Oxford Cambridge and RSA

A Level Physics A

H556/03 Unified physics

Question Set 2

1 A small thin rectangular slice of semiconducting material has width *a* and thickness *b* and carries a current *I*. The current is due to the movement of electrons. Each electron has charge – *e* and mean drift velocity *v*. A uniform magnetic field of flux density *B* is perpendicular to the direction of the current and the top face of the slice as shown in Fig. 2.1.

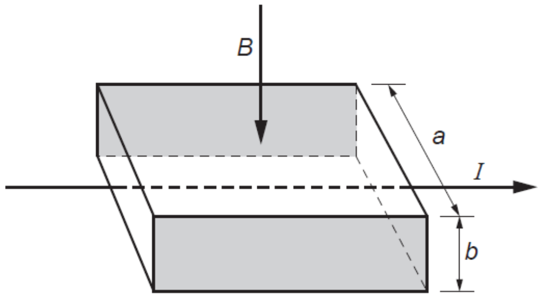

Fig. 2.1

(a) As soon as the current is switched on, the moving electrons in the current are forced towards the shaded rear face of the slice where they are stored. This causes the shaded faces to act like charged parallel plates. Each electron in the current now experiences both electric and magnetic forces. The resultant force on each electron is now zero.

Write the expressions for the electric and magnetic forces acting on each electron and use these to show that the magnitude of the potential difference *V* between the shaded faces is given by

$$V = Bva.$$

[3]

(b) Here are some data for the slice in a particular experiment.

number of conducting electrons per cubic metre, $n = 1.2 \times 10^{23}\ \text{m}^{-3}$
$a = 5.0$ mm
$b = 0.20$ mm
$I = 60$ mA
$B = 0.080$ T

Use this data to calculate

(i) the mean drift velocity v of electrons within the semiconductor

$v =$ .... m s^{-1} **[3]**

(ii) the potential difference V between the shaded faces of the slice.

$V =$ .... V **[1]**

(c) The slice is mounted and used as a measuring instrument called a Hall probe. A cell is connected to provide the current in the slice. The potential difference across the slice is measured by a separate voltmeter.

A student wants to measure the magnetic flux density between the poles of two magnets mounted on a steel yoke as shown in Fig. 2.2. The magnitude of the flux density is between 0.02 T and 0.04 T.

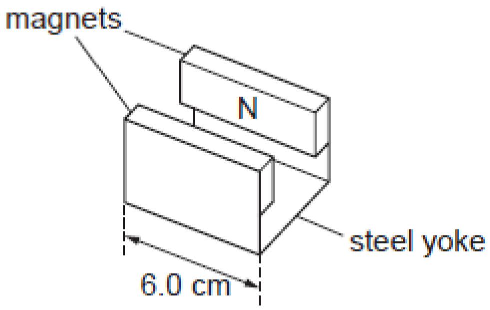

Fig. 2.2

(i) Suggest **one** reason why this Hall probe is **not** a suitable instrument to measure the magnetic flux density for the arrangement shown in Fig. 2.2.

[1]

(ii) Another method of measuring the magnetic flux density for the arrangement shown in Fig. 2.2 is to insert a current-carrying wire between the poles of the magnet.
Explain how the magnetic flux density can be determined using this method and discuss which measurement in the experiment leads to the greatest uncertainty in the value for the magnetic flux density.

[4]

Total Marks for Question Set 2: 12