Exercise-1

✍ **Marked Questions can be uesed as Revision Questions.**

OBJECTIVE QUESTION

Section (A) : Flux And Faraday's laws of electromagnetic induction

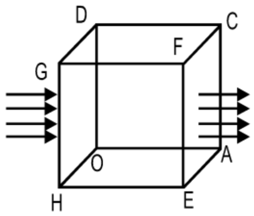
A-1 The horizontal component of earth's magnetic field is 3×10^{-5} Wb/m^2. The magnetic flux linked with a coil of area 1 m^2 and having 5 turns, whose plane is normal to the magnetic field, will be -
(1) 3×10^{-5} Wb (2) 5×10^{-5} Wb (3) 15×10^{-5} Wb (4) 1×10^{-5} Wb

A-2 Tesla is a unit of
(1) magnetic flux (2) magnetic flux density
(3) electric flux (4) self inductance

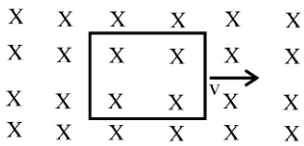
A-3✍ The formula of the induced emf due to rate of change of magnetic flux passing through a coil will be-
(1) $e = -\frac{d}{dt}(\vec{B}.\vec{A})$ (2) $e = \frac{d\vec{B}}{dt}$
(3) $e = -\vec{A}.\left(\frac{d\vec{B}}{dt}\right)$ (4) $e = -\vec{B}.\frac{d\vec{A}}{dt}$

A-4 Unit of magnetic flux density is
(1) weber/metre (2) weber (3) weber/m^2 (4) ampere/m

A-5✍ A cube of side a is placed in a magnetic field B. The magnetic flux emerging out of the cube will be -
(1) Ba^2
(2) –Ba^2
(3) 2Ba^2
(4) zero

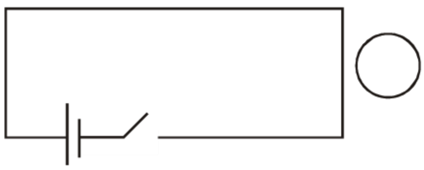


A-6✍ A conducting square loop of side ℓ and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A uniform and constant magnetic field B exists along the perpendicular to the plane of the loop in fig. The current induced in the loop is -



(1) $B\ell\upsilon/R$ clockwise (2) $B\ell\upsilon/R$ anticlockwise
(3) $2B\ell\upsilon/R$ anticlockwise (4) zero

A-7✍ Consider the situation shown in fig. If the switch is closed and after some time it is opened again, the closed loop will show
(1) an anticlockwise current-pulse
(2) a clockwise current-pulse
(3) an anticlockwise current-pulse and then a clockwise current-pulse
(4) a clockwise current-pulse and then an anticlockwise current-pulse



A-8✍ Solve the previous question if the closed loop is completely enclosed in the circuit containing the switch.
(1) an anticlockwise current-pulse
(2) a clockwise current-pulse
(3) an anticlockwise current-pulse and then a clockwise current-pulse
(4) a clockwise current-pulse and then an anticlockwise current-pulse

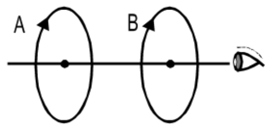
A-9 A small, conducting circular loop is placed inside a long solenoid carrying a current. The plane of the loop contains the axis of the solenoid. If the current in the solenoid is varied, the current induced in the loop is
(1) clockwise (2) anticlockwise (3) zero
(4) clockwise or anticlockwise depending on whether the resistance in increased or decreased.

Section (B) : Lenz's Law

B-1 Lenz's law is based on the law of conservation of -
(1) charge (2) momentum (3) mass (4) energy

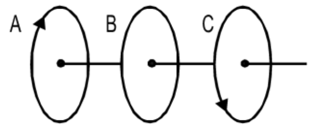
B-2 A bar magnet is dropped vertically downward through a metal ring held horizontally. The acceleration of falling magnet will be -
(1) equal to g (2) greater than g
(3) less than g (4) dependent on the radius of the ring

B-3 Two identical coils A and B are arranged coaxially as shown in the figure and the sign convention adopted is that the direction of currents are taken as positive when they flow in the direction of arrows. Which of the following statements is correct



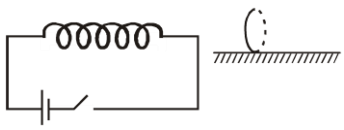
(1) If A carries a steady positive current and A is moved towards B, than a positive current is induced in B.
(2) If A carries a steady positive current and B is moved towards A, then a negative current is induced in B
(3) If both coils carry positive current, then the coils repel each other.
(4) If a positive current flowing in A is switched off, then a negative current is induced momentarily in B

B-4 Three identical coils A, B and C are placed coaxially with their planes parallel to each other. The coil A and C carry equal currents in opposite direction as shown. The coils B and C are fixed and the coil A is moved towards B with a uniform speed, then (consider no effect of A on C)



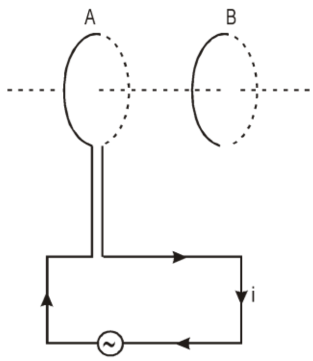
(1) there will be induced current in coil B which will be opposite to the direction of current in A
(2) there will be induced current in coil B in the same direction as in A.
(3) there will be no induced current in B.
(4) current induced by coils A and C in coil B will be equal and opposite, therefore net current in B will be zero

B-5 Fig. shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a frictionless track, the axis of the ring being along the axis of the solenoid. As the switch is closed, the ring will



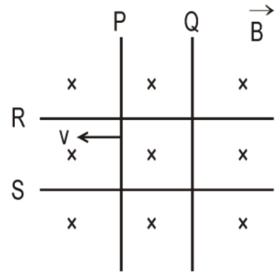
(1) remain stationary
(2) move towards the solenoid
(3) move away from the solenoid
(4) move towards the solenoid or away from it depending on
which terminal (positive or negative) of the battery is connected to the left end of the solenoid.

B-6 Two circular coils A and B are facing each other as shown in figure. The current i through A can be altered



(1) there will be repulsion between A and B if i is increased
(2) there will be attraction between A and B if i is increased
(3) there will be neither attraction nor repulsion when i is changed
(4) attraction or repulsion between A and B depends on the direction of current. It does not depend whether the current is increased or decreased.

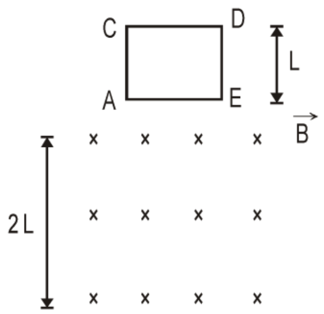
B-7✍ Two identical conductors P and Q are placed on two frictionless fixed conducting rails R and S in a uniform magnetic field directed into the plane. If P is moved in the direction shown in figure with a constant speed, then rod Q



(1) will be attracted towards P
(2) will be repelled away from P
(3) will remain stationary
(4) may be repelled or attracted towards P

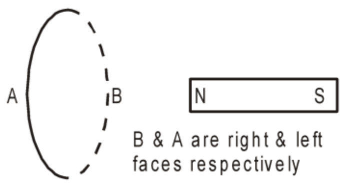
B-8 Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other
(1) the current in each loop will decrease
(2) the current in each loop will increase
(3) the current in each loop will remain the same
(4) the current in one loop will increase and in the other loop will decrease

B-9✍ 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



(1) less than g for all the time till the loop crosses the magnetic field completely
(2) less than g when it enters the field and greater than g when it comes out of the field
(3) g all the time
(4) less than g when it enters and comes out of the field but equal to g when it is within the field

B-10✍ In the figure shown, the magnet is pushed towards the fixed ring along its axis and it passes through the ring.



(1) when magnet goes towards the ring the face B becomes south pole and the face Abecomes north pole
(2) when magnet goes away from the ring the face B becomes north pole and the face Abecomes south pole
(3) when magnet goes away from the ring the face A becomes north pole and the face B becomes south pole
(4) the face A will always be a north pole.

Section (C) : Induced EmF in a moving rod in uniform magnetic field

C-1 A wire of length 2m is moving with a velocity of 1 m/s normal to a magnetic field of 0.5 Wb/m^2. The emf induced in it will be - $(\ell \perp \vec{v})$

(1) 0.5 V (2) 0.1 V (3) 2 V (4) 1 V

C-2 An aeroplane having a distance of 50 m between the edges of its wings is flying horizontally with a speed of 720 km/hour. If the vertical component of the earth's magnetic field is 2×10^{-4} Wb/m^2, then the induced emf will be -

(1) 2mV (2) 2V (3) 200V (4) 0.2mV

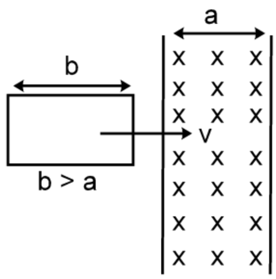
C-3 A straight conductor of length 0.4 m is moved in a magnetic field of 0.9 weber/m^2 with a velocity of 7 m/s. The maximum emf induced in the conductor will be -

(1) 2.52 V (2) 25 V (3) 2.8 V (4) 63 V

C-4 A conducting rod is moved with a constant velocity $\vec{\upsilon}$ in a magnetic field. A potential difference appears across the two ends

(1) if $\vec{\upsilon} \,||\, \vec{\ell}$ (2) if $\vec{\upsilon} \,||$ (3) if $\vec{\ell} \,||\, \vec{B}$ (4) none of these

C-5 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:



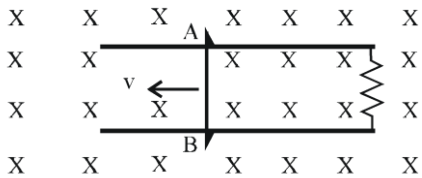
(1) $\frac{2b}{v}$ (2) $\frac{2a}{v}$

(3) $\frac{(a+b)}{v}$ (4) $\frac{2(a-b)}{v}$

C-6 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:

(1) zero (2) 25 v (3) 20 v (4) 15 v

C-7 Consider the situation shown in fig. The resistanceless wire AB is slid on the fixed rails with a constant velocity. If the wire AB is replaced by a resistanceless semicircular wire, the magnitude of the induced current will



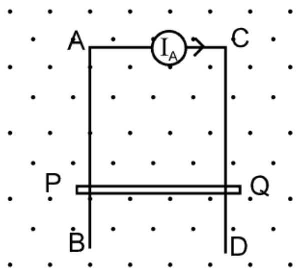
(1) increase (2) remain the same

(3) decrease

(4) increase or decrease depending on whether the semicircle bulges towards the resistance or away from it.

Section (D) : Circuit Problems & Mechanics

D-1 AB and CD are fixed conducting smooth rails placed in a vertical plane and joined by a constant current source at its upper end. PQ is a conducting rod which is free to slide on the rails. A horizontal uniform magnetic field exists in space as shown. If the rod PQ is released from rest then,



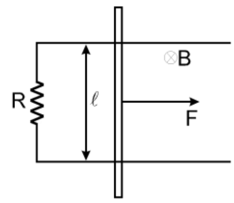
(1) The rod PQ may move downward with constant acceleration

(2) The rod PQ may move upward with constant acceleration

(3) The rod will move downward with decreasing acceleration and finally aquire a constant velocity

(4) either A or B.

D-2 A constant force F is being applied on a rod of length 'ℓ' kept at rest on two parallel conducting rails connected at ends by resistance R in uniform magnetic field B as shown.



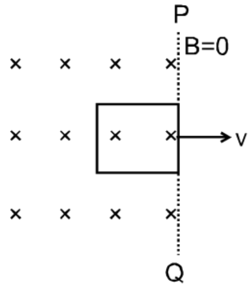
(1) the power delivered by force will be constant with time

(2) the power delivered by force will be increasing first and then will decrease

(3) the rate of power delivered by the external force will be increasing continuously

(4) the rate of power delivered by external force will be decreasing continuously.

D-3✍ Figure shows a square loop of side 0.5 m and resistance 10 Ω. The magnetic field on left side of line PQ has a magnitude B = 1.0T. The work done in pulling the loop out of the field uniformly in 2.0 s is



(1) 3.125×10^{-3} J
(2) 6.25×10^{-4} J
(3) 1.25×10^{-2} J
(4) 5.0×10^{-4} J

Section (E) : Induced emf in a rod, Ring, Disc rotating in a uniform magnetic field

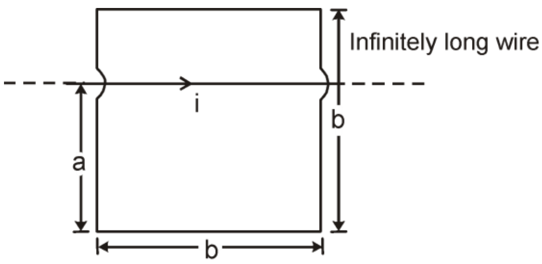
E-1 A conductor of length L is rotated about an axis passing through one end of it with an angular velocity ω in a normal and uniform magnetic field B. The emf induced between its end will be -

(1) ωBL^2 (2) $\frac{\omega BL^2}{2}$ (3) $2\,\omega BL^2$ (4) ωBL

E-2 A metal rod of length L is placed normal to a magnetic field and rotated in a circular path with frequency f. The potential difference between it ends will be -

(1) $\pi L^2 Bf$ (2) BL/f (3) $\pi L^2 B/f$ (4) fBL

E-3✍ For the situation shown in the figure, flux through the square loop is :



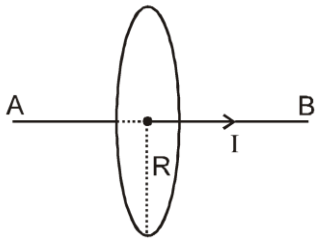
(1) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{a}{2a-b}\right)$

(2) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{2b-a}\right)$

(3) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{b-a}\right)$

(4) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{2a}{b-a}\right)$

E-4✍ A long conductor AB lies along the axis of a circular loop of radius R. If the current in the conductor AB varies at the rate of I ampere/second, then the induced emf in the loop is



(1) $\frac{\mu_0 IR}{2}$ (2) $\frac{\mu_0 IR}{4}$

(3) $\frac{\mu_0 \pi IR}{2}$ (4) zero

Section (F) : Fixed loop in a time varying magnetic field & Induced electric field

F-1 One ampere current ($I = I_0 \sin\omega t$)of frequency n_1 is passed through a coil and then same amount of current of frequency n_2 is passed. If the magnitude of maximum induced emf's in the two cases are ε_1 and ε_2 respectively, then $\varepsilon_1 : \varepsilon_2$ will be -

(1) $n_2 : n_1$ (2) $n_1^2 : n_2^2$ (3) $n_1 : n_2$ (4) $n_2^2 : n_1^2$

F-2✍ Current passing through a coil is changing at the rate of 1.5 ampere per second. If it induces emf of 45 volt, then the self inductance of the coil will be -

(1) 30 H (2) 67.5 H (3) 60 H (4) 33.3 H

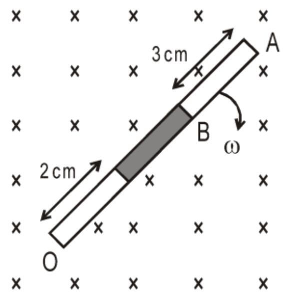
F-3 The resistance of a coil is 5 ohm and a current of 0.2 A is induced in it due to a varying magnetic field. The rate of change of magnetic flux in it will be -

(1) 0.5 Wb/s (2) 0.05 Wb/s (3) 1 Wb/s (4) 20 Wb/s

F-4✍ A rod of length ℓ rotates with a 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

(1) zero (2) $\frac{1}{2}\omega B\ell^2$ (3) $B\omega\ell^2$ (4) $2B\omega\ell^2$

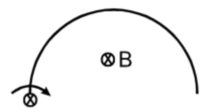
F-5✍ A rod of length 10 cm made up of conducting and non-conducting material (shaded part is non-conducting). The rod is rotated with constant angular velocity 10 rad/sec about point O, in constant magnetic field of 2 tesla as shown in the figure. The induced emf between the point A and B of rod will be



(1) 0.029 v (2) 0.1 v

(3) 0.051 v (4) 0.064 v

F-6✍ A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is



: (1) $B\omega R^2/2$ (2) $2B\omega R^2$ (3) is variable (4) none of these

Section (G) : Self induction, self inductance self induced emF & Magnetic energy density

G-1 If the length and area of cross-section of an inductor remain same but the number of turns is doubled, its self-inductance will become -

(1) half (2) four times (3) double (4) one-fourth

G-2 Dimensions of coefficient of self-induction are -

(1) $MLT^{-2}A^{-2}$ (2) $ML^{-2}T^{-2}A^{-2}$ (3) $ML^2T^{-2}A^{-2}$ (4) $M^2LT^{-2}A^{-2}$

G-3 Self-inductance of a solenoid depend on -

(1) the number of turns N of the coil (2) the area of cross-section A and length ℓ of the coil.

(3) the permeability of the core of the coil (4) all the above

G-4 Equivalent unit of self-inductance is -

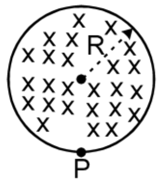
(1) $\frac{\text{volt} \times \text{ampere}}{\text{second}}$ (2) $\frac{\text{volt} \times \text{second}}{\text{ampere}}$

(3) $\frac{\text{ampere}}{\text{volt} \times \text{second}}$ (4) $\frac{\text{ampere} \times \text{second}}{\text{volt}}$

G-5 When current flowing in a coil changes from 3A to 2A in one millisecond, 5 volt emf is induced in it. The self-inductance of the coil will be -

(1) zero (2) 5kH (3) 5H (4) 5 mH

G-6 A uniform magnetic field of induction B is confined to a cylindrical region of radius R. The magnetic field is increasing at a constant rate of $\frac{dB}{dt}$ (tesla/second). An electron of charge q, placed at the point P on the periphery of the field experiences an acceleration :



(1) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward left
(2) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward right
(3) $\frac{eR}{m}\frac{dB}{dt}$ toward left
(4) zero

G-7 Two different coils have self-inductance L_1 = 8 mH, 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 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 which is incorrect :

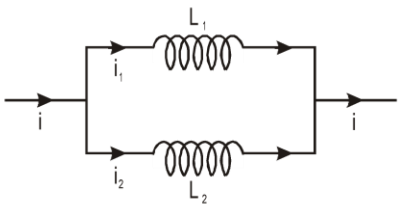
(1) $\frac{i_1}{i_2}=\frac{1}{4}$
(2) $\frac{i_1}{i_2}=4$
(3) $\frac{W_2}{W_1}=4$
(4) $\frac{V_2}{V_1}=\frac{1}{4}$

Section (H) : Circuit containing inductance, Resistance & battery, Growth and decay Of Current in a circuit containing inductor

H-1 L, C and R represent the physical quantities inductance, capacitance and resistance.Which of the following combinations have dimensions of time ?

(1) $\frac{1}{RC}$
(2) $\frac{R}{L}$
(3) $\frac{1}{\sqrt{LC}}$
(4) $\sqrt{LC}$

H-2 Two inductors L_1 and L_2 are connected in parallel and a time varying current i flows as shown. The ratio of currents i_1/i_2 at any time t is



(1) L_1/L_2
(2) L_2/L_1
(3) $\frac{L_1^2}{(L_1+L_2)^2}$
(4) $\frac{L_2^2}{(L_1+L_2)^2}$

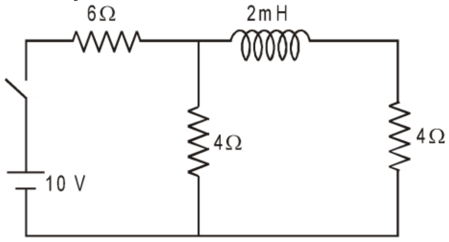
H-3 An LR circuit with a battery is connected at t =0. Which of the following quantities is not zero just after the connection ?

(1) current in the circuit
(2) magnetic field energy in the inductor
(3) power delivered by the battery
(4) emf induced in the inductor

H-4 In an LR circuit current at t = 0 is 20 A. After 2s it reduces to 18 A. The time constant of the circuit is (in second):

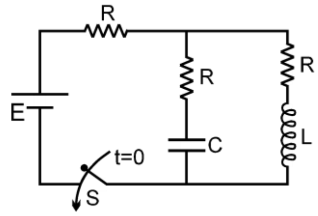
(1) $\ell n\left(\frac{10}{9}\right)$
(2) 2
(3) $\frac{2}{\ell n\left(\frac{10}{9}\right)}$
(4) $2\ \ell n\left(\frac{10}{9}\right)$

H-5 In the given circuit find the ratio of i_1 to i_2. Where i_1 is the initial (at t = 0) current, and i_2 is steady state (at t = ∞) current through the battery :



(1) 1.0
(2) 0.8
(3) 1.2
(4) 1.5

H-6✍ In the circuit shown in figure, switch S is closed at t = 0. Then:
(1) after a long time interval potential difference across capacitor and inductor will be equal.
(2) after a long time interval charge on capacitor will be E C.
(3) after a long time interval current in the inductor will be E /R.
(4) after a long time interval current through battery will be same as initial current through it.



Section (I) : Mutual Induction & Mutual inductance

I-1✍ Two coils are at fixed locations. When coil 1 has no current and the current in coil 2 increases at the rate 15.0 A/s the e.m.f. in coil 1 is 25.0 mV, when coil 2 has no current and coil 1 has a current of 3.6 A, flux linkage in coil 2 is
(1) 16 mWb (2) 10 mWb (3) 4.00 mWb (4) 6.00 mWb

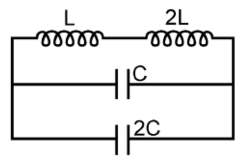
I-2✍ A long straight wire is placed along the axis of a circular ring of radius R. The mutual inductance of this system is
(1) $\frac{\mu_0 R}{2}$ (2) $\frac{\mu_0 \pi R}{2}$ (3) $\frac{\mu_0}{2}$ (4) 0

I-3 The unit of mutual inductance is
(1) volt (2) weber (3) tesla (4) henry

I-4✍ The self-inductances of two identical coils are 0.1 H. They are wound over each other. Mutual inductance will be -
(1) 0.1 H (2) 0.2 H (3) 0.01 H (4) 0.05 H

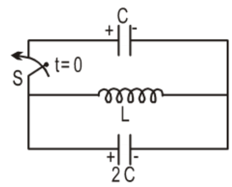
Section (J) : L C oscillations

J-1✍ The frequency of oscillation of current in the inductor is:



(1) $\frac{1}{3\sqrt{LC}}$ (2) $\frac{1}{6\pi\sqrt{LC}}$
(3) $\frac{1}{\sqrt{LC}}$ (4) $\frac{1}{2\pi\sqrt{LC}}$

J-2✍ In the given LC circuit if initially capacitor C has charge Q on it and 2C has charge 2Q .The polarities are as shown in the figure. Then after closing switch S at t = 0.
(1) energy will get equally distributed in both the capacitor just after closing the switch.
(2) initial rate of growth of current in inductor will be 2 Q/3 C L
(3) maximum energy in the inductor will be 3 Q^2/2 C
(4) none of these



Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

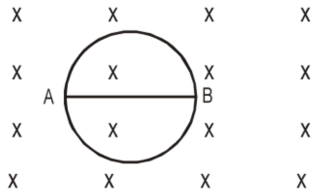
PART - I : OBJECTIVE QUESTION

1. An inductor coil stores energy U when a current i is passed through it and dissipates heat energy at the rate of P. The time constant of the circuit when this coil is connected across a battery of zero internal resistance is :
(1) $\frac{4U}{P}$ (2) $\frac{U}{P}$ (3) $\frac{2U}{P}$ (4) $\frac{2P}{U}$

2. A metal rod of resistance 20 Ω is fixed along a diameter of conducting ring of radius 0.1 m and lies in x-y plane. There is a magnetic field $\vec{B} = (50T)\hat{k}$. The ring rotates with an angular velocity ω = 20 rad/s about its axis. An external resistance of 10 Ω is connected across the centre of the ring and rim. The current through external resistance is

(1) $\frac{1}{4}$ A (2) $\frac{1}{2}$ A (3) $\frac{1}{3}$ A (4) zero

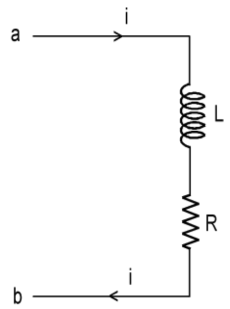
3. The radius of the circular conducting loop shown in figure is R. Magnetic field is decreasing at a constant rate α. Resistance per unit length of the loop is ρ. Then current in wire AB is (AB is one of the diameters)



(1) $\frac{R\alpha}{2\rho}$ from A to B (2) $\frac{R\alpha}{2\rho}$ from B to A

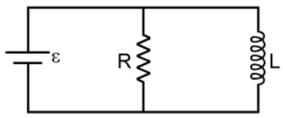
(3) $\frac{2R\alpha}{\rho}$ from A to B (4) Zero

4. When the current in the portion of the circuit shown in the figure is 2A and increasing at the rate of 1A/s, the measured potential difference V_{ab} = 8V. However when the current is 2A and decreasing at the rate of 1A/s, the measured potential difference V_{ab} = 4V. The values of R and L are :



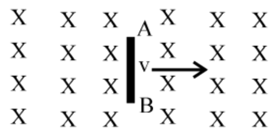
(1) 3 ohm and 2 henry respectively
(2) 2 ohm and 3 henry respectively
(3) 10 ohm and 6 henry respectively
(4) 6 ohm and 1 henry respectively

5. The battery shown in the figure is ideal. The values are ε = 10 V, R = 5Ω, L = 2H . Initially the current in the inductor is zero. The current through the battery at t = 2s is



(1) 12 A (2) 7 A (3) 3 A (4) none of these

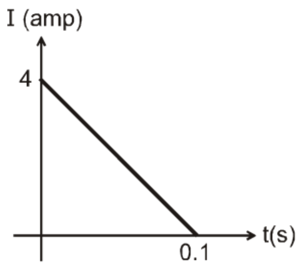
6. A rod AB moves with a uniform velocity v in a uniform magnetic field as shown in fig.



(1) The rod becomes electrically charged
(2) The end A becomes positively charged
(3) The end B become positively charged
(4) The rod becomes hot because of Joule heating

7. A conducting ring lies fixed on a horizontal plane. If a charged nonmagnetic particle is released from a point (on the axis) at some height from the plane, then :
(1) an induced current will flow in clockwise or anticlockwise direction in the loop depending upon the nature of the charge
(2) the acceleration of the particle will decrease as it comes down
(3) the rate of production of heat in the ring will increase as the particle comes down
(4) no heat will be produced in the ring.

8. Some magnetic flux is changed in a coil of resistance 10 ohm. As a result an induced current is developed in it, which varies with time as shown in figure. The magnitude of change in flux through the coil in Webers is



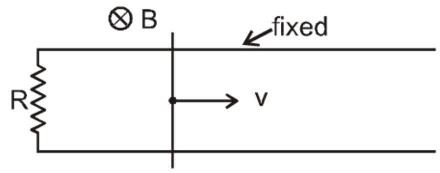
(1) 2 (2) 4
(3) 6 (4) 8

9. A bar magnet is released from rest coaxially along the axis of a very long, vertical copper tube. After some time the magnet
(1) will stop in the tube
(2) will move with almost constant speed
(3) will move with an acceleration g
(4) will oscillate

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/Reasoning

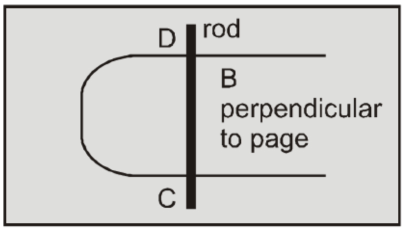
A-1. **STATEMENT-1 :** A resistance R is connected between the two ends of the parallel smooth conducting rails. A conducting rod lies on these fixed horizontal rails and a uniform constant magnetic field B exists perpendicular to the plane of the rails as shown in the figure. If the rod is given a velocity v and released as shown in figure, it will stop after some time. The total work done by magnetic field is negative **.**



STATEMENT-2 : If force acts opposite to direction of velocity its work done is negative.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

A-2. **STATEMENT-1 :** Two coplaner conducting rings of different radii are placed concentric in space. The mutual inductance of both the rings is maximum if the rings are also coplanar.
STATEMENT-2 : 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.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

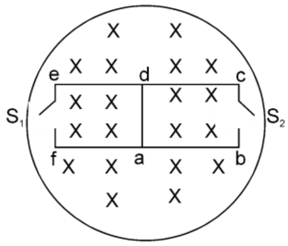
A-3. **STATEMENT–1 :** Consider the arrangement shown below. A smooth conducting rod, CD, is lying on a smooth U-shaped conducting wire making good electrical contact with it. The U-shape conducting wire is fixed and lies in horizontal plane. There is a uniform and constant magnetic field B in vertical direction (perpendicular to plane of page in figure). If the magnetic field strength is decreased, the rod moves towards right.



STATEMENT–2 : In the situation of statement-1, the direction in which the rod will slide is that which tends to maintain constant flux through the loop. Providing a larger loop area counteracts the decrease in magnetic flux. So the rod moves to the right independent of the fact that the direction of magnetic field is into the page or out of the page.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

Section (B) : Match the column

B-1. The magnetic field in the cylindrical region shown in figure increases at a constant rate of 10.0 mT/s Each side of the square loop abcd and defa has a length of 2.00 cm and resistance of 2.00 Ω . Correctly match the current in the wire 'ad' in four different situations as listed in column-I with the values given in column-II.



Column-I	**Column-II**
(1) the switch S_1 is closed but S_2 is open	(p) 5×10^{-7} A, d to a
(2) S_1 is open but S_2 is closed	(q) 5×10^{-7} A, a to d
(3) both S_1 and S_2 are open	(r) 2.5×10^{-8} A, d to a
(4) both S_1 and S_2 are closed.	(s) 2.5×10^{-8} A, a to d
	(t) No current flows

B-2. A small circular loop of area A and a large circular loop of area nA (n is very large) are concentric fig (a). The mutual inductance of this system is M_1. Now the small circular loop is turned by $\frac{\pi}{2}$ to position shown in fig (b)

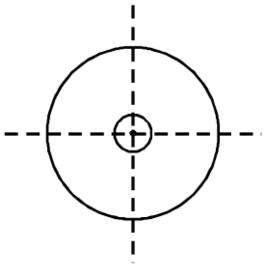


fig (a)

The mutual inductance now is M_2.
Now the larger loop is cut at Q and made into a long straight wire as shown in fig (c)

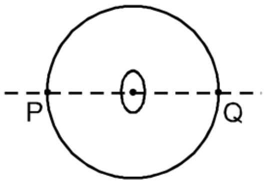


fig (b)

Now the mutual inductance is M_3 .

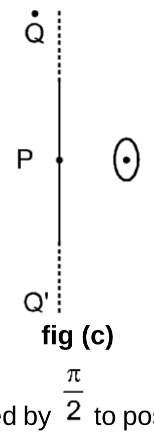


fig (c)

Now the plane of the smaller loop is rotated by $\frac{\pi}{2}$ to position as shown fig (d). Now the mutual inductance is M_4.
Then match the following.

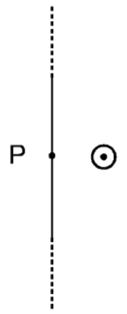
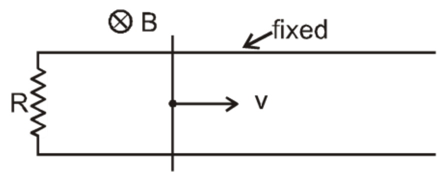


fig (d)

	Column–I		Column–II
(1)	M_1	**(p)**	depends only A
(2)	M_2	**(q)**	depends only on n
(3)	M_3	**(r)**	depends on both A and n
(4)	M_4	**(s)**	depends on neither A nor n

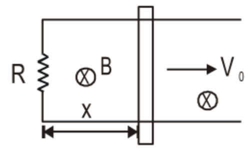
Section (C) : One or More Than One Options Correct

C-1. A resistance R is connected between the two ends of the parallel smooth conducting rails. A conducting rod lies on these fixed horizontal rails and a uniform constant magnetic field B exists perpendicular to the plane of the rails as shown in the figure. If the rod is given a velocity v and released as shown in figure, it will stop after some time, which option are correct:



(1) The total work done by magnetic field is negative.
(2) The total work done by magnetic field is positive.
(3) The total work done by magnetic field is zero.
(4) loss in kinetic energy of conducting rod is equal to heat generate between R.

C-2. A conducting rod of length ℓ is moved at constant velocity 'v_0' on two parallel, conducting, smooth, fixed rails, that are placed in a uniform constant magnetic field B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rail. Then which of the following is/are correct



(1) The thermal power dissipated in the resistor is equal to rate of work done by external person pulling the rod.
(2) If applied external force is doubled than a part of external power increases the velocity of rod.
(3) Lenz's Law is not satisfied if the rod is accelerated by external force
(4) If resistance R is doubled then power required to maintain the constant velocity v_0 becomes half.

C-3. A conducting ring is placed in a uniform magnetic field with its plane perpendicular to the field. An emf is induced in the ring if
(1) it is rotated about its axis (2) it is translated
(3) it is rotated about a diameter (4) it is deformed

C-4. A conducting loop rotates with constant angular velocity about its fixed diameter in a uniform magnetic field in a direction perpendicular to that fixed diameter.
(1) The emf will be maximum at the moment when flux is zero.
(2) The emf will be '0' at the moment when flux is maximum.
(3) The emf will be maximum at the moment when plane of the loop is parallel to the magnetic field
(4) The phase difference between the flux and the emf is $\pi/2$

C-5✍. A super conducting loop having an inductance 'L' is kept in a magnetic field which is varying with respect to time. If φ is the total flux, ε = total induced emf, then:
(1) φ = constant (2) I = 0 (3) $\varepsilon = 0$ (4) $\varepsilon \neq 0$

C-6. An LR series circuit with a battery is connected at t =0. Which of the following quantities are zero just after the connection ?
(1) current in the circuit
(2) magnetic field energy in the inductor
(3) power delivered by the battery
(4) emf induced in the inductor

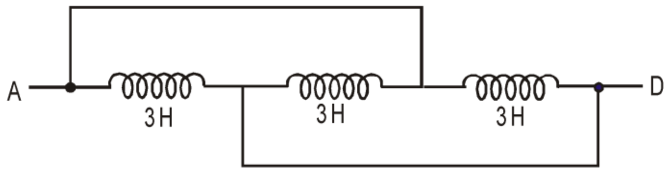
Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

*** Marked Questions may have more than one correct option.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. The inductance between A and D is : **[AIEEE 2002, 4/300]**



(1) 3.66 H (2) 9 H (3) 0.66 H (4) 1 H

2. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon : **[AIEEE 2003, 4/300]**
(1) the rates at which currents are changing in the two coils
(2) relative position and orientation of the two coils
(3) the materials of the wires of the coils
(4) the currents in the two coils

3. When the current changes from +2 A to –2 A in 0.05 second, an emf of 8 V is induced in a coil. The coefficient of self-induction of the coil is : **[AIEEE 2003, 4/300]**
(1) 0.2 H (2) 0.4 H (3) 0.8 H (4) 0.1 H

4. In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is : **[AIEEE 2003, 4/300]**
(1) Q/2 (2) $Q/\sqrt{3}$ (3) $Q/\sqrt{2}$ (4) Q

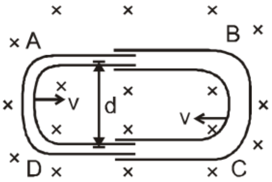
5. A coil having n turns and resistance R Ω is connected with a galvanometer of resistance 4RΩ. This combination is moved in time t seconds from a magnetic field W_1 Weber to W_2 Weber. The induced current in the circuit is : **[AIEEE 2004, 4/300]**
(1) $\frac{(W_2 - W_1)A}{5Rnt}$ (2) $-\frac{n(W_2 - W_1)A}{5Rt}$ (3) $-\frac{(W_2 - W_1)A}{Rnt}$ (4) $-\frac{n(W_2 - W_1)A}{Rt}$

6. In a uniform magnetic field of induction B, a wire in the form of semicircle of radius r rotates about the diameter of the circle with angular frequency ω. If the total resistance of the circuit is R, the mean power generated per period of rotation is : **[AIEEE 2004, 4/300]**
(1) $\frac{B\pi^2\omega}{2R}$ (2) $\frac{(B\pi r^2\omega)^2}{8R}$ (3) $\frac{(B\pi r\omega)^2}{2R}$ (4) $\frac{(B\pi r\omega^2)^2}{8R}$

7. A metal conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 radians per second. If the horizontal component of earth's magnetic field is 0.2×10^{-4} T, then the emf developed between the two ends of the conductor is : **[AIEEE 2004, 4/300]**

(1) 5 μV (2) 50 μV (3) 5 mV (4) 50 mV

8. One conducting u tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure. If each tube moves towards the other at a constant speed v, then the emf induced in the circuit in terms of B, ℓ and v, where ℓ is the width of each tube, will be **[AIEEE 2005, 4/300]**

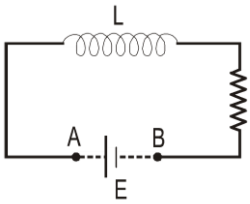


(1) $B\ell v$ (2) $-B\ell v$ (3) zero (4) $2B\ell v$

9. A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in : **[AIEEE 2005, 4/300]**

(1) 0.05 s (2) 0.1 s (3) 0.15 s (4) 0.3 s

10. An inductor (L = 100 mH), a resistor (R = 100 Ω) and a battery (E = 100 V) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit, 1 ms after the short circuit is : **[AIEEE 2006, 4½/180]**

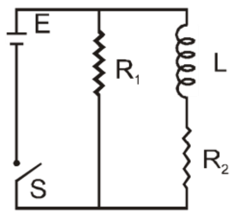


(1) 1 A (2) 1/e A
(3) e A (4) 0.1 A

11. Two coaxial solenoids are made by winding thin insulated wire over a pipe of cross-sectional area A =10cm^2 and length = 20 cm. If one of the solenoids has 300 turns and the other 400 turns, their mutual inductance is ($\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1}) : **[AIEEE-2008, 3/105]**

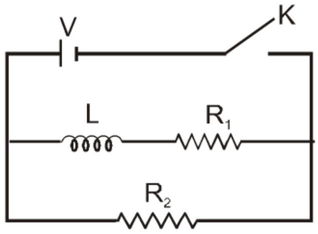
(1) $4.8\pi \times 10^{-4}$ H (2) $4.8\pi \times 10^{-5}$ H (3) $2.4\pi \times 10^{-4}$ H (4) $2.4\pi \times 10^{-5}$ H

12. An inductor of inductance L = 400 mH and resistors of resistances R_1 = 2 Ω and R_2 = 2 Ω are connected to a battery of emf 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at t = 0. The potential drop across L as a function of time is : **[AIEEE-2009, 4/144]**



(1) $\frac{12}{t}e^{-3t}$ V (2) $6\left(1-e^{-t/0.2}\right)$ V (3) $12\,e^{-5t}$ V (4) $6\,e^{-5t}$ V

13. In the circuit shown below, the key K is closed at t = 0. The current through the battery is : **[AIEEE 2010, 4/144, –1]**



(1) $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = 0 and $\frac{V}{R_2}$ at t = ∞ (2) $\frac{V}{R_2}$ at t = 0 and $\frac{V(R_1+R_2)}{R_1R_2}$ at t = ∞

(3) $\frac{V}{R_2}$ at t = 0 and $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = ∞ (4) $\frac{V(R_1+R_2)}{R_1R_2}$ at t = 0 and $\frac{V}{R_2}$ at t = ∞

14. A fully charged capacitor C with initial charge q_0 is connected to a coil of self inductance L at t = 0. The time at which the energy is stored equally between the electric and the magnetic fields is : **[AIEEE - 2011, 4/120, –1]**

(1) $\pi\sqrt{LC}$ (2) $\frac{\pi}{4}\sqrt{LC}$ (3) $2\pi\sqrt{LC}$ (4) $\sqrt{LC}$

15. A boat is moving due east in a region where the earth's magnetic field is 5.0×10^{-5} $NA^{-1}m^{-1}$ due north and horizontal. The boat carries a vertical aerial 2m long. If the speed of the boat is 1.50 ms^{-1}, the magnitude of the induced emf in the wire of aerial is : **[AIEEE - 2011, 4/120, –1]**

(1) 1 mV (2) 0.75 mV (3) 0.50 mV (4) 0.15 mV

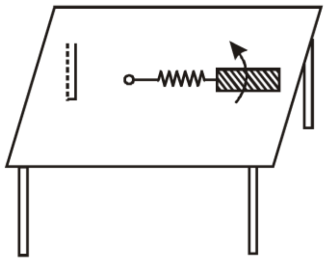
16. A horizontal straight wire 20 m long extending from to east to west falling with a speed of 5.0 M\s, at right angles to the horizontal component of the earth's magnetic field 0.30×10^{-4} Wb \ m^2. The instantaneous Value of the e.m. f. induced in the wire will be : **[AIEEE 2011, 11 May; 4/120, –1]**

(1) 3 mV (2) 4.5 mV (3) 1.5 mV (4) 6.0mV

17. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; it is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to : **[AIEEE 2012 ; 4/120, –1]**

(1) developement of air current when the plate is placed.
(2) induction of electrical charge on the plate
(3) shielding of magnetic lines of force as aluminium is a paramagnetic material.
(4) Electromagnetic induction in the aluminium plate giving rise to electromagnetic damping.

18. A metallic rod of length 'l' is tied to a string of length 2l and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e.m.f. induced across the ends of the rod is: **[JEE(Main)-2013, 4/120, –1]**



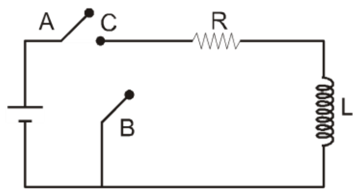
(1) $\frac{2B\omega l^2}{2}$ (2) $\frac{3B\omega l^2}{2}$

(3) $\frac{4B\omega l^2}{2}$ (4) $\frac{5B\omega l^2}{2}$

19. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is **[JEE(Main)-2013, 4/120, –1]**

(1) 9.1×10^{-11} weber (2) 6×10^{-11} weber
(3) 3.3×10^{-11} weber (4) 6.6×10^{-9} weber

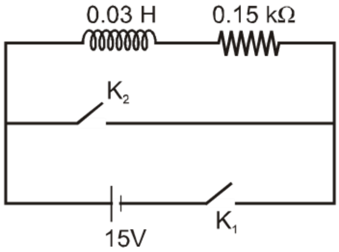
20. In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly point 'C' is disconnected from point 'A' and connected to point 'B' at time t = 0. Ratio of the voltage across resistance and the inductor at t = L/R will be equal to : **[JEE(Main)-2014; 4/120. –1]**



(1) $\frac{e}{1-e}$ (2) 1 (3) –1 (4) $\frac{1-e}{e}$

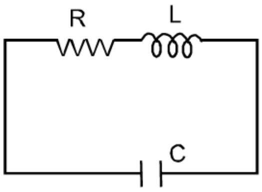
21. An inductor (L = 0.03H) and a resistor (R = 0.15 kΩ) are connected in series to a battery of 15V EMF in a circuit shown below. The key K_1 has been kept closed for a long time. Then at t = 0, K_1 is opened and key K_2 is closed simultaneously. At t = 1ms, the current in the circuit will be : ($e^5 \cong 150$)

[JEE(Main)-2015; 4/120, –1]

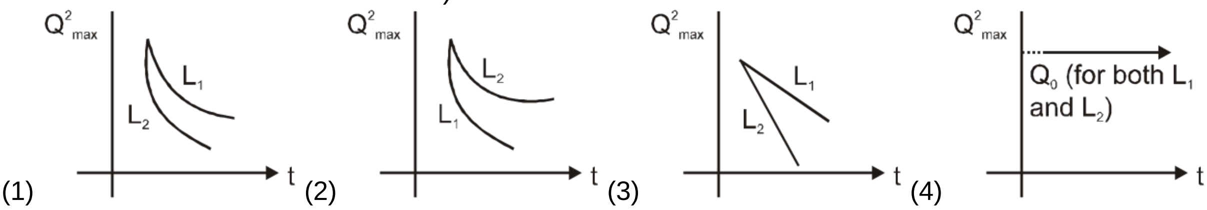


(1) 100 mA (2) 67 mA (3) 6.7 mA (4) 0.67 mA

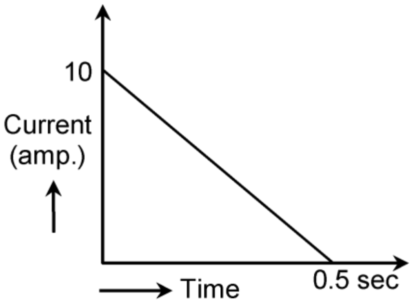
22. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below : **[JEE(Main)-2015; 4/120, –1]**



If a student plots graphs of the square of maximum charge (Q^2_{Max}) on the capacitor with time (t) for two different values L_1 and L_2($L_1 > L_2$) of L then which of the following represents this graph correctly ? (plots are schematic and not drawn to scale)



23. In a coil resistance 100Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is : **[JEE(Main) 2017; 4/120,–1]**

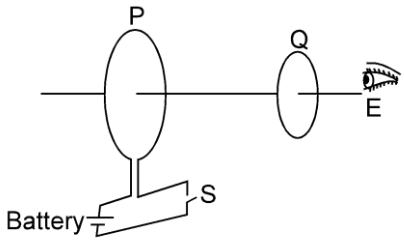


(1) 275 Wb (2) 200 Wb (3) 225 Wb (4) 250 Wb

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. As shown in the fig. P and Q are two coaxial conducting loops separated by some distance. When the switch S is closed, a clockwise current I_P flows in P (as seen by E) and an induced current I_{Q1} flows in Q The switch remains closed for a long time. When S is opened, a current I_{Q2} flows in Q. Then the directions of I_{Q1} and I_{Q2} (as seen by E) are **[JEE Screening 2002, 3/90, –1]**.



(A) respectively clockwise and anti-clockwise
(B) both clockwise
(C) both anti-clockwise
(D) respectively anti-clockwise and clockwise.

2. A short circuited coil is placed in a time-varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved keeping the radius of the loop unchanged, the electrical power dissipated would be: **[JEE Screening 2002, 3/90, –1]**

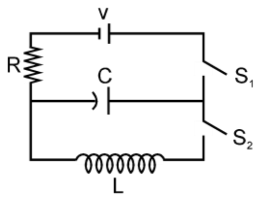
(A) halved (B) the same (C) doubled (D) quadrupled

3. An infinitely long cylindrical conducting rod is kept along + Z direction. A constant magnetic field is also present in + Z direction. Then current induced will be **[JEE (Scr. 2005) 3/84, –1]**

(A) 0 (B) along +z direction
(C) along clockwise as seen from + Z (D) along anticlockwise as seen from + Z

Comprehension-1

The capacitor of capacitance C can be charged (with the help of a resistance R) by a voltage source V, by closing switch S_1 while keeping switch S_2 open. The capacitor can be connected in series with an inductor 'L' by closing switch S_2 and opening S_1



4. Initially, the capacitor was uncharged. Now, switch S_1 is closed and S_2 is kept open. If time constant of this circuit is τ, then **[JEE 2006, 5/184, –2]**

(A) after time interval τ, charge on the capacitor is CV/2
(B) after time interval 2τ, charge on the capacitor is $CV(1 - e^{-2})$
(C) the work done by the voltage source will be half of the heat dissipated when the capacitor is fully charged
(D) after time interval 2τ, charge on the capacitor is $CV(1 - e^{-1})$

5. After the capacitor gets fully charged, S_1 is opened and S_2 is closed so that the inductor is connected in series with the capacitor. Then, **[JEE 2006, 5/184, –2]**

(A) at t = 0, energy stored in the circuit is purely in the form of magnetic energy
(B) at any time t > 0, current in the circuit is in the same direction
(C) at t > 0, there is no exchange of energy between the inductor and capacitor
(D) at any time t > 0, instantaneous current in the circuit will have maximum value $V\sqrt{\frac{C}{L}}$, where C is the capacitance and L is the inductance.

6. If the total charge stored in the LC circuit is Q_0, then for $t \geq 0$ **[JEE 2006, 5/184, –2]**

(A) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} + \frac{t}{\sqrt{LC}}\right)$

(B) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{LC}}\right)$

(C) the charge on the capacitor is $Q = -LC\frac{d^2Q}{dt^2}$

(D) the charge on the capacitor is $Q = -\frac{1}{\sqrt{LC}}\frac{d^2Q}{dt^2}$

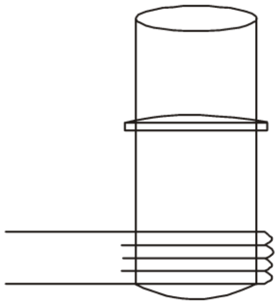
7. **STATEMENT**

A vertical iron rod has a coil of wire wound over it at the bottom end. An alternating current flows in the coil. The rod goes through a conducting ring as shown in the figure. The ring can float at a certain height above the coil.

because

STATEMENT- 2

In the above situation, a current is induced in the ring which interacts with the horizontal component of the magnetic field to produce an average force in the upward direction **[JEE 2007' 3/162, –1]**



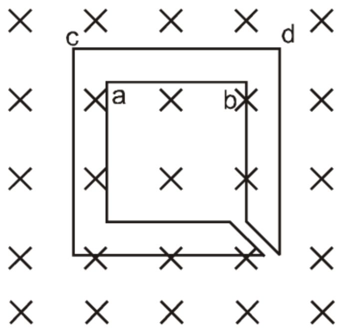
(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True.

8. The figure shows certain wire segments joined together to form a coplanar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time. I_1 and I_2 are the currents in the segments **ab** and **cd**. Then, **[JEE - 2009, 3/240, –1]**



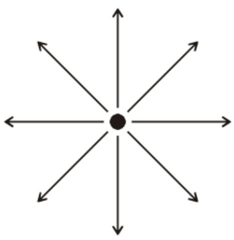
(A) $I_1 > I_2$

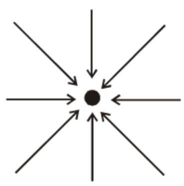
(B) $I_1 < I_2$

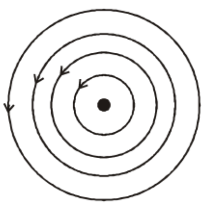
(C) I_1 is in the direction **ba** and I_2 is in the direction **cd**

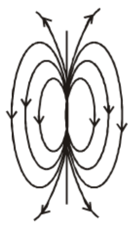
(D) I_1 is in the direction **ab** and I_2 is in the direction **dc**

9. Which of the field patterns given below is valid for electric field as well as for magnetic field? **[JEE - 2011' 3/160, –1]**


(A)


(B)


(C)


(D)

Answers

EXERCISE # 1

Section (A) :

A-1	(3)	**A-2**	(2)	**A-3**	(1)
A-4	(3)	**A-5**	(1)	**A-6**	(4)
A-7	(4)	**A-8**	(3)	**A-9**	(3)

Section (B) :

B-1	(4)	**B-2**	(3)	**B-3**	(2)
B-4	(1)	**B-5**	(3)	**B-6**	(1)
B-7	(1)	**B-8**	(1)	**B-9**	(4)
B-10	(3)				

Section (C) :

C-1	(4)	**C-2**	(2)	**C-3**	(1)
C-4	(4)	**C-5**	(2)	**C-6**	(2)
C-7	(2)				

Section (D) :

D-1	(4)	**D-2**	(4)	**D-3**	(1)

Section (E) :

E-1	(2)	**E-2**	(1)	**E-3**	(3)
E-4	(4)				

Section (F) :

F-1	(3)	**F-2**	(1)	**F-3**	(3)
F-4	(1)	**F-5**	(3)	**F-6**	(2)

Section (G) :

G-1	(2)	**G-2**	(3)	**G-3**	(4)
G-4	(2)	**G-5**	(4)	**G-6**	(1)
G-7	(2)				

Section (H) :

H-1	(4)	**H-2**	(2)	**H-3**	(4)
H-4	(3)	**H-5**	(2)	**H-6**	(4)

Section (I) :

I-1	(4)	**I-2**	(4)	**I-3**	(4)
I-4	(1)				

Section (J) :

J-1	(2)	**J-2**	(3)

EXERCISE # 2

PART-I

1.	(3)	**2.**	(3)	**3.**	(4)
4.	(1)	**5.**	(1)	**6.**	(2)
7.	(4)	**8.**	(1)	**9.**	(2)

PART-II

Section (A) :

A-1.	(4)	**A-2.**	(1)	**A-3.**	(1)

Section (B) :

B-1. (1 → q); (2 → p); (3 → t); (4 → t)

B-2. (1 → r); (2 → s); (3 → s); (4 → r)

Section (C) :

C-1.	(3,4)	**C-2.**	(1,2,4)	**C-3.**	(3,4)
C-4.	(1,2,3,4)			**C-5.**	(1,3)
C-6.	(1,2,3)				

EXERCISE # 3

PART-I

1.	(4)	**2.**	(2)	**3.**	(4)
4.	(3)	**5.**	(2)	**6.**	(2)
7.	(2)	**8.**	(4)	**9.**	(2)
10.	(2)	**11.**	(3)	**12.**	(3)
13.	(2)	**14.**	(2)	**15.**	(4)
16.	(1)	**17.**	(4)	**18.**	(4)
19.	(1)	**20.**	(3)	**21.**	(4)
22.	(1)	**23.**	(4)		

PART-II

1.	(D)	**2.**	(B)	**3.**	(A)
4.	(B)	**5.**	(D)	**6.**	(C)
7.	(A)	**8.**	(D)	**9.**	(C)