Magnetic Effect of Current

EXERCISES

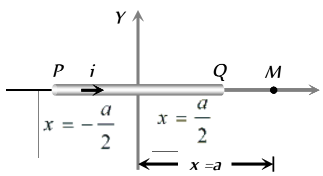
ELEMENTRY

Q.1 (4)

$$dB = \frac{\mu_0}{4\pi}\cdot\frac{idl\sin\theta}{r^2} \Rightarrow d\vec{B} = \frac{\mu_0}{4\pi}\cdot\frac{i(d\vec{l}\times\vec{r})}{r^3}$$

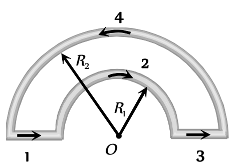
Q.2 (4)

Magnetic field at a point on the axis of a current carrying wire is always zero.



Q.3 (1)

In the following figure, magnetic fields at *O* due to sections 1, 2, 3 and 4 are considered as B_1, B_2, B_3 and B_4 respectively.



$$B_1 = B_3 = 0$$

$$B_2 = \frac{\mu_0}{4\pi}\cdot\frac{\pi i}{R_1}\otimes$$

$$B_4 = \frac{\mu_0}{4\pi}\cdot\frac{\pi i}{R_2}\odot \qquad \text{As } |B_2| > |B_4|$$

$$\text{So } B_{net} = B_2 - B_4 \Rightarrow B_{net} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\otimes$$

Q.4 (4)

The magnetic induction at O due to the current in portion AB will be zero because O lies on AB when extended.

Q.5 (3)

The magnetic induction due to both semicircular parts will be in the same direction perpendicular to the paper inwards.

$$\therefore B = B_1 + B_2 = \frac{\mu_0 i}{4r_1} + \frac{\mu_0 i}{4r_2} = \frac{\mu_0 i}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right)\otimes$$

Q.6 (1)

Magnetic field due to one side of the square at centre *O*

$$B_1 = \frac{\mu_0}{4\pi}\cdot\frac{2i\sin 45^o}{a/2} \Rightarrow B_1 = \frac{\mu_0}{4\pi}\cdot\frac{2\sqrt{2}i}{a}$$

Hence magnetic field at centre due to all side

$$B = 4B_1 = \frac{\mu_0(2\sqrt{2}i)}{\pi a}$$

Magnetic field due to *n* turns

$$B_{net} = nB = \frac{\mu_0 2\sqrt{2}ni}{\pi a} = \frac{\mu_0 2\sqrt{2}ni}{\pi(2l)} = \frac{\sqrt{2}\mu_0 ni}{\pi l} \quad (\because a = 2l)$$

Q.7 (1)

$$B = \mu_0 ni \Rightarrow i = \frac{B}{\mu_0 n} = \frac{20\times10^{-3}}{4\pi\times10^{-7}\times20\times100} = 7.9 \text{ amp} = 8 \text{ amp}$$

Q.8 (2)

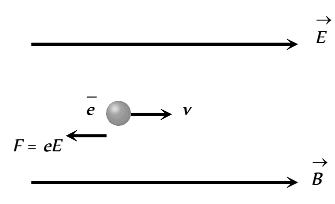
Magnetic field at the centre of solenoid (B)= μ_0 ni

Where *n* = Number of *turns /meter*

$\therefore B = 4\pi\times10^{-7}\times4250\times5 = 2.7\times10^{-2}\ Wb/m^2$

Q.9 (4)

Since electron is moving is parallel to the magnetic field, hence magnetic force on it $F_m = 0$..



The only force acting on the electron is electric force which reduces it's speed.

Q.10 (2)

$$B = \frac{mv}{qr} = \frac{9\times10^{-31}\times10^6}{1.6\times10^{-19}\times0.1} = 5.6\times10^{-5}T$$

Q.11 (2)

This is according to the cross product $\vec{F} = q(\vec{v}\times\vec{B})$ otherwise can be evaluated by the left-hand rule of Fleming.

Q.12 (1)

Lorentz force is given by

$$\vec{F} = \vec{F}_e + \vec{F}_m = q\vec{E} + q(\vec{v}\times\vec{B}) = q[\vec{E} + (\vec{v}\times\vec{B})]$$

Q.13 (2)

$$r = \frac{\sqrt{2mK}}{qB} \text{ i.e. } \quad r \propto \frac{\sqrt{m}}{q}$$

Here kinetic energy *K* and *B* are same.

$$\therefore \frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}} \times \frac{q_p}{q_e} \Rightarrow \frac{r_e}{r_p}\sqrt{\frac{m_e}{m_p}} \quad (\because q_e = q_p)$$

Since $m_e < m_p$, therefore $r_e < r_p$

Q.14 (3)

$$r = \frac{1}{B}\sqrt{\frac{2mV}{q}} \Rightarrow r \propto \sqrt{\frac{m}{p}} \Rightarrow \frac{r_x}{r_y} = \sqrt{\frac{m_x}{q_x} \times \frac{q_y}{m_y}}$$

$$\Rightarrow \frac{R_1}{R_2} = \sqrt{\frac{m_x}{m_y} \times \frac{2}{1}} \Rightarrow \frac{m_x}{m_y} = \frac{R_1^2}{2R_2^2}$$

Q.15 (4)

The deflection produced by the electric field may be nullified by that produced by magnetic field.

Q.16 (2)

$$r = \frac{m\nu}{qB} \Rightarrow r \propto m\nu \quad (q \text{ and } B \text{ are constant})$$

$$\because r_A > r_B \Rightarrow m_A\nu_A > m_B\nu_B$$

Q.17 (4)

Magnetic field produced by wire at the location of charge is perpendicular to the paper inwards. Hence by applying Fleming's left hand rule, force is directed along *OY*.

Q.18 (1)

$$F = \frac{\mu_0}{4\pi}\frac{2\times i_1 i_2}{a} = \frac{10^{-7}\times 2\times 5\times 5}{0.1} = 5\times 10^{-5} \text{ N/m}$$

Q.19 (1)

$$F = \frac{\mu_0}{4\pi}\frac{2i_1 i_2}{a} = 10^{-7}\times\frac{2\times 10\times 10}{0.1} = 2\times 10^{-4} \text{ N}$$

Direction of current is same, so force is attractive.

Q.20 (3)

$M = i\pi r^2$

Q.21 (1)

Because $\tau = NiAB\cos\theta$

Q.22 (2)

$w = MB(\cos\theta_1 - \cos\theta_2)$

$= (NiA)B(\cos 0^o - \cos 180^o) = 2\,NAIB$

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (3)

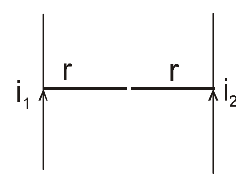
Charge the rest produces only electric field but charge in motion produces both electric and magnetic field.

Q.2 (3)

$i_1 > i_2$

$$\frac{\mu_0}{2r}(i_1 - i_2) = 20$$

$$\frac{\mu_0}{2r}(i_1 + i_2) = 30$$



$$\frac{i_1 + i_2}{i_1 - i_2} = \frac{3}{2} \Rightarrow \frac{i_1}{i_2} = \frac{5}{1}$$

Q.3 (3)

$$\vec{B}_{\text{due to first loop}} = 4\frac{\mu_0 i}{4\pi\frac{a}{2}}[\cos 45^0 + \cos 45^0]$$

$$= \frac{2\sqrt{2}\mu_0 i}{\pi a}$$

$$\vec{B}_{\text{due to second loop}} = -\frac{4\mu_0 i}{4\pi\frac{2a}{2}}[\cos 45^0 + \cos 45^0]$$

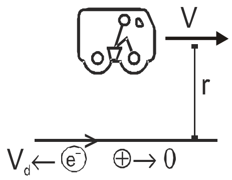
$$= \frac{-\sqrt{2}\mu_0 i}{\pi a}$$

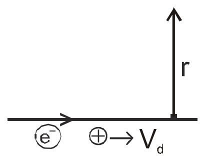
$$\vec{B} = \frac{2\sqrt{2}\mu_0 i}{\pi a}\left[1 - \frac{1}{2} + \ldots\ldots\ldots\ldots \infty\right]$$

$$= \frac{2\sqrt{2}\mu_0 i}{\pi a}\ln 2$$

Q.4 (1)

In observer frame of refernece





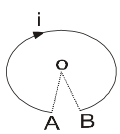
$$B = \frac{\mu_0 i}{2\pi r}$$

Q.5 (1)

$$B = \frac{\mu_0 i}{4\pi R'}(2\pi - \theta)$$

where; $(2\pi - \theta) R' = 2\pi R$

$$R' = \frac{2\pi R}{2\pi - \theta}$$

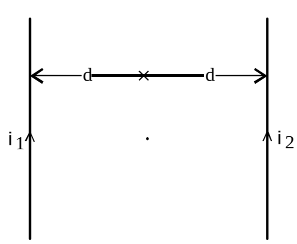


$$B = \frac{\mu_0 i}{2R}\left(\frac{2\pi - \theta}{2\pi}\right)^2$$

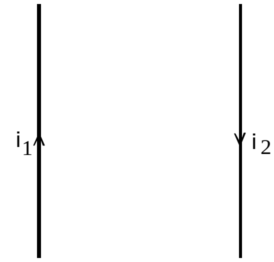
Q.6 (2)

Zero, because magnetic field due to each wire will be cancelled by another wire.

Q.7 (3)



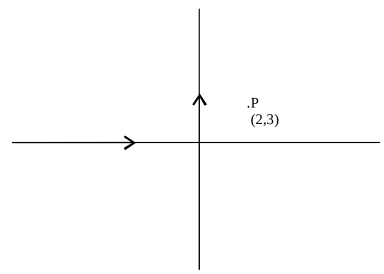
$$B_{net} = \frac{\mu_0 (i_1 - i_2)}{2\pi d} = 10\,\mu T \quad .....(1)$$



$$\vec{B} = \frac{\mu_0 (i_1 + i_2)}{2\pi d} = 30\,\mu T \quad ....(2)$$

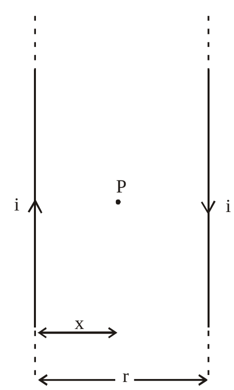
from (1) & (2) $\frac{i_1}{i_2} = 2$

Q.8 (3)



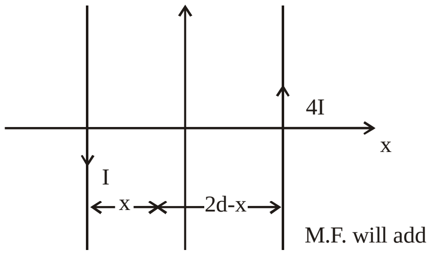
$$B_{net} = \frac{\mu_0 I}{2\pi(2)} - \frac{\mu_0 I}{2\pi(3)},\ B_{net} = \frac{\mu_0 I}{12\pi} \otimes$$

Q.9 (2)



At point P $\frac{\mu_0 i}{2\pi}\left[\frac{1}{x} + \frac{1}{r-x}\right]$

Q.10 (3)



In b/w wire

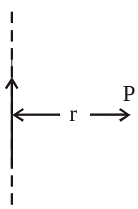
$$B = \frac{\mu_0 I}{2\pi x} + \frac{4\mu_0 i}{2\pi(2d - x)}$$

To find the minima

$$\frac{dB}{dx} = 0$$

Which gives $x = d/3$.
Hence there is a minima close to 1.

Q.11 (2)



$$B = \frac{\mu_0 i}{2\pi r}$$

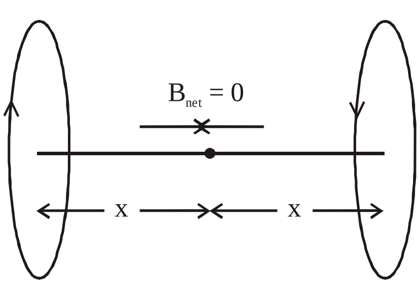
Now, $\frac{B_1}{B_2} = \frac{r_2}{r_1} = \frac{4}{3}$

Q.12 (1)

$$B \propto \frac{1}{r^3}$$

$$\frac{B_1}{B_2} = \left(\frac{3x}{x}\right)^3 = \frac{27}{1}$$

Q.13 (2)



Q.14 (2)

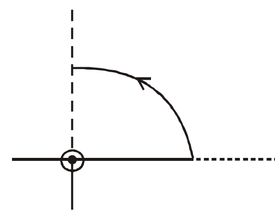
$$B_1 = \frac{\mu_0 i}{2R}$$

$$2\pi R = 2\pi R' \times 2$$

$$R' = \frac{R}{2}$$

$$B_2 = \frac{\mu_0 i \times 2}{2(R/2)} = 4B_1$$

Q.15 (4)



$$B = \frac{\mu_0 i}{8R}$$

from the above in the given Ques.

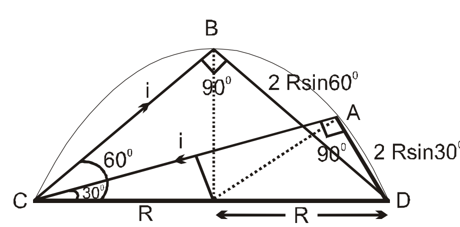
$$B = \frac{\mu_0 i}{8}\left[\frac{1}{R} + \frac{3}{R'}\right]$$

Q.16 (2)

$$B_{\text{due to AC}} = \frac{\mu_0 i}{4\pi\ 2R \sin 30^0}\ [\cos 30^0 + \cos 90^0]$$

$$= \frac{\mu_0 i\sqrt{3}}{8\pi R}$$

$$B_{\text{due to BC}} = \frac{\mu_0 i}{4\pi\ 2R \sin 60^0}\ [\cos 60^0 + \cos 90^0]$$



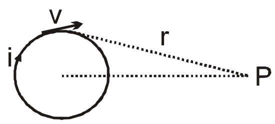
$$= \frac{\mu_0 i}{8\pi R\sqrt{3}}$$

$$B_{Net} = B_{\text{due to AC}} - B_{\text{due to BC}}$$

$$= \frac{\mu_0 i}{4\pi R\sqrt{3}}$$

Q.17 (1)

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q(\vec{v}\times\vec{r})}{r^3}$$



Magnitude fixed but direction keeps on changing

Q.18 (4)

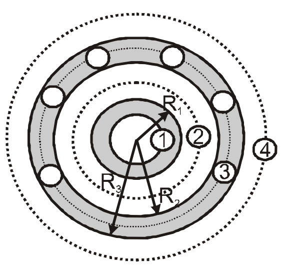
$B = \mu_0\mu_r ni$
$= 10^{-7}\times 4\pi\times 4000\times 1000\times 5$
$= 8\pi\,T$
$= 25.12\,T$

Q.19 (3)

loop (1)

$$B = \frac{\mu_0 \frac{i}{\pi R_1^2}\times \pi r^2}{2\pi r}$$

$$= \frac{\mu_0 i}{2\pi R_1^2} r \quad B \propto r$$



loop (2)

$$B = \frac{\mu_0 i}{2\pi r} \quad B \propto \frac{1}{r}$$

loop (3)

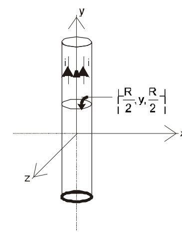
$$B = \frac{\mu_0\left(i - \frac{i}{R_3^2 - R_2^2}\left[r^2 - R_2^2\right]\right)}{2\pi r} = \frac{\mu_0(R_3^2 - r^2)}{2\pi r(R_3^2 - R_2^2)}$$

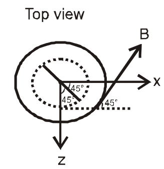
loop (4)

$$B = \frac{\mu_0(i - i)}{2\pi r} = 0$$

Q.20 (1)

$$B = \frac{\frac{\mu_0 i}{\pi R^2}\times\pi\left(\frac{R}{\sqrt{2}}\right)^2}{2\pi\sqrt{2}\frac{R}{2}}\ [\cos 45^\circ\,\hat{i} - \cos 45^\circ\,\hat{k}]$$

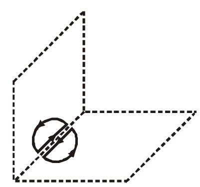




$$= \frac{\mu_0 i^2}{4\pi R}(\hat{i} - \hat{k})$$

Q.21 (4)

$$\oint_{ABCDA}\vec{B}.\vec{dl} = \oint_{ABCA}\vec{B}.\vec{dl} + \oint_{CDAC}\vec{B}.\vec{dl}$$

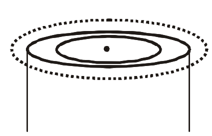


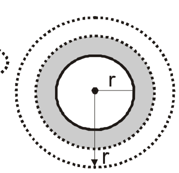
$= \mu_0(i_1 + i_3) + \mu_0(i_2 - i_3)$
$= \mu_0(i_1 + i_2)$

Q.22 (2)

$$\oint\vec{B}.\vec{dl} = \mu_0\frac{i}{\pi R^2}\times\pi r^2$$

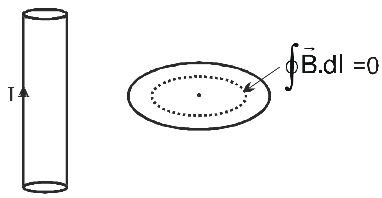
$$= \frac{\mu_0 i r^2}{R^2}$$





$$\oint\vec{B}.\vec{dl} = \mu_0 i$$

Q.23 (2)

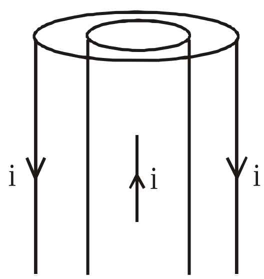


$\oint \vec{B}.dl = 0$

$B = 0$

Q.24 (1)

Q.25 (1)

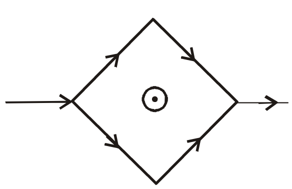


Inside the conductor magnetic field due to both have same direction so we add them.
Out side the conductor magnetic field due to both have opposite direction. so we subtract them.

Q.26 (4)
$B = \mu_0 ni$
$3.14 \times 10^{-2} = 4\pi \times 10^{-7} \times n \times 10$
$n = 2500$ turns/ m.

Q.27 (2)
$F = qVB$
$F_{Min} = q_{Min} VB$
As from the given options Li^{++} has maximum charge.

Q.28 (4)



Q.29 (3)

$$qV = \frac{1}{2}mv^2$$

$$R = \frac{mv}{qB}$$

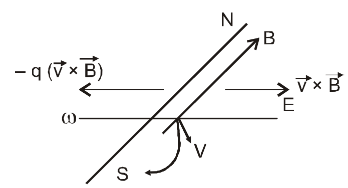
$$= \frac{m\sqrt{\frac{2qV}{m}}}{qB}$$

$$= \sqrt{\frac{2mv}{qB^2}}$$

$$\frac{R_1}{R_2} = \sqrt{\frac{m_1}{m_2}}$$

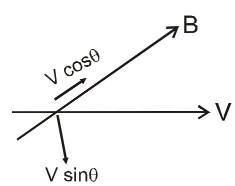
$$\frac{m_1}{m_2} = \left(\frac{R_1}{R_2}\right)^2$$

Q.30 (2)



F towards west
So particle will be deflected towards west

Q.31 (3)

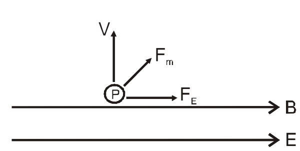


$$\frac{mv^2}{R} = q\,v\,(B \sin\theta)$$

$$R = \frac{mv}{qB\sin\theta}$$

Q.32 (4)
$F_E = qE,\ F_m = qvB$

$$R = \frac{mv}{qB}$$



Pitch $p = V_{||} T$

$T = \frac{2\pi R}{V}$

$V_{\parallel} = 0 + \frac{qE\,t}{m}$

Q.33 (1)

$R = \frac{mv}{qB}$

$q \times 12 \times 10^3 = \frac{1}{2}\, m\,(10^6)^2$

$\frac{m}{q} = 24 \times 10^{-9}$ $\Rightarrow R = \frac{24 \times 10^{-9} \times 10^6}{0.2} = 12\text{ cm}$

Q.34 (2)

$R \propto \frac{m}{q}$

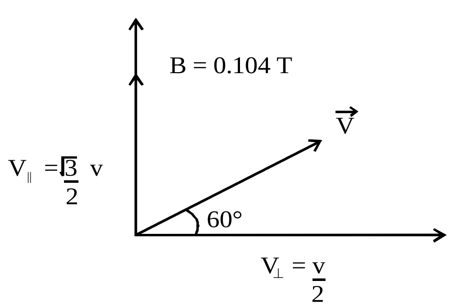
$R_p : R_e : R_{\alpha} = \frac{m_P}{q} : \frac{m_e}{q} : \frac{4m_P}{2q}$.

$R = \frac{mv}{qB}$

α-particle has maximum R, so the path followed is B.

Q.35 (2)
A particle starting from rest moves in direction of electric field. As both electric & magnetic field are parallel. Hence $\vec{v}$ and $\vec{B}$ are also parallel. Hence there is on force on particle.

Q.36 (3)

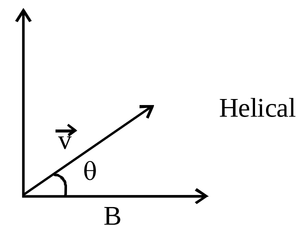


$\because$ $\vec{v}$ is not parallel to $\vec{B}$
$\therefore$ Path of the proton is helical

radius $= \frac{mv_{\perp}}{qB} = 0.1$ m

$T = \frac{2\pi m}{qB} = 2\pi \times 10^{-7}$

Q.37 (3)
Path of particle will be helical



Q.38 (2)

$R = \frac{mv}{qB}$

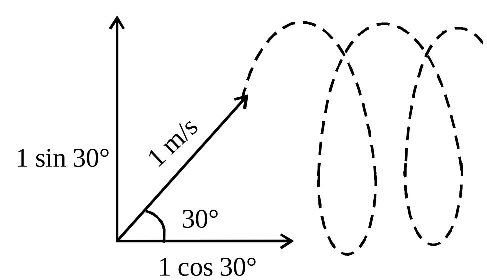
$R \propto v$

Q.39 (1)

$T = \frac{2\pi m}{qB}$

Same for all electrons as time is independant of velocity.

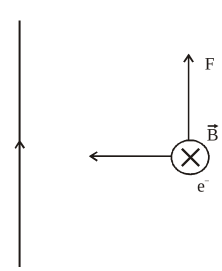
Q.40 (2)



Pitch = $V_{\parallel}$. T

$= V\cos\theta \,.\, \frac{2\pi m}{qB} = \frac{\sqrt{3}}{2} \times 2\pi = \sqrt{3}\pi$

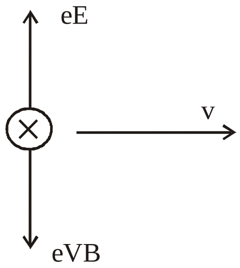
Q.41 (1)



Applying right hand thumb rule.

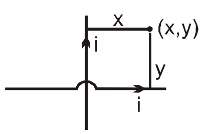
Q.42 (2)

Force on electron due to electric field is in positive y-direction so force due to magnetic field should be in negative y-direction. Hence direction of magnetic field should be in –ve z-direction.



Q.43 (1)

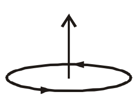
$$\frac{\mu_0 i}{2\pi x} = \frac{\mu_0 i}{2\pi y}$$



$y = x$

only in first quadrant the fields will be oppositely directed.

Q.44 (3)

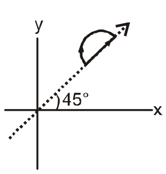


In uniform magnetic filed force acting on a closed loop = 0.

Q.45 (2)

$$\vec{B} = 3\hat{i} + 4\hat{j} + \hat{k}$$

$$\vec{l} = \frac{2}{\sqrt{2}}(\hat{i} + \hat{j})$$

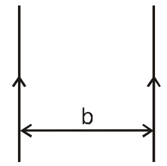


$$\vec{F} = I(\vec{l} \times \vec{B})$$

$$= \sqrt{2}\,[(\hat{i} + \hat{j}) \times (3\hat{i} + 4\hat{j} + \hat{k})]$$

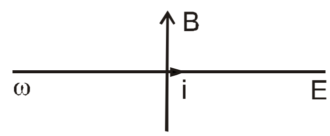
$$= \sqrt{2}\,(\hat{i} - \hat{j} + \hat{k})$$

Q.46 (2)



$$F = \frac{\mu_0}{4\pi} \cdot \frac{2i^2}{b} = \frac{\mu_0 i^2}{2\pi b}$$

Q.47 (3)



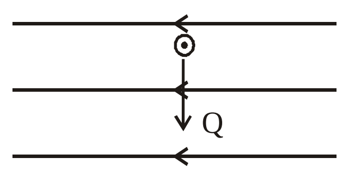
$F = BiL$

$= 10^{-4} \times 10 \times 1 = 10^{-3}$ N

Q.48 (2)

By formula $F = i\left(\vec{\ell} \times \vec{B}\right)$

direction of ℓ in direction of i.



Q.49 (1)

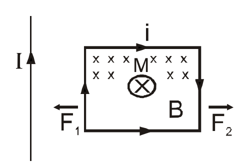
From $\dfrac{\mu_0 i_1 i_2}{2\pi d} = F$

when current in same direction there is attraction force.

$$F' = \frac{\mu_0 \frac{i_1}{2}\frac{i_2}{2}}{2\pi d} = \frac{F}{4}$$

Q.50 (3)

$\vec{M} \times \vec{B} = 0$



$\tau = 0$

Loop will Not rotate

$F_1 > F_2$

So loop move towards the wire

Q.51 (2)

$U_i = -MB$

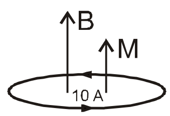
$U_f = MB$

$W = \Delta U = 2\,MB$

$= 2 \times 2.5 \times 0.2$

$= 1\ J$

Q.52 (1)



$\vec{\tau} = \vec{M} \times \vec{B} = 0$

Q.53 (2)

$i = qf$

$= \dfrac{qv}{2\pi r}$

$T = \dfrac{2\pi r}{v}$

$M.M. = i\pi r^2 = \dfrac{qvr}{2}$

Q.54 (2)

Torque on a current carrying loop is given by

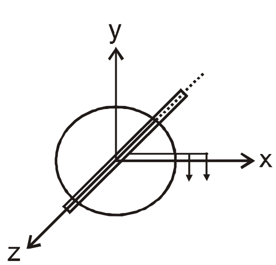
$\vec{\tau} = \vec{M} \times \vec{B}$

Hence $\vec{\tau}$ does not depend on shape of loop.

JEE-ADVANCED
OBJECTIVE QUESTIONS

Q.1 (A)

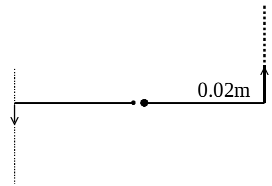
Take any two points along x - axis, direction of B is same .



Take any two points on a circle, magnitude of B is same .

Take two diametrically opposite points field are in opposite directions .

Q.2 (A)



$$B_{net} = \frac{2\mu_0 i}{4\pi r}$$

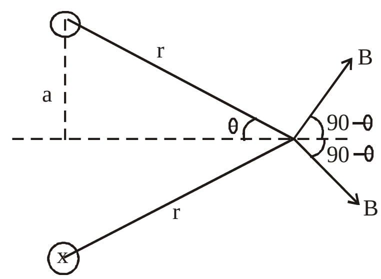
$$= \frac{2 \times 10^{-7} \times 10}{0.02}$$

$$= 1 \times 10^{-4}\ \text{Wb/m}^2$$

Q.3 (A)

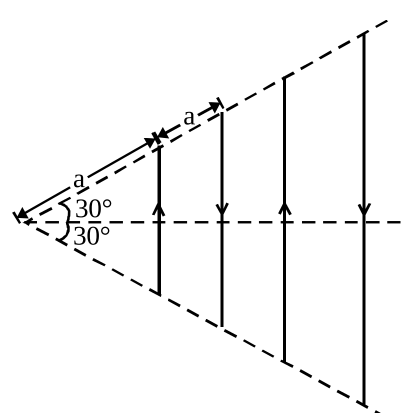
$$B_1 = B_2 = B_3 = B_4 = \frac{\mu_0 I}{d}$$

Q.4 (D)



$$B_{net} = 2B\sin\theta = \frac{2\mu_0 ia}{2\pi r.r} = \frac{\mu_0 ia}{\pi r^2}$$

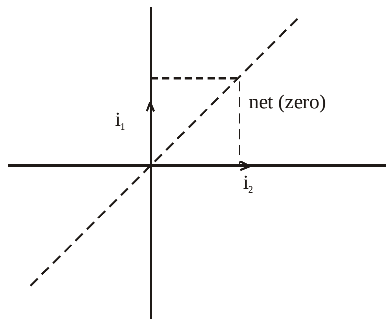
Q.5 (B)



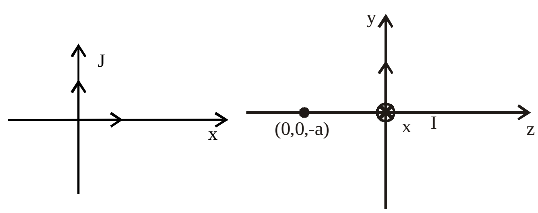
$$\infty = \frac{\mu_0 i}{4\pi}\left(\frac{2\sin 30°}{\cos 30°}\right)\left(\frac{1}{a}-\frac{1}{2a}+\frac{1}{3a}\right)$$

$$= \frac{\mu_0 i}{4\pi\sqrt{3}a}\ln 2^2 = \frac{\mu_0 i}{4\pi a\sqrt{3}}\ln 4$$

Q.6 (C)

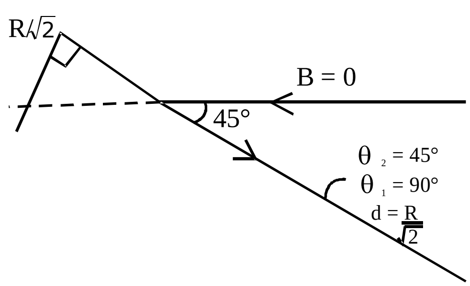


Q.7 (A)



$$B_{net} = \frac{\mu_0 i}{2\pi a}(\hat{j}-\hat{i})$$

Q.8 (A)



Induction of magnetic field = $\dfrac{\mu_0 I}{4\pi \dfrac{R}{\sqrt{2}}}\left(1-\dfrac{1}{\sqrt{2}}\right)$

Q.9 (A)
When resistance on both side are different. So current is different and hence magnetic field produced by both the segments is not equal. Hence net magnetic field at centre is nonzero.

Q.10 (C)
In (C) there is magnetic field at centre due to the straight wire.

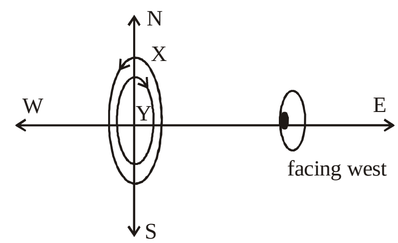
Q.11 (A)

Magnetic field at centre of the ring $\dfrac{\mu_0 I}{2R}$

As the three rings are mutually perpendicular. Hence the magnetic field due to each one of them will be mutually ⊥ to other. Hence magnitude of B_{net}.

$$\Rightarrow B = \frac{\sqrt{3}\mu_0 I}{2R}$$

Q.12 (A)

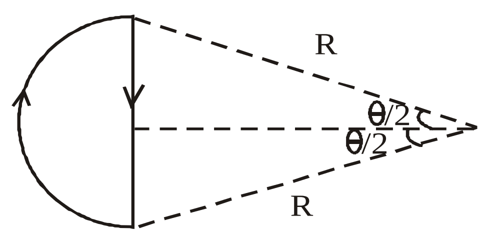


for X $B = \dfrac{\mu_0\, 20\times 16}{2\times 16\times 10^{-2}} = 4\pi\times 10^{-4}$ T (East)

for Y $B = \dfrac{\mu_0\, 25\times 18}{2\times 10\times 10^{-2}} = 9\pi\times 10^{-4}$ T (West

Q.13 (C)
Curl the finger in the direction of current then the thumb gives the direction of magnetic field.

Q.14 (C)

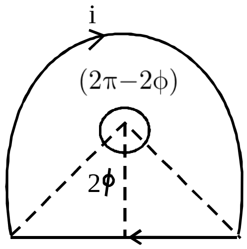


B due to arc = $\dfrac{\mu_0 i}{4\pi R}.\theta \otimes$

B due to wire = $\dfrac{\mu_0 i}{4\pi R\cos\theta/2}.2\sin\theta/2$

$= \dfrac{\mu_0 i}{4\pi R}.2\tan\theta/2 \odot$ $\qquad B_{wire} > B_{arce}$

Q.15 (A)



Magnetic field due to Arc

$$B_1 = \frac{\mu_0 i}{4\pi R}(2\pi - 2\phi)$$

$$B_1 = \frac{\mu_0 i}{2\pi R}(\pi - \phi) \otimes$$

Magnetic field due to straight wire

$$B_2 = \frac{\mu_0 i}{4\pi R\cos\phi} 2\sin\phi$$

$$B_2 = \frac{\mu_0 i}{2\pi R}\tan\phi \odot$$

$$B_{net} = B_1 + B_2$$

$$\therefore B_{net} = \frac{\mu_0 i}{2\pi R}[\pi - \phi + \tan\phi]$$

Q.16 (A)

$$\frac{2\pi}{8} = \frac{\pi}{4} \rightarrow \text{for each arc}$$

$$\frac{4\mu_0 i}{4\pi}\left(\frac{1}{r} + \frac{1}{2r}\right)\times\frac{\pi}{4} = \frac{3\mu_0 i}{8r}$$

Q.17 (A)

Net force = $eV(B_1 + B_2)$

$$3.2\times10^{-20} = 1.6\times10^{-19}\times4\times10^5\left[\frac{\mu_0(2.5)}{2\pi(5)} + \frac{\mu_0 i}{2\pi(2)}\right]$$

$i = 4A$

Q.18 (A)

$$E = \frac{F}{q} \qquad \mu_0\epsilon_0 = \frac{1}{C^2}$$

$$B = \frac{F}{il}$$

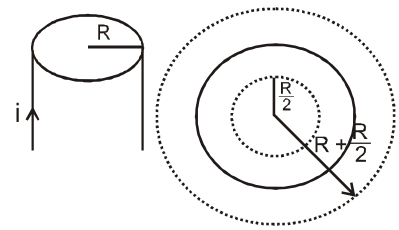
Hence the dimensions are $\frac{L^2}{[L^2T^{-2}][T^2]}$ $= M^0L^0T^0$

Dimensionless.

Q.19 (D)

$$B_{inside} = \frac{\mu_0 \frac{i}{\pi R^2}\times\frac{\pi R^2}{4}}{2\pi\frac{R}{2}} = \frac{\mu_0 i}{4\pi R}$$

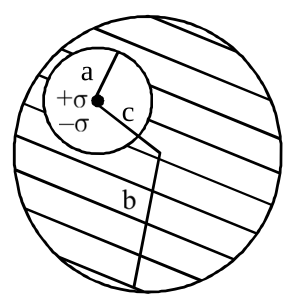
$$B_{Outside} = \frac{\mu_0 i}{2\pi\frac{3R}{2}} = \frac{\mu_0 i}{3\pi R}$$



Energy density $\propto B^2$

$$\frac{\varepsilon_1}{\varepsilon_2} = \left[\frac{B_1}{B_2}\right]^2 = \frac{9}{16}$$

Q.20 (B)



$$\sigma = \frac{i}{\pi(b^2 - a^2)}, \oint \vec{B}dl = \mu_0 ir$$

$$B(2\pi c) = \frac{\mu_0 i\pi c^2}{\pi(b^2 - a^2)}$$

$$B_1 = \frac{\mu_0 ic}{2\pi(b^2 - a^2)}$$

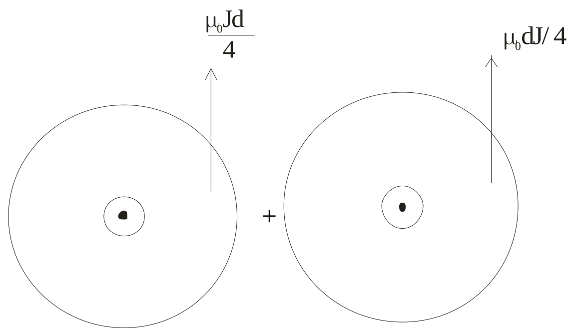
when $-\sigma$ is taken

$B_2 = 0$

$\Rightarrow B_{net} = B_1$

Q.21 (A)

Assume + J and – J in empty space

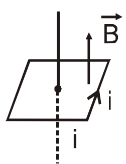


$$B_{net} = \frac{\mu_0 Jd}{2}$$

Q.22 (C)

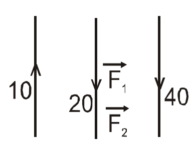
Field produced by loop at the centre will be along the axis of the loop i.e. || to st. wire .

So $F = i(\vec{i} \times \vec{B}) = 0$



Q.23 (B)

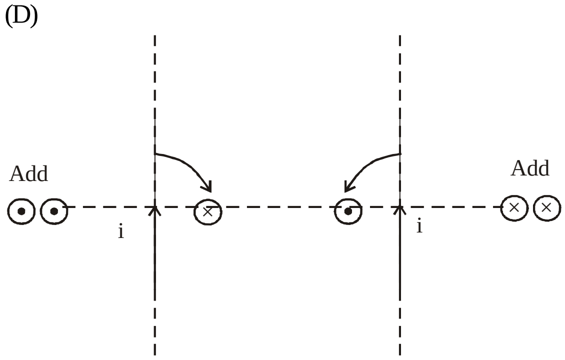
$$F_1 = \frac{\mu_0 (10 \times 20)}{2\pi l}$$



$$F_2 = \frac{\mu_0 (20 \times 40)}{2\pi l}$$

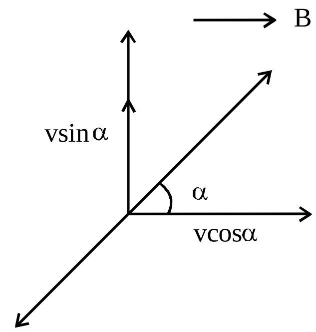
F_1 and F_2 both points in the same direction towards 40 A wire.

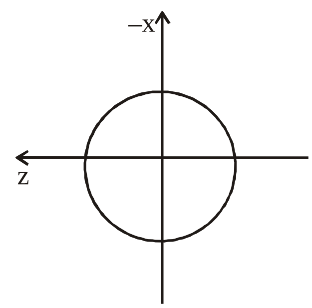
Q.24 (D)



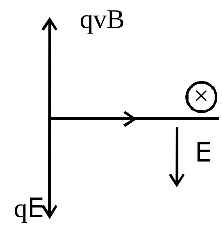
Q.25 (A)

Force will be in negative x- direction. Particle will circle in x-y plane and hence its x-coordinate will never be +ve.





Q.26 (D)



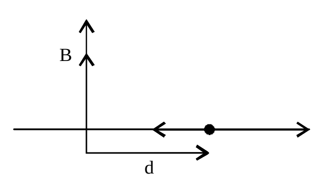
(a) qE remain is same direction but qvB changes its directions.

(b) qvB remain in same direction but qE change its direction.

(c) $qE = qvB \Rightarrow \left(\frac{E}{B}\right)$ is fixed

(d) $2qE = 2qvB$

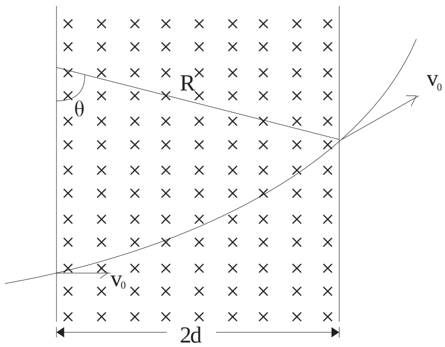
Q.27 (B)



$d > \frac{mv}{qB}$

$v_{max} = \frac{qBd}{m}$

Q.28 (B)



$\sin\theta = \frac{2d}{R}$

$t = \frac{\theta R}{v} = \frac{m}{qB}\sin^{-1}\left(\frac{2d}{R}\right)$

Q.29 (C)

$R = \frac{mv}{qB}, = \frac{\sqrt{2mK.E.}}{qB} = \sqrt{\frac{2}{g}}R$

Q.30 (B)

$\vec{B} = Bx\hat{i} + By\hat{j} + Bz\hat{k}$

$= \left(4.0\hat{i} + 3.0\hat{j}\right) \times 10^{-13}$

$= -e\left(2.5\hat{k} \times \left(Bx\hat{i} + By\hat{j} + Bz\hat{k}\right) \times 10^{7}\right)$

$= \left(-2.5eB_x\hat{j} + 2.5eB_y\hat{i}\right) \times 10^{7}$

$10^{-13} \times 4 = 2.5 \times 1.6 \times 10^{-19} B_y \times 10^{7}$

$B_y = 0.1$

$B_x = -0.075$

Q.31 (C)

$qv = \frac{1}{2}mv^2 = K.E.$

$\frac{d}{2} = \frac{\sqrt{2mqv}}{qB}$

$m = \frac{qB^2d^2}{8v}$

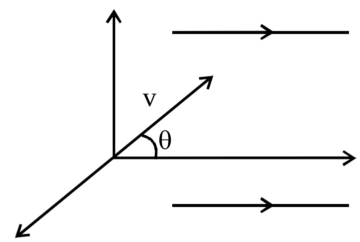
Q.32 (A)

From the given data we conclude that B is in $\hat{k}$ direction

so when $\vec{v} = 2\hat{k}$ then

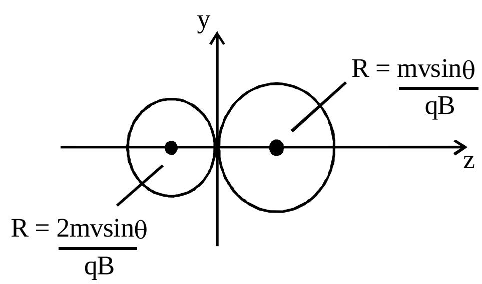
$F = 0$

Q.33 (D)



$T = \frac{2\pi m}{qB} \Rightarrow T_1 : T_2 = \frac{1}{2}$

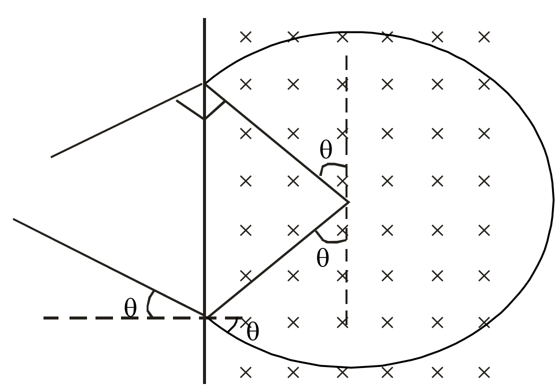
circle y – z plane



Meet after two revolution

$= \frac{4\pi mv\cos\theta}{qB}$

Q.34 (C)



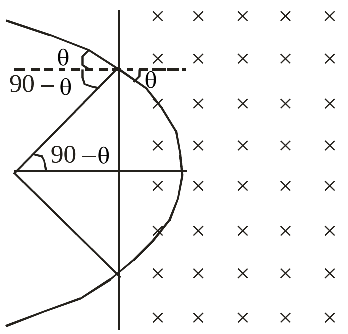
Time spent

$$= \frac{T}{2} + \frac{\theta R}{v} + \frac{\theta R}{v}, = \frac{T}{2} + \frac{2\theta R}{v}$$

$$= \frac{\pi m}{qB} + \frac{2\theta mv}{qBv}, = \frac{2\pi m}{qB}\left(\frac{\pi + 2\theta}{2\pi}\right)$$

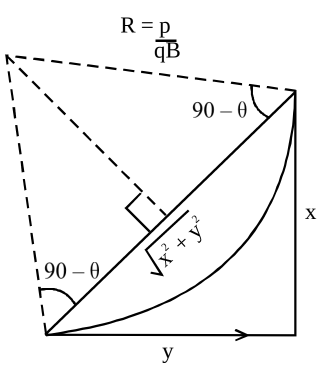
time spent $= T\left(\frac{\pi + 2\theta}{2\pi}\right)$

Q.35 (D)



Time spent $t = \left(\frac{\pi - 2\theta}{v}\right)$

Q.36 (C)



$$2R\sin\theta = \sqrt{y^2 + x^2}$$

$$\frac{2R.x}{\sqrt{y^2 + x^2}} = \sqrt{y^2 + x^2}$$

$$\frac{2P}{qB} = \frac{y^2 + x^2}{x}$$

$$P = \frac{qB}{2}\left(y^2/x + x\right)$$

Q.37 (C)

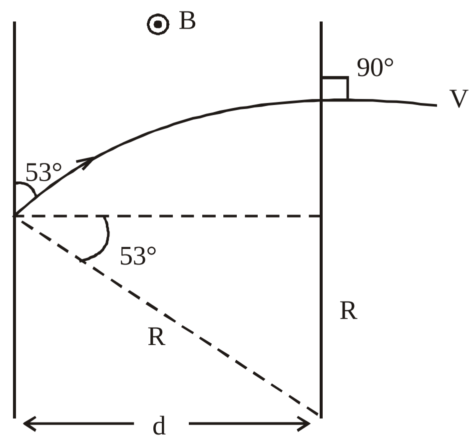
Contact looses when N = 0

$V = g\sin\theta \,.\, t$

$mg\cos\theta = q\, g\sin\theta\, t\, B \qquad [N = 0]$

$$t = \frac{m\cot\theta}{qB}$$

Q.38 (C)



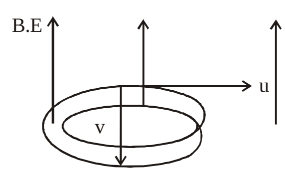
$$d = \frac{3mv}{5qB}, R = \frac{mv}{qB}$$

Q.39 (C)

K.E of α-particle = work done by electric force.

$$qE_0 x_0 = \frac{1}{2}m5^2,\ x_0 = \frac{25}{2\alpha E_0}$$

Q.40 (C)



$$T = \frac{2\pi m}{qB}$$

for E.F. $a = \frac{qE}{m}\uparrow$

$u_i = v\downarrow$

$$S = 0\ V.t = \frac{1}{2}\frac{qE}{m}.t^2$$

$$t = \frac{2mV}{qE}$$

for touching t = nT

$$\frac{2mV}{qE} = \frac{n2\pi m}{qB}$$

$n = \frac{VB}{\pi E}$

Q.41 (D)

$2V_0 = \sqrt{V_0^2 + V_x^2}$

$4V_0^2 = V_0^2 + V_x^2$

$V_x^2 = 3V_0^2$

$\because \sqrt{3}V_0 = \frac{qE_0 t}{m}$

$t = \frac{\sqrt{3}mV_0}{qE_0}$

Q.42 (D)

$qE = \frac{mV_0^2}{r_1}$

$qV_0B = \frac{mV_0^2}{r_2}$

$r_1 = \frac{mV_0^2}{qE}$

$r_2 = \frac{mV_0}{qB}$

Q.43 (C)

$qVB = qE$

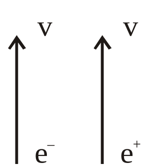
$VB = E$ and $R = \frac{mV}{qB}$

Q.44 (B)

As the radius of the circle is constantly decreasing hence we conclude that B is increasing as $r = \frac{mv}{qB}$.

A particle looses energy by ionising the air.

Q.45 (A)



$C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$F_e = \frac{Ke^2}{r^2} = \frac{e^2}{4\pi\varepsilon_0 r^2}$

$\vec{B} = \frac{\mu_0}{4\pi}\frac{q(\vec{v}\times\vec{r})}{r^3}$

$B = \frac{\mu_0 qV}{4\pi r^2}$

$F_m = q(\vec{v}\times\vec{B}) = \frac{\mu_0 e^2 v^2}{4\pi r^2}$

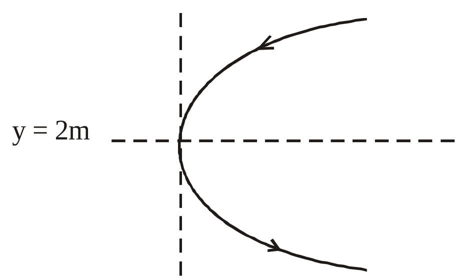
$\therefore$ ratio $= \frac{1}{\mu_0\varepsilon_0 v^2} = \frac{c^2}{V^2}$

Q.46 (A)

$i\ell B = mg$

$\frac{V\ell B}{R} = mg,\ B = \frac{mgR}{V\ell}$

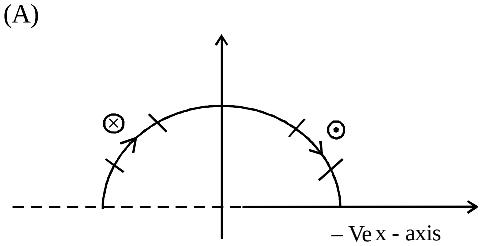
Q.47 (B)



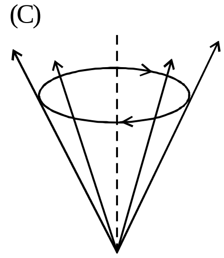
$\therefore$ Total length = 4m

force $= 2 \times 4 \times 4 = 32\ i$

Q.48 (A)

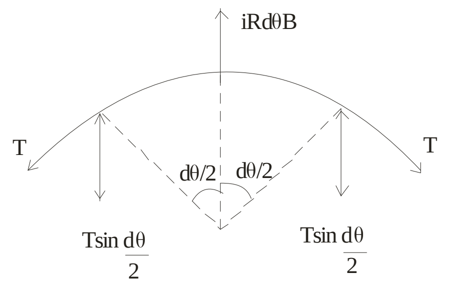


Q.49 (C)



Net force $= 2\pi\ aIB \sin\theta$

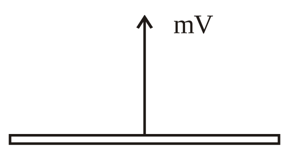
Q.50 (D)



$$2T\frac{d\theta}{2} = iRd\theta B$$

$T = 10N$

Q.51 (D)



in time dt

$$i = \frac{q}{dt}$$

$$v = \sqrt{2gh}$$

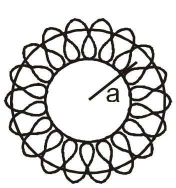
$$m.\sqrt{2gh} = F.dt$$

$$m.\sqrt{2}gh = Bi\ell dt$$

$$m.\sqrt{2}gh = B\ell \times q$$

$$q = \frac{m\sqrt{2}gh}{B\ell}$$

Q.52 (A)



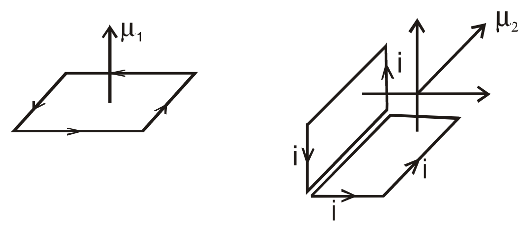
$$\Sigma \vec{M} = 0$$

$$\vec{\tau} = \vec{M} \times \vec{B}$$

Q.53 (C)

$\mu_1 = L^2$

$$\mu_2 = \sqrt{2} \times L \times \frac{L}{2}$$



$$\mu_2 = \frac{L^2}{\sqrt{2}}$$

$$\frac{\mu_1}{\mu_2} = \sqrt{2}$$

Q.54 (A)

Angle b/w $\vec{B}$ & $\vec{A}$ is zero

so $\vec{\tau} = 0$

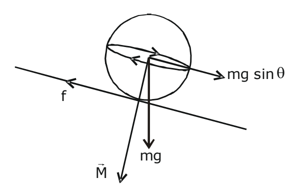
Q.55 (A)

$\vec{\tau} = I\alpha$

$$Bi\pi R^2 = \frac{mR^2}{2}\alpha$$

$$\alpha = \frac{2Bi\pi}{m} = \frac{2 \times 10 \times 4\pi}{2} = 40\pi \text{ rad/s}^2$$

Q.56 (B)



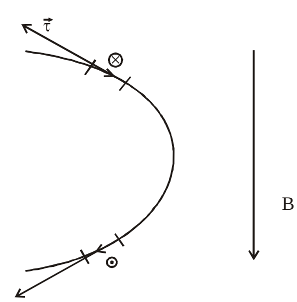
$mg\sin\theta = f$

$f.R = i\pi R^2 B\sin\theta$

$mg\sin\theta . R = i\pi R^2 B \sin\theta$

$$B = \frac{mg}{i\pi R}$$

Q.57 (B)



The force on upper segment is in direction inside the plane of paper while on the lower segment it is perpendicular to plane of paper coming outwards.

When we calculate $\vec{\tau} = \vec{r} \times \vec{F}$ the direction of torque are as shown. The vertical components cancel out leaving horizontal components in left direction.

Q.58 (B)
$\tau = 2n\,(2L)\,(2a)\,B \sin 30°$
$= 8\,\mathrm{Ban}\,I \cos 60°$

Q.59 (A)

$$\vec{A} = \overrightarrow{DA} \times \overrightarrow{AB}$$

$$= 0.01\,(\cos 60\ \hat{i}\ - \sin 60°\ \hat{k})$$

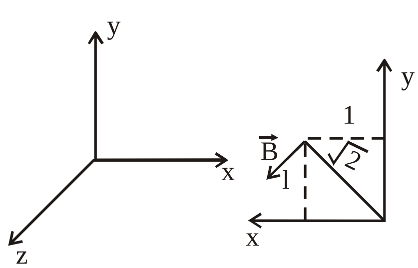
$$\vec{A} = \frac{0.01}{2}\left(\hat{i} - \sqrt{3}\hat{k}\right)$$

JEE-ADVANCED

MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (B, D)
In point A & C
$r = 1$ m
In point B & D
$r = \sqrt{2}$ m

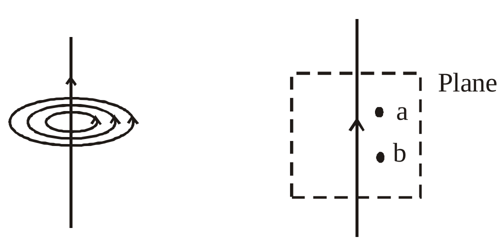
Q.2 (A, D)



$$B = \frac{\mu_0 i}{2\sqrt{2}\pi}$$

As direction of magnetic field is ⊥ to line joining wire and point hence angle between xy plane & magnetic field is 45º.

Q.3 (A, B, C)



both point a & b have same B.

Q.4 (A, B, C)

$$x = \frac{E}{B}\ \text{m/sec.}$$

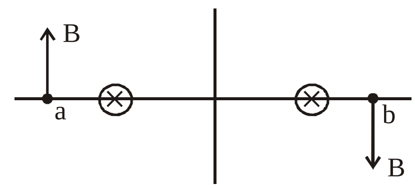
$$z = \frac{l}{CR}\ \text{m/sec}$$

$$y = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}\ \text{m/sec.}$$

All have dimensions (LT^{-1})

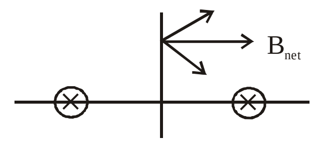
Q.5 (A,B,C,D)
(A) Direction of magnetic field produced due to the two wires on x axis have opposite direction
$\Rightarrow B_{net} = 0$.

(B)



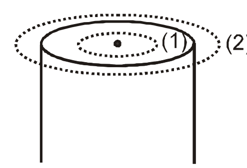
a & b have only z component.

(C)



B_{net} has only y component as z component gets cancelled
(D) $B_x = 0$ in net B

Q.6 (B, C, D)
Loop (1)
$B\,(2\pi r) = 0$
$B = 0$
Loop (2)
$B\,(2\pi r) = \mu_0 i$



$$B \propto \frac{1}{r}$$

Q.7 (B, C)
Work Done by magnetic force = 0

$$f = q\left(\vec{v} \times \vec{B}\right)$$

Q.8 (A, D)

$$T = \frac{2\pi m}{qB}\ ;\ \frac{T_1}{T_2} = 1$$

$$r_1 = \frac{mV \sin 30°}{qB}\ ;\ r_2 = \frac{mV \sin 60°}{qB}$$

$b = \frac{1}{\sqrt{3}}$

Pitch $_1$ = vcos30° T_1
Pitch_2 = vcos60° T_2
abc = 1

$c = \sqrt{3}$

a = bc

Q.9 (C, D)
W. D. by mag. field is zero

$F_{mg} = q\left(\vec{v} \times \vec{B}\right)$

Q.10 (A, C)

	H^+	He^+	O^{2+}
$\frac{q}{m}$	$\frac{1}{1}$	$\frac{1}{4}$	$\frac{2}{16}$
$\frac{q}{\sqrt{m}}$	1	$\frac{1}{2}$	$\frac{2}{4}$

$R = \frac{mv}{qB}$

$= \frac{\sqrt{2km}}{qB}$

$= \frac{\sqrt{m}}{q} \frac{\sqrt{2k}}{B}$

$R_{He^+} = R_{O^{2+}}$

$R \propto \frac{1}{\frac{q}{\sqrt{m}}}$ $R_{H^+} : R_{He^+} : R_{O^{2+}} = 1 : 2 : 2$

Q.11 (C, D)

$R = \frac{mv}{eB} = \frac{P}{eB}$

Energy gained = 0
As $W_B = 0$

$F_C = \frac{mv^2}{r} = e\,v\,B = \frac{ePB}{m}$

Q.12 (A,D)
$F_E = qE$, $F_m = qvB$
v = 0
$\Rightarrow F_m = 0$
B may or may not be zero.
No electric force = 0

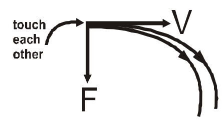
$\vec{E} = 0$

Q.13 (B,D)

$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$
If does not deflect then
None of the forces must be present

Q.14 (B,D)

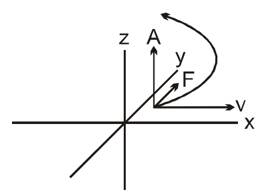
$R = \frac{mv}{qB}$



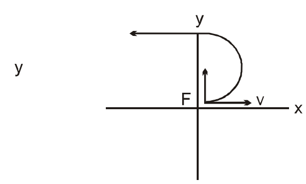
More q means less R

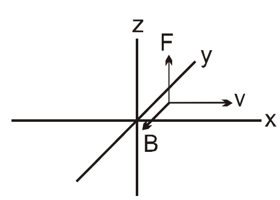
$\left(\frac{R_1}{R_2}\right) = \left(\frac{q_2}{q_1}\right)$

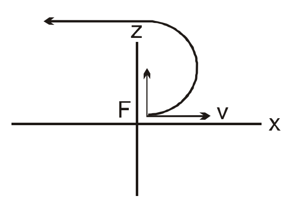
Q.15 (A,B)



i.e.







Q.16 (A, B, D)

$\omega_E + \omega_B = \Delta k$

$\Rightarrow$ $qE\,(2a) = \frac{1}{2} m\,(2v)^2 - \frac{1}{2} mv^2$

$= \frac{3}{2} mv^2$

$$E = \frac{3}{4}\frac{mv^2}{qa}$$

At P Rate of work done by E = qEv = $\frac{3}{4}\frac{mv^3}{a}$

At Q Rate of work done by E = qE (2v) cos90° = 0

At Q Rate of work done by B = 0

Q.17 (A, B, C)

$\vec{V}$ constant in direction and may be in magnetude

$\vec{a} = 0$

$q\vec{E} + q(\vec{V} \times \vec{B}) = 0$

I^{st} posibility

$\vec{E} = 0$ & $\vec{B} = 0$

$\longrightarrow V$

II^{nd} posibility

$\vec{E} = 0$ & $\vec{V} \,||\, \vec{B}$ i.e. $\vec{B} \neq 0$

III^{rd} posibility

$\longrightarrow V$

$\longrightarrow E$

$\vec{E} \,||\, \vec{V}$ & $B = 0$

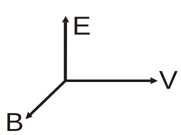
IV^{th} posibility

$\longrightarrow B$

$\longrightarrow V$ $\qquad \vec{E} \,||\, \vec{V} \,||\, \vec{B}$

$\longrightarrow E$ $\qquad \vec{V} \times \vec{B} = 0$

V^{th} posibility



$q\vec{E} = -q(\vec{V} \times \vec{B})$

Q.18 (B)

When charge is accelerated by electric field it gains energy for first time $KE_1 = \frac{qV}{2}$

for second time $KE_2 = \frac{3}{2}qV$

for third time $KE_3 = \frac{5}{2}qV$

hence the ratio of radii are

$$r_1 : r_2 : r_3 : \ldots\ldots\ldots : : \frac{\sqrt{2m\frac{qv}{2}}}{qB} : \frac{\sqrt{2m\frac{3}{2}qv}}{qB} : \ldots\ldots\ldots$$

$$r_1 : r_2 : r_3 \ldots\ldots : : \sqrt{1} : \sqrt{3} : \sqrt{5} \ldots\ldots\ldots$$

Q.19 (A)

In one full cycle it gets accelerated two times so change in KE = 2 qV.

Q.20 (A)

$$f = \frac{qB}{2\pi m} \Rightarrow 10^6 = \frac{10^6 B}{2\pi} \Rightarrow 2\pi T.$$

Q.21 (A)

Distance travelled by particle in one time period :

$\pi(r_1 + r_2) : \pi(r_3 + r_4) : \pi(r_5 + r_6) \ldots\ldots\ldots\ldots$

$$: : \frac{\sqrt{2m\frac{qV}{2}}}{qB} + \frac{\sqrt{2m\frac{3qV}{2}}}{qB} : \frac{\sqrt{2m\frac{5qV}{2}}}{qB} + \frac{\sqrt{2m\frac{7qV}{2}}}{qB} :$$

$$\frac{\sqrt{2m\frac{9qV}{2}}}{qB} + \frac{\sqrt{2m\frac{11qV}{2}}}{qB} \ldots\ldots$$

$S_1 : S_2 : S_3 \ldots\ldots\ldots\ldots : : (\sqrt{1} + \sqrt{3}) : (\sqrt{5} + \sqrt{7}) : (\sqrt{9} + \sqrt{11})$

Q.22 (C)

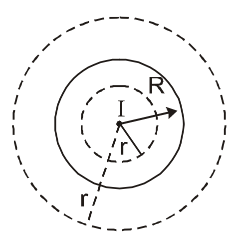
Frequency of A.C. depends on charge and mass only so it can be tuned by magnetic field only.

Q.23 (C)

Inside the cylinder

$$B.2\pi r = \mu_0 . \frac{I}{\pi R^2} \pi r^2$$

$$B = \frac{\mu_0 I}{2\pi R^2}.r \qquad \ldots\ldots\ldots\ldots(1)$$



outside the cylinder

$B.2\pi r = \mu_0 I$

$$\therefore B = \frac{\mu_0 I}{2\pi r} \qquad \ldots\ldots\ldots\ldots(2)$$

Inside cylinder B α r and outside B α $\frac{1}{r}$

So at the surface nature of magnetic field changes. Hence clear from graph, wire 'c' has greatest radius.

Q.24 (A)

Magnitude of magnetic field is maximum at the surface of wire 'a'.

Q.25 (A)

Inside the wire

$$B(r) = \frac{\mu_0}{2\pi}\cdot\frac{I}{R^2}.r = \frac{\mu_0 Jr}{2}$$

$$\frac{dB}{dr} = \frac{\mu_0 J}{2}$$

i.e. slope $\propto J \propto$ current density

It can be seen that slope of curve for wire a is greater than wire C.

Q.26 (A) p,q, r (B) p, q, r, s (C) r (D) p, q, r, s

The magnetic field is along negative y-direction in p,q,r. Hence z-component of magnetic field is zero in all cases.

The magnetic field at P is $\frac{\mu_0}{4\pi}\frac{i}{d}$ for case (r)

The magnetic field at P is less than $\frac{\mu_0}{2\pi}\frac{i}{d}$ for all cases.

Q.27 (A) p, q; (B) p, r; (C) p; (D) p, q, s

The Force on a magnetic dipole placed in uniform magnetic field is zero. Hence option p is common to all the four situations. Torque on magnetic dipole is $\vec{\tau} = \vec{\mu}\times\vec{B}$ and potential energy of dipole in external magnetic $U = -\vec{\mu}\times\vec{B}$

(A) Since $\theta = 0$, therefore $\tau = 0$

(B) Since $\theta = \pi/2$, therefore $\tau = \mu B$

(C) Since θ is acute, torque is non zero and less than μB in magnitude

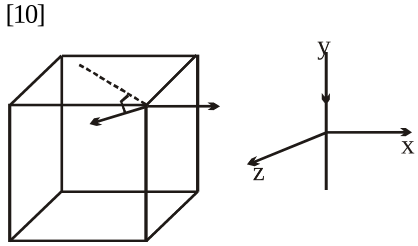
(D) Since $\theta = \pi$, therefore $\tau = 0$ and $U = \mu B$

Q.28 (i) R, (ii) Q,V (iii) V, (iv) U

NUMERICAL VALUE BASED

Q.1 [10]

Sol.



$$B = \frac{4\pi\times10^{-7}}{2\pi}\times\frac{8}{\sqrt{2}}\left[\frac{1}{\sqrt{2}}-\hat{i}+\frac{1}{\sqrt{2}}\hat{k}\right]+1.4\times10^{-6}\,\hat{i}$$

$$= \left(-8\hat{i}+8\hat{k}+14\hat{i}\right)\times10^{-7}$$

$$= (6\hat{i}+8\hat{k})\times10^{-7}$$

$B = 10\times10^{-7}$ T

Ans 10

Q.2 [3]

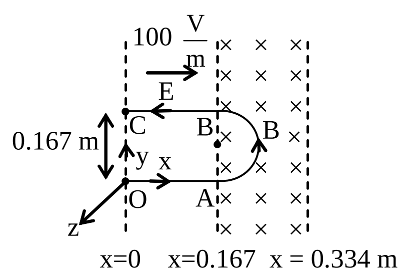
$qE = qV_d B$

$$\frac{V}{L} = \frac{i}{neLw}B$$

$$\frac{V}{L} = \frac{4.8\times1}{10^{29}\times1.6\times10^{-19}\times L\times10^{-3}} \quad = \frac{4.8}{10^7\times1.6} = 3\times10^{-7}\,V$$

Q.3 [0007]

The situation described in the problem is shown in fig As electric field is along x-axis, so proton will be accelerated by the electric field and will enter the magnetic field at A(i.e., x = 0.167, y = 0) with velocity v along x-axis such that



$$\frac{1}{2}mv^2 = W = Fd = qEd$$

$$\text{i.e. } v = \left[\frac{2qEd}{m}\right]^{1/2}$$

$$= \left[\frac{2\times1.6\times10^{-19}\times100\times0.167}{1.67\times10^{-27}}\right]^{1/2}$$

$$= 4\sqrt{2}\times10^4\,\frac{m}{s}$$

Now as proton is moving perpendicular to magnetic field so it will describe a circular path in the magnetic field with radius r such that

$$r = \frac{mv}{qB}$$

And as it comes back at C[x = 0; y = 0.167m] its path in the magnetic field will be a semicircle such that

$$y = 2r = \frac{2mv}{qB} \text{ i.e. } B = \frac{2mv}{qy}$$

$$\text{i.e., } B = \frac{2\times1.67\times10^{-27}\times4\sqrt{2}\times10^4}{1.6\times10^{-19}\times0.167}$$

$= \dfrac{1}{\sqrt{2}} \times 10^{-2}$

$= 7.07\ \text{mT}$

Q.4 [0006]

$R = \dfrac{mv}{qB}$

$q \times 12 \times 10^3 = \dfrac{1}{2} m \times (10^6)^2$

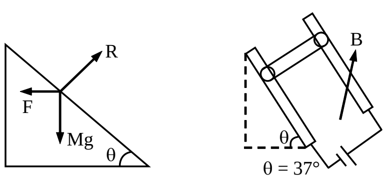
$\dfrac{24 \times 10^3}{10^{12}} = \dfrac{m}{q}$

$R = \dfrac{24 \times 10^3 \times 10^6}{10^{12} \times 0.2}$

$R = 12 \times 10^{-2}\ \text{m}$

$R = 12\ \text{cm}$

Q.5 [3]



$F\cos\theta = Mg\sin\theta$

$BIL\cos\theta = Mg\sin\theta$

$B = \dfrac{Mg}{IL}\tan\theta$

$= 0.3$ Tesla

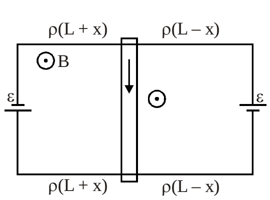
Q.6 [0001]

If rod is in middle, i = 0 $\Rightarrow$ F = 0

$$\text{Eq. emf} = \dfrac{\dfrac{\varepsilon}{2\rho(L-x)} - \dfrac{\varepsilon}{3\rho(L+x)}}{\dfrac{1}{2\rho(L-x)} + \dfrac{1}{2\rho(L+x)}} = \dfrac{\varepsilon\left[\dfrac{2x}{\ell^2 - x^2}\right]}{\dfrac{2\ell}{L^2 - x^2}}$$

$$\Rightarrow \quad \dfrac{\varepsilon x}{L}$$

$$\dfrac{1}{R_{eq.}} = \dfrac{1}{2\rho(L-x)} + \dfrac{1}{2\rho(L+x)} = \dfrac{1}{2\rho} \times \dfrac{2L}{L^2 - x^2}$$



$$\Rightarrow \quad R_{eq.} = \dfrac{\rho(L^2 - x^2)}{L}$$

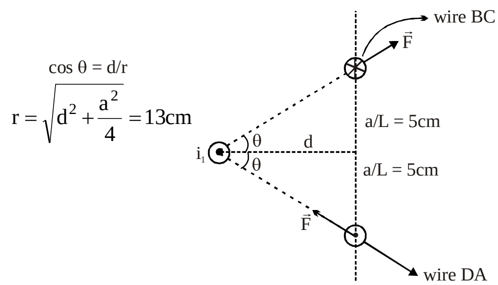
$$i = \dfrac{\dfrac{\varepsilon x}{L}}{\dfrac{\rho(L^2 - x^2)}{L} + R} = \dfrac{\varepsilon x}{\rho(L^2 - x^2) + RL}$$

$$ma = F = -i\ell B = \dfrac{-\varepsilon x \ell B}{\rho(L^2 - x^2) + RL} \approx \dfrac{-\varepsilon \ell B}{\rho L^2 + RL} x$$

$$a = \dfrac{-\varepsilon \ell B}{m(\rho L^2 + RL)} x$$

$$\Rightarrow T = 2\pi\sqrt{\dfrac{m(\rho L^2 + RL)}{\varepsilon \ell B}} \Rightarrow T = 1 \text{ sec.}$$

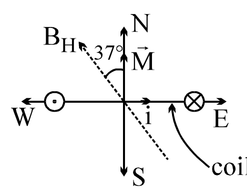
Q.7 [0720]



$$\text{Torque} = \left(\dfrac{\mu_0 i_1 i_2}{2\pi r} a \cos\theta\right) a$$

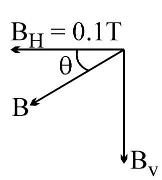
Q.8 [0005]

$B_v = B_H \tan\theta = 0.1 \times (4/5) = (4/50)T$



Top view of coil

$B_{HN} = 0.1 \cos 37° = (4/50)T$

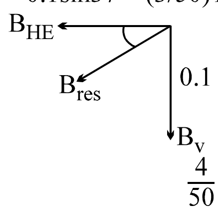


$B_{HE} = 0.1 \sin 37° = (3/50)T$

τ on the coil due to component of B in N direction = 0

$|\vec{\tau}| = |\vec{M} \times \vec{B}| = 1 \times 2^2 \times 0.1 = 0.4\ \text{Nm}$

$0.1\sin 37 = (3/50)T$

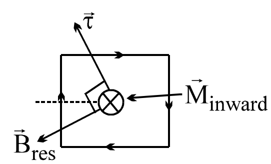


$$B_{res} = \sqrt{\left(\frac{3}{50}\right)^2 + \left(\frac{4}{50}\right)^2} = \frac{5}{50} = 0.1 \text{ T}$$

$\vec{\tau}$ has direction as shown

In its plane, I can be found by $\perp$ axis theorem

$$\left(3\times\frac{2^2}{12} + 3\times 1^2\right)\times 4 = I_1 = 2I$$

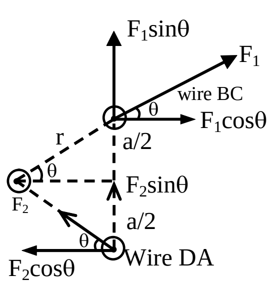


Front view (looking from south towards north)

$I = 8 \text{ kg m}^2$

$$\alpha = \frac{\tau}{I} = \frac{0.4}{8} = 0.05 \text{ rad/s}^2$$

Q.9 [6]



Total force = $(F_1 + F_2)\sin\theta$

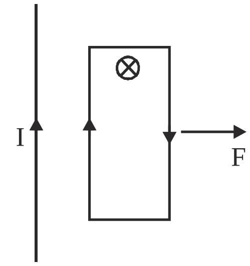
$$F_1 = F_2 = \frac{\mu_0 i_1 i_2}{2\pi r}\frac{a}{2r} = \frac{\mu_0 i_1 i_2 a}{4\pi r^2}$$

$= 6 \times 10^{-4}$ Newton

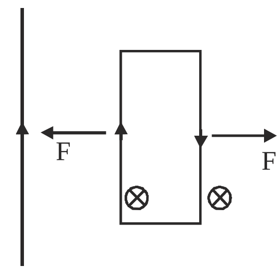
KVPY PREVIOUS YEAR'S

Q.1 (B)

Flux is inward and it si decreasing as loop is going away from wire

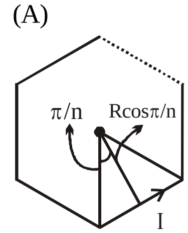


$\therefore$ direction of induce current is clockwise



Force on left side is in left and force n right side is in right.

Q.2 (A)



$B_{net} = n \times B_1$

$$= n.\frac{\mu_0}{4\pi}.\frac{I}{R\cos\frac{\pi}{n}}2\sin\frac{\pi}{n}$$

Q.3 (D)

$$q\vec{E} + q\left(\vec{V}\times\vec{B}\right) = 0$$

Hence, into the paper

Q.4 (B)

$\because$ work done = 0

Hence kinetic energy = constant.

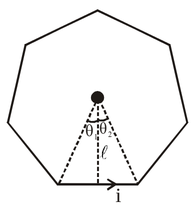
Q.5 (B)

$$\text{B due to Arc} = \frac{\mu_0 i\theta}{4\pi r}$$

$\frac{\mu_0 i}{8}\left[\frac{1}{r}-\frac{1}{R}\right]$ out of the page

Q.6 (A)

Q.7 (A)



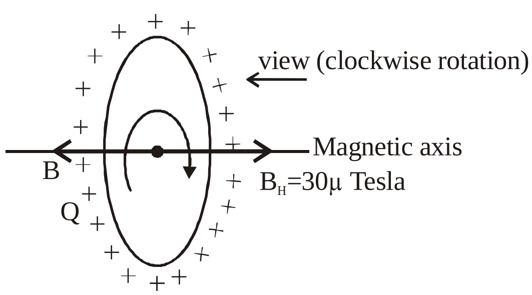
n sides, n wires

$\theta_1 = \theta_2 = \frac{\pi}{n}$

B_{net} at centre = n × B due to one side

$B_{net} = \frac{n \times \mu_0 I}{4\pi\ell}\left[\sin\theta_1 + \sin\theta_2\right] \Rightarrow \frac{n\mu_0 I}{2\pi\ell}\sin\frac{\pi}{n}$

Q.8 (A)



$B = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{Q\omega}{R}\right)$

$B = B_H$ (at centre effective magnetic field become zero)

$\frac{\mu_0 Q\omega}{4\pi R} = B_H$

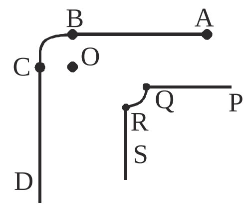
$\omega = \frac{B_H(4\pi R)}{\mu_0 Q}$ ($B_H = 30 \times 10^{-6}$ T; R = 1 mm; $Q = 3 \times 10^{-12}$ C)

$\omega = 10^{11}$ rad/s

Q.9 (C)

In setup B, A metal is placed, due to which metal may get magnetized and it may also exert force on current carrying wire but force between two wire remain same however net force on wire may get charge due to magnetic field produced by magnetized metal.

Q.10 (D)



$(\vec{B})_0 = (\vec{B})_{wire\ AB} + (\vec{B})$BC Arc

$+\vec{B}_{CD\ wire} + (\vec{B})_{PQ\ wire}$

$+\vec{B}_{QR(Arc)} + \vec{B}_{Rs\ wire}$

$B_{PQ} = B_{RS} = 0$

$\vec{B}_{BC} = -\vec{B}_{QR}$

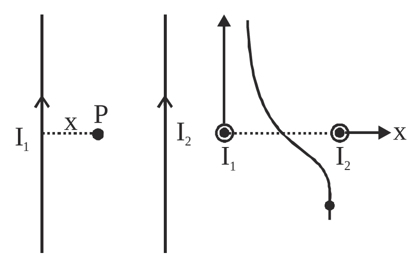
$(\vec{B})_{wireAB} = \vec{B}_{CD}$

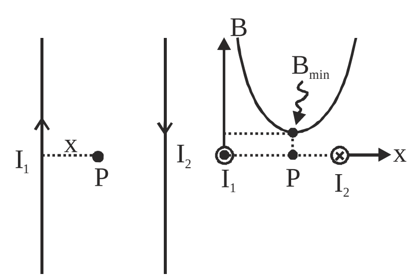
$\vec{B}net = (B)_{wire\ AB} + (B)_{wire\ CD}$

$\Rightarrow \frac{\mu_0 I}{4\pi r} + \frac{\mu_0 I}{4\pi r}$

$\vec{B}_{net} = \frac{\mu_0 I}{2\pi r}$

Q.11 (A)





$B_p = \frac{\mu_0 I_1}{2\pi x} + \frac{\mu_0 I_2}{2\pi(4-x)}$

$\frac{dB_p}{dx} = 0$ for minima of B_p

$$\Rightarrow \frac{\pi_0 I_1}{2\pi}\left[\frac{-1}{x^2}\right]+\frac{\mu_0 I_2}{2\pi}\frac{1}{(4-x)^2}=0$$

$$\frac{I_1}{x^2}=\frac{I_2}{(4-x)^2}$$

$$\frac{I_1}{x^2}=\left(\frac{x}{4-x}\right)^2$$

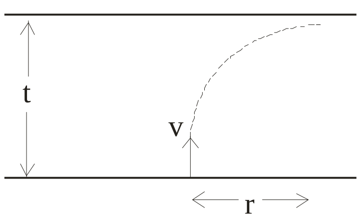
$$\frac{I_1}{x^2}=\left(\frac{1}{4-1}\right)^2$$

$$\frac{I_2}{I_1}=\frac{9}{1}$$

Q.12 (C)

A ⇒If stream lines intersect then there will be two direction of fluid flow at a point, which is absurd.
B ⇒ Lines of forces in electrostatic never intersect
D ⇒ Line of force in magnetism never intersect each other.

Q.13 (B)



IOns will hit if $r > w$
$w = q\Delta V$

$$\frac{1}{2}mv^2 = qV$$

$$v=\sqrt{\frac{2qV}{m}}$$

$$\frac{mv^2}{r}=qvB$$

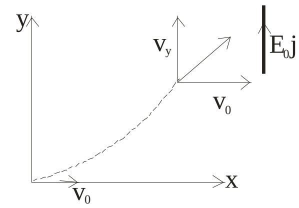
$$\Rightarrow r=\frac{mv}{qB}=\frac{m}{qB}\sqrt{\frac{2qV}{m}}$$

$$r=\frac{1}{B}\sqrt{\frac{2mV}{q}}$$

$$\frac{1}{B}\sqrt{\frac{2mV}{q}}>w$$

$$\frac{2mV}{q}>w^2B^2 \quad \Rightarrow q<\frac{2mV}{w^2B^2}$$

Q.14 (B)



$$\lambda=\frac{h}{mv}\Rightarrow \lambda \propto \frac{1}{v}$$

$$v=\sqrt{v_y^2+v_0^2}$$

$$v_y = u_y + a_y t$$

$$v_y = 0 + \frac{qE_0}{m}t$$

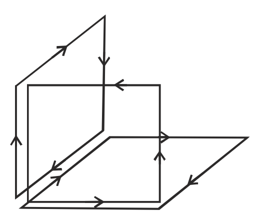
$$(3v_0)=\sqrt{v_y^2+v_0^2}$$

$$\Rightarrow v_y^2=8v_0^2$$

$$\Rightarrow \frac{qE_0}{m}t=2\sqrt{2}v_0$$

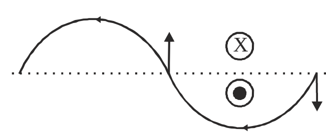
$$t=\frac{2\sqrt{2}m}{qE_0}v_0 \Rightarrow t\propto\frac{1}{E_0}$$

Q.15 (C)



$$B_{net}=\sqrt{3}B$$

Q.16 (D)



Q.17 (C)

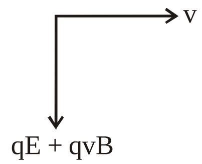
$$F=M\frac{\partial B}{\partial r}=\frac{mv^2}{r}$$

$$\Delta B=\frac{mv^2}{Mr}\Delta r$$

$$=\frac{1.67\times10^{-27}\times54^2\times0.01}{9.67\times10^{-27}\times1}=5.03T$$

Q.18 (C)

For charged particles



net force is in downward direction, so they won.t be able to go through the hole P.

And uncharged particle don.t deviate so they will be able to go through hole P.

JEE-MAIN
PREVIOUS YEAR'S

Q.1 (1)

$F = qVB = \frac{qPB}{m}$ $\qquad V = \frac{P}{m}$

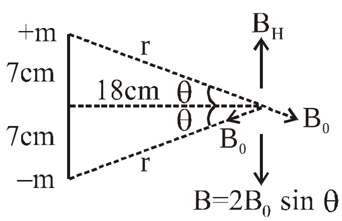
$F_1 = \frac{qPB}{m}$ $\qquad V_1 = \frac{P}{m}$

$F_2 = \frac{qPB}{2m}$ $\qquad V_2 = \frac{P}{2m}$

$F_3 = \frac{2qPB}{4m} = \frac{qPB}{2m}$ $\qquad V_3 = \frac{P}{4m}$

$F_1 : F_2 : F_3 = 2:1:1$ $\qquad V_1 : V_2 : V_3 = 4:2:1$

Q.2 (3)



i.e. $\frac{2\mu_0}{4\Sigma}\frac{m}{r^2}\times\frac{7}{r} = 0.4\times 10^{-4}$

$\Rightarrow 2\times 10^{-7}\times \frac{m\times 7}{\ ^2 + \ ^{2\ 3/2}} \times 10^4$

$= 0.4 \times 10^{-4}$

$m = \frac{4\times 10^{-2}\times(373)^{3/2}}{14}$

$M = m \times 14\text{ cm} = m\times\frac{14}{100}$

$\frac{0.04\times(373)^{3/2}}{14}\times\frac{14}{100}$

$= 4 \times 10^{-4} \times 7203.82 = 2.88$ J/T

Q.3 (3)

Since force on a point charge by magnetic field is always perpendicular to $\vec{v}\left[\vec{F} = q\vec{V}\times\vec{B}\right]$

$\therefore$ Work by magnetic force on the point charge is zero.

Q.4 (1)

$B = \mu nI = \mu_0\mu_r nI$

$B = 4\pi \times 10^{-7} \times 500 \times 1000 \times 5$

$B = \pi$ Tesla

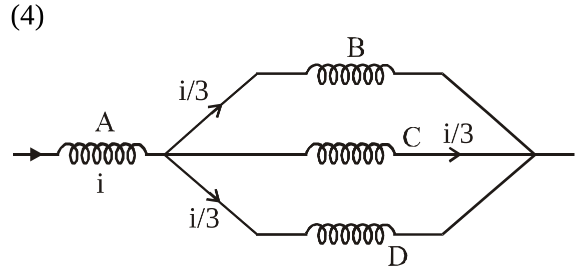
Q.5 (2)

(2) $B = 2 \times B_{\text{st.wire}} + B_{\text{loop}}$

$B = 2\times\frac{\mu_0 i}{4\pi r} + \frac{\mu_0 i}{2r}\left(\frac{\pi}{2\pi}\right)$

$B = \frac{\mu_0 i}{4\pi r}(2+\pi)$

Q.6 (4)



$\phi \propto i$

$\Rightarrow B \propto i$

so, field at centre of C $= \frac{3}{3} = 1$T

Q.7 (4)

$r = \frac{mv}{qB}\ \ \frac{p}{qB}$ $\qquad \frac{m_\alpha}{m_p} = 4$

$\frac{r_p}{r_\alpha} = \frac{p_p}{q_p}\frac{q_\alpha}{p_\alpha} = \frac{2}{1}$

$\frac{p_p}{p_\alpha} = \frac{2q_p}{q_\alpha} = 2\left(\frac{1}{2}\right)$

$\frac{p_p}{p_\alpha} = 1$

$\frac{K_p}{K_\alpha} = \frac{p_p^2}{p_\alpha^p}\frac{m_\alpha}{m_p}$ = (1) (4)

Q.8 (2)

Q.9 (4)

Q.10 (1)

Q.11 [80]

Q.12 (2)

Q.13 (3)

Q.14 (1)
Conceptual question
Option (1)

Q.15 (1)

Q.16 [3]

Q.17 [543]

Q.18 (4)

Q.19 (1)

Q.20 [250]

Q.21 (1)
$\vec{B}$ must not be parallel to the plane of coil for non zero flux and according to lenz law if B is outward it should be decreasing for anticlockwise induced current.

Q.22 (3)

$$\vec{F} = q(\vec{V}\times\vec{B})$$

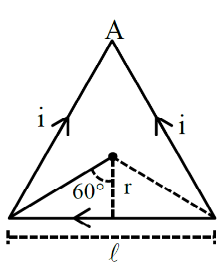
$$\vec{F}_1 = 4\pi\left[0.5c\hat{i}\times B_0\left(\frac{\hat{i}+\hat{j}}{2}\right)\cos\left(K.\frac{\pi}{K}-0\right)\right]$$

$$F_2 = \vec{F}_2 = 2\pi\left[0.5c\hat{i}\times B_0\left(\frac{\hat{i}+\hat{j}}{2}\right)\cos\left(K.\frac{3\pi}{K}-0\right)\right]$$

$\cos\pi = -1, \cos 3\pi = -1$

$$\therefore \frac{F_1}{F_2} = 2$$

Q.23 (4)



$$B = 3\left[\frac{\mu_0 i}{4\pi\rho}(\sin 60^o + \sin 60^o)\right]$$

$$\tan 60^o = \frac{\ell/2}{r}$$

$$\text{Where } r = \frac{9\times10^{-2}}{2\sqrt{3}}M$$

$\therefore B = 3\times10^{-5}$ T

Current is flowing in clockwise direction so, $\vec{B}$ is inside plane of triangle by right handd rule.

Q.24 (1)

Q.25 (2)

Q.26 (4)

$$B_{axis} = \frac{\mu_0 iR^2}{2(R^2+x^2)^{3/2}}$$

$$B_{centre} = \frac{\mu_0 i}{2R}$$

$$\therefore B_{centre} = \frac{\mu_0 i}{2a}$$

$$\therefore B_{axis} = \frac{\mu_0 ia^2}{2(a^2+r^2)^{3/2}}$$

$\therefore$ fractional change in magnetic field =

$$= \frac{\frac{\mu_0 i}{2a} - \frac{\mu_0 ia^2}{2(a^2+r^2)^{3/2}}}{\frac{\mu_0 i}{2a}} = 1 - \frac{1}{\left[1+\left(\frac{r^2}{a^2}\right)\right]^{3/2}}$$

$$\approx 1 - \left[1 - \frac{3}{2}\frac{r^2}{a^2}\right] = \frac{3}{2}\frac{r^2}{a^2}$$

$$\text{Note : } \left(1+\frac{r^2}{a^2}\right)^{-3/2} \approx \left(1 - \frac{3}{2}\frac{r^2}{a^2}\right)$$

[True only if r << a]
Hence option (4) is the most suitable option

Q.27 (1)

$$B_{\text{due to wire (1)}} = \frac{\mu_0 I}{4\pi xy}[\sin 90 + \sin\theta_1]$$

$$\frac{\mu_0 I}{4\pi xy}\left[1 + \frac{x}{\sqrt{x^2+y^2}}\right] .....(1)$$

$$B_{\text{due to wire (2)}} = \frac{\mu_0}{4\pi}\frac{I}{x}\left[1+\frac{y}{\sqrt{x^2+y^2}}\right] .....(2)$$

Total magnetic field

$B = B_1 + B_2$

$$B = \frac{\mu_0 I}{4\pi}\left[\frac{1}{y}+\frac{x}{y\sqrt{x^2+y^2}}+\frac{1}{x}+\frac{y}{x\sqrt{x^2+y^2}}\right]$$

$$B = \frac{\mu_0 I}{4\pi}\left[\frac{x+y}{xy}+\frac{x^2+y^2}{xy\sqrt{x^2+y^2}}\right]$$

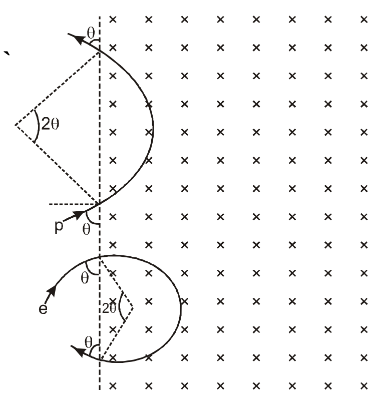
$$B = \frac{\mu_0 I}{4\pi}\left[\frac{x+y}{xy}+\frac{\sqrt{x^2+y^2}}{xy}\right]$$

$$B = \frac{\mu_0 I}{4\pi xy}\left[\sqrt{x^2+y^2}+(x+y)\right]$$

Option (1)

JEE-ADVANCED
PREVIOUS YEAR'S

Q.1 (B, D)



$$t_p = \frac{2\theta \times R_P}{v} = \frac{2\theta \times m_p v}{eBv} = \frac{2\theta m_p}{eB}$$

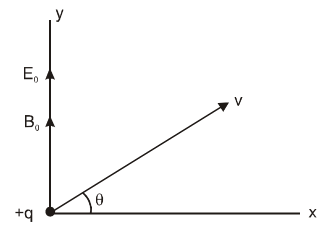
$$t_e = \frac{(2\pi - 2\theta)\times R_e}{v}$$

$$= \frac{(2\pi-2\theta)m_e v}{eBv} = \frac{(2\pi-2\theta)m_e}{eB} \because t_e \neq t_p$$

Q.2 (A)

$$B = \int \frac{\mu_0 dNi}{2x} = \int \frac{\mu_0\left(\frac{N}{b-a}dx\right)i}{2x} = \frac{\mu_0 Ni}{2(b-a)}\ell n\frac{b}{a}$$

Q.3 (C, D)



If θ = 0° then due to magnetic force path is circular but due to force qE_0 (↑) q will have accelerated motion along y–axis. So combined path of q will be a helical path with variable pitch so (A) and (B) are wrong.

If θ = 10° then due to vcosθ, path is circular and due to qE_0 and vsinθ, q has accelerated motion along y-axis so combined path is a helical path with variable pitch (C) is correct.

If θ = 90° then $F_B = 0$ and due to qE_0 motion is accelerated along y-axis. (D)

Q.4 (5)

$$B_1 = \frac{\mu_o J a}{2} - \frac{\mu_o J a}{12}$$

$$= \left(\frac{\mu_o J a}{2}\right)\left(1-\frac{1}{6}\right) = \frac{5}{6}\left(\frac{\mu_o J a}{2}\right) = \frac{5\mu_0 aJ}{12} = \frac{N}{12}\mu_0 aJ$$

N = 5

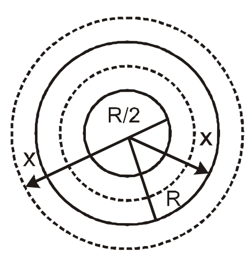
Q.5 (B)

$$\text{Area} = a^2 + 4\times\frac{\pi\left(\frac{a}{2}\right)^2}{2} = a^2 + \frac{\pi a^2}{2}$$

$$A = \left(1+\frac{\pi}{2}\right) a^2 \,\hat{k}$$

Q.6 (D)

Case-I $x < \frac{R}{2}$



|B| = 0

Case-II $\frac{R}{2} \le x < R$

$\int \vec{B}.d\vec{\ell} = \mu_0 I$

$|B|\,2\pi x = \mu_0 \left[\pi x^2 - \pi\left(\frac{R}{2}\right)^2\right] J$

$|B| = \frac{\mu_0 J}{2x}\left(x^2 - \frac{R^2}{4}\right)$

Case-III $x \geq R$

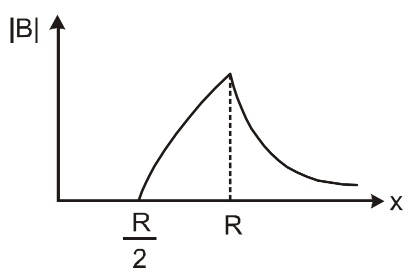
$\int \vec{B}.\,d\vec{\ell} = \mu_0 I$

$|B|\;2\pi x = \mu_0 \left[\pi R^2 - \pi\left(\frac{R}{2}\right)^2\right] J$

$|B| = \frac{\mu_0 J}{2x}\,\frac{3}{2}\,R^2$

$|B| = \frac{3\mu_0 J R^2}{8x}$

so



Q.7 (A,C)
Component of final velocity of particle is in positive y direction.
Centre of circle is present on positive y axis. so magnetic field is present in negative z-direction
Angle of deviation is 30° because

$\tan\theta = \frac{v_y}{v_x} = \frac{1}{\sqrt{3}}$

$\theta = \frac{\pi}{6}$

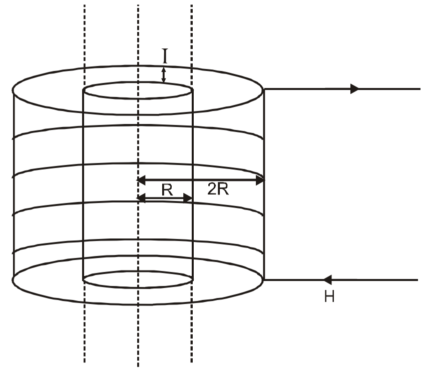
$\omega t = \theta$

$\theta = \frac{QB}{M}t$

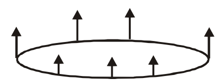
$B = \frac{M\theta}{Qt}$

$B = \left(\frac{50M\pi}{3Q}\right)$

Q.8 (A, D)



(A) For $0 < r < R \Rightarrow B \neq 0$

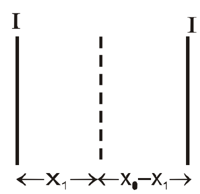


(D) For $r > 2R \Rightarrow B \neq 0$

Q.9 (3)

$B_2 = \frac{\mu_0 I}{2\pi x_1} + \frac{\mu_0 I}{2\pi(x - x_1)}$ (opposite)

$B_1 = \frac{\mu_0 I}{2\pi x_1} - \frac{\mu_0 I}{2\pi(x - x_1)}$ (same)



Case - 1 When current is in the same direction

$B = B_1 = \frac{3\mu_0 I}{2\pi x_0} - \frac{3\mu_0 I}{4\pi x_0} = \frac{3\mu_0 I}{4\pi x_0}$

$R_1 = \frac{mv}{qB_1}$

Case-2 When current is in oposite direction

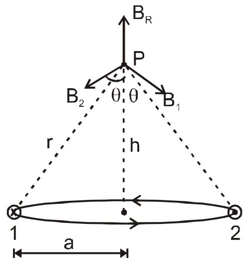
$B = B_2 = \frac{9\mu_0 I}{4\pi x_0}$

$R_2 = \frac{mv}{qB_2}$

$\frac{R_1}{R_2} = \frac{B_2}{B_1} = \frac{9}{3} = 3$

Q.10 (C)

$\vec{B}_R = \vec{B}$ due to ring



$\vec{B}_1 = \vec{B}$ due to wire - 1

$\vec{B}_2 = \vec{B}$ due to wire -2

In magnitudes $B_1 = B_2 = \frac{\mu_0 I}{2\pi r}$

Resultant of B_1 and $B_2 = 2B_1 \cos\theta = \frac{\mu_0 Ia}{\pi r^2}$

$B_R = \frac{2\mu_0 I\pi a^2}{4\pi r^3}$

For zero magnetic field at P

$$\frac{\mu_0 Ia}{\pi r^2} = \frac{2\mu_0 I\pi a^2}{4\pi r^3}$$

$\Rightarrow h \approx 1.2a$

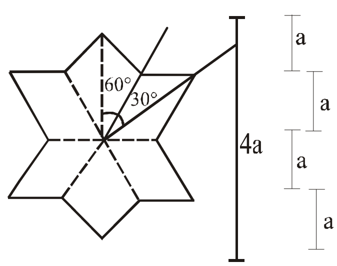
Q.11 (B)

Magnetic field at mid point of two wires = $\frac{\mu_0 I}{\pi d} \otimes$

Magnetic moment of loop = $I\pi a^2$

Torque on loop = M B sin 150° = $\frac{\mu_0 I^2 a^2}{2d}$

Q.12 (A)



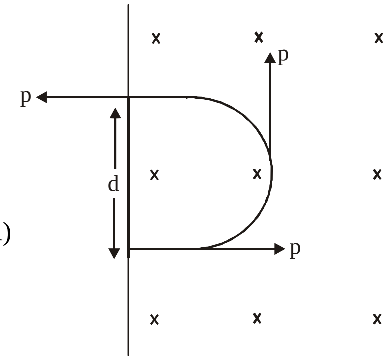
Total Mgnetic Field
at centre = 12 times magnetic field due to one wire

$$B = \frac{12\mu_0 I}{4\pi a}[\sin 60° - \sin 30°] = \frac{\mu_0 I}{4\pi a} \times 12\left[\frac{\sqrt{3}}{2} - \frac{1}{2}\right]$$

$$\Rightarrow B = \frac{\mu_0 I}{4\pi a} \times 6\left(\sqrt{3} - 1\right)$$

Q.13 (C,D)

(A)



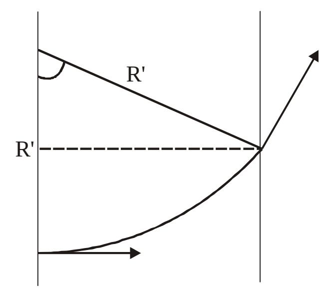
$|\Delta\vec{p}| = \sqrt{2}p$

(B) $R' = \frac{mv}{QB}$

$d = 2R' = \frac{2mv}{QB}$ $\quad d \propto m$

(C) $R'(1 - \cos\theta) = R$

$R'\sin\theta = \frac{3R}{2}$

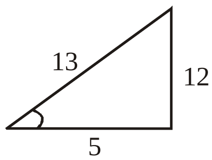


$$\frac{\sin\theta}{1 - \cos\theta} = \frac{3}{2}$$

$$\frac{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}}{2\sin^2\frac{\theta}{2}} = \frac{3}{2}$$

$$\cot\frac{\theta}{2} = \frac{3}{2} \Rightarrow \tan\frac{\theta}{2} = \frac{2}{3}$$

$$\Rightarrow \tan\theta = \frac{2\left(\frac{2}{3}\right)}{1 - \frac{4}{9}} = \frac{\frac{4}{3}}{\frac{5}{9}} = \frac{4}{3} \times \frac{9}{5} = \frac{12}{5}$$



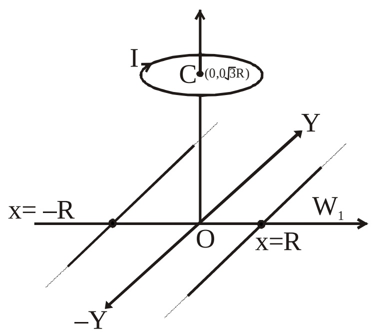
$\sin\theta = \frac{12}{13}$

$$R'\left(\frac{12}{13}\right) = \frac{3R}{2}; R' = \frac{13R}{8} = \frac{P}{QB}; B = \frac{8P}{13QR}$$

(D) $\frac{P}{QB} < \frac{3R}{2}$

$$B > \frac{2P}{3QR}$$

Q.14 (A, B, D)

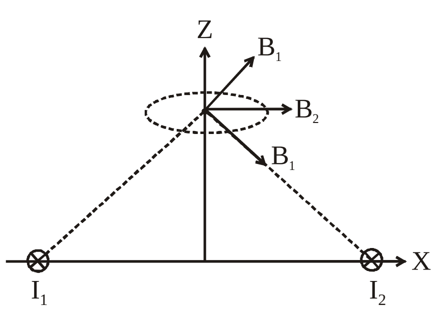


(A) at origin, $\vec{B} = 0$ due to two wires if $I_1 = I_2$, hence $(\vec{B}_{net})$ at origin is equal to $\vec{B}$ due to ring, which is non-zero.

(B) If $I_1 > 0$ and $I_2 < 0$, $\vec{B}$ at origin due to wires will be along $+\hat{k}$ direction and $\vec{B}$ due to ring is along $-\hat{k}$ direction and hence $\vec{B}$ can be zero at origin.

(C) If $I_1 < 0$ and $I_2 > 0$, $\vec{B}$ at origin due to wires will is along $-\hat{k}$ and also along $-\hat{k}$ due to ring, hence $\vec{B}$ cannot be zero.

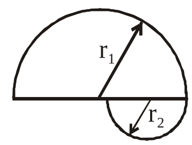
(D)



At centre of ring, $\vec{B}$ due two wires is along x-axis, hence z-component is only because of ring which $\vec{B} = \frac{\mu_0 i}{2R}(-\hat{k})$.

Q.15 [2.00]

(1) Average speed along x-axis



$$(v_x) = \frac{\int |\vec{v}_x| dt}{\int dt} = \frac{d_1 + d_2}{t_1 + t_2}$$

(2) we have

$r_1 = \frac{mv}{qB_1}$, $r_2 = \frac{mv}{qB_2}$

Since, $B_1 = \frac{B_2}{4}$

$\therefore r_1 = 4r_2$

Time in $B_1 \Rightarrow \frac{\pi m}{qB_1} = t_1$

Time in $B_2 \Rightarrow \frac{\pi m}{qB_2} = t_2$

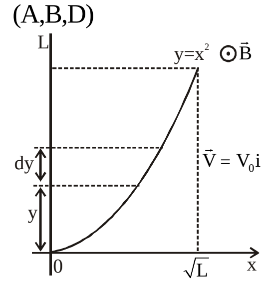
Total distance along x-axis

$d_1 + d_2 = 2r_1 + 2r_2 = 2(r_1 + r_2) = 2(5r_2)$

Total time $T = t_1 + t_2 = 5t_2$

Average speed $= \frac{10r_2}{5t_2} = 2\frac{mv}{qB_2} \times \frac{qB_2}{\pi m} = 2$

Q.16 (A,B,D)



$y = x^2$

$$B = B_0\left[1 + \left(\frac{y}{L}\right)^{\beta}\right]\hat{k}$$

$$\int d\phi = \int_0^L V_0 B_0 \left(1 + \frac{y^{\beta}}{L^{\beta}}\right).dy$$

$$\Delta\phi = V_0 B_0 \left[L + \frac{L^{\beta+1}}{(\beta+1)L^{\beta}}\right]$$

$$\Delta \phi = B_0 V_0 \left(L + \frac{L}{\beta + 1} \right)$$

$$\because |\Delta \phi| = V_0 B_0 \left(1 + \frac{1}{\beta + 1} \right) . L$$

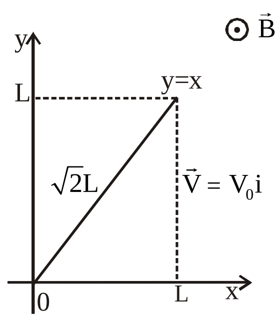
$|\Delta \phi| \propto L$ $\therefore$ option '2' is also correct
If $\beta = 0$
$\Delta\phi = V_0 B_0 [L + L]$
$\Delta\phi = 2V_0 B_0 L \Rightarrow$ option (3) is incorrect
If $\beta = 2$

$$\Delta\phi = V_0 B_0 \left[L + \frac{L}{3} \right]$$

$\Delta\phi = \frac{4}{3} V_0 B_0 L$ option (4) is correct

$\Delta\phi$ = will be same if the wire is repaleced by the straight wire of length $\sqrt{2}L$ and y = x

$\because$ range of y remains same



$\therefore$ option 1 is correct.

Q.17 [4]

Q.18 (AB)

Q.19 (A)

Q.20 (C)

Electromagnetic Induction

EXERCISES

ELEMENTRY

Q.1 (3)

Because induced e.m.f. is given by $E = -N\dfrac{d\phi}{dt}$

Q.2 (1)

$$e = -\frac{d\phi}{dt} = \frac{-3B_0A_0}{t}$$

Q.3 (1)

$\phi = BA = 10$ weber

Q.4 (4)

$$|e| = N\left(\frac{\Delta B}{\Delta t}\right).A\cos\theta = 500\times 1\times(10\times 10^{-2})^2\cos\theta = 5V$$

Q.5 (3)

The induced current will be in such a direction so that it opposes the change due to which it is produced.

Q.6 (2)

$$\phi = \mu_0 niA = 4\pi\times 10^{-7}\times\frac{3000}{1.5}\times 2\times\pi(2\times 10^{-2})^2$$

$= 9.31\times 10^{-6}$ Wb

Q.7 (4)

$$q = -\frac{N}{R}(B_2 - B_1)A\cos\theta$$

$$32\times 10^{-6} = -\frac{100}{(160+40)}(0-B)\times\pi\times(6\times 10^{-3})^2\times\cos 0°$$

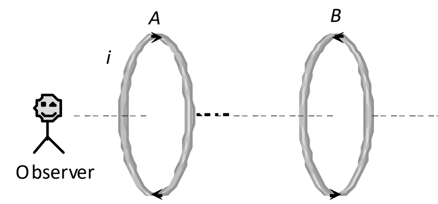
$\Rightarrow B = 0.565T$

Q.8 (4)

$$e = -\frac{d\phi}{dt} = -(10t-4) \Rightarrow (e)_{t=2} = -(10\times 0.2 - 4) = 2\text{ volt}$$

Q.9 (4)

If current through A increases, crosses (X) linked with coil B increases, hence anticlockwise current induces in coil B. As shown in figure both the current produces repulsive effect.



Q.10 (1)

$\phi = BA$

$\Rightarrow$ Change in flux $d\phi = B.dA = 0.05\,(101-100)\,10^{-4}$

$= 5.10^{-6}$ Wb

Now, charge $dQ = \dfrac{d\phi}{dt} = \dfrac{5\times 10^{-6}}{2} = 2.5\times 10^{-6}$ C

Q.11 (3)

Rate of decay of current between t = 5 ms to 6 ms = $\dfrac{dI}{dt}$

= – (Slope of the line BC)

$= -\left(\dfrac{5}{1\times 10^{-3}}\right) = -5\times 10^3$ A/s. Hence induced emf e =

$$-L\frac{di}{dt} = -4.6\times(5\times 10^3) = 23\times 10^3\ V$$

Q.12 (4)

(d) Conductor cuts the flux only when, if it moves in the direction of M.

Q13 (2)

If player is running with rod in vertical position towards east, then rod cuts the magnetic field of earth perpendicularly (magnetic field of earth is south to north).

Hence Maximum emf induced is

$$e = Bvl = 4\times 10^{-5}\times\frac{30\times 1000}{3600}\times 3 = 1\times 10^{-3}\text{volt}$$

When he is running with rod in horizontal position, no field is cut by the rod, so $e = 0$.

Q.14 (4)
Perpendicular length is more so induced emf is more]

Q.15 (3)

Q.16 (3)

Self inductance $L = \mu_0 N^2 A/l = \mu_0 n^2 lA$

Where *n* is the number of turns per unit length and *N* is the total number of turns and N = n*l*

In the given question n is same. A is increased 4 times and l is increased 2 times and hence L will be increased 8 times.

Q.17 (4)

$$e = M\frac{di}{dt} = 1.25 \times 80 = 100 \text{ V}$$

Q.18 (4)

$$e = M\frac{di}{dt} = 0.09 \times \frac{20}{0.006} = 300 \text{ V}$$

Q.19 (1)

Q.20 (4)

As we know $e = -\frac{d\phi}{dt} = -L\frac{di}{dt}$

Work done against back e.m.f. e in time dt and current i is

$$dW = -eidt = L\frac{di}{dt}idt = Li\, di \quad \Rightarrow$$

$$W = L\int_0^i i\, di = \frac{1}{2}Li^2$$

Q21 (3)

Q.22 (3)

$L = \mu_0 N^2 A/l$

Q.23 (1)

$$U = \frac{1}{2}Li^2 = \frac{1}{2}\times(50\times10^{-3})\times(4)^2 = 400\times10^{-3} = 0.4\text{J}$$

Q.24 (2)

Q.25 (4)

Time constant $= \frac{L}{R} = \frac{40}{8} = 5$ sec.

Q.26 (4)

Q.27 (3)

$$\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times3.14\sqrt{5\times10^{-4}\times20\times10^{-6}}}$$

$$\nu_0 = \frac{10^4}{6.28} = 1592 \text{ Hz}$$

Q.28 (1)

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{200}{100} = \frac{V_s}{120} \Rightarrow V_s = 240 \text{ V}$$

Also $\frac{V_s}{V_p} = \frac{i_p}{i_s} \Rightarrow \frac{240}{120} = \frac{10}{i_s} \Rightarrow i_s = 5\text{A}$

Q.29 (1)

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = k \Rightarrow \frac{V_s}{30} = \frac{3}{2} \Rightarrow V_s = 45 \text{ V}$$

Q.30 (1)
Transformer works on ac only.

Q.31 (1)

$$U = \frac{1}{2}Li^2 = \frac{1}{2}\times100\times10^{-3}\times(10)^2 = 5\text{J}$$

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (4)
Since $\Delta\phi = 0$ hence EMF induced is zero.

Q.2 (4)
The direction of current in the loop such that it opposes the the change in magnetic flux in it.

Q.3 (3)
The direction of current in the loop such that it opposes the the change in magnetic flux in it.

Q.4 (3)
Since the magnetic flux in the loop is zero hence the current induced in it is zero.

Q.5 (1)
$\phi = BA\cos\theta$

$$10^{-13} = B(0.02)\left(\frac{1}{2}\right)$$

$B = 10^{-1}\,T = 0.1\,T.$

Q.6 (1)

$\phi = NBA$

$= 500\times5\times10^{-3}\times2\times10^{-3}$

$= 50\times10^{2}\times10^{-6}$

$= 5\times10^{-3}$ Wb.

Q.7 (3)

$\phi = B.\pi\,(R_0 + t)^2$

$$E = \frac{d\phi}{dt} = 2B\pi\,(R_0 + t)$$

Q.8 (4)

$$\varepsilon = \frac{d\phi}{dt} = -\left(12t - 5\right)$$

at $t = 0.25$ sec.

$$\varepsilon = -\left[12\left(10.25\right) - 5\right] = 2$$

$$i = \frac{\varepsilon}{R} = \frac{2}{10} = 0.2A$$

Q.9 (4)

$\phi = NBA$

$M = iA$

Q.10 (2)

We know that

$$\phi = \frac{\mu_0 i}{2R}.\pi r^2$$

$$\phi = \frac{\mu_0 e r^2}{4R}.\alpha.t$$

$$E = \frac{d\phi}{dt} = \frac{\mu_0 e r^2}{4R}.\alpha$$

Q.11 (3)

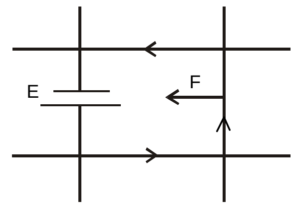
By moving away from solenoid the ring will resist the changing flux in it.

Q.12 (1)

The repulsion is to resist the increasing magnetic flux in coil B.

Q.13 (1)

Q will move towards P to resist the increasing magnetic flux in the loop formed due to rails R,S and conductors P,Q.



Q.14 (1)

The decrease in current in to oppose increasing magnetic flux in the circular loops.

Q.15 (1)

Q.16 (1)

$$\text{Average } \varepsilon\text{mf} = \frac{20\times(.1)^2}{\Delta t} = \frac{.2}{\Delta t} \Rightarrow$$

$$\left(\frac{.2}{\Delta t}\right) = 10$$

$\Delta t = 20$ msec

Q.17 (4)

$$\varepsilon = \frac{d\phi}{dt} = \frac{d}{dt}\left(NBA\right)$$

$$= NA\frac{dB}{dt}$$

$= 100\times10^{-2}\times10^{3}$

$= 10^{3}$ V

Q.18 (1)

$i = i_0 \sin\omega t$

$$B = m_0 ni = 4\pi\times10^{-7}\times\frac{1000}{10^{-2}}\times(1)\sin\omega t = 4\pi\times10^{-2}\sin\omega t$$

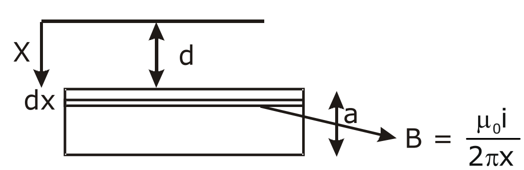
$\phi = NBA = 50\times4\pi\times10^{-2}\sin\omega t\times10^{-4}$

$= 2\pi\times10^{-4}\sin\omega t$

$$\varepsilon = \frac{d\phi}{dt} = 2\pi^2\times10^{-2} = 2\pi\times10^{-4}\,\omega$$

$f = 50$ Hz.

Q.19 (2)



$$\int d\phi = \int_{d}^{a+d}\frac{\mu_0 i}{2\pi x}.b.dx$$

$$\phi = \frac{\mu_0 ib}{2\pi} \ \ell n \left(\frac{d+a}{a}\right)$$

$$\frac{d\phi}{dt} = \frac{\mu_0 bi}{2\pi\tau} \ \ln\left(\frac{d+a}{a}\right)$$

Q.20 (3)

$$q = \frac{\Delta\phi}{R} = \frac{2AB}{R}$$

Q.21 (3)

$$\varepsilon = \frac{d\phi}{dt} = \frac{d}{dt}(NBA)$$

$$= NA\frac{dB}{dt}$$

$$= 100 \times 10^{-2} \times 10^{-3}$$

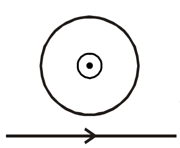
$$= 10^{3} V$$

$\vec{B}$ and $\vec{A}$ are $\perp$ to each other.

Q.22 (4)
When the coil is entering and coming out of the field the magnetic flux in it is changing but when it is within the field the magnetic flux in it is constant.

Q.23 (3)
When the magnetic goes away from the ring the flux in the ring decreases hence the induced current will be such that it opposes the decreasing flux in it hence ring will behave like a magnet having face A as north pole and face B as south pole.

Q.24 (1)
On increasing the current in wire magnetic filled will increase outwards. So in order to decrease field outwards the current induced in loop will be in clockwise direction.

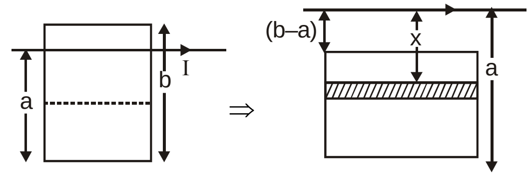


i↑ B↑ i → Clockwise

Q.25 (2)
The direction of induced current is such that it opposes the effect of change in magnetic field.

Q.26 (2)
The direction of induced current is such that it opposes the effect of change in magnetic field.

Q.27 (3)



$$\int d\phi = \int \frac{\mu_0 I}{2\pi x}(bdx)$$

$$\phi = \frac{\mu_0 Ib}{2\pi}\int_{(b-a)}^{a}\frac{dx}{x}$$

$$\phi = \frac{\mu_0 Ib}{2\pi}\ell n\left(\frac{a}{b-a}\right).$$

$$\phi = \frac{\mu_0 Ib}{2\pi}\ell n\left(\frac{a}{b-a}\right).$$

Q.28 (4)
Since magnetic field lines around the wire AB are circular, therefore magnetic flux through the circular loop will be zero, hence induced emf in the loop will be zero.

Q.29 (2)
This is in accordance with Lenz law.

Q.30 (4)
Since the magnitude flux in the ring due to motion of charge particle is zero hence the induced emf will be zero.

Q.31 (1)
electrons will move becuase of internal electric field.

$$\frac{eE}{m} = \frac{F_1 - F_2}{M} \Rightarrow E = \frac{|F_1 - F_2| . m}{Me}$$

Q.32 (4)

If $\vec{\upsilon} \,||\, \vec{\ell}$ or $\vec{\upsilon} \,||\, \vec{B}$ or $\vec{\ell} \,||\, \vec{B}$ then $\frac{d\phi}{dt}$ is zero. Hence potential difference is zero.

Q.33 (2)
When the loop enters the magnetic field the magnetic flux in it changes till it covers a distance 'a'. Hence the EMF induced in the surface after that flux in it remains constant till its back portion has not entered in magnetic field. No emf is induced during this time.when it is out of magnetic field the magnetic flux in it decreases. EMF is again induced in the circuit hence total time for which emf is induced is $\frac{2a}{v}$.

Q.34 (2)

$\varepsilon = \vec{B}.(\vec{V} \times \vec{\ell})$

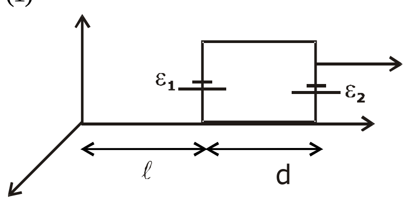
$= (3\hat{i} + 4\hat{j} + 5\hat{k}).[1\hat{i} \times 5\hat{j}]$

$\varepsilon = 25$ volt.

Q.35 (2)

$\varepsilon = \left(\vec{v} \times \vec{B}\right) \cdot \vec{l}$

Q.36 (1)



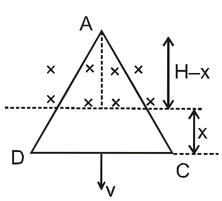
$\varepsilon_1 = v_0 d\, B_0 \left(1 + \frac{l}{a}\right)$, $\varepsilon_2 = v_0 d.\, B_0 \left(1 + \frac{l + d}{a}\right)$

$\varepsilon_2 - \varepsilon_1 = \frac{v_0\ B_0 d}{a} = \frac{v_0\ B_0\ d^2}{a}$

Q.37 (2)

dl vector is same in both the cases.

Q.38 (2)



$\phi = -\frac{1}{2}\ (2)\ \frac{H - I}{\sqrt{3}}\ (H - X)$

$|-d\phi/dt| = \varepsilon = \frac{2(H - x)}{\sqrt{3}}$

$i = \frac{2}{\sqrt{3}R}\ (H\text{–}x)$

Hence answer is (2)

Q.39 (4)

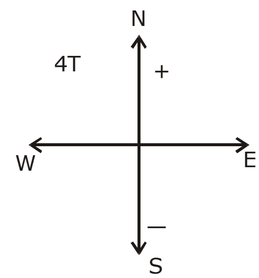
Induced motional emf in MNQ is equivalent to the motional emf in an imaginary wire MQ i.e.,

$e_{MNQ} = e_{MQ} = Bv\ell = Bv\,(2R)$

$[\ell = MQ = 2\,R]$

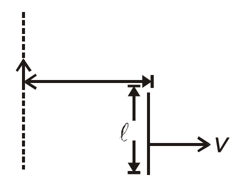
Therefore , potential difference developed across the ring is 2RBv with Q at higher potential.

Q.40 (1)



$vB\ell = 12$ V

Q.41 (2)



$v_A - v_B = vB\ell = \frac{\mu_0 iv\ell}{2\pi r}$

Q.42 (4)

As there is no current,

$F_{net} = 0$

Q.43 (4)

Force acting on the rod because of the induced current due to change in magnetic flux will try to oppose the motion of rod. Hence the acceleration of the rod will decrease with time $\frac{dP}{dt} = F\frac{dv}{dt} =$ F × a. Thus, rate of power delivered by external force will be decreasing continuously.

Q.44 (1)

$W = (L)F$

$= L \times ILB$

$= L \times \frac{L^2 B^2 V}{R} = 1$ J

Q.45 (4)

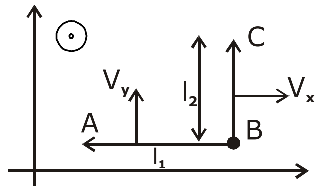
It the magnitude of I_A is very large such that force due to magnetic field on PQ exceeds its weight then it will move upwards otherwise it will move downwards.

Q.46 (2)

W.D. by force = Q

$F.V = Q,\ F = \frac{Q}{V}$

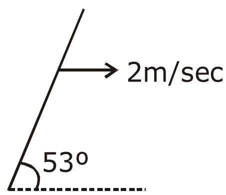
Q.47 (3)



$V_B - V_A = V_y l_1 B$, $V_B - V_C = V_x l_2 B$

Q.48 (1)

$\vec{V} = 2\hat{i}$ $\vec{B} = \left(3\hat{j} + 4\hat{k}\right)$



$\vec{l} = 3\hat{i} + 4\hat{j}$

e.m.f. = $\left(\vec{v} \times \vec{B}\right) . \vec{l}$

Q.49 (4)

$q = CV$

$= CV\,Bl = \text{constant}$

Q.50 (3)

$E = \dfrac{B\omega l^2}{2}$ $\because \ell = \ell_{leffective}$

$\Rightarrow \dfrac{1}{2} B\omega (L^2 + \ell^2)$

Q.51 (4)

$t = \dfrac{\pi/2}{\omega}$

$\therefore$ $Av_{e.m.f} = \dfrac{2BA\omega}{\pi}$

Q.52 (2)

$\phi = BA \sin \omega t$

$E = \dfrac{d\phi}{dt} = BA\omega \cos \omega t$

$i_0 = BA \dfrac{\omega}{R}$

Q.53 (2)

Here effective length is 2R

$\varepsilon = \dfrac{1}{2} B\omega(2R)^2 = 2B\omega R^2$

Q.54 (1)

$\varepsilon = \dfrac{1}{2} B\,\omega R^2$

$= \dfrac{1}{2} \times \left(5 \times 10^{-3}\right)\left(130\right)\left(25 \times 10^{-2}\right)^2$

$= 20 \times 10^{-3}$ V

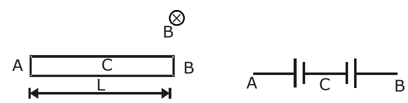
Q.55 (4)

$\varepsilon = \dfrac{1}{2} B\omega R^2$

$3.14 \times 10^{-3} = \dfrac{1}{2} \times 5 \times 10^{-5} \ (1)^2$

f = 20 rev./s

Q.56 (1)



$\therefore$ $V_A - V_C = V_B - V_C$

$V_A - V_B = 0$

Q.57 (1)

$I = \dfrac{\frac{1}{2} B\omega L^2}{R} = \dfrac{\frac{1}{2} \times 0.10 \times 40 \times (5 \times 10^{-2})^2}{1} .= 5\text{ mA}$

Q.58 (1)

The work done in pulling out loop equal to heat generated in t = 2 sec in following circuit.

$E = vb\,\ell = \dfrac{1}{8}$

$\Rightarrow i = \dfrac{E}{R}$

$H = i^2 RT$

$H = 3.125 \times 10^{-3}$ J

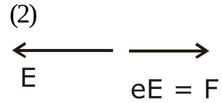
Q.59 (1)

$\phi = BA$

$\left(\vec{v} \times \vec{B}\right) . \dfrac{d\phi}{dt} = e = \dfrac{AdB}{dt} = CA$ (Straight line)

$E_{in} \downarrow$ as r > R

Q.60 (2)



Q.61 (2)

If the circuit Q C P containing rod PQ is completed then the direction of induced current will be from Q to C to P hence Q will be at higher potential than P.

Q.62 (1)

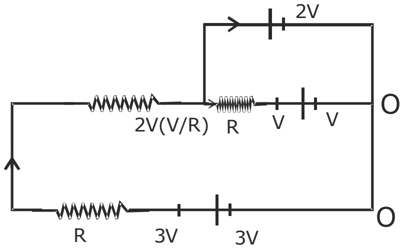
$$a = \frac{qE}{m} = \frac{1}{2}\frac{eR}{m}\frac{dB}{dt} \text{ .(towards lefts)}$$

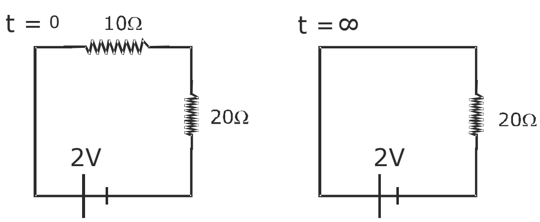
Q.63 (1)

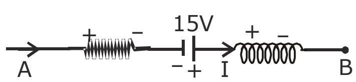
$$L = \frac{\phi}{i}, \quad iL = N\phi, \; iL = NBA \Rightarrow i = \frac{NBA}{L}$$

Q.64 (2)

$$\frac{-V}{R} e^{-Rt/L}$$



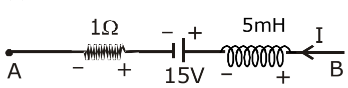




$$V_A - V_B = IR - 15 + L\frac{di}{dt}$$

$$V_A - V_B = -15$$
$$V_B - V_A = 15$$

Q.65 (3)



$$V_B - V_A = \frac{Ldi}{dt} + 15 + IR$$

$$V_B - V_A = 15 \text{ Volt}$$

Q.66 (1)

Q.67 (2)

$$L_1 \frac{di_1}{dt} = L_2 \frac{di_2}{dt}$$

or $L_1 di_1 = L_2 di_2$ or $L_1 i_1 = L_2 i_2$

$$\therefore \frac{i_1}{i_2} = \frac{L_2}{L_1}$$

Q.68 (3)

$$\varepsilon_2 = -M\frac{di,}{dt}$$

$$= -4\frac{(0-5)}{10^{-3}} = 2 \times 10^4 \text{ V.}$$

Q.69 (2)

$L \times N^2$

$$\frac{108}{L'} = \left(\frac{600}{500}\right)^2$$

$$L' = 100 \times \frac{25}{36} = 75 \text{ mH}$$

Q.70 (3)

Self inductance for a solenoid is given as

$$L = \frac{\mu_0 N^2 \pi r^2}{l}$$

Where N is numbers of turns

$$N_1 = \frac{100}{2\pi r}$$

$$L_1 = \frac{\mu_0 \left(\frac{100}{2\pi r}\right)^2 \pi R^2}{l} = L$$

$$L_2 = \frac{\mu_0 \left(\frac{100}{2\pi r}\right)^2 \pi \left(\frac{R}{2}\right)^2}{l}$$

$$\frac{L_1}{L_2} = 1$$

$$L_2 = L$$

Q.71 (2)

Let a currect i flow in coil of radius R.

Magentic field at the center of coil = $\frac{\mu_0 i}{2R}\pi r^2$

or $\quad Mi = \frac{\mu_0 i}{2R}. \pi r^2, \qquad M = \frac{\mu_0}{2R}\pi r^2$

Q.72 (4)

$$\text{EMF} = \left|-M\frac{dI}{dt}\right| \; 25 \times 10^{-3} = M \times 15$$

or $\quad M = \frac{5}{3} \times 10^{-3}$ H

$\phi = MI = \frac{5}{3} \times 10^{-3} \times 3.6 = 6.00$ mWb.

Q.73 (1)

$\phi = M \times I$

$$\frac{\int_d^{d+b} B.ds}{I} = M$$

$$M = \frac{\mu_0 a}{2\pi} \ell n \frac{b+d}{d}$$

Hence $M \propto a$.

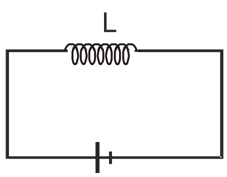
Q.74 (1)

$M_{max} = \sqrt{L_1 L_2} = \sqrt{100 \times 400}$ mH = 200 mH.

Q.75 (4)

As the flux in the ring due to wire will be zero hence mutual inductance will be zero.

Q.76 (4)



$$\frac{Ldi}{dt} = V$$

Ldi = v. dt

Li = vt

$4 \times 5 = 2 \times t$

t = 10 sec.

Q.77 (1)

$i_0 = 2A$; $V_{max.} = 6V$

$$i_{finally} = \frac{V_{max}}{R}$$

$$R = \frac{6}{2} = 3\Omega$$

$$\tau = \frac{L}{R} = 1 \text{ ms}$$

Q.78 (1)

$\because \quad M \le \sqrt{L_1 L_2}$

For M maximum

$M = \sqrt{L_1 L_2}$

Q.79 (4)

Winding the coil on common core increases the flux linked with the coils.

Q.80 (4)

$q = CV \Rightarrow i.t. = CV \Rightarrow v = \frac{i}{C} . t$

Q.81 (4)

at t = 0 the circuit will be open $\Rightarrow$ i = 0

$\Rightarrow \quad U = 0$ But $\frac{Ldi}{dt} \ne 0$

P = 0

Q.82 (1)

Check all the options

Q.83 (1)

An inductor behave as an open circuit initially and a closed circuit at t=∞.

Q.84 (3)

A rapid flux change in L

Q.85 (2)

The induced emf in L oppose the current flow so brighness of the lamp is initially low then increases slowly.

Q.86 (1)

Check all the options

Q.87 (3)

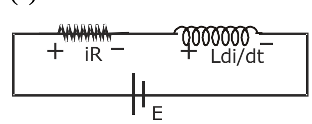
Initially L is open $i_{min} = \frac{10}{10} = 1A$

finally L is short.

$i_{max.} = \frac{10}{5} = 2A$

$i_{max} - i_{min} = 2 - 1 = 1A$

Q.88 (1)



$\frac{Ldi}{dt} = E - iR$ (straight line with -ve slope)

Q.89 (3)

$E = \frac{1}{2} Li^2 \quad \frac{dE}{dt} = \frac{1}{2}.2.Li \frac{di}{dt} = Li \frac{di}{dt}$

$= 2 \times 2 \times 4 = 16$ J/sec.

Q.90 (1)

$\frac{Ldi}{dt}$ depends on slope of I-T curve

one has grater slope than two

Q.91 (1)

$\frac{1}{RC}$ & $\frac{R}{L}$ (Frequency)

Q.92 (3)

$i = i_0\left(e^{\frac{-t}{\tau}}\right)$ or $t = \frac{2}{\ln\left(\frac{10}{9}\right)}$.

Q.93 (2)

Initially the inductor offers infinite resistance hence i_1 is 1A. Finally, at steady state inductor offers zero resistance and current i_2 is 1.25 A in the battery.

Q.94 (1)

$$\frac{1}{2}Li^2 = \frac{1}{2}\times 5\times\left(\frac{100}{20}\right)^2$$

$$\frac{125}{2} = 62.5 \text{ Joule}$$

$$\frac{1}{2}Li^2 = \frac{1}{2}\times 5\times\left(\frac{100}{20}\right)^2$$

$$\frac{125}{2} = 62.5 \text{ Joule}$$

Q.95 (2)

$i = i_0\, e^{-R/L}\ t$

$$= i_0 e^{-\frac{R}{6}\times\frac{2L}{R}} = i_0 e^{-2} = \frac{i_0}{e^2} = 0.136\, i_0 = 13.6\%$$

Q.96 (3)

Given $\frac{1}{2}Li^2 = U$

$P = \frac{U}{t} \Rightarrow t = \frac{U}{P}$

Now $i^2Rt = \frac{1}{2}Li^2$

$\frac{L}{R} = 2t = \frac{2U}{P}$

Q.97 (2)

$$f = \frac{1}{2\pi}\frac{1}{\sqrt{L_{eff}\times c_{eff}}} = \frac{1}{2\pi\sqrt{3L\times 3C}} = \frac{1}{6\pi\sqrt{LC}}.$$

Q.98 (3)

$C_{eq} = 3C$

$Q_{eq} = 3Q$

$$E = \frac{1}{2}\frac{Q^2_{eq}}{C_{eq}} = \frac{3Q^2}{2C}.$$

Q.99 (1)

Transmitting high voltage & low current electrical energy results in less energy loss over long distance.

Q.100 (1)

$V_P = 220\,V$

$I_P = 5A$

$P_P = 1100$ Watts

$V_S = 11\,V$

$I_S = 90\,A$

$P_S = 990$ Watts

$$\eta = \frac{P_S}{P_P} = \frac{990\times 100}{1100} = 90\,\%$$

Q.101 (2)

$$\frac{N_P}{N_S} = \frac{1}{25}$$

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$$

$$\frac{I_S}{I_P} = \frac{1}{25}$$

$I_P = 2\times 25$

$= 50\,A$

Q.102 (3)

$$\frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$\frac{24}{240} = \frac{0.7}{I_S}$$

$I = 7\,A$

JEE-ADVANCED

MCQ/COMPREHENSION/COLUMN MATCHING

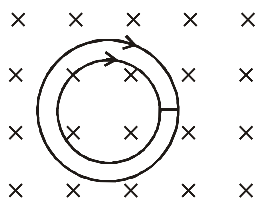
Q.1 (C,D)

EMF is induced in the ring if there is change in flux which occurs either due to rotation about a diameter or due to its deformation.

Q.2 (B,C)

Magnetic lines of force comeout of north pole and reach towards the south pole in a magnet. When the north pole faces the ring and the magnet moves towards it the flux in the ring increases and current is induced in the anticlockwise direction in the ring and similarly when south pole faces the ring and the magnet moves away from it.

Q.3 (A, C, D)
Both are individual loop



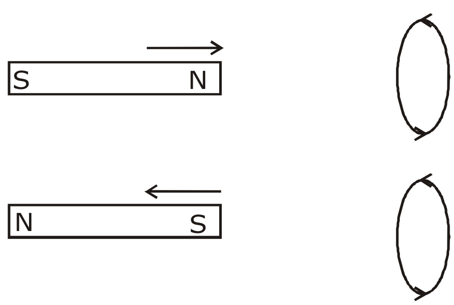
$B\downarrow$
So current induced in clockwise direction (by Lenz law)

Q.4 (A,C)
Magnetic lines of force do noy pass inside a super conducting loop
hence $\varepsilon = 0$

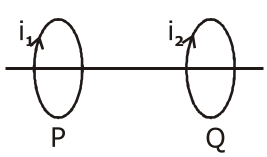
$$\frac{d\phi}{dt} = 0$$

or ϕ = constant.

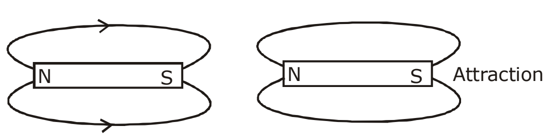
Q.5 (B, C)



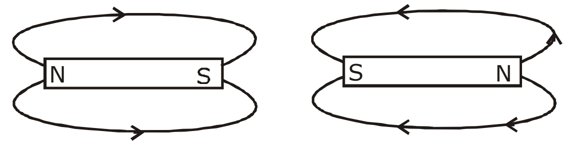
Q.6 (B, D)



(A) $i_2 = 0$ and P moves towards right.
Induced current Q is in opposite direction of i_1
(B) $i_1 = 0$ and Q moves towards left.
Induced current in P is opposite to i_2
(C) $I_1 \neq 0,\ I_2 \neq 0$ and in same direction



(D) $I_1 \neq 0,\ I_2 \neq 0$
and in opposite direction



Q.7 (A,B,C,D)

$\vec{\ell}$ & $\vec{B}$ are parallel.

Q.8 (A,B,C,D)

$$e = -\frac{d\phi}{dt},\ e = -\frac{dBA\sin\omega t}{dt} = -BAw\cos\omega t.$$

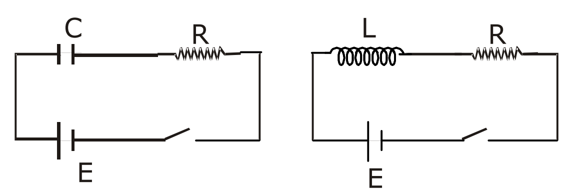
Q.9 (A,D)
Since the other resistance is attached parallel to the battery hence the time constant of the circuit will be $\frac{L}{R}$. At steady State the inductor offers zero resistance have hence at that time current in inductor will be $\frac{E}{R}$.

Q.10 (B,D)
$i_{max_1} = i_{max_2}$
$R_1 = R_2$ and $\tau_2 > \tau_1 \Rightarrow L_2 > L_1$

Q.11 (A,B,C)

$$\frac{1}{RC} = \frac{R}{L} = \frac{1}{\sqrt{LC}} = \text{Frequency}$$

Q.12 (B,D)



at t = 0 C acts as an open ckt
$\Rightarrow$ Q = CE
at t = 0 L acts as short circuit.

$$\Rightarrow\ i = \frac{E}{R}$$

Q.13 (A,D)
Initially inductor acts as an open circuit.
at (t = 0) i.e. V_L max., i = 0
$\Rightarrow\ V_R = 0$
and at t = ∞ inductor behaves as a short circuit.
$\Rightarrow\ V_L = 0\ \ i_{max.} \Rightarrow V_R$ max

Q.14 (A,C,D)

$\text{Power} = \frac{Ldi}{dt} i \Rightarrow L_1 i_1 = L_2 i_2$

$\Rightarrow \frac{V_2}{V_1} = \frac{1}{4} \Rightarrow \frac{W_2}{W_1} = 4 \Rightarrow \frac{i_1}{i_2} = \frac{1}{4}$

Q.15 (A,C,D)

$\text{Since } P_2 = P_2 \text{ or } i_1 v_1 = i_2 v_2 \ \& \ \frac{L_1 \frac{di_1}{dt}}{L_2 \frac{di_2}{dt}} = \frac{v_1}{v_2} \text{ or } \frac{v_1}{v_2} = 4 \ \&$

$\frac{i_1}{i_2} = \frac{1}{4} \quad \frac{w_2}{w_1} = \frac{\frac{1}{2} L_2 I_2^2}{\frac{1}{2} L_1 I_1^2} = 4.$

Q.16 (A,B,C)

EMF induced $= -L\frac{di}{dt} \neq 0$, rest quantities are zero.

Q.17 (A,C,D)

$\text{Since } P_2 = P_2 \text{ or } i_1 v_1 = i_2 v_2 \ \& \ \frac{L_1 \frac{di_1}{dt}}{L_2 \frac{di_2}{dt}} = \frac{v_1}{v_2} \text{ or } \frac{v_1}{v_2} = 4 \ \&$

$\frac{i_1}{i_2} = \frac{1}{4} \quad \frac{w_2}{w_1} = \frac{\frac{1}{2} L_2 I_2^2}{\frac{1}{2} L_1 I_1^2} = 4.$

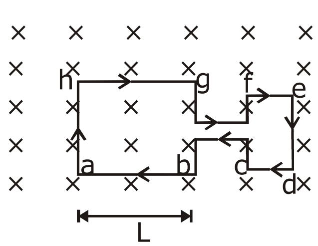
Q.18 (A,B,C)

EMF induced $= -L\frac{di}{dt} \neq 0$, rest quantities are zero.

Q.19 (C)

Q.20 (C)

Q.21 (B)



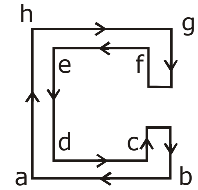
case (1)

$\phi = BA$

$\phi = B^2(L^2 - l^2)$

$\phi = BA$

$\phi = B^2(L^2 + l^2)$



Q.22 (B)

$I_1 > I_2$ because in case 1 both loop support each other and in case II both loops oppose each other.

Q.23 (A)

$\frac{dB}{dt} = 2T/s$

$E = -\frac{AdB}{dt} = -800 \times 10^{-4}\, m^2 \times 2 = -0.16\, V$

$i = \frac{0.16}{1\Omega} = 0.16\, A$, clockwise

Q.24 (B)

At t = 2s

$B = 4T;\ \frac{dB}{dt} = 2T/s$

t = 2 s –

$B = 4T;\ \frac{dB}{dt} = 2T/s$

$A = 20 \times 30\, cm^2$

$= 600 \times 10^{-4}\, m^2;\ \frac{dA}{dt} = -(5 \times 20)\, cm^2/s$

$= -100 \times 10^{-4}\, m^2/s$

$E = -\frac{d\phi}{dt} = -\left[\frac{d(BA)}{dt}\right] = -\left[\frac{BdA}{dt} + \frac{AdB}{dt}\right]$

$= -[4 \times (-100 \times 10^{-4}) + 600 \times 10^{-4} \times 2]$

$= -[-0.04 + 0.120] = -0.08\, v$

Alternative :

$\phi = BA = 2t \times 0.2\,(0.4 - vt)$

$= 0.16t - 0.4\, vt^2$

$E = -\frac{d\phi}{dt} = 0.8\, vt - 0.16$

at t = 2s

$E = -0.08\, V$

Q.25 (C)

At t = 2s, length of the wire = (2 × 30 cm) + 20 cm = 0.8 m

Resistance of the wire = 0.8 Ω

Current through the rod $= \frac{0.08}{0.8} = \frac{1}{10}$ A

Force on the wire = il B $= \frac{1}{10} \times (0.2) \times 4$

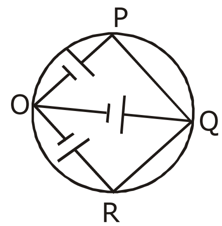
= 0.08 N
Same force is applied on the rod in opposite direction to make net force zero.

Q.26 (B,D)

$v_P - v_O = v_R - v_O$

$= \frac{1}{2} B\omega \left(\sqrt{2}\ R\right)^2$

$= B\omega R^2$



$v_Q - v_O = \frac{1}{2} B\omega (2R)^2$

$= 2B\,\omega R^2$

Q.27 (C)
The potential is given w.r.t to hinged point always.

Q.28 (D)

effective $\vec{\ell}$ is zero.

Q.29 (C)
Inductance and potential difference across terminals will not change with time.

Q.30 (A)
Even after insertion of the rod the current in circuit will increase with time till steady state is reached.

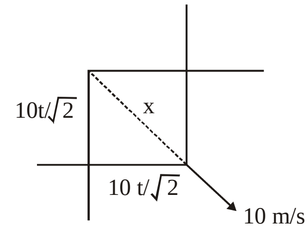
Q.31 (C)
At steady state inductor will offer zero resistance and

hence $I = \frac{\varepsilon}{R}$.

Q.32 (A) q,s (B) p,r (C) p,r (D) q,s
(A) Due to current carrying wire, the magnetic field in loop will be inwards the paper. As current is increased, magnetic flux associated with loop increases. So a current will be induced so as to decrease magnetic flux inside the loop. Hence Induced current in the loop will be anticlockwise. The current in left side of loop shall be downwards and hence repelled by wire. The current in right side of loop is upwards and is hence attracted by wire. Since left side of loop is nearer to wire, repulsive force will dominate. Hence wire will repel the loop
(B) Options in (B) will be opposite of that in (A)

Q.33 (A) q (B) p (C) s (D) s
When both S_1 and S_2 are either open or closed; current through ad is zero. With S_1 closed, current 2×10^{-7} A flows from a to d. With S_2 closed, current 2×10^{-7} A flows from d to a.
(C) When the loop is moved away from wire, magnetic flux decreases in the loop. Hence the options for this case shall be same as in (B)
(D) When the loop is moved towards the wire, magnetic flux increases in the loop. Hence the options for this case shall be same as in (A)

Q.1 [35 A]



x = 10t

$\phi = B\left[\frac{10t}{\sqrt{2}}\right]^2$

$$\frac{d\varphi}{dt} = 100Bt = 100 \times (.10) \times (.10) = 1V$$

$$\frac{d\varphi}{dt} = 100Bt = 100 \times (.10) \times (.10) = 1V$$

$R = (.01) \times 4\left(\frac{10t}{\sqrt{2}}\right)$

$i = \frac{1}{R}\frac{d\phi}{dt} = 35.35 \approx 35$ A **Ans.**

Q.2 [320.00]
For constant velocity,
a = 0
$F_0 = F_m$

$= i\ell B = \left(\frac{\varepsilon}{R}\right)\ell B = \left(\frac{B\ell v_0}{R}\right)\ell B$

$v_0 = \frac{F_0 R}{B^2\ell^2}$ velocity at point 'P'

Now, retardation $a = \frac{F_m}{m} = \frac{i\ell B}{m}$

$a = \frac{B^2\ell^2}{mR} v$

$\Rightarrow -v\frac{dv}{ds} = \frac{B^2\ell^2}{mR} v$

or $-\int_{v_0}^{0} dv = \frac{B^2\ell^2}{mR}\int_0^s ds$

or $v_0 = \frac{B^2\ell^2}{mR} s$

or $s = \frac{mRv_0}{B^2\ell^2} = \frac{F_0 mR^2}{B^4\ell^4} = 320$ m

Q.3 [21]

$\varepsilon = \vec{B}(\vec{V}_{cm} \times \vec{L})$

$= (6\hat{k})\left(\left(\frac{3}{2}\hat{i} - \frac{4}{2}\hat{j}\right) \times (4\hat{i} + 3\hat{j})\right) = 21$

Q.4 [0120]

When the rod moves with constant velocity, net force on the bar is zero

$\therefore$ W = gravitational force = mg = ilB

[i = induced current in the circuit]

$\therefore \quad i = \frac{0.2 \times 10}{2 \times 0.25} = 4A$

To produce 4A current in the bar, induced emf ε in the circuit is $\frac{100 + \varepsilon}{40} = 4 \quad \Rightarrow \varepsilon = 60\text{ V}$

We know, $\varepsilon = Bl V \Rightarrow \quad V = \frac{\varepsilon}{Bl} = \frac{60}{2 \times 0.25} = 120$ m/s

Q.5 [1250]

Induced EMF = $\frac{1}{2}B\omega l^2$

At any time t

$$L\frac{di}{dt} + iR = \frac{B\omega l^2}{2}$$

Solving for i, we get

$$i = \frac{B\omega l^2}{2R}[1 - e^{-Rt/L}]$$

Torque about the hinge P is

$$\tau = \int_0^l idxB \cdot x = \frac{1}{2}iBl^2$$

$$= \frac{Bl^2}{2}\frac{B\omega l^2}{2R}[1 - e^{-Rt/L}]$$

$$= \frac{B^2\omega l^4}{4R}[1 - e^{-Rt/L}]$$

Max. value occur at t = ∞ and half of this is equal to

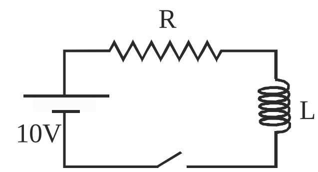
$i_1 = \frac{B^2\omega l^2}{4R} \quad$ when $1 - e^{-Rt/L} = \frac{1}{2}$

$\therefore$ Torque at this instant = $\frac{B^2\omega l^4}{8R} = 1.25$

KVPY
PREVIOUS YEAR'S

Q.1 (D)

$|e| = \frac{V}{R}e^{-\frac{R}{L}\times t}$



Q.2 (B)

This is in accordance with Lenz's law

Q.3 (A)

Due to energy conservation

Q.4 (C)

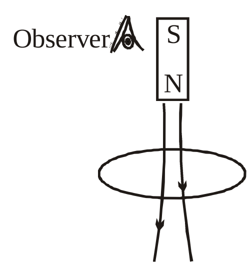
No EMF Induce if ring rotate about its own axis ($\because \Delta\phi = 0$)

Hence, I, II & IV are correct

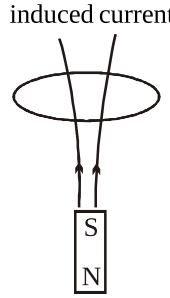
Q.5 (C)

I-t graph is for L-R series circuit.

Q.6 (C)

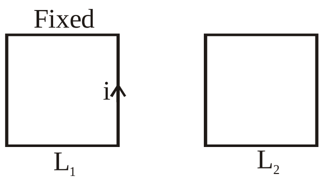


Magnet is approaching sing due to which downward flux through ring is increasing. According to lenz law induced current is anticlockwise or counter clockwise.



When magnet is below the plane of ring and moving away from ring flux in downward decreasing due to which induced current is clockwise.

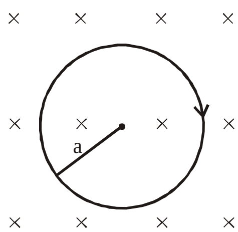
Q.7 (D)



When current through L_1 increases then flux linked through L_2 will increase.

$\therefore$ According to lenz law L_2 will move away.

Q.8 (C)



i(as a unknown)
R=resistance
$B = B_0 \sin\omega t$

$$\text{Emf} = \frac{-d\phi}{dt} \Rightarrow \varepsilon = -\frac{d}{dt}(BA) \Rightarrow \varepsilon = -\frac{AdB}{dt}$$

$$\Rightarrow \varepsilon = -AB_0\omega \cos\omega t \Rightarrow i = \frac{\varepsilon}{R}$$

$$i = -\frac{B_0\omega A}{R}\cos\omega t$$

current oscillates with 'ω' .

Heating loss = i^2R

$$H \propto i^2 \qquad \left[i = -\frac{B_0\omega(\pi a^2)}{R}\cos\omega t \right]$$

$$H \propto B_0^2\omega^2 a^4$$

Force on $d\ell$ length

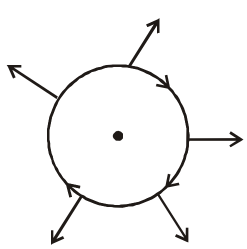
$$|F| = Bid\ell$$

$$|F| = B_0 \sin\omega t\left(\frac{B_0\omega\pi a^2}{R}\right)\cos\omega t \,.\, d\ell$$

$$\text{Force per unit length } = \frac{|F|}{d\ell} = \frac{B_0^2\omega\pi a^2}{R}\sin\omega t \cos\omega t$$

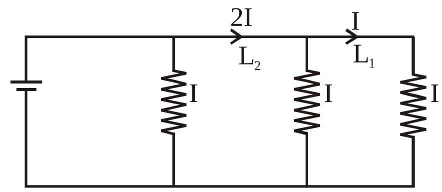
Force per unit length $\propto B_0^2$

Net force on ring will be zero.



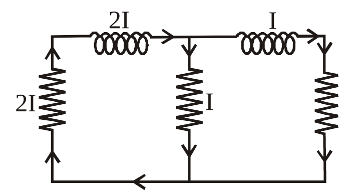
(Force cancel)

Q.9 (A)



(After long time for switched on)

Initially circuit is in steady state current through each resistor as all are identical & are in parallel combination. When switch is off current through L_1 and L_2 just after remain same.



In right & middle wire current is I downward and in left wire current is 2I upward.

Q.10 (A)

According to Lenz's Law

Q.11 (C)

$F = iB\lambda$

$$a = \frac{iB\ell}{m}$$

$$\phi = B.A$$

$$\frac{d\phi}{dt} = B.\ell.\left(\frac{dx}{dt}\right)$$

$$\varepsilon = (B.\ell v)$$

$$i = \varepsilon / R = \frac{B.\ell v}{R}$$

$$a = \left(\frac{B\ell v}{R}\right)\frac{B\ell}{m}$$

$$a = \frac{B^2\ell^2}{Rm}.v$$

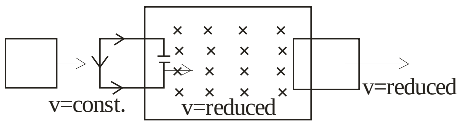
$$\Rightarrow a = v.\frac{dv}{dx}$$

$$\Rightarrow v.\frac{dv}{dx} = \frac{B^2\ell^2}{Rm}.v$$

$$\Rightarrow \int dv = \frac{B^2\ell^2}{Rm}.\int dx$$

$$\Rightarrow \frac{B^2\ell^2}{Rm}.'X'\left[X = \frac{vRM}{B'\ell^2}\right]$$

Q.12 (B)



Inside B speed will be constant therefore B option is correct, representation of speed.

Q.13 (B)

$-e\vec{E} = \frac{mv^2}{R} \Rightarrow$ Electric field will be directed away from centre, so centre will be at higher potential

Q.14 (A)

$\frac{-q}{c} = L\frac{di}{dt}$ ....(i) from KVL

antiquely $L\,i_0 - 0 = \phi$

$i_0 = \frac{\phi}{L}$

from (1) $\frac{-q}{c} = \frac{d^2q}{dt^2}$

$\Rightarrow q = q_0 \sin(\omega_0 t)$

$\Rightarrow I = q_0\,\omega \cos(\omega_0 t) = i_0 \cos(\omega_0 t)$

$i = \frac{\phi}{L}\cos(\omega_0 t)$

Q.15 (B)

$f_s = Mi_L$

$(n\ell).B_L.\pi r^2 = Mi_L$

$n\ell[\mu_0 N i_L]\pi r^2 = Mi_L$

$M = \pi\mu_0 n N \ell r^2$

Q.16 (B)

Flux is increasing while coming out of plane

$\therefore$ Induced electric field will be in clockwise direction.

$\therefore \int_a^b \vec{E}.\vec{ds}$ will be +ve ε_0.

for path- 1

$V_b - V_a = -\varepsilon_0$

In path-2 if we see a & b very close and Net emf in path = 0

Q.17 (D), (C or D)

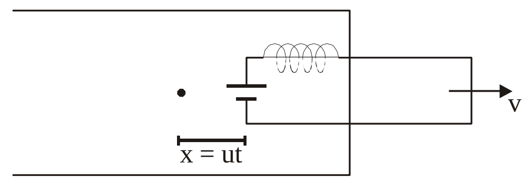
$$\oint \vec{B}.\vec{d\ell} = \mu_0\left(I + \varepsilon_0\left(\frac{d\phi_E}{dt}\right)\right)$$

$$\frac{d\phi_E}{dt} = eE\ell$$

$$\therefore \oint \vec{B}.\vec{d\ell} = \mu_0\varepsilon_0 vE\ell \Rightarrow \frac{vE\ell}{C^2}$$

Direction of electric field is not given in the question therefore both options are possible.

Q.18 (B)



$VB\ell - L\frac{di}{dt} = 0$

$VB\ell = L\frac{di}{dt}$

$\Rightarrow \frac{di}{dt} = \frac{VB\ell}{L}$

= +ve slope

$x = ut \Rightarrow \frac{dx}{dt} = V$

$\frac{di}{dx} = \frac{B\ell}{L}$ = +ve slop

Q.19 (D)

Emf = VBL

$I = \frac{VBL}{R}$

$\text{Heat} = I^2R = \frac{V^2B^2L^2}{R}$

Given $V^1 = 2V$

So $= \frac{H^1}{H} = 4$

JEE MAIN

PREVIOUS YEAR'S

Q.1 (1)

Since key is open, circuit is series

$15i_{RMS}(60)$

$\therefore \quad i_{RMS} = \frac{1}{4}A$

Now, $20 \times \frac{1}{4} \times X_L = \frac{1}{4}(\omega L)$

$\therefore \quad L = \frac{4}{5} = 0.8H$

& $\quad 10 = \frac{1}{4}\,\frac{1}{100\,(C)}$

$\therefore \quad C = \frac{1}{4000}F = 250\,\mu F$

Q.2 [144 J]

$\frac{Ldi}{dt} = 3t$

$\therefore \quad \int Ldi \int 3tdt$

$\therefore \quad Li = \frac{3t^2}{2}$

$\therefore \quad i = \frac{3t^2}{2L}$

So energy = $\frac{1}{2} \times L \times \left(\frac{3t^2}{2L}\right)^2 = \frac{1}{2} \times \frac{9t^4}{4L}$

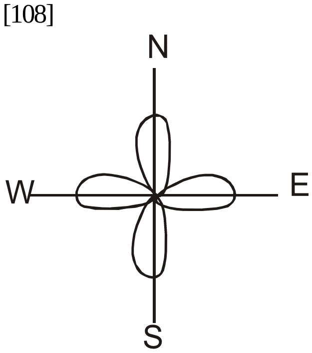
$= \frac{9}{8} \times \frac{16 \times 16}{2} = 144J$

Q.3 (1)

$\varepsilon = \beta\,\ell v \sin 60^o$

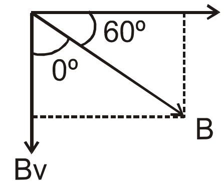
$= 0.25 \times 10 \times 180 \times \frac{5}{18} \times \frac{\sqrt{3} \times 10^{-3}}{2} = 108.1\,mV$

Q.4 [108]



$\Sigma = B_\perp v\,\ell$

$\sin 60^o = \frac{Bv}{B}$



$\frac{\sqrt{3}}{2} = \frac{Bv}{B}$

$Bv = \frac{\sqrt{3}}{2}B$

$E = \frac{\sqrt{3}}{2}B\ell v$

$= \frac{\sqrt{3}}{2} \times 2.5 \times 10^{-4} \times 10 \times 180 \times \frac{5}{18}$

$= \frac{\sqrt{3}}{2} \times 2.5 \times 5 \times 10^{-2}$

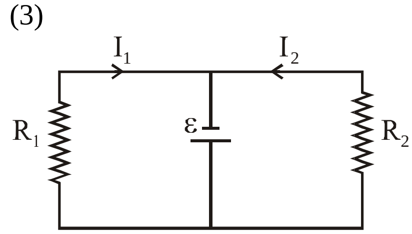
$= 10.825 \times 10^{-2}$

$= 108\,mv$

Q.5 (1)

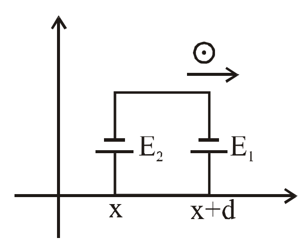
$i = \frac{9}{4}A = 2.25\,A$

Q.6 (3)



Q.7 (3)

$E_1 = \frac{B_0(x+d)}{a}v_0 d$



$E_2 = \frac{B_0(x)}{a}v_0 d$

$E_{net} = E_1 - E_2$

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

Q.8 (3)

Magnetic energy = $\frac{1}{2}$ Li2 = 25%

$\text{ME} \Rightarrow 25\% \Rightarrow i = \frac{i_0}{2}$

i i(1–R–Rt / L) for charging

$t = \frac{L}{R}\ell n2$

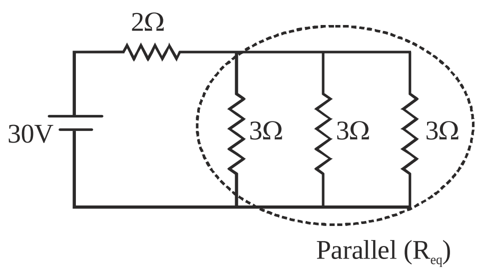
Q.9 (3)

Q.10 (74)

Q.11 (60)

Q.12 (3)

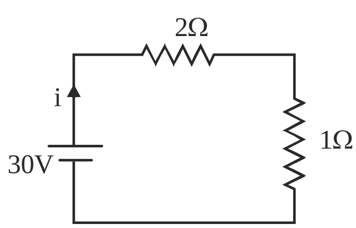
In Steady state, inductor behaves as a conducting wire.
So, equivalent circuit becomes



$$\frac{1}{R_{eq}} = \frac{1}{3}+\frac{1}{3}+\frac{1}{3} = 1$$

$\Rightarrow R_{eq} = 1\Omega$

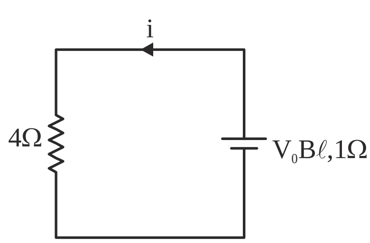
$\Rightarrow$ Circuit becomes



$$\Rightarrow i = \frac{30}{3} = 10\text{A}$$

Q.13 (2)

Equivalent circuit



$$i = \frac{V_0 B\ell}{4+1} \Rightarrow V_0 = \frac{5(2\text{mA})}{5\times .2} = 10^{-2}\text{ m/s} = 1\text{ cm/s}$$

Option (2)

Q.14 (3)

Q.15 [60]

Q.16 (4)

$$U - \frac{1}{2}Li^2 = 64 \Rightarrow L = 2$$

$i^2R = 640$

$$R = \frac{640}{(8)^2} = 10$$

$$\tau = \frac{L}{R} = \frac{1}{5} = 0.2$$

Option (4)

Q.17 (3)

JEE-ADVANCED PREVIOUS YEAR'S

Q.1 [6]

Flux through circular ring

$\phi = (\mu_0 ni)\,\pi r^2$

$$\phi = \frac{\mu_0}{L}\pi r^2\ I_0 \cos 300\,t$$

$$i = \frac{d\phi}{Rdt}$$

$$i = \frac{\mu_0 \pi r^2 I_0}{RL}\ .\sin 300\,t \times 300$$

$$= \mu_0 I_0 \sin 300\,t \left[\frac{\pi r^2 .300}{RL}\right]$$

$M = I\,.\,\pi r^2$

$$= \mu_0 I_0 \sin 300\,t \left[\frac{\pi^2 r^4 .300}{RL}\right] \ (\text{Take } \pi^2 = 10\ )$$

$$= \frac{10\times 10^{-4}\times 300}{100\times 10}$$

N = 6 **Ans.**

Q.2 (C)

True for induced electric field and magnetic field.

Q.3 [7]

$$B = \frac{\mu_0 i R^2}{2(R^2+X^2)^{3/2}}$$

$$B = \frac{\mu_0 i R^2}{2(R^2+3R^2)^{3/2}} = \frac{\mu_0 i R^2}{2(4R^2)^{3/2}}$$

$= \dfrac{\mu_0 i R^2}{2 \cdot 2^3 \cdot R} = \dfrac{\mu_0 i}{16R}$

$\phi = NBA \cos 45°$

$= 2\dfrac{\mu_0 i}{16R} a^2 \dfrac{1}{\sqrt{2}}$

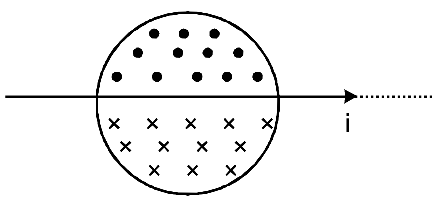
$\phi = \dfrac{\mu_0 i a^2}{8\sqrt{2}R}$

$M = \dfrac{\phi}{i}$

$M = \dfrac{\mu_0 a^2}{2^{7/2} R} = \dfrac{\mu_0 a^2}{2^{P/2} R}$

$P = 7$

Q.4 (A,C)



$(\phi)_{loop} = 0$ for all cases

so induced emf $= 0$

Q.5 (B)

$\oint E.dl = -A \dfrac{dB}{dt}$

$E.\,2\pi R = -\pi R^2 B$

$E = \dfrac{-BR}{2}$

Alternat

$E2\pi R = \dfrac{-d\phi}{dt} = -\pi R^2 \dfrac{dB}{dt}$

$E = \dfrac{-R}{2}\dfrac{dB}{dt} = \dfrac{-BR}{2}$

Q.6 (B)

Megnetic dipole moment $M = \gamma J$

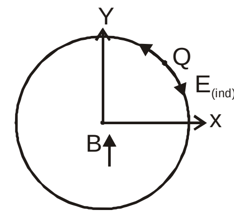
$\Delta M = \gamma \Delta J$--------(i)

$\dfrac{\Delta J}{\Delta t} = -Q\dfrac{dB}{dt}.\dfrac{R}{2}R.$

$\Delta J = -\dfrac{QB}{2}R^2$

so $\Delta M = -\dfrac{\gamma QBR^2}{2}$

Alternet



$\dfrac{M}{L} = \dfrac{Q}{2m}$

$M = \dfrac{Q\omega}{2\pi}\pi R^2 = \dfrac{Q\omega R^2}{2}$

induced electric field is oppsite. to the ω so the charge is retarded.

$\omega' = \omega - \alpha t$

$\omega' = \omega - \dfrac{QB}{2}1 (a_t = QE/m),$

$(\alpha = \dfrac{QE}{mR} = \dfrac{Q}{R} x \dfrac{BR}{2m} = \dfrac{QB}{2m})$

$M_f = \dfrac{Q\omega' R^2}{2} = Q\left(\omega - \dfrac{QB}{2m}\right)\dfrac{R^2}{2}$

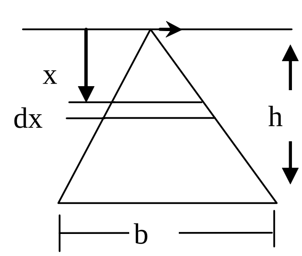
$\Lambda m = M_f - M_i$

$= \dfrac{Q\omega R^2}{2} - \dfrac{Q^2BR^2}{4m} - \dfrac{Q\omega R^2}{2} = -\gamma\dfrac{BQR^2}{2}$

Q.7 (C,D)

If current *i* flows through long wire then flux through loop is

$\phi = \int \dfrac{\mu_0 i}{2\pi x} \times \left(\dfrac{bx}{h}\right) dx = \dfrac{\mu_0 i b}{2\pi}$



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

$= \dfrac{\mu_0 b}{2\pi}\dfrac{di}{dt} = \dfrac{\mu_0}{2\pi}(20 \times 10^{-2}) \times 10 = \dfrac{\mu_0}{\pi}$ volt

Hence, According to principle of reciprocity, if current *i* flows in loop then same emf is induced in wire.
Rotation of loop will not change flux.

Q.8 (8)

$t = 0, R_{eq} = 12\Omega$

when *t* ’! “, $\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{4} + \frac{1}{12}$

$\Rightarrow R_{eq} = \frac{3}{2}\Omega$

$\therefore \frac{I_{max}}{I_{min}} = \frac{12}{3/2} = 8$

Q.9 (B,D)

Initially flux increases than becomes constant & then decreases.
Hence, (b, d)

Q.10 (BC)

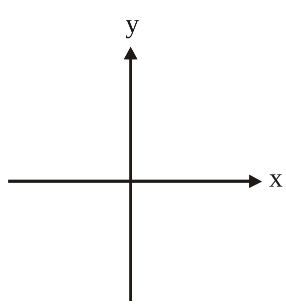
$\phi = BS\cos\theta = BS\cos\omega t$

$$e = \left|\frac{d\phi}{dt}\right| = BS\omega\sin\omega t$$

$$\frac{d\phi}{dt} = \max. \Rightarrow \sin\omega t = 1 \Rightarrow \omega t = \frac{\pi}{2}$$

Net emf, $e = 2BA\omega\sin\omega t - BA\omega\sin\omega t$

Q.11 (C)



For constant velocity

$$\vec{F} = q\vec{E} + q\left(\vec{V}\times\vec{B}\right) = 0$$

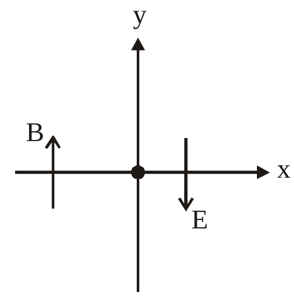
$$\vec{E} = -\left(\vec{V}\times\vec{B}\right)$$

$$-E_0\hat{x} = -\left[\frac{E_0}{B_0}\hat{y}\times B_0\hat{z}\right]$$

Q.12 (A)

For helix with axis along positive z-direction magnetic field should be along z-direction.

Q.13 (A)



Force due to Electric field is along –y axis and force due to $\vec{B}$ is zero.

Q.14 (A,C,D)

(A) & (C) After long time current through $R = I = \frac{V}{R}$

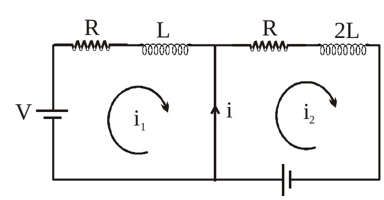
$$\frac{I_1}{I_2} = \frac{L_2}{L_1}$$

$$I_1 = \frac{L_2 I}{L_1 + L_2}$$

$$I_2 = \frac{L_1 I}{L_1 + L_2} = \left(\frac{L_1}{L_1 + L_2}\right)\frac{V}{R}$$

(B) t = 0 I = 0

Q.15 (B,D)



$i_{max} = (i_2 - i_1)_{max}$

$$\Delta i = (i_2 - i_1) = \frac{V}{R}\left[1 - e^{-\left(\frac{R}{2L}\right)t}\right] - \frac{V}{R}\left[1 - e^{\left(\frac{R}{L}\right)t}\right]$$

$$\frac{V}{R}\left[e^{-\left(\frac{R}{2L}\right)t} - e^{-\left(\frac{R}{2L}\right)t}\right]$$

For $(\Delta i)_{max}$ $\frac{d(\Delta i)}{dt} = 0$

$$\frac{V}{R}\left[\frac{R}{L}e^{-\left(\frac{R}{L}\right)t} - \left(-\frac{R}{2L}\right)e^{-\left(\frac{R}{2L}\right)t}\right] = 0$$

$$e^{-\left(\frac{R}{L}\right)t} = \frac{1}{2}e^{-\left(\frac{R}{2L}\right)t}$$

$$e^{-\left(\frac{R}{L}\right)t} = \frac{1}{2}$$

$$\left(\frac{R}{2L}\right)t = \ln 2$$

$t = \frac{2L}{R}\ln 2$ $\rightarrow$ time when i is maximum

$$i_{max} = \frac{V}{R}\left[e^{-\frac{R}{L}\left(\frac{2L}{R}\ln 2\right)} - e^{-\left(\frac{R}{2L}\right)\left(\frac{2L}{R}\ln 2\right)}\right]$$

$$|i_{max}| = \frac{V}{R}\left|\left[\frac{1}{4} - \frac{1}{2}\right]\right| = \frac{1}{4}\frac{V}{R}$$

Q.16 [0.63]

Since velocity of PQ is constant. So emf developed across it remains constant.

$\varepsilon = Blv$ where ℓ = length of wire PQ

current at any time t is given by

$$i = \frac{\varepsilon}{R}\left(1 - e^{\frac{Rt}{L}}\right)$$

$$i = \frac{B\ell v}{R}\left(1 - e^{\frac{Rt}{L}}\right) = 1 \times \left(\frac{10}{100}\right) \times \left(\frac{1}{100}\right) \times \frac{1}{1}\left(1 - e^{\frac{-1\times10^{-3}}{1\times10^{-3}}}\right)$$

$$= \frac{1}{1000} \times (1 - e^{-1}) = \frac{1}{1000} \times (1 - 0.37)$$

$i = 0.63 \times 10^{-3}$ A $\Rightarrow$ x = 0.63

Q.17 (B)

When the magnet is moved, it creates a state where the plate moves through the magnetic flux, due to which an electromotive force is generated in the plate and eddy currents are induced. These currents are such that it opposes the relative motion $\Rightarrow$ disc will rotate in the direction of rotation of magnet.

Note : This apparatus is called Arago's disk.

Q.18 (B)

Torque experienced by circular loop $= \vec{M} \times \vec{B}$

where $\vec{M}$ is magnetic moment

$\vec{B}$ is magnetic field

$\therefore \tau = i\pi R^2 N B_0$ [at the instant shown $\theta = \pi/2$]

$\therefore \vec{\tau}dt = d\vec{L} = i\pi R^2 N B_0 dt = Q\pi R^2 N B_0$ [idt=Q]

Q.19 [55.00]

Mutal inductance is producing flux in same direction as self inductance.

$$\therefore U = \frac{1}{2}L_1I_1^2 + \frac{1}{2}L_2I_2^2 + MI_1I_2$$

$$\Rightarrow U = \frac{1}{2}\times\left(10\times10^{-3}\right)1^2 + \frac{1}{2}\times\left(20\times10^{-3}\right)\times 2^2$$

$+ (5\times10^{-3})\times1\times2$

$= 55$ mJ

JEE-ADVANCED PREVIOUS YEAR'S

Q.20 (AC)

EXERCISES

ELEMENTRY

Q.1 (3)

Q.2 (2)

Q.3 (2)

Q.4 (3)

Q.5 (2)

Q.6 (2)

Q.7 (3)

Q.8 (4)

Q.9 (1)

Q.10 (1)

Q.11 (2)

Q.12 (4)

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (4)

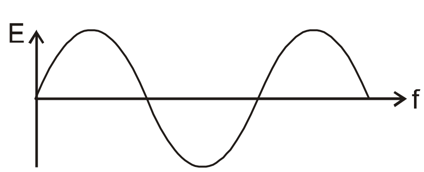
$$I_O = \frac{V_0}{\omega L} = \frac{10}{100\times5\times10^{-3}}$$

Q.2 (2)

$$E = 10\cos\left(2\pi\times50\times\frac{1}{600}\right) = 5\sqrt{3}$$

Q.3 (3)
V = 100 sin100π t cos 100 π t
V = 50 sin 200 π t
here $V_O = 50$ & ω = 200 π f = 100 Hz

Q.4 (4)
If net area of E – t curve is zero for given inteval then average value will be zero.

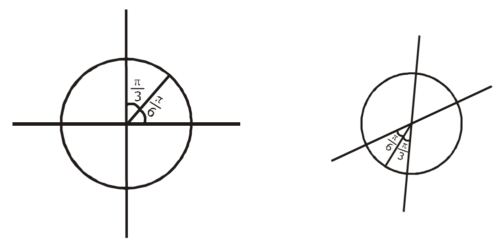


Q.5 (4)
D.C. Voltmeter measures to Average value only

Q.6 (4)
Given T = 1μs = 10^{-6} s

$$f = \frac{1}{T} = \frac{1}{10^{-6}} = 10^6\ \text{Hz}$$

Q.7 (2)
Given i = 4 sin (100 πt + 30°)



at t = 0; $i = 4\sin30° = 2A$

$$\frac{\pi}{3} = 100\pi t$$

$$t = \frac{1}{300}\ \text{sec.}$$

Q.8 (B)

at t = 0, i = 2 sin (100 πt + $\frac{\pi}{3}$)

i = 2 sin $\frac{\pi}{3}$, i = $\sqrt{3}$ Amp.

Q.9 (3)

$$I_{avg} = \frac{\int_0^{T/2} 10\sin(314t)\,dt}{\int_0^{T/2} dt}$$

$$= \frac{2i_0}{\pi} = 0.637\,i_0 = 0.637\times10 = 6.37\ \text{A}$$

Q.10 (1)
By concept

Q.11 (B)
1 Cycle $\rightarrow$ 2 times
50 Cycle $\rightarrow$ 100 times

Q.12 (2)
$e = 500 \sin 100\pi t$

$\omega = 100\,\pi$

$2\pi f = 100\pi$

$f = 50$

Q.13 (3)

$$V_{rms} = \frac{V_0}{\sqrt{2}} = 220$$

$$V_0 = 220\sqrt{2} = 311 \text{ volt}$$

Q.14 (1)

$$I_{avg} = \frac{\int_0^{\frac{T}{2}} I_0 \sin \omega t\, dt}{\int_0^{\frac{T}{2}} dt} = \frac{2I_0}{T}\left[\frac{-\omega s\, \omega t}{\omega}\right]_0^{\frac{T}{2}} = \frac{2I_0}{\pi}$$

Q.15 (B)
$E = 200 \sin (2\pi \times 50t)$
$= 200 \sin 314t$

Q.16 (2)

$E = E_0 \cos (\omega t + \frac{\pi}{3})$ can be written as

$$E = E_0 \sin\left(\omega t + \frac{\pi}{2} + \frac{\pi}{3}\right)$$

$$= E_0 \sin\left(\omega t + \frac{5\pi}{6}\right)$$

Phase diff. $= \frac{5\pi}{6}$

Q.17 (2)

Q.18 (1)

$X_C = \frac{1}{\omega C}$ will decrease if we increase frequency then z will decrease so current will increase & intensity will increase.

Q.19 (1)

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{\sqrt{R^2 + (\omega L)^2}} = 2A$$

$$\tan\phi = \frac{\omega L}{R} = \frac{66}{88} = \frac{3}{4}.$$

Q.20 (2)

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{100}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

P.d. across resistance = R I_{rms} = 100 volt.

Q.21 (3)

$R = \frac{V_0}{I_0} = \frac{200}{5} = 40\ \Omega$ (For circuit x)

$X_L = \frac{V_0}{I_0} = 40\ \Omega$

(For circuit y)
If x & y are in series

$$I = \frac{200}{40 \times \sqrt{2}} = \frac{5}{\sqrt{2}} \text{ Amp.}$$

$$\Rightarrow I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{5}{2} \text{ amp.}$$

Q.22 (4)

$$I_0 = \sqrt{2}\ I_{rms} = \sqrt{2}\frac{V_{rms}}{Z}$$

$$I_0 = \frac{\sqrt{2} \times 130\sqrt{2}}{\sqrt{R^2 + (\omega L)^2}}$$

$$\tan\phi = \frac{\omega L}{R}$$

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right).$$

Q.23 (3)

$\tan\phi = \tan 45^\circ = \dfrac{\omega L}{R}$

$X_L = \omega L = R.$

Q.24 (2)

$V_{net} = \sqrt{V_R^2 + V_L^2} = \sqrt{(20)^2 + (16)^2} = 25.6.$

Q.25 (2)

$I = \dfrac{200\sqrt{2}}{(X_C)\times\sqrt{2}} = 200 \times \omega C = 20$ mA.

Q.26 (1)

$R = \dfrac{100}{1} = 100\ \Omega$ $\qquad x = \sqrt{Z^2 - R^2}$

$Z = \dfrac{100}{0.5} = 200\ \Omega$ $\qquad L = \dfrac{x}{\omega} = \dfrac{1}{3}$ H.

Q.27 (4)
Voltage of source is always less than $(V_1 + V_2 + V_3)$,

Q.28 (2)
At resonance voltages across C and L are in opposite phase so net voltage will be zero.
So, $V_2 = 0$.

Q.29 (1)
At resonance $(V_C = V_L)$
$V = I_{rms} \times R$

$= \dfrac{V_{rms}}{Z} \times R$ (here z = R)

$V = V_{rms} = 100$ volt & $I_{rms} = \dfrac{100}{50} = 2$ Amp.

Q.30 (3)

$X_L = \omega t = 1000\ \Omega$

$(X_L)_{new} = (2\omega)(2t) = 4 \times 1000 = 4000\ \Omega$

Q.31 (1)
At resonance condition $X_L = X_C$ then
$Z = R$

$i = \dfrac{100 \times 10^{-3}}{1} = 100$ m.Amp

Q.32 (4)

$X_L = \omega L = 100 \times 0.1 = 10\ \Omega$

$i = \dfrac{100}{10}\sin\left(100t - \dfrac{\pi}{2}\right) = -10\cos(100t)$ A

Q.33 (2)

Q.34 (2)
$X_L = \omega L = 2\pi f \times L$
$100 = 2\pi \times 50 \times L$
....(Eqn. 1)
$(X_L)_{new} = 2\pi \times 150 \times L$
....(Eqn. 2)
from eqn. (i) & (ii)
$(X_L)_{new} = 300\ \Omega$

Q.35 (2)

Given $R = 50\ \Omega$, $L = \dfrac{20}{\pi}$ H, $C = \dfrac{5}{\pi}\ \mu F$

$X_L = \omega L = 2\pi \times 50 \times \dfrac{20}{\pi} = 2000\ \Omega$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi \times 50 \times \dfrac{5}{x} \times 10^{-6}} = 2000\ \Omega \Rightarrow X_L =$

X_C then $Z = R$

Q.36 (1)

At resonance $\omega L = \dfrac{1}{\omega C}$

$L \propto \dfrac{1}{C}$.

Q.37 (4)
So, current lags behind voltage.
If n > nr

$\omega L > \dfrac{1}{\omega C}$

$X_L > X_C$

Q.38 (1)
Given potential difference between the ends of the resistance wire $= V_R$
across capacitor $V_C = 2V_R$
and across the inductor $V_L = 3V_R$
then

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$= \sqrt{V_R^2 + (3V_R - 2V_R)^2} = \sqrt{2}\,V_R$$

Q.39 (1)

$$\%\,\text{increase} = \frac{\frac{R}{0.5} - \frac{R}{0.866}}{\frac{R}{0.866}} \times 100 = 73.2\ \%$$

Q.40 (3)

In resonance condition

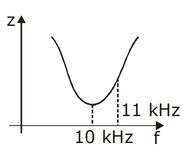
$$\omega = \frac{1}{\sqrt{LC}}$$

when L ↑ 25% and C ↓ 20% then

$$\omega_{new} = \frac{1}{\sqrt{\frac{125}{100}L \times \frac{80}{100}C}} = \frac{1}{\sqrt{\frac{5}{4}L \times \frac{4}{5}C}}$$

$$\omega_{new} = \frac{1}{\sqrt{LC}} \Rightarrow \omega_{new} = \omega$$

Q.41 (3)



Inductive

Q.42 (1)

Q.43 (1)

Q.44 (4)

Q.45 (3)

Q.46 (4)

Given R = 3Ω, X_L = 4Ω, X_C = 8Ω

$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$

$$Z = \sqrt{3^2 + (8-4)^2} = 5\Omega$$

then

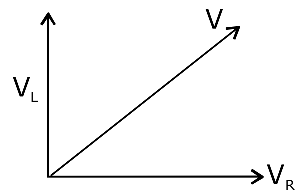
$$P = VI\cos\phi = VI\frac{R}{Z} \qquad (\cos\phi = \frac{R}{Z})$$

$$= V\frac{V}{Z}\frac{R}{Z} = \frac{V^2}{Z}\frac{R}{Z}$$

$$= \frac{50 \times 50 \times 3}{5 \times 5} = 300\ \text{watt}$$

Q.47 (3)

Given V_L = 176



$$V_R = \sqrt{V^2 - V_L^2}$$

$$= \sqrt{(220)^2 - (176)^2}$$

V_R = 132 V

Q.48 (B)

Q.49 (3)

Q.50 (1)

$P_{av} = v_{rms}\, I_{rms} \cos\phi$

Here ϕ = 90° so P_{av} = 0

Q.51 (2)

Wattless current = $I_{rms} \sin\phi$

Where $\tan\phi = \frac{\omega L}{R} = \frac{2\pi f L}{R} = 1$

and $I_{rms} = \frac{v_{rms}}{z} = \frac{v_{rms}}{\sqrt{R^2 + (\omega L)^2}} = \frac{1}{\sqrt{2}}$

Q.52 (3)

$$\frac{H_{D.C.}}{H_{A.C.}} = \frac{I^2R}{I_{rms}^2R} = 2$$

Q.53 (2)

$$\langle P\rangle = I^2_{rms} R = \left(\frac{I_P}{\sqrt{2}}\right)^2 R = \frac{I_P^2 R}{2}$$

Q.54 (3)

$P = I^2_{rms} R = [(2)^2 R] \times 3$

$\Rightarrow I_{rms} = 2\sqrt{3}$ A

Q.55 (2)

I^2R = 100

$R = \frac{100}{I^2} = \frac{100}{(2)^2} = 25.$

Q.56 (2)

$\tan\phi = \frac{x}{R} = \frac{4}{3}$

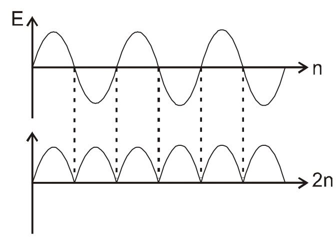
$\cos\phi = \frac{3}{5} = 0.6$

Q.57 (B)

$\cos\phi = \frac{R}{z}$

% change $= \frac{z' - z}{z} \times 100 = 100\%$.

Q.58 (2)



Q.59 (4)
When all (L,C,R) are connected then net phase difference = 60 – 60 = 0. So, there will be resoance.

$I = \frac{V}{R} = 2A$ & $P = I^2 R = 400$ watt.

Q.60 (4)

$\cos\phi = \frac{R}{z} = \frac{R}{\sqrt{R^2 + (x_L - x_C)^2}} = 1$

Because $x_L = x_C$

Q.61 (4)
At resonance $x_L = x_C$
So, z = R, $\Rightarrow \cos\phi = 1$

Q.62 (4)

Given E = 5 cosωt, I = 2 sinωt , $\phi = \frac{\pi}{2}$

then
$P = V_{rms} I_{rms} \cos\phi$

$= \frac{5}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \cos\frac{\pi}{2} = 0$

Q.63 (1)
Given R = 0 then
$P = I^2R = 0$

Q.64 (4)

$\because \cos\phi = \frac{R}{z}$

$\cos\phi_1 = \frac{1}{2} = z_1 = 2R$

$\cos\phi_2 = \frac{1}{4} = z_2 = 4R$

% increase $= \frac{4R - 2R}{2R} \times 100$

= 100 %

Q.65 (B)
In series LCR circuit at resonance $X_L = X_C$
then Z = R

$\cos\phi = \frac{R}{Z} = 1$

$P = E_{rms} I_{rms} \cos\phi$

Q.66 (4)

$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{8}{1}$

$V_2 = 8 \times 120 = 960$ volt

$I = \frac{960}{10^4} = 96$ mA.

Q.67 (i)(3)

$\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{1}{5}$

$E_2 = \frac{1000}{5} = 200$ volt.

(ii) (B)
$E_2I_2 = E_1I_1 \times \eta$ %

$9000 = 1000 \times I_1 \times \frac{90}{100}$

$I_1 = 10$ amp.

(iii)(1)

copper loss in the primary coil

$= I_1^2 R_1 = (10)^2 \times 1 = 100.$

total loss= $E_1I_1 - E_2I_2$

$= 10{,}000 - 9000$

$= 1000$

(iv) (3)

Cu losses in secondary coil

$= (1000 - 700) - 100$

$= 200$ watt.

(v) (B)

$E_2 I_2 = 9000 + 200$

$I_2 = \dfrac{9200}{200} = 46$ A.

(vi) (B)

$I_2^2 = R_2 = 200$

$R_2 = \dfrac{200}{(46)^2} = 0.0945.$

JEE-ADVANCED
OBJECTIVE QUESTIONS

Q.1 (B)

$$I_{rms} = \left[\frac{\int_O^T i^2\,dt}{T}\right]^{\frac{1}{2}} =$$

$$\left[\int_0^T \frac{[3+4\sin(\omega t+\pi/3)]^2}{T}dt\right]^{1/2} = \sqrt{17}\ .$$

Q.2 (D)

$$V^2_{rms} = \int_0^T \frac{(e_1 \sin\omega t + e_2 \cos\omega t)^2\,dt}{T} = \sqrt{\frac{e_1^2 + e_2^2}{2}}$$

where $\omega = \dfrac{2\pi}{T}$.

Q.3 (D)

$$I_{ms} = \sqrt{I_0^2 + \frac{I_1^2}{2}} = \sqrt{9 + \frac{36}{2}} = \sqrt{9+18} = \sqrt{27} = 3\sqrt{3}$$

Q.4 (C)

$$I_{rms} = \sqrt{\frac{1}{T}\left[\int_0^T I_1^2\cos^2\omega t + I_2^2\sin^2\omega t + 2I_1I_2\sin\omega t\cos\omega t\,dt\right]}$$

$$= \sqrt{\frac{1}{T}\left[\frac{I_{-1}^2}{2}T + \frac{I_{-2}^2}{2}T\right]} = \frac{\left(I_1^2 + I_2^2\right)^{\frac{1}{2}}}{\sqrt{2}}$$

Q.5 (D)

Given

$I_{rms} = 10$A, f = 50 Hz

$t = \dfrac{T}{4} = \dfrac{1}{4f} = \dfrac{1}{200}$

t = 5 ms

$I_0 = I_{rms} \times \sqrt{2} = 14.14$ A

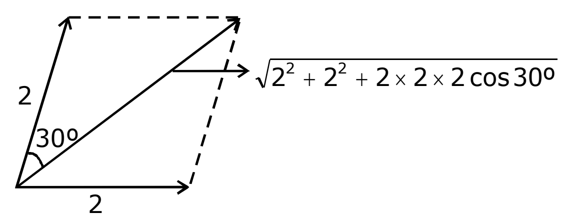
Q.6 (C)

$i_0^2 R = i_{rms}^2 R$

$i_0 = i_{rms} = \sqrt{4} = 2$ Amp.

Q.7 (D)

$i = 2 \sin 100\pi t + 2 \sin (100\pi t + 30)$



$= 2\sqrt{2+\sqrt{3}} = i_0$

$i_{rms} = \dfrac{2\sqrt{2+\sqrt{3}}}{\sqrt{2}}$

Q.8 (B)

Q.9 (A)

$I_{rms} = \dfrac{60}{120} = \dfrac{1}{2}$ Amp.

$V_L = I_{rms} \times (\omega L)$

$40 = \frac{1}{2} \times (40 \times 10^3) \times L$

$L = 20$ mH

At resonance $V_C = I_{rms}\left(\frac{1}{\omega c}\right) = V_L$

$C = \frac{1}{2} \times \frac{1}{4\times10^3} \times \frac{1}{40}$

$C = \frac{25}{8}$ μF.

Q.10 (D)

Given

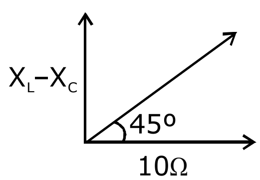
$V_0 = 283$ V $\quad R = 3\ \Omega$

$L = 25 \times 10^{-3}$ H $\quad C = 400 \times 10^{-6}$ F

For maximum power $X_L = X_C$

$\omega C = \frac{1}{\omega L} \Rightarrow \omega^2 = \frac{1}{LC}$

Q.11 (C)



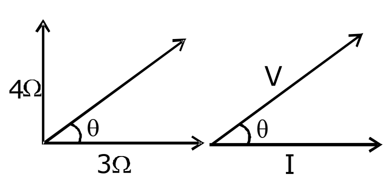
$\cos\phi = \frac{1}{\sqrt{2}}$

$\omega_L - \frac{1}{\omega_C} = 10\Omega$

$\Rightarrow \left(100 \times 0.1 - \frac{1}{100 \times c}\right) = 10\Omega$

$2\pi f = 100 \quad C = 500$ μF

Q.12 (D)



$\theta = 53^o$

$Z = 5\Omega$

$\because$ $i = 2 \sin(\omega t - 53^o)$

$V_L = 8 \sin(\omega t - 53^o + 90^o)$

$= 8 \sin(\omega t + 37^o)$

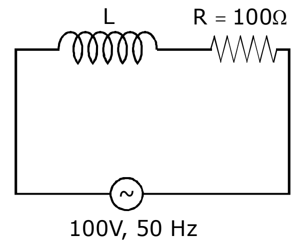
$= 8 \sin(\pi + 37^o)$

$= -8 \sin 37^o$

$= -8 \times \frac{3}{5}$

$= -4.8$ volts

Q.13 (D)



Given V = 100 V $\quad$ I = 1 A

R = 100 Ω $\quad$ z = V/I

$z = \frac{100}{0.5}$ $z = 200\Omega$

$\Rightarrow z = \sqrt{(100)^2 + (2\pi 50L)^2}$

$\Rightarrow L = 0.55$ H

Q.14 (C)

Given $\quad R = 10\ \Omega$

L = 2 H

V = 120 V $\quad$ f = 60 Hz

$X_L = 2\pi \times f \times L$

$= 2\pi \times 60 \times 2$

$= 240\ \pi\Omega$

$I_{rms} = V/Z$

$i_{rms} = \frac{120}{\sqrt{(10)^2 + (240\pi)^2}} \approx 0.16$ A

Q.15 (B)

9V or 1 Volt

Q.16 (C)

Given $\quad$ f = 50 Hz

C = 100 μF

$I_0 = 1.57$ A

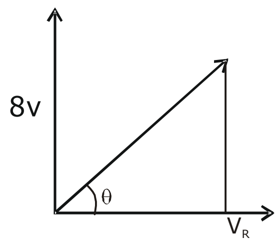
Then $\quad V_C = I_0 X_C \sin(\omega t - \frac{\pi}{2})$

$= 1.57 \times \frac{1}{2\pi 50 \times 100 \times 10^{-6}} \sin\left(100\pi t - \frac{\pi}{2}\right)$

$= 50 \sin\left(100\pi t - \frac{\pi}{2}\right)$

Q.17 (A)

From Given data



$V_{applied} = 10$ V

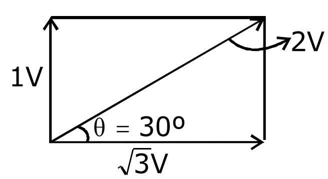
$V_C = 8$ V $V_R = ?$

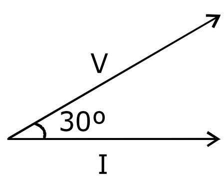
$8^2 + x^2 = 10^2$

x = 6 volt

$\theta = \tan^{-1}\left(\frac{4}{3}\right)$

Q.18 (B)





Q.19 (D)

$L = \frac{0.4}{\pi}$ H R = 30 Ω

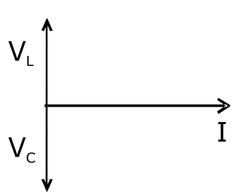
V = 200 V $Z = \sqrt{x_L^2 + R^2}$

$= \sqrt{(\omega L)^2 + R^2} = \sqrt{\left(2\pi \times 50 \times \frac{0.4}{\pi}\right)^2 + 30^2}$

$= \sqrt{40^2 + 30^2} = 50\ \Omega$

$i = \frac{V_{rms}}{z} = \frac{200}{50} = 4$ A

Q.20 (D)



Q.21 (D)

In LCR circuit net impedence Given by

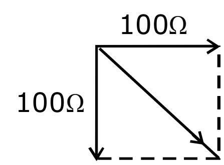
$Z = \sqrt{R^2 + (x_L - x_C)^2}$

When tuned to resonance then

$X_L = X_C$

Z = R

Q.22 (A)



$i_{rms} = \frac{V_{rms}}{2}$ ($X_L = 100\ \Omega$)

$\Rightarrow\ 2.2 = \frac{220}{\sqrt{(100)^2 + (100 - X_C)^2}}$

$\Rightarrow\ (100)^2 + (100 - X_C)^2 = (100)^2$

$X_C = 100$

$\cos 45^o = \frac{1}{\sqrt{2}}$

Q.23 (A)

V = 5 cos ωt = 5 sin (ωt + π/2)

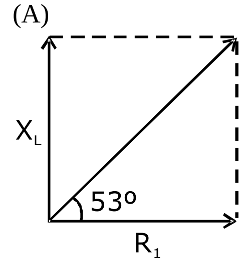
i = 2 sin ωt

$\Rightarrow\ \phi = \pi/2$

$P = V_{rms} \times I_{rms} \cos \phi$

$= \frac{5}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \cos \pi/2 = 0$

Q.24 (A)

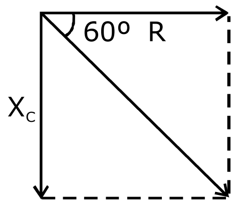


$\cos\phi = 0.6 = \frac{3}{5}$

$\phi = 53^o$

$\cos \phi = 0.5$

$\phi = 60^o$



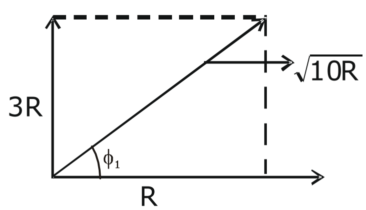
$\Rightarrow X_C = X_L$

$\tan 53° = \dfrac{X_L}{R_1}$ & $\tan 60° = \dfrac{X_C}{R_2}$

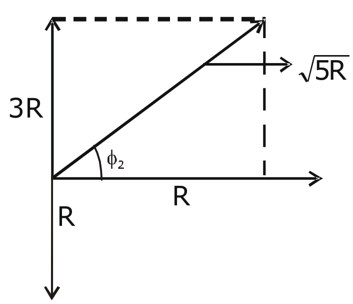
$\Rightarrow \dfrac{4}{3} = \dfrac{X_L}{R_1}$ & $\sqrt{3} = \dfrac{X_4}{R_4}$

$\boxed{\dfrac{R_1}{R_2} = \dfrac{3\sqrt{3}}{4}}$

Q.25 (D)



$\cos\phi_1 = \dfrac{R}{\sqrt{10}R}$



$\cos\phi_2 = \dfrac{R}{\sqrt{5}R} = \dfrac{1}{\sqrt{5}}$

$\dfrac{\cos\phi_2}{\cos\phi_1} = \dfrac{1/\sqrt{5}}{1/\sqrt{10}} = \sqrt{2}$

Q.26 (C)

$P_{average} = i_{rms} V_{rms} \cdot \dfrac{R}{2}$

$= i_{rms}^2 . R$
$= 2^2 \times 5\Omega = 20\Omega$

Q.27 (C)
Given $V = 100 \sin 100t$
$i = 100 \sin (100t + \pi/3)$
$\phi = \pi/3$

$I_{rms} = \dfrac{100}{\sqrt{2}} \times 10^{-3}$ A

$V_{rms} = \dfrac{100}{\sqrt{2}}$

$P = V_{rms} I_{rms} \cos\phi$

$= \dfrac{100}{\sqrt{2}} \times \dfrac{100}{\sqrt{2}} \times 10^{-3} \cos\left(\dfrac{\pi}{3}\right)$

$P = 2.5$ W

JEE-ADVANCED
MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (A,B)

Q.2 (A,B,C)

$I_0 = \dfrac{V_0}{\omega L} = \dfrac{10}{\omega \times 5 \times 10^{-3}}$

Q.3 (A,B)

Q.4 (A,B,C,D)

$Z = \sqrt{R^2 + \left(\omega L - \dfrac{1}{\omega C}\right)^2} = \sqrt{(100)^2 + (100 - 200)^2}$

$= 100\sqrt{2}$

$I_{rms} = \dfrac{V_{rms}}{Z}$

$P_R = I_{rms}^2 R$
$P_L = 0$
$P_C = 0$

Q.5 (A,B,D)

Q.6 (A,B,C)

Resonance frequency $f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}} = 500$ Hz

At resonance

$Z = R$ & $I = \frac{V}{z} = \frac{V}{R}$

L & C are in out of phase.

Q.7 (B,C)

$$I_C = \frac{220}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$$

Brightness of $B_1 = I_C^2 R$

$$I_L = \frac{220}{\sqrt{R^2 + (\omega L)^2}}$$

Brightness of $B_2 = I_L^2 R$

here $I_L > I_C$

So, B_2 will be brighter.

Q.8 (A,C)

Q.9 (B,D)

$P_{avr} = I_{rms} V_{rms} \cos\phi$

$\cos\phi$ can not be more than 1 so power can not be more than 1000.

Q.10 (A,B)

Joule heat $I^2_{rms} R$

Energy in inducting coil = $\frac{1}{2} L I^2_{rms}$.

Q.11 (B,D)

Q.12 (A,C)

Q.13 (D)

As current is leading the source voltage, so circuit should be capacitive in nature and as phase difference is not $\frac{\pi}{2}$, it must contain resistor also.

Q.14 (A)

Time delay = $\frac{\phi}{\omega} = \frac{\pi}{400} \Rightarrow \phi = \frac{\pi}{4}$

$\tan^{-1}\left(\frac{1}{R\omega C}\right) = \frac{\pi}{4} \Rightarrow \frac{1}{\omega C} = R$

$$i_0 = \frac{v_0}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$$

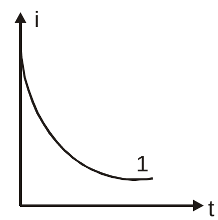
$\sqrt{2} = \frac{100}{\sqrt{R^2 + R^2}} \rightarrow R = 50\ \Omega$

and $C = \frac{1}{50 \times 100} = 200\ \mu F$

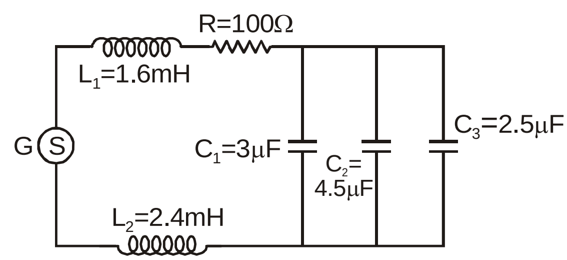
Q.15 (B)

For DC circuit

$i = i_0 e^{-\frac{t}{RC}}$ and RC = 0.01 sec.



An ac generator G with an adjustable frequency of oscillation is used in the circuit, as shown.



Q.16 (C)

Current drawn is maximum at resonant angular frequency. $L_{eq} = 4$ mH $C_{eq} = 10\ \mu F$

$L_{eq} = 4$ mH $C_{eq} = 10\ \mu F$

$\omega = \frac{1}{\sqrt{LC}} = 5000$ rad/s

Q.17 (D)

(D) C_{eq} decreases thereby increasing resonant frequency.

Q.18 (B)

At resonance $i_{rms} = \frac{100}{100} = 1A$

Power supplied $= V_{rms} I_{rms} \cos\phi$ ($\phi = 0$ at resonance)

P = 100 W

Q.19 (B)

Average energy stored = $\frac{1}{2}$ Li^2_{rms}

= $\frac{1}{2}$ $(2.4 \times 10^{-3}$ H) . (1 A)^2 = 1.2 mJ

Q.20 (D)

As 1μs time duration is very less than time period T at resonance, thermal energy produced is not possible to calculate without information about start of the given time duration.

Q.21 (A)

Q.22 (C)

Q.23 (D)

$R_{coil} = \frac{12}{4} = 3\Omega$

$z = \sqrt{R^2 + X_L^2} = \frac{120}{24} = 5$

$X_L^2 = 16 \Rightarrow X_L = 4\Omega$

Now $\cos\phi = \frac{3}{\sqrt{3^2 (X_C - X_L)^2}}$

$= \frac{3}{\sqrt{9 + \left(\frac{1}{\omega_L} - \omega_L\right)^2}} = \frac{3}{5}$

$P = V_{rms}\ I_{rms} \cos\phi = 12 \times 2.4 \times \frac{3}{5} = 17.28\ \omega$

for resonant freq. $\omega = \frac{1}{\sqrt{LC}}$ $\quad \left| \begin{array}{l} L = \frac{4}{50} \\ = \frac{2}{25} \end{array} \right.$

$\omega^2 = \frac{1}{\sqrt{\frac{2}{25} \times 2500 \times 10^{-6}}}$

ω = 70.7 rad/sec

So current, increases continuously from ω = 25 to 50 and maximum at 70.7 rad/sec.

Q.24 (A)

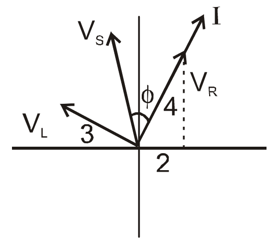
Let at an instant $v_R = (V_R)_m \sin(\omega t + \theta)$

∴ $2 = 4 \sin(\omega t + \theta)$

$\sin(\omega t + \theta) = ½$

∴ $\omega t + \theta = 30°$.

Since V_L is 90° ahead of V_R



$v_L = (V_L)_m \sin(\omega t + \theta + 90)$

∴ $|(V_L)_m| = 3 \cos 30°$

Q.25 (B)

From phasor diagram $(V_S)_m = \sqrt{(V_R)_m{}^2 + (V_L)_m{}^2} = 5$ volt.

$\tan\phi = \frac{V_L)_m}{V_R)_m} = \frac{3}{4}$

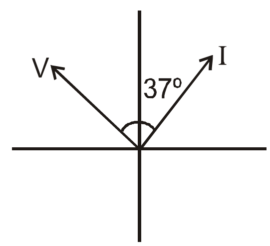
∴ ϕ = 37°

∴ $|v_S| = |(V_S)_m \sin(\omega t + \theta + 37°)|$

= 5 | sin (30° + 37°)| = 5 sin 67°

Q.26 (D)

From phasor diagram it is clear that instantaneous current will decrease or increases, we cannot say.



Q.27 (A) q,r (B) q,r (C) p,q,r,s (D) q,r, s

(A) Inductance of a coil depends on its shape and magnetic properties of its core (medium inserted)

(B) Capacitance of capacitor depends on its shape and dielectric properties of medium inserted.

(C) Impedance of coil $\sqrt{R^2 + \omega^2 L^2}$ depends on resistivity (due to R), shape (for L), magnetic properties of core inserted and also depends on angular frequency ω of external voltage source.

(D) Reactance of capacitor = $\frac{1}{\omega C}$ depends on shape (for C), nature of dielectric medium (for C) and external voltage source (due to ω).

Q.28 (A) r, (B) q, (C) p, (D) q

1 to 2 : When connected with the DC source

$$R = \frac{12}{4} = 3\ \Omega$$

When connected to ac source

$$I = \frac{V}{Z}$$

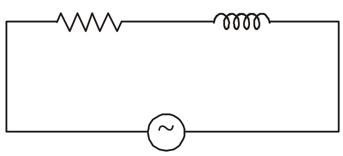
$$\therefore\ 2.4 = \frac{12}{\sqrt{3^2 + \omega^2 L^2}} \qquad \Rightarrow L = 0.08\ H$$

Using $P = I_{rms}\ V_{rms}\ \cos\ \phi \quad = \frac{V_{rms}^2}{Z} \cos\ \phi =$

$$\frac{V_{rms}^2\ \ R}{R^2 + (\omega L - \frac{1}{\omega C})^2} = 24\ W$$

NUMERICAL VALUE BASED

Q.1 [0064]



$$i = \frac{V_0}{Z} = \frac{V_0}{R}$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1.6 \times 250 \times 10^{-6}}}$$

$$V_C = i_0 \times i_0 \times \frac{1}{\omega_C} = \frac{V_0}{\omega CR}$$

$$\frac{10^3}{4 \times 5} = 50$$

$$400 = \frac{32}{50 \times 250 \times 10^{-6} \times R}$$

$$R = \frac{32 \times 10^{-6}}{50 \times 250 \times 400} = 6.4\Omega \quad \Rightarrow \quad \textbf{64 Ans.}$$

Q.2 [0000]

z = x + y i + ωL = x + (y + ωL) for power factor to be one y + ωL = 0 ⇒ y = – 10

$$I = \frac{V_0}{x},\ x = \frac{V_0}{I} = \frac{25}{5} = 5$$

Impedance of box = 5 – 10 i

$$\cos\phi = \frac{5}{\sqrt{10^2 + 5^2}} = \frac{1}{\sqrt{5}} = 0.447$$

Q.3 [5]

Current at resonance $= \frac{V}{R} \Rightarrow R = \frac{V}{I} = \frac{24}{6} = 4\Omega$

Current by 12V battery $= \frac{E}{R + r} = \frac{12}{4 + 4} = 1.5\ A$

KVPY
PREVIOUS YEAR'S

Q.1 (A)

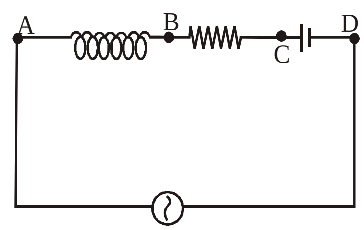
R.M.S. value = 220 V

Peak value = 220 $\sqrt{2}$

ω = 2πn = 2π × 50 = 100 π

$V(t) = 220\sqrt{2}\cos(100\pi t)$

Q.2 (A)



Voltmeter between A & B V_L = 36 V ....(1)

between A & C $\sqrt{V_L^2 + V_R^2} = 39$ ....(2)

between B & D $\sqrt{V_L^2 + V_R^2} = 25$ ....(3)

from equation (1) & (2) $V_R^{\ 2} = 39^2 - 36^2$ ....(4)

V_R = 15 V

From Eq. (3) & (4) $V_C^2 = 25^2 - 15^2$

V_C = 20 V ....(5)

When connected through AD

$$V_{rms} = \sqrt{(V_L - V_C)^2 + V_R^2}$$

$$\Rightarrow \sqrt{16^2 + 15^2}$$

$$\Rightarrow \sqrt{481}$$

Q.3 (C)

Since the voltage production is based upon A.C. supply and this voltage is D.C which is constant. Therefore, no flux will change in secondary and no voltage will be induced.

Answer is (C) 0V.

Q.4 **(C)**

$X_C = \frac{1}{\omega C}$ = is very large therefore bird does after very high capacitive reactance in the path of A.C. current.

Q.5 **(B)**

$V_{Output} = V_R$

$= i_{rms} R$

$$= \frac{V_0 R}{Z} = \frac{V_0 R}{\sqrt{R^2 + (X_L - X_C)^2}}$$

For peak $X_L = X_C \Rightarrow V_{peak} = V_0$

For $V_{Output} = \frac{V_0}{2}$

$$\frac{V_0}{2} = \frac{V_0 R}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$R^2 + (X_L - X_C)^2 = 4R^2$

$X_L - X_C = \pm\sqrt{3}R$

$$\omega L - \frac{1}{\omega C} = \pm\sqrt{3}R$$

$$\omega^2 LC \mp \sqrt{3}R\omega C - 1 = 0$$

$$\omega = \frac{\pm\sqrt{3}RC \pm \sqrt{3R^2C^2 + 4LC}}{2LC}$$

$$\omega_1 = \frac{-\sqrt{3}RC + \sqrt{3R^2C^2 + 4LC}}{2LC} = 200 \times 2\pi$$

$$\omega_2 = \frac{+\sqrt{3}RC + \sqrt{3R^2C^2 + 4LC}}{2LC} = 800 \times 2\pi$$

$$\omega_2 - \omega_1 = 600 \times 2\pi = \sqrt{3}\frac{R}{L}$$

$$\text{Bandwith} = \frac{R}{L} = \frac{2\pi \times 600}{\sqrt{3}}$$

$$\Delta f = \frac{1}{2\pi}\frac{R}{L} = \frac{600}{\sqrt{3}} = 200\sqrt{3}$$

JEE-MAINS PREVIOUS YEAR'S

Q.1 (1)

Since ϕ remains same,

circuit is in resonance.

$$\therefore \quad i_{RMS} = \frac{V_{RMS}}{Z} = \frac{220}{110} = 2A$$

Q.2 (1)

$$I = \sqrt{I_1^2 + I_2^2 + 2I_1I_2\cos 90^o}$$

$$I_0 = \sqrt{I_1^2 + I^2}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$= \sqrt{\frac{I_1^2 + I_2^2}{2}}$$

Q.3 [283]

$$Q = \frac{x_L}{R} = \frac{w_L}{R} = \frac{1}{\sqrt{LC}} \times \frac{L}{R} = \frac{\sqrt{L}}{R\sqrt{C}}$$

$$Q^1 = \frac{\sqrt{2L}.2}{\sqrt{C}R} = 2\sqrt{2}\ Q$$

$Q^1 = 2\sqrt{2}\ (100) = 282.8 = 283$

Q.4 (2)

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{120^2 + (10 - 100)^2}$$

$= 150\ \Omega$

$$I_0 = \frac{V_0}{z} = \frac{30}{150} = 0.2A$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-1} \times 10^{-4}}} = \frac{1}{\sqrt{10^{-5}}} = 2\pi f$$

$$f = \frac{100}{2\pi\sqrt{10}} = \frac{100}{2 \times 10} = 5Hz$$

Q.5 [2000]

$$Q = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{2\pi f L}{R}$$

$$Q = \frac{2\pi \times 10^6 \times 10 \times 2 \times 10^{-4}}{6.28} = 2000$$

$Q = 2000$

Q.6 [440]

$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$

$$\frac{N_P}{24} = \frac{220}{12}\ ; \qquad N_P = 440$$

Q.7 [900]

$$\frac{(120)^2}{R} = 16$$

$$R = \frac{14400}{16} = 800\Omega$$

Q.8 [4]

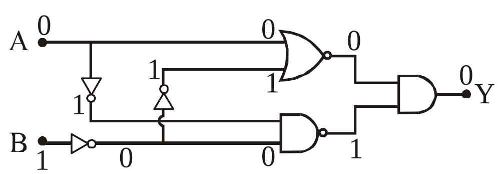
At resonance power (P)

$$P = \frac{(V_{rms})^2}{R}$$

$$P = \frac{\left(250/\sqrt{2}\right)^2}{8} = 3906.25\ W$$

≈ 4 kW

Q.9 [0]



Q.10 (3)

$$V_S = \frac{P}{i} = \frac{60}{0.11} = 545.45$$

$V_P = 220$

$V_S > V_P$

$\Rightarrow$ Step up transformer

Q.11 (2)

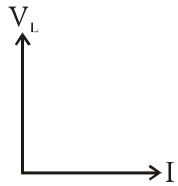
$I = I_1 \sin \omega t + I_2 \cos \omega t$

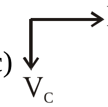
$$\therefore\ I_0 = \sqrt{I_1^2 \quad I_2^2}$$

$$\therefore\ I_{rms} = \frac{I_0}{\sqrt{2}} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$$

Q.12 **(4)**

(a) 

(b) 

(c) 

(d) $$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$$

Q.13 **(2)**

(2) $X_L = \omega L$

$$i = \frac{v_0}{\omega L}$$

Q.14 **(1)**

Bandwidth = R/L

Bandwidth $\propto$ R

So bandwidth will increase

Q.15 **(1)**

$i = i_0 \cos(\omega t)$

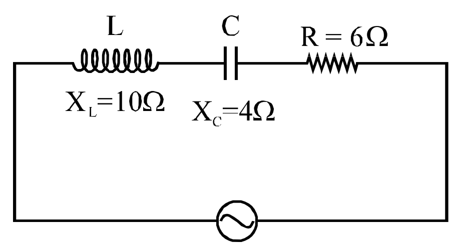
$i = i_0$ at $t = 0$

$$i = \frac{i_0}{\sqrt{2}} \text{ at } \omega t = \frac{\pi}{4}$$

$$t = \frac{\pi}{4\omega} = \frac{\pi}{4(2\pi f)} = \frac{1}{8f}$$

$$t = \frac{1}{400} = 2.5\ ms$$

Q.16 **(3)**

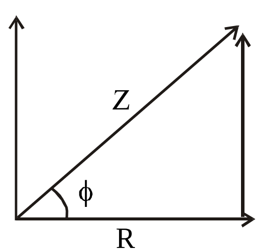


We know that power factor is $\cos\phi$,

$$\cos \phi = \frac{R}{Z} \qquad \text{... (1)}$$

$$Z = \sqrt{R^2 + \ X_L(-X_C)^2} \qquad \text{... (2)}$$

$(\omega L - 1/\omega C)$



$\Rightarrow Z = \sqrt{6^2 \quad (10 \quad 4)^2}$

$\Rightarrow Z = 6\sqrt{2}$ | $\cos\phi = \dfrac{6}{6\sqrt{2}}$

$\cos\phi = \dfrac{1}{\sqrt{2}}$

Q.17 **[3]**

Q.18 [125]

Q.19 (4)

Q.20 **(1)**

Q.21 (3)

Q.22 (1)

Q.23 (1)

Q.24 [1]

Q.25 (1)
For maximum average power
$X_L = X_C$

$250\pi = \dfrac{1}{2\pi(50)C}$

$C = 4 \times 10^{-6}$
Option (1)

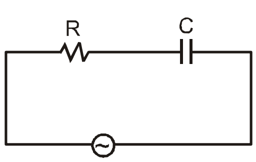
Q.26 (3)

Q.27 [3840]
$E = i_2 RT$
$192 = 16(R)\ (1)$
$R = 12\ W$
$E^1 = (8)^2\ (12)\ (5)$
$= 3840\ J$

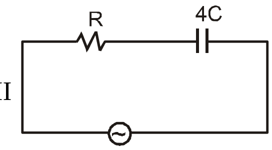
Q.28 [11]

JEE-ADVANCED
PREVIOUS YEAR'S

Q.1 (B,C)

Case I


$Z = \sqrt{R^2 + \left(\dfrac{1}{\omega C}\right)^2}$

Case II


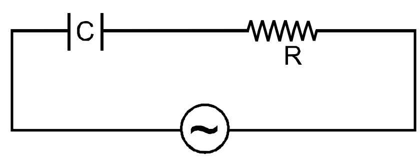
$I_R^A = \dfrac{V}{Z}$ $Z' < Z$

$I_R^B = \dfrac{V}{Z'}$ $I_R^A < I_R^B$

$V_R^A < V_R^B$

So. $V_C^A > V_C^B \because V_R^2 + V_C^2 = V_0^2$

Q.2 4



$W = 500$ rad/s

$Z = \sqrt{\left(\dfrac{1}{\omega C}\right)^2 + R^2} = R\sqrt{1.25}$

$\left(\dfrac{1}{\omega C}\right)^2 + R^2 = R^2\ (1.25)$

$\left(\dfrac{1}{\omega C}\right)^2 + R^2 = R^2 + \dfrac{R^2}{4}$

$\Rightarrow \dfrac{1}{\omega C} = \dfrac{R}{2}$

$CR = \dfrac{2}{w} = \dfrac{2}{500}$ sec.

$= \dfrac{2}{500} \times 10^3$ ms

$= \dfrac{2 \times 1000}{500}$ ms

$= 4$ ms

Q.3 (A,C or C)

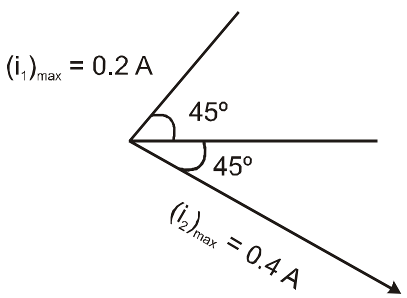
Since $I_{rms} = \frac{1}{\sqrt{10}} \approx$ 0.3 A so A may or may not be correct.

$C = 100\ \mu F,\ \frac{1}{\omega C} = \frac{1}{(100)(100\times10^{-6})}$

$X_C = 100\ \Omega,\qquad X_L = \omega L = (100)(.5) = 50\ \Omega$

$Z_1 = \sqrt{x_C^2 + 100^2} = 100\sqrt{2}\Omega$

$Z_2 = \sqrt{x_L^2 + 50^2} = \sqrt{50^2 + 50^2} = 50\sqrt{2}$



$\varepsilon = 20\sqrt{2}\sin\omega t$

$i_1 = \frac{20\sqrt{2}}{100\sqrt{2}}\sin(\omega t + \pi/4)$

$i_1 = \frac{1}{5}\sin(\omega t + \pi/4)$

$I_2 = \frac{20\sqrt{2}}{50\sqrt{2}}\sin(\omega t - \pi/4)$

$I = \sqrt{(.2)^2 + (.4)^2}$

$= (.2)\sqrt{1+4}$

$= \frac{1}{5}\sqrt{5} = \frac{1}{\sqrt{5}}$

$(I)_{rms} = \frac{1}{\sqrt{2}\sqrt{5}} = \frac{1}{\sqrt{10}} = \frac{\sqrt{10}}{10}$

$\approx 0.3A$

$(V_{100\Omega})_{rms} = (I_1)_{rms}) \times 100$

$= \left(\frac{0.2}{\sqrt{2}}\right) \times 100 = \frac{20}{\sqrt{2}} = 10\sqrt{2}$ V

$V_{50\Omega})_{rms} = \left(\frac{0.4}{\sqrt{2}}\right) \times 50 = \frac{20}{\sqrt{2}} = 10\sqrt{2}$ V

Since $I_{rms} = \frac{1}{\sqrt{10}} \approx$ 0.3 A so A may or may not be correct.

Q.4 (B)

$P = 600 \times 1000 = 4000 \times I \Rightarrow I = 150$ A

$\frac{dH}{dt} = (150)^2 \times 0.4 \times 20 \times 2$

$= 0.3 \Rightarrow 30\ \%$

Q.5 (A)

$\frac{N_p}{N_s} = \frac{40,000}{200} = \frac{200}{1}$

Q.6 (C, D)

Charge on capacitor will be maximum at $t = \frac{\pi}{2\omega}$

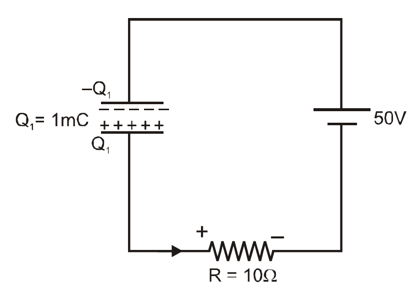
$Q_{max} = 2 \times 10^{-3}$ C

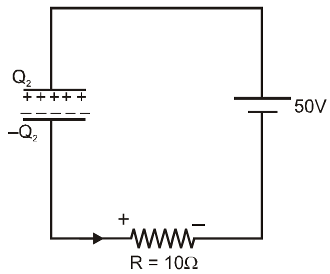
(A) charge supplied by source from t = 0 to $t = \frac{7\pi}{6\omega}$

$$Q = \int_0^{\frac{7\pi}{6\omega}} \cos(500t)dt = \left[\frac{\sin 500t}{500}\right]_0^{\frac{7\pi}{6\omega}} = \frac{\sin\frac{7\pi}{6}}{500} = -1mC$$

Just after switching

In steady state





Apply KVL just after switching

$$50 + \frac{Q_1}{C} - IR = 0 \Rightarrow \quad I = 10\text{ A}$$

In steady state $\quad Q_2 = 1\text{mC}$

net charge flown from battery = 2mC

Q.7 (C,D)

Current will be in phase with voltage at resonant frequency.

$$\omega L = \frac{1}{\omega C} \quad \Rightarrow \quad \omega_0 = \frac{1}{\sqrt{LC}} = 10^6 \sec^{-1}$$

If $\omega > \omega_0$

Circuit behaves like inductive.

If $\omega \sim 0 \quad Z \to \infty \quad \Rightarrow I \to 0$

Q.8 (A,C)

$$V_{xy} = V_x - V_y = \left(V_{xy}\right)_0 \sin\left(\omega t + \phi_1\right)$$

$$\left(V_{xy}\right)_0 = \sqrt{V_0^2 + V_0^2 - 2V_0^2 \cos\frac{2\pi}{3}} = \sqrt{3}V_0$$

$$\left(V_{xy}\right)_{rms} = \frac{\left(V_{xy}\right)_0}{\sqrt{2}} = \sqrt{\frac{3}{2}}V_0$$

$$V_{yz} = V_y - V_z = (V_{yz})_0 \sin(\omega t + \phi_2)$$

$$\left(V_{yz}\right)_0 = \sqrt{V_0^2 + V_0^2 - 2V_0^2 \cos\frac{2\pi}{3}} = \sqrt{3}V_0$$

$$\left(V_{yz}\right)_{rms} = \frac{\left(V_{yz}\right)_0}{\sqrt{2}} = \sqrt{\frac{3}{2}}V_0$$

$$V_{xz} = V_x - V_z = (V_{xz})_0 \sin(\omega t + \phi_3)$$

$$\left(V_{xz}\right)_0 = \sqrt{V_0^2 + V_0^2 - 2V_0^2 \cos\frac{4\pi}{3}} = \sqrt{3}V_0$$

$$\left(V_{xz}\right)_{rms} = \frac{\left(V_{yz}\right)_0}{\sqrt{2}} = \sqrt{\frac{3}{2}}V_0$$

Q.9 [100.00]

Q.10 [60.00]