Unit 16 · Magnetic Fields

HARDER PRACTICE QUESTIONS

Full marks 34

Write your answers on separate paper. Show your working. Take $\mu_0 = 4\pi \times 10^{-7}$ H/m, e = 1.6×10^{-19} C and the mass of a proton 1.67×10^{-27} kg.

1 Spot the error [3]

Find the mistake in the working and correct it.

A coil of 100 turns, each of area 100 cm^2, lies with its plane at 20° to a uniform field of 0.2 T. Shristi wrote:
"$N\varphi = NBA\cos\theta = 100 \times 0.2 \times 0.01 \times \cos 20° = 0.19$ Wb."

2 A real setting [4]

Kapil puts a compass on a bench in Kathmandu, where the horizontal part of the Earth's field is about 35 μT, and lays a long straight wire north–south 2.0 cm above it.

i. What current in the wire makes a field at the compass equal to the Earth's horizontal field?
ii. With that current, through what angle does the needle turn? Why?
iii. Which way would it turn if the current were reversed?

3 Show that [3]

A charge q of mass m moves at right angles to a uniform field B. Show that the time it takes to go once round its circle does not depend on its speed, and find the frequency of its motion.

4 Compare [4]

A Hall probe is a slice of semiconductor 0.20 mm thick with 2.0×10^{22} free electrons per m^3. With a current of 20 mA through it, held with its face at right angles to a field, it gives a Hall voltage of 6.0 mV.

i. Find the field.
ii. Find the Hall voltage a copper slice of the same thickness, with 10^{29} free electrons per m^3, would give with the same current in the same field.
iii. Why are Hall probes made of semiconductors?

5 Predict, then explain [3]

Write your prediction first, then explain it.

Two long parallel wires 10 cm apart carry 6 A and 4 A in opposite directions. Predict whether they attract or repel, and whether the 6 A wire feels a larger force than the 4 A wire. Then find the force on 1 m of each.

6 Add the fields [4]

For the two wires of question 5 (6 A and 4 A in opposite directions, 10 cm apart):

i. Find the magnetic field halfway between them.
ii. Show that there is a point where the field is zero, 20 cm beyond the 4 A wire on the line joining them.

7 Work backwards [3]

A proton moves in a uniform field of 0.10 T along a helix of radius 2.0 cm whose pitch (the distance it goes along the field in one round) is 10 cm. Find the angle between its velocity and the field, and its speed.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Ujwal wrote: “A strong enough magnetic field can speed up a slow electron. The field inside a long solenoid is strongest near its ends. Magnetic lines of force start at the north pole and end at the south pole.”

9 Design it [3]

Anisha needs a field of 10 mT inside a solenoid 40 cm long, using a current of 2.0 A. How many turns must she wind? Suggest two other ways she could get the same field with fewer turns.

10 Think [2]

A long straight wire carries a steady current. An electron moves parallel to the wire, in the same direction as the current. Will it be pushed towards the wire or away from it? Explain.

11 Make your own [2]

Write a problem about a circular coil whose answer is “the field at its center is 1.0 mT”. Solve it to show it works.