

7.2 Electromagnetism and the motor effect

Name: _____ Class: _____ Date: _____

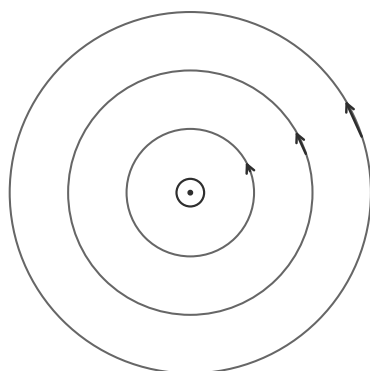
Total: 24 marks**KEY WORDS** solenoid • electromagnet • magnetic flux density

Objective

Describe and draw the fields of a wire and a solenoid, use Fleming's left-hand rule with $F = BIl$, and explain motors and loudspeakers. Wire/solenoid fields are common-tier; the motor effect is HT, and loudspeakers are physics-only HT. Original questions for spec statements 4.7.2.1–4.7.2.4.

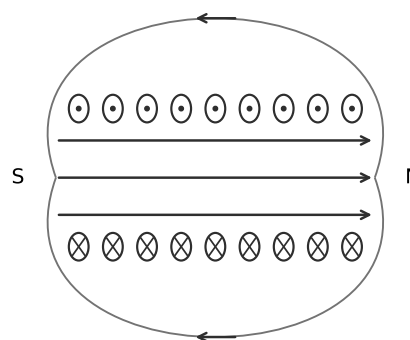
1 Key knowledge and worked examples

Wire: anticlockwise field



Dot: current out of page

Solenoid: uniform field inside



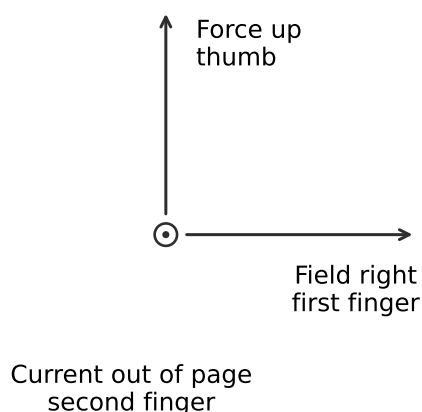
Dots out; crosses into page

Right-hand grip: thumb with current, fingers curl with the field.

- Current in a **wire**: concentric circular field; stronger with more current, weaker with distance.
- **Solenoid** : strong, **uniform** field inside; outside shaped like a bar magnet's; an **iron core** strengthens it – an **electromagnet** (switchable, adjustable).

Motor effect (HT): a current-carrying conductor in a magnetic field feels a force.

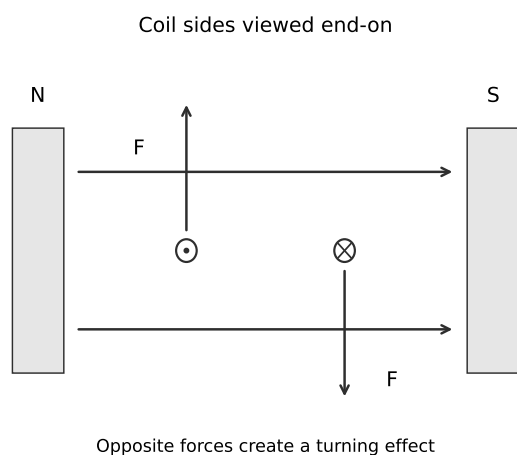
Fleming's LEFT hand



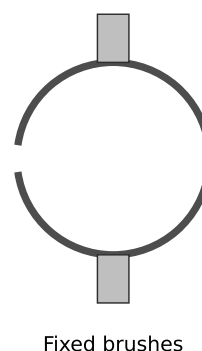
Thumb = force, first finger = field, second finger = current.

$$F = BIl$$

- B magnetic flux density in T; I in A; l = length **in the field** in m.
- Bigger force: stronger B , bigger I , longer l ; maximum at right angles to the field.



Split-ring commutator



The commutator reverses the current each half-turn so rotation continues.

Loudspeaker (physics only): an alternating current makes the coil vibrate in and out; the cone produces pressure variations – sound with the same frequency as the signal.

Worked example. A copper rod of length 5.0 cm carries 3.0 A at right angles to a 0.20 T field.

- Convert: $l = 0.050$ m.

$$F = BIl = 0.20 \times 3.0 \times 0.050 = 0.030 \text{ N}$$

2 Practice

2.1 State two ways to strengthen the field of a solenoid. [2]

2.2 A 0.15 m wire carries 2.0 A perpendicular to a 0.50 T field. Calculate the force. [2]

2.3 State the three factors that increase the motor-effect force. [3]

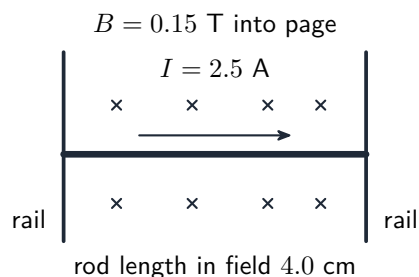
3 Exam-style questions

3.1 A copper rod rests on rails, perpendicular to a uniform 0.15 T field. The whole stated rod length is in the field.

(a) The rod is 4.0 cm long and carries 2.5 A. Calculate the force on it. [3]

(b) State two changes that would double the force. [2]

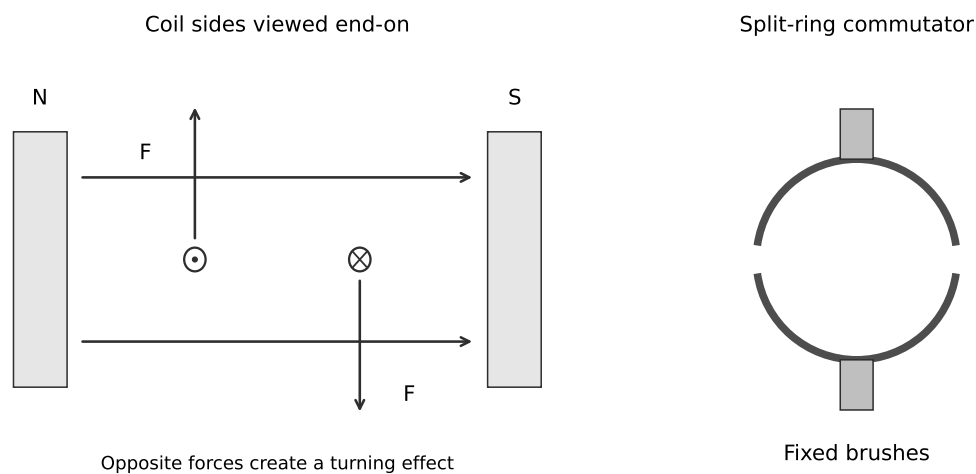
(c) The current's direction is reversed. State the change in the force. [1]



3.2 Explain how a moving-coil loudspeaker turns an electrical signal into sound. [4]

3.3 A motor coil spins between poles.

- (a) Explain why the coil rotates, using Fleming's left-hand rule. [3]
- (b) Explain the role of the split-ring commutator. [2]
- (c) Give two changes that increase the turning effect at the same coil orientation, assuming other conditions are unchanged. [2]



Solutions

2.1 Larger current through the solenoid; add an iron core inside it.

2.2 Known: $B = 0.50 \text{ T}$, $I = 2.0 \text{ A}$, $l = 0.15 \text{ m}$, all perpendicular.

$$F = BIl = 0.50 \times 2.0 \times 0.15 = \mathbf{0.15 \text{ N}}$$

(equation C1, answer with unit A1)

2.3 Stronger magnetic flux density; larger current; longer conductor in the field.

3.1 (a) Convert: $l = 0.040 \text{ m}$ (C1).

$$F = BIl = 0.15 \times 2.5 \times 0.040 = \mathbf{1.5 \times 10^{-2} \text{ N}}$$

(C1, A1) **3.1** (b) Any two of: double the current; double the flux density; double the length in the field. **3.1** (c) The force reverses direction (same size).

3.2 The signal is an alternating current in the coil, sitting in a permanent magnetic field; by the motor effect the coil experiences a force whose direction reverses with the current, making the coil move in and out; the coil is attached to the cone, which pushes and pulls the air; creating pressure variations – sound waves at the same frequency as the signal.

3.3 (a) Each side of the coil carries a current at right angles to the field; by Fleming's left-hand rule each side feels a force perpendicular to the coil face – one up, one down, because the currents in the two sides flow opposite ways; the equal and opposite forces form a couple that rotates the coil. **3.3** (b) Without switching connections, the turning effect would reverse after the coil passes its zero-moment position; the commutator swaps connections every half-turn, reversing current in each physical side to maintain the turning sense. Inertia carries the moving coil through the zero-moment position. **3.3** (c) Any two: stronger magnets (larger B); larger current; more turns carrying the same current.