Moving Charges and Magnetism

Standard difficulty · 20 questions · 40 marks · Time: 38 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. A proton moves at 2×10^{6} m/s at 150° to a magnetic field of 6×10^{-1} T. The force on it is: ($e = 1.6 \times 10^{-19}$ C)

(a) 9.6×10^{-15} N **(b)** 1.92×10^{-13} N **(c)** 0 N **(d)** 9.6×10^{-14} N

2. A circular coil of 74 turns and radius 16 cm carries 9 A. The field at its centre is: ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

(a) $4.1625\pi \times 10^{-4}$ T **(b)** $8.325\pi \times 10^{-6}$ T
(c) $8.325\pi \times 10^{-4}$ T **(d)** 8.325×10^{-4} T

3. The magnetic field 3 cm from a long straight wire carrying 20 A is: ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

(a) 1.33×10^{-6} T **(b)** 6.67×10^{-5} T **(c)** $1.33\pi \times 10^{-4}$ T **(d)** 1.33×10^{-4} T

4. Particles X (charge 4e, mass m) and Y (charge 4e, mass 6m) enter the same magnetic field at the same speed, at right angles to it. The ratio of the radii of their paths, r_X : r_Y, is:

(a) 1 : 6 **(b)** 1 : 1 **(c)** 2 : 6 **(d)** 6 : 1

5. The SI unit of magnetic field is the:

(a) tesla **(b)** gauss **(c)** weber **(d)** henry

6. Two long parallel wires 11 cm apart carry 17 A and 3 A in the same direction. The force on each metre of wire is: ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

(a) 9.27×10^{-5} N, attractive **(b)** 4.64×10^{-5} N, attractive
(c) 9.27×10^{-5} N, repulsive **(d)** 9.27×10^{-7} N, attractive

7. A long solenoid has 1000 turns per metre and carries 10 A. The field inside it is: ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

(a) $4\pi \times 10^{-1}$ T **(b)** $2\pi \times 10^{-3}$ T **(c)** $4\pi \times 10^{-3}$ T **(d)** 4×10^{-3} T

8. Assertion (A): A proton moving at 6×10^{6} m/s at right angles to an 8×10^{-1} T magnetic field speeds up steadily.
Reason (R): The magnetic force on a moving charge is perpendicular to its velocity, so it does no work.

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. A circular coil of radius 19 cm has 12 turns and carries 7 A. Find the field at its centre. ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

10. A wire 8 cm long carrying 16 A lies at 90° to a uniform field of 9×10^{-1} T. Find the force on it.

11. A coil of 139 turns and area 32 cm^2 carries 5 A in a field of 7×10^{-1} T. Find the torque on it when its plane makes 0° with the field (normal at 90°).

12. A galvanometer of resistance 70 Ω gives full-scale deflection for 10 mA. What shunt converts it into an ammeter reading up to 8 A?

13. A galvanometer of resistance 85 Ω gives full-scale deflection for 9 mA. What resistance in series converts it into a voltmeter reading up to 20 V?

14. Two long parallel wires 5 cm apart carry 19 A and 8 A in opposite directions. Find the force per metre between them, and say whether they attract or repel. ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

15. A particle of mass 9×10^{-26} kg and charge 3e moves at 2×10^{5} m/s at right angles to a field of 7×10^{-1} T. Find the radius of its path. ($e = 1.6 \times 10^{-19}$ C)

16. A toroid has 1600 turns and carries 3 A. Find the field inside its core at a radius of 20 cm. ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

Section C — Word problems — 4 × 4 = 16 marks

17. A galvanometer has resistance 40 Ω and full-scale current 2 mA. Show how to convert it into (a) an ammeter of range 0–8 A, (b) a voltmeter of range 0–440 V, and find the resistance of each meter.

18. A particle of mass 8×10^{-26} kg and charge 3e enters a field of 5×10^{-1} T at right angles with speed 9×10^{5} m/s. Find the radius of its path, the time for one revolution, and its frequency. Does the time depend on the speed? ($e = 1.6 \times 10^{-19}$ C)

19. Two long parallel wires 10 cm apart carry 18 A and 13 A in opposite directions. Find the magnetic field midway between them and the force on each metre of either wire. ($\mu_0 = 4\pi \times 10^{-7}$ T m/A)

20. A rectangular coil of 175 turns, area 45 cm^2, carries 5 A in a uniform field of 8×10^{-1} T. Find its magnetic moment, the largest torque on it, and the torque when its normal makes 30° with the field.

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Answer key

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Q	Answer	Working
1	**(d) 9.6×10^{-14} N**	$F = qvB \sin\theta = 1.6 \times 10^{-19} \times 2 \times 10^{6} \times 6 \times 10^{-1} \times \sin 150°$
2	**(c) $8.325\pi \times 10^{-4}$ T**	$B = \mu_0 NI/(2R)$
3	**(d) 1.33×10^{-4} T**	$B = \mu_0 I/(2\pi r) = 2 \times 10^{-7}\, I/r$
4	**(a) 1 : 6**	$r = mv/(qB) \propto m/q$
5	**(a) tesla**	—
6	**(a) 9.27×10^{-5} N, attractive**	$F/L = \mu_0 I_1 I_2/(2\pi d)$
7	**(c) $4\pi \times 10^{-3}$ T**	$B = \mu_0 nI$
8	**(d) A is false, but R is true.**	A is false: the magnetic force does no work, so the speed cannot change. R is true.
9	**$8.84\pi \times 10^{-5}$ T**	$B = \mu_0 NI/(2R) = 4\pi \times 10^{-7} \times 12 \times 7 \div (2 \times 19 \times 10^{-2})$
10	**1.152 N**	$F = BIL \sin\theta = 9 \times 10^{-1} \times 16 \times 8 \times 10^{-2} \times \sin 90°$
11	**1.5568 N m**	$\tau = NIAB \sin\theta$
12	**0.0876 Ω in parallel**	$S = I_g G/(I - I_g) = 10 \times 10^{-3} \times 70 \div (8 - 10 \times 10^{-3})$
13	**2,137.22 Ω**	$R = V/I_g - G$
14	**6.08×10^{-4} N/m; they repel**	$F/L = 2 \times 10^{-7}\, I_1 I_2/d$
15	**0.0536 m**	$r = mv/(qB) = 9 \times 10^{-26} \times 2 \times 10^{5} \div (3 \times 1.6 \times 10^{-19} \times 7 \times 10^{-1})$
16	**4.8×10^{-3} T**	$B = \mu_0 NI/(2\pi r) = 2 \times 10^{-7} \times 1600 \times 3 \div (20 \times 10^{-2})$
17	**(a) shunt 0.01 Ω in parallel; ammeter resistance 0.01 Ω; (b) 219,960 Ω in series; voltmeter resistance 220,000 Ω**	$S = I_g G/(I - I_g)$; $R = V/I_g - G$
18	**r = 0.3 m; $T = 6.67\pi \times 10^{-7}$ s; f = 1/T; no, $T = 2\pi m/(qB)$ does not depend on v**	$r = mv/(qB)$; $T = 2\pi r/v$
19	**1.24×10^{-4} T; 4.68×10^{-4} N/m, repulsive**	each wire gives $2 \times 10^{-7}\, I/(5 \times 10^{-2})$ at the midpoint; they add
20	**m = 3.9375 A m²; τmax = 3.15 N m; τ = 1.575 N m**	$m = NIA$; $\tau = mB \sin\theta$