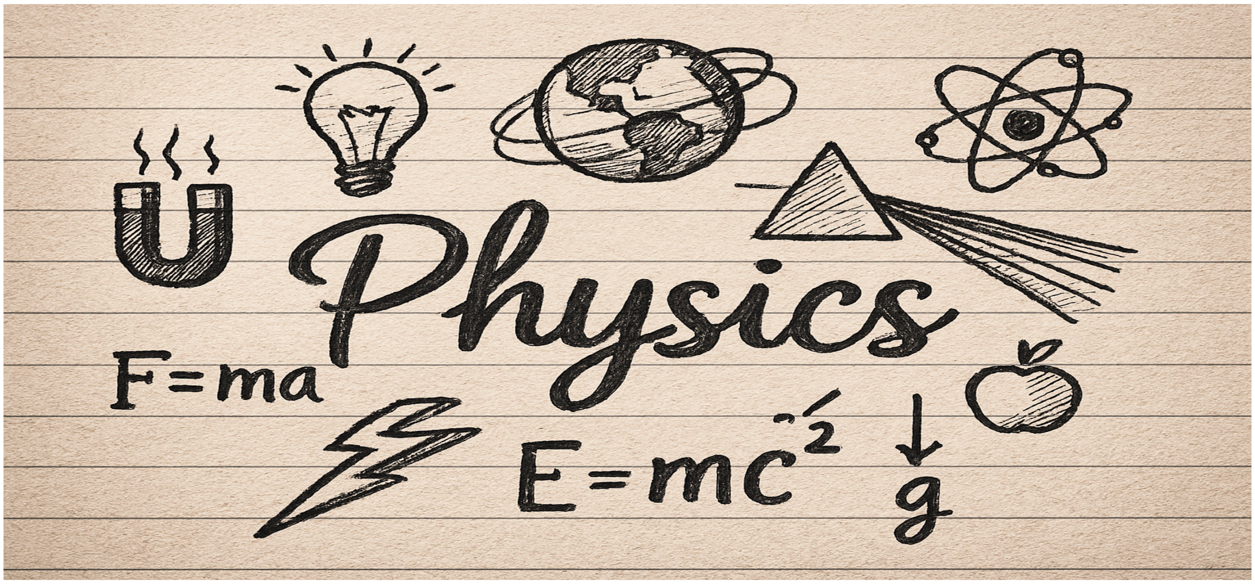


Class: 12th

Subject: Physics

Chapter 14: ELECTROMAGNETISM

🩸 Important MCQs (From Key Points)

1. A magnetic field is produced around:

(a) A stationary conductor

(b) A current-carrying conductor ✅

(c) A resistor

(d) A capacitor

2. Right hand rule is used to determine:

(a) Direction of current

(b) Magnitude of current

(c) Direction of magnetic field around a conductor ✅

(d) Resistance of conductor

3. According to right hand rule, the thumb points to:

(a) Magnetic field direction

(b) Current direction ✅

(c) Force on wire

(d) Electron motion

4. The strength of magnetic field is measured in:

(a) Newton

(b) Tesla ✅

(c) Ampere

(d) Weber

5. One tesla is defined as the magnetic field which exerts:

(a) 1 N force on 1 m of conductor carrying 1 A at right angles ✅

(b) 1 N force on 1 m of conductor carrying 2 A

(c) 1 N force on 1 cm of conductor

(d) 1 N force on 1 m of conductor with zero current

6. Magnetic flux Φ through a plane of area A in uniform B is given by:

(a) Φ = B + A

(b) Φ = B · A ✅

(c) Φ = B / A

(d) $\Phi = B \times I$

7. Ampere's circuital law states:

(a) $\sum B.L = \mu_0 * I$ ✅

(b) $\sum B.A = \mu_0 * I$

(c) $\sum I.L = B * \mu_0$

(d) $\sum F = B * L$

8. Force on a moving charge in magnetic field is:

(a) $F = qE$

(b) $F = q(v \times B)$ ✅

(c) $F = B/I$

(d) $F = I \times B$

9. A Cathode Ray Oscilloscope (CRO) is used for:

(a) Measuring resistance

(b) Measuring current

(c) Displaying waveform of voltage ✅

(d) Measuring capacitance

10. CRO works by deflecting:

(a) Protons

(b) Electrons ✅

(c) Neutrons

(d) Ions

11. Torque on a current-carrying coil in magnetic field is:

(a) $\tau = ILB$

(b) $\tau = IBA \cos \alpha$ ✅

(c) $\tau = BIL \sin \theta$

(d) $\tau = qvB$

12. A galvanometer detects:

(a) Voltage

(b) Current ✅

(c) Resistance

(d) Capacitance

13. A galvanometer is converted into an ammeter by:

(a) Connecting high resistance in series

(b) Connecting low resistance in parallel (shunt) ✅

(c) Increasing magnetic field

(d) Decreasing number of turns

14. A galvanometer is converted into a voltmeter by:

(a) Connecting low resistance in parallel

(b) Connecting high resistance in series ✅

(c) Connecting battery

(d) Using shunt resistor

15. In a galvanometer, the coil rotates due to:

(a) Electric field only

(b) Magnetic torque acting on current-carrying coil ✅

(c) Weight of coil

(d) Resistance of coil

🩸 Important MCQs:

1. When a heavy current is passed through a vertical wire, the compass needles around it:

(a) Point N-S direction

(b) Remain fixed

(c) Set themselves tangential to a circle ✅

(d) Point E-W direction

2. The lines of force around a current-carrying straight wire are:

(a) Straight

(b) Elliptical

(c) Circular ✅

(d) Parabolic

3. The direction of magnetic field around a current-carrying wire depends on:

(a) Thickness of wire

(b) Length of wire

(c) Direction of current ✅

(d) Resistance of wire

4. A magnetic field exists around a current-carrying conductor:

(a) Even if current is zero

(b) Only as long as current flows ✅

(c) Only when conductor is long

(d) Only in a vacuum

5. The rule used to find the direction of magnetic field around a straight wire is:

(a) Left-hand rule

(b) Fleming’s rule

(c) Right-hand rule ✅

(d) Ampere’s rule

6. According to the right-hand rule, the thumb represents:

(a) Magnetic field direction

(b) Force direction

(c) Direction of current ✅

(d) Direction of voltage

7. When a current-carrying conductor is placed in an external magnetic field, it experiences:

(a) No effect

(b) A force ✅

(c) Heating only

(d) Electric field

8. The force on a conductor is maximum when it is placed:

(a) Parallel to the field

(b) At 45° to the field

(c) At 90° to the field ✅

(d) Any angle

9. The force on a conductor is zero when it is placed:

(a) Parallel to the field ✅

(b) At 45° to the field

(c) At 90° to the field

(d) Any angle

10. The force on a current-carrying conductor is directly proportional to:

(a) Current ✅

(b) Mass of conductor

(c) Voltage only

(d) Temperature

11. The force on a current-carrying conductor is also proportional to:

(a) Magnetic field strength ✅

(b) Resistance

(c) Voltage

(d) Wire color

12. The force on a conductor is also proportional to:

(a) Temperature

(b) Length of conductor in field ✅

(c) Type of material

(d) Thickness of wire

13. SI unit of magnetic field (B) is:

(a) Weber

(b) Tesla ✅

(c) Henry

(d) Gauss

14. 1 Tesla is equal to:

(a) 1 $N \cdot A^{-1} \cdot m^{-1}$ ✅

(b) 1 $J \cdot m^{-1}$

(c) 1 $Wb \cdot m^{-2}$

(d) 1 $A \cdot m$

15. According to $F = ILB \sin\theta$, the force is zero when:

(a) $\theta = 0°$ ✅

(b) $\theta = 30°$

(c) $\theta = 90°$

(d) $\theta = 45°$

16. The direction of force on a current-carrying conductor is given by:

(a) Right-hand thumb rule

(b) Right-hand rule of vector product ✅

(c) Coulomb's law

(d) Lenz's law

17. A current flowing towards the reader is represented by:

(a) Cross (×)

(b) Dot (•) ✅

(c) Arrow

(d) Plus (+)

18. A current flowing away from the reader is represented by:

(a) Cross (×) ✅

(b) Dot (•)

(c) Arrow

(d) Minus (-)

19. The conductor in a magnetic field moves towards:

(a) Stronger part of field

(b) Weaker part of field ✅

(c) Neutral field

(d) Any direction

20. The vector formula for force on a current-carrying conductor is:

(a) F = I × L

(b) F = I L B sinθ ✅

(c) F = B × L

(d) F = IL

21. Magnetic flux (ΦB) through a plane area A in a uniform magnetic field B is given by:

(a) ΦB = B + A

(b) $\Phi B = B \times A \times \sin\theta$

(c) $\Phi B = B \cdot A$ ✅

(d) $\Phi B = B / A$

22. Magnetic flux is maximum when:

(a) Field is perpendicular to area ✅

(b) Field is parallel to area

(c) Field is zero

(d) Area is zero

23. Magnetic flux through a surface is zero when:

(a) Field is perpendicular to area

(b) Field is parallel to area ✅

(c) Field is strong

(d) Area is large

24. The unit of magnetic flux is:

(a) Tesla

(b) Weber ✅

(c) Henry

(d) Ampere

25. Magnetic flux density (B) is also called:

(a) Magnetic induction ✅

(b) Magnetic current

(c) Magnetic resistance

(d) Magnetic potential

26. The unit of magnetic flux density (B) is:

(a) Wb/m^2 ✅

(b) Wb/m^3

(c) Tesla²

(d) N·A⁻¹

27. Magnetic flux through a curved surface is calculated by:

(a) Considering the whole area as single plane

(b) Dividing the surface into small plane elements ✅

(c) Multiplying B with total volume

(d) Using only the largest element

28. Ampere's circuital law relates:

(a) Magnetic field and resistance

(b) Magnetic flux density along a path and current enclosed ✅

(c) Electric flux and voltage

(d) Force and area

29. In Ampere's law, μ_0 represents:

(a) Permeability of free space ✅

(b) Magnetic flux

(c) Current density

(d) Magnetic potential

30. The value of μ_0 in SI units is:

(a) $4\pi \times 10^{-6}$ H/m

(b) $4\pi \times 10^{-7}$ $Wb \cdot A^{-1} \cdot m^{-1}$ ✅

(c) 10^{-7} T

(d) $4\pi \times 10^{-8}$ N/A^2

31. In a long solenoid, the magnetic field inside is:

(a) Uniform and strong ✅

(b) Weak and negligible

(c) Zero

(d) Non-uniform

32. Outside a long solenoid, the magnetic field is:

(a) Strong

(b) Uniform

(c) Very weak and can be neglected ✅

(d) Equal to inside field

33. Magnetic field inside a solenoid is given by:

(a) $B = \mu_0 I / n$

(b) $B = \mu_0 n I$ ✅

(c) $B = \mu_0 I n^2$

(d) $B = \mu_0 / n I$

34. Right-hand grip rule for solenoid states:

(a) Thumb points opposite to current

(b) Thumb points along axis in direction of field ✅

(c) Fingers point along axis

(d) Palm gives field direction

35. The total current enclosed by a solenoid with n turns per unit length, length l, and current I is:

(a) I

(b) n I

(c) n × l × I ✅

(d) I / n

36. The force on a moving charge q in a magnetic field B with velocity v is given by:

(a) F = qv

(b) F = qvB ✅

(c) F = qE

(d) F = qE + qv

37. The force on a moving positive charge in a magnetic field is:

(a) Opposite to vector v × B

(b) In the direction of v × B ✅

(c) Along the velocity

(d) Along the field

38. The force on a moving negative charge in a magnetic field is:

(a) Same as positive charge

(b) Opposite to the direction of v × B ✅

(c) Along velocity

(d) Zero

39. Magnetic force on a charge is maximum when:

(a) Velocity is parallel to field

(b) Velocity is at 45° to field

(c) Velocity is perpendicular to field ✅

(d) Velocity is zero

40. Magnetic force on a charge is zero when:

(a) Velocity is perpendicular to field

(b) Velocity is parallel to field ✅

(c) Charge is negative

(d) Velocity is constant

41. The relation between current I and motion of charges in a conductor is:

(a) I = nqvA ✅

(b) I = nALq

(c) I = qv

(d) I = Bv

Formula:

I = n q v A

42. Force on a small segment of current-carrying conductor:

(a) F = IL

(b) F = ILB ✅

(c) F = qvB

(d) F = qE

43. For a single moving charge in magnetic field:

(a) F = ILB

(b) F = qvB ✅

(c) F = qv sinθ

(d) F = qE

44. The direction of force on a moving charge in a magnetic field is given by:

(a) Left-hand rule

(b) Right-hand rule ✅

(c) Fleming’s rule

(d) Ampere’s rule

45. Lorentz force is the total force on a moving charge in:

(a) Electric field only

(b) Magnetic field only

(c) Both electric and magnetic fields ✅

(d) None

Formula:

F = q **E** + q (**v** × **B**)

46. Magnetic force does:

(a) Work on moving charge

(b) No work, only deflects charge ✅

(c) Accelerates charge along field

(d) Increases charge magnitude

47. Electric force on a charge q in electric field E is:

(a) F = qv

(b) F = qE ✅

(c) F = qvB

(d) F = qE + qv

48. Acceleration of a particle in electric field:

(a) a = qB/m

(b) a = qE/m ✅

(c) a = vB/m

(d) a = I/m

49. Motion of electron in uniform magnetic field perpendicular to velocity:

(a) Linear motion

(b) Circular motion ✅

(c) Helical motion

(d) Random motion

50. Magnetic force provides centripetal force for electron motion:

(a) $evB = m v^2/r$ ✅

(b) $evB = mv/r$

(c) ev = B

(d) F = m v B

51. Charge to mass ratio (e/m) of electron is given by:

(a) $e/m = v/(B r)$ ✅

(b) $e/m = v B r$

(c) $e/m = v^2/(B r)$

(d) $e/m = 2V/(B^2 r^2)$

52. Velocity of electron accelerated through potential difference V:

(a) $v = Ve/m$

(b) $v = \sqrt{2Ve/m}$ ✅

(c) $v = V/m$

(d) $v = \sqrt{V/m}$

53. Charge to mass ratio of electron using radius r of circular path:

(a) $e/m = v/(Br)$ ✅

(b) $e/m = Bv/r$

(c) $e/m = Br/v$

(d) $e/m = v^2/(Br)$

54. Using potential difference V and radius r, e/m is:

(a) $e/m = V/(B^2 r^2)$

(b) $e/m = 2V/(B^2 r^2)$ ✅

(c) $e/m = V^2/(2B^2 r^2)$

(d) $e/m = B^2 r^2 /2V$

55. The magnetic force on electron in perpendicular field is always:

(a) Along velocity

(b) Opposite to velocity

(c) Perpendicular to both velocity and field ✅

(d) Zero

56. Cathode ray oscilloscope (CRO) **primarily works on:**

(a) Deflection of light

(b) Deflection of electrons ✅

(c) Magnetic induction

(d) Sound waves

57. The electron beam in a CRO is produced by:

(a) Anode

(b) Cathode ✅

(c) Grid

(d) Fluorescent screen

58. In CRO, horizontal deflection of the electron beam is due to:

(a) Voltage applied across y-plates

(b) Voltage applied across x-plates ✅

(c) Magnetic field

(d) Grid voltage

59. Vertical deflection of the beam on CRO screen is caused by:

(a) Voltage across x-plates

(b) Voltage across y-plates ✅

(c) Current through cathode

(d) Time base generator

60. The voltage applied to x-plates of CRO is called:

(a) Synchronization voltage

(b) Saw tooth or time base voltage ✅

(c) AC mains voltage

(d) Grid voltage

61. CRO can be used to measure:

(a) Voltage

(b) Frequency

(c) Phase difference

(d) All of the above ✅

62. For stationary waveform display on CRO, the time period T of sweep voltage should be:

(a) Shorter than waveform period

(b) Longer than waveform period

(c) Equal to or multiple of waveform period ✅

(d) Half of waveform period

63. Torque on a rectangular current-carrying coil in uniform magnetic field is maximum when:

(a) Plane of coil is parallel to field

(b) Plane of coil is perpendicular to field ✅

(c) Current is zero

(d) Field is zero

Formula:

$\tau = I B A \sin\theta$

64. Torque on a coil when magnetic field makes angle α with plane of coil:

(a) $\tau = IBA \sin\alpha$

(b) $\tau = IBA \cos\alpha$ ✅

(c) $\tau = ILB \sin\alpha$

(d) $\tau = ILB \cos \alpha$

65. The forces on sides of coil parallel to magnetic field are:

(a) Maximum

(b) Zero ✅

(c) Depends on current

(d) Depends on coil area

66. A galvanometer works on the principle of:

(a) Ohm's law

(b) Magnetic effect of current ✅

(c) Electric field effect

(d) Capacitive effect

67. Torque on a current-carrying coil in a galvanometer is given by:

(a) τ = IBA sin α

(b) τ = NIBA cos α ✅

(c) τ = ILB sin θ

(d) τ = IB sin θ

68. In a radial magnetic field of a galvanometer, the angle α is:

(a) 90°

(b) 45°

(c) 0° ✅

(d) 180°

69. In a moving coil galvanometer, restoring torque is provided by:

(a) Magnetic field

(b) Torsion of suspension wire ✅

(c) Weight of coil

(d) Coil current

70. To increase the sensitivity of a galvanometer, one can:

(a) Decrease N (number of turns)

(b) Increase c (torsional constant)

(c) Increase B, A, or N ✅

(d) Decrease magnetic field

Formula for sensitivity:

$\theta \propto I$, $\theta = (N I B A) / c$

71. A galvanometer that comes to rest quickly after current is applied is called:

(a) Stable or dead-beat galvanometer ✅

(b) Moving iron galvanometer

(c) Suspension coil galvanometer

(d) Radial coil galvanometer

72. An ammeter is basically a galvanometer with:

(a) High series resistance

(b) Low parallel shunt resistor ✅

(c) No resistance

(d) High magnetic field

73. Shunt resistance R required to convert a galvanometer into an ammeter is:

(a) R = Ig/(I - Ig) * Rg ✅

(b) R = (I - Ig)/Ig * Rg

(c) R = I*Rg

(d) R = Ig * I

74. A voltmeter is made by connecting a high resistance:

(a) In parallel with galvanometer ✅

(b) In series with galvanometer

(c) Across the battery

(d) Across shunt

75. Series resistance for voltmeter is calculated by:

(a) Rh = V/Ig - Rg ✅

(b) Rh = Ig * Rg

(c) Rh = V * Ig

(d) Rh = V + Rg

76. Ohmmeter measures resistance by:

(a) Measuring current only

(b) Using a galvanometer with series resistance and battery ✅

(c) Using shunt resistor only

(d) Using voltage only

77. In an ohmmeter, zero on the scale corresponds to:

(a) Infinite resistance

(b) Zero resistance ✅

(c) Maximum voltage

(d) Maximum current

78. In an ohmmeter, infinite resistance is indicated when:

(a) Terminals are shorted

(b) Terminals are open ✅

(c) Current flows fully

(d) Voltage is zero

79. AVO meter can measure:

(a) Current

(b) Voltage

(c) Resistance

(d) All of the above ✅

80. Voltage measuring part of an AVO meter consists of:

(a) Low parallel resistances

(b) Series high resistances ✅

(c) Only galvanometer

(d) Shunt resistor

81. Current measuring part of an AVO meter consists of:

(a) Series high resistances

(b) Low parallel resistances ✅

(c) Shunt resistances in series

(d) Battery

82. Resistance measuring part of an AVO meter is basically:

(a) Multirange voltmeter

(b) Multirange ohmmeter ✅

(c) Multirange ammeter

(d) Digital multimeter

83. Before measuring unknown resistance with an ohmmeter, the meter should be:

(a) Disconnected from circuit

(b) Zeroed ✅

(c) Set to maximum range

(d) Heated

84. Full-scale deflection current of a galvanometer is:

(a) Maximum current it can measure ✅

(b) Zero current

(c) Minimum current

(d) Infinite current

85. Digital multimeter (DMM) measures:

(a) Only AC voltage

(b) Only DC current

(c) Resistance, current, voltage ✅

(d) Magnetic field

86. Advantages of DMM over analog AVO meter include:

(a) Eliminates human reading errors

(b) Displays digital values with units

(c) Shows polarity

(d) All of the above ✅

87. Series resistance in voltmeter is used to:

(a) Increase current

(b) Limit current ✅

(c) Reduce voltage

(d) Increase deflection

88. Shunt resistance in ammeter is used to:

(a) Increase deflection

(b) Bypass excess current ✅

(c) Reduce resistance of galvanometer

(d) Increase voltage

89. Sensitivity of a galvanometer depends upon:

(a) N, B, A and c ✅

(b) Only N

(c) Only B

(d) Only A

90. Stable galvanometer is preferred in experiments because:

(a) It has high current range

(b) It comes to rest quickly ✅

(c) It has low magnetic field

(d) It has zero resistance

🩸 Important Short Questions (From Key Points)

1. What is produced around a current-carrying conductor?

Answer:

👉 A magnetic field is produced around a current-carrying conductor.

2. State the right-hand rule for finding the direction of magnetic field.

Answer:

👉 If the wire is grasped in the right hand with the thumb showing the direction of current, the fingers curl in the direction of the magnetic field.

3. Define magnetic field strength or magnetic induction.

Answer:

👉 It is the force acting on one metre length of a conductor placed at right angle to the magnetic field when 1 ampere current flows through it.

4. What is meant by one tesla?

Answer:

👉 One tesla is the magnetic field strength that exerts a force of one newton on one metre length of a conductor carrying one ampere current placed perpendicular to the field.

5. Write the formula for magnetic flux.

Answer:

👉 Magnetic flux is given by the formula: $\Phi = B \cdot A$.

6. State Ampere's circuital law.

Answer:

👉 The sum of $B \cdot \Delta l$ around a closed loop is equal to μ_0 times the total current enclosed by the loop.

7. Write the expression for the force on a moving charge in a magnetic field.

Answer:

👉 The force on a moving charge is given by: $F = q(v \times B)$.

8. What is a CRO and how does it work?

Answer:

👉 A CRO (Cathode Ray Oscilloscope) is a high-speed graph-plotting device that works by deflecting an electron beam between two sets of parallel plates.

9. Why does a current-carrying coil experience torque in a magnetic field?

Answer:

👉 A current-carrying coil experiences torque because magnetic forces act on opposite sides of the coil, causing it to rotate.

10. How is a galvanometer converted into an ammeter and a voltmeter?

Answer:

👉 A galvanometer is converted into an ammeter by connecting a low resistance (shunt) in parallel.

👉 It is converted into a voltmeter by connecting a high resistance in series.

🩸 Important Short Questions:

1. What is the shape of magnetic field lines around a long straight current-carrying wire?

Answer:

👉 The magnetic field lines around a straight current-carrying wire are circular with the wire at the centre.

2. State the right-hand rule for finding the direction of magnetic field around a straight conductor.

Answer:

👉 If the wire is held in the right hand with the thumb pointing in the direction of current, the curled fingers show the direction of the magnetic field.

3. What happens to a compass needle placed near a current-carrying straight wire?

Answer:

👉 The compass needle deflects and sets itself tangential to the circular magnetic field around the wire. When current is stopped, it returns to N-S direction.

4. On which factors does the force on a current-carrying conductor in a magnetic field depend?

Answer:

👉 **The force depends on:**

1. Current in the conductor (I)

2. Length of conductor (L)

3. Magnetic field strength (B)

4. Angle between conductor and magnetic field (α)

5. When is the force on a current-carrying conductor maximum and when is it zero?

Answer:

👉 The force is maximum when the conductor is at 90° (right angle) to the magnetic field.

👉 The force is zero when the conductor is parallel to the magnetic field.

6. Write the formula for magnetic flux through a plane area and define the terms.

Answer:

👉 Magnetic flux through a plane area is given by: $\Phi = B \cdot A = BA \cos \theta$, where B is the magnetic flux density, A is the area vector perpendicular to the surface, and θ is the angle between B and the normal to the area.

7. When is the magnetic flux through a surface maximum and when is it zero?

Answer:

👉 The flux is maximum when the magnetic field is along the normal to the surface ($\theta = 0°$).

👉 The flux is zero when the magnetic field is parallel to the surface ($\theta = 90°$).

8. Define magnetic flux density (magnetic induction) and its SI unit.

Answer:

👉 Magnetic flux density (B) is the magnetic flux per unit area perpendicular to the magnetic field.

👉 Its SI unit is weber per square metre (Wb/m^2) or tesla (T).

9. State Ampere's circuital law.

Answer:

👉 **Ampere's circuital law states:**

"The sum of B · ΔL around a closed path is equal to μ_0 times the total current enclosed by the path."

Mathematically: $\Sigma (B \cdot \Delta L) = \mu_0 I$

10. Write the formula for the magnetic field inside a long solenoid and state the rule for its direction.

Answer:

👉 The magnetic field inside a long solenoid is: $B = \mu_0 n I$,

where n is the number of turns per unit length and I is the current.

👉 Its direction is given by the right-hand grip rule: curl the fingers along the current in the coils, the thumb points in the direction of the magnetic field.

11. How is the force on a moving charge in a magnetic field calculated?

Answer:

👉 The magnetic field exerts a force on moving charges, causing the conductor carrying current to experience a force. The force depends on the charge, its velocity, and the magnetic field.

12. Write the expression for the force on a single charge moving with velocity v in a magnetic field B.

Answer:

👉 $F = q (v \times B)$,

where q is the charge, v is the velocity, and B is the magnetic field.

13. When is the magnetic force on a moving charge maximum and when is it zero?

Answer:

👉 Maximum when the velocity is perpendicular to the magnetic field (θ = 90°).

👉 Zero when the velocity is parallel to the magnetic field (θ = 0°).

14. What is the direction of force on a moving positive charge in a magnetic field?

Answer:

👉 The direction is given by the vector v × B. Rotate v towards B through the smaller angle, curl the fingers of the right hand in the direction of rotation, thumb points in the force direction.

15. What is the direction of force on a moving negative charge in a magnetic field?

Answer:

👉 The force is opposite to that on a positive charge. For an electron, the direction is opposite to v × B.

16. Write the formula for the force experienced by a charge in an electric field.

Answer:

👉 F = qE, where q is the charge and E is the electric field.

17. What is the acceleration of a charge q of mass m in a uniform electric field E?

Answer:

👉 a = F/m = qE/m

18. Define Lorentz force. Write its formula.

Answer:

👉 Lorentz force is the total force on a charge moving in electric and magnetic fields.

👉 **Formula**: $F = qE + q(v \times B)$

19. How does a charged particle move when projected perpendicular to a uniform magnetic field?

Answer:

👉 It moves along a circular path because the magnetic force acts as a centripetal force, perpendicular to the velocity, keeping the speed constant.

20. How can the charge-to-mass ratio (e/m) of an electron be determined using a magnetic field?

Answer:

👉 By projecting electrons perpendicular to a magnetic field and measuring the radius r of their circular path:

$e/m = v / (B r)$,

where v is the velocity of electrons. If electrons are accelerated through potential difference V, $v = \sqrt{2Ve/m}$ and $e/m = 2V / (B^2 r^2)$.

21. What is a Cathode Ray Oscilloscope (CRO)?

Answer:

👉 CRO is a versatile electronic instrument and a high-speed graph plotting device. It works by deflecting a beam of electrons through a uniform electric field to display voltage waveforms on a fluorescent screen.

22. How does the electron beam in a CRO get deflected?

Answer:

👉 The electron beam is deflected by two sets of parallel plates:

- **x-plates:** Deflect the beam horizontally (along x-axis).
- **y-plates:** Deflect the beam vertically (along y-axis).

The beam is provided by an electron gun, consisting of a heated cathode, grid, and anodes which accelerate and focus the beam.

23. What is the function of x and y deflection plates in a CRO?

Answer:

- 👉 **x-plates:** Produce horizontal deflection, controlled by the time-base generator.
- 👉 **y-plates:** Produce vertical deflection, proportional to the applied voltage.

This allows plotting of voltage vs. time on the screen.

24. List the main uses of a CRO.

Answer:

1. Display the waveform of voltages.

2. Measure voltage magnitude and frequency.

3. Determine phase difference between two voltages.

4. Study instantaneous and peak values of voltages.

25. Write the formula for torque on a current carrying rectangular coil in a magnetic field.

Answer:

👉 $\tau = I B A \cos \alpha$

Where:

I = current in the coil

B = magnetic field

A = area of the coil

α = angle between the plane of the coil and magnetic field

26. What is a galvanometer?

Answer:

👉 An electrical instrument used to detect the passage of current through a coil in a magnetic field.

27. What causes the deflection of a coil in a galvanometer?

Answer:

👉 The deflecting couple (torque) produced by the magnetic field on the current-carrying coil.

28. Write the formula for deflecting torque in a galvanometer.

Answer:

$\tau = N\, I\, B\, A \cos \alpha$

29. What is restoring torque in a galvanometer?

Answer:

👉 Torque produced by the suspension wire or springs that tries to bring the coil back to its original position.

30. How is the sensitivity of a galvanometer increased?

Answer:

👉 By increasing N (number of turns), B (magnetic field), A (area of coil), or by decreasing the torsional constant c of the suspension wire.

31. What is a dead beat galvanometer?

Answer:

👉 A galvanometer in which the coil comes to rest quickly after the current is applied or stopped.

32. How is a galvanometer converted into an ammeter?

Answer:

👉 By connecting a low-value shunt resistor in parallel so most current bypasses the galvanometer.

33. How is a galvanometer converted into a voltmeter?

Answer:

👉 By connecting a high-value series resistor with the galvanometer so it can measure potential difference without drawing significant current.

34. What is an ohmmeter?

Answer:

👉 A device for measuring resistance, consisting of a galvanometer, series resistor, and a battery.

35. How is an ohmmeter calibrated?

Answer:

👉 By adjusting the series resistance so that the galvanometer shows full-scale deflection when terminals are short-circuited (R = 0).

36. What is an AVO meter (multimeter)?

Answer:

👉 An instrument that can measure current, voltage, and resistance using a single moving coil galvanometer with different circuits.

37. How does an AVO meter measure AC voltage?

Answer:

👉 AC voltage is first converted to DC using a diode rectifier, then measured like DC voltage.

38. What is the role of the function switch in an AVO meter?

Answer:

👉 It connects the galvanometer to the appropriate measuring circuit (voltage, current, or resistance).

39. What is the purpose of a range selection switch in an AVO meter?

Answer:

👉 To select the desired range for voltage, current, or resistance measurement.

40. What is a digital multimeter (DMM)?

Answer:

👉 A digital version of an AVO meter that shows readings of voltage, current, and resistance on a digital display, reducing human reading errors.

🩸 Important long questions:

🌟 Q.1 Explain the magnetic field produced by a current in a long straight wire

❖ **Answer:**

When an electric current flows through a long straight wire, it generates a magnetic field around the wire. This magnetic field exists in the space surrounding the wire and forms concentric circles around it. The direction of the field depends on the direction of the current.

Experiment to Demonstrate

1. Take a long straight copper wire and pass it vertically through a horizontal piece of cardboard.

2. Place small compass needles on the cardboard along a circle whose center is the wire.

3. Observations:

Without current: All compass needles point along the north-south direction.

With current: The needles deflect and align tangentially to imaginary circles around the wire.

Reversing current: The direction of deflection is reversed.

Stopping current: Needles return to their original N-S direction.

Conclusions from the Experiment

1. A magnetic field is present around a current-carrying conductor.

2. The field lines are circular, concentric around the wire.

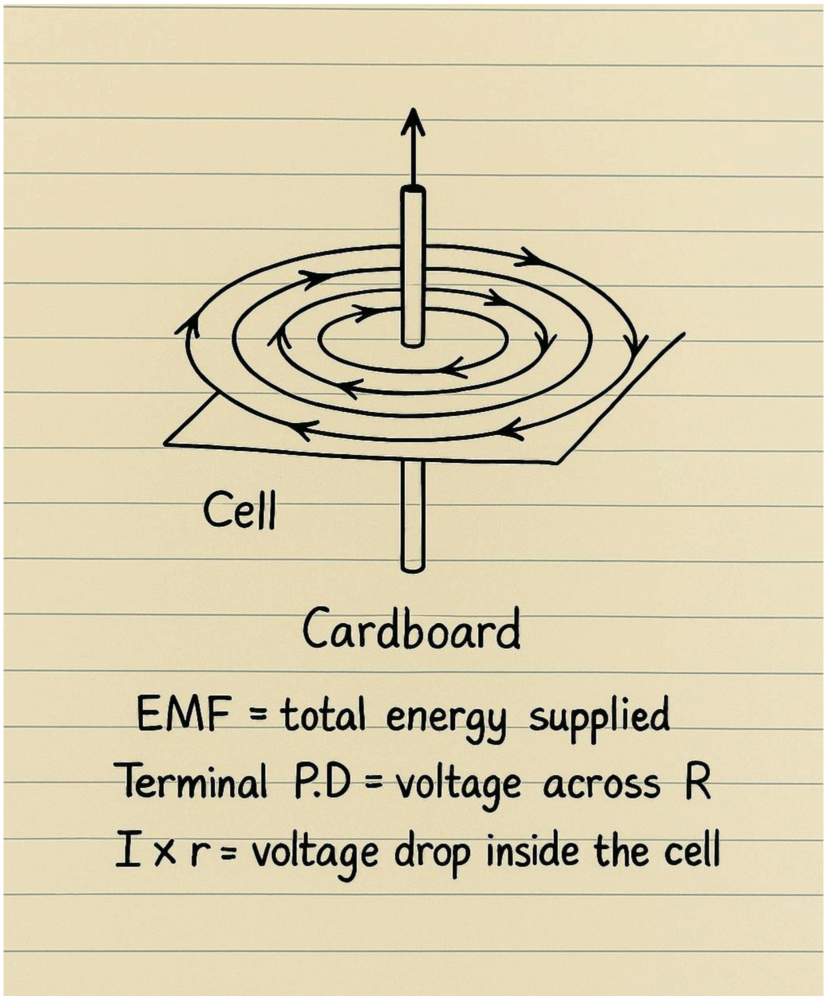
3. The direction of the magnetic field depends on the direction of current.

4. The magnetic field exists only when current is flowing.

- Right-Hand Rule (to determine the direction of the magnetic field)
- If the wire is held in the right hand with the thumb pointing in the direction of current, the curl of the fingers shows the direction of the magnetic field lines around the wire.

- This is a simple and reliable way to determine the field direction in all straight current-carrying conductors.

✦ **Digram:**



✅ Key Points to Remember for Exams:

- Magnetic field is stronger near the wire and weakens as you move away.
- Field is tangential to circles around the wire.

- Reversing current reverses the direction of magnetic field.
- Right-hand rule is used to find field direction.

🌟 **Q.2 Explain the force on a current-carrying conductor in a uniform magnetic field.**

❖ **Answer:**

A current-carrying conductor produces its own magnetic field. When it is placed in an external magnetic field, the interaction of the two fields produces a force on the conductor.

Experiment:

- Place a copper rod on a pair of rails between the poles of a horseshoe magnet.
- Pass a current through the rod from a battery.
- The rod moves along the rails.

Observations and Direction:

- The force is always perpendicular to both the conductor and the magnetic field.

Direction of force can be found using the right-hand rule:

- Vector L along the current, vector B along the magnetic field, thumb points in the direction of force F.

Magnitude of Force:

$F \propto I$

$F \propto L$

$F \propto B$

$F \propto \sin(\alpha)$

Combining all factors:

$F = I * L * B * \sin(\alpha)$

Where:

- F = force on the conductor (N)
- I = current (A)

- L = length of conductor in the field (m)
- B = magnetic field strength (T)
- α = angle between conductor and magnetic field

Definition of Magnetic Field Strength (B):

1 T = 1 N / (1 A * 1 m)

A magnetic field of 1 tesla exerts a force of 1 newton on a conductor of 1 m length carrying 1 A current, placed perpendicular to the field.

Direction of Force (Extended Right-Hand Rule):

- Current towards the reader: dot (•)
- Current away from reader: cross (×)

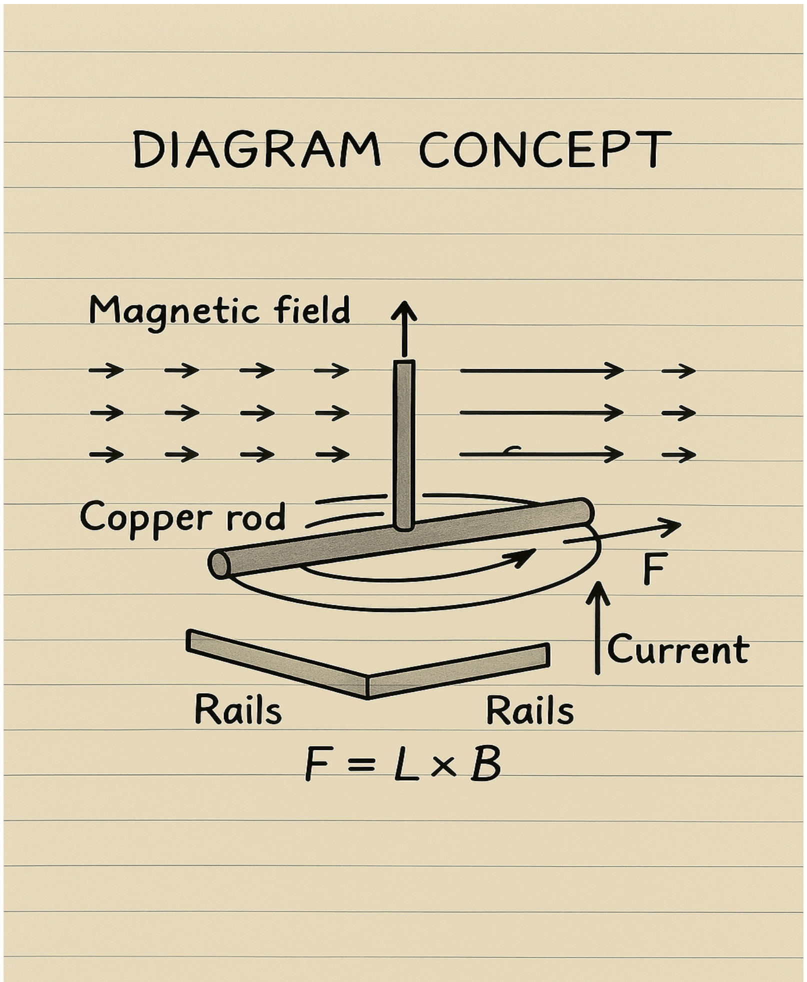
The conductor experiences force towards the weaker side of the combined magnetic fields.

Vector Form:

- F = I * (L × B)
- L = vector along current

- B = vector along magnetic field
- F = vector perpendicular to both L and B

✦ **Diagram:**



✦ Keypoints:

- Copper rod placed on rails in magnetic field.
- Current flows along the rod.
- Magnetic field is perpendicular to the plane.

Force (F) acts on rod:

F= L*B

- Direction of F given by right-hand rule.

🌟 **Q3. Explain magnetic flux and flux density. Give its unit and explain with an example.**

❖ **Answer:**

Magnetic Flux (Φ):

Magnetic flux is the total magnetic field passing through a surface.

For a plane surface in a uniform magnetic field:

$\Phi_B = B \cdot A = B * A * \cos(\theta)$

Where:

- B = magnetic flux density (T)
- A = area of the surface (m^2)

- θ = angle between B and the normal to the surface

Special Cases:

1. If the field is along the normal (θ = 0°):

Φ = B * A (maximum flux)

2. If the field is parallel to the surface (θ = 90°):

Φ = 0

For curved or non-uniform surfaces, divide the surface into small elements and sum their contributions:

Φ = Σ (B · ΔA)

Unit of Magnetic Flux:

Weber (Wb)

Magnetic Flux Density (B):

Magnetic flux density (magnetic induction) is the flux per unit area perpendicular to the field:

$B = \Phi / A$

Unit of B: Wb/m^2 or Tesla (T)

Example:

- **Loop area:** $A = 5.0\ cm^2 = 5 \times 10^{-4}\ m^2$
- **Magnetic field:** $B = (40i - 18k)\ Wb/m^2$

Only z-component contributes along the normal:

$B_z = -18\ Wb/m^2$

Magnetic flux through the loop:

$\Phi = B_z \times A = (-18) \times (5 \times 10^{-4}) = -9 \times 10^{-3}\ Wb$

- The negative sign indicates direction opposite to chosen normal.

✦ Summary:

- Magnetic flux (Φ) = total field through a surface
- Flux density (B) = flux per unit area
- **Units**: Φ in Weber (Wb), B in Tesla (T)

🌟 Q4. State and explain Ampere's circuital law. How is it applied to find magnetic field in a solenoid?

❖ Answer:

Ampere's Circuital Law:

The sum of B · ΔL around a closed path is equal to the permeability of free space times the total current enclosed by the path:

$$\Sigma (\mathbf{B} \cdot \Delta \mathbf{L}) = \mu_0 I_{enclosed}$$

Where:

- μ_0 = permeability of free space = $4\pi \times 10^{-7}$ Wb A^{-1} m^{-1}
- $I_{enclosed}$ = total current passing through the area enclosed by the path

This law relates the magnetic field around a closed loop to the current passing through the loop.

Application to Solenoid:

1. Consider a long solenoid with:

- n = number of turns per unit length
- I = current through each turn

2. Choose a rectangular Amperean loop along the axis of the solenoid.

3. Evaluate B · ΔL along the loop:

Inside solenoid: B is parallel to the element →

$(B \cdot \Delta L)\_{inside} = B * l_1$

Outside solenoid: B ≈ 0 →

$(B \cdot \Delta L)\_{outside} = 0$

4. Total current enclosed by the loop:

$I_{enclosed} = n * l_1 * I$

5. Apply Ampere's law:

- $B * l_1 = \mu_0 * n * l_1 * I$

6. Solve for B:

$B = \mu_0 * n * I$

Direction of B: Along the axis of the solenoid. Determined by right-hand grip rule: curl fingers in direction of current; thumb points along B.

Example:

- Solenoid length = 15.0 cm = 0.15 m
- Number of turns = 300
- Current I = 5.0 A

Number of turns per unit length:

- n = 300 / 0.15 = 2000 turns/m

Magnetic field inside solenoid:

$B = \mu_0 n I = (4\pi \times 10^{-7}) \times 2000 \times 5 \approx 1.26 \times 10^{-2}$ T

🌟 **Q.5 Explain the force on a moving charge in a magnetic field. Derive the formula.**

Force on a Moving Charge in a Magnetic Field

When a current flows through a conductor, it is due to the motion of electric charges. A magnetic field exerts a force on these moving charges, which in turn results in a force on the conductor.

Consider a conductor segment

Let a conductor have:

- Length = L
- Cross-sectional area = A
- Charge carriers per unit volume = n

- Charge of each carrier = q
- Velocity of carriers = v

✦ Derivation of Force

1. Number of charges in the segment:

- Number of charge carriers = $n \times A \times L$

2. Charge transported through area A in time Δt:

- $\Delta Q = n \times A \times L \times q$

Time taken for charges to cross the segment:

$\Delta t = L / v$

Current through the conductor:

$I = \Delta Q / \Delta t = (n \times A \times L \times q) / (L / v) = n \times A \times q \times v$

Force on the conductor segment of length L in a magnetic field B:

$F_L = I \times (L \times B)$

Substitute $I = n \times A \times q \times v$:

$F_L = n \times A \times q \times (v \times L \times B)$

Force on a single charge carrier:

$F = F_L / (n \times A \times L) = q \times (v \times B)$

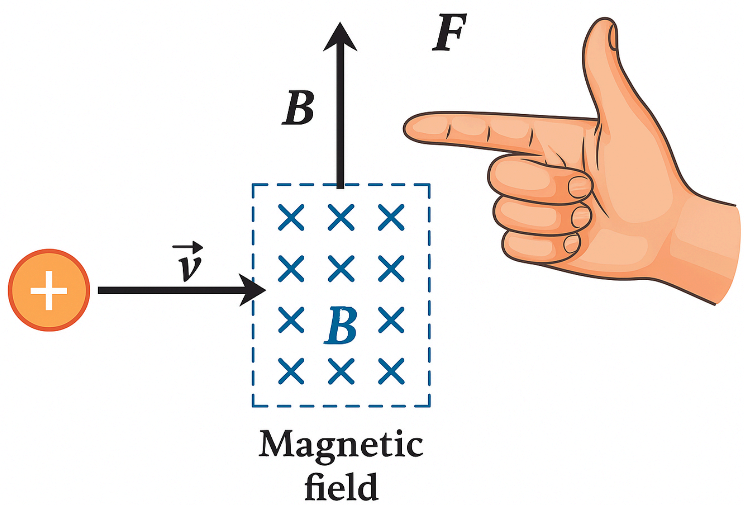
Magnitude of Force:

Condition	Force Magnitude
$\theta = 90°$ ($v \perp B$)	Maximum: $F = qvB$
$\theta = 0°$ ($v \parallel B$)	Zero: $F = 0$
General angle θ	$F = qvB \sin\theta$

Here, θ is the angle between the velocity vector v and magnetic field B.

✦ Direction of Force

Use Right-Hand Rule:



1. Fingers point in the direction of velocity v

2. Curl fingers toward the magnetic field B

3. Thumb points along the direction of force F (for positive charges)

For negative charges (electrons), the force is in the opposite direction.

Example:

- A proton moving into a magnetic field is deflected upward.
- An electron moving into the same field is deflected downward.

🌟 **Q.6 Explain the motion of a charged particle in electric and magnetic fields. Define Lorentz force**.

- Motion of a Charged Particle in Electric and Magnetic Fields
- A charged particle experiences forces when placed in electric and magnetic fields. The nature of its motion depends on the type of field present.

1. Motion in an Electric Field

If a particle of charge q is placed in a uniform electric field E, it experiences a force F along the direction of the field:

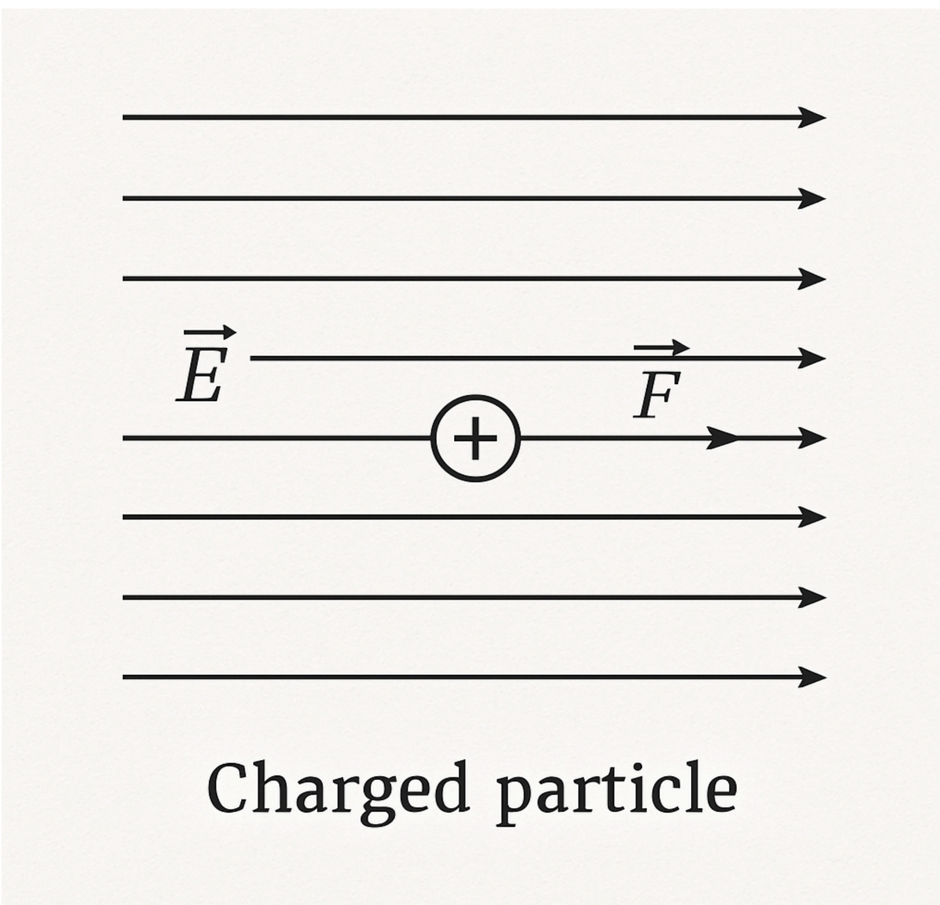
$F = q E$

If the particle is free to move, it accelerates according to Newton's second law:

$a = F / m = (q E) / m$

- Since the electric field is uniform, the acceleration is constant, and the particle moves with uniformly accelerated motion.
- Its displacement and velocity at any instant can be calculated using the standard kinematic equations.

Diagram:



2. Motion in a Magnetic Field

When a particle with charge q moves with velocity v in a magnetic field B, it experiences a magnetic force perpendicular to both v and B:

$$F = q\,(v \times B)$$

Magnitude:

$$F = q\,v\,B\sin\theta$$

where θ is the angle between v and B.

Special Cases:

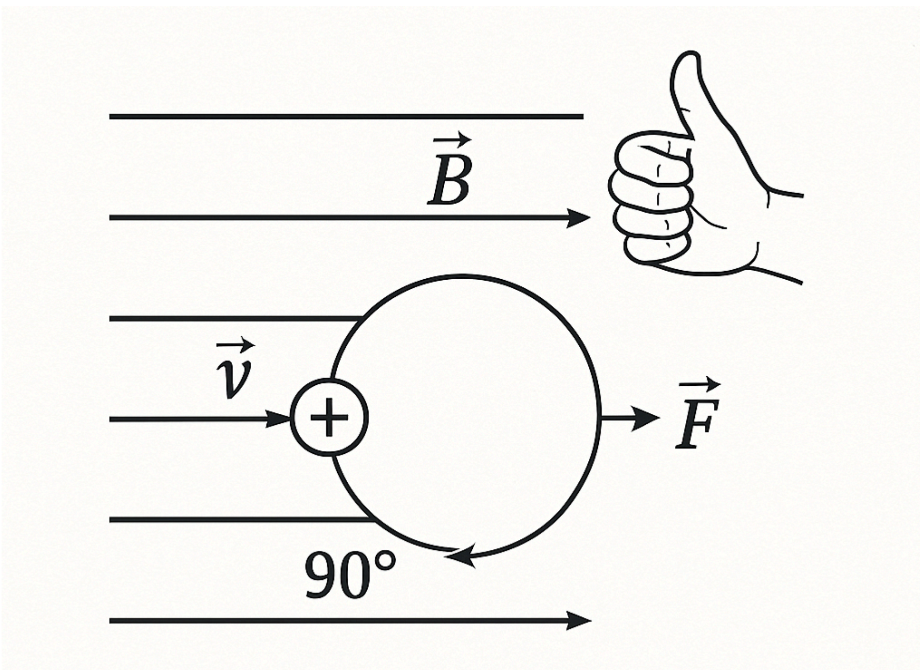
- $\theta = 90^\circ \rightarrow$ Force is maximum, particles move in a circular path.
- $\theta = 0^\circ \rightarrow$ Force is zero, particles continue in a straight line.

The magnetic force does not work on the particle; it only changes the direction of velocity, not its magnitude.

Example:

- A proton enters a magnetic field perpendicular to its velocity ⟶ moves in a circular path.
- An electron enters the same field ⟶ moves in a circle in the opposite direction due to negative charge.

Diagram:



Particle entering magnetic field at 90°

3. Motion in Combined Electric and Magnetic Fields

If a particle moves in a region with both electric field E and magnetic field B, the total force on the particle is the vector sum of electric and magnetic forces:

$$F = q E + q (v \times B)$$

Here, F is called the Lorentz Force.

Important Points:

- **Electric force:** does work → changes speed.
- **Magnetic force:** does no work → only deflects particle.

Definition of Lorentz Force

> The Lorentz force is the total force experienced by a charged particle moving in an electric field E and magnetic field B, given by:

$$F = q E + q (v \times B)$$

Direction is along E + (v × B)

Magnitude depends on charge, velocity, and field strengths.

🌟 **Q.7 Derive the expression for of an electron using motion in a magnetic field.**

- Derivation of e/m of an Electron Using Motion in a Magnetic Field
- When an electron is projected perpendicular to a uniform magnetic field, it experiences a magnetic force which acts as the centripetal force, making the electron move in a circular path. This method is used to determine the charge-to-mass ratio (e/m) of an electron.

1. Magnetic Force on a Moving Electron

A charge q moving with velocity v in a magnetic field B experiences a force:

$F = q\,(v \times B)$

For an electron (charge = -e), the magnitude is:

$F = e v B$

Direction: Perpendicular to both v and B (given by right-hand rule for positive charges; opposite for electrons).

2. Centripetal Force for Circular Motion

An electron moving in a circle of radius r with speed v experiences a centripetal force:

$F_c = m v^2 / r$

where:

- m = mass of the electron
- v = speed of the electron
- r = radius of the circular path

3. Equating Magnetic Force and Centripetal Force

The magnetic force provides the centripetal force:

$F = F_c$

$e v B = m v^2 / r$

Solving for e/m:

$e / m = v / (B r) \qquad (1)$

4. Electron Velocity from Accelerating Potential

If an electron is accelerated through a potential difference V, it gains kinetic energy:

$(1/2) m v^2 = e V$

$v = \sqrt{2 e V / m} \qquad (2)$

5. Substituting Velocity into e/m Expression

Substitute $v = \sqrt{2 e V / m}$ into $e/m = v / (B r)$:

$e / m = \sqrt{2 e V / m} / (B r)$

Squaring both sides:

$(e / m)^2 = (2 e V) / (m B^2 r^2)$

Simplifying:

$e / m = 2 V / (B^2 r^2)$ (3)

This is the charge-to-mass ratio of an electron.

Key Points:

1. Magnetic force is perpendicular to the velocity of the electron → circular motion.

2. Radius r of the path is measured experimentally.

3. Formula for e/m:

$e / m = 2 V / (B^2 r^2)$

4. Direction of deflection: electron moves opposite to right-hand rule direction for positive charges.

5. Maximum force occurs when electron moves perpendicular to magnetic field. Zero force if moving parallel to the field.

🌟 Q.8 Describe the conversion of a galvanometer into an ammeter. Derive the formula for the required shunt resistance.

1. Explain the construction and working of a Moving Coil Galvanometer.

A moving coil galvanometer is a sensitive electrical instrument used to detect and measure very small currents in a circuit. Its working is based on the principle that a current-carrying conductor placed in a magnetic field experiences a force. When this conductor is in the form of a coil, a torque acts on it and causes rotation.

➤ Construction of a Moving Coil Galvanometer

A moving coil galvanometer mainly consists of the following parts:

1. Rectangular Coil

- A light rectangular coil is made of fine enameled copper wire.
- It is wound on a frame of non-magnetic material (usually aluminum).
- This coil is free to rotate.

2. Suspension Wire

- A fine metallic suspension wire is used to support the coil and also carry current into the coil.
- It provides a small restoring torque when twisted.

3. Soft Iron Cylinder

A soft iron core is placed inside the coil.

Its purpose is:

- to make the magnetic field radial,
- to make the field strong,
- and to keep the plane of the coil always parallel to the field.

Due to the radial field, the angle between magnetic field and plane of coil always remains 0°, making torque maximum.

4. Permanent Magnet

A powerful U-shaped permanent magnet with concave pole pieces surrounds the coil.

This creates:

- a strong magnetic field,
- uniform distribution,
- and high sensitivity.

5. Spiral/Hair Springs

At the lower end, a spiral spring is connected.

It serves:

as the return current path, and provides restoring torque when the coil turns.

6. Mirror or Pointer

- In sensitive galvanometers, a small mirror is attached to the coil.
- A beam of light reflects on a scale to show deflection.
- In laboratory galvanometers, a pointer moves over a scale.

➢ Working of a Moving Coil Galvanometer

When current passes through the coil, the following steps occur:

1. Production of Deflecting Torque

- Current flowing through the coil experiences a magnetic force in the field.

A couple acts on opposite sides of the coil and produces a deflecting torque:

$\tau_d = N\,I\,B\,A\cos\alpha$

Since the coil is in a radial field,

$\alpha = 0° \Rightarrow \cos \alpha = 1$

2. Production of Restoring Torque

- As the coil rotates, the suspension wire twists.
- This twist produces a restoring torque that tries to bring the coil back to its original position.

$\tau_r = c\,\theta$

where

c = torsional constant of suspension wire

θ = angle of deflection

3. Condition for Equilibrium

When the coil stops rotating, deflecting torque equals restoring torque:

$N I B A = c \theta$

$I = (c / (N B A)) \theta$

This means:

➢ The angle of deflection (θ) is directly proportional to the current (I).

Thus, the galvanometer works as a current-detecting and measuring instrument.

➢ **Advantages / Features**

- Very sensitive to small currents
- Linear scale (because $\theta \propto I$)
- Strong magnetic field increases accuracy

✦ **Summary:**

A moving coil galvanometer consists of a rectangular coil suspended between the pole pieces of a strong magnet with a soft iron core. When current flows, the coil experiences a magnetic torque that causes rotation. A restoring torque develops in the suspension wire. When both torques balance, the coil comes to rest. The angle of deflection is directly proportional to the current, enabling the galvanometer to detect and measure small currents.

🌟 **Q.9 What is meant by sensitivity of a galvanometer? Describe any two methods to increase its sensitivity.**

- Meaning of Sensitivity of a Galvanometer
- The sensitivity of a galvanometer refers to how much the coil deflects for a small amount of current.
- A galvanometer is said to be sensitive if it gives a large deflection even for a very small current.

Mathematically:

Sensitivity $\propto \theta / I$

where

- θ= angle of deflection
- I = current through the galvanometer

A highly sensitive galvanometer can detect very small currents and hence is more useful in low-current measurements.

Methods to Increase Sensitivity of a Galvanometer

We increase sensitivity by making the value of:

c / (N B A)

as small as possible,

where

- c = torsional constant of suspension wire
- N = number of turns
- B = magnetic field strength
- A = area of coil

Below are the two most important methods.

1. Increasing the Magnetic Field (B)

By using a stronger magnet or by placing a soft iron core, we increase the magnetic field strength.

Effects:

- Higher magnetic field produces larger deflecting torque
- A small current can cause a large deflection
- **Hence**, sensitivity increases

This is the easiest and most commonly used method.

2. Increasing the Number of Turns (N)

If the rectangular coil has more turns of fine wire:

$\tau d = N\ I\ B\ A$

Increasing N directly increases the deflecting torque for the same current.

Effects:

- Larger deflection for the same current

- Galvanometer becomes more sensitive

However, N cannot be increased indefinitely because too many turns make the coil heavy.

✦ **Summary:**

- Sensitivity means the amount of deflection produced per unit current.
- A galvanometer is more sensitive if it gives large deflection for small currents.

Sensitivity can be increased by:

1. Increasing the magnetic field (B)

2. Increasing the number of turns (N)

(**Other methods:** increase area A, decrease torsional constant c)

🌟 **Q.10 How can a galvanometer be converted into an ammeter? Derive the formula for shunt resistance.**

❖ **Answer:**

A galvanometer is a sensitive device which can detect very small currents. To measure large current, it cannot be used directly because a high current would damage the coil. Therefore, a galvanometer is converted into an ammeter by connecting a low resistance, called shunt resistance, parallel to the galvanometer.

When both are connected in parallel, most of the current passes through the shunt, and only a small safe current passes through the galvanometer.

✦ Construction

To convert the galvanometer into an ammeter:

1. A low resistance Rs (shunt) is connected in parallel with the galvanometer.

2. The galvanometer has its own resistance Rg and it can bear a maximum current Ig (full-scale current).

3. The total current I coming from the circuit divides into two parts:

- Ig through the galvanometer
- (I - Ig) through the shunt

✦ Working

Because the shunt and galvanometer are in parallel, the potential difference across both must be equal.

Therefore:

$$I_g * R_g = (I - I_g) * R_s$$

This equation ensures that the galvanometer carries only its safe current Ig while the remaining large current flows through the shunt.

Derivation of the Formula for Shunt Resistance

Starting with the basic condition:

Ig * Rg = (I - Ig) * Rs

Now isolate Rs:

Rs = (Ig * Rg) / (I - Ig)

This is the required formula.

Final Formula

Shunt resistance:

Rs = (Ig * Rg) / (I - Ig)

Where:

- Rg = resistance of galvanometer
- Ig = full-scale galvanometer current
- I = total current to be measured
- Rs = shunt resistance

🌟 Q11. What is an AVO Meter (Multimeter)? Describe how it works as a voltmeter, ammeter, and ohmmeter.

❖ **Answer:**

An AVO Meter, also called a multimeter, is an electrical instrument used to measure current (amperes), voltage (volts), and resistance (ohms). It is essentially a sensitive moving coil galvanometer that is modified according to the type of measurement required.

The AVO meter has a function switch (FS) which connects the galvanometer to the appropriate circuit for measuring voltage, current, or resistance. The main terminals X and Y are connected to the circuit under test.

1. Working as a Voltmeter

1. To measure voltage, the galvanometer is connected in series with a high resistance.

2. The high series resistance ensures that very little current flows through the galvanometer, preventing damage.

3. By selecting the desired range using a range switch, different series resistances can be connected to the galvanometer, allowing measurement of higher voltages.

4. The scale of the galvanometer is calibrated in volts, and the pointer indicates the potential difference between the two points where the meter is connected.

5. Connection: Always connected in parallel with the component or circuit.

2. Working as an Ammeter

1. To measure current, the galvanometer is connected in parallel with a low resistance called a shunt.

2. The shunt allows most of the current to bypass the galvanometer, protecting it from high currents.

3. By selecting the range using a range selection switch, different shunt resistances are used to measure different currents.

4. The scale is calibrated in amperes, showing the total current flowing through the circuit.

5. Connection: Always connected in series with the circuit.

3. Working as an Ohmmeter

1. To measure resistance, the galvanometer is connected in series with a battery and a variable resistor.

2. The terminals of the meter are connected across the unknown resistance.

3. If the terminals are short-circuited ($R = 0$), the galvanometer shows full-scale deflection.

4. If the terminals are open ($R = \infty$), the galvanometer shows zero deflection.

5. By adjusting the variable resistor, the scale is calibrated in ohms, and the pointer indicates the unknown resistance.

6. This allows direct reading of resistance on the meter.

🌟 Q.12 Explain the role of shunt and multiplier resistances in extending the range of a galvanometer.

A galvanometer is a sensitive instrument used to detect small currents. By itself, it can measure only small currents. To measure larger currents or voltages, the range of the galvanometer can be extended using shunt and multiplier resistances.

1. Shunt Resistance (for Ammeter):

A shunt resistance is a low-value resistor connected in parallel with the galvanometer to convert it into an ammeter. It allows most of the current to bypass the galvanometer, so that the galvanometer only carries a fraction of the total current.

The value of the shunt resistance is given by:

$$R_s = (I_g * R_g) / (I - I_g)$$

Where:

- R_s = Shunt resistance
- R_g = Resistance of the galvanometer
- I_g = Current required for full-scale deflection of the galvanometer

- I = Desired full-scale current of the ammeter

This ensures that the galvanometer is protected from excessive current while the ammeter measures higher currents.

2. Multiplier Resistance (for Voltmeter):

A multiplier resistance is a high-value resistor connected in series with the galvanometer to convert it into a voltmeter. It limits the current through the galvanometer when connected across a higher voltage.

The value of the series resistance is given by:

$$R_m = (V / I_g) - R_g$$

Where:

- R_m = Multiplier (series) resistance
- V = Desired full-scale voltage of the voltmeter
- I_g = Current required for full-scale deflection of the galvanometer
- R_g = Resistance of the galvanometer

This ensures that the galvanometer can safely measure high voltages without damage.

✦ **Summary:**

- Shunt resistance ⟶ extends range for current measurement (ammeter)
- Multiplier resistance ⟶ extends range for voltage measurement (voltmeter)

🩸 Exercise Questions

🌟 14.1 Magnetic Flux Through a Plane Loop

Question: A plane conducting loop is placed in a uniform magnetic field directed along the x-axis.

1. For what orientation of the loop is the magnetic flux maximum?

2. For what orientation of the loop is the magnetic flux minimum?

❖ **Answer:**

The magnetic flux (Φ) through a plane loop is given by:

$\Phi = B \times A \times \cos(\theta)$

Where:

B is the magnetic field strength,

A is the area of the loop,

θ is the angle between the normal to the plane of the loop and the magnetic field.

Maximum Flux:

The flux is maximum when $\cos(\theta) = 1$, which occurs when the normal to the plane of the loop is parallel to the magnetic field. In this case, the plane of the loop is perpendicular to the magnetic field.

$\Phi_{max} = B \times A$

Minimum Flux:

The flux is minimum when cos(θ) = 0, which occurs when the normal to the plane of the loop is perpendicular to the magnetic field. In this case, the plane of the loop is parallel to the magnetic field.

$\Phi\_min = 0$

🌟**14.2: A current in a conductor produces a magnetic field, which can be calculated using Ampere's law. Since current is defined as the rate of flow of charge, what can you conclude about the magnetic field due to stationary charges? What about moving charges?**

❖ **Answer:**

1. Magnetic Field Due to Stationary Charges:

- Stationary charges do not move, so there is no current.
- Since magnetic fields are produced by moving charges or currents, stationary charges do not produce any magnetic field.

Example: A charge sitting still in space does not create a magnetic field around it, though it may create an electric field.

2. Magnetic Field Due to Moving Charges:

- Moving charges constitute an electric current, which produces a magnetic field.
- The direction of the magnetic field around a moving charge or current-carrying conductor is given by the right-hand rule.

The strength of this magnetic field depends on:

The amount of current (rate of charge flow),

Distance from the conductor,

Geometry of the conductor (straight wire, loop, solenoid, etc.).

✦ **Summary:**

- Stationary charges ⟶ No magnetic field.
- Moving charges ⟶ Magnetic field exists.

This is why magnetic effects are only observed when charges are in motion.

🌟 **14.3:Describe the change in the magnetic field inside a solenoid carrying a steady current I, if**

(a) the length of the solenoid is doubled but the number of turns remains the same, and

(b) the number of turns is doubled, but the length remains the same.

❖ **Answer:**

The magnetic field inside a long solenoid is given by:

$B = \mu_0 * (N / L) * I$

Where:

- B = magnetic field inside the solenoid
- μ_0 = permeability of free space
- N = number of turns

- L = length of the solenoid
- I = current

(a) Length doubled (L ⟶ 2L), N same:

$B' = \mu_0 * (N / 2L) * I = (1/2) * B$

- The magnetic field becomes half.
- Magnetic field is inversely proportional to length for constant N and I.

(b) Number of turns doubled (N ⟶ 2N), L same:

$B' = \mu_0 * (2N / L) * I = 2 * B$

- The magnetic field becomes twice.
- The magnetic field is directly proportional to the number of turns for constant L and I.

✦ **Summary:**

- Doubling length ⟶ halves B
- Doubling turns ⟶ doubles B

🌟 **14.4: At a given instant, a proton moves in the positive x-direction in a region where there is a magnetic field in the negative z-direction. What is the direction of the magnetic force? Will the proton continue to move in the positive x-direction? Explain.**

❖ **Answer:**

The magnetic force on a moving charge is given by the Lorentz force law:

$$F = q\,(v \times B)$$

Where:

- F = magnetic force on the charge
- q = charge of the particle (positive for proton)
- v = velocity of the particle
- B = magnetic field

Given:

- **Velocity of proton**: v = +x direction

- **Magnetic field:** B = -z direction

Using the right-hand rule for a positive charge:

1. Point your fingers in the direction of velocity (x-axis).

2. Curl them toward the direction of the magnetic field (-z axis).

3. Thumb points in the direction of the force.

Result: Force F is in the negative y-direction.

Will the proton continue in the +x direction?

No.

The magnetic force is always perpendicular to velocity, so it does not change the speed, only the direction.

The proton will undergo circular motion in the xy-plane, moving in a curved path rather than a straight line along +x.

✦ **Summary:**

Direction of magnetic force: negative y-axis

Proton's motion: deflected from +x, moves in a circular path in the plane perpendicular to B.

🌟 **14.5: Two charged particles are projected into a region where there is a magnetic field perpendicular to their velocities. If the charges are deflected in opposite directions, what can you say about them?**

❖ **Answer:**

The magnetic force on a moving charge is given by the Lorentz force law:

$F = q (v \times B)$

Where:

- F = magnetic force on the particle
- q = charge of the particle
- v = velocity of the particle
- B = magnetic field

Given:

- Velocities of both particles are perpendicular to the magnetic field.
- The particles are deflected in opposite directions.

Analysis:

According to the right-hand rule, the direction of deflection depends on the sign of the charge:

- **Positive charge:** deflected in one direction.
- **Negative charge:** deflected in the opposite direction.

Since the two particles are deflected in opposite directions, it means their charges are of opposite sign.

✦ **Summary:**

- One particle is positively charged.
- The other particle is negatively charged.

Their magnitudes of charge and mass may differ, but the opposite deflection confirms opposite signs of charge.

🌟 **14.6: Suppose that a charge q is moving in a uniform magnetic field with a velocity v. Why is there no work done by the magnetic force that acts on the charge q?**

❖ **Answer:**

The magnetic force acting on a moving charge is given by the Lorentz force:

$F = q\,(v \times B)$

Where:

- q = charge of the particle
- v = velocity of the particle
- B = magnetic field

Reason why no work is done:

1. Definition of work:

Work done by a force is defined as:

$W = F \cdot d = F * d * \cos\theta$

where θ is the angle between the force and the displacement of the particle.

2. Direction of magnetic force:

The magnetic force is always perpendicular to the velocity of the particle ($F \perp v$).

Therefore, the angle θ between the force and displacement is 90°.

3. Substitute in work formula:

$W = F * d * \cos 90° = F * d * 0 = 0$

✦ **Summary:**

The magnetic force changes only the direction of the velocity of the particle, not its magnitude.

Since work is related to a change in kinetic energy, and the speed remains constant, no work is done by the magnetic force.

Extra note:

This is why charged particles in a uniform magnetic field move in circular or helical paths rather than accelerating along the field.

🌟 **14.7 If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero?**

❖ **Answer:**

Not necessarily. A charged particle moving in a straight line does not always imply that the magnetic field is zero.

Explanation:

1. Magnetic force on a moving charge:

The magnetic force on a charge q moving with velocity v in a magnetic field B is:

$F = q\,(v \times B)$

- The force depends on the cross product of v and B.
- This means the force is maximum when $v \perp B$ and zero when $v \parallel B$.

2. Case of straight-line motion:

- If the particle moves parallel or antiparallel to the magnetic field ($v \parallel B$), the cross product $v \times B = 0$.
- Hence, the magnetic force $F = 0$.
- In this case, the particle continues in a straight line even though $B \neq 0$.

✦ **Summary:**

- Straight-line motion of a charged particle only guarantees that the magnetic force on it is zero at that instant.
- It does not prove that the magnetic field is zero.

- The field may exist but be aligned along the velocity of the particle.

✅ **Key point:** Straight-line motion occurs either if B = 0 or v is parallel to B.

🌟 14.8: Why does the picture on a TV screen become distorted when a magnet is brought near the screen?

❖ **Answer:**

The distortion of the picture on a TV screen occurs because of the effect of a magnetic field on the electron beams inside the TV.

✦ **Explanation:**

1. Working of a TV screen:

- A TV uses a cathode ray tube (CRT) in which a beam of electrons is accelerated toward the screen.
- The electrons strike the phosphorescent screen to produce images.
- The position of the electron beam is controlled by electric or magnetic deflection systems.

2. Effect of a magnet:

- When a magnet is brought near the screen, its magnetic field interacts with the moving electrons.

The magnetic force on an electron is given by:

$F = q (v \times B)$

where q = electron charge, v = velocity of electron, B = magnetic field of the magnet.

This force deflects the electron beam from its intended path.

3. Result:

- The electron beams no longer hit the correct points on the screen.
- This causes the picture to become distorted, displaced, or warped.

✅ **Key point:** A nearby magnet creates an external magnetic field that interferes with the controlled path of electrons in a CRT, leading to image distortion.

🌟 **14.9: Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? Explain.**

❖ **Answer:**

Yes, it is possible to orient a current-carrying loop in a uniform magnetic field so that it does not tend to rotate.

✦ **Explanation:**

1. Torque on a current loop:

A current-carrying loop in a magnetic field experiences a torque given by:

$\tau = I \times A \times B \times \sin\theta$

where:

- I = current in the loop
- A = area of the loop
- B = magnetic field
- θ = angle between the normal to the plane of the loop and the magnetic field

This torque tends to rotate the loop so that its plane aligns with the magnetic field.

2. Condition for no rotation:

Torque is zero when $\sin\theta = 0$, i.e., $\theta = 0°$ or $180°$.

This occurs when the plane of the loop is parallel to the magnetic field, or equivalently, the normal to the plane is along the field.

✦ **Conclusion:**

In this orientation, the forces on opposite sides of the loop cancel each other, so the loop does not experience any net torque and will not rotate.

✅ **Key point:** A current loop will not rotate if its plane is parallel to the magnetic field, meaning the loop's normal is along the direction of the field.

🌟 **14.10: How can a current loop be used to determine the presence of a magnetic field in a given region of space?**

❖ **Answer:**

A current-carrying loop can act as a simple detector of a magnetic field due to the torque it experiences in the field.

✦ **Explanation:**

1. Torque on a current loop:

A loop carrying current I in a magnetic field B experiences a torque:

$\tau = I \times A \times B \times \sin\theta$

where A is the area of the loop and θ is the angle between the normal to the loop and the magnetic field.

2. Observation:

If a current loop is placed in a region:

- **No magnetic field present:** The loop experiences no torque, so it remains stationary.
- **Magnetic field present:** The loop experiences a torque, causing it to rotate or tend to align with the field.

3. Procedure:

- Connect a small current through the loop.
- Observe if the loop rotates or experiences a twisting force.
- Any observed rotation indicates the presence of a magnetic field.

✅ **Key point:** A current loop can detect a magnetic field because it experiences a torque in the field; the rotation of the loop confirms that a magnetic field is present.

🌟 14.11: How can you use a magnetic field to separate isotopes of a chemical element?

❖ **Answer:**

The separation of isotopes of an element using a magnetic field is achieved through a device called a mass spectrometer, which utilizes the motion of charged particles in a magnetic field.

✦ **Explanation:**

1. Ionization of atoms:

- The atoms of the element are first ionized to form positively charged ions.

2. Acceleration:

- These ions are accelerated using an electric field to give them a high velocity.

3. Entry into magnetic field:

- The moving ions then enter a uniform magnetic field perpendicular to their velocity.

According to the magnetic force on a moving charge:

$F = q \times v \times B$

where q is charge, v is velocity, and B is magnetic field strength.

4. Deflection depends on mass:

The ions experience a centripetal force due to the magnetic field:

$q \times v \times B = m \times v^2 / r$

where m is the mass of the ion and r is the radius of its circular path.

Rearranging:

$r = (m \times v) / (q \times B)$

5. Separation of isotopes:

- Ions of different isotopes have different masses (m) but the same charge (q) and velocity (v).
- **Therefore**, they follow circular paths of different radii in the magnetic field.
- By placing a detector or collector at suitable positions, ions of different isotopes can be collected separately.

✅ **Key point:** A magnetic field separates isotopes because ions of different masses are deflected by different amounts, allowing their collection at different points.

🌟 **14.12: What should be the orientation of a current-carrying coil in a magnetic field so that the torque acting upon the coil is (a) maximum and (b) minimum?**

❖ **Answer:**

The torque (τ) acting on a current-carrying coil in a magnetic field is given by:

$\tau = N \times B \times I \times A \times \sin\theta$

Where:

- N = Number of turns of the coil
- B = Magnetic field strength
- I = Current through the coil
- A = Area of the coil
- θ = Angle between the normal to the plane of the coil and the magnetic field

(a) Maximum Torque:

Torque is maximum when $\sin\theta = 1$, i.e., $\theta = 90°$.

This occurs when the plane of the coil is perpendicular to the magnetic field (or the normal to the coil is parallel to the magnetic field).

(b) Minimum Torque:

Torque is minimum when $\sin\theta = 0$, i.e., $\theta = 0°$ or $180°$.

This occurs when the plane of the coil is parallel to the magnetic field (or the normal to the coil is perpendicular to the magnetic field).

✦ **Summary:**

Torque	**Coil Orientation**
Maximum	Plane perpendicular to B
Minimum	Plane parallel to B

🌟 **14.13: A loop of wire is suspended between the poles of a magnet with its plane parallel to the pole faces. What happens if a direct current is put through the coil? What happens if an alternating current is used instead?**

❖ **Answer:**

When a Direct Current (DC) is passed through the coil:

- The coil experiences a torque due to the magnetic force acting on its sides.

- Torque causes the coil to rotate until it reaches a position where the plane of the coil becomes perpendicular to the magnetic field (equilibrium).
- Once equilibrium is reached, the coil stops rotating because the torque becomes zero at this orientation.
- The coil does not oscillate continuously unless mechanically disturbed.

When an Alternating Current (AC) is passed through the coil:

- The current changes direction periodically.
- As the current reverses, the direction of the torque on the coil also reverses.
- This causes the coil to oscillate back and forth continuously.
- The coil keeps rotating in alternate directions, producing a continuous motion.

✦ **Summary:**

- **DC:** Coil rotates and comes to rest at equilibrium.
- **AC:** Coil oscillates continuously due to reversing torque.

This principle is applied in devices like AC galvanometers and moving coil meters.

🌟 14.14: Why should the resistance of an ammeter be very low?

❖ **Answer:**

An ammeter is connected in series with the circuit whose current is to be measured.

If the ammeter has high resistance, it will oppose the flow of current, thereby reducing the actual current in the circuit.

This would lead to inaccurate measurements of current.

Therefore, the resistance of an ammeter is made very low to ensure it does not significantly affect the current in the circuit.

✅ **Key point:** Low resistance ensures accurate current measurement without altering the circuit.

🌟 14.15: Why should the resistance of a voltmeter be very high?

❖ **Answer:**

A voltmeter is connected in parallel across the component whose potential difference is to be measured.

If the voltmeter has low resistance, it will allow a significant current to pass through itself, diverting current from the main circuit.

This would alter the potential difference across the component and give incorrect readings.

Therefore, a voltmeter is designed with a very high resistance to ensure it draws negligible current and does not affect the circuit.

✅ **Key point:** High resistance ensures accurate voltage measurement without disturbing the circuit.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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