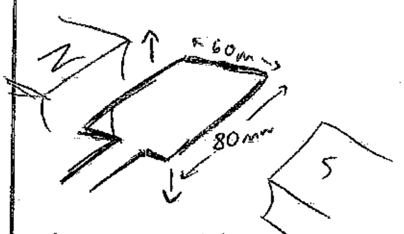
24 MAGNETIC FIELDS

24.1 Current-Carrying Conductors in a magnetic field

1. a) $F = 0.2 \times 3 \times 0.04$
   0.024 N west
   b) $I = 0.036/(0.2 \times 0.04)$
   4.5 A East to west
   c) $B = 0.024/(3 \times 0.04)$
   0.20 T down
   d) $F = 0.1 \times 2 \times 0.04 = \underline{0.008\text{N}}$

2. a) $F = BIL = (55 \times 10^{-3}) \times 4 \times 0.1$
   $= \underline{0.022\text{ N}}$ (East)

   b) $I = \dfrac{F}{BL} = \dfrac{28 \times 10^{-3}}{(140 \times 10^{-3}) \times (50 \times 10^{-3})} = \underline{4\text{ A}}$ towards East

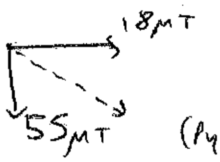
3.) 

(arrows could be reversed)

60mm sides; force $= 0$ (as they are parallel to field)

80mm sides; $L_{\text{TOTAL}} = 80 \times 10^{-3} \times 50$ turns

Force $= (85 \times 10^{-3}) \times 8.0 \times (80 \times 10^{-3} \times 50)$
$= \underline{2.72\text{N}}$

4. a) 

(Pythagoras)

Resultant field $= \sqrt{(18 \times 10^{-6})^2 + (55 \times 10^{-6})^2}$
$= \underline{5.8 \times 10^{-5}\text{T}}$ or $58\,\mu$T

b) Vertical wire → so only horizontal component of B is perpendicular and ~~East~~ used

$F = BIL = (18 \times 10^{-6}) \times 4.5 \times 0.8 = \underline{6.45 \times 10^{-5}}$ East

24.2 Moving charges in a magnetic field

1. a) i) Force would reverse direction (↑)
   ii) Force would decrease
   iii) Force would increase

   b) i) $F = BQv \underbrace{\sin\theta}_{\sin 90^\circ = 1} = (150 \times 10^{-3}) \times (1.6 \times 10^{-19}) \times 8 \times 10^{6} = \underline{1.9 \times 10^{-13}\text{ N}}$

   ii) $\sin\theta = 0$, so $\underline{\text{force} = 0}$

2. $F = BQv = (95 \times 10^{-3}) \times (1.6 \times 10^{-19}) \times 2.5 \times 10^{-3}$
   $= \underline{3.8 \times 10^{-23}\text{N}}$ East

3. a) Parallel to field ∴ no force
   b) Force experienced perpendicular to both the magnetic field direction and the velocity of the particles.

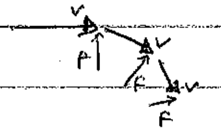
4. a) Charge carriers passing through the slice of semi-conductor are deflected by the field - creating a p.d. between the top and bottom of the slice.

b) i) $F = BQv \rightarrow v = \frac{F}{BQ} = \frac{6.4\times10^{-20}}{(90\times10^{-3})\times(1.6\times10^{-19})} = \underline{4.4\,\mathrm{ms^{-1}}}$

ii) $F = (120\times10^{-3})\times(1.6\times10^{-19})\times 4.4 = \underline{8.5\times10^{-20}\,\mathrm{N}}$

24.3 Charged particles in circular orbits

1. a i) Electrons experience a force at right-angles to their direction of motion, causing their path to bend ~~in~~



ii) $r = \frac{mv}{BQ} = \frac{(9.11\times10^{-31})\times(3.2\times10^{7})}{(8.5\times10^{-3})\times(1.6\times10^{-19})} = \underline{0.021\,\mathrm{m}}$

b) $B = \frac{mv}{rQ} = \frac{(9.11\times10^{-31})\times(3.2\times10^{7})}{(0.065)\times(1.6\times10^{-19})} = \underline{0.0028\,\mathrm{T}}$ or $2.8\,\mathrm{mT}$

2. a) $B = \frac{mv}{rQ} = \frac{(9.11\times10^{-31})\times(2.9\times10^{7})}{(0.035)\times(1.6\times10^{-19})} = \underline{0.0047}$ or $4.7\,\mathrm{mT}$

b) $r = \frac{mv}{BQ} \rightarrow r \propto v$, so v halved means r halves $= \frac{35\,\mathrm{mm}}{2}$ $= \underline{17.5\,\mathrm{mm}}$

3. a) $r = \frac{mv}{BQ} \rightarrow v = \frac{rBQ}{m} = \frac{\left(\frac{0.28}{2}\right)\times 1.1\times(1.6\times10^{-19})}{1.67\times10^{-27}} = \underline{1.54\times10^{7}\,\mathrm{ms^{-1}}}$

b) $E_k = \frac{1}{2}mv^2 = \frac{1}{2}\times(1.67\times10^{-27})\times(1.5\times10^{7})^2 = 1.8788\times10^{-13}\,\mathrm{J}$

$\rightarrow \mathrm{eV} = \underline{1.17\times10^{6}\,\mathrm{eV}}$ or $1.2\,\mathrm{MeV}$

4. a) Specific charge $= \frac{Q}{m}$ $\quad r = \frac{mv}{BQ} \rightarrow \frac{Q}{m} = \frac{v}{Br}$

$\frac{Q}{m} = \frac{7.6\times10^{6}}{(680\times10^{-3})\times\left(\frac{0.028}{2}\right)} = \underline{7.98\times10^{6}\,\mathrm{C\,kg^{-1}}}$

b) $\frac{Q}{m} = \frac{v}{Br} = \frac{7.6\times10^{6}}{(400\times10^{-3})\times\left(\frac{0.028}{2}\right)} = \underline{1.4\times10^{7}\,\mathrm{C\,kg^{-1}}}$