

How to use this worksheet. Thirty questions, about 35 minutes. Torque uses the angle between the **normal** to the coil and the field, not the plane of the coil. When a wire crosses a circular field region off-centre, the length inside the field is a **chord**, not the diameter.

Formula sheet

$B = \mu_0 I / 2\pi r$ (long wire) | $B = \mu_0 NI / 2R$ (centre of coil) | $B = \mu_0 nI$ (solenoid)

$F = qvB \sin\theta$ | $F = BIL \sin\theta$ | $\tau = NIAB \sin\theta$ | $m = NIA$ | $r = mv/qB$

Force per length between parallel wires: $\mu_0 I_1 I_2 / 2\pi d$ | $\mu_0 = 4\pi \times 10^{-7} \text{ T m/A}$

Section A · Level 1 — Definitions and direct formulas

Ten questions. None should take more than twenty seconds.

1. The SI unit of magnetic field strength is the:

(1) Weber (2) Tesla (3) Henry (4) Gauss

2. The magnetic force on a charge q moving with velocity v at an angle θ to a field B is:

(1) $qvB \cos\theta$ (2) $qvB \sin\theta$ (3) qv / B (4) qB / v

3. The magnetic force on a stationary charge placed in a magnetic field is:

(1) Maximum (2) qB (3) Zero (4) Equal to its weight

4. The Biot-Savart law gives the:

(1) Force between two charges (2) Magnetic field due to a current element (3) Electric field due to a dipole (4) Induced emf in a coil

5. The magnetic field at the centre of a circular coil of N turns, radius R , carrying current I is:

(1) $\mu_0 NI / 2R$ (2) $\mu_0 NI / 2\pi R$ (3) $\mu_0 NIR / 2$ (4) $\mu_0 I / 2\pi R$

6. The magnetic field inside a long solenoid with n turns per unit length carrying current I is:

(1) $\mu_0 nI / 2$ (2) $\mu_0 n / I$ (3) $\mu_0 nI$ (4) $\mu_0 I / 2\pi n$

7. Two long parallel wires carrying current in the same direction will:

(1) Repel each other (2) Attract each other (3) Exert no force (4) Rotate about each other

8. The work done by a magnetic force on a moving charged particle is:

(1) Always positive (2) Always negative (3) Zero (4) Equal to qvB

9. A moving charge travelling parallel to a uniform magnetic field experiences a force of:

(1) qvB (2) Zero (3) $qvB / 2$ (4) Infinity

10. A galvanometer is converted into an ammeter by connecting a:

(1) High resistance in series (2) Low resistance in parallel (3) High resistance in parallel (4) Capacitor in series

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Fields, forces and torques

Nine questions. Substitute carefully and watch the powers of ten.

11. A straight wire of length 0.4 m carrying 2 A lies perpendicular to a field of 0.5 T. The force on it is:

(1) 0.4 N (2) 4 N (3) 0.04 N (4) 1.0 N

12. A charge of $1.6 \times 10^{-19} \text{ C}$ moves at 10^6 m/s perpendicular to a 0.2 T field. The force on it is:

(1) $3.2 \times 10^{-14} \text{ N}$ (2) $3.2 \times 10^{-13} \text{ N}$ (3) $1.6 \times 10^{-14} \text{ N}$ (4) $8.0 \times 10^{-14} \text{ N}$

13. The magnetic field at the centre of a single circular loop of radius 0.1 m carrying 2 A is closest to:

- (1) $1.26 \times 10^{-5} \text{ T}$ (2) $1.26 \times 10^{-6} \text{ T}$ (3) $2.51 \times 10^{-5} \text{ T}$ (4) $6.28 \times 10^{-6} \text{ T}$

14. A solenoid has 1000 turns per metre and carries 2 A. The field inside is closest to:

- (1) $2.5 \times 10^{-4} \text{ T}$ (2) $2.5 \times 10^{-3} \text{ T}$ (3) $1.3 \times 10^{-3} \text{ T}$ (4) $5.0 \times 10^{-3} \text{ T}$

15. The radius of the circular path of a charged particle moving perpendicular to a magnetic field is:

- (1) qB / mv (2) mv / qB (3) $mvqB$ (4) qvB / m

16. Two long parallel wires 1 m apart each carry 1 A. The force per unit length between them is:

- (1) $2 \times 10^{-7} \text{ N/m}$ (2) $2 \times 10^{-6} \text{ N/m}$ (3) $4\pi \times 10^{-7} \text{ N/m}$ (4) $1 \times 10^{-7} \text{ N/m}$

17. The torque on a current loop of N turns, area A, carrying current I in a field B, when the plane of the loop is parallel to the field, is:

- (1) Zero (2) $NIAB$ (3) $NIAB / 2$ (4) NIA / B

18. The magnetic dipole moment of a coil of 10 turns and area 0.01 m^2 carrying 2 A is:

- (1) 0.02 A m^2 (2) 0.2 A m^2 (3) 2 A m^2 (4) 20 A m^2

19. A galvanometer is converted into a voltmeter by connecting a:

- (1) Low resistance in parallel (2) High resistance in series (3) Low resistance in series (4) High resistance in parallel

Working space — Questions 11 to 19

Write the formula before you substitute.

Section C · Level 3 — Motion of charges and field geometry

Eight questions. Each needs two steps or a physical insight.

20. A coil of 100 turns and radius 0.05 m carries 1 A. The field at its centre is closest to:

- (1) $1.26 \times 10^{-3} \text{ T}$ (2) $1.26 \times 10^{-4} \text{ T}$ (3) $6.28 \times 10^{-4} \text{ T}$ (4) $2.51 \times 10^{-3} \text{ T}$

21. The torque on a current loop is maximum when the normal to the loop makes an angle with the field of:

- (1) 0° (2) 45° (3) 90° (4) 180°

22. The frequency of revolution of a charged particle in a cyclotron is:

- (1) $qB / 2\pi m$ (2) $2\pi m / qB$ (3) $qBm / 2\pi$ (4) mv / qB

23. A wire passes through a cylindrical field region of radius 10 cm at a perpendicular distance of 6 cm from the axis. The length of wire inside the field is:

- (1) 0.08 m (2) 0.12 m (3) 0.16 m (4) 0.20 m

24. A proton and an alpha particle enter the same magnetic field with the same speed, perpendicular to the field. Compared with the proton, the alpha particle follows a path of radius:

- (1) Half as large (2) The same (3) Twice as large (4) Four times as large

25. A charged particle moves in a helical path in a uniform magnetic field. This happens when its velocity is:

- (1) Parallel to B (2) Perpendicular to B (3) At an angle to B other than 0° or 90° (4) Zero

26. Inside a long current-carrying solenoid, the magnetic field:

- (1) Increases with distance from the axis (2) Decreases with distance from the axis (3) Is uniform across the cross-section (4) Is zero

27. The magnetic field at a perpendicular distance r from a long straight wire carrying current I is proportional to:

- (1) r (2) r^2 (3) $1 / r$ (4) $1 / r^2$

Working space — Questions 20 to 27*Write the formula before you substitute.***Section D · Previous year questions — Straight from the AAI ATC papers***Three questions, every one exactly as it appeared in the 2021 papers.*

28. A uniform magnetic field of 2 T exists in a cylindrical region of radius 10 cm, its direction parallel to the axis along east to west. A wire carrying current 6 A in the north to south direction passes through the region. What is the magnitude of the force on the wire if (a) the wire intersects the axis, and (b) the wire in the N-S direction is lowered from the axis by a distance of 6 cm? **[PYQ 2021 · Shift 2]**

(1) 2.4 N, 1.54 N respectively (2) 2.4 N, 1.92 N respectively (3) 2.1 N, 1.54 N respectively (4) 2.1 N, 1.92 N respectively

29. A circular coil of 50 turns and radius 10 cm carrying a current of 5.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 90° with the normal of the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning. **[PYQ 2021 · Shift 2]**

(1) 3.13 N m (2) 7.85 N m (3) 2.83 N m (4) 6.32 N m

30. A galvanometer coil has a resistance of $14\ \Omega$ and shows full scale deflection for a current of 4 mA. What series resistance converts it into a voltmeter of range 0 to 16 V? **[PYQ 2021 · Shift 3]**

(1) 3986 Ω (2) 4000 Ω (3) 4014 Ω (4) 64 Ω

Working space — Questions 28 to 30*Write the formula before you substitute.***Stuck on any of these? Bring them to a live class.**

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