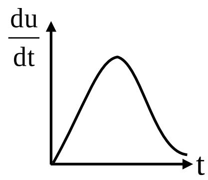
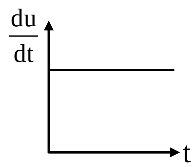
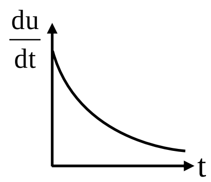
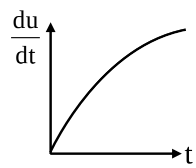
Q.1 Rate of increment of energy in an inductor with time in series LR circuit getting charge with battery of e.m.f. E is best represented by :
[inductor has initially zero current]

(A)


(B)


(C)


(D)


[A]

Sol. Rate of increment of energy in inductor

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

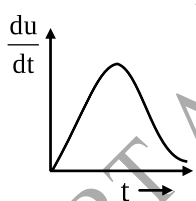
Current in the inductor at time t is :

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

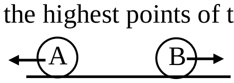
$\frac{du}{dt} = \frac{Li_0^2}{\tau}\ e^{-\frac{t}{\tau}}\ (1 - e^{-\frac{t}{\tau}})$

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

Hence E is best represented by :

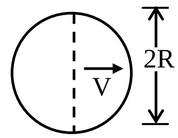


Q.2 Two identical conducting ring A and B of radius R are in pure rolling over a horizontal conducting plane with same speed (of center of mass) v but in opposite direction. A constant magnetic field B is present pointing inside the plane of paper. Then the potential difference between the highest points 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(100π 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 $\varepsilon = M\,\frac{dI}{dt}$

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

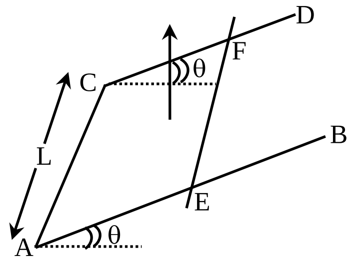
$= M I_0\omega \cos\omega t$

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

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

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 :



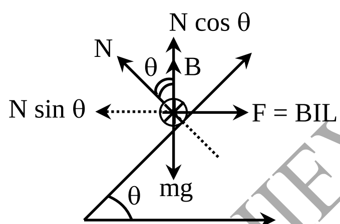
(A) I must flow from E to F

(B) BIL = mg cos θ

(C) BIL = mg sin θ

(D) BIL = mg

Sol. **[A]**



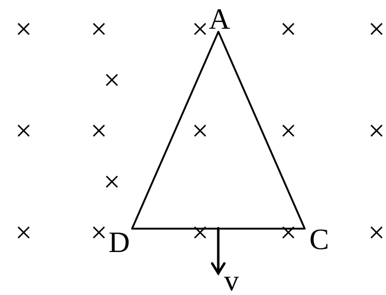
$N \cos\theta = mg$ …..(1)

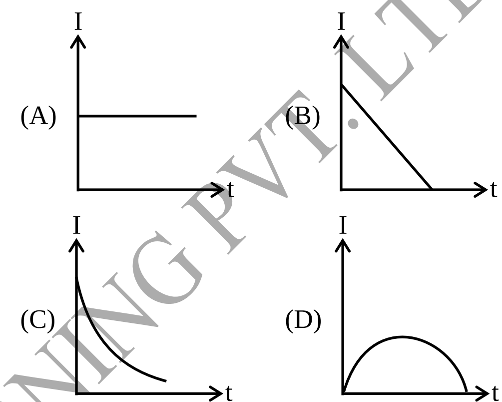
[⊗ indicates current I is flowing into the paper]

$N \sin\theta = BIL$ …..(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]**

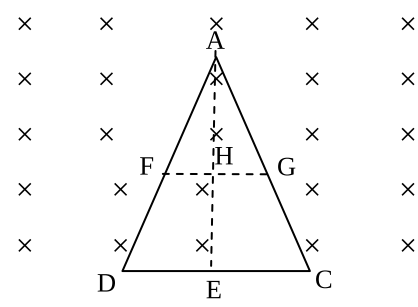
Let 2a be the side of the triangle and b the length AE.

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

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

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

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



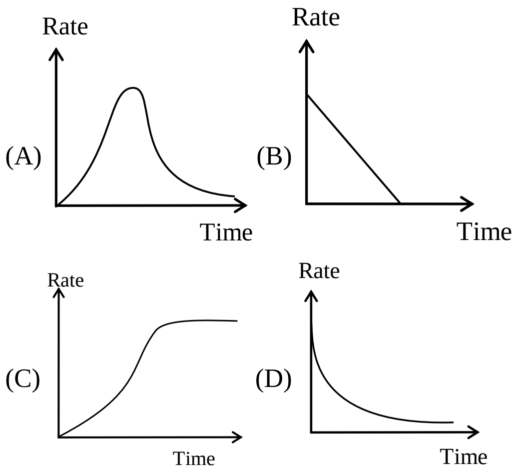
Induced e.m.f., $e = Bv(FG) = 2Bv\left(a - \frac{a}{b}vt\right)$

$\therefore$ 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]**

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

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

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

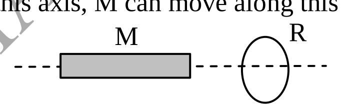
(B) reads the back e.m.f. in the motor

(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

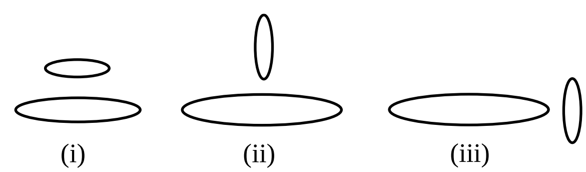


Fig.

(A) maximum in situation (i)

(B) maximum in situation (ii)

(C) maximum in situation (iii)

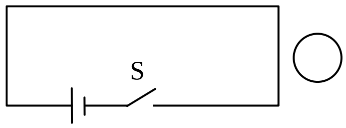
(D) the same in all situations **[A]**

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-



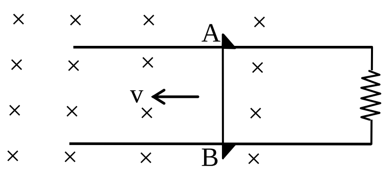
(A) an anticlockwise current-pulse

(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.

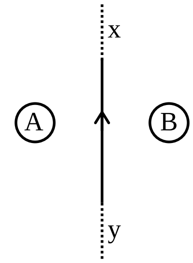
(A) Both a and b are true

(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 -



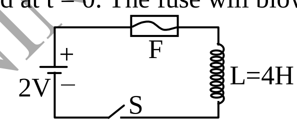
(A) clockwise in A and anticlockwise in B

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

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

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

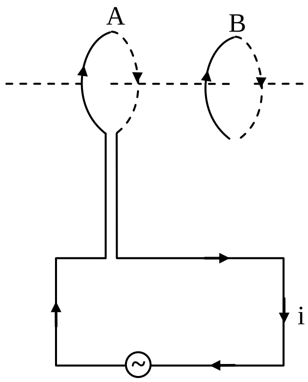
$i = \frac{2}{4}\times t$

$i = 0.5t$

$5 = 0.5t$

$t = 10$ 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-

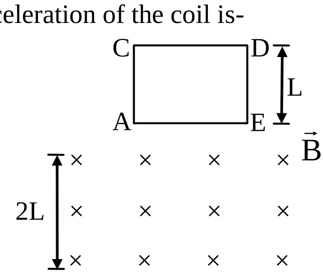


(A) there will be repulsion between A and B if i is increased
(B) there will be attraction between A and B if i is increased
(C) there will be neither attraction nor repulsion when i is changed
(D) attraction or repulsion between A and B depends on the direction of current, it does not depend whether 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-

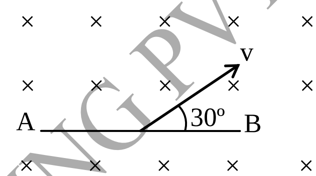
(A) the current in each loop will decrease
(B) the current in each loop will increase
(C) the current in each loop will remain the same
(D) the current in one loop will increase and in the other loop will decrease **[A]**

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-



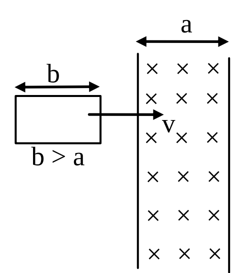
(A) less than g for all the time till the loop crosses the magnetic field completely
(B) less than g when it enters the field and greater than g when it comes out of the field
(C) g all the time
(D) less than g when it enters and comes out of the field but equal to g when it is within the field **[D]**

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

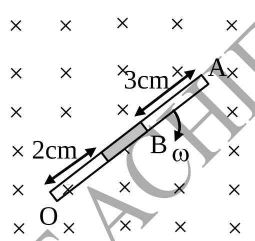
(C) $\sqrt{2}$ RBV (D) $\frac{RBV}{2}$ **[A]**

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

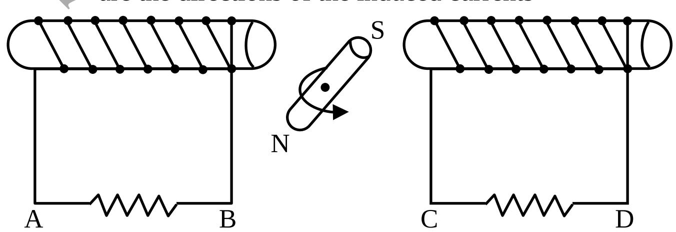


Fig.

(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

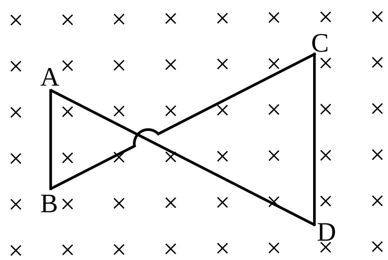


Fig.

(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.

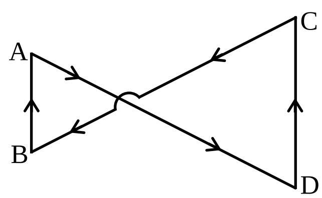


Fig.

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

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

$e \propto A$

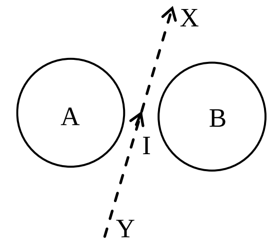
Hence the net current induced in the complete loop will be along DCBAD. Therefore the answer is (D).

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.

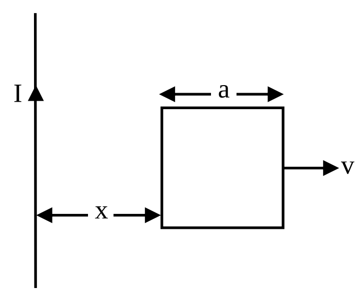


Fig.

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

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

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

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

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

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

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

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 –

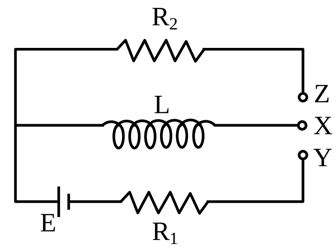


Fig.

(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 $L = \mu_0 n^2 l_0 \pi r^2$

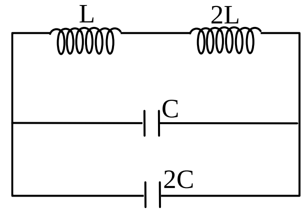
or $n = \sqrt{\frac{L}{\mu_0 l_0 \pi r^2}}$

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

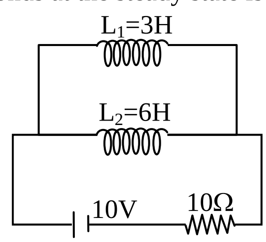
Q.36 The frequency of oscillation of current in the inductor is-



(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. –

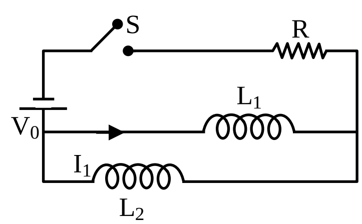


Fig.

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

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 –

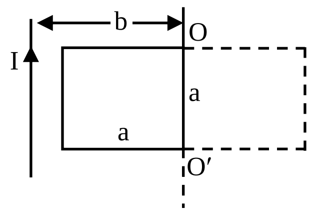


Fig.

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

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

[C]

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

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

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

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

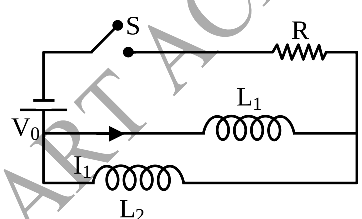


Fig.

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

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

[C]

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

Q.41 Mutual inductance in Fig. shown is –

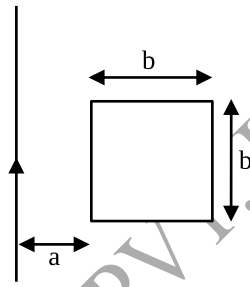


Fig.

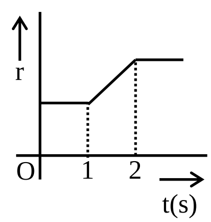
(A) Zero (B) $\frac{\mu_0 b}{2\pi} \log_e \frac{a}{b}$

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

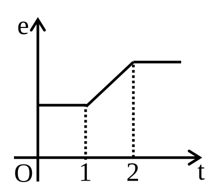
[C]

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

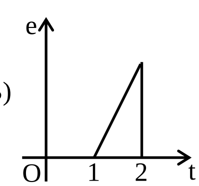
Q.42 A circular coil is placed in uniform magnetic field such that its plane is perpendicular to field. The radius of coil changes with time as shown in the figure . Then which of the following graph represent the induced emf in the coil with time –



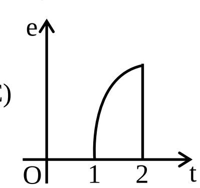
(A)



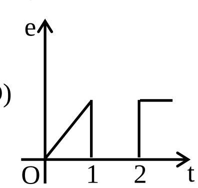
(B)



(C)

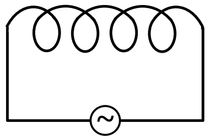


(D)



[B]

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



V = 10 sin ωt
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 –

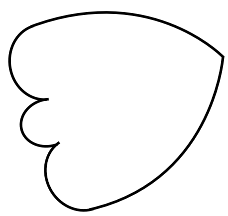
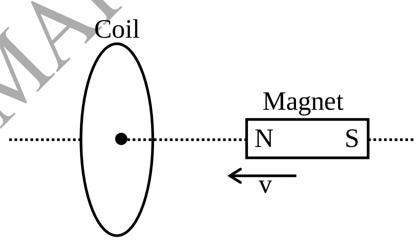


Fig.

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

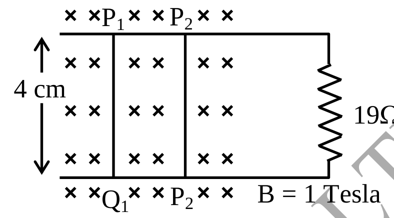
Sol. QV because induced electric field so generated is non conservative i.e. $\oint E.dl = V$.

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-



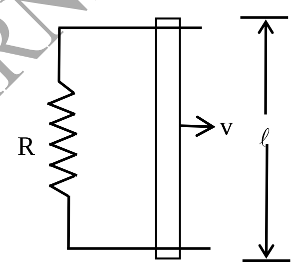
(A) e. (B) 2e
(C) e/2 (D) 4e **[B]**

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

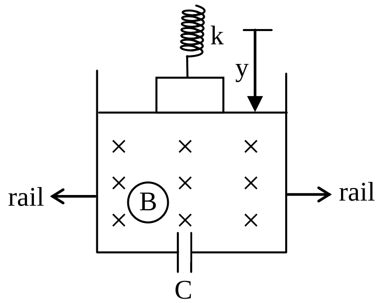
(C) $\dfrac{vB^2\ell^2}{(R+r)}$ (D) zero **[C]**

Sol. $F = I\ell B$

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

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

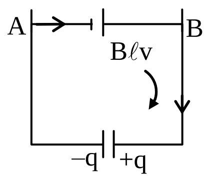
Q.48 A heavy block is attached to the ceiling by a spring that has a force constant 'k'. A conducting rod is attached to block. The combined mass of the block and the rod is m. The rod can slide without friction along two vertical parallel rails, which are a distance L apart. A capacitor of known capacitance 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) $2\pi\sqrt{\dfrac{m+CB^2L^2}{k}}$ (B) $2\pi\sqrt{\dfrac{m^2+CBL}{k}}$

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

Sol.



Using Kirchoff 's equation

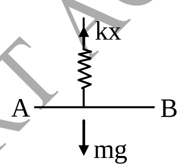
$\dfrac{+q}{C} - B\ell v = 0$ [Where $v = \dfrac{dy}{dt}$]

$q = CB\ell v$

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

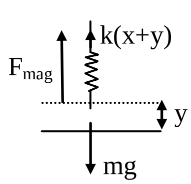
Magnetic force on AB bar or block = $Bi\ell$

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



For initial equilibrium,

$kx = mg$ ... (1)



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

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

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

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

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

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

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.

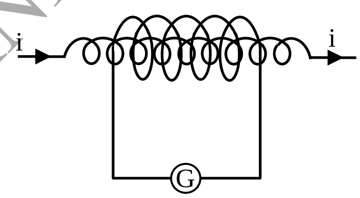


Fig.

(A) Zero (B) 800 μc

(C) 400 μC (D) 600 μC **[B]**

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

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

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

$\Delta Q = \dfrac{100 \times \pi \times (2\times10^{-2})^2 \times 10^4 \times 4\pi \times 10^{-7} \times 10}{20}$

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

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) $\frac{AB}{R}$

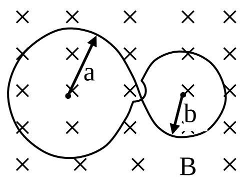
(C) ABR (D) $\frac{B^2A}{R^2}$

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 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 $50 \times 10^{-3}\ \Omega$/m. The inductance of the loop is negligible. **[0001]**



Sol. Instantaneous flux

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

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

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

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

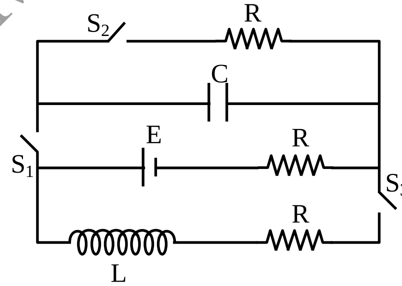
$i = \dfrac{\ell}{R}$

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

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

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

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

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

2. Growth of current in L-R circuit

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

now $i_1 = i_2$

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

given $L = 4CR^2$

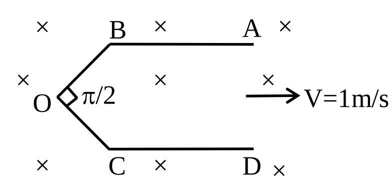
$\therefore\ \dfrac{L}{2R} = 2RC = \dfrac{1}{\ln 2}$

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

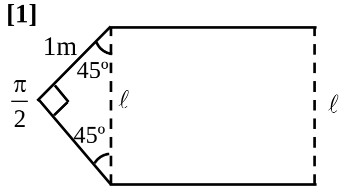
$\Rightarrow$ t ln2 = ln2

$\Rightarrow$ t = 1sec.

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 $\dfrac{\ell}{\sin 90^o} = \dfrac{1}{\sin 45^o}$

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

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 $= \frac{2Q}{R^2} x \times K x^2 t \times x dx = \frac{2KQ}{R^2} x^4 t\, dx$

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