Chapter
21

Magnetic Effect of Current

Oersted found that a magnetic field is established around a current carrying conductor.

Magnetic field exists as long as there is current in the wire.

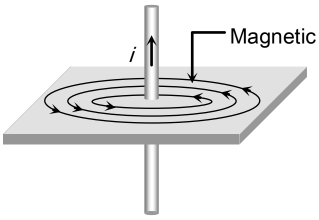


Fig. 21.1

Biot-Savart's Law

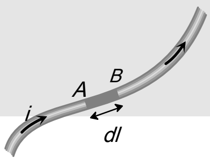
Biot-Savart's law is used to determine the magnetic field at any point due to a current carrying conductor.

This law is although for infinitesimally small conductor yet it can be used for long conductors. In order to understand the Biot-Savart's law, we need to understand the term current-element.

Current element

It is the product of current and length of infinitesimal segment of current carrying wire.

The current element is taken as a vector quantity. Its direction is same as the direction of current.



Current element $AB = i\vec{dl}$

According to Biot-Savart Law, magnetic field at point 'P due to the current element $i\vec{dl}$ is given by the expression,

$\vec{dB} = k\dfrac{i\,dl\sin\theta}{r^2}\hat{n}$ also $\vec{B} = \int d\vec{B} = \dfrac{\mu_0 i}{4\pi}.\int\dfrac{dl\sin\theta}{r^2}\hat{n}$

In C.G.S. k = 1 and in S.I. : $k = \dfrac{\mu_0}{4\pi}$

where μ_0 = Absolute permeability of air or vacuum $= 4\pi\times10^{-7}\dfrac{Wb}{Amp-metre}$. It's other units are

$\dfrac{Henry}{metre}$ or $\dfrac{N}{Amp^2}$ or $\dfrac{Tesla-metre}{Ampere}$

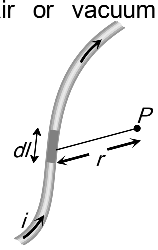


Fig. 21.2

Vectorially, $d\vec{B} = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i(\vec{dl}\times\hat{r})}{r^2} = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i(\vec{dl}\times\vec{r})}{r^3}$

Direction of Magnetic Field

The direction of magnetic field is determined with the help of the following simple laws :

(1) **Maxwell's cork screw rule :** According to this rule, if we imagine a right handed

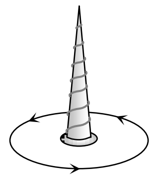


Fig. 21.3

screw placed along the current carrying linear conductor, be rotated such that the screw moves in the direction of flow of current, then the direction of rotation of the thumb gives the direction of magnetic lines of force.

(2) **Right hand thumb rule :** According to this rule if a straight current carrying conductor is held in the right hand such that the thumb of the hand represents the direction of current flow, then the direction of folding fingers will represent the direction of magnetic lines of force.

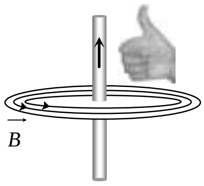


Fig. 21.4

(3) **Right hand thumb rule of circular currents :** According to this rule if the direction of current in circular conducting coil is in the direction of folding fingers of right hand, then the direction of magnetic field will be in the direction of stretched thumb.

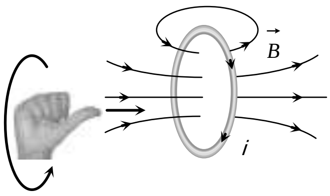


Fig. 21.5

(4) **Right hand palm rule**

If we stretch our right hand such that fingers point towards the point. At which magnetic field is required while thumb is in the direction of current then normal to the palm will show the direction of magnetic field.

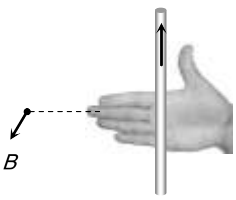


Fig. 21.6

Meaning of Cross ⊗ and dot ⊙

If magnetic field is directed perpendicular and into the plane of the paper it is represented by ⊗ (cross) while if magnetic field is directed perpendicular and out of the plane of the paper it is represented by ⊙ (dot)

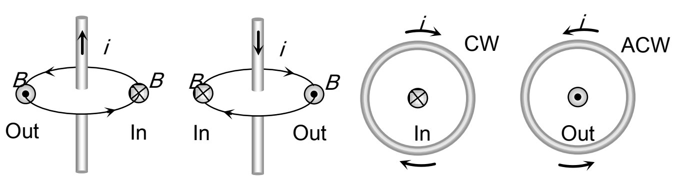


Fig. 21.7

In : Magnetic field is away from the observer or perpendicular inwards.

Out : Magnetic field is towards the observer or perpendicular outwards.

Ampere's Law

Amperes law gives another method to calculate the magnetic field due to a given current distribution.

Line integral of the magnetic field $\vec{B}$ around any closed curve is equal to μ_0 times the net current *i* threading through the area enclosed by the curve *i.e.*

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \Sigma i = \mu_0 (i_1 + i_3 - i_2)$$

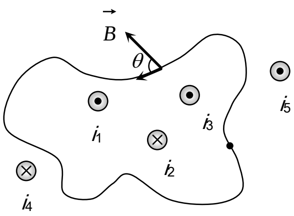


Fig. 21.8

Also using $\vec{B} = \mu_0 \vec{H}$ (where $\vec{H}$ = magnetising field)

$$\oint \mu_0 \vec{H}.\vec{dl} = \mu_0 \Sigma i \Rightarrow \oint \vec{H}.\vec{dl} = \Sigma i$$

Total current crossing the above area is $(i_1 + i_3 - i_2)$. Any current outside the area is not included in net current. (Outward ⊙ → +*ve*, Inward ⊗ → – *ve*)

Table 21.1 : Biot-Savart's law v/s Ampere's law

Biot-Savart's law	Ampere's law
this law is valid for all current distributions	This law is valid for symmetrical current distributions
This law is the differential form of $\vec{B}$ or $\vec{H}$	Basically this law is the integral from of $\vec{B}$ or $\vec{H}$
This law is based only on the principle of magnetism	This law is based on the principle of electromagnetism.

Magnetic Field Due to Circular Current

If a coil of radius *r*, carrying current *i* then magnetic field on it's axis at a distance *x* from its centre given by (Application of B

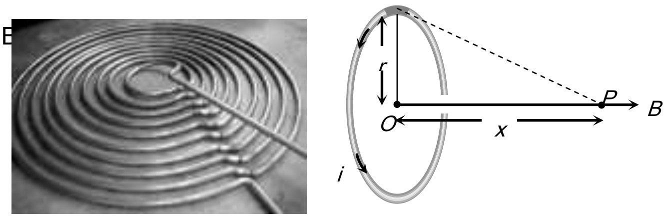


Fig. 21.9

(1) $B_{axis} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi N i r^2}{(x^2 + r^2)^{3/2}}$; where *N* = number of turns in coil.

(2) At centre *x* = 0 $\Rightarrow B_{centre} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi Ni}{r} = \frac{\mu_0 Ni}{2r} = B_{max}$

(3) The ratio of magnetic field at the centre of circular coil and on it's axis is given by $\frac{\boldsymbol{B_{centre}}}{\boldsymbol{B_{axis}}} = \left(\boldsymbol{1} + \frac{\boldsymbol{x^2}}{\boldsymbol{r^2}}\right)^{3/2}$

(4) If *x* >> *r* $\Rightarrow B_{axis} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi N i r^2}{x^3} = \frac{\mu_0}{4\pi} \cdot \frac{2NiA}{x^3}$

where *A* = πr^2 = Area of each turn of the coil.

(5) ***B-x* curve** : The variation of magnetic field due to a circular coil as the distance *x* varies as shown in the figure.

B varies non-linearly with distance *x* as shown in figure and is maximum when $x^2 = \min = 0$, *i.e.*, the point is at the centre of the coil and it is zero at *x* = ± ∞.

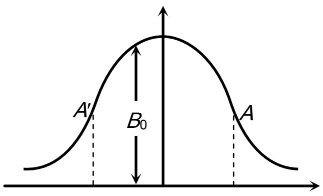


Fig. 21.10

(6) **Point of inflection** (*A* and *A*′) **:** Also known as points of curvature change or points of zero curvature.

(i) At these points *B* varies linearly with *x* $\Rightarrow \frac{dB}{dx} =$ constant $\Rightarrow \frac{d^2B}{dx^2} = 0$.

(ii) These are located at $x = \pm \frac{r}{2}$ from the centre of the coil and the magnetic field at $x = \frac{r}{2}$ is $B = \frac{4\mu_0 Ni}{5\sqrt{5}\, r}$

(7) **Helmholtz coils**

(i) This is the set-up of two coaxial coils of same radius such that distance between their centres is equal to their radius.

(ii) At axial mid point *O*, magnetic field is given by $B = \frac{8\mu_0 Ni}{5\sqrt{5}R} = 0.716 \frac{\mu_0 Ni}{R} = 1.432\, B$, where $B = \frac{\mu_0 Ni}{2R}$

(iii) Current direction is same in both coils otherwise this arrangement is not called Helmholtz's coil arrangement.

(iv) Number of points of inflextion ⇒ Three (*A*, *A*′, *A*″)

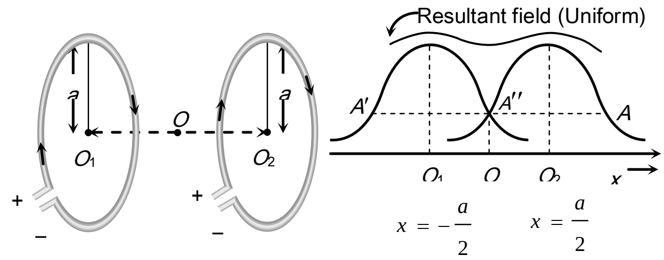
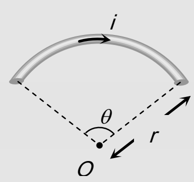
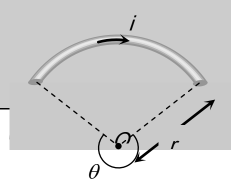
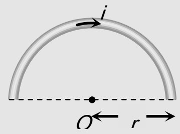
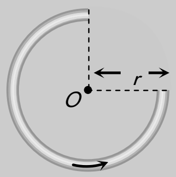
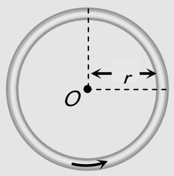
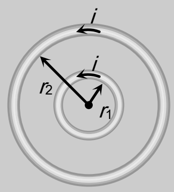
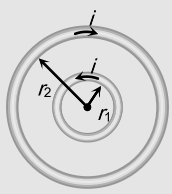
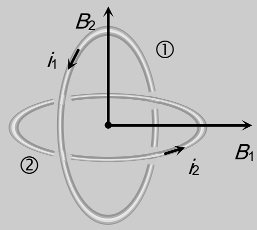
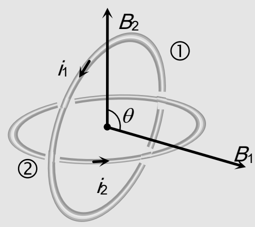
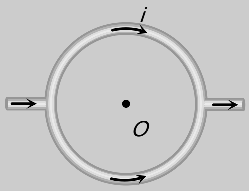
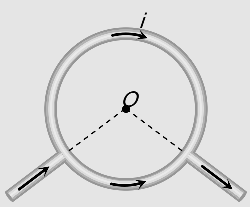


Fig. 21.11

Magnetic Field at Centre *O* in Different Conditions of Circular Current

Condition	Figure	Magnetic field
Arc subtends angle θ at the centre		$B = \frac{\mu_0}{4\pi} \cdot \frac{\theta\, i}{r}$
Arc subtends		

angle $(2\pi-\theta)$ at the centre		$B=\frac{\mu_0}{4\pi}\cdot\frac{(2\pi-\theta)i}{r}$
Semi-circular arc		$B=\frac{\mu_0}{4\pi}\cdot\frac{\pi i}{r}=\frac{\mu_0 i}{4r}$
Three quarter semi-circular current carrying arc		$B=\frac{\mu_0}{4\pi}\cdot\frac{\left(2\pi-\frac{\pi}{2}\right)i}{r}$ $=\frac{3\mu_0 i}{8r}$
Circular current carrying arc		$B=\frac{\mu_0}{4\pi}\frac{2\pi i}{r}$ $=\frac{\mu_0 i}{2r}$
Concentric co-planer circular loops carries current in the same direction		$B_1=\frac{\mu_0}{4\pi}2\pi i\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$
Concentric co-planer circular loops carries current in the opposite direction		$B_2=\frac{\mu_0}{4\pi}2\pi i\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$
Concentric loops but their planes are perpendicular to each other		$B=\sqrt{B_1^2+B_2^2}$ $=\frac{\mu_0}{2r}\sqrt{i_1^2+i_2^2}$
Concentric loops but their planes are at an angle θ with each other		$B=\sqrt{B_1^2+B_2^2+2B_1B_2\cos\theta}$
Distribution of current across the diameter		$B=0$
Distribution of current between any two points on the circumference		$B=0$

Magnetic Field Due to a Straight Wire

Magnetic field due to a current carrying wire at a point *P* which lies at a perpendicular distance *r* from the wire as shown is given as

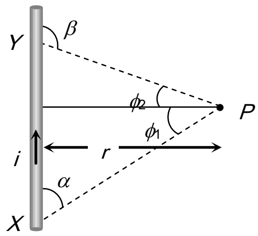


Fig. 21.12

$$B = \frac{\mu_0}{4\pi}.\frac{i}{r}(\sin\phi_1 + \sin\phi_2)$$

From figure $\alpha = (90^o - \phi_1)$

and $\beta = (90^o + \phi_2)$

Hence $B = \frac{\mu_o}{4\pi}.\frac{i}{r}(\cos\alpha - \cos\beta)$

(1) **For a wire of finite length :** Magnetic field at a point which lies on perpendicular bisector of finite length wire

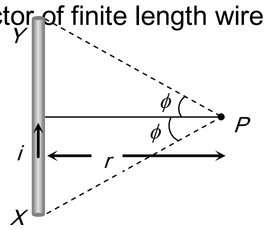


Fig. 21.13

$\phi_1 = \phi_2 = \phi$

So $B = \frac{\mu_0}{4\pi}.\frac{i}{r}(2\sin\phi)$

(2) **For a wire of infinite length :** When the linear conductor *XY* is of infinite length and the point *P* lies near the centre of the conductor $\phi_1 = \phi_2 = 90^o$.

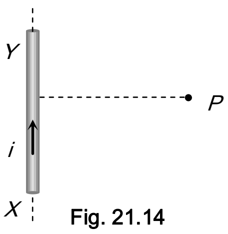


Fig. 21.14

So, $B = \frac{\mu_0}{4\pi}\frac{i}{r}[\sin 90^o + \sin 90^o]$

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

(3) **For a wire of semi-infinite length :** When the linear conductor is of infinite length and the point *P* lies near the end *Y* or *X*. $\phi_1 = 90^o$ and $\phi_2 = 0^o$

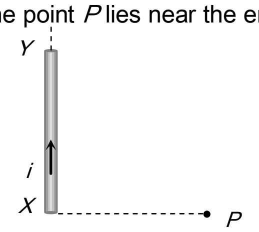


Fig. 21.15

So, $B = \frac{\mu_0}{4\pi}\frac{i}{r}[\sin 90^o + \sin 0^o]$

$= \frac{\mu_0 i}{4\pi r}$

(4) **For axial position of wire :** When point *P* lies on axial position of current carrying conductor then magnetic field at *P*

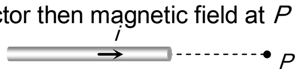


Fig. 21.16

B = 0

Magnetic Field Due to a Cylindrical Wire

Magnetic field due to a cylindrical wire is obtained by the application of Ampere's law

(1) **Outside the cylinder**

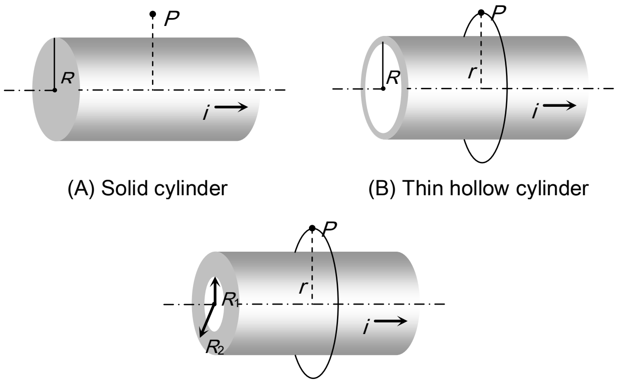


Fig. 21.17

In all above cases magnetic field outside the wire at *P*

$$\oint \vec{B}.\vec{dl} = \mu_0 i \Rightarrow B\int dl = \mu_0 i \Rightarrow B \times 2\pi r = \mu_0 i \Rightarrow B_{out} = \frac{\mu_0 i}{2\pi r}$$

In all the above cases $B_{surface} = \frac{\mu_0 i}{2\pi R}$

(2) **Inside the hollow cylinder :** Magnetic field inside the hollow cylinder is zero.

(A) Thin hollow cylinder (B) Thick hollow cylinder

Fig. 21.18

(3) **Inside the solid cylinder :** Current enclosed by loop (*i*′) is lesser then the total current (*i*)

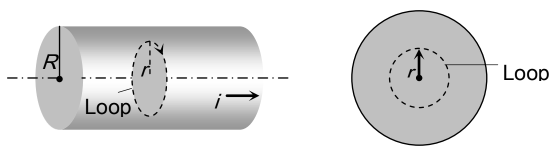


Fig. 21.19

Current density is uniform *i.e.* $J = J' \Rightarrow i' = i \times \frac{A'}{A} = i\left(\frac{r^2}{R^2}\right)$

Hence at inside point $\oint \overrightarrow{B_{in}}.\overrightarrow{dl} = \mu_0 i' \Rightarrow B = \frac{\mu_0}{2\pi}.\frac{ir}{R^2}$

(4) **Inside the thick portion of hollow cylinder :** Current enclosed by loop is given as $i' = i \times \frac{A'}{A} = i \times \frac{(r^2 - R_1^2)}{(R_2^2 - R_1^2)}$

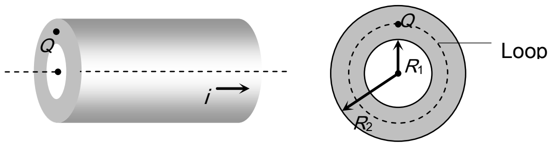


Fig. 21.20

Hence at point Q $\oint \vec{B}.\vec{dl} = \mu_0 i' \Rightarrow B = \frac{\mu_0 i}{2\pi r}.\frac{(r^2 - R_1^2)}{(R_2^2 - R_1^2)}$

Magnetic Field Due to an Infinite Sheet Carrying Current

The figure shows an infinite sheet of current with linear current density j (A/m). Due to symmetry the field line pattern above and below the sheet is uniform. Consider a square loop of side l as shown in the figure.

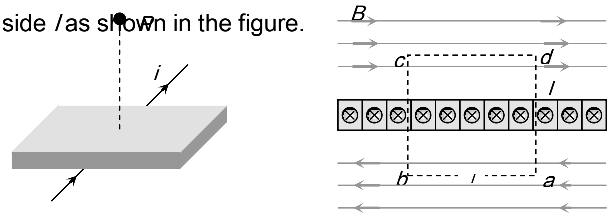


Fig. 21.21

$$\int_a^b \vec{B}.\vec{dl} + \int_b^c \vec{B}.\vec{dl} + \int_c^d \vec{B}.\vec{dl} + \int_d^a \vec{B}.\vec{dl} = \mu_0 i \quad \text{(By Ampere's law)}$$

Since $B \perp dl$ along the path $b \rightarrow c$ and $d \rightarrow a$, therefore,

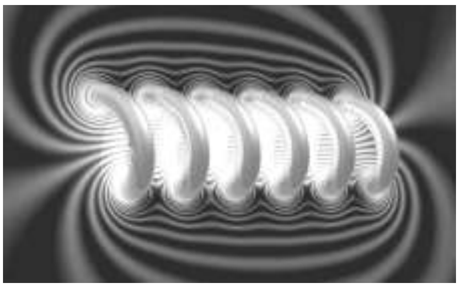
$\int_b^c \vec{B}.\vec{dl} = 0$; $\int_d^a \vec{B}.\vec{dl} = 0$

Also, $B \parallel dl$ along the path $a \rightarrow b$ and $c \rightarrow d$, thus

$\int_a^b \vec{B}.\vec{dl} + \int_d^a \vec{B}.\vec{dl} = 2Bl$

The current enclosed by the loop is $i = jl$. Therefore, according to Ampere's law $2Bl = \mu_0(jl)$ or $B = \frac{\mu_0 j}{2}$

Solenoid



A cylinderical coil of many tightly wound turns of insulated wire with generally diameter of the coil smaller than its length is called a solenoid.

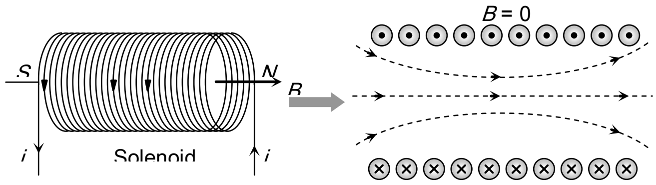


Fig. 21.22

A magnetic field is produced around and within the solenoid. The magnetic field within the solenoid is uniform and parallel to the axis of solenoid.

(1) **Finite length solenoid :** If N = total number of turns, l = length of the solenoid, n = number of turns per unit length $= \frac{N}{l}$

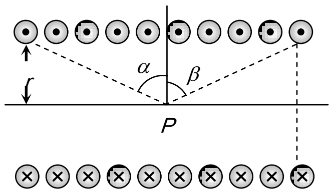


Fig. 21.23

(i) Magnetic field inside the solenoid at point P is given by $B = \frac{\mu_0}{4\pi}(2\pi ni)[\sin\alpha + \sin\beta]$

(ii) **Infinite length solenoid :** If the solenoid is of infinite length and the point is well inside the solenoid *i.e.* $\alpha = \beta = (\pi/2)$.

So $\boldsymbol{B_{in} = \mu_0 ni}$

(iii) If the solenoid is of infinite length and the point is near one end *i.e.* $\alpha = 0$ and $\beta = (\pi/2)$ so $\boldsymbol{B_{end} = \frac{1}{2}(\mu_0 ni)}$

$(B_{end} = \frac{1}{2} B_{in})$

Toroid

A toroid can be considered as a ring shaped closed solenoid. Hence it is like an endless cylindrical solenoid.

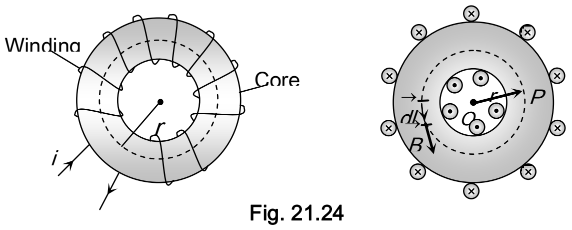


Fig. 21.24

Consider a toroid having *n* turns per unit length. Magnetic field at a point *P* in the figure is given as

$$B = \frac{\mu_0 Ni}{2\pi r} = \mu_o ni \text{ where } n = \frac{N}{2\pi r}$$

Force On a Charged Particle in Magnetic Field

If a particle carrying a positive charge *q* and moving with velocity *v* enters a magnetic field *B* then it experiences a force *F* which is given by the expression $\vec{F} = q(\vec{v} \times \vec{B}) \Rightarrow F = qvB\sin\theta$

where $\vec{v} =$ velocity of the particle, $\vec{B} =$ magnetic field

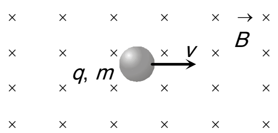


Fig. 21.25

(1) **Zero force :** Force on charged particle will be zero (*i.e.* *F* = 0) if

(i) No field *i.e.* *B* = 0 ⇒ *F* = 0

(ii) Neutral particle *i.e.* *q* = 0 ⇒ *F* = 0

(iii) Rest charge *i.e.* *v* = 0 ⇒ *F* = 0

(iv) Moving charge *i.e.* $\theta = 0^o$ or $\theta = 180^o \Rightarrow F = 0$

(2) **Direction of force :** The force $\vec{F}$ is always perpendicular to both the velocity $\vec{v}$ and the field $\vec{B}$ in accordance with Right Hand Screw Rule, though $\vec{v}$ and $\vec{B}$ themselves may or may not be p… h other.

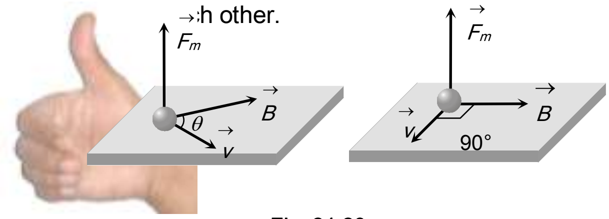


Fig. 21.26

Direction of force on charged particle in magnetic field can also be find by Fleming's Left Hand Rule (FLHR).

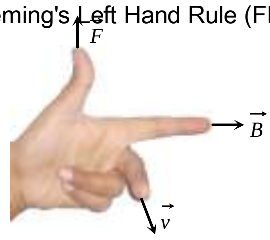


Fig. 21.27

Here, *First finger* (indicates) → Direction of magnetic field

Middle finger → Direction of motion of positive charge or direction, Opposite to the motion of negative charge.

Thumb → Direction of force

Trajectory of a Charged Particle in a Magnetic Field

(1) **Straight line :** If the direction of a $\vec{v}$ is parallel or antiparallel to $\vec{B}$, $\theta = 0$ or $\theta = 180^o$ and therefore *F* = 0. Hence the trajectory of the particle is a straight line.

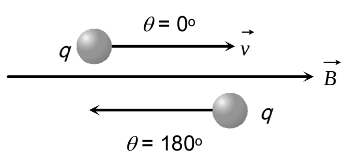


Fig. 21.28

(2) **Circular path :** If $\vec{v}$ is perpendicular to $\vec{B}$ *i.e.* θ = 90°, hence particle will experience a maximum magnetic force ***F_{max} = qvB*** which act's in a direction perpendicular to the motion of charged particle. Therefore the trajectory of the particle is a circle.

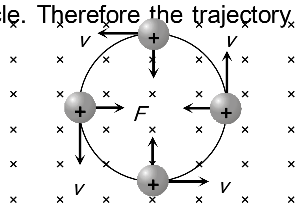


Fig. 21.29

(i) In this case path of charged particle is circular and magnetic force provides the necessary centripetal force *i.e.*

$qvB = \frac{mv^2}{r}$ $\Rightarrow$ radius of path

$\boldsymbol{r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}}$

where *p* = momentum of charged particle and *K* = kinetic energy of charged particle (gained by charged particle after accelerating through potential difference *V*) then $p = mv = \sqrt{2mK} = \sqrt{2mqV}$

(ii) If *T* is the time period of the particle then $T = \frac{2\pi m}{qB}$ (*i.e.*, time period (or frequency) is independent of speed of particle).

(3) **Helical path :** When the charged particle is moving at an angle to the field (other than 0°, 90°, or 180°). Particle describes a path called helix.

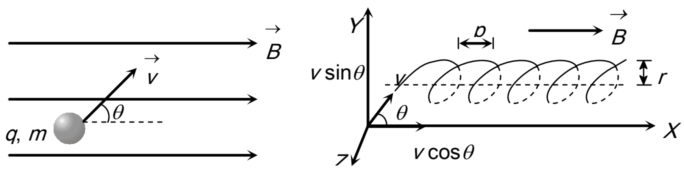


Fig. 21.30

(i) The radius of this helical path is $\boldsymbol{r = \frac{m(v\sin\theta)}{qB}}$

(ii) Time period and frequency do not depend on velocity and so they are given by $T = \frac{2\pi m}{qB}$ and $\nu = \frac{qB}{2\pi m}$

(iii) The *pitch* of the *helix*, (*i.e.*, linear distance travelled in one rotation) will be given by $p = T(v\cos\theta) = 2\pi\frac{m}{qB}(v\cos\theta)$

(iv) If pitch value is *p*, then number of pitches obtained in length *l* given as

Number of pitches $= \frac{l}{p}$ and time required $t = \frac{l}{v\cos\theta}$

Lorentz Force

When the moving charged particle is subjected simultaneously to both electric field $\vec{E}$ and magnetic field $\vec{B}$, the moving charged particle will experience electric force $\vec{F_e} = q\vec{E}$ and magnetic force $\vec{F_m} = q(\vec{v} \times \vec{B})$; so the net force on it will be $\boldsymbol{\vec{F} = q[\vec{E} + (\vec{v} \times \vec{B})]}$. Which is the famous 'Lorentz-force equation'.

Depending on the directions of $\vec{v}, \vec{E}$ and $\vec{B}$ following situations are possible

(i) **When $\vec{v}, \vec{E}$ and $\vec{B}$ all the three are collinear :** In this situation the magnetic force on it will be zero and only electric force will act and so $\vec{a} = \frac{\vec{F}}{m} = \frac{q\vec{E}}{m}$

(ii) The particle will pass through the field following a straight-line path (parallel field) with change in its speed. So in this situation speed, velocity, momentum and kinetic energy all will change without change in direction of motion as shown

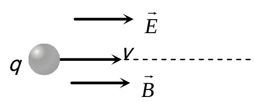


Fig. 21.31

(iii) **$\vec{v}, \vec{E}$ and $\vec{B}$ are mutually perpendicular :** In this situation if $\vec{E}$ and $\vec{B}$ are such that $\vec{F} = \vec{F_e} + \vec{F_m} = 0$ *i.e.*, $\vec{a} = (\vec{F}/m) = 0$

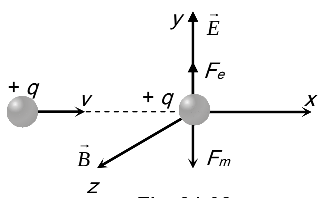


Fig. 21.32

as shown in figure, the particle will pass through the field with same velocity, without any deviation in path.

And in this situation, as $F_e = F_m$ *i.e.*, $qE = qvB$ $v = E/B$

This principle is used in 'velocity-selector' to get a charged beam having a specific velocity.

Cyclotron

Cyclotron is a device used to accelerated positively charged particles (like, α-particles, deutrons *etc.*) to acquire enough energy to carry out nuclear disintegration *etc.*

It is based on the fact that the electric field accelerates a charged particle and the magnetic field keeps it revolving in circular orbits of constant frequency.

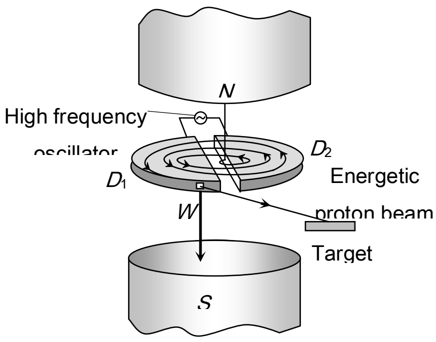


Fig. 21.33

It consists of two hollow *D*-shaped metallic chambers D_1 and D_2 called dees. The two dees are placed horizontally with a small gap separating them. The dees are connected to the source of high frequency electric field. The dees are enclosed in a metal box containing a gas at a low pressure of the order of 10^{-3} *mm* mercury. The whole apparatus is placed between the two poles of a strong electromagnet *NS* as shown in fig. The magnetic field acts perpendicular to the plane of the dees.

(1) **Cyclotron frequency :** Time taken by ion to describe a semicircular path is given by $t = \frac{\pi r}{v} = \frac{\pi m}{qB}$

If T = time period of oscillating electric field then $T = 2t = \frac{2\pi m}{qB}$ the cyclotron frequency $\nu = \frac{1}{T} = \frac{Bq}{2\pi m}$

(2) **Maximum energy of particle :** Maximum energy gained by the charged particle $E_{\max} = \left(\frac{q^2B^2}{2m}\right)r^2$

where r_0 = maximum radius of the circular path followed by the positive ion.

Hall Effect

The Phenomenon of producing a transverse emf in a current carrying conductor on applying a magnetic field perpendicular to the direction of the current is called Hall effect.

Hall effect helps us to know the nature and number of charge carriers in a conductor.

Consider a conductor having electrons as current carriers. The electrons move with drift velocity $\vec{v}$ opposite to the direction of flow of current

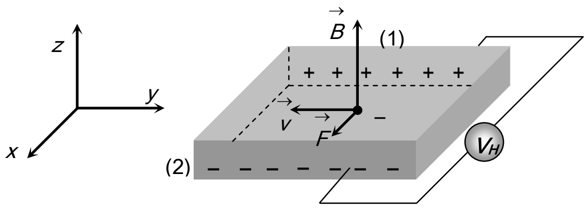


Fig. 21.34

Force acting on electron $F_m = -e(\vec{v} \times \vec{B})$. This force acts along *x*-axis and hence electrons will move towards face (2) and it becomes negatively charged.

Force On a Current Carrying Conductor In Magnetic Field

In case of current carrying conductor in a magnetic field force experienced by its small length element is $d\vec{F} = i d\vec{l} \times \vec{B}$; $i d\vec{l}$ = current element $d\vec{F} = i(d\vec{l} \times \vec{B})$

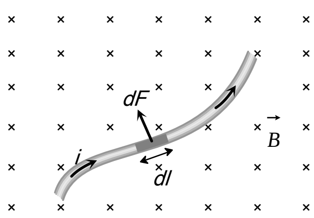


Fig. 21.35

Total magnetic force $\vec{F}=\int d\vec{F}=\int i(d\vec{l}\times\vec{B})$. If magnetic field is uniform *i.e.*, $\vec{B}$ = constant $\vec{F}=i\left[\int d\vec{l}\right]\times\vec{B}=i(\vec{L}\times\vec{B})$

$\int d\vec{l}=\vec{L}'=$ vector sum of all the length elements from initial to final point. Which is in accordance with the law of vector addition is equal to length vector $\vec{L}$ joining initial to final point.

(For a straight conductor $F=Bil\sin\theta$)

Direction of force : The direction of force is always perpendicular to the plane containing $i\vec{dl}$ and $\vec{B}$ and is same as that of cross-product of two vectors $(\vec{A}\times\vec{B})$ with $\vec{A}=i\vec{dl}$.

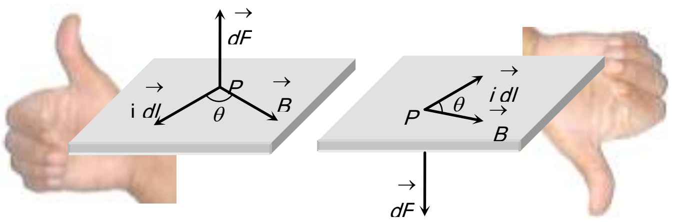


Fig. 21.36

The direction of force when current element $i\vec{dl}$ and $\vec{B}$ are perpendicular to each other can also be determined by applying either of the following rules

Fleming's left-hand rule : Stretch the fore-finger, central finger and thumb of left hand mutually perpendicular. Then if the fore-finger points in the direction of field $\vec{B}$ and the central in the direction of current *i*, the thumb will point in the direction of force.

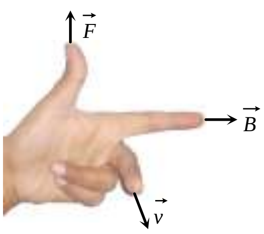


Fig. 21.37

Right-hand palm rule : Stretch the fingers and thumb of right hand at right angles to each other. Then if the fingers point in the direction of field $\vec{B}$ and thumb in the direction of current *i*, then normal to the palm will point in the direction of force

Fig. 21.38

Force Between Two Parallel Current Carrying Conductors

The force on a length *l* of each of two long, straight, parallel wires carrying currents i_1 and i_2 and separated by a distance *a* is

$$F=\frac{\mu_0}{4\pi}\cdot\frac{2i_1i_2}{a}\times l$$

Hence force per unit length

$$\frac{F}{l}=\frac{\mu_0}{4\pi}\cdot\frac{2i_1i_2}{a}\left(\frac{N}{m}\right) \text{ or } \frac{F}{l}=\frac{2i_1i_2}{a}\left(\frac{dyne}{cm}\right)$$

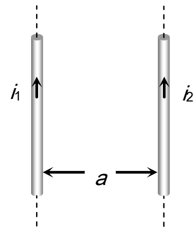


Fig. 21.39

Direction of force : If conductors carries current in same direction, then force between them will be attractive. If conductor carries current in opposite direction, then force between them will be repulsive.

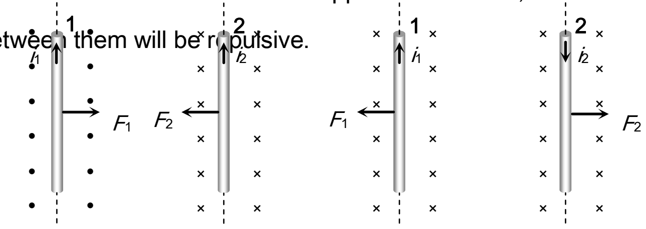


Fig. 21.40

Force Between Two Moving Charges

If two charges q_1 and q_2 are moving with velocities v_1 and v_2 respectively and at any instant the distance between them is r, then

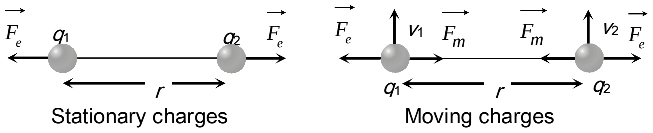


Fig. 21.41

Magnetic force between them is $F_m = \frac{\mu_0}{4\pi} \cdot \frac{q_1 q_2 v_1 v_2}{r^2}$ .... (i)

and Electric force between them is $F_e = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$ .... (ii)

From equation (i) and (ii) $\frac{F_m}{F_e} = \mu_0 \varepsilon_0 v^2$ but $\mu_0 \varepsilon_0 = \frac{1}{c^2}$;

where c is the velocity of light in vacuum. So $\frac{F_m}{F_e} = \left(\frac{v}{c}\right)^2$

As $v < c$ so $F_m < F_e$

Standard Cases For Force on Current Carrying Conductors

***Case* 1 :** When an arbitrary current carrying loop placed in a magnetic field (⊥ to the plane of loop), each element of loop experiences a magnetic force due to which loop stretches and open into circular loop and tension developed in it's each part.

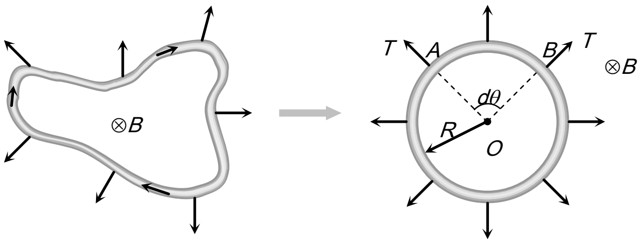


Fig. 21.42

***Case* 2 : Equilibrium of a current carrying conductor :** When a finite length current carrying wire is kept parallel to another infinite length current carrying wire, it can suspend freely in air as shown below

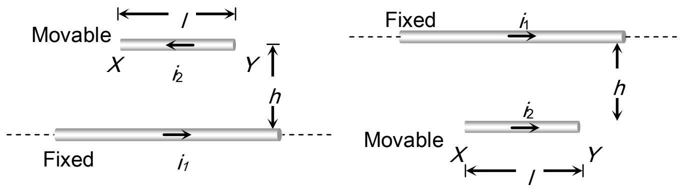


Fig. 21.43

In both the situations for equilibrium of XY it's downward weight = upward magnetic force *i.e.* $mg = \frac{\mu_0}{4\pi} \cdot \frac{2 i_1 i_2}{h} \cdot l$

***Case* 3 : Current carrying spring :** If current is passed through a spring, then it will contract because current will flow through all the turns in the same direction.

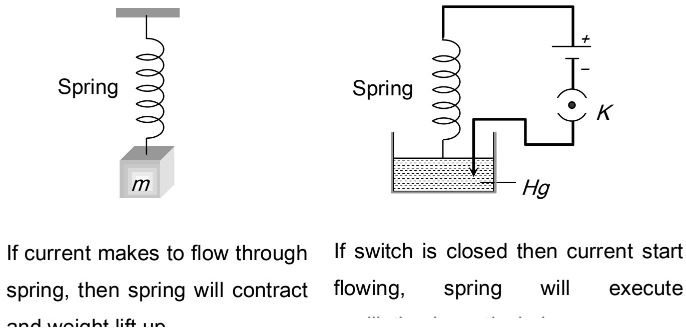


Fig. 21.44

***Case* 4 : Tension less strings :** In the following figure the value and direction of current through the conductor XY so that strings becomes tensionless?

Strings becomes tensionless if weight of conductor XY balanced by magnetic force (F_m).

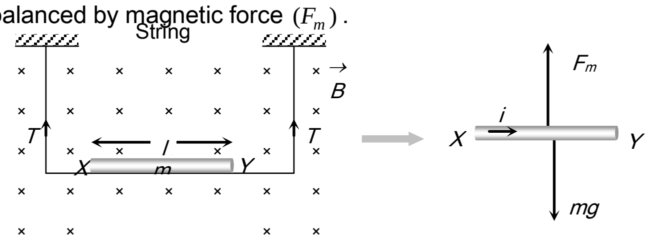


Fig. 21.45

Hence direction of current is from $X \rightarrow Y$ and in balanced condition $F_m = mg \Rightarrow Bil = mg \Rightarrow i = \frac{mg}{Bl}$

Case 5 : **Sliding of conducting rod on inclined rails :** When a conducting rod slides on conducting rails.

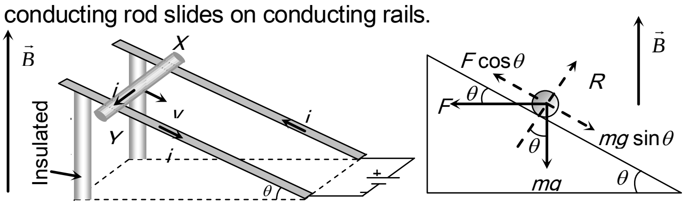


Fig. 21.46

In the following situation conducting rod (*X*, *Y*) slides at constant velocity if

$$F\cos\theta = mg\sin\theta \Rightarrow Bil\cos\theta = mg\sin\theta \Rightarrow B = \frac{mg}{il}\tan\theta$$

Current Loop as a Magnetic Dipole

A current carrying circular coil behaves as a bar magnet whose magnetic moment is *M* = *NiA*; *Where N* = Number of turns in the coil, *i* = Current through the coil and *A* = Area of the coil

Magnetic moment of a current carrying coil is a vector and it's direction is given by right hand thumb rule

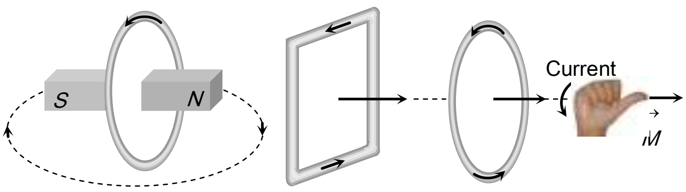


Fig. 21.47

(1) For a given perimeter circular shape have maximum area. Hence maximum magnetic moment.

(2) For a any loop or coil $\vec{B}$ at centre due to current in loop, and $\vec{M}$ are always parallel.

Fig. 21.48

Behaviour of Current Loop in a Magnetic Field

(1) **Torque :** Consider a rectangular current carrying coil *PQRS* having *N* turns and area *A*, placed in a uniform field $\vec{B}$, in such a way that the normal $(\hat{n})$ to the coil makes an angle θ with the direction of $\vec{B}$. the coil experiences a torque given by τ = *NBiA* sinθ. Vectorially $\vec{\tau} = \vec{M} \times \vec{B}$

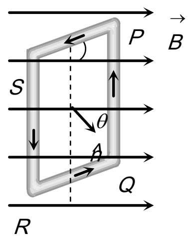


Fig. 21.49

(i) τ is zero when θ = 0, *i.e.*, when the plane of the coil is perpendicular to the field.

(ii) τ is maximum when $\theta = 90^o$, *i.e.*, the plane of the coil is parallel to the field $\tau_{max} = NBiA$

(2) **Workdone :** If coil is rotated through an angle θ from it's equilibrium position then required work. $W = MB(1 - \cos\theta)$. It is maximum when θ = 180° $\Rightarrow$ W_{max} = 2 *MB*

(3) **Potential energy :** *U* = – *MB* cosθ $\Rightarrow U = -\vec{M}.\vec{B}$

Moving Coil Galvanometer

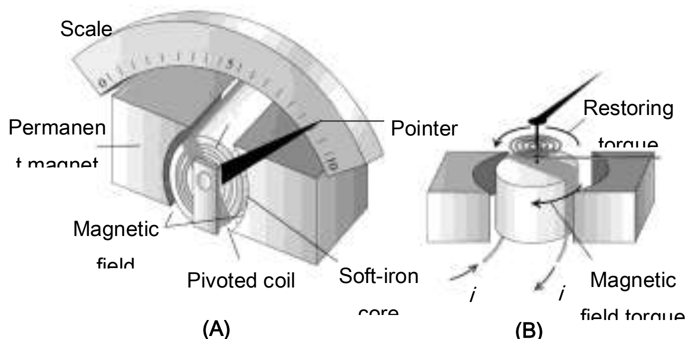


Fig. 21.50

In a moving coil galvanometer the coil is suspended between the pole pieces of a strong horse-shoe magnet. The pole pieces are made cylindrical and a soft iron cylindrical core is placed within the coil without touching it. This makes the field radial. In such a field the plane of the coil always remains parallel to the field. Therefore $\theta = 90^o$ and the deflecting torque always has the maximum value.

$$\tau_{\text{def}} = NBiA \qquad ......(i)$$

Coil deflects, a restoring torque is set up in the suspension fibre. If α is the angle of twist, the restoring torque is

$$\tau_{\text{rest}} = C\alpha \qquad .....(ii)$$

where *C* is the torsional constant of the fibre.

When the coil is in equilibrium *NBiA* = *C*α $\Rightarrow i = K\alpha$,

where $K = \frac{C}{NBA}$ is the galvanometer constant. This linear relationship between *i* and α makes the moving coil galvanometer useful for current measurement and detection.

Current sensitivity (S_i) : The current sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit current flowing through it.

$$S_i = \frac{\alpha}{i} = \frac{NBA}{C}$$

Voltage sensitivity (S_V) : Voltage sensitivity of a galvanometer is defined as the deflection produced in the galvanometer per unit voltage applied to it.

$$S_V = \frac{\alpha}{V} = \frac{\alpha}{iR} = \frac{S_i}{R} = \frac{NBA}{RC}$$

Tips & Tricks

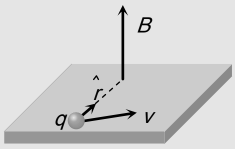
✍ The device whose working principle based on Halmholtz coils and in which uniform magnetic field is used called as "Halmholtz galvanometer".

✍ The value of magnetic field induction at a point, on the centre of separation of two linear parallel conductors carrying equal currents in the same direction is zero.

✍ If a current carrying circular loop (*n* = 1) is turned into a coil having n identical turns then magnetic field at the centre of the coil becomes n^2 times the previous field *i.e.* $B_{(n\ turn)} = n^2 B_{(single\ turn)}$

✍ When a current carrying coil is suspended freely in earth's magnetic field, it's plane stays in **East-West** direction.

✍ Magnetic field ($\vec{B}$) produced by a moving charge *q* is given by $\vec{B} = \frac{\mu_0}{4\pi}\frac{q(\vec{v} \times \vec{r})}{r^3} = \frac{\mu_0}{4\pi}\frac{q(\vec{v} \times \hat{r})}{r^2}$; where *v* = velocity of charge and *v* << *c* (speed of light).



✍ If an electron is revolving in a circular path of radius *r* with speed *v* then magnetic field produced at the centre of circular path $B = \frac{\mu_0}{4\pi}\cdot\frac{ev}{r^2} \Rightarrow r \propto \sqrt{\frac{v}{B}}$

✍ The line integral of magnetising field $(\vec{H})$ for any closed path called magnetomotive force (MMF). It's S.I. unit is amp.

✍ Ratio of dimension of e.m.f. to MMF is equal to the dimension of resistance.

✍ The positive ions are produced in the gap between the two dees by the ionisation of the gas. To produce proton, hydrogen gas is used; while for producing alpha-particles, helium gas is used.

✍ Cyclotron frequency is also known as magnetic resonance frequency.

✍ Cyclotron can not accelerate electrons because they have very small mass.

✍ The energy of a charged particle moving in a uniform magnetic field does not change because it experiences a force in a direction, perpendicular to it's direction of motion. Due to which the speed of charged particle remains unchanged and hence it's K.E. remains same.

✍ Magnetic force does no work when the charged particle is displaced while electric force does work in displacing the charged particle.

✍ Magnetic force is velocity dependent, while electric force is independent of the state of rest or motion of the charged particle.

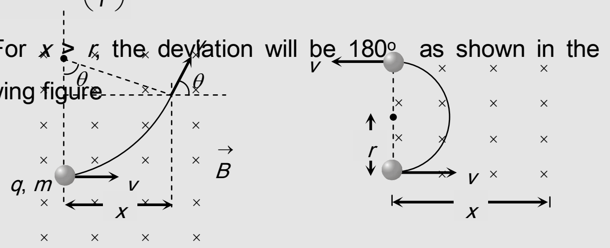
✍ If a particle enters a magnetic field normally to the magnetic field, then it starts moving in a circular orbit. The point at which it enters the magnetic field lies on the circumference. (Most of us confuse it with the centre of the orbit)

✍ Deviation of charged particle in magnetic field : If a charged particle (*q*, *m*) enters a uniform magnetic field $\vec{B}$ (extends upto a length x) at right angles with speed v as shown in figure. The speed of the particle in magnetic field does not change. But it gets deviated in the magnetic field.

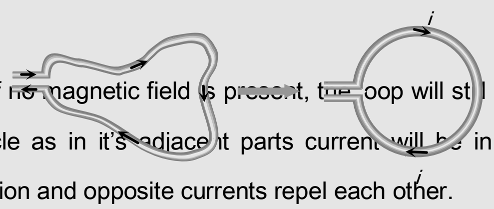
Deviation in terms of time t; $\theta = \omega t = \left(\frac{Bq}{m}\right)t$

Deviation in terms of length of the magnetic field; $\theta = \sin^{-1}\left(\frac{x}{r}\right)$. This relation can be used only when $x \le r$.

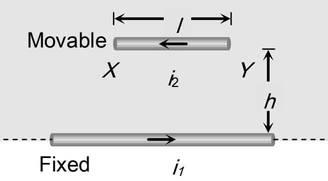
For $x > r$, the deviation will be 180° as shown in the following figure



✍ If no magnetic field is present, the loop will still open into a circle as in it's adjacent parts current will be in opposite direction and opposite currents repel each other.



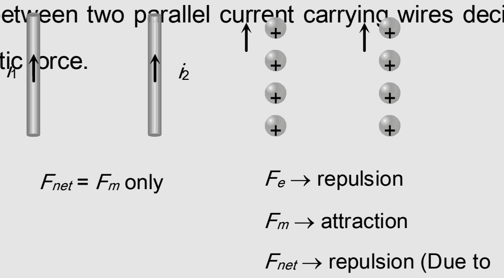
✍ In the following case if wire *XY* is slightly displaced from its equilibrium position, it executes SHM and it's time period is given by $T = 2\pi\sqrt{\frac{h}{g}}$.



✍ In the previous case if direction of current in movable wire is reversed then it's instantaneous acceleration produced is 2*g* ↓.

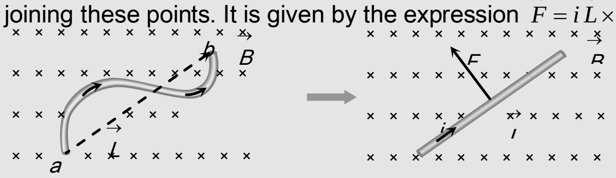
✍ Electric force is an absolute concept while magnetic force is a relative concept for an observer.

✍ The nature of force between two parallel charge beams decided by electric force, as it is dominator. The nature of force between two parallel current carrying wires decided by magnetic force.



✍ If a straight current carrying wire is placed along the axis of a current carrying coil then it will not experience magnetic force because magnetic field produced by the coil is parallel to the wire.

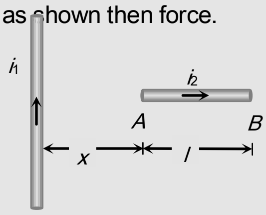
✍ The force acting on a curved wire joining points *a* and *b* as shown in the figure is the same as that on a straight wire joining these points. It is given by the expression $\vec{F} = i\vec{L} \times \vec{B}$



✍ If a current carrying conductor AB is placed transverse to a long current carrying conductor as shown then force.

Experienced by wire AB

$$F = \frac{\mu_0 i_1 i_2}{2\pi} \log_e \left(\frac{x+l}{x} \right)$$



Ordinary Thinking

Objective Questions

Biot-savart's Law and Ampere's Law

1. A length L of wire carries a steady current I. It is bent first to form a circular plane coil of one turn. The same length is now bent more sharply to give a double loop of smaller radius. The magnetic field at the centre caused by the same current is **[NCERT 1980; AIIMS 1980; MP PMT 1995, 99]**
   (a) A quarter of its first value
   (b) Unaltered
   (c) Four times of its first value
   (d) A half of its first value

2. A vertical straight conductor carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west at the same distance. The magnetic field at P is **[MNR 1986; DPMT 2004]**
   (a) Greater than at Q
   (b) Same as at Q
   (c) Less than at Q
   (d) Greater or less than at Q depending upon the strength of the current

3. If a copper rod carries a direct current, the magnetic field associated with the current will be **[CPMT 1984]**
   (a) Only inside the rod
   (b) Only outside the rod
   (c) Both inside and outside the rod
   (d) Neither inside nor outside the rod

4. If a long hollow copper pipe carries a direct current, the magnetic field associated with the current will be

[CBSE PMT 1999; AFMC 1999; CPMT 1984, 2000; Pb. PET 2000; JIPMER 2002]

(a) Only inside the pipe

(b) Only outside the pipe

(c) Neither inside nor outside the pipe

(d) Both inside and outside the pipe

5. The magnetic field $d\vec{B}$ due to a small current element $d\vec{l}$ at a distance $\vec{r}$ and element carrying current i is,

or

Vector form of Biot-savart's law is

[CBSE PMT 1996; MP PET 2002; MP PMT 2000]

(a) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r} \right)$ (b) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r} \right)$

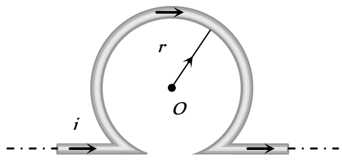
(c) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r^2} \right)$ (d) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r^3} \right)$

6. A charge q *coulomb* moves in a circle at n revolutions per second and the radius of the circle is r *metre*. Then magnetic field at the centre of the circle is

(a) $\frac{2\pi q}{nr} \times 10^{-7}$ *N/amp/metre* (b) $\frac{2\pi q}{r} \times 10^{-7}$ *N/amp/metre*

(c) $\frac{2\pi nq}{r} \times 10^{-7}$ *N/amp/metre* (d) $\frac{2\pi q}{r}$ *N/amp/metre*

7. An infinitely long straight conductor is bent into the shape as shown in the figure. It carries a current of i *ampere* and the radius of the circular loop is r *metre*. Then the magnetic induction at its centre will be [MP PMT 1999]



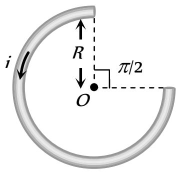
(a) $\frac{\mu_0}{4\pi} \frac{2i}{r} (\pi + 1)$

(b) $\frac{\mu_0}{4\pi} \frac{2i}{r} (\pi - 1)$

(c) Zero

(d) Infinite

8. A current i *ampere* flows in a circular arc of wire whose radius is R, which subtend an angle $3\pi/2$ radian at its centre. The magnetic induction B at the centre is



(a) $\frac{\mu_0 i}{R}$

(b) $\frac{\mu_0 i}{2R}$

(c) $\frac{2\mu_0 i}{R}$

(d) $\frac{3\mu_0 i}{8R}$

9. A current i *ampere* flows along the inner conductor of a coaxial cable and returns along the outer conductor of the cable, then the magnetic induction at any point outside the conductor at a distance r *metre* from the axis is

(a) ∞ (b) Zero

(c) $\frac{\mu_0}{4\pi} \frac{2i}{r}$ (d) $\frac{\mu_0}{4\pi} \frac{2\pi i}{r}$

10. A straight section PQ of a circuit lies along the X-axis from $x = -\frac{a}{2}$ to $x = \frac{a}{2}$ and carries a steady current i. The magnetic field due to the section PQ at a point $X = +a$ will be

(a) Proportional to a (b) Proportional to a^2

(c) Proportional to $1/a$ (d) Zero

11. A helium nucleus makes a full rotation in a circle of radius 0.8 *metre* in two seconds. The value of the magnetic field B at the centre of the circle will be

[CPMT 1988; KCET 1998; UPSEAT 2001]

(a) $\frac{10^{-19}}{\mu_0}$ (b) $10^{-19} \mu_0$

(c) $2 \times 10^{-10} \mu_0$ (d) $\frac{2 \times 10^{-10}}{\mu_0}$

12. A solenoid of 1.5 *metre* length and 4.0 *cm* diameter posses 10 turn per *cm*. A current of 5 *ampere* is flowing through it. The magnetic induction at axis inside the solenoid is

[CPMT 1990]

(a) $2\pi \times 10^{-3}$ *Tesla* (b) $2\pi \times 10^{-5}$ *Tesla*

(c) $4\pi \times 10^{-2}$ *Gauss* (d) $2\pi \times 10^{-5}$ *Gauss*

13. The magnetic induction at a point P which is distant 4 *cm* from a long current carrying wire is 10^{-8} *Tesla*. The field of induction at a distance 12 *cm* from the same current would be

(a) 3.33×10^{-9} *Tesla* (b) 1.11×10^{-4} *Tesla*

(c) 3×10^{-3} *Tesla* (d) 9×10^{-2} *Tesla*

14. The strength of the magnetic field at a point r near a long straight current carrying wire is B. The field at a distance $\frac{r}{2}$ will be

(a) $\frac{B}{2}$ (b) $\frac{B}{4}$

(c) $2B$ (d) $4B$

15. Field at the centre of a circular coil of radius r, through which a current I flows is [MP PMT 1993]

(a) Directly proportional to r

(b) Inversely proportional to I

(c) Directly proportional to I

(d) Directly proportional to I^2

16. A current of 0.1 A circulates around a coil of 100 turns and having a radius equal to 5 *cm*. The magnetic field set up at the centre of the coil is

$(\mu_0 = 4\pi \times 10^{-7}$ *weber / ampere – metre*$)$ [MP PMT 1993]

(a) $4\pi \times 10^{-5}$ *tesla* (b) $8\pi \times 10^{-5}$ *tesla*

(c) 4×10^{-5} *tesla* (d) 2×10^{-5} *tesla*

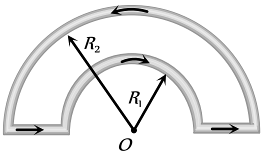
17. The magnetic field B with in the solenoid having n turns per metre length and carrying a current of i *ampere* is given by

[MP PET 1993]

(a) $\frac{\mu_0 ni}{e}$ (b) $\mu_0 ni$

(c) $4\pi\mu_0 ni$ (d) ni

18. The magnetic induction at the centre O in the figure shown is [IIT 1988; KCET 2002]



(a) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

(b) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

(c) $\frac{\mu_0 i}{4}(R_1 - R_2)$

(d) $\frac{\mu_0 i}{4}(R_1 + R_2)$

19. Field inside a solenoid is [MP PMT 1993]

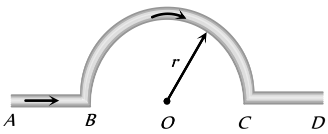
(a) Directly proportional to its length

(b) Directly proportional to current

(c) Inversely proportional to total number of turns

(d) Inversely proportional to current

20. In the figure, shown the magnetic induction at the centre of there arc due to the current in portion AB will be



(a) $\frac{\mu_0 i}{r}$

(b) $\frac{\mu_0 i}{2r}$

(c) $\frac{\mu_0 i}{4r}$

(d) Zero

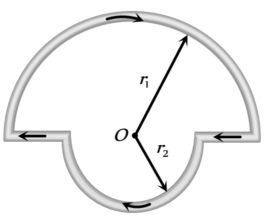
21. In the above question, the magnetic induction at O due to the whole length of the conductor is

[MP PMT/PET 1998; RPET 2002]

(a) $\frac{\mu_0 i}{r}$ (b) $\frac{\mu_0 i}{2r}$

(c) $\frac{\mu_0 i}{4r}$ (d) Zero

22. In the figure shown there are two semicircles of radii r_1 and r_2 in which a current i is flowing. The magnetic induction at the centre O will be



(a) $\frac{\mu_0 i}{r}(r_1 + r_2)$

(b) $\frac{\mu_0 i}{4}(r_1 - r_2)$

(c) $\frac{\mu_0 i}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right)$

(d) $\frac{\mu_0 i}{4}\left(\frac{r_2 - r_1}{r_1 r_2}\right)$

23. The magnetic moment of a current carrying loop is $2.1\times10^{-25}\ amp\times m^2$. The magnetic field at a point on its axis at a distance of $1\,\mathring{A}$ is

(a) $4.2\times10^{-2}\ weber/m^2$ (b) $4.2\times10^{-3}\ weber/m^2$

(c) $4.2\times10^{-4}\ weber/m^2$ (d) $4.2\times10^{-5}\ weber/m^2$

24. Two straight horizontal parallel wires are carrying the same current in the same direction, d is the distance between the wires. You are provided with a small freely suspended magnetic needle. At which of the following positions will the orientation of the needle be independent of the magnitude of the current in the wires

(a) At a distance $d/2$ from any of the wires

(b) At a distance $d/2$ from any of the wires in the horizontal plane

(c) Anywhere on the circumference of a vertical circle of radius d and centre halfway between the wires

(d) At points halfway between the wires in the horizontal plane

25. A particle carrying a charge equal to 100 times the charge on an electron is rotating per second in a circular path of radius 0.8 *metre*. The value of the magnetic field produced at the centre will be (μ_0 = permeability for vacuum)

[CPMT 1986; KCET 2001; BHU 2001]

(a) $\frac{10^{-7}}{\mu_0}$ (b) $10^{-17}\mu_0$

(c) $10^{-6}\mu_0$ (d) $10^{-7}\mu_0$

26. A circular coil of radius R carries an electric current. The magnetic field due to the coil at a point on the axis of the coil located at a distance r from the centre of the coil, such that $r >> R$, varies as [EAMCET 1987

(a) $\frac{1}{r}$ (b) $\frac{1}{r^{3/2}}$

(c) $\frac{1}{r^2}$ (d) $\frac{1}{r^3}$

27. In hydrogen atom, an electron is revolving in the orbit of radius $0.53\,\mathring{A}$ with 6.6×10^{15} *rotations/second*. Magnetic field produced at the centre of the orbit is [MP PET 2003]

(a) $0.125\ wb/m^2$ (b) $1.25\ wb/m^2$

(c) $12.5\ wb/m^2$ (d) $125\ wb/m^2$

28. The magnetic induction due to an infinitely long straight wire carrying a current i at a distance r from wire is given by

[MP PET 1994]

(a) $|\mathbf{B}| = \left(\frac{\mu_0}{4\pi}\right)\frac{2i}{r}$ (b) $|\mathbf{B}| = \left(\frac{\mu_0}{4\pi}\right)\frac{r}{2i}$

(c) $|\mathbf{B}| = \left(\frac{4\pi}{\mu_0}\right)\frac{2i}{r}$ (d) $|\mathbf{B}| = \left(\frac{4\pi}{\mu_0}\right)\frac{r}{2i}$

29. Magnetic effect of current was discovered by [MP PET 1994]

(a) Faraday (b) Oersted

(c) Ampere (d) Bohr

30. Two concentric circular coils of ten turns each are situated in the same plane. Their radii are 20 and 40 *cm* and they carry respectively

0.2 and 0.3 *ampere* current in opposite direction. The magnetic field in $weber\ /\ m^2$ at the centre is

[MP PMT 1994]

(a) $\frac{35}{4}\mu_0$ (b) $\frac{\mu_0}{80}$

(c) $\frac{7}{80}\mu_0$ (d) $\frac{5}{4}\mu_0$

31. A long solenoid has a radius *a* and number of turns per unit length is *n*. If it carries a current *i*, then the magnetic field on its axis is directly proportional to [MP PMT 1994]

(a) *ani* (b) *ni*

(c) $\frac{ni}{a}$ (d) n^2i

32. A cell is connected between two points of a uniformly thick circular conductor. The magnetic field at the centre of the loop will be

(a) Zero (b) $\frac{\mu_0}{2a}(i_1 - i_2)$

(c) $\frac{\mu_0}{2a}(i_1 + i_2)$ (d) $\frac{\mu_0}{a}(i_1 + i_2)$

(Here i_1 and i_2 are the currents flowing in the two parts of the circular conductor of radius '*a*' and μ_0 has the usual meaning)

33. A long solenoid is formed by winding 20 *turns/cm*. The current necessary to produce a magnetic field of 20 *millitesla* inside the solenoid will be approximately

$(\frac{\mu_0}{4\pi} = 10^{-7}\ tesla\text{–}metre\ /\ ampere)$ [MP PMT 1994]

(a) 8.0 *A* (b) 4.0 *A*

(c) 2.0 *A* (d) 1.0 *A*

34. A battery is connected between two points *A* and *B* on the circumference of a uniform conducting ring of radius *r* and resistance *R*. One of the arcs *AB* of the ring subtends an angle θ at the centre. The value of the magnetic induction at the centre due to the current in the ring is [IIT 1995]

(a) Proportional to $2(180° - \theta)$

(b) Inversely proportional to *r*

(c) Zero, only if $\theta = 180°$

(d) Zero for all values of θ

35. A current of 1 *ampere* is passed through a straight wire of length 2.0 *metres*. The magnetic field at a point in air at a distance of 3 *metres* from either end of wire and lying on the axis of wire will be

(a) $\frac{\mu_0}{2\pi}$ (b) $\frac{\mu_0}{4\pi}$

(c) $\frac{\mu_0}{8\pi}$ (d) Zero

36. A long copper tube of inner radius *R* carries a current *i*. The magnetic field *B* inside the tube is [MP PMT 1995]

(a) $\frac{\mu_0 i}{2\pi R}$ (b) $\frac{\mu_0 i}{4\pi R}$

(c) $\frac{\mu_0 i}{2R}$ (d) Zero

37. A straight wire of length (π^2) *metre* is carrying a current of 2*A* and the magnetic field due to it is measured at a point distant 1 *cm* from it. If the wire is to be bent into a circle and is to carry the same current as before, the ratio of the magnetic field at its centre to that obtained in the first case would be

(a) 50 : 1 (b) 1 : 50

(c) 100 : 1 (d) 1 : 100

38. The direction of magnetic lines of forces close to a straight conductor carrying current will be

[RPMT 2002; RPET 2003; MP PET 2003]

(a) Along the length of the conductor

(b) Radially outward

(c) Circular in a plane perpendicular to the conductor [MP PMT 1994]

(d) Helical

39. If the strength of the magnetic field produced 10 *cm* away from a infinitely long straight conductor is $10^{-5}\ Weber/m^2$, the value of the current flowing in the conductor will be

[MP PET 1996]

(a) 5 *ampere* (b) 10 *ampere*

(c) 500 *ampere* (d) 1000 *ampere*

40. Due to 10 *ampere* of current flowing in a circular coil of 10 *cm* radius, the magnetic field produced at its centre is $3.14 \times 10^{-3}\ Weber/m^2$. The number of turns in the coil will be

(a) 5000 (b) 100

(c) 50 (d) 25

41. There are 50 turns of a wire in every *cm* length of a long solenoid. If 4 *ampere* current is flowing in the solenoid, the approximate value of magnetic field along its axis at an internal point and at one end will be respectively

[MP PET 1996]

(a) $12.6 \times 10^{-3}\ Weber/m^2,\ 6.3 \times 10^{-3}\ Weber/m^2$

(b) $12.6 \times 10^{-3}\ Weber/m^2,\ 25.1 \times 10^{-3}\ Weber/m^2$

(c) $25.1 \times 10^{-3}\ Weber/m^2,\ 12.6 \times 10^{-3}\ Weber/m^2$

(d) $25.1 \times 10^{-5}\ Weber/m^2,\ 12.6 \times 10^{-5}\ Weber/m^2$

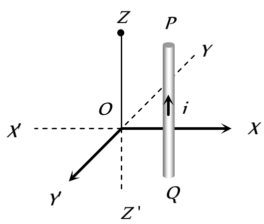
42. A solenoid is 1.0 *metre* long and it has 4250 turns. If a current of 5.0 *ampere* is flowing through it, what is the magnetic field at its centre $[\mu_0 = 4\pi \times 10^{-7}\ weber\ /\ amp - m]$ [MP PET 1995]

[MP PMT 1996]

(a) $5.4 \times 10^{-2}\ weber\ /\ m^2$ (b) $2.7 \times 10^{-2}\ weber\ /\ m^2$

(c) $1.35 \times 10^{-2}\ weber\ /\ m^2$ (d) $0.675 \times 10^{-2}\ weber\ /\ m^2$

43. A vertical wire kept in *Z-X* plane carries a current from *Q* to *P* (see figure). The magnetic field due to current will have the direction at the origin *O* along



(a) *OX*

(b) *OX'*

(c) OY

(d) OY'

44. One metre length of wire carries a constant current. The wire is bent to form a circular loop. The magnetic field at the centre of this loop is *B*. The same is now bent to form a circular loop of smaller radius to have four turns in the loop. The magnetic field at the centre of this new loop is

(a) 4 B (b) 16 B

(c) $B/2$ (d) $B/4$

45. In a hydrogen atom, an electron moves in a circular orbit of radius $5.2\times10^{-11}\ m$ and produces a magnetic induction of 12.56 T at its nucleus. The current produced by the motion of the electron will be (Given $\mu_0 = 4\pi\times10^{-7}\ Wb/A-m$) [MP PET 1997]

(a) 6.53×10^{-3} *ampere* (b) 13.25×10^{-10} *ampere*

(c) 9.6×10^{6} *ampere* (d) 1.04×10^{-3} *ampere*

46. An arc of a circle of radius *R* subtends an angle $\frac{\pi}{2}$ at the centre. It carries a current *i*. The magnetic field at the centre will be

(a) $\frac{\mu_0 i}{2R}$ (b) $\frac{\mu_0 i}{8R}$

(c) $\frac{\mu_0 i}{4R}$ (d) $\frac{2\mu_0 i}{5R}$

47. At a distance of 10 *cm* from a long straight wire carrying current, the magnetic field is 0.04 *T*. At the distance of 40 *cm*, the magnetic field will be [MP PMT 1997]

(a) 0.01 T (b) 0.02 T

(c) 0.08 T (d) 0.16 T

48. A uniform wire is bent in the form of a circle of radius *R*. A current *I* enters at *A* and leaves at *C* as shown in the figure :

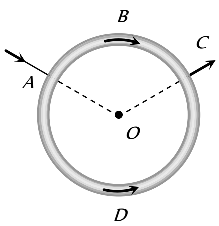
If the length *ABC* is half of the length *ADC*, the magnetic field at the centre *O* will be [MP PMT 1997]

(a) Zero

(b) $\frac{\mu_0 I}{2R}$

(c) $\frac{\mu_0 I}{4R}$

(d) $\frac{\mu_0 I}{6R}$



49. The magnetic induction at any point due to a long straight wire carrying a current is [MP PMT/PET 1998]

(a) Proportional to the distance from the wire

(b) Inversely proportional to the distance from wire

(c) Inversely proportional to the square of the distance from the wire

(d) Does not depend on distance

50. The expression for magnetic induction inside a solenoid of length *L* carrying a current *I* and having *N* number of turns is

(a) $\frac{\mu_0}{4\pi}\frac{N}{LI}$ (b) $\mu_0 NI$

(c) $\frac{\mu_0}{4\pi}NLI$ (d) $\mu_0\frac{N}{L}I$

51. In a current carrying long solenoid, the field produced does not depend upon [MP PET 1999]

(a) Number of turns per unit length

(b) Current flowing

(c) Radius of the solenoid

(d) All of the above three

52. The earth's magnetic induction at a certain point is $7\times10^{-5}\ Wb/m^2$. This is to be annulled by the magnetic induction at the centre of a circular conducting loop of radius 5 *cm*. The required current in the loop is [MP PET 1999; MP PMT 2002]

(a) 0.56 A (b) 5.6 A

(c) 0.28 A (d) 2.8 A

53. Magnetic field due to 0.1 *A* current flowing through a circular coil of radius 0.1 *m* and 1000 turns at the centre of the coil is

(a) $2\times10^{-1}\ T$ (b) $4.31\times10^{-2}\ T$

(c) $6.28\times10^{-4}\ T$ (d) $9.81\times10^{-4}\ T$

54. Magnetic field intensity at the centre of coil of 50 turns, radius 0.5 *m* and carrying a current of 2 *A* is [MP PET 2003] [CBSE PMT 1999; BHU 2002]

(a) $0.5\times10^{-5}\ T$ (b) $1.25\times10^{-4}\ T$

(c) $3\times10^{-5}\ T$ (d) $4\times10^{-5}\ T$

55. A circular coil '*A*' has a radius *R* and the current flowing through it is *I*. Another circular coil '*B*' has a radius 2*R* and if 2*I* is the current flowing through it, then the magnetic fields at the centre of the circular coil are in the ratio of (*i.e.* B_A to B_B)

(a) 4 : 1 (b) 2 : 1

(c) 3 : 1 (d) 1 : 1

56. The magnetic field at a distance *r* from a long wire carrying current *i* is 0.4 *Tesla*. The magnetic field at a distance 2*r* is [CBSE PMT 1992; DPMT 2004]

(a) 0.2 *Tesla* (b) 0.8 *Tesla*

(c) 0.1 *Tesla* (d) 1.6 *Tesla*

57. A current *I* flows along the length of an infinitely long, straight and thin-walled pipe. Then [IIT-JEE 1993]

(a) The magnetic field at all points inside the pipe is the same but not zero

(b) The magnetic field at any point inside the pipe is zero

(c) The magnetic field is zero only on the axis of the pipe

(d) The magnetic field is different at different points inside the pipe

58. The magnetic field at the centre of current carrying coil is [CPMT 1996; RPET 2002, 03]

(a) $\frac{\mu_0 ni}{2r}$ [MP PMT/PET 1998] (b) $\frac{\mu_0}{2\pi}\frac{ni}{r}$

(c) $\frac{\mu_0 ni}{4r}$ (d) $\mu_0 ni$

59. A straight wire of diameter 0.5 *mm* carrying a current of 1 *A* is replaced by another wire of 1 *mm* diameter carrying the same current. The strength of magnetic field far away is [CBSE PMT 1997, 99]

(a) Twice the earlier value
(b) Half of the earlier value
(c) Quarter of its earlier value
(d) Unchanged

60. A neutral point is obtained at the centre of a vertical circular coil carrying current. The angle between the plane of the coil and the magnetic meridian is [SCRA 1998]

(a) 0 (b) 45° (c) 60° (d) 90°

61. One *Tesla* is equal to [AFMC 1998]

(a) 10^7 *gauss* (b) 10^{-4} *gauss*
(c) 10^4 *gauss* (d) 10^{-8} *gauss*

62. A current carrying wire in the neighborhood produces [AFMC 1999]

(a) No field
(b) Electric field only
(c) Magnetic field only
(d) Electric and magnetic fields

63. Tesla is the unit of [AIIMS 1999]

(a) Electric flux (b) Magnetic flux
(c) Electric field (d) Magnetic field

64. The magnetic induction in air at a point 1*cm* away from a long wire that carries a current of 1*A*, will be [BHU 1999]

(a) $1\times10^{-5}T$ (b) $2\times10^{-5}T$
(c) $3\times10^{-5}T$ (d) $4\times10^{-5}T$

65. The magnetic field at the centre of coil of *n* turns, bent in the form of a square of side $2l$, carrying current *i*, is [AMU (Engg.) 1999]

(a) $\frac{\sqrt{2}\mu_0 ni}{\pi l}$ (b) $\frac{\sqrt{2}\mu_0 ni}{2\pi l}$
(c) $\frac{\sqrt{2}\mu_0 ni}{4\pi l}$ (d) $\frac{2\mu_0 ni}{\pi l}$

66. Which of the following gives the value of magnetic field according to, Biot-Savart's law' [BHU 2000]

(a) $\frac{i\Delta l\sin\theta}{r^2}$ (b) $\frac{\mu_0}{4\pi}\frac{i\Delta l\sin\theta}{r}$
(c) $\frac{\mu_0}{4\pi}\frac{i\Delta l\sin\theta}{r^2}$ (d) $\frac{\mu_0}{4\pi}i\Delta l\sin\theta$

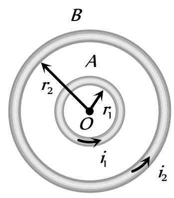
67. A toroid has number of turns per unit length *n*, current *i*, then the magnetic field is [RPET 2000]

(a) $\mu_0 ni$ (b) $\mu_0 n^2 i$
(c) $\mu_0 i/n$ (d) None of these

68. Magnetic field due to a ring having *n* turns at a distance *x* on its axis is proportional to (if *r* = radius of ring) [RPET 2000]

(a) $\frac{r}{(x^2+r^2)}$ (b) $\frac{r^2}{(x^2+r^2)^{3/2}}$
(c) $\frac{nr^2}{(x^2+r^2)^{3/2}}$ (d) $\frac{n^2r^2}{(x^2+r^2)^{3/2}}$

69. *A* and *B* are two concentric circular conductors of centre *O* and carrying currents i_1 and i_2 as shown in the adjacent figure. If ratio of their radii is 1 : 2 and ratio of the flux densities at *O* due to *A* and *B* is 1 : 3, then the value of i_1/i_2 is [KCET 2000]



(a) $\frac{1}{6}$
(b) $\frac{1}{4}$
(c) $\frac{1}{3}$
(d) $\frac{1}{2}$

70. A long straight wire carries an electric current of 2*A*. The magnetic induction at a perpendicular distance of 5*m* from the wire is

(a) $4\times10^{-8}T$ (b) $8\times10^{-8}T$
(c) $12\times10^{-8}T$ (d) $16\times10^{-8}T$

71. A straight wire carrying a current 10 *A* is bent into a semicircular arc of radius 5 *cm*. The magnitude of magnetic field at the center is

(a) $1.5\times10^{-5}T$ (b) $3.14\times10^{-5}T$
(c) $6.28\times10^{-5}T$ (d) $19.6\times10^{-5}T$

72. A long solenoid of length *L* has a mean diameter *D*. It has n layers of windings of *N* turns each. If it carries a current '*i*' the magnetic field at its centre will be [MP PMT 2000]

(a) Proportional to *D*
(b) Inversely proportional to *D*
(c) Independent of *D*
(d) Proportional to *L*

73. A circular loop of radius 0.0157*m* carries a current of 2.0 amp. The magnetic field at the centre of the loop is

$(\mu_0 = 4\pi\times10^{-7}$ *weber / amp – m*)

(a) 1.57×10^{-5} *weber / m*^{2} (b) 8.0×10^{-5} *weber / m*^{2}
(c) 2.5×10^{-5} *weber / m*^{2} (d) 3.14×10^{-5} *weber / m*^{2}

74. A long solenoid has 200 turns per *cm* and carries a current of 2.5 *amps*. The magnetic field at its centre is $(\mu_0 = 4\pi\times10^{-7}$ *weber / amp - m*)

(a) 3.14×10^{-2} *weber / m*^{2}
(b) 6.28×10^{-2} *weber / m*^{2}

(c) $9.42 \times 10^{-2} weber / m^2$

(d) $12.56 \times 10^{-2} weber / m^2$

75. Two concentric coplanar circular loops of radii r_1 and r_2 carry currents of respectively i_1 and i_2 in opposite directions (one clockwise and the other anticlockwise.) The magnetic induction at the centre of the loops is half that due to i_1 alone at the centre. If $r_2 = 2r_1$. the value of i_2 / i_1 is

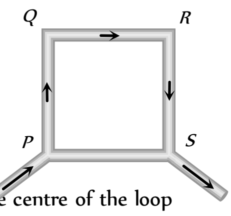
[MP PET 2000]

(a) 2 (b) 1/2

(c) 1/4 (d) 1

76. *PQRS* is a square loop made of uniform conducting wire the current enters the loop at *P* and leaves at *S*. Then the magnetic field will be

[KCET 2000]



(a) Maximum at the centre of the loop

(b) Zero at the centre of loop

(c) Zero at all points inside the loop

(d) Zero at all points outside of the loop

77. Magnetic fields at two points on the axis of a circular coil at a distance of 0.05*m* and 0.2*m* from the centre are in the ratio 8 : 1. The radius of the coil is

[KCET 2002]

(a) 1.0 *m* (b) 0.1 *m*

(c) 0.15 *m* (d) 0.2 *m*

78. An electric current passes through a long straight wire. At a distance 5 *cm* from the wire, The magnetic field is *B*. The field at 20 *cm* from the wire would be

[CPMT 2001; Pb PET 2002]

(a) $\frac{B}{6}$ (b) $\frac{B}{4}$

(c) $\frac{B}{3}$ (d) $\frac{B}{2}$

79. A closely wound flat circular coil of 25 turns of wire has diameter of 10 *cm* and carries a current of 4 *ampere*. Determine the flux density at the centre of a coil

[AIIMS 2001]

(a) $1.679 \times 10^{-5} tesla$ (b) $2.028 \times 10^{-4} tesla$

(c) $1.257 \times 10^{-3} tesla$ (d) $1.512 \times 10^{-6} tesla$

80. The dimension of the magnetic field intensity *B* is

[MP PET 2001]

(a) $MLT^{-2}A^{-1}$ (b) $MT^{-2}A^{-1}$

(c) ML^2TA^{-2} (d) $M^2LT^{-2}A^{-1}$

81. A current of 2 *amp*. flows in a long, straight wire of radius 2 *mm*. The intensity of magnetic field on the axis of the wire is

(a) $\left(\frac{\mu_o}{\pi}\right) \times 10^3$ *Tesla* (b) $\left(\frac{\mu_o}{2\pi}\right) \times 10^3$ *Tesla*

(c) $\left(\frac{2\mu_o}{\pi}\right) \times 10^3$ *Tesla* (d) Zero

82. The magnetic field at the centre of a circular coil of radius *r* carrying current *I* is B_1. The field at the centre of another coil of radius 2 *r* carrying same current *I* is B_2. The ratio $\frac{B_1}{B_2}$ is

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

(c) 2 (d) 4

83. 1*A* current flows through an infinitely long straight wire. The magnetic field produced at a point 1 *metres* away from it is

[MP PMT 2001]

(a) 2×10^{-3} *Tesla* (b) $\frac{2}{10}$ *Tesla*

(c) 2×10^{-7} *Tesla* (d) $2\pi \times 10^{-6}$ Tesla

84. Two infinitely long parallel wires carry equal current in same direction. The magnetic field at a mid point in between the two wires is [MP PMT 2001]

(a) Twice the magnetic field produced due to each of the wires

(b) Half of the magnetic field produced due to each of the wires

(c) Square of the magnetic field produced due to each of the wires

(d) Zero

85. A wire in the form of a square of side '*a*' carries a current *i*. Then the magnetic induction at the centre of the square wire is (Magnetic permeability of free space = μ_o) [EAMCET 2001]

(a) $\frac{\mu_0 i}{2\pi a}$ (b) $\frac{\mu_0 i\sqrt{2}}{\pi a}$

(c) $\frac{2\sqrt{2}\mu_o i}{\pi a}$ (d) $\frac{\mu_0 i}{\sqrt{2}\pi a}$

86. What should be the current in a circular coil of radius 5*cm* to annul $B_H = 5 \times 10^{-5} T$ [DCE 2001]

(a) 0.4 *A* (b) 4 *A*

(c) 40 *A* (d) 1 *A*

87. A current of 0.1 *A* circulates around a coil of 100 turns and having a radius equal to 5*cm*. The magnetic field set up at the centre of the coil is ($\mu_o = 4\pi \times 10^{-7}$ *weber/amp-metre*)

[DPMT 2002]

(a) 2×10^{-5} *Tesla* (b) 4×10^{-5} *Tesla*

(c) $8\pi \times 10^{-5}$ *Tesla* (d) $4\pi \times 10^{-5}$ *Tesla*

88. An electron moving in a circular orbit of radius *r* makes *n* rotation per second. The magnetic field produced at the centre has a magnitude of

[KCET 2001; UPSEAT 2001, 02]

(a) $\frac{\mu_0 ne}{2r}$ (b) $\frac{\mu_0 n^2 e}{2r}$

(c) $\frac{\mu_0 ne}{2\pi r}$ (d) Zero

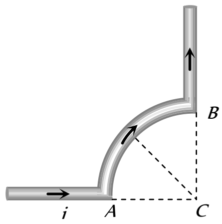
89. A long solenoid has n turns per meter and current I A is flowing through it. The magnetic field at the ends of the solenoid is

(a) $\frac{\mu_0 nI}{2}$ (b) $\mu_0 nI$

(c) Zero (d) $2\mu_0 nI$

90. A wire carrying current i is shaped as shown. Section AB is a quarter circle of radius r. The magnetic field is directed

[KCET 2002]



(a) At an angle $\pi/4$ to the plane of the paper

(b) Perpendicular to the plane of the paper and directed in to the paper

(c) Along the bisector of the angle ACB towards AB

(d) Along the bisector of the angle ACB away from AB

91. Two long straight wires are set parallel to each other. Each carries a current i in the same direction and the separation between them is $2r$. The intensity of the magnetic field midway between them is

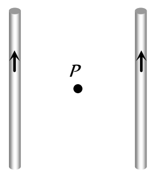
[Kerala PET 2002; DCE 2002]

(a) $\mu_o i/r$

(b) $4\mu_o i/r$

(c) Zero

(d) $\mu_o i/4r$



92. A magnetic field can be produced by [AIEEE 2002]

(a) A moving charge (b) A changing electric field

(c) None of these (d) Both of these

93. Unit of magnetic permeability is [AFMC 2002]

(a) *Amp/metre* (b) *Amp/* m^2

(c) *Henry* (d) *Henry/metre*

94. A long straight wire carries a current of $\pi\, amp$. The magnetic field due to it will be $5\times10^{-5}\, weber/m^2$ at what distance from the wire [μ_o = permeability of air]

[MP PMT 2002]

(a) $10^4\mu_o$ *metre* (b) $\frac{10^4}{\mu_o}$ *metre*

(c) $10^6\mu_o$ *metre* (d) $\frac{10^6}{\mu_o}$ *metre*

95. When a certain length of wire is turned into one circular loop, the magnetic induction at the centre of coil due to some current flowing is B_1 If the same wire is turned into three loops to make a circular coil, the magnetic induction at the center of this coil for the same current will be

[MP PMT 2002]

(a) B_1 (b) $9B_1$

[MP PMT 2001; MP PET 2002]

(c) $3B_1$ (d) $27B_1$

96. Gauss is unit of which quantity [MP PET 2002]

(a) H (b) B

(c) ϕ (d) I

97. On connecting a battery to the two corners of a diagonal of a square conductor frame of side a the magnitude of the magnetic field at the centre will be [MP PET 2002]

(a) Zero (b) $\frac{\mu_o}{\pi a}$

(c) $\frac{2\mu_o}{\pi a}$ (d) $\frac{4\mu_o i}{\pi a}$

98. The ratio of the magnetic field at the centre of a current carrying coil of the radius a and at a distance 'a' from centre of the coil and perpendicular to the axis of coil is

[MP PET 2002]

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

(c) $\frac{1}{2\sqrt{2}}$ (d) $2\sqrt{2}$

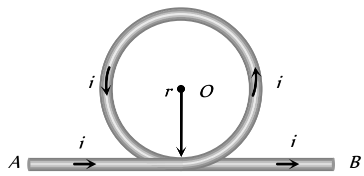
99. A part of a long wire carrying a current i is bent into a circle of radius r as shown in figure. The net magnetic field at the centre O of the circular loop is [UPSEAT 2002]

(a) $\frac{\mu_o i}{4r}$

(b) $\frac{\mu_o i}{2r}$

(c) $\frac{\mu_o i}{2\pi r}(\pi+1)$

(d) $\frac{\mu_o i}{2\pi r}(\pi-1)$



100. The current in the windings on a toroid is 2.0A. There are 400 turns and the mean circumferential length is 40cm. If the inside magnetic field is 1.0 T, the relative permeability is near to

(a) 100 (b) 200

(c) 300 (d) 400

101. "On flowing current in a conducting wire the magnetic field produces around it." It is a law of [RPET 2003]

(a) Lenz (b) Ampere

(c) Ohm (d) Maxwell

102. The magnetic field near a current carrying conductor is given by

(a) Coulomb's law (b) Lenz' law

(c) Biot-savart's law (d) Kirchoff's law

103. A current of 10A is passing through a long wire which has semicircular loop of the radius 20cm as shown in the figure. Magnetic field produced at the centre of the loop is

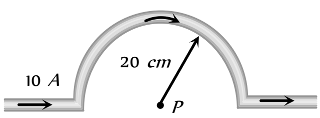
[Orissa JEE 2003]

(a) $10\pi\mu T$

(b) $5\pi\mu T$

(c) $4\pi\mu T$

(d) $2\pi\mu T$



104. A wire in the form of a circular loop of one turn carrying a current produces a magnetic field B at the centre. If the same wire is looped into a coil of two turns and carries the same current, the new value of magnetic induction at the centre is [CBSE 2002; KCET 2003]

(a) $5B$ (b) $3B$
(c) $2B$ (d) $4B$

105. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per *cm* is halved, the new value of the magnetic field is [CBSE PMT 2003]

(a) B (b) $2\ B$
(c) $4\ B$ (d) $B/2$

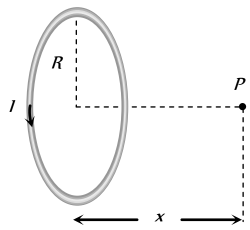
106. A long straight wire carrying current of 30*A* is placed in an external uniform magnetic field of induction 4×10^{-4} *T*. The magnetic field is acting parallel to the direction of current. The magnitude of the resultant magnetic induction in *tesla* at a point 2.0 cm away from the wire is [EAMCET 2003]

(a) 10^{-4} (b) 3×10^{-4}
(c) 5×10^{-4} (d) 6×10^{-4}

107. The earth's magnetic field at a given point is $0.5\times10^{-5}Wb\text{-}m^{-2}$. This field is to be annulled by magnetic induction at the center of a circular conducting loop of radius 5.0*cm*. The current required to be flown in the loop is nearly [AIIMS 2003]

(a) 0.2 *A* (b) 0.4*A*
(c) 4*A* (d) 40*A*

108. A coil having *N* turns carry a current *I* as shown in the figure. The magnetic field intensity at point *P* is [BHU 2003; CPMT 2004]



(a) $\frac{\mu_0 NIR^2}{2(R^2+x^2)^{3/2}}$

(b) $\frac{\mu_0 NI}{2R}$

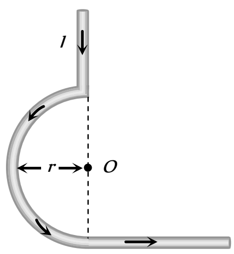
(c) $\frac{\mu_0 NIR^2}{(R+x)^2}$

(d) Zero

109. Two similar coils are kept mutually perpendicular such that their centres coincide. At the centre, find the ratio of the magnetic field due to one coil and the resultant magnetic field by both coils, if the same current is flown [BHU 2003; CPMT 2004]

(a) $1:\sqrt{2}$ (b) $1:2$
(c) $2:1$ (d) $\sqrt{3}:1$

110. In the figure, what is the magnetic field at the point *O* [MP PMT 2004]



(a) $\frac{\mu_0 I}{4\pi r}$

(b) $\frac{\mu_0 I}{4\pi r}+\frac{\mu_0 I}{2\pi r}$

(c) $\frac{\mu_0 I}{4r}+\frac{\mu_0 I}{4\pi r}$

(d) $\frac{\mu_0 I}{4r}-\frac{\mu_0 I}{4\pi r}$

111. The magnetic moment of a current (*i*) carrying circular coil of radius (*r*) and number of turns (*n*) varies as [AIIMS 2004]

(a) 1/ *r* (b) 1/ *r*
(c) *r* (d) *r*

112. A current flows in a conductor from east to west. The direction of the magnetic field at a points above the conductor is .....

(a) Towards north (b) Towards south
(c) Towards east (d) Towards west

113. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is *B*. It is then bent into a circular loop of *n* turns. The magnetic field at the centre of the coil will be [AIEEE 2004]

(a) *nB* (b) nB
(c) 2*nB* (d) $2nB$

114. The magnetic field due to a current carrying circular loop of radius 3 *cm* at a point on the axis at a distance of 4 *cm* from the centre is 54 μT. What will be its value at the centre of the loop

(a) 250 μ *T* (b) 150 μ *T*
(c) 125 μ *T* (d) 75 μ *T*

115. The magnetic induction at the centre of a current carrying circular of coil radius *r*, is [J & K CET 2004]

(a) Directly proportional to *r*
(b) Inversely proportional *r*
(c) Directly proportional to *r*
(d) Inversely proportional to *r*

116. The current is flowing in south direction along a power line. The direction of magnetic field above the power line (neglecting earth's field) is [Pb. PMT 2004; Kerala PMT 2004]

(a) South (b) East
(c) North (d) West

117. Two wires of same length are shaped into a square and a circle. If they carry same current, ratio of the magnetic moment is

(a) $2:\pi$ (b) $\pi:2$
(c) $\pi:4$ (d) $4:\pi$

118. When the current flowing in a circular coil is doubled and the number of turns of the coil in it is halved, the magnetic field at its centre will become [DPMT 2003]

(a) Four times (b) Same
(c) Half (d) Double

119. An electron is revolving round a proton, producing a magnetic field of 16 *weber/m* in a circular orbit of radius 1Å. It's angular velocity will be [RPMT 2002]

(a) 10^{17} *rad/sec* (b) $1/2\pi \times 10^{12}$ *rad/sec*
(c) $2\ \pi \times 10^{12}$ *rad/sec* (d) $4\ \pi \times 10^{12}$ *rad/sec*

120. 20 *ampere* current is flowing in a long straight wire. The intensity of magnetic field at a distance 10 *cm* from the wire will be

(a) 4×10^{-5} *Wb/m*^{2} (b) 9×10^{-5} *Wb/m*^{2}
(c) 8×10^{-5} *Wb/m*^{2} (d) 6×10^{-5} *Wb/m*^{2}

121. The field due to a long straight wire carrying a current *I* is proportional to [MP PMT 1993]

(a) *I* (b) I^3
(c) $\sqrt{I}$ (d) $1/I$

122. Two concentric coils each of radius equal to 2π *cm* are placed at right angles to each other. 3 *ampere* and 4 *ampere* are the currents flowing in each coil respectively. The magnetic induction in

$Weber/m^2$ at the centre of the coils will be ($\mu_0 = 4\pi \times 10^{-7} Wb/A.m$) [AIEEE 2005]

(a) 5×10^{-5} (b) 7×10^{-5}

(c) 12×10^{-5} (d) 10^{-5}

123. A wire carrying current I and other carrying $2I$ in the same direction produces a magnetic field B at the mid point. What will be the field when $2I$ wire is switched off [AFMC 2005]

(a) $B/2$ (b) $2B$

(c) B (d) $4B$

124. Two long parallel wires P and Q are both perpendicular to the plane of the paper with distance 5 m between them. If P and Q carry current of 2.5 amp and 5 amp respectively in the same direction, then the magnetic field at a point half way between the wires is

(a) $\frac{\sqrt{3}\mu_0}{2\pi}$ (b) $\frac{\mu_0}{\pi}$

(c) $\frac{3\mu_0}{2\pi}$ (d) $\frac{\mu_0}{2\pi}$

(e) $\frac{\sqrt{3}\mu_0}{\pi}$

125. The direction of magnetic lines of force produced by passing a direct current in a conductor is given by [J & K CET 2005]

(a) Lenz's law (b) Fleming's left hand rule

(c) Right hand palm rule (d) Maxwell's law

126. For the magnetic field to be maximum due to a small element of current carrying conductor at a point, the angle between the element and the line joining the element to the given point must be

(a) 0° (b) 90°

(c) 180° (d) 45°

Motion of Charged Particle In Magnetic Field

1. A proton moving with a constant velocity passes through a region of space without any change in its velocity. If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic fields respectively, then this region of space may have

[IIT-JEE 1985; AMU 1995; AFMC 2001; Roorkee 2000; AMU (Med.) 2000]

(a) $E = 0, B = 0$ (b) $E = 0, B \neq 0$

(c) $E \neq 0, B = 0$ (d) $E \neq 0, B \neq 0$

2. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction. An electron is projected with its velocity pointing in the same direction

[NCERT 1980; CBSE PMT 1993; JIPMER 1997; AIEEE 2005]

(a) The electron will turn to its right

(b) The electron will turn to its left

(c) The electron velocity will increase in magnitude

(d) The electron velocity will decrease in magnitude

3. Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describes circular path of radius R_1 and R_2 respectively. The ratio of mass of X to that of Y is[IIT-JEE 1988; CBSE PMT1995; M

(a) $\left(\frac{R_1}{R_2}\right)^{1/2}$ (b) $\frac{R_2}{R_1}$

(c) $\left(\frac{R_1}{R_2}\right)^2$ (d) $\frac{R_1}{R_2}$

4. A beam of ions with velocity $2 \times 10^5\ m/s$ enters normally into a uniform magnetic field of $4 \times 10^{-2}\ tesla$. If the specific charge of the ion is $5 \times 10^7\ C/kg$, then the radius of the circular path described will be [NCERT 1983; BVP 2003]

[Kerala PMT 2005]

(a) 0.10 m (b) 0.16 m

(c) 0.20 m (d) 0.25 m

5. The radius of curvature of the path of the charged particle in a uniform magnetic field is directly proportional to

[MNR 1995; UPSEAT 1999, 2000]

(a) The charge on the particle

(b) The momentum of the particle

(c) The energy of the particle

(d) The intensity of the field

6. An electron has mass $9 \times 10^{-31}\ kg$ and charge $1.6 \times 10^{-19}\ C$ is moving with a velocity of $10^6\ m/s$, enters a region where magnetic field exists. If it describes a circle of radius 0.10 m, the intensity of magnetic field must be

[NCERT 1982; CPMT 1989; DCE 2005]

[J & K CET 2005]

(a) $1.8 \times 10^{-4}\ T$ (b) $5.6 \times 10^{-5}\ T$

(c) $14.4 \times 10^{-5}\ T$ (d) $1.3 \times 10^{-6}\ T$

7. A proton (mass m and charge $+e$) and an α – particle (mass $4m$ and charge $+2e$) are projected with the same kinetic energy at right angles to the uniform magnetic field. Which one of the following statements will be true [NCERT 1983]

(a) The α – particle will be bent in a circular path with a small radius that for the proton

(b) The radius of the path of the α – particle will be greater than that of the proton

(c) The α – particle and the proton will be bent in a circular path with the same radius

(d) The α – particle and the proton will go through the field in a straight line

8. A charged particle moving in a magnetic field experiences a resultant force [MP PMT 1994]

(a) In the direction of field

(b) In the direction opposite to that field

(c) In the direction perpendicular to both the field and its velocity

(d) None of the above

9. If the direction of the initial velocity of the charged particle is perpendicular to the magnetic field, then the orbit will be

or

The path executed by a charged particle whose motion is perpendicular to magnetic field is

[MP PMT 1993; CPMT 1996]

(a) A straight line (b) An ellipse

(c) A circle (d) A helix

10. If the direction of the initial velocity of the charged particle is neither along nor perpendicular to that of the magnetic field, then the orbit will be [MP PET 1993]
(a) A straight line (b) An ellipse
(c) A circle (d) A helix

11. Particles having positive charges occasionally come with high velocity from the sky towards the earth. On account of the magnetic field of earth, they would be deflected towards the
(a) North (b) South
(c) East (d) West

12. A 2 *MeV* proton is moving perpendicular to a uniform magnetic field of 2.5 *tesla*. The force on the proton is [CPMT 1989]
(a) $2.5\times10^{-10}\ N$ (b) $7.6\times10^{-11}\ N$
(c) $2.5\times10^{-11}\ N$ (d) $7.6\times10^{-12}\ N$

13. A charged particle moves with velocity v in a uniform magnetic field $\vec{B}$. The magnetic force experienced by the particle is
(a) Always zero
(b) Never zero
(c) Zero, if $\vec{B}$ and $\vec{v}$ are perpendicular
(d) Zero, if $\vec{B}$ and $\vec{v}$ are parallel

14. A proton is moving along *Z*-axis in a magnetic field. The magnetic field is along *X*-axis. The proton will experience a force along
(a) *X*-axis (b) *Y*-axis
(c) *Z*-axis (d) Negative *Z*-axis

15. A proton of mass m and charge $+e$ is moving in a circular orbit in a magnetic field with energy 1 *MeV*. What should be the energy of $\alpha-$particle (mass = $4m$ and charge = + $2e$), so that it can revolve in the path of same radius [BHU 1997]
(a) 1 *MeV* (b) 4 *MeV*
(c) 2 *MeV* (d) 0.5 *MeV*

16. An electron is moving with a speed of $10^8\ m/\sec$ perpendicular to a uniform magnetic field of intensity *B*. Suddenly intensity of the magnetic field is reduced to *B*/2. The radius of the path becomes from the original value of r [MP PET 1993]
(a) No change (b) Reduces to $r/2$
(c) Increases to $2r$ (d) Stops moving

17. A proton and an $\alpha-$particle enter a uniform magnetic field perpendicularly with the same speed. If proton takes 25 μ sec to make 5 revolutions, then the periodic time for the $\alpha-$particle would be [MP PET 1993]
(a) 50 μ sec (b) 25 μ sec
(c) 10 μ sec (d) 5 μ sec

18. A proton (mass $=1.67\times10^{-27}\ kg$ and charge $=1.6\times10^{-19}\ C$) enters perpendicular to a magnetic field of intensity 2 $weber/m^2$ with a velocity $3.4\times10^7\ m/\sec$. The acceleration of the proton should be [DPMT 1999]
(a) $6.5\times10^{15}\ m/\sec^2$ (b) $6.5\times10^{13}\ m/\sec^2$
(c) $6.5\times10^{11}\ m/\sec^2$ (d) $6.5\times10^{9}\ m/\sec^2$

19. An $\alpha-$particle travels in a circular path of radius 0.45 m in a magnetic field $B=1.2\ Wb/m^2$ with a speed of $2.6\times10^7\ m/\sec$. The period of revolution of the $\alpha-$particle is
(a) 1.1×10^{-5} sec (b) 1.1×10^{-6} sec
(c) 1.1×10^{-7} sec (d) 1.1×10^{-8} sec

20. A uniform magnetic field B is acting from south to north and is of magnitude 1.5 Wb/m^2. If a proton having mass $=1.7\times10^{-27}\ kg$ and charge $=1.6\times10^{-19}\ C$ moves in this field vertically downwards with energy 5 *MeV*, then the force acting on it will be [NCERT 1977]
(a) $7.4\times10^{12}\ N$ (b) $7.4\times10^{-12}\ N$
(c) $7.4\times10^{19}\ N$ (d) $7.4\times10^{-19}\ N$

21. A strong magnetic field is applied on a stationary electron, then [BIT 1989; MP P
(a) The electron moves in the direction of the field
(b) The electron moves in an opposite direction
(c) The electron remains stationary
(d) The electron starts spinning

22. A uniform magnetic field acts at right angles to the direction of motion of electrons. As a result, the electron moves in a circular path of radius 2 *cm*. If the speed of the electrons is doubled, then the radius of the circular path will be [CBSE PMT 1990] [CBSE PMT 1991]
(a) 2.0 *cm* (b) 0.5 *cm*
(c) 4.0 *cm* (d) 1.0 *cm*

23. A deutron of kinetic energy 50 *keV* is describing a circular orbit of radius 0.5 *metre* in a plane perpendicular to magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of radius 0.5 *metre* in the same plane with the same $\vec{B}$ is
(a) 25 *keV* (b) 50 *keV*
(c) 200 *keV* (d) 100 *keV*

24. If a proton is projected in a direction perpendicular to a uniform magnetic field with velocity v and an electron is projected along the lines of force, what will happen to proton and electron
(a) The electron will travel along a circle with constant speed and the proton will move along a straight line
(b) Proton will move in a circle with constant speed and there will be no effect on the motion of electron
(c) There will not be any effect on the motion of electron and proton
(d) The electron and proton both will follow the path of a parabola

25. An electron is travelling horizontally towards east. A magnetic field in vertically downward direction exerts a force on the electron along
(a) East (b) West
(c) North (d) South

26. Lorentz force can be calculated by using the formula [MP PET 1994, 2002, 03; CBSE PMT 2002]
(a) $\vec{F}=q(\vec{E}+\vec{v}\times\vec{B})$ (b) $\vec{F}=q(\vec{E}-\vec{v}\times\vec{B})$
(c) $\vec{F}=q(\vec{E}+\vec{v}\cdot\vec{B})$ (d) $\vec{F}=q(\vec{E}\times\vec{B}+\vec{v})$

27. A magnetic field [MP PET 1994; Pb PMT 2003]
(a) Always exerts a force on a charged particle
(b) Never exerts a force on a charged particle
(c) Exerts a force, if the charged particle is moving across the magnetic field lines
(d) Exerts a force, if the charged particle is moving along the magnetic field lines

28. A proton enters a magnetic field of flux density $1.5\, weber / m^2$ with a velocity of $2\times10^7\, m/\sec$ at an angle of $30°$ with the field. The force on the proton will be [MP PET 1994 ; Pb. PMT 2004]

(a) $2.4\times10^{-12}\, N$ (b) $0.24\times10^{-12}\, N$

(c) $24\times10^{-12}\, N$ (d) $0.024\times10^{-12}\, N$

29. If a particle of charge $10^{-12}\, coulomb$ moving along the $\hat{\mathbf{x}}-$direction with a velocity $10^5\, m/s$ experiences a force of $10^{-10}\, newton$ in $\hat{\mathbf{y}}-$direction due to magnetic field, then the minimum magnetic field is [MP PMT 1994]

(a) $6.25\times10^3\, tesla$ in $\hat{\mathbf{z}}-$direction

(b) $10^{-15}\, tesla$ in $\hat{\mathbf{z}}-$direction

(c) $6.25\times10^{-3}\, tesla$ in $\hat{\mathbf{z}}-$direction

(d) $10^{-3}\, tesla$ in $\hat{\mathbf{z}}-$direction

30. If a proton, deutron and $\alpha-$particle on being accelerated by the same potential difference enters perpendicular to the magnetic field, then the ratio of their kinetic energies is [MP PMT 2003; J & K CET 2005]

(a) 1 : 2 : 2 (b) 2 : 2 : 1

(c) 1 : 2 : 1 (d) 1 : 1 : 2

31. Which of the following statement is true [Manipal MEE 1995]

(a) The presence of a large magnetic flux through a coil maintains a current in the coil if the circuit is continuous

(b) A coil of a metal wire kept stationary in a non-uniform magnetic field has an e.m.f. induced in it

(c) A charged particle enters a region of uniform magnetic field at an angle of $85°$ to the magnetic lines of force; the path of the particle is a circle

(d) There is no change in the energy of a charged particle moving in a magnetic field although a magnetic force is acting on it

32. An electron and a proton enter region of uniform magnetic field in a direction at right angles to the field with the same kinetic energy. They describe circular paths of radius r_e and r_p respectively. Then

(a) $r_e = r_p$

(b) $r_e < r_p$

(c) $r_e > r_p$

(d) r_e may be less than or greater than r_p depending on the direction of the magnetic field

33. A proton of mass $1.67\times10^{-27}\, kg$ and charge $1.6\times10^{-19}\, C$ is projected with a speed of $2\times10^6\, m/s$ at an angle of $60°$ to the $X-$axis. If a uniform magnetic field of 0.104 *Tesla* is applied along $Y-$axis, the path of proton is [IIT-JEE 1995]

(a) A circle of radius = 0.2 m and time period $\pi\times10^{-7}\, s$

(b) A circle of radius = 0.1 m and time period $2\pi\times10^{-7}\, s$

(c) A helix of radius = 0.1 m and time period $2\pi\times10^{-7}\, s$

(d) A helix of radius = 0.2 m and time period $4\pi\times10^{-7}\, s$

34. A proton and a deutron both having the same kinetic energy, enter perpendicularly into a uniform magnetic field *B*. For motion of proton and deutron on circular path of radius R_p and R_d respectively, the correct statement is [MP PET 1995]

(a) $R_d = \sqrt{2}\, R_p$ (b) $R_d = R_p/\sqrt{2}$

(c) $R_d = R_p$ (d) $R_d = 2R_p$

35. A proton (or charged particle) moving with velocity *v* is acted upon by electric field *E* and magnetic field *B*. The proton will move undeflected if [MP PMT 1995, 2003; UPSEAT 2002; DPMT 2003]

(a) *E* is perpendicular to *B*

(b) *E* is parallel to *v* and perpendicular to *B*

(c) *E*, *B* and *v* are mutually perpendicular and $v = \frac{E}{B}$

(d) *E* and *B* both are parallel to *v*

36. A proton and an electron both moving with the same velocity *v* enter into a region of magnetic field directed perpendicular to the velocity of the particles. They will now move in circular orbits such that [MP PMT 1995]

(a) Their time periods will be same

(b) The time period for proton will be higher

(c) The time period for electron will be higher

(d) Their orbital radii will be same

37. A charge $+Q$ is moving upwards vertically. It enters a magnetic field directed to the north. The force on the charge will be towards[MP PMT 1995; AM

(a) North (b) South

(c) East (d) West

38. An electron is moving on a circular path of radius *r* with speed *v* in a transverse magnetic field *B*. *e*/*m* for it will be [MP PMT 2003]

(a) $\frac{v}{Br}$ [Manipal MEE 1995] (b) $\frac{B}{rv}$

(c) Bvr (d) $\frac{vr}{B}$

39. A beam of well collimated cathode rays travelling with a speed of $5\times10^6\, ms^{-1}$ enter a region of mutually perpendicular electric and magnetic fields and emerge undeviated from this region. If $|\mathbf{B}| = 0.02\, T$, the magnitude of the electric field is

(a) $10^5\, Vm^{-1}$ (b) $2.5\times10^8\, Vm^{-1}$

(c) $1.25\times10^{10}\, Vm^{-1}$ (d) $2\times10^3\, Vm^{-1}$

40. An electron having charge $1.6\times10^{-19}\, C$ and mass $9\times10^{-31}\, kg$ is moving with $4\times10^6\, ms^{-1}$ speed in a magnetic field $2\times10^{-1}\, tesla$ in a circular orbit. The force acting on electron and the radius of the circular orbit will be [MP PET 1996; JIPMER 2000; BVP 2003]

(a) $12.8\times10^{-13}\, N, 1.1\times10^{-4}\, m$

(b) $1.28\times10^{-14}N, 1.1\times10^{-3}m$

(c) $1.28\times10^{-13}N, 1.1\times10^{-3}m$

(d) $1.28\times10^{-13}N, 1.1\times10^{-4}m$

41. An electron enters a magnetic field whose direction is perpendicular to the velocity of the electron. Then [MP PMT 1996; CBSE PMT 2003]

(a) The speed of the electron will increase

(b) The speed of the electron will decrease

(c) The speed of the electron will remain the same

(d) The velocity of the electron will remain the same

42. An electron is moving in the north direction. It experiences a force in vertically upward direction. The magnetic field at the position of the electron is in the direction of [MP PET 2003]

(a) East (b) West

(c) North (d) South

43. A current carrying long solenoid is placed on the ground with its axis vertical. A proton is falling along the axis of the solenoid with a velocity v. When the proton enters into the solenoid, it will

(a) Be deflected from its path

(b) Be accelerated along the same path

(c) Be decelerated along the same path

(d) Move along the same path with no change in velocity

44. A charged particle of mass m and charge q describes circular motion of radius r in a uniform magnetic field of strength B. The frequency of revolution is [MP PET 1997; RPET 2001]

(a) $\frac{Bq}{2\pi m}$ (b) $\frac{Bq}{2\pi rm}$

(c) $\frac{2\pi m}{Bq}$ (d) $\frac{Bm}{2\pi q}$

45. An electron is accelerated by a potential difference of 12000 *volts*. It then enters a uniform magnetic field of $10^{-3}\,T$ applied perpendicular to the path of electron. Find the radius of path. Given mass of electron $=9\times10^{-31}\,kg$ and charge on electron $=1.6\times10^{-19}\,C$ [MP PET 1997]

(a) 36.7 *m* (b) 36.7 *cm*

(c) 3.67 *m* (d) 3.67 *cm*

46. The charge on a particle Y is double the charge on particle X. These two particles X and Y after being accelerated through the same potential difference enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is [MP PET 1997]

(a) $\left(\frac{2R_1}{R_2}\right)^2$ (b) $\left(\frac{R_1}{2R_2}\right)^2$

(c) $\frac{R_1^2}{2R_2^2}$ (d) $\frac{2R_1}{R_2}$

47. A particle with 10^{-11} *coulomb* of charge and $10^{-7}\,kg$ mass is moving with a velocity of $10^8\,m/s$ along the *y*-axis. A uniform static magnetic field $B=0.5\,Tesla$ is acting along the *x*-direction. The force on the particle is [MP PMT 1997]

(a) $5\times10^{-11}\,N$ along $\hat{i}$ (b) $5\times10^{3}\,N$ along $\hat{k}$

(c) $5\times10^{-11}\,N$ along $-\hat{j}$ (d) $5\times10^{-4}\,N$ along $-\hat{k}$

48. A particle of charge q and mass m moving with a velocity v along the *x*-axis enters the region $x > 0$ with uniform magnetic field B along the $\hat{k}$ direction. The particle will penetrate in this region in the *x*-direction upto a distance d equal to

(a) Zero (b) $\frac{mv}{qB}$

(c) $\frac{2mv}{qB}$ (d) Infinity

49. A charged particle is moving with velocity v in a magnetic field of induction B. The force on the particle will be maximum when

(a) v and B are in the same direction

(b) v and B are in opposite directions

(c) v and B are perpendicular

(d) v and B are at an angle of $45°$

50. A charged particle enters a magnetic field H with its initial velocity making an angle of $45°$ with H. The path of the particle will be [MP PET 1999;

(a) A straight line (b) A circle

(c) An ellipse (d) A helix

51. An electron and a proton enter a magnetic field perpendicularly. Both have same kinetic energy. Which of the following is true

(a) Trajectory of electron is less curved

(b) Trajectory of proton is less curved

(c) Both trajectories are equally curved

(d) Both move on straight-line path

52. A charged particle moves in a uniform magnetic field. The velocity of the particle at some instant makes an acute angle with the magnetic field. The path of the particle will be [MP PMT 1999]

(a) A straight line

(b) A circle

(c) A helix with uniform pitch

(d) A helix with non-uniform pitch

53. An electron is moving along positive *x*-axis. To get it moving on an anticlockwise circular path in *x-y* plane, a magnetic filed is applied

(a) Along positive *y*-axis (b) Along positive *z*-axis

(c) Along negative *y*-axis (d) Along negative *z*-axis

54. A moving charge will gain energy due to the application of [CPMT 1999]

(a) Electric field (b) Magnetic field

(c) Both of these (d) None of these

55. A proton, a deuteron and an $\alpha-$particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_d and r_α denote respectively the radii of the trajectories of these particles, then

[IIT 1997 Re-Exam]

(a) $r_\alpha = r_p < r_d$ (b) $r_\alpha > r_d > r_p$

(c) $r_\alpha = r_d > r_p$ (d) $r_p = r_d = r_\alpha$

56. When a magnetic field is applied in a direction perpendicular to the direction of cathode rays, then their [EAMCET 1994; BHU 2005]

(a) Energy decreases

(b) Energy increases

(c) Momentum increases

(d) Momentum and energy remain unchanged

57. A charge moves in a circle perpendicular to a magnetic field. The time period of revolution is independent of [RPET 1997; AIEEE 2002]

(a) Magnetic field (b) Charge

(c) Mass of the particle (d) Velocity of the particle

58. A proton of energy 200 *MeV* enters the magnetic field of 5 *T*. If direction of field is from south to north and motion is upward, the force acting on it will be [RPET 1997]

(a) Zero (b) $1.6 \times 10^{-10}\, N$

(c) $3.2 \times 10^{-8}\, N$ (d) $1.6 \times 10^{-6}\, N$

59. An electron enters a region where magnetic (*B*) and electric (*E*) fields are mutually perpendicular to one another, then [CBSE PMT1993]

(a) It will always move in the direction of *B*

(b) It will always move in the direction of *E*

(c) It always possess circular motion

(d) It can go undeflected also

60. A charge moving with velocity *v* in *X*-direction is subjected to a field of magnetic induction in the negative *X*-direction. As a result, the charge will [CBSE PMT1993]

(a) Remain unaffected

(b) Start moving in a circular path *Y*-*Z* plane

(c) Retard along *X*-axis

(d) Move along a helical path around *X*-axis

61. An electron and a proton with equal momentum enter perpendicularly into a uniform magnetic field, then [BHU 1997; AIEEE 2002; MH CET (Med.) 2000]

(a) The path of proton shall be more curved than that of electron

(b) The path of proton shall be less curved than that of electron

(c) Both are equally curved

(d) Path of both will be straight line

62. A positively charged particle moving due east enters a region of uniform magnetic field directed vertically upwards. The particle will

(a) Get deflected vertically upwards

(b) Move in a circular orbit with its speed increased

(c) Move in a circular orbit with its speed unchanged

(d) Continue to move due east

63. A particle moving in a magnetic field increases its velocity, then its radius of the circle [BHU 1998]

(a) Decreases (b) Increases

(c) Remains the same (d) Becomes half

64. A particle is moving in a uniform magnetic field, then [BHU 1998]

(a) Its momentum changes but total energy remains the same

(b) Both momentum and total energy remain the same

(c) Both will change

(d) Total energy changes but momentum remains the same

65. If an electron is going in the direction of magnetic field $\vec{B}$ with the velocity of $\vec{v}$ then the force on electron is [RPMT 1999]

(a) Zero (b) $e(\vec{v} \cdot \vec{B})$

(c) $e(\vec{v} \times \vec{B})$ (d) None of these

66. One proton beam enters a magnetic field of $10^{-4}\, T$ normally, Specific charge = $10^{11}\, C/kg$. velocity = $10^7\, m/s$. What is the radius of the circle described by it [DCE 1999]

(a) 0.1 *m* (b) 1 *m*

(c) 10 *m* (d) None of these

67. In a cyclotron, the angular frequency of a charged particle is independent of [CPMT 1999]

(a) Mass (b) Speed

(c) Charge (d) Magnetic field

68. A charged particle is moving in a uniform magnetic field in a circular path. Radius of circular path is *R*. When energy of particle is doubled, then new radius will be [CPMT 1999; Pb. PET 2002]

(a) $R\sqrt{2}$ (b) $R\sqrt{3}$

(c) 2 *R* (d) 3 *R*

69. The radius of curvature of the path of a charged particle moving in a static uniform magnetic field is [Roorkee 1999]

(a) Directly proportional to the magnitude of the charge on the particle

(b) Directly proportional to the magnitude of the linear momentum of the particle

(c) Directly proportional to the kinetic energy of the particle

(d) Inversely proportional to the magnitude of the magnetic field

70. A proton moving with a velocity, $2.5 \times 10^7\, m/s$, enters a magnetic field of intensity 2.5 *T* making an angle 30^o with the magnetic field. The force on the proton is [AFMC 2000; CBSE PMT 2000]

(a) $3 \times 10^{-12}\, N$ (b) $5 \times 10^{-12}\, N$

(c) $6 \times 10^{-12}\, N$ (d) $9 \times 10^{-12}\, N$

71. Maximum kinetic energy of the positive ion in the cyclotron is [CBSE PMT 1997]

(a) $\frac{q^2 B r_0}{2m}$ (b) $\frac{qB^2 r_o}{2m}$

(c) $\frac{q^2 B^2 r_0^2}{2m}$ (d) $\frac{qBr_0}{2m^2}$

72. A charge *q* is moving in a magnetic field then the magnetic force does not depend upon [RPET 2000]

(a) Charge (b) Mass

(c) Velocity (d) Magnetic field

73. An electron is travelling in east direction and a magnetic field is applied in upward direction then electron will deflect in

(a) South (b) North

(c) West (d) East

74. A charge of 1*C* is moving in a magnetic field of 0.5 *Tesla* with a velocity of 10 *m/sec* Perpendicular to the field. Force experienced is

(a) 5 *N* (b) 10 *N*

(c) 0.5 *N* (d) 0 *N*

75. An electron of mass *m* and charge *q* is travelling with a speed *v* along a circular path of radius *r* at right angles to a uniform of magnetic field *B*. If speed of the electron is doubled and the magnetic field is halved, then resulting path would have a radius of [Kerala PMT 2004; KCET 2000, 05]

(a) $\frac{r}{4}$ (b) $\frac{r}{2}$

(c) $2r$ (d) $4r$

76. If an electron enters a magnetic field with its velocity pointing in the same direction as the magnetic field, then [MP PMT 2000]

(a) The electron will turn to its right

(b) The electron will turn to its left

(c) The velocity of the electron will increase

(d) The velocity of the electron will remain unchanged

77. A particle of mass *m* and charge *q* enters a magnetic field *B* perpendicularly with a velocity *v*, The radius of the circular path described by it will be [MP PMT 2000]

(a) Bq/mv (b) mq/Bv

(c) mB/qv (d) mv/Bq

78. An electron moving towards the east enters a magnetic field directed towards the north. The force on the electron will be directed

(a) Vertically upward (b) Vertically downward

(c) Towards the west (d) Towards the south

79. An electron (mass = 9.0×10^{-31} *kg* and charge $=1.6\times10^{-19}$ *coulomb*) is moving in a circular orbit in a magnetic field of 1.0×10^{-4} $weber/m^2$. Its period of revolution is

(a) 3.5×10^{-7} *sec* (b) 7.0×10^{-7} *sec*

(c) 1.05×10^{-6} *sec* (d) 2.1×10^{-6} *sec*

80. An electron (charge *q* coulomb) enters a magnetic field of *H* $weber/m^2$ with a velocity of $v\,m/s$ in the same direction as that of the field the force on the electron is [MP PET 2000]

(a) *Hqv* Newton's in the direction of the magnetic field

(b) *Hqv* dynes in the direction of the magnetic field

(c) *Hqv* Newton's at right angles to the direction of the magnetic field

(d) Zero

81. A homogeneous electric field *E* and a uniform magnetic field $\vec{B}$ are pointing in the same direction. A proton is projected with its velocity parallel to $\vec{E}$. It will [Roorkee 2000]

(a) Go on moving in the same direction with increasing velocity

(b) Go on moving in the same direction with constant velocity

(c) Turn to its right

(d) Turn to its left

82. The radius of circular path of an electron when subjected to a perpendicular magnetic field is [Pb. PMT 1999; DCE 2000; MH CET (Med.) 2000]

(a) $\frac{mv}{Be}$ (b) $\frac{me}{Be}$

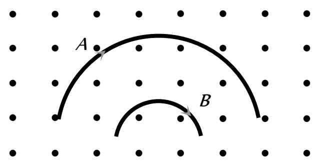
(c) $\frac{mE}{Be}$ [RPMT 2000] (d) $\frac{Be}{mv}$

83. Cyclotron is used to accelerate [AIIMS 2001; BCECE 2004]

(a) Electrons (b) Neutrons

(c) Positive ions (d) Negative ions

84. Two particles *A* and *B* of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively, and the trajectories are as shown in the figure. Then [IIT-JEE (Screening) 2001]



(a) $m_A v_A < m_B v_B$

(b) $m_A v_A > m_B v_B$

(c) $m_A < m_B$ and $v_A < v_B$

(d) $m_A = m_B$ and $v_A = v_B$

85. A proton and an alpha particle are separately projected in a region where a uniform magnetic field exists. Their initial velocities are perpendicular to direction of magnetic field. If both the particles move around magnetic field in circles of equal radii, the ratio of momentum of proton to alpha particle $\left(\frac{P_p}{P_\alpha}\right)$ is

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

(c) 2 [MP PET 2000] (d) $\frac{1}{4}$

86. A particle of mass 0.6 *g* and having charge of 25 *nC* is moving horizontally with a uniform velocity $1.2\times10^4\,ms^{-1}$ in a uniform magnetic field, then the value of the magnetic induction is $(g=10\,ms^{-2})$ [EAMCET 2001] [MP PET 2000; Pb PET 2003]

(a) Zero (b) 10 *T*

(c) 20 *T* (d) 200 *T*

87. An α particle and a proton travel with same velocity in a magnetic field perpendicular to the direction of their velocities, find the ratio of the radii of their circular path [AIIMS 2004; DCE 2001, 03; Kerala PMT 2005]

(a) 4 : 1 (b) 1 : 4

(c) 2 : 1 (d) 1 : 2

88. Motion of a moving electron is not affected by [AMU (Engg.) 2001]

(a) An electric field applied in the direction of motion

(b) Magnetic field applied in the direction of motion

(c) Electric field applied perpendicular to the direction of motion

(d) Magnetic field applied perpendicular to the direction of motion

89. When a charged particle enters a uniform magnetic field its kinetic energy [MP PMT 2001; MP PET 2002]

(a) Remains constant (b) Increases

(c) Decreases (d) Becomes zero

90. If cathode rays are projected at right angles to a magnetic field, their trajectory is [JIPMER 2002]

(a) Ellipse (b) Circle

(c) Parabola (d) None of these

91. At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit

(i) Electrons (ii) Protons

(iii) He^{2+} (iv) Neutrons

The emission at the instant can be [AIEEE 2002]

(a) i, ii, iii (b) i, ii, iii, iv

(c) iv (d) ii, iii

92. Which particles will have minimum frequency of revolution when projected with the same velocity perpendicular to a magnetic field

(a) *Li* (b) Electron

(c) Proton (d) He^{+}

93. Mixed He^{+} and O^{2+} ions (mass of $He^{+} = 4\ amu$ and that of $O^{2+} = 16\ amu$) beam passes a region of constant perpendicular magnetic field. If kinetic energy of all the ions is same then

(a) He^{+} ions will be deflected more than those of O^{2+}

(b) He^{+} ions will be deflected less than those of O^{2+}

(c) All the ions will be deflected equally

(d) No ions will be deflected

94. An electron (mass = 9×10^{-31} *kg*. Charge = 1.6×10^{-19} *C*) whose kinetic energy is 7.2×10^{-18} *joule* is moving in a circular orbit in a magnetic field of 9×10^{-5} *weber/m*. The radius of the orbit is

(a) 1.25 *cm* (b) 2.5 *cm*

(c) 12.5 *cm* (d) 25.0 *cm*

95. An electron enters a region where electrostatic field is 20*N*/*C* and magnetic field is 5*T*. If electron passes undeflected through the region, then velocity of electron will be

[DPMT 2002]

(a) $0.25 ms^{-1}$ (b) $2 ms^{-1}$

(c) $4 ms^{-1}$ (d) $8 ms^{-1}$

96. A charged particle is released from rest in a region of steady uniform electric and magnetic fields which are parallel to each other the particle will move in a

[IIT-JEE 1999; DPMT 2000; UPSEAT 2003]

(a) Straight line (b) Circle

(c) Helix (d) Cycloid

97. A particle of mass *M* and charge *Q* moving with velocity $\vec{v}$ describes a circular path of radius *R* when subjected to a uniform transverse magnetic field of induction *B*. The work done by the field when the particle completes one full circle is

(a) $BQv 2\pi R$ (b) $\left(\frac{Mv^2}{R}\right) 2\pi R$

(c) Zero (d) $BQ 2\pi R$

98. A particle of charge -16×10^{-18} *coulomb* moving with velocity $10\ ms^{-1}$ along the *x*-axis enters a region where a magnetic field of induction *B* is along the *y*-axis, and an electric field of magnitude 10^4 *V*/*m* is along the negative *z*-axis. If the charged particle continues moving along the *x*-axis, the magnitude of *B* is

(a) $10^{-3} Wb/m^2$ (b) $10^{3} Wb/m^2$

(c) $10^{5} Wb/m^2$ (d) $10^{16} Wb/m^2$

99. Two ions having masses in the ratio 1 : 1 and charges 1 : 2 are projected into uniform magnetic field perpendicular to the field with speeds in the ratio 2 : 3. The ratio of the radii of circular paths along which the two particles move is

[EAMCET 2003]

(a) 4 : 3 (b) 2 : 3

(c) 3 : 1 (d) 1 : 4

[Orissa JEE 2002]

100. An electron is travelling along the *x*-direction. It encounters a magnetic field in the *y*-direction. Its subsequent motion will be

(a) Straight line along the *x*-direction

(b) A circle in the *xz*-plane

(c) A circle in the *yz*-plane

(d) A circle in the *xy*-plane

[Orissa JEE 2002]

101. An electron and a proton have equal kinetic energies. They enter in a magnetic field perpendicularly, Then

[UPSEAT 2003]

(a) Both will follow a circular path with same radius

(b) Both will follow a helical path

(c) Both will follow a parabolic path

(d) All the statements are false

102. Electrons move at right angles to a magnetic field of 1.5×10^{-2} *Tesla* with a speed of $6\times 10^{7} m/s$. If the specific charge of the electron is 1.7×10^{11} *C*/*kg*. The radius of the circular path will be [MP PMT 2002] [BHU 2003]

(a) 2.9 *cm* (b) 3.9 *cm*

(c) 2.35 *cm* (d) 3 *cm*

103. The cyclotron frequency of an electron grating in a magnetic field of 1 *T* is approximately [AIIMS 2004]

(a) 28 *MHz* (b) 280 *MHz*

(c) 2.8 *GHz* (d) 28 *GHz*

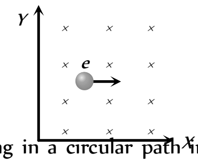
104. In the given figure, the electron enters into the magnetic field. It deflects in ...... direction [Orissa PMT 2004]

(a) + *ve X* direction

(b) – *ve X* direction

(c) + *ve Y* direction

(d) – *ve Y* direction



105. A proton of energy 8 *eV* is moving in a circular path in a uniform magnetic field. The energy of an alpha particle moving in the same magnetic field and along the same path will be

(a) 4 *eV* (b) 2 *eV*

(c) 8 *eV* (d) 6 *eV*

[AIEEE 2003]

106. An electron, a proton, a deuteron and an alpha particle, each having the same speed are in a region of constant magnetic field perpendicular to the direction of the velocities of the particles. The radius of the circular orbits of these particles are respectively R_e, R_p, R_d and R_α. It follows that

(a) $R_e = R_p$ (b) $R_p = R_d$

(c) $R_d = R_\alpha$ (d) $R_p = R_\alpha$

107. An electron moving with a uniform velocity along the positive *x*-direction enters a magnetic field directed along the positive *y*-direction. The force on the electron is directed along

[AIEEE 2003]

(a) Positive *y*-direction (b) Negative *y*-direction

(c) Positive z-direction (d) Negative z-direction

108. An electron is projected along the axis of a circular conductor carrying some current. Electron will experience force

(a) Along the axis

(b) Perpendicular to the axis

(c) At an angle of 4° with axis

(d) No force experienced

109. A very high magnetic field is applied to a stationary charge. Then the charge experiences [DCE 2004]

(a) A force in the direction of magnetic field

(b) A force perpendicular to the magnetic field

(c) A force in an arbitrary direction

(d) No force

110. A electron ($q = 1.6 \times 10^{-19}$ C) is moving at right angle to the uniform magnetic field 3.534×10^{-5} T. The time taken by the electron to complete a circular orbit is [MH CET 2004]

(a) 2 μs (b) 4 μs

(c) 3 μs (d) 1 μs

111. In case Hall effect for a strip having charge Q and area of cross-section A, the Lorentz force is [DCE 2004]

(a) Directly proportional to Q

(b) Inversely proportional to Q

(c) Inversely proportional to A

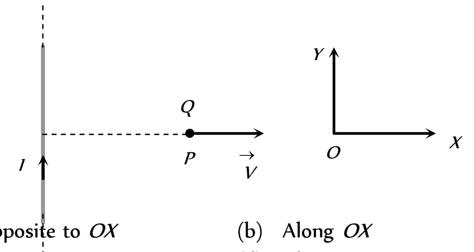
(d) Directly proportional to A

112. A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is

(a) $\frac{2\pi qB}{m}$ (b) $\frac{2\pi m}{qB}$

(c) $\frac{2\pi mq}{B}$ (d) $\frac{2\pi q^2B}{m}$

113. A very long straight wire carries a current I. At the instant when a charge $+Q$ at point P has velocity $\vec{V}$, as shown, the force on the charge is [CBSE PMT 2005]



(a) Opposite to OX (b) Along OX

(c) Opposite to OY (d) Along OY

114. The electron in the beam of a television tube move horizontally from south to north. The vertical component of the earth's magnetic field points down. The electron is deflected towards

(a) West (b) No deflection

(c) East (d) North to south

115. An electron moves in a circular orbit with a uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is proportional to [CBSE PMT 2005]

(a) $\frac{B}{v}$ (b) $\frac{v}{R}$

(c) $\sqrt{\frac{v}{B}}$ (d) $\sqrt{\frac{B}{v}}$

116. An electric field of 1500 V/m and a magnetic field of 0.40 *weber / meter* act on a moving electron. The minimum uniform speed along a straight line the electron could have is [DCE 2002]

(a) 1.6×10^{15} m/s (b) 6×10^{-16} m/s

(c) 3.75×10^{3} m/s (d) 3.75×10^{2} m/s

117. An electron (mass = 9.1×10^{-31} kg; charge = 1.6×10^{-19} C) experiences no deflection if subjected to an electric field of 3.2×10^5 V/m, and a magnetic fields of 2.0×10^{-3} Wb/m. Both the fields are normal to the path of electron and to each other. If the electric field is removed, then the electron will revolve in an orbit of radius [BCECE 2005]

(a) 45 m (b) 4.5 m

(c) 0.45 m (d) 0.045 m

118. An electron, moving in a uniform magnetic field of induction of intensity $\vec{B}$, has its radius directly proportional to [DPMT 2005]

(a) Its charge (b) Magnetic field

(c) Speed (d) None of these

Force and Torque on a Current Carrying Conductor

1. Two free parallel wires carrying currents in opposite direction [CPMT 1977; MP PMT 1993; AFMC 2002; CPMT 2003]

(a) Attract each other

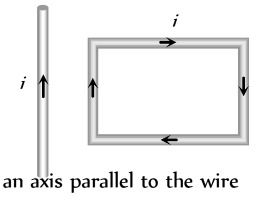
(b) Repel each other

(c) Neither attract nor repel

(d) Get rotated to be perpendicular to each other

[AIEEE 2005]

2. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to the one of the sides of the loop and is in the plane of the loop. If a steady current I is established in wire as shown in figure, the loop will [IIT 1985; MP PET 1995; MP PMT 1995, 99; AIIMS 2003]



(a) Rotate about an axis parallel to the wire

(b) Move away from the wire or towards right

(c) Move towards the wire

(d) Remain stationary

3. A circular coil of radius 4 cm and of 20 turns carries a current of 3 *amperes*. It is placed in a magnetic field of intensity of 0.5 $weber/m^2$. The magnetic dipole moment of the coil is

(a) 0.15 $ampere-m^2$ (b) 0.3 $ampere-m^2$

(c) 0.45 $ampere-m^2$ [KCET 2005] (d) 0.6 $ampere-m^2$

4. A conducting circular loop of radius r carries a constant current i. It is placed in a uniform magnetic field $\vec{B}$, such that $\vec{B}$ is perpendicular to the plane of the loop. The magnetic force acting on the loop is [BIT 1992; MP PET 1994; IIT 1983; MP PMT 1999; AMU (Engg.) 2000]

(a) $ir\vec{B}$ (b) $2\pi ri\vec{B}$

(c) Zero (d) $\pi ri\vec{B}$

5. Two thin long parallel wires separated by a distance b are carrying a current i *amp* each. The magnitude of the force per unit length exerted by one wire on the other is

[CPMT 1991; IIT 1986; Bihar MEE 1995; RPMT 1997; MP PET 1996; MP PMT 1994, 96, 99; UPSEAT 2001, 03]

(a) $\frac{\mu_0 i^2}{b^2}$ (b) $\frac{\mu_0 i^2}{2\pi b}$

(c) $\frac{\mu_0 i}{2\pi b}$ (d) $\frac{\mu_0 i}{2\pi b^2}$

6. Through two parallel wires *A* and *B*, 10 and 2 *ampere* of currents are passed respectively in opposite direction. If the wire *A* is infinitely long and the length of the wire *B* is 2 *m*, the force on the conductor *B*, which is situated at 10 *cm* distance from *A* will be [CPMT 1988; MP PMT 1994]

(a) $8\times10^{-5}\,N$ (b) $4\times10^{-7}\,N$

(c) $4\times10^{-5}\,N$ (d) $4\pi\times10^{-7}\,N$

7. If two streams of protons move parallel to each other in the same direction, then they [MP PET 1999; AIIMS 2004]

(a) Do not exert any force on each other

(b) Repel each other

(c) Attract each other

(d) Get rotated to be perpendicular to each other

8. A straight wire carrying a current i_1 *amp* runs along the axis of a circular current i_2 *amp*. Then the force of interaction between the two current carrying conductors is

(a) ∞ (b) Zero

(c) $\frac{\mu_0}{4\pi}\frac{2i_1 i_2}{r}\,N/m$ (d) $\frac{2i_1 i_2}{r}\,N/m$

9. Two parallel wires are carrying electric currents of equal magnitude and in the same direction. They exert

[CPMT 1990; MP PET/PMT 1988; Orissa JEE 2003; AFMC 2003]

(a) An attractive force on each other

(b) A repulsive force on each other

(c) No force on each other

(d) A rotational torque on each other

10. Two long and parallel wires are at a distance of 0.1 *m* and a current of 5 *A* is flowing in each of these wires. The force per unit length due to these wires will be [CPMT 1977]

(a) $5\times10^{-5}\,N/m$ (b) $5\times10^{-3}\,N/m$

(c) $2.5\times10^{-5}\,N/m$ (d) $2.5\times10^{-4}\,N/m$

11. Two straight parallel wires, both carrying 10 *ampere* in the same direction attract each other with a force of $1\times10^{-3}\,N$. If both currents are doubled, the force of attraction will be

[MP PET 1994]

(a) $1\times10^{-3}\,N$ (b) $2\times10^{-3}\,N$

(c) $4\times10^{-3}\,N$ (d) $0.25\times10^{-3}\,N$

12. A circular coil of radius 4 *cm* has 50 turns. In this coil a current of 2 *A* is flowing. It is placed in a magnetic field of 0.1 $weber/m^2$. The amount of work done in rotating it through $180°$ from its equilibrium position will be

[CPMT 1977]

(a) 0.1 *J* (b) 0.2 *J*

(c) 0.4 *J* (d) 0.8 *J*

13. 3 *A* of current is flowing in a linear conductor having a length of 40 *cm*. The conductor is placed in a magnetic field of strength 500 *gauss* and makes an angle of $30°$ with the direction of the field. It experiences a force of magnitude

[MP PET 1993]

(a) 3×10^4 *newton* (b) 3×10^2 *newton*

(c) 3×10^{-2} *newton* (d) 3×10^{-4} *newton*

14. The radius of a circular loop is r and a current i is flowing in it. The equivalent magnetic moment will be [CPMT 1990]

(a) ir (b) $2\pi ir$

(c) $i\pi r^2$ (d) $\frac{1}{r^2}$

15. A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon

[CPMT 1985; RPMT 1997; Kerala PMT 2002]

(a) Shape of the loop (b) Area of the loop

(c) Value of the current (d) Magnetic field

16. To make the field radial in a moving coil galvanometer

[MP PET 1993]

(a) The number of turns in the coil is increased

(b) Magnet is taken in the form of horse-shoe

(c) Poles are cylindrically cut

(d) Coil is wounded on aluminium frame

17. The deflection in a moving coil galvanometer is

[MP PMT 1993]

(a) Directly proportional to the torsional constant

(b) Directly proportional to the number of turns in the coil

(c) Inversely proportional to the area of the coil

(d) Inversely proportional to the current flowing

18. A moving coil sensitive galvanometer gives at once much more deflection. To control its speed of deflection

[MP PET 1985]

(a) A high resistance is to be connected across its terminals

(b) A magnet should be placed near the coil

(c) A small copper wire should be connected across its terminals

(d) The body of galvanometer should be earthed

19. In a moving coil galvanometer, the deflection of the coil θ is related to the electrical current i by the relation

[MP PMT 1996, 2000, 03; RPMT 1997; CPMT 1975; MP PET 1999]

(a) $i\propto\tan\theta$ (b) $i\propto\theta$

(c) $i\propto\theta^2$ (d) $i\propto\sqrt{\theta}$

20. The unit of electric current "*ampere*" is the current which when flowing through each of two parallel wires spaced 1 *m* apart in vacuum and of infinite length will give rise to a force between them equal to

[BIT 1987; CBSE PMT1998; MP PET 1999; MP PMT 2002]

(a) $1\,N/m$ (b) $2\times10^{-7}\,N/m$

(c) $1\times10^{-2}\ N/m$ (d) $4\pi\times10^{-7}\ N/m$

21. A moving coil galvanometer has *N* number of turns in a coil of effective area *A*, it carries a current *I*. The magnetic field *B* is radial. The torque acting on the coil is [MP PMT 1994]

(a) NA^2B^2I (b) $NABI^2$

(c) N^2ABI (d) *NABI*

22. A small coil of *N* turns has an effective area *A* and carries a current *I*. It is suspended in a horizontal magnetic field $\vec{B}$ such that its plane is perpendicular to $\vec{B}$. The work done in rotating it by $180°$ about the vertical axis is [MP PMT 1994]

(a) *NAIB* (b) 2*NAIB*

(c) $2\pi NAIB$ (d) $4\pi NAIB$

23. A small coil of *N* turns has area *A* and a current I flows through it. The magnetic dipole moment of this coil will be [MP PMT 1994]

(a) NI/A (b) NI^2A

(c) N^2AI (d) *NIA*

24. A current of 10 *ampere* is flowing in a wire of length 1.5 *m*. A force of 15 *N* acts on it when it is placed in a uniform magnetic field of 2 *tesla*. The angle between the magnetic field and the direction of the current is [MP PMT 1994]

(a) $30°$ (b) $45°$

(c) $60°$ (d) $90°$

25. A rectangular loop carrying a current *i* is placed in a uniform magnetic field *B*. The area enclosed by the loop is *A*. If there are *n* turns in the loop, the torque acting on the loop is given by

(a) $ni\vec{A}\times\vec{B}$ (b) $ni\vec{A}\cdot\vec{B}$

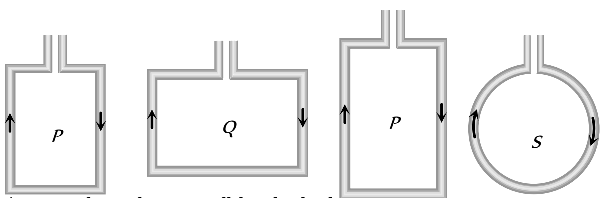
(c) $\frac{1}{n}(i\vec{A}\times\vec{B})$ (d) $\frac{1}{n}(i\vec{A}\cdot\vec{B})$

26. An electron moves with a constant speed *v* along a circle of radius *r*. Its magnetic moment will be (*e* is the electron's charge)

(a) *evr* (b) $\frac{1}{2}evr$

(c) $\pi r^2 ev$ (d) $2\pi rev$

27. Four wires each of length 2.0 *metres* are bent into four loops *P*, *Q*, *R* and *S* and then suspended into uniform magnetic field. Same current is passed in each loop. Which statement is correct



(a) Couple on loop *P* will be the highest

(b) Couple on loop *Q* will be the highest

(c) Couple on loop *R* will be the highest

(d) Couple on loop *S* will be the highest

28. A current carrying rectangular coil is placed in a uniform magnetic field. In which orientation, the coil will not tend to rotate

(a) The magnetic field is parallel to the plane of the coil

(b) The magnetic field is perpendicular to the plane of the coil

(c) The magnetic field is at 45° with the plane of the coil

(d) Always in any orientation

29. A current carrying circular loop is freely suspended by a long thread. The plane of the loop will point in the direction [MP PMT 1995]

(a) Wherever left free

(b) North-south

(c) East-west

(d) At $45°$ with the east-west direction

30. A current carrying loop is free to turn in a uniform magnetic field. The loop will then come into equilibrium when its plane is inclined at [CBSE PMT 1992; Haryana CEE 1996]

(a) $0°$ to the direction of the field

(b) $45°$ to the direction of the field

(c) $90°$ to the direction of the field

(d) $135°$ to the direction of the field

31. The expression for the torque acting on a coil having area of cross-section *A*, number of turns *n*, placed in a magnetic field of strength *B*, making an angle θ with the normal to the plane of the coil, when a current *i* is flowing in it, will be [MP PET 1996]

(a) $niAB\tan\theta$ (b) $niAB\cos\theta$

(c) $niAB\sin\theta$ (d) $niAB$

32. The pole pieces of the magnet used in a pivoted coil galvanometer are [MP PET 1996]

(a) Plane surfaces of a bar magnet

(b) Plane surfaces of a horse-shoe magnet [MP PMT 1994]

(c) Cylindrical surfaces of a bar magnet

(d) Cylindrical surfaces of a horse-shoe magnet

33. The sensitiveness of a moving coil galvanometer can be increased by decreasing [MP PMT 1996]

(a) The number of turns in the coil [MP PMT 1994]

(b) The area of the coil

(c) The magnetic field

(d) The couple per unit twist of the suspension

34. A metallic loop is placed in a magnetic field. If a current is passed through it, then [UPSEAT 2003]

[MP PET 1995; DPMT 1999]

(a) The ring will feel a force of attraction

(b) The ring will feel a force of repulsion

(c) It will move to and fro about its centre of gravity

(d) None of these

35. Two parallel conductors *A* and *B* of equal lengths carry currents I and 10 I, respectively, in the same direction. Then [MP PET 2003]

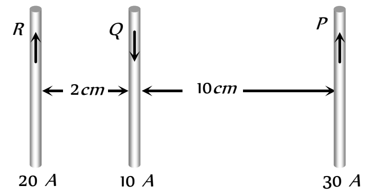
(a) *A* and *B* will repel each other with same force

(b) *A* and *B* will attract each other with same force

(c) A will attract *B*, but *B* will repel *A*

(d) *A* and *B* will attract each other with different forces

36. Three long, straight and parallel wires carrying currents are arranged as shown in figure. The force experienced by 10 *cm* length of wire *Q* is [MP PET 1997] [MP PMT 1995]



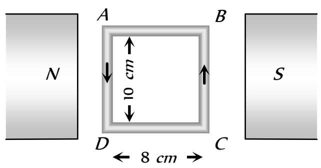
(a) $1.4\times10^{-4}\,N$ towards the right

(b) $1.4\times10^{-4}\,N$ towards the left

(c) $2.6\times10^{-4}\,N$ to the right

(d) $2.6\times10^{-4}\,N$ to the left

37. A 100 turns coil shown in figure carries a current of 2 *amp* in a magnetic field $B = 0.2\,Wb/m^2$. The torque acting on the coil is



(a) 0.32 *Nm* tending to rotate the side *AD* out of the page

(b) 0.32 *Nm* tending to rotate the side *AD* into the page

(c) 0.0032 *Nm* tending to rotate the side *AD* out of the page

(d) 0.0032 *Nm* tending to rotate the side *AD* into the page

38. A current of 5 *ampere* is flowing in a wire of length 1.5 *metres*. A force of 7.5 *N* acts on it when it is placed in a uniform magnetic field of 2 *Tesla*. The angle between the magnetic field and the direction of the current is

[MP PET 1997; Pb. PET 2003]

(a) $30°$ (b) 45°

(c) 60° (d) 90°

39. A conductor in the form of a right angle *ABC* with *AB* = 3 *cm* and *BC* = 4 *cm* carries a current of 10 *A*. There is a uniform magnetic field of 5 *T* perpendicular to the plane of the conductor. The force on the conductor will be

[MP PMT 1997]

(a) 1.5 *N* (b) 2.0 *N*

(c) 2.5 *N* (d) 3.5 *N*

40. The coil of a galvanometer consists of 100 turns and effective area of 1 *square cm*. The restoring couple is $10^{-8}\,N-m/radian$. The magnetic field between the pole pieces is 5 *T*. The current sensitivity of this galvanometer will be

(a) $5\times10^{4}\,rad/\mu amp$ (b) 5×10^{-6} *per amp*

(c) 2×10^{-7} *per amp* (d) $5\,rad/\mu amp$

41. A rectangular coil $20\,cm\times20\,cm$ has 100 turns and carries a current of 1 *A*. It is placed in a uniform magnetic field *B* = 0.5 *T* with the direction of magnetic field parallel to the plane of the coil. The magnitude of the torque required to hold this coil in this position is [MP PMT 1997]

(a) Zero (b) 200 *N-m*

(c) 2 *N-m* (d) 10 *N-m*

42. If a current is passed in a spring, it

[MP PMT/PET 1998; AIEEE 2002]

(a) Gets compressed (b) Gets expanded

(c) Oscillates (d) Remains unchanged

43. A current carrying small loop behaves like a small magnet. If *A* be its area and *M* its magnetic moment, the current in the loop will be

[MP PMT/PET 1998; RPET 2001; MP PMT 2003]

(a) M/A (b) A/M

(c) *MA* (d) A^2M

44. In hydrogen atom, the electron is making $6.6\times10^{15}\,rev/\sec$ around the nucleus in an orbit of radius 0.528 *Å*. The magnetic moment $(A-m^2)$ will be

[MP PET 1999]

(a) 1×10^{-15} [MP PET 1997] (b) 1×10^{-10}

(c) 1×10^{-23} (d) 1×10^{-27}

45. A triangular loop of side *l* carries a current *I*. It is placed in a magnetic field *B* such that the plane of the loop is in the direction of *B*. The torque on the loop is [MP PET 2003]

(a) Zero (b) *IBl*

(c) $\frac{\sqrt{3}}{2}Il^2B^2$ (d) $\frac{\sqrt{3}}{4}IBl^2$

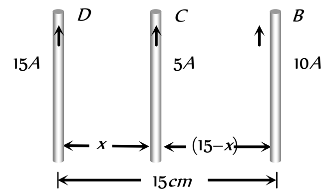
46. Three long, straight and parallel wires carrying currents are arranged as shown in the figure. The wire *C* which carries a current of 5.0 *amp* is so placed that it experiences no force. The distance of wire *C* from wire *D* is then [AMU 1995]

(a) 9 *cm*

(b) 7 *cm*

(c) 5 *cm*

(d) 3 *cm*



47. A vertical wire carrying a current in the upward direction is placed in horizontal magnetic field directed towards north. The wire will experience a force directed towards

[SCRA 1994]

(a) North (b) South

(c) East (d) West

48. A coil carrying electric current is placed in uniform magnetic field, then [CBSE PMT 1993]

(a) Torque is formed

[MP PMT 1997] (b) E.M.F. is induced

(c) Both (a) and (b) are correct

(d) None of these

49. A circular loop carrying a current is replaced by an equivalent magnetic dipole. A point on the axis of the loop is

(a) An end-on position (b) A broad side-on position

(c) Both (a) and (b) (d) Neither (a) nor (b)

50. A power line lies along the east-west direction and carries a current of 10 *ampere*. The force per metre due to the earth's magnetic field of 10^{-4} *tesla* is [Roorkee 1992]

(a) $10^{-5}\,N$ (b) $10^{-4}\,N$

(c) $10^{-3}\,N$ (d) $10^{-2}\,N$

51. A straight wire of length 0.5 *metre* and carrying a current of 1.2 *ampere* placed in a uniform magnetic field of induction 2 *Tesla*. The magnetic field is perpendicular to the length of the wire. The force on the wire is

[CBSE PMT 1992; BHU 1998; DPMT 2001; RPET 2003]

(a) 2.4 *N* (b) 1.2 *N*

(c) 3.0 *N* (d) 2.0 *N*

52. Two parallel wires in free space are 10 *cm* apart and each carries a current of 10 *A* in the same direction. The force one wire exerts on the other per metre of length is

[CBSE PMT 1997; AFMC 1999]

(a) $2\times10^{-4}\,N$, attractive (b) $2\times10^{-4}\,N$, repulsive

(c) $2\times10^{-7}\,N$, attractive (d) $2\times10^{-7}\,N$, repulsive

53. The current sensitivity of a moving coil galvanometer can be increased by [Roorkee 1999]

(a) Increasing the magnetic field of the permanent magnet

(b) Increasing the area of the deflecting coil

(c) Increasing the number of turns in the coil

(d) Increasing the restoring couple of the coil

54. A circular coil of diameter 7*cm* has 24 turns of wire carrying current of 0.75*A*. The magnetic moment of the coil is

[AMU (Med.) 1999]

(a) $6.9\times10^{-2} amp-m^2$ (b) $2.3\times10^{-2} amp\text{-}m^2$

(c) $10^{-2} amp-m^2$ (d) $10^{-3} amp-m^2$

55. Two long parallel wires carrying equal current separated by 1*m*, exert a force of $2\times10^{-7}\,N/m$ on one another. The current flowing through them is [AMU (Engg.) 1999]

(a) 2.0 *A* (b) $2.0\times10^{-7}\,A$

(c) 1.0 *A* (d) $1.0\times10^{-7}\,A$

56. Two parallel beams of electrons moving in the same direction produce a mutual force [MP PET 1996; DCE 1999]

(a) Of attraction in plane of paper

(b) Of repulsion in plane of paper

(c) Upwards perpendicular to plane of paper

(d) Downwards perpendicular to plane of paper

57. A circular loop of area $0.01m^2$ carrying a current of 10 *A*, is held perpendicular to a magnetic field of intensity 0.1*T*. The torque acting on the loop is [Pb. PMT 2000]

(a) Zero (b) 0.01 *N-m*

(c) 0.001 *N-m* (d) 0.8 *N-m*

58. Magnetic dipole moment of a rectangular loop is

[RPET 2000]

(a) Inversely proportional to current in loop

(b) Inversely proportional to area of loop

(c) Parallel to plane of loop and proportional to area of loop

(d) Perpendicular to plane of loop and proportional to area of loop

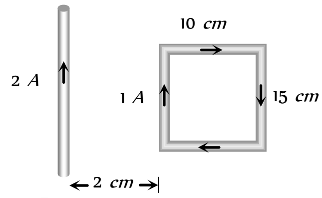
59. If *m* is magnetic moment and *B* is the magnetic field, then the torque is given by [DCE 2000]

(a) $\vec{m}.\vec{B}$ (b) $\dfrac{|\vec{m}|}{|\vec{B}|}$

(c) $\vec{m}\times\vec{B}$ (d) $|\vec{m}|.|\vec{B}|$

60. What is the net force on the square coil

[DCE 2000; RPMT 2000]



(a) $25\times10^{-7}\,N$ moving towards wire

(b) $25\times10^{-7}\,N$ moving away from wire

(c) $35\times10^{-7}\,N$ moving towards wire

(d) $35\times10^{-7}\,N$ moving away from wire

61. Two long parallel copper wires carry currents of 5*A* each in opposite directions. If the wires are separated by a distance of 0.5*m*, then the force between the two wires is

[EAMCET (Engg.) 2000]

(a) $10^{-5}\,N$, attractive (b) $10^{-5}\,N$, repulsive

(c) $2\times10^{-5}\,N$, attractive (d) $2\times10^{-5}\,N$, repulsive

62. In order to increase the sensitivity of a moving coil galvanometer, one should decrease [MP PMT 2000]

(a) The strength of its magnet

(b) The torsional constant of its suspension

(c) The number of turns in its coil

(d) The area of its coil

63. A circular loop has a radius of 5 *cm* and it is carrying a current of 0.1 *amp*. Its magnetic moment is [MP PMT 2000]

(a) $1.32\times10^{-4} amp-m^2$

(b) $2.62\times10^{-4} amp\text{-}m^2$

(c) $5.25\times10^{-4} amp\text{-}m^2$

(d) $7.85\times10^{-4} amp\text{-}m^2$

64. Due to the flow of current in a circular loop of radius *R*, the magnetic induction produced at the centre of the loop is *B*. The magnetic moment of the loop is

(μ_0 = permeability constant) [MP PET 2000]

(a) $BR^3/2\pi\mu_0$ (b) $2\pi BR^3/\mu_0$

(c) $BR^2/2\pi\mu_0$ (d) $2\pi BR^2/\mu_0$

65. The magnetic moment of a circular coil carrying current is

[MP PET 2000]

(a) Directly proportional to the length of the wire in the coil

(b) Inversely proportional to the length of the wire in the coil

(c) Directly proportional to the square of the length of the wire in the coil

(d) Inversely proportional to the square of the length of the wire in the coil

66. A long wire *A* carries a current of 10 *amp*. Another long wire *B*, Which is parallel to *A* and separated by 0.1*m* from *A*, carries a current of 5 *amp*, in the opposite direction to that in *A*. what is the magnitude and nature of the force experienced per unit length of *B*

($\mu_0 = 4\pi\times10^{-7}$ *weber / amp - m*) [MP PET 2000]

(a) Repulsive force of $10^{-4}\ N/m$

(b) Attractive force of $10^{-4}\ N/m$

(c) Repulsive force of $2\pi\times10^{-5}\ N/m$

(d) Attractive force of $2\pi\times10^{-5}\ N/m$

67. A stream of electrons is projected horizontally to the right. A straight conductor carrying a current is supported parallel to electron stream and above it. If the current in the conductor is from left to right then what will be the effect on electron stream

(a) The electron stream will be pulled upward

(b) The electron stream will be pulled downward

(c) The electron stream will be retarted

(d) The electron beam will be speeded up towards the right

68. The relation between voltage sensitivity (σ_V) and current sensitivity (σ_i) of a moving coil galvanometer is (Resistance of Galvanometer = *G*) [CPMT 2001]

(a) $\frac{\sigma_i}{G}=\sigma_V$ (b) $\frac{\sigma_V}{G}=\sigma_i$

(c) $\frac{G}{\sigma_V}=\sigma_i$ (d) $\frac{G}{\sigma_i}=\sigma_V$

69. What is shape of magnet in moving coil galvanometer to make the radial magnetic field [RPET 2001]

(a) Concave (b) Horse shoe magnet

(c) Convex (d) None of these

70. If a wire of length 1 *meter* placed in uniform magnetic field 1.5 *Tesla* at angle 30^o with magnetic field. The current in a wire 10 *amp*. Then force on a wire will be [RPET 2001]

(a) 7.5 *N* (b) 1.5 *N*

(c) 0.5 *N* (d) 2.5 *N*

71. A current *i* flows in a circular coil of radius *r*. If the coil is placed in a uniform magnetic field *B* with its plane parallel to the field, magnitude of the torque that acts on the coil is [MP PET 2001]

(a) Zero (b) $2\pi riB$

(c) $\pi r^2 iB$ (d) $2\pi r^2 iB$

72. An arbitrary shaped closed coil is made of a wire of length *L* and a current *I* ampere is flowing in it. If the plane of the coil is perpendicular to magnetic field $\vec{B}$, the force on the coil is [MP PMT 2001]

(a) Zero (b) *IBL*

(c) 2*IBL* (d) $\frac{1}{2}IBL$

73. A circular coil having *N* turns is made from a wire of length *L* meter. If a current *I* ampere is passed through it and is placed in a magnetic field of *B Tesla*, the maximum torque on it is

(a) Directly proportional to *N*

(b) Inversely proportional to *N*

(c) Inversely proportional to N^2

(d) Independent of *N*

74. A small cylindrical soft iron piece is kept in a galvanometer so that

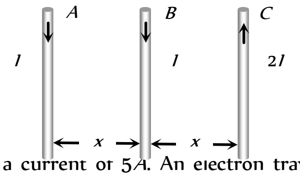
(a) A radial uniform magnetic field is produced

(b) A uniform magnetic field is produced

(c) There is a steady deflection of the coil

(d) All of these

75. *A*, *B* and *C* are parallel conductors of equal length carrying currents *I*, *I* and 2*I* respectively. Distance between *A* and *B* is *x*. Distance between *B* and *C* is also *x*. F_1 *is* the force exerted by *B* on *A* and F_2 is the force exerted by *B* on *A* choose the correct answer



(a) $F_1=2F_2$

(b) $F_2=2F_1$

(c) $F_1=F_2$

(d) $F_1=-F_2$

76. A straight conductor carries a current of 5*A*. An electron travelling with a speed of $3\times10^6\ ms^{-1}$ parallel to the wire at a distance of 0.1*m* from the conductor, experiences a force of [Roorkee 2000]

(a) $8\times10^{-20}\ N$ (b) $3.2\times10^{-19}\ N$

(c) $8\times10^{-18}\ N$ (d) $1.6\times10^{-19}\ N$

77. Two galvanometers *A* and *B* require 3*mA* and 5*mA* respectively to produce the same deflection of 10 divisions. Then

(a) *A* is more sensitive than *B*

(b) *B* is more sensitive than *A*

(c) *A* and *B* are equally sensitive

(d) Sensitiveness of *B* is 5/3 times that of *A*

78. Two long straight parallel conductors separated by a distance of 0.5*m* carry currents of 5*A* and 8*A* in the same direction. The force per unit length experienced by each other is

(a) $1.6\times10^{-5}\ N$ (attractive) (b) $1.6\times10^{-5}\ N$ (repulsive)

(c) $16\times10^{-5}\ N$ (attractive) (d) $16\times10^{-5}\ N$ (repulsive)

79. If the current is doubled, the deflection is also doubled in [Orissa JEE 2002]

(a) A tangent galvanometer

(b) A moving coil galvanometer

(c) Both (a) and (b)

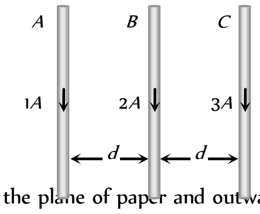
(d) None of these

80. Which is a vector quantity [AFMC 2003]

(a) Density (b) Magnetic flux

(c) Intensity of magnetic field (d) Magnetic potential

81. There long straight wires *A*, *B* and *C* are carrying current as shown figure. Then the resultant force on *B* is directed ..... [KCET 2004]



(a) Towards *A*

(b) Towards *C*

(c) Perpendicular to the plane of paper and outward

(d) Perpendicular to the plane of paper and inward

82. Two long conductors, separated by a distance *d* carry current I_1 and I_2 in the same direction. They exert a force *F* on each other. Now the current in one of them is increased to two times and its directions is reversed. The distance is also increased to 3*d*. The new value of the force between them is [AIEEE 2004] [MP PMT 2001]

(a) – 2*F* (b) *F*/3

(c) 2*F*/3 (d) – *F*/3

83. The resultant magnetic moment of neon atom will be [J & K CET 2004]

(a) Infinity (b) μ_r

(c) Zero (d) $\mu_r/2$

84. A one metre long wire is lying at right angles to the magnetic field. A force of 1 *kg wt.* is acting on it in a magnetic field of 0.98 *Tesla.* The current flowing in it will be [J & K CET 2004]

(a) 100 *A* (b) 10 *A*

(c) 1 *A* (d) Zero

85. A beam of electrons and protons move parallel to each other in the same direction, then they [DCE 2004]

(a) Attract each other (b) Repel each other

(c) No relation (d) Neither attract nor repel

86. Two parallel wires of length 9 *m* each are separated by a distance 0.15 *m.* If they carry equal currents in the same direction and exerts a total force of 30×10^{-7} *N* on each other, then the value of current must be [MH CET 2003]

(a) 2.5 *amp* (b) 3.5 *amp*

(c) 1.5 *amp* (d) 0.5 *amp*

87. Current *i* is carried in a wire of length *L.* If the wire is turned into a circular coil, the maximum magnitude of torque in a given magnetic field *B* will be [Pb. PET 2004]

(a) $\frac{LiB^2}{2}$ (b) $\frac{Li^2B}{2}$

(c) $\frac{L^2iB}{4\pi}$ (d) $\frac{Li^2B}{4\pi}$

88. In ballistic galvanometer, the frame on which the coil is wound is non-metallic to [MH CET 2004]

(a) Avoid the production of induced e.m.f.

(b) Avoid the production of eddy currents

(c) Increase the production of eddy currents

(d) Increase the production of induced e.m.f.

89. Two thin, long, parallel wires, separated by a distance '*d*' carry a current of '*i*' *A* in the same direction. They will [AIEEE 2005]

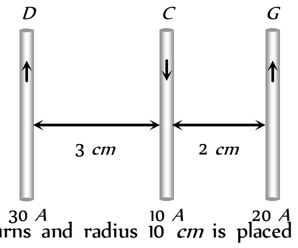
(a) Attract each other with a force of $\mu_0 i^2/(2\pi d^2)$

(b) Repel each other with a force of $\mu_0 i^2/(2\pi d^2)$

(c) Attract each other with a force of $\mu_0 i^2/(2\pi d)$

(d) Repel each other with a force of $\mu_0 i^2/(2\pi d)$

90. Three long, straight parallel wires carrying current, are arranged as shown in figure. The force experienced by a 25 *cm* length of wire *C* is [KCET 2005]



(a) 10^{-3} *N*

(b) 2.5×10^{-3} *N*

(c) Zero

(d) 1.5×10^{-3} *N*

91. A circular coil of 20 turns and radius 10 *cm* is placed in uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in coil is 5 A, then the torque acting on the coil will be [J & K CET 2005]

(a) 31.4 *Nm* (b) 3.14 *Nm*

(c) 0.314 *Nm* (d) Zero

Critical Thinking

Objective Questions

1. A circular current carrying coil has a radius R. The distance from the centre of the coil on the axis where the magnetic induction will be $\frac{1}{8}th$ to its value at the centre of the coil, is [MP PMT 1997]

(a) $\frac{R}{\sqrt{3}}$ (b) $R\sqrt{3}$

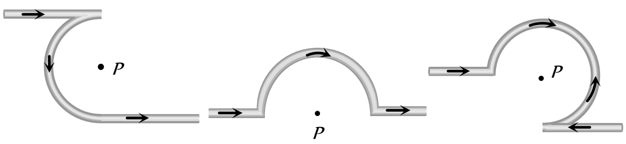
(c) $2\sqrt{3}\,R$ (d) $\frac{2}{\sqrt{3}}R$

2. The field normal to the plane of a wire of n turns and radius r which carries a current i is measured on the axis of the coil at a small distance h from the centre of the coil. This is smaller than the field at the centre by the fraction

(a) $\frac{3}{2}\frac{h^2}{r^2}$ (b) $\frac{2}{3}\frac{h^2}{r^2}$

(c) $\frac{3}{2}\frac{r^2}{h^2}$ (d) $\frac{2}{3}\frac{r^2}{h^2}$

3. The magnetic field at the centre of a circular coil of radius r is π times that due to a long straight wire at a distance r from it, for equal currents. Figure here shows three cases : in all cases the circular part has radius r and straight ones are infinitely long. For same current the B field at the centre P in cases 1, 2, 3 have the ratio [CPMT 1989]



(1) (2) (3)

(a) $\left(-\frac{\pi}{2}\right):\left(\frac{\pi}{2}\right):\left(\frac{3\pi}{4}-\frac{1}{2}\right)$

(b) $\left(-\frac{\pi}{2}+1\right):\left(\frac{\pi}{2}+1\right):\left(\frac{3\pi}{4}+\frac{1}{2}\right)$

(c) $-\frac{\pi}{2}:\frac{\pi}{2}:3\frac{\pi}{4}$

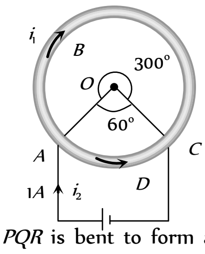
(d) $\left(-\frac{\pi}{2}-1\right):\left(\frac{\pi}{2}-\frac{1}{4}\right):\left(\frac{3\pi}{4}+\frac{1}{2}\right)$

4. Two straight long conductors AOB and COD are perpendicular to each other and carry currents i_1 and i_2. The magnitude of the magnetic induction at a point P at a distance a from the point O in a direction perpendicular to the plane $ACBD$ is

(a) $\frac{\mu_0}{2\pi a}(i_1+i_2)$ (b) $\frac{\mu_0}{2\pi a}(i_1-i_2)$

(c) $\frac{\mu_0}{2\pi a}(i_1^2+i_2^2)^{1/2}$ (d) $\frac{\mu_0}{2\pi a}\frac{i_1 i_2}{(i_1+i_2)}$

5. A cell is connected between the points A and C of a circular conductor $ABCD$ of centre O with angle $AOC = 60^o$. If B_1 and B_2 are the magnitudes of the magnetic fields at O due to the currents in ABC and ADC respectively, the ratio $\frac{B_1}{B_2}$ is



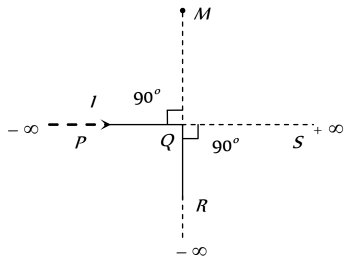
(a) 0.2

(b) 6

(c) 1

(d) 5

6. An infinitely long conductor PQR is bent to form a right angle as shown. A current I flows through PQR The magnetic field due to this current at the point M is H. Now another infinitely long straight conductor QS is connected at Q so that the current is $I/2$ in QR as well as in QS, *The current in PQ* remaining unchanged. The magnetic field at M is now H_2. The ratio H_1/H_2 is given by [IIT-JEE (Screening) 2000]



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

(b) 1

(c) $\frac{2}{3}$

(d) 2

7. Two coaxial solenoids 1 and 2 of the same length are set so that one is inside the other. The number of turns per unit length are n_1 and n_2. The currents i_1 and i_2 are flowing in opposite directions. The magnetic field inside the inner coil is zero. This is possible when

(a) $i_1 \neq i_2$ and $n_1 = n_2$

(b) $i_1 = i_2$ and $n_1 \neq n_2$

(c) $i_1 = i_2$ and $n_1 = n_2$

(d) $i_1 n_1 = i_2 n_2$

8. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. When a current I passes through the coil, the magnetic field at the centre is

(a) $\frac{\mu_0 NI}{b}$ (b) $\frac{2\mu_0 NI}{a}$

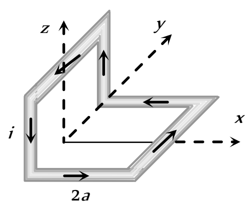
(c) $\frac{\mu_0 NI}{2(b-a)}\ln\frac{b}{a}$ (d) $\frac{\mu_0 I^N}{2(b-a)}\ln\frac{b}{a}$

[MP PMT 1994]

9. A non-planar loop of conducting wire carrying a current I is placed as shown in the figure. Each of the straight sections of the loop is of length $2a$. The magnetic field due to this loop at the point P (a,0,a) points in the direction [IIT-JEE (Screening) 2001]

(a) $\frac{1}{\sqrt{2}}(-\hat{j}+\hat{k})$

(b) $\frac{1}{\sqrt{3}}(-\hat{j}+\hat{k}+\hat{i})$



(c) $\frac{1}{\sqrt{3}}(\hat{i}+\hat{j}+\hat{k})$

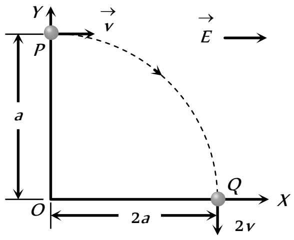
(d) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{k})$

10. A long straight wire along the *z*-axis carries a current *I* in the negative *z* direction. The magnetic vector field $\vec{B}$ at a point having coordinates (*x, y*) in the *z* = 0 plane is [IIT-JEE (Screening) 2002]

(a) $\frac{\mu_o I(y\hat{i}-x\hat{j})}{2\pi(x^2+y^2)}$ (b) $\frac{\mu_o I(x\hat{i}+y\hat{j})}{2\pi(x^2+y^2)}$

(c) $\frac{\mu_o I(x\hat{j}-y\hat{i})}{2\pi(x^2+y^2)}$ (d) $\frac{\mu_o I(x\hat{i}-y\hat{j})}{2\pi(x^2+y^2)}$

11. A particle of charge +*q* and mass *m* moving under the influence of a uniform electric field $E\hat{i}$ and a uniform magnetic field $B\hat{k}$ follows trajectory from *P* to *Q* as shown in figure. The velocities at *P* and *Q* are $v\hat{i}$ and $-2v\hat{j}$ respectively. Which of the following statement(s) is/are correct [IIT 1991; BVP 2003]



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

(b) Rate of work done by electric field at *P* is $\frac{3}{4}\frac{mv^3}{a}$

(c) Rate of work done by electric field at *P* is zero

(d) Rate of work done by both the fields at *Q* is zero

12. H^+, He^+ and O^{++} ions having same kinetic energy pass through a region of space filled with uniform magnetic field *B* directed perpendicular to the velocity of ions. The masses of the ions H^+, He^+ and O^{++} are respectively in the ratio $1:4:16$. As a result

(a) H^+ ions will be deflected most

(b) O^{++} ions will be deflected least

(c) He^+ and O^{++} ions will suffer same deflection

(d) All ions will suffer the same deflection

13. An ionized gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the +*x* direction and a magnetic field along the +*z* direction, then [IIT-JEE (Screening) 2000]

(a) Positive ions deflect towards +*y* direction and negative ions towards –*y* direction

(b) All ions deflect towards +*y* direction

(c) All ions deflect towards –*y* direction

(d) Positive ions deflect towards –*y* direction and negative ions towards +*y* direction

14. An electron moves with speed 2×10^5 *m/s* along the positive *x*-direction in the presence of a magnetic induction $B=\hat{i}+4\hat{j}-3\hat{k}$ (in *Tesla*.) The magnitude of the force experienced by the electron in Newton's is (charge on the electron $=1.6\times10^{-19}C$) [EAMCET 2001]

(a) 1.18×10^{-13} (b) 1.28×10^{-13}

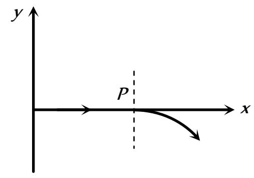
(c) 1.6×10^{-13} (d) 1.72×10^{-13}

15. A particle of mass *m* and charge *q* moves with a constant velocity *v* along the positive *x* direction. It enters a region containing a uniform magnetic field *B* directed along the negative *z* direction, extending from *x* = *a* to *x* = *b*. The minimum value of *v* required so that the particle can just enter the region $x>b$ is

(a) $qb\,B/m$ (b) $q(b-a)B/m$

(c) $qa\,B/m$ (d) $q(b+a)B/2m$

16. For a positively charged particle moving in a *x-y* plane initially along the *x*-axis, there is a sudden change in its path due to the presence of electric and/or magnetic fields beyond P. The curved path is shown in the *x-y* plane and is found to be non-circular. Which one of the following combinations is possible



(a) $\vec{E}=0; \vec{B}=b\hat{i}+c\hat{k}$ (b) $\vec{E}=a\hat{i}; \vec{B}=c\hat{k}+a\hat{i}$

(c) $\vec{E}=0; \vec{B}=c\hat{j}+b\hat{k}$ (d) $\vec{E}=a\hat{i}; \vec{B}=c\hat{k}+b\hat{j}$

17. A horizontal rod of mass 10 *gm* and length 10 *cm* is placed on a smooth plane inclined at an angle of $60°$ with the horizontal, with the length of the rod parallel to the edge of the inclined plane. A uniform magnetic field of induction *B* is applied vertically downwards. If the current through the rod is 1.73 *ampere*, then the value of *B* for which the rod remains stationary on the inclined plane is

(a) 1.73 *Tesla* (b) $\frac{1}{1.73}$ *Tesla*

(c) 1 *Tesla* (d) None of the above

18. Two long wires are hanging freely. They are joined first in parallel and then in series and then are connected with a battery. In both cases, which type of force acts between the two wires

(a) Attraction force when in parallel and repulsion force when in series

(b) Repulsion force when in parallel and attraction force when in series

(c) Repulsion force in both cases

(d) Attraction force in both cases

19. A wire of length *L metre* carrying a current of *I ampere* is bent in the form of a circle. Its magnitude of magnetic moment will be[MP PET 1995; M

(a) $\frac{IL}{4\pi}$ (b) $\frac{IL^2}{4\pi}$

(c) $\frac{I^2L^2}{4\pi}$ (d) $\frac{I^2L}{4\pi}$

20. A thin circular wire carrying a current *I* has a magnetic moment *M*. The shape of the wire is changed to a square and it carries the same current. It will have a magnetic moment [MP PET 2003; MP PMT 2004]

(a) M (b) $\frac{4}{\pi^2}M$

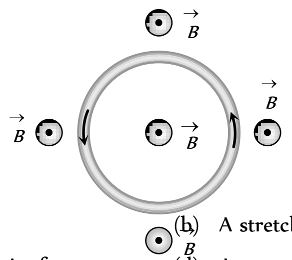
(c) $\frac{4}{\pi}M$ (d) $\frac{\pi}{4}M$

21. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on

(a) ω and q (b) ω q and m

(c) q and m (d) ω and m

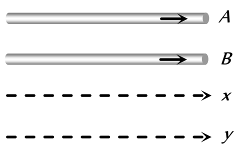
22. An elastic circular wire of length *l* carries a current *I*. It is placed in a uniform magnetic field $\vec{B}$ (Out of paper) such that its plane is perpendicular to the direction of $\vec{B}$. The wire will experience



(a) No force (b) A stretching force

(c) A compressive force (d) A torque

23. A and B are two conductors carrying a current i in the same direction. x and y are two electron beams moving in the same direction [Karnataka CET (Engg./Med.) 2002]



(a) There will be repulsion between A and B attraction between x and y

(b) There will be attraction between A and B, repulsion between x and y

(c) There will be repulsion between A and B and also x and y

(d) There will be attraction between A and B and also x and y

24. Wires 1 and 2 carrying currents i_1 and i_2 respectively are inclined at an angle θ to each other. What is the force on a small element dl of wire 2 at a distance of r from wire 1 (as shown in figure) due to the magnetic field of wire1

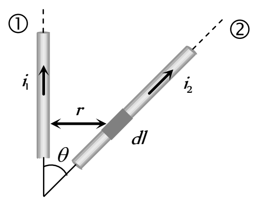
[AIEEE 2002]

(a) $\frac{\mu_0}{2\pi r}i_1 i_2 \, dl \tan\theta$

(b) $\frac{\mu_0}{2\pi r}i_1 i_2 \, dl \sin\theta$

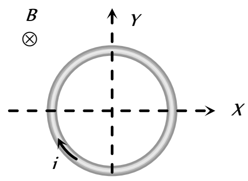
(c) $\frac{\mu_0}{2\pi r}i_1 i_2 \, dl \cos\theta$

(d) $\frac{\mu_0}{4\pi r}i_1 i_2 \, dl \sin\theta$



25. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to

[IIT-JEE (Screening) 2003]



(a) Contract

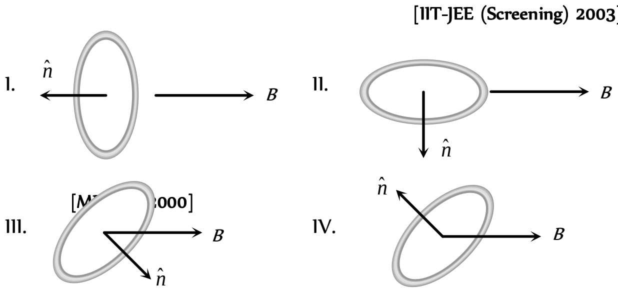
(b) Expand

(c) Move towards $+ve$ x-axis

(d) Move towards $-ve$ x-axis

26. A current carrying loop is placed in a uniform magnetic field in four different orientations, I,II, III & IV arrange them in the decreasing order of potential Energy

[IIT-JEE (Screening) 2003]



(a) I > III > II > IV (b) I > II >III > IV

(c) I > IV > II > III (d) III > IV > I > II

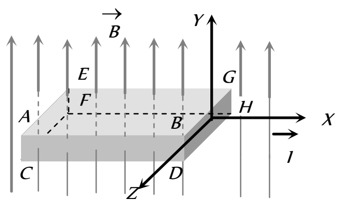
27. A metallic block carrying current *I* is subjected to a uniform magnetic induction $\vec{B}$ as shown in the figure. The moving charges experience a force $\vec{F}$ given by .... which results in the lowering of the potential of the face .... Assume the speed of the carriers to be v [IIT 1996]

(a) $eVB\hat{k}$, $ABCD$

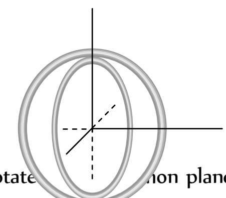
(b) $eVB\hat{k}$, $EFGH$

(c) $-eVB\hat{k}$, $ABCD$

(d) $-eVB\hat{k}$, $EFGH$



28. Two insulated rings, one of slightly smaller diameter than the other are suspended along their common diameter as shown. Initially the planes of the rings are mutually perpendicular. When a steady current is set up in each of them [IIT 1995]



(a) The two rings rotate into a common plane

(b) The inner ring oscillates about its initial position

(c) The inner ring stays stationary while the outer one moves into the plane of the inner ring

(d) The outer ring stays stationary while the inner one moves into the plane of the outer ring

29. Two particles each of mass m and charge q are attached to the two ends of a light rigid rod of length $2R$. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moment of the system and its angular momentum about the centre of the rod is [IIT 1998]

(a) $\frac{q}{2m}$ (b) $\frac{q}{m}$

(c) $\frac{2q}{m}$ (d) $\frac{q}{\pi m}$

30. Two very long, straight and parallel wires carry steady currents *I* and *I* respectively. The distance between the wires is *d*. At a certain instant of time, a point charge *q* is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity *v* is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is [IIT 1998]

(a) $\frac{\mu_0 Iqv}{2\pi d}$ (b) $\frac{\mu_0 Iqv}{\pi d}$

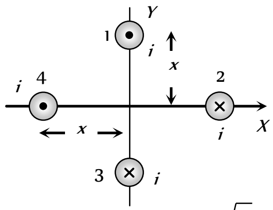
(c) $\frac{2\mu_0 Iqv}{\pi d}$ (d) 0

31. A ring of radius *R*, made of an insulating material carries a charge *Q* uniformly distributed on it. If the ring rotates about the axis passing through its centre and normal to plane of the ring with constant angular speed ω, then the magnitude of the magnetic moment of the ring is [MP PET 2001]

(a) $Q\omega R^2$ (b) $\frac{1}{2}Q\omega R^2$

(c) $Q\omega^2 R$ (d) $\frac{1}{2}Q\omega^2 R$

32. What will be the resultant magnetic field at origin due to four infinite length wires. If each wire produces magnetic field '*B*' at origin



(a) 4 *B* (b) $\sqrt{2}\,B$

(c) $2\sqrt{2}\,B$ (d) Zero

33. The ratio of the magnetic field at the centre of a current carrying circular wire and the magnetic field at the centre of a square coil made from the same length of wire will be

(a) $\frac{\pi^2}{4\sqrt{2}}$ (b) $\frac{\pi^2}{8\sqrt{2}}$

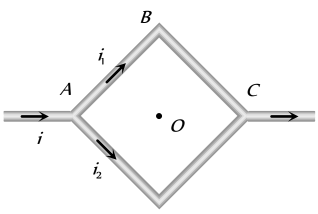
(c) $\frac{\pi}{2\sqrt{2}}$ (d) $\frac{\pi}{4\sqrt{2}}$

34. Two infinite length wires carries currents 8*A* and 6*A* respectively and placed along *X* and *Y*-axis. Magnetic field at a point $P(0,0,d)m$ will be

(a) $\frac{7\mu_0}{\pi d}$ (b) $\frac{10\mu_0}{\pi d}$

(c) $\frac{14\mu_0}{\pi d}$ (d) $\frac{5\mu_0}{\pi d}$

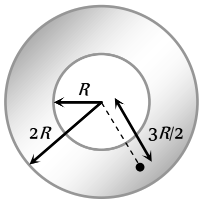
35. Figure shows a square loop *ABCD* with edge length *a*. The resistance of the wire *ABC* is *r* and that of *ADC* is 2*r*. The value of magnetic field at the centre of the loop assuming uniform wire is



(a) $\frac{\sqrt{2}\,\mu_0 i}{3\pi a}\odot$ (b) $\frac{\sqrt{2}\,\mu_0 i}{3\pi a}\otimes$

(c) $\frac{\sqrt{2}\,\mu_0 i}{\pi a}\odot$ (d) $\frac{\sqrt{2}\,\mu_0 i}{\pi a}\otimes$

36. Figure shows the cross-sectional view of the hollow cylindrical conductor with inner radius '*R*' and outer radius '2*R*', cylinder carrying uniformly distributed current along it's axis. The magnetic induction at point '*P*' at a distance $\frac{3R}{2}$ from the axis of the cylinder will be



(a) Zero

(b) $\frac{5\mu_0 i}{72\pi R}$

(c) $\frac{7\mu_0 i}{18\pi R}$

(d) $\frac{5\mu_0 i}{36\pi R}$

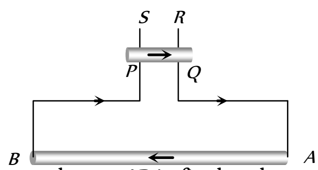
37. A long wire *AB* is placed on a table. Another wire *PQ* of mass 1.0 *g* and length 50 *cm* is set to slide on two rails *PS* and *QR*. A current of 50*A* is passed through the wires. At what distance above *AB*, will the wire *PQ* be in equilibrium

(a) 25 *mm*

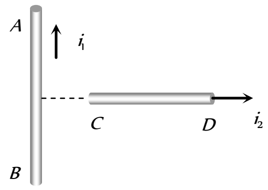
(b) 50 *mm*

(c) 75 *mm*

(d) 100 *mm*



38. An infinitely long, straight conductor *AB* is fixed and a current is passed through it. Another movable straight wire *CD* of finite length and carrying current is held perpendicular to it and released. Neglect weight of the wire



(a) The rod *CD* will move upwards parallel to itself

(b) The rod *CD* will move downward parallel to itself

(c) The rod *CD* will move upward and turn clockwise at the same time

(d) The rod *CD* will move upward and turn anti –clockwise at the same time

39. A steady current *i* flows in a small square loop of wire of side *L* in a horizontal plane. The loop is now folded about its middle such that half of it lies in a vertical plane. Let $\vec{\mu}_1$ and $\vec{\mu}_2$ respectively denote the magnetic moments due to the current loop before and after folding. Then

[IIT-JEE 1993]

(a) $\overrightarrow{\mu_2} = 0$

(b) $\overrightarrow{\mu_1}$ and $\overrightarrow{\mu_2}$ are in the same direction

(c) $\frac{|\overrightarrow{\mu_1}|}{|\overrightarrow{\mu_2}|} = \sqrt{2}$

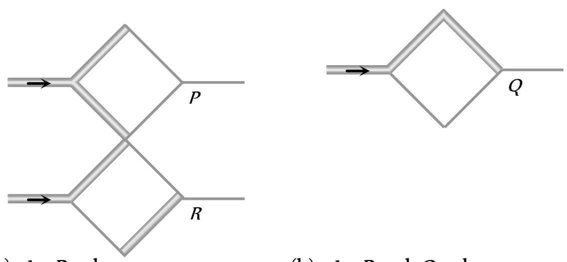
(d) $\frac{|\overrightarrow{\mu_1}|}{|\overrightarrow{\mu_2}|} = \left(\frac{1}{\sqrt{2}}\right)$

40. A current i is flowing in a straight conductor of length L. The magnetic induction at a point distant $\frac{L}{4}$ from its centre will be

(a) $\frac{4\mu_0 i}{\sqrt{5}\pi L}$ (b) $\frac{\mu_0 i}{2\pi L}$

(c) $\frac{\mu_0 i}{\sqrt{2}L}$ (d) Zero

41. Two thick wires and two thin wires, all of the same materials and same length form a square in the three different ways P, Q and R as shown in fig with current connection shown, the magnetic field at the centre of the square is zero in cases



(a) In P only (b) In P and Q only

(c) In Q and R only (d) P and R only

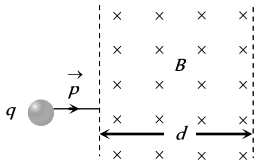
42. A particle with charge q, moving with a momentum p, enters a uniform magnetic field normally. The magnetic field has magnitude B and is confined to a region of width d, where $d < \frac{p}{Bq}$, The particle is deflected by an angle θ in crossing the field

(a) $\sin\theta = \frac{Bqd}{p}$

(b) $\sin\theta = \frac{p}{Bqd}$

(c) $\sin\theta = \frac{Bp}{qd}$

(d) $\sin\theta = \frac{pd}{Bq}$

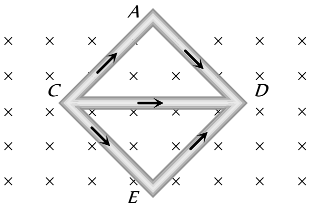


43. Same current $i = 2A$ is flowing in a wire frame as shown in figure. The frame is a combination of two equilateral triangles ACD and CDE of side $1m$. It is placed in uniform magnetic field $B = 4T$ acting perpendicular to the plane of frame. The magnitude of magnetic force acting on the frame is

(a) 24 N

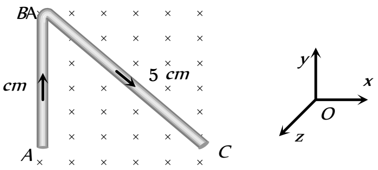
(b) Zero

(c) 16 N



(d) 8 N

44. A uniform conducting wire ABC has a mass of 10g. A current of 2A flows through it. The wire is kept in a uniform magnetic field $B = 2T$. The acceleration of the wire will be



(a) Zero

(b) $12\, ms^{-2}$ along y-axis

(c) $1.2 \times 10^{-3} ms^{-2}$ along y-axis

(d) $0.6 \times 10^{-3} ms^{-2}$ along y - axis

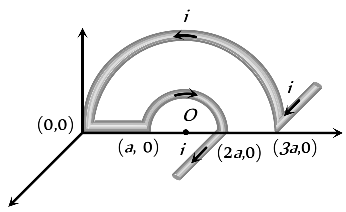
45. In the given figure net magnetic field at O will be

(a) $\frac{2\mu_0 i}{3\pi a}\sqrt{4 - \pi^2}$

(b) $\frac{\mu_0 i}{3\pi a}\sqrt{4 + \pi^2}$

(c) $\frac{2\mu_0 i}{3\pi a^2}\sqrt{4 + \pi^2}$

(d) $\frac{2\mu_0 i}{3\pi a}\sqrt{(4 - \pi^2)}$



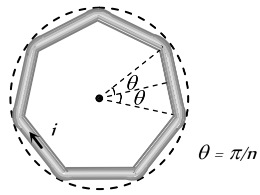
46. In the following figure a wire bent in the form of a regular polygon of n sides is inscribed in a circle of radius a. Net magnetic field at centre will be

(a) $\frac{\mu_0 i}{2\pi a}\tan\frac{\pi}{n}$

(b) $\frac{\mu_0 ni}{2\pi a}\tan\frac{\pi}{n}$

(c) $\frac{2}{\pi}\frac{ni}{a}\mu_0 \tan\frac{\pi}{n}$

(d) $\frac{ni}{2a}\mu_0 \tan\frac{\pi}{n}$



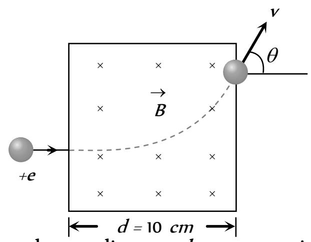
47. A proton accelerated by a potential difference $500\ KV$ moves though a transverse magnetic field of $0.51\ T$ as shown in figure. The angle θ through which the proton deviates from the initial direction of its motion is

(a) 15^o

(b) 30^o

(c) 45^o

(d) 60^o



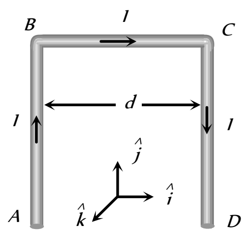
48. AB and CD are long straight conductor, distance d apart, carrying a current I. The magnetic field at the midpoint of BC is

(a) $\frac{-\mu_0 I}{2\pi d}\hat{k}$

(b) $\frac{-\mu_0 I}{\pi d}\hat{k}$

(c) $\frac{-\mu_0 I}{4\pi d}\hat{k}$

(d) $\frac{-\mu_0 I}{8\pi d}\hat{k}$

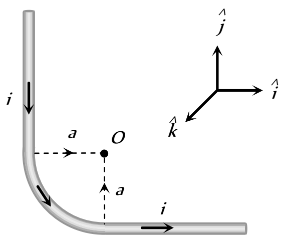


49. An electron is moving along the positive X-axis. You want to apply a magnetic field for a short time so that the electron may reverse its direction and move parallel to the negative X-axis. This can be done by applying the magnetic field along

(a) Y-axis (b) X-axis

(c) Y-axis only (d) None of these

50. The unit vectors $\hat{i}$, $\hat{j}$ and $\hat{k}$ are as shown below. What will be the magnetic field at O in the following figure



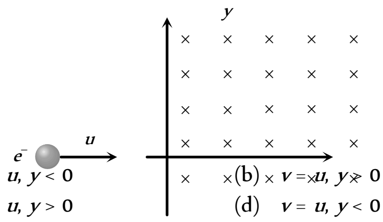
(a) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2-\frac{\pi}{2}\right)\hat{j}$

(b) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{j}$

(c) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{i}$

(d) $\frac{\mu_0}{4\pi}\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{k}$

51. An electron moving with a speed u along the positive x-axis at $y = 0$ enters a region of uniform magnetic field $\vec{B} = -B_0\hat{k}$ which exists to the right of y-axis. The electron exits from the region after some time with the speed v at co-ordinate y, then [IIT-JEE (Screening 2004)]

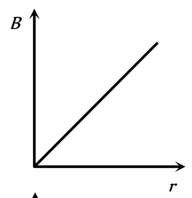


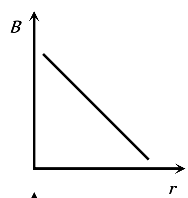
(a) $v > u$, $y < 0$ (b) $v = u$, $y > 0$

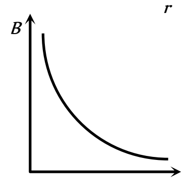
(c) $v > u$, $y > 0$ (d) $v = u$, $y < 0$

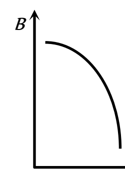
GQ Graphical Questions

1. Which of the following graphs shows the variation of magnetic induction B with distance r from a long wire carrying current [NCERT 1984; MNR 1998; MP PMT 1999]

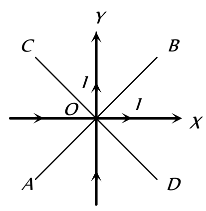
(a)


(b)


(c)


(d)


2. Two very thin metallic wires placed along X and Y-axis carry equal currents as shown here. AB and CD are lines at 45° with the axes with origin of axes at O. The magnetic field will be zero on the line [MP PMT 1995; CBSE PMT 1996]



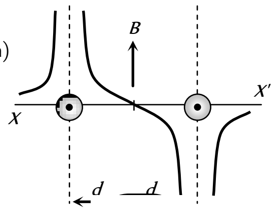
(a) AB

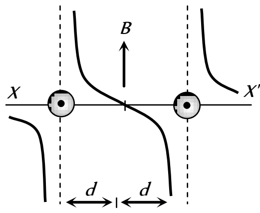
(b) CD

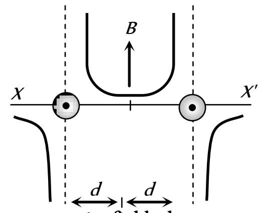
(c) Segment OB only of line AB

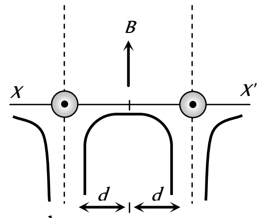
(d) Segment OC only of line CD

3. Two long parallel wires are at a distance $2d$ apart. They carry steady equal currents flowing out of the plane of the paper, as shown. The variation of the magnetic field B along the line XX' is given by

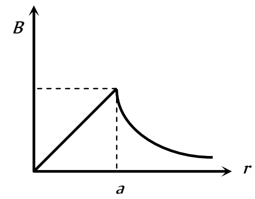
(a)


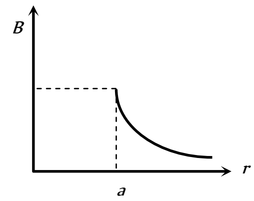
(b)


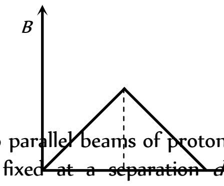
(c)


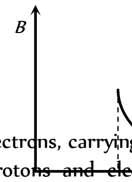
(d)


4. The magnetic field due to a straight conductor of uniform cross section of radius a and carrying a steady current is represented by

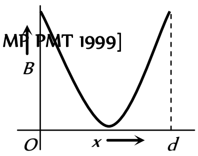
(a)


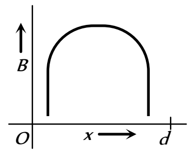
(b)


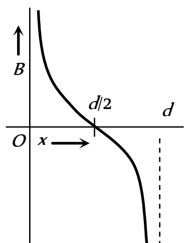
(c)


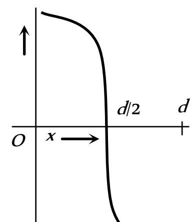
(d)


5. Two parallel beams of protons and electrons, carrying equal currents are fixed at a separation d. The protons and electrons move in opposite directions. P is a point on a line joining the beams, at a distance x from any one beam. The magnetic field at P is B. If B is plotted against x, which of the following best represents the resulting curve

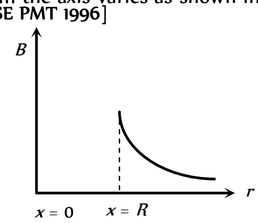
(a)


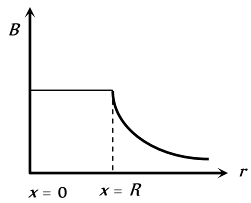
(b)


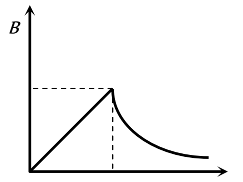
(c)


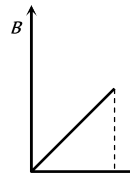
(d)


6. A long thin hollow metallic cylinder of radius 'R' has a current i ampere. The magnetic induction 'B'-away from the axis at a distance r from the axis varies as shown in

(a)


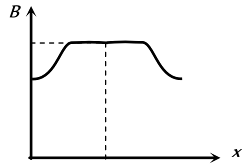
(b)


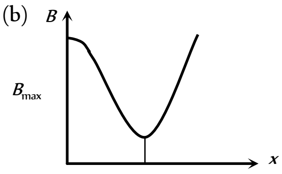


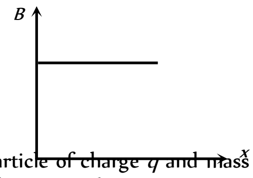


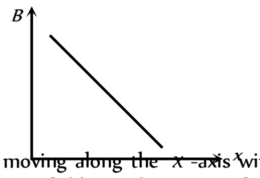
(c) (d)

7. The correct curve between the magnetic induction (B) along the axis of a long solenoid due to current flow i in it and distance x from one end is

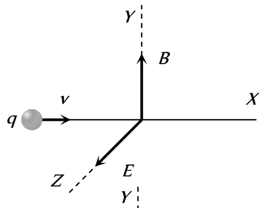
(a) 

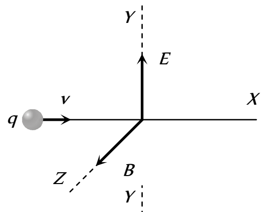
(b) 

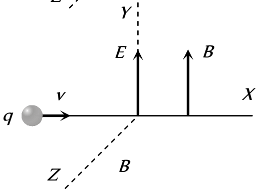
(c) 

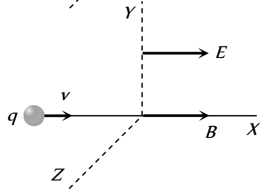
(d) 

8. A particle of charge q and mass m is moving along the x-axis with a velocity v and enters a region of electric field E and magnetic field B as shown in figure below for which figure the net force on the charge may be zero

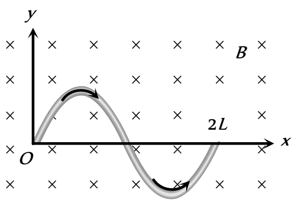
(a) 

(b) 

(c) 

(d) 

9. A wire carrying a current i is placed in a uniform magnetic field in the form of the curve $y = a\sin\left(\frac{\pi x}{L}\right) 0 \le x \le 2L$. The force acting on the wire is



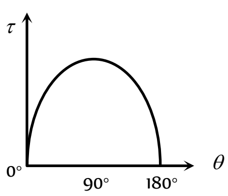
(a) $\frac{iBL}{\pi}$

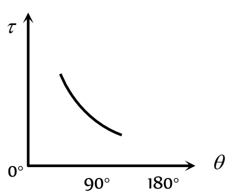
(b) $iBL\pi$

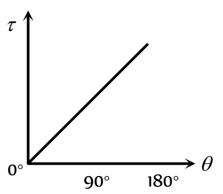
(c) $2iBL$

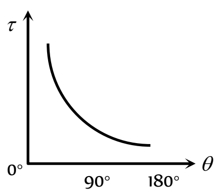
(d) Zero

10. The $(\tau - \theta)$ graph for a coil is

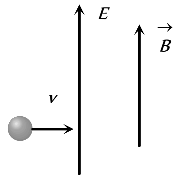
(a) 

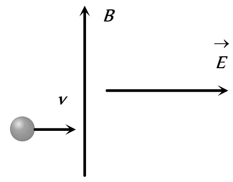
(b) 

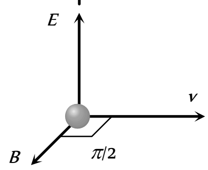
(c) 

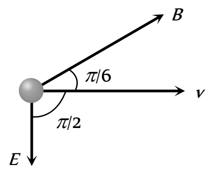
(d) 

11. A uniform magnetic field B and a uniform electric field E act in a common region. An electron is entering this region of space. The correct arrangement for it to escape undeviated is

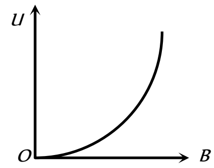
(a) 

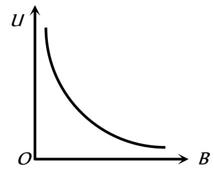
(b) 

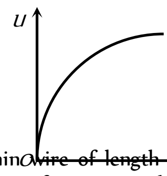
(c) 

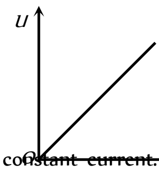
(d) 

12. If induction of magnetic field at a point is B and energy density is U then which of the following graphs is correct

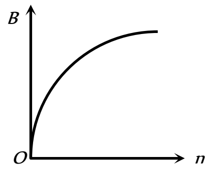
(a) 

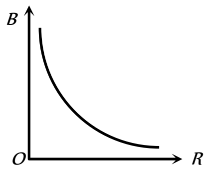
(b) 

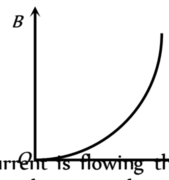
(c) 

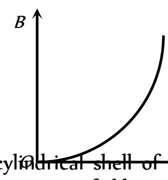
(d) 

13. A thin wire of length l is carrying a constant current. The wire is bent to form a circular coil. If radius of the coil, thus formed, is equal to R and number of turns in it is equal to n, then which of the following graphs represent (s) variation of magnetic field induction (B) at centre of the coil

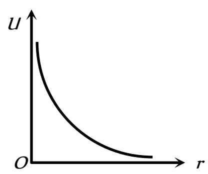
(a) 

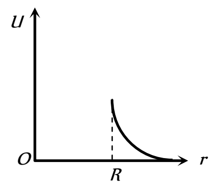
(b) 

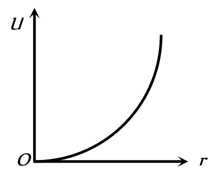
(c) 

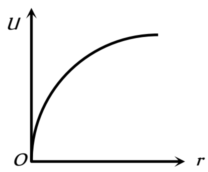
(d) 

14. A current is flowing through a thin cylindrical shell of radius R. If energy density in the medium, due to magnetic field, at a distance r from axis of the shell is equal to U then which of the following graphs is correct

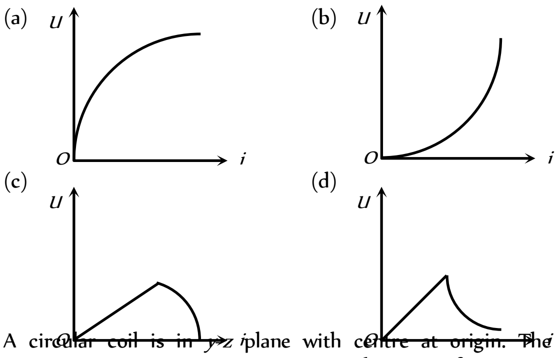
(a) 

(b) 

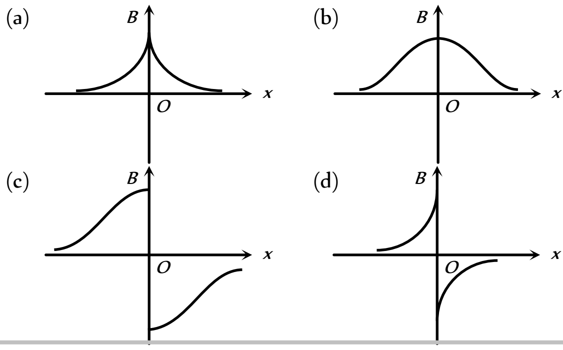
(c) 

(d) 

15. If current flowing through shell of previous objective is equal to i, then energy density at a point distance $2R$ from axis of the shell varies according to the graph



16. A circular coil is in y-z plane with centre at origin. The coil is carrying a constant current. Assuming direction of magnetic field at $x = -25$ cm to be positive direction of magnetic field, which of the following graphs shows variation of magnetic field along x-axis



Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Cyclotron does not accelerate electron.
Reason : Mass of the electron is very small.
[AIIMS 2000]

2. Assertion : Cyclotron is a device which is used to accelerate the positive ion.
Reason : Cyclotron frequency depends upon the velocity. [AIIMS 1997]

3. Assertion : Magnetic field interacts with a moving charge and not with a stationary charge.
Reason : A moving charge produces a magnetic field.

4. Assertion : If an electron is not deflected while passing through a certain region of space, then only possibility is that there is no magnetic region.
Reason : Force is directly proportional to the magnetic field applied.

5. Assertion : Free electron always keep on moving in a conductor even then no magnetic force act on them in magnetic field unless a current is passed through it.
Reason : The average velocity of free electron is zero.

6. Assertion : The ion cannot move with a speed beyond a certain limit in a cyclotron.
Reason : As velocity increases time taken by ion increases.

7. Assertion : The coil is bound over the metallic frame in moving coil galvanometer.
Reason : The metallic frame help in making steady deflection without any oscillation.

8. Assertion : A circular loop carrying current lies in XY plane with its center at origin having a magnetic flux in negative Z-axis.
Reason : Magnetic flux direction is independent of the direction of current in the conductor.

9. Assertion : The energy of charged particle moving in a uniform magnetic field does not change.
Reason : Work done by magnetic field on the charge is zero.

10. Assertion : If an electron, while coming vertically from outerspace, enter the earth's magnetic field, it is deflected towards west.
Reason : Electron has negative charge.

11. Assertion : A direct current flows through a metallic rod, produced magnetic field only outside the rod.
Reason : There is no flow of charge carriers inside the rod.

12. Assertion : An electron and proton enters a magnetic field with equal velocities, then, the force experienced by the proton will be more than electron.
Reason : The mass of proton is 1837 times more than electron.

13. Assertion : Torque on the coil is the maximum, when coil is suspended in a radial magnetic field.
Reason : The torque tends to rotate the coil on its own axis.

14. Assertion : A loosely round helix made of stiff wire is suspended vertically with the lower end just touching a dish of mercury. When a current is passed through the wire, the helical wire executes oscillatory motion with the lower end jumping out of and inside of mercury.
Reason : When electric current is passed through helix, a magnetic field is produced both inside and outside the helix.

15. Assertion : The magnetic filed at the ends of a very long current carrying solenoid is half of that at the center.
Reason : If the solenoid is sufficiently long, the field within it is uniform.

16. Assertion : If a charged particle is moving on a circular path in a perpendicular magnetic field, the momentum of the particle is not changing,.
Reason : Velocity of the particle in not changing in the magnetic field.

17. Assertion : If a proton and an α-particle enter a uniform magnetic field perpendicularly, with the same speed, then the time period of revolution of the α-particle is double than that of proton.
Reason : In a magnetic field, the time period of revolution of a charged particle is directly proportional to mass.

18. Assertion : If two long wires, hanging freely are connected to a battery in series, they come closer to each other.

Reason : Force of attraction acts between the two wires carrying current.

19. Assertion : A current I flows along the length of an infinitely long straight and thin walled pipe. Then the magnetic field at any point inside the pipe is zero.

Reason : $\oint \vec{B}.d\vec{l} = \mu_o I$

Answers

Biot-Savart's Law and Amperes Law

1	c	2	b	3	c	4	b	5	d
6	c	7	b	8	d	9	b	10	d
11	b	12	a	13	a	14	c	15	c
16	a	17	b	18	a	19	b	20	d
21	c	22	c	23	a	24	d	25	b
26	d	27	c	28	a	29	b	30	d
31	b	32	a	33	a	34	d	35	d
36	d	37	b	38	c	39	a	40	c
41	c	42	b	43	d	44	b	45	d
46	b	47	a	48	a	49	b	50	d
51	c	52	b	53	c	54	b	55	d
56	a	57	b	58	a	59	d	60	d
61	c	62	c	63	d	64	b	65	a
66	c	67	a	68	c	69	a	70	b
71	c	72	c	73	b	74	b	75	d
76	b	77	b	78	b	79	c	80	b
81	d	82	c	83	c	84	d	85	c
86	b	87	d	88	a	89	a	90	b
91	c	92	d	93	d	94	a	95	b
96	b	97	a	98	d	99	c	100	d
101	b	102	c	103	b	104	d	105	a
106	c	107	b	108	a	109	a	110	c
111	d	112	a	113	b	114	a	115	b
116	d	117	c	118	b	119	a	120	a
121	a	122	a	123	c	124	d	125	c
126	b								

Motion of Charged Particle In Magnetic Field

1	abd	2	d	3	c	4	a	5	b
6	b	7	c	8	c	9	c	10	d
11	c	12	d	13	d	14	b	15	a
16	c	17	c	18	a	19	c	20	b
21	c	22	c	23	d	24	b	25	d
26	a	27	c	28	a	29	d	30	d
31	d	32	b	33	c	34	a	35	c
36	b	37	d	38	a	39	a	40	d
41	c	42	a	43	d	44	a	45	b
46	c	47	d	48	b	49	c	50	d
51	b	52	c	53	b	54	a	55	a
56	d	57	d	58	b	59	d	60	a
61	c	62	c	63	b	64	a	65	a
66	b	67	b	68	a	69	bd	70	b
71	c	72	b	73	b	74	a	75	d
76	d	77	d	78	b	79	a	80	d
81	a	82	a	83	c	84	b	85	b
86	c	87	c	88	b	89	a	90	b
91	a	92	a	93	c	94	d	95	c
96	a	97	c	98	b	99	a	100	b
101	d	102	c	103	d	104	d	105	c
106	c	107	d	108	d	109	d	110	d
111	a	112	b	113	d	114	c	115	c
116	c	117	c	118	c				

Force and Torque on a Current Carrying Conductor

1	b	2	c	3	b	4	c	5	b
6	a	7	b	8	b	9	a	10	a
11	c	12	a	13	c	14	c	15	a
16	c	17	b	18	b	19	b	20	b
21	d	22	b	23	d	24	a	25	a
26	b	27	d	28	b	29	c	30	c
31	c	32	d	33	d	34	d	35	b
36	a	37	a	38	a	39	c	40	d
41	c	42	a	43	a	44	c	45	d
46	a	47	d	48	a	49	a	50	c
51	b	52	a	53	abc	54	a	55	c
56	b	57	a	58	d	59	c	60	a
61	b	62	b	63	d	64	b	65	c
66	a	67	b	68	a	69	a	70	a
71	c	72	a	73	a	74	d	75	d
76	c	77	a	78	a	79	b	80	c
81	b	82	c	83	c	84	b	85	a
86	d	87	c	88	b	89	c	90	c
91	d								

Critical Thinking Questions

1	b	2	a	3	a	4	c	5	c
6	c	7	cd	8	c	9	d	10	a
11	abd	12	ac	13	c	14	c	15	b
16	b	17	c	18	a	19	b	20	d
21	c	22	b	23	b	24	c	25	b
26	c	27	a	28	a	29	a	30	d
31	b	32	c	33	b	34	d	35	b
36	d	37	a	38	c	39	c	40	a
41	d	42	a	43	a	44	b	45	b
46	b	47	b	48	b	49	a	50	d
51	d								

Graphical Questions

1	c	2	a	3	b	4	a	5	c
6	a	7	a	8	b	9	c	10	a
11	c	12	a	13	bc	14	b	15	b
16	b								

Assertion and Reason

1	a	2	c	3	a	4	e	5	a
6	c	7	a	8	c	9	a	10	b
11	d	12	e	13	b	14	b	15	b
16	d	17	b	18	d	19	a		

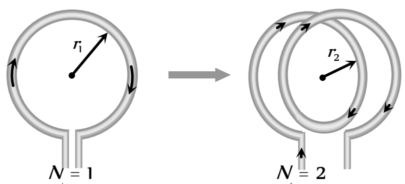
Answers and Solutions

Biot-Savart's Law and Amperes Law

1. (c) Magnetic field at the centre of current carrying coil is given by

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi Ni}{r} \Rightarrow B \propto \frac{N}{r} \Rightarrow \frac{B_1}{B_2} = \frac{N_1}{N_2}\times\frac{r_2}{r_1}.$$

The following figure shows that single turn coil changes to double turn coil.



$N_1 = 1$ $\quad$ $N_2 = 2$

$r_1 = r$ $\quad$ $r_2 = r/2$

$B_1 = B$ $\quad$ $B_2 = ?$

$$\Rightarrow \frac{B}{B_2} = \frac{1}{2}\times\frac{r/2}{r} = \frac{1}{4} \Rightarrow B_2 = 4B$$

Short trick : For such type of problems remember $B_2 = n^2 B_1$

2. (b) If distance is same field will be same $\left(\because B = \frac{\mu_0}{4\pi}\cdot\frac{2i}{r}\right)$

3. (c) Magnetic field lies inside as well as outside the solid current carrying conductor.

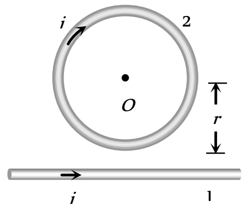
4. (b) Because for inside the pipe $i = 0$

$$\therefore B = \frac{\mu_0 i}{2\pi r} = 0$$

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

6. (c) The magnetic field at the centre of the circle $= \frac{\mu_o}{4\pi}\times\frac{2\pi i}{r} = 10^{-7}\times\frac{2\pi(nq)}{r} = \frac{2\pi nq}{r}\times 10^{-7}\ N/A\text{-}m$

7. (b) The given shape is equivalent to the following diagram



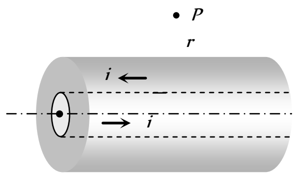
The field at O due to straight part of conductor is $B_1 = \frac{\mu_o}{4\pi}.\frac{2i}{r}\odot$. The field at O due to circular coil is $B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r}\otimes$. Both fields will act in the opposite direction, hence the total field at O.

i.e. $B = B_2 - B_1 = \left(\frac{\mu_o}{4\pi}\right)\times(\pi-1)\frac{2i}{r} = \frac{\mu_o}{4\pi}.\frac{2i}{r}(\pi-1)$

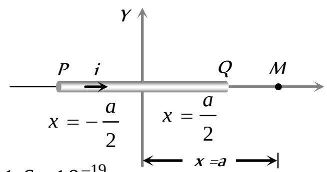
8. (d) $B = \frac{\mu_0}{4\pi}\frac{(2\pi-\theta)i}{R} = \frac{\mu_0}{4\pi}\frac{\left(2\pi-\frac{\pi}{2}\right)\times i}{R} = \frac{3\mu_0 i}{8R}$

9. (b) The respective figure is shown below

Magnetic field at P due to inner and outer conductors are equal and opposite. Hence net magnetic field at P will be zero.



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



11. (b) $i = \frac{q}{T} = \frac{2\times1.6\times10^{-19}}{2} = 1.6\times10^{-19}\ A$

$$\therefore B = \frac{\mu_o i}{2r} = \frac{\mu_o\times1.6\times10^{-19}}{2\times0.8} = \mu_o\times10^{-19}$$

12. (a) $B = \mu_o ni = 4\pi\times10^{-7}\times5\times1000 = 2\pi\times10^{-3}$ *Tesla*

13. (a) $B = \frac{\mu_0}{4\pi}\cdot\frac{2i}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{10^{-8}}{B_2} = \frac{12}{4}$

$$\Rightarrow B_2 = 3.33\times10^{-9}\ Tesla$$

14. (c) $B \propto \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{B}{B_2} = \frac{r/2}{r} \Rightarrow B_2 = 2B$

15. (c) Field at the centre of a circular coil of radius r is $B = \frac{\mu_o I}{2r}$

16. (a) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi\times10^{-7}\times100\times0.1}{2\times5\times10^{-2}} = 4\pi\times10^{-5}$ *Tesla*

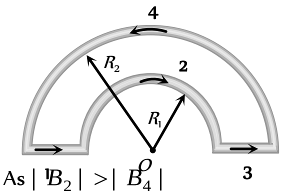
17. (b) Magnetic field inside the solenoid $B_{in} = \mu_0 ni$

18. (a) 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.

$$B_1 = B_3 = 0$$

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

$$B_4 = \frac{\mu_0}{4\pi}.\frac{\pi i}{R_2}\odot$$



As $|B_2| > |B_4|$

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

19. (b) $B = \mu_o ni$

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

21. (c) The induction due to AB and CD will be zero. Hence the whole induction will be due to the semicircular part BC.

$B = \frac{\mu_o i}{4r}$

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

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

23. (a) Field at a point x from the centre of a current carrying loop on the axis is

$B = \frac{\mu_0}{4\pi}.\frac{2M}{x^3} = \frac{10^{-7} \times 2 \times 2.1 \times 10^{-25}}{(10^{-10})^3}$

$= 4.2 \times 10^{-32} \times 10^{30} = 4.2 \times 10^{-2}\, W/m^2$

24. (d) At these points, the resultant field $= 0$

25. (b) $i = \frac{q}{t} = 100 \times e$

$B_{centre} = \frac{\mu_o}{4\pi}.\frac{2\pi i}{r} = \frac{\mu_o}{4\pi}.\frac{2\pi \times 100e}{r}$

$= \frac{\mu_o \times 200 \times 1.6 \times 10^{-19}}{4 \times 0.8} = 10^{-17}\mu_o$

26. (d) $B = \frac{\mu_o}{4\pi}.\frac{2\pi NiR^2}{r^3} \Rightarrow B \propto \frac{1}{r^3}$

27. (c) $B = \frac{\mu_0}{4\pi}.\frac{2\pi(qv)}{r}$

$= 10^{-7} \times \frac{2 \times 3.14 \times (1.6 \times 10^{-19} \times 6.6 \times 10^{15})}{0.53 \times 10^{-10}} = 12.5\, Wb/m^2$

28. (a)

29. (b)

30. (d) Two coils carrying current in opposite direction, hence net magnetic field at centre will be difference of the two fields.

i.e. $B_{net} = \frac{\mu_0}{4\pi} \cdot 2\pi N\left[\frac{Ni_1}{r_1} - \frac{i_2}{r_2}\right] = \frac{10\mu_0}{2}\left[\frac{0.2}{0.2} - \frac{0.3}{0.4}\right] = \frac{5}{4}\mu_0$

31. (b) Because $B = \mu_0 ni \Rightarrow B \propto ni$.

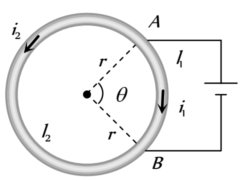
32. (a) See solution 34.

33. (a) $B = \mu_0 ni \Rightarrow i = \frac{B}{\mu_0 n} = \frac{20 \times 10^{-3}}{4\pi \times 10^{-7} \times 20 \times 100}$

$= 7.9\, amp = 8\, amp$

34. (d) Directions of currents in two parts are different, so directions of magnetic fields due to these currents are opposite. Also applying Ohm's law across AB

$i_1 R_1 = i_2 R_2 \Rightarrow i_1 l_2 = i_2 l_2$



$\left(\because R = \rho\frac{l}{A}\right)$

Also $B_1 = \frac{\mu_o}{4\pi} \times \frac{i_1 l_1}{r^2}$ and $B_2 = \frac{\mu_o}{4\pi} \times \frac{i_2 l_2}{r^2}$ $\qquad (\because l = r\theta)$

$\therefore \frac{B_2}{B_1} = \frac{i_1 l_1}{i_2 l_2} = 1$

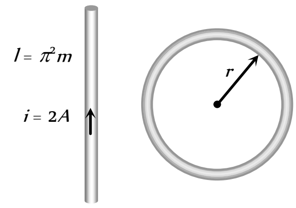
Hence, two field induction's are equal but of opposite direction. So, resultant magnetic induction at the centre is zero and is independent of θ.

35. (d) The magnetic field at any point on the axis of wire be zero.

36. (d) Magnetic field inside the hollow conductor (tube) is zero.

37. (b) If a wire of length l is bent in the form of a circle of radius r then $2\pi r = l \Rightarrow$

$r = \frac{l}{2\pi}$

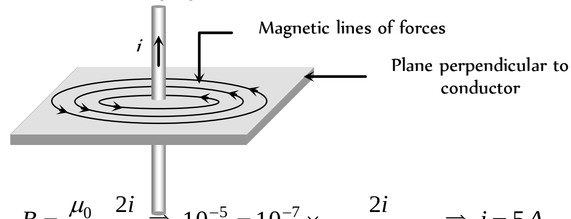


$r = \frac{l}{2\pi} = \frac{\pi^2}{2\pi} = \frac{\pi}{2}$

Magnetic field due to straight wire $B_1 = \frac{\mu_0}{4\pi}.\frac{2i}{r} = \frac{\mu_0}{4\pi} \times \frac{2 \times 2}{1 \times 10^{-2}}$ also magnetic field due to circular loop $B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} = \frac{\mu_0}{4\pi}.\frac{2\pi \times 2}{\pi/2} \Rightarrow$

$\frac{B_2}{B_1} = \frac{1}{50}$

38. (c) See the following figure



39. (a) $B = \frac{\mu_0}{4\pi}.\frac{2i}{r} \Rightarrow 10^{-5} = 10^{-7} \times \frac{2i}{(10 \times 10^{-2})} \Rightarrow i = 5A$

40. (c) $B = \frac{\mu_0}{4\pi}.\frac{2\pi Ni}{r}$

$\Rightarrow 3.14 \times 10^{-3} = \frac{10^{-7} \times 2 \times 3.14 \times N \times 10}{(10 \times 10^{-2})} \Rightarrow N = 50$

41. (c) The magnetic field in the solenoid along its axis (i) At an internal point $= \mu_o ni$

$= 4\pi \times 10^{-7} \times 5000 \times 4 = 25.1 \times 10^{-3}\, Wb/m^2$

(Here $n = 50\, turns/cm = 5000\, turns/m$)

(ii) At one end

$B_{end} = \frac{1}{2}B_{in} = \frac{\mu_0 ni}{2} = \frac{25.1 \times 10^{-3}}{2} = 12.6 \times 10^{-3}\, Wb/m^2$

42. (b) Magnetic field at the centre of solenoid $(B) = \mu_0 ni$

Where n = Number of *turns /meter*

$\therefore B = 4\pi \times 10^{-7} \times 4250 \times 5 = 2.7 \times 10^{-2}\, Wb/m^2$

43. (d) Use Right hand palm rule, or Maxwell's Cork screw rule or any other.

44. (b) $B' = n^2 B \Rightarrow B' = (4)^2 B = B' = 16B$

45. (d) $B = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} \Rightarrow 12.56 = 10^{-7} \times \frac{2\pi \times i}{5.2 \times 10^{-11}}$

$\Rightarrow i = 1.04 \times 10^{-3}\ A$

46. (b) $B = \frac{\mu_0}{4\pi}\frac{\theta i}{r} = \frac{\mu_0}{4\pi} \times \frac{\pi}{2} \times \frac{i}{R} = \frac{\mu_0 i}{8R}$

47. (a) $B \propto \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{0.04}{B_2} = \frac{40}{10} \Rightarrow B_2 = 0.01\,T$

48. (a) See solution 34.

49. (b) $B = \frac{\mu_0 i}{2\pi r}$ or $B \propto \frac{1}{r}$

50. (d) $B = \mu_0 ni = \mu_0 \frac{N}{L} i$

51. (c) Here $B = \mu_0 ni$

where n is number of turns per unit length $= \frac{N}{l}$

52. (b) $\frac{\mu_0}{4\pi} \times \frac{2\pi i}{r} = H \Rightarrow \frac{(10^{-7}) \times 2 \times 3.142 \times i}{0.05} = 7 \times 10^{-5}$

$\therefore i = \frac{7 \times 0.05 \times 10^{-5}}{2 \times 3.142 \times 10^{-7}} = \frac{35}{2 \times 3.142} = 5.6$ *amp*

53. (c) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 1000 \times 0.1}{2 \times 0.1} = 6.28 \times 10^{-4}\ T$

54. (b) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 50 \times 2}{2 \times 0.5} = 1.25 \times 10^{-4}\ T$

55. (d) $B \propto \frac{i}{r}$

56. (a) $B = \frac{\mu_0 i}{2\pi r}$ i.e. $B \propto \frac{1}{r}$ i.e. when r is doubled, B is halved.

57. (b) Applying Ampere's law $\oint B.dl = \mu_0 i$ to any closed path inside the pipe we find no current is enclosed. Hence $B = 0$.

58. (a) Magnetic field at the centre of current carrying coil is

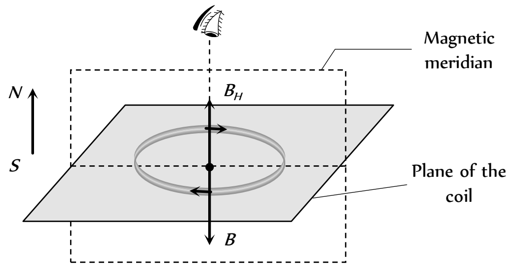
$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi ni}{r} = \frac{\mu_0 ni}{2r}$

59. (d) The magnetic field is given by $B = \frac{\mu_0}{4\pi}\frac{2i}{r}$.

It is independent of the radius of the wire.

60. (d) Magnetic meridian is a vertical *N-S* plane, the earth's magnetic field (B_H) lies in it. (For more details see magnetism).

To obtain neutral point at the centre of coil, magnetic field due to current (B) and B_H must cancel each other. Hence plane of the coil and magnetic meridian must be perpendicular to each other as shown



61. (c) 1 *Tesla* $= 10^4$ *Gauss*

62. (c)

63. (d)

64. (b) $B = \frac{\mu_0}{4\pi} \times \frac{2i}{r} = 10^{-7} \times \frac{2 \times 1}{10^{-2}} = 2 \times 10^{-5}$ *Tesla*

65. (a) Magnetic field due to one side of the square at centre O

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

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

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

66. (c)

67. (a)

68. (c) Magnetic field on the axis of circular current

$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi nir^2}{(x^2 + r^2)^{3/2}} \Rightarrow B \propto \frac{nr^2}{(x^2 + r^2)^{3/2}}$

69. (a) $r_1 : r_2 = 1 : 2$ and $B_1 : B_2 = 1 : 3$ We know that

$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi ni}{r} \Rightarrow \frac{i_1}{i_2} = \frac{B_1 r_1}{B_2 r_2} = \frac{1 \times 1}{3 \times 2} = \frac{1}{6}$

70. (b) $B = 10^{-7}\frac{2i}{r} = 10^{-7} \times \frac{2 \times 2}{5} = 8 \times 10^{-8}\ T$

71. (c) $B = \frac{\mu_0}{4\pi} \times \frac{\pi i}{r} \Rightarrow B = 10^{-7} \times \frac{\pi \times 10}{5 \times 10^{-2}} = 6.28 \times 10^{-5}\ T$

72. (c) Magnetic field due to solenoid is independent of diameter (Because $B = \mu_0 ni$).

73. (b) $B = \frac{\mu_0}{4\pi}\frac{2\pi i}{r} = 10^{-7} \times \frac{2\pi \times 2}{0.0157} = 8 \times 10^{-5} Wb/m^2$

74. (b) $B = \mu_0 ni = 4\pi \times 10^{-7} \times \frac{200}{10^{-2}} \times 2.5 = 6.28 \times 10^{-2} Wb/m^2$

75. (d) Magnetic field at centre due to smaller loop

$B_1 = \frac{\mu_0}{4\pi}.\frac{2\pi i_1}{r_1}$ ..... (i)

Due to Bigger loop $B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi i_2}{r_2}$ So net magnetic field at centre

$B = B_1 - B_2 = \frac{\mu_0}{4\pi} \times 2\pi\left(\frac{i_1}{r_1} - \frac{i_2}{r_2}\right)$

According to question $B = \frac{1}{2} \times B_1$

$$\Rightarrow \frac{\mu_0}{4\pi}.2\pi\left(\frac{i_1}{r_1}-\frac{i_2}{r_2}\right)=\frac{1}{2}\times\frac{\mu_0}{4\pi}.\frac{2\pi i_1}{r_1}$$

$$\frac{i_1}{r_1}-\frac{i_2}{r_2}=\frac{i_1}{2r_1}\Rightarrow\frac{i_1}{2r_1}=\frac{i_2}{r_2}\Rightarrow\frac{i_1}{i_2}=1 \qquad \{r_2=2r_1\}$$

76. (b)

77. (b) $B=\frac{\mu_0}{4\pi}\times\frac{2\pi NiR^2}{(R^2+x^2)^{3/2}}\Rightarrow B\propto\frac{1}{(r^2+x^2)^{3/2}}$

$$\Rightarrow\frac{8}{1}=\frac{(R^2+x_2^2)^{3/2}}{(R^2+x_1^2)^{3/2}}\Rightarrow\left(\frac{8}{1}\right)^{2/3}=\frac{R^2+0.04}{R^2+0.0025}$$

$$\Rightarrow\frac{4}{1}=\frac{R^2+0.04}{R^2+0.0025}$$. On solving $R=0.1m$

78. (b) $B=10^{-7}\frac{2i}{r}\Rightarrow\frac{B}{B'}=\frac{20}{5}\Rightarrow B'=B/4$

79. (c) $B=10^{-7}\frac{2\pi ni}{r}=10^{-7}\times\frac{2\times\pi\times25\times4}{5\times10^{-2}}=1.257\times10^{-3}\,T$

80. (b) $F=Bil\Rightarrow[B]=\frac{[F]}{[i][l]}=\frac{MLT^{-2}}{AL}=MT^{-2}A^{-1}$

81. (d) Magnetic field on the axis of conductor is zero.

82. (c) $B\propto\frac{1}{r}\Rightarrow\frac{B_1}{B_2}=\frac{r_2}{r_1}=\frac{2r}{r}=2$

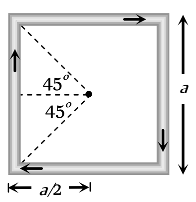
83. (c) $B=10^{-7}\times\frac{2i}{r}=10^{-7}\times\frac{2\times1}{1}=2\times10^{-7}\,T$

84. (d) At midpoint, magnetic fields due to both the wires are equal and opposite. So $B=0$.

85. (c) $B_0=4\times\frac{\mu_0}{4\pi}\times\frac{i}{(a/2)}(\sin45°+\sin45°)$

$$=4\times\frac{\mu_0}{4\pi}\times\frac{2i}{a}\times\frac{2}{\sqrt2}$$

$$=\frac{\mu_0 i2\sqrt2}{\pi a}$$



86. (b) $B=10^{-7}\frac{2\pi i}{r}$; according to question $B=B$

$$\Rightarrow5\times10^{-5}=10^{-7}\times\frac{2\times3.14\times i}{5\times10^{-2}}\Rightarrow i=4A$$

87. (d) $B=\frac{\mu_0}{4\pi}.\frac{2\pi Ni}{r}=\frac{10^{-7}\times2\pi\times100\times0.1}{5\times10^{-2}}=4\pi\times10^{-5}\,T$

88. (a) Corresponding current $i=en$

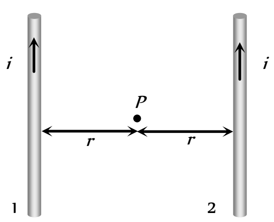
So $B=\frac{\mu_0}{4\pi}.\frac{2\pi(en)}{r}=\frac{\mu_0 ne}{2r}$

89. (a) B at ends of solenoid is $\frac{\mu_0}{2}ni$

90. (b) Use Right hand palm rule or Maxwell's Cork screw rule.

91. (c) At P

$\Rightarrow B_{net}=B_1-B_2$



Since $|B_1|=|B_2|$

So, $B=0$

92. (d) A moving charge and changing electric field both produces magnetic field.

93. (d)

94. (a) $B=\frac{\mu_0}{2\pi}\frac{i}{r}\Rightarrow5\times10^{-5}=\frac{\mu_0}{2\pi}\times\frac{\pi}{r}\Rightarrow r=10^4\mu_0\ metre$

95. (b) $B'=n^2B=(3)^2B=9B$

96. (b) B represents the magnetic field.

97. (a)

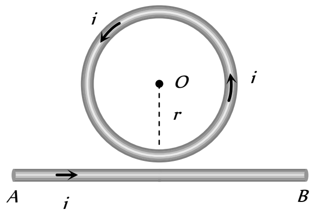
98. (d) $\frac{B_c}{B_a}=\left(1+\frac{x^2}{a^2}\right)^{3/2}=\left(1+\frac{a^2}{a^2}\right)^{3/2}=(1+1)^{3/2}=2\sqrt2$

99. (c) The given circuit can be considered as follows

$B_{loop}=\frac{\mu_0 i}{2r}\odot$

$B_{conductor}=\frac{\mu_0 i}{2\pi r}\odot$

$B_{net}=\frac{\mu_0 i}{2\pi r}(\pi+1)\odot$



100. (d) $B=\frac{\mu_0\mu_r Ni}{2\pi r}\Rightarrow1=\frac{4\pi\times10^{-7}\times\mu_r\times400\times2}{0.4}\Rightarrow\mu_r=400$

101. (b)

102. (c)

103. (b) $B=10^{-7}\times\frac{\pi\times i}{r}=10^{-7}\times\frac{\pi\times10}{20\times10^{-2}}=B=5\pi\mu T$

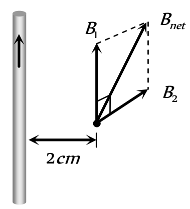
104. (d) $B'=n^2B=(2)^2B=4B$

105. (a) $B=\mu_0 ni\Rightarrow\frac{B}{B'}=\frac{n}{n'}\times\frac{i}{i'}=\frac{1}{(1/2)}\times\frac{1}{2}=1\Rightarrow B'=B$

106. (c) $B_1=4\times10^{-4}T$

$B_2=10^{-7}\times\frac{2\times30}{2\times10^{-2}}=3\times10^{-4}T$

$\therefore\ B_{net}=\sqrt{B_1^2+B_2^2}=5\times10^{-4}T$



107. (b) Magnetic field at the centre of circular loop

$B=\frac{\mu_0}{4\pi}\frac{2\pi i}{r}\Rightarrow0.5\times10^{-5}=\frac{10^{-7}\times2\times3.14\times i}{5\times10^{-2}}$

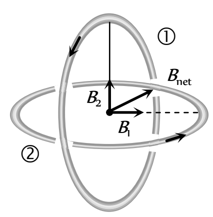
$i=0.4\ A$

108. (a)

109. (a) $B_1=B_2=B=\frac{\mu_0}{4\pi}\times\frac{2\pi i}{r}$

$B_{net}=\sqrt2B$

$\Rightarrow\frac{B}{B_{net}}=\frac{1}{\sqrt2}$



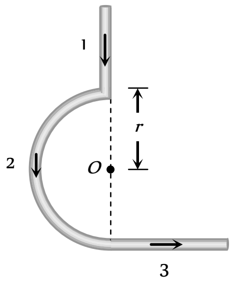
110. (c) Magnetic field due to different parts are

$B_1 = 0$

$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{r} \odot$

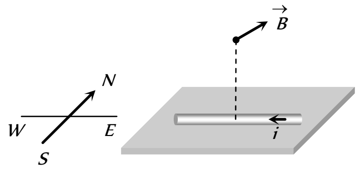
$B_3 = \frac{\mu_0}{4\pi} \cdot \frac{i}{r} \odot$

$\therefore B_{net} = B_2 + B_3 = \frac{\mu_0 i}{4r} + \frac{\mu_0 i}{4\pi r}$



111. (d) $M = niA = ni(\pi r^2) \Rightarrow M \propto r^2$

112. (a)



113. (b) Magnetic field at the center of single turn loop $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r}$, magnetic field at the center of *n*-turn loop

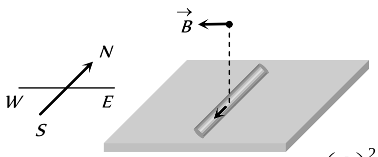
$B_n = \left(\frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r/n}\right) \times n \Rightarrow B_n = n^2 B$

114. (a) $\frac{B_{center}}{B_{axis}} = \left(1 + \frac{x^2}{r^2}\right)^{3/2} \Rightarrow \frac{B_{center}}{54} = \left(1 + \left(\frac{4}{3}\right)^2\right)^{3/2} = \frac{125}{27}$

$B_{center} = 250\mu T$

115. (b) $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r} \Rightarrow B \propto \frac{1}{r}$

116. (d)



117. (c) Suppose length of each wire *is l*. $A_{square} = \left(\frac{l}{4}\right)^2 = \frac{l^2}{16}$

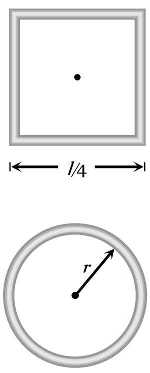
$A_{cirde} = \pi r^2 = \pi\left(\frac{l}{2\pi}\right)^2 = \frac{l^2}{4\pi}$

$\because$ Magnetic moment

$M = iA$

$\Rightarrow \frac{M_{square}}{M_{cirde}} = \frac{A_{square}}{A_{cirde}}$

$= \frac{l^2/16}{l^2/4\pi} = \frac{\pi}{4}$



118. (b) $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi n i}{r} \Rightarrow B \propto ni$

119. (a) Magnetic field due to revolution of electron

$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi \cdot \left(\frac{e\omega}{2\pi}\right)}{r} = 10^{-7} \times \frac{e\omega}{r}$

$\Rightarrow 16 = 10^{-7} \times \frac{1.6 \times 10^{-19}\omega}{1 \times 10^{-10}} \Rightarrow \omega = 10^{17} rad/\sec$.

120. (a) $B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r} = 10^{-7} \times \frac{2 \times 20}{10 \times 10^{-2}} = 4 \times 10^{-5} Wb/m^2$

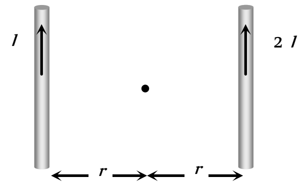
121. (a) $B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r} \Rightarrow B \propto i$

122. (a) $B_{net} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi}{r} \sqrt{i_1^2 + i_2^2}$

$= 10^{-7} \times \frac{2\pi}{2\pi \times 10^{-2}} \sqrt{(3)^2 + (4)^2} = 5 \times 10^{-5}\ wb/m^2$

123. (c) When two parallel conductors carrying current *I* and 2*I* in same direction, then magnetic field at the midpoint is

$B = \frac{\mu_0 2I}{2\pi r} - \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi r}$



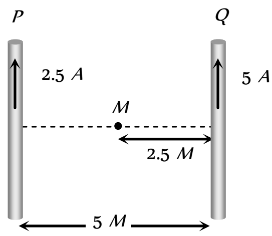
When current 2*I* is switched off then magnetic field due to conductor carrying current *I* is $B = \frac{\mu_0 I}{2\pi r}$.

124. (d) In the following figure magnetic field at mid point *M* is given by

$B_{net} = B_Q - B_P$

$= \frac{\mu_0}{4\pi} \cdot \frac{2}{r}(i_Q - i_P)$

$= \frac{\mu_0}{4\pi} \times \frac{2}{2.5}(5 - 2.5) = \frac{\mu_0}{2\pi}$



125. (c)

126. (b) The magnetic field due to small element of conductor of length is given by $dB = \frac{\mu_0}{4\pi} \frac{Idl\sin\theta}{r^2}$

This value will be maximum when

$\sin\theta = 1 = \sin 90°$ or, $\theta = 90°$

Motion of Charged Particle in Magnetic Field

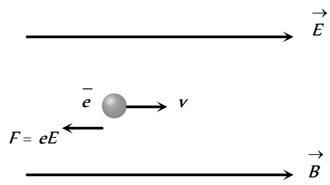
1. (a, b, d).

Here the proton has no acceleration so $E = B = 0$.

When $E = 0$ but $B \neq 0$, but parallel to the motion of proton, there will be no force acting.

When $E \neq 0$ and $B \neq 0$ and *E, B* and motion of proton (v) are mutually perpendicular, there may be no net force. Forces due to *E* and *B* cancel each other.

2. (d) 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.

3. (c) $r = \frac{\sqrt{2mk}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}} \Rightarrow r \propto \sqrt{m} \Rightarrow \frac{m_1}{m_2} = \left(\frac{R_1}{R_2}\right)^2$

4. (a) $r = \frac{mv}{Bq} = \frac{v}{(q/m)B} = \frac{2\times10^5}{5\times10^7\times4\times10^{-2}} = 0.1m$

5. (b) $r = \frac{p}{qB} \Rightarrow r \propto p$

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

7. (c) $r = \frac{\sqrt{2mK}}{qB}$ *i.e.* $r \propto \frac{\sqrt{m}}{q}$

Here kinetic energy K and B are same.

$$\therefore \frac{r_p}{r_\alpha} = \frac{\sqrt{m_p}}{\sqrt{m_\alpha}}.\frac{q_\alpha}{q_p} = \frac{\sqrt{m_p}}{\sqrt{4m_p}}.\frac{2q_p}{q_p} = 1$$

8. (c) $\vec{F} = q\vec{v}\times\vec{B}$

9. (c)

10. (d)

11. (c) East, (By $\vec{F} = q(\vec{v}\times\vec{B})$) or by applying Fleming's left hand rule.

12. (d) $F = qvB = 1.6\times10^{-19}\times\left[\sqrt{\frac{2E}{m}}\right]2.5$

$$= 4\times10^{-19}\sqrt{\frac{2\times2\times1.6\times10^{-19}\times10^6}{1.66\times10^{-27}}} = 7.6\times10^{-12}N$$

13. (d) $\vec{F} = q(\vec{v}\times\vec{B})$; if $\vec{v} \parallel \vec{B}$ then $\vec{F} = 0$

14. (b) 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.

15. (a) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow K \propto \frac{q^2}{m} \Rightarrow \frac{K_p}{K_\alpha} = \left(\frac{q_p}{q_\alpha}\right)^2 \times \frac{m_\alpha}{m_p}$

$$\Rightarrow \frac{1}{K_\alpha} = \left(\frac{q_p}{2q_p}\right)^2 \times \frac{4m_p}{m_p} = 1 \Rightarrow K_\alpha = 1\,MeV.$$

16. (c) $r \propto \frac{1}{B}$ *i.e.* $\frac{r_1}{r_2} = \frac{B_2}{B_1} \Rightarrow r_2 = \frac{B_1}{B_1/2}\times r = 2r$

17. (c) Time period of proton $T_p = \frac{25}{5} = 5\mu\sec$

By using $T = \frac{2\pi m}{qB} \Rightarrow \frac{T_\alpha}{T_p} = \frac{m_\alpha}{m_p}\times\frac{q_p}{q_\alpha} = \frac{4m_p}{m_p}\times\frac{q_p}{2q_p}$

$$\Rightarrow T_\alpha = 2T_p = 10\mu\sec.$$

18. (a) $F = ma = qvB \Rightarrow a = \frac{qvB}{m} = \frac{1.6\times10^{-19}\times2\times3.4\times10^7}{1.67\times10^{-27}}$

$= 6.5\times10^{15}\,m/sec^2$

19. (c) $T = \frac{2\pi m}{qB} = \frac{2\pi r}{v} = \frac{2\times3.14\times0.45}{2.6\times10^7} = 1.08\times10^{-7}\sec$

20. (b) $F = qvB$ and $K = \frac{1}{2}mv^2 \Rightarrow F = qB\sqrt{\frac{2k}{m}}$

$$= 1.6\times10^{-19}\times1.5\sqrt{\frac{2\times5\times10^6\times1.6\times10^{-19}}{1.7\times10^{-27}}}$$

$$= 7.344\times10^{-12}N$$

21. (c) Magnetic force acts on a moving charge.

22. (c) $r = \frac{mv}{qB} \Rightarrow r \propto v, \Rightarrow r_2 = 2r_1 = 2\times2 = 4cm$

23. (d) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow K \propto \frac{q^2}{m}$

$$\Rightarrow \frac{K_p}{K_d} = \left(\frac{q_p}{q_d}\right)^2 \times \frac{m_d}{m_p} = \left(\frac{1}{1}\right)^2 \times \frac{2}{1} = \frac{2}{1}$$

$$\Rightarrow K_p = 2\times50 = 100\,keV.$$

24. (b) Maximum force will act on proton so it will move on a circular path. Force on electron will be zero because it is moving parallel to the field.

25. (d) Fleming's left hand rule is used to the determine the direction of force.

26. (a) Lorentz force is given by

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

27. (c) $\vec{F} = q\vec{v}\times\vec{B}$

28. (a) $F = qvB\sin\theta$

$$= 1.6\times10^{-19}\times2\times10^7\times1.5\sin30^o$$

$$= 1.6\times10^{-19}\times2\times10^7\times1.5\times\frac{1}{2} = 2.4\times10^{-12}N$$

29. (d) $F = qvB\sin\theta \Rightarrow B = \frac{F}{qv\sin\theta}$

$B_{\min} = \frac{F}{qv}$ (when $\theta = 90$)

$\therefore B_{\min} = \frac{F}{qv} = \frac{10^{-10}}{10^{-12}\times10^5} = 10^{-3}$ *Tesla* in $\hat{z}$ -direction.

30. (d) Kinetic energy in magnetic field remains constant and it is $K = qV \Rightarrow K \propto q$ (V = constant)

$$\therefore K_p : K_d : K_\alpha = q_p : q_d : q_a = 1:1:2$$

31. (d) When charged particle enters perpendicularly in a magnetic field, it moves on a circular path with a constant speed. Hence it's kinetic energy also remains constant.

32. (b) $r = \frac{\sqrt{2mK}}{qB}$ *i.e.* $r \propto \frac{\sqrt{m}}{q}$

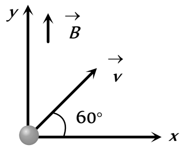
Here kinetic energy K and B are same.

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

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

33. (c) Path of the proton will be a helix of radius $r = \frac{mv\sin\theta}{qB}$

(where θ = Angle between $\vec{B}$ and $\vec{v}$)



$\Rightarrow r = \frac{1.67\times10^{-27}\times2\times10^{6}\times\sin30^{o}}{1.6\times10^{-19}\times0.104}$

$= 0.1m$

Time period $T = \frac{2\pi m}{qB} = \frac{2\pi\times1.67\times10^{-27}}{1.6\times10^{-19}\times0.104}$

$= 2\pi\times10^{-7}\,sec$

34. (a) $\frac{mv^2}{R} = qvB$. For proton $R_p = \frac{mv}{qB} = \frac{\sqrt{2m_pE}}{qB}$

and for deutron $R_d = \frac{\sqrt{2m_dE}}{qB}$

$\Rightarrow \frac{R_d}{R_p} = \sqrt{\frac{m_d}{m_p}} = \sqrt{2} \Rightarrow R_d = \sqrt{2}R_p$

35. (c) In this case $|\vec{F_e}| = |\vec{F_m}|$ and both forces are opposite to each other.

36. (b) We know that time period $T = \frac{2\pi m}{qB}$ $i.e.\ T\propto m$

(Since q and B are same)

$\because$ Mass of proton > Mass of electron

$\therefore$ Time period of proton > Time period of electron

37. (d) According to Fleming's right hand rule.

38. (a) $r = \frac{mv}{eB} \Rightarrow \frac{e}{m} = \frac{v}{rB}$

39. (a) Using $eE = evB \Rightarrow E = vB = 5\times10^{6}\times0.02 = 10^{5}\,Vm^{-1}$

40. (d) $F = evB = 1.6\times10^{-19}\times4\times10^{6}\times2\times10^{-1} = 1.28\times10^{-13}\,N$

Also $\frac{mv^2}{r} = evB \Rightarrow r = \frac{mv}{eB}$

$\Rightarrow r = \frac{9\times10^{-31}\times4\times10^{6}}{1.6\times10^{-19}\times2\times10^{-1}} = 1.1\times10^{-4}m$

41. (c) Force acts perpendicular to the velocity in a magnetic field, so speed of electron will remain same.

42. (a) By Fleming left hand rule.

43. (d) Direction of motion of proton is same as that of direction of magnetic field.

44. (a) Time period is given by $T = \frac{2\pi m}{qB}$

$\Rightarrow$ Frequency $\nu = \frac{1}{T} = \frac{qB}{2\pi m}$

45. (b) $r = \frac{\sqrt{2mK}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$

$= \frac{1}{10^{-3}}\sqrt{\frac{2\times9\times10^{-31}\times12000}{1.6\times10^{-19}}}$ = 0.367 m = 36.7 cm

46. (c) $r = \frac{1}{B}\sqrt{\frac{2mV}{q}} \Rightarrow r\propto\sqrt{\frac{m}{q}} \Rightarrow \frac{r_x}{r_y} = \sqrt{\frac{m_x}{q_x}\times\frac{q_y}{m_y}}$

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

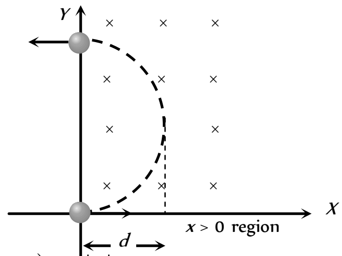
47. (d) $\vec{F} = q(\vec{v}\times\vec{B}) = 10^{-11}(10^{8}\hat{j}\times0.5\hat{i})$

$= 5\times10^{-4}(\hat{j}\times\hat{i}) = 5\times10^{-4}\,N(-\hat{k})$

48. (b) It is easy to understand the given problem, along with the following figure.

d = radius of path

$= \frac{mv}{qB}$



49. (c) Lorentz force $F = q(v\times B)$ or $|F| = qvB\sin\theta$

F will be maximum. when $\theta = 90^{o}$

50. (d) The component of velocity perpendicular to H will make the motion circular while that parallel to H will make it move along a straight line. The two together will make the motion helical.

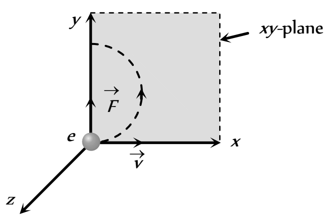
51. (b) We have $qvB = \frac{mv^2}{r}$ or $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

For same kinetic energy K, we have $r\propto\sqrt{m}$

Hence path of proton will have larger r and is therefore less curved.

52. (c) When particle enters at angle other than 0° or 90° or 180°, path followed is helix.

53. (b) To move the electron in xy plane, force on it must be acting in the y-direction initially. The direction of $\vec{F}$ is known, and the direction of v is known, hence by applying Fleming's left hand rule, the direction of magnetic field is also determined.



54. (a) A moving charge gains energy in electric field only because in magnetic field energy remains constant.

55. (a) Given that $K_p = K_d = K_\alpha = K$ (say)

We know that $m_p = m$, $m_d = 2m$ and $m_\alpha = 4m$ and $q_p = e$, $q_d = e$ and $q_\alpha = 2e$

Further $r = \frac{\sqrt{2mK}}{qB} \Rightarrow r_p = \frac{\sqrt{2mK}}{eB}$, $r_d = \frac{\sqrt{2(2m)K}}{eB} = \sqrt{2}r_p$

and $r_\alpha = \frac{\sqrt{2(4m)K}}{(2e)B} = r_p$. Hence $r_\alpha = r_p < r_d$

56. (d) Since force is perpendicular to direction of motion. energy and magnitude of momentum remains constant.

57. (d) $T = \frac{2\pi m}{qB} \Rightarrow T \; \alpha \; v^o$

58. (b) $F = qvB$ also Kinetic energy $K = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2K}{m}}$

$\therefore \; F = q\sqrt{\frac{2K}{m}}B$

$= 1.6 \times 10^{-19}\sqrt{\frac{2 \times 200 \times 10^6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}} \times 5$

$= 1.6 \times 10^{-10} \, N$

59. (d) The deflection produced by the electric field may be nullified by that produced by magnetic field.

60. (a) $\vec{F_m} = q(\vec{v} \times \vec{B})$

When the angle between $\vec{v}$ and $\vec{B}$ is 180°, $F_m = 0$

61. (c) $r = mv/qB$

Since both have same momentum, therefore the circular path of both will have the same radius.

62. (c) When particle enters perpendicularly in a magnetic field, it moves along a circular path with constant speed.

63. (b) For motion of a charged particle in a magnetic field, we have $r = mv/qB$ *i.e.* $r \propto v$

64. (a) The charged particle moving in a magnetic field does not gain energy. However, the direction of its velocity changes continuously. Hence momentum changes.

65. (a) $F = qvB\sin\theta = qvB\sin 0 = 0$

66. (b) $r = \frac{mv}{qB} = \frac{10^7}{10^{11} \times 10^{-4}} = 1m \; (\because q/m = 10^{11} \, C/kg)$

67. (b) $\omega = \frac{2\pi}{T} = \frac{qB}{m} \Rightarrow \omega \propto v^\circ \; \left(\because T = \frac{2\pi m}{qB}\right)$

68. (a) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow r \propto \sqrt{K} \Rightarrow \frac{R}{R_2} = \sqrt{\frac{K}{2K}} \Rightarrow R_2 = R\sqrt{2}$

69. (b, d) $r = \frac{mv}{qB} = \frac{P}{qB}$

70. (b) $F = qvB\sin\theta = 1.6 \times 10^{-19} \times 2.5 \times 2.5 \times 10^7 \sin 30^o$

$F = 1.6 \times 10^{-19} \times 6.25 \times 10^7 \times \frac{1}{2} = 5 \times 10^{-12} \, N$

71. (c) $K_{\max} = \frac{1}{2}mv^2$ and $r_0 = \frac{mv}{qB} \Rightarrow v = \frac{qBr_0}{m}$

$\Rightarrow K_{\max} = \frac{1}{2}m\left(\frac{qBr_0}{m}\right)^2 = \frac{q^2B^2r_0^2}{2m}$

72. (b) $F = qvB\sin\theta$; Independent of mass

73. (b) By Fleming left hand rule.

74. (a) $F = qBv = 1 \times 0.5 \times 10 = 5N$

75. (d) $r = \frac{mv}{qB} \Rightarrow \frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{B_2}{B_1} \Rightarrow \frac{r_1}{r_2} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

$r_2 = 4r_1$

76. (d) Magnetic force on charge will be zero.

77. (d)

78. (b) Apply Fleming's left hand rule.

79. (a) $T = \frac{2\pi m}{qB} = \frac{2 \times 3.14 \times 9 \times 10^{-31}}{1.6 \times 10^{-19} \times 1 \times 10^{-4}} = 3.5 \times 10^{-7} \, sec$

80. (d) $\vec{F} = q(\vec{v} \times \vec{B}) = 0$ as $\vec{v}$ and $\vec{B}$ are parallel.

81. (a) Here magnetic force is zero, but the velocity increases due to electric force.

82. (a)

83. (c)

84. (b) $r = \frac{mv}{qB} \Rightarrow r \propto mv$ (q and B are constant)

$\because r_A > r_B \Rightarrow m_A v_A > m_B v_B$

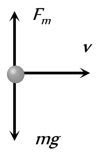
85. (b) $r = \frac{p}{qB} \Rightarrow p \propto q$ ($\because$ r and B are constant)

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

86. (c) Particle will move with uniform velocity when it's acceleration is zero.

i.e. $|F_m| = mg \Rightarrow mg = qvB$

$\Rightarrow B = \frac{mg}{qv} = \frac{0.6 \times 10^{-3} \times 10}{25 \times 10^{-9} \times 1.2 \times 10^4} = 20 \, T$



87. (c) $r = \frac{mv}{qB} \Rightarrow \frac{r_\alpha}{r_p} = \frac{m_\alpha}{m_p} \times \frac{q_p}{q_\alpha} = \frac{4}{1} \times \frac{1}{2} = \frac{2}{1}$

88. (b) When field is parallel to the direction of motion of charge, magnetic force on it is zero.

89. (a) Since $\vec{F}$ and $\vec{v}$ are perpendicular to each other work done by force is zero. Hence K.E. is constant.

90. (b)

91. (a) Charged particles deflects in magnetic field.

92. (a) $v = \frac{qB}{2\pi m} \Rightarrow v \propto \frac{q}{m}$

$\left(\frac{q}{m}\right)_{Li^+}$ is minimum so v_{Li^+} is minimum.

93. (c) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow r \propto \frac{\sqrt{m}}{q} \Rightarrow \frac{r_{He^+}}{r_{O^{++}}} = \sqrt{\frac{m_{He^+}}{m_{O^{++}}}} \times \frac{q_{O^{++}}}{q_{He^+}}$

$= \sqrt{\frac{4}{16}} \times \frac{2}{1} = \frac{1}{1}$. Then will deflect equally.

94. (d) $r = \frac{\sqrt{2mE}}{qB} = \frac{\sqrt{2 \times 9 \times 10^{-31} \times 7.2 \times 10^{-18}}}{1.6 \times 10^{-19} \times 9 \times 10^{-5}}$

$= 0.25\ m = 25\ cm$

95. (c) $v = \frac{E}{B} = \frac{20}{5} = 4 m/\sec$

96. (a) Because magnetic force on charge will be zero.

97. (c) $W = F.d \cos 90^o = 0$

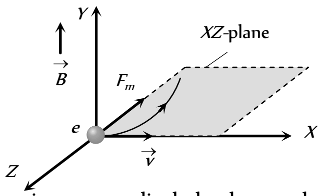
98. (b) Since particle is moving undeflected.

So $qE = qvB \Rightarrow B = E/v = \frac{10^4}{10} = 10^3 Wb/m^2$

99. (a) $r = \frac{mv}{qB} \Rightarrow \frac{r_1}{r_2} = \frac{m_1 v_1}{m_2 v_2} \times \frac{q_2}{q_1} = \frac{1 \times 2}{1 \times 3} \times \frac{2}{1} = \frac{4}{3}$

100. (b) $\vec{F} = -e(\vec{v} \times \vec{B}) \Rightarrow \vec{F} = -e[v\hat{i} \times B\hat{j}] = evB[-\hat{k}]$

i.e. Force on electron is acting towards negative *z*-axis. Hence particle will move on a circle in *xz*-plane.



101. (d) Particles entering perpendicularly, hence they will describe circular path. Since their masses are different so they will describe path of different radii.

102. (c) $r = \frac{mv}{qB} = \frac{6 \times 10^7}{1.7 \times 10^{11} \times 1.5 \times 10^{-2}} = 2.35\ cm$

103. (d) Cyclotron frequency $\nu = \frac{Bq}{2\pi m}$

$\Rightarrow \nu = \frac{1 \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}} = 2.79 \times 10^{10} H_z$

$= 27.9 \times 10^9\ HZ \cong 28\ GHZ$

104. (d) By Fleming's left hand rule.

105. (c) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow q \propto \sqrt{mK} \Rightarrow K \propto \frac{q^2}{m}$

$\Rightarrow \frac{K_\alpha}{K_p} = \left(\frac{q_\alpha}{q_p}\right)^2 \times \frac{m_p}{m_\alpha} \Rightarrow \frac{K_\alpha}{8} = \left(\frac{2q_p}{q_p}\right)^2 \times \frac{m_p}{4m_p} = 1$

$\Rightarrow K_\alpha = 8\ eV$

106. (c) By using $r = \frac{mv}{qB} = \frac{v}{\left(\frac{q}{m}\right)B} \Rightarrow r \propto \frac{1}{(q/m)}$

$\because \left(\frac{q}{m}\right)_{e^-} > \left(\frac{q}{m}\right)_{p^+} > \left\{\left(\frac{q}{m}\right)_d = \left(\frac{q}{m}\right)_\alpha\right\}$

$\therefore R_d = R_\alpha$

107. (d) By using Fleming's left hand rule.

108. (d) Along the axis of coil. $\vec{v}$ and $\vec{B}$ are parallel, so $F = 0$

109. (d) $F_m = qvB\sin\theta$, if $v = 0 \Rightarrow F_m = 0$

110. (d) $T = \frac{2\pi m}{qB} = \frac{2 \times 3.14 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19} \times 3.534 \times 10^{-5}}$

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

111. (a)

112. (b)

113. (d) 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*.

114. (c) From Fleming's left hand rule the force on electron is towards the east means it is deflected towards east.

115. (c) Electric current corresponds to the revolution of electron is $i = \frac{ev}{2\pi r}$

Magnetic field due to circular current at the centre

$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r} = \frac{\mu_0}{4\pi} \cdot \frac{ev}{r^2} \Rightarrow r = \sqrt{\frac{\mu_0}{4\pi} \cdot \frac{ev}{B}} \Rightarrow r \propto \sqrt{\frac{v}{B}}$.

116. (c) When electron moves in both electric and magnetic field then $qE = qvB$.

$\therefore v = \frac{E}{B} = \frac{1500}{0.40} = 3750\ m/s = 3.75 \times 10^3 m/s$.

117. (c) For no deflection in mutually perpendicular electric and magnetic field $v = \frac{E}{B} = \frac{3.2 \times 10^5}{2 \times 10^{-3}} = 1.6 \times 10^8\ m/s$.

If electric field is removed then due to only magnetic field radius of the path described by electron

$r = \frac{mv}{qB} = \frac{9.1 \times 10^{-31} \times 1.6 \times 10^8}{1.6 \times 10^{-19} \times 2 \times 10^{-3}} = 0.45 m$

118. (c) $r = \frac{mv}{qB} \Rightarrow r \propto v$

Force and Torque on Current Carrying Conductor

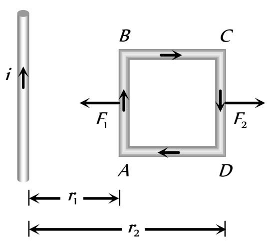
1. (b) Two wires, if carries current in opposite direction, they repel each other.

2. (c) $\because r_1 < r_2$

So $F_1 > F_2$

$\Rightarrow F_{net} = (F_1 - F_2)$

towards the wire.



3. (b) $M = NiA = 20 \times \frac{22}{7}(4 \times 10^{-2})^2 3 = 0.3\ A - m^2$

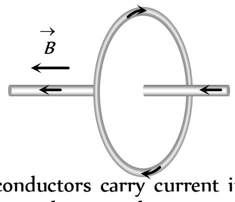
4. (c) Net force on a current carrying closed loop is always zero, if it is placed in an uniform magnetic field.

5. (b) Force per unit length $=\frac{\mu_0}{4\pi}.\frac{2i_1i_2}{r}=\frac{\mu_0}{2\pi}.\frac{i^2}{b}$

6. (a) $F=\frac{\mu_0}{4\pi}.\frac{2i_1i_2}{a}\times l\Rightarrow F=10^{-7}\times\frac{2\times10\times2}{(10\times10^{-2})}\times2=8\times10^{-5}N$

7. (b) For charge particles, if they are moving freely in space, electrostatic force is dominant over magnetic force between them. Hence due to electric force they repel each other.

8. (b) As shown in the following figure straight wire is placed parallel to the magnetic field produced by circular current. Hence force on wire $F=0$



9. (a) Two straight conductors carry current in same direction, then attractive force acts between them.

10. (a) $F=\frac{\mu_0}{4\pi}\frac{2\times i_1i_2}{a}=\frac{10^{-7}\times2\times5\times5}{0.1}=5\times10^{-5}N/m$

11. (c) $F=\frac{\mu_0}{4\pi}\frac{2i_1i_2}{a}=10^{-3}N$

When current in both the wires is doubled, then

$F'=\frac{\mu_0}{4\pi}\frac{2(2i_1\times2i_2)}{a}=4\times10^{-3}N$

12. (a) The magnetic moment of current carrying loop

$M=niA=ni(\pi r^2)$

Hence the work done in rotating it through 180°

$W=MB(1-\cos\theta)=2MB=2(ni\pi r^2)B$

$=2\times(50\times2\times3.14\times16\times10^{-4})\times0.1=0.1J$

13. (c) $F=Bil\sin\theta$

$=500\times10^{-4}\times3\times(40\times10^{-2})\times\frac{1}{2}=3\times10^{-2}N$

14. (c) $M=i\pi r^2$

15. (a) Because $\tau=NiAB\cos\theta$

16. (c)

17. (b) $\theta=\frac{NiAB}{C}\Rightarrow\theta\propto N$ (Number of turns)

18. (b) Magnet provides damping.

19. (b) $i=\frac{C\theta}{NAB}\Rightarrow i\propto\theta$

20. (b) Force per unit length on two parallel current carrying conductor is given by $\frac{F}{l}=10^{-7}\times2\frac{i_1i_2}{a}$

$\Rightarrow\frac{F}{l}=10^{-7}\times2\times\frac{1\times1}{1}=2\times10^{-7}N/m$

21. (d) $\tau=MB\sin\theta\Rightarrow\tau_{max}=NiAB,$ $(\theta=90°)$

22. (b) $W=MB(\cos\theta_1-\cos\theta_2)$

$=(NiA)B(\cos0°-\cos180°)=2NAIB$

23. (d) Magnetic dipole moment of coil = NIA

24. (a) $F=Bil\sin\theta\Rightarrow\sin\theta=\frac{F}{Bil}=\frac{15}{2\times10\times1.5}=\frac{1}{2}\Rightarrow\theta=30°$

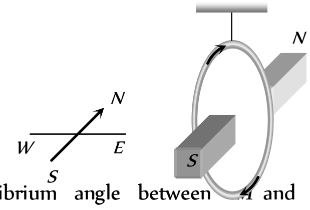
25. (a)

26. (b) $M=i(\pi r^2)=\frac{ev}{2\pi r}\times\pi r^2\Rightarrow M=\frac{1}{2}evr$

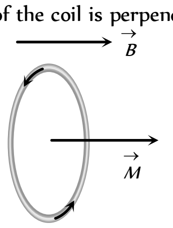
27. (d) Couple of force on loop S will be maximum because for same perimeter the area of loop will be maximum and magnetic moment of loop $=i\times A$. So, it will also be maximum for loop S.

28. (b) According to the definition.

29. (c) Current carrying loop, behaves as a bar magnet. A freely suspended bar magnet stays in the $N-S$ direction.



30. (c) In equilibrium angle between $\vec{M}$ and $\vec{B}$ is zero. It is happened, when plane of the coil is perpendicular to $\vec{B}$



31. (c)

32. (d)

33. (d) Sensitivity $S=\frac{\theta}{i}=\frac{nBA}{C}$

34. (d)

35. (b) By Fleming left hand rule.

36. (a) Force on wire Q due to wire P is

$F_P=10^{-7}\times\frac{2\times30\times10}{0.1}\times0.1=6\times10^{-5}N$ (Towards left)

Force on wire Q due to wire R is

$F_R=10^{-7}\times\frac{2\times20\times10}{0.02}\times0.1=20\times10^{-5}N$ (Towards right)

Hence $F_{net}=F_R-F_P=14\times10^{-5}N=1.4\times10^{-4}N$

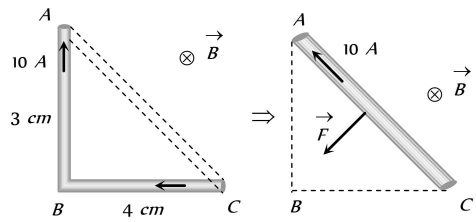
(Towards right)

37. (a) $\tau=NBiA=100\times0.2\times2\times(0.08\times0.1)=0.32N\times m$

Direction can be found by Fleming's left hand rule.

38. (a) $F=Bil\sin\theta\Rightarrow7.5=2\times5\times1.5\sin\theta\Rightarrow\theta=30°$

39. (c) According to the question figure can be drawn as shown below.



Force on the conductor ABC = Force on the conductor AC

= 5 × 10 × (5 × 10·) = 2.5 N

40. (d) Current sensitivity $\frac{\theta}{i} = \frac{NBA}{C}$

$$\Rightarrow \frac{\theta}{i} = \frac{100 \times 5 \times 10^{-4}}{10^{-8}} = 5\ rad/\mu\ Amp$$

41. (c) $\tau = NBiA = 100 \times 0.5 \times 1 \times 400 \times 10^{-4} = 2\ N - m$

42. (a) When current is passed through a spring, it gets compressed.

43. (a) $M = iA \Rightarrow i = M/A$

44. (c) $i = 6.6 \times 10^{15} \times 1.6 \times 10^{-19} = 10.5 \times 10^{-4} amp$

$$A = \pi R^2 = 3.142 \times (0.528)^2 \times 10^{-20} m^2$$

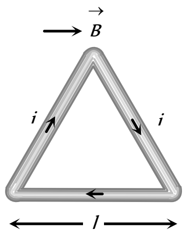
$$\Rightarrow M = iA = 10.5 \times 10^{-4} \times 3.142 \times (0.528)^2 \times 10^{-20}$$

$$= 10 \times 10^{-24} units = 1 \times 10^{-23} units$$

45. (d) Since $\theta = 90°$

Hence $\tau = NIAB = 1 \times I \times \left(\frac{\sqrt{3}}{4} l^2\right) B$

$$= \frac{\sqrt{3}}{4} l^2 B$$



46. (a) For no force on wire C, force on wire C due to wire D= force on wire C due to wire B

$$\Rightarrow \frac{\mu_0}{4\pi} \times \frac{2 \times 15 \times 5}{x} \times l = \frac{\mu_0}{4\pi} \times \frac{2 \times 5 \times 10}{(15 - x)} \times l \Rightarrow x = 9cm.$$

47. (d) By Fleming's left hand rule.

48. (a)

49. (a)

50. (c) Force on the wire = Bil

Force per unit length $= Bi = 10^{-4} \times 10 = 10^{-3}\ N$

51. (b) $F = Bil = 2 \times 1.2 \times 0.5 = 1.2N$

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

Direction of current is same, so force is attractive.

53. (a,b,c) Sensitivity $\frac{\theta}{i} = \frac{NAB}{C}$

54. (a) $M = NiA = 24 \times 0.75 \times 3.14 \times (3.5 \times 10^{-2})^2$

$$= 6.9 \times 10^{-2} A\text{-}m^2$$

55. (c) $\frac{F}{l} = \frac{\mu_0}{4\pi} \times \frac{2i_1 i_2}{a} = \frac{\mu_0}{4\pi} \frac{2i^2}{a}$ $(\because i_1 = i_2 = i)$

$$\Rightarrow 2 \times 10^{-7} = 10^{-7} \times \frac{2i^2}{1} \Rightarrow i = 1A$$

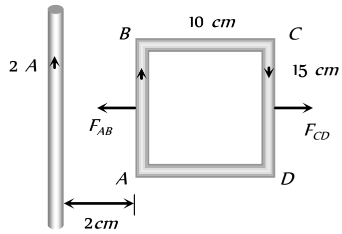
56. (b)

57. (a) $\tau = NiAB\sin\theta = 0$ $(\because \theta = 0^o)$

58. (d) $M = NiA$

59. (c)

60. (a) Force on side BC and AD are equal but opposite so their net will be zero.



But $F_{AB} = 10^{-7} \times \frac{2 \times 2 \times 1}{2 \times 10^{-2}} \times 15 \times 10^{-2} = 3 \times 10^{-6}\ N$

and $F_{CD} = 10^{-7} \times \frac{2 \times 2 \times 1}{(12 \times 10^{-2})} \times 15 \times 10^{-2} = 0.5 \times 10^{-6}\ N$

$$\Rightarrow F_{net} = F_{AB} - F_{CD} = 2.5 \times 10^{-6}\ N$$

$= 25 \times 10^{-7}\ N$, towards the wire.

61. (b) $F = 10^{-7} \frac{2i_1 i_2}{a} = 10^{-7} \times \frac{2 \times 5 \times 5}{0.5} = 10^{-5}\ N$ (repulsive)

62. (b) Sensitivity $= \frac{NAB}{C}$

63. (d) $M = iA = 0.1 \times \pi \times (0.05)^2$

$$= (0.1) \times 3.14 \times 25 \times 10^{-4} = 7.85 \times 10^{-4} amp - m^2$$

64. (b) $B = \frac{\mu_0 i}{2R} \Rightarrow i = \frac{B \times 2R}{\mu_0}$

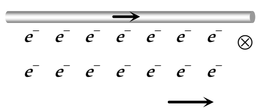
Now, $M = i \times A = i\pi R^2 = \frac{B \times 2R}{\mu_0} \times \pi R^2 = \frac{2\pi BR^3}{\mu_0}$

65. (c) $M = NiA \Rightarrow M \propto A \Rightarrow M \propto r^2$ $(\text{As}\ l = 2\pi r \Rightarrow l \propto r)$

$$\Rightarrow M \propto l^2$$

66. (a) $F = \frac{\mu_0}{4\pi} \frac{2i_1 i_2}{a} = 10^{-7} \times \frac{2 \times 10 \times 5}{0.1} = 10^{-4}\ N$ (Repulsive)

67. (b) According to Fleming's left hand rule, magnetic force on electrons will be downward.

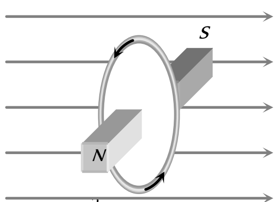


68. (a) $\sigma_i = \frac{\theta}{i} = \frac{\theta}{iG} \cdot G = \sigma_v G \Rightarrow \frac{\sigma_i}{G} = \sigma_v$

69. (a)

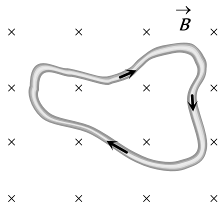
70. (a) $F = Bil\sin 30^o = 1.5 \times 10 \times 1 \times \frac{1}{2} = 7.5N$

71. (c) As shown in the following figure, the given situation is similar to a bar magnet placed in a uniform magnetic field perpendicularly. Hence torque on it



$\tau = MB\sin 90° = (i\pi r^2)B$

72. (a) As shown in figure, since $\vec{L} = 0$



Hence according to $\vec{F} = i(\vec{L} \times \vec{B}) \Rightarrow \vec{F} = 0$

73. (a) Because $\tau_{max} = BiNA \Rightarrow \tau \propto N$.

74. (d)

75. (d) $F = \frac{\mu_0}{4\pi}\frac{2i_1 i_2}{a}$

$F_1 = \frac{\mu_0}{4\pi} = \frac{2i^2}{x}$ (Attraction)

$F_2 = \frac{\mu_0}{4\pi} = \frac{2i \times 2i}{2x} = \frac{\mu_0}{4\pi}\frac{2i^2}{x}$ (Repulsion)

Thus $F_1 = -F_2$

76. (c) Magnetic field produced by wire is perpendicular to the motion of electron and it is given by

$B = \frac{\mu_0}{4\pi}\cdot\frac{2i}{a} = 10^{-7} \times \frac{2 \times 5}{0.1} = 10^{-5}\ Wb/m^2$

Hence force on electron

$F = qvB = (1.6 \times 10^{-19}) \times 5 \times 10^6 \times 10^{-5} = 8 \times 10^{-18}\ N$

77. (a) Sensitivity $(S) = \frac{\theta}{i} \Rightarrow \frac{S_A}{S_B} = \frac{i_B}{i_A} = \frac{5}{3} \Rightarrow S_A > S_B$

78. (a) $F = 10^{-7}\frac{2i_1 i_2}{a} = 10^{-7} \times \frac{2 \times 5 \times 8}{0.5} = 1.6 \times 10^{-5}$ (Attractive)

79. (b) In moving coil galvanometer $i \propto \theta$.

80. (c)

81. (b) $F \propto i_1 i_2$, so force on B due to C will be greater than that due A. Hence net force on B acts towards C.

82. (c) $F \propto \frac{i_1 i_2}{a}$; Since one of the current increase two times and distance increases three times, so force become $\frac{2}{3}$ times. Also due to the reversal of direction of current force becomes negative.

83. (c) Neon molecule is diatomic, so it's net magnetic moment is zero.

84. (b) $F = Bil \Rightarrow 1 \times 9.8 = 0.98 \times i \times 1 \Rightarrow i = 10A$

85. (a)

86. (d) $F = 10^{-7} \times \frac{2i^2}{a} \times l \Rightarrow 30 \times 10^{-7} = 10^{-7} \times \frac{2i^2}{0.15} \times 9$

$\Rightarrow i = 0.5A$

87. (c) $\tau_{max} = NiAB = 1 \times i \times (\pi r^2) \times B \quad \left(2\pi r = L, \Rightarrow r = \frac{L}{2\pi}\right)$

$\tau_{max} = \pi i\left(\frac{L}{2\pi}\right)^2 B = \frac{L^2 iB}{4\pi}$

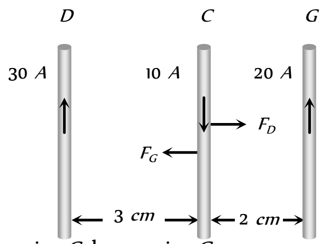
88. (b)

89. (c) $\left(\frac{F}{l}\right) = \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{a} \Rightarrow \left(\frac{F}{l}\right) = \frac{\mu_0}{4\pi}.\frac{2i^2}{d} = \frac{\mu_0 i^2}{2\pi d}$ (Attractive)

90. (c) Force on wire C due to wire D

$F_D = 10^{-7} \times \frac{2 \times 30 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ N$

(towards right)



Force on wire C due to wire G

$F_G = 10^{-7} \times \frac{2 \times 20 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ N$

(towards left)

$\Rightarrow$ Net force on wire C is $F_{net} = F_D - F_G = 0$

91. (d) Since $\theta = 0°$ so $\tau = 0$ $(\because \tau = NiAB\sin\theta)$

Critical Thinking Questions

1. (b) $\frac{B_{centre}}{B_{axis}} = \left(1 + \frac{x^2}{R^2}\right)^{3/2}$, also $B_{axis} = \frac{1}{8}B_{centre}$

$\Rightarrow \frac{8}{1} = \left(1 + \frac{x^2}{R^2}\right)^{3/2} \Rightarrow 2 = \left(1 + \frac{x^2}{R^2}\right)^{1/2}$

$\Rightarrow 4 = 1 + \frac{x^2}{R^2} \Rightarrow 3 = \frac{x^2}{R^2} \Rightarrow x^2 = 3R^2 \Rightarrow x = \sqrt{3}R$

2. (a) Field at the centre $B_1 = \frac{\mu_0}{4\pi} \times \frac{2\pi i n}{r} = \frac{\mu_0}{2}.\frac{ni}{r}$

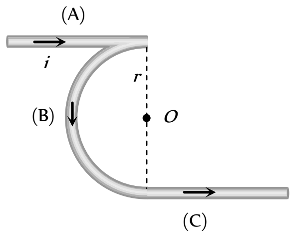
Field at a distance h from the centre

$B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi n i r^2}{(r^2 + h^2)^{3/2}} = \frac{\mu_0}{2}.\frac{n i r^2}{r^3\left(1 + \frac{h^2}{r^2}\right)^{3/2}}$

$$= B_1\left(1+\frac{h^2}{r^2}\right)^{-3/2} = B_1\left(1-\frac{3}{2}\cdot\frac{h^2}{r^2}\right) \text{(By binomial theorem)}$$

Hence B is less than B by a fraction $= \dfrac{3}{2}\dfrac{h^2}{r^2}$

3. (a) ***Case* 1 :** $B_A = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i}{r}\otimes$



$B_B = \dfrac{\mu_0}{4\pi}\cdot\dfrac{\pi i}{r}\odot$

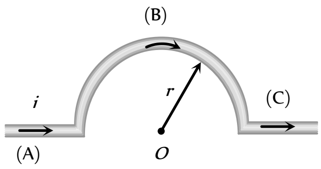
$B_C = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i}{r}\odot$

So net magnetic field at the centre of case 1

$B_1 = B_B - B_C - B_A \Rightarrow B_1 = \dfrac{\mu_0}{4\pi}\cdot\dfrac{\pi i}{r}\odot$ ..... (i)

***Case* 2 :** As we discussed before magnetic field at the centre O in this case

$B_2 = \dfrac{\mu_0}{4\pi}\cdot\dfrac{\pi i}{r}\otimes$ ..... (ii)

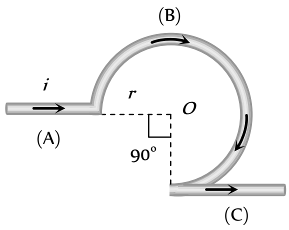


***Case 3* :** $B_A = 0$

$B_B = \dfrac{\mu_0}{4\pi}\cdot\dfrac{(2\pi-\pi/2)i}{r}\otimes$

$B_C = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i}{r}\odot$

$= \dfrac{\mu_0}{4\pi}\cdot\dfrac{3\pi i}{2r}\otimes$



So net magnetic field at the centre of case 3

$B_3 = \dfrac{\mu_0}{4\pi}\cdot\dfrac{i}{r}\left(\dfrac{3\pi}{2}-1\right)\otimes$ ..... (iii)

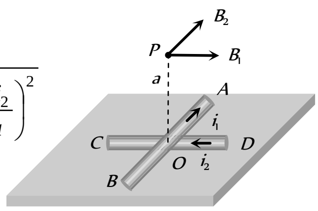
From equation (i), (ii) and (iii)

$B_1 : B_2 : B_3 = \pi\odot : \pi\otimes\left(\dfrac{3\pi}{2}-1\right)\otimes = -\dfrac{\pi}{2}:\dfrac{\pi}{2}:\left(\dfrac{3\pi}{4}-\dfrac{1}{2}\right)$

4. (c) At P: $B_{net} = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left(\dfrac{\mu_0}{4\pi}\dfrac{2i_1}{a}\right)^2 + \left(\dfrac{\mu_0}{4\pi}\dfrac{2i_2}{a}\right)^2}$

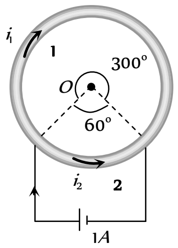
$= \dfrac{\mu_0}{2\pi a}(i_1^2 + i_2^2)^{1/2}$



5. (c) $B = \dfrac{\mu_0}{4\pi}\dfrac{\theta i}{r} \Rightarrow B \propto \theta i$ (but $\dfrac{i_1}{i_2} = \dfrac{l_2}{l_1} = \dfrac{\theta_2}{\theta_1}$)

$\Rightarrow \dfrac{B_1}{B_2} = \dfrac{\theta_1}{\theta_2}\cdot\dfrac{i_1}{i_2}$

So, $\dfrac{B_1}{B_2} = \dfrac{\theta_1}{\theta_2}\times\dfrac{\theta_2}{\theta_1}$



$\Rightarrow B_1 = B_2$

6. (c) Magnetic field at any point lying on the current carrying straight conductor is zero.

Here H_1 = Magnetic field at M due to current in PQ.

H_2 = Magnetic field at M due to QR

+ magnetic field at M due to QS

+ magnetic field at M due to PQ

$= 0 + \dfrac{H_1}{2} + H_1 = \dfrac{3}{2}H_1 \Rightarrow \dfrac{H_1}{H_2} = \dfrac{2}{3}$

7. (c, d) $B_{net} = B_1 - B_2 \Rightarrow B_1 - B_2 = 0 \Rightarrow B_1 = B_2$

$\Rightarrow B \propto ni$. So $n_1 i_1 = n_2 i_2$ or $n_1 = n_2$ and $i_1 = i_2$

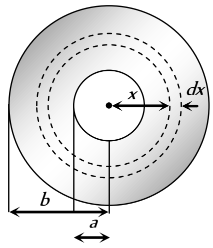
8. (c) Number of turns per unit width $= \dfrac{N}{b-a}$

Consider an elemental ring of radius x and with thickness dx

Number of turns in the ring $= dN = \dfrac{Ndx}{b-a}$

Magnetic field at the centre due to the ring element

$dB = \dfrac{\mu_0 (dN)i}{2x} = \dfrac{\mu_0 i}{2}\cdot\dfrac{Ndx}{(b-a)}\cdot\dfrac{1}{x}$



$\therefore$ Field at the centre

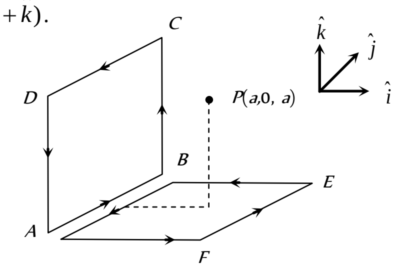
$= \int dB = \dfrac{\mu_0 Ni}{2(b-a)}\int_a^b \dfrac{dx}{x}$

$= \dfrac{\mu_0 Ni}{2(b-a)}\ln\dfrac{b}{a}$.

9. (d) The magnetic field at $P(a, 0, a)$ due to the loop is equal to the vector sum of the magnetic fields produced by loops $ABCDA$ and $AFEBA$ as shown in the figure.

Magnetic field due to loop $ABCDA$ will be along $\hat{i}$ and due to loop $AFEBA$, along $\hat{k}$. Magnitude of magnetic field due to both the loops will be equal.

Therefore, direction of resultant magnetic field at P will be $\dfrac{1}{\sqrt{2}}(\hat{i}+\hat{k})$.

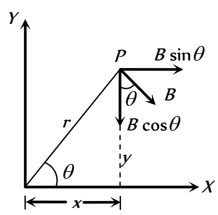


10. (a) Magnetic field at P is $\vec{B}$, perpendicular to OP in the direction shown in figure.

So, $\vec{B} = B\sin\theta\,\hat{i} - B\cos\theta\,\hat{j}$

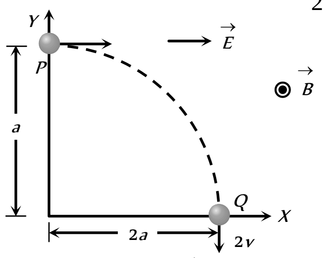
Here $B = \dfrac{\mu_0}{2\pi}\dfrac{I}{r}$

$\sin\theta = \dfrac{y}{r}$ and $\cos\theta = \dfrac{x}{r}$



$\therefore\ \vec{B} = \frac{\mu_0 I}{2\pi}\cdot\frac{1}{r^2}(y\hat{i} - x\hat{j}) = \frac{\mu_0 I(y\hat{i} - x\hat{j})}{2\pi(x^2+y^2)}$ (as $r^2 = x^2 + y^2$)

11. (a, b, d) Kinetic energy of the particle at point $P = \frac{1}{2}mv^2$



K.E. of the particle at point $Q = \frac{1}{2}m(2v)^2$

Increase in K.E. $= \frac{3}{2}mv^2$

It comes from the work done by the electric force qE on the particle as it covers a distance $2a$ along the x-axis. Thus $\frac{3}{2}mv^2 = qE \times 2a \Rightarrow E = \frac{3}{4}\frac{mv^2}{qa}$. The rate of work done by the electric field at P $= F \times v = qE \times v = 3\frac{mv^3}{4a}$

At $Q, \vec{F_e} = q\vec{E}$ is along x-axis while velocity is along negative y-axis. Hence rate of work done by electric field $= \vec{F_e}.\vec{v} = 0$ $(\because \theta = 90^o)$ Similarly, according to equation $\vec{F_m} = q(\vec{v} \times \vec{B})$

Force $\vec{F_m}$ is also perpendicular to velocity vector v.

Hence the rate of work done by the magnetic field = 0

12. (a, c) $r \propto \frac{\sqrt{m}}{q} \Rightarrow r_H : r_{He} : r_o = \frac{\sqrt{1}}{1} : \frac{\sqrt{4}}{1} : \frac{\sqrt{16}}{2} = 1:2:2$

Radius is smallest for H^+, so it is deflected most.

13. (c) As the electric field is switched on, positive ion will start to move along positive x-direction and negative ion along negative x-direction. Current associated with motion of both types of ions is along positive x-direction. According to Fleming's left hand rule force on both types of ions will be along negative y-direction.

14. (c) $\vec{v} = 2\times 10^5 \hat{i}$ and $\vec{B} = (\hat{i} + 4\hat{j} - 3\hat{k})$

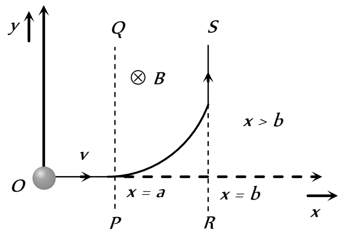
$\vec{F} = q(\vec{v}\times\vec{B}) = -1.6\times 10^{-19}[2\times 10^5 \hat{i} \times (\hat{i} + 4\hat{j} - 3\hat{k})]$

$= -1.6\times 10^{-19} \times 2\times 10^5[\hat{i}\times\hat{i} + 4(\hat{i}\times\hat{j}) - 3(\hat{i}\times\hat{k})]$

$= -3.2\times 10^{-14}[0 + 4\hat{k} + 3\hat{j}] = 3.2\times 10^{-14}(-4\hat{k} - 3\hat{k})$

$\Rightarrow |\vec{F}| = 3.2\times 10^{-14} \times 5 = 1.6\times 10^{-13} N.$

15. (b) In the figure, the z-axis points out of the paper, and the magnetic field is directed into the paper, existing in the region between PQ and RS. The particle moves in a circular path of radius r in the magnetic field. It can just enter the region $x > b$ for $r \geq (b - a)$



Now, $r = \frac{mv}{qB} \geq (b - a)$

or $v \geq \frac{q(b-a)B}{m} \Rightarrow v_{min} = \frac{q(b-a)B}{m}$

16. (b) Electric field can deviate the path of the particle in the shown direction only when it is along negative y-direction. In the given options $\vec{E}$ is either zero or along x-direction. Hence it is the magnetic field which is really responsible for its curved path. Options (a) and (c) can't be accepted as the path will be helix in that case (when the velocity vector makes an angle other than 0°, 180° or 90° with the magnetic field, path is a helix) option (d) is wrong because in that case component of net force on the particle also comes in k direction which is not acceptable as the particle is moving in x-y plane. Only in option (b) the particle can move in x-y plane.

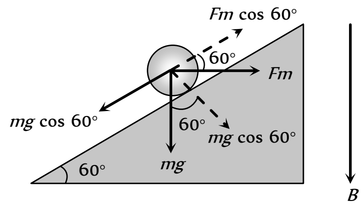
In option (d) : $\vec{F}_{net} = q\vec{E} + q(\vec{v}\times\vec{B})$

Initial velocity is along x-direction. So let $\vec{v} = v\hat{i}$

$\therefore\ \vec{F}_{net} = qa\hat{i} + q[(v\hat{i})\times(c\hat{k} + b\hat{j})] = qa\hat{i} - qvc\hat{j} + qvb\hat{k}$

In option (b) $\vec{F}_{net} = q(a\hat{i}) + q[(v\hat{i})\times(c\hat{k} + a\hat{i})] = qa\hat{i} - qvc\hat{j}$

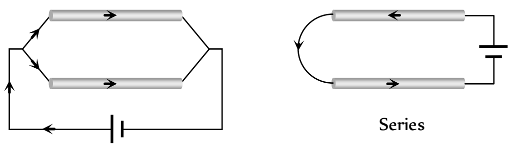
17. (c) The given situation can be drawn as follows



$F = ilB \Rightarrow mg\sin 60^o = ilB\cos 60^o$

$\Rightarrow B = \frac{0.01\times 10\times\sqrt{3}}{0.1\times 1.73} = 1\,T$

18. (a) When connected in parallel the current will be in the same direction and when connected in series the current will be in the opposite direction.



19. (b) If the radius of circle is r, then $2\pi r = L \Rightarrow r = \frac{L}{2\pi}$

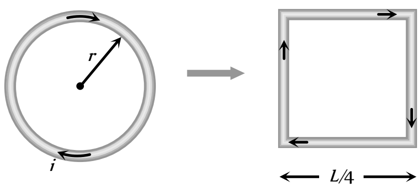
Area $= \pi r^2 = \frac{\pi L^2}{4\pi^2} = \frac{L^2}{4\pi}$

Magnetic moment $= IA = \frac{IL^2}{4\pi}$

20. (d) Initially for circular coil $L = 2\pi r$ and $M = i \times \pi r^2$

$= i \times \pi \left(\frac{L}{2\pi}\right)^2 = \frac{iL^2}{4\pi}$ ..... (i)

Finally for square coil $M' = i \times \left(\frac{L}{4}\right)^2 = \frac{iL^2}{16}$ ..... (ii)



Solving equation (i) and (ii) $M' = \frac{\pi M}{4}$

21. (c) The effective current $i = \frac{q\omega}{2\pi}$ and $A = \pi r^2$.

Magnetic moment $M = iA = \frac{1}{2} q\omega r^2$

Angular moment $L = I\omega = mr^2\omega \Rightarrow \frac{M}{L} = \frac{q}{2m}$

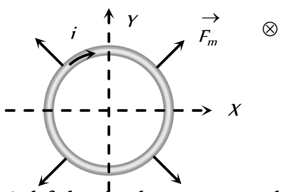
22. (b) On applying Fleming's left hand rule.

23. (b) Current carrying conductors will attract each other, while electron beams will repel each other.

24. (c) Length of the component *dl* which is parallel to wire (1) is $dl\cos\theta$, so force on it.

$F = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2}{r}(dl\cos\theta) = \frac{\mu_0 i_1 i_2 dl\cos\theta}{2\pi r}$

25. (b) Net force on a current carrying loop in uniform magnetic field is zero. Hence the loop can't translate. So, options (c) and (d) are wrong.



From Fleming's left hand rule we can see that if magnetic field is perpendicular to paper inwards and current in the loop is clockwise (as shown) the magnetic force $\vec{F}_m$ on each element of the loop is radially outwards, or the loops will have a tendency to expand.

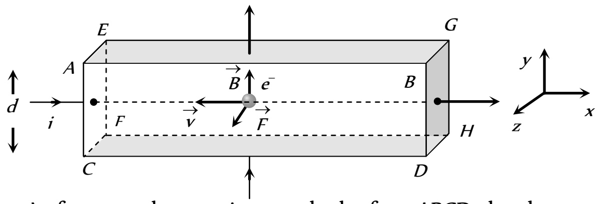
26. (c) $U = -MB\cos\theta$; where $\theta =$ Angle between normal to the plane of the coil and direction of magnetic field.

27. (a) As the block is of metal, the charge carriers are electrons, so for current along positive *x*-axis, the electrons are moving along negative *x*-axis, *i.e.* $\vec{v} = -v\hat{i}$

and as the magnetic field is along the *y*-axis, *i.e.* $\vec{B} = B\hat{j}$

so $\vec{F} = q(\vec{v} \times \vec{B})$ for this case yield $\vec{F} = (-e)[-v\hat{i} \times B\hat{j})]$

i.e., $\vec{F} = evB\hat{k}$ [As $\hat{i} \times \hat{j} = \hat{k}$]



As force on electrons is towards the face *ABCD*, the electrons will accumulate on it an hence it will acquire lower potential.

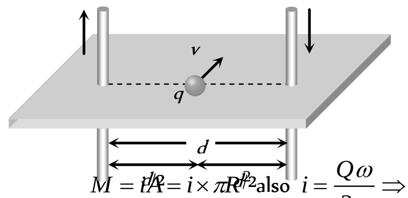
28. (a)

29. (a) $i = \frac{2q\omega}{2\pi} = \frac{q\omega}{\pi}$; $\therefore M = iA = \frac{q\omega}{\pi}\pi R^2 = q\omega R^2$

$L = 2R.mv = 2R.mR\omega = 2mR^2\omega$ $(\because v = R\omega)$

$\Rightarrow \frac{M}{L} = \frac{q}{2m}$

30. (d) According to gives information following figure can be drawn, which shows that direction of magnetic field is along the direction of motion of charge so net force on it is zero.

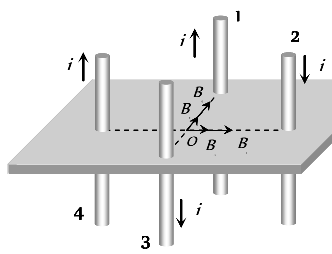


31. (b) $M = iA = i \times \pi R^2$ also $i = \frac{Q\omega}{2\pi} \Rightarrow M = \frac{1}{2}$

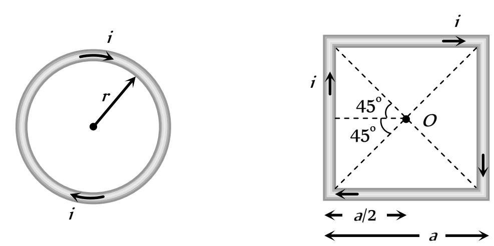
32. (c) Direction of magnetic field (B, B, B and B) at origin due to wires 1, 2, 3 and 4 are shown in the following figure.

$B_1 = B_2 = B_3 = B_4 = \frac{\mu_0}{4\pi} \cdot \frac{2i}{x} = B$. So net magnetic field at origin *O*

$B_{net} = \sqrt{(B_1 + B_3)^2 + (B_2 + B_4)^2} = \sqrt{(2B)^2 + (2B)^2} = 2\sqrt{2}B$



33. (b) Circular coil Square coil



Length $L = 2\pi r$ Length $L = 4a$

Magnetic field at the centre of circular coil

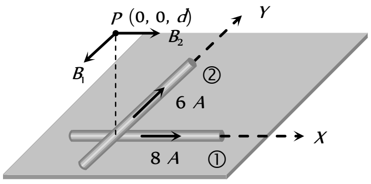
$$B_{circular} = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} = \frac{\mu_0}{4\pi}.\frac{4\pi^2 i}{L}$$

Magnetic field at the centre of square coil

$$B_{square} = \frac{\mu_0}{4\pi}.\frac{8\sqrt{2}\,i}{a} = \frac{\mu_0}{4\pi}.\frac{32\sqrt{2}\,i}{L}$$

Hence $\dfrac{B_{circular}}{B_{square}} = \dfrac{\pi^2}{8\sqrt{2}}$

34. (d) Magnetic field at P due to wire 1, $B_1 = \dfrac{\mu_0}{4\pi}.\dfrac{2(8)}{d}$



and due to wire 2, $B_2 = \dfrac{\mu_0}{4\pi}.\dfrac{2(6)}{d}$

$$\Rightarrow B_{net} = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0}{4\pi}.\frac{16}{d}\right)^2 + \left(\frac{\mu_0}{4\pi}.\frac{12}{d}\right)^2}$$

$$= \frac{\mu_0}{4\pi}\times\frac{2}{d}\times 10 = \frac{5\mu_0}{\pi d}$$

35. (b) According to question resistance of wire ADC is twice that of wire ABC. Hence current flows through ADC is half that of ABC *i.e.* $\dfrac{i_2}{i_1} = \dfrac{1}{2}$. Also $i_1 + i_2 = i \Rightarrow i_1 = \dfrac{2i}{3}$ and $i_2 = \dfrac{i}{3}$

Magnetic field at centre O due to wire AB and BC (part 1 and 2) $B_1 = B_2 = \dfrac{\mu_0}{4\pi}.\dfrac{2i_1 \sin 45^o}{a/2} \otimes = \dfrac{\mu_0}{4\pi}.\dfrac{2\sqrt{2}\,i_1}{a} \otimes$

and magnetic field at centre O due to wires AD and DC (*i.e.* part 3 and 4) $B_3 = B_4 = \dfrac{\mu_0}{4\pi}\dfrac{2\sqrt{2}\,i_2}{a} \odot$

Also $i_1 = 2i_2$. So $(B_1 = B_2) > (B_3 = B_4)$

Hence net magnetic field at centre O

$$B_{net} = (B_1 + B_2) - (B_3 + B_4)$$

$$= 2\times\frac{\mu_0}{4\pi}.\frac{2\sqrt{2}\times\left(\frac{2}{3}i\right)}{a} - \frac{\mu_0}{4\pi}.\frac{2\sqrt{2}\left(\frac{i}{3}\right)\times 2}{a}$$

$$= \frac{\mu_0}{4\pi}.\frac{4\sqrt{2}\,i}{3a}(2-1)\otimes = \frac{\sqrt{2}\,\mu_0 i}{3\pi a}\otimes$$

36. (d) By using $B = \dfrac{\mu_0 i}{2\pi r}\left(\dfrac{r^2 - a^2}{b^2 - a^2}\right)$ here $r = \dfrac{3R}{2}$, $a = R$, $b = 2R$

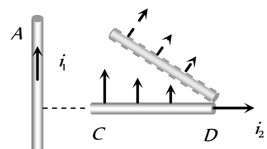
$$\Rightarrow B = \frac{\mu_0 i}{2\pi\left(\frac{3R}{2}\right)}\times\left\{\frac{\left(\frac{3R}{2}\right)^2 - R^2}{(2R^2) - R^2}\right\} = \frac{5.\mu_o i}{36\pi R}.$$

37. (a) Suppose in equilibrium wire PQ lies at a distance r above the wire AB

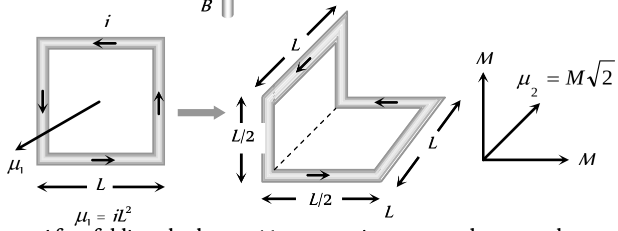
Hence in equilibrium $mg = Bil \Rightarrow mg = \dfrac{\mu_0}{4\pi}\left(\dfrac{2i}{r}\right)\times il$

$$\Rightarrow 10^{-3}\times 10 = 10^{-7}\times\frac{2\times(50)^2}{r}\times 0.5 \Rightarrow r = 25\,mm$$

38. (c) Since the force on the rod CD is non-uniform it will experience force and torque. From the left hand side it can be seen that the force will be upward and torque is clockwise.



39. (c) Initial magnetic moment = $\mu_1 = iL^2$



After folding the loop, M = magnetic moment due to each part

$$= i\left(\frac{L}{2}\right)\times L = \frac{iL^2}{2} = \frac{\mu_1}{2}$$

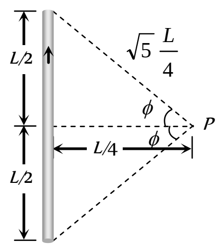
$$\Rightarrow \mu_2 = M\sqrt{2} = \frac{\mu_1}{2}\times\sqrt{2} = \frac{\mu_1}{\sqrt{2}}$$

40. (a) By using $B = \dfrac{\mu_0}{4\pi}.\dfrac{i}{a}(\sin\phi_1 + \sin\phi_2)$

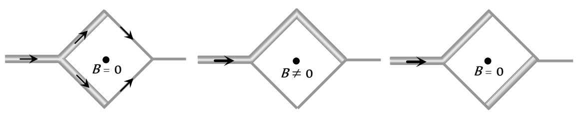
$$\Rightarrow B = \frac{\mu_0}{4\pi}.\frac{i}{(L/4)}(2\sin\phi)$$

Also $\sin\phi = \dfrac{L/2}{\sqrt{5}L/4} = \dfrac{2}{\sqrt{5}}$

$$\Rightarrow B = \frac{4\mu_0 i}{\sqrt{5}\pi L}$$



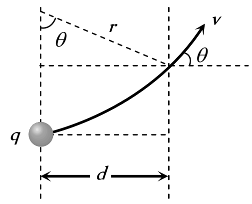
41. (d) In P and R loops, currents are divided in same proportion because the branches have equal resistance. Hence magnetic field produced at centre due to each segment is of equal magnitude but of opposite direction, so net field is zero.



42. (a) From figure it is clear that

$\sin\theta = \dfrac{d}{r}$ also $r = \dfrac{p}{qB}$

$$\therefore \sin\theta = \frac{Bqd}{p}$$

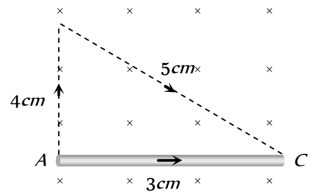


43. (a) $\vec{F}_{CAD} = \vec{F}_{CD} = \vec{F}_{CED}$

$\therefore$ Net force on frame $= 3\vec{F}_{CD} = (3)(2)(1)(4)$ ($F = ilB$)

$= 24\ N$

44. (b) The given curved wire can be treated as a straight wire as shown

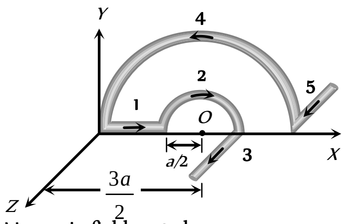


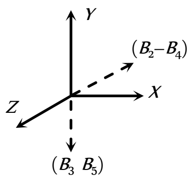
Force acting on the wire AC, $F = Bil = 2 \times 2 \times 3 \times 10^{-2}$

$= 12 \times 10^{-2} N$ along y-axis.

So acceleration of wire $= \dfrac{F}{m} = \dfrac{12 \times 10^{-2}}{10 \times 10^{-3}} = 12\, m/s^2$

45. (b)





Magnetic field at O due to

Part (1) : $B_1 = 0$

Part (2): $B_2 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{\pi i}{(a/2)} \otimes$ (along –Z-axis)

Part (3): $B_3 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{(a/2)} (\downarrow)$ (along – Y-axis)

Part (4): $B_4 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{\pi i}{(3a/2)} \odot$ (along +Z-axis)

Part (5): $B_5 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{(3a/2)} (\downarrow)$ (along – Y-axis)

$B_2 - B_4 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{\pi i}{a}\left(2 - \dfrac{2}{3}\right) = \dfrac{\mu_0 i}{3a} \otimes$ (along – Z-axis)

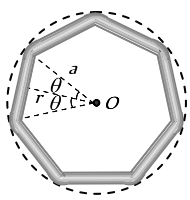
$B_3 + B_5 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{1}{a}\left(2 + \dfrac{2}{3}\right) = \dfrac{8\mu_0 i}{12\pi a} (\downarrow)$ (along – Y-axis)

Hence net magnetic field

$B_{net} = \sqrt{(B_2 - B_4)^2 + (B_3 + B_5)^2} = \dfrac{\mu_0 i}{3\pi a}\sqrt{\pi^2 + 4}$

46. (b) Magnetic field at the centre due to one side

$B_1 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{2i \sin\theta}{r}$ where $r = a\cos\theta$

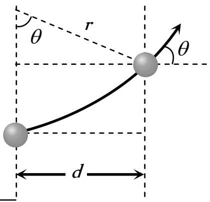


So $B_1 = \dfrac{\mu_0}{4\pi} \cdot \dfrac{2i\sin\theta}{a\cos\theta} = \dfrac{\mu_0 i}{2\pi a}\tan\theta$

Hence net magnetic field

$B_{net} = n \times \dfrac{\mu_0 i}{2\pi a}\tan\dfrac{\pi}{n}$.

47. (b) According to following figure $\sin\theta = \dfrac{d}{r}$



also $r = \dfrac{\sqrt{2mk}}{qB} = \dfrac{1}{B}\sqrt{\dfrac{2mV}{q}}$

$\therefore \sin\theta = Bd\sqrt{\dfrac{q}{2mV}}$

$= 0.51 \times 0.1\sqrt{\dfrac{1.6 \times 10^{-19}}{2 \times 1.67 \times 10^{-27} \times 500 \times 10^3}}$

$= \dfrac{1}{2} \Rightarrow \theta = 30^o$

48. (b) The field at the midpoint of BC due to AB is $\left(-\dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{d/2}\hat{k}\right)$ and the same is due to CD. Therefore the total field is $\left[-\left(\dfrac{\mu_0 i}{\pi d}\right)\hat{k}\right]$

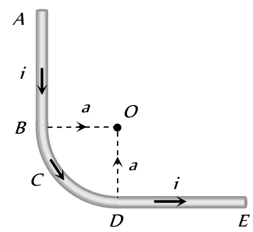
49. (a) The electron reverses it's direction. It can be done by covering semi-circular path in x-z or x-y plane.

50. (d) The field at O due to AB is $\dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{a}\hat{k}$ and that due to DE is

also $\dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{a}\hat{k}$.

However the field due to BCD is $\dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{a}\left(\dfrac{\pi}{2}\right)\hat{k}$.

Thus the total field at O is $\dfrac{\mu_0}{4\pi} \cdot \dfrac{i}{a}\left(2 + \dfrac{\pi}{2}\right)\hat{k}$



51. (d) The energy of a charged particle moving in magnetic field remains constant because the magnetic field does not do any work. Therefore kinetic energy is constant *i.e.* $u = v$.

The force on electron will act along negative y-axis initially. The electron will undergo circular motion in clockwise direction and emerge out the field. So $y < 0$.

Graphical Questions

1. (c) $|\vec{B}| = \dfrac{\mu_0}{4\pi} \cdot \dfrac{2\pi i}{r} \Rightarrow |\vec{B}| \propto \dfrac{1}{r}$

2. (a) Every point on line AB will be equidistant from X and Y-axis. So magnetic field at every point on line AB due to wire 1 along X-axis is equal in magnitude but opposite in direction to the magnetic field due to wire along Y-axis. Hence B_{net} on $AB = 0$

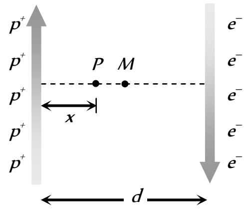
3. (b) If the current flows out of the paper, the magnetic field at points to the right of the wire will be upwards and to the left will be downward. Now magnetic field at *C*, is zero. The field in the region BX' will be upwards (+*ve*) because all points lying in this region are to the right of both the wires. Similarly, magnetic field in the region *AX* will be downwards (– *ve*). The field in the region *AC* will be upwards (+*ve*) because points are closer to *A* compared to *B*. Similarly magnetic field in region *BC* will be downward (–*ve*). Graph *(b)* satisfies all these conditions.

4. (a) Magnetic field inside the conductor $B_{in} \propto r$ and magnetic field outside the conductor $B_{out} \propto \frac{1}{r}$

(where *r* is the distance of observation point from axis)

5. (c) The magnetic field at points to the right of the proton beam acts perpendicular to the paper inwards (×). The magnetic field at points to the left of the electron beam acts perpendicular to the paper outwards (·).

Magnetic field at mid point *M* is zero.



Magnetic field at the points closer to proton beam acts perpendicular to the paper inwards (*i.e.* (×)) and at the points closer to electron beam it acts outwards *i.e.* (·). In the given options graph *(c)* satisfies all the conditions.

6. (a) Magnetic field inside the hollow metallic cylinder $B_{in} = 0$, and magnetic field outside it $B_{out} \propto \frac{1}{r}$

7. (a) Magnetic field in the middle of the solenoid's is maximum, magnetic field at the and $B_{end} = \frac{1}{2}B_{...}$.

8. (b) The charge will not experience any force if $|\vec{F_e}| = |\vec{F_m}|$. This condition is satisfied in option (*b*) only.

9. (c) The given portion of the curved wire may be treated as a straight wire of length $2L$ which experiences a magnetic force $F_m = Bi(2L)$

10. (a) $\tau = NBiA\sin\theta$ so the graph between τ and θ is a sinusoidal graph.

11. (c) For undeviated motion $|\vec{F_e}| = |\vec{F_m}|$, which happened when $\vec{v}, \vec{E}$ and $\vec{B}$ are mutually perpendicular to each other.

12. (a) If at a place, magnetic induction is *B*, then energy density will be equal to $U = \frac{B^2}{2\mu_0}$. It means, graph between *U* and *B* will be a parabola passing through origin and symmetric about *U*-axis.

13. (b, c) Since length of the wire is equal to *l*, therefore, $2\pi Rn = l$ or $n = \frac{l}{2\pi R}$.

Magnetic induction at centre of a circular coil is given by $B = \frac{\mu_0}{4\pi}.\frac{2\pi n i}{R} = \frac{\mu_0 l\, i}{4\pi R^2} \Rightarrow B \propto \frac{1}{R^2}$

It means, when $R \to 0, B \to \infty$ and $R \to \infty, B \to 0$,

Hence (b) is correct and (d) is wrong.

Substituting $R = \frac{l}{2\pi n}$ in $B = \frac{\mu_0}{4\pi}.\frac{2\pi n i}{R}$

$B \propto n^2$. It means graph between *B* and *n* will be a parabola having increasing slope and passing through origin. Hence (c) is correct and (a) is wrong.

14. (b) When a current flows through cylindrical shell, then according to Ampere circuital law, magnetic induction inside it will be equal to zero. Hence energy density at $r < R$ is equal to zero.

Therefore, (a), (c) and (d) are wrong.

When $r > R$, $B = \frac{\mu_0 i}{2\pi r}$.

Since $U = \frac{B^2}{2\mu_0}$, therefore, outside the shell, $U = \frac{\mu_0 i^2}{8\pi^2 r^2}$. It means, just outside the shell, $U = \frac{\mu_0 i^2}{8\pi^2 R^2}$ and when $r \to \infty, U \to 0$.

Hence (b) is correct.

15. (b) Energy density in previous objective, at $r = 2R$, will be equal to $U = \frac{\mu_0 i^2}{32\pi^2 R^2}$ or $U \propto i^2$. It means, graph-between *U* and *i* will be a parabola, passing through origin, symmetric about *U*-axis and having increasing slope. Hence (b) is correct.

16. (b) Direction of magnetic field at every point on axis of a current carrying coil remains same though magnitude varies. Hence magnetic induction for whole the *x*-axis will remain positive.

Therefore, (c) and (d) are wrong.

Magnitude of magnetic field will very with *x* according to law, $B = \frac{\mu_0 NIR^2}{2(R^2 + x^2)^{3/2}}$.

Hence, at $x = 0$, $B = \frac{\mu_0 NI}{2R}$ and when $x \to \infty$, $B \to 0$.

Slope of the graph will be $\frac{dB}{dx} = -\frac{3\mu_0 NIR^2 .x}{2(R^2 + x^2)^{5/2}}$.

It means, at $x = 0$, slope is equal to zero or tangent to the graph at $x = 0$, must be parallel to x-axis.

Hence (b) is correct and (a) is wrong.

Assertion and Reason

1. (a) Cyclotron is suitable for accelerating heavy particles like protons, α-particles *etc*, and not for electrons because of low mass. Because electrons acquire very high velocities very near to velocity of light and appreciable variation in their mass, occurs.

2. (c) Cyclotron is utilised to accelerate the positive ion. And cyclotron frequency is given by $\nu = \frac{Be}{2\pi m}$. It means cyclotron frequency doesn't depends upon velocity. Therefore, assertion is true and reason false.

3. (a) A moving charge experiences a force in magnetic field. It is because of interaction of two magnetic fields, one which is produced due to the motion of charge and other in which charge is moving.

4. (e) In this case we can not be sure about the absence of the magnetic field because if the electron moving parallel to the direction of magnetic field, the angle between velocity and applied magnetic field is zero ($F = 0$). Then also electron passes without deflection. Also $F = evB\sin\theta \Rightarrow F \propto B$.

5. (a) In the absence of the electric current, the free electrons in a conductor are in a state of random motion, like molecules in a gas. Their average velocity is zero. *i.e.* they do not have any net velocity in a direction. As a result, there is no net magnetic force on the free electrons in the magnetic field. On passing the current, the free electrons acquire drift velocity in a definite direction, hence magnetic force acts on them, unless the field has no perpendicular component.

6. (c) Time taken is independent of velocity and radius of path. However, maximum velocity will be given by $v_{max} = \frac{qBR}{m}$ where R is radius of Dee's.

7. (a) Due to metallic frame the deflection is only due to current in a coil and magnetic field, not due to vibration in the strings. If string start oscillating, presence of metallic frame in the field make these oscillations damped.

8. (c) The direction of magnetic field due to current carrying conductor can be found by applying right hand thumb rule or right hand palm rule. When electric current is passed through a circular conductor, the magnetic field lines near the center of the conductor are almost straight lines. Magnetic flux direction is determined only by the direction of current.

9. (a) The force on a charged particle moving in a uniform magnetic field always acts in direction perpendicular to the direction of motion of the charge. As work done by magnetic field on the charge is zero, [$W = FS\cos\theta$], so the energy of the charged particle does not change.

10. (b) We know that the direction of the earth's magnetic field is toward north and the velocity of electron is vertically downward. Applying Fleming's left hand rule, the direction of force is towards west. Therefore, an electron coming from outer space will be deflected toward west.

11. (d) In the case of metallic rod, the charge carriers flow through whole of the cross section. Therefore, the magnetic field exists both inside as well as outside. However magnetic field inside the rod will go on decreasing as we go towards the axis.

12. (e) The force experienced by a charge particle in a magnetic field is given by, $\vec{F} = q(\vec{v} \times \vec{B})$ which is independent of mass. As q, v and B are same for both the electron and proton, hence both will experience same force.

13. (b) The torque on the coil in a magnetic field is given by $\tau = nIBA\cos\theta$

    For radial field, the coil is set with its plane parallel to the direction of the magnetic field B, then $\theta = 0^\circ$ and $\cos\theta = 1 \Rightarrow$ Torque $= nIBA$ (1) $= nIBA$ (maximum).

14. (b) The winding of helix carry currents in the same direction therefore they experience an attractive force pulling the lower end out of mercury. As a result of this, the circuit breaks, current becomes zero and hence the force of attraction vanishes. Therefore helix comes back to its final position, completing the circuit again. In this way, the process is repeated and helix executes oscillatory motion.

15. (b) For a solenoid $B_{end} = \frac{1}{2}(B_{in})$. Also for a long solenoid, magnetic field is uniform within it but this reason is not explaining the assertion.

16. (d) When a charged particle is moving on a circular path in a magnetic field, the magnitude of velocity does not change but direction of velocity is changing every moment. Hence velocity is changing, so momentum $(m\vec{v})$ is also changing.

17. (b) Time period, $T = \frac{2\pi m}{Bq}$ as $\left(\frac{m}{q}\right)_\alpha = 2\left(\frac{m}{q}\right)_p \Rightarrow T_\alpha = 2T_p$

    Also $T \propto m$, but then $T_\alpha = 4T_p$ which is not the case.

18. (d) When two long parallel wires, are connected to a battery in series. They carry currents in opposite directions, hence they repel each other.

19. (a) Here, both Assertion and Reason are correct and reason is the correct explanation of assertion.

Magnetic Effect of Current

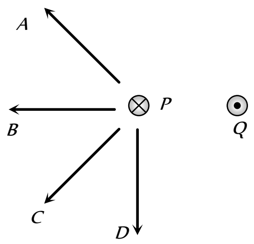
SET Self Evaluation Test -21

1. In the hydrogen atom, the electron is making 6.6×10^{15} $r.p.s.$ If the radius of the orbit is 0.53×10^{-10} *metre*, then magnetic field produced at the centre of the orbit is
   (a) 140 *Tesla* (b) 12.5 *Tesla*
   (c) 1.4 *Tesla* (d) 0.14 *Tesla*

2. A coil carrying a heavy current and having large number of turns mounted in a *N-S* vertical plane and a current flows in clockwise direction. A small magnetic needle at its cente will have its north pole in
   (a) East-north direction (b) West-north direction
   (c) East-south direction (d) West-south direction

3. A charged particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to
   (a) The velocity (b) The momentum
   (c) The kinetic energy (d) None of these

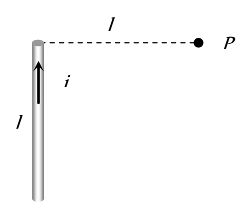
4. In figure shows three long straight wires *P*, *Q* and *R* carrying currents normal to the plane of the paper. All three currents have the same magnitude. Which arrow best shows the direction of the resultant force on the wire *P*



   (a) *A* (b) *B*
   (c) *C* (d) *D*

5. A moving coil galvanometer has 48 turns and area of coil is $4 \times 10^{-2} m^2$. If the magnetic field is 0.2 *T*, then to increase the current sensitivity by 25% without changing area (A) and field (B) the number of turns should become
   (a) 24 (b) 36
   (c) 60 (d) 54

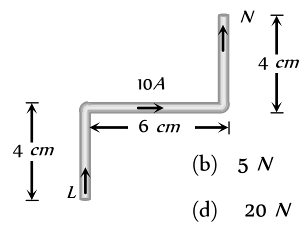
6. Figure shows a straight wire of length *l* current *i*. The magnitude of magnetic field produced by the current at point *P* is



   (a) $\frac{\sqrt{2}\mu_0 i}{\pi l}$
   (b) $\frac{\mu_0 i}{4\pi l}$
   (c) $\frac{\sqrt{2}\mu_0 i}{8\pi l}$
   (d) $\frac{\mu_0 i}{2\sqrt{2}\pi l}$

7. A winding wire which is used to frame a solenoid can bear a maximum 10 *A* current. If length of solenoid is 80*cm* and it's cross sectional radius is 3 *cm* then required length of winding wire is $(B = 0.2\,T)$
   (a) $1.2 \times 10^2\ m$ (b) $4.8 \times 10^2\ m$
   (c) $2.4 \times 10^3\ m$ (d) $6 \times 10^3\ m$

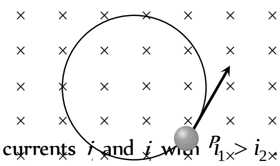
8. A current carrying wire *LN* is bent in the from shown below. If wire carries a current of 10 *A* and it is placed in a magnetic field of 5 *T* which acts perpendicular to the paper outwards then it will experience a force



   (a) Zero (b) 5 *N*
   (c) 30 *N* (d) 20 *N*

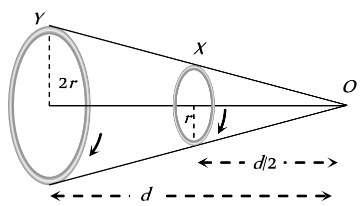
9. A wire of length *L* is bent in the form of a circular coil and current *i* is passed through it. If this coil is placed in a magnetic field then the torque acting on the coil will be maximum when the number of turns is
   (a) As large as possible (b) Any number
   (c) 2 (d) 1

10. A particle having a charge of $10.0\,\mu C$ and mass $1\,\mu g$ moves in a circle of radius 10 cm under the influence of a magnetic field of induction $0.1T$. When the particle is at a point P, a uniform electric field is switched on so that the particle starts moving along the tangent with a uniform velocity. The electric field is
   (a) 0.1 *V/m*
   (b) 1.0 *V/m*
   (c) 10.0 *V/m*
   (d) 100 *V/m*



11. Two parallel long wires carry currents i_1 and i_2 with $i_1 > i_2$. When the currents are in the same direction, the magnetic field midway between the wires is 10 μT. When the direction of i_2 is reversed, it becomes 40 μT. the ratio i_1 / i_2 is
   (a) 3 : 4 (b) 11 : 7
   (c) 7 : 11 (d) 5 : 3

12. Two circular coils *X* and *Y*, having equal number of turns, carry equal currents in the same sense and subtend same solid angle at point *O*. If the smaller coil, *X* is midway between *O* and *Y*, then if we represent the magnetic induction due to bigger coil *Y* at *O* as B_Y and that due to smaller coil *X* at *O* as B_X, then
   (a) $\frac{B_Y}{B_X} = 1$
   (b) $\frac{B_Y}{B_X} = 2$
   (c) $\frac{B_Y}{B_X} = \frac{1}{2}$



(d) $\frac{B_Y}{B_X} = \frac{1}{4}$

13. A fixed horizontal wire carries a current of 200 *A*. Another wire having a mass per unit length $10^{-2} kg/m$ is placed below the first wire at a distance of 2 *cm* and parallel to it. How much current must be passed through the second wire if it floats in air without any support? What should be the direction of current in it

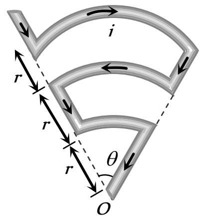
(a) 25A (direction of current is same to first wire)

(b) 25A (direction of current is opposite to first wire)

(c) 49 A (direction of current is same to first wire)

(d) 49 A (direction of current is opposite to first wire)

14. Find magnetic field at *O*



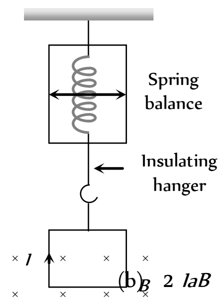
(a) $\frac{5\mu_0 i\theta}{24\pi r}$

(b) $\frac{\mu_0 i\theta}{24\pi r}$

(c) $\frac{11\mu_0 i\theta}{24\pi r}$

(d) Zero

15. A square loop of side a hangs from an insulating hanger of spring balance. The magnetic field of strength *B* occurs only at the lower edge. It carries a current *I*. Find the change in the reading of the spring balance if the direction of current is reversed



(a) *IaB*

(b) 2 *IaB*

(c) $\frac{IaB}{2}$

(d) $\frac{3}{2} IaB$

16. A charge of $2.0\,\mu C$ moves with a speed of $3.0\times10^{6} ms^{-1}$ along + *ve X*-axis A magnetic field of strength $\vec{B} = -0.2\,\hat{k}$ *Tesla* exists in space. What is the magnetic force $(\vec{F}_m)$ on the charge

(a) $F_m = 1.2\,N$ along + *ve x* – direction

(b) $F_m = 1.2\,N$ along – *ve x* – direction

(c) $F_m = 1.2\,N$ along + *ve y* – direction

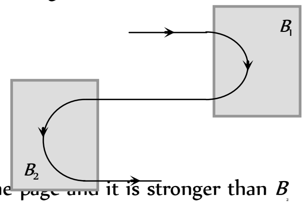
(d) $F_m = 1.2\,N$ along – *ve y* – direction

17. Five very long, straight wires are bound together to form a small cable. Currents carried by the wires are $I_1 = 20A$, $I_2 = -6A$, $I_3 = 12A, I_4 = -7A, I_5 = 18A$. The magnetic induction at a distance of 10 *cm* from the cable is

(a) 34 μT (b) 74 *mT*

(c) 34 *mT* (d) 74 μT

18. Following figure shows the path of an electron that passes through two regions containing uniform magnetic fields of magnitudes B_1 and B_2. It's path in each region is a half circle, choose the correct option



(a) B_1 is into the page and it is stronger than B_2

(b) B_1 is in to the page and it is weaker than B_2

(c) B_1 is out of the page and it is weaker than B_2

(d) B_1 is out of the page and it is stronger than B_2

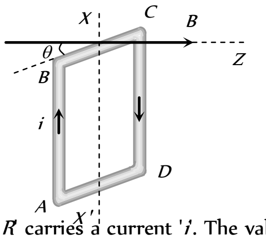
19. The square loop *ABCD*, carrying a current *i*, is placed in uniform magnetic field *B*, as shown. The loop can rotate about the axis *XX'*. The plane of the loop makes and angle θ (θ < 90°) with the direction of *B*. Through what angle will the loop rotate by itself before the torque on it becomes zero

(a) θ

(b) 90°– θ

(c) 90° + θ

(d) 180°– θ



20. A cylindrical conductor of radius '*R*' carries a current '*i*'. The value of magnetic field at a point which is *R*/4 distance inside from the surface is 10 *T*. Find the value of magnetic field at point which is 4*R* distance outside from the surface

(a) $\frac{4}{3}T$ (b) $\frac{8}{3}T$

(c) $\frac{40}{3}T$ (d) $\frac{80}{3}T$

21. Three long straight wires are connected parallel to each other across a battery of negligible internal resistance. The ratio of their resistances are 3 : 4 : 5. What is the ratio of distances of middle wire from the others if the net force experienced by it is zero

(a) 4 : 3 (b) 3 : 1

(c) 5 : 3 (d) 2 : 3

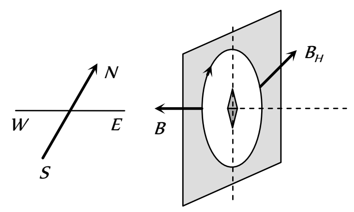
Answers and Solutions

(SET -21)

1. (b) $i = q\nu$

$$B = \frac{\mu_0 i}{2r} = \frac{\mu_0 q\nu}{2r} = \frac{4\pi\times10^{-7}\times1.6\times10^{-19}\times6.6\times10^{15}}{2\times0.53\times10^{-10}}$$

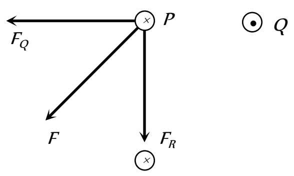
$$= \frac{2\pi\times1.6\times6.6}{5.3} = 12.518 \text{ Tesla}$$



2. (b)

3. (c) $r = \frac{\sqrt{2mK}}{qB}$ and $A = \pi r^2 \Rightarrow A = \frac{\pi(2mK)}{q^2B^2} \Rightarrow A \propto K.$

4. (c) The forces F_Q and F_R are the forces applies by wires Q and R respectively on the wire P as shown in figure. Their resultant force F is best shown by C.



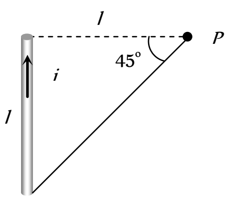
5. (c) As we know

Current sensitivity $S_i = \frac{NBA}{C}$

$\Rightarrow S_i \propto N \Rightarrow \frac{(S_i)_1}{(S_i)_2} = \frac{N_1}{N_2} \Rightarrow \frac{100}{125} = \frac{48}{N_2} \Rightarrow N_2 = 60$.

6. (c) The given situation can be redrawn as follow.

As we know the general formula for finding the magnetic field due to a finite length wire



$B = \frac{\mu_0}{4\pi}.\frac{i}{r}(\sin\phi_1 + \sin\phi_2)$

Here $\phi_1 = 0^o, \phi = 45^o$

$\therefore B = \frac{\mu_0}{4\pi}.\frac{i}{r}(\sin 0^o + \sin 45^o) = \frac{\mu_0}{4\pi}.\frac{i}{\sqrt{2}l} \Rightarrow B = \frac{\sqrt{2}\mu_0 i}{8\pi l}$

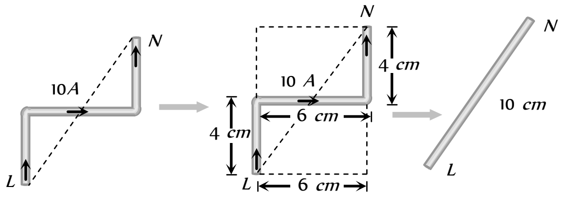
7. (c) $B = \frac{\mu_0 Ni}{l}$ where N = Total number of turns, l = length of the solenoid

$\Rightarrow 0.2 = \frac{4\pi \times 10^{-7} \times N \times 10}{0.8} \Rightarrow N = \frac{4 \times 10^4}{\pi}$

Since N turns are made from the winding wire so length of the wire $(L) = 2\pi r \times N$ [$2\pi r$ = length of each turns]

$\Rightarrow L = 2\pi \times 3 \times 10^{-2} \times \frac{4 \times 10^4}{\pi} = 2.4 \times 10^3 m$

8. (b) The given wire can be replaced by a straight wire as shown below



Hence force experienced by the wire

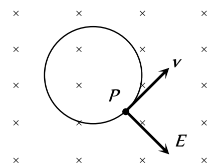
$F = Bil = 5 \times 10 \times 0.1 = 5N$

9. (d) $\tau_{max} = MB$ or $\tau_{max} = ni\pi r^2 B$. Let number of turns in length l is n so $l = n(2\pi r)$ or $\alpha = \frac{l}{2\pi n}$

$\Rightarrow \tau_{max} = \frac{ni\pi Bl^2}{4\pi^2 n^2} = \frac{l^2 iB}{4\pi n_{min}} \Rightarrow \tau_{max} \propto \frac{1}{n_{min}} \Rightarrow n_{min} = 1$

10. (c) When the particle moves along a circle in the magnetic field B, the magnetic force is radially inward. If an electric field of proper magnitude is switched on which is directed radially outwards, the particle may experience no force. It will then move along a straight line with uniform velocity. This will be the case when $qE = qvB \Rightarrow E = vB$

also $r = \frac{mv}{qB} \Rightarrow v = \frac{qBr}{m}$

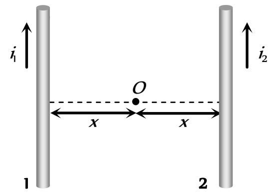


So $E = \frac{qB^2r}{m}$

$= \frac{(10 \times 10^{-6}) \times (0.1)^2 \times 10 \times 10^{-2}}{1 \times 10^{-3} \times 10^{-6}} = 10\ V/m$

11. (d) Initially when wires carry currents in the same direction as shown.

Magnetic field at mid point O due to wires 1 and 2 are respectively



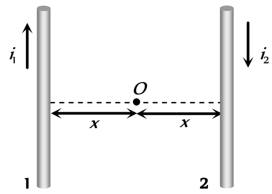
$B_1 = \frac{\mu_0}{4\pi}.\frac{2i_1}{x} \otimes$

and $B_2 = \frac{\mu_0}{4\pi}.\frac{2i_2}{x} \odot$

Hence net magnetic field at O $B_{net} = \frac{\mu_0}{4\pi} \times \frac{2}{x} \times (i_1 - i_2)$

$\Rightarrow 10 \times 10^{-6} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 - i_2)$ ..... (i)

If the direction of i is reversed then



$B_1 = \frac{\mu_0}{4\pi}.\frac{2i_1}{x} \otimes$

and $B_2 = \frac{\mu_0}{4\pi}.\frac{2i_2}{x} \otimes$

So $B_{net} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 + i_2)$

$\Rightarrow 40 \times 10^{-6} = \frac{\mu_0}{4\pi}.\frac{2}{x}(i_1 + i_2)$ ..... (ii)

Dividing equation (ii) by (i) $\frac{i_1 + i_2}{i_1 - i_2} = \frac{4}{1} \Rightarrow \frac{i_1}{i_2} = \frac{5}{3}$

12. (c) Magnetic field at O due to bigger coil Y, is

$B_Y = \frac{\mu_0}{4\pi}.\frac{2\pi i(2r)^2}{\{d^2 + (2r)^2\}^{3/2}} = \frac{\mu_0}{4\pi}.\frac{8\pi ir^2}{(d^2 + 4r^2)^{3/2}}$

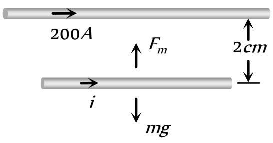
Magnetic field at O due to smaller coil X is

$B_X = \frac{\mu_0}{4\pi}.\frac{2\pi ir^2}{\left\{\left(\frac{d}{2}\right)^2 + r^2\right\}^{3/2}} = \frac{\mu_0}{4\pi}.\frac{16\pi ir^2}{(d^2 + 4r^2)^{3/2}}$

$\Rightarrow \frac{B_Y}{B_X} = \frac{1}{2}$

13. (c) For floating the second wire

$\begin{vmatrix}\text{Down ward weight} \\ \text{of second wire}\end{vmatrix} = \begin{vmatrix}\text{Magnetic force} \\ \text{on it}\end{vmatrix}$



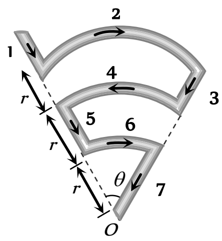
$\Rightarrow mg = \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{a} \times l$

$\Rightarrow \left(\frac{m}{l}\right)g = \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{a}$

$\Rightarrow 10^{-2} \times 9.8 = 10^{-7} \times \frac{2 \times 200 \times i}{2 \times 10^{-2}} \Rightarrow i = 49A$

(Direction of current is same to first wire)

14. (a) $B_1 = B_3 = B_5 = 0$



$B_2 = \frac{\mu_0}{4\pi}.\frac{\theta i}{3r} \otimes,\ B_4 = \frac{\mu_0}{4\pi}.\frac{\theta i}{2r} \odot$

and $B_6 = \frac{\mu_0}{4\pi}.\frac{\theta i}{r} \otimes$

$\therefore$ Net magnetic field at O,

$B_{net} = B_2 - B_4 + B_6 = \frac{\mu_0}{4\pi}.\frac{\theta i}{r}\left(\frac{1}{3} - \frac{1}{2} + 1\right) = \frac{5\mu_0 \theta i}{24\pi r}$

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15. (b) Initially $F_1 = mg + IaB$ (down wards)

when the direction of current is reversed

$F_2 = mg - IaB$ (down wards) $\Rightarrow \Delta F = 2IaB$

16. (c) By using $\vec{F}_m = q(\vec{v} \times \vec{B})$

$\Rightarrow \vec{F}_m = 2 \times 10^{-6}\{3 \times 10^6 \hat{i} \times (-0.2)\hat{k}\} = -1.2(\hat{i} \times \hat{k}) = +1.2\hat{j}$

i.e., 1.2 N in positive y direction.

17. (d) $i_{net} = 20 - 6 + 12 - 7 + 18 = 37A$ so $B = \frac{\mu_0}{4\pi}.\frac{2i}{a}$

$= 10^{-7} \times \frac{2 \times 37}{10 \times 10^{-2}} = 74 \times 10^{-6} T = 74 \mu T$

18. (a) Direction of field can be find using Fleming left hand rule and $r \propto \frac{1}{B}$.

19. (c) In the position shown, AB is outside and CD is inside the plane of the paper. The Ampere force on AB acts into the paper. The torque on the loop will be clockwise, as seen from above. The loop must rotate through an angle $(90^o + \theta)$ before the plane of the loop becomes normal to the direction of the direction of B and the torque becomes zero.

20. (b) Magnetic field inside the cylindrical conductor

$B_{in} = \frac{\mu_0}{4\pi}.\frac{2ir}{R^2}$ (R=Radius of cylinder, r = distance of observation point from axis of cylinder)

Magnetic field out side the cylinder at a distance r' from it's axis $B_{out} = \frac{\mu_0}{4\pi}.\frac{2i}{r'}$

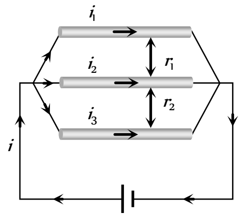
$\Rightarrow \frac{B_{in}}{B_{out}} = \frac{rr'}{R^2} \Rightarrow \frac{10}{B_{out}} = \frac{\left(R - \frac{R}{4}\right)(R + 4R)}{R^2} \Rightarrow B_{out} = \frac{8}{3}T$

21. (c) The wires are in parallel and ratio of their resistances are 3 : 4 : 5, Hence currents in wires are in the ratio $\frac{1}{3} : \frac{1}{4} : \frac{1}{5}$

$i_1 = \frac{k}{3}$

$i_2 = \frac{k}{4}$

$i_3 = \frac{k}{5}$



Force between top and middle wire $F_1 = \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{r_1}$

$= \frac{\mu_0}{4\pi} \times \frac{2\left(\frac{1}{3}\right)\left(\frac{1}{4}\right)k^2}{r_1}$. Force between bottom and middle wire $F_2 = \frac{\mu_0}{4\pi} \frac{\left(\frac{1}{4}\right)\left(\frac{1}{5}\right)k^2}{r_2}$. As the forces are equal and opposite so $F_1 = F_2 \Rightarrow \frac{r_1}{r_2} = \frac{5}{3}$.