Solutions

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

2.1

- the product of the **magnetic flux density** and the **area perpendicular** to it ($\Phi = BA$)

2.2

- $\Phi = BA$
- flux linkage $= N\Phi = NBA$

2.3

- the induced e.m.f. is **proportional to the rate of change of flux linkage**

2.4

- the induced e.m.f. (or current) is in a direction that **opposes the change** that produces it

3.1 B

- Faraday: e.m.f. $\propto$ **rate of change of flux linkage**

3.2

- $E = N\Delta\Phi/\Delta t = NA\Delta B/\Delta t$

$$E = 200 \times \frac{(0.010\ \text{m}^2)(0.30\ \text{T} - 0.10\ \text{T})}{0.50\ \text{s}} = \mathbf{0.80}\ \text{V}$$

3.3

- the induced e.m.f./current **opposes the change** producing it
- if it aided the change, the current would grow without an energy source — impossible
- so opposing it conserves energy (work must be done against the force)

3.4

- move a **magnet into a coil** connected to a galvanometer
- the galvanometer **deflects** while the flux changes (and reads zero when the magnet is still)

3.5

(a) $E = BLv$

$$E = (4.5 \times 10^{-5}\ \text{T})(30\ \text{m})(250\ \text{m s}^{-1}) = \mathbf{0.34}\ \text{V}$$

(b) $\Phi = E\Delta t$

$$\Phi = (0.34\ \text{V})(15\ \text{s}) = \mathbf{5.1}\ \text{Wb}$$

3.6

(a) the magnitude of the induced e.m.f. is **proportional to the rate of change of magnetic flux linkage**

- the flux linkage is the flux through the circuit multiplied by the number of turns

(b) $\Phi = \varepsilon t$

$$\Phi = (0.55\ \text{V})(15\ \text{s}) = \mathbf{8.25}\ \text{Wb}$$

— the weber, equal to a volt second

(c) $\Phi = BA$, so $A = \Phi/B$

$$A = \frac{8.25\ \text{Wb}}{4.4 \times 10^{-5}\ \text{T}} = \mathbf{1.9 \times 10^5}\ \text{m}^2$$

(d) the wings sweep an area $A =$ (span) $\times$ (distance)

$$\text{distance} = \frac{1.875 \times 10^5\ \text{m}^2}{34\ \text{m}} = 5.5 \times 10^3\ \text{m}$$

$$v = \frac{5515\ \text{m}}{15\ \text{s}} = \mathbf{3.7 \times 10^2}\ \text{m s}^{-1}$$

(e) the induced e.m.f. drives a current in the direction that **opposes the change producing it**

- imagine completing the circuit: the induced current must create a magnetic field opposing the change in flux through it
- the wingtip that the conventional current flows **towards** inside the wing is the one at the higher potential

(f) the e.m.f. becomes **zero**

- only the component of the field **perpendicular** to the swept area cuts through it, and a horizontal field is parallel to the area a horizontally-flying wing sweeps out, so no flux is cut