Moving Charges and Magnetism

Class 12 Physics · 24 NEET MCQs with answers & explanations

Moving Charges and Magnetism covers the magnetic force on moving charges and current-carrying conductors, Biot-Savart law, Ampere's circuital law, cyclotron, solenoid and toroid. NEET tests Lorentz force, radius of circular motion in magnetic field, Biot-Savart law application and force between parallel currents.

Key Magnetic Force Concepts

Concept	Key Formula
Lorentz force	F = qv × B = qvB sinθ; perpendicular to both v and B
Circular motion in B	r = mv/qB; T = 2πm/qB (independent of velocity)
Biot-Savart law	dB = (μ_0/4π)(Idl × r̂)/r²; field at centre of loop: B = μ_0I/2R
Ampere's law	∮B·dl = μ_0I_enc; useful for solenoid (B = μ_0nI) and toroid
Force on conductor	F = BIL sinθ; direction by Fleming's left-hand rule
Parallel currents	Same direction → attract; opposite → repel; F/L = $\mu_0 I_1 I_2$/2πd

Questions

Q1. A proton enters a uniform magnetic field perpendicular to it with speed v. If the speed becomes 3v while mass, charge, and field remain unchanged, the new radius of the circular path is:

(A) r/3
(B) r
(C) 3r
(D) 9r

Q2. A proton enters a uniform magnetic field of magnitude B with velocity v making an angle θ with the field. The magnitude of magnetic force acting on it is:

(A) qvB
(B) qvBcosθ
(C) qvBsinθ
(D) qvBtanθ

Q3. According to Ampere's Circuital Law, the line integral of the magnetic field around any closed Amperian path is equal to:

(A) μ_0 times the total magnetic field
(B) μ_0 times the net current enclosed by the path
(C) μ_0 times the total current in all nearby conductors
(D) The magnetic field times the area enclosed

Q4. The force per unit length between two parallel conductors separated by distance d is directly proportional to:

(A) Separation d between the conductors
(B) Product of the two currents $I_1 I_2$
(C) Inverse of the product $I_1 I_2$
(D) Square root of the separation d

Q5. A proton enters a uniform magnetic field perpendicularly with speed 2×10^6 m/s. If the magnetic field is doubled while the speed remains unchanged, the radius of the circular path becomes:

(A) Unchanged
(B) Half
(C) Double
(D) Four times

Q6. A charged particle enters a uniform magnetic field perpendicular to its velocity. The path followed by the particle is:

(A) Straight line
(B) Parabola
(C) Circle
(D) Helix

Q7. A rectangular current-carrying loop of n turns, area A, carrying current I is placed in a uniform magnetic field B. The angle between the magnetic moment and the magnetic field is θ. The torque acting on the loop is:

(A) nIAB
(B) nIABcosθ
(C) nIABsinθ
(D) nIB/A

Q8. According to the Biot–Savart law, the magnetic field dB due to a small current element Idl at a point P is directly proportional to:

(A) Idl cosθ/r²
(B) I/r
(C) Idl/r²
(D) Idl sinθ/r²

Q9. A solenoid has a total of N turns wound over length L and carries current I. Which expression correctly gives the magnetic field inside it?

(A) $\mu_0(N/L)I$
(B) $\mu_0 NI/2\pi r$
(C) $\mu_0 I/2\pi r$
(D) $\mu_0 I/2R$

Q10. The working principle of a moving coil galvanometer is based on:

(A) Torque experienced by a current-carrying coil placed in a magnetic field
(B) Electromagnetic induction due to changing magnetic flux
(C) Electrostatic force between oppositely charged plates
(D) Lenz's law opposing the change in flux through the coil

Q11. A galvanometer is converted into an ammeter by connecting:

(A) A low resistance (shunt) in parallel with the galvanometer
(B) A high resistance in series with the galvanometer
(C) A low resistance in series with the galvanometer
(D) A high resistance in parallel with the galvanometer

Q12. Which physical quantity is always perpendicular to both the velocity of a charged particle and the magnetic field?

(A) Magnetic force
(B) Electric field
(C) Velocity
(D) Current

Q13. A straight conductor of length l carrying current I is placed perpendicular to a uniform magnetic field B. The magnetic force acting on it is:

(A) BIl
(B) BI/l
(C) B/Il
(D) BIl^2

Q14. A charged particle moves parallel to a uniform magnetic field. The magnetic force on the particle is:

(A) qvB
(B) Zero
(C) qvB/2
(D) qB/v

Q15. A charged particle moves perpendicular to a uniform magnetic field. Which of the following correctly describes the effect of the magnetic force on the particle?

(A) It increases the speed of the particle
(B) It decreases the kinetic energy of the particle
(C) It changes only the direction of velocity, not the speed
(D) It brings the particle to rest eventually

Q16. An electron enters a magnetic field normally with speed v. If both magnetic field and speed are doubled, the magnetic force becomes:

(A) 2F
(B) 3F
(C) 8F
(D) 4F

Q17. Which of the following particles experiences the maximum magnetic force when moving with the same speed perpendicular to the same magnetic field?

(A) Neutron
(B) Proton
(C) Alpha particle
(D) Deuteron

Q18. A charged particle moves in a region with both electric and magnetic fields. Which of the following statements about magnetic force is correct?

(A) Magnetic force is always perpendicular to the velocity of the particle
(B) Magnetic force can do positive work on the particle
(C) Magnetic force acts along the direction of the magnetic field
(D) Magnetic force depends on the mass of the particle

Q19. Which one of the following statements is INCORRECT regarding magnetic force on a moving charge?

(A) It depends upon the magnitude of charge
(B) It acts along the direction of velocity
(C) It depends upon the strength of the magnetic field
(D) It depends upon the angle between velocity and magnetic field

Q20. A particle of charge 2 μC moves with speed 5×10^6 m/s perpendicular to a magnetic field of 0.4 T. The magnetic force is:

(A) 2 N
(B) 3 N
(C) 6 N
(D) 4 N

Q21. Which formula correctly represents the vector form of magnetic force on a moving charge?

(A) $F=q(v\times B)$
(B) $F=q(v\cdot B)$
(C) $F=qB/v$
(D) $F=qv+B$

Q22. A positively charged particle moves towards the east while the magnetic field acts vertically downward. The magnetic force acts towards:

(A) East
(B) West
(C) North
(D) South

Q23. A charged particle enters a uniform magnetic field with velocity making an angle 30° with the field. If the magnetic force is F, then the force when the angle becomes 90° is:

(A) F/2
(B) $F/\sqrt{3}$
(C) $\sqrt{3}F$
(D) 2F

Q24. A magnetic field cannot do work on a moving charged particle because:

(A) Magnetic force is always perpendicular to the instantaneous velocity of the particle
(B) Magnetic force is always parallel to the displacement
(C) Magnetic force depends on the charge of the particle
(D) Magnetic force increases the kinetic energy of the particle

Answer key

1-C	2-C	3-B	4-B	5-B	6-C	7-C	8-D

9-A	10-A	11-A	12-A	13-A	14-B	15-C	16-D
17-C	18-A	19-B	20-D	21-A	22-C	23-D	24-A

Answers with explanations

Q1 — Answer: (C) 3r
Using r = mv/qB, radius is directly proportional to speed. Tripling speed gives new radius = 3r. Option A reverses the proportionality; Option D squares the ratio, a common student error.

Q2 — Answer: (C) qvBsinθ
Magnetic force F=qvBsinθ. Force is maximum when θ=90° and zero when θ=0° or 180°. Option qvBtanθ has no physical basis in electromagnetic theory.

Q3 — Answer: (B) μ_0 times the net current enclosed by the path
$\oint B \cdot dl = \mu_0 I_enclosed$; only net current through the bounded surface counts. Option A is dimensionally wrong. Option C is a classic misconception — external currents cancel in the integral. Option D confuses the law with magnetic flux.

Q4 — Answer: (B) Product of the two currents $I_1 I_2$
$F/L = \mu_0 I_1 I_2/2\pi d$ shows direct proportionality to $I_1 I_2$ and inverse proportionality to d. Options A and D reverse this relationship. Option C inverts the current dependence entirely.

Q5 — Answer: (B) Half
r = mv/qB; radius is inversely proportional to B. Doubling B gives r_new = r/2. Mass, charge, and speed are all unchanged. Option C (Double) is the trap — students confuse direct and inverse proportion.

Q6 — Answer: (C) Circle
When v⊥B (θ=90°), magnetic force F=qvB acts perpendicular to velocity at every instant, providing centripetal force for uniform circular motion. Speed is unchanged since magnetic force does no work.

Q7 — Answer: (C) nIABsinθ
τ=nIABsinθ where M=nIA is the magnetic moment. Torque is maximum at θ=90° and zero at θ=0°. Option D is dimensionally wrong: nIB/A has units A·T/m², not N·m.

Q8 — Answer: (D) Idl sinθ/r²
$dB=(\mu_0/4\pi)(Idl\ \sin\theta/r^2)$: field is proportional to I, dl, sinθ, and inversely to r². Option A uses cosθ — wrong trigonometric factor. Options B and C are dimensionally incorrect, missing the sinθ dependence.

Q9 — Answer: (A) μ_0(N/L)I
$B = \mu_0 nI$ where n = N/L. Option B ($\mu_0 NI/2\pi r$) is the toroid formula — uses total N and mean radius, not length. Option C is the long straight wire formula. Option D is the field at the centre of a single circular loop — different geometry entirely.

Q10 — Answer: (A) Torque experienced by a current-carrying coil placed in a magnetic field
A current-carrying coil in a uniform magnetic field experiences deflecting torque τ = nBIA. This torque causes the coil to deflect against a restoring spring until equilibrium. Option B is the trap — EMI involves changing flux; galvanometer responds to steady current.

Q11 — Answer: (A) A low resistance (shunt) in parallel with the galvanometer
An ammeter needs very low resistance. A low-resistance shunt in parallel allows most current to bypass the galvanometer. Series connection (Option C) would increase resistance, opposite of requirement.

Q12 — Answer: (A) Magnetic force
F = q(v × B). The cross product yields a vector perpendicular to both v and B simultaneously. Electric field and current are not defined by this cross product relationship.

Q13 — Answer: (A) BIl
F=BIlsinθ. At θ=90°, sin90°=1 giving F=BIl. Options B and C have incorrect dimensions (not newtons). Option D introduces an extra length factor with no physical basis.

Q14 — Answer: (B) Zero
When velocity is parallel to B, θ=0°, so sin0°=0 and F=qvBsin0°=0. Magnetic force vanishes for parallel motion regardless of charge or speed.

Q15 — Answer: (C) It changes only the direction of velocity, not the speed
Magnetic force F=q(v×B) is always perpendicular to velocity, so work done is zero and kinetic energy is unchanged. Only direction changes, not speed or energy.

Q16 — Answer: (D) 4F
F=qvB. Substituting 2v and 2B gives F'=q(2v)(2B)=4qvB=4F. Force scales with the product of speed and field, not their sum.

Q17 — Answer: (C) Alpha particle
F=qvB depends on charge magnitude. Alpha particle carries +2e, proton and deuteron carry +e, neutron carries zero charge. Alpha particle experiences double the force of a proton.

Q18 — Answer: (A) Magnetic force is always perpendicular to the velocity of the particle
Magnetic force F=q(v×B) is perpendicular to v by definition of the cross product. It cannot do work, has no component along B, and is entirely independent of the particle's mass.

Q19 — Answer: (B) It acts along the direction of velocity
Magnetic force F=qvBsinθ is always perpendicular to both velocity and magnetic field. It never acts along the velocity direction. All other options correctly describe F=qvBsinθ.

Q20 — Answer: (D) 4 N
F=qvB=$(2\times10^{-6})(5\times10^{6})(0.4)$=4 N. Common error: forgetting that $10^{-6}\times10^{6}=10^{0}=1$, leading to answers of 2 N (dropping the 0.4) or 6 N (arithmetic slip).

Q21 — Answer: (A) F=q(v×B)
Lorentz magnetic force is the cross product F=q(v×B). The dot product in Option B yields a scalar, not a force. Options C and D have no physical meaning in this context.

Q22 — Answer: (C) North
v=+î (east), B=−k̂ (downward). F=q(v×B)=q[î×(−k̂)]=q(ĵ)=north. Common error: applying right-hand rule without accounting for the negative sign on B.

Q23 — Answer: (D) 2F
F_1=qvBsin30°=qvB/2. At θ=90°, F_2=qvBsin90°=qvB=$2F_1$. Option √3F is the trap for students who use sin60° instead of the ratio sin90°/sin30°.

Q24 — Answer: (A) Magnetic force is always perpendicular to the instantaneous velocity of the particle
W=F·ds·cosθ. Since magnetic force is perpendicular to velocity (θ=90°), cos90°=0 and W=0. Speed and kinetic energy remain constant; only direction changes.

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