5 Two long straight vertical wires X and Y pass through a horizontal card, as shown in Fig. 5.1.

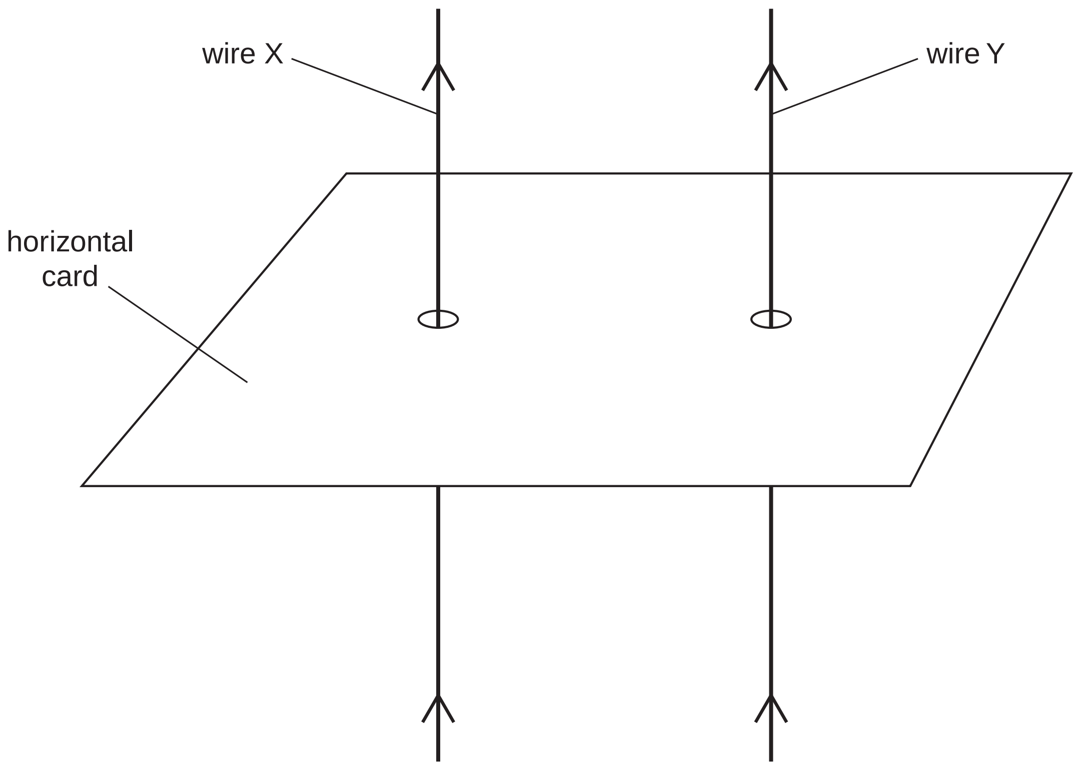

Fig. 5.1

The current in each wire is in the upward direction.

The top view of the card, seen by looking vertically downwards at the card, is shown in Fig. 5.2.

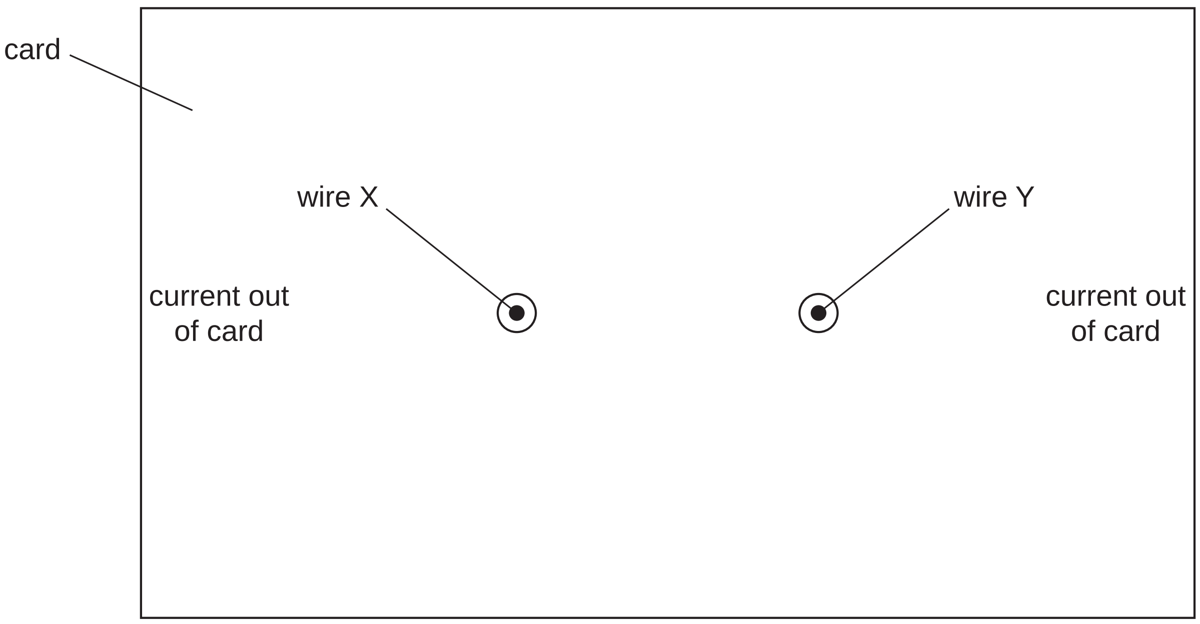

Fig. 5.2 (not to scale)

For Examiner's Use

(a) On Fig. 5.2,

(i) draw four field lines to represent the pattern of the magnetic field around wire X due solely to the current in wire X, [2]

(ii) draw an arrow to show the direction of the force on wire Y due to the magnetic field of wire X. [1]

(b) The magnetic flux density B at a distance x from a long straight wire due to a current I in the wire is given by the expression

$$B = \frac{\mu_0 I}{2\pi x},$$

where μ_0 is the permeability of free space.

The current in wire X is 5.0 A and that in wire Y is 7.0 A. The separation of the wires is 2.5 cm.

(i) Calculate the force per unit length on wire Y due to the current in wire X.

force per unit length = ... $N\,m^{-1}$ [4]

(ii) The currents in the wires are not equal.

State and explain whether the forces on the two wires are equal in magnitude.

....

....

.... [2]