Magnetic Fields - 1

Exercise A

1 The table below relates the force on a current-carrying wire which is at right angles to the lines of force of a magnetic field and the current. Complete the table below by working out the missing data in each column.

▼ Table 1

	(a)	(b)	(c)	(d)
B/T	0.20 T vertically down	0.20 T vertically down	?	0.1 T horizontal due?
I/A	3.0 A horizontal due north	?	3.0 A horizontal due north	2.0 A vertically up
l/m	0.040 m	0.040 m	0.040 m	0.040 m
F/N	?	0.036 N horizontal due south	0.024 N horizontal due west	? horizontal due east

2 a A straight vertical wire of length 0.10 m carries a downward current of 4.0 A in a uniform horizontal magnetic field of flux density 55 mT that acts due north. Determine the magnitude and direction of the force on the wire.

b A straight horizontal wire of length 50 mm carrying a constant current is in a uniform magnetic field of flux density 140 mT which acts vertically downwards. The wire experiences a force of 28 mN in a direction which is due north. Determine the magnitude and the direction of the current in the wire.

3 A rectangular coil of width 60 mm and of length 80 mm has 50 turns. The coil was placed horizontally in a uniform horizontal magnetic field of flux density 85 mT with its shorter side parallel to the field lines. A current of 8.0 A was passed through the coil. Sketch the arrangement and determine the force on each side of the coil.

4 The Earth's magnetic field at a certain position on the Earth's surface has a horizontal component of 18 μT due north and a downwards vertical component of 55 μT. Calculate:

a the magnitude of the Earth's magnetic field at this position,

b the magnitude and direction of the force on a vertical wire of length 0.80 m carrying a current of 4.5 A downwards.

Exercise B

$e = 1.6 \times 10^{-19}$ C

1 **a** In Figure 1, how would the force on the electrons in the magnetic field differ if:

i the magnetic field was reversed in direction,

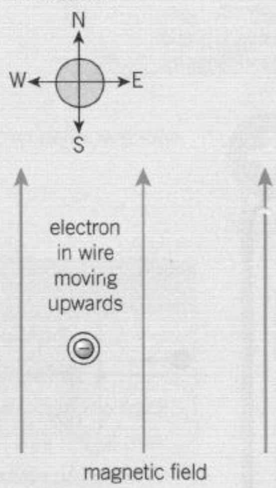
ii the magnetic field was reduced in strength,

iii the speed of the electrons was increased.

b Calculate the force on an electron that enters a uniform magnetic field of flux density 150 mT at a velocity of 8.0×10^{6} m s^{-1} at an angle of

i 90°, **ii** 0° to the field.

2 Electrons in a vertical wire move upwards at a speed of 2.5×10^{-3} m s^{-1} into a uniform horizontal magnetic field of magnetic flux density 95 mT. The field is directed along a line from south to north as shown in Figure 6. Calculate the force on each electron and determine its direction.



▲ **Figure 6**

3 A beam of protons and π^{+} mesons moving at the same speed is directed into a uniform magnetic field in the same direction as the field.

a Explain why the beam is not deflected by the field.

b If the particles had been directed into the field in a direction at right angles to the field lines at the same speed, state and explain what effect this would have had on the beam.

4 In a Hall probe, electrons passing through the semiconductor experience a force due to a magnetic field.

a Explain why a potential difference is created across the semiconductor as a result of the application of the magnetic field.

b When the magnetic flux density was 90 mT, each electron moving through the slice experiences a force of 6.4×10^{-20} N due to the magnetic field. Calculate:

i the mean speed of the electrons passing through the slice,

ii the magnetic force on each electron if the magnetic flux density is increased to 120 mT.

Exercise C

$e = 1.6 \times 10^{-19}$ C, $\frac{e}{m}$ for the electron $= 1.76 \times 10^{11}$ C kg^{-1}

1 A beam of electrons at a speed of 3.2×10^7 m s^{-1} is directed into a uniform magnetic field of flux density 8.5 mT in a direction perpendicular to the field lines. The electrons move on a circular orbit in the field.

a i Explain why the electrons move on a circular orbit.

ii Calculate the radius of the orbit.

b The flux density is adjusted until the radius of orbit is 65 mm. Calculate the flux density for this new radius.

2 A narrow beam of electrons was directed at a speed of 2.9×10^7 m s^{-1} into a uniform magnetic field.

a The beam followed a circular path of radius 35 mm in the magnetic field. Calculate the flux density of the magnetic field.

b The speed of the electrons in the beam was halved by reducing the anode voltage. Calculate the new radius of curvature of the beam in the field.

3 The first cyclotron, used to accelerate protons, was 0.28 m in diameter and was in a magnetic field of flux density 1.1 T.

a Show that protons emerged from this cyclotron at a maximum speed of 1.5×10^7 m s^{-1}.

b Calculate the maximum kinetic energy, in MeV, of a proton from this accelerator.

The mass of a proton $= 1.67 \times 10^{-27}$ kg,
1 MeV $= 1.6 \times 10^{-13}$ J

4 In a mass spectrometer, a beam of ions at a speed of 7.6×10^4 m s^{-1} was directed into a uniform magnetic field of flux density 680 mT.

a An ion was deflected in a semi-circular path of diameter 28 mm on to the detector. Calculate the specific charge of the ion.

b A different type of ion was deflected onto the same detector when the magnetic flux density was changed to 400 mT. Calculate the specific charge of this ion.