Electromagnetic Induction

Question1

A rectangular loop of length 2.5m and width 2m is placed at 60° to a magnetic field of 4T. The loop is removed from the field in 10 sec. The average emf induced in the loop during this time is

[27-Jan-2024 Shift 1]

Options:

A.

$-2V$

B.

$+2V$

C.

$+1V$

D.

$-1V$

Answer: C

Solution:

$$\text{Average emf} = \frac{\text{Change influx}}{\text{Time}} = -\frac{\Delta\phi}{\Delta t}$$

$$= -\frac{0-(4\times(2.5\times 2)\cos 60^{\circ})}{10}$$

$$= +1V$$

Question2

Two coils have mutual inductance 0.002H. The current changes in the first coil according to the relation $i = i_0 \sin \omega t$, where $i_0 = 5A$ and $\omega = 50\pi$ rad/ s. The maximum value of emf in the second coil is π/α V. The value of α is____

[27-Jan-2024 Shift 1]

Options:

Answer: 2

Solution:

$$\phi = Mi = Mi_0 sin\ \omega t$$

$$EMF = -M\frac{di}{dt} = -0.002(i_0\omega \cos \omega t)$$

$$EMF_{max} = i_0\omega(0.002) = (5)(50\pi)(0.002)$$

$$EMF_{max} = \frac{\pi}{2}V$$

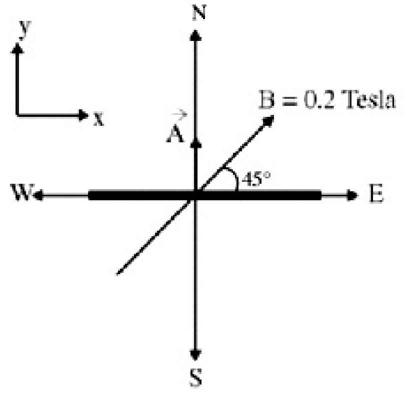
Question3

A square loop of side 10cm and resistance 0.7Ω is placed vertically in east-west plane. A uniform magnetic field of 0.20T is set up across the plane in north east direction. The magnetic field is decreased to zero in 1 s at a steady rate. Then, magnitude of induced emf is $\sqrt{x} \times 10^{-3}$V. The value of x is___

[29-Jan-2024 Shift 1]

Answer: 2

Solution:



$$\vec{A} = (0.1)^2\hat{j}$$

$$\vec{B} = \frac{0.2}{\sqrt{2}}\hat{i} + \frac{0.2}{\sqrt{2}}\hat{j}$$

Magnitude of induced emf

$$e = \frac{\Delta\phi}{\Delta t} = \frac{\vec{B}\cdot\vec{A} - 0}{1} = \sqrt{2}\times 10^{-3}V$$

Question4

A horizontal straight wire 5m long extending from east to west falling freely at right angle to horizontal component of earth's magnetic field 0.60×10^{-4}Wbm^{-2}. The instantaneous value of emf induced in the wire when its velocity is 10ms^{-1} is _____ $\times 10^{-3}$V

[29-Jan-2024 Shift 2]

Answer: 3

Solution:

$B_H = 0.60 \times 10^{-4}$ Wb/m^2

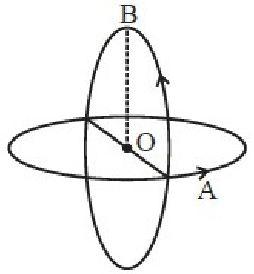
Induced emf $e = B_H v\ell$

$= 0.60 \times 10^{-4} \times 10 \times 5$

$= 3 \times 10^{-3}$V

Question5

Two insulated circular loop A and B radius ' a ' carrying a current of ' I ' in the anti clockwise direction as shown in figure. The magnitude of the magnetic induction at the centre will be :



[30-Jan-2024 Shift 1]

Options:

A.

$\frac{\sqrt{2}\mu_0 I}{a}$

B.

$\frac{\mu_0 I}{2a}$

C.

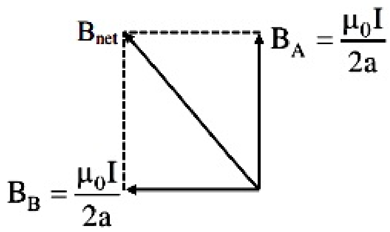
$$\frac{\mu_0 I}{\sqrt{2}a}$$

D.

$$\frac{2\mu_0 I}{a}$$

Answer: C

Solution:



$$\because B_{net} = \frac{\sqrt{2}\mu_0 I}{2a}$$

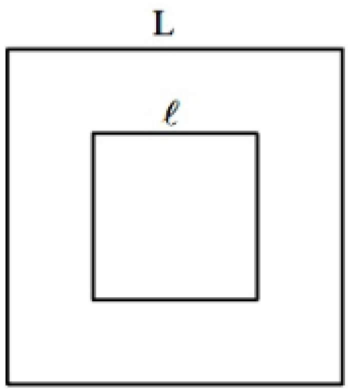
Question6

A small square loop of wire of side ℓ is placed inside a large square loop of wire of side L ($L = \ell^2$). The loops are coplanar and their centers coinside. The value of the mutual inductance of the system is $\sqrt{x} \times 10^{-7}$ H, where x =____

[31-Jan-2024 Shift 1]

Answer: 128

Solution:



Flux linkage for inner loop.

$$\phi = B_{cenkr} \cdot \ell^2$$

$$= 4 \times \frac{\mu_0 i}{4\pi \frac{L}{2}} (\sin 45 + \sin 45) \ell^2$$

$$\phi = 2\sqrt{2} \frac{\mu_0 i}{\pi L} \ell^2$$

$$M = \frac{\phi}{i} = \frac{2\sqrt{2}\mu_0 \ell^2}{\pi L} = 2\sqrt{2} \frac{\mu_0}{\pi}$$

$$= 2\sqrt{2} \frac{4\pi}{\pi} \times 10^{-7}$$

$$= 8\sqrt{2} \times 10^{-7} H$$

$$= \sqrt{128} \times 10^{-7} H$$

$$x = 128$$

Question7

The magnetic flux φ (in weber) linked with a closed circuit of resistance 8Ω varies with time (in seconds) as $\varphi = 5t^2 - 36t + 1$. The induced current in the circuit at t = 2 s is _____A.

[31-Jan-2024 Shift 2]

Answer: 2

Solution:

$$\varepsilon = -\left(\frac{d\phi}{dt}\right) = 10t - 36$$

$$\text{at } t = 2, \varepsilon = 16V$$

$$i = \frac{\varepsilon}{R} = \frac{16}{8} = 2A$$

Question8

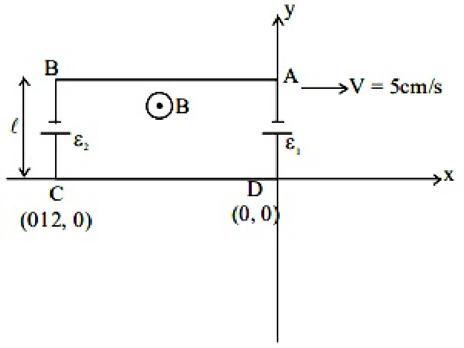
A rectangular loop of sides 12cm and 5cm, with its sides parallel to the x-axis and y-axis respectively moves with a velocity of 5cm/ s in the

positive x axis direction, in a space containing a variable magnetic field in the positive z direction. The field has a gradient of 10^{-3}T/cm along the negative x direction and it is decreasing with time at the rate of 10^{-3}T/ s. If the resistance of the loop is 6mΩ, the power dissipated by the loop as heat is _____$\times 10^{-9}$W.

[1-Feb-2024 Shift 1]

Answer: 216

Solution:



B_0 is the magnetic field at origin

$$\frac{dB}{dx} = -\frac{10^{-3}}{10^{-2}}$$

$$\int_{B_0}^{B} dB = -\int_0^x 10^{-1}\,dx$$

$$B - B_0 = -10^{-1}x$$

$$B = \left(B_0 - \frac{x}{10}\right)$$

Motional emf in AB = 0

Motional emf in CD = 0

Motional emf in AD $= \varepsilon_1 = B_0 \ell v$

Magnetic field on rod BC B

$$= \left(B_0 - \frac{(-12\times 10^{-2})}{10}\right)$$

Motional emf in BC $= \varepsilon_2 = \left(B_0 + \frac{12\times 10^{-2}}{10}\right)\ell \times v$

$$\varepsilon_{eq} = \varepsilon_2 - \varepsilon_1 = 300 \times 10^{-7}\text{V}$$

For time variation

$$(\varepsilon_{eq})' = A\frac{dB}{dt} = 60 \times 10^{-7}\text{V}$$

$$(\varepsilon_{eq})_{net} = \varepsilon_{eq} + (\varepsilon_{eq})' = 360 \times 10^{-7}\text{V}$$

$$\text{Power} = \frac{(\varepsilon_{eq})_{net}^{\,2}}{R} = 216 \times 10^{-9}\text{W}$$

Question9

A coil of 200 turns and area $0.20 m^2$ is rotated at half a revolution per second and is placed in uniform magnetic field of 0.01T perpendicular to axis of rotation of the coil. The maximum voltage generated in the coil is 2π/β volt. The value of β is____ .

[1-Feb-2024 Shift 2]

Answer: 5

Solution:

$\phi = NAB\cos(\omega t)$

$\varepsilon = -\frac{d\phi}{dt} = NAB\,\omega\,sin\,(\omega t)$

$\varepsilon_{max} = NAB\,\omega$

$= 200 \times 0.2 \times 0.01 \times \pi$

$= \frac{4\pi}{10} = \frac{2\pi}{5}$ volt

Question10

A conducting loop of radius $\frac{10}{\sqrt{\pi}}$ cm is placed perpendicular to a uniform magnetic field of 0.5T. The magnetic field is decreased to zero in 0.5 s at a steady rate. The induced emf in the circular loop at 0.25 s is: [24-Jan-2023 Shift 1]

Options:

A. emf = 1 mV

B. emf = 100 mV

C. emf = 10 mV

D. emf = 5 mV

Answer: B

Solution:

$$\text{EMF} = \frac{d\varphi}{dt} = \frac{BA - 0}{t}$$

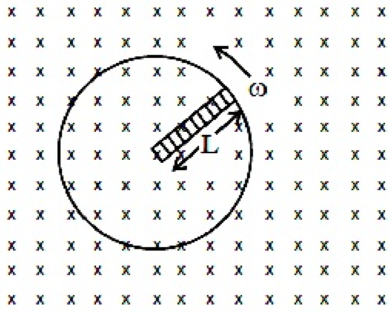
$$A = \pi r^2 = \pi\left(\frac{0.1^2}{\pi}\right) = 0.01$$

$$B = 0.5$$

$$\text{EMF} = \frac{(0.5)(0.01)}{0.5} = 0.01\text{V} = 10\,\text{mV}$$

Question11

A metallic rod of length ' L ' is rotated with an angular speed of ' ω ' normal to a uniform magnetic field ' B ' about an axis passing through one end of rod as shown in figure. The induced emf will be :



[24-Jan-2023 Shift 2]

Options:

A. $\frac{1}{4}B^2L\omega$

B. $\frac{1}{4}BL^2\omega$

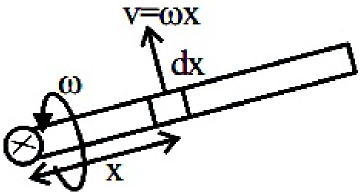
C. $\frac{1}{2}BL^2\omega$

D. $\frac{1}{2}B^2L^2\omega$

Answer: C

Solution:

Solution:



$\int d\varepsilon = \int B(\omega x)\,dx$

$\varepsilon = B\omega\int_0^L x\,dx = \frac{B\omega L^2}{2}$

Question12

A wire of length 1m moving with velocity 8m / s at right angles to a magnetic field of 2T. The magnitude of induced emf, between the ends of wire will be ________.
[25-Jan-2023 Shift 2]

Options:

A. 20V

B. 8V

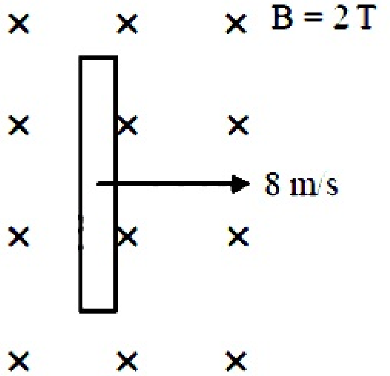
C. 12V

D. 16V

Answer: D

Solution:

Solution:



Induced emf across the ends $= Bv\ell$

$= 2 \times 8 \times 1 = 16V$

Question13

A certain elastic conducting material is stretched into a circular loop. It is placed with its plane perpendicular to a uniform magnetic field $B = 0.8T$. When released the radius of the loop starts shrinking at a constant rate of $2cm^{-1}$. The induced emf in the loop at an instant when the radius of the loop is $10\,cm$ will ______be mV.
[29-Jan-2023 Shift 1]

Answer: 10

Solution:

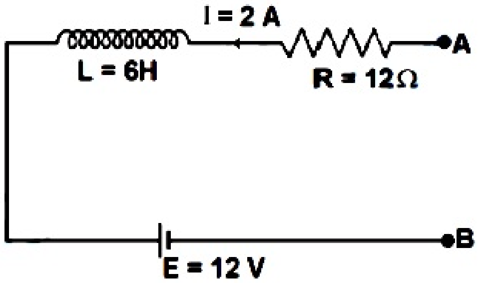
$$EMF = \frac{d}{dt}(B\pi r^2)$$

$$= 2B\pi r\frac{dr}{dt} = 2 \times \pi \times 0.1 \times 0.8 \times 2 \times 10^{-2}$$

$$= 2\pi \times 1.6 = 10.06 \;\; [\text{round off } 10.06 = 10]$$

Question14

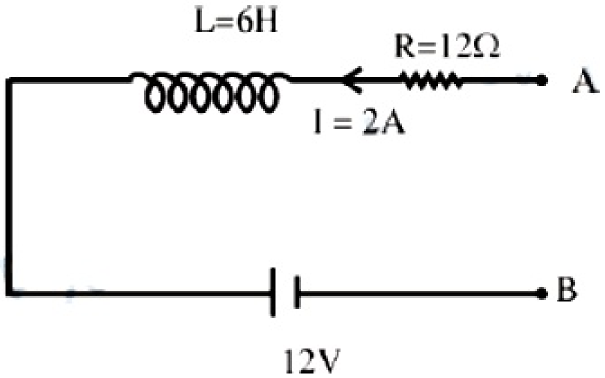
As per the given figure, if $\frac{dI}{dt} = -1A/\ s$ then the value of V_{AB} at this instant will be ______ V.



[30-Jan-2023 Shift 1]

Answer: 30

Solution:



$$\frac{dI}{dt} = -1\ \frac{A}{sec}$$

$$V_A - IR - L\frac{dI}{dt} - 12 = V_B$$

$$V_A - 2 \times 12 - 6(-1) - 12 = V_B$$

$$V_A - V_B = 36 - 6 = 30 \text{ volt}$$

Question15

An inductor of 0.5 mH, a capacitor of 20μF and resistance of 20Ω are connected in series with a 220V ac source. If the current is in phase with the emf, the amplitude of current of the circuit is $\sqrt{x}$A. The value of x is -
[31-Jan-2023 Shift 1]

Answer: 242

Solution:

$X_L = X_C$

So, $Z = R = 20\Omega$

$$i_{ms} = \frac{220}{20} = 11$$

$$i_{max} = 11\sqrt{2} = \sqrt{242}$$

Ans: 242

Question16

The induced emf can be produced in a coil by
A. moving the coil with uniform speed inside uniform magnetic field
B. moving the coil with non uniform speed inside uniform magnetic field
C. rotating the coil inside the uniform magnetic field
D. changing the area of the coil inside the uniform magnetic field
Choose the correct answer from the options given below :
[6-Apr-2023 shift 1]

Options:

A. B and D only

B. C and D only

C. B and C only

D. A and C only

Answer: B

Solution:

Solution:
Induced emf can be induced in a coil by changing magnetic flux.
And $\varphi = \vec{B} \cdot d\vec{A}$
By rotating coil, angle between coil and magnetic field changes and hence flux changes.
By changing area, magnetic flux changes.

Question17

For the plane electromagnetic wave given by $E = E_0 \sin(\omega t - kx)$ and $B = B_0 \sin(\omega t - kx)$, the ratio of average electric energy density to average magnetic energy density is
[6-Apr-2023 shift 1]

Options:

A. 2

B. 1 / 2

C. 1

D. 4

Answer: C

Solution:

In EM waves, average electric energy density is equal to average magnetic energy density.

$\frac{1}{4}E_{0}E_{0}^{2} = \frac{1}{4\mu_0}B_0^2$

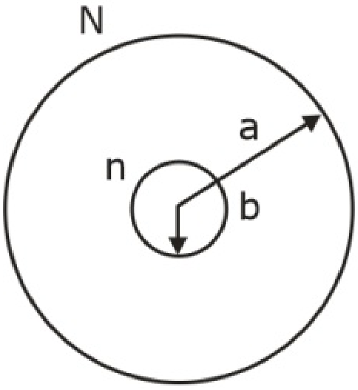
Question18

Two concentric circular coils with radii 1 cm and 1000 cm, and number of turns 10 and 200 respectively are placed coaxially with centers coinciding. The mutual inductance of this arrangement will be ______ $\times 10^{-8}$H (Take, $\pi^2 = 10$)
[6-Apr-2023 shift 2]

Answer: 4

Solution:

Solution:



Given
$a = 1000\,cm$
$b = 1\,cm$
or $b << a$
we will take larger coil as primary

$B = \frac{\mu_0 i_p N}{2a}$

flux $\varphi_s = BA = \frac{\mu_0 i_p N}{2a} \times \pi b^2 \times n$

Mutual inductance $M = \frac{\varphi_s}{i_p}$

$M = \frac{\mu_0 N n\pi b^2}{2 \times a}$

or $M = \frac{4\pi \times 10^{-7} \times 200 \times 10 \times \pi \times 1 \times 10^{-4}}{2 \times 1000 \times 10^{-2}}$

$= 4\pi^2 \times 10^{-9}$

or $M = 4 \times 10^{-8}$(using $\pi^2 = 10$)

Question19

An emf of 0.08V is induced in a metal rod of length 10 cm held normal to a uniform magnetic field of 0.4T, when moves with a velocity of: [8-Apr-2023 shift 2]

Options:

A. $2 ms^{-1}$

B. $20 ms^{-1}$

C. $3.2 ms^{-1}$

D. $0.5 ms^{-1}$

Answer: A

Solution:

Solution:

$\varepsilon = Blv$

$\Rightarrow 0.08 = v \times 0.4 \times \frac{10}{100}$

$\Rightarrow v = 2 m / s$

Question20

The energy of an electromagnetic wave contained in a small volume oscillates with [10-Apr-2023 shift 1]

Options:

A. double the frequency of the wave

B. the frequency of the wave

C. zero frequency

D. half the frequency of the wave

Answer: A

Solution:

Solution:

double the frequency of the wave

$E = E_0 \sin(wt - kx)$

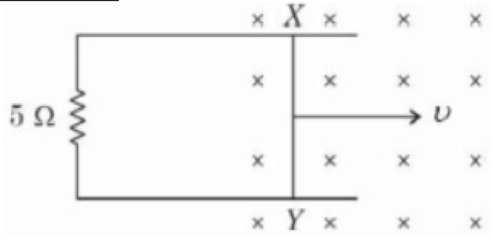
$\text{Energy density} = \frac{1}{2}\varepsilon_0 E_{net}$

$= \frac{1}{2}\varepsilon_0 {E_0}^2 \sin^2(wt - kx)$

$= \frac{1}{4}\varepsilon_0 {E_0}^2 (1 - \cos(2wt - 2kx))$

Question21

A 1m long metal rod XY completes the circuit as shown in figure. The plane of the circuit is perpendicular to the magnetic field of flux density 0.15T. If the resistance of the circuit is 5Ω, the force needed to move the rod in direction, as indicated, with a constant speed of 4m / s will be ______ 10^{-3}N.



[10-Apr-2023 shift 1]

Answer: 18

Solution:

$$F = I\ell B = \left(\frac{e}{R}\right)\ell B = \frac{(Bv\ell)B\ell}{R} = \frac{B^2\ell^2 v}{R}$$

$$= \frac{(\cdot 15)^2 \times (1)^2 \times 4}{5} = 180 \times 10^{-4}$$

$$= 18 \times 10^{-3} = 18 \text{ Ans.}$$

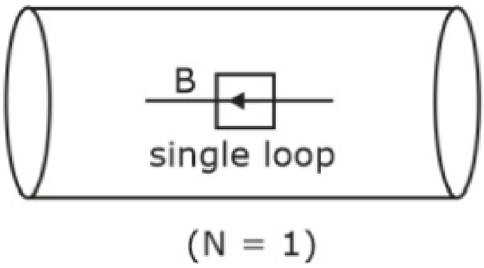
Question22

A square loop of side 2.0 cm is placed inside a long solenoid that has 50 turns per centimeter and carries a sinusoidally varying current of amplitude 2.5A and angular frequency 700 rad s^{-1}. The central axes of the loop and solenoid coincide. The amplitude of the emf induced in the loop is $x \times 10^{-4}$V. The value of x is _______. (Take, $\pi = \frac{22}{7}$)

[10-Apr-2023 shift 2]

Answer: 44

Solution:



emf induced in solenoid $\Rightarrow$ BAWN $\sin(\omega t)$, w = 700 rad / s

Amplitude $\Rightarrow$ BAWN

Area (A) = 2 cm × 2 cm

$= 4cm^2$

$= 4 \times 10^{-4} m^2$

$(B)_{solenoid} = \mu_0 ni$

$= 4\pi \times 10^{-7} \times 5000 \times 2.5$

$= 5\pi \times 10^{-3}$

$n = \frac{50 \text{ turns}}{cm} = \frac{5000}{m}$

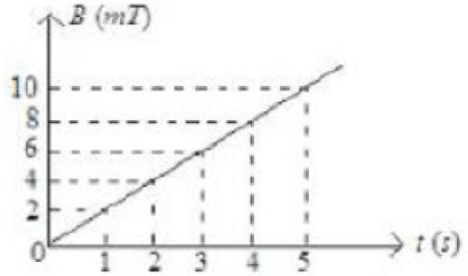
i = 2.5

Amplitude of emf $= (5p \times 10^{-3})(4 \times 10^{-4})(700)(1)$

$= 5 \times \frac{22}{7} \times 4 \times 700 \times 10^{-7} = 44 \times 10^{-4}$

Question23

The magnetic field B crossing normally a square metallic plate of area $4m^2$ is changing with time as shown in figure. The magnitude of induced emf in the plate during t = 2s to t = 4s, is ______ mV.



[11-Apr-2023 shift 1]

Answer: 8

Solution:

$\text{emf} = \frac{d\varphi}{dt}$

$\text{Emf} = \frac{dBA}{dt} = \frac{AdB}{dt}$

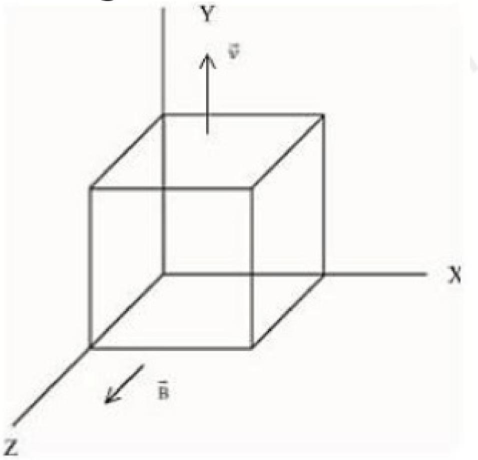
Emf = 4· Slope of B.t curve

$= 4 \cdot \left[\frac{8-4}{4-2}\right] = 4 \times 2$

Emf = 8 Volt

Question24

A metallic cube of side 15 cm moving along y-axis at a uniform velocity of $2ms^{-1}$. In a region of uniform magnetic field of magnitude 0.5T directed along z-axis. In equilibrium the potential difference between the faces of higher and lower potential developed because of the motion through the field will be _______ mV.



[11-Apr-2023 shift 2]

Answer: 150

Solution:

qVB = qE
E = VB
$\Delta V = EL = VBL$
$\Delta V = 2 \times 0.5 \times \frac{15}{100} = \frac{15}{100}$ volt
$= 15 \times 10^{-2}$ volt
$= 150 \times 10^{-3}$ v

Question25

A coil has an inductance of 2H and resistance of 4Ω. A 10V is applied across the coil. The energy stored in the magnetic field after the current has built up to its equilibrium value will be _______ $\times 10^{-2}$J.
[11-Apr-2023 shift 2]

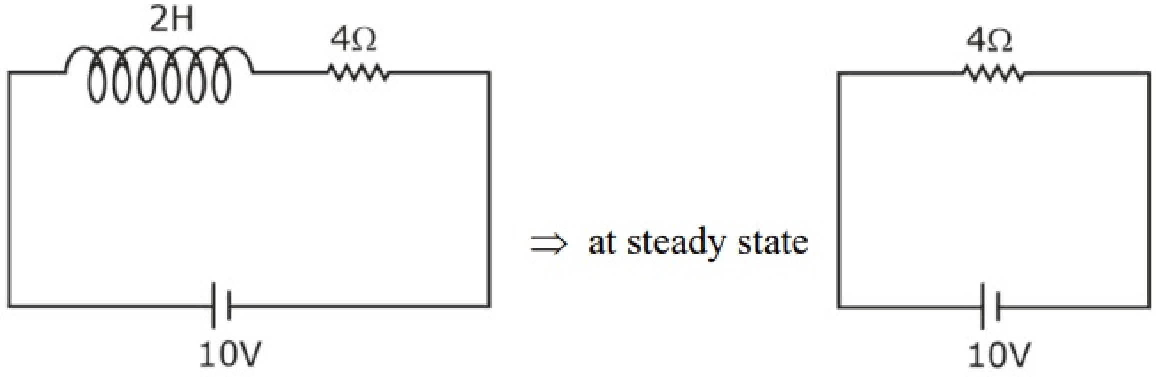
Answer: 625

Solution:

At steady state, inductor will act as a short circuit.

$I = \frac{V}{R} = \frac{10}{4} = \frac{5}{2}A$

$E = \frac{1}{2}LI^2 = \frac{1}{2} \times 2 \times \left(\frac{5}{2}\right)^2 = \frac{25}{4} = 6.25 = 625 \times 10^{-2}J$



Question26

A conducting circular loop is placed in a uniform magnetic field of 0.4T with its plane perpendicular to the field. Somehow, the radius of the loop starts expending at a constant rate of 1 mm / s. The magnitude of induced emf in the loop at an instant when the radius of the lop is 2 cm will be ________ μV.
[12-Apr-2023 shift 1]

Answer: 50

Solution:

$B = 0.4T$

Rate $\frac{dr}{dt} = 1\,mm/\,sec$ Einduced = ?

$R = 2\,cm$

$\varphi = B\pi r^2$ (($\varphi = B \cdot A$)

$\varepsilon = \frac{d\varphi}{dt} = B\pi(2r)\frac{dr}{dt}$

Ein $= 0.4 \times \pi \times 4 \times 10^{-2} \times 10^{-3}$

Ein $= 16\pi \times 10^{-6}$

Ein $= 50\mu V$

Question27

The source of time varying magnetic field may be
(A) A permanent magnet
(B) An electric field changing linearly with time
(C) Direct current

(D) A decelerating charge particle
(E) An antenna fed with a digital signal
Choose the correct answer from the options given below:
[13-Apr-2023 shift 1]

Options:

A. (B) and (D) only

B. (C) and (E) only

C. (D) only

D. (A) only

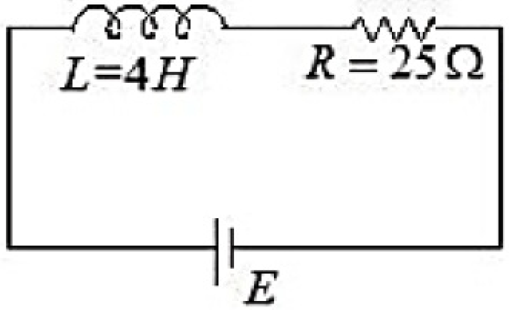
Answer: C

Solution:

Solution:
Accelerated charge particle produces EMW which has time varying E and B. If E is linear function of time then B will be constant.

Question28

In the given figure, an inductor and a resistor are connected in series with a batter of emf E volt. $\frac{E^a}{2b}$J / s represents the maximum rate at which the energy is stored in the magnetic field (inductor). The numerical value of $\frac{b}{a}$ will be ________



[13-Apr-2023 shift 1]

Answer: 25

Solution:

Solution:
$U = \frac{1}{2}LI^2$
$I = I_0(1 - e^{-t/t})$
Rate of energy, $P = \frac{dU}{dt}$

$P = LI\frac{dI}{dt}$

$\frac{dP}{dt} = L\left(I\frac{d^2I}{dt^2} + \left(\frac{dI}{dt}\right)^2\right)$

For maximum rate, $\frac{dP}{dt} = 0$

$I\frac{d^2I}{dt^2} = -\left(\frac{dI}{dt}\right)^2$

$I = I_0(1 - e^{t/\tau})$

$\frac{dI}{dt} = \frac{I_0}{\tau}e^{-t/\tau}$

$\frac{d^2I}{dt^2} = -\frac{I_0}{\tau^2}e^{-t/\tau}$

By equation (1),

$I_0(1 - e^{-t/\tau}) \times \frac{I_0}{\tau^2}e^{-t/\tau} = \frac{-I_0^2}{\tau^2}e^{-2t/\tau}$

Let $e^{-t/t} = x$

$x - x^2 = x^2$

$x = \frac{1}{2}$

Maximum power,

$P = LI\frac{dI}{dt}$

$P = LI_0\left(1 - \frac{1}{2}\right)\left(\frac{I_0}{\tau} \times \frac{1}{2}\right)$

$P = \frac{LI_0^2}{4 \times \frac{L}{R}} = \frac{I_0^2R}{4}$

$P = \frac{E^2}{4R}$

$a = 2, 2b = 4R$

$b = 2R = 50$

$\frac{b}{a} = 25$

Question29

An insulated copper wire of 100 turns is wrapped around a wooden cylindrical core of the cross-sectional area 24cm^2. The two ends of the wire are connected to a resistor. The total resistance in the circuit is 12Ω. If an externally applied uniform magnetic field in the core along its axis changes from 1.5T in one direction to 1.5T in the opposite direction, the charge flowing through a point in the circuit during the change of magnetic field will be ________ mC.
[13-Apr-2023 shift 2]

Answer: 60

Solution:

Solution:

$|\Delta Q| = \frac{\Delta\varphi}{R} = \frac{2NBA}{R}$

$$= \frac{2 \times 100 \times 1.5 \times 24 \times 10^{-4}}{12}$$
$= 6 \times 10^{-2} c$
$= 60\,mc$

Question30

A 12V battery connected to a coil of resistance 6Ω through a switch, drives a constant current in the circuit. The switch is opened in 1 ms. The emf induced across the coil is 20V. The inductance of the coil is : [15-Apr-2023 shift 1]

Options:

A. 8 mH

B. 10 mH

C. 12 mH

D. 5 mH

Answer: B

Solution:

Solution:

$e = -L \frac{di}{dt}$

$i_1 = \frac{E}{R} = \frac{12}{6} = 2A$

$20 = -L \left(\frac{0-2}{10^{-3}} \right)$

$L = 10\,mH$

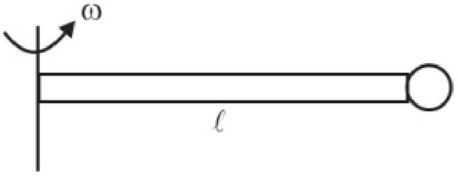
Question31

A 20 cm long metallic rod is rotated with 210 rpm about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field 0.2T parallel to the axis exists everywhere. The emf developed between the centre and the ring is ________ mV. (Take π = 22 / 7) [15-Apr-2023 shift 1]

Answer: 88

Solution:

A $20\,\mathrm{cm}$ long metallic rod is rotated with $210\,\mathrm{rpm}$ about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field $0.2\mathrm{T}$ parallel to the axis exists everywhere. The emf developed between the centre and the ring is mV. (Take $\pi = 22/7$)



Question32

A circular coil of 1000 turns each with area $1\mathrm{m}^2$ is rotated about its vertical diameter at the rate of one revolution per second in a uniform horizontal magnetic field of 0.07T. The maximum voltage generation will be ____V.
[24-Jun-2022-Shift-2]

Answer: 440

Solution:

Solution:
$V_{max} = N\,AB\omega$
$= 1000 \times 1 \times 0.07 \times (2\pi \times 1)$
$\simeq 440$ volts

Question33

The current in a coil of self inductance 2.0H is increasing according to $I = 2\sin(t^2)\,A$. The amount of energy spent during the period when current changes from 0 to A is ______J.
[25-Jun-2022-Shift-1]

Answer: 4

Solution:

Solution:
$U = \frac{1}{2}LI^2$
$= \frac{1}{2}2 \times 2^2 = 4\mathrm{J}$

Question34

The magnetic flux through a coil perpendicular to its plane is varying according to the relation $\varphi = (5t^3 + 4t^2 + 2t - 5)$ Weber. If the resistance of the coil is 5 ohm, then the induced current through the coil at t = 2s will be,
[26-Jun-2022-Shift-1]

Options:

A. 15.6A

B. 16.6A

C. 17.6A

D. 18.6A

Answer: A

Solution:

Solution:

$\varphi = 5t^3 + 4t^2 + 2t - 5$

$|e| = \frac{d\varphi}{dt} = 15t^2 + 8t + 2$

At t = 2, $|e| = 15 \times 2^2 + 8 \times 2 + 2$

$\Rightarrow e = 78V$

$\Rightarrow I = \frac{e}{R} = \frac{78}{5} = 15.60$

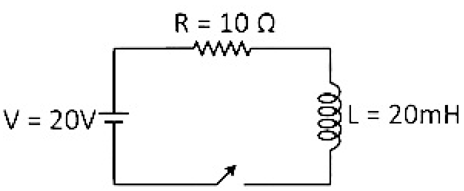
Question35

A 10Ω, 20 mH coil carrying constant current is connected to a battery of 20V through a switch. Now after switch is opened current becomes zero in 100μ s. The average e.m.f. induced in the coil is ______V.
[26-Jun-2022-Shift-1]

Answer: 400

Solution:

Solution:



Initially current, $I_0 = \frac{20}{10} = 2A$ (when initially switch closed) average emf induced in coil $= \frac{L\,di}{dt}$

$\Rightarrow e_{avg} = \frac{20 \times 10^{-3} \times (2 - 0)}{100 \times 10^{-6}}$

$e_{avg} = 400V$

Question36

Two coils of self inductance L_1 and L_2 are connected in series combination having mutual inductance of the coils as M . The equivalent self inductance of the combination will be :

[26-Jun-2022-Shift-2]

Options:

A. $\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{M}$

B. $L_1 + L_2 + M$

C. $L_1 + L_2 + 2M$

D. $L_1 + L_2 - 2M$

Answer: D

Solution:

Solution:
Self inductances are in series but their mutual inductances are linked oppositely so equivalent self inductance
$L = L_1 + L_2 - M - M = L_1 + L_2 - 2M$

Question37

A metallic conductor of length 1m rotates in a vertical plane parallel to east-west direction about one of its end with angular velocity $5\,rad\,s^{-1}$. If the horizontal component of earth's magnetic field is 0.2×10^{-4}T, then emf induced between the two ends of the conductor is: [26-Jun-2022-Shift-2]

Options:

A. 5μV

B. 50μV

C. 5 mV

D. 50mv

Answer: B

Solution:

Solution:

$E\,mf = \frac{1}{2}B\omega l^2$

$= \frac{1}{2} \times 0.2 \times 10^{-4} \times 5 \times 1^2 V$

$= 0.5 \times 10^{-4} V$

$= 50 \mu V$

Question38

A metallic rod of length 20 cm is placed in North-South direction and is moved at a constant speed of 20m / s towards East. The horizontal component of the Earth's magnetic field at that place is 4×10^{-3}T and the angle of dip is 45°. The emf induced in the rod is ______mV
[27-Jun-2022-Shift-2]

Answer: 16

Solution:

Solution:

$E = Bl\,v$

$= 4 \times 10^{-3} \times \frac{20}{100} \times 20$ Volts

$= 16\,mV$

Question39

Given below are two statements :
Statement I : The electric force changes the speed of the charged particle and hence changes its kinetic energy; whereas the magnetic force does not change the kinetic energy of the charged particle.
Statement II : The electric force accelerates the positively charged particle perpendicular to the direction of electric field. The magnetic force accelerates the moving charged particle along the direction of magnetic field.
In the light of the above statements, choose the most appropriate answer from the options given below :
[29-Jun-2022-Shift-2]

Options:

A. Both Statement I and Statement II are correct.

B. Both Statement I and Statement II are incorrect.

C. Statement I is correct but Statement II is incorrect.

D. Statement I is incorrect but Statement II is correct.

Answer: C

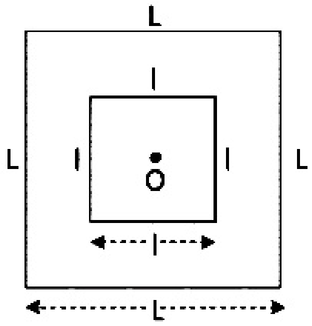
Solution:

Solution:

Electric field accelerates the particle in the direction of field $\left(\vec{F} = q\vec{E} = m\vec{a}\right)$ and magnetic field accelerates the particle perpendicular to the field $\left(\vec{F} = q\vec{v} \times \vec{B} = m\vec{a}\right)$.

Question40

A small square loop of wire of side l is placed inside a large square loop of wire L(L> > l). Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is :



[25-Jul-2022-Shift-1]

Options:

A. $\frac{2\sqrt{2}\mu_0 L^2}{\pi l}$

B. $\frac{\mu_0 l^2}{2\sqrt{2}\pi L}$

C. $\frac{2\sqrt{2}\mu_0 l^2}{\pi L}$

D. $\frac{\mu_0 T^2}{n \cdot \sqrt{2}\pi l}$

Answer: C

Solution:

Solution:

We know $\varphi = M i$

Let i current be flowing in the larger loop

$\Rightarrow \varphi \simeq \left[4 \times \frac{\mu_0 i}{4\pi(L_L / 2)}[\sin 45^\circ + \sin 45^\circ]\right] \times$ Area

$= \frac{2\sqrt{2}\mu_0 i}{\pi L} \times I^2$

$\Rightarrow M = \frac{\varphi}{i} = \frac{2\sqrt{2}\mu_0 I^2}{\pi L}$

Question41

Magnetic flux (in weber) in a closed circuit of resistance 20Ω varies with time t(s) at $\varphi = 8t^2 - 9t + 5$. The magnitude of the induced current at t = 0.25s will be ____mA.
[25-Jul-2022-Shift-2]

Answer: 250

Solution:

Solution:
$R = 20\Omega$
$\varphi = 8t^2 - 9t + 5$
$\varepsilon = \left| -\frac{d\varphi}{dt} \right| = \left| 16t - 9 \right| = \left| 16(0.25) - 9 \right| = 5$
$i = \frac{\varepsilon}{R} = \frac{5}{20} = 0.25A = \frac{0.25}{10^3} \times 10^3 A = 250mA$

Question42

A velocity selector consists of electric field $\vec{E} = E\hat{k}$ and magnetic field $\vec{B} = B\hat{j}$ with B = 12mT . The value of E required for an electron of energy 728eV moving along the positive x-axis to pass undeflected is :
(Given, mass of electron $= 9.1 \times 10^{-31}$ kg)
[26-Jul-2022-Shift-2]

Options:

A. $192kVm^{-1}$

B. $192mVm^{-1}$

C. $9600kVm^{-1}$

D. $16kVm^{-1}$

Answer: A

Solution:

Solution:
$\vec{E} = E\hat{k}$ B = 12 mT
$\vec{B} = B\hat{j}$ Energy = 728 eV
Energy $= \frac{1}{2}mv^2$

$728\,eV = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$

$728 \times 1.6 \times 10^{-19} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$

$v = 16 \times 10^6 m / s$

$E = vB$

$E = 16 \times 10^6 \times 12 \times 10^{-3}$

$E = 192 \times 10^3 V / m$

Question43

A beam of light travelling along X -axis is described by the electric field $E_y = 900 \sin \omega(t - x / c)$.

The ratio of electric force to magnetic force on a charge q moving along Y -axis with a speed of $3 \times 10^7 ms^{-1}$ will be :

(Given speed of light $= 3 \times 10^8 ms^{-1}$)

[27-Jul-2022-Shift-1]

Options:

A. 1 : 1

B. 1 : 10

C. 10 : 1

D. 1 : 2

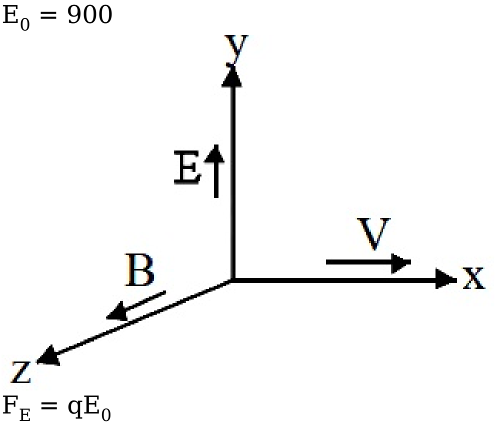
Answer: C

Solution:

Solution:

$E_y = 900 \sin\left(\omega t - \frac{\omega x}{c}\right)$

$E_0 = 900$



$F_E = qE_0$

$F_B = qvB_0$

$\frac{F_E}{F_B} = \frac{E_0}{vB_0} = \frac{c}{v} = \frac{3 \times 10^8}{3 \times 10^7} = 10 : 1$

Question44

A conducting circular loop is placed in $X - Y$ plane in presence of

magnetic field $\vec{B} = \left(3t^3\hat{j} + 3t^2\hat{k}\right)$ in SI unit. If the radius of the loop is 1m, the induced emf in the loop, at time, t = 2s is nπV. The value of n is ________.
[27-Jul-2022-Shift-2]

Answer: 12

Solution:

Solution:
$\varphi = \vec{B} \cdot \vec{A}$
$= \left(3t^3\hat{j} + 3t^2\hat{k}\right) \cdot \left(\pi(1)^2\hat{k}\right)$
$\varphi = 3t^2\pi$
$\varepsilon_{IND} = \left|\frac{d\varphi}{dt}\right| = 6t\pi$
at $t = 2$, $\varepsilon_{IND} = 12$

Question45

A transformer operating at primary voltage 8 kV and secondary voltage 160V serves a load of 80 kW. Assuming the transformer to be ideal with purely resistive load and working on unity power factor, the loads in the primary and secondary circuit would be
[28-Jul-2022-Shift-2]

Options:

A. 800Ω and 1.06Ω

B. 10Ω and 500Ω

C. 800Ω and 0.32Ω

D. 1.06Ω and 500Ω

Answer: C

Solution:

Solution:
$V_1 i_1 = V_2 i_2 = 80\,\text{kW}$
$\Rightarrow i_1 = 10\text{A}$ and $i_2 = \frac{80 \times 1000}{160} = 500\text{A}$
$\Rightarrow R_1 = \frac{V_1}{i_1} = 800\Omega$ and $R_2 = \frac{160}{500} = 0.32\Omega$

Question46

An aeroplane with its wings spread 10m, is flying at a speed of 180km / h in a horizontal direction. The total intensity of Earth's field at that part is $2.5 \times 10^{-4} Wb / m^2$ and the angle of dip is 60°. The emf induced between the tips of the plane wings will be
[26 Feb 2021 Shift 2]

Options:

A. 108.25mV

B. 54.125mV

C. 88.37mV

D. 62.50mV

Answer: A

Solution:

Solution:
Given, length of aeroplane wing, $I = 10m$
Speed of aeroplane, $v = 180km / h = 50ms^{-1}$
Magnetic flux density, $B = 2.5 \times 10^{-4} Wb / m^2$
Angle of dip, $\theta = 60^\circ$
The emf induced between the tips of plane wings,
$\varepsilon = B / v \sin\theta$
$= 2.5 \times 10^{-4} \times 10 \times 50 \sin 60^\circ$
$= 2.5 \times 5 \times 10^{-2} \times \sqrt{3} / 2$
$= 6.25 \times 1.732 \times 10^{-2}$
$= 108.25 \times 10^{-3} = 108.25mV$

Question47

A coil of inductance 2H having negligible resistance is connected to a source of supply whose voltage is given by V = 3tV (where, t is in second). If the voltage is applied when t = 0, then the energy stored in the coil after 4s is .... J.
[25 Feb 2021 Shift 1]

Answer: 144

Solution:

Solution:
Given, inductance of coil, $L = 2H$
Supply voltage, $V = 3tV$
Let E be the energy stored in the coil.
Since, emf $V = L \cdot \frac{dl}{dt}$
$3t = L\frac{dl}{dt} \Rightarrow 3t\,dt = L\,dl$

$3t = L\frac{dI}{dt} \Rightarrow 3t\,dt = L\,dI$

On integrating both sides, we get

$3\frac{t^2}{2} = LI$

At t = 4s,

At t = 4s,

$\frac{3}{2} \times 4^2 = LI \Rightarrow \frac{3}{2} \times \frac{16}{L} = I$

$\frac{24}{L} = I \ldots$ (i)

As, $E = 1/2LI^2$

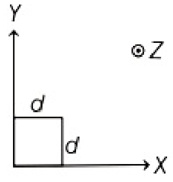
$E = 1/2L\frac{24^2}{L^2}$ [From Eq. (i)]

$= \frac{1}{2}\frac{24^2}{L} = \frac{24^2}{2 \times 2}$

$\therefore = 144J$

Question48

The magnetic field in a region is given by $B = B_0\left(\frac{x}{a}\right)\hat{k}$. A square loop of side d is placed with its edges along the X and Y -axes. The loop is moved with a constant velocity $v = v_0\hat{i}$. The emf induced in the loop is



[16 Mar 2021 Shift 2]

Options:

A. $\frac{B_0 v_0^2 d}{2a}$

B. $\frac{B_0 v_0 d}{2a}$

C. $\frac{B_0 v_0 d^2}{a}$

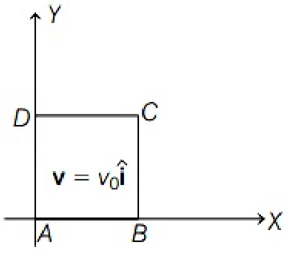
D. $\frac{B_0 v_0 d^2}{2a}$

Answer: C

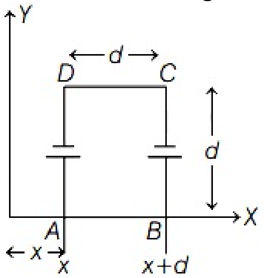
Solution:

Solution:

The given situation can be shown as



From the above figure, it can be seen that emf induced in side DC and AB will be zero. It is because v is parallel to length of conductor along X -axis.



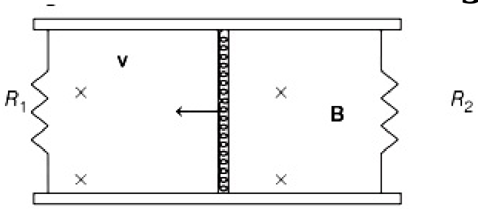
∴ Net emf induced $= E_{BC} - E_{AD}$

$$= \frac{B_0(x + d)v_0 d}{a} - \frac{B_0 x v_0 d}{a}$$

$$= \frac{B_0 v_0 d^2}{a}$$

Question49

A conducting bar of length L is free to slide on two parallel conducting rails as shown in the figure



Two resistors R_1 and R_2 are connected across the ends of the rails. There is a uniform magnetic field B pointing into the page. An external agent pulls the bar to the left at a constant speed v. The correct statement about the directions of induced currents I_1 and I_2 flowing through R_1 and R_2 respectively is [16 Mar 2021 Shift 1]

Options:

A. both I_1 and I_2 are in anti-clockwise direction.

B. both I_1 and I_2 are in clockwise direction.

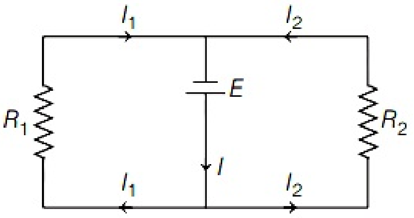
C. I_1 is in clockwise direction and I_2 is in anti-clockwise direction.

D. I_1 is in anticlockwise direction and I_2 is in clockwise direction.

Answer: C

Solution:

Solution:
According to Lenz's law, "An induced current flows in a direction in such a way that it always opposes the cause that induced it".
Considering this, it can be concluded that I_1 is in the clockwise direction and I_2 is in the anti-clockwise direction and the effective circuit with the directions of I_1 and I_2 can be shown as follows



Question50

The time taken for the magnetic energy to reach 25% of its maximum value, when a solenoid of resistance R, inductance L is connected to a battery, is
[18 Mar 2021 Shift 2]

Options:

A. $\frac{L}{R}\ln 5$

B. infinite

C. $\frac{L}{R}\ln 2$

D. $\frac{L}{R}\ln 10$

Answer: C

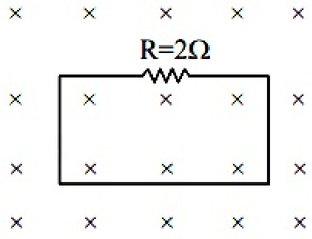
Solution:

Solution:
The expression of the magnetic energy stored in the solenoid,
$U = \frac{LI^2}{2}$
The maximum value of the magnetic energy stored in the solenoid,
$U_0 = \frac{LI_0^2}{2}$
Given, $U = 25\% \times U_0$
$\Rightarrow \frac{LI^2}{2} = \frac{1}{4} \times \frac{LI_0^2}{2} \Rightarrow I = \frac{I_0}{2}$
Therefore, using the formula for the decay current in $L - R$ circuit,
$I = I_0(1 - e^{-t/\tau})$
$\frac{I_0}{2} = I_0(1 - e^{-2/\tau})$
$e^{-t/\tau} = \frac{1}{2} \Rightarrow t = \tau \ln 2$
$\Rightarrow t = \frac{L}{R}\ln 2$

Question51

In the given figure the magnetic flux through the loop increases according to the relation $\phi_B(t) = 10t^2 + 20t$, where ϕ_B is in milliwebers and tis in seconds.

The magnitude of current through R = 2Ω resistor at t = 5s is ____mA



[27 Jul 2021 Shift 2]

Answer: 60

Solution:

Solution:

$|\in| = \frac{d\phi}{dt} = 20t + 20mV$

$|i| = \frac{|\in|}{R} = 10t + 10mA$

at t = 5

$|i| = 60mA$

Question52

A circular conducting coil of radius 1m is being heated by the change of magnetic field $\vec{B}$ passing perpendicular to the plane in which the coil is laid. The resistance of the coil is 2μΩ. The magnetic field is slowly switched off such that its magnitude changes in time as

$$B = \frac{4}{\pi} \times 10^{-3} T \left(1 - \frac{t}{100}\right)$$

The energy dissipated by the coil before the magnetic field is switched off completely is E = —— mJ

[25 Jul 2021 Shift 1]

Answer: 80

Solution:

Solution:

$\phi = \vec{B} \cdot \vec{S}$

$\phi = \frac{4}{\pi} \times 10^{-3} \left(1 - \frac{t}{100}\right) \cdot \pi R^2$

$\phi = 4 \times 10^{-3} \times (1)^2 \left(1 - \frac{t}{100}\right)$

$\varepsilon = \frac{-d\phi}{dt}$

$\varepsilon = \frac{-d}{dt}\left(4 \times 10^{-3}\left(1 - \frac{t}{100}\right)\right)$

$\varepsilon = 4 \times 10^{-3}\left(\frac{1}{100}\right) = 4 \times 10^{-5}V$

When B = 0

$1 - \frac{t}{100} = 0$

t = 100sec

Heat $= \frac{\varepsilon^2}{R}t$

Heat $= \frac{(4 \times 10^{-5})^2}{2 \times 10^{-6}} \times 100J$

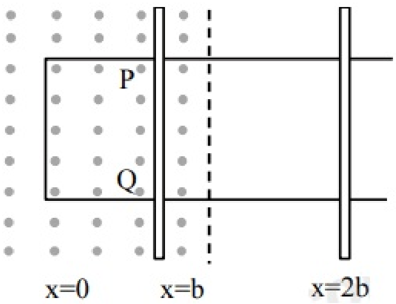
Heat $= \frac{16 \times 10^{-10} \times 100}{2 \times 10^{-6}}J$

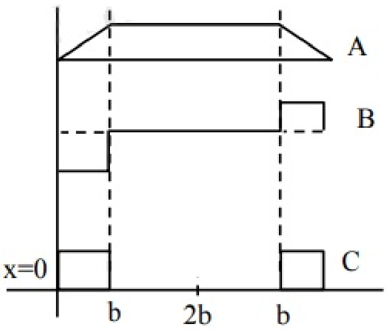
Heat = 0.08J

Heat = 80mJ

Question53

The arm PQ of a rectangular conductor is moving from x = 0 to x = 2b outwards and then inwards from x = 2b to x = 0 as shown in the figure. A uniform magnetic field perpendicular to the plane is acting from x = 0 to x = b. Identify the graph showing the variation of different quantities with distance :





[20 Jul 2021 Shift 1]

Options:

A. A-Flux, B-Power dissipated, C-EMF

B. A-Power dissipated, B-Flux, C-EMF

C. A-Flux, B-EMF, C-Power dissipated

D. A-EMF, B-Power dissipated, C-Flux

Answer: C

Solution:

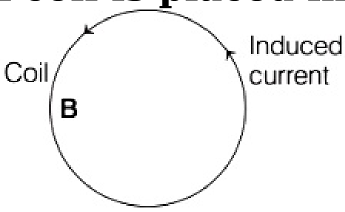
As rod moves in field area increases upto x = b then field is absent and again flux is generated on return journey from x = b to x = 0. Thus plot A for flux.

$\Rightarrow e = -\frac{d\phi}{dt} \Rightarrow$ curve B for emf

⇒ Power dissipated = vi ⇒ curve C for power dissipated

Question54

A coil is placed in a magnetic field B as shown below.



A current is induced in the coil because B is
[31 Aug 2021 Shift 2]

Options:

A. outward and decreasing with time

B. parallel to the plane of coil and decreasing with time

C. outward and increasing with time

D. parallel to the plane of coil and increasing with time

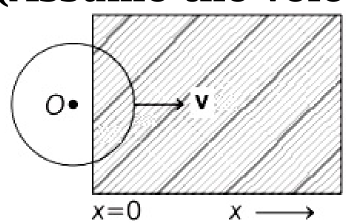
Answer: A

Solution:

Solution:
In the given figure, the magnetic field is outward, means N-pole is formed on outward face and S-pole is formed on inward (back) face. As the induced current is anti-clockwise which is also making N-pole on outward face.
According to the Lenz's law, the induced current always opposes the nature by which it is produced.
Hence, induced current is in the direction, so the strength of N-pole is maintained as it is decreasing.

Question55

A constant magnetic field of 1T is applied in the x > 0 region. A metallic circular ring of radius 1m is moving with a constant velocity of 1m / s along the X-axis. At t = 0s, the centre of O of the ring is at x = −1m.What will be the value of the induced emf in the ring at t = 1s? (Assume the velocity of the ring does not change.)



[27 Aug 2021 Shift 2]

Options:

A. 1 V

B. 2 π V

C. 2 V

D. 0

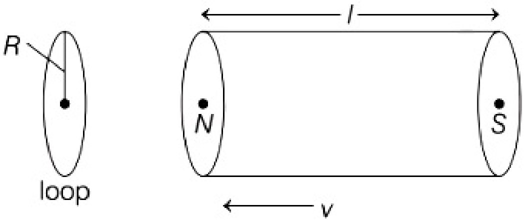
Answer: C

Solution:

Solution:
Given, magnetic field, $B = 1T$
Radius of ring, $R = 1m$
Velocity of ring, $v = 1m/s$
Time taken, $t = 1s$
Let emf be ε
Since,
$\varepsilon = Bl v \sin\theta$
$\therefore$
$= 1 \times 2R \times 1 \times \sin 90^{\circ}$
$= 2R = 2V$

Question56

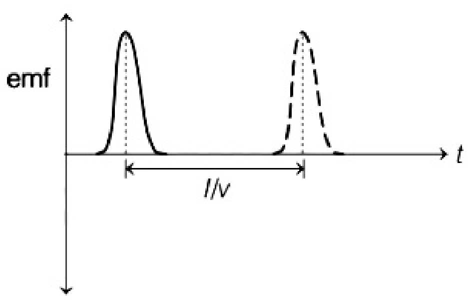
A bar magnet is passing through a conducting loop of radius R with velocity v. The radius of the bar magnet is such that it just passes through the loop. The induced emf in the loop can be represented by the approximate curve



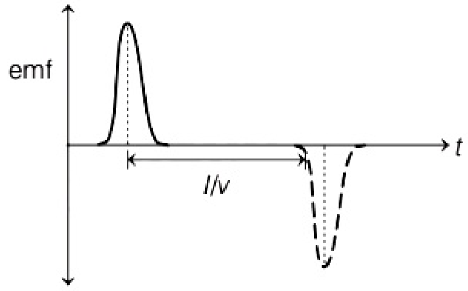
[27 Aug 2021 Shift 1]

Options:

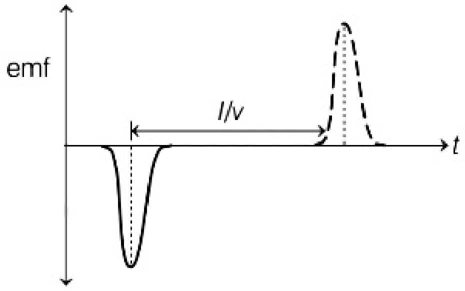
A.



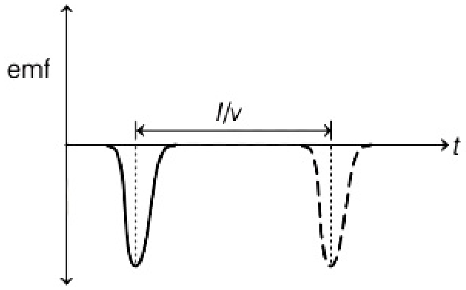
B.



C.



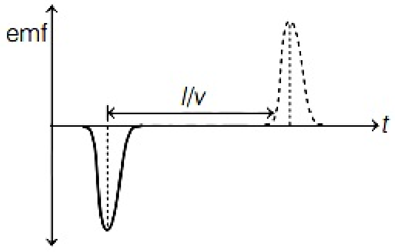
D.



Answer: C

Solution:

Solution:
Given, radius of loop is R and velocity of the bar magnet is v.
According to Faraday’s law of electromagnetic induction, the emf induced in loop is given by
$e = -\frac{Nd\phi}{dt}$ ...(i)
As initially the bar magnet is moving towards the coil, so the rate of change of magnetic flux linked with the coil will increase. Thus, initially the emf induced in coil will decrease as per Eq. (i) (due to –ve sign).
When magnet reaches the middle point in the coil, for that moment the emf induced will be equal to zero because in this situation, change in magnetic flux associated with bar magnet becomes zero.
Now, after that when magnet moves forward, the magnetic flux again starts changing but the polarity of magnetic flux change will be reversed. So, the emf will now increase in opposite direction.
The graph for change in emf of coil is shown below.



Question57

A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical

diameter with an angular speed of $50\,\text{rad s}^{-1}$ in a uniform horizontal magnetic field of 3.0×10^{-2}T. The maximum emf induced in the coil will be .... $\times 10^{-2}$V.
(rounded off to the nearest integer.)
[26 Aug 2021 Shift 2]

Answer: 60

Solution:

Given, radius of circular coil, r = 8.0 cm = 0.08 m
Number of turns, N = 20
Angular speed of coil, $\omega = 50\,\text{rad s}^{-1}$
Magnetic field, $B = 3.0 \times 10^{-2}\text{T}$
The maximum emf induced in a coil can be expressed as
$\varepsilon = \omega NBA$
Here, A is the area of coil.
$\varepsilon = NB\omega(\pi r^2)$
Substituting the given values, we get
$\varepsilon = 20 \times 3.0 \times 10^{-2} \times 50 \times \pi \times (0.08)^2$
$= 60.3 \times 10^{-2}\text{V}$
$\simeq 60 \times 10^{-2}\text{V}$

Question58

A small square loop of side a and one turn is placed inside a larger square loop of side b and one turn (b> > a). The two loops are coplanar with their centres coinciding. If a current / is passed in the square loop of side b, then the coefficient of mutual inductance between the two loops is
[31 Aug 2021 Shift 1]

Options:

A. $\frac{\mu_0}{4\pi} 8\sqrt{2} \frac{a^2}{b}$

B. $\frac{\mu_0}{4\pi} \frac{8\sqrt{2}}{a}$

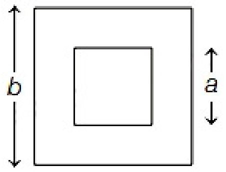
C. $\frac{\mu_0}{4\pi} 8\sqrt{2} \frac{b^2}{a}$

D. $\frac{\mu_0}{4\pi} \frac{8\sqrt{2}}{b}$

Answer: A

Solution:

Given, side of one square loop = a
Side of 2nd square loop = b
b> > a
Current = i



Since, $\phi = Mi$
$M = \frac{\phi}{i} = \frac{B . A}{i}$
where, M = mutual inductance,
ϕ = magnetic flux,
B = magnetic field
and A = area.
Mutual inductance by 4 straight conductor,
$M = \frac{4B . A}{i}$

$$\Rightarrow M = \frac{4\left[\frac{\mu_0}{4\pi}\frac{i}{\frac{b}{2}}\left(\sin\frac{\pi}{4} + \sin\frac{\pi}{4}\right)\right]a^2}{i}$$

$$\Rightarrow M = \frac{4}{i}\left(\frac{\mu_0}{4\pi}\frac{2i}{b}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right)a^2\right)$$

$$= \left(\frac{\mu_0}{4\pi}\frac{1}{b}8\sqrt{2}a^2\right) = \left(\frac{\mu_0}{4\pi}8\sqrt{2}\frac{a^2}{b}\right)$$

Question59

An inductor coil stores 64J of magnetic field energy and dissipates energy at the rate of 640W when a current of 8A is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit in seconds.
[26 Aug 2021 Shift 1]

Options:

A. 0.4

B. 0.8

C. 0.125

D. 0.2

Answer: D

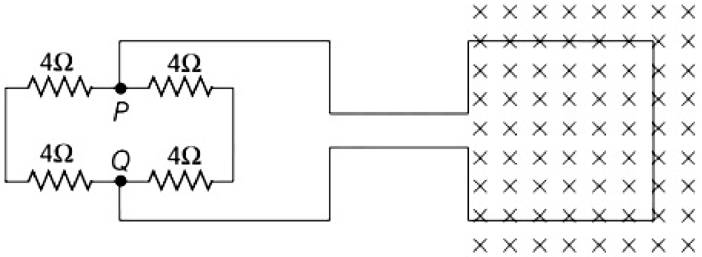
Solution:

Solution:
Magnetic energy is stored in an inductor, whereas energy isdissipated through resistor.
Given, $U_m = 64J$
i = 8 A and
P = 640 W
As, magnetic energy, $U_m = \frac{1}{2}Li^2$
$\Rightarrow 64 = \frac{1}{2} \times L \times 64$
$\Rightarrow$ L = 2 H

Energy dissipated, $P = i^2R$
⇒ 640 64 = R
R = 10 Ω
Time constant of R-L circuit is given by
$\tau = \frac{L}{R}$
$\Rightarrow \tau = \frac{2}{10} = \frac{1}{5} = 0.2s$

Question60

A square loop of side 20 cm and resistance 1Ω is moved towards right with a constant speed v_0. The right arm of the loop is in a uniform magnetic field of 5T. The field is perpendicular to the plane of the loop and is going into it. The loop is connected to a network of resistors each of value 4Ω. What should be the value of v_0, so that a steady current of 2 mA flows in the loop?



[1 Sep 2021 Shift 2]

Options:

A. 1m / s

B. 1 cm / s

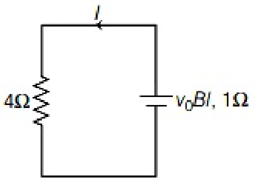
C. 10^2m / s

D. 10^{-2} cm / s

Answer: B

Solution:

Solution:
According to given circuit diagram, equivalent resistance between point P and Q.
$R_{PQ} = (4+4) || (4+4)$
$= \frac{8 \times 8}{8+8} = 4\Omega$
The equivalent circuit can be drawn as,



Equivalent resistance, $R_{eq} = 4 + 1 = 5\Omega$
Magnetic field, B = 5T
The side of the square loop, l = 20 cm = 0.20 m
The steady value of the current, $I = 2\,mA = 2 \times 10^{-3}A$
Induced emf, $e = Bv_0l$

Induced current, $I = \frac{e}{R_{eq}}$

Substituting the values in the above equation, we get

$2 \times 10^{-3} = \frac{5 \times v_0 \times 0.2}{5}$

$\Rightarrow v_0 = 10^{-2} m / s = 1\, cm / s$

$\therefore$ The value of $v_0 = 1\, cm$/ so that a steady current of $2\, mA$ flows in the loop.

Question61

In a fluorescent lamp choke (a small transformer) 100 V of reverse voltage is produced when the choke current changes uniformly from 0.25 A to 0 in a duration of 0.025 ms. The self- inductance of the choke (in mH) is estimated to be ______.
[NA 9 Jan. 2020 I]

Answer: 10

Solution:

Solution:

Given $d\,I = 0.25 - 0 = 0.25A$

$d\,t = 0.025ms$

Induced voltage

$E_{ind} = 100v$

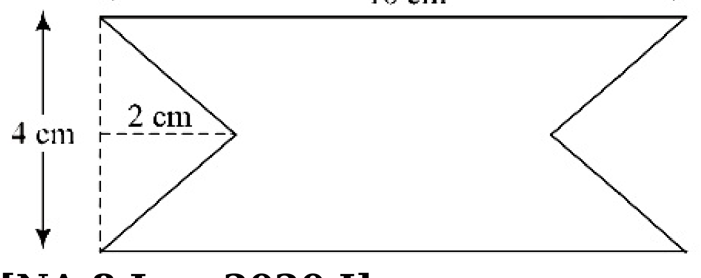
Self-inductance, $L = ?$

Using, $E_{ind} = \frac{\Delta\phi}{\Delta t} \Rightarrow 100 = \frac{L(0.25 - 0)}{025 \times 10^{-3}}$

$\Rightarrow L = 10^{-3}H = 10mH$

Question62

At time t = 0 magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5 s, then induced EMF in the loop is:



[NA 8 Jan. 2020 I]

Options:

A. 56 μV

B. 28 μV

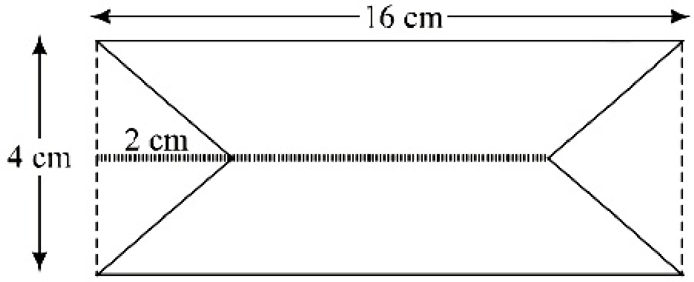
C. 48 μV

D. 36 μV

Answer: A

Solution:

Solution:
According to question, $dB = 1000 - 500 = 500$ gauss $= 500 \times 10^{-4}T$
Time $dt = 5s$
Using faraday law
Induced EMF, $e = \left|-\frac{d\phi}{dt}\right| = A\left|\frac{dB}{dt}\right|$
$\frac{dB}{dt} = \frac{1000 - 500}{5} \times 10^{-4} = 10^{-2}T$ / sec



Area, A = ar of ▭ − 2 ar of Δ = ($16 \times 4 - 2 \times$ Area of triangle)cm^2
$= \left(64 - 2 \times \frac{1}{2} \times 2 \times 4\right)cm^2$
$= 56 \times 10^{-4}m^2$
$\therefore \varepsilon_{induced} = \left|A\frac{dB}{dt}\right| = 56 \times 10^{-4} \times 10^{-2} = 56 \times 10^{-6}V = 56\mu V$

Question63

Consider a circular coil of wire carrying constant current I, forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by ϕ_i. The magnetic flux through the area of the circular coil area is given by ϕ_0. Which of the following option is correct?
[7 Jan. 2020 I]

Options:

A. $\phi_i = \phi_0$

B. $\phi_i > \phi_0$

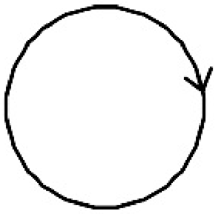
C. $\phi_i < \phi_0$

D. $\phi_i = -\phi_0$

Answer: D

Solution:

As magnetic field lines form close loop, hence every magnetic field line creating magnetic flux through the inner region (ϕ_i) must be passing through the outer region. Since flux in two regions are in opposite region.
$\therefore \phi_i = -\phi_0$



Question64

A long solenoid of radius R carries a time (t) - dependent current $I(t) = I_0 t(1 - t)$. A ring of radius 2R is placed coaxially near its middle. During the time interval $0 \le t \le 1$, the induced current (I_R) and the induced EMF (V_R) in the ring change as:
[7 Jan. 2020 I]

Options:

A. Direction of I_R remains unchanged and V_R is maximum at t = 0.5

B. At t = 0.25 direction of I_R reverses and V_R is maximum

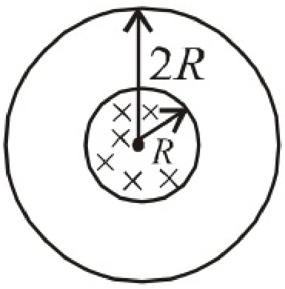
C. Direction of I_R remains unchanged and V_R is zeroat t = 0.25

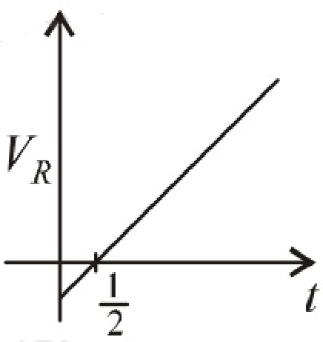
D. At t = 0.5 direction of I_R reverses and V_R is zero

Answer: D

Solution:

Solution:





According to question,
$I(t) = I_0 t(1 - t)$
$\therefore I = I_0 t - I_0 t^2$
$\phi = B \cdot A$
$\phi = (\mu_0 n I) \times (\pi R^2)$
$(\because B = \mu_0 n I$ and $A = \pi R^2)$
$V_R = \frac{-d\phi}{dt}$
$V_R = \mu_0 n \pi R^2 (I_0 - 2I_0 t)$
$\Rightarrow V_R = 0$ at $t = \frac{1}{2}$s

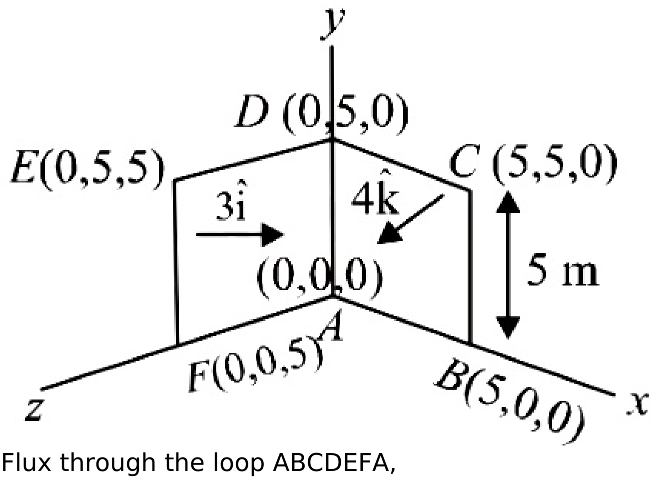
Question65

A loop ABCDEFA of straight edges has six corner points A(0, 0, 0), B{5, 0, 0), C(5, 5, 0), D(0, 5, 0), E(0, 5, 5) and F(0, 0, 5). The magnetic field in this region is
$\vec{B} = (3\hat{i} + 4\hat{k})$ T . The quantity of flux through the loop ABCDEFA (in Wb) is _______.
[NA 7 Jan. 2020 I]

Answer: 175

Solution:

Solution:



Flux through the loop ABCDEFA,
$\phi = \vec{B} \cdot \vec{A} = (3\hat{i} + 4\hat{k}) \cdot (25\hat{i} + 25\hat{k})$
$\Rightarrow \phi = (3 \times 25) + (4 \times 25) = 175$ weber

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Question66

A planar loop of wire rotates in a uniform magnetic field. Initially, at t = 0, the plane of the loop is perpendicular to the magnetic field. If it rotates with a period of 10 s about an axis in its plane then the

magnitude of induced emf will be maximum and minimum, respectively at:
[7 Jan. 2020 II]

Options:

A. 2.5 s and 7.5 s

B. 2.5 s and 5.0 s

C. 5.0 s and 7.5 s

D. 5.0 s and 10.0 s

Answer: B

Solution:

Solution:
We have given, time period, $T = 10$ s
∴ Angular velocity, $\omega = \frac{2\pi}{10} = \frac{\pi}{5}$
Magnetic flux, $\phi(t) = BA\cos\omega t$
Emfinduced, $E = \frac{-d\phi}{dt} = BA\omega\sin\omega t = BA\omega\sin(\omega t)$
Induced emf, $|\varepsilon|$ is maximum when $\omega t = \frac{\pi}{2}$
$\Rightarrow t = \frac{\frac{\pi}{2}}{\frac{\pi}{5}} = 2.5s$
For induced emf to be minimum i.e zero
$\omega t = \pi \Rightarrow t = \frac{\pi}{\frac{\pi}{5}} = 5s$
∴ Induced emf is zero at $t = 5s$

Question67

Two concentric circular coils, C_1 and C_2, are placed in the XY plane. C_1 has 500 turns, and a radius of $1cm$. C_2 has 200 turns and radius current $20cm$. C_2 carries a timedependent current $I(t) = (5t^2 - 2t + 3)$ A Where t is in s. The emf induced in C_1(in mV), at the instant $t = 1s$ is $\frac{4}{x}$. The value of x is ______.
[NA Sep. 05, 2020 (I)]

Answer: 5

Solution:

Solution:
For coil C_1, No. of turns $N_1 = 500$ and radius, $r = 1cm$.

For coil C_2, No. of turns $N_2 = 200$ and radius, R = 20cm.

$I = (5t^2 - 2t + 3) \Rightarrow \frac{dI}{dt} = (10t - 2)$

$\phi_{small} = BA = \left(\frac{\mu_0 I N_2}{2R}\right)(\pi r^2)$

Induced emf in small coil,

$e = \frac{d\phi}{dt} = \left(\frac{\mu_0 N_2}{2r}\right)\pi r^2 N_1 \frac{di}{dt} = \left(\frac{\mu_0 N_1 N_2 \pi r^2}{2R}\right)(10t - 2)$

At t = 1s

$e = \left(\frac{\mu_0 N_1 N_2 \pi r^2}{2R}\right)8 = 4\frac{\mu_0 N_1 N_2 \pi r^2}{R}$

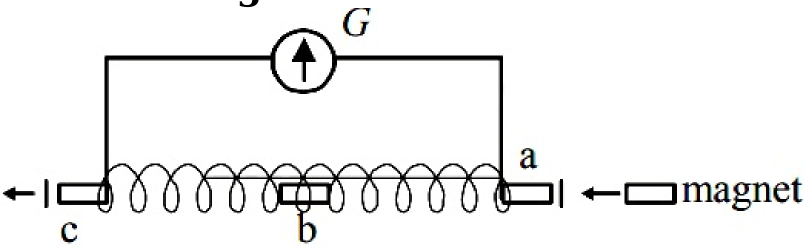
$= \frac{4(4\pi)10^{-7} \times 200}{20} \times 500 \times \frac{10^{-4}}{10^{-2}}\pi$

$= 80 \times \pi^2 \times 10^{-7} \times 10 \times 10^2 \times 10^{-2}$

$= 8 \times 10^{-4}$ volt $= 0.8\text{mV} = \frac{4}{x} \Rightarrow x = 5.$

Question68

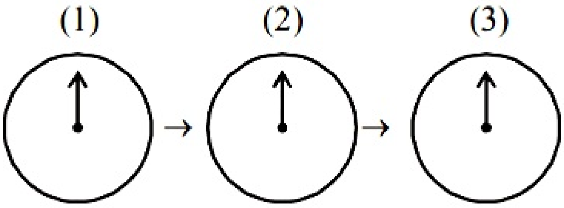
A small bar magnet is moved through a coil at constant speed from one end to the other. Which of the following series of observations will be seen on the galvanometer G attached across the coil ?



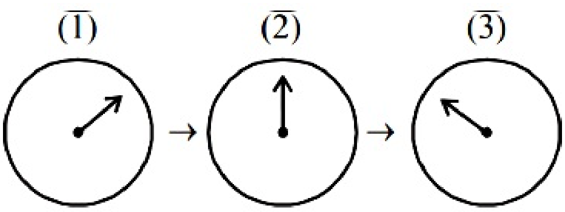
Three positions shown describe : (1) the magnet's entry (2) magnet is completely inside and (3) magnet's exit.
[Sep. 04, 2020 (I)]

Options:

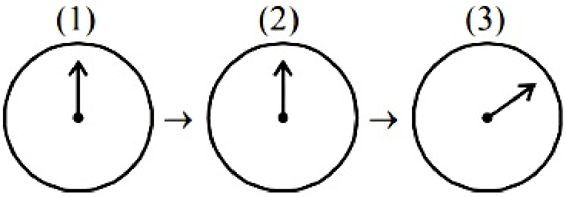
A.



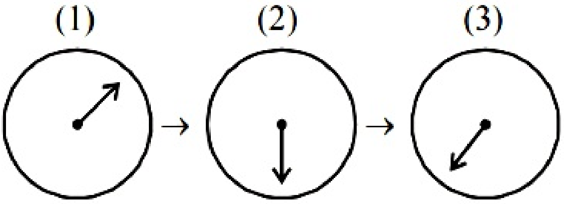
B.



C.



D.



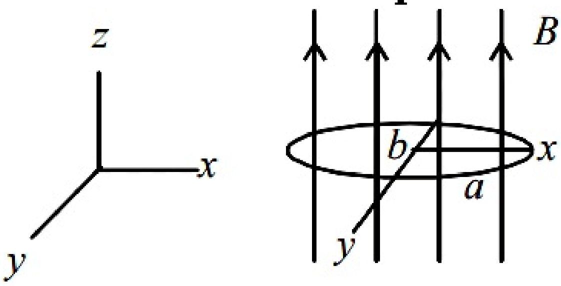
Answer: B

Solution:

Solution:
Case (a): When bar magnet is entering with constant speed, flux (ϕ) will change and an e.m.f. is induced, so galvanometer will deflect in positive direction.
Case (b): When magnet is completely inside, flux (ϕ) will not change, so galvanometer will show null deflection.
Case (c) : When bar magnet is making on exit, again flux(\ϕ) will change and an e.m.f. is induced in opposite direction so galvanometer will deflect in negative direction i.e. reverse direction.

Question69

An elliptical loop having resistance R, of semi major axis a, and semi minor axis b is placed in a magnetic field as shown in the figure. If the loop is rotated about the x-axis with angular frequency ω, the average power loss in the loop due to Joule heating is :



[Sep. 03, 2020 (I)]

Options:

A. $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$

B. zero

C. $\frac{\pi a b B \omega}{R}$

D. $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{R}$

Answer: A

Solution:

Solution:

The correct option is **A** $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$

As we know, the induced emf is,

$E = NAB\omega \sin(\omega t)$ [$\because$ Here, $N = 1$]

The average power is,

$<P> = \frac{E^2}{R} = <\frac{A^2B^2\omega^2 \sin^2 \omega t}{R}> = \frac{A^2B^2\omega^2}{R}(\frac{1}{2})$

Therefore, average power loss in the loop due to Joule's heating effect is,

$<P> = \frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$ $(A = \pi ab)$

<!--td {border: 1px solid #ccc;}br {mso-data-placement:same-cell;}--> Hence, (A) is the correct answer.

Question70

A uniform magnetic field B exists in a direction perpendicular to the plane of a square loop made of a metal wire. The wire has a diameter of 4 mm and a total length of 30 cm. The magnetic field changes with time at a steady rate dB/dt = 0.032 Ts^{-1} . The induced current in the loop is close to (Resistivity of the metal wire is 1.23×10^{-8} Ωm)
[Sep. 03, 2020 (II)]

Options:

A. 0.43 A

B. 0.61 A

C. 0.34 A

D. 0.53 A

Answer: B

Solution:

Solution:
Given,
Length of wire, $l = 30\text{cm}$
Radius of wire, $r = 2\text{mm} = 2 \times 10^{-3}\text{m}$
Resistivity of metal wire, $\rho = 1.23 \times 10^{-8}\Omega\text{m}$

Emfgenerated, $|e| = \frac{d\phi}{dt} = \frac{dB}{dt}(A)$ $(\because \phi = B.A.)$

Current, $i = \frac{e}{R}$

But, resistance of wire, $R = \rho\frac{l}{A}$

$\therefore i = \left|\frac{dB}{dt}\right|\frac{(A)^2}{\rho l} = \frac{0.032 \times \{\pi \times 2 \times 10^{-3}\}^2}{1.23 \times 10^{-8} \times 0.3} = 0.61A$

Question71

A circular coil of radius 10cm is placed in a uniform magnetic field of $3.0 \times 10^{-5}T$ with its plane perpendicular to the field initially. It is rotated at constant angular speed about an axis along the diameter of coil and perpendicular to magnetic field so that it undergoes half of rotation in 0.2s. The maximum value of EMF induced (in μV) in the coil will be close to the integer ______.
[NA Sep. 02, 2020 (I)]

Answer: 15

Solution:

Solution:
Here, $B = 3.0 \times 10^{-5}T$, $R = 10cm = 0.1m$

$\omega = \frac{2\pi}{2T} = \frac{\pi}{0.2}$

Flux as a function of time $\phi = \vec{B}.\vec{A} = AB\cos(\omega t)$

Emf induced, $e = \frac{-d\phi}{dt} = AB\omega\sin(\omega t)$

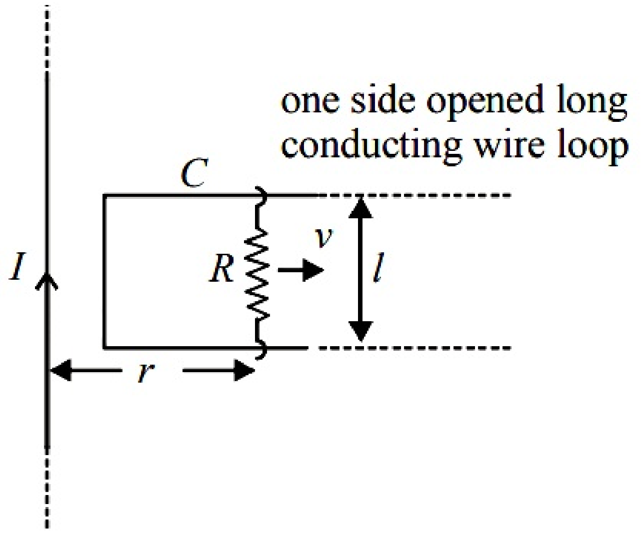
Max. value of Emf $= AB\omega = \pi R^2 B\omega$

$= 3.14 \times 0.1 \times 0.1 \times 3 \times 10^{-5} \times \frac{\pi}{0.2}$

$= 15 \times 10^{-6}V = 15\mu V$

Question72

An infinitely long straight wire carrying current I, one side opened rectangular loop and a conductor C with a sliding connector are located in the same plane, as shown in the figure. The connector has length l and resistance R. It slides to the right with a velocity v. The resistance of the conductor and the self inductance of the loop are negligible. The induced current in the loop, as a function of separation r, between the connector and the straight wire is :



[Sep. 05, 2020 (II)]

Options:

A. $\frac{\mu_0}{4\pi}\frac{I\,vl}{Rr}$

B. $\frac{\mu_0}{\pi}\frac{I\,vl}{Rr}$

C. $\frac{2\mu_0}{\pi}\frac{I\,vl}{Rr}$

D. $\frac{\mu_0}{2\pi}\frac{I\,vl}{Rr}$

Answer: D

Solution:

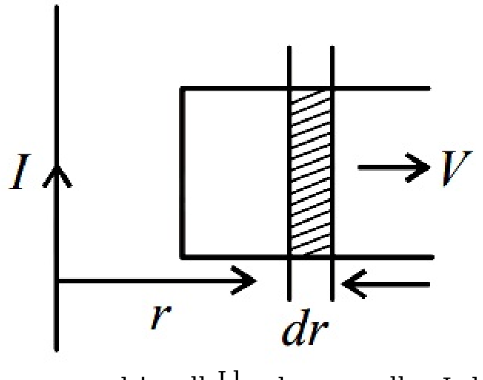
Solution:

Magnetic field at a distance r from the wire $B = \frac{\mu_0 I}{2\pi r}$

Magnetic flux for small displacement dr,

$\phi = B \cdot A = Bl\,d\,r$ [$\because A = l\,d\,r$ and $B \cdot A = BA\cos 0°$]

$\Rightarrow \phi = \frac{\mu_0 I}{2\pi r} l\,d\,r$



Emf, $e = \frac{d\,\phi}{d\,t} = \frac{\mu_0 I\,l}{2\pi r} \cdot \frac{d\,r}{d\,t} \Rightarrow e = \frac{\mu_0}{2\pi} \cdot \frac{I\,vl}{r}$

Induce current in the loop, $i = \frac{e}{R} = \frac{\mu_0}{2\pi} \cdot \frac{I\,vl}{Rr}$

Question73

A 10m long horizontal wire extends from North East to South West. It is falling with a speed of $5.0 ms^{-1}$, at right angles to the horizontal component of the earth's magnetic field, of $0.3 \times 10^{-4} Wb/m^2$. The value of the induced emf in wire is :
[12 Jan. 2019 II]

Options:

A. $1.5 \times 10^{-3} V$

B. $1.1 \times 10^{-3} V$

C. $2.5 \times 10^{-3} V$

D. $0.3 \times 10^{-3} V$

Answer: A

Solution:

Solution:
Induced emf, $\varepsilon = Bvl$
$= 0.3 \times 10^{-4} \times 5 \times 10$
$= 1.5 \times 10^{-3} V$

Question74

There are two long co-axial solenoids of same length l. The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2, respectively. The ratio of mutual inductance to the self-inductance of the inner-coil is:
[11 Jan. 2019 I]

Options:

A. $\frac{n_1}{n_2}$

B. $\frac{n_2}{n_1} \cdot \frac{r_1}{r_2}$

C. $\frac{n_2}{n_1} \cdot \frac{r_2^{\,2}}{r_1^{\,2}}$

D. $\frac{n_2}{n_1}$

Answer: D

Solution:

Solution:
The rate of mutual inductance is given by

$M = \mu_0 n_1 n_2 \pi r_1^2$ ....(i)
The rate of self inductance is given by
$L = \mu_0 n_1^2 \pi r_1^2$........(ii)
Dividing (i) by (ii) $\Rightarrow \frac{M}{L} = \frac{n_2}{n_1}$

Question75

A copper wire is wound on a wooden frame, whose shape is that of an equilateral triangle. If the linear dimension of each side of the frame is increased by a factor of 3, keeping the number of turns of the coil per unit length of the frame the same, then the self inductance of the coil: [11 Jan. 2019 II]

Options:

A. decreases by a factor of 9

B. increases by a factor of 27

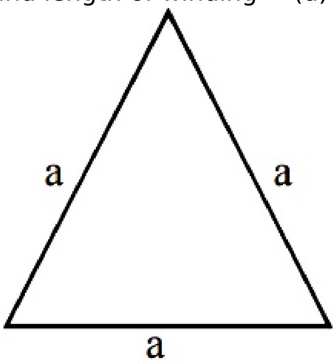
C. increases by a factor of 3

D. decreases by a factor of $9\sqrt{3}$

Answer: C

Solution:

Solution:
As total length L of the wire will remain constant
L = (3a) N   (N = total turns)
and length of winding = (d) N



(d = diameter of wire)
self inductance $= \mu_0 n^2 A l$
$= \mu_0 n^2 \left(\frac{\sqrt{3}a^2}{4}\right) d\,N$
$\propto a^2 N \propto a \left[\text{as} N = L/3a \Rightarrow N \propto \frac{1}{a}\right]$
Now 'a' increased to '3a'
So self inductance will become 3 times

Question76

A solid metal cube of edge length 2 cm is moving in a positive y-

direction at a constant speed of 6 m/s. There is a uniform magnetic field of 0.1 T in the positive z-direction. The potential difference between the two faces of the cube perpendicular to the x-axis, is:
[10 Jan. 2019 I]

Options:

A. 12 mV

B. 6 mV

C. 1 mV

D. 2 mV

Answer: A

Solution:

Solution:
Potential difference between two faces perpendicular to x-axis
$= l V . B = 2 \times 10^{-2}(6 \times 0.1) = 12 mV$

Question77

An insulating thin rod of length l has a linear charge density $\rho(x) = \rho_0 \frac{x}{l}$ on it. The rod is rotated about an axis passing through the origin (x = 0) and perpendicular to the rod. If the rod makes n rotations per second, then the time averaged magnetic moment of the rod is:
[10 Jan. 2019 I]

Options:

A. $\pi n \rho l^3$

B. $\frac{\pi}{3} n \rho l^3$

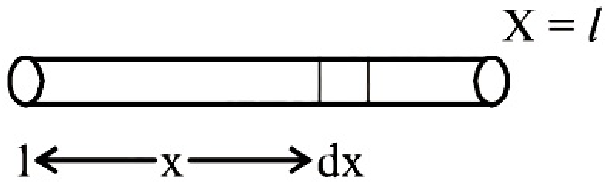
C. $\frac{\pi}{4} n \rho l^3$

D. $n \rho l^3$

Answer: C

Solution:

Solution:



Magnetic moment, M = NIA
$dQ = \rho dx$

$dI = \frac{dQ}{2\pi}.\omega$
$dM = dI \times A$
$= \frac{\omega}{2\pi}.\frac{\rho_0}{l}.x\pi x^2 dx \Rightarrow M = \frac{\rho_0}{l} n\pi \int_0^l x^3 dx$
$= \frac{\pi}{4}.n\rho l^3$

Question78

A conducting circular loop made of a thin wire, has area 3.5 × 10^{-3}m^2 and resistance 10W. It is placed perpendicular to a time dependent magnetic field B (t) = (0.4T) sin (50pt). The the net charge flowing through the loop during t = 0 s and t = 10 ms is close to: [9 Jan. 2019 I]

Options:

A. 14 mC

B. 7 mC

C. 21 mC

D. [Bonus]

Answer: D

Solution:

Solution:
Net charge $Q = \frac{\Delta\phi}{R} = \frac{1}{10}A(B_f - B_i) = \frac{1}{10} \times 3.5 \times 10^{-3}$
$\left(0.4 \sin\frac{\pi}{2} - 0\right)$
$= \frac{1}{10}(3.5 \times 10^{-3})(0.4 - 0)$
$= 1.4 \times 10^{-4}$
No option matches, So it should be a bonus.

Question79

The self induced emf of a coil is 25 volts. When the current in it is changed at uniiform rate from 10 A to 25 A in 1s, the change in the energy of the inductance is: [9 Jan. 2019 II]

Options:

A. 740 J

B. 437.5 J

C. 540 J

D. 637.5 J

Answer: B

Solution:

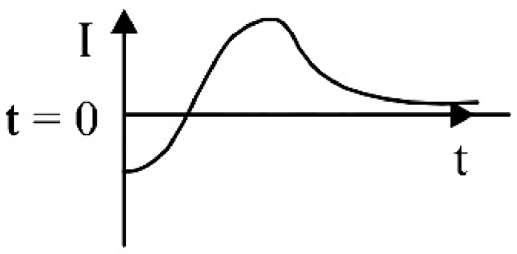
Solution:
According to faraday's law of electromagnetic induction,
$e = \frac{-d\phi}{dt}$
$L \times \frac{di}{dt} = 25 \Rightarrow L \times \frac{15}{1} = 25$ or $L = \frac{5}{3}H$
Change in the energy of the inductance,
$\Delta E = \frac{1}{2}L(i_1{}^2 - i_2{}^2) = \frac{1}{2} \times \frac{5}{3} \times (25^2 - 10^2)$
$= \frac{5}{6} \times 525 = 437.5J$

Question80

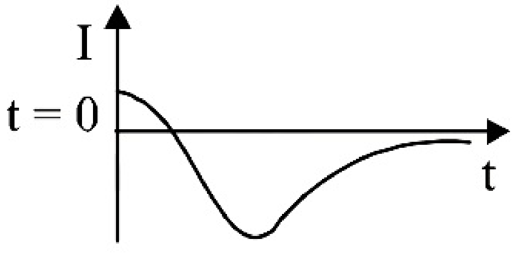
A very long solenoid of radius R is carrying current $I(t) = kte^{-\alpha t}(k > 0)$, as a function of time $(t \geq 0)$. Counter clockwise current is taken to be positive. A circular conducting coil of radius 2R is placed in the equatorial plane of the solenoid and concentric with the solenoid. The current induced in the outer coil is correctly depicted, as a function of time, by:
[9 Apr. 2019 II]

Options:

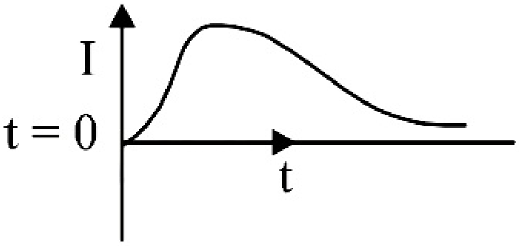
A.



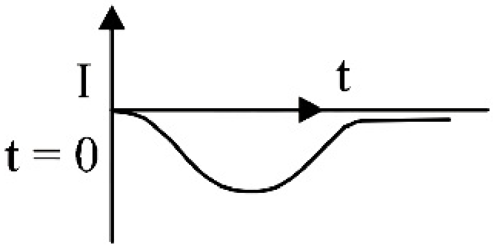
B.



C.



D.



Answer: A

Solution:

Solution:

$Q = BA$

$= (\mu_0 n_i)A$

$= \mu_0 n(kte^{-\alpha t})A$

$e = -\frac{dQ}{dt} = -\mu_0 nAk\frac{d}{dt}(te^{-\alpha t})$

$= -\mu_0 nAk[t(-1)e^{-\alpha t} + e^{-\alpha t} \times 1]$

$= -\mu_0 nAk[e^{-\alpha t}(1 - t)]$

$i = \frac{e}{R} = \frac{-\mu_0 nAk}{R}[e^{-\alpha t}(1 - t)]$

At $t = 0$, $i \Rightarrow -ve$

Question81

Two coils 'P' and 'Q' are separated by some distance. When a current of 3A flows through coil 'P', a magnetic flux of 10^{-3} Wb passes through 'Q'. No current is passed through'Q'. When no current passes through 'P' and a current of 2A passes through 'Q', the flux through 'P' is:
[9 Apr. 2019 II]

Options:

A. 6.67×10^{-4} Wb

B. 3.67×10^{-3} Wb

C. 6.67×10^{-3} Wb

D. 3.67×10^{-4} Wb

Answer: A

Solution:

Solution:
$Q_{coil} = (N\,Q) \propto i$

So, $\frac{Q_1}{Q_2} = \frac{i_1}{i_2} = \frac{3}{2}$

or $Q_2 = \frac{2}{3}Q_1 = \frac{2}{3} \times 10^{-3} = 6.67 \times 10^{-4} Wb$

Question82

The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to : [9 April 2019 I]

Options:

A. L

B. L^2

C. $1 / L^2$

D. $1 / L$

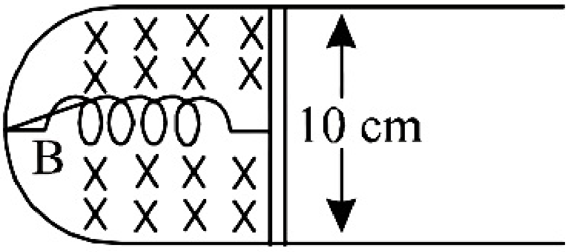
Answer: D

Solution:

Solution:
Inductance $= \frac{\mu_0 N^2 A}{L}$

Question83

A thin strip 10 cm long is on a U shaped wire of negligible resistance and it is connected to a spring of spring constant 0.5 Nm^{-1} (see figure). The assembly is kept in a uniform magnetic field of 0.1 T. If the strip is pulled from its equilibrium position and released, the number of oscillations it performs before its amplitude decreases by a factor of e is N. If the mass of strip is 50 grams, its resistance 10Ω and air drag negligible, N will be close to :



[8 April 2019 I]

Options:

A. 1000

B. 50000

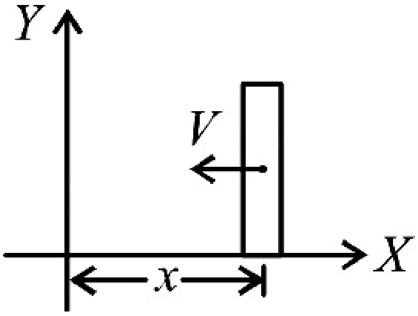
C. 5000

D. 10000

Answer: C

Solution:

Solution:
Force on the strip when it is at stretched position x from mean position is



$F = -kx - iIB = -kx - \frac{BIv}{R} \times IB$

$F = -kx - \frac{B^2 I^2}{R} \times v$

Above expression shows that it is case of damped oscillation, so its amplitude can be given by$\Rightarrow A = A_0 e^{-\frac{bt}{2m}}$

$\Rightarrow \frac{A_0}{e} = A_0 e^{-\frac{bt}{2m}}$ [as per question $A = \frac{A_0}{e}$]

$\Rightarrow t = \frac{2m}{\left(\frac{B^2 I^2}{R}\right)} = \frac{2 \times 50 \times 10^{-3} \times 10}{0.01 \times 0.01}$

Given, $m = 50 \times 10^{-3}$kg
$B = 0.1T$
$l = 0.1m$
$R = 10\Omega$
$k = 0.5N$

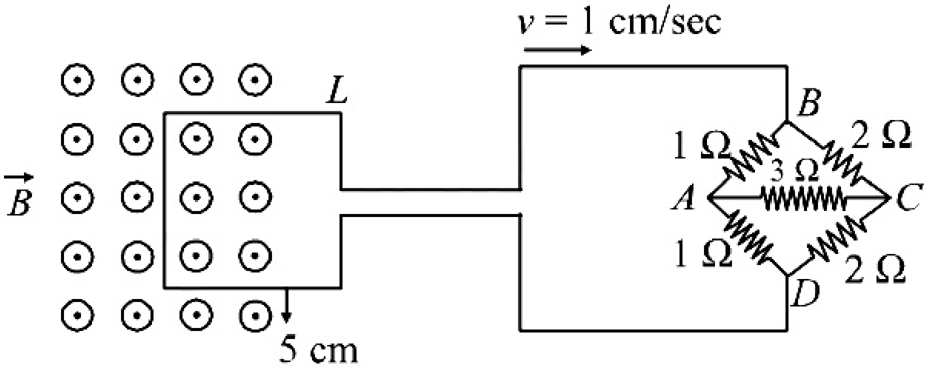
Time period, $T = 2\pi \sqrt{\frac{m}{k}} \simeq 2s$

so, required number of oscillations,

$N = \frac{10000}{2} = 5000$

Question84

The figure shows a square loop L of side 5 cm which is connected to a network of resistances. The whole setup is moving towards right with a constant speed of 1 cm s^{-1}. At some instant, a part of L is in a uniform magnetic field of 1 T, perpendicular to the plane of the loop. If the resistance of L is 1.7 &!, the current in the loop at that instant will be close to :



[12 Apr. 2019 I]

Options:

A. 60 μA

B. 170 μA

C. 150 μA

D. 115 μA

Answer: B

Solution:

Solution:
Induced emf, $e = Bvl = 1 \times 10^{-2} \times 0.05 = 5 \times 10^{-4} V$
Equivalent resistance,
$R = \frac{4 \times 2}{4 + 2} + 1.7 = \frac{4}{3} + 1.7 \simeq 3\Omega$
Current, $i = \frac{e}{R} = \frac{5 \times 10^{-4}}{3} \simeq 170 \mu A$

Question85

A coil of cross-sectional area A having n turns is placed in a uniform magnetic field B. When it is rotated with an angular velocity w, the maximum e.m.f. induced in the coil will be [Online April 16, 2018]

Options:

A. nBAω

B. $\frac{3}{2}$nBAω

C. 3nBAw

D. $\frac{1}{2}$nBAω

Answer: A

Solution:

Solution:

Induced emf in a coil, $e = -\frac{d\phi}{dt} = NBA\sin\omega t$

Also, $e = e_0 \sin\omega t$

∴ Maximum emf induced, $e_0 = nBA\omega$

Question86

An ideal capacitor of capacitance 0.2 μF is charged to a potential difference of 10V. The charging battery is then disconnected. The capacitor is then connected to an ideal inductor of self inductance 0.5mH. The current at a time when the potential difference across the capacitor is 5V, is:
[Online April 15, 2018]

Options:

A. 0.17A

B. 0.15A

C. 0.34A

D. 0.25A

Answer: A

Solution:

Solution:

Given: Capacitance, $C = 0.2\mu F = 0.2 \times 10^{-6} F$

Inductance $L = 0.5 mH = 0.5 \times 10^{-3} H$

Current $I = ?$

Using energy conservation

$\frac{1}{2}CV^2 = \frac{1}{2}CV_1^2 + \frac{1}{2}LI^2$

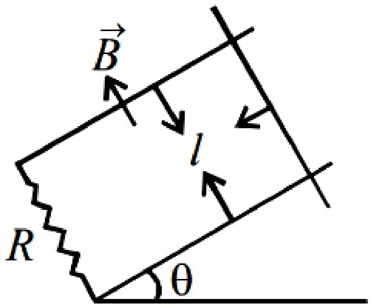
$\frac{1}{2} \times 0.2 \times 10^{-6} \times 10^2 + 0$

$= \frac{1}{2} \times 0.2 \times 10^{-6} \times 5^2 + \frac{1}{2} \times 0.5 \times 10^{-3} I^2$

$\therefore I = \sqrt{3} \times 10^{-1} A = 0.17A$

Question87

A copper rod of mass m slides under gravity on two smooth parallel rails, with separation l and set at an angle of θ with the horizontal. At the bottom, rails are joined by a resistance R.There is a uniform magnetic field B normal to the plane of the rails, as shown in the figure. The terminal speed of the copper rod is:



[Online April 15, 2018]

Options:

A. $\frac{mgR\cos\theta}{B^2 l^2}$

B. $\frac{mgR\sin\theta}{B^2 l^2}$

C. $\frac{mgR\tan\theta}{B^2 l^2}$

D. $\frac{mgR\cot\theta}{B^2 l^2}$

Answer: B

Solution:

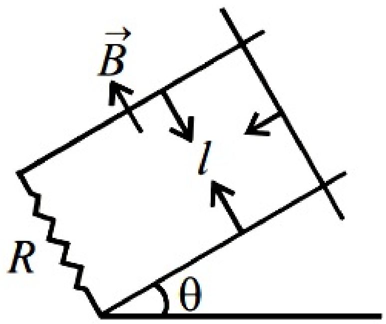
Solution:
From Faraday's law of electromagnetic induction,

$e = \frac{d\phi}{dt} = \frac{d(BA)}{l\,t} = \frac{d(Bl\,l)}{dt}$

$= \frac{Bd\,l \times l}{dt} = BV\,l$

Also, $F = il\,B = \left(\frac{BV}{R}\right)(l^2 B) = \frac{B^2 l^2 V}{R}$

At equilibrium



$mg\sin\theta = \frac{B^2 l\,V}{R} \Rightarrow V = \frac{mgR\sin\theta}{B^2 l^2}$

Question88

At the centre of a fixed large circular coil of radius R, a much smaller circular coil of radius r is placed. The two coils are concentric and are in the same plane. The larger coil carries a current I. The smaller coil is set to rotate with a constant angular velocity ω about an axis along their common diameter. Calculate the emf induced in the smaller coil after a

time t of its start of rotation.
[Online April 15, 2018]

Options:

A. $\frac{\mu_0 I}{2R}\omega r^2 \sin\omega t$

B. $\frac{\mu_0 I}{4R}\omega\pi r^2 \sin\omega t$

C. $\frac{\mu_0 I}{2R}\omega\pi r^2 \sin\omega t$

D. $\mu_0 I\, 4R\omega r^2 \sin\omega t$

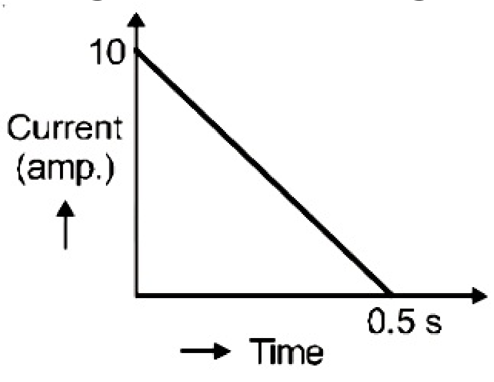
Answer: C

Solution:

Solution:
According to Faraday's law of electromagnetic induction,
$e = -\frac{d\phi}{dt}$ and $\phi = BA\cos\omega t = B\pi r^2\cos\omega t$
$\Rightarrow e = -\frac{d}{dt}(\pi r^2 B\cos\omega t) = \pi r^2 B\sin\omega t(\omega)$
$\therefore e = \frac{\mu_0 I}{2R}\pi\omega r^2\sin\omega t \left(\because B = \frac{\mu_0 I}{2R}\right)$

Question89

In a coil of resistance 100 Ω , 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



[2017]

Options:

A. 250 Wb

B. 275 Wb

C. 200 Wb

D. 225 Wb

Answer: A

Solution:

Solution:
According to Faraday's law of electromagnetic induction, $\varepsilon = \frac{d\phi}{dt}$
Also, $\varepsilon = iR$
$\therefore iR = \frac{d\phi}{dt} \Rightarrow \int d\phi = R\int i\,dt$
Magnitude of change in flux $(d\phi) = R\times$ area under current vs time graph
or, $d\phi = 100 \times \frac{1}{2} \times \frac{1}{2} \times 10 = 250 Wb$

Question90

A conducting metal circular-wire-loop of radius r is placed perpendicular to a magnetic field which varies with time as $B = B_0 e^{-t/\tau}$, where B_0 and tau are constants, at time t = 0. If the resistance of the loop is R then the heat generated in the loop after a long time ($t \to \infty$) is ;
[Online April 10,2016]

Options:

A. $\frac{\pi^2 r^4 B_0{}^4}{2\tau R}$

B. $\frac{\pi^2 r^4 B_0{}^2}{2\tau R}$

C. $\frac{\pi^2 r^4 B_0{}^2 R}{\tau}$

D. $\frac{\pi^2 r^4 B_0{}^2}{\tau R}$

Answer: B

Solution:

Solution:
Electric flux is given by
$\phi = B.A$
$\phi = B_0 \pi r^2 e^{-t/\tau} (\because B = B_0 e^{-t/\tau})$
Induced E.m.f. $\varepsilon = \frac{d\phi}{dt} = \frac{B_0 \pi r^2}{\tau^2} e^{-t/\tau}$
Heat $= \int_0^\infty \frac{\varepsilon^2}{R} = \frac{\pi^2 r^4 B_0{}^2}{2\tau R}$

Question91

When current in a coil changes from 5 A to 2 A in 0.1 s average voltage of 50 V is produced. The self - inductance of the coil is :

[Online April 10, 2015]

Options:

A. 6 H

B. 0.67 H

C. 3 H

D. 1.67 H

Answer: D

Solution:

Solution:
According to Faraday's law of electromagnetic induction,
Induced emf, $e = \frac{L d i}{d t}$
$50 = L\left(\frac{5-2}{0.1 \sec}\right)$
$\Rightarrow L = \frac{50 \times 0.1}{3} = \frac{5}{3} = 1.67H$

Question92

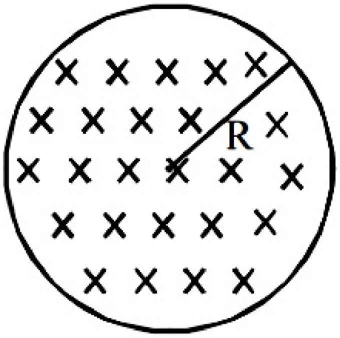
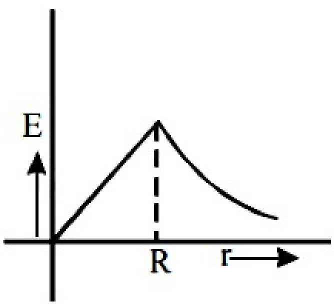


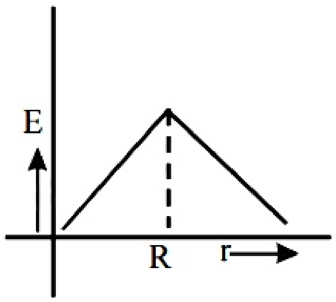
Figure shows a circular area of radius R where a uniform magnetic field $\vec{B}$ is going into the plane of paper and increasing in magnitude at a constant rate. In that case, which of the following graphs, drawn schematically, correctly shows the variation of the induced electric field E(r)?
[Online April 19, 2014]

Options:

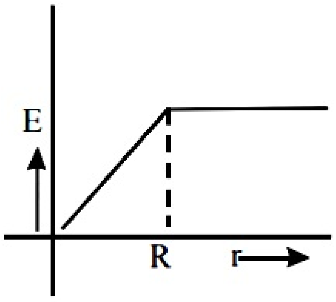
A.



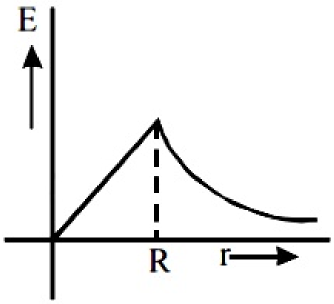
B.



C.



D.



Answer: A

Solution:

Solution:

Inside the sphere field varies linearly i.e., $E \propto r$ with distance and outside varies according to $E \propto \frac{1}{r^2}$

Hence the variation is shown by curve (a)

Question93

A coil of circular cross-section having 1000 turns and 4 cm^2 face area is placed with its axis parallel to a magnetic field which decreases by 10^{-2} Wb m^{-2} in 0.01 s. The e.m.f. induced in the coil is: [Online April 11, 2014]

Options:

A. 400 mV

B. 200 mV

C. 4 mV

D. 0.4 mV

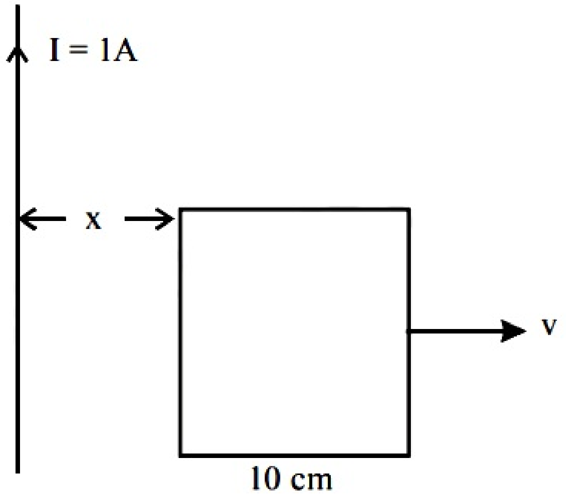
Answer: A

Solution:

Solution:
Given: No. of turns $N = 1000$
Face area, $A = 4cm^2 = 4 \times 10^{-4} m^2$
Change in magnetic field,
$\Delta B = 10^{-2} wbm^{-2}$
Time taken, $t = 0.01s = 10^{-2} sec$
Emf induced in the coil $e = ?$
Applying formula,
Induced emf, $e = \frac{-d\phi}{dt} = N\left(\frac{\Delta B}{\Delta t}\right) A\cos\theta$
$= \frac{1000 \times 10^{-2} \times 4 \times 10^{-4}}{10^{-2}} = 400mV$

Question94

A square frame of side 10 cm and a long straight wire carrying current 1 A are in the plate of the paper. Starting from close to the wire, the frame moves towards the right with a constant speed of 10 ms^{-1} (see figure).



The e.m.f induced at the time the left arm of the frame is at x = 10 cm from the wire is:
[Online April 19, 2014]

Options:

A. 2 μV

B. 1 μV

C. 0.75 μV

D. 0.5 μV

Answer: B

Solution:

Solution:
In the given question,
Current flowing through the wire, I = 1A
Speed of the frame, $v = 10 ms^{-1}$
Side of square loop, $l = 10 cm$
Distance of square frame from current carrying wires x = 10 cm.
We have to find, e.m.f induced e = ?
According to Biot-Savart's law

$B = \frac{\mu_0}{4\pi}\frac{I\,d\,l\,\sin\theta}{x^2}$

$= \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{1 \times 10^{-1}}{(10^{-1})^2}$

$= 10^{-6}$

Induced e.m.f. e $= Bl\,v$

$= 10^{-6} \times 10^{-1} \times 10 = 1\mu v$

Question95

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 [2013]

Options:

A. 9.1×10^{-11} weber

B. 6×10^{-11} weber

C. 3.3×10^{-11} weber

D. 6.6×10^{-9} weber

Answer: A

Solution:

Solution:
As we know, Magnetic flux, $\phi = B \,.\, A$

$\frac{\mu_0(2)(20 \times 10^{-2})^2}{2[(0.2)^2 + (0.15)^2]} \times \pi(0.3 \times 10^{-2})^2$

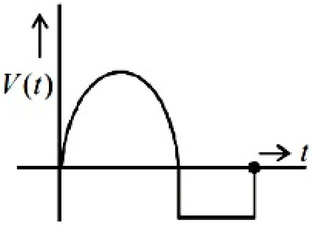
On solving $= 9.216 \times 10^{-11} = 9.2 \times 10^{-11}$ weber

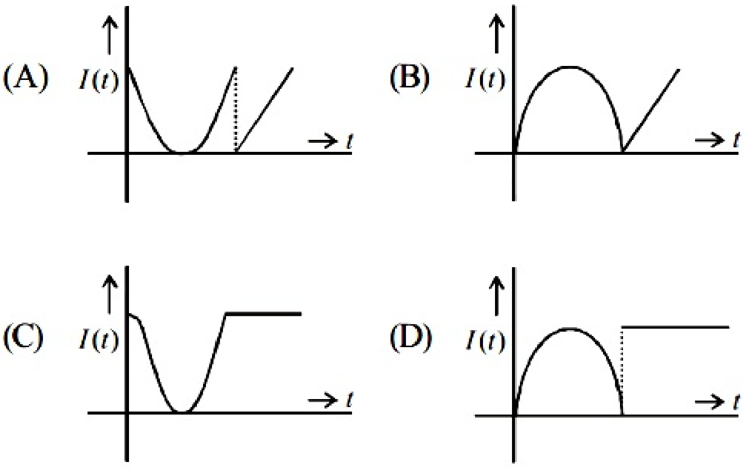
----

Question96

Two coils, X and Y, are kept in close vicinity of each other. When a varying current, I(t), flows through coil X, the induced emf (V(t)) in coil Y, varies in the manner shown here. The variation of I(t), with time, can

then be represented by the graph labelled as graph :





[Online April 9, 2013]

Options:

A. A

B. C

C. B

D. D

Answer: A

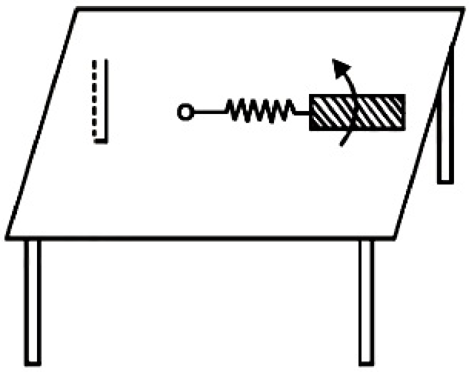
Solution:

Solution:

Induced emf$\varepsilon \propto \frac{-d\,i}{d\,t}$

Question97

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



[2013]

Options:

A. $\frac{2B\omega l^2}{2}$

B. $\frac{3B\omega l^2}{2}$

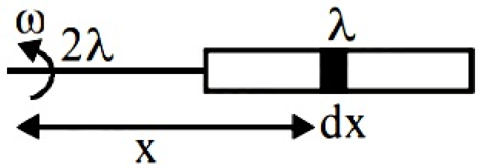
C. $\frac{4B\omega l^2}{2}$

D. $\frac{5B\omega l^2}{2}$

Answer: D

Solution:

Solution:
Here, induced e.m.f



$e = \int_{2l}^{3l} (\omega x) B d x = B\omega \frac{[(3l)^2 - (2l)^2]}{2}$

$= \frac{5B\omega l^2}{2}$

Question98

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 : [2012]

Options:

A. developement of air current when the plate is placed

B. induction of electrical charge on the plate

C. shielding of magnetic lines of force as aluminium is a paramagnetic material.

D. electromagnetic induction in the aluminium plate giving rise to electromagnetic damping.

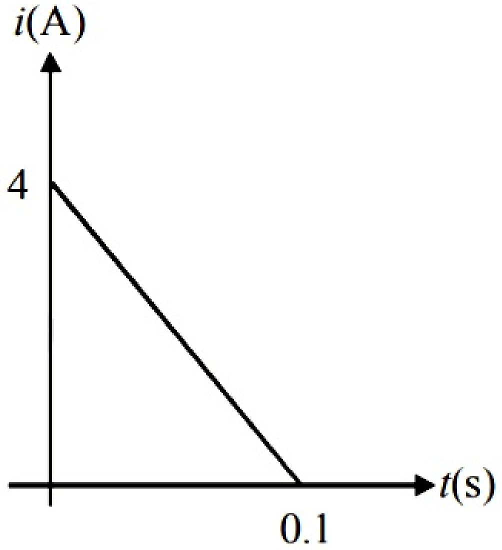
Answer: D

Solution:

Solution:
Because of the Lenz's law of conservation of energy.
Length of straignt wire, $l = 20\mathrm{m}$ Earth's Magneti field, $B = 0.30 \times 10^{-4} \mathrm{W\,b} / \mathrm{m}^2$.

Question99

Magnetic flux through a coil of resistance 10Ω is changed by Δϕ in 0.1 s. The resulting current in the coil varies with time as shown in the figure. Then |Δϕ| is equal to (in weber)



[Online May 12, 2012]

Options:

A. 6

B. 4

C. 2

D. 8

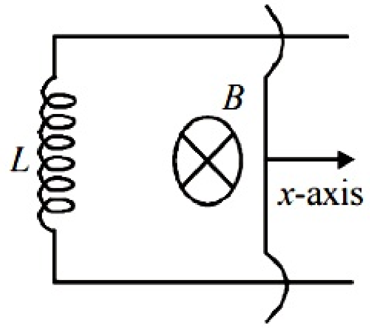
Answer: C

Solution:

Solution:
As $e = \frac{\Delta\phi}{\Delta t}$ or $Ri = \Delta\phi\Delta t \quad (\because e = Ri)$
$\Rightarrow \Delta\phi = R(i \,.\, \Delta t)$
$= R \times$ area under $i - t$ graph
$= 10 \times \frac{1}{2} \times 4 \times 0.1 = 2$ weber

Question100

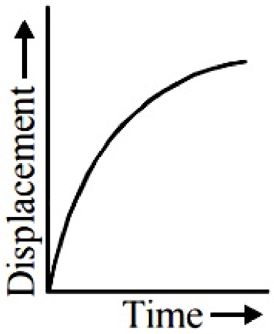
A coil of self inductance L is connected at one end of two rails as shown in figure. A connector of length l , mass m can slide freely over the two parallel rails. The entire set up is placed in a magnetic field of induction B going into the page. At an instant t = 0 an initial velocity v_0 is imparted to it and as a result of that it starts moving along x -axis. The displacement of the connector is represented by the figure.



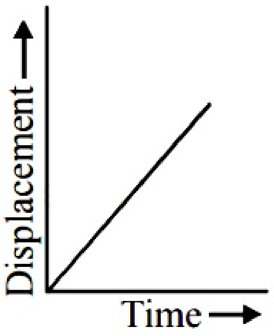
[Online May 19, 2012]

Options:

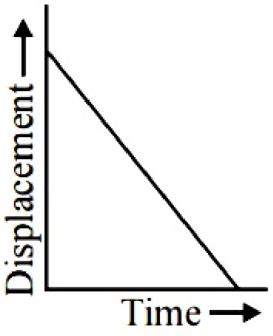
A.



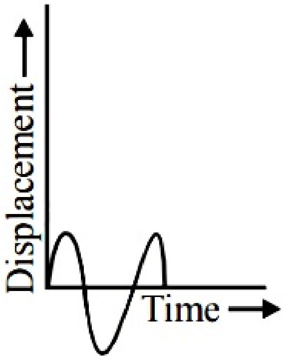
B.



C.



D.



Answer: D

Solution:

Solution:

Question101

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement 1: Self inductance of a long solenoid of length L, total number of turns N and radius r is less than $\frac{\pi\mu_0 N^2 r^2}{L}$.

Statement 2 : The magnetic induction in the solenoid in Statement 1 carrying current I is $\frac{\mu_0 N I}{L}$ in the middle of the solenoid but becomes less as we move towards its ends.

[Online May 19, 2012]

Options:

A. Statement 1 is true, Statement 2 is false.

B. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

C. Statement 1 is false, Statement 2 is true.

D. Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

Answer: B

Solution:

Solution:

Self inductance of a long solenoid is given by $L = \frac{\mu_0 N^2 A}{l}$

Magnetic field at the centre of solenoid $B = \frac{\mu_0 N I}{l}$

So both the statements are correct and statement 2 is correct explanation of statement 1

Question102

A boat is moving due east in a region where the earth's magnetic field is $5.0 \text{ times } 10^{-5} \mathrm{N\,A^{-1}\,m^{-1}}$ due north and horizontal. The boat carries a vertical aerial 2m long. If the speed of the boat is $1.50\mathrm{ms^{-1}}$, the magnitude of the induced emf in the wire of aerial is:
[2011]

Options:

A. 0.75 mV

B. 0.50 mV

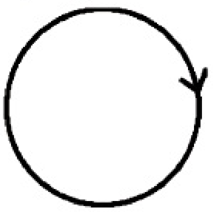
C. 0.15 mV

D. 1 mV

Answer: D

Solution:

Solution:
As magnetic field lines form close loop,
hence every magnetic field line creating magnetic flux through the inner region (ϕ_i) must be passing through the outer region. Since flux in two regions are in opposite region.
$\therefore \phi_i = -\phi_0$



Question103

A horizontal straight wire 20 m long extending from 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 $0.30 \times 10^{-4} \mathrm{Wb/m^2}$. The instantaneous value of the e.m.f. induced in the wire will be
[2011 RS]

Options:

A. 3 mV

B. 4.5 mV

C. 1.5 mV

D. 6.0 mV

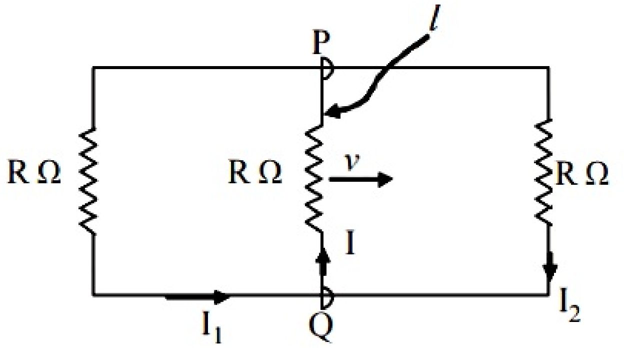
Answer: A

Solution:

Solution:
Induced, emF , $\varepsilon = Bvl$
$= 0.3 \times 10^{-4} \times 5 \times 20$
$= 3 \times 10^{-3} V = 3 mV$

Question104

A rectangular loop has a sliding connector PQ of length l and resistance Rω and it is moving with a speed v as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents I_1, I_2 and I are



[2010]

Options:

A. $I_1 = -I_2 = \frac{Blv}{6R}, I = \frac{2Blv}{6R}$

B. $I_1 = I_2 = \frac{Blv}{3R}, I = \frac{2Blv}{3R}$

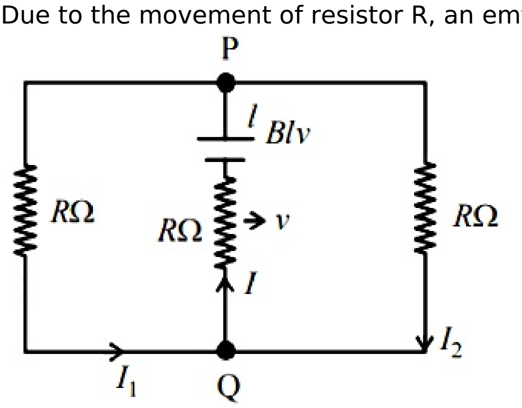
C. $I_1 = I_2 = I = \frac{Blv}{R}$

D. $I_1 = I_2 = \frac{Blv}{6R}, I = \frac{Blv}{3R}$

Answer: B

Solution:

Solution:
Due to the movement of resistor R, an emf equal to Blv will be induced in it as shown in figure clearly,



$I = I_1 + I_2$ Also, $I_1 = I_2$

Solving the circuit,
we get $I_1 = I_2 = \frac{Bl\,v}{3R}$
and $I = 2I_1 = \frac{2Bl\,v}{3R}$

Question105

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

Options:

A. $2.4\pi \times 10^{-5}\text{H}$

B. $4.8\pi \times 10^{-4}\text{H}$

C. $4.8\pi \times 10^{-5}\text{H}$

D. $2.4\pi \times 10^{-4}\text{H}$

Answer: D

Solution:

Solution:
Given, Area of cross-section of pipe,
$A = 10\text{cm}^2$
Length of pipe, $l = 20\text{cm}$
$M = \frac{\mu_0 N_1 N_2 A}{l}$
$= \frac{4\pi \times 10^{-7} \times 300 \times 400 \times 100 \times 10^{-4}}{0.2}$
$M = \frac{\mu_0 N_1 N_2 A}{l}$
$= 2.4\pi \times 10^{-4}\text{H}$

Question106

The flux linked with a coil at any instant 't' is given by $\phi = 10t^2 - 50t + 250$. The induced emf at t = 3s is
[2006]

Options:

A. -190V

B. -10V

C. 10V

D. 190V

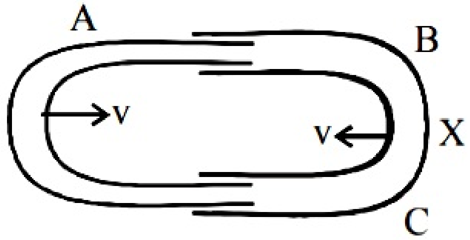
Answer: B

Solution:

Solution:
Electric flux, $\phi = 10t^2 - 50t + 250$
Induced emf, $e = -\frac{d\phi}{dt} = -(20t - 50)$
$e_{t=3} = -10V$

Question107

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



[2005]

Options:

A. – Blv

B. Blv

C. 2 Blv

D. zero

Answer: C

Solution:

Solution:
Relative velocity of the tube of width l,
$= v - (-v)v = 2v$
$\therefore$ Induced emf. $= B \cdot l\,(2v)$

Question108

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 e.m.f. developed between

the two ends of the conductor is
[2004]

Options:

A. 5 mV

B. 50 μV

C. 5 μV

D. 50 mV

Answer: B

Solution:

Solution:
Given, length of conductor $l = 1\text{m}$,
Angular speed, $\omega = 5\text{rad} / \text{s}$
Magnetic field, $B = 0.2 \times 10^{-4}\text{T}$
EmF generated between two ends of conductor
$\varepsilon = \frac{B\omega l^2}{2} = \frac{0.2 \times 10^{-4} \times 5 \times 1}{2} = 50\mu\text{V}$

Question109

A coil having n turns and resistance Rω 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
[2004]

Options:

A. $-\frac{(W_2 - W_1)}{Rnt}$

B. $-\frac{n(W_2 - W_1)}{5Rt}$

C. $-\frac{(W_2 - W_1)}{5Rnt}$

D. $-\frac{n(W_2 - W_1)}{Rt}$

Answer: B

Solution:

Solution:
$\frac{\Delta\phi}{\Delta t} = \frac{(W_2 - W_1)}{t}$
$R_{tot} = (R + 4R)\Omega = 5R\Omega$
$i = \frac{nd\phi}{R_{tot}dt} = \frac{-n(W_2 - W_1)}{5Rt}$

(∵2 &W $_1$ are magnetic flux)

Question110

Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
[2003]

Options:

A. the rates at which currents are changing in the twocoils

B. relative position and orientation of the two coils

C. the materials of the wires of the coils

D. the currents in the two coils

Answer: B

Solution:

Solution:
Mutual inductance depends on the relative position and orientation of the two coils.

Question111

When the current changes from +2 A to –2A in 0.05 second, an e.m.f. of 8 V is induced in a coil. The coefficient of self -induction of the coil is
[2003]

Options:

A. 0.2 H

B. 0.4 H

C. 0.8 H

D. 0.1 H

Answer: D

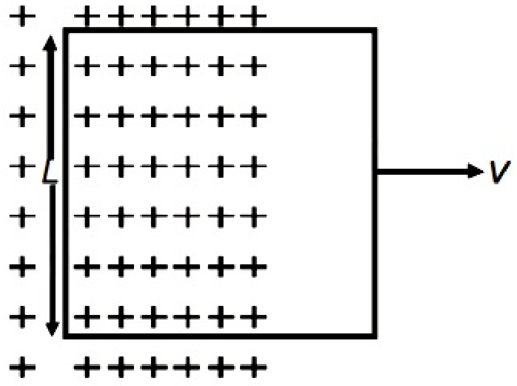
Solution:

Solution:
Induced emf,
$e = -\frac{\Delta\phi}{\Delta t} = \frac{-\Delta(LI)}{\Delta t} = -L\frac{\Delta I}{\Delta t}$
$\therefore |e| = L\frac{\Delta I}{\Delta t}$
$\Rightarrow 8 = L \times \frac{[2-(-2)]}{0.05}$

$\Rightarrow L = \frac{8 \times 0.05}{4} = 0.1H$

Question112

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 magnetic induction B constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field, as shown in figure. The induced emf is



[2002]

Options:

A. zero

B. RvB

C. vBL/R

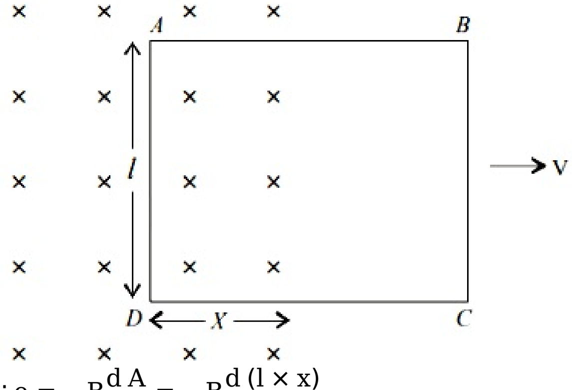
D. vBL

Answer: D

Solution:

Solution:
As the side BC is outside the field, no emf is induced across BC. Further, sides AB and CD are not cutting any flux. So, they will not centribute in flux.
Only side AD is cutting the flux 50 emf will be induced due to AD only.
The induced emf is

$e = \frac{-d\phi}{dt} = -\frac{d(\vec{B}.\vec{A})}{dt} = \frac{-d(BA\cos 0°)}{dt}$



$\therefore e = -B\frac{dA}{dt} = -B\frac{d(l \times x)}{dt}$

$$\therefore e = -Bl\frac{dx}{dt} = -Blv$$
