CBSE Test Paper-02

Class - 12 Physics (Electromagnetic Induction)

1. If current in a coil is changing with time, relationship of current to emf is described by
   a. Inductance
   b. Capacitance
   c. Conductance
   d. Ressistance
2. An emf of 100 mV is induced in a coil when current in another near by coil becomes 10 A from 0 in 0.1 S. The coefficient of mutual induction between the two coils will be:
   a. 100 mH
   b. 1 mH
   c. 1000 mH
   d. 10 mH
3. A rectangular wire loop of sides 8 cm and 2 cm with a small cut is moving out of a region of uniform magnetic field of magnitude 0.3 T directed normal to the loop. What is the emf developed across the cut if the velocity of the loop is 1 cm s^{-1} in a direction normal to the shorter side of the loop? For how long does the induced voltage last _______?
   a. 0.02mV, lasting 8 s.
   b. 0.06mV, lasting 8 s.
   c. 0.06mV, lasting 4 s.
   d. 0.02mV, lasting 4 s.
4. If two coils of inductances L_1 and L_2 are linked such that their mutual inductance is M, then
   a. M = L_1 - L_2
   b. M = L_1 + L_2

c. $M = L_1 \times L_2$

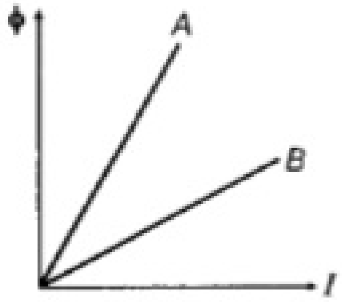
d. The maximum value of M is $\sqrt{(L_1 L_2)}$

5. A wheel with 10 metallic spokes each 0.5 m long is rotated with a speed of 60 rev/min in a plane normal to the horizontal component of earth's magnetic field HE at a place. If HE = 0.4 G at the place, what is the induced emf between the axle and the rim of the wheel? Note that 1 G = 10-4 T.

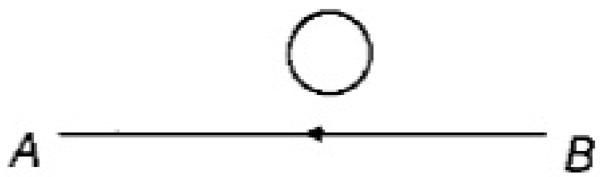
   a. 3.00×10^{-5}V
   b. 2.24×10^{-5}V
   c. 2.44×10^{-5}V
   d. 3.14×10^{-5}V

6. Why is the core of a transformer laminated?

7. A plot of magnetic flux, ϕ versus current (I) is shown in the figure for two inductors A and B. Which of the two has larger value of self-inductance?



8. The electric current flowing in a wire in the direction from B to A is decreasing. Find out the direction of the induced current in the metallic loop kept near the wire as shown in the figure.

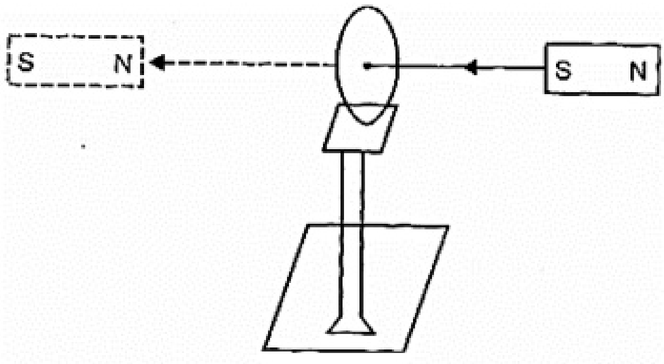


9. Two identical loops, one of copper and the other of aluminium are rotated with the same angular speed in the same magnetic field. Compare

   i. the induced emf and

ii. the current produced in the two coils. Justify your answer.

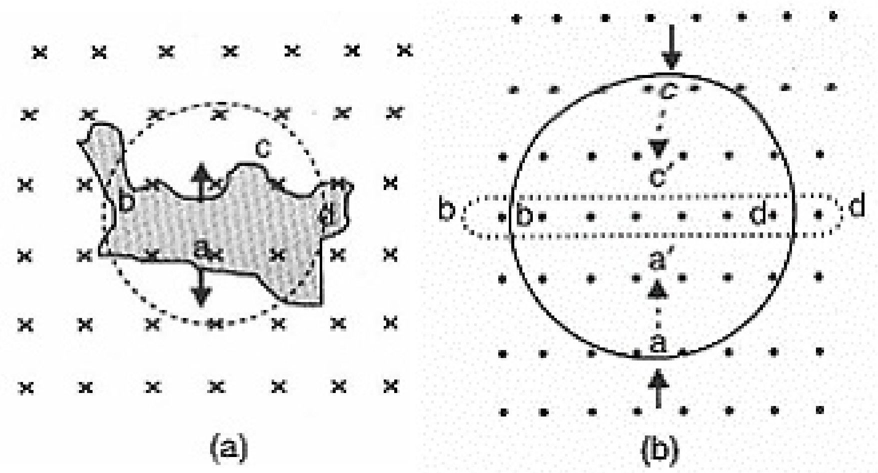
10. Give the direction in which the induced current flows in the coil mounted on an insulating stand when a bar magnet is quickly moved along the axis of the coil from one side to the other as shown in the figure.



11. Two concentric circular coils, one of small radius r and the other of large radius R, such that R >> r, are placed coaxially with centres coinciding. Obtain the mutual inductance of the arrangement.

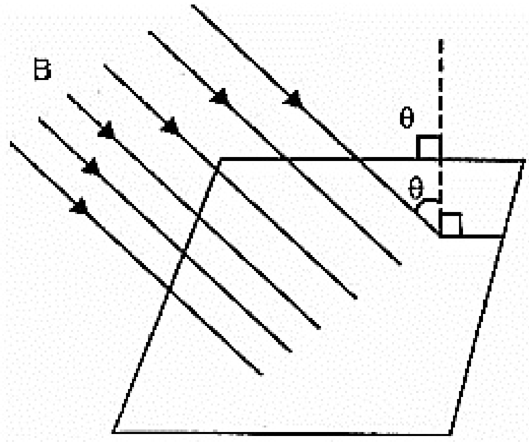
12. Use Lenz's law to determine the direction of induced current in the situation described by figure:

a. A wire of irregular shape turning into a circular shape.
b. A circular loop being deformed into a narrow straight wire.



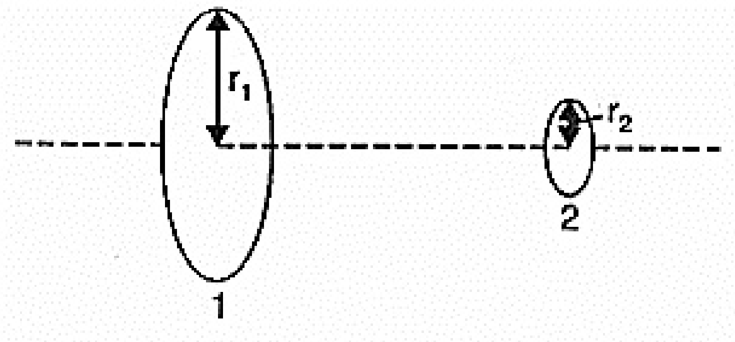
13. Two circular coils, one of radius r and the other of radius R are placed coaxially with their centres coinciding. For R > > r, obtain an expression for the mutual inductance of the arrangement.

14. A square loop of wire of side 5 cm is lying on a horizontal table. An electromagnet above and to one side of the loop is turned on, causing a uniform magnetic field that is downwards at an angle of 30° to the vertical, as shown in figure. The magnetic induction is 0.50 T. Calculate the average induced emf in the loop, if the field increase from zero to its final value is 0.2 s.



15. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm.

   a. What is the flux linking the bigger loop if a current of 2.0 A flows through the smaller loop?
   b. Obtain the mutual inductance of the two loops.



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Answers

1. a. Inductance

   Explanation: $e = -L\left(\frac{di}{dt}\right)$

   $e = -M\left(\frac{di}{dt}\right)$

2. b. 1 mH

   Explanation: $M = -\frac{e_2}{\frac{\Delta i}{\Delta t}} = \frac{100\times10^{-3}}{\frac{10}{0.1}} = 10^{-3}H$

   = 1 mH

3. b. 0.06mV, lasting 8 s.

   Explanation:

   $|e| = Bl_2v = 0.3 \times 2 \times 10^{-2} \times 10^{-2} = 0.6 \times 10^{-4}\text{V} = 0.06\text{mV}$

   duration of |e| is $= \frac{l_1}{v} = \frac{8\times10^{-2}}{10^{-2}} = 8\,\text{sec}$

4. d. The maximum value of M is

   Explanation: $M = k\sqrt{L_1L_2}$

   here k is coefficient of coupling. Its maximum value is 1 for tight coupling.

5. d. 3.14×10^{-5}V.

   Explanation: $e = \frac{1}{2}B\omega l^2 = \frac{1}{2} \times 0.4 \times 10^{-4} \times 2 \times 3.14 \times 1 \times 0.5 \times 0.5$
   $= 3.14 \times 10^{-5}V$

   $\omega = 2\pi n$

   $n = \frac{60}{60} = 1\text{rev/sec}$

6. The core of a transformer is laminated to prevent eddy current(which causes heating effect in the transformer and responsible for the damage of the transformer) being produced in the core.

7. Self-inductance of the inductor, $L = \phi/I$
   In the above graph, A is showing more steeper graph than B. Hence the slope of the given ϕ-I graph gives self-inductance of the coil. Inductor A have got greater slope than that of inductor B, therefore self-inductance of A is greater than self-inductance

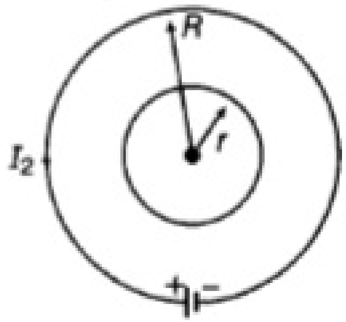
of B.

8. According to Lenz's law, the direction of induced current will be clockwise.

9. i. From the formula of induced emf in this case, $e = \frac{1}{2} B\omega L^2$, we can say that the induced emf in both the loops will be same as areas of the loop(i.e. πL^2) and time periods($T = 2\pi/\omega$) are same as they are identical and rotated with same angular speed(ω).
   ii. The current induces in Cu coil is more than Al coil as Cu coil has less resistance than the Al coil and $I \propto \frac{1}{R}$ (for the same voltage).
10. i. If seen from the right hand side, current flows clockwise when S-pole moves towards the coil.
    ii. If seen from the right hand side, current flows anticlockwise when N-pole moves away from the coil.

11. Let a current I_2 flows through the outer circular coil of radius R. The magnetic field at the centre of the coil is

$B_2 = \mu_0 I_2/2R$



As r << R, hence field B2 may be considered to be constant over the entire cross-sectional area of inner coil of radius r. Hence,magnetic flux linked with the smaller coil will be

$\phi_1 = B_2 A_1 = \frac{\mu_0 I_2}{2R} \cdot \pi r^2$

As, by definition $\phi_1 = M_{12} I_2$

Now mutual inductance, $M_{12} = \phi_1 / I_2 = \frac{\mu_0 \pi r^2}{2R}$

Say $M_{12} = M_{21} = M \therefore M = \frac{\mu_0 \pi r^2}{2R}$

12. a. When a wire of irregular shape turns into a circular loop, area of the loop tends to increase. Therefore, magnetic flux linked with the loop increases. According to

Lenz's law, the direction of induced current must oppose the magnetic field, for which induced current should flow along adcba.

b. In this case, the magnetic flux tends to decrease. Therefore, induced current must support the magnetic field for which induced current should flow along adcba.

13. Suppose a current I_2 flows through the outer circular coil. Magnetic field at the centre of the coil is

$B_2 = \frac{\mu_0 I_2}{2R}$

Field B_2 may be considered constant over the cross-sectional area of the inner smaller coil.

Hence

$\phi = B.A$

$\phi_1 = \pi r^2 B_2 = \frac{\mu_0 \pi r^2 I_2}{2R} = MI_2$

$\therefore M = \frac{\phi_1}{I_2} = \frac{\mu_0 \pi r^2}{2R}$

14. Area of the loop, $A = (5 \times 10^{-2})^2 m^2$

$= 2.5 \times 10^{-3} m^2$

Magnetic flux $\phi = AB\cos\theta$

Where $B\cos\theta$ is the component of magnetic induction perpendicular to the plane of the loop.

Therefore, $\phi = 2.5 \times 10^{-3} \times 0.50 \times \cos 30^\circ$

$= 1.0825 \times 10^{-3} Wb$

Average induced emf is

$e = \frac{\Delta\phi}{\Delta t} = \frac{1.0825 \times 10^{-3}}{0.2}$

$= 5.4 \times 10^{-3} V$

The induced emf is in an anticlockwise direction around the loop during the time when the downward magnetic flux is increasing.

15. We know from the considerations of symmetry that $M_{12} = M_{21}$. Direct calculation of flux linking the bigger loop due to the field by the smaller loop will be difficult to handle. Instead, let us calculate the flux through the smaller loop due to a current in the bigger loop. The smaller loop is so small in area that one can take the simple formula for field B on the axis of the bigger loop and multiply B by the small area of

the loop to calculate flux without much error. Let 1 refer to the bigger loop and 2 the smaller loop. Field B_2 at 2 due to I_1 in 1 is:

$$B_{21} = \frac{\mu_0 I_1 r_1^2}{2\left(x^2+r_1^2\right)^{\frac{3}{2}}}$$

Here x is distance between the centres.

$$\phi_{21} = B_{21} \times A_2$$

$$\phi_{21} = B_2 \pi r_2^2 = \frac{\pi\mu_0 r_1^2 r_2^2}{2\left(x^2+r_1^2\right)^{\frac{3}{2}}} I_1$$

But

$$\phi_{21} = M_{21} I_1$$

$$\therefore M_{21} = \frac{\pi\mu_0 r_1^2 r_2^2}{2\left(x^2+r_1^2\right)^{\frac{3}{2}}} = M_{12}$$

$$\therefore \phi_{12} = M_{12} I_2 = \frac{\pi\mu_0 r_1^2 r_2^2}{2\left(x^2+r_1^2\right)^{\frac{3}{2}}} I_2$$

$$M_{12} = M_{21} = \frac{\pi\mu_0 r_1^2 r_2^2}{2\left(x^2+r_1^2\right)^{\frac{3}{2}}}$$

Using the given data

$$M_{12} = M_{21} = 4.55 \times 10^{-11} H$$

$$\phi_1 = 9.1 \times 10^{-11} Wb$$