UNIT : 3 ELECTROMAGNETIC INDUCTION & AC CIRCUITS

1.A magnet is allowed to fall through a metallic ring.During fall what will be its acceleration? (Less than g)Can a choke coil can be used as a step-up and step-down transformer.Justify

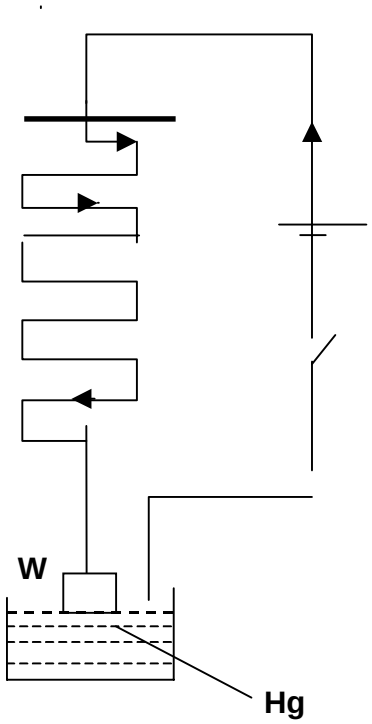
2.A magnetic flux linked with a coil,in webers, is given the equation $\varphi = 4t^2+2t+15$.The magnitude of induced emf at t = 2 Sec. is how much?

3.A radio frequency choke is air cored whereas an audio frequency choke is iron-cored Give reason for this difference.

4.Define self-inductance in terms of work done against the induced emf.

(L = $\frac{2W}{I^2}$; Self-inductance is defined as double the work done against the induced emf in producing unit current in the coil itself)

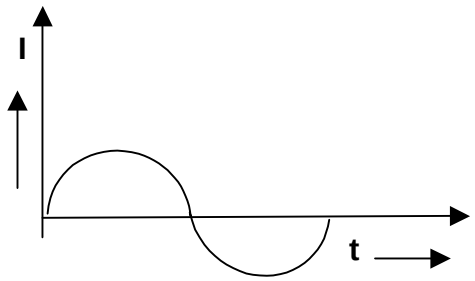
5.A circuit with a vertical copper wire bends as shown supports a small wodden piece W which floats in mercury. What do you expect when key is closed and current flows through the circuit?



(The wodden block sinks when current flows through the circuit, as parallel wires

carrying currents in the opposite directions repel)

The given wave form shows the input current of a transformer.



6. Draw the wave form of out put current. Substantiate your answer

(180^0 phase diff.due to Lenz's law)

7.An electron beam is deflected in a given field. Identify whether it is an electric field or a magnetic field in the following cases?

The trajectory of the beam is a parabola and its K.E changes.

8.The trajectory of the beam is circular and its K.E. remains the same.Justify your answer.

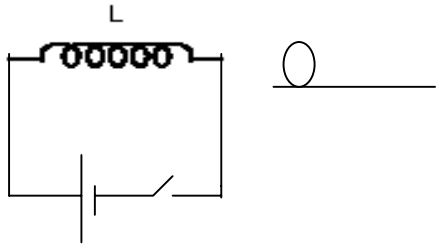
9.A resting electron near a stationery bar magnet does not set into motion. But a moving magnet near an electron set it into motion. Why?

10.An irrequlary shaped flexible current carrying loop when placed In an external magnetic field will assume a circular shape. Give reason

11.Three identical inductors L_1 ,L_2 and L_3 are connected as shown is a part of a circuit.The magnetic field at the centre of inductor L_1 is 0.2 Tesla. What is the magnetic field inside the inductor L_2 ?

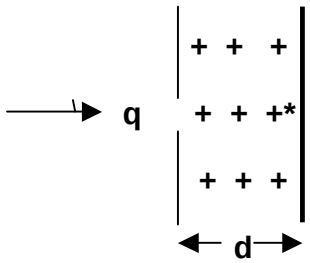
12.Alpha particles (m = 6.68 X 10^{-27} Kg. , q = +2e) accelerated through a potential difference V to 2 KeV, enter a magnetic field B = 0.2 T perpendicular to their direction of motion. Calculate the radius of their path.

(r = $\frac{1}{B}\sqrt{\frac{2Vm}{q}}$ = 32 m.)



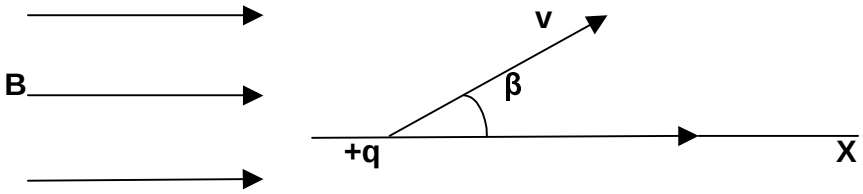
13. The above figure shows a horizontal solenoid connected to a battery and a switch.A copper ring is placed on a frictionless track near the solenoid, the axis of the ring being along the axis of the solenoid. What will happen to the ring as the switch is closed? Justify your answer.

14.A particle with charge 'q' and mass ' m' is shot with kinetic energy K into the region between two plates as shown in the figure. If the magnetic field between the plates is B and as shown, how large must B be if the particle isj to miss collision with the opposite plate?

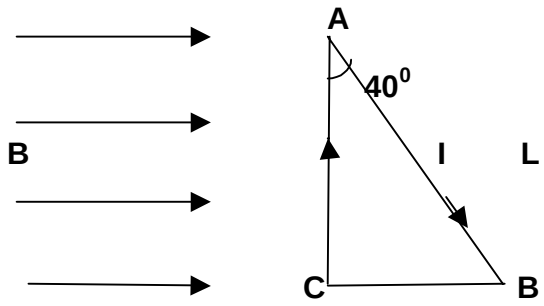


(Just to miss the opposite plate, the particle must move in a circular path with radius d so that $Bqv = mv^2/d$, $B = (2mK)^{1/2}/(qd)$)

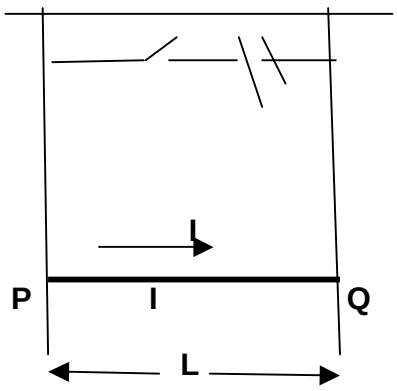
15.In the following diagram, a proton of charge q and mass m is shot with speed v at an angle β to an x-directed field B. Show that the proton will spiral along the x-axis and radius of the spiral = mv Sinβ / qB and the pitch of the helix (distance traveled during one revolution) = 2πrCot β.



16.For the circuit shown below, find the magnitude and direction the force on wire AC, wire BC and wire AB. Also show that net force is zero.

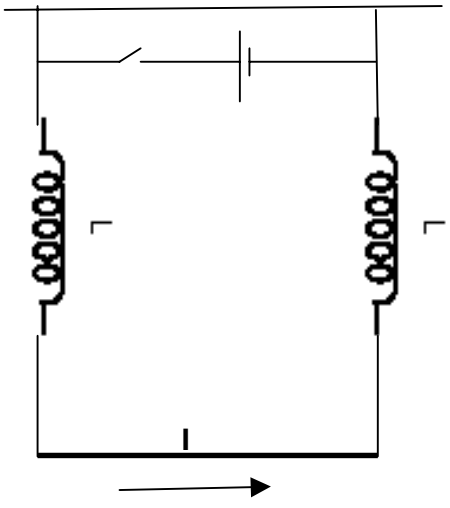


17.A bar PQ of mass M is suspended by two wires as shown below. Assume that a uniform magnetic field B is directed into the page. Find the tension in each supporting wire when the current through the bar is I.



{According to the RHR, the magnetic force ILB is directed upward. Equilibrium in the vertical direction yields 2T + ILB = Mg, so that T = (Mg – ILB)/2 }

18.A bar of mass M is suspended by two springs as shown below . Assume that a magnetic field B is directed out of the page. Each spring has a spring constant K . Describe the bar's displacement when a current I is sent through it in the direction shown.

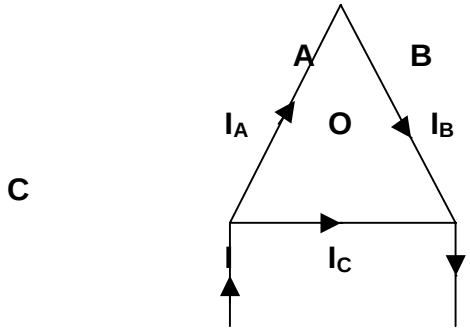


{Due to RHR the magnetic force ILB is directed downward. This constant force shifts

the equilibrium position downward by a displacement = (ILB)/2K }

19.Five very long , straight , insulated wires are closely bound together to form a small cable. Currents carried by the wires are I_1 = 20A, I_2 = -6A, I_3 = 12A, I_4 = -7A, I_5 = 18A.Show that the magnetic field at a distance of 10 cm from the cable B = 74 μT.

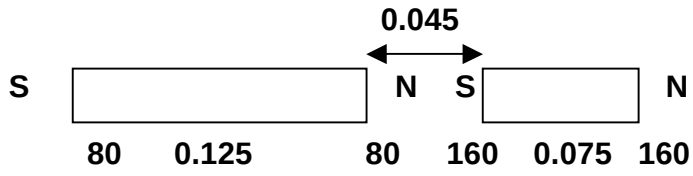
20.An equilateral triangle is formed from a piece of uniform resistance wire. Current is fed into one corner and led out of the other as detailed in the figure below. Show that the current flowing through the sides of the triangle produces no magnetic field at its centre 'O' (the intersection of the medians).



(Wires A and B are in series. $I_A = I_B = I/3$, $I_C = 2I/3$.Wire C makes a contribution to the field at O whose magnitude is twice that of A or B. By RHR, directions of field due to

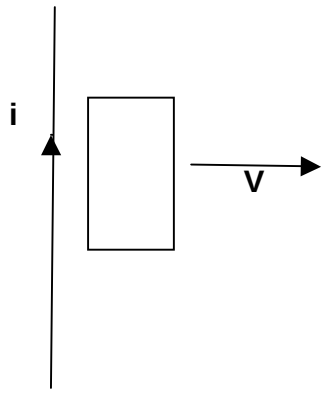
Wire A and B are directed down into the page. That due to wire C is upward. Net field at O is zero)

The axes of two magnets are collinear. One has poles of strength 80 Am separated by 125 mm, and the second has a magnetic moment of 12 A-m^2 with poles of strength 160 Am. Find the attractive force between the magnets if the north pole of one is 45 mm from the south pole of the second.



{Resultant force F = 2 attractive forces + 2 repulsive forces = 520 mN (attractive) }

21.In the following figure, the rectangular loop of wire is being pulled to the right, away from the long straight wire through which a steady current i flows upward as shown. Does the current induced in the loop flow in the clockwise sense or in the counter clockwise sense ? Justify



{Due to Lenz's law , the magnetic field produced by the induced current must counteract the decrease in flux and hence it must be directed ino the plane of the figure(within the loop).So the induced current must be clock –wise.}

22.Determine the separate effects on the induced emf of a generator if (a) the flux per pole is doubled, and (b) the speed of the armature is doubled.

(In both the cases the induced emf doubles)

23.An electromagnet has stored 648 J of magnetic energy when a current of 9A exists in its coils.What average emf is induced if the current is reduced to zero in 0.45 s ?

(E = $\frac{1}{2} LI^2$, L = 16 H and e = 320 V)

24.A 40 Ohm resistor is connected across a 15 V variable frequency electronic oscillator. Find the current through the resistor when the frequency is (a) 100 Hz and (b) 100KHz. What is the current if the 40 Ohm resistor is replaced by a 2 mH inductor?

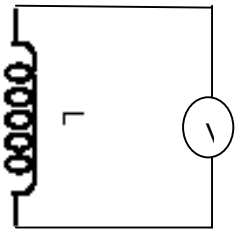
{ With resistor ,current is same both for 100 Hz and 100kHz. With inductor , the current is 11.9 A and 11.9 mA respectively}

25.The current in a long solenoid of radius R and having n turns per unit length is given by $I = i_0 \sin\omega t$. A coil having N turns is wound around it near the centre. Find (a) the induced emf in the coil and (b) the mutual inductance between the solenoid and the coil.

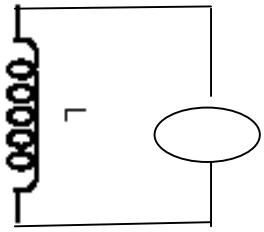
{ (a) $\pi\mu_0 i_0 nN\omega R^2 Cos\omega t$ (b) $\pi\mu_0 nNR^2$ }

Give the condition for a current carrying loop not to rotate in a magnetic field

26.A coil A is connected to voltmeter V and the other coil B to an alternating current source D. If a large copper sheet CC is placed between the two coils, how does the induced e.m.f in the coil A change due to current in coil B?



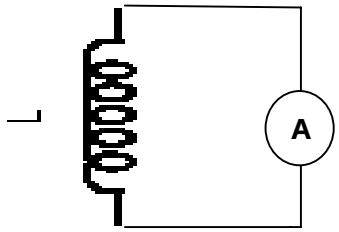
Coil A with Voltmeter



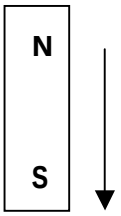
Coil B with AC source

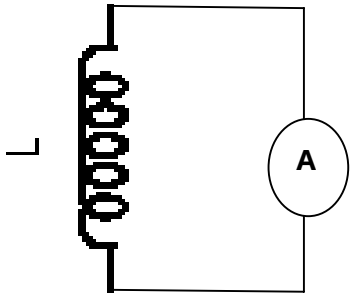
(The induced e.m.f in coil A decreases due to large copper plate introduced between the two coils as Cu is diamagnetic material)

27.A magnet is moved in the direction indicated by an arrow between two coils A and B as shown below.Suggest the direction of induced current in each coil



Coil A





Coil B

(Due to Lenz's law, end A will behave as south pole and end B will behave as north pole.The end face A will have clock wise direction of current and end face B will have anti clock wise direction of current when seen from the magnet side.)

28.An LC circuit contains a 20 mH inductor and a 50 μF capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant the circuit is closed be t = 0

What is the total energy stored initially? Is it conserved during LC oscillations?

What is the natural frequency of the circuit?

At what time is the energy stored

(a)Completely electrical (stored in capacitor)

(b)Completely magnetic (stored in inductor)

29.At what time is the total energy share equally between the inductor and the capacitor?

If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?

{Hint:

Total energy = $1/2Q_0^2/C$ = 1J; Yes;

159 Hz

(c) $Q = Q_0 Cos(2\pi\gamma t)$,

$I = dq/dt = I_0 Sin(2\pi\gamma t)$: (i) At T = 0,T/2,T,3T/2,…… (ii) At T = T/4,3T/4,5T/4,……

For this , the energy stored in the capacitor should become just half of its initial value .hence ,the time t =T/8,3T/8,5T/8,…..

If a resistor is inserted in the circuit, the energy stored will eventually be lost in the form of Joule's heating}.

30.Determine the separate effects on the induced emf of a generator if (a) the flux per pole is doubled, and (b) the speed of the armature is doubled.

31.An electromagnet has stored 648 J of magnetic energy when a current of 9 A exists in its coils. What average emf is induced if the current is reduced to zero in 0.45 sec.

(Calculate = 16 H. e = L di/dt = 320 V)