For Examiner's Use

3 A long straight copper wire is placed at an angle of 90° to a uniform magnetic field of flux density 5.2×10^{-2} T, as shown in Fig. 3.1.

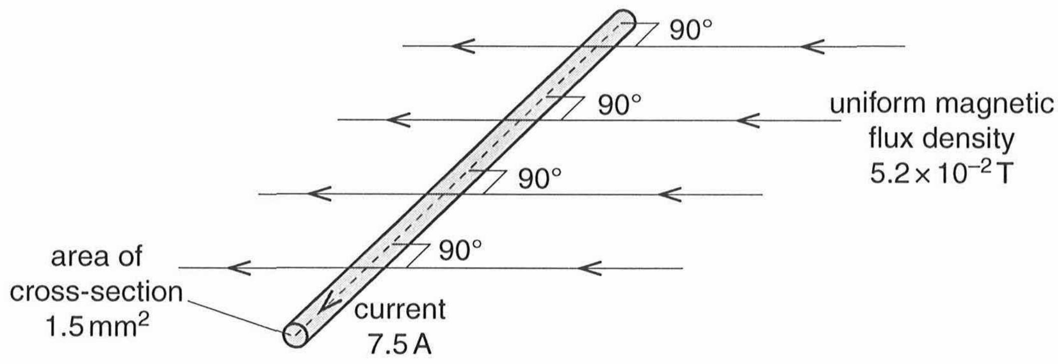

Fig. 3.1

The current in the wire is 7.5 A.
There is a force on the current-carrying wire due to the magnetic field.

(a) For this force,

(i) on Fig. 3.1, mark its direction with an arrow, [1]

(ii) calculate the force per unit length on the wire.

force per unit length = ... $\mathrm{N\,m^{-1}}$ [2]

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(b) The current in the wire is a movement of free electrons along the wire. The electrons may be assumed to be moving with speed v along the wire.
The number of free electrons per unit volume of the wire is $7.8 \times 10^{28}\,\text{m}^{-3}$.
The area of cross-section of the wire is $1.5\,\text{mm}^2$.

The force on the wire is equal to the total force on the free electrons as they move along the wire.

For a free electron as it moves along the wire in the magnetic field,

(i) use your answer in **(a)(ii)** to show that the magnitude of the force on each free electron is $3.3 \times 10^{-24}\,\text{N}$,

[2]

(ii) determine the speed v of the free electron.

speed = ... $\text{m}\,\text{s}^{-1}$ [2]

(c) A circuit contains a battery, a lamp and a switch, as shown in Fig. 3.2.

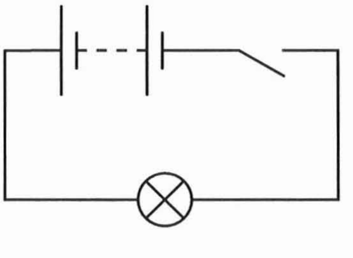

Fig. 3.2

Suggest why, when the switch is closed, the lamp is lit almost immediately and yet the free electrons in the wire are moving at less than $1\,\text{mm}\,\text{s}^{-1}$.

....

....

.... [2]