A Level H2 Physics Tutorial 16: Electromagnetism

Syllabus :

(a) show an understanding that a magnetic field is an example of a field of force produced either by current carrying conductors or by permanent magnets

(b) sketch flux patterns due to currents in a long straight wire, a flat circular coil and a long solenoid

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1. Sketch magnetic flux patterns due to current in :

   (a) a long straight wire,

   (b) a flat circular wire, and

   (c) a long solenoid.

(c) use $B = \mu_0 I / 2\pi d$, $B = \mu_0 N I / 2r$ and $B = \mu_0 n I$ for the flux densities* of the fields due to currents in a long straight wire, a flat circular coil and a long solenoid respectively.

* Magnetic flux density B is a measure of how strong the magnetic field is at a point. The definition will be given later.

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2. Find the magnetic flux density :

(i) at 10 cm from a long straight wire with 1 A current,

(ii) at the centre of a flat circular coil with 0.5 A and radius 5 cm, and

(iii) at the centre of a long solenoid with current 0.1 A and 10 turns per cm.

(d) show an understanding that the magnetic field due to a solenoid may be influenced by the presence of a ferrous core

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(e) show an understanding that a current-carrying conductor placed in a magnetic field might experience a force

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(f) recall and solve problems using the equation $F = BIl \sin \theta$, with directions as interpreted by Fleming's left hand rule

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3.

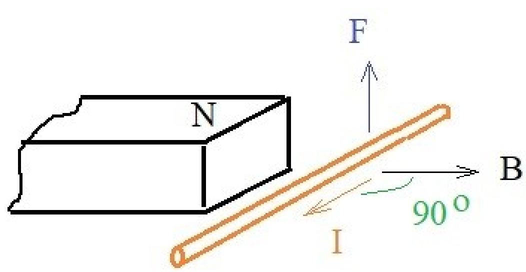

Figure 16-1

(i) The magnetic field strength B at the wire in the above figures is 0.01 T. A current I of 0.1 A flows in the wire in the direction shown. Calculate the resulting upward force F. I is perpendicular to the B.

(ii) The direction of the force can be determined using Fleming's left hand rule. State which finger I, which one is B, and which one F.

(g) define magnetic flux density

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4. Define magnetic flux density.

(h) show an understanding of how the force on a current-carrying conductor can be used to measure the flux density of a magnetic field using a current balance

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5. A straight wire 10 cm long is taped to a weighing scale. A uniform magnetic field is placed over the 10 cm length of the wire. When a current of 0.1 A is switched on through the wire, the reading on the weighing scale changes by 0.010 kg. Find the magnetic flux density.

(i) explain the forces between current-carrying conductors and predict the direction of the forces

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6. The figure here shows the magnetic field between currents in two parallel wires.

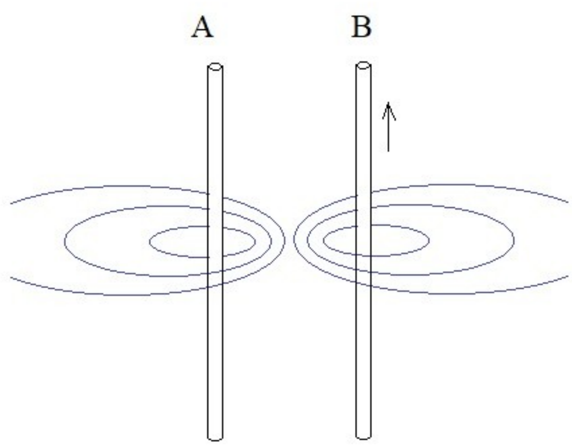

Figure 16-2

(a) State the formula for magnetic flux density around a long straight wire.

(b) State whether the two wires above attract or repel each other, and state the direction of the electric current in wire A.

(c) Write down the formulae for

(i) magnetic flux density around a long straight wire, and
(ii) force on a current in a straight wire perpendicular to a uniform magnetic field.

(d) Derive an expression for the force between currents in two parallel wires with currents I_1 and I_2, at distance r apart.

(j) predict the direction of the force on a charge moving in a magnetic field

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7. A positive ion of charge q with velocity v travels through a magnetic field as shown.

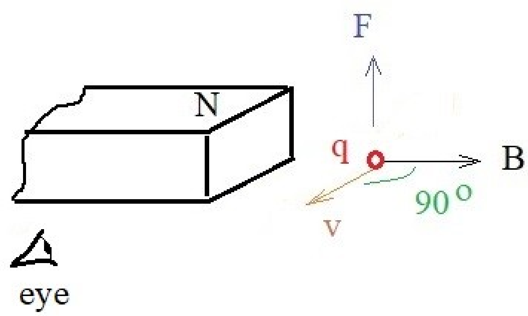

Figure 16-3

Another view from roughly the direction of the eye above is shown below.

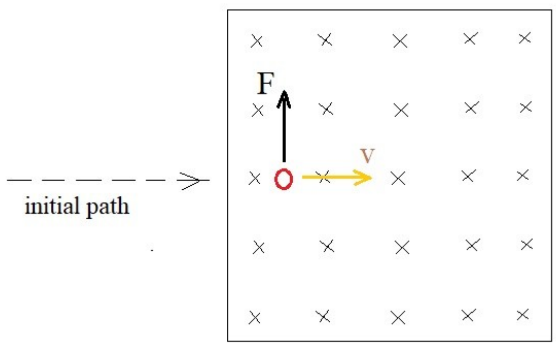

Figure 16-4

Using Fleming's right hand rule, predict the shape and direction of motion in the field.

(k) recall and solve problems using the equation $F = BQv \sin \theta$

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8. A proton of speed 1×10^7 m/s travels through a uniform magnetic field B of 0.1 T. The magnetic field direction is into the page.

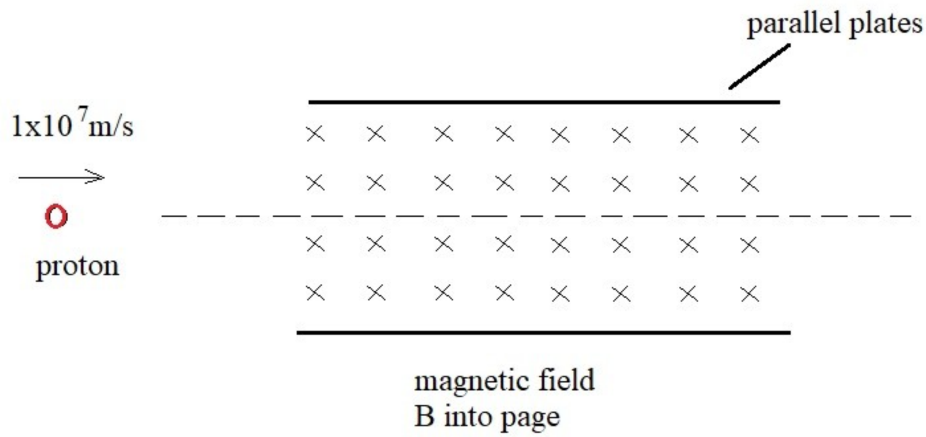

Figure 16-5

A proton of speed 1×10^6 m/s travels through a uniform magnetic field of $B = 0.1$ T. Direction of B is into the page.

(i) Find the force from the magnetic field on the proton, and the direction of the force. Find the radius of the path of the proton,

(ii) A voltage applied across the parallel plates makes the proton go straight. Distance between the plates is 10 cm. Find the voltage across the plate.

(l) describe and analyse deflections of beams of charged particles by uniform electric and uniform magnetic fields

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9. State and explain the shapes of the paths of a charged particle travelling through :

(a) (i) a uniform magnetic field parallel to the initial particle path,
(ii) a uniform magnetic field perpendicular to the initial particle path,

(b) (i) a uniform electric field parallel to the initial particle path,
(ii) a uniform electric field perpendicular to the initial particle path.

(m) explain how electric and magnetic fields can be used in velocity selection for charged particles.

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10. An electron with speed v of 1 x 10^7 m/s goes through a small hole in to a region with magnetic field B and electric field E as shown.

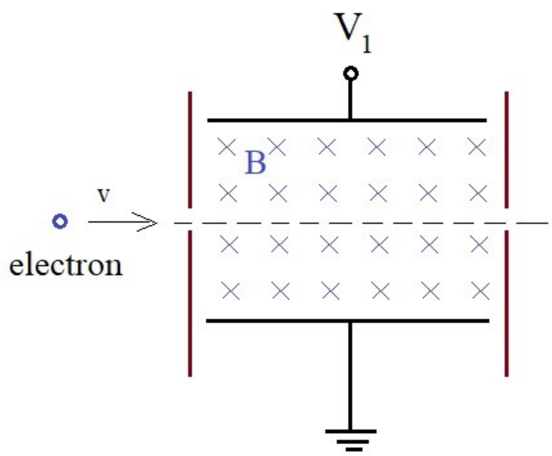

Figure 16-6

B is 0.1 T, in a horizontal direction at 90° to v. E is in a vertical direction, perpendicular to both v and B. E is provided by two parallel metal plates with a voltage of V_1 across them.

The plates are 0.1 m apart. The electron enters through a small hole on the plate on the hand side.

(i) Calculate the force on the electron from the magnetic field when the electron is in between the plates.

(ii) The voltage is adjusted until the electron can come out through the small hole on the right. Calculate the electric field strength.

(iii) Derive an expression relating v to E and B.

(iv) Suggest a possible use of this setup.

Updated 24 Feb 2025