The following questions consists of two statements each, printed as Assertion and Reason. While answering these questions you are to choose any one of the following four responses.

(A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

(B) If both Assertion and Reason are true but Reason is not correct explanation of the Assertion.

(C) If Assertion is true but Reason is false.

(D) If Assertion is false but Reason is true.

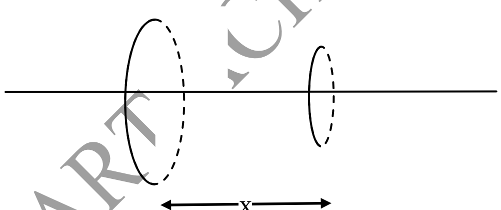
Q. 1 **Assertion :** An e.m.f is induced in a closed loop where magnetic flux is varied. The induced E is not a conservating field.

Reason: The line integral of $\vec{E}.d\vec{\ell}$ around the closed loop is non-zero. **[A]**

Q.2 **Assertion :** Two coaxial conducting rings of different radii are placed in space. The mutual inductance of both the rings is maximum if the rings are also coplanar.

Reason : For two coaxial conducting rings of different radii, the magnitude of magnetic flux in one ring due to current in other ring is maximum when both rings are coplanar.

Sol. **[D]**



When x = 0, the flux linkage in one ring due to current in other coaxial ring is maximum.

Q. 3 **Assertion :** When a current flows in the coil of transformer then its core becomes hot.

Reason: The core of transformer is made of iron.

Sol. **[B]**

A – True

R – True but Not correct explanation

Heating of core is due to hysterises loss.

Q.4 **Assertion** : The magnetic flux through a closed surface is zero

Reason : Gauss's law is applied in the case of electric flux only **[B]**

Q.5 **Assertion** : Use is made of eddy currents in induction brakes.

Reason : As eddy currents always oppose the relative motion. **[C]**

Q.6 **Assertion** : A spark occurs sometime when an electric iron is switched off.

Reason : Sparking is due to large self induced e.m.f. in the circuit, during make. **[A]**

Q.7 **Assertion** : A step up transformer can also be used as a step down transformer.

Reason : This is because $\frac{E_s}{E_P} = \frac{n_s}{n_p}$. **[A]**

Q.8 **Assertion** : The net magnetic flux coming out of a closed surface is always zero.

Reason : Unlike poles of equal strength exist together. **[A]**

Q.9 **Assertion** : A thin aluminium disc, spinning freely about a central pivot, is quickly brought to rest when placed between the poles of a strong U-shaped magnet.

Reason : A current induced in a disc rotating in a magnetic field produces a force which tends to oppose the motion of the disc **[A]**

Q.10 **Assertion** : The presence of large magnetic flux through a coil maintains a current in the coil if the circuit is continuous.

Reason : Only a change in magnetic flux will maintain an induced current in the coil. **[D]**

Q.11 **Assertion** : If a varying current is flowing through a machine of iron, eddy currents are produced

Reason : Change in the magnetic flux through an area causes eddy currents. **[A]**

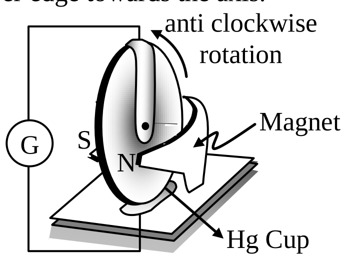
Q.12 **Assertion :** When a current flow in the coil of a transformer then its core becomes hot.

Reason : The core of transformer is made of iron.

Sol **[B]**

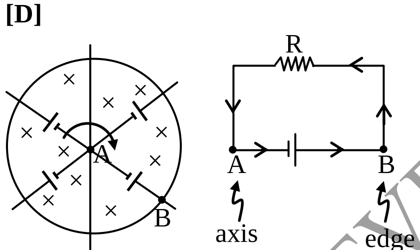
Heating of core happened due to hysterisis loss, not just because core is made of iron.

Q.13 **Assertion :** A copper disc is secured on a horizontal axis and placed between the poles of a strong magnet. Bottom of the disc is arranged in a cup of mercury. Axis of disc and cup are connected through galvanometer. When disc rotate clockwise induced current will flow from lower edge towards the axis.



Reason : Axis of disc will be at lower potential than edge of disc.

Sol. **[D]**



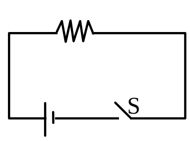
Q.14 **Assertion :** Soft iron is used in the core of a transformer.

Reason : Soft iron is a conductor of electricity. **[B]**

Sol. To ensure hundred % flux linkage between the primary & secondary coil, soft iron is used.

Q.15 **Assertion :** A spark occur between the poles of a switch when the switch S is opened.

Reason : Current flowing in the conductor produces magnetic field. **[B]**



Sol. When switch S is opened, then current will drop in loop, due to which magnetic field in the circuit drop, thus magnetic flux linked with loop decrease. Due to self induction, current will try continue to flow. This cause spark.

Q.16 **Assertion :** A bar magnet is dropped into a long vertical copper tube. Even taking air resistance as negligible, the magnet attains a constant terminal velocity. If the tube is heated, the terminal velocity gets increased.

Reason : The terminal velocity depends on eddy current produced in bar magnet. **[B]**

Sol. When magnet falls, eddy currents are produced in tube which will oppose falling of magnet. After sometime opposing force of eddy current get equal to gravitational force then net force on magnet become zero, thus velocity of magnet become constant.

When the tube gets heated in resistance get increased due to which eddy currents become weak. Hence opposing force also gets reduced and the terminal velocity of magnet gets increased.

Q.17 **Assertion :** When a current flows in the coil of transformer then its core becomes hot.

Reason : The core of transformer is made of iron. **[B]**

Sol. Heating of core is due to hysterisis loss.

Q.18 **Assertion :** Magnetic flux can produce induced emf.

Reason : Faraday established induced emf experimentally. **[D]**

Q.19 **Assertion :** When a current flow in the coil of a transformer then its core becomes hot.

Reason : The core of transformer is made of iron. **[B]**

Sol. Heating of core happened due to hysterisis loss, not just because core is made of iron.

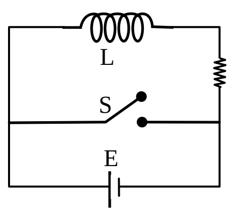
Q.20 **Statement I :** A thin aluminium disc, spinning freely about a central pivot, is quickly brought to rest when placed between the poles of a strong U-shaped magnet.

Statement II : A current induced in a disc rotating in a magnetic field produces a force which tends to oppose the motion of the disc.

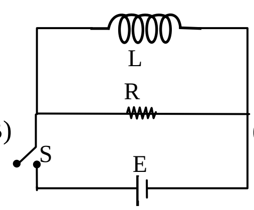
[A]

Q.1 In Column I, some circuits are given. In all the circuits, except in A switch S remains closed for long time and then it is opened at t = 0, while for A, the switch remain opened for long time and then it is closed suddenly. Column II tells something about certain quantities. Match the entries of column I with the entries of column II -

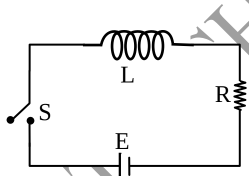
Column-I **Column-II**

(A)


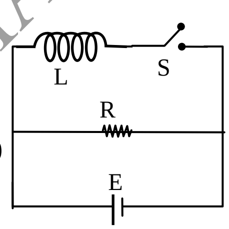
(P) Induced e.m.f can be greater than E

(B)


(Q) Induced e.m.f would be less than E

(C)


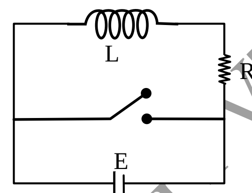
(R) Finally, energy stored in inductor is zero

(D)


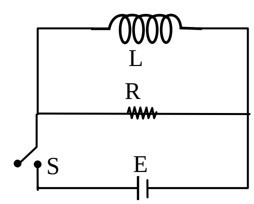
(S) Finally energy stored in inductor is non-zero

Sol. **A → Q,R ; B → P,R ; C → P,S ; D → P,S**

For A : Before closing the switch, the current through inductor and resistor are same having steady state value equal to E/R. But when the switch is closed, the battery gets by passed from the circuit and current in the circuit starts decaying. As a result, at any time induced emf < E and total energy of inductor gets dissipated as thermal energy through R.



For B : Before opening the switch, the circuit in steady state have different values and current in resistor is very small as compared to current in inductor. But when switch is opened, current in L and R acquires same value as that of current through L before opening the switch and then starts decaying through R. In this process e.m.f. induced > E and finally no energy is stored in inductor.



For C : Before opening the switch the current through L and R in steady state is E/R. As switch is opened, current through R becomes zero due to open circuit, but inductor tries to oppose this variation, as a result, a large e.m.f gets induced across L and energy of inductor has not been dissipated.

For D : When switch S is closed, situation is same as that of B but when switch opens, there is no path through which magnetic energy stored in inductor would be released.

Q.2

	Column I		Column II
(A)	Electromagnetic damping	(P)	Magnetic Energy
(B)	Transformer	(Q)	Flux change
(C)	Inductor	(R)	Alternating source
(D)	Electromotive force	(S)	Eddy currents

Ans. A $\rightarrow$ S ; B $\rightarrow$ R ; C $\rightarrow$ P ; D $\rightarrow$ Q

Q.3 **Column-I** **Column II**

(A) A stationary uniformly charged dielectric ring — (P) Time independent electrostatic field out of system

(B) Dielectric ring uniformly charged rotating with angular velocity ω. — (Q) Magnetic field

(C) Constant current in ring i_0 — (R) Induced electric field

(D) $i = i_0 \cos\omega t$ — (S) Magnetic moment

[IIT-2006]

Ans. A $\rightarrow$ P, B $\rightarrow$ P, Q, R ; C $\rightarrow$ Q, S ; D $\rightarrow$ Q, R, S

Q.4 Suppose we have two solenoids of same length their diameters differ only to the extent to which one can fitted on to the other. The inductances of two solenoids can be considered the same and equal to L.

Column I (Ways on which the solenoids are connected)	Column II (Equivalent inductance)
(A) Solenoids are connected in series and one is fitted on the other and the sense of turns coincides	(P) $\frac{L}{2}$
(B) Solenoids are connected in parallel and one is fitted on the other and the sense of turns coincides	(Q) 4L
(C) Solenoids are connected in series, one is fitted on the other and the sense of turns are opposite	(R) L
(D) Solenoids are connected in parallel and are separated by a large distance and the sense of turns are opposite	(S) 0

Ans. **A$\rightarrow$ Q ; B$\rightarrow$ R; C$\rightarrow$ S; D$\rightarrow$ P**

Q.5 Some phenomena are mentioned in column I and some machines/instruments in column II.

Column I	Column II
(A) Electromagnetic induction	(P) DC Motor
(B) Photoelectric effect	(Q) Photocell
(C) Mutual induction	(R) DC generator
(D) Torque on current carrying coil	(S) Transformer

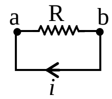
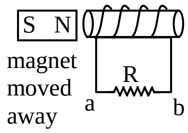
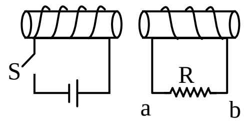
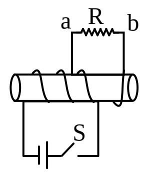
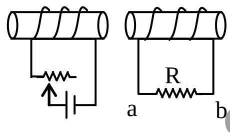
Ans. **A $\rightarrow$ R,S; B $\rightarrow$ Q; C $\rightarrow$ S; D $\rightarrow$ R**

Q.6 Match the list I with the list II from the combination shown. In the left side (list I) there are four different conditions and in the right side (list II), there are ratios of heat produced in each resistance of each condition :

List I	List II
(A) Two wires of same resistance are connected in series and same current is passed through them	(P) 1 : 2
(B) Two wires of resistance R and 2R ohm are connected in series and same p.d. is applied across them	(Q) 4 : 1
(C) Two wires of same resistance are connected in parallel and same current is flowing through them	(R) 1 : 1
(D) Two wires of resistance in the ratio 1 : 2 are S) 2 : 1 connected in parallel and same p.d. is applied across them	(S) 2 : 1

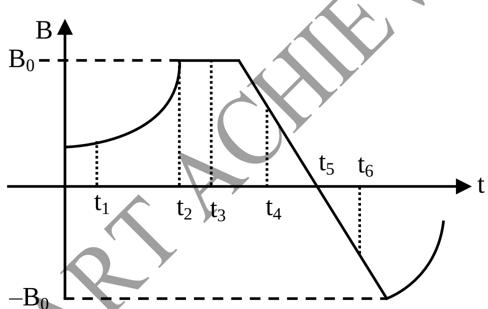
Sol. **A $\rightarrow$ Q, B $\rightarrow$ P; C $\rightarrow$ R; D $\rightarrow$ S**

Q.7 Match the following -

	Column I		Column II
(A)	The current in resistor R is from a to b	(P)	 *i* decrease rapidly to zero
(B)	The current in resistor R is from b to a	(Q)	
(C)	Magnetic flux linked with circuit containing resistor R is increasing	(R)	 when switch S is closed
(D)	Magnetic flux linked with circuit containing resistor R is decreasing	(S)	 when switch S is closed
		(T)	 when Resistance of Rheostate is decreased

Sol. A → P, Q, R, T ; B → S ; C → R, S, T; D → P, Q

Q.8



A Loop is kept in a magnetic field. It is fixed such that field lines pass perpendicular to its area. At any instant, magnetic flux density over the entire area has the same value but it varies with time

Column-I	Column-II
(A) Magnetic flux is maximum	(P) at t_4
(B) induced current is maximum	(Q) at t_2
(C) induced current is non zero	(R) at t_3
(D) induced current is constant for same time interval	(S) at t_5

1. A → P ; B → Q ; C → P, Q, S ; D → P, S

Q.9 Match the following -

Phenomena on which machine work — Machine or instrument

Column-I	Column-II
(A) Electromagnetic induction	(P) Photocell
(B) Light of suitable frequency falling on a material result in emission of electrons from the material	(Q) DC motor
(C) Change of orientation of a coil in a magnetic field results in emf across the coil	(R) AC generator
(D) Mutual induction	(S) Transformer

Sol. A → R, S ; B → P ; C → R; D → S

Q.10 Match the following -

Column-I	Column-II
(A) Magnetic flux density due to a current carrying circular coil.	(P) zero
(B) Magnetic flux density at a point on a current carrying thin wire	(Q) Maximum or zero at centre
(C) Electric field strength due to an uniformly charged	(R) continuously decrease as we move away from the centre

ring	along the axis.
(D) Electric potential due to an uniformly charged ring.	(S) continuously increases as we move away from the centre into a definite distance along the axis.

Sol A $\rightarrow$ Q,R B $\rightarrow$ P C $\rightarrow$ Q,S D $\rightarrow$ Q,R

Q.11 Column-I gives situation involving a charged particle which may be realised under the condition given in Column-II. Match the situations in Column-I with the condition in Column-II.

	Column-I		**Column-II**
(A)	Increase in speed of a charged particle	(P)	Electric field uniform in space and constant in time
(B)	Exert a force on an electron initially at rest	(Q)	Magnetic field uniform in space and constant in time
(C)	Move a charged particle in a circle with uniform speed	(R)	Magnetic field uniform in space but varying with time
(D)	Accelerate a moving charged particle	(S)	Magnetic field non-uniform in space but constant with time
		(T)	Electric field uniform in space but varying with time

Sol. A $\rightarrow$ P,R,T; B $\rightarrow$ P,R,T ;
C $\rightarrow$ Q,S ; D $\rightarrow$P,Q,R,S,T
Conceptual.

Q.1 The magnetic flux (ϕ) linked with a coil depends on time t as $\phi = at^n$, where a and n are constants. The emf induced in the coil is e.

(A) If $0 < n < 1$, $e = 0$

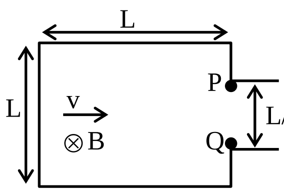
(B) If $0 < n < 1$, $e \neq 0$ and $|e|$ decreases with time

(C) If $n = 1$, e is constant

(D) If $n > 1$, $|e|$ increases with time

[B,C,D]

Q.2 The loop shown moves with a velocity v in a uniform magnetic field B, directed into the paper. The potential difference between P and Q is **e**



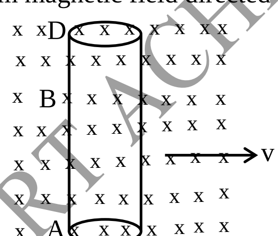
(A) $e = \frac{1}{2} B\ell v$

(B) $e = B\ell v$

(C) P is positive with respect to Q

(D) Q is positive with respect to P **[A,C]**

Q.3 The conductor AD moves to the right in a uniform magnetic field directed into the paper.



(A) The free electrons in conductor move toward A

(B) D will acquire a positive potential with respect to A

(C) If D and A are joined by a conductor externally, a current will flow from A to D in conductor.

(D) The current in AD flows from lower potential to higher potential **[All]**

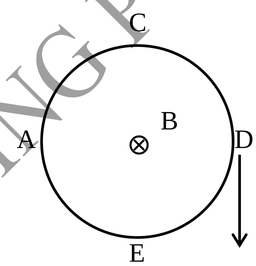
Q.4 The SI unit of inductance, the henry, can be written as -

(A) weber/amp. (B) volt sec./amp.

(C) joule/ampere^2 (D) ohm second

[All]

Q.4 A vertical conducting ring of radius R falls vertically in a horizontal magnetic field of magnitude B. The direction of B is perpendicular to the plane of ring. When the speed of the ring is v –



(A) no correct flows in the ring

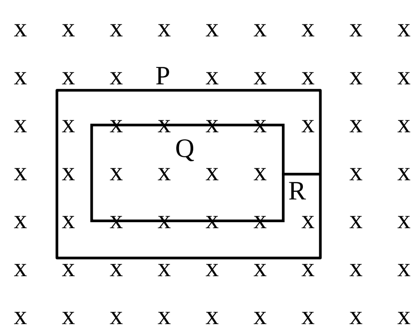
(B) A and D are at the same potential

(C) C and E are at the same potential

(D) the potential difference between A and D is 2BRv, with D at a higher potential

[A,C,D]

Q.5 Figure shows a plane figure made of a conductor located in magnetic field along the inward normal to the plane of the figure. If the magnetic field starts diminishing, the induced current :



(A) at point P is clockwise

(B) at point Q is anti-clockwise

(C) at point Q is clockwise

(D) a point R is zero **[A,C,D]**

Q.6 The magnetic field perpendicular to the plane of a conducting ring of radius r changes at the rate $\frac{dB}{dt}$.

(A) The emf induced in the ring is $\pi r^2 \frac{dB}{dt}$

(B) The emf induced in the ring is $2\pi r \frac{dB}{dt}$

(C) The potential difference between diametrically opposite points on the ring is half of the induced emf.

(D) All points on the ring are at the same potential **[A,D]**

Q.7 The magnitude of the earth's magnetic field at the North pole is B_0. A horizontal conductor of length ℓ moves with a velocity **v**. The direction of v is perpendicular to the conductor. The induced emf is

(A) zero, if v is vertical

(B) $B_0\ell v$, if v is vertical

(C) zero,if v is horizontal

(D) $B_0\ell v$, if v is horizonta **[A,D]**

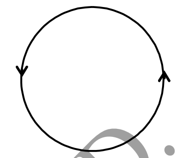
Q.8 Two different coils have self - inductance, L_1 = 8 mH, and L_2 = 2 mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate . At a certain instant of time, the power given to the two coils is the same. At that time the current ,, the induced voltage and the energy stored in the first coil are i_1, v_1 and w_1 respectively. Corresponding values for the second coil at the same instant are i_2, v_2 and w_2 respectively . Then **[IIT- 1994]**

(A) $\frac{i_1}{i_2} = \frac{1}{4}$ (B) $\frac{i_1}{i_2} = 4$

(C) $\frac{w_2}{w_1} = 4$ (D) $\frac{v_2}{v_1} = \frac{1}{4}$

[A,C,D]

Q.9 The given figure shows lines of force of a particular field. Out of the following option, the field line can not represent. **[IIT-2006]**



(A) An electrostatic field

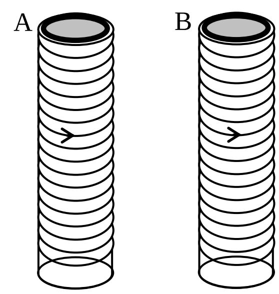
(B) A magneto static field

(C) A gravitational field

(D) An induced electric field

[A,C]

Q.10 Two metallic rings A and B, identical in shape and size but having different resistivities ρ_A and ρ_B, are kept on top of two identical solenoids as shown in the figure. When current I is switched on in both the solenoids in identical manner, the rings A and B jump to heights h_A and h_B, respectively, with $h_A > h_B$. The possible relation(s) between their resistivities and their masses m_A and m_B is (are) – **[IIT-2009]**



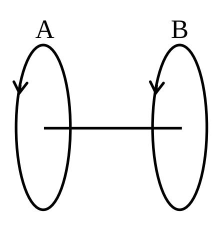
(A) $\rho_A > \rho_B$ and $m_A = m_B$

(B) $\rho_A < \rho_B$ and $m_A = m_B$

(C) $\rho_A > \rho_B$ and $m_A > m_B$

(D) $\rho_A < \rho_B$ and $m_A < m_B$ **[B,D]**

Q.11 Two contours whose planes are parallel to each other and are separated by a certain distance. Both are carrying current in the same direction. A is fixed & B can be positioned in different manner with respect to the first.



Different positions are such that the plane of B tuned by 90º, or by 180º, and in third case it is just moved parallel to itself over a certain distance. One has to do work to bring B in any of above positions. These works are W_1 for 90º, W_2 for 180º and for third case W_3. Among W_1 W_2, W_3 -

(A) W_1 is maximum & W_3 is minimum

(B) W_2 is maximum & W_3 is minimum

(C) W_3 is minimum

(D) $W_2 > W_1 > W_3$ **[B,C,D]**

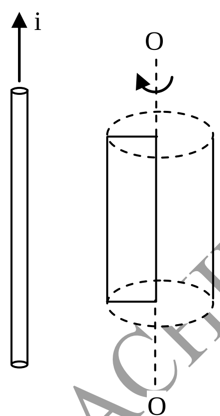
Sol. That

$W = I (\phi_2 - \phi_1)$

ϕ_2 is final flux & ϕ_1 is initial flux

$W_1 = - I\phi_1$, $W_2 = - 2I\phi_1$, $W_3 = I (\phi_2 - \phi_1)$

Q.12 A rectangular wire frame rotates with a constant velocity around one of its sides parallel to a current carrying & rectilinear conductor nearly as shown in diagram –



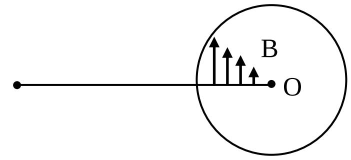
(A) When rectangular wire frame is in the plane passing through rectilinear conductor flux linked through rectangular wire frame is minimum

(B) When rectangular wire frame is in the plane passing through rectilinear conductor emf induced in rectangular wire frame is minimum

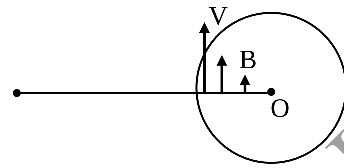
(C) When rectangular wire frame is in plane perpendicular to the plane passing through conductor then, emf is maximum

(D) When rectangular wire frame is in plane perpendicular to the plane passing through conductor then, flux is minimum **[B,C,D]**

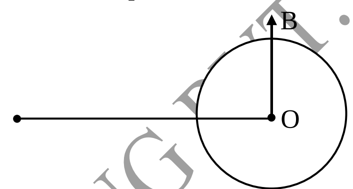
Sol. Top view



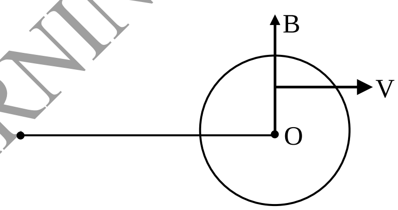
Flux is maximum



B & V are parallel so no induced emf

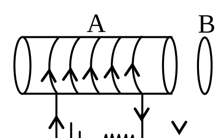


Flux is zero



Angle between B & V is 90°. So max. induced emf

Q.13 An aluminium ring B faces an electromagnet A. The current i through A can be altered -



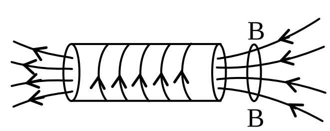
(A) If i increase, A will repel B

(B) If i increases, A will attract B

(C) If i decreases, A will attract B

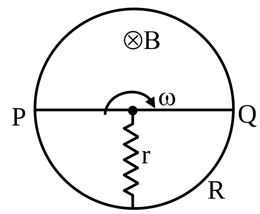
(D) If i decreases, A will repel B **[A,C]**

Sol.



When i is increased flux through B increased therefore according to Lenz law current induced in B will produced in such a way that it will go away from electromagnet, similarly when current is decreased then B will come near to A.

Q.14 In the figure shown, 'R' is a fixed conducting fixed ring of negligible resistance and radius 'a'. PQ is a uniform rod of resistance r. It is hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity ω. There is a uniform magnetic field of strength 'B' pointing inwards, 'r' is a stationary resistance, then -



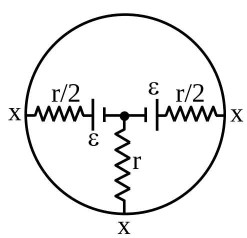
(A) Current through 'r' is zero

(B) Current through 'r' is $\frac{2B\omega a^2}{5r}$

(C) Direction of current in external 'r' is from centre to circumference

(D) Direction of current in external 'r' is from circumference to centre **[B,D]**

Sol. Equivalent circuit



Induced emf e = $\frac{B\omega r^2}{2} = \frac{B\omega a^2}{2}$

($\because$ Radius = a)

By nodal equation, nodal

$4\left(\frac{x-e}{r}\right) + \left(\frac{x-0}{r}\right) = 0$

$5x = 4e$

$x = 4e/5$

and $i = \frac{x}{r} = \frac{2B\omega a^2}{5}$

$\left\{ i = \frac{e}{r + r/4} = \frac{4e}{5r} \right\}$

Q.15 An inductance L, resistance R, battery B and switch S are connected in series voltmeter V_L and V_R are connected across L and R respectively. When 'S' is closed –

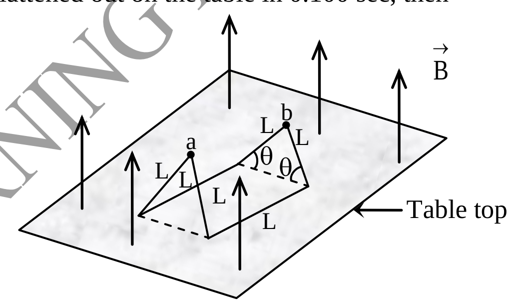
(A) the initial reading in V_L will be greater than that in V_R

(B) the initial reading in V_L will be less than that in V_R

(C) the initial readings in V_L and V_R will be same

(D) the reading in V_L will decrease as time increases, while that in V_R will increase to maximum value **[A,D]**

Q.16 The wire as shown in figure is bent in the shape of a tent, with θ = 60° and L = 1.50 m and is placed in a uniform magnetic field of magnitude 0.300 T perpendicular to the table top. The wire is rigid but hinged at points a and b. If the tent is flattened out on the table in 0.100 sec, then –



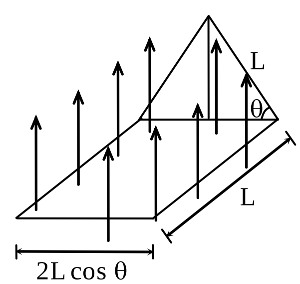
(A) Average induced emf in the wire during this time is 6.75 V

(B) Average induced emf in the wire during this time is clockwise

(C) Average induced emf in the wire during this time is anticlockwise

(D) Average induced emf in the wire during this time is 2.75 V **[A,B]**

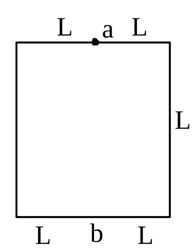
Sol.



$\phi_i = 2Lx \cos\theta \times B$

$\phi_f = 2L^2B$

$\Delta\phi = 2L^2B\,[\cos\theta - 1]$



$e = \frac{\Delta\phi}{\Delta t} = \frac{2LBx[\cos\theta - 1]L}{0.1}$

$= \frac{2\times1.5\times0.3[0.5]\times1.5}{0.1}$

= – 6.75 volt clockwise

Q.17 When a small motor is joined in series with a suitable light bulb and battery and the current is switch on –

(A) the light bulb is bright at first and then become dim

(B) the light bulb has the same brightness throughout

(C) the speed of the motor is proportional to its back emf

(D) the filament resistance decreases as the current increases **[A,C]**

Q.18 A solenoid is connected to a source of constant emf for a long time. A soft iron piece is inserted into it, then -

(A) self inductance of the solenoid gets increased

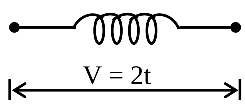
(B) flux linked with the solenoid increases hence steady state current gets decrease

(C) energy stored in the solenoid gets increased

(D) magnetic moment of the solenoid increased

Sol. **[A,C,D]**

Q.19 A variable voltage V = 2t is applied across an inductor of inductance L = 2 Henry as shown in figure. Then -



(A) current versus time graph is a parabola

(B) energy stored in magnetic field at t = 2s is 4 joule

(C) potential energy at time t = 1 s in magnetic field is increasing at a rate of 1 J/s

(D) energy stored in magnetic field is zero all time **[A,B,C]**

Sol. $V = \frac{Ldi}{dt} \Rightarrow 2t = 2 \times \frac{di}{dt}$

$C + \frac{t^2}{2} = i \Rightarrow i = \frac{t^2}{2}$

(A) is correct

$U = \frac{1}{2}Li = \frac{1}{2} \times 2 \times \frac{t^4}{4} = 4$ joule

(B) is correct

$\frac{dU}{dt} = Li\frac{di}{dt} = 2 \times \frac{t^2}{2} \times t = 1$ j/s

(C) is correct

Q.20 Which of the following statement is correct regarding induced electric field (Symbols have their usual meaning) -

(A) Potential difference due to induced electric field is defined

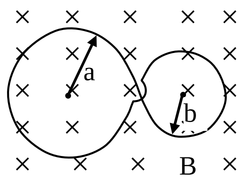
(B) Induced electric field is conservative in nature

(C) Induced electric lines of force form closed loops

(D) Induced emf in the loop i.e. $\varepsilon = \oint \vec{E}.\vec{d\ell} = -\frac{d\phi}{dt}$

Sol. **[C, D]**

Q.1 A plane loop is shaped in the form as shown in figure with radii a = 20 cm and b = 10 cm and is placed in a uniform time varying magnetic field $B = B_0 \sin \omega t$, where B_0 = 10 mT and ω = 100 rad/s. Find the amplitude of the current induced in the loop if its resistance per unit length is equal to 50×10^{-3} Ω/m. The inductance of the loop is negligible. **[0001]**



Sol. Instantaneous flux

$= \pi a^2 B \cos 0° + \pi b^2 B \cos 180°$

$= \pi (a^2 - b^2) B$

$\phi = \pi(a^2 - b^2) B_0 \sin \omega t$

$\ell = \frac{d\phi}{dt}$

$i = \frac{\ell}{R}$

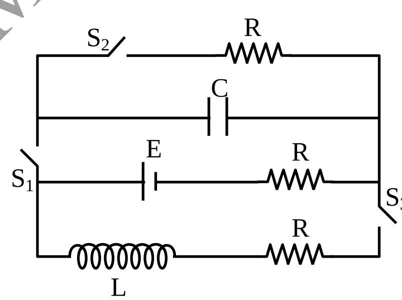
$i = \frac{\pi(a^2 - b^2)B_0\omega\cos\omega t}{R}$

$R = \rho \times 2\pi (a + b)$

$\therefore \quad i_{max} = \frac{1}{2\ell}(a-b)B_0\omega = 1$ Amp

Q.2 In the given circuit, initially switch S_1 is closed and S_2 and S_3 are open. After charging of capacitor, at t = 0, S_1 is open and S_2 and S_3 are closed. If the relation between inductance capacitance and resistance is $L = 4CR^2$ then find the time (in sec) after which current passing through capacitor and inductor will be same.

(given R = $\ln_2$ mΩ, L = 2 mH)



Sol. **[1]**

After charging, charge on capacitor = Cε

Now at t = 0 two circuits formed

1. Discharging of capacitor

$\therefore \mathbf{q} = C\,\varepsilon\, e^{-t/\tau_L} = C\varepsilon\, e^{-t/2RC}$

$\therefore i_1 = \frac{\varepsilon}{2R} e^{-t/2RC}$

2. Growth of current in L-R circuit

$i_2 = \frac{\varepsilon}{2R}\left[1 - e^{-t/\tau_L}\right]$

now $i_1 = i_2$

$\frac{\varepsilon}{2R}\, e^{-t/\tau_C} = \frac{\varepsilon}{2R}\left[1 - e^{-t/\tau_L}\right]$ …(1)

given $L = 4CR^2$

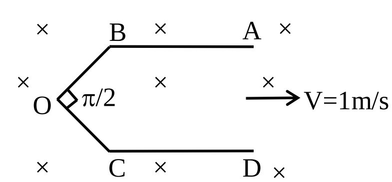
$\therefore \frac{L}{2R} = 2RC = \frac{1}{\ln 2}$

$\Rightarrow$ ln from equation (1) $2\,e^{-t\ln 2} = 1$

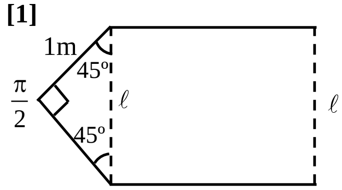
$\Rightarrow t \ln 2 = \ln 2$

$\Rightarrow t = 1$sec.

Q.3 A conductor ABOCD moves along its bisector with a velocity 1 m/s through a perpendicular magnetic field of 1 wb/m^2, as shown in figure. If all the four sides are 1 m length each, then the induced emf between A and D in approx is ….. volt



Sol. **[1]**



$V_A - V_D = V \times B \times \ell$

$= 1 \times 1 \times \sqrt{2}$

$= 1.41$ volt

sine rule $\frac{\ell}{\sin 90^o} = \frac{1}{\sin 45^o}$

$\Rightarrow \ell = \sqrt{2} = 1.414$

Q.4 A uniform disc of radius R having charge Q distributed uniformly all over its surface is placed on a smooth horizontal surface. A magnetic field $B = Kxt^2$, where K = constant, x is the distance (in metre) from the centre of the disc and t is the time (in second) is switched on perpendicular to the plane of the disc. The torque (in N - m) acting on the disc after 15 sec. (Take 2 KQ = 1 S.I. unit and R = 1 metre) in N - m is –

Sol. **[3]**

Consider a ring of thickness dx

Torque on this ring = QE × x

$E \times 2\pi x = \pi x^2 \times \frac{dB}{dt}$

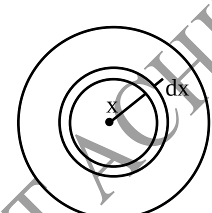
$E = \frac{x}{2} \times 2Kxt - Kx^2t$

charge on ring = $\frac{Q}{\pi R^2} \times 2\pi x dx$

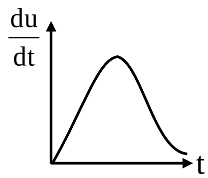
Torque on ring $= \frac{2Q}{R^2} x \times K\ x^2\ t \times xdx = \frac{2KQ}{R^2} x^4 t\ dx$

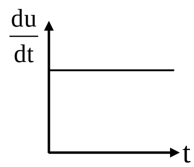
Total torque = $\int_0^R \frac{2KQ}{R^2} x^4 t\ dx = \left[\frac{2KQtx^5}{R^2 \times 5}\right]_0^R$

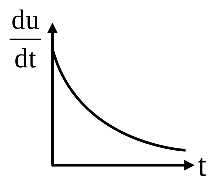
$= \frac{2KQR^3t}{5} = 3$ N- m

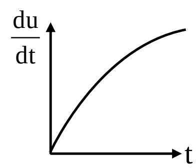


Q.1 Rate of increment of energy in an inductor with time in series LR circuit getting charge with battery of e.m.f. E is best represented by :
[inductor has initially zero current]

(A) 

(B) 

(C) 

(D) 

[A]

Sol. Rate of increment of energy in inductor

$= \frac{du}{dt} = \frac{d}{dt}\left(\frac{1}{2}Li^2\right) = Li\ \frac{di}{dt}$

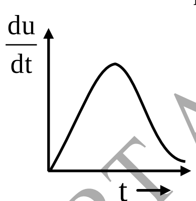
Current in the inductor at time t is :

$i = i_0\left(1 - e^{-\frac{t}{\tau}}\right)$ and $\frac{di}{di} = \frac{i_0}{\tau}\ e^{-\frac{t}{\tau}}$

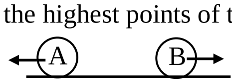
$\frac{du}{dt} = \frac{Li_0^2}{\tau}\ e^{-\frac{t}{\tau}}\ (1 - e^{-\frac{t}{\tau}})$

$\frac{du}{dt} = 0$ at $t = 0$ and $t = \infty$

Hence E is best represented by :

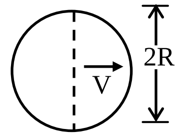


Q.2 Two identical conducting ring A and B of radius R are in pure rolling over a horizontal conducting plane with same speed (of center of mass) v but in opposite direction. A constant magnetic field B is present pointing inside the plane of paper. Then the potential difference between the highest points of the two rings, is:



(A) Zero (B) 2BvR
(C) 4BvR (D) None of these

[A]

Sol. 

Considering a projected length 2R on the ring in vertical plane. This length will move at a speed v perpendicular to the field.
This results in an induced emf:
e = Bv (2R) in the ring
In Ring ''A'' : $e_A = B(-V\ (2R)$
In Ring ''B'': $e_B = B(V)\ (2R) - B\ (-V)\ (2R) = 4$ BvR
Note- There will be no potential difference across a diameter due to rotation.

Q.3 A copper disc of radius 0.1 m is rotated about its centre with 20 revolution per second in a uniform magnetic field of 0.1 T with its plane perpendicular to the field. The emf induced across the radius of the disc is -

(A) $\frac{\pi}{20}$ volt (B) $\frac{\pi}{10}$ volt
(C) 20 π millivolt (D) 100 π millivolt

[C]

Sol. $\varepsilon = \frac{B\omega R^2}{2}$

$= \frac{0.1 \times (2\pi \times 20)(0.1)^2}{2}$

$= 20\ \pi \times 10^{-3}$ volt

Q.4 A current $I = 10\sin(100\pi\ t)$ amp. is passed in first coil, which induces a maximum e.m.f of 5π volt in second coil. The mutual inductance between the coils is -

(A) 10 mH (B) 15 mH
(C) 25 mH (D) 5 mH **[D]**

Sol. Let $I = I_0 \sin\omega t$,
where $I_0 = 10$, $\omega = 100\ \pi$

then $\varepsilon = M\ \frac{dI}{dt}$

$= M\ \frac{d}{dt}\ I_0 \sin \omega t$

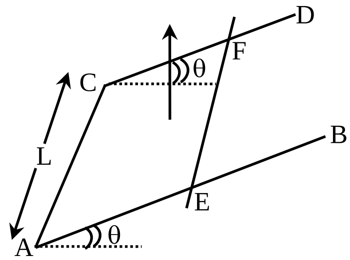
$= M\ I_0\omega \cos\omega t$

$\therefore\ \varepsilon_{max} = MI_0\omega$

$5\pi = M \times 10 \times 100\pi$

M = 5mH

Q. 5 AB and CD are smooth parallel rails, separated by a distance L and inclined to the horizontal at an angle θ. A uniform magnetic field of magnitude B, directed vertically upwards, exists in the region. EF is a conductor of mass m, carrying a current I. For EF to be in equilibrium :



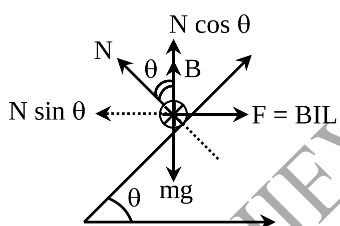
(A) I must flow from E to F

(B) BIL = mg cos θ

(C) BIL = mg sin θ

(D) BIL = mg

Sol. **[A]**



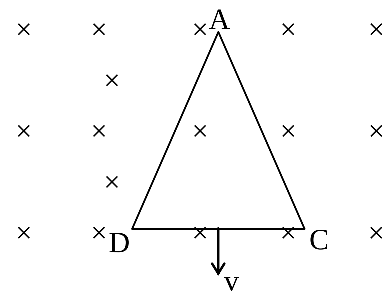
N cos θ = mg …..(1)

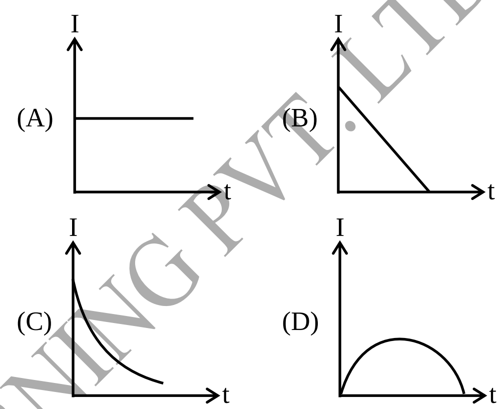
[⊗ indicates current I is flowing into the paper]

N sin θ = BIL …..(2)

$\therefore\ \tan\theta = \dfrac{BIL}{mg}$

Q. 6 An equilateral triangular loop ADC of uniform specific resistivity having some resistance is pulled with a constant velocity v out of a uniform magnetic field directed into the paper. At time t = 0 , side DC of the loop is at the edge of the magnetic field. The induced current (I) versus time (t) graph will be as :





Sol. **[B]**

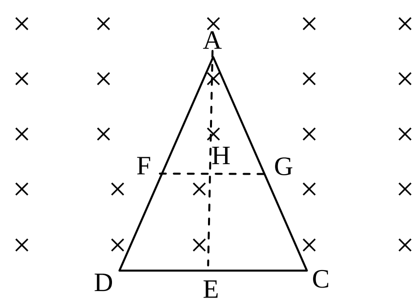
Let 2a be the side of the triangle and b the length AE.

$$\frac{AH}{AE} = \frac{GH}{EC}$$

$$\therefore\ GH = \left(\frac{AH}{AE}\right)EC$$

$$= \frac{b - vt}{b}.a = a - \left(\frac{a}{b}\right)vt$$

$$\therefore\ FG = 2GH = 2\left[a - \frac{a}{b}vt\right]$$



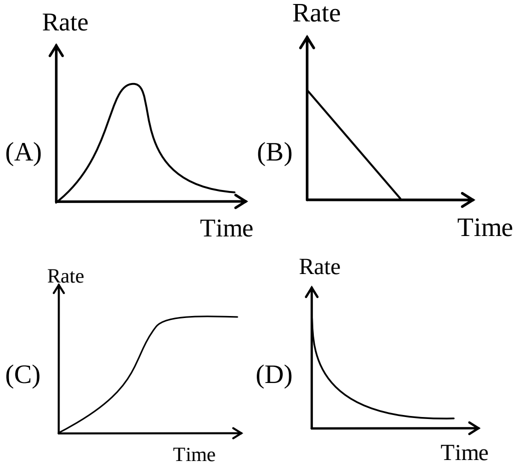
Induced e.m.f., $e = Bv(FG) = 2Bv\left(a - \frac{a}{b}vt\right)$

$\therefore$ Induced current, $I = \dfrac{e}{R} = \dfrac{2Bv}{R}\left[a - \dfrac{a}{b}vt\right]$

or $I = k_1 - k_2t$

Thus, I – t graph is a straight line with negative slope and positive intercept.

Q. 7 In a LR circuit connected to a battery the rate at which energy is stored in the inductor is plotted against time during the growth of current in the circuit. Which of the following best represents the resulting curve ?



Sol. **[A]**

$U = \frac{1}{2} LI_2$

Rate = $\frac{dU}{dt} = LI\left(\frac{dI}{dt}\right)$

At t = 0 , I = 0

$\therefore$ Rate = 0

At $t = \infty$, $I = I_0$ but $\frac{dI}{dt} = 0$, therefore, rate = 0

Q. 8 A voltmeter is connected across the terminals of a dc motor joined to a suitable battery. When the motor is used to rotate a machine X and current flows, the volt meter -

(A) reads the e.m.f. of the battery

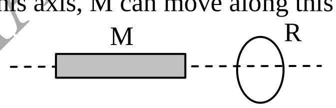
(B) reads the back e.m.f. in the motor

(C) reading is a measure of the power supplied toX

(D) reads the energy per coulomb supplied to X

[D]

Q. 9 A conducting ring R is placed on the axis of a bar magnet M. The plane of R is perpendicular to this axis, M can move along this axis.



(A) M will repel R when it is moving towards R

(B) M will attract R when it is moving towards R

(C) M will repel R when moving towards as well as away from R

(D) M will attract R when moving towards as well as away from R **[A]**

Q.10 A superconducting loop of radius R has self inductance L. A uniform and constant magnetic field B is applied perpendicular to the plane of the loop. Initially current in this loop is zero. The loop is rotated by 180º. The current in the loop after rotation is equal to -

(A) zero (B) $\frac{B\pi R^2}{L}$

(C) $\frac{2B\pi R^2}{L}$ (D) $\frac{B\pi R^2}{2L}$

Sol. **[C]**

Flux cannot change in a superconduction loop.

$\Delta\phi = 2\pi R^2 .B$

Initially current was zero, so self flux was zero.

$\therefore$ Finally $Li = 2\pi R^2 \times B$.

$i = \frac{2\pi R^2 \times B}{L}$

Q.11 Two circular coils can be arranged in any of the three situations shown in figure. their mutual inductance will be

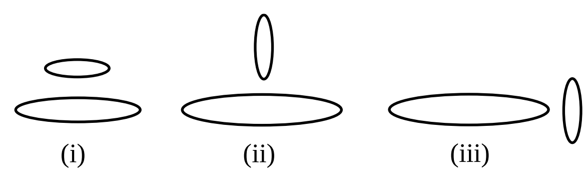


Fig.

(A) maximum in situation (i)

(B) maximum in situation (ii)

(C) maximum in situation (iii)

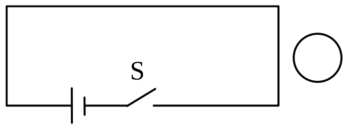
(D) the same in all situations **[A]**

Sol. As the mutual inductance of two coils will be maximum when there is minimum leakage of magnetic flux. In situation (1) we find that, magnetic flux linked with one coil threads fully through the other coil.

$\therefore$Mutual inductance is maximum in situation (1)

Therefore the answer is (A).

Q.12 Consider the situation shown in figure. If the switch is closed and after some time it is opened again, the closed loop will show-



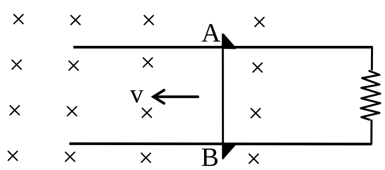
(A) an anticlockwise current-pulse

(B) a clockwise current-pulse

(C) an anticlockwise current-pulse and then a clockwise current-pulse

(D) a clockwise current-pulse and then an anticlockwise current-pulse **[D]**

Q.13 Consider the situation shown in figure. The wire AB is slid on the fixed rails with constant velocity v. If the wire AB is replaced by a semicircular wire, the magnitude of the induced current will-



(A) increase

(B) remain the same

(C) decrease

(D) increase or decrease depending on whether the semicircle bulges towards the resistance or away from it **[B]**

Q.14 Consider the following statements-

(a) An emf can be induced by moving a conductor in a magnetic field.

(b) An emf can be induced by changing the magnetic field.

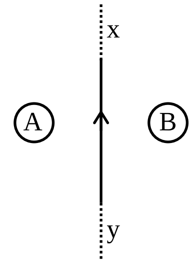
(A) Both a and b are true

(B) a is true but b is false

(C) b is true but a is false

(D) Both a and b are false **[A]**

Q.15 Consider the situation shown in figure . If the current I in the long straight wire xy is increased at a steady rate the induced current in loop A and B will be -



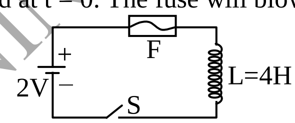
(A) clockwise in A and anticlockwise in B

(B) anticlockwise in A and clockwise in B

(C) clockwise in both A and B

(D) anticlockwise in both A and B **[A]**

Q.16 In the circuit shown the cell is ideal. The coil has an inductance of 4H and zero resistance. F is a fuse of zero resistance and will blow when the current through it reaches 5A.The switch is closed at t = 0. The fuse will blow -



(A) after 5 sec (B) after 2 sec

(C) after 10 sec (D) almost at once **[C]**

Sol. $E = L\frac{di}{dt}$

$di = \frac{E}{L}dt$

$i = \frac{E}{L}t$

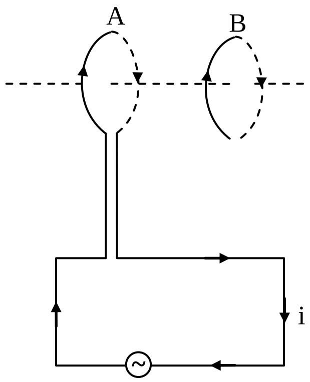
$i = \frac{2}{4}\times t$

$i = 0.5t$

$5 = 0.5t$

$t = 10$ sec

Q.17 Two circular coils A and B are facing each other as shown in figure. The current 'i' through A can be altered-



(A) there will be repulsion between A and B if i is increased

(B) there will be attraction between A and B if i is increased

(C) there will be neither attraction nor repulsion when i is changed

(D) attraction or repulsion between A and B depends on the direction of current, it does not depend whether the current is increased or decreased **[A]**

Q.18 Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other-

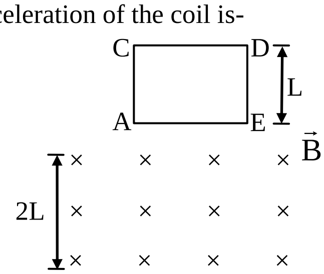
(A) the current in each loop will decrease

(B) the current in each loop will increase

(C) the current in each loop will remain the same

(D) the current in one loop will increase and in the other loop will decrease **[A]**

Q.19 A square coil ACDE with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length 2L. The acceleration of the coil is-



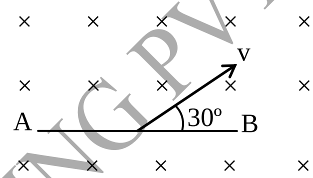
(A) less than g for all the time till the loop crosses the magnetic field completely

(B) less than g when it enters the field and greater than g when it comes out of the field

(C) g all the time

(D) less than g when it enters and comes out of the field but equal to g when it is within the field **[D]**

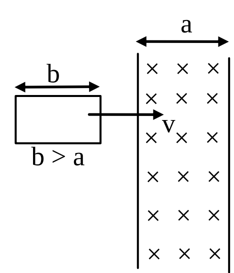
Q.20 A conducting rod AB of length ℓ = 1 m is moving at a velocity v = 4 m/s making an angle 30º with its length. A uniform magnetic field B = 2T exists in a direction perpendicular to the plane of motion. Then-



(A) $V_A - V_B = 8V$ (B) $V_A - V_B = 4V$

(C) $V_B - V_A = 8V$ (D) $V_B - V_A = 4V$ **[B]**

Q.21 In the given arrangement, the loop is moved with constant velocity v in a uniform magnetic field B in a restricted region of width 'a'. The time for which the emf is induced in the circuit is-



(A) $\frac{2b}{v}$ (B) $\frac{2a}{v}$

(C) $\frac{(a+b)}{v}$ (D) $\frac{2(a-b)}{v}$ **[B]**

Q.22 A uniform magnetic field exists in region given by $\vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$. A rod of length 5 m is placed along y-axis is moved along x-axis with constant speed 1 m/sec. Then induced e.m.f. in the rod will be-

(A) zero (B) 25 volt

(C) 20 volt (D) 15 volt **[B]**

Q.23 A solid conducting sphere of radius R is moved with a velocity V in a uniform magnetic field of strength B such that $\vec{B}$ is perpendicular to $\vec{V}$. The maximum e.m.f. induced between two points of the sphere is-

(A) 2 RBV (B) RBV

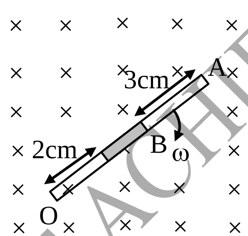
(C) $\sqrt{2}$ RBV (D) $\frac{RBV}{2}$ **[A]**

Q.24 A vertical rod of length ℓ is moved with constant velocity v towards East. The vertical component of the earth's magnetic field is B and the angle of dip is θ. The induced e.m.f. in the rod is-

(A) $B\ell v \cot\theta$ (B) $B\ell v \sin\theta$

(C) $B\ell v \tan\theta$ (D) $B\ell v \cos\theta$ **[A]**

Q.25 A rod of length 10 cm made up of conducting and non-conducting material (shaded part is non-conducting). The rod is rotated with constant angular velocity 10 rad/sec about point O, in constant magnetic field of 2 tesla as shown in the figure. The induced emf between the point A and B of rod will be-



(A) 0.029 volt (B) 0.1 volt

(C) 0.051 volt (D) 0.064 volt **[C]**

Q.26 The magnet in fig. rotates as shown on a pivot through its centre. At the instant shown, what are the directions of the induced currents

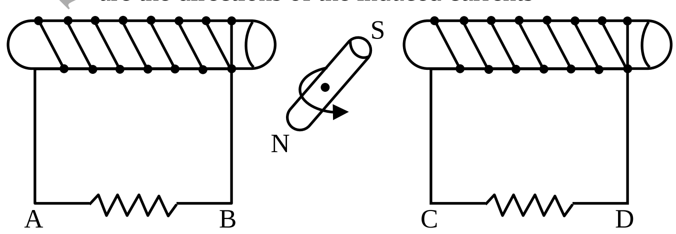


Fig.

(A) A to B and C to D

(B) B to A and C to D

(C) A to B and D to C

(D) B to A and D to C **[A]**

Sol. N pole moves closer to coil CD and S pole moves closer to coil AB on rotation of magnet.
According to Lenz's law, N pole should develop at the end corresponding to C.
∴ Induced current flows from C to D
Also S pole should develop at the end corresponding to B.
∴ Induced current flows from A to B
Therefore the answer is (A).

Q.27 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohm. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 weber/meter^2. The amount of charge flowing through the coil if it is turned over (rotated through 180°) will be-

(A) 1.6×10^{-19} C

(B) 1.6×10^{-9} C

(C) 1.6×10^{-3} C

(D) 1.6×10^{-2} C **[C]**

Q.28 A rod of length ℓ rotates with a small but uniform angular velocity ω about its perpendicular bisector. A uniform magnetic field B exists parallel to the axis of rotation. The potential difference between the two ends of the rod is-

(A) zero (B) $\frac{1}{2}\omega B\ell^2$

(C) $\omega B\ell^2$ (D) $2\omega B\ell^2$ **[A]**

Q.29 A conducting wire frame is placed in a magnetic field, which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced currents in wires AB and CD are

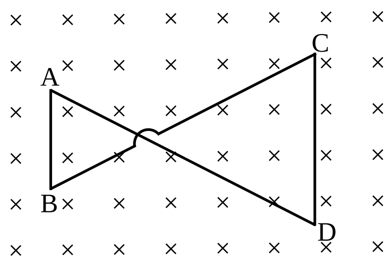


Fig.

(A) A to B and C to D

(B) B to A and C to D

(C) A to B and D to C

(D) B to A and D to C **[D]**

Sol. In the given question the magnetic field directed into the paper is increasing at a constant rate.

$\therefore$ induced current should produce a magnetic field directed out of the paper. Thus current in both loops must be anticlockwise.

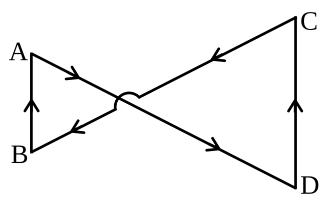


Fig.

Induced emf on right side of loop will be more as area of its loop on right side is more.

$$\left[\because e = -\frac{d\phi}{dt} = -A\frac{dB}{dt}\right]$$

$e \propto A$

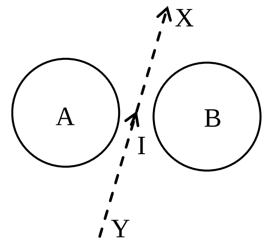
Hence the net current induced in the complete loop will be along DCBAD. Therefore the answer is (D).

Q.30 5.5×10^{-4} magnetic flux lines are passing through a coil of resistance 10 ohm and number of turns 1000. If the number of flux lines reduces to 5×10^{-5} in 0.1 sec. The electromotive force and the current induced in the coil will be respectively-

(A) 5 V, 0.5 A (B) 5×10^{-4} V, 5×10^{-4}A

(C) 50 V, 5 A (D) none of the above **[A]**

Q.31 Consider the situation shown in figure. If the current I in the long straight wire XY is increased at a steady rate then the induced emf's in loops A and B will be-



(A) clockwise in A, anticlockwise in B

(B) anticlockwise in A, clockwise in B

(C) clockwise in both A and B

(D) anticlockwise in both A and B **[A]**

Q.32 A thin copper wire of length 100 metres is wound as a solenoid of length ℓ and radius r. Its self inductance is found to be L. Now if the same length of wire is wound as a solenoid of length ℓ but of radius r/2, then its self inductance will be-

(A) 4 L (B) 2 L (C) L (D) L/2

[C]

Q.33 A square frame with side **a** as shown in Fig. is moved with a velocity v from a long straight wire carrying current I. Initial separation between straight long wire and square frame is **x**. Find the emf induced in the frame as a function of distance x.

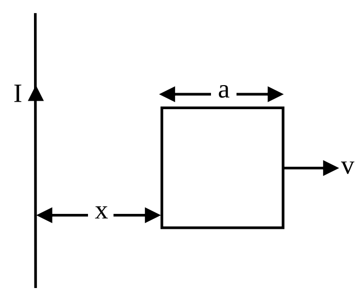


Fig.

(A) $\dfrac{\mu_0 I a^2 v}{2\pi x(x+a)}$ (B) $\dfrac{\mu_0 I a x v}{2\pi x(x+a)}$

(C) $\dfrac{\mu_0 I a^2 v}{4\pi x(x+a)}$ (D) Zero **[A]**

Sol. $\varepsilon_1 = \dfrac{\mu_0 I a v}{2\pi x}$

and $\varepsilon_2 = \dfrac{\mu_0 I a v}{2\pi(x+a)}$

$\varepsilon_{net} = \varepsilon_1 - \varepsilon_2$

$= \dfrac{\mu_0 I a v}{2\pi}\left[\dfrac{1}{x} - \dfrac{1}{x+a}\right]$

$= \frac{\mu_0 I a^2 v}{2\pi x(x+a)}$

Q.34 In the circuit shown X is joined to Y for a long time and then X is joined to Z. The total heat produced in R_2 is –

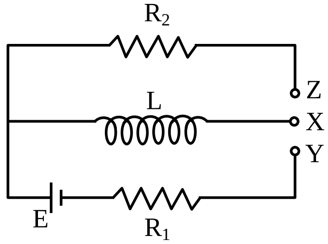


Fig.

(A) $\frac{LE^2}{2R_1^2}$ (B) $\frac{LE^2}{2R_2^2}$

(C) $\frac{LE^2}{2R_1R_2}$ (D) $\frac{LE^2R_2}{2R_1^3}$ **[A]**

Sol. Steady state current in L = $i_0 = \frac{E}{R_1}$ Energy stored in L = $\frac{1}{2}L\left(\frac{E}{R_1}\right)^2$ = heat produced in R_2 during discharge = $\frac{LE^2}{2R_1^2}$.

Q.35 How many meters of a thin wire are required to design a solenoid of length 1m and L = 1mH? Assume cross-sectional diameter is very small –

(A) 10 m (B) 40 m

(C) 70 m (D) 100 m **[D]**

Sol. Length of the wire $l = nl_0 2\pi r$ and $L = \mu_0 n^2 l_0 \pi r^2$

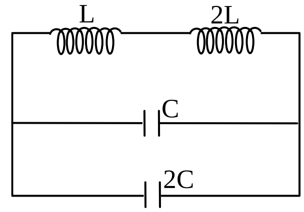
or $n = \sqrt{\frac{L}{\mu_0 l_0 \pi r^2}}$

Thus $l = \sqrt{\frac{L}{\mu_0 l_0 \pi r^2}}\, l_0 2\pi r$

$2\pi r = \sqrt{\frac{L l_0 4\pi}{\mu_0}}$

$= \sqrt{\frac{10^{-3}\times 1\times 4\pi}{4\pi\times 10^{-7}}}$ = 100 m

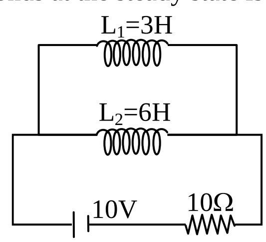
Q.36 The frequency of oscillation of current in the inductor is-



(A) $\frac{1}{3\sqrt{LC}}$ (B) $\frac{1}{6\pi\sqrt{LC}}$

(C) $\frac{1}{\sqrt{LC}}$ (D) $\frac{1}{2\pi\sqrt{LC}}$ **[B]**

Q.37 Two inductor coils of self inductance 3H and 6H respectively are connected with a resistance 10 Ω and a battery 10 V as shown in figure. The ratio of total energy stored in the inductors to that of heat developed in resistance in 10 seconds at the steady state is-



(A) $\frac{1}{10}$ (B) $\frac{1}{100}$

(C) $\frac{1}{1000}$ (D) 1 **[B]**

Q.38 Find the steady state current through L_1 in the Fig. –

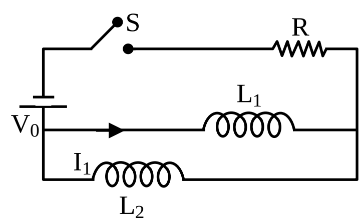


Fig.

(A) $\frac{V_0}{R}$ (B) $\frac{V_0L_1}{R(L_1+L_2)}$

(C) $\frac{V_0L_2}{R(L_1+L_2)}$ (D) None of these

[C]

Sol. $I_0 = \dfrac{V_0}{R}$ divide the current in L_1 and L_2 like resistors $I_1 = I_0 \dfrac{L_2}{L_1 + L_2}$

Q.39 A square wire frame of side a is placed a distance b away from a long straight conductor carrying current I. The frame has resistance R and self inductance L. The frame is rotated by 180º about OO′ as shown in Fig. Find the electric charge flown through the frame –

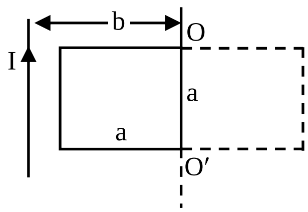


Fig.

(A) $\dfrac{2\mu_0 i a^2}{2\pi R b}$ (B) $\dfrac{\mu_0 i}{2\pi R}\log_e \dfrac{b+a}{b-a}$

(C) $\dfrac{\mu_0 i a}{2\pi R}\log_e \dfrac{b+a}{b-a}$ (D) None of these

[C]

Sol. $i = \dfrac{1}{R}\left[\dfrac{d\phi}{dt} + L\dfrac{di}{dt}\right]$

$q = \int i dt = \dfrac{1}{R}[\Delta\phi + 0] = \dfrac{\Delta\phi}{R} = \dfrac{1}{R}\int_{b-a}^{b+a} Badx$

$= \dfrac{1}{R}\int_{b-a}^{b+a} \dfrac{\mu_0 i a}{2\pi x} dx = \dfrac{\mu_0 i a}{2\pi R}\log_e \dfrac{b+a}{b-a}$

Q.40 Find the steady state current through L_1 in the Fig. –

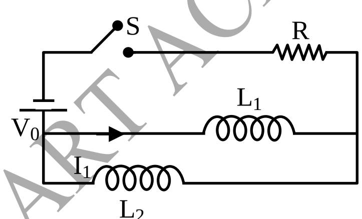


Fig.

(A) $\dfrac{V_0}{R}$ (B) $\dfrac{V_0 L_1}{R(L_1+L_2)}$

(C) $\dfrac{V_0 L_2}{R(L_1+L_2)}$ (D) None of these

[C]

Sol. $I_0 = \dfrac{V_0}{R}$ divide the current in L_1 and L_2 like resistors $I_1 = I_0 \dfrac{L_2}{L_1 + L_2}$

Q.41 Mutual inductance in Fig. shown is –

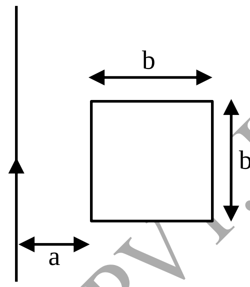


Fig.

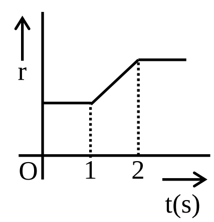
(A) Zero (B) $\dfrac{\mu_0 b}{2\pi}\log_e \dfrac{a}{b}$

(C) $\dfrac{\mu_0 b}{2\pi}\log_e\left(1+\dfrac{b}{a}\right)$ (D) $\dfrac{\mu_0 b}{2\pi}\log_e\left(1+\dfrac{a}{b}\right)$

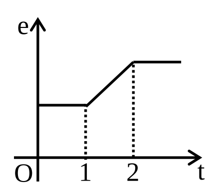
[C]

Sol. $B = \dfrac{\mu_0 I}{2\pi y}$ $d\phi = Bbdy$

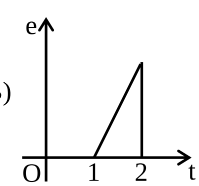
Q.42 A circular coil is placed in uniform magnetic field such that its plane is perpendicular to field. The radius of coil changes with time as shown in the figure . Then which of the following graph represent the induced emf in the coil with time –



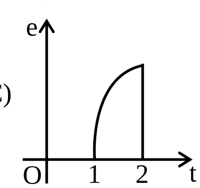
(A)



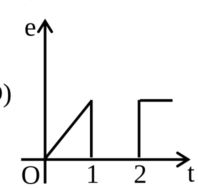
(B)



(C)

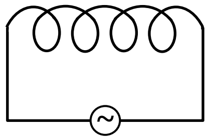


(D)



[B]

Q.43 If a Bismuth rod is introduced in the air coil as shown then current in the coil –



$V = 10 \sin \omega t$

Fig.

(A) increases
(B) remains unchanged
(C) decreases
(D) None of these **[A]**

Sol. L will decrease as Bi is diamagnetic

$\therefore I = \dfrac{V}{X_L}$ will increase

Q.44 As a result of change in magnetic flux linked to the closed loop shown in Fig., an emf V volt is induced in the loop. The work done in taking a charge Q coulomb once along the loop is –

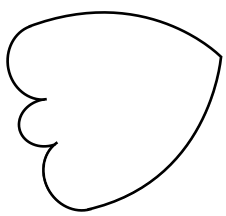
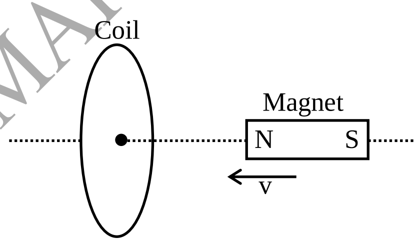


Fig.

(A) QV (B) 2QV
(C) QV/2 (D) Zero **[A]**

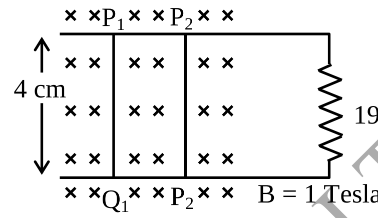
Sol. QV because induced electric field so generated is non conservative i.e. $\oint E.dl = V$.

Q.45 In the figure, the magnet is moved towards the coil with a speed **v** and induced emf is **e**. If magnet and coil recede away from one another each moving with speed v the induced emf of the coil will be-



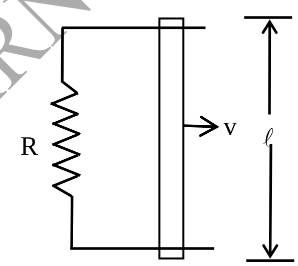
(A) e. (B) 2e
(C) e/2 (D) 4e **[B]**

Q.46 In figure , wires P_1Q_1 and P_2Q_2, both are moving towards right with speed 5 cm/sec. Resistance of each wire is 2Ω. Then current through 19Ω resistor is –



(A) 0 (B) 0.1 mA
(C) 0.2 mA (D) 0.3 mA **[B]**

Q.47 A conducting rod of resistance r moves uniformly with a constant speed v. If the rod keeps moving uniformly, then the amount of force required is –



(A) $\dfrac{vB^2\ell^2}{R}$ (B) $\dfrac{2vB^2\ell^2}{(R+r)}$

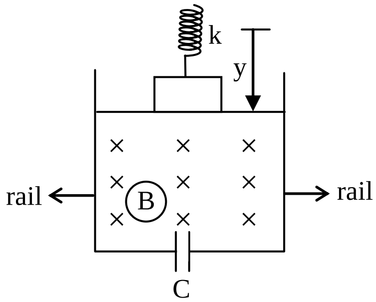
(C) $\dfrac{vB^2\ell^2}{(R+r)}$ (D) zero **[C]**

Sol. $F = I\ell B$

$= \dfrac{vB\ell}{(R+r)}\ell B$

$= \dfrac{vB^2\ell^2}{(R+r)}$

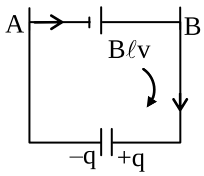
Q.48 A heavy block is attached to the ceiling by a spring that has a force constant 'k'. A conducting rod is attached to block. The combined mass of the block and the rod is m. The rod can slide without friction along two vertical parallel rails, which are a distance L apart. A capacitor of known capacitance C is attached to the rails by the wires. The entire system is placed in a uniform magnetic field B. Find the time period T of the vertical oscillations of the block. Neglect the electrical resistance of the rod and all wires –



(A) $2\pi\sqrt{\frac{m+CB^2L^2}{k}}$ (B) $2\pi\sqrt{\frac{m^2+CBL}{k}}$

(C) $4\pi\sqrt{\frac{m^2+CB^2L^2}{k}}$ (D) None of these **[A]**

Sol.



Using Kirchoff 's equation

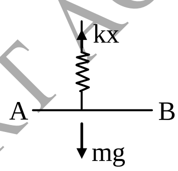
$\frac{+q}{C} - B\ell v = 0$ [Where $v = \frac{dy}{dt}$]

$q = CB\ell v$

$i = \frac{dq}{dt} = CB\ell \frac{dv}{dt}$

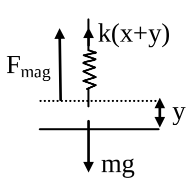
Magnetic force on AB bar or block = $Bi\ell$

$F_{mag} = B^2\ell^2C \frac{dv}{dt}$



For initial equilibrium,

kx = mg ... (1)



$mg - k(x + y) - B^2\ell^2C\frac{dv}{dt} = ma$ ... (2)

$mg - kx - ky - B^2\ell^2Ca = ma$

$a = \frac{-k}{m + B^2\ell^2Ca}y$

Comparing equation of a by $a = -\omega^2 y$

$\omega = \sqrt{\frac{k}{m+B^2\ell^2C}}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m+CB^2L^2}{k}}$

Q.49 A long solenoid of radius 2 cm has 100 turns/cm and is surrounded by a 100 turn coil of radius 4 cm having a total resistance 20Ω. If current changes from 5 A to – 5A, find the charge through galvanometer.

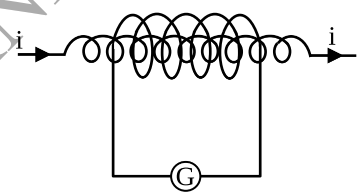


Fig.

(A) Zero (B) 800 μc

(C) 400 μC (D) 600 μC **[B]**

Sol. $\phi = B\pi r^2$ $\varepsilon = \frac{d\phi}{dt} = N\pi r^2\frac{dB}{dt}$

$= N\pi r^2\mu_0 n\frac{di}{dt}$

$I = \frac{\varepsilon}{R}$ and $\Delta Q = I\Delta t = \frac{N\pi r^2\mu_0 n}{R}\Delta t$

$\Delta Q = \frac{100\times\pi\times(2\times10^{-2})^2\times10^4\times4\pi\times10^{-7}\times10}{20}$

$= 8 \times 10^{-4}c = 800\ \mu C$

Q.50 A thin circular ring of area A is held perpendicular to a uniform magnetic field of induction B. A small cut is made in ring and a galvanometer is connected across the ends such that total resistance of the circuit is R. When the ring is suddenly squeezed to zero area, the charge flowing through the galvanometer is -

(A) $\frac{BR}{A}$ (B) $\frac{AB}{R}$

(C) ABR (D) $\frac{B^2A}{R^2}$

Sol. [B] $\phi_1 = BA\cos 0° = BA$

$\phi_2 = B(0)\cos\theta = 0$

$\Rightarrow q_{ind} = -\frac{d\phi}{R} = \frac{BA}{R}$

Q.1 A circular loop of wire 10 cm in diameter is placed with its normal making an angle of 30º with the direction of a uniform 5000-gauss magnetic field. The loop is "wobbled" so that its normal rotates about the field direction at the constant rate of 100 rev/min; the angle between the normal and the field direction (= 30º) remains unchanged during this process. What emf appears in the loop?

Ans. Zero

Q.2 In (Fig.) the magnetic flux through the loop perpendicular to the plane of the coil and directed into the paper is varying according to the relation

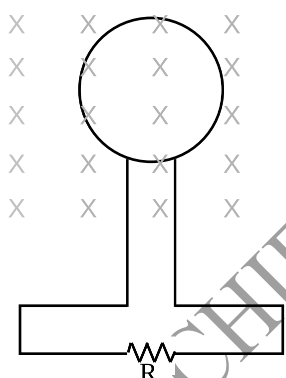
$$\Phi_B = 6t^2 + 7t + 1,$$

where Φ_B is in milliweber

(1 milliweber = 10^{-3} weber) and t is in second.

(a) What is the magnitude of the emf induced in the loop when t = 2 s ?

(b) What is the direction of the current through R ?



Ans. (a) 31mV (b) from left to right

Q.3 A long solenoid has magnetic field induction $3{\cdot}8 \times 10^{-2}$ T at its centre. A 100 turn close-packed coil of diameter 2 cm is placed at the centre of the solenoid. This coil is arranged so that at the centre of the solenoid is parallel to its axis. The current in the solenoid is reduced to zero and then raised to its initial value in other direction at a steady rate over a period of 0·05 s. What induced emf appears in the coil while the current is being changed ?

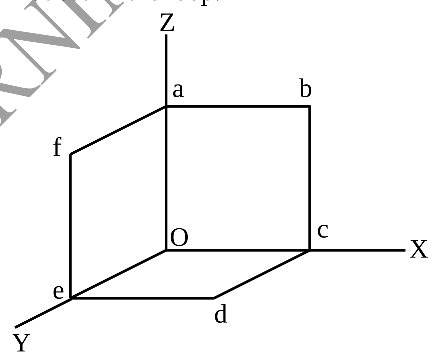
Ans. – 48 mV

Q.4 You are given 50 cm of copper wire (diameter = 0.040 in.). It is formed into a circular loop and placed at right angles to a uniform magnetic field that is increasing with time at the constant rate of 100 gauss/s. At what rate is Joule heat generated in the loop?

[Resistivity of copper = $1.7 \times 10^{-8}\ \Omega$ m]

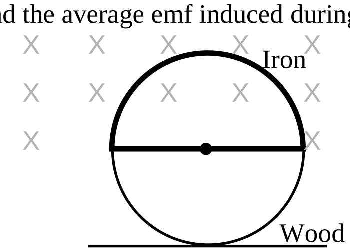
Ans. 3.8×10^{-6} watt

Q.5 Figure shows a conducting loop abcdefa made of six segments *ab, bc, cd, de, ef* and *fa,* each of length *l*. Each segment makes a right angle with the next so that abc is in the *X*–*Z* plane, cde in *X*–*Y* plane and efa in the *Y*–*Z* plane. A uniform magnetic field *B* exists along the *X*–axis. If the magnetic field changes at a rate , find the emf induced in the loop.



Ans. $\frac{dB}{dt} l^2$

Q.6 Figure shows a circular wheel of radius 10·0 cm whose upper half, shown dark in the figure, is made of iron and the lower half of wood. The two junctions are joined by an iron rod. A uniform magnetic field *B* of magnitude $2{\cdot}00 \times 10^{-4}$ T exists in the space above the central line as suggested by the figure. The wheel is set into pure rolling on the horizontal surface. If it takes 2·00 seconds for the iron part to come down and the wooden part to go up, find the average emf induced during this period.



Ans. $1{\cdot}57 \times 10^{-6}$ V

Q.7 A circular coil of one turn of radius 5·0 cm is rotated about a diameter with a constant angular speed of 80 revolutions per minute. A uniform magnetic field B = 0·010 T exists in a direction perpendicular to the axis of rotation. Find (a) the maximum emf induced, (b) the average emf induced in the coil over a long period and (c) the average of the squares of emf induced over a long period.

Ans. (a) $6·6 \times 10^{-4}$ V (b) zero (c) $2·2 \times 10^{-7}$ V^2

Q.8 A conducting circular loop of face area $2·5 \times 10^{-3}$ m^2 is placed perpendicular to a magnetic field which varies as $B = (0·20\text{ T}) \sin[(50\pi\text{ s}^{-1})t]$.

(a) Find the charge flowing through any cross-section during the time t = 0 to t = 40 ms.

(b) If the resistance of the loop is 10 Ω, find the thermal energy developed in the loop in this period.

Ans. (a) 0, (b) $1·25 \times 10^{-5}$ J

Q.9 Calculate the coefficient of self-induction of a solenoid of 2000 turns, length 0.5 m and radius 5 cm with

(a) air core and

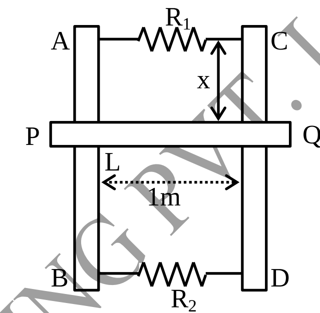
(b) soft iron core. The magnetic permeability constant for soft iron = 1000

Ans. (a) 78.96 mH, (b) 78.96H

Q.10 Calculate the time constant τ of a straight solenoid of length l = 1.0 m having a single-layer winding of copper wire whose total mass is equal to m = 1.0 kg. The cross-sectional diameter of the solenoid is assumed to be considerably less than its length. Given, density of copper = 9×10^3 kg m^{-3} and resistively of copper = 1.7×10^{-8} Ω m.

Ans. $\tau = \frac{\mu_0}{4\pi}\frac{m}{\ell\rho\rho_0}$ = 0.7 ms, where ρ is the resistivity. ρ_0 is the density of copper.

Q.11 Two parallel vertical metallic rails AB and CD are separated by 1m. They are connected at the two ends by resistances R_1 and R_2 as shown in the figure. A horizontal metallic bar L of mass 0.2 kg slides without friction, vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6 T perpendicular to the plane of the rails. If it is observed that when the terminal velocity is attained, the powers dissipated in R_1 and R_2 are 0.76 W and 1.2 W respectively. Find the terminal velocity of the bar L and the values of R_1 and R_2. **[IIT-1994]**



Ans. $V_t = 1$ ms^{-1}, R_1 = 0.474 Ω, R_2 = 0.3 Ω

Q.12 The current in a discharging LR circuit without the battery drops from 2·0 A to 1·0 A in 0·10 s. (a) Find the time constant of the circuit. (b) If the inductance of the circuit is 4·0 H, what is its resistance ?

Ans. (a) 0.144 sec. (b) 27.7Ω

Q.13 A coil of inductance 2 henry and resistance 10 Ω are in closed series circuit with an open key and a cell of constant 100 volt with negligible resistance. At time t = 0, the key is closed. Find:

(i) the time constant of the circuit

(ii) the maximum steady current in the circuit

(iii) the current in the circuit at 't' = 1 second

(iv) the energy stored in the magnetic field linked with the coil at the steady state.

Ans. [(i) 0.2s (ii) 10 A (iii) 9.933A (iv) 100 J]

Q.14 A source of steady potential difference of 10 V with negligible internal resistance is applied across a coil of inductance 0.5 H and resistance 2.5 Ω. Find:

(i) the current in the coil after 0.2 second

(ii) the time after switching on the p.d. for the current to attain a value 2A.

If after attaining the steady state the source of p.d. is shorted, find

(iii) the time taken after the shorting for the current to reduce to half its original steady value.

Ans. (i) 2.528 A (ii) 0.1386 s (iii) 0.1386 s

Q.15 A solenoid 85·0 cm long has a cross-sectional area of 17·0 cm^2. There are 95·0 turns of wire carrying a current of 6·6 A.

(a) Calculate the energy density of the magnetic field inside the solenoid.

(b) Find the total energy stored in the magnetic field there.

Ans. (a) 0.020 J/m^3 (b) 29 μJ

Q.16 A thin uniformly charged ring of radius a = 10 cm rotates about its axis with an angular velocity ω = 100 rad/s. Find the ratio of volume energy densities of magnetic and electric fields on the axis of the ring at a point removed from its centre by a distance $l = a$.

Ans. $w_m/w_e = \varepsilon_0 \mu_0 \omega^2 a^4 / \ell^2 = 1.1 \times 10^{-15}$

Q.17 A power transformer is used to step up an alternating e.m.f. of 200 V to 4 kV and to transmit 5kW power. If the primary consists of 1000 turns, calculate

(i) the number of turns in the secondary and

(ii) the current rating of the secondary

(Assume the transformer to be ideal)

Ans. [(i) 20000 (ii) 1.25 A]

Q.18 A solenoid of length 20 cm, area of cross-section 4·0 cm^2 and 4000 turns is placed inside another solenoid of 2000 turns having a cross-sectional area 8·0 cm^2 and length 10 cm. Find the mutual inductance between the solenoids.

Ans. $2 \cdot 0 \times 10^{-2}$ H

Q.19 The windings of a transformer have an inductance L_1 = 6 H, L_2 = 0.06 H and a coefficient of coupling K = 0.9. Find the emf induced in both windings when the primary current increases at the rate of 1000 A/s. (L_1 is inductance of primary winding)

Ans. 540 V

Q.20 Two coils, A of 5000 turns and B of 3000 turns lie in parallel planes. A current of 6A in coil A produces a flux of 0.1 mwb with one turn of coil B. If 60% of the flux produced by coil A links with the turns of coil B, calculate the emf induced in coil B when the current in coil A changes from 5A to –5A in 0.01 second.

Ans. e_M = 30V