A2 Level Physics

Chapter 7 – Electric and Magnetic Fields

7.3.2 Magnetic Fields

Worked Examples

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Exam Style Question 1

Fig. 5.1 shows a rigid, straight metal rod XY placed perpendicular to a magnetic field. The magnetic field is produced by two magnets that are placed on a U-shaped steel core. The steel core sits on a digital balance.
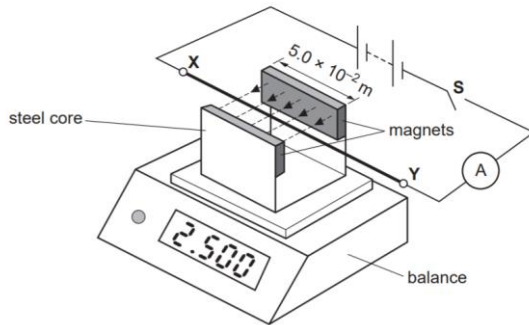

Fig. 5.1

The weight of the steel core and the magnets is $2.500\ N$. The rod is clamped at points X and Y. The rod is connected to a battery, switch and ammeter as shown in Fig. 5.1. The direction of the magnetic field is perpendicular to the rod

Switch S is closed.

(a) State the direction of the force that now acts on the rod due to the magnetic field.

(b) State how you determined the direction of the force

(c) The length of the rod in the magnetic field is $5.0 \times 10^{-2}\ m$ and the current in the rod is $4.0\ A$. Assume that the magnets provide a uniform magnetic field of magnetic flux density $0.080T$.

(i)   Calculate the force acting on the rod due to the magnetic field.

(ii) State and explain the new reading on the balance.

(a) State the direction of the force that now acts on the rod due to the magnetic field.
Downwards

(b) State how you determined the direction of the force.
Fleming's left-hand rule

(c) (i) Calculate the force acting on the rod due to the magnetic field.
Use $F = BIL$
$$F = (0.080\ T)(4.0\ A)(5.0 \times 10^{-2}\ m)$$
$$F = 0.016\ N$$

(ii) State and explain the new reading on the balance.
$$reading = 2.500 - 0.016$$
$$reading = 2.484\ N$$

The rod applies a downwards force of 0.016 N on the steel core. According to Newtons 3rd law the forces on the rod and magnets are equal and opposite. So the steel core has two forces acting on it. It has a downwards force of $2.500\ N$ and an upwards force of $0.016\ N$. Therefore the resultant force or the reading on the balance would be $2.500\ N - 0.016\ N = 2.484N$.
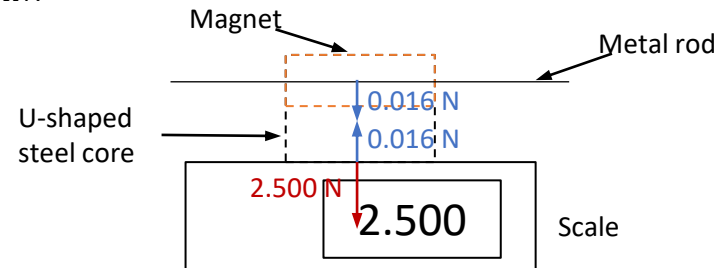
Exam Style Question 2

A U-shaped permanent magnet of mass 85.0 g rests on an electronic balance as shown in the diagram. An aluminium rod connected in a circuit is supported between the opposite poles of the magnet so that it is unable to move.

Clamp

Magnet

Aluminium rod

Electronic balance
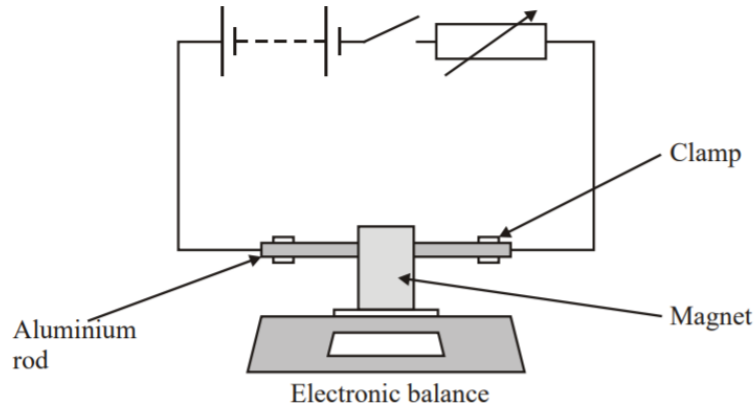
The switch is closed. The reading on the balance increases to 85.4 g.

(a) (i) Calculate the additional force on the magnet when there is current in the circuit.

(ii) Explain how this additional force originates. You may be awarded a mark for the clarity of your answer.

(iii) The rod is 20.0 cm long and the magnet is 5.0 cm wide. The magnetic flux density of the magnet is 30.0 mT. Calculate the current in the rod.

(iiii) The direction of the current is reversed. What would be the new reading on the balance?

(a)(i) Calculate the additional force on the magnet when there is current in the circuit.
We know the magnet is 85.0 g and when the switch is closed the reading on the balance is 85.4 g. Therefore the additional mass is 0.4g so the additional force is:
$$0.4 \times 10^{-3} \ kg \times 9.81 \ N \ kg^{-1} = 3.9 \times 10^{-3} \ N$$

(ii) Explain how this additional force originates.
The current running through the rod produces a magnetic field around the rod.
A resultant magnetic field is created when the field around the wire interacts with the field between the poles of the U-shaped permanent magnet, causing a force on the wire.
If the wire is free to move, it will experience this force in an upward direction, which can be determined using Fleming's left hand rule.
(Additionally, it's important to note that if the force on the rod is downward, the reading on the balance will decrease, while it will increase if the force is upward. In this particular case, the increase in the reading to 85.4 g indicates that the rod is experiencing an upward force.)

(iii) Calculate the current in the rod.
Use $F = BIL$ and rearrange for I
$$I = \frac{F}{BL} = \frac{(3.9 \times 10^{-3} \ N)}{(30 \times 10^{-3} \ T)(5 \times 10^{-2} \ m)}$$
$$I = 2.6 \ A$$

(iiii) The direction of the current is reversed. What would be the new reading on the balance?
If the current is reversed that means the rod experiences a downwards force. We already know the additional mass is 0.4 g therefore the reading on the balance is:
$$mass \ of magnet - additional \ mass = balance \ reading$$
$$85.0g - 0.4g = 84.6 \ g$$

Please see **'7.3.1 Magnetic Fields notes'** pack for revision notes.

For more revision notes, tutorials and worked examples please visit **www.tutorpacks.co.uk**.