clockwise

B. anticlockwise

C. in a direction which depends on the ratio of the loop radii.

D. zero

Answer: B

Solution:

Since the clockwise current is increasing, the induced current in the loop will be such as to oppose the change in magnetic flux and hence it will flow in anticlockwise direction.

Question133

A straight conductor of length 0.6 M is moved with a speed of 10 ms $^{-1}$ perpendicular to magnetic field of induction 1.2 weber m^{-2}. The induced e.m.f. across the conductor is

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Options:

A. 6 V

B. 7.2 V

C. 0.72 V

D. 12 V

Answer: B

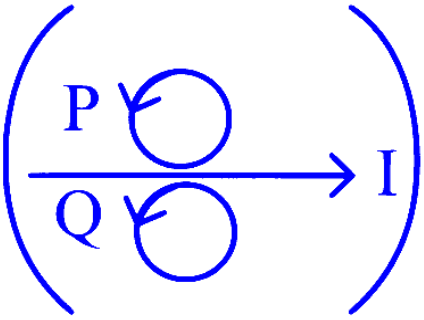
Solution:

The induced emf is given by

$e = Blv = 1.2 \times 0.6 \times 10 = 7.2$ V

Question134

Metal rings P and Q are lying in the same plane, where current I is increasing steadily. The induced current in metal rings is shown correctly in figure



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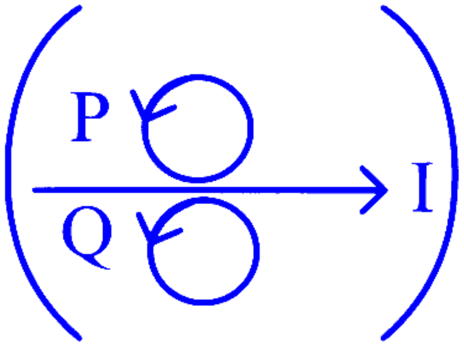
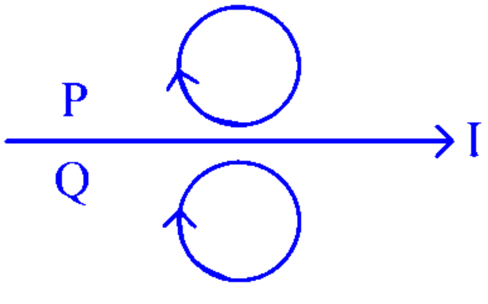
Options:

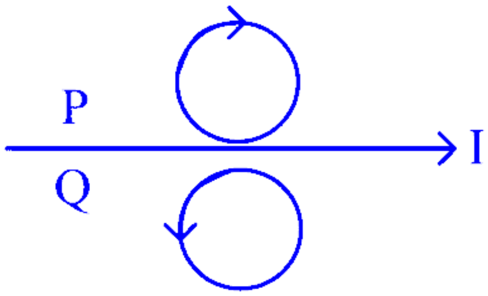
A.



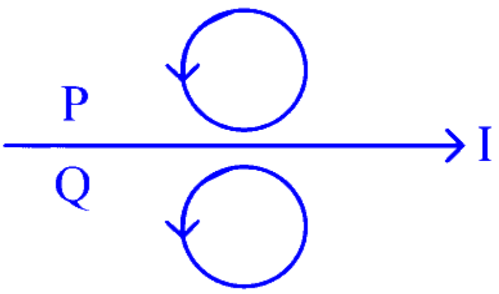
B.



C.



D.



Answer: C

Solution:

According to right hand thumb rule, the direction of magnetic field in ring P, due to current in wire will be perpendicularly outward from plane of paper.

Using Lenz's law, when the current in the wire is increasing, the direction of induced current in ring P will be such that, it opposes the increasing current in wire. For this, the upper face of the ring acts like South pole and lower face acts like North pole. Thus, the direction of induced current in ring P is clockwise.

Similarly, the direction of induced current in ring Q is anti-clockwise.

Question135

The length of solenoid is I whose windings are made of material of density D and resistivity ρ. The winding resistance is R. The inductance of solenoid is [m = mass of winding wire, μ_0 = permeability of free space]

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Options:

A. $\frac{\mu_0}{4\pi I}\left(\frac{Rm}{\rho D}\right)$

B. $\frac{\mu_0}{2\pi I}\left(\frac{Rm}{\rho D}\right)$

C. $\frac{\mu_0}{2\pi I}\left(\frac{\rho D}{Rm}\right)$

D. $\frac{\mu_0}{4\pi/}\left(\frac{\rho D}{Rm}\right)$

Answer: A

Solution:

The self-inductance of solenoid,

$L=\mu_0 N^2 \frac{A}{l}$ .... (i)

where, A is the area of cross-section of solenoid and N is number of turns.

If x is the length of wire, then

$R=\frac{\rho x}{A}$ and $m=AxD$

$$\therefore \quad Rm=\frac{\rho x}{A}(AxD)$$

$$\Rightarrow \quad x=\sqrt{\frac{Rm}{\rho D}} \quad \text{.... (ii)}$$

Also, $x=2\pi rN \Rightarrow N=\frac{x}{2\pi r}=\frac{1}{2\pi r}\sqrt{\frac{Rm}{\rho D}}$ [from Eq. (ii)]]

Substituting values in Eq. (i), we get

$$L=\mu_0\left(\frac{\sqrt{Rm}}{2\pi r\sqrt{\rho D}}\right)^2 \times \frac{A}{l}=\mu_0 \frac{Rm}{4\pi^2 r^2 \rho D}\cdot\frac{\pi r^2}{l}$$
$$=\frac{\mu_0}{4\pi I}\left(\frac{Rm}{\rho D}\right)$$

Question136

A coil of n turns and resistance $R\Omega$ is connected in series with a resistance $\frac{R}{2}$. The combination is moved for time t second through magnetic flux ϕ_1 to ϕ_2. The induced current in the circuit is

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Options:

A. $\frac{n(\phi_1-\phi_2)}{3Rt}$

B. $\frac{2n(\phi_1-\phi_2)}{3Rt}$

C. $\frac{2n(\phi_1-\phi_2)}{Rt}$

D. $\frac{n(\phi_1-\phi_2)}{Rt}$

Answer: B

Solution:

When a coil of n turns moves through a magnetic flux from ϕ_1 to ϕ_2, the emf induced in the coil is

$\theta = -\frac{nd\phi}{dt} = \frac{-n(\phi_2-\phi_1)}{t} = \frac{n(\phi_1-\phi_2)}{t}$ ..... (i)

As, resistance R of coil and $\frac{R}{2}$ are in series, so equivalent resistance is

$R_{\text{eq}} = R + \frac{R}{2} = \frac{3R}{2}$ ..... (ii)

The induced current in the circuit is,

$I = \frac{\theta}{R_{\text{eq}}} = \frac{n(\phi_1-\phi_2)}{t\left(\frac{3R}{2}\right)} = \frac{2n(\phi_1-\phi_2)}{3Rt}$

Question137

2. Two coils have a mutual inductance of 0.01 H . The current in the first coil changes according to equation, $I = 5\sin 200\pi t$. The maximum value of emf induced in the second coil is

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Options:

A. $10\pi V$

B. 0.1π V

C. πV

D. 0.01π V

Answer: A

Solution:

Given, mutual inductance in the coil, $M = 0.01\text{H}$ and current in coil, $l = 5\sin 200\pi t$.

Emf induced in secondary coil is given,

$e = M\frac{dl}{dt}$

putting the value in above relation,

$$e = 0.01 \times \frac{d}{dt}(5\sin 200\pi t)$$
$$= 0.01 \times 5 \times 200\pi\cos 200\pi t = 10\pi\cos 200\pi t$$

Comparing the above equation with the general equation of induced emf, which is represented as,

$e = e_0\cos\omega t$

where, e_0 is the maximum value of the emf.

$\therefore$ In the question, the maximum value of emf induced in the coil is; $e_0 = 10\pi$ V.
