Solutions

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

2.1

- $F = BQv \sin\theta$

2.2

- $F = BQv$

$$F = (0.50 \text{ T})(1.6 \times 10^{-19} \text{ C})(2.0 \times 10^{6} \text{ m s}^{-1}) = \mathbf{1.6 \times 10^{-13}} \text{ N}$$

2.3

- a **circle**

2.4

- the force is always **perpendicular** to the velocity, so it does no work (the speed is unchanged)

3.1 C

- a charge moving perpendicular to B follows a **circle**

3.2

- $BQv = mv^2/r \Rightarrow r = mv/(BQ)$

$$r = \frac{(9.1 \times 10^{-31} \text{ kg})(3.0 \times 10^{6} \text{ m s}^{-1})}{(0.020 \text{ T})(1.6 \times 10^{-19} \text{ C})} = \mathbf{8.5 \times 10^{-4}} \text{ m}$$

3.3

- the magnetic force is always **perpendicular** to the velocity
- so it does **no work** — the kinetic energy and hence speed stay constant

3.4

- crossed **electric** and **magnetic** fields exert opposite forces on the charge
- only when they **balance** ($qE = Bqv$, i.e. $v = E/B$) does the charge travel straight through — selecting that speed

3.5

(a) the magnetic force $F = BQv$ is always **perpendicular to the velocity**

- so it does no work on the electron: the speed is unchanged and only the direction turns, which is circular motion

(b) $F = BQv$

$$F = (3.5 \times 10^{-3} \text{ T})(1.60 \times 10^{-19} \text{ C})(2.4 \times 10^{7} \text{ m s}^{-1}) = \mathbf{1.3 \times 10^{-14}} \text{ N}$$

(c) $BQv = mv^2/r$, so $r = mv/(BQ)$

$$r = \frac{(9.11 \times 10^{-31}\ \mathrm{kg})(2.4 \times 10^{7}\ \mathrm{m\ s^{-1}})}{(3.5 \times 10^{-3}\ \mathrm{T})(1.60 \times 10^{-19}\ \mathrm{C})} = \mathbf{3.9 \times 10^{-2}}\ \mathrm{m}$$

(d) $T = 2\pi r/v$

$$T = \frac{2\pi(0.039\ \mathrm{m})}{2.4 \times 10^{7}\ \mathrm{m\ s^{-1}}} = \mathbf{1.0 \times 10^{-8}}\ \mathrm{s}$$

- doubling the speed doubles the radius as well, so the time is **unchanged** — the period does not depend on the speed

(e) undeflected means $QE = BQv$

$$E = Bv = (3.5 \times 10^{-3}\ \mathrm{T})(2.4 \times 10^{7}\ \mathrm{m\ s^{-1}}) = \mathbf{8.4 \times 10^{4}}\ \mathrm{V\ m^{-1}}$$

- the electric force must act **opposite** to the magnetic force