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PHYSICS & CHEMISTRY

Physics

HSC Course

Module 2
Motors and Generators

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PHYSICS & CHEMISTRY

SCIENCE Years 7 – 10

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Foundation

1. State the motor effect.
   When a current-carrying conductor is placed in a magnetic field, it experiences a force.

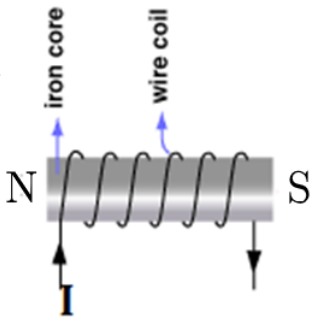
2. (a) State the right hand grip rule.
   Using your right hand, when your thumb points towards the direction of the current, your fingers will curl in the direction of the magnetic field.

   (b) What is this rule used for?
   To determine the direction of the magnetic field created by a current carrying wire.

3. (a) State the right hand coil rule.
   Using your right hand, when your fingers coil in the same direction as the current, your thumb will point to the north polarity.

   (b) What is this rule used for?
   To determine the polarity of a coil or solenoid.

4. Determine the polarity (north and south poles) of the following electromagnet.



5. (a) State the right hand palm rule.
   Using your right hand, when your thumb points in the direction of the current and your fingers point in the direction of the external magnetic field, your palm will point towards the direction of the force.

   (b) What is this rule used for?
   To determine the direction of the magnetic force

Development

1. Calculate the magnetic field strength (or magnetic induction) at a distance of 3.0 m from a long straight wire carrying a current of 48 A. **1**

$$\begin{aligned} B &= \frac{kI}{d} \\ &= \frac{2.0 \times 10^{-7}\ \text{N A}^{-2} \times 48\ \text{A}}{3.0\ \text{m}} \\ &= 3.2 \times 10^{-6}\ \text{T} \end{aligned}$$

1 mark – Calculates the correct magnetic field strength

2. The magnetic field strength at a distance of 3.0×10^{-2} m from a long straight conductor is 6.0×10^{-5} T. What is the current flowing in the conductor? **1**

$$\begin{aligned} B &= \frac{kI}{d} \\ 6.0 \times 10^{-5}\ \text{T} &= \frac{2.0 \times 10^{-7}\ \text{N A}^{-2} \times I}{3.0 \times 10^{-2}\ \text{m}} \\ \implies I &= 9.0\ \text{A} \end{aligned}$$

1 mark – Calculates the correct current

3. (a) If a conductor of length 30 cm carries a current of 45 mA, calculate the magnitude of the force acting on it when it is placed at 45° to a magnetic field of strength 0.8 T. **2**

$$\begin{aligned} L &= 30\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} \\ &= 0.30\ \text{m} \\ I &= 45\ \text{mA} \times \frac{1\ \text{A}}{1000\ \text{mA}} \\ &= 45 \times 10^{-3}\ \text{A} \end{aligned}$$

$$\begin{aligned} F &= BIL\sin\theta \\ &= 0.8\ \text{T} \times 45 \times 10^{-3}\ \text{A} \times 0.30\ \text{m} \times \sin(45) \\ &= 0.00764\ \text{N} \end{aligned}$$

2 marks – Calculates the correct force, ensuring all the units have been converted appropriately

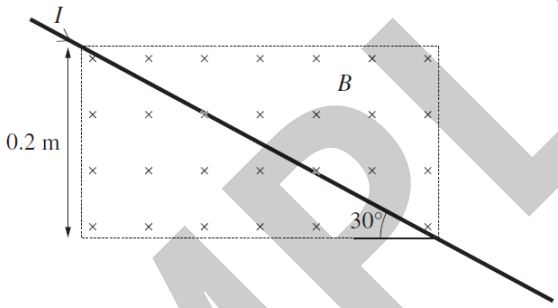
(b) A 10 cm length of wire experiences a force of 0.04 N when at right angles to a magnetic field of 3.0×10^{-2} T. Calculate the current flowing through this wire. **1**

$$L = 10 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}}$$
$$= 0.10 \text{ m}$$

$$F = BIL\sin\theta$$
$$0.04 \text{ N} = 3.0 \times 10^{-2} \text{ T} \times I \times 0.1 \text{ m} \times \sin(90)$$
$$I = 13.3 \text{ A}$$

1 mark – Calculates the correct current

4. (a) A current-carrying wire passes through a region of uniform magnetic field with a magnitude 0.1 T, and as a result experiences a force of magnitude 0.05 N. Calculate the current. **1**

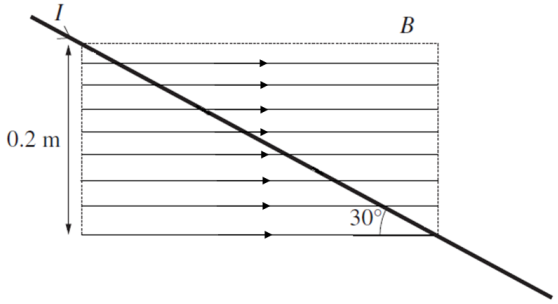


$$L = \frac{0.2 \text{ m}}{\sin(30)} = 0.4 \text{ m}$$

$$F = BIL\sin\theta$$
$$0.05 \text{ N} = 0.1 \text{ T} \times I \times 0.4 \text{ m} \times \sin(90)$$
$$I = 1.25 \text{ A}$$

1 mark – Calculates the correct current

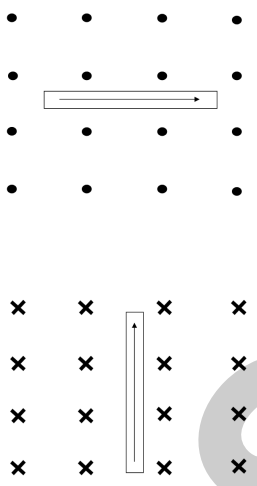
(b) The same current-carrying wire is placed in a different uniform magnetic field with magnitude 0.1 T, and as a result experiences a force of 0.05 N. Calculate the current. **1**

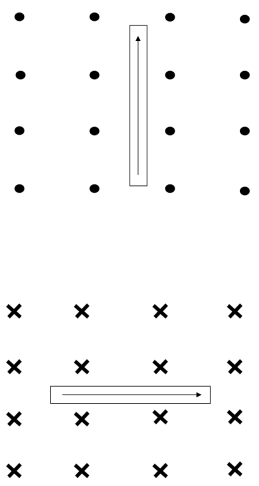


$$F = BIL\sin\theta$$
$$0.05 \text{ N} = 0.1 \text{ T} \times I \times 0.4 \text{ m} \times \sin(30)$$
$$I = 2.5 \text{ A}$$

1 mark – Calculates the correct current

5. Using the right-hand palm rule, determine the direction of the force acting on the current-carrying wire placed in a magnetic field in each of the following diagrams. **4**

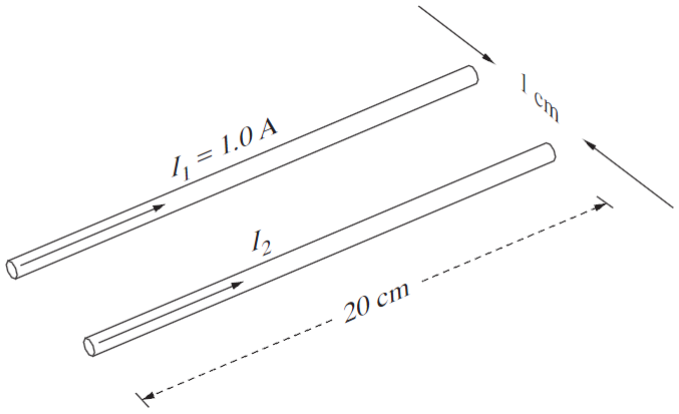




Top left: F ↓ Top right: F → Bottom left: F ← Bottom right: F ↑

4 marks – Identifies the correct direction of the force in each case (1 mark each)

6. (a) Calculate the force between the two parallel conductors below, given that $I_1 = 1.0$ A and $I_2 = 2$ A. **2**

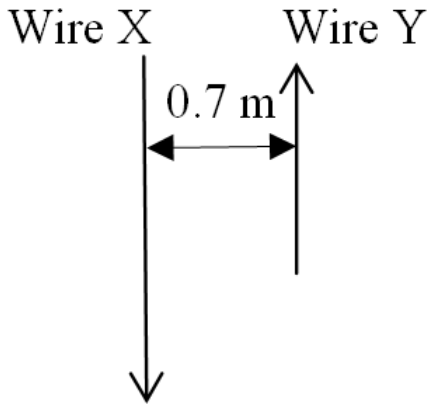


$$L = 20 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}}$$
$$= 0.20 \text{ m}$$
$$d = 1 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}}$$
$$= 0.01 \text{ m}$$

$$F = \frac{kI_1I_2L}{d}$$
$$= \frac{2.0 \times 10^{-7} \text{ N A}^{-2} \times 1.0 \text{ A} \times 2 \text{ A} \times 0.20 \text{ m}}{0.01 \text{ m}}$$
$$= 8 \times 10^{-6} \text{ N attractive}$$

2 marks – Calculates the magnitude of the force and indicates the direction (1 mark each)

(b) Two parallel wires are separated by a distance of 0.7 m. Wire X carries a current of 2 A and is considered infinitely long. Wire Y carries a current of 10 A and is 3 m long. The direction of the current in each wire is shown below. **2**

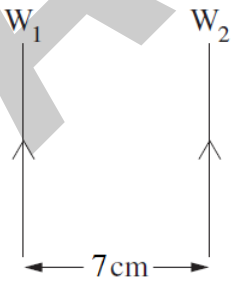


Calculate the magnitude and direction of the force that exists between the two wires.

$$\begin{aligned} F &= \frac{kI_1I_2L}{d} \\ &= \frac{2.0 \times 10^{-7}\ \text{N A}^{-2} \times 2\ \text{A} \times 10\ \text{A} \times 3\ \text{m}}{0.7\ \text{m}} \\ &= 1.7 \times 10^{-5}\ \text{N repulsive} \end{aligned}$$

2 marks – Calculates the correct magnitude of the force and indicates the direction (1 mark each)

7. Two identical wires, W_1 and W_2, each 3 m in length, are orientated as shown. They carry identical currents in the direction indicated.



NOT TO SCALE

(a) Identify the direction of the force W_2 experiences as a result of the current in W_1. **1**

Towards the left

1 mark – Identifies the correct direction

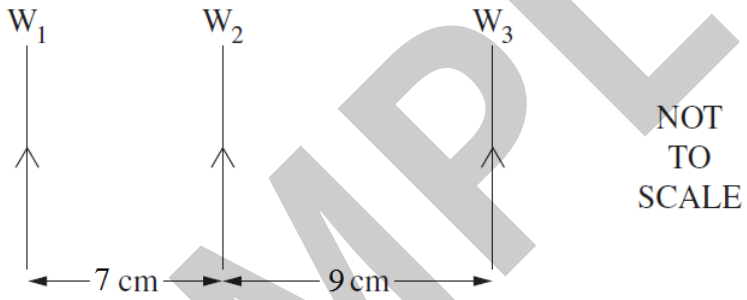
(b) Calculate the current in each wire, given that the wires experience a force of 5.0×10^{-4} N. **2**

$$
\begin{aligned}
d &= 7 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \\
&= 0.07 \text{ m} \\
I_1 &= I_2 = I
\end{aligned}
$$

$$
\begin{aligned}
F &= \frac{kI_1I_2L}{d} \\
5.0 \times 10^{-4} \text{ N} &= \frac{2.0 \times 10^{-7} \text{ N A}^{-2} \times I^2 \times 3 \text{ m}}{0.07 \text{ m}} \\
I &= 7.64 \text{ A}
\end{aligned}
$$

2 marks – Calculates the correct current with working out

(c) A third wire, W_3, carries a current of 3 A. Calculate the net force on W_2 due to W_1 and W_3. **3**



$$F_{W_1/W_2} = 5.0 \times 10^{-4} \text{ N left}$$

$$
\begin{aligned}
d &= 9 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \\
&= 0.09 \text{ m}
\end{aligned}
$$

$$
\begin{aligned}
F &= \frac{kI_1I_2L}{d} \\
F_{W_3/W_2} &= \frac{2.0 \times 10^{-7} \text{ N A}^{-2} \times 7.64 \text{ A} \times 3 \text{ A} \times 3 \text{ m}}{0.09 \text{ m}} \\
&= 1.53 \times 10^{-4} \text{ N right} \\
F_{\text{net}} &= (5.0 \times 10^{-4} - 1.53 \times 10^{-4}) \text{ left} \\
&= 3.47 \times 10^{-4} \text{ N left}
\end{aligned}
$$

2 marks – Calculates the correct magnitude of the force that W_3 applies on W_2 and indicates the direction (1 mark each)

1 mark – Calculates the correct net force