



Attempt all questions before checking the answer key. Use $\mu_0 = 4\pi \times 10^{-7}$ H/m and $e = 1.6 \times 10^{-19}$ C. Neglect relativistic effects.

A. Very short answers - 1 mark each

1. When is magnetic force on a moving charge zero?
2. Why can a magnetic force change direction of velocity without changing speed?
3. State the SI unit of magnetic dipole moment of a current loop.
4. What is the direction of force between parallel wires carrying currents in the same direction?
5. Why is a radial magnetic field used in a moving-coil galvanometer?

B. Short answers / practice - 2 marks each

6. A 0.20 m wire carries 5 A perpendicular to a 0.4 T field. Calculate the magnetic force.
7. An electron moves parallel to a uniform magnetic field. Describe its path; repeat for perpendicular entry.
8. State Biot-Savart law and explain the meaning of its vector direction.
9. A circular loop of radius 0.10 m carries 2 A. Find the magnetic field at its centre.
10. A charge passes undeflected through perpendicular electric and magnetic fields of magnitudes 3×10^4 V/m and 0.02 T. Find its speed and state the required force directions.
11. Can a static magnetic field do work on an isolated moving point charge?
12. Find force on 2 μ C moving at 10^3 m/s perpendicular to 0.5 T.
13. A proton's speed doubles in a fixed perpendicular field. How do radius and period change?
14. Find field 2 cm from a long wire carrying 5 A.
15. Find magnetic moment of a 20-turn, 0.01 m^2 coil carrying 0.5 A.
16. Explain why an ammeter is connected in series.
17. Can a charged particle travel straight through a non-zero magnetic field?
18. A coil's turns double at fixed area and current. How does maximum torque change?
19. Explain the effect of reversing current in one of two parallel wires on their interaction.
20. State the direction of force on a positive charge moving along +x in a field along +z.

C. Short answers - 3 marks each

21. A proton of mass 1.67×10^{-27} kg enters a 0.20 T field perpendicularly at 2×10^6 m/s. Find orbit radius and time period.
22. A charged particle enters a uniform magnetic field obliquely. Explain the helical path and obtain its radius and pitch in terms of velocity components.
23. Two long parallel wires 0.05 m apart carry 4 A and 6 A in opposite directions. Find force per unit length and its direction.
24. A 100-turn coil of area $2 \times 10^{-3} \text{ m}^2$ carries 0.5 A in a 0.2 T field. Find maximum torque and torque when its plane is perpendicular to the field.
25. A galvanometer has resistance 50 Ω and full-scale current 2 mA. Find the shunt for a 1 A ammeter and the series resistance for a 10 V voltmeter.

D. Long answers - 5 marks each

26. Use Biot-Savart law to derive the magnetic field on the axis of a circular current loop. Obtain the field at its centre.
27. State Ampere's circuital law and apply it to an infinitely long straight wire. Describe qualitatively the field pattern of a long current-carrying solenoid.
28. Derive force per unit length between two long parallel current-carrying wires. Explain attraction and repulsion and the traditional force-based ampere definition.
29. Derive torque on a rectangular current loop in a uniform field. Introduce its magnetic moment and discuss the orientation for maximum torque.
30. Explain construction, principle and working of a moving-coil galvanometer. Derive its current sensitivity and explain conversion to an ammeter and voltmeter.

ANSWER KEY - Numerical / short answers

- 6) 0.40 N. 9) $4\pi \times 10^{-6}$ T $\approx 1.26 \times 10^{-5}$ T. 10) 1.5×10^6 m/s; electric and magnetic forces oppose. 11) No; force is perpendicular to velocity. 12) 1.0×10^{-3} N. 13) Radius doubles; period is unchanged. 14) 5.0×10^{-5} T. 15) 0.10 A m^2 . 17) Yes, with velocity parallel or antiparallel to the field. 18) It doubles. 20) Along -y. 21) $r \approx 0.104$ m; $T \approx 3.28 \times 10^{-7}$ s. 22) $r = mv_{\perp}/(|q|B)$; pitch = $2\pi mv_{\parallel}/(|q|B)$. 23) 9.6×10^{-5} N/m; repulsive. 24) Maximum 0.020 N m; stated orientation: zero. 25) Shunt $\approx 0.1002 \Omega$; series resistance = 4950 Ω .