**S.I UNIT OF MAGNETIC FIELD OF INDUCTION TESLA (T)**

The unit of magnetic field of induction can be obtained by using the equation.

If,

And,

Then,

Since,

Where tesla is S.I unit of magnetic field of induction and can be define as,

Magnetic field of induction is said to be of a charge of moving with a velocity of at right angle to the field experience a force of .

ANOTHER UNIT GAUSS (G)

**MAGNETIC FLUX**

**DEFINITION: -**

The total number of lines of magnetic induction passing through a surface held perpendicular to the magnetic field is called the magnetic flux through that surface. It is denoted by .

**OR**

Numerically magnetic flux is the dot product of strength of magnetic field of induction and the vector area . i.e.

Where,

is the angle between .

**EXPLANATION: -**

1. Vector area is a vector quantity. Its magnitude is equal to the area of the surface and direction is along the normal drawn to the surface.
2. If the surface is placed parallel to the direction of magnetic field of induction then the angle between and outward normal to the surface is .

Is given as,

1. If the surface is placed perpendicular to the direction of magnetic field of induction then the angle between and outward normal to the surface is .

Is given as,

**UNIT: -**

The S.I unit of magnetic flux is weber which is derived as:

**MAGNETIC FLUX DENSITY: -**

The magnetic flux passing per unit area of a surface held perpendicular to the magnetic field is called as magnetic flux density.

**MATHEMATICAL EXPRESSION: -**

**UNIT: -**

Since the unit of magnetic flux is weber.

∴ magnetic flux density is measured in is equivalent .

Also,

**FORCE ON A CURRENT CARRYING CONDUCTOR IN A UNIFORM MAGNETIC FIELD**

Consider a conductor of length carrying current in a uniform magnetic field of induction as shown.

Let,

Then,

Volume of the conductor is given as . So that the total number of electrons (charge carriers). In the given volume of the conductor . If be the charge on each electron (charge carrier) then the total charge passing through the conductor is given as:

If charges would take time to cross the Length of a conductor then velocity of charge carrier (electron) may be found as:

Hence the current flowing through the conductor is given as,

Force on a charge moving with velocity at angle to the magnetic field of induction is given as:

Force on a conductor may be found as:

Where is the unit vector in the direction of .

If length of the conductor is treated as vector having direction along conventional current then,

**DIRECTION: -**

The Force acts perpendicular to both length any magnetic field of induction and its direction is determined by “RIGHT HAND RULE.”

* Current flowing into the page or flowing away from a reader

**ALTERNATE METHODS: -**

The conductor always experiences a force directed from the region where the two fields reinforce each other to the region where they cancel.

**TRAJECTORY OF A CHARGED PARTICLE PROJECTED PERPENDICULAR IN A UNIFORM MAGNETIC**

The force on a charge moving with velocity in a uniform magnetic field at an angle to the magnetic field of induction is given as:

Or,

If the particle is projected perpendicularly then the above force is given as:

This force acts at right angle to both and and its direction is found by right hand rule.

Rotate to coincide with through smaller angle of rotation and curl the fingers of the right hand along the direction of rotation then thumb will point in the direction of the force.

As the force is acting perpendicular to the velocity of a particle, therefore it does not change the magnitude of velocity rather it changes its direction only. Hence the particle is under the influence of a force of constant magnitude which is perpendicular to its velocity at all points of its motion. These are the characteristics of a centripetal force. Thus the force due to magnetic field on the charged particle deflects the particle to move in a circle. Hence the trajectory of a charged particle is a circle as shown below:

**IMPORTANT POINT TO REMEMBER: -**

The force on negatively charged particle moving with a velocity in a uniform magnetic field at an angle to the magnetic field of induction is given as:

As,

So the direction of the force in case of negative charge is in the direction of vector . Following figure illustrates the idea:

**EXPRESSION FOR THE RADIUS OF THE CIRCLE IN WHICH PARTICLE IS MOVING**

As we know that centripetal force is given as:

But this is produced by the action of magnetic field. Therefore force on a charged particle moving with a velocity in a uniform magnetic field to the .

Where,

radius of the circle in which particle is moving and is the velocity of the charged particle directed along the tangent to the circle at all points.

**TORQUE ON A CURRENT CARRYING RECTANGULAR COIL PLACED IN A MAGNETIC FIELD**

Consider a rectangular coil with its plane parallel to a uniform magnetic field of induction .

Let,

As shown below:

The Force acting on a conductor carrying current in a uniform magnetic field is given as:

Or,

Where is at right angle to both length of the conductor and magnetic field and its direction is determined by right hand rule.

**FORCE ON SIDES**

The side of the coil are at right angles to the field. Therefore force on each of these sides may be written as:

**DIRECTION OF FORCE ON SIDES**

A force acts on the side of the coil in the downward direction or into the paper while an equal and opposite force acts on side of the coil. In the upward direction or out of the paper.

If the coil can rotate freely about an axis .

The forces on sides constitute a couple.

**TORQUE OF COUPLE**

Since the coil is free to rotate about an axis passing through the centre of the coil then torque say on the left and right sides respectively are given by:

And,

Where, is the breadth of the coil.

As both the torques are in same direction (i.e. in anticlockwise direction).

Therefore the total torque acting on the coil is given as:

**Or**

Or,

eq. (i) holds for a single turn. If the coil has turns instead of a single turn then,

**IMPORTANT POINT TO REMEMBER**

The force on sides is zero because the current in these sides are parallel to the field so .

By equation:

We get,

**WHEN THE PLANE OF COIL MAKES AN ANGLE WITH**

If the plane of the coil makes an angle with the direction of magnetic field of induction then perpendicular distance between equal and opposite parallel forces is as shown below:

In this situation torque of couple is calculated as:

By definition:

For N turns:

If the plane of the coil is parallel to field

If the plane of the coil is perpendicular to the field.

In this position maximum flux crosses the coil.

* For values of other than zero the field exerts forces on but these force are always parallel to the axis of rotation make no contribution to the torque.
* In this situation sides are still perpendicular to the magnetic field and therefore magnitudes and direction of forces on these sides do not change.

**MOTIONAL EMF**

When a conductor is moved across a magnetic field a potential difference is setup between its ends. This potential difference is called motional E.M.F.

**DERIVATION OF RELEVANT FORMULA**

Consider a wire of length moving with a speed in a uniform magnetic field of induction . The free electrons in the wire are also moving with the conductor and thus experience a Force.

**Or**

The right hand rule of cross product shows that each electron experience a force in the direction of or from .

Due to this force electrons move from end to end due to this movement of electrons the end becomes positive while the end becomes negative. Due to this electric field is produced inside the wire and this field exert force on the electrons. When this force become equal to the force due to the motion of the conductor the electrons stop further accumulating at . This shows that a potential difference is setup between .

If a charge moves from one end to the other end, the force on this charge is given by

Where, is the angle between .

Work done by this force is given as,

Since,

i.e.

By definition potential difference between the ends (terminals) of conductor = motional E.M.F.

If the conductor is moved at right angle to the magnetic field. i.e.

Then,

**ALTERNATING CURRENT GENERATOR**

**DEFINITION: -**

An A.C generator is a device which converts mechanical energy into electrical energy.

**PRINCIPLE OF THE GENERATOR: -**

It works on the principle of electromagnetic induction. The principle of an A.C generator is based on the fact that when there is a change of flux on the coil an induced e.m.f is produced in it.

**CONSTRUCTION: -**

The basic parts of an A.C generator are:

1. **ARMATURE: -**

The armature consisting of coil of many turns wound on a soft iron cylinder. It is capable of rotating between the poles of a strong magnet about an axis . Alternating e.m.f is produced in armature coil.

1. **FIELD MAGNET: -**

It is usually an electromagnet or permanent magnet.

1. **SLIP RINGS: -**

The two ends of the coil are connected to two circular rings , called slip rings which rotate along with the coil.

1. **CARBON BRUSHES: -**

Two carbon brushes rest against slip rings. Their function is to collet current from armature coil and convey it to the external circuit. For the construction of an a.c generator following figure illustrates the idea:

**WORKING: -**

The coil is made to rotate by some means in the field. The magnetic flux linked with it changes and an induced e.m.f is produced in it. In order to explain the working of an A.C generator consider a rectangular coil rotating clockwise about its axis . We consider the different positions of the coil during its one revolution as shown.

We start with the plane of the coil at right angles to the magnetic field.

1. In the beginning of the rotation the induced e.m.f is zero because the velocity vector of the side is parallal to the magnetic field.
2. During the first quarter of the cycle the angle between velocity of side and magnetic field increases from and therefore induced e.m.f increases from 0 to its maximum value. E.M.F. induced in side varies in the same.
3. During the second quarter of the cycle the angle between velocity of side and magnetic field varies from and therefore induced e.m.f reduces to zero from its maximum value. E.M.F. induced in side varies in the same fashion.
4. During the remaining half rotation induced e.m.f becomes 0 to maximum at and become zero at in the opposite direction.
5. From the above observation we conclude that sides always move in the opposite direction and therefore e.m.f of the side supports each other.
6. The variation of e.m.f as a function of time is given by a graph as shown below.

The induced e.m.f shown in the graph is called as “Alternating e.m.f”. The current caused by such as e.m.f is called alternating current. Therefore this generator is called A.C generator.

**EXPRESSION FOR THE E.M.F GENERATED**

Consider the rectangular coil of length and breadth votating in a magnetic field of strength with a velocity as shown:

We consider the instant when the velocity of side makes an angle with the magnetic field. There is no motional e.m.f in side because the sides rotate in the same direction with same velocity therefore the e.m.f induced in them will cancel each other. Since the sides are moving in opposite direction therefore e.m.f produced in these sides support each other. Hence the net e.m.f produced in the coil is given:

The coil is rotating in a circle of radius .

As we know that,

Where,

is the angular velocity.

Where,

For turns:

According to the definition of angular velocity

∴ The above equation becomes:

Or

Where is the cyclic frequency equation no. (5) represents the instantaneous value of alternating e.m.f. e.m.f is maximum when

Or,

**DETERMINATION OF CHARGE TO MASS RATIO (e/m) OF AN ELECTRON: (SIR J.J THOMSON’S METHOD)**

**INTRODUCTION: -**

, the charge to mass ratio of electron was first measured by Sir J.J Thomson in 1897 at Cavendish laboratory in Cambridge, England.

**BASIS: -**

When a charge is projected at right angle to magnetic field of induction with a velocity , it experience the force.

Under the influence of this force the charge particle moves in a circle.

**CONSTRUCTION OF APPARATUS: -**

J.J Thomson method is based on the apparatus which consist of:

1. An evacuated glass tube of pair shape.
2. A filament made up of tungsten to produce electron.
3. A cylindrical cathode.
4. Two metallic dices with hole at their centre which acts as a anode.
5. Two identical coils carrying current which produces magnetic field inside the tube.
6. Pates to produce an electric field at right angle to both magnetic field and motion of electrons.
7. A fluorescent screen coated with Zinc sulphide for receiving beam of electron.

Following figure illustrates the idea:

**DETAIL INFORMATION OF EXPERIMENT**

**STEP NO # 1:**

Filament is heated by battery . The hot filament emits out electrons. The filament is surrounded by a cylinder having negative potential. It collects the electron which scatter from the filament. The electrons are accelerated by potential difference towards positive electrode . The electrons are collected into thin beam by the holes and the beam strikes a point which becomes visible as a bright spot on the fluorescent screen coated with Zinc Sulphide.

**STEP NO # 2:**

When there is no magnetic field applied in the way of electrons and no potential difference is applied across the plates electron beam goes straight but when a magnetic field is applied at right angle to the motion of electron beam, it causes the electrons to move along a circular path and therefore bright spot on screen shifts from . Hence in this case:

From the above expression of electron can be calculated provided that are known:

**STEP NO # 3:**

**MATHEMATICAL TREATMENT**

1. **CALCULATION OF RADIUS:**

Let,

Where electrons enter the magnetic field.

In ,

Where,

**CONCLUSION: -**

Thus by knowing E, B and ‘r’ the charge to mass ratio is formed to be

**ELECTROMAGNETIC INDUCTION**

**DEFINITION: -**

When magnetic flux linked with a conductor charges a potential difference is produced across its terminals. This potential difference is known as induced E.M.F. and the phenomena is called electromagnetic induction.

**OR**

The phenomenon of generation of induced E.M.F. in a circuit is called as electromagnetic induction.

**EXPLANATION: -**

1. **INDUCED CURRENT:**

The current caused by induced E.M.F. is called induced current.

1. According to the phenomenon of electromagnetic induction any charge of magnetic flux linked with a conductor induces an E.M.F. in it.
2. Consider a coil connected with a galvanometer and placed near a bar magnet as shown below:

Experiments shows that: