**Moving Charges And Magnetism**

We can define a magnetic field **B** at some point in space in terms of the magnetic force F*B* that the field exerts on a test object, for which we use a charged particle moving with a velocity **v**.

The **Magnetic Field** is given by the expression **F*B* =** *q* **v x B**

* The magnitude *FB* of the magnetic force exerted on the particle is proportional to the charge *q* and to the speed *v* of the particle.

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***Quiz :*** What is the maximum work that a constant magnetic field **B** can perform on a charge q moving through the field with velocity **v**?

**Solution :** Zero. Because the magnetic force exerted by the field on the charge is always perpendicular to the velocity of the charge, the field can never do any work on the charge: *W* = F*B* . *d*s = (F*B* .v)*dt =* 0.Work requires a

component of force along the direction of motion.

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There are several important differences between electric and magnetic forces:

• The electric force acts in the direction of the electric field, whereas the magnetic force acts perpendicular to the magnetic field.

• The electric force acts on a charged particle regardless of whether the particle is moving, whereas the magnetic force acts on a charged particle only when the particle is in motion.

• The electric force does work in displacing a charged particle, whereas the magnetic force associated with a steady magnetic field does no work when a particle is displaced.

From the last statement and on the basis of the work–kinetic energy theorem,we conclude that the kinetic energy of a charged particle moving through a magnetic field cannot be altered by the magnetic field alone. In other words,

**“when a charged particle moves with a velocity v through a magnetic field, the field can alter the direction of the velocity vector but cannot change the speed or kinetic energy of the particle.”**

SI unit of magnetic field is the newton per coulomb-meter per second, which is called the **tesla** (T):

Because a coulomb per second is defined to be an ampere, we see that A non-SI magnetic-field unit in common use, called the ***gauss***(G), is related to the tesla through the conversion 1 T = 104 G

***Quiz :***The north-pole end of a bar magnet is held near a positively charged piece of plastic. Is the plastic attracted, repelled, or unaffected by the magnet?

**Solution :** Unaffected. The magnetic force exerted by a magnetic field on a charge is proportional to the charge’s velocity relative to the field. If the charge is stationary, as in this situation, there is no magnetic force

**Lorentz Force**

Let us suppose that there is a point charge *q* (moving with a velocity **v** and, located at **r** at a given time *t* ) in presence of both the electric field **E (r)** and the magnetic field **B (r).** The force on an electric charge *q* due to both of them can be written as

**F** = *q* [ **E** (r) + **v** × **B** (r)] ≡ Felectric +Fmagnetic

This force was given first by H.A. Lorentz based on the extensive experiments of Ampere and others. It is called the *Lorentz force*.

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**Magnetic Force Acting On A Current-Carrying Conductor F*B* = (*I* Lx B)**

Now let us consider a curved wire carries a current *I* and is located in a uniform magnetic field **B**,. Because the field is uniform,

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**Torque On A Current Loop In A Uniform Magnetic Field** **τ =** I **A** x **B**

A convenient expression for the torque exerted on a loop placed in a uniform

magnetic field **B** is

**τ =** *I* **A x B (29.9)**

where **A**, the vector shown in Figure 29.13, is perpendicular to the plane of the loop and has a magnitude equal to the area of the loop. We determine the direction of **A** using the right-hand rule described in Figure 29.14. When you curl the fingers of your right hand in the direction of the current in the loop, your thumb points in the direction of **A**. The product *I***A** is defined to be the **magnetic dipole moment** **μ** (often simply called the “magnetic moment”) of the loop:

**μ =** *I* **A (29.10)**

The SI unit of magnetic dipole moment is ampere–meter2 (A-m2).

Using this definition, we can express the torque exerted on a current-carrying loop in a magnetic field **B** as

**τ = μ x B (29.11)**

In electrostatics, we found that the potential energy of an electric dipole in an electric field is given by *U* = -**p.E**. This energy depends on the orientation of the dipole in the electric field.

Likewise, the potential energy of a magnetic dipole in a magnetic field depends on the orientation of the dipole in the magnetic field and is given by

***U* = - μ .B (29.12)**

From this expression, we see that a magnetic dipole has its lowest energy ***Umin* = - μB** when **μ** points in the same direction as **B**. The dipole has its highest energy ***Umax* = μB** when **μ** points in the direction opposite **B .**

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**Motion Of A Charged Particle In A Uniform Magnetic Field**

Let us now consider the special case of a positively charged particle moving in a uniform magnetic field with the initial velocity vector of the particle perpendicular to the field. Let us assume that the direction of the magnetic field is into the page. Figure 29.17 shows that the particle moves in a circle in a plane perpendicular to the magnetic field.



The particle moves in this way because the magnetic force **F*B***is at right angles to **v** and **B** and has a constant magnitude *qvB.* As the force deflects the particle,the directions of **v** and **F*B***change continuously, as Figure 29.17 shows.

Because **F*B*** always points toward the center of the circle, **it changes only the direction of v and not its magnitude**. As Figure 29.17 illustrates, the rotation is counterclockwise for a positive charge. If *q* were negative, the rotation would be clockwise.

We can equate this magnetic force to the radial force required to keep the charge moving in a circle:

****

**(29.13)**

That is, the radius of the path is proportional to the linear momentum ***mv***of the particle and inversely proportional to the magnitude of the charge on the particle and to the magnitude of the magnetic field.



The angular speed of the particle is

*w* ***=*** *v/r = qB/m* (29.14)

The period of the motion (the time that the particle takes to complete one revolution) is equal to the circumference of the circle divided by the linear speed of the particle:

**T =** 2π r / *v* = 2π/ *w* = 2π m/ *qB* (29.15)

These results show that the angular speed of the particle and the period of the circular motion do not depend on the linear speed of the particle or on the radius of the orbit. The angular speed *w* is often referred to as the cyclotron frequency because charged particles circulate at this angular speed in the type of accelerator called a *cyclotron.*

If a charged particle moves in a uniform magnetic field with its velocity at some arbitrary angle with respect to **B**, its path is a helix. For example, if the field is directed in the *x* direction, as shown in Figure 29.18, there is no component of force in the *x* direction. As a result, *ax* = 0, and the *x* component of velocity remains constant.

However, the magnetic force *q* **v** x **B** causes the components *vy* and *vz* to change in time, and the resulting motion is a helix whose axis is parallel to the magnetic field. The projection of the path onto the *yz* plane (viewed along

the *x* axis) is a circle. (The projections of the path onto the *xy* and *xz* planes are sinusoids!)

Equations 29.13 to 29.15 still apply provided that *v* is replaced by

**A Proton Moving Perpendicular to a Uniform Magnetic Field**

A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35-T magnetic field perpendicular to the velocity of the proton. Find the linear speed of the proton.

**Solution** From Equation 29.13, we have



***Exercise*** If an electron moves in a direction perpendicular to the same magnetic field with this same linear speed, what is the radius of its circular orbit?

***Answer :*** 7.6 x 10-5 m.

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**Bending an Electron Beam**

In an experiment designed to measure the magnitude of a uniform magnetic field, electrons are accelerated from rest through a potential difference of 350 V. The electrons travel along a curved path because of the magnetic force exerted on them, and the radius of the path is measured to be 7.5 cm. If the magnetic field is perpendicular to the beam,

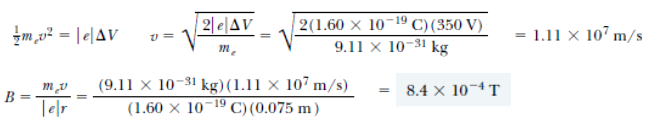
(a) what is the magnitude of the field?

(b) What is the angular speed of the electrons?

**Solution** First we must calculate the speed of the electrons. We can use the fact that the increase in their kinetic energy must equal the decrease in their potential energy = q ∆V(because of conservation of energy). Then we can use

Equation 29.13 to find the magnitude of the magnetic field.

Because Ki = 0 and Kf = ½ mv2 we have ½ mv2 = q ∆V

**



(b) What is the angular speed of the electrons?

**Solution** Using Equation 29.14, we find that

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***Exercise*** What is the period of revolution of the electrons?

***Answer*** 43 ns.

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**Motion Of A Charged Particle In A Non -Uniform Magnetic Field**

When charged particles move in a nonuniform magnetic field, the motion is complex. For example, in a magnetic field that is strong at the ends and weak in the middle, such as that shown in Figure 29.20, the particles can oscillate back and forth between the end points. A charged particle starting at one end spirals along the field lines until it reaches the other end, where it reverses its path and spirals back. This configuration is known as a *magnetic bottle* because charged particles can be trapped within it. The magnetic bottle has been used to confine a *plasma,* a gas consisting of ions and electrons. Such a plasma-confinement scheme could fulfil a crucial role in the control of nuclear fusion, a process that could supply us with an almost endless source of energy.

Unfortunately, the magnetic bottle has its problems. If a large number of particles are trapped, collisions between them cause the particles to eventually leak from the system.

The Van Allen radiation belts consist of charged particles (mostly electrons and protons) surrounding the Earth in doughnut-shaped regions (Fig. 29.21).

The particles, trapped by the Earth’s nonuniform magnetic field, spiral around the field lines from pole to pole, covering the distance in just a few seconds. These particles originate mainly from the Sun, but some come from stars and other heavenly objects. For this reason, the particles are called *cosmic rays.* Most cosmic rays are deflected by the Earth’s magnetic field and never reach the atmosphere. However, some of the particles become trapped; it is these particles that make up the Van Allen belts. When the particles are located over the poles, they sometimes collide with atoms in the atmosphere, causing the atoms to emit visible light. Such collisions are the origin of the beautiful Aurora Borealis, or Northern Lights, in the northern hemisphere and the Aurora Australis in the southern hemisphere.

**Applications Involving Charged Particles Moving In A Magnetic Field**

A charge moving with a velocity **v** in the presence of both an electric field **E** and a magnetic field **B** experiences both an electric force *q***E** and a magnetic force *q* **v** x **B**.

The total force (called the Lorentz force) acting on the charge is

ΣF = *q***E** + *q***v** x **B** (29.16)

**Velocity Selector**

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In many experiments involving moving charged particles, it is important that the particles all move with essentially the same velocity. This can be achieved by applying a combination of an electric field and a magnetic field oriented as shown in Figure 29.22.

A uniform electric field is directed vertically downward (in the plane of the page in Fig. 29.22a), and a uniform magnetic field is applied in the direction

perpendicular to the electric field (into the page).

For *q* positive, the magnetic force *q***v** x **B** is upward and the electric force *q***E** is downward.

When the magnitudes of the two fields are chosen so that *q*E = *q*v x B the particle moves in a straight horizontal line through the region of the fields. From the expression *q*E = *qv* x B we find that

*v = E/B* (29.17)

Only those particles having speed *v* pass undeflected through the mutually perpendicular electric and magnetic fields. The magnetic force exerted on particles moving at speeds greater than this is stronger than the electric force, and the particles are deflected upward. Those moving at speeds less than this are deflected downward.

**The Mass Spectrometer**

A mass spectrometer separates ions according to their mass-to-charge ratio. In one version of this device, known as the *Bainbridge mass spectrometer,* a beam of ions first passes through a velocity selector and then enters a second uniform magnetic field B0 that has the same direction as the magnetic field in the selector . Upon entering the second magnetic field, the ions move in a semicircle of radius *r* before striking a photographic plate at *P*. Therefore, we can determine *m*/*q* by measuring the radius of curvature .

**The Cyclotron**

A cyclotron can accelerate charged particles to very high speeds. Both electric and magnetic forces have a key role. The energetic particles produced are used to bombard atomic nuclei and thereby produce nuclear reactions of interest to researchers.

A number of hospitals use cyclotron facilities to produce radioactive substances for diagnosis and treatment.

A schematic drawing of a cyclotron is shown in Figure 29.26. The charges

move inside two semicircular containers D1 and D2 , referred to as *dees.* A highfrequency alternating potential difference is applied to the dees, and a uniform magnetic field is directed perpendicular to them. A positive ion released at *P* near the center of the magnet in one dee moves in a semicircular path (indicated by the dashed red line in the drawing) and arrives back at the gap in a time *T*/2, where *T* is the time needed to make one complete trip around the two dees, given by Equation 29.15.



The frequency of the applied potential difference is adjusted so that the polarity of the dees is reversed in the same time it takes the ion to travel around one dee. If the applied potential difference is adjusted such that D2 is at a lower electric potential than D1 by an amount ∆*V*, the ion accelerates across the gap to D2 and its kinetic energy increases by an amount *q*∆*V*.

It then moves around D2 in a semicircular path of greater radius (because its speed has increased).

After a time *T*/2, it again arrives at the gap between the dees. By this time, the polarity across the dees is again reversed, and the ion is given another “kick” across the gap. The motion continues so that for each half-circle trip around one dee, the ion gains additional kinetic energy equal to *q*∆*V*.



When the radius of its path is nearly that of the dees, the energetic ion leaves the system through the exit slit. It is important to note that the operation of the cyclotron is based on the fact that *T* is independent of the speed of the ion and of the radius of the circular path.

We can obtain an expression for the kinetic energy of the ion when it exits the cyclotron in terms of the radius *R* of the dees. From Equation 29.13 we know that **v** = qBR/m.

Hence, the kinetic energy is K = ½ mv2 = q2 B2 R2/2m (29.19)

When the energy of the ions in a cyclotron exceeds about 20 MeV, relativistic

effects come into play and it is observed that *T* increases and that the moving ions do not remain in phase with the applied potential difference. Some accelerators overcome this problem by modifying the period of the applied potential difference so that it remains in phase with the moving ions.

**The Hall Effect**

When a current-carrying conductor is placed in a magnetic field, a potential difference is generated in a direction perpendicular to both the current and the magnetic field. This phenomenon, first observed by Edwin Hall (1855–1938) in 1879,is known as the *Hall effect.*

It arises from the deflection of charge carriers to one side of the conductor as a result of the magnetic force they experience. The Hall effect gives information regarding the sign of the charge carriers and their density; it can also be used to measure the magnitude of magnetic fields.

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**Magnetic Field Due To A Current Element, Biot-Savart Law**



(30.1)

where μ0 is a constant called the **permeability of free space**:

μ0 = 4π x 10-7 T.m/A (30.2)

It is important to note that the field *d***B** in Equation 30.1 is the field created by the current in only a small length element *d***s** of the conductor.

To find the total magnetic field **B** created at some point by a current of finite size, we must sum up contributions from all current elements *Id***s** that make up the current. That is, we must evaluate **B** by integrating Equation 30.1:

**** (30.3)

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**Magnetic Field Surrounding a Thin, Straight Conductor =**

**Magnetic Field on the Axis of a Circular Current Loop**

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-To find the **magnetic field at the center** of the loop, we set *x* = 0 in Equation 30.7. At this special point, therefore,

*B = μoI/2R (at x=0) (30.8)*



**The Magnetic Force Between Two Parallel Conductors**

**parallel conductors carrying currents in the same direction attract each other, and parallel conductors carrying currents in opposite directions repel each other**.

**(30.12)**

***Quiz :*** For *I1*  = 2A and *I2* = 6A in Figure 30.7, which is true: (a)F1 = 3F2 (b) F1 = F2/3 (c) F1 = F2

**Solution** : (c) F1 = F2 because of Newton’s third law. Another way to arrive at this answer is to realize that Equation 30.11 gives the same result whether the multiplication of currents is (2 A)(6 A) or (6 A)(2 A)

***Quiz :*** A loose spiral spring is hung from the ceiling, and a large current is sent through it. Do the coils move closer together or farther apart?

**Solution** : Closer together; the coils act like wires carrying parallel currents and hence attract one another.

**Ampere’s Circuital Law**

*The line integral of* ***B.ds*** *around any closed path equals μ0I, where I is the total continuous current passing through any surface bounded by the closed path.*

****

**(30.13)**

Ampère’s law describes the creation of magnetic fields by all continuous current configurations, but at our mathematical level it is useful only for calculating the magnetic field of current configurations having a high degree of symmetry. Its use is similar to that of Gauss’s law in calculating electric fields for highly symmetric charge distributions.

** *Quiz*** Rank the magnitudes of ϕB.ds for the closed paths in Figure 30.9, from least to greatest.

**Solution** *b*, *d*, *a*, *c*. Equation 30.13 indicates that the value of the line integral depends only on the net current through each closed path. Path *b* encloses 1 A, path *d* encloses

3 A, path *a* encloses 4 A, and path *c* encloses 6 A.

***Quiz*** Rank the magnitudes of ϕB.ds for the closed paths in Figure 30.10, from least to greatest.

**Solution**b, then a =c = d .Paths a, c, and d all give the same non zero value μ0I because the size and shape of the paths do not matter. Path b does not enclose the current,and hence its line integral is zero.

**The Magnetic Field Created By A Long Current-Carrying Wire**



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**The Magnetic Field Created by a Toroid**

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**Magnetic Field Created by an Infinite Current Sheet**

This result shows that *the magnetic field is independent of distance from the current sheet,* as we suspected**.**

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**The Magnetic Field Of A Solenoid**

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**Magnetic Flux**

**Gauss’s Law In Magnetism**

Gauss’s law in magnetism states that **“the net magnetic flux through any closed surface is always zero”**

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(30.20)

This statement is based on the experimental fact, **that isolated magnetic poles (monopoles) have never been detected and perhaps do not exist.** Nonetheless, scientists continue the search because certain theories that are otherwise successful in explaining fundamental physical behaviour suggest the possible existence of monopoles.

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**SUMMARY**

1. The total force on a charge *q* moving with velocity **v** in the presence of magnetic and electric fields **B** and **E,** respectively is called the *Lorentz force*. It is given by the expression:

**F** = *q* (**v × B + E**)

The magnetic force *q* (**v × B**) is normal to **v** and work done by it is zero.

2. A straight conductor of length *l* and carrying a steady current *I* experiences a force **F** in a uniform external magnetic field **B**, **F** = *I* **l × B**

where|**l**| = *l* and the direction of **l** is given by the direction of the current.

3. In a uniform magnetic field **B**, a charge *q* executes a circular orbit in a plane normal to **B**. Its frequency of uniform circular motion is called the *cyclotron frequency* and is given by:

ν*c = qB/2* π *m*

This frequency is independent of the particle’s speed and radius. This fact is exploited in a machine, the cyclotron, which is used to accelerate charged particles.

4. The *Biot-Savart* law asserts that the magnetic field d**B** due to an element d**l** carrying a steady current *I* at a point P at a distance *r* from the current element is:

To obtain the total field at P, we must integrate this vector expression over the entire length of the conductor.

5. The magnitude of the magnetic field due to a circular coil of radius *R* carrying a current *I* at an axial distance *x* from the centre is



At the center this reduces to



6. *Ampere’s Circuital Law:* Let an open surface S be bounded by a loop C. Then the Ampere’s law states that

where *I* refers to the current passing through S. The sign of *I* is determined from the right-hand rule. We have discussed a simplified form of this law. If **B** is directed along the tangent to every point on the perimeter *L* of a closed curve and is constant in magnitude along perimeter then, *BL* = μ0 *Ie*

where *Ie* is the net current enclosed by the closed circuit.

7. The magnetic induction B due to a straight wire of finite length carrying current I at a distance d is given by:

where ϕ1 andϕ2 the angles made by upper and lower ends of the wire with the perpendicular distance d at the point of observation.



-If the wire is intinitely long, then ϕ1 = ϕ2 =900. Hence

The field lines are circles concentric with the wire.

8. The magnitude of the field *B* inside a *long solenoid* carrying a current *I* is *B* = μ0*nI*

where *n* is the number of turns per unit length. For a *toroid* one obtains,

where *N* is the total number of turns and *r* is the average radius.

9. Parallel currents attract and anti-parallel currents repel.

10. A planar loop carrying a current *I*, having *N* closely wound turns, and an area *A* possesses a magnetic moment **m** where,

**m** = N *I* **A**

and the direction of **m** is given by the right-hand thumb rule : curl the palm of your right hand along the loop with the fingers pointing in the direction of the current. The thumb sticking out gives the direction of **m** (and **A**)

-When this loop is placed in a uniform magnetic field **B**, the force **F** on it is:

*F = 0*

And the torque on it is, τ **= m × B**

In a moving coil galvanometer, this torque is balanced by a counter torque

due to a spring, yielding

*k*φ *= NI AB*

where φ is the equilibrium deflection and *k* the torsion constant of the spring.

11. An electron moving around the central nucleus has a magnetic moment

μ*l* given by:

where *l* is the magnitude of the angular momentum of the circulating electron about the central nucleus. The smallest value of μ*l* is called the Bohr magneton μB and it is μB = 9.27×10–24 J/T

12. A moving coil galvanometer can be converted into a ammeter by introducing a shunt resistance *rs,* of small value in parallel. It can be converted into a voltmeter by introducing a resistance of a large value in series.

- An electric field cannot be produced without a charge whereas a magnetic field can be produced without a magnet

- No poles are produced in a coil carrying current but such a coil shows north and south polarities.

**Points To Ponder**

1. Electrostatic field lines originate at a positive charge and terminate at a negative charge or fade at infinity. Magnetic field lines always form closed loops.

2. The discussion in this Chapter holds only for steady currents which do not vary with time.

When currents vary with time Newton’s third law is valid only if momentum carried by the electromagnetic field is taken into account.

3. Recall the expression for the Lorentz force, **F** = *q* (**v** × **B** + **E**)

This velocity dependent force has occupied the attention of some of the greatest scientific thinkers. If one switches to a frame with instantaneous velocity **v**, the magnetic part of the force vanishes. The motion of the charged particle is then explained by arguing that there exists an appropriate electric field in the new frame. We shall not discuss the details of this mechanism. However, we stress that the resolution of this paradox implies that electricity and magnetism are linked phenomena (*electromagnetism*) and that the Lorentz force expression *does not* imply a universal preferred frame of reference in nature.

4. Ampere’s Circuital law is not independent of the Biot-Savart law. It can be derived from the Biot-Savart law. Its relationship to the Biot-Savart law is similar to the relationship between Gauss’s law and Coulomb’s law.

**Home assignment – Moving Charges And Magnetism**

1.Define the following with expression and units wherever applicable :

* Magnetic Flux
* Lorentz Force

2. What is the maximum work that a constant magnetic field B can perform on a charge q moving through the field with velocity v?

3.Write 3 differences between Electric force & Magnetic force ?

4. The north-pole end of a bar magnet is held near a positively charged piece of plastic. Is the plastic attracted, repelled, or unaffected by the magnet?

5.Derivations : Derive the expression for

(a) - the force acting on a current carrying element placed in a magnetic field ?

(b) - Torque On A Current Loop In A Uniform Magnetic Field

6. Write the working and principle of the following :

(a) - Velocity Selector

(b) - The Mass Spectrometer

(c) - The Cyclotron

7.Explain Biot –Savart’s Law ?

8. Derive the expression for

(a) - Magnetic Field on the Axis of a Circular Current Loop

(b) - The Magnetic Force Between Two Parallel Conductors

9. A loose spiral spring is hung from the ceiling, and a large current is sent through it. Do the coils move closer together or farther apart?

10.Explain Ampere’s Circuital Law ?

11. Write the expression for

(a) - The Magnetic Field Created By A Long Current-Carrying Wire both inside and outside the wire.

(b) - The Magnetic Field Created by a Toroid

(c) - Magnetic Field Created by an Infinite Current Sheet

(d) The Magnetic Field Of A Solenoid

12.State Gauss’s Law in Magnetism ?

**NCERT Solved**

13. A straight wire of mass 200 g and length 1.5 m carries a current of 2 A. It is suspended in mid-air by a uniform horizontal magnetic field **B** perpendicular to the length**.** What is the magnitude of the magnetic field?

14. If the magnetic field is parallel to the positive *y*-axis and the charged particle is moving along the positive *x*-axis. which way would the Lorentz force be for (a) an electron (negative charge), (b) a proton (positive charge).

15. What is the radius of the path of an electron (mass 9 × 10-31 kg and charge 1.6 × 10–19 C) moving at a speed of 3 ×107 m/s in a magnetic field of 6 × 10–4 T perpendicular to it? What is its frequency? Calculate its energy in keV. ( 1 eV = 1.6 × 10–19 J).

16. A cyclotron’s oscillator frequency is 10 MHz. What should be the operating magnetic field for accelerating protons? If the radius of its ‘dees’ is 60 cm, what is the kinetic energy (in MeV) of the proton beam produced by the accelerator ?

17. An element Δ**l** = Δ*x* ˆ**i** is placed at the origin and carries a large current *I =* 10 A (Fig. 4.10). What is the magnetic field on the *y*-axis at a distance of 0.5 m. Δ*x* = 1 cm.

18. A straight wire carrying a current of 12 A is bent into a semi-circular arc of radius 2.0 cm as shown in Fig. 4.13(a). Consider the magnetic field **B** at the centre of the arc. (a) What is the magnetic

field due to the straight segments? (b) In what way the contribution to **B** from the semicircle differs from that of a circular loop and in what way does it resemble? (c) Would your answer be different if the wire were bent into a semi-circular arc of the same radius but in the opposite way as shown in Fig. 4.13(b)?

19. A solenoid of length 0.5 m has a radius of 1 cm and is made up of 500 turns. It carries a current of 5 A. What is the magnitude of the magnetic field inside the solenoid?

20. The horizontal component of the earth’s magnetic field at a certain place is 3.0 ×10–5 T and the direction of the field is from the geographic south to the geographic north. A very long straight conductor is carrying a steady current of 1A. What is the force per unit length on it when it is placed on a horizontal table and the direction of the current is (a) east to west; (b) south to north?

21. A current-carrying circular loop lies on a smooth horizontal plane. Can a uniform magnetic field be set up in such a manner that the loop turns around itself (i.e., turns about the vertical axis).

22. A current-carrying circular loop is located in a uniform external magnetic field. If the loop is free to turn, what is its orientation of stable equilibrium? Show that in this orientation, the flux of the total field (external field + field produced by the loop) is maximum.

23. A loop of irregular shape carrying current is located in an external magnetic field. If the wire is flexible, why does it change to a circular shape?

24. In the circuit (Fig. 4.27) the current is to be measured. What is the value of the current if the ammeter shown (a) is a galvanometer with a resistance  *G* = 60.00 Ω; (b) is a galvanometer described in (a) but converted to an ammeter by a shunt resistance *S* = 0.02 Ω; (c) is an ideal ammeter with zero

resistance?

**NCERT Unsolved**

25. A horizontal overhead power line carries a current of 90 A in east to west direction. What is the magnitude and direction of the magnetic field due to the current 1.5 m below the line?

26. Two long and parallel straight wires A and B carrying currents of 8.0 A and 5.0 A in the same direction are separated by a distance of 4.0 cm. Estimate the force on a 10 cm section of wire A.

27. A 3.0 cm wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27 T. What is the magnetic force on the wire?

28. A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8 cm. If the current carried is 8.0 A, estimate the magnitude of **B** inside the solenoid

near its centre.

29. A square coil of side 10 cm consists of 20 turns and carries a current of 12 A. The coil is suspended vertically and the normal to the plane of the coil makes an angle of 30º with the direction of a uniform horizontal magnetic field of magnitude 0.80 T. What is the magnitude of torque experienced by the coil?

30. In a chamber, a uniform magnetic field of 6.5 G (1 G = 10–4 T) is maintained. An electron is shot into the field with a speed of 4.8 × 106 m/s normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. (*e* = 1.6 × 10–19 C, *me* = 9.1×10–31 kg)

31.(a) A circular coil of 30 turns and radius 8.0 cm carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 60º with the normal of the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning.

(b) Would your answer change, if the circular coil in (a) were replaced by a planar coil of some irregular shape that encloses the same area? (All other particulars are also unaltered.)

**Exemplar**

32. Verify that the cyclotron frequency ω = *eB*/*m* has the correct dimensions of [T]–1.

33. Show that a force that does no work must be a velocity dependent force.

34. Describe the motion of a charged particle in a cyclotron if the frequency of the electric field were doubled.

35. A charged particle of charge *e* and mass *m* is moving in an electric field **E** and magnetic field **B**. Construct dimensionless quantities and quantities of dimension [*T* ]–1.

**Objective Moving Charges & Magnetism (Ch-4)**

1.Two free parallel wires carrying current in the opposite directions :

(a) attract each other (b) repel each other

(c) do not affect each other (d) get rotated to be perpendicular to each other

2. Two parallel wires carrying currents in the same direction attract each other because of:

(a) potential difference between them (b) mutual inductance between them

(c) electric forces between them (d) magnetic forces between them

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

(a) only inside the pipe (b) only outside the pipe

(c) both inside and outside the pipe (d) neither inside nor outside the pipe

4. 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 the proton and the electron?

(a) The electron will travel along a circle with constant speed and the proton will travel along a straight line

(b) the proton will move in a circle with constant speed and there will be no effect on the motion of the electron

(c) There will not be any effect on the motion of the electron and the proton

(d) The electron and the proton both will follow the path of a parabola

5. A circular coil of radius 4 cm and 20 turns carries a current of 3 ampere. It is placed in a magnetic field of 0.5 tesla. The magnetic dipole moment of the coil is:

(a) 0.3 am2 (b) 0.45 am2 (c) 0.6 am2  (d) 0.15 am2

6. Two particles X and Y having equal charges after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe a circular path of radii R1 & R2 respectively. The ratio of masses X & Y is (a) (R1/R2)½ (b) (R2/R1) (c) (R1/R2)2 (d) (R1/R2)

7.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) 3h2/2r2 (b) 2h2/3r2 (c) 3r2/2h2 (d) 2r2/3h2

8. A circular current carrying coil has a radius R. The distance from the centre of the coil on the axis where magnetic induction will be (1/8)th of it’s value at the centre of the coil is

(a) R/√3 (b) R√3 (c) 2 R√3 (d) 2R/√3

9. A square conducting loop of side ‘L’ carries a current I. The magnetic field at the centre of the loop is :

(a)Independent of L (b) proportional to L2

(c) inversely proportional to L (d) linearly proportional to L

10. A current of I ampere flows in a circular arc of wire which subtends an angle of (3π/2) radians at its centre, whose radius is R. The magnitude of magnetic induction B at the centre is :

(a) μoI/R (b) μoI/2R (c) 2μoI/R (d) 3μoI/8R

11. A steam of electrons is projected horizontally to the right. A straight conductor carrying a current is supported parallel to the electron stream and above it.If the current in the conductor is from left to right, what will be the effect on the electron stream?

(a) The electron stream will be pulled upwards. (b) The electron stream will be pulled downwards.

(c) The electron stream will be retarded (d) The electron stream will be speeded up towards the right

12. A person is facing magnetic north. An electron in front of him flies horizontally towards the north and deflects towards east. He is in/at: (a) northern hemisphere (b) southern hemisphere

(c) equator (d) cannot be predicted by these data

13. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction. An electron is projected with it’s velocity pointed in the same direction:

(a) the electron will turn to it’s right (b) the electron will turn to it’s left

(c) the electron velocity will increase in magnitude (d) the electron velocity will decrease in magnitude

14. A proton (of mass m and charge +e ) and an alpha particle (of mass 4m and charge +2e ) are projected with the same kinetic energy at right angles to a uniform magnetic field. Which one of the following statements will be true ?

(a)The alpha-particle will be bent in a circular path with a smaller radius than that of the proton.

(b)The alpha-particle will be bent in a circular path with a greater radius than that of the proton.

(c)The alpha-particle will be bent in a circular path with a same radius than that of the proton.

(d)The alpha-particle and proton will go in a straight line.

15 Current I flows through a long conducting wire bent at right angles as shown in the fig 33.13.The magnetic field at a point P on the right bisector of the angle XOY at a distance r from O is:

(a) μoI/πr (b) 2μoI/πr (c) μoI(√2+1)/4πr (d) 2μoI(√2+1)/4πr

16. A circular coil of wire carries a current(fig 33.14). PQ is a part of a very long wire carrying a current and passing close to the circular coil. If the directions of currents are those shown in figure, what is the direction of force acting on PQ,

(a) Parallel to PQ towards P. (b) Parallel to PQ towards Q.

(c) At right angles to PQ , to the right (d) At right angles to PQ , to the left

17. A cyclotron is used to accelerate€ protons, deuterons, α particles etc. If the energy attained; after acceleration, by the protons is E, the energy attained by α particles shall be

(a) 4E (b) 2E (c) E (d) E/4

18.Two identical wires A & B have the same length L and carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side ‘a’.If B1 and B2 are the values of magnetic induction at the centre of the circle and the centre of the square respectively, then the ratio of B1/B2 is :

(a) π2/8(b) π2/8√2 (c) π2/16 (d) π2/16√2

19. Two thin long parallel wires, separated by a distance d carry a current of I amp in the same direction. They will: (a) attract each other with a force of μoI2/2πd2 per unit length.

(b) repel each other with a force of μoI2/2πd2 per unit length.

(c) attract each other with a force of μoI2/2πd per unit length.

(d) repel each other with a force of μoI2/2πd per unit length.

20. 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) 2πqB/m(b) 2πm/qB (c) 2π qm/B (d) mq/2πB

21. 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/m2) at the centre of the coils will be: (a) 5 x 10-5 (b) 7 x 10-5  (c) 12 x 10-5  (d) 10-5

22. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity then:

(a) it will turn towards right of direction of motion (b) it will turn towards left of direction of motion

(c) its velocity will decrease (d) its velocity will increase

23. 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:

(a)√(B/*v*) (b) ) (B/*v*) (c) )√( *v*/B) (d) ) *v*/B

24. A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity ***v***, as shown(fig 33.43), the force on the charge is:

(a) along OY (b) opposite to OY (c) along OX (d) opposite to OX

25. A wire carrying current I and other carrying current 2I in the same direction produce a magnetic field B at the mid-point. What will be the field when 2I wire is switched off ?

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

26. If a charged particle enters perpendicularly in the uniform magnetic field, then:

(a) energy and momentum both remain constant (b) energy remains constant but momentum changes

(c) both energy and momentum change (d) energy changes but momentum remains constant



27.. Three long straight parallel wires, carrying current, are arranged as shown in figure(33.44). Direction of current is same in wire ‘D’ & ‘G’’. The force experienced by a 25cm length of wire C will be:(a) 10-3 N (b) 2.5 x 10-3 N (c) zero (d) 1.5 x 10-3 N

28. The direction of induced magnetic field **dB** due to a current element i***dl*** at a point of distance r from it, when a current i passes through a long conductor is in the direction:

(a) of position vector **r** of the point (b) of current element ***dl***

(c) perpendicular to both ***dl*** and **r** ? (d) perpendicular to ***dl*** only

29. An electric field of 1500 v/m and a magnetic field of 0.40 weber/metre2 act on a moving electron. The minimum uniform speed along a straight line the electron could have is :

(a) 1.6 x 1015 m/s (b) 6 x 10-16 m/s (c) 3.75 x 103 m/s (d) 3.75 x 102 m/s

30. Electron of mass m and charge q is travelling with a speed u along a circular path of radius r at right angles to a uniform magnetic field of intensity B. If the speed of the electron is doubled and the magnetic field is halved, the resulting path would have a radius: (a) 2r (b) 4r (c) r/4 (d) r/2

31. In a cyclotron, if a deuteron can gain an energy of 40 MeV, then a proton can gain an energy of:

(a) 40 MeV (b) 80 MeV (c) 20 MeV (d) 60 MeV

32. An electron moving in a uniform magnetic field of induction of intensity B, has its radius directly proportional to: (a) its charge (b) magnetic field (c) speed (d) none of these

33. An electron having mass (9.1 x 10-31 kg) and charge (1.6 x 10-19 C) moves in a circular path of radius 0.5 m with a velocity 106 m/s in a magnetic field. Strength of magnetic field is:

(a) 1.13 x l0-5 T (b) 5.6 x 10-6 T (c) 2.8 x 10-6 T (d) none of these

34. Two circular coils 1 and 2 are made from the same wire but the radius of the lst coil is twice that of the 2nd coil. What ratio of potential differences in volts should be applied, across them so that the magnetic field at their centres is the same? (a) 2 (b) 3 (c) 4 (d) 6

35.When a charged particle moving with velocity ***v*** is subjected to a magnetic field of induction **B**, the force on it is non-zero.This implies that:

(a) angle between ***v*** and **B** is either zero or 1800 (b) angle between ***v*** and **B** is necessarily 900

(c) angle between ***v*** and **B** can have any value other than 900

(d) angle between ***v*** and **B** can have any value other than zero or 1800

36.A long solenoid has 200 turns per cm and carries a current *i*. The magnetic field at its centre is 6.28 x 10-2 Weber/m2. Another long solenoid has 100 turns per cm and it carries a current *i*/3. The value of the magnetic field at its centre is:

(a) 1.05 x l0-4 T (b) 1.05 x 10-2 T (c) 1.05 x 10-5 T (d) 1.05 x 10-3 T

37.A circular loop of a wire and a long straight wire carry currents Ic and IL respectively as 'shown in the figure(33.45). Assuming that these are placed in the same plane. Magnetic induction would be zero at the centre of the loop when separation H is :

(a) ILR/Icπ (b) IcR/ILπ (c) Icπ/ ILR (d) ILπ/IcR

38. A straight wire of mass 200 g and length 1.5 m carries a current of 2 A. It is suspended in mid-air by a uniform horizontal magnetic field B. The magnitude of B (in tesla) is:

(a) 2 (b) 1.5 (c) 0.55 (d) 0.66

39.A solenoid 1.5 m long and 0.4 cm in diameter possesses 10 turns per cm length. A current of 5 A flows through it. The magnetic field at the axis inside the solenoid is:

(a) 2π x l0-3 T (b) 2π x l0-5 T (c) 4π x l0-2 T (d) 4π x l0-3 T

40. A wire PQR is bent as shown in figure(33.46) and is placed in a region of uniform magnetic field B. The length of PQ = QR = *l*. A current I ampere flows through the wire as shown. The magnitude of force on PQ and QR will be (a) BI*l*,0 (b) 2 BI*l*, O (c) 0, BI*l (d) 0, 0*

41. A solenoid of 0.4 m length with 500 turns carries a current of 3 A. A coil of 10 turns and of radius 0.01 m carries a current of 0.4 A. The torque required to hold the coil with its axis at right angles to that of solenoid in the middle part of it, is: (a) 6 π2 x10-7 Nm (b) 3 π2 x 10-7 Nm

(c) 9 π2 x10-7 Nm (d) 12 π2 x10-7 Nm

42. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off and the same magnetic field is maintained, the electrons move:

(a) in a circular orbit (b) along a parabolic path (c) along a straight line (d) in an elliptical orbit

43. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B .lf V and B are kept constant, the ratio ( charge /mass of ion) will be proportional to:

(a) l/R2 (b) R2 (c) R (d) 1/R

44. A charged particle (charge q) is moving in a circle of radius R with uniform speed u. The associated magnetic moment μ is given by: (a) quR2 (b) quR2/2 (c) quR (d) quR/2

45. Under the influence of a uniform magnetic field a charged particle is moving in a circle of radius R with constant speed u. The time period of the motion:

(a) depends on both R and u (b) is independent of both R and u

c) depends on R but not on u (d) depends on u but not on R

46.Two wires A and B are having lengths of 40 cm and 30 cm. A is bent into a circle of radius *r* and B into an arc of radius *r*. A current I1, is passed through A and I2 through B. To have the same magnetic induction at the centre the ratio of I1/I2 is: (a)3:4 (b)3:5 (c)2:3 (d)4:3



47. In the figure (33.49) the magnetic field induction at the point O will be:



48. An electron and proton having same kinetic energy enter into a magnetic field perpendicular to it. Then:

(a) the path of electron is less curved (b) the path of proton is less curved

(c) both have equal curved paths (d) both have straight line paths

49. The magnetic force on a charged particle moving in the field does no work, because:

(a) kinetic energy of the charged particle does not change (b) the charge of the particle remains same

(c) the magnetic force is parallel to velocity of the particle (d) the magnetic force is parallel to magnetic field

50. A uniform electric field and a uniform magnetic field exist in a region in the same direction. An electron is projected with a velocity pointed in the same direction. Then, the electron will:

(a) be deflected to the left without increase in speed (b) be deflected to the right without increase in speed

(c) not be deflected but its speed will decrease (d) not be deflected but its speed will increase

(e) be deflected to the right with increase in speed

51. A conducting rod of 1 m length and 1 kg mass is suspended by two vertical wires through its ends. An external magnetic field of 2 T is applied normal to the rod. Now, the current to be passed through the rod so as to make the tension in the wires zero is: (Take g = 10 ms-2)

(a) 0.5 A (b) 15 A (c) 5 A (d) l.5 A (e) 2.5 A

52. If a long copper rod carries a direct current, field associated with the current will be:

(a) only inside the rod (b) only outside the rod

(c) both inside and outside the rod (d) neither inside nor outside the rod

53. A circular coil carrying a certain current produces a magnetic field B at its centre. The coil is now rewound so as to have 3 turns and the same current is passed through it. The new magnetic field at the centre is: (a) B/9 (b) 9B (c) B/3 (d) 3B

54. A proton and a deuteron with the same initial kinetic energy enter in a magnetic field in a direction perpendicular to the direction of the field. The ratio of the radii of the circular trajectories described by them is: (a)1:4 (b)1:√2 (c)1:1 (d)1:2

55. A charged particle is moving in a magnetic field of strength B perpendicular to the direction of the field. lf q and m denote the charge and mass of the particle respectively, then the frequency of rotation of the particle is: (a) qB/2πm (b) qB/2πm2 (c) 2π2m/qB (d) 2πm/qB



56. A and B are two infinitely long straight parallel conductors. C is another straight conductor of length 1 m kept parallel to A and B as shown in the figure(33.50). Then the force experienced by C is:

(a) towards A equal to 0.6 x 10-5 N (b) towards B equal to 5.4 x 10-5 N

(c) towards A equal to 5.4 x 10-5 N (d) towards B equal to 0.6 x 10-5 N

57. The strength of the magnetic field around a long straight wire, carrying current, is: (a) same everywhere around the wire at any distance

(b) inversely proportional to the distance from the wire

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

(d) directly proportional to the square of the distance from the wire

(e) directly proportional to the distance from the wire

58. A proton with energy of 2 MeV enters in a uniform magnetic field of 2.5 T normally. The magnetic force on the proton is:(Take mass of proton to be 1.6 x 10-27 kg)

(a) 3 x l0-12 N (b) 8 x l0-10 N (c) 8 x l0-12 N (d) 2 x l0-10 N (e) 3 x l0-10 N

59. A long straight wire of radius ‘a’ carries a steady current *i*. The current is uniformly distributed across its cross-section. The ratio of the magnetic field at a/2 and 2a is:

(a) ½ (b) ¼ (c) 4 (d) 1

60. A current *I* flows along the length of an infinitely long, straight and thin walled pipe. Then:

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

(b) the magnetic field is zero on the axis of the pipe

(c) the magnetic field is different at different point inside the pipe

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

61. A charged particle with charge q enters in a region of constant, uniform and mutually orthogonal fields **E** & **B** with a velocity ***v*** perpendicular to both **E** & **B** and comes out without any change in magnitude or direction of ***v***. Then (a) ***v*** = (**B** x **E)/**E2  (b) ***v*** = (**E** x **B)/**B2  (c) ***v*** = (**B** x **E)/**B2  (d) ***v*** = (**E** x **B)/**E2

62. Identify the correct statement from the following:

(a) Cyclotron frequency is dependent on speed of the charged particle.

(b) Kinetic energy of charged particle in cyclotron does not depend on its mass.

(c) Cyclotron frequency does not depend on speed of charged particle.

(d) Kinetic energy of charged particle in cyclotron is independent of its charge.

63.Two identical conducting wires AOB and COD are placed at right angles to each other. The wire AOB carries an electric current I1 and COD carries a current I2.The magnetic field at a point lying at a distance *d* from O, in a direction perpendicular to the plane of the wires AOB and COD, will be given by



64. A proton of energy 1 MeV describes a circular path in plane at right angles to a uniform magnetic field of 6.28 x 10-4 T. The mass of the proton is 1.7 x l0-27 kg. The cyclotron frequency of the proton is very nearly equal to: (a) 107 Hz (b) 105 Hz (c) 106 Hz (d) 104 Hz

65. An electron enter a region, where magnetic field B and Electric field E are mutually perpendicular, then

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

(c)It will always possess circular motion (d)It can go undeflected also

66. The magnetic force acting on a charged particle of charge - 2 μC in a magnetic field of 2 T acting in Y-direction, when the particle velocity is (2 i + 3j) x 106 m/s, is

(a) 4 N in Z-direction (b) 8 N in Y-direction (c) 8N in Z-direction (d) 8N in - Z-direction

67. Two long parallel wires carry currents i1 and i2 such that i1 > i2. When the currents are in the same direction, the magnetic field at a point midway between the wires is 6 x 10-6 T. If the direction of i2 is reversed, the field becomes 3 x 10-5 T. The ratio of i1/i2 is

(a) ½ (b) 2 (c) ⅔ (d) 3/2 (e) l/5

68. A current *I* enters a circular coil of radius R, branches into two parts and then recombines as shown in the circuit diagram(33.58). The resultant magnetic field at the centre of the coil is:

(a) 0 (b) μoI/2R (c) ¾(μoI/2R) (d) ¼(μoI/2R) (e) ½(μoI/2R)

69. A long, straight wire is turned into a loop of radius 10 cm (see figure33.59). If a current of 8 A is passed through the loop, then the value of the magnetic field and its direction at the centre C of the loop shall be close to:

(a) 5.0 x l0-5 newton/(amp-meter), upward (b) 3.4 x 10-5 newton/(amp-meter), upward

(c) 1.6 x 10-5 newton/(amp-meter), downward (d) 1.6 x 10-5 newton/(amp-meter), upward

70.A thin flexible wire of length L is connected to two adjacent fixed points and carries a current I in the clockwise direction, as shown in the figure(33.60). When the system is put in a uniform magnetic field of strength **B** going into the plane of the paper, the wire takes the shape of a circle The tension in the wire is:

(a) IBL (b) IBL /π (c) IBL /2π (d) IBL /4π

71. A proton and a α –particle (Alpha),moving with the same velocity, enter into a uniform magnetic field, acting normal to the plane of their motion. The ratio of the radii of the circular paths described by the proton and the alpha particle will be (a) 1:2 (b) 1:4 (c) 1:16 (d) 4:1

72. An electron travelling with velocity ***v***, enters a region of space in which electric and magnetic fields exist. Then the electron goes undeflected for all values of fields

(a) if both electric and magnetic fields are normal to ***v*** (b) if the magnetic field alone is normal to ***v***

(c) if both electric and magnetic fields are parallel to ***v*** (d) if the electric field is along normal to ***v***

73. A charge *q* coulomb makes *n* revolutions in one second in a circular orbit of radius r. The magnetic field at the centre of the orbit in NA-1m-1 is

(a) (2πm/q )x 10-7 (b) (2πq/r )x 10-7 (c) (2πq/nr )x 10-7 (d) (2πnq/r )x 10-7



74. An electron is moving in an orbit of radius R with a time period T as shown in the figure(33.61). The magnetic moment produced may be given by:



75. The ratio of magnetic field and magnetic moment at the centre of a current carrying circular loop is *x*. When both the current and radius is doubled the ratio will be:

(a) *x*/8 (b) *x*/4 (c) *x*/2 (d) 2*x*

76. A charged particle is moving in a circular orbit of radius 6 cm with a uniform speed of 3 x 106 m/s under the action of a uniform magnetic field 2 x 10-4 Wb/m2 at right angles to the plane of the orbit. The charge to mass ratio of the particle

(a) 5 x 109 C/kg (b) 2.5 x 1011 C/kg(c) 5 x 1011 C/kg (d) 5 x 1012 C/kg

77.A current loop consists of two identical semicircular parts each of radius R, one lying in the x, y- plane and the other in x-z plane .If the current in the loop is i. The resultant magnetic field due to the two semicircular parts at their common centre is:

(a) μoi/R2√2 (b) μoi/2R (c) μoi/4R (d) μoi/R√2

78. A closely wound solenoid of 2000 turns and area of cross-section 1.5 x 10-4 m2 carries a current of 2.0 A. It is suspended through its centre and perpendicular to its length, allowing it to turn in a horizontal plane in a uniform magnetic field 5 x l0-2 tesla making an angle of 300 with the axis of the solenoid. The torque on the solenoid will be: (a) 3 x 10-3 Nm (b) 1.5 x 10-3 Nm (c) 1.5 x 10-2 Nm (d) 3 x 10-2 Nm

79. A particle having a mass of 10-2 kg carries a charge of 5 x 10-8 C. The particle is given an initial horizontal velocity . of 105 m/s in the presence of electric field **E** and magnetic field **B**. To keep the particle moving in a horizontal direction, it is necessary that

(i) **B** should be perpendicular to the direction of velocity and **E** should be along the direction of velocity.

(ii) Both **B** and **E** should be along the direction of velocity

(iii) Both **B** and **E** are mutually perpendicular and perpendicular to the direction of velocity

(iv) **B** should be along the direction of velocity and **E** should be perpendicular to the direction of velocity

Which one of the following pairs of statements is possible?

(a) (i) & (iii) (b) (iii) & (iv) (c) (ii) & (iii) (d) (ii) & (iv)

80. The magnitude of the magnetic field required to accelerate protons (mass =1.67 x 10-27 kg) in a cyclotron that is operated at an oscillator frequency of 12 MHz is approximately:

(a) 0.8 T (b) 1.6 T (c) 2.0 T (d) 3.2 T



81. Magnetic field induction at the centre O of a square loop of side ‘a’ carrying current I as shown in the figure(33.62) is:

(a) μoI/πa √2 (b) 2√2 μoI/πa (c) 2μoI/πa (d) μoI/2πa (e) 0

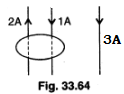


82. Two circular concentric loops of radii r1=20 cm and r2=30 cm are placed in the X, Y-plane as shown in the figure(33.63). A current I =7 amp is flowing through them. The magnetic moment of this loop system is:

(a) 0.4 **k** Am2 (b) -1.5 **k** Am2 (c) 1.1 **k** Am2 (d) 1.3 **j** Am2

83. A uniform magnetic field B =1.2 mT is directed vertically upward throughout the volume of a laboratory chamber. A proton (m =1.67 x 10-27 kg) enters the laboratory horizontally from south to north. Calculate the magnitude of centripetal acceleration of the proton if its speed is 3 *x* 107 m/s.

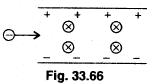
(a) 3.45 x 1012 m/s2 (b) 1.67 x 1012 m/s2 (c) 5.25 x 1012 m/s2 (d) 2.75 x 1012 m/s2

84. Two wires with currents 2 A and 1 A are enclosed in circular loop. Another wire with current 3 A is situated outside the loop as shown(33.64). The **∫*B.dl*** around the loop is :

(a) μo (b) 3μo (c) 6μo (d) 2μo (e) 0

85. PQ and RS are long parallel conductors separated by certain distance. M is the mid-point between them (see the figure 33.65). The net magnetic field at M is B. Now, the current 2 A is switched off. The field at M now becomes :

(a) 2B (b) B (c) B/2 (d) 3B

86. An electron enters the space between the plates of a charged capacitor as shown(33.66). The charge density on the plate is **σ**. Electric field intensity in the space between the plates is **E**. A uniform magnetic field **B** also exists in that space perpendicular to the direction of' **E**. The electron moves perpendicular to both **E** and **B** without any change in direction. The time taken by the electron to travel a distance *l* in the space is:

(a) σ*l*/∈oB (b) σB/∈o*l* (c) ∈oB *l*/σ (d) *l*∈o/Bσ

87. A long solenoid has 200 turns per cm and carries a current *I*. The magnetic field at its centre is 6.28 x 10-2 Wb/m2. Another long solenoid has 100 turns per cm and it carries a current I/ 3. The value of the magnetic Field at its centre is

(a) 1.05 x l0-2 Wb/m2 (b) 1.05 x l0-5 Wb/m2 (c) 1.05 x l0-3 Wb/m2 (d) 1.05 x l0-4 Wb/m2

88. 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 paths : (a) 4:1 (b) 1:4 (c) 2:1 (d) 1:2

89. Electron move at right angle to a magnetic field of 1.5 x l0-2 tesla with speed of 6 x 107 m/s. If the specific charge of the electron is l.7 x 1011 C/kg. The radius of circular path will be:

(a) 3.31cm (b) 4.31cm (c) 1.31cm (d) 2.35cm

90. A current of 5 amp is flowing in a wire of length 1.5m. A force of 7.5 N acts on it when it is placed in a uniform magnetic field of 2 tesla and the direction of the current is:(a) 900 (b) 600  (c) 450  (d) 300

91.An infinitely long straight wire contains a uniformly continuous current of l0A. The radius of the wire is 4 x l0-2 m. The magnetic field at 2 x l0-2 m from the centre of the wire will be :

(a) 0 (b) 2.5 x 10-5 T (c) 5 x 10-5 T (d) none

92. An electron is travelling with velocity ***v* =3i +5j** m/s in a magnetic field ***B = 6i +4j*** T. what is the magnitude and direction of the force **F** acting on the electron :

(a) 18e N along +ve z-axis (b) l8e N along -ve z-axis (c) 36e N along -ve z-axis (d) 54e N along +ve z-axis

93.Consider a particle of charge q describing a closed orbit like that of an electron in an atom. The angular momentum of the particle **L** and the magnetic dipole moment **M** of the corresponding current loop are related as : (a) **M** =q**L**/2m (b) **M** = -q**L**/2m (c) **L** = -q**M**/2m (d) none of these

94. lf the radius of a coil is halved and the number of turns doubled, then the magnetic field at the centre of the coil, for the same current will : (a) get doubled (b) get halved (c) become 4 times (d) remain unchanged

95.An electron of charge -e, mass m , enters a uniform magnetic field **B** = B***i*** with an initial velocity

***v*** = *vx* **i** + vy**j** .What is the velocity of the electron after a time interval of t second ?

(a) *vx* **i** + *vy* **j +** (e/m) *vy*Bt **k** (b) *vx* **i** + *vy* **j -** (e/m) *vy*Bt **k**

(c) *vx* **i** + *vy* **j +** (e/m) *vy*Bt **j** (d) *vx* **i** + *vy* **j +** (e/m) *vy*Bt **i**



96. A long insulated copper wire is closely wound as a spiral of N turns (fig 33.67). The spiral has inner radius ‘a’ and outer radius ‘b’. The spiral lies in the X-Y plane and a steady current I flows through the wire. The Z-component of the magnetic field at the centre of the spiral is :



97. Two wires of same length are shaped into a square and a circle. If they carry the same current, then the ratio of the magnetic moments is (a) *2: π* (b) *π: 2* (c) *π* :4 (d) *4: π*

98. An electron moving around the nucleus with an angular momentum *l* has a magnetic moment :

(a) *el/m* (b) *el/2m* (c) 2*el/m* (d) *el/2πm* (e) *el/4πm*

99. The force between two parallel current carrying wires is independent of :

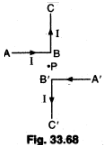
(a) their distance of separation (b) the length of the wires (c) the magnitude of currents (d) the radii of the wires (e) the medium in which they are placed

100.Two identical magnetic dipoles of magnetic moment 2 A-m2 are placed at a separation of 2 m with their axis perpendicular to each other in air. The resultant magnetic field at a mid-point between the dipoles is :

(a)4√5 x 10-5 T (b) 2√5 x 10-5 T (c) 4√5 x 10-7 T (d) 2√5 x 10-7 T (e) 4√2 x 10-7 T

101. A proton, a deuteron and an α-particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. .lf rp,rd & rα denote respectively the radii of the trajectories of these particles then:

(a) rα = rd  >rp (b) rα = rd  =rp (c) rα < rd  <rp (d) rα = rp  <rd (e) rα > rd  >rp

102. Two particles A and B having equal charges +6 C after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii 2 cm and 3 cm respectively. The ratio of mass of A to that of B is :

(a) 4/9 (b) 9/5 (c) ½ (d) ⅓ (e) 9/4

103. Ampere's circuital law can be derived from :

(a) Ohm's law (b) Biot-Savart's law (c) Kirchhoffs law (d) Gauss' law (e) Coulomb's law

104. Current thru ABC & A’B’C’ is I. What is the magnetic field at P(fig 33.68) ? (Given that BP=PB’ =R & C’B’PBC are collinear) (a) 2I/4πR (b) 2μoI/4πR (c) μoI/4πR (d) zero

105. The magnetic field at the point of intersection of diagonals of a square wire, loop of side L carrying a current I is :

(a) μo I/πL (b) 2μo I/πL (c) √2 μo I/πL (d) 2√2 μo I/πL

**Answers Explanations Objective Questions- Moving Charges & Magnetism**

|  |  |  |  |
| --- | --- | --- | --- |
| 1. B | 1. D | 1. B | 1. B |
| 1. A | 1. C | 1. A | 1. B |
| 1. C | 1. D | 1. B | 1. B |
| 1. D | 1. C | 1. D | 1. D |
| 1. C | 1. B | 1. C | 1. B |
| 1. A | 1. C | 1. C | 1. A |
| 1. C | 1. B | 1. C | 1. C |
| 1. C | 1. B | 1. B | 1. C |
| 1. A | 1. C | 1. D | 1. B |
| 1. A | 1. D | 1. A | 1. C |
| 1. A | 1. A | 1. A | 1. D |
| 1. B | 1. A | 1. B | 1. A |
| 1. A | 1. C | 1. C | 1. C |
| 1. B | 1. B | 1. A | 1. D |
| 1. B | 1. C | 1. D | 1. D |
| 1. B | 1. C | 1. C | 1. D |
| 1. D | 1. D | 1. D | 1. A |
| 1. B | 1. C | 1. A | 1. C |
| 1. D | 1. D | 1. A | 1. B |
| 1. A | 1. C | 1. C | 1. A |
| 1. E | 1. C | 1. A | 1. A |
| 1. B | 1. C | 1. A | 1. C |
| 1. D | 1. D | 1. B | 1. A |
| 1. A | 1. C | 1. A | 1. A |
| 1. C | 1. B | 1. D | 1. D |
| 1. D | 1. A | 1. B | 1. B |
| 1. D |  |  |  |

