9 A rigid copper wire is held horizontally between the pole pieces of two magnets, as shown in Fig. 9.1.

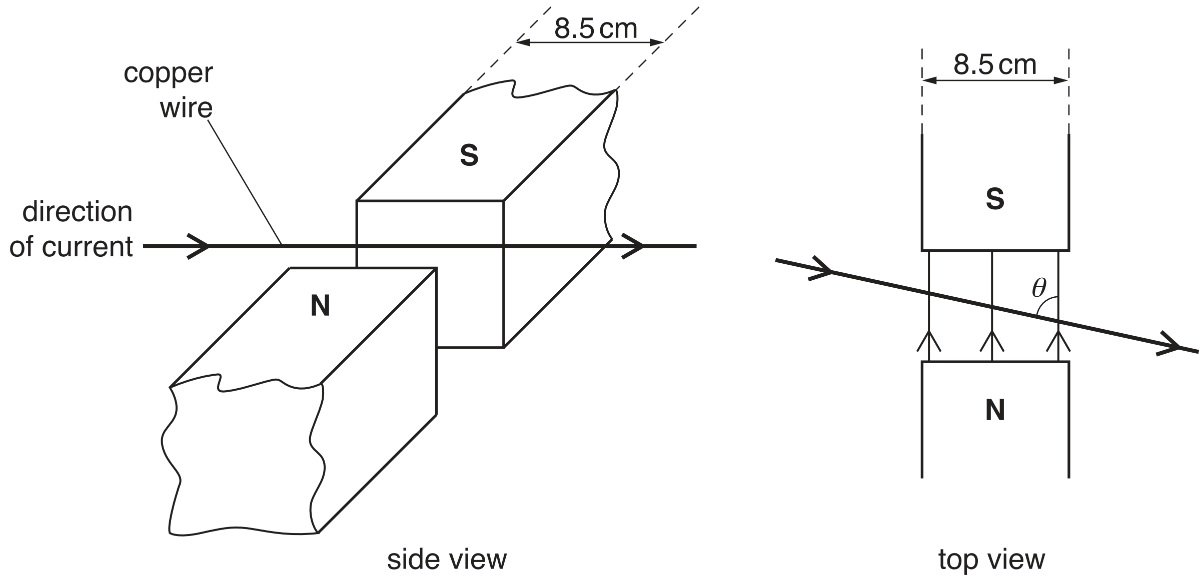

Fig. 9.1

The width of each pole piece is 8.5 cm.
The uniform magnetic flux density B in the region between the poles of the magnets is 3.7 mT and is zero outside this region.
The angle between the wire and the direction of the magnetic field is θ.
The current in the wire is in the direction shown on Fig. 9.1.

(a) By reference to the **side** view of Fig. 9.1, state and explain the direction of the force on the **magnets**.

....

....

....

....[2]

(b) The constant current in the wire is 5.1 A.

(i) For angle θ equal to 90°, calculate the force on the wire.

force = ... N [2]

(ii) The angle θ is changed to 60°.

The length of wire in the magnetic field is $\left(\frac{8.5}{\sin 60°}\right)$ cm.

Calculate the force on the wire.

force = ... N [1]

(c) The constant current in the wire is now changed to an alternating current of frequency 20 Hz and root-mean-square (r.m.s.) value 5.1 A.

The angle between the wire and the direction of the magnetic field is 90°.

On Fig. 9.2, sketch a graph to show the variation with time t of the force F on the wire for two cycles of the alternating current.

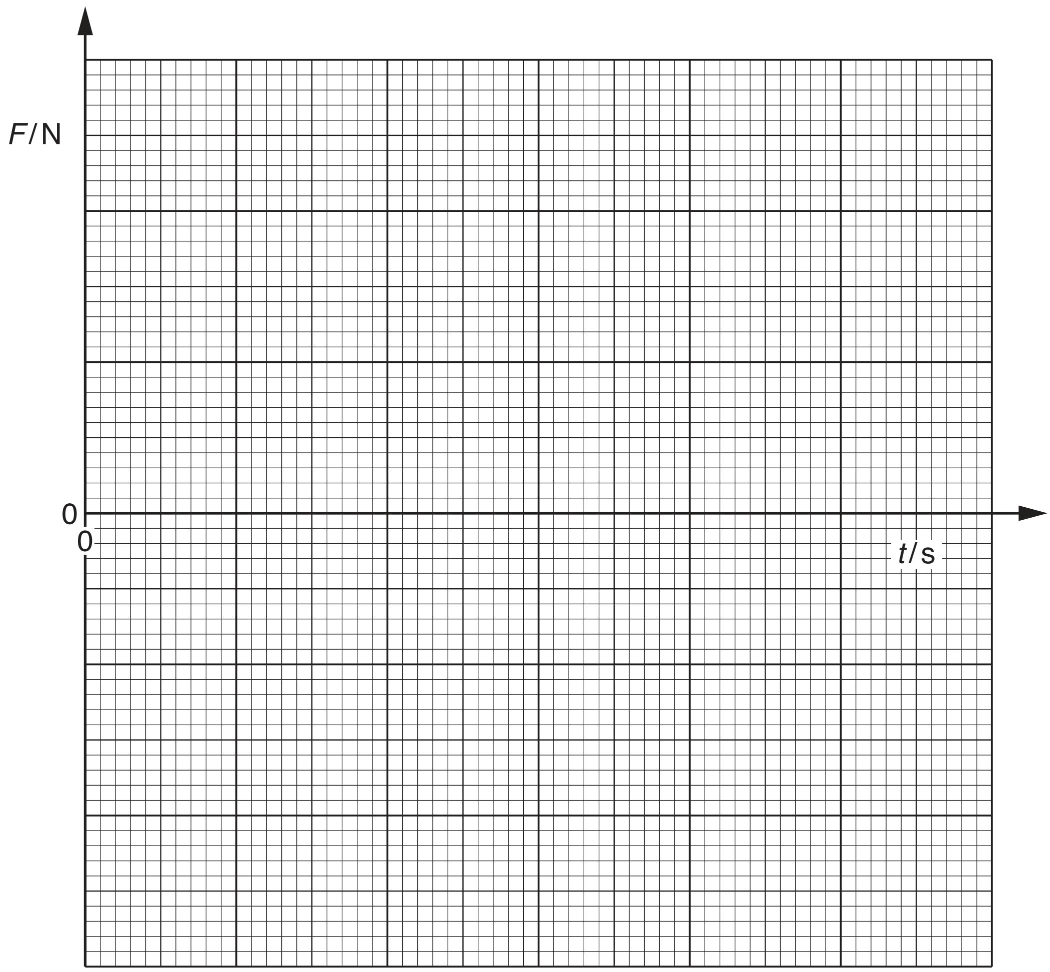

Fig. 9.2

[3]

[Total: 8]