O P JINDAL SCHOOL, SAVITRINAGAR

ASSIGNMENT

CLASS XII PHYSICS

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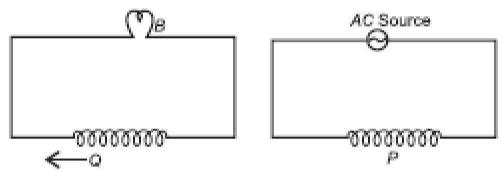
31 A coil Q is connected to low voltage bulb B and placed near another coil P as shown in the figure. Give reasons to explain the following observations:

(a) The bulb B lights.

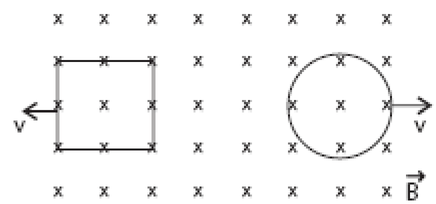
(b) Bulb gets dimmer if the coil Q is moved towards left. 2



ANS: (a) The bulb B lights because an emf is induced in coil Q due to change in magnetic flux crossing through it.

(b) Bulb gets dimmer if the coil Q is moved towards left because of mutual induction, and hence induced emf in coil Q decreases with separation between the coils.

32 A rectangular loop and a circular loop are moving out of a uniform magnetic field to a field-free region with a constant velocity v as shown in the figure. Explain in which loop do you expect the induced emf to be constant during the passage out of the field region. The magnetic field is normal to the loops. 2

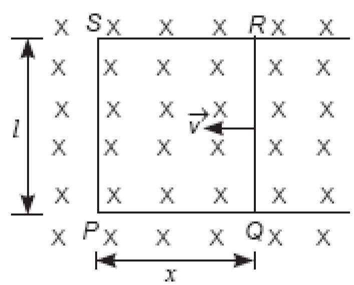


ANS: Induced emf is constant in case of rectangular loop.
As area is changing at constant rate, the flux linked with it will also change with constant rate.

According to Faraday's law, i.e. $|\varepsilon| = \frac{d\phi}{dt}$. So, emf induced is constant.

33 A conducting rod of length l 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 $|\varepsilon| = Blv$. 2

ANS: We consider a rectangular conductor placed in a uniform magnetic field normal to its plane. One arm of this conductor is free to more. Let the arm be moved inwards with a speed v. The flux through the loop is Blx.



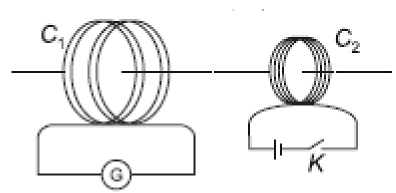
Thus, due to the motion of the arm emf induced is given by

$$\varepsilon = -\frac{d}{dt}(Blx) = -Bl\frac{dx}{dt} \Rightarrow |\varepsilon| = +Blv$$ This emf is called motional emf.

34 (i) How are eddy currents reduced in a metallic core? 2
(ii) Give two uses of eddy currents.

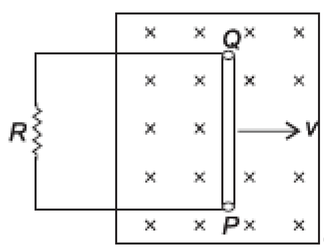
ANS: (i) By using stripped metal and not continuous metallic core and by filling the gaps, thus, created by non-conducting paste, one can reduce eddy currents.
(ii) (a) To make electric brakes.
(b) To produce heat in electric furnaces.

35 A current is induced in coil C_1 due to the motion of current carrying coil C_2.
(a) Write any two ways by which a large deflection can be obtained in the galvanometer *G*.
(b) Suggest an alternative device to demonstrate the induced current in place of a galvanometer. 2



ANS: (a) (i) By increasing the motion of current carrying coil C_2.
(ii) By switching off and on of the key.
(iii) By increasing the current.(any two)
(b) By joining a bulb or an LED.

36 A conducting rod, PQ, of length l, connected to a resistor R, is moved at a uniform speed, v, normal to a uniform magnetic field, B, as shown in the figure. 3



(i) Deduce the expression for the emf induced in the conductor.
(ii) Find the force required to move the rod in the magnetic field.
(iii) Mark the direction of induced current in the conductor.

ANS: (i) Expression for the emf induced in the conductor

When the conductor PQ moves through the magnetic field, free charge carriers of the conductor experience a Lorentz force. Consider a free charge q, in the conductor moving with speed v in the magnetic field. Lorentz force will act on the charge towards end Q of the conductor.

Its magnitude is given by

$$F = qBv \qquad (\because \theta = 90^\circ)$$

Work done in moving the charge from P to Q,

$$W = qvBl$$

Since, emf is the work done per unit charge

$$\varepsilon = W/q = Blv$$

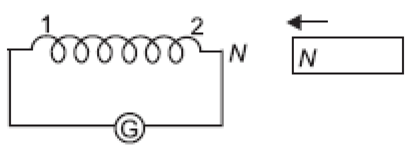
(ii) Force required to move the rod, $F = IlB$

when $I = \frac{\varepsilon}{R} = \frac{Blv}{R}$ then, $F = \frac{B^2l^2v}{R}$

(iii) The direction of induced current is determined by Faraday's right hand rule. It is from P to Q.

37 State Lenz's Law. Does it violate the principle of conservation of energy. Justify your answer. 3

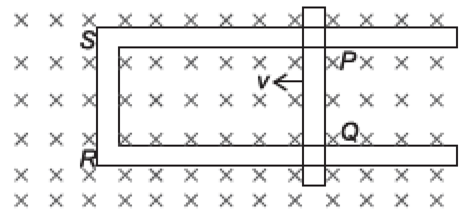
ANS: **Lenz's Law:** The current induced in a circuit always flows in such a direction that it opposes the change or the cause that produces it. Mathematically, $\varepsilon = -\frac{d\phi}{dt}$ No, it does not violate the principle of conservation of energy.



Justification: Lenz's law complies with the principle of conservation of energy. For example, when the N-pole of a bar magnet is pushed into a coil as shown, the direction of induced current in the coil will be such that the end 2 of the coil will act as N-pole. Thus, work has to be done against the magnetic repulsive force to push the magnet into the coil. The electrical energy produced in the coil is at the expense of this work done.

38 Figure shows a rectangular loop conducting *PQRS* in which the arm *PQ* is free to move. A uniform magnetic field acts in the direction perpendicular to the plane of the loop. Arm *PQ* is moved with a velocity *v* towards the arm *RS*. Assuming that the 3

arms *QR*, *RS* and *SP* have negligible resistances and the moving arm *PQ* has the resistance *r*, obtain the expression for (i) the current in the loop (ii) the force and (iii) the power required to move arm *PQ*.



ANS:

(i) An emf induced at the ends of the arm *PQ* is $\varepsilon = Blv$.

(where l is the length of the arm *PQ*)

So, the current in the loop, $I = \frac{Blv}{R}$

(ii) The current flows through the arm *PQ*. A current carrying wire experiences a force in the magnetic field.

$$\therefore \quad |\vec{F}| = |I(\vec{l} \times \vec{B})| = BIl \sin 90° = \frac{B^2 l^2 v}{R}$$

(iii) Power dissipated, $P = Fv = B^2 l^2 v^2 / R$

39 (a) Obtain the expression for the magnetic energy stored in a solenoid due to the current *I* flowing in it, in terms of magnetic field *B*, area of cross-section *A* and length *l* of the solenoid.
(b) How is this magnetic energy per unit volume compared with the electrostatic energy per unit volume stored in a parallel plate capacitor? 3

ANS: (a) Let *I* be the current at any instant in the solenoid and $\frac{dI}{dt}$ be the rate of change of current at that instant. The induced *emf* in the solenoid of inductance *L* is

$$e = L\frac{dI}{dt}$$ (ignoring the – ve sign which gives the direction)

∴ Instantaneous power, $P_I = eI = LI\frac{dI}{dt}$ Small amount of work done in a small time *dt* is calculated as

$dw = eI\,dt = LI\frac{dI}{dt}dt = LIdI$ ∴ Total work done as the current increases from 0 to I is given by

$w = \int_0^I LIdI = L\left[\frac{I^2}{2}\right]_0^I = \frac{1}{2}LI^2$ ∴ Energy stored in a solenoid, $U = \frac{1}{2}LI^2 \quad \ldots(i)$ Also, $L = \mu_0 n^2 Al \quad \ldots(ii)$ where *n* = number of turns/length, *A* is the area of cross-section of the solenoid and *l* is its length.

and $B = \mu_0 nI$

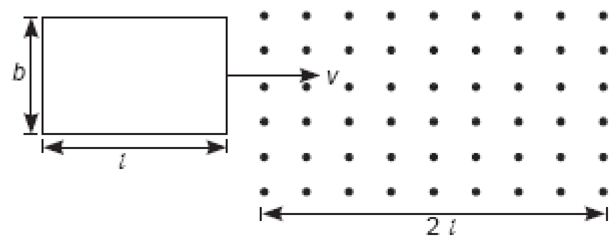
$I = \frac{B}{\mu_0 n} \quad \ldots(iii)$ Putting the values of *L* and *I* from (ii) and (iii) into (i), we get

$$U = \frac{1}{2}\mu_0 n^2 Al.\frac{B^2}{\mu_0^2 n^2}$$

∴ Energy stored in a solenoid, ∴ $U_B = \frac{1}{2}\frac{AB^2 l}{\mu_0}$ (b) Magnetic energy for unit volume,

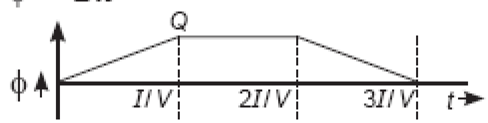
$u_B = \frac{U_B}{Al} = \frac{1}{2}\frac{AB^2 l}{\mu_0 \times Al} = \frac{1}{2}\frac{B^2}{\mu_0}$ We already know that the energy stored per unit volume in parallel plate capacitor is given by $U_E = \frac{1}{2}\varepsilon_0 E^2$ It is clear that in both cases the energy stored per unit volume is proportional to the square of the field intensity.

40 A rectangular conducting loop of length *l* and breadth *b* enters a uniform magnetic field *B* as shown.
The loop is moving at constant speed *v* and at *t* = 0 it just enters the field *B*. Sketch the following graphs for the time interval *t* = 0 to 3*l*/*v*. 3
(i) Magnetic flux – time (ii) Induced emf – time (iii) Power – time
Resistance of the loop is R.

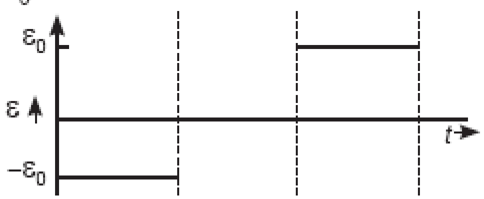


ANS:

(i) $\phi = Blb$



(ii) $\varepsilon_0 = Bvb$



(iii) $P_0 = \dfrac{\varepsilon_0^2}{R} = \dfrac{B^2 v^2 b^2}{R}$