Solutions

Each answer shows the steps, then the **result**.

2.1

- **moving charges (currents)** and **permanent magnets**

2.2

- from **N to S**

2.3

- a **stronger** magnetic field

3.1 B

- outside a magnet, field lines run **N to S**

3.2

- curved lines from **N to S** outside the magnet
- closer together near the **poles**

3.3

- a **current** (moving charges) in a wire
- a **permanent magnet**

3.4

(a) a region in which a **force** is experienced by a moving charge, a current-carrying conductor or a magnetic pole

(b) four **concentric circles** centred on the wire

- drawn with the spacing **increasing** with distance, because the field weakens as $1/r$
- arrows **clockwise**, from the right-hand grip rule with the current into the page

(c) $F/L = BI$

$$\frac{F}{L} = (2.5 \times 10^{-5}\ \mathrm{T})(3.0\ \mathrm{A}) = \mathbf{7.5 \times 10^{-5}}\ \mathrm{N\ m^{-1}}$$

(d) the force is **towards** the first wire, i.e. the two wires **attract**

- currents in the same direction attract; applying the left-hand rule with the field of one wire and the current in the other gives a force pointing along the line joining them

(e) by **Newton's third law** the forces on the two wires are equal in magnitude and opposite in direction

- so the force per unit length on the first wire is also $7.5 \times 10^{-5}\ \mathrm{N\ m^{-1}}$
- check: $BI = (1.5 \times 10^{-5}\ \mathrm{T})(5.0\ \mathrm{A}) = 7.5 \times 10^{-5}\ \mathrm{N\ m^{-1}}$ — a smaller field acting on a larger current gives the same product