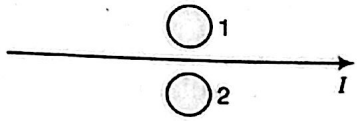
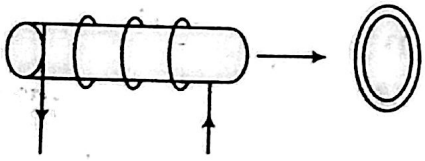
1 Mark Questions

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

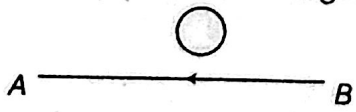


2. A long straight current carrying wire passes normally through the centre of circular loop. If the current through the wire increases, will there be an induced emf in the loop? Justify.

3. Figure shows a current carrying solenoid moving towards conducting loop. Find the direction of the current induced in the loop.



4. 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.



5. Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why?
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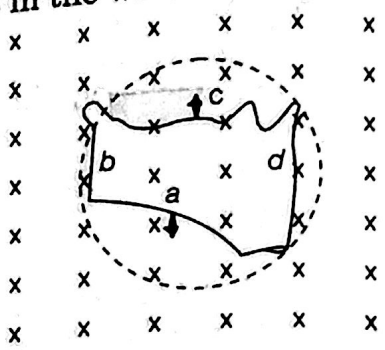
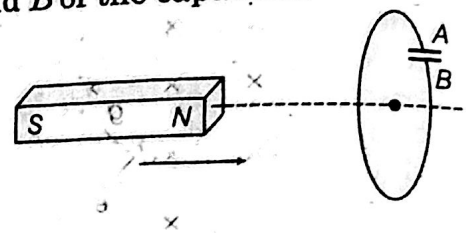
6. A flexible wire of irregular shape, *abcd* as shown in the figure, turns into a circular shape when placed in a magnetic field which is directed normal to the plane of the loop away from the reader. Predict the direction of the induced current in the wire.



7. In the given figure, a bar magnet is quickly moved towards a conducting loop having a capacitor. Predict the polarity of the plates A and B of the capacitor.

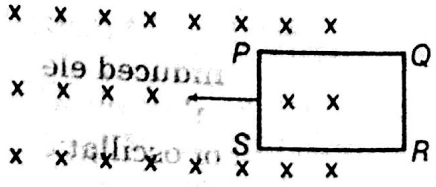


8. State Lenz's law. A metallic rod held horizontally along east-west direction, is allowed to fall under gravity. Will there be an emf induced at its ends? Justify your answer.

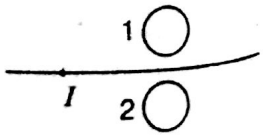
9. On what factors, does the magnitude of the emf induced in the circuit due to magnetic flux depend?

10. State the Faraday's law of electromagnetic induction.

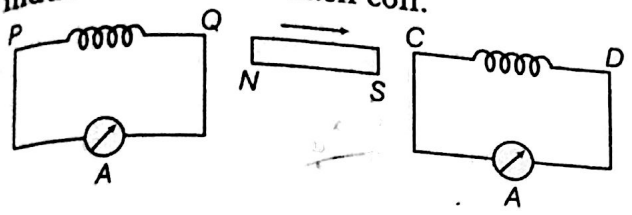
11. The closed loop $PQRS$ of wire is moved into a uniform magnetic field at right angles to the plane of the paper as shown in the figure. Predict the direction of the induced current in the loop.



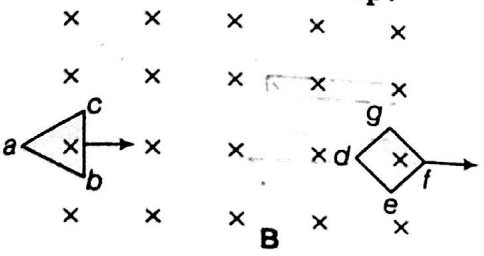
12. Predict the direction of induced current in metal rings 1 and 2 when current I in the wire is steadily decreasing?



13. A bar magnet is moved in the direction indicated by the arrow between two coils PQ and CD. Predict the directions of induced current in each coil.



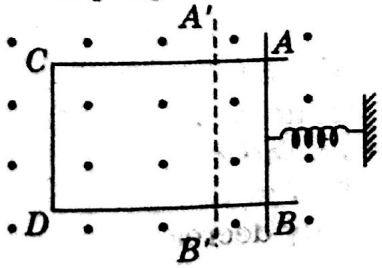
14. Two loops of different shapes are moved into a region of uniform magnetic field in the directions marked by arrows as shown in the figure. What is the direction of the induced current in each loop?



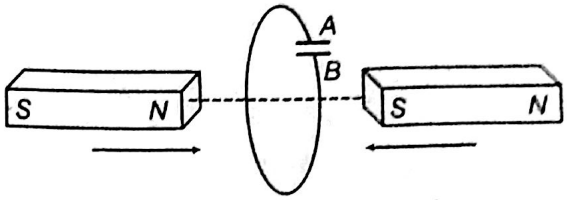
2 Marks Questions

15. An aeroplane is flying horizontally from west to east with a velocity of 900 km/h. Calculate the potential difference developed between the ends of its wings having a span of 20 m. The horizontal component of the earth's magnetic field is 5×10^{-4} T and the angle of dip is 30°.

16. A rectangular frame of wire is placed in a uniform magnetic field directed outwards, normal to the paper. AB is connected to a spring which is stretched to $A'B'$ and then released at time $t = 0$. Explain qualitatively how induced electro motive force in the coil would vary with time. (Neglect damping of oscillations of spring)

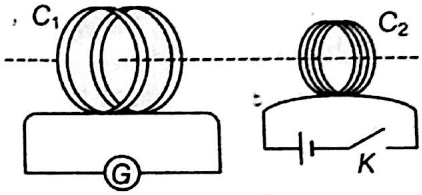


17. Predict the polarity of the capacitor in the situation described by adjoining as shown in figure. Explain the reason too.



18. A metallic rod of length L is rotated with angular frequency of ω with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Deduce the expression for the emf between the centre and the metallic ring.

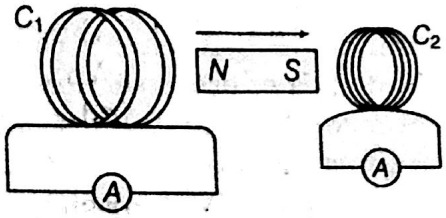
19. A current is induced in coil C_1 due to the motion of current carrying coil C_2.



(i) Write any two ways by which a large deflection can be obtained in the galvanometer G.

(ii) Suggest an alternative device to demonstrate the induced current in place of a galvanometer.

20. A magnet is quickly moved in the direction indicated by an arrow between two coils C_1 and C_2 as shown in the figure.



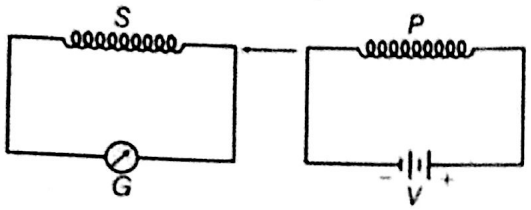
What will be the direction of induced current in each coil as seen from the magnet? Justify your answer.

21. 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.

22. (i) When primary coil P is moved towards secondary coil S (as shown in the figure below), the galvanometer shows momentary deflection. What can be done to have larger deflection in the galvanometer with the same battery?

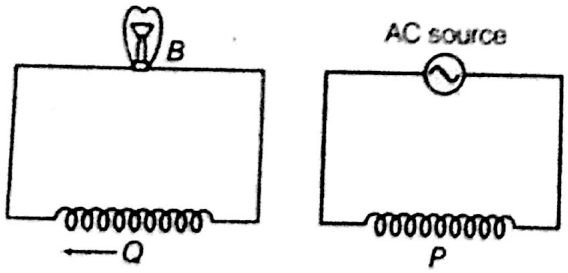


(ii) State the related law.

23. A coil Q is connected to low voltage bulb B and placed near another coil P as shown in the figure. Give reasons to explain the following observations.

(i) The bulb B lights.

(ii) Bulb gets dimmer, if the coil Q is moved towards left.



3 Marks Questions

24. (a) Derive an expression for the induced emf developed when a coil of N turns and area of cross-section A is rotated at a constant angular speed ω in a uniform magnetic field B.

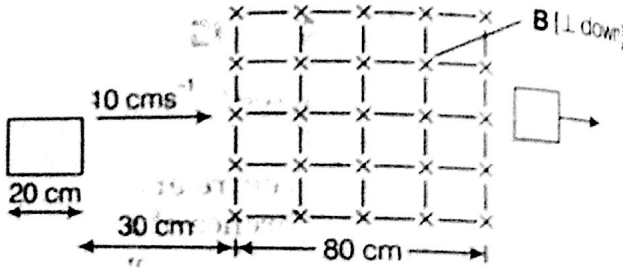
(b) A wheel with 100 metallic spokes each 0.5 m long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of the Earth's magnetic field. If the resultant magnetic field at that place is 4×10^{-4} T and the angle of dip at the place is 30°, find the emf induced between the axle and the rim of the wheel.

25. A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s^{-1} till it goes out of the field. Plot a graph showing the variation of

(i) magnetic flux (ϕ) through the loop with time (t).

(ii) induced emf (ε) in the loop with time t.

(iii) induced current in the loop, if it has resistance of 0.1Ω.



26. (i) A rod of length l is moved horizontally with a uniform velocity v in a direction perpendicular to its length through a region in which a uniform magnetic field is acting vertically downward. Derive the expression for the emf induced across the ends of the rod.

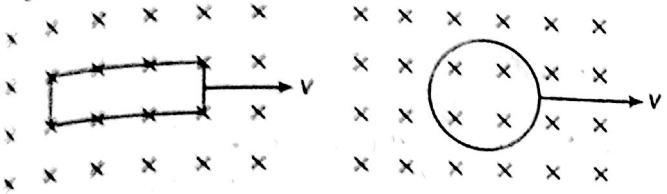
(ii) How does one understand this motional emf by invoking the Lorentz force acting on the free charge carriers of the conductor? Explain.

27. Consider the motion of a charged particle of mass m and charge q moving with velocity $\mathbf{v}$ in a magnetic field $\mathbf{B}$.

(i) If $\mathbf{v}$ is perpendicular to $\mathbf{B}$, then show that it describes a circular path having angular frequency $\omega = qB/m$.

(ii) If the velocity v has a component parallel to the magnetic field B, then trace the path described by the particle. Justify your answer.

28. 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.



5 Marks Questions

29. A metallic rod of length l and resistance R is rotated with a frequency v, with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius l, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere.

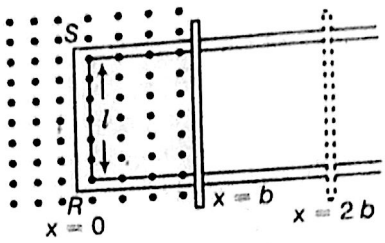
(i) Derive the expression for the induced emf and the current in the rod.

(ii) Due to the presence of the current in the rod and of the magnetic field, find the expression for the magnitude and direction of the force acting on this rod.

(iii) Hence, obtain the expression for the power required to rotate the rod.

30. State Faraday's law of electromagnetic induction.

Figure shows a rectangular conductor $PQRS$ in which the conductor PQ is free to move in a uniform magnetic field B perpendicular to the plane of the paper.



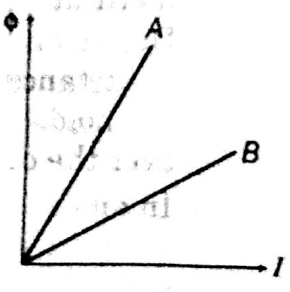
The field extends from $x = 0$ to $x = b$ and is zero for $x > b$. Assume that only the arm PQ possesses resistance r.

When the arm PQ is pulled outward from $x = 0$ to $x = 2b$ and is then moved backward to $x = 0$ with constant speed v, obtain the expressions for the flux and the induced emf.

Sketch the variation of these quantities with distance $0 \leq x \leq 2b$.

1 Mark Questions

1. Define mutual inductance and write its SI unit.
2. Define the term self-inductance of a coil. Write its SI unit.
3. A metallic piece gets hot when surrounded by a coil carrying high frequency alternating current. Why?
4. Why is the core of a transformer laminated?
5. The motion of copper plate is damped, when it is allowed to oscillate between the two poles of a magnet. What is the cause of this damping?
6. A light metal disc on the top of an electromagnet is thrown up as the current is switched on. Why? Give reason.
7. How does the mutual inductance of a pair of coils change, when
   (i) distance between the coils is increased and
   (ii) number of turns in the coils is increased?
8. How can the self-inductance of a given coil having N number of turns, area of cross-section A and length l be increased?
9. 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?



2 Marks Questions

10. Derive the expression for the magnetic energy stored in an inductor, when a current I develops in it. Hence, obtain the expression for the magnetic energy density.
11. What are eddy currents? Write their two applications.
12. Define mutual inductance between two long coaxial solenoids. Find out the expression for the mutual inductance of inner solenoid of length l having the radius r_1 and the number of turns n_1 per unit length due to the second outer solenoid of same length and n_2 number of turns per unit length.
13. Current in a circuit falls steadily from 2.0 A to 0.0 A in 10 ms. If an average emf of 200 V is induced, then calculate the self-inductance of the circuit.
14. 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.
15. 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.
16. 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 to build up the current I is $\frac{1}{2} LI^2$.

3 Marks Questions

17. State the principle of an AC generator and explain its working with the help of a labelled diagram. Obtain the expression for the emf induced in a coil having N turns each of cross-sectional area A, rotating with a constant angular speed ω in a

magnetic field (B), directed perpendicular to the axis of rotation.

18. (i) Define the term 'self-inductance' and write its SI unit.

(ii) Obtain the expression for the mutual inductance of two long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.

19. Define mutual inductance between a pair of coils. Derive an expression for the mutual inductance of two long coaxial solenoids of same length wound one over the other.

20. (i) Define mutual inductance.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil?

21. (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 to 4.0 in 0.1s, then what is the induced emf in the loop while the current is changing?

22. Draw a schematic sketch of an AC generator describing its basic elements. State briefly its working principle. Show a plot of variation of

(i) magnetic flux and

(ii) alternating emf *versus* time generated by a loop of wire rotating in a magnetic field.

23. Define the term self-inductance of a solenoid. Obtain the expression for the magnetic energy stored in an inductor of self-inductance L to build up a current I through it.

24. The current flowing in the two coils of self-inductance $L_1 = 16$ mH and $L_2 = 12$ mH are increasing at the same rate. If the power supplied to the two coils are equal, then find the ratio of

(i) induced voltages

(ii) the currents and

(iii) the energies stored in the coil at a given instant.

25. Starting from the expression for the energy $W = \frac{1}{2}LI^2$, stored in a solenoid of self-inductance L to build up the current I, obtain the expression for the magnetic energy in terms of the magnetic field B, area A and length l of the solenoid having n number of turns per unit length. Hence, show that the energy density is given by $B^2/2\mu_0$.

5 Marks Questions

26. (i) Explain the meaning of the term mutual inductance. Consider two concentric circular coils, one of the radius r_1 and the other of radius $r_2 (r_1 < r_2)$ placed coaxially with centres coinciding with each other. Obtain the expression for the mutual inductance of the arrangement.

(ii) A rectangular coil of area A, having number of turns N is rotated at f revolutions per second in a uniform magnetic field B, the field being perpendicular to the coil.

Prove that the maximum emf induced in the coil is $2\pi fNBA$.

27. (i) Define mutual inductance and write its SI units.

(ii) Derive an expression for the mutual inductance of two long coaxial solenoids of same length wound one over the other.

(iii) In an experiment, two coils C_1 and C_2 are placed close to each other. Find out the expression for the emf

induced in the coil C_1 due to a change in the current through the coil C_2.

28. (i) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce a current which opposes the change of magnetic flux that produces it.

(ii) The current flowing through an inductor of self-inductance L is continuously increasing. Plot a graph showing the variation of

(a) magnetic flux *versus* the current.

(b) induced emf *versus* dI/dt.

(c) magnetic potential energy stored *versus* the current.

29. (i) Draw a labelled diagram of AC generator and state its working principle.

(ii) How is magnetic flux linked with the armature coil changed in a generator?

(iii) Derive the expression for maximum value of the induced emf and state the rule that gives the direction of the induced emf.

(iv) Show the variation of the emf generated *versus* time as the armature is rotated with respect to the direction of the magnetic fields.

30. (i) State the principle on which AC generator works. Draw a labelled diagram and explain its working.

(ii) A conducting rod held horizontally along East-West direction is dropped from rest from a certain height near the Earth's surface. Why should there be an induced emf across the ends of the rod?

Draw a plot showing the instantaneous variation of emf as a function of time from the instant it begins to fall.

31. State the working of AC generator with the help of a labelled diagram. The coil of an AC generator having N turns, each of area A, is rotated with a constant angular velocity ω. Deduce the expression for the alternating emf generated in the coil. What is the source of energy generation in this device?