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Chapter-4

Moving Charges & Magnetism

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Q.1. Choose the correct answer for the following question.

i) Cyclotron is used to accelerate
a) Some Kind of charged particles.
b) Any Kind of charged particle.
c) both charged and neutral particles.
d) none of these.

Ans-> The correct option is:
a) ~~Any~~ Some Kind of charged particle.

ii) The force that accelerates the particles in the cyclotron is
a) Only electrostatic force
b) Only magnetic force
c) both electrostatic and magnetic force called Lorentz force.
d) none of these.

Ans- The correct option is:
a) Only electrostatic force.

iii) Choose the correct option.
a) Conductor shields any charge within it from electric fields created outside the conductor.
b) a conductor shields any charge within it from magnetic fields created outside the conductor.
c) a conductor shields any charge within it from

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c) both electric and magnetic fields created outside the conductor.

d) none of these.

Ans- The correct option is :-

a) Conductor shields any charge within it from electric field created outside the conductor.

Because,

Inside the conductor, there exist no electric field. So, the electric field created outside the conductor due to the charges inside it, will not form any close loops. So, this acts as shielding and thus conductors shields any charges within it.

And as the charge is in static equilibrium inside the conductor, no magnetic field will be produced ~~with~~ outside it.

iv) Inside a dee

a) The particle's speed changes.

b) The particle's velocity changes.

c) The particle's velocity does not change.

d) The particle's Kinetic energy changes.

Ans- The correct option is :-

b) The particle's velocity changes.

Because,

When a particle is left from middle of the dee, it is accelerated due to the electric fields to either of the two plates and then the magnetic field gives it a sprial trajectory. After making a semicircle when it comes again to the

middle it is again accelerated by the electric ~~magnetic~~ field toward another plate.
So, As the particle was already in motion, it's velocity increases due to the continuous acceleration given by the electric field.

v) What is the formula for maximum speed attained by a charged particle in a cyclotron.

a) $V_{max} = \frac{qBR}{m}$

b) $V_{max} = \frac{mBR}{q}$

c) $V_{max} = \frac{qR}{Bm}$

d) none of these.

Ans- Lets consider,
The radius of the dee to be R.
Now,
In a cyclotron, the charged particle is accelerated due to the magnetic field and follows a circular path due to the magnetic field. So, with continuous acceleration, the velocity of particle increase and at the same time the radius of the path followed by the particle also increases.
Here,
As the charge particle follows a circular path due to the force experinced by the magnetic field, it provides a centripetal force to describe the circular motion.

$\therefore$ Centripetal Force, $F_c = \frac{mv^2}{r}$

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As we know,
Magnetic force experienced by the charged particle, $F_m = Bvq.\sin\theta$

Here,
As the particle follows a circular path the angle between F_m and v is $90°$

$\therefore F_m = Bvq \sin 90°$
$= Bvq.$

Hence,
Centripetal force = Magnetic force

$\Rightarrow F_c = F_m$

$\Rightarrow \frac{mv^2}{r} = Bvq.$

$\Rightarrow \frac{mv}{r} = Bq.$

$\Rightarrow v = \frac{Bqr}{m}.$

For, the particle's velocity to be maximum, the radius of circular path should be equal with the radius of Dees.

i.e. $r = R.$

$\therefore V_{max} = \frac{BqR}{m}.$

$\therefore$ The correct option is a) $V_{max} = \frac{BqR}{m}.$

vi) In a Cyclotron.
a) any speed can be obtained by a charged particle by choosing dee radius.
b) Maximum speed attained by a charged particle is limited by the relativistic variation of mass with speed.

c) electrons are best particles to be accelerated.
d) none of these.

Ans- The correct option is.
b) Maximum speed attained by a charged particle is limited by the relativistic variation of mass with speed

Because,
As the velocity of particle approaches to that of light. it's mass increases. according to the Einstien's Relativistic principle
i.e.,

$$m = \frac{m_0}{\left[1 - \left(\frac{v^2}{c^2}\right)\right]^{1/2}} \quad (m \text{ varies with } v)$$

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

So, this limits, the velocity of the particle and makes it less than the light speed.

Q2. Choose the correct answer for the following question.

i) Galvanometer was named after
a) Italian electricity reasearcher Luigi Galvani
b) Italian electricity researcher Luigi Galvani who discovered galvanometer.
c) Italian electricity researcher Luigi Galvani who discovered that a current carrying conductor

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produces magnetic field.
d) none of these.

Ans- The correct option is.
a) Italian electricity ~~reacher~~ researcher Luigi Galvani

ii) Galvanometer is used
a) to detect and measure small ~~ectri~~ electric current,
b) to detect but not to measure small electric current.
c) to measure any amount of electric current.
d) none of these.

Ans- The Correct option is.
a) to detect and measure small electric current.

iii) Choose the correct option for current sensitivity of galvanometer.
a) $S_i = \frac{\theta}{i} = \frac{NBA}{C}$
b) $S_i = \frac{\theta}{i} = \frac{NB}{CA}$
c) $S_i = \theta i = \frac{C}{NB\vec{A}}$
d) none of these.

Ans- Lets consider,
The couple per unit angular twist in a galvanometer to be C
The angular twist to be θ

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As we know,
Restoring torque on the coil is the product of the couple per unit angular twist and the angular twist of the coil.
i.e., $\tau = \theta C$ .... (1)
And.
Torque experienced by the coil due to magnetic field is given by.
$\tau = NIAB \sin\phi$ .... (2).
Now,
On equating both eq^n (1) & (2), we get.
$\theta C = NIAB \sin\phi$ (At equilibrium)
$\Rightarrow I = \frac{C}{NAB \sin\phi} \cdot \theta$
In galvanometer,
as the Radial magnetic field is taken, the angle between the plane of the coil and magnetic field will always be zero on every deflection.
Hence,
$i = \frac{C}{NAB \sin 90^\circ} \theta$ $[\phi = 90^\circ - \alpha]$ $\alpha = 0^\circ$
$= \frac{C}{NAB} \cdot \theta$
So, current sensistivity of Galvanometer is the deflection of galvanometer per unit current
$S_i = \frac{\theta}{i} = \theta \div \frac{C\theta}{NAB}$
$= \theta \times \frac{NAB}{C\theta} = \frac{NAB}{C}$
$\therefore$ The correct option is, a) $S_i = \frac{\theta}{i} = \frac{NBA}{C}$

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iv) Increasing the current sensitivity
a) surely increases the voltage sensitivity
b) may not change the voltage sensitivity.
c) never changes the voltage sensitivity.
d) none of these.

Ans- The correct option is:-
d) none of these.
Because,
The voltage sensitivity depends upon the resistance factor (R). With the increase in current sensitivity, the resistance factor increases as the current flowing in galvanometer increases.
So, As voltage sensitivity is inversely ~~pro~~ related to the resistance factor (R) i.e.,

$$V_S = \frac{NAB}{KR} \Rightarrow V \propto \frac{1}{R}$$

So, voltage sensitivity decreases with increase in current sensitivity.

v) Choose the correct option for design formulae of galvanometer.
a) $i = \left(\frac{C}{BNA}\right)\theta$
b) $i = \left(\frac{CA}{BN}\right)\theta$
c) $i = \left(\frac{C}{BNA\theta}\right)$
d) none of these.

Ans- Here,

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Torque experienced by the coil due to the magnetic force

$\tau = NiAB\sin\phi$

Where,
ϕ is the angle between, $\vec{B}$ and the Area vector normal to the coil.

Now,
Restoring torque in the coil

$\tau = C\theta$

Where,
C is the couple per angular twist &
θ is the angular twist of coil.

Now
At equilibrium,

$C\theta = NiAB\sin\phi$

$\Rightarrow i = \left(\frac{C}{NAB\sin\phi}\right)\theta$

As, we know,
In galvanometer, there is radial magnetic field. So, with every deflection of the coil, the angle between $\vec{B}$ and plane of the coil will be zero. $(\alpha = 0°)$

Hence,
The current flowing in galvanometer.

$i = \left(\frac{C}{NAB\sin 90°}\right)\theta \quad [\phi = 90° - \alpha]$

$= \left(\frac{C}{NAB}\right)\theta$

$\therefore$ The correct opotion is, a) $i = \left(\frac{C}{BNA}\right)\theta$

vi) In the galvanometer the radial magnetic field

makes the magnetic torque:
a) directly proportional to $\sin\theta$
b) independent of θ
c) zero.
d) none of these.

Ans- The correct option is:-
b) independent of θ.
because,
In radial magnetic field, ~~with~~ the plane of the coil is always parallel to the magnetic field lines, with any deflection.
So, the angle between the plane of coil and magnetic field always comes to be zero.
And hence,
Also, the angle between the normal to the plane of the coil and magnetic field always comes out to be 90°
So, it makes the magnetic torque of the coil independent of θ.
i.e., $\tau = NIAB\cos\theta$
$= NIAB\cos 0^\circ$
$= NIAB$.
$\theta \rightarrow$ Angle between $\vec{B}$ and plane of coil.
similarly, $\tau = NIAB\sin\phi$
$= NIAB\sin(90^\circ - \theta)$
$= NIAB\sin(90^\circ - 0)$
$= NIAB\sin 90^\circ$
$= NIAB$
Hence, it proves, it is independent of θ.

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Q.3. Answer with. (A), (B), (C), (D).

i) Assertion:
A steady angular deflection is produced by the spring to produce a Cocenter torque which balances the magnetic torque.
Reason:
In order to improve the strength of the magnetic field and to make the field radial a soft iron Core is placed inside the coil.

Ans The Answer is:-
(B.) Assertion and Reason both are true but the Reason is not a Correct explanation of the Assertion.
Because,
The lower part of the coil of galvanometer is attached to the spring which is the phosphor Bronze Spring having a small number of turns. This phosphor bronze spring produces steady angular deflection.

ii) Assertion:
Moving Coil Galvanometer uses phosphor-bronze wire for Suspension.
Reason:
The phosphor-bronze wire has a small couple per unit twist.

Ans- The Answer is:-
(A.) Both Assertion and Reason are true and Reason is the correct explanation of the Assertion.

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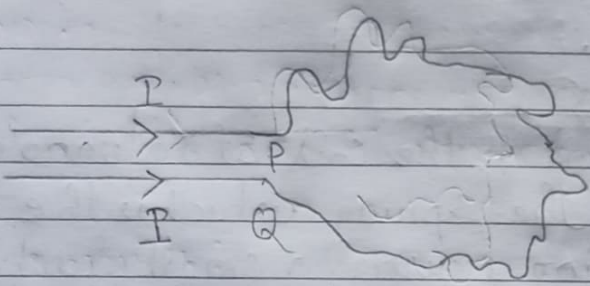
Because,
As phosphor Bronze wire has a small couple per unit twist, the restoring torque for phosphor Bronze wire will also be less or small.
Hence, it can be used for suspension.

iii) Assertion:
A wire bent into an irregular shape with the points P and Q fixed. If a current I is passed through the wire, then the area enclosed by the irregular portion of the wire increases.
Reason:
Opposite currents carrying wire repel each other.

Ans-



The Answer is.
(A.) both Assertion and Reason are correct and the Reason is the correct explanation for the Assertion.
Because,
When the wire is carrying current, the magnetic force is exerted due to the magnetic field created through each current element in the wire carrying current.
And as the currents in the wire are in the opposite direction, the force exerted on this is also opposite. So, the repel each other and hence area is increased.

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iv) Assertion:
When a magnetic dipole is placed in a non-uniform magnetic field, only a torque acts on the dipole.
Reason:
Force would also act on dipole if magnetic field were uniform.

Ans- The Answer is
(D.) both Assertion and Reason are false.
Because,
When magnetic dipole is placed in a non uniform magnetic field, both torque and force will act on the dipole.
Force will not act on dipole if magnetic field were uniform.

v) Assertion:
If the resistance of shunt of an ammeter is increased, the range of ammeter is reduced.
Reason:
If the Series resistance of a voltmeter is increased the range of voltmeter is increased.

Ans- The Answer is:-
(B.) both Assertion and Reason are true but the Reason is not the correct explanation of the Assertion.
Because,
The shunt resistance is connected to the ammeter. So that, ~~it can~~ all the current flowing through it should pass through it without

having any potential drop. as, the shunt resistance have a negligible resistance. This helps to increase the range of ammeter.
But.
if the resistance of the shunt is increased then the shunt resistance will have a potential drop through current flowing through it and thus it reduces the current passing through it and which reduces the range of ammeter,

vi) Assertion:
Galvanometer cannot as such be used as an ammeter to measure the value of the current in a given circuit.
Reason:
Galvanometer gives a full scale deflection for a current of the order of micro ampere.

Ans- The Answer is:
(A) Both Assertion and Reason are true and Reason is the correct explanation of the Assertion
Because,
Galvanometer is basically used for measuring small amount of current in terms of μA.
And to measure the current it has to be connected in series.
It can be used to measure more current as ammeter by converting it into ammeter. And it is done by connecting a shunt resistance in parallel with Galvanometer which increases it's range

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Q.4. Multiple Choice Question. (MCQ)

i) 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 statement is true?

a) a voltmeter is connected in parallel and current through it is negligible.
b) an ammeter is connected in parallel and potential difference across it is small.
c) a voltmeter is connected in series and potential difference across it is small.
d) an ammeter is connected in series in a circuit and the current through it is negligible

Ans- The answer is.
(a) a Voltmeter is connected in parallel and current through it is negligible.
Because,
The potential is constant in parallel connection, So, the total potential through circuit can be measured by the voltmeter.

ii) The resistance of an ideal voltmeter is.
a) zero.
b) 100 Ω.
c) Infinity.
d) 500 Ω.

Ans- The correct option is. (c) Infinity.
Because,

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For the current flowing through it to be negligible, the resistance has to be of a greater value so, that the voltage through out the circuit can be measured by the voltmeter.

iii) Two identical galvanometers are ~~connected~~ converted into an ammeter and a milli-ammeter. Resistance of the shunt of milliammeter through which current passes through will be

a) more.
b) equal.
c) less
d) zero.

Ans- The correct option is: (a) more.,
Because,
The shunt resistance is used to increase or decrease the range of the ammeter. It is used to convert galvanometer into ammeter.
Here,
With more shunt resistance, the range of ammeter decreases and smaller the shunt resistance; range of ammeter increases.
Now;
As in this ~~call~~ case the galvanometer is converted into milliammeter, it's range decreases which means that the shunt resistance connected is more for milliammeter.

iv) Choose the correct option for design formulae of galvanometer.

a) $i = \left(\frac{C}{BNA}\right)\theta$

b) $i = \left(\frac{CA}{BN}\right)\theta$

c) $i = \left(\frac{C}{BNA\theta}\right)$

d) none of these.

Ans- The correct option is : a) $i = \left(\frac{C}{BNA}\right)\theta$

Because,
It is the formula for the current flowing through the galvanometer.
Now,
In a galvanometer,
Torque experienced by the coil due to the magnetic field

$$\tau = NIAB\sin\phi$$

Restoring torque experienced in the coil.

$$\tau = C\theta$$

Now,
At static equilibrium,

$$NIAB\sin\phi = C\theta$$

$$\Rightarrow I = \left(\frac{C}{NAB\sin\phi}\right)\theta$$

As in galvanometer, radial magnetic field is produced,
the angle between the normal to the plane of coil and the magnetic field is 90° ($\phi = 90°$)
Now,

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$$I = \left(\frac{C}{NAB\sin 90^\circ}\right)\theta$$

$$\Rightarrow I = \left(\frac{C}{BNA}\right)\theta \quad \text{[Proved]}$$

v) Choose the correct option for current sensitivity of galvanometer.

a) $S_i = \frac{\theta}{i} = \frac{NBA}{C}$

b) $S_i = \frac{\theta}{i} = \frac{NB}{CA}$

c) $S_i = \theta i = \frac{C}{NBA}$

d) none of these.

Ans- The correct option is a) $S_i = \frac{\theta}{i} = \frac{NBA}{C}$

Because,
As we know,
The expression of current for galvanometer.

$$I = \left(\frac{C}{NBA}\right)\theta.$$

where,
$I \to$ Current flowing through galvanometer.
$C \to$ couple per angular twist.
$\theta \to$ angular twist.
$B \to$ magnetic field in coil,
$N \to$ no. of turns.
$A \to$ Area of crosssection of the coil.
Now,
As we know that,
The current sensitivity for a galvanometer.

is the deflection of galvanometer per unit current i.e.,

$$S_i = \frac{\theta}{I} = \frac{\theta}{\left(\frac{C}{NBA}\right)\theta}$$

$$= \frac{1}{\frac{C}{NBA}} = \frac{NBA}{C}$$

$$\Rightarrow S_i = \frac{\theta}{I} = \frac{NBA}{C}$$ [Proved].