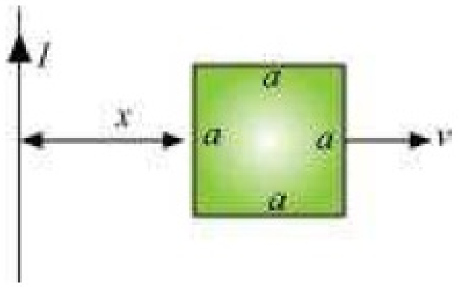
CBSE Test Paper-05

Class - 12 Physics (Electromagnetic Induction)

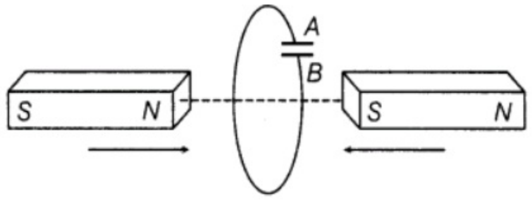
1. For a coil having L = 2×10^{3} H, current flows at the rate of 10^{-3} A/s. The emf induced is:
   a. 2 V
   b. 3 V
   c. 4 V
   d. 1 V
2. Magnetic flux (Φ_B) through a surface S is given by
   a. $\vec{B}.\overrightarrow{ds}$
   b. $\int \vec{B} \times \overrightarrow{ds}$
   c. $\int \vec{B}.\overrightarrow{ds}$
   d. $\int \mu_0 \vec{B}.\overrightarrow{ds}$
3. A straight wire carries a current of 50 A and the loop as in figure is moved to the right with a constant velocity, v $= 10\mathrm{m/s}$. Take a $= 0.1\mathrm{m}$ and assume that the loop has a large resistance. Induced emf in the loop at the instant when x = 0.2 m is



   a. $2.3 \times 10 - 5\mathrm{V}$
   b. $2.6 \times 10^{-5}\mathrm{V}$
   c. $2.0 \times 10 - 5\mathrm{V}$
   d. $1.7 \times 10^{-5}\mathrm{V}$
4. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon:
   a. the rates at which currents are changing in the two coils
   b. the materials of the wires of the coils

c. relative position and orientation of the two coils
d. the currents in the two coils

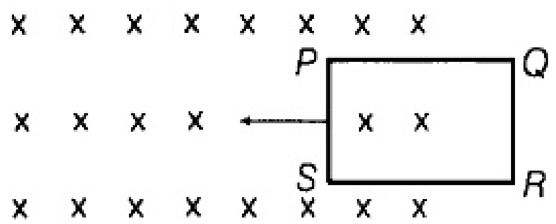
5. Predict the polarity of the capacitor in the situation described by fig.



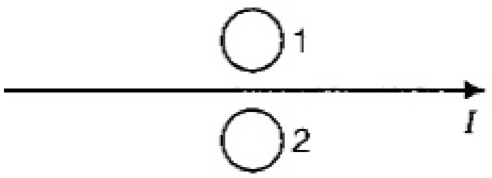
a. Not enough information
b. A' will be positive with respect to plate 'B'.
c. No current induced
d. B' will be positive with respect to plate 'A'

6. Mention any two useful applications of eddy currents.

7. The closed-loop PQRS of wire is moved into a uniform magnetic field at right angles to the plane of the paper as shown in the figure. Predict the direction of the induced current in the loop.



8. what is the direction of induced current in metal rings 1 and 2, when current I in the wire is increasing steadily?



9. A source of emf e is used to establish a current I through a coil of self-inductance L. show that the work done by the source of build up the current I is $\frac{1}{2}LI^2$.

10. If the number of turns of solenoid is doubled, keeping the other factors constant, how does the self induction of the solenoid change?

11. Two concentric circular coils C_1 and C_2, radius r_1 and r_2 ($r_1 << r_2$) respectively are

kept coaxially. If current is passed through C_2, then find an expression for mutual inductance between the two coils.

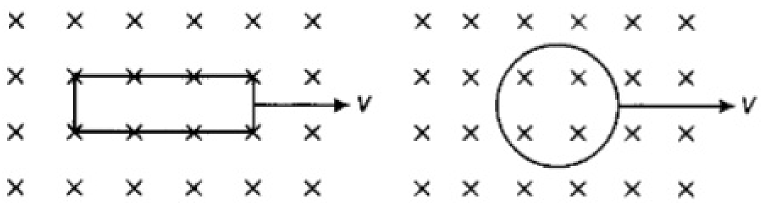
12. A conducting rod of length m is moved in a magnetic field of magnitude B with velocity v such that the arrangement is mutually perpendicular. Prove that the emf induced in the rod is $|E| = Blv$.

13. How is mutual inductance of a pair of coils affected when:

    i. separation between the coils is increased
    ii. the number of turns of each coil is increased
    iii. a thin iron sheet is placed between the two coils, other factors remaining the same.

14. i. Define self-inductance. Write its SI unit.
    ii. A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0. ls, then what is the induced emf in the loop while the current is changing?

15. A rectangular loop and a circular loop are moving out of a uniform magnetic field region with a constant velocity v as shown in the figure. In which loop, do you expect the induced emf to be constant during the passage out of the field region? The field is normal to the loops.



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Answers

1. b. 2 V

   Explanation: $e = L\frac{di}{dt} = 2 \times 10^3 \times 10^{-3} = 2\text{V}$

2. c. $\int \vec{B}.\overrightarrow{ds}$

   Explanation: if ***dS*** is area of an element of any arbitrary shape and magnetic field at this element is **B.**

   The total magnetic flux through the surface is the sum of the contributions from the individual area elements.

3. d. $1.7 \times 10^{-5}\text{V}$

   Explanation: $\phi = \frac{\mu_0 a}{2\pi} ln(1 + \frac{1}{x})$

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

4. c. relative position and orientation of the two coils

   Explanation: Mutual inductance of the pair of coils depends upon the geometry of the coils, distance between the coils, relative position and orientation of the coils, number of turns in the coil, permeability of the medium in the coils and degree of coupling.

5. b. A' will be positive with respect to plate 'B'.

   Explanation: A will become positive with respect to B because current induced is in clockwise direction.

6. i. Magnetic brake.(are used in trains, cars etc)

   ii. Magnetic furnace.(are used in alloying additions with molten metal)

7. Since magnetic flux increases when the loop moves into uniform magnetic field. So according to lenz law current will be in the clockwise direction.

8. Clockwise in first and anticlockwise in second coil.

9. Here we will use the concept of work energy theorem.

   Let, I current flows through the coil of self-inductance L at any instant t when rate of change of current in coil is dl/dt,

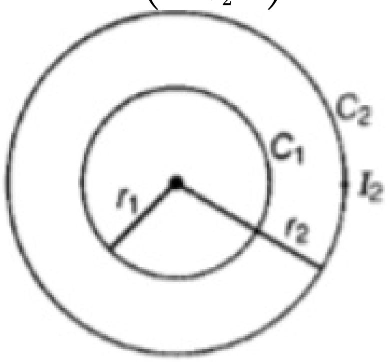
$\therefore$Induced emf, E = $-L\frac{dI}{dt}$
Magnitude, |E| = LdI/dt
$\therefore$ Work done in establishing the current in small-time interval dt is given by
$dW = Pdt = EIdt = \left(L\frac{dl}{dt}\right) Idt$
$dW = LIdI$
$\therefore$ Total work done in increasing the current from zero to I.
$\therefore W = \int_0^1 LIdI = L\int_0^I Idl = L\left[\frac{I^2}{2}\right]_0^I = \frac{1}{2}L\left(I^2 - 0^2\right)$
$W = \frac{1}{2}LI^2$
This work is stored as the energy in the inductor.

10. Coefficient of self induction
$L = \frac{N\mu_0 A}{1}$
$\therefore$ when l is made doubled, the coefficient of self induction becomes half.

11. Let current I_2 passes through the coil C_2.

Magnetic field at centre due to current loop C_2.
$B_2 = \frac{\mu_0 N_2 I_2}{2r_2}$
where,N_2 = number of turns in coil C_2 .

$\therefore$ Total magnetic flux linked with coil C_1

$\phi_1 = N_1 B_2 A_1$
$\phi_1 = N_1\left(\frac{\mu_0 N_2 I_2}{2r_2}\right)\left(\pi r_1^2\right)$


But $\phi \Rightarrow MI_2 = \frac{\mu_0 N_1 N_2 I_2}{2r_2}\pi r_1^2$
$M = \frac{\mu_0 \pi N_1 N_2 r_1^2}{2r_2}$

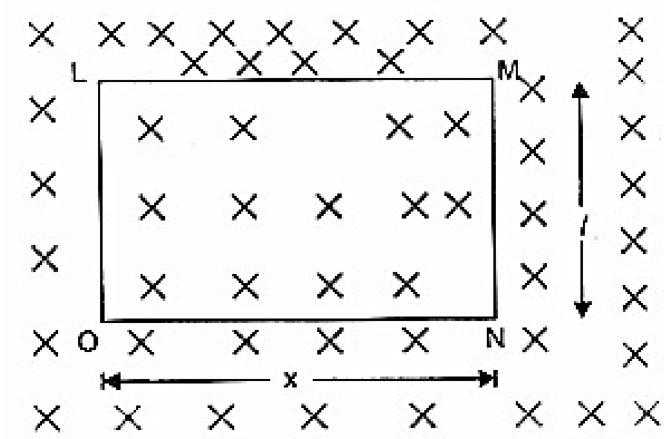
12. Let us assume a rectangular loop LMNO is placed in a uniform magnetic field B.

Suppose at any instant, length ON = x

Flux through the loop $\phi = Blx$ $[\because \text{max. } flux,\ \phi = BA]$

Induced emf, $E = -\frac{d\phi}{dt} = -\frac{d}{dt}Blx$

or $E = -Bl\frac{dx}{dt} = -Bl\,v$



where $\frac{dx}{dt} = -v$, is the velocity of conductor MN.

13. i. When separation between the coils is increased, magnetic flux linked with secondary coil decreases. Therefore, mutual inductance (M) of pair of coils decreases.
    ii. When number of turns of each coil is increased. M increases, because $M = \frac{\mu_0 N_1 N_2 A}{1}$
    iii. As $M = \mu_r$ therefore, mutual inductance will increase on placing a thin iron sheet between the two coils.

14. **Self-Inductance:** When the current in a coil is changed, a back emf is induced in the same coil. This phenomenon is called self-induction. And self-inductance is the magnetic flux linked with the coil when a unit current flows through it. If L is self-inductance of coil, then net magnetic flux,

$N\phi \propto I \Rightarrow N\phi = LI$

$\Rightarrow \quad L = \frac{N\phi}{I}$

The SI unit of self-inductance is Herny (H).

(ii) Mutual inductance of solenoid coil system

$M = \frac{\mu_0 N_1 N_2 A}{l}$

Here, $N_1 = 15, N_2 = 1, l = 1\text{cm} = 10^{-2}\text{m}$

$A = 20\text{cm}^2 = 20 \times 10^{-4}\text{m}^2$

$\therefore M=\frac{4\pi\times10^{-7}\times15\times1\times2.0\times10^{-4}}{10^{-2}}$
$=120\pi\times10^{-9}\mathrm{H}$
Induced emf in the loop
$|e_2|=M\frac{dI_1}{dt}$ (numerically) $=120\pi\times10^{-9}\times\frac{(4-2)}{0.1}$
$=120\times3.14\times10^{-9}\times\frac{2}{0.1}$
$=7.5\times10^{-6}\mathrm{V}=7.5\mu\mathrm{V}$

15. Magnitude of Induced emf is directly proportional to the rate of area moving out of the field for a constant magnetic field.
$\varepsilon=-\frac{d\phi}{dt}=-B\frac{dA}{dt}$
For the rectangular coil, the rate of area moving out of the field remain same while it is not so for the circular coil. Therefore, the induced emf for the rectangular coil remains constant.