8 **(a)** A current-carrying rigid copper wire AB is held horizontally between the pole pieces of two magnets, as shown in Fig. 8.1.

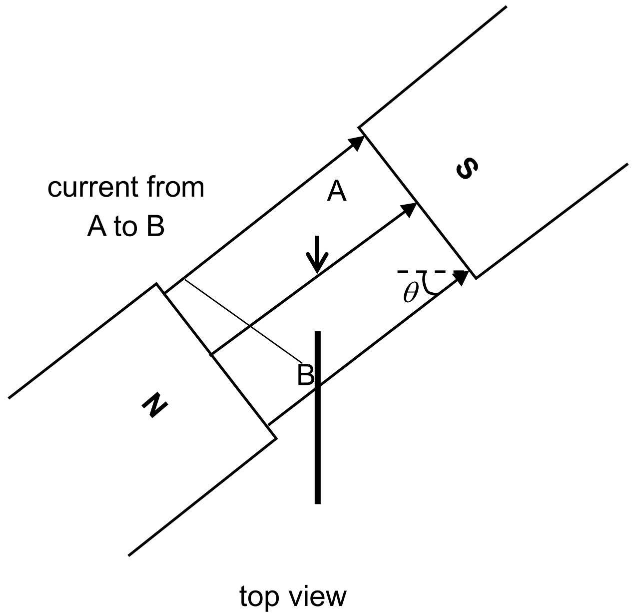

Fig. 8.1

(i) By reference to Fig. 8.1, state and explain the direction of the force by wire AB on the magnets.

....

....

……………………………………………………………………………………….…………....[2]

(ii) The angle θ is varied from 0 ° to 60 ° by rotating the magnet in the horizontal plane.

Describe the changes in the force on the wire.

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………….…………....[2]

(b) The magnet in **(a)** is fixed in position at $\theta = 0\,°$ such that its magnetic field is perpendicular to wire AB. The magnetic flux density between the poles of the magnet is 0.45 T. The current in the copper wire is now switched off.

The wire is moved at constant speed of 5.0 m s^{-1} vertically out of the plane to cut the region of magnetic field.

(i) The movement of the wire causes conduction electrons in the wire to experience magnetic force.

Show that the magnetic force acting on an electron is 3.6×10^{-19} N.

[1]

(ii) The magnetic force in **(b)(i)** causes conduction electrons in the wire to move, creating a potential difference across the ends of wire AB.

State and explain which end of the wire is at a higher potential.

……………………………………………………………………………………………...................

……………………………………………………………………………………………...................

……………………………………………………………………………………………....[2]

(iii) The conduction electrons will move until the potential difference across the ends of wire AB is large enough such that the electrons in the wire reach an equilibrium.

1. Explain why electrons in the wire reach an equilibrium.

……………………………………………………………………………………..................

……………………………………………………………………………………..................

……………………………………………………………………………………....[2]

2. With reference to **(b)(i)**, calculate the electric field strength generated across the ends of the wire AB.

electric field strength = ……………………………. N C^{-1} [2]

3. The length of the wire within the region of field is 0.20 m. Using the answer in **(b)(iii)2.**, calculate the induced e.m.f across wire AB.

induced e.m.f = ... V [1]

(c) A 2.0 cm square copper frame is moving on a smooth surface with a constant speed of 1.0 cm s^{-1} towards two uniform magnetic fields, as shown in Fig. 8.2.

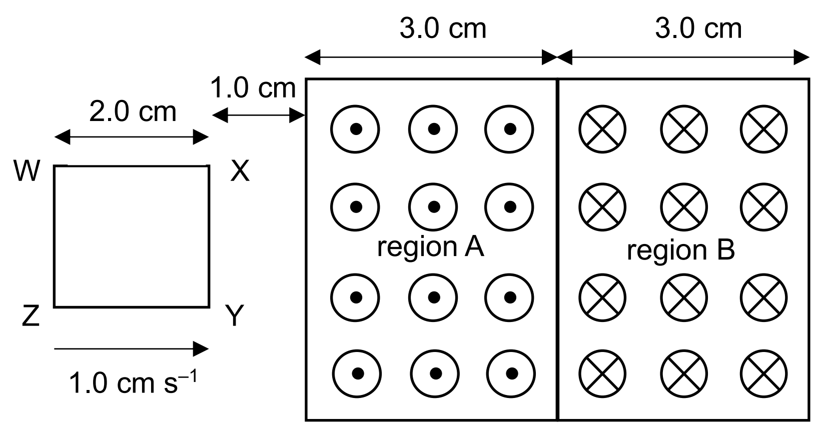

Fig. 8.2

An external force *F* is applied on the frame when necessary to ensure that the frame moves at a constant speed. The position of the frame in Fig. 8.2 is taken to be at *t* = 0 s.

The magnetic field in region A is directed out of the paper while the magnetic field in region B is directed into the paper. The magnetic flux density of both fields is 1.0 T. The resistance of the frame is 8.0×10^{-4} Ω.

A short instant later, the side XY of the frame enters region A.

(i) Explain why an external force *F* is necessary to maintain the constant speed of the frame as it enters region A.

....

....

....

....

....[3]

(ii) Determine the magnitude of the external force *F* at this instant.

F = ... N [3]

(iii) On Fig. 8.3, sketch the variation of external force F with time t, from t = 0 s till the frame completely emerges from region B. The graph for region A has been drawn. Values on F axis are not required.

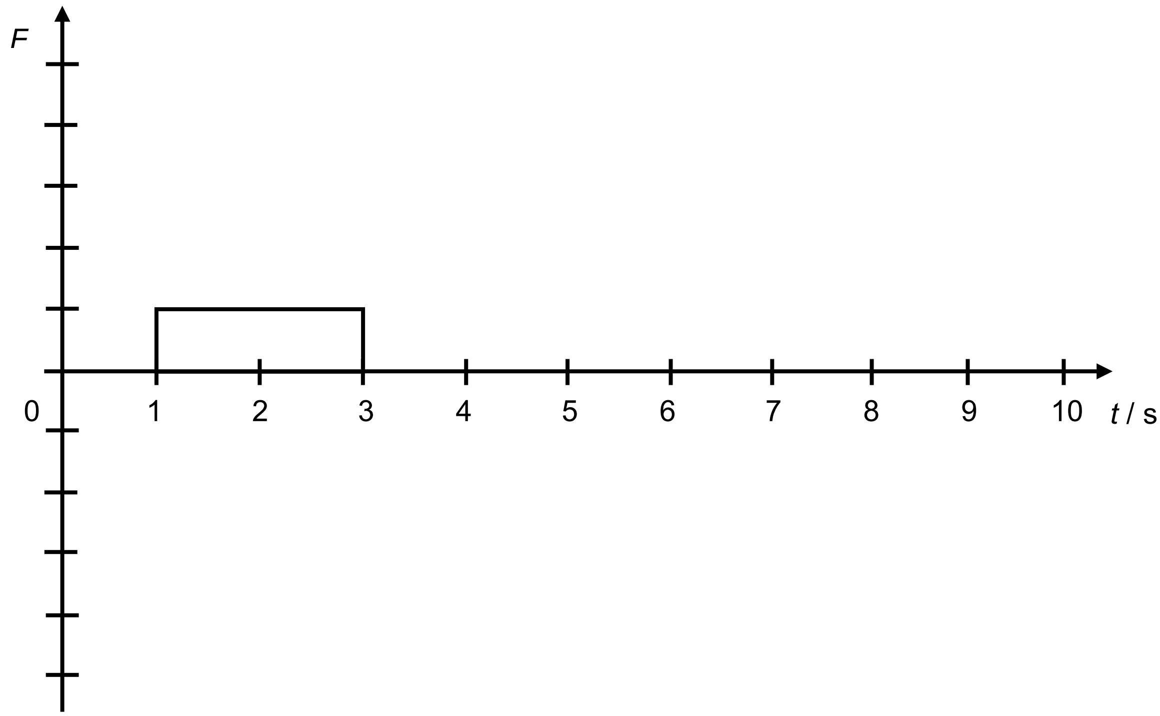

Fig. 8.3

[2]

[Total: 20]