05. Magnetic Effect of Electric Current

5.0 Basic concepts :

Introduction :

1. A current carrying conductor produces a magnetic field in the surrounding space. This was first discovered by Oersted in 1820.
2. The direction of magnetic field depends on the direction of current and magnitude of magnetic field depends on the magnitude of current.
3. Magnetic field can be produced not only permanent magnets and electromagnets but also by moving charges, by current carrying conductors and by variable electric field.
4. Stationary charges can not produce magnetic field. In a conductor, motion of free electrons produces the magnetic field.
5. Magnetic effect can be treated as relative electric effect.
6. A static charge produces only electric field.
7. Moving electric charge produces both electric and magnetic fields.

Magnetic field:

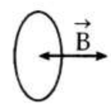
1. It is a region of space around a magnet or current carrying conductor or a moving charge, in which its magnetic effect can be felt.
2. Magnetic field induction is a vector quantity.
3. A magnetic field is represented by the lines of magnetic induction.
4. If the lines of magnetic induction in a region are crowded together, the magnetic field strength in that region will be strong. If the lines of magnetic induction in region are far apart, there the magnetic field strength is weak.
5. The lines of magnetic induction for a nonuniform magnetic field are curved or unequally spaced or both.
6. Unit: Tesla (T) or Wb/m^2 or N/Am in SI system and gauss (G) or oersted or maxwell/cm^2 in CGS system.

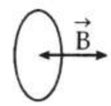
   1 gauss = 10^{-4} T

Magnetic force:

$$|\vec{F}| = q|\vec{v} \times \vec{B}| = qv B \sin\theta.$$

Magnetic induction:

1. The total number of magnetic lines of force passing normally through a unit area is called as magnetic induction.
2. The number of lines of force passing normally through a given area is called magnetic flux.
3. 

$\phi = BA$
4. 

$\phi = BA\cos\theta$

   for n turns

   $\phi = n\,AB\cos\theta$
5. Magnetic induction due to north pole of pole strength is defined as force acting per unit pole strength of N-pole.
6. **Formula:**

$$\vec{B} = \frac{\vec{F}}{m}$$

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

   where 'm' is pole strength of 'N' pole, 'r' is distance of point from N pole.
7. **Unit of ϕ :** weber in SI system

   maxwell in CGS system

   1 maxwell = 10^{-8} Weber

Magnetic dipole moment:

1. Magnetic dipole moment is defined as product of pole strength and magnetic length.
2. Magnetic dipole moment is also defined as torque required to hold a magnet perpendicular to the direction of masnetic field of unit maGnetic induction.
3. **Formula:**

i) $M = m \times 2l$

where 'M' is magnetic dipole moment, 'm' is pole strength, $2l$ is magnetic length.

ii) $M = nIA$

where n is number of turns of coil, A is area of coil, I is electric current.

iii) $\tau = MB \sin\theta$

where τ is torque acting on a magnet placed in uniform magnetic field of induction B.

4. **Unit:** $A\,m^2$ in SI system.
5. **Dimension:** $[M^0L^2T^0A^1]$
6. It is a vector quantity directed from S-pole to N-pole along the axis.

Magnetic meridian: A plane passing through magnetic N-pole and S-pole of the earth is called as magnetic meridian.

Earth's magnetic field:

1. The resultant of earth's magnetic field can be resolved into two components.

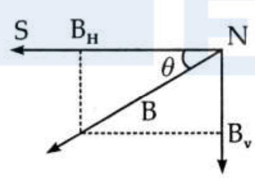
i) BHalong magnetic meridian i.e. along N-S direction.

ii) Byperpendicular to the magnetic meridian i.e. along E-W direction.

2. Therefore, $B_H = 0$ and B_v = maximum at poles.
3. $B_v = 0$ and B_H = maximum at equator.

Angle of dip:

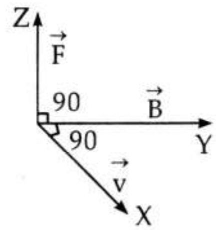
Angle made by the resultant of earth's magnetic field with respect to B_H is called as angle of dip.



$$\therefore \quad \tan\theta = \frac{B_v}{B_H}$$

Fleming's left hand rule:

If we stretch the first finger, central finger and thumb of left hand mutually perpendicular to each other such that the fore finger points along the direction of magnetic field, the central finger along the direction of current then the thumb represents the direction of the force experienced by the charge particle.



Biot Savart law I Laplace's law / Inverse square law:

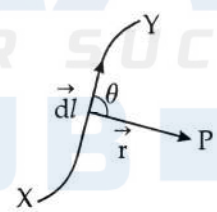
1. **Laplace's law or Biot-savart's law:** The magnitude of the magnetic field at a point near a conductor carrying current was given by Laplace's law. This law was experimentally confirmed by Biot-Savart.
2. The magnetic induction produced at a point due to a small element of current carrying conductor (dB) is

i) Directly proportional to the current flowing through the conductor $\Rightarrow dB \propto I$.

ii) Directly proportional to the length of the element $\Rightarrow dB \propto dl$.

iii) Directly proportional to the sine of the angle between $\vec{d}l$ and $\vec{r}$ $\Rightarrow dB \propto \sin\theta$.

iv) Inversely proportional to the square of the distance of the point from the element $\Rightarrow dB \propto 1/r^2$.



$$dB \propto \frac{Idl\sin\theta}{r^2}$$

$$\Rightarrow dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

In vector from $$\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\vec{r}}{r^3}$$

3. The direction of magnetic field at the reference point is at right angles to the plane of $\vec{dl}$ and $\vec{r}$.
4. The total magnetic field due to whole length of the conductor is,

$$\vec{B} = \frac{\mu_0}{4\pi}\int\frac{I\vec{dl}\times\vec{r}}{r^3}$$

5. Biot-Savart law in terms of charge and its velocity can be expressed as

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

6. When $\vec{d}l$ and $\vec{r}$ mutually parallel i.e. the point of observation is in the direction of current flow, the $\theta = 0$ and B = 0.

7. When $\vec{d}l$ and $\vec{r}$ mutually perpendicular to each other i.e. the point of observation is at right angles to the direction of current flow, the $\theta = 90°$ and B is maximum $B = \frac{\mu_0}{4\pi}\frac{Idl}{r^2}$

8. Magnetic induction due to current carrying straight conductor is

$$B = \frac{\mu_0}{4\pi}\frac{2I}{a}$$

where 'a' is distance of a point from the conductor and its direction is given by right hand rule.

9. Magnetic induction at the centre of a circular coil is

$$B = \frac{\mu_0 nI}{2a}$$

where 'a' is radius of coil, n is number of turns of coil, I is electric current.

Direction: Right hand rule and perpendicular to the plane of paper.

For clockwise current magnetic induction is perpendicular to the plane of the coil and it is directed inwards. For anticlockwise current magnetic induction is directed outwards and perpendicular to the plane of the toil.

10. The magnetic induction at any point along the axis of circular coil is

$$B = \frac{\mu_0 nIa^2}{2(x^2+a^2)^{3/2}}$$

$$B = \frac{\mu_0 nIa^2}{2r^3} \qquad \text{where } r^2 = x^2 + a^2$$

where x is distance of a point from centre of a coil, 'a' is radius of a coil, I is electric current, n is number of turns of a coil.

11. Force acting on charge q moving with velocity $\vec{v}$ in a uniform magnetic field of induction $\vec{B}$ is

$$\vec{F} = q\vec{v}\times\vec{B}$$

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

where θ is angle between $\vec{v}$ and $\vec{B}$.

Direction: It is given by Fleming's left hand rule. The charge does not experience any force, if it is at rest or if it moves along the direction of magnetic field. The force- is- maximum, when charge moves perpendicular to the direction of field.

12. The force acting on a current carrying conductor in uniform magnetic field $\vec{B}$ is given by $\vec{F} = I\vec{l}\times\vec{B}$

$F = Il\,B\sin\theta$.

Direction: It is given by Fleming's left hand rule. If the length of conductor is parallel to field then the force on conductor is zero. The force acting on current carrying conductor is maximum if the length of the conductor is perpendicular to the magnetic field.

13. Force per unit length between two infinitely long parallel current carrying conductors is

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$$

where 'a' is distance between two conductors.

For like currents there is force of attraction and for unlike currents there is force of repulsion.

14. If a magnetic needle is placed in a magnetic field then it experiences force as well as torque.

15. Torque on a coil :

i) The torque acting on a current carrying coil placed in a uniform magnetic field of induction B is

$$\tau = BinA\sin\theta$$

where θ is angle between normal to plane and direction of field.

ii) If the plane of coil is perpendicular to the direction of magnetic field i.e. $\theta = 0°$ then $\tau = 0$ (minimum).

iii) If the plane of coil is parallel to the direction of magnetic field i.e. $\theta = 90°$ then $\tau = nIB$ (maximum).

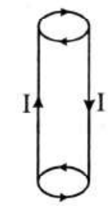
iv) The net force acting on a current loop is zero but the torque acts on it.

16. **Tangent law:** If a bar magnet is suspended into two mutually perpendicular magnetic fields of

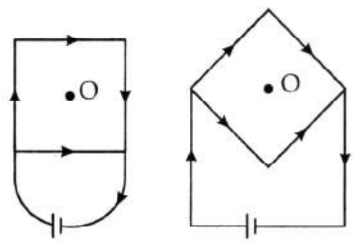
induction B and B_H, the magnet comes to rest making an angle θ with B_H, such that

$$B = B_H \tan \theta$$

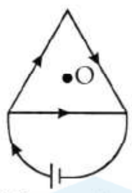
17. Some special cases where the resultant magnetic field is zero:



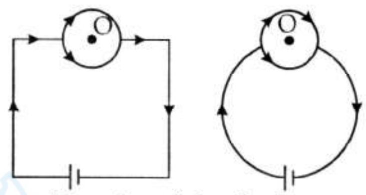
Inside the tube



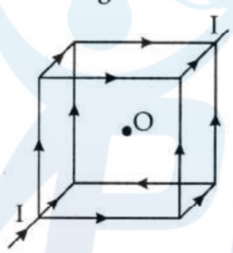
At centre of square loop



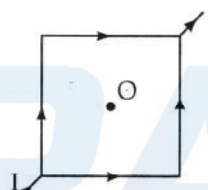
At the centroid of traingle



At centre of circular loop



At the centre of cube



At centre of rectangular loop

5.1 Ampere's law and its applications

1. The line integral of the resultant magnetic induction ($\vec{B}$) around any closed loop is equal to μ_0 times the total current enclosed by that loop. Here μ_0 is permeability of free space.

$$\therefore \quad \oint \vec{B}.\vec{d}l = \mu_0 I$$

2. The closed loop is called as Amperean loop.
3. Ampere's law is a scalar equation and is analogous to gauss theorem in electrostatics.
4. **Magnetic field due to a straight conductor carrying current:**

$$B = \frac{\mu_0 I}{2\pi a}$$

5. **Magnetic field due to long solenoid:**

$$B = \mu_0 nI$$

i) A long cylindrical current carrying coil is known as a solenoid.

ii) It is made by winding a thick wire around an insulating cylinder.

iii) The radius of an ideal solenoid is negligible in comparison to its length.

iv) On passing current in the solenoid, a magnetic field is produced around it.

a) The magnetic field inside the solenoid is along its axis and is uniform everywhere.

b) The magnetic field at large distance from the axis of the solenoid outside it is almost zero .

c) The magnetic induction at the ends of the solenoid is half its value in the middle. (i.e. $B = \mu_0 nI/2$).

v) The value of B does not depend on the length and area of cross-section of the solenoid.

vi) It is a source to produce a uniform standard magnetic field.

6. **Magnetic field due to toroid:**

$$B = \mu_0 nI$$

i) The shape obtained by bending an endless solenoid into circular form is known as a toroid.

ii) The radius of an ideal toroid is very large in comparison to its thickness.

iii) On passing current in the toroidal coil, the magnetic field at all points inside the toroid is uniform whereas it is zero at all points outside it.

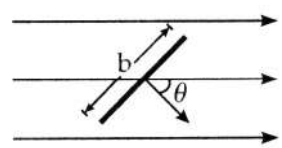
iv) The direction of B inside the toroid is along the tangent to its axis and its magnitude is uniform along its whole axis.

v) The magnetic field at all points outside its core is zero because the net current enclosed by any outer circle is zero.

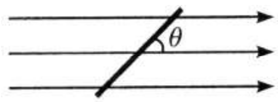
5.2 Moving coil galvanometer

Deflecting torque on a current loop In uniform magnetic field :

1. When coil carrying current is placed in a uniform magnetic field, the net force on it always is zero. Here different parts experience forces in different directions so that the loop may experience a torque or couple.



2. A rectangular coil of area A having n turns and carrying current I is placed in a uniform magnetic field of induction $\vec{B}$. If θ is the angle between the normal to the plane of the coil and the magnetic field, then torque acting on the coil is,



τ = nIAB sin θ = MB sin θ.

In vector form $\vec{\tau} = \vec{M} \times \vec{B}$ ($\because$ M = nIA)

Here A = lb where l and b denote length and breadth of the rectangle.

If 'θ' is the angle between the plane of the coil and the magnetic field, then torque acting on the coil is,

τ = nIAB cos θ = MB cos θ.

If plane of the coil is parallel to the magnetic field, then the torque r = nIAB (maximum torque).

3. When θ = 0° or 180°, i.e. plane of the coil is perpendicular to the field, τ = 0.
4. Potential energy of the coil is,

$U = -\vec{M} \cdot \vec{B}$

Work done in turning the coil through an angle 'θ' from the field direction is,

W = MB(1 – cos θ).

Radial magnetic induction:

1. A magnetic filed in which the plane of the coil in any position is always parallel to the magnetic induction is called radial magnetic field.
2. It is produced due to the concave pole pieces of the magnet. To obtain radial magnetic field, poles of the magnets will be cylindrically cut.
3. In radial magnetic field, magnetic lines of induction are along radii, hence it is radial field. The magnetic lines of induction will start from N-pole, converge at the centre and diverge at south pole.
4. In M.C.G., radial magnetic field is used to make its scale linear.

Moving coil galvanometer:

1. It is used to detect the current. It works on magnetic effect of an electric current. It was designed by Kelvin and modified by 0'Arsonval. It is also known as American type (western type) galvanometer.

There are two types of M.C.G.

a) Suspended coil type M.C.G.

b) Pivoted coil type M.C.G.

2. **Principle:** Whenever current carrying coil is suspended in radial magnetic field, it experiences a torque which will deflect the coil. The deflection of coil is directly proportional to current flowing through the coil.
3. **Construction:** The rectangular coil is suspended in radial magnetic field by thin fibre of phosphor bronze or silvered quartz. Phosphor bronze has high Young's modulus and less rigidity modulus. The lower end of coil is connected to copper strip so as to avoid oscillations of coil. The radial magnetic field is produced by "Strong magnets having concave poles. The soft iron core is used to increase magnetic induction. The concave mirror is used to measure the deflection of coil by lamp and scale arrangement.
4. The deflecting torque = τ_n = nIAB. It is also called as turning effect or turning torque.
5. The restoring torque is given by,

$\tau_r = K\theta$

where K is restoring torque per unit twist or torsional constant. It depends on dimensions of fibre and elasticity constant of the fibre.

6. The current through the coil of M.C.G. is given by,

$$I = \frac{K}{nAB}\theta$$

In M.C.G., $\frac{K}{nAB}$ = G, is called galvanometer constant.

7. "The current through the coil is directly proportional to deflection of coil" is the principle of working of M.C.G.
8. **Pivoted coil type M.C.G. :**

i) In pivoted coil type M.C.C., the coil is pivoted in radial magnetic field by two spiral springs. In pivoted coil type M.C.C. the deflection of coil is measured by long and thin aluminium pointer.

ii) Suspended coil type M.C.C. is more sensitive and accurate compared to pivoted coil type M.C.C.

iii) Suspended coil type M.C.C. is not portable and it is costly compared to pivoted coil type M.C.C.

9. **Advantages of M.C.G. :**

i) It is very sensitive and hence it used to measure very low current of about 10^{-10} A.

ii) $I \propto \theta$, is principle of M.C.C. Hence uniformly calibrated linear scale is used for the measurement of current.

iii) Internal magnetic field of M.C.C. is very strong. Hence external magnetic field does not affects the reading of M.C.C.

iv) Any type of initial adjustment of the instrument is not required.

10. Disadvantages of M.C.G. :

i) Changes in temperature affect restoring torque.

ii) Restoring torque cannot be easily changed.

iii) Possibility of damage of phosphor bronze fibre suspension and hair helical springs arising out of severe stress.

iv) Such instrument can not be used for alternating current (a.c.) measurement.

5.3 Ammeter

1. A moving coil galvanometer designed for the measurement of current is called ammeter. The ammeter is low resistance galvanometer and is connected in series with the circuit.
2. The M.C.C. can be converted into ammeter by connecting low resistance called as shunt in parallel with galvanometer. Thus, ammeter is parallel combination of galvanometer and shunt.
3. If a large current is passed through galvanometer, galvanometer may damage because i) large current produces large deflection of the pointer and in an attempt to go out of scale, pointer may break, ii) large current produces large amount of heat which will damage the galvanometer.
4. The requirements of ideal ammeter are,

i) Its resistance should be nearly zero

ii) Its should be sensitive and accurate

iii) It should be direct reading type

iv) It should be of proper range

5. The functions of shunt in ammeter are,

i) It lowers the effective resistance of galvanometer

ii) It protects the galvanometer by providing alternative path to the current.

iii) It decides the range of ammeter.

6. i) The M.C.C. can be converted into ammeter by connecting low resistance in parallel with it, which is given by,

$$S = \left(\frac{I_g}{I - I_g}\right).G.$$

ii) The current through the galvanometer in ammeter is given by,

$$I_g = \left(\frac{S}{S+G}\right) I$$

iii) The current through the shunt of ammeter is given by,

$$I_S = \left(\frac{G}{S+G}\right) I$$

iv) The galvanometer of resistance C and current range I, is to be converted into ammeter of range nI ampere. The value of shunt required is given by,

$$S = \frac{G}{(n-1)}$$

v) Sensitivity of ammeter $\frac{I_g}{I} = \frac{S}{G+S}$

7. The resistance of ammeter is,

$$R_A = \frac{SG}{S+G}$$

8. If the range of ammeter of resistance C_A is to be increased form I_1 to I_2 then the shunt resistance to be connected is

$$S = \frac{I_1 G_A}{I_2 - I_1}, \text{ If } I_2 = nI_1\ S = \frac{G_A}{(n-1)}$$

9. The resistance of ideal ammeter is zero, so that it does not change the current through the circuit.
10. Resistance of microammeter is greater than resistance of milliammeter, which is greater than resistance of ammeter.
11. The range of ammeter can be increased by decreasing the value of shunt.

5.4 Voltmeter

1. A moving coil galvanometer designed for the measurement of potential difference is called as voltmeter.
   The voltmeter is high resistance galvanometer connected in parallel with the component across which p.d. is to be measured.

2. The M.C.C. can be converted into voltmeter by connecting high resistance in series with the galvanometer. Thus, voltmeter is series combination of galvanometer and high resistance.
3. The requirement of ideal voltmeter are,
   i) Its resistance should be very large.
   ii) It should be sensitive and accurate.
   iii) It should be direct reading type.
   iv) It should be of proper range.
4. The functions of high resistance in voltmeter are,
   i) It increases the effective resistance of galvanometer
   ii) It reduces the current through the galvanometer and hence protect it.
   iii) It decides the range of voltmeter.
5. i) The M.C.G. can be converted into voltmeter by connecting high resistance in series with the galvanometer which is given by,

$$R = \frac{V}{I_g} - G$$

ii) The current flowing through the galvanometer in voltmeter is given by,

$$I_g = \frac{V}{R + G}$$

6. The galvanometer of resistance G and voltage range V volt is to be converted into voltmeter of range nV volt. The value of high resistance required is given by,

   $R = (n - 1)\, G$
7. The resistance of voltmeter is, $R_V = R + G$
8. If the range of a voltmeter of resistance G_V is increased from V_1 to V_2 then the

$$R = \left(\frac{V_2 - V_1}{V_1}\right) G_V.$$

$R = (n - 1)\, G \qquad (\because V_2 = nV_1)$

9. The resistance of ideal voltmeter is infinity so that it does not change the current through the component of a circuit and hence potential difference across it.
10. Resistance of voltmeter is greater than the resistance of millivoltmeter which is greater than the resistance of microvoltmeter.
11. The range of voltmeter can be increased by increasing the value of series resistance.
12. The ammeter can be converted into voltmeter by connecting high resistance in series with it. The voltmeter can be converted into ammeter by connecting low resistance in parallel with it.

Remark:

1. If an ammeter of range I and resistance G_A is to be converted into voltmeter of range V, then the resistance R to be connected in series is

$$R = \frac{V}{I} - G_A$$

2. If the voltmeter of range V and resistance G_v is to be converted into ammeter of range 1then the shunt resistance S to be connected in parallel is

$$S = \frac{G_v}{(IG_v / V) - 1} \text{ or } S = \frac{VG_v}{IG_v - V}$$

5.5 Sensitivity and accuracy of M.C.G.

Sensitivity of M.C.G. :

1. **Current sensitivity:** The deflection produced per unit current is called current sensitivity.

   i.e. $S_I = \dfrac{d\theta}{dI}$.

   The S.I. unit of current sensitivity is radian/A.
2. The reverse of current sensitivity is known as figure of merit of galvanometer.
3. The current sensitivity of M.C.G. is given by,

$$S_i = \frac{nAB}{K}$$

4. The current sensitivity of M.C.G. can be increased by,
   i) Increasing number of turns
   ii) Increasing area of the coil
   iii) Increasing magnetic induction
   iv) Decreasing torsional constant.
5. **Voltage sensitivity:** The deflection produced per unit voltage is called as voltage sensitivity.

   i.e. $S_v = \dfrac{d\theta}{dV}$

   In S.I. system, unit of voltage sensitivity is radian/ vol t.
6. The voltage sensitivity of M.C.G. is given by,

$$S_v = \frac{nAB}{KG}$$

7. The relation between voltage sensitivity, current sensitivity and resistance of M.C.G. is given by,

$$S_v = \frac{S_i}{G}$$

Accuracy of M.C.G. :

1. If the fractional error i.e. relative error i.e. dl/I in the measurement of current is minimum then accuracy of M.C.G. is said to be maximum.
2. The accuracy of M.C.G. is given by, $\frac{dI}{I} = \frac{d\theta}{\theta}$
3. The accuracy of M.C.G. can be increased by,
   i) Taking maximum deflection of coil
   ii) Decreasing the number of turns and
   iii) Decreasing the area of the coil.

   Remark: Ballistic galvanometer and dead beat galvanometer are the types of galvanometer. "Charge is directly proportional to the deflection of coil", is principle of working of ballistic galvanometer.

5.6 Cyclotron

1. Cyclotron is a device used to accelerate positively charged particles (like protons, a-particles, deuterons etc.) to acquire enough energy to carry out nuclear disintegrations. It was invented by E. O. Lawerence and M. S. Livingstone in 1932.
2. **Principle:** When a positively charged particle is made to move in periodic time again and again in a high frequency electric field and using strong magnetic field, it gets accelerated and acquires sufficiently large amount of energy.
3. The radius of the path traced by positive charge in cyclotron is given by

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

4. Time taken by the particle to complete the semicircle inside the dee is,

$$t = \frac{\pi m}{qB}$$

   This shows that time taken by the positively charged particle to complete any semicircle is same.
5. **Time period:** The time period of the alternating electric field is,

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

6. **Cyclotron frequency:** Cyclotron frequency which is also called as magnetic resonance frequency is given by

$$\nu = \frac{1}{T} = \frac{qB}{2\pi m}$$

7. Cyclotron angular frequency is given by,

$$\omega = 2\pi\nu = \frac{qB}{m}$$

8. **Energy gained:** Energy gained by the positively charged particle is given by,

$$E = \frac{q^2B^2r^2}{2m}$$

   Thus, maximum energy gained by the charged particle is,

$$E_{max} = \frac{q^2B^2}{2m} r^2_{max}$$

   Thus, the positively charged particle will acquire maximum energy when it is at the- periphery of the dees where r is maximum.
9. **Limitations of cyclotron:**

i) Cyclotron can not accelerate uncharged particles like neutron.

ii) Cyclotron can not accelerate electrons because they have very small mass. Electrons start moving at a very high speed when they gain small energy in the cyclotron. Oscillating electric field makes them to go quickly out of step because of their very high speed.

iii) The positively charged particles having large mass i.e. ions can not move at limit less speed in a cyclotron. When the speed of the ion becomes comparable to the speed of light, the. mass of ion increases as per relation

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

where, m_0 - mass of ion at rest
m - mass of ion at velocity v
c - velocity of light.

Time taken by the ion to describe semicircular path depends directly upon its mass. As such increased mass will not allow ion to arrive in the gap between the two dees exact when the polarity of dees is reversed, hence there will be no further acceleration of the particle. The positive ion can accelerate only up to the time when it does not take longer time to describe semicircular path than the time for half cycle of the electric field.

10. **Uses of cyclotron:** The high speed, positively charged particles are used for the artificial disintegration of atomic nuclei and for the production of radioactive isotopes.

11. **Advantages of cyclotron:**

i) It produces high energetic positively charged particles of energy of about 50 MeV.

ii) The size of cyclotron is small.

iii) It operates on low voltage.

iv) It provides continuous stream of charged particles.

❍❍❍

MULTIPLE CHOICE QUESTIONS

5.0 Basic concept

Electric Current

1. The phenomenon in which magnetic field is produced in the space near a conductor carrying current is called
a) thermionic effect
b) photoelectric effect
c) heating effect
d) magnetic effect of electric current

2. An electric current is always accompanied by a magnetic field', was discovered by
a) Ampere b) Oersted
c) Kelvin d) Fleming

3. The energy resides in a current carrying conductor in the form of
a) magnetic field b) mechanical work
c) electrostatic field d) gravitational field

4. An electric charge e moves with a constant speed v parallel to the lines of force of a uniform magnetic field B, the force experienced by the charge is
a) $\frac{ev}{B}$ b) $\frac{e}{Bv}$
c) eBv d) zero

5. The direction of force experienced by the current carrying conductor in auniform magnetic field is given by
a) Fleming's right hand rule
b) Fleming's left hand rule
c) Lenz's law
d) none of these

6. The current in a wire is directed towards east and the wire is placed in magnetic field directed towards north. The force on the wire is
a) due east
b) due south
c) vertically upwards
d) vertically downwards

7. A current carrying coil in a uniform magnetic field behaves like a
a) magnetic pole
b) magnetic dipole
c) magnetic substance
d) non magnetic substance

8. When a conductor of length l carrying a current I is placed in a magnetic field of induction B at an angle θ with respect to $\vec{B}$, the force experienced by it is
a) $F = I B l$ b) $F = I B l \sin \theta$
c) $F = I B l \cos \theta$ d) $F = I B l \tan \theta$

9. The magnetic field at the centre of the current carrying coil
a) is directed normal to the plane of the coil
b) is directed parallel to the plane of the coil
c) is zero
d) has none of the above characteristics

10. A current carrying conductor placed in a uniform magnetic field, experience
a) a weak force
b) a strong force
c) a mechanical push on it
d) an electrostatic imbalance

11. If a current flowing in a circular coil is in anti clockwise direction, then direction of magnetic field will be
a) towards you
b) away from you
c) at an angle of 45°
d) in parallel of the coil

12. The magnetic field at a point due to a current carrying conductor is directly proportional to
a) resistance of the conductor
b) thickness of the conductor
c) distance from the conductor
d) current flowing through the conductor

13. The direction of the magnetic field produced by a linear current is given by
a) Joule's law
b) Ampere's law
c) right hand thumb rule
d) Flemings left hand rule

14. The radius and number of turns of a' circular coil are doubled. The magnetic intensity at its centre will be
a) one fourth b) four times
c) double d) no change

15. In C.C.S. system unit of magnetic flux is
a) maxwell b) weber
c) newton d) tesla

16. 1 maxwell = ... weber
 a) 10^{-8} b) 10^{-4}
 c) 10^{-6} d) 10^{-3}

17. The magnetic effect of an electric current was discovered by
 a) Fleming b) Faraday
 c) Ampere d) Oersted

18. Which of the following is not the unit of magnetic induction?
 a) maxwell b) gauss
 c) oersted d) weber/meter^2

19. A magnetic field is measured by
 a) ammeter b) pyrometer
 c) flux meter d) thermopile

20. Which of the following is the unit of magnetic induction?
 a) T b) Wb/m^2
 c) N/Am d) all of these

21. The force between two wires is 2×10^{-7} N/m, spaced 1 m apart to each other in vacuum. The electric current flowing through the wire is
 a) zero b) 2×10^{-7} A
 c) 5×10^{6} A d) unit ampere

5.1 Ampere's law and its applications

22. The magnetic field inside a solenoid is
 a) directly proportional to its length
 b) inversely proportional to the total number of turns
 c) inversely proportional to the current
 d) directly proportional to the current

23. Which is the only 'vector quantity from the following?
 a) Current flowing in a metallic conductor
 b) Electrostatic potential
 c) Charge on a capacitor
 d) Magnetic induction

24. The magnetic field inside a long solenoid is
 a) non uniform b) zero
 c) uniform d) infinity

25. The magnetic field intensity due to a long solenoid at its end is
 a) $\mu_0 nI$ b) $2\mu_0 nI$
 c) $\mu_0 nI / 2$ d) $\sqrt{\mu_0 nI}$

26. The strength of the magnetic field along solenoid having 5000 turns per meter is 3.14×10^{-2} T. The current flowing through the solenoid is
 a) 2 A b) 3 A
 c) 4 A d) 5 A

27. The field produced inside a current carrying long solenoid does not depend upon
 a) the number of turns for unit length
 b) the current flowing through the coil
 c) the diameter of the solenoid
 d) all the above factors

28. The magnitude of magnetic induction (B) inside a solenoid of length L, number of turns N and carrying a current I is given by
 a) $\frac{\mu_0}{4\pi}\frac{N}{L}I$ b) μ NIL
 c) $\frac{\mu_0}{4\pi}$NIL d) $\mu_0 \frac{NI}{L}$

29. A long solenoid carrying a current produces a magnetic field B along its axis. If the number of turns per cm is doubled and the current in the solenoid is halved, then the new value of the magnetic field along its axis will be
 a) 2 B b) B/2
 c) B d) 4 B

30. A straight wire of length 1 m, and carrying a current of 1.8 A, is placed in a uniform magnetic field of induction 2T. If the magnetic field is perpendicular to the length of the wire, then the force acting on the wire is
 a) 1.8 N b) 3.6 N
 c) 0.9 N d) 2.5 N

31. A charged particle of charge q moving with a velocity v, enters along the axis of a solenoid carrying a current. If B is the magnetic induction along the axis of the solenoid then the force acting on the charged particle will be
 a) qvB b) less than qvB
 c) zero d) more than qvB

32. The unit of current elements i.e. pole strength is
 a) A/m b) Am
 c) Am^2 d) A/m^2

33. If a current is passed in a spring then
 a) it is compressed
 b) it gets expanded
 c) it performs a vertical SHM
 d) remains unchanged

34. Ampere's law is similar to

a) Faraday's law
b) Gauss's theorem in electrostatics
c) Joule's law
d) Kirchhoff's law

35. A current of I A flows along an infinitely long straight thin walled tube. What is the magnetic induction at any point inside the tube?
a) Zero b) Infinity
c) $\frac{\mu_0 I}{2\pi r}$ d) $\frac{\mu_0 I}{2}$

36. A charge q coulomb moves in a circle at n revolutions per second and the radius of the circle is r metre. Then magnetic field at the centre of the circle is
a) $\frac{2\pi q}{nr} \times 10^{-7}$ N/Am
b) $\frac{2\pi q}{nr} \times 10^{-7}$ N/Am
c) $\frac{2\pi nq}{r} \times 10^{-7}$ N/Am
d) $\frac{2\pi q}{nr}$ N/Am

37. A solenoid of 1.5 m length and 4.0 cm diameter posses 10 turn per cm. A current of 5 A is flowing through it. The magnetic induction at axis inside the solenoid is
a) $2\pi \times 10^{-3}$ tesla b) $2\pi \times 10^{-5}$ tesla
c) $4\pi \times 10^{-2}$ gauss d) $2\pi \times 10^{-5}$ gaus

38. The magnetic induction at a point P which is at a distance 4 cm from a long current carrying wire is 10^{-8} Tesla. The field of induction at a distance 12 cm from the same current would be
a) 3.33×10^{-9} tesla b) 1.11×10^{-4} tesla
c) 3×10^{-3} tesla d) 9×10^{-2} tesla

39. A current of 0.1 A circulates around a coil of 100 turns and having a radius equal to 5 cm. The magnetic field set up at the centre of the coil is ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A m)
a) $4\pi \times 10^{-5}$ tesla b) $8\pi \times 10^{-5}$ tesla
c) 4×10^{-5} tesla d) 2×10^{-5} tesla

40. Field inside a toroid is
a) directly proportional to its length
b) directly proportional to current
c) inversely proportional to total number of turns
d) inversely proportional to current

41. A long solenoid has a radius 'a' and number of turns per unit length is 'n'. If it carries a current 'i', then the magnetic field on its axis is directly proportional to
a) ani b) ni
c) ni/a d) n^2 i

42. A long solenoid is formed by winding 20 turns/cm. The current necessary to produce a magnetic field of 20 mT inside the solenoid will be approximately ($\mu_0/4\pi = 10^{-7}$ tesla m / A)
a) 8.0 A b) 4.0 A
c) 2.0 A d) 1.0 A

43. Due to 10 A of current flowing in a circular coil of 10 cm radius, the magnetic field produced at its centre is 3.14×10^{-3} Wb/m². The number of turns in the coil will be
a) 5000 b) 100
c) 50 d) 25

44. A solenoid is 1.0 m long and it has 4250 turns. If a current of 5.0 A is flowing through it, what is the magnetic field at its centre?
($\mu_0 = 4\pi \times 10^{-7}$ Wb/A m)
a) 5.4×10^{-2} Wb/m² b) 2.7×10^{-2} Wb/m²
c) 1.35×10^{-2} Wb/m² d) 0.675×10^{-2} Wb/m²

45. In a current carrying toroid, the field produced does not depend upon
a) number of turns per unit length
b) current flowing
c) radius of the solenoid
d) all of the above three

46. A toroid has number of turns per unit length n, current if then the magnetic field is
a) μ_0 ni b) $\mu_0 n^2 i$
c) μ_0 i/n d) none of these

47. A long solenoid of length L has a mean diameter D. It has n layers of windings of N turns each. If it carries a current 'i' the magnetic field at its centre will be
a) proportional to D
b) inversely proportional to D
c) independent of D
d) proportional to L

48. A long solenoid has 200 turns per ern and carries a current of 2.5 A. The magnetic field at its centre is ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A m)
a) 3.14×10^{-2} Wb/m² b) 6.28×10^{-2} Wb/m²
c) 9.42×10^{-2} Wb/m² d) 12.56×10^{-2} Wb/m²

49. A toroid has n turns per metre and current I A is flowing through it. The magnetic field inside the toroid is
a) μ_0 nI/2 b) $\mu_0$0 nI
c) zero d) $2\mu_0$ nI

50. A solenoid of 1.5 metre length and 4.0 cm diameter possesses 10 turn per cm. A current of 10 A is flowing through it. The magnetic induction at axis inside the solenoid is
a) $4\pi \times 10^{-3}$ T b) $2\pi \times 10^{-5}$ T
c) $2\pi \times 10^{-2}$ gauss d) $2\pi \times 10^{-5}$ gauss

51. Field at one end of a solenoid is
a) directly proportional to its length
b) directly proportional to current
c) inversely proportional to total number of turns
d) inversely proportional to current

52. The field due to a long straight wire carrying a current I is proportional to
a) I b) $\sqrt{I}$
c) I^2 d) 1/I

53. Two concentric circular coils of ten turns each are situated in the same plane. Their radii are 20 cm and 40 cm and they carry respectively 0.2 A and 0.3 A current in opposite direction. The magnetic field in Wb/m^2 at the centre is
a) $\mu_0/80$ b) $7\mu_0/80$
c) (5/4) μ_0 d) zero

54. An electron (mass = 9×10^{-31} kg, charge = 1.6×10^{-19} C) moving with a velocity of 106 m/s enters a magnetic field. If it describes a circle of radius 0.1 m, then strength of magnetic field must be
a) 4.5×10^{-5} T b) 1.4×10^{-5} T
c) 55×10^{-5} T d) 2.6×10^{-5} T

55. A uniform magnetic field acts at right angle to the direction of motion of electron. As a result of this, the electron describers a circular path of radius 2 cm. If the speed of electron is doubled, the radius of circular path will becomes
a) 4 cm b) 2 cm
c) 1 cm d) 8 cm

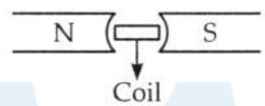
5.2 Moving Coil Galvanometer

56. If K is the restoring torque per unit twist of the fiber and θ is the deflection of the coil of M.C.G. then the restoring torque is given by
a) $\tau = K\theta$ b) τ = nIAB
c) $\tau = K$ d) $\tau = \theta$

57. The torque acting on the coil is maximum if it is suspended in
a) uniform magnetic field
b) radial magnetic field
c) earths magnetic field
d) none of these

58. A magnetic needle is kept in a non uniform magnetic field. It experiences
a) a force and a torque
b) a force but not a torque
c) a torque but not a force
d) neither a force nor a torque

59. Figure shows the north and south poles of a permanent magnet in which n turn coil of area of cross section A is resting such that for a current I passed through the coil, the plane of the coil makes an angle θ with respect to direction of magnetic field B. If the plane of magnetic field and the coil are horizontal and vortical respectively, the torque on the coil will be



a) nIAB cos θ
b) nIAB sin θ
c) nIAB
d) none of the above since the magnetic field is radial

60. When a current carrying coil is placed in a uniform magnetic field of induction B, then a torque τ acts on it. If I is the current, n is the number of turns and A is the face area of the coil and the normal to the coil makes on angle θ with B, then
a) τ = nIAB b) τ = nIAB cos θ
c) τ = nIAB sin θ d) τ = nIAB tan θ

61. If a coil carrying an electric current is placed in a uniform magnetic field then
a) e.m.f. is induced
b) torque is produced
c) torque is not produced
d) both 'a' and 'b'

62. To make the field radial in a moving coil galvanometer
a) the number of turns in the coil is increased
b) magnet is taken in the form of horse shoe type
c) poles are cylindrically cut

d) coil is wound on aluminium frame

63. A moving coil galvanometer is based upon the principle that a wire carrying a current
a) experiences a force in magnetic field
b) does not produce any field
c) produces magnetic field
d) none of these

64. When a current is passed in a moving coil galvanometer the coil gets deflected because
a) the current deflects any thing
b) current in the coil produces a magnetic field
c) current in the coil produces an electric field
d) a couple acts on the coil

65. In a moving coil galvanometer, a radial magnetic field is produced due to the
a) concave pole pieces of the magnet
b) rectangular coil
c) iron core
d) mirror

66. The lamp and scale arrangement of M.C.G. is used to measure the
a) current flowing through the coil
b) voltage
c) e.m.f. of the cell
d) deflection of the coil

67. In a moving coil galvanometer, we use a radial magnetic field so that the galvanometer scale is
a) linear b) algebraic
c) logarithmic d) exponential

68. In a moving coil galvanometer, the turning effect on the coil is proportional to
a) I^3 b) I^2
c) I d) I^{-1}

69. In a moving coil galvanometer, the deflection of the coil θ is related to the electric current I by the relation
a) $I \propto \tan\theta$ b) $I \propto \theta$
c) $I \propto \theta^2$ d) $I \propto \sqrt{\theta}$

70. The coil of a sensitive M.C.G. swings too far on both sides. This movement can be quickly stopped by
a) holding a magnet near the coil
b) earthing the case of the galvanometer
c) connecting a large resistance across the ends of the coil
d) connecting a short length of copper wire across the ends of the coil

71. The current flowing through the coil of M.C.G. depends on
a) torsional constant of suspension fibre
b) area of the coil
c) magnetic induction
d) all of these

72. Which of the following equation gives the current flowing through the coil of M.C.G.?
a) $I = \frac{K\theta}{nAB}$ b) $I = \frac{n\theta}{KAB}$
c) $I = \frac{\theta A}{KnB}$ d) $I = \frac{B\theta}{nAB}$

73. Stray magnetic field does not affect the deflection of a coil of M.C.C. because
a) magnetic field of M.C.C. is strong
b) magnetic field of M.C.C. is weak
c) M.C.C. is portable
d) none of these

74. A.M.C.C. is based on
a) heating effect of current
b) chemical effect of current
c) magnetic effect of current
d) thermoelectric effect

75. Earths magnetic field always has a horizontal component except at
a) the geographical poles
b) the magnetic poles
c) the magnetic equator
d) altitude of 60°

76. The magnetic field is made radial in a M.C.C.
a) to make field stronger
b) to make field weaker
c) to make scale linear
d) to reduce its resistance

77. The coil of a suspended coil galvanometer has very high resistance. When a momentary current is passed through the coil, it
a) oscillates with decrease in amplitude
b) oscillates with the same amplitude
c) gets deflected and comes to rest slowly
d) shows steady deflection

78. A moving coil D' Arsonval galvanometer is based on the
a) heating effect of current

b) magnetic effect of current
c) chemical effect of current
d) peltier effect of current

79. The pole pieces used in moving coil galvanometer should produce a magnetic field
a) equal to earths magnetic field
b) much stronger than earths magnetic field
c) much weaker than earths magnetic field
d) any arbitrary magnetic field

80. Ohm meter is a device for directly measuring the resistance of a conductor. It is a modification of
a) a moving coil galvanometer
b) a voltmeter
c) a rheostat
d) all are true

81. The pointer of a dead beat galvanometer gives a steady deflection because
a) eddy currents are produced in the conducting frame over which the coil is wound
b) its magnet is very strong
c) its pointer is very light
d) its frame is made of ebonite

82. In a ballistic galvanometer the deflection is proportional to
a) charge b) current
c) potential difference d) none of these

83. The deflection θ in a moving coil galvanometer is
a) directly proportional to torsional constant
b) directly proportional to number of turns in the coil
c) inversely proportional to area of the coil
d) inversely proportional to the current flowing through the coil

84. In radial magnetic field, the plane of the coil of M.C.G. for any position is always
a) perpendicular to the lines of force
b) parallel to the lines of force
c) inclined with 45° with the lines of force
d) none of these

85. In radial magnetic field, the torque acting on the current carrying freely suspended coil is
a) zero b) maximum
c) less than zero d) none of these

86. The concave pole pieces of the strong magnets are used to produce
a) uniform magnetic field
b) non uniform magnetic field
c) radial magnetic field
d) all of these

87. In radial magnetic field lines of force are
a) parallel b) curved
c) along radii d) none of these

88. In moving coil galvanometer, the magnetic field is
a) uniform b) non uniform
c) radial d) none of these

89. The suspension wire in the moving coil galvanometer is made up of
a) brass b) copper
c) platinum d) phospher bronze

90. The galvanometer has been named so, because it is based on
a) magnetic effect of electric current
b) sine rule
c) cosine rule
d) tangent rule

91. In M.C.G., the coil of M.C.G. will be in equilibrium position if
a) deflecting torque = restoring torque
b) deflecting torque> restoring torque
c) deflecting torque < restoring torque
d) none of these

92. Any external magnetic field does not affects the readings of M.C.G. because
a) internal magnetic field is strong
b) internal magnetic field is weak
c) M.C.G. is simple in construction
d) none of these

93. A soft iron core is placed at the centre of rectangular coil in M.C.G. because
a) it increases magnetic field
b) it decreases magnetic field
c) more current to pass through the coil
d) all of these

94. The lamp and scale arrangement is used for the measurement of deflection in
a) suspended coil type M.C.G.
b) pivoted coil type M.C.G.
c) tangent galvanometer
d) potentiometer

95. In suspended coil type M.C.G. the coil is suspended in radial magnetic field by thin fibre of phosphor bronze because

a) it has high torsional constant
b) it has low torsional constant
c) negative torsional constant
d) none of these

96. The poles of the magnet in a moving coil galvanometer are curved to make the field
a) radial b) intense
c) uniform d) non uniform

97. A centre zero galvanometer is connected in series with a switch and a battery. When the switch is closed and opened periodically (nearly about 4 times/sec) its needle
a) reads always zero
b) gives steady reading
c) swings backward and forward across zero
d) swings backward and forward from zero on one side.

98. The moving coil galvanometer has 60 turns, a width of 2 cm and a length of 3 cm. It hangs in uniform magnetic field of 500 cgs unit. If the maximum controlling couple, due to the twist in the suspension wire is 18 dyne ern, then the current flowing through it is
a) 10^{-2} A b) 10^{-3} A
c) 10^{-4} A d) 3×10^{-5} A

99. The moving coil galvanometer has a current 2A for a particular number of turns and area of coil and magnetic field of (B) = 4×10^{-3} Wb/m^2. If the magnetic field is replaced by 8×10^{-3} Wb/m^2 in a galvanometer then the current for same deflection becomes
a) 1A b) 2A
c) 3A d) 4 A

100. If the number of turns in a galvanometer becomes half, then deflection for the same current will become
a) half b) same
c) double d) 4 times

101. The deflection in a M.C.G. is reduced to half, when it is shunted with a 40 Ω coil. The resistance of the galvanometer is
a) 60 Ω b) 40 Ω
c) 20 Ω d) 10 Ω

102. The deflection in a M.C.G. falls from 50 divisions to 10 divisions, when a shunt of 12 Ω is applied. The resistance of the galvanometer coil is
a) 12 Ω b) 24 Ω
c) 48 Ω d) 50 Ω

103. A rectangular coil of a M.C.G. of effective area 0.05 m^2 is suspended freely in a radial magnetic field of induction 0.01 Wb/m^2. If the torsional constant of the suspension fibre is 5×10^{-9} Nm per degree. When a current of 300 μA is passed through it, deflection of coil is
a) 15° b) 30°
c) 45° d) 60°

5.3 Ammeter

104. Ammeter is used for the measurement of
a) current b) potential difference
c) resistance d) power

105. For the measurement of current ammeter is connected in
a) parallel with the circuit
b) series with the circuit
c) both 'a' and 'b'
d) neither 'a' nor 'b'

106. The parallel combination of galvanometer and shunt is called
a) voltmeter b) ohmmeter
c) ammeter d) speedometer

107. The function of the shunt in ammeter is
a) to allow minimum current through the galvanometer
b) to reduce the resistance of galvanometer
c) both 'a' and 'b'
d) to increase resistance of galvanometer

108. An ammeter is a
a) low resistance galvanometer and is always connected in parallel with a circuit
b) low resistance galvanometer and it is always connected in series with the circuit
c) high resistance galvanometer and is always connected in series with the circuit
d) high resistance galvanometer and is always connected in parallel with the circuit

109. The resistance of an ideal ammeter is
a) low b) zero
c) high d) infinite

110. An ammeter should have very low resistance, so that it may
a) not burn out
b) have better stability
c) show large deflection

d) not change the value of the current

111. An ammeter has a resistance of G Ω and range of I amperes. The value of the resistance used in parallel to convert it into an ammeter of range nI amperes is
a) nG b) G/n
c) (n – 1) G d) G/(n – 1)

112. To convert a moving coil galvanometer into an ammeter, one needs to connect a
a) small resistance in series
b) large resistance in series
c) small resistance in parallel
d) large resistance in parallel

113. The M.C.G. has resistance G and I_g be the minimum current for it full scale deflection. To convert M.C.G. into ammeter of range IA, the required shunt is
a) $S = \left(\frac{I_g}{I - I_g}\right) G$ b) $S = \left(\frac{I_g - G}{I}\right)$
c) $S = \frac{I_g}{G(I - I_g)}$ d) none of these

114. When a galvanometer of resistance G is converted into an ammeter of range IA then the current passing through shunt (S) is
a) $I_s = \left(\frac{G}{G+S}\right) I$ b) $I_s = \left(\frac{S}{S+G}\right) I$
c) $I_s = \left(\frac{SI+G}{S}\right)$ d) $I_s = S \times G$

115. The range of ammeter can be increased by
a) decreasing shunt b) increasing shunt
c) changing scale d) none of these

116. A voltmeter can be converted into ammeter by connecting
a) a low resistance in series
b) a low resistance in parallel
c) a high resistance in series
d) a high resistance in parallel

117. An ammeter has resistance R_0 and range I. What resistance should be connected in parallel with it to increase its range to nI ?
a) R_0/n b) R_0 / (n – 1)
c) R_0(n + 1) d) R_0/(n + 1)

118. An ammeter of low range can be converted into an ammeter of higher range by connecting
a) a high resistance in series
b) a high resistance in parallel
c) a low resistance in series
d) a low resistance in parallel

119. To decrease the range of an ammeter its resistance need to be increased. An ammeter has resistance R_0 and range I. Which of the following resistance can be connected in series with it to decrease its range to I/n
a) R_0/n b) R_0 / (n – 1)
c) R_0 / (n + 1) d) none of these

120. To measure the current in an electric device
a) put an ammeter in parallel with .it
b) put a voltmeter in parallel with it
c) put an ammeter in series with it
d) put a voltmeter in series with it

121. When an ammeter is connected in parallel the resistance of the circuit is
a) increased b) decreased
c) is unchanged d) none of these

122. The function of shunt resistance in ammeter is
a) it lowers resistance of galvanometer
b) it protects galvanometer
c) it decides range of ammeter
d) all of these

123. The requirements of ideal ammeter are
a) its resistance should be nearly zero
b) it should be direct reading type
c) it should be sensitive and accurate
d) all of these

124. Which of the following has largest resistance?
a) ammeter b) milliammeter
c) microamrneter d) all of these

125. A galvanometer of resistance 100 Ω gives a full scale deflection for a current of 10^{-5} A. To convert it into an ammeter capable of measuring upto 1 A, we should connect a resistance of
a) 10^{-3} Ω in series b) 100 Ω in parallel
c) 100 Ω in series d) 10^{-3} Ω in parallel

126. If a galvanometer current is 10 mA, resistance of the galvanometer is 40 Ω and shunt of 2 Ω is connected to the galvanometer, the maximum current which can be measured by this ammeter is
a) 0.21 A b) 2.1 A
c) 210 A d) 21 A

127. The resistance of an ammeter of 1 A range is $0.018\ \Omega$. How will you convert it to an ammeter measuring up to 10 ampere?
a) $0.2\ \Omega$ b) $0.02\ \Omega$
c) $0.002\ \Omega$ d) $0.001\ \Omega$

128. A galvanometer has a resistance of $118\ \Omega$ and gives full scale deflection for a current of 50 mA. If it is required to convert into an ammeter of range 3 A, the shunt resistance should be
a) $0.2\ \Omega$ b) $0.28\ \Omega$
c) $2\ \Omega$ d) $2.8\ \Omega$

129. If a galvanometer is shunted by (1/n)th of its resistance then the fraction of the total current passing through the galvanometer is
a) 1/n b) n
c) 1/(n + 1) d) 1/(n – 1)

130. A potential difference of 0.75 V applied across a galvanometer causes a current of 15 mA to pass through it. If it can be converted into ammeter of range of 25 A, the required shunt should be
a) $0.3\ \Omega$ b) $0.03\ \Omega$
c) $0.003\ \Omega$ d) $0.0003\ \Omega$

131. An ammeter has a resistance of 1000 A potential difference of 50 mV between its terminals gives full scale deflection. How will you convert it into an ammeter of range 5 A ?
a) $0.01\ \Omega$ b) $0.1\ \Omega$
c) $1\ \Omega$ d) $10\ \Omega$

132. The combined resistance of a galvanometer of resistance of $500\ \Omega$ and its shunt is $25\ \Omega$. The resistance of shunt is
a) $25\ \Omega$ b) $50\ \Omega$
c) $23.6\ \Omega$ d) $26.3\ \Omega$

133. A resistance of $2\ \Omega$ is connected in parallel to a galvanometer of resistance $48\ \Omega$. The fraction of the total current passing through the resistance of $2\ \Omega$ is
a) 92 % b) 94 %
c) 96 % d) 98 %

134. An ammeter is obtained by shunting a $30\ \Omega$ galvanometer with a $30\ \Omega$ resistance. What additional shunt should be connected across it to double its range?
a) $10\ \Omega$ b) $15\ \Omega$
c) $30\ \Omega$ d) none of these

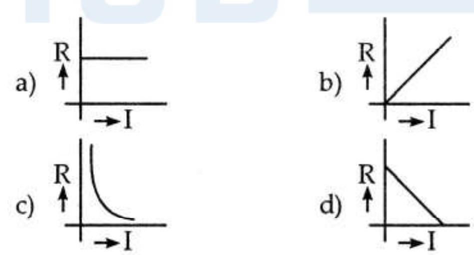
135. The sensitivity of a galvanometer is 60 divisions/amp. When a shunt is used, its sensitivity becomes 10 divisions/amp. If galvanometer is of resistance $20\ \Omega$, the value of shunt used is
a) $4\ \Omega$ b) $5\ \Omega$
c) $20\ \Omega$ d) $8\ \Omega$

136. In an ammeter 5% of the main current is passing through the galvanometer. If the resistance of galvanometer is G, then the resistance of shunt S will be
a) G/19 b) G/5
c) 5 G d) 19 G

137. To send 10% of the main current through a moving coil galvanometer of resistance $99\ \Omega$, the shunt required is
a) $9.9\ \Omega$ b) $10\ \Omega$
c) $11\ \Omega$ d) $9\ \Omega$

138. A galvanometer has a resistance $G\ \Omega$. It is shunted by a resistance of $S\ \Omega$. How much resistance should be added in series so that the main current in the circuit remains unchanged?
a) $\frac{S}{S+G}$ b) $\frac{G}{G+S}$
c) $\frac{G^2}{G+S}$ d) $\frac{SG}{G+S}$

139. Of the following graphs, the one which shows the relationship between the resistance R of multirange moving coil ammeter and its range I is



5.4 Voltmeter

140. The potential difference across any component in electric circuit is measured by,
a) ammeter b) voltmeter
c) ohmmeter d) none of these

141. For the measurement of potential difference voltmeter is connected
a) in parallel with the circuit

b) in series with the circuit
c) in open circuit
d) none of these

142. The series combination of galvanometer and high resistance is called as
a) ammeter b) potentiometer
c) voltmeter d) ohmmeter

143. The function of high resistance connected in series with the galvanometer in voltmeter is
a) to increase the effective resistance of galvanometer
b) to determine the range of voltmeter
c) it reduces current through the galvanometer and hence protect it
d) all of these

144. A galvanometer can be converted into a voltmeter by connecting a
a) high resistance in series
b) high resistance in 'parallel
c) low resistance in series
d) low resistance in parallel

145. The resistance of an ideal voltmeter is
a) zero b) low
c) high d) infinity

146. Which of the following is likely to have the largest resistance?
a) Ammeter of range 1A
b) Voltmeter of range 10 V
c) Moving coil galvanometer
d) All will have same resistance

147. The net resistance of a voltmeter should be large to ensure that it may
a) not get overheated
b) not draw excessive current
c) measure large potential difference
d) not change the value of potential difference

148. A voltmeter has a resistance of $G\,\Omega$ and range V volt. The value of resistance used in series to convert it into voltmeter of range nV volt is
a) nG b) G/n
c) (n – 1)G d) G/(n–1)

149. A voltmeter is a
a) low resistance galvanometer and is always connected in parallel with a circuit
b) low resistance galvanometer and is always connected in series with the circuit
c) high resistance galvanometer and is connected in series with the circuit
d) high resistance galvanometer and is connected in parallel with the circuit

150. The M.C.G. has a resistance G and I_g be the minimum current for its full scale deflection. To convert it into voltmeter of range V volt required high resistance is
a) $R = \frac{V}{I_g} - G$ b) $R = \frac{G}{I_g - V}$
c) $R = V - \frac{G}{I_g}$ d) none of these

151. To increase the range of voltmeter the series resistance should be
a) increased b) decreased
c) unchanged d) none of these

152. A galvanometer is to be converted into a voltmeter and an ammeter successively by using either of two resistances R_1 and R_2 ($R_1 > R_2$)
a) R_1 in series with galvanometer and R_2 in parallel
b) R_2 in series with galvanometer and R_1 in parallel
c) R_1 in parallel with galvanometer and R_2 in series
d) R_2 in parallel with galvanometer and R_1 in series

153. To measure the resistance of a device using Ohm's law, which of the following mode of connection is used
a) ammeter in series, voltmeter in parallel
b) voltmeter in series, ammeter in parallel
c) both voltmeter and ammeter in parallel
d) both voltmeter and ammeter in series

154. Which of the following is correct statement?
a) Ammeter is high resistance galvanometer and voltmeter is low resistance galvanometer
b) Ammeter is low resistance galvanometer and voltmeter is high resistance galvanometer
c) Ammeter and voltmeter can not be distinguished on the basis of their resistance
d) None of these

155. An ammeter can be converted into voltmeter by connecting
a) a low resistance in series
b) a low resistance in parallel
c) a high resistance in series
d) a high resistance in parallel

156. A voltmeter has resistance R_0 and range V. What

resistance should be connected in series with it to increase its range to nV?

a) nR_0 b) $(n + 1) R_0$

c) $(n-1)R_0$ d) R_0/n

157. To reduce the range of voltmeter, its resistance need to be reduced. A voltmeter has resistance Roand range V. Which of the following resistances, when connected in parallel, will convert it into a voltmeter of range V/n ?

a) nR_0 b) $(n + 1) R_0$

c) $(n-1)R_0$ d) none of these

158. Which one of the following statement is wrong?

a) A voltmeter should have high resistance

b) An ammeter should have low resistance

c) An ammeter is placed in parallel across the conductor and voltmeter in series in the circuit

d) An ammeter is placed in series in the circuit and voltmeter in parallel across conductor

159. Which of the following resistances must be used to convert galvanometer into voltmeter for maximum sensitiveness?

a) $1\ \Omega$ b) $10^2\ \Omega$

c) $10^5\ \Omega$ d) $10^7\ \Omega$

160. The requirements of ideal voltmeter are

a) its resistance should be large

b) it should be direct reading type

c) it should be sensitive and accurate

d) all of these

161. Which of the following has largest resistance?

a) Voltmeter b) Millivoltmeter

c) Microvoltmeter d) All of these

162. A moving coil galvanometer gives full scale deflection when a current of 0.005 A is passed through its coil. It is converted into a voltmeter reading up to 5V, by using an external resistance of $975\ \Omega$. The resistance of the galvanometer coil is

a) $25\ \Omega$ b) $30\ \Omega$

c) $40\ \Omega$ d) $50\ \Omega$

163. A moving coil galvanometer of resistance $50\ \Omega$ gives a full scale deflection, when a current of 0.5 mA is passed through it. To convert it to a voltmeter of range 10 V, the resistance required to be placed in series is

a) $1995\ \Omega$ b) $2000\ \Omega$

c) $10000\ \Omega$ d) $19950\ \Omega$

164. A galvanometer of resistance $50 \times 10^3\ \Omega$ is used to measure voltage in a circuit. To increase its range to three times, the additional resistance to be put in series is

a) $10^5\ \Omega$ b) $1.5 \times 10^5\ \Omega$

c) $9 \times 10^5\ \Omega$ d) $9 \times 10^6\ \Omega$

165. A galvanometer of resistance (G) $10\ \Omega$ and a series resistance (R) $250\ \Omega$ is used to convert it into a voltmeter of 2 V reading. The current passing through the voltmeter is nearly

a) 0.0077 mA b) 0.077 mA

c) 0.77 mA d) 7.7 mA

166. A voltmeter can measure up to 25 V and its resistance is $1000\ \Omega$. How much resistance should be connected in series so that it can measure voltage up to 250 V ?

a) $90\ \Omega$ b) $900\ \Omega$

c) $9000\ \Omega$ d) $90000\ \Omega$

167. A milliammeter of resistance $10\ \Omega$ has range 0–25 mA. How will you convert it into a voltmeter of range 0–25 volts?

a) $99\ \Omega$ b) $990\ \Omega$

c) $9900\ \Omega$ d) $99000\ \Omega$

168. A voltmeter of resistance $2000\ \Omega$ reads 1 volt/division. The resistance required to be connected in series with voltmeter to make it to read 10 volt/division is

a) $18\ \Omega$ b) $180\ \Omega$

c) $1800\ \Omega$ d) $18000\ \Omega$

169. A galvanometer of resistance $40\ \Omega$ gives the full scale deflection for a current of 10 mA through it. A resistance of $9960\ \Omega$ is connected in series with the galvanometer coil. The maximum voltage that can be measured by the voltmeter is

a) 10 V b) 100 V

c) 50 V d) 500 V

170. A voltmeter has a resistance of $100\ \Omega$ and measures 10 V. How can it be used to measure 50 V?

a) $40\ \Omega$ in series b) $40\ \Omega$ in parallel

c) $400\ \Omega$ in series d) $400\ \Omega$ in parallel

171. A micro ammeter has a resistance of $100\ \Omega$ and a full scale range of $50\ \mu A$. It can be used as a voltmeter or as a higher range ammeter provided resistance is added to it. Pick the correct range and resistance combinations

a) 50 V range and 10 kΩ resistance in series

b) 10 V range and 200 kΩ resistance in series

c) 5 mA range with 1 Ω resistance in parallel

d) both 'b' and 'c'

172. A voltmeter of resistance 1000 Ω reads 2 volt/division. The resistance required to be connected in series with voltmeter to make it to read 20 volt/division is

a) 18000 Ω b) 1800 Ω

c) 9000 Ω d) 900 Ω

173. What resistance should be connected in series with a 0.5 A ammeter to convert it into a 15 V voltmeter? Given that the resistance of ammeter is 2 Ω.

a) 2 Ω b) 5 Ω

c) 15 Ω d) none of these

174. A galvanometer gives full scale deflection when current passed through it is 1 mA. Its resistance is 100 Ω. Without connecting additional resistance in series with it, it can be used as a voltmeter of range

a) 1.000 V b) 0.100 V

c) 0.010 V d) 0.001 V

175. A voltmeter always gives lower value of potential difference because

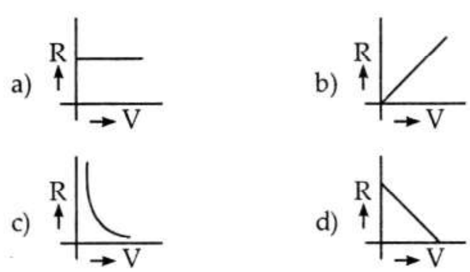
a) some energy is lost in moving the needle

b) it takes current for its own deflection

c) it absorbs some energy

d) both 'a' and 'b'

176. Of the following graphs the one which shows the relationship between the resistance R of a multirange moving coil voltmeter and its voltage range V is



5.5 Sensitivity and accuracy of M.C.G.

177. The sensitivity of a M.C.G. will increase if

a) a strong magnet is used

b) radius of coil is increased

c) number of turns in coil is increased

d) all of these

178. Which of the following has no effect on the sensitivity of a M.C.G. ?

a) The current it measures

b) The thickness of the suspension fibre

c) The magnetic field of the permanent magnet

d) Number of turns in the coil of the galvanometer

179. The current that must flow through the coil of a galvanometer so as to produce a deflection of one division on its scale is called,

a) microvolt sensitivity

b) figure of merit

c) charge sensitivity

d) current sensitivity

180. For the maximum accuracy of M.C.G. deflection should be

a) large b) zero

c) infinity d) none of these

181. What is the relation between voltage sensitivity S_v and the current sensitivity S_i of a moving coil galvanometer of resistance G ?

a) $S_v = GS$ b) $S_v = \frac{S_i}{G}$

c) $S_v\ S_i = G$ d) none of these

182. The sensitivity of a moving coil galvanometer depends on

a) the angle of deflection

b) earths magnetic field

c) torsional constant of the spring

d) the moment of inertia of the coil

183. The sensitivity of a moving coil galvanometer increases with the decrease in

a) number of turns b) area of coil

c) magnetic field d) none of these

184. If n is number of turns, B magnetic field strength, A area of coil and K torsional constant of suspension wire, then sensitivity is given by

a) $\frac{nAB}{K}$ b) $\frac{K}{nAB}$

c) nABK d) $\frac{nAB\sin\theta}{K}$

185. If the fractional error in the measurement of current by M.C.G. is minimum then accuracy of M.C.G. is

a) minimum b) maximum
c) negative d) none of these

186. The accuracy of M.C.G. can be increased by
a) taking large deflection
b) decreasing number of turns
c) decreasing area of the coil
d) all of these

187. The deflection produced per unit voltage in M.C.G. is called
a) charge sensitivity b) current sensitivity
c) voltage sensitivity d) all of these

188. The S.I. unit of current sensitivity is
a) ohm/div b) rad/A
c) amp/div d) volt/div

189. The voltage sensitivity of M.C.G. is given by
a) $S = \frac{nAB}{K}$ b) $S = \frac{nAB}{KG}$
c) $S = nABKG$ d) $S = \frac{KG}{nAB}$

190. A rectangular coil of M.C.G. of 100 turns of effective area 12 cm^2 hangs in a magnetic field of 1.5×10^{-2} T. If the torsional constant of the suspension fibre is 1.5×10^{-8} Nm per radian then current sensitivity of M.C.G. is
a) 0.12 radian/μ A b) 12 radian/μA
c) 120 radian/A d) 0.24 radian/A

5.6 Cyclotron

191. A cyclotron is a device which is generally used to
a) accelerate –ve ions
b) accelerate +ve ions
c) accelerate both positive and negative ions
d) keep the charged particle along a circular path of constant radius

192. In a cyclotron, the charged particles cannot be accelerated upto
a) KeV b) BeV
c) MeV d) 500 eV

193. In a cyclotron, the resonance condition is that the frequency of the charged particle is equal to
a) the frequency of applied magnetic field
b) the frequency of the applied a.c. voltage source
c) frequency of the applied magnetic field, and the frequency of the applied a.c. source
d) none of these

194. In a cyclotron, the applied magnetic field
a) changes only the direction of the charged particle
b) increases only the speed of the charged particle
c) changes the direction of the particle and increases the speed of the particle
d) neither increases the speed nor changes the direction

195. In a cyclotron, the charged particle cannot be accelerated to energies of the order of billion electron volt because if the speed of the particle is increased
a) the frequency of revolution is increased
b) the frequency of revolution is decreased
c) the frequency of a.c. source is decreased
d) the frequency of a.c. source is increased

196. A cyclotron is used to
a) produce charged particles
b) accelerate charged particles to very high energies
c) accelerate charged particles to moderately high speed
d) to produce positive and negative ions

197. Which one of the following particles cannot be accelerated by a cyclotron?
a) Proton b) Positron
c) Neutron d) α –particles

198. The cyclotron frequency of an electron rotating in a magnetic field of 1 T is approximately equal to
a) 28 MHz b) 280 MHz
c) 2.8×10^{10} Hz d) 2.8×10^{9} Hz

199. A proton of energy E is moving in a circular path in a uniform magnetic field. The energy of an α –particle moving in the same magnetic field and along the same path will be equal to
a) E b) 2 E
c) E/2 d) 0.75 E

200. A beam of ions with velocity 2×10^5 m/s enters normally into a uniform magnetic field of 4×10^{-2} tesla. If the specific charge of the ion is 5×10^7 C/kg, then the radius of the circular path described will be
a) 0.10 m b) 0.16 m
c) 0.20 m d) 0.25 m

201. An α –particle travels in a circular path of radius 0.45 m in a magnetic field B = 1.2 Wb/m^2 with a

speed of 2.6×10^7 m/s. The period of revolution of the α–particle is

a) 1.1×10^{-5} s b) 1.1×10^{-6} s
c) 1.1×10^{-7} s d) 1.1×10^{-8} s

202. A charged particle of mass m and charge q describes circular motion of radius r in a uniform magnetic field of strength B. The frequency of revolution is

a) $\frac{Bq}{2\pi m}$ b) $\frac{Bq}{2\pi rm}$
c) $\frac{2\pi m}{Bq}$ d) $\frac{Bq}{2\pi q}$

203. One proton beam enters a magnetic field of 10^{-4} T normally, specific charge = 10^{11} C/kg, velocity = 10^7 m/s. What is the radius of the proton described by it ?

a) 0.1 m b) 1 m
c) 10 m d) none of these

204. In a cyclotron the angular frequency of a charged particle is independent of

a) mass b) speed
c) charge d) magnetic field

205. Maximum kinetic energy of the positive ion in the cyclotron is

a) $\frac{q^2Br_0}{2m}$ b) $\frac{qB^2r_0}{2m}$
c) $\frac{q^2B^2r_0^2}{2m}$ d) $\frac{qBr_0}{2m^2}$

206. A particle of mass m and charge q enters a magnetic field B perpendicular with a velocity v. The radius of the circular path described by it will be

a) Bq/mb b) mq/Bv
c) mv/Bq d) mB/qv

207. Cyclotron is used to accelerate

a) electrons b) neutrons
c) positive ions d) negative ions

208. The cyclotron frequency of an electron gaining in a magnetic field of 2 T is approximately

a) 28 MHz b) 280 MHz
c) 2.8 GHz d) 56 GHz

209. A proton of energy 8 eV is moving in a circular path in a uniform magnetic field. The energy of an α–particle moving in the same magnetic field along the same path will be

a) 4 eV b) 2 eV
c) 8 eV d) 6 eV

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

a) $\frac{2\pi qB}{m}$ b) $\frac{2\pi m}{qB}$
c) $\frac{2\pi mq}{B}$ d) $\frac{2\pi q^2B}{m}$

211. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 m, in a plane perpendicular to magnetic field $\vec{B}$. The kinetic energy of a proton that describes a circular orbit of radius 0.5 m in the same plane with the same magnetic field $\vec{B}$ is

a) 200 keV b) 50 keV
c) 100 keV d) 25 keV

212. What is cyclotron frequency of an electron with an energy of 100 eV in the earth's magnetic field of 1×10^{-4} Wb/m² if its velocity is perpendicular to magnetic field

a) 0.7 MHz b) 2.8 MHz
c) 1.4 MHz d) 2.1 MHz

213. Cyclotron employs

a) gas at low pressure
b) low frequency electric field
c) high frequency electric field
d) gas at high pressure

214. A cyclotron can accelerate

a) β–particles b) high velocity γ–rays
c) α–particles d) high velocity x–rays

215. A cyclotron is used for accelerating

a) mesons b) leptons
c) protons d) atoms

216. Cyclotron is used for

a) production of electrons
b) production of x–rays
c) production of radioactive isotopes
d) to produce induced emf

217. A charged particle moving ,ina uniform magnetic field penetrates a layer of lead and thereby loses one half of its kinetic energy; How does the radius of curvature of its pathchange ?

a) The radius increases to $r\sqrt{2}$

b) The radius reduces to $r/\sqrt{2}$

c) The radius remains the same

d) The radius becomes r/2

218. A proton, a deuteron and an α –particle accelerated through the same potential difference enter a region of uniform magnetic field, moving at right angles to B. What is the ratio of their kinetic energy?

a) 2 : 1 : 1 b) 2 : 2 : 1
c) 1 : 2 : 1 d) 2 : 1 : 2

219. A proton, a deuteron and an α –particle enter a magnetic field perpendicular to field with same velocity. What is the ratio of the radii of circular paths?

a) 1 : 2 : 2 b) 2 : 1 : 1
c) 1 : 1 : 2 d) 1 : 2 : 1

220. The velocity of two α –particles A and B in a uniform magnetic field is in the ratio of 1 : 3. They move in different circular orbits in the magnetic field. The ratio of radius of curvature of their paths is

a) 1 : 2 b) 1 : 3
c) 3 : 1 d) 2 : 1

221. A deuteron of kinetic energy 25 keV is describing a circular orbit of radius 0.5 m in a plane perpendicular to magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of radius 0.5m in the same plane with the same $\vec{B}$ is

a) 200 keV b) 50 keV
c) 100 keV d) 25 keV

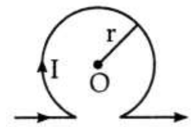
222. A proton is to circulate the earth along the equator with a speed of 1×10^7 m/s. The minimum magnetic field which should be created at the equator for this purpose will be
($m_p = 1.7 \times 10^{-27}$ kg and $R = 6.37 \times 10^6$ m)

a) 1.6×10^{-8} T b) 2.6×10^{-8} T
c) 3.6×10^{-8} T d) 4.6×10^{-8} T

223. A proton of mass m and charge + e is moving in a circular orbit of magnetic field with energy 1 MeV. What should be the energy of α –particle so that it can revolve in the path of same radius?

a) 1 MeV b) 2 MeV
c) 1.5 MeV d) 4 MeV

230. An infinitely long straight conductor is bent into shape as shown in figure. It carries a current I A and the radius of circular loop is r m. The magnetic induction at the centre of the circular loop is



a) $\frac{\mu_0 I}{2\pi r}(\pi - 1)$ b) $\frac{\mu_0 I}{2\pi r}(\pi + 1)$

c) $\frac{\mu_0 I}{2\pi r}(2\pi - 1)$ d) $\frac{\mu_0 I}{2\pi r}(2\pi + 1)$

231. Two identical coils carrying equal currents have a common centre and their planes are at right angles to each other. What is the ratio of magnitudes of the resultant magnetic field and the field due to one coil alone at the centre?

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

232. A length of wire carries a steady current. It is bent first to form a circular plane loop of one turn. The magnetic field at the centre of loop is B. The same length is now bent more sharply to give a double loop of smaller radius. The magnetic field at the centre caused by the same current is

a) B b) 2 B
c) 3 B d) 4 B

233. 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 circular paths of radii R_1 and R_2 respectively. The ratio of mass X to that of Y is

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

c) $\frac{R_2}{R_1}$ d) $\frac{R_1}{R_2}$

234. A 2 MeV proton is moving perpendicular to a uniform magnetic field of 2.5 T.
The force on the proton is

a) 8×10^{-10} N b) 4×10^{-10} N
c) 6×10^{-10} N d) 8×10^{-12} N

235. A wire of length L metre carrying a current I A is bent in the form of a circle. The magnitude of magnetic moment is

a) $\frac{1L}{4\pi}$ b) $\frac{I^2L}{4\pi}$

c) $\frac{IL^2}{4\pi}$ d) $\frac{IL^2}{\pi}$

236. Currents of 10 A and 2A are passed through two parallel wires A and B respectively in opposite directions. If the wire A is infinitely long and length of wire B is 2 m. The force on conductor B at separation 10 cm from A will be

a) 2×10^{-5} N b) 8×10^{-5} N

c) 5×10^{-5} N d) 7×10^{-5} N

237. A galvanometer has a resistance 100 Ω and gives a full scale deflection for a current of 0.1 A. It is to be converted into a voltmeter of range of 50 V. The resistance of voltmeter so formed is

a) 400 Ω b) 500 Ω

c) 200 Ω d) 80 Ω

238. Two circular coils are made of two identical wire of same length. If the number of turns of the coil are 4 and 2, then the ratio of magnetic induction at centres will be

a) 4/1 b) 1/4

c) 1/2 d) 2/1

239. A particle of charge q and mass m moves in a circular orbit of radius r with an angular speed ω. The ratio of its magnetic moment to that of its angular momentum is

a) q/m b) 2q/m

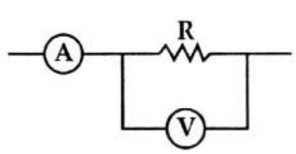
c) q/2m d) q^2/2m

240. A moving coil galvanometer is converted into an ammeter reading up to 0.03 A by connecting a shunt of resistance 4 r across it and into an ammeter up to 0.06 A when a shunt of resistance r is used. The maximum current sent through the galvanometer if no shunt is used is

a) 0.01 A b) 0.02 A

c) 0.03 A d) 0.04 A

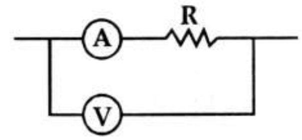
241. In given figure an ammeter reads 5 A and voltmeter reads 40 V. The actual value of resistance R is



a) 8 Ω b) greater than 8 Ω

c) less than 8 Ω d) 200 Ω

242. In given figure the ammeter A reads 5 A and voltmeter V reads 40 V. The actual value of resistance R is



a) 8 Ω b) greater than 8 Ω

c) less than 8 Ω d) 200 Ω

243. A galvanometer of resistance 20 Ω gives a full scale deflection when a current of 0.04 A is passed through it. It is desired to convert it into an ammeter reading 20 A in full scale. The only shunt available is 0.05 Ω. The resistance that must be connected in series with the coil of the galvanometer is

a) 2.95 Ω b) 4.95 Ω

c) 4.35 Ω d) 4.25 Ω

244. When a battery of emf 2 V is directly connected to a galvanometer of resistance 100 Ω, it shows full scale deflection. To measure 1 A current, the shunt must be

a) $\frac{49}{10}\ \Omega$ b) $\frac{10}{49}\ \Omega$

c) $\frac{100}{49}\ \Omega$ d) $\frac{49}{100}\ \Omega$

245. A galvanometer with a full scale sensitivity of 1 mA requires a 900 Ω resistor to make a voltmeter reading full scale when 1V is applied. What series resistor is required to make the same galvanometer into 50 V full scale voltmeter?

a) 59000 b) 49000

c) 49900 d) 4900

246. A voltmeter has a range O – V with a series resistance R. With a series resistance 2 R its range is O–V. The correct relation between V and V' is

a) V' < 2 V b) V' > 2 V

c) V' = 2 V d) V' = V

247. A galvanometer has a resistance G and a current I_g produces a full scale deflection. S_1 is the value of shunt which converts it into an ammeter at range O–I and S_2 is the value of shunt for the range O–2I. The ratio S_1/S_2 is

a) $\frac{1}{2}\frac{(I-I_g)}{(2I-I_g)}$ b) $\frac{2I-I_g}{I-I_g}$

c) 1 d) 2

248. A 100 V voltmeter of internal resistance 20 kΩ in series with a high resistance R is connected to a 110 V line. The voltmeter reads 5 V, the value of R is

a) 420 kΩ b) 42 kΩ

c) 4.2 kΩ d) 420 Ω

249. A voltmeter reading upto 10 V has a resistance of 1000 Ω. It can be converted into an ammeter reading up to 10 A by connecting a shunt of

a) 1 Ω b) 0.1 Ω

c) 2 Ω d) 0.2 Ω

250. A rectangular coil of a moving coil galvanometer has 50 turns and an area of 12 cm^2. It is suspended in a radial magnetic field of induction 0.025 Wb/m^2. The torsional constant of the suspension fibre is 1.5 × 10^{-9} Nm/degree. The current required to produce the deflection of 5° is

a) 5 μA b) 2 μA

c) 4.5 μA d) 5.5 μA

251. A rectangular coil of 100 turns each of area 10 cm^2 hangs freely in radial magnetic field. The coil deflects through an angle of 30°, when current of 0.5 mA is passed through it. If torsional constant of suspension fibre is 2.5 × 10^{-9} Nm/rad, then magnetic field will be,

a) 3.6 × 10^{-5} Wb/m^2 b) 2.2 × 10^{-5} Wb/m^2

c) 2.6 × 10^{-5} Wb/m^2 d) 4.2 × 10^{-5} Wb/m^2

252. A rectangular coil of 20 turns, each of area 10 cm^2, is suspended freely in a uniform magnetic field of induction 2.5 × 10^{-2} T with its plane inclined at 45° with the field. The torque acting on the coil when a current of 10 mA is passed through it is

a) 5.5 × 10^{-6} Nm b) 3.5 × 10^{-6} Nm

c) 3.3 × 10^{-6} Nm d) 5.3 × 10^{-6} Nm

253. A rectangular coil of M.C.G. of 100 turns, each of length 4 cm and breadth 3 cm, is suspended freely in a radial magnetic field of induction 2 × 10^{-2} N/Am. The torsional constant of the suspension fibre is 2 × 10^{-8}. Nm per radian. The deflection of the coil when a current of 2 J..1Ais passed through it is nearly

a) 14° b) 12°

c) 13° d) 15°

254. A galvanometer having a resistance of 75 ngives the full scale deflection for the current of 25 mA. The shunt required to convert it into an ammeter to measure the current up to 50 A is

a) 0.017 Ω b) 0.047 Ω

c) 0.027 Ω d) 0.037 Ω

255. The combined resistance of a galvanometer of resistance 495 ohm and its shunt is 9.9 Ω. The shunt resistance is

a) 1.01 Ω b) 8.9 Ω

c) 10.1 Ω d) 9.1 Ω

256. A galvanometer has a resistance of 98 Ω. It is shunted by 2 Ω resistance. The fraction of the total current passing through the galvanometer is

a) 2 % b) 2.5 %

c) 4 % d) 4.5 %

257. A galvanometer of resistance 100 Ω gives full scale deflection for the current of 0.1 A. The series resistance required to convert it into voltmeter of range 100 V is

a) 800 Ω b) 900 Ω

c) 700 Ω d) 600 Ω

258. A galvanometer has current range 0 to 25 mA and voltage range 0 to 500 mV. How will you adopt it to read the potential difference up to 10V ?

a) 480 Ω b) 280 Ω

c) 830 Ω d) 380 Ω

259. The current measuring capacity of a galvanometer of resistance 50 Ω is to be increased from x mA to 101 × mA. The shunt resistance is

a) 0.5 Ω b) 0.25 Ω

c) 1.5 Ω d) 0.35 Ω

260. A galvanometer has a current sensitivity of 5 div/mA and a voltage sensitivity of 2 div/m V. If the instrument has 30 divisions. How will you use it to measure a current of 3 A ?

a) 0.001 Ω b) 0.005 Ω

c) 0.002 Ω d) 0.004 Ω

261. A galvanometer of resistance 100 Ω gives the full scale deflection for a current of 10 mA. If a resistance of 1 Ω is connected in parallel to the

coil of the galvanometer, then maximum current that can be measured with the galvanometer will be

a) 1.01 A b) 1.11 A
c) 10.1 A d) 0.01 A

262. A galvanometer has a resistance of 55 ohms. It gives a full scale deflection by a current of 10 mA. What resistance must be connected across it to enable it to read 1 ampere?

a) 5.55 Ω b) 0.555 Ω
c) 55.5 Ω d) 0.055 Ω

263. A gal vanometer having a resistance of 20 ohm and capable of carrying a maximum current of 40 mA is to be converted into an ammeter of range 0–5 A. What is the resistance needed?

a) 1.6 Ω in parallel b) 0.16 Ω in parallel
c) 16.1 Ω in parallel d) None of these

264. A moving coil galvanometer has 100 turns and a resistance of 10 ohm. The coil is 5 cm long and 4 cm wide. A potential difference of 100 mV produces a full scale deflection (the coil is turned through 60°). The flux density in the gap is 1000G. The required torque of the controlling spring is

a) 1 Nm b) 0.1 Nm
c) 1×10^{-2} Nm d) 1×10^{-4} Nm

265. A very long solenoid has 800 tunrs per meter length of the solenoid. A current of 1.6 ampere flows through it. Then, magnetic induction at the end of the solenoid on Its axis is

a) 16×10^{-4} T b) 8×10^{-4} T
c) 32×10^{-4} T d) 4×10^{-4} T

266. We have a galvanometer of resistance 25 Ω. It is shunted by a 2.5 Ω. The part of total current that flows through the galvanometer is given as

a) $\frac{I}{I_0} = \frac{1}{11}$ b) $\frac{I}{I_0} = \frac{2}{11}$

c) $\frac{I}{I_0} = \frac{3}{11}$ d) $\frac{I}{I_0} = \frac{4}{11}$

267. A cyclotron is operating at a frequency of 12×10^6 Hz. Mass of deutron is 3.3×10^{-27} kg and charge on deutron is 1.6×10^{-19} coulomb. To accelerate deutrons the magnetic field is

a) 0.016 tesla b) 0.16 tesla
c) 16 tesla d) 1.6 tesla

268. A proton and an alpha particle having the same initial spped, enter a region of uniform magnetic field and describe circular paths. If the radii of the circles are R_1 and R_2 respectively, the ratio $R_1 : R_2$ is

a) 1 : 1 b) 1 : 2
c) 1 : 4 d) 2 : 1

269. To convert a 400 mV range galvanometer of resistance 20 Ω into a ammeter of 100 mA ranges, the required shunt resistance to be connected is

a) 5 Ω b) 4 Ω
c) 2.5 Ω d) 1.5 Ω

Questions given in MHT–CET

270. We have a galvanometer of resistance 25 Ω. It is shunted by a 2.5 Ω. The part of total current that flows through the galvanometer is given as

a) $\frac{I}{I_0} = \frac{1}{11}$ b) $\frac{I}{I_0} = \frac{2}{11}$

c) $\frac{I}{I_0} = \frac{3}{11}$ d) $\frac{I}{I_0} = \frac{4}{11}$

271. The sensitivity of a moving coil galvanometer increases with a decrease in

a) number of turns b) area of the coil
c) magnetic field d) none of these

272. A sensitive galvanometer, like a moving coil galvanometer, can be converted into an ammeter or a voltmeter by connecting a proper resistance to it. Which of the following statements is not true?

a) a voltmeter is connected parallel and current through it is negligible

b) a voltmeter is connected parallel and potential difference across the circuit is small

c) an ammeter is connected in series and potential difference across it is small

d) an ammeter is connected in series in circuit and the current through it is negligible

273. Resistance of galvanometer is 500 Ω. Effective resistance of ammeter with shunt is 25 Ω. What is the value of shunt?

a) $\frac{500}{19}\ \Omega$ b) $\frac{250}{19}\ \Omega$

c) $\frac{1000}{19}\ \Omega$ d) $\frac{125}{19}\ \Omega$

274. Magnetic dipole moment $\vec{M}$ of the coil, placed in uniform magnetic field of induction $\vec{B}$ does not depends on
a) number of turns of coil
b) current through coil
c) area of the cross section
d) magnetic field of induction

275. Accuracy of tangent galvanometer maximum at
a) 0° b) 45°
c) 60° d) 90°

276. When a current of 318 mA is passed through a tangent galvanometer, a deflection of 45° is obtained. If radius of coil is 10 cm and number of turns 50, then what is a value of horizontal component of earth's magnetic field?
a) 10^{-6} T b) 10^{-7} T
c) 10^{-2} T d) 10^{-4} T

277. Resistance of the voltmeter is 10000 Ω to increase range of voltmeter from 25 V to 250 V, resistance connected in series is
a) 990 Ω b) 999 Ω
c) 90000 Ω d) 90 Ω

278. Decrease in number of turns of coil in tangent galvanometer is
a) to decrease sensitivity
b) to decrease resistance of galvanometer
c) to increase a field at centre of coil
d) can not be predicted

279. A 0–25 mA ammeter having resistance 10 Ω is to be converted into voltmeter with a range 0–25 V. A resistance connected in series is
a) 900 Ω b) 990 Ω
c) 1000 Ω d) 1100 Ω

280. If galvanometer is shunted by $(1/n)^{th}$ of its value, then fraction of total current passing through the galvanometer is
a) 1/n b) n
c) 1/(1 + n) d) n – 1

281. In an ammeter, 4% of the main current is passing through the galvanometer. If shunt resistance is 5 Ω, then resistance of galvanometer will be
a) 60 Ω b) 120 Ω
c) 240 Ω d) 480 Ω

282. Three moving coil galvanometers A, B and C made of coil of three different material having torsional constant 1.8×10^{-8}, 2.8×10^{-8} and 3.8×10^{-8} respectively. If three galvanometers are identical in all other respects, then which galvanometer has maximum sensitivity?
a) A b) B
c) C d) constant in each case

283. To increases the sensitivity of MCG, we must decrease
a) area of coil b) torsional constant
c) magnetic field d) number of turns

284. In T.G., a deflection of 45° is obtained when a current of 173 mA is passed through it. The deflection in T.G. is 30°, when current through is
a) 100 mA b) 150 mA
c) 300 mA d) 600 mA

285. 50 turns of a wire of diameter 1 mm is wound on a cylinder of radius 5 cm. If the specific resistance of the material of the wire is 4.5×10^{-6} Ω m, then its resistance is
a) 9 kΩ b) 900 Ω
c) 250 Ω d) 90 Ω

286. The range of an ammeter, of resistance G, is increased from I to nI. This can be done by connecting
a) a series resistance of Gn
b) a parallel resistance of G/(n – 1)
c) a series resistance of G (n – 1)
d) a parallel resistance of G/n

287. The magnetic field at the centre or the MCG is 0.25 T. The coil has an area of 0.2 m^2 and has 28 turns. If the sensitivity of the MCG is to be increased by 25%, the number of turns of the coil should be ...... Assume all other things remaining constant
a) 30 b) 32
c) 35 d) 38

288. The current sensitivity of a galvanometer is × div/mA and voltage sensitivity is y div/V. The resistance of galvanometer is g. Then relation between x and y is
a) $G = \frac{x}{y} \times 10^3$ b) $G = \frac{y}{x}$
c) $G = \frac{x}{y}$ d) $y = G \times 10^3$

289. Tangent galvanometer shows a deflection of 45° for some current. When the current is reduced

to $1/\sqrt{3}$ times the original, what is the deflection?

a) increases by 15° b) decreases by 15°

c) increases by 30° d) decreases by 30°

290. In order to convert a moving coil galvanometer into a voltmeter

a) a high resistance is connected in parallel with the galvanometer

b) a high resistance is connected in series with the galvanometer

c) a low resistance is connected in parallel with the galvanometer

d) a low resistance is connected in series with the galvanometer

291. The tangent galvanometer is set into magnetic meridian

a) to minimise error due to parallax.

b) to produce strong magnetic field.

c) to make magnetic field due to current carrying coil, exactly parallel to horizontal component of earth's magnetic field.

d) to make magnetic field due to current carrying coil, exactly perpendicular to horizontal component of earth's magnetic field.

292. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the magnetic field at the centre of coil is B. It is then bent into a circular loop of n turns. The magnetic field at the centre of the coil for same current will be

a) n B b) n^2 B

c) 2 n B d) 2 n^2 B

293. A galvanometer having a coil resistance of 60 W shows full scale deflection when a current of 1 A passes through it. It can be converted into an 301. ammeter to read currents upto 5 A by a resistance of

a) 240 Ω in parallel b) 15 Ω in series

c) 240 Ω in series d) 15 Ω in parallel

294. Two particles of masses m_a and m_b and same perpendicular magnetic field. They travel along circular paths of radius r_a and r_b such that $r_a > r_b$. Then which of the following eq^n. is true?

a) $m_a v_a > m_b v_b$

b) $m_a > m_b$ and $v_a > v_b$

c) $m_a = m_b$ and $v_a > v_b$

d) $m_b v_b > m_a v_a$

295. Toroid is

a) ring shaped closed solenoid

b) rectangular shaped solenoid

c) ring shaped open solenoid

d) square shaped solenoid

296. A voltmeter has a range O – V with a series resistance R. With a series resistance 2 R its range is O–V'. The correct relation between V and V' is

a) V' < 2 V b) V' > 2 V

c) V' = 2 V d) V' = V

297. Two coils are made of same material such that radius of one coil is twice of the other and magnetic field is same at the centres then ratio of potential difference applied across 1st to second coil is

a) 2 times b) same

c) 4 times d) 3 times

298. The magnetic field inside a solenoid is

a) directly proportional to its length

b) inversely proportional to the total number of turns

c) inversely proportional to the current

d) directly proportional to the current

299. The sensitivity of a galvanometer is 60 divisions/amp. When a shunt is used, its sensitivity becomes 10 divisions/amp. If galvanometer is of resistance 20 Ω, the value of shunt used is

a) 4 Ω b) 5 Ω

c) 20 Ω d) 8 Ω

300. A current loop in a magnetic field

a) can be in equilibrium in one orientation

b) can be in equilibrium in two orientation, both the equilibrium states are unstable

c) can be in equilibrium in two orientation, one stable while the other is unstable

d) experiences a torque whether the field is uniform or non uniform in all orientations.

301. When a proton is released from rest in a room, it starts with an initial acceleration ao towards west. When it is projected towards north with a speed Vo it moves with the initial acceleration 3ao towards west. The electric and magnetic fields in the room are

a) $\dfrac{ma_0}{2}$ west, $\dfrac{2ma_0}{ev_0}$ down

b) $\dfrac{ma_0}{e}$ east, $\dfrac{3ma_0}{ev_0}$ up

c) $\frac{ma_0}{e}$ east, $\frac{3ma_0}{ev_0}$ down

d) $\frac{ma_0}{e}$ west, $\frac{2ma_0}{ev_0}$ up

302. In cyclotron, for a given magnet, radius of the semicircle traced by positive ion is directly proportional to (v = velocity of positive ion)

a) v^{-2} b) v^{-1}
c) v d) v^2

303. Magnetic induction produced at the centre of a circular loop carrying current is 'B'. The magnetic moment of the loop of radius 'R' is
(μ_0 = permeability of free space)

a) $\frac{BR^3}{3\pi\mu_0}$ b) $\frac{2\pi BR^3}{\mu_0}$
c) $\frac{BR^2}{2\pi\mu_0}$ d) $\frac{2\pi BR^2}{\mu_0}$

304. Sensitivity of a moving coil galvanometer can be increased by

a) decreasing the number of turns of coil
b) increasing the number of turns of coil
c) decreasing the area of a coil
d) by using a weak magnet

305. A range of galvanometer is 'V', when 50 Ω resistance is connected in series. Its range gets doubled when 500 Ω resistance is connected in series. Galvanometer resistance is

a) 100 Ω b) 200 Ω
c) 300 Ω d) 400 Ω

❍❍❍

Answers

1. (d)	2. (b)	3. (a)	4. (d)	5. (b)	6. (c)	7. (b)	8. (b)	9. (a)	10. (c)
11. (a)	12. (d)	13. (c)	14. (d)	15. (a)	16. (a)	17. (d)	18. (a)	19. (c)	20. (d)
21. (d)	22. (d)	23. (d)	24. (c)	25. (c)	26. (d)	27. (c)	28. (d)	29. (c)	30. (b)
31. (c)	32. (b)	33. (a)	34. (b)	35. (a)	36. (c)	37. (a)	38. (a)	39. (a)	40. (b)
41. (b)	42. (a)	43. (c)	44. (b)	45. (c)	46. (a)	47. (c)	48. (b)	49. (b)	50. (a)
51. (b)	52. (a)	53. (c)	54. (c)	55. (a)	56. (a)	57. (b)	58. (b)	59. (c)	60. (c)
61. (d)	62. (c)	63. (a)	64. (d)	65. (a)	66. (d)	67. (a)	68. (c)	69. (b)	70. (d)
71. (d)	72. (a)	73. (a)	74. (c)	75. (b)	76. (c)	77. (a)	78. (b)	79. (b)	80. (c)
81. (a)	82. (a)	83. (b)	84. (b)	85. (b)	86. (c)	87. (c)	88. (c)	89. (d)	90. (a)
91. (a)	92. (a)	93. (a)	94. (a)	95. (b)	96. (a)	97. (c)	98. (b)	99. (a)	100. (a)
101. (b)	102. (c)	103. (b)	104. (a)	105. (b)	106. (c)	107. (c)	108. (b)	109. (b)	110. (d)
111. (d)	112. (c)	113. (a)	114. (a)	115. (a)	116. (b)	117. (b)	118. (d)	119. (d)	120. (c)
121. (b)	122. (d)	123. (d)	124. (c)	125. (d)	126. (a)	127. (c)	128. (c)	129. (c)	130. (b)
131. (a)	132. (d)	133. (c)	134. (b)	135. (a)	136. (a)	137. (c)	138. (c)	139. (c)	140. (b)
141. (a)	142. (c)	143. (d)	144. (a)	145. (d)	146. (b)	147. (d)	148. (c)	149. (d)	150. (a)
151. (a)	152. (a)	153. (a)	154. (b)	155. (c)	156. (c)	157. (d)	158. (c)	159. (d)	160. (d)
161. (a)	162. (a)	163. (d)	164. (a)	165. (d)	166. (c)	167. (b)	168. (d)	169. (b)	170. (c)
171. (d)	172. (c)	173. (d)	174. (b)	175. (b)	176. (b)	177. (d)	178. (a)	179. (b)	180. (a)
181. (b)	182. (c)	183. (d)	184. (a)	185. (b)	186. (d)	187. (c)	188. (b)	189. (b)	190. (a)
191. (b)	192. (b)	193. (b)	194. (b)	195. (b)	196. (b)	197. (c)	198. (c)	199. (a)	200. (a)
201. (c)	202. (a)	203. (b)	204. (b)	205. (c)	206. (c)	207. (c)	208. (d)	209. (c)	210. (b)
211. (c)	212. (b)	213. (c)	214. (c)	215. (c)	216. (c)	217. (b)	218. (d)	219. (a)	220. (b)
221. (b)	222. (a)	223. (a)	224. (a)	225. (b)	226. (b)	227. (a)	228. (c)	229. (a)	230. (a)
231. (a)	232. (d)	233. (a)	234. (d)	235. (c)	236. (b)	237. (b)	238. (a)	239. (c)	240. (b)
241. (b)	242. (c)	243. (b)	244. (c)	245. (c)	246. (a)	247. (b)	248. (a)	249. (a)	250. (a)
251. (c)	252. (b)	253. (a)	254. (d)	255. (c)	256. (a)	257. (b)	258. (d)	259. (a)	260. (b)
261. (a)	262. (b)	263. (b)	264. (d)	265. (b)	266. (a)	267. (d)	268. (b)	269. (a)	270. (a)
271. (d)	272. (d)	273. (a)	274. (d)	275. (b)	276. (d)	277. (c)	278. (a)	279. (b)	280. (c)
281. (b)	282. (a)	283. (b)	284. (a)	285. (d)	286. (b)	287. (c)	288. (a)	289. (b)	290. (b)
291. (d)	292. (b)	293. (d)	294. (a)	295. (a)	296. (a)	297. (c)	298. (d)	299. (a)	300. (c)
301. (a)	302. (c)	303. (b)	304. (b)	305. (d)					

Hint / Solutions

14. Magnetic intensity at the centre of a circular coil carrying current is directly proportional to number of turns and inversely proportional to radius of the coil.

21. From the definition of S.I. unit of current.

26. $I = \dfrac{B}{\mu_0 n} = \dfrac{3.14\times10^{-2}}{4\pi\times10^{-7}\times5000} = 5\text{ A}$

29. $B \propto nI \quad \therefore \dfrac{B_2}{B_1} = \dfrac{n_2}{n_1}\dfrac{I_2}{I_1} = \dfrac{2n_1}{n_1}\dfrac{I_1}{2I_1}$

$\therefore B_2 = B_1 = B$

30. $F = IBl\sin\theta = 1.8\times2\times1\times\sin 90 = 3.6\text{ N}$

36. $B = \dfrac{\mu_0 I}{2r} = \dfrac{4\pi\times10^{-7}\times nq}{2r}$

$= \dfrac{2\pi\, nq}{r}\times10^{-7}\text{ N/Am} \qquad \left[\because I = \dfrac{nq}{t}\right]$

37. $B = \mu_0 nI = 4\pi\times10^{-7}\times10\times10^{-2}\times5$

$= 2\pi\times10^{-3}\text{ T}$

38. $B = \dfrac{\mu_0 I}{2\pi a} \quad \therefore B\propto\dfrac{1}{a} \qquad \dfrac{B_2}{B_1} = \dfrac{a_1}{a_2}$

$B_2 = \dfrac{4\times10^{-2}\times10^{-8}}{12\times10^{-2}} = 3.3\times10^{-9}\text{ T}$

39. $B = \dfrac{\mu_0 nI}{2a} = \dfrac{4\pi\times10^{-7}\times100\times0.1}{2\times5\times10^{-2}} = 4\pi\times10^{-5}\text{ T}$

42. $B = \mu_0 nI$

$\therefore I = \dfrac{B}{\mu_0 n} = \dfrac{20\times10^{-3}\times10^{7}}{4\pi\times20\times10^{2}} = 8\text{ A}$

43. $B = \dfrac{\mu_0 nI}{2a}$

$\therefore n = \dfrac{3.14\times10^{-3}\times2\times10^{-1}}{4\times\pi\times10^{-7}\times10} = 50$

44. $B = \mu_0 nI = 4\pi\times10^{-7}\times4250\times5$

$= 60\times4.25\times10^{-4} = 2.7\times10^{-2}\text{ T}$

48. $B = \mu_0 nI$

$= 4\pi\times10^{-7}\times200\times10^{2}\times2.5 = 6.28\times10^{-2}\text{ T}$

50. $B = \mu_0 nI$

$= 4\pi\times10^{-7}\times10\times10^{2}\times10 = 4\pi\times10^{-3}\text{ T}$

53. $B = \dfrac{\mu_0 nI}{2a} \quad \therefore B\propto\dfrac{nI}{a}$

$B_1 - B_2 = \dfrac{\mu_0 n}{2}\left[\dfrac{I_1}{a_1} - \dfrac{I_2}{a_2}\right]$

$= \dfrac{10\times4\pi\times10^{-7}}{2\times10^{-2}}\left[\dfrac{0.2}{20} - \dfrac{0.3}{40}\right]$

$B_1 - B_2 = \dfrac{4\pi\times10\times2\times10^{-7}}{2\times10^{-2}\times800} = 1.57\times10^{-6} = \dfrac{5\mu_0}{4}\text{ T}$

54. $r = \dfrac{mv}{Be} \quad \therefore B = \dfrac{10^6}{0.1\times1.76\times10^{11}} = 5.5\times10^{-5}\text{ T}$

55. $r = \dfrac{mv}{Be} \quad \therefore r\propto v \qquad \dfrac{r_2}{r_1} = \dfrac{v_2}{v_1}$

$r_2 = 2\times2 = 4\text{ cm}$

59. If the plane of magnetic field and the coil are horizontal and vertical respectively then $\theta = 0$. Thus, torque on the coil is given by,

$\tau_n = nIAB\cos\theta = nIAB\cos0 = nIAB$

63. A moving coil galvanometer is based on the force acting on a conductor carrying a current placed in uniform magnetic induction.

74. A force acts on every side of the coil due to the magnetic field, when current is passed through the coil. Due to these forces a couple is exerted on the coil.

77. If resistance of galvanometer is very large, momentary current produce oscillations with decreasing amplitude.

85. In radial magnetic field, plane of the coil is always parallel to magnetic induction.

$\therefore \theta = 0$

Thus, $\tau_n = nIAB\cos\theta = nIAB\cos0$

$= nIAB$ (maximum).

98. $\tau_n = nIAB$

$\therefore I = \dfrac{\tau_n}{nAB} = \dfrac{18\times10^{-5}\times10^{-2}}{60\times6\times10^{-4}\times500\times10^{-4}}$

$= 10^{-3}\text{ A}$

99. $I = \dfrac{K}{nAB}\theta$ ($\because$ K, θ, n & A are constant)

$\therefore I \propto 1/B \Rightarrow I_1B_1 = I_2B_2$

$\therefore I_2 = \dfrac{B_1}{B_2}I_1 = \dfrac{4\times10^{-3}\times2}{8\times10^{-3}} = 1\text{ A}$

100. For same current, deflection of M.C.G. is directly proportional to current.

101. $I \propto \theta \qquad \therefore I = K\theta$

and $I_g \propto \theta' \qquad \therefore I_g = K\theta'$

$\therefore \dfrac{I_g}{I} = \dfrac{\theta'}{\theta}$ But $I_g = \left(\dfrac{S}{S+G}\right)I$

$\therefore \dfrac{\left(\dfrac{S}{S+G}\right)I}{I} = \dfrac{\theta'}{\theta} \qquad \therefore \dfrac{S}{S+G} = \dfrac{\theta'}{\theta}$

$\therefore \quad \dfrac{40}{40+G} = \dfrac{\theta}{2\theta} \qquad \therefore\ G = 40\ \Omega$

102. From problem (67), we have,

$$\frac{S}{S+G} = \frac{\theta'}{\theta} \qquad \therefore\ \frac{12+G}{12} = \frac{50}{10}$$

$\therefore \quad G = 48\ \Omega$

103. $$I = \frac{K}{nAB}\theta$$

$$\therefore \quad \theta = \frac{nABI}{K} = \frac{1\times0.05\times0.01\times300\times10^{-6}}{5\times10^{-9}}$$

$$= 30^\circ$$

119. It is not possible to decrease the range in the way. A series resistance can not change the current that will produce full scale deflection.

125. $$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{10^{-5}}{1-0.00001}\right)\times100$$

$= 10^{-3}\ \Omega$ in parallel.

126. $$I = \left(\frac{S+G}{S}\right)I_g = \left(\frac{2+40}{2}\right)\times0.01 = 0.21\ A$$

127. $$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{1}{10-1}\right)\times0.018 = 0.002\ \Omega$$

128. $$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{0.050}{3-0.05}\right)\times118 = 2\ \Omega$$

129. $$I_g = \left(\frac{S}{S+G}\right)I = \left(\frac{(G/n)}{(G/n)+G}\right)I = \left(\frac{1}{n+1}\right)I$$

130. $$V_g = I_gG \quad \therefore\ G = V_g/I_g = 50\ \Omega$$

$$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{0.015}{25-0.015}\right)\times50 = 0.03\ \Omega$$

131. $$V_g = I_gG \quad \therefore\ I_g = V_g/G = 5\times10^{-4}\ A$$

$$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{5\times10^{-4}}{5-0.0005}\right)\times100 = 0.01\ \Omega$$

132. The combined resistance of galvanometer and its shunt is,

$$R_A = \frac{SG}{S+G} \qquad \therefore\ 25 = \frac{500\times S}{500+S}$$

$\therefore \quad S = 26.3\ \Omega$

133. $$I_S = \left(\frac{G}{S+G}\right)I = \left(\frac{48}{2+48}\right)I = \left(\frac{48}{50}\right)I$$

$= 0.96\ I$

Thus, 96% of total current will pass through shunt of resistance of 2 Ω.

134. $$S = \left(\frac{G}{n-1}\right) = \left(\frac{30}{2-1}\right) = 30\ \Omega$$

$$I_g = \left(\frac{S}{S+G}\right)I = \left(\frac{30}{30+30}\right)I = 0.5\ I$$

Now, $$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{0.5I}{2I-0.5I}\right)30 = 10\ \Omega$$

Now, the effective resistance of galvanometer and its shunt is 10 Ω. Let R be the additional resistance connected across it.

Thus, $$\frac{1}{10} = \frac{1}{30}+\frac{1}{R} \qquad \therefore\ R = 15\ \Omega.$$

135. Let x be the total number of divisions.

$\therefore \quad I_g = x/60$ and $I = x/10$

$$\therefore \quad S = \left(\frac{I_g}{I-I_g}\right)G = \left[\frac{\left(\frac{x}{60}\right)}{\left(\frac{x}{10}-\frac{x}{60}\right)}\right]20 = 4\ \Omega$$

136. $$I_g = \frac{5I}{100} = 0.05\ I$$

$$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{0.05I}{I-0.05I}\right)G = \frac{G}{19}$$

137. $$I_g = \left(\frac{10}{100}\right)I = 0.1\ I$$

$$S = \left(\frac{I_g}{I-I_g}\right)G = \left(\frac{0.1I}{I-0.1I}\right)99 = 11\ \Omega$$

138. Required resistance which should be added in series so that, the current in the circuit is given by,

Initial resistance = Final resistance

i.e. $$G = \left(\frac{GS}{G+S}\right)+R$$

$$\therefore \quad R = G-\left(\frac{GS}{G+S}\right) = \frac{G^2}{G+S}$$

153. Resistance = p.d. / current.
Thus, the measurement of current ammeter is connected in series with the circuit, because current in series circuit is same. For measurement of potential difference voltmeter is connected in parallel because potential difference in parallel circuit is same.

157. When a resistance is connected in parallel, it will only reduce the resistance of the combination, but will not reduce the range. For reducing the range, the resistance in series with the galvanometer need to be reduced. This can not be achieved by connecting a resistance in parallel with the galvanometer.

162. $R = \frac{V}{I_g} - G$

$\therefore \quad G = \frac{V}{I_g} - R = \frac{5}{0.005} - 975 = 25\ \Omega$

163. $R = \frac{V}{I_g} - G = \frac{10}{0.5\times10^{-3}} - 50 = 19950\ \Omega$

164. $R = G(n-1) = 50 \times 10^3 (3-1) = 10^5\ \Omega$

165. $I_g = \frac{V}{R+G} = \frac{2}{250+10} = 7.7\ \text{mA}$

166. $R = G(n-1) = 1000(10-1) = 9000\ \Omega$

167. $R = \frac{V}{I_g} - G = \frac{25}{25\times10^{-3}} - 10 = 990\ \Omega$

168. Let x be the total number of divisions on voltmeter. Thus, $V_g = x$ and $V = 10x$.

Now, $V_g = I_g G \quad \therefore I_g = V_g / G = x/2000$

Thus, $R = \frac{V}{I_g} - G = \frac{10x}{(x/2000)} - 2000$

$= 18000\ \Omega$

169. $V = I_g(R+G)$

$= 10 \times 10^{-3}(9960 + 40) = 100\ \text{V}$

170. $R = G(n-1) = 100(5-1)$

$= 400\ \Omega$ in series.

171. i) $R = \frac{V}{I_g} - G = \frac{10}{50\times10^{-6}} - 100 \approx 200\ \text{k}\Omega$

For converting galvanometer into voltmeter a high resistance is joined in series with the galvanometer.

ii) $S = \left(\frac{I_g}{I - I_g}\right) G = \left(\frac{50\times10^{-6}}{50\times10^{-3} - 50\times10^{-6}}\right) 100 \approx 1\ \Omega.$

For converting galvanometer into ammeter a low resistance is joined in parallel with the galvanometer.

172. $R = G(n-1) = 1000 \times (10-1) = 9000\ \Omega$

173. $R = \frac{V}{I_g} - G = \frac{15}{0.5} - 2 = 28\ \Omega$

174. As galvanometer gives full scale deflection for a current of 1 mA and its own resistance is 100Ω, hence without connecting additional resistance it can be used to measure the maximum voltage which is given by,

$Ig\,G = 0^{-3} \times 100 = 0.1\text{V}$

i.e. it can be used as a voltmeter of range 0.1 V.

175. A voltmeter always gives lower value of p.d. because of the drop of potential across internal resistance of the cell.

181. $S_i = \frac{nAB}{K}$ and $S_v = \frac{nAB}{KG}$

$\therefore \quad S_v = \frac{S_i}{G}$

190. $S = \frac{nAB}{K} = \frac{100\times12\times10^{-4}\times1.5\times10^{-2}}{1.5\times10^{-8}}$

$= 0.12$ radian/μA

198. $\nu = \frac{qB}{2\pi m} = \frac{1.76\times10^{11}\times1}{2\times3.14} = 2.8 \times 10^{10}\ \text{Hz}$

199. $E = \frac{q^2B^2r^2}{2m}$

$\therefore \quad \frac{E_\alpha}{E_P} = \left(\frac{q_\alpha}{q_P}\right)^2 \frac{m_P}{m_\alpha} = \frac{4}{1}\times\frac{1}{4}$

$\therefore \quad E_\alpha = E_P = E$

200. $r = \frac{mv}{qB} = \frac{2\times10^5}{5\times10^7\times4\times10^{-2}} = 0.1\ \text{m}$

201. $T = \frac{2\pi m}{qB} = \frac{2\pi mr}{mv} = \frac{2\pi r}{v}$

$= 1.1 \times 10^{-7}\ \text{s}$

203. $r = \frac{mv}{qB} = \frac{10^7}{10^{11}\times10^{-4}} = 1\ \text{m}$

208. $\nu = \frac{qB}{2\pi m} = \frac{1.76\times10^{11}\times2}{2\times3.14} = 56\ \text{GHz}$

209. $E = \frac{q^2B^2r^2}{2m}$

$\therefore \quad \frac{E_\alpha}{E_P} = \left(\frac{q_\alpha}{q_P}\right)^2 \frac{m_P}{m_\alpha} = \frac{4}{1}\times\frac{1}{4}$

$\therefore \quad E_\alpha = E_P = 8\ \text{eV}$

211. $E = \frac{q^2B^2r^2}{2m}$

$\therefore \quad \frac{E_P}{E_d} = \left(\frac{q_d}{q_P}\right)^2 \frac{m_P}{m_d} = 2$

$\therefore \quad E_P = 2E_d = 2 \times 50 = 100\ \text{k eV}$

218. $E = \frac{q^2B^2r^2}{2m}$

$\therefore \quad E \propto \frac{q^2}{m}$

$E_P : E_d : E_\alpha = \frac{q_P^2}{m_P} : \frac{q_d^2}{m_d} : \frac{q_\alpha^2}{m_\alpha}$

$= \frac{q_P^2}{m_P} : \frac{q_P^2}{2m_P} : \frac{4q_P^2}{4m_P}$

$= 2:1:2$

219. $r \propto \dfrac{m}{q}$

$$\therefore \quad r_P : r_d : r_\alpha = \frac{m_P}{q_P} : \frac{m_d}{q_d} : \frac{m_\alpha}{q_\alpha}$$

$$= \frac{m_P}{q_P} : \frac{2m_P}{q_P} : \frac{4m_P}{2q_P}$$

$$= 1 : 2 : 2$$

220. $\dfrac{r_1}{r_2} = \dfrac{v_1}{v_2} = \dfrac{1}{3}$

221. $E = \dfrac{q^2B^2r^2}{2m}$

$$\therefore \quad \frac{E_P}{E_d} = \left(\frac{q_d}{q_P}\right)^2 \frac{m_P}{m_d} = 2$$

$$\therefore \quad E_P = 2\,E_d = 2 \times 25 = 50\ \text{k eV}$$

222. For circular motion the required centripetal force is provided by magnetic force.

i.e. $qvB = \dfrac{mv^2}{r} \quad \therefore \ B = \dfrac{mv}{qr}$

$$B \approx 1.6 \times 10^{-8}\ \text{T}$$

223. $r = \dfrac{mv}{qB} \quad \left(E_k = \dfrac{1}{2}mv^2 \ \therefore \ v = \sqrt{\dfrac{2E_k}{m}}\right)$

$$r = \frac{m\sqrt{\dfrac{2E_k}{m}}}{qB} = \frac{\sqrt{2mE_k}}{qB}$$

$$\therefore \quad E_k = \frac{q^2B^2r^2}{2\,m}$$

As B and r, are same

$$E_p = \frac{e^2B^2r^2}{2\,m} \quad \text{and} \quad E_\alpha = \frac{(2e)^2B^2r^2}{2\,(4\,m)}$$

i.e. $\dfrac{E_p}{E_\alpha} = 1 \qquad \therefore \ E_p = E_\alpha = 1\ \text{MeV.}$

224. $B = \dfrac{\mu_0 I}{2a} \quad \left(I = \dfrac{q}{T} = \dfrac{2e}{T}\right)$

Since for helium, $q = 2e$

$$B = \frac{\mu_0 2e}{2aT}$$

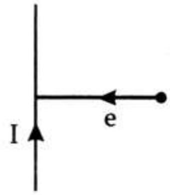
$$= \frac{4\pi \times 10^{-7} \times 2 \times 1.6 \times 10^{-19}}{2 \times 0.8 \times 2.5}$$

$$B = 3.2\,\pi \times 10^{-26}\ \text{T}$$

225. $B = \dfrac{\mu_0 I}{2\pi a} \qquad \therefore \ B \propto \dfrac{1}{a}$

$$\frac{B_2}{B_1} = \frac{a_1}{a_2} \qquad \therefore \ B_2 = \frac{B}{4}$$

226. $B = \dfrac{\mu_0 I}{2\pi a}$



$$F = qvB\ \sin\theta,\ \theta = 90^\circ$$

$$F = qvB = evB$$

$$= eV\ \frac{\mu_0 I}{2\pi a}$$

$$= 3.2 \times 10^{-16}\ \text{N}$$

227. $B = \dfrac{\mu_0 I}{2\pi a} \qquad \left(I = \dfrac{q}{T} = ef\right)$

$$B = \frac{\mu_0 ef}{2\,a} = 14\ \text{T}$$

$$M = nIA,\ n = 1,\ A = \pi r^2$$

$$= 9 \times 10^{-24}\ \text{Am}^2$$

228. The voltmeter of large resistance measures accurate value of potential difference because for ideal voltmeter, its resistance is infinity.

229. $F = I\,b\,l\,\sin\theta = \dfrac{10^{-4}}{\sqrt{2}}\ \text{N}$

230. The magnetic field due to straight portion of the conductor is

$$B_1 = \frac{\mu_0 I}{2\pi r}\ \text{(upward)}$$

The magnetic induction due to circular loop is

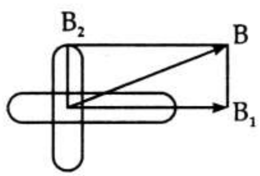
$$B_2 = \frac{\mu_0 I}{2\,r}$$

Net magnetic induction is given by,

$$B = B_2 - B_1 = \frac{\mu_0 I}{2\,r} - \frac{\mu_0 I}{2\pi r}$$

$$= \frac{\mu_0 I}{2\pi r}(\pi - 1)\ \text{downward}$$

231.



$$B = \sqrt{B_1^2 + B_2^2} = \sqrt{2\,B_1^2} = \sqrt{2}\,B_1$$

Magnetic field due to one coil alone is B_1

$$\therefore \quad \frac{B}{B_1} = \frac{\sqrt{2}}{1}$$

232. $$B_1 = B = \frac{\mu_0 n_1 I}{2 r_1} = B$$

When same length is bent into 2 turns radius of coil is halved

$$B_2 = \frac{\mu_0 n_2 I}{2 r_2} = 4\frac{\mu_0 I}{2r} = 4B$$

$$\frac{B_2}{B_1} = \frac{4B}{B} = \frac{4}{1}$$

$$B_2 = 4B_1 = 4B$$

233. $$R = \frac{mv}{qB} = \frac{\sqrt{2mqV}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

For same charge and potential difference,

$$R \propto \sqrt{m} \Rightarrow \frac{R_1}{R_2} = \sqrt{\frac{m_1}{m_2}}$$

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

234. $$E_k = \frac{1}{2} mv^2 \qquad (v = 2 \times 10^7 \text{ m/s})$$

$$F = qvB \sin 90 = 8 \times 10^{-12} \text{ N.}$$

235. $$M = nIA = IA = I\pi r^2$$

Here $L = 2\pi r \Rightarrow r = \dfrac{L}{2\pi}$

$$M = I\pi\left(\frac{L}{2\pi}\right)^2 = \frac{IL^2}{4\pi}$$

236. $$F = \frac{\mu_0 I_1 I_2 l}{2\pi a} = 8 \times 10^{-5} \text{ N.}$$

237. $$\frac{F_m}{F_e} = \frac{v^2}{c^2} = \frac{(3\times10^5)^2}{(3\times10^8)^2} = 10^{-6}$$

238. $$L = n_1 2\pi a_1 = n_2 2\pi a_2$$

$$\Rightarrow n_1 a_1 = n_2 a_2 \Rightarrow \frac{a_1}{a_2} = \frac{n_2}{n_1}$$

Now, $$\frac{B_1}{B_2} = \frac{\mu_0 n_1 I/2a_1}{\mu_0 n_2 I/2a_2} = \frac{n_1}{n_2}\frac{a_2}{a_1}$$

$$\therefore \quad \frac{B_1}{B_2} = \left(\frac{n_1}{n_2}\right)^2 = \frac{4}{1}$$

239. Magnetic moment is given by,

$$M = IA = \frac{q}{T}\pi r^2 = \frac{2\pi}{T}\frac{qr^2}{2} = \frac{\omega q r^2}{2}$$

Angular momentum $= L = I\omega = mr^2\omega$

$$\therefore \quad \frac{M}{L} = \frac{\omega q r^2/2}{mr^2\omega} = \frac{q}{2m}$$

240. $$I_g = \left(\frac{S_1}{S_1+G}\right) I = \left(\frac{S_2}{S_2+G}\right) I$$

From this $G = 2r$.

$$I_g = \frac{4r}{4r+2r} \times 0.03 = 0.02 \text{ A.}$$

241. Combined resistance of R and voltmeter

$$= \frac{40}{5} = 8\,\Omega \Rightarrow \frac{1}{8} = \frac{1}{R} + \frac{1}{R_v}$$

$$\Rightarrow R > 8\,\Omega$$

242. Combined resistance of R and ammeter $= 8\,\Omega$

Now, $R_A + R = 8 \Rightarrow R < 8\,\Omega$

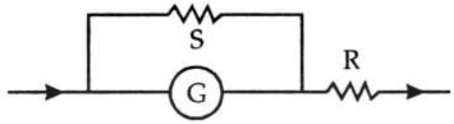
243. In parallel combination potential is same

$$\therefore \quad I_g(G+R) = (I - I_g)S$$

$$0.04\,(20+R) = (20-0.04)\,0.05$$

$$\therefore \quad R = 4.95\,\Omega$$

244.



For same current,

Initial resistance = Final resistance of circuit

i.e. $$G = \frac{G\cdot S}{G+S} + R \qquad \therefore\ R = \frac{G^2}{G+S}$$

245. $$R_1 = \frac{V_1}{I_g} - G \qquad \therefore\ G = 100\,\Omega$$

Now, $$R_2 = \frac{V_2}{I_g} - G = 49{,}900\,\Omega$$

246. $$I_g = \frac{V}{R+G} = \frac{V'}{2R+G}$$

$$\therefore \quad \frac{V'}{V} = \frac{2R+G}{R+G} = \frac{2(R+G)-G}{R+G}$$

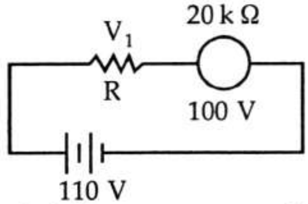
$$= 2 - \frac{G}{R+a} < 2$$

$$\Rightarrow V' < 2V$$

247. $$S_1 = \left(\frac{I_g}{I-I_g}\right) G \quad \text{and} \quad S_2 = \left(\frac{I_g}{2I-I_g}\right) G$$

$$\frac{S_1}{S_2} = \frac{2I-I_g}{I-I_g}$$

248.



Potential difference across voltmeter = 5 V

$\therefore$ Current in circuit $= \dfrac{5}{20\times10^3}$

$= 0.25\times10^{-3}$ A

Potential difference across R $= 105$ V $= I R$

$$\therefore \quad R = \frac{105}{0.25\times10^{-3}} = 420\ k\Omega$$

249. $$I_g = \frac{V}{R_v} = \frac{10}{1000} = \frac{1}{100}\ A$$

Here $R_V = G$

$\therefore$ Required shunt,

$$S = \left(\frac{I_g}{I-I_g}\right)\cdot G = 1\ \Omega$$

250. $$I = \frac{K}{nAB}\theta = \frac{1.5\times10^{-9}\times5}{50\times12\times10^{-4}\times25\times10^{-3}} = 5\ \mu A$$

251. $$B = \frac{K\theta}{nAI} = \frac{2.5\times10^{-9}\times\pi}{10^2\times10^{-3}\times5\times6\times10^{-4}}$$

$= 2.6\times10^{-6}$ Wb/m^2

252. $\tau_n = nIAB\cos\theta$

$= 20\times10^{-2}\times10^{-3}\times2.5\times10^{-2}\times0.7$

$\approx 3.5\times10^6$ Nm

253. $$\theta = \frac{BnAI}{K} = \frac{2\times10^{-2}\times10^2\times12\times10^{-4}\times2\times10^{-6}}{2\times10^{-8}}$$

$$= 0.24\times\frac{180}{\pi} \approx 14^\circ$$

254. $$S = \left(\frac{I_g}{I-I_g}\right)G = \frac{25\times10^{-3}}{(50-0.025)}\times75 = 0.0375\ \Omega$$

255. $$R_A = \frac{GS}{S+G}$$

$9.9\,S + 495\times9.9 = 495\,S \qquad S = \dfrac{495\times9.9}{485.1} = 10.1\ \Omega$

256. $$\frac{I_S}{I} = \frac{S}{S+G} = \frac{2}{100} = 0.02 = 2\%$$

257. $$R = \frac{V}{I_g} - G = \frac{100}{0.1} - 100 = 900\ \Omega$$

258. (i) $V = I_g G \qquad G = \dfrac{500\times10^{-3}}{2.5\times10^{-3}} = 20\ \Omega$

(ii) $R = \dfrac{V}{I_g} - G = \dfrac{10}{25\times10^{-3}} - 20 = 400 - 20 = 380\ \Omega$

259. $$S = \frac{G}{(n-1)} = \frac{50}{(101-1)} = \frac{50}{100} = 0.5\ \Omega$$

260. (i) $S_V = \dfrac{S_i}{G} \qquad G = \dfrac{S_i}{S_V} = \dfrac{5}{2} = 2.5\ \Omega$

(ii) For 1 mA, the deflection is 5 divisions. Thus, for 30 divisions, i.e. current required for maximum deflection is 6 mA, i.e. I_g. Therefore,

$$S = \left(\frac{I_g}{I-I_g}\right)G = \frac{6\times10^{-3}}{(3-0.006)}\times2.5 = 5\ m\Omega$$

$= 0.005\ \Omega$

261. $$S = \left(\frac{I_g}{I-I_g}\right)G$$

$I - I_g = \dfrac{10^{-2}\times10^2}{1} = 1 \qquad \therefore I = 1 + 0.01 = 1.01$ A

292. For same length, $B \propto n^2$

$$\therefore \quad \frac{B_2}{B_1} = \left(\frac{n_2}{n_1}\right)^2$$

$$B_2 = \left(\frac{n}{1}\right)^2\times B = n^2 B.$$

293. $$S = \frac{I_g\cdot G}{I-I_g}$$

$$= \frac{1\times60}{5-1} = \frac{60}{4}$$

$= 15\ \Omega$ in parallel.

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

According to given equation,

$r_a > r_b$

$$\frac{m_a v_a}{qB} > \frac{m_b v_b}{qB}$$

i.e., $m_a v_a > m_b v_b$.

295. From the definition of solenoid

296. $$I_g = \frac{V}{R+G} = \frac{V'}{2R+G}$$

$$\therefore \quad \frac{V'}{V} = \frac{2R+G}{R+G}$$

$$= \frac{2(R+G)-G}{R+G} = 2 - \frac{G}{R+a} < 2$$

$\Rightarrow \quad V' < 2V$

297. For same length

$$B = \frac{\mu_0 nI}{2a}$$

$I = \dfrac{B2a}{\mu_0 n} \qquad$ i.e. $I \propto \dfrac{1}{a^2}$ for same length

$$\therefore \quad \frac{I_2}{I_1} = \left(\frac{a_1}{a_2}\right)^2$$

$$\frac{I_2}{I_1} = \left(\frac{2a_2}{a_2}\right)^2$$

$$I_2 = 4\,I_1 \qquad (\because\ V \propto I)$$

i.e., $V_2 = 4\,V_1$.

298. $B = \mu_0 n I$

$\therefore\ B \propto I$

299. $n = \frac{I}{I_g} = \frac{60}{10} = 6$

$\therefore\ S = \frac{G}{n-1} = \frac{20}{6-1} = \frac{20}{5} = 4\,\Omega.$

300. $\vec{\tau} = \vec{M} \times \vec{B} \Rightarrow \tau = MB\sin\alpha$

$\alpha = 0^0$ corresponds to stable equilibrium,

$\alpha = 180^0$ corresponds to unstable equilibrium.

301. $ma_0 = eE \Rightarrow \boxed{E = \frac{ma_0}{e}}$

and $\frac{eV_0B + eE}{m} = 3a_0$

$\Rightarrow ev_0B = 3ma_0 - eE = 3ma_0 - ma_0 = 2ma_0$

$\Rightarrow \boxed{B = \frac{2ma_0}{ev_0}}$

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

Since, $\frac{v}{qB}$ is constant $\therefore\ r \propto v$.

303. $B = \frac{\mu_0 nI}{2a} = \frac{\mu_0 nI}{2a} \times \frac{A}{A}$

$B = \frac{\mu_0 M}{2a \times \pi a^2}$

$\therefore\ M = \frac{2\pi Ba^3}{\mu_0}$

i.e., $M = \frac{2\pi BR^3}{\mu_0}$

305. $G = \frac{V_1}{I_g} - R_1 = \frac{V_2}{I_g} - R_2$

$\therefore\ \frac{V}{I_g} - 50 = \frac{2V}{I_g} - 500$

$\therefore\ V = 450\,I_g$

Now, $G = \frac{450\,I_g}{I_g} - 50 = 400\,\Omega.$