Solutions

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

2.1

- **concentric circles** centred on the wire, drawn further apart as the distance grows
- arrows **clockwise** when the current goes into the page (right-hand grip rule)
- reversing the current keeps the same circles but reverses every arrow, to anticlockwise

2.2

- any one: add a **ferrous/iron core**; increase the **current**; increase the **number of turns**

2.3

- they **attract**

3.1 A

- parallel currents in the same direction **attract**

3.2

- **concentric circles** centred on the wire
- closer together near the wire, with a direction (arrow) shown

3.3

- each wire lies in the other's magnetic field and feels a force ($F = BIL$)
- for opposite-direction currents Fleming's left-hand rule gives forces pushing the wires **apart** (repulsion)

3.4

(a) the field inside is **uniform**: straight lines parallel to the axis, evenly spaced

- running from the south end to the north end **inside** the solenoid

(b) at least three **concentric circles** centred on the wire

- spaced further apart as the distance grows
- arrows **anticlockwise** for a current out of the page

(c) any two: increase the **number of turns per unit length**; insert a **soft-iron core**; wind the turns closer together over a shorter length

(d) flux through one turn $= BA$

$$\Phi = (6.0 \times 10^{-3}\ \text{T})(1.8 \times 10^{-4}\ \text{m}^2) = 1.08 \times 10^{-6}\ \text{Wb}$$

- flux **linkage** $= N\Phi$

$$N\Phi = 50 \times 1.08 \times 10^{-6}\ \text{Wb} = \mathbf{5.4 \times 10^{-5}}\ \text{Wb}$$

(e) $\varepsilon = \Delta(N\Phi)/\Delta t$

$$\varepsilon = \frac{5.4 \times 10^{-5}\ \text{Wb}}{0.020\ \text{s}} = \mathbf{2.7 \times 10^{-3}}\ \text{V}$$

- the linkage falls to zero, so the whole of it is the change