B14 · Extra practice, worked solutions

The motor effect | Diploma-style set of 8

Easy · B14-X01. A straight wire 0.120 m long carries 3.5 A at right angles to a magnetic field of 0.400 T. Find the size of the magnetic force on the wire, in newtons.

1. Givens: I = 3.5 A; L = 0.120 m; B = 0.400 T; angle 90°. Question: F.

2. F = ILB.

3. F = (3.5)(0.120)(0.400) = 0.168 N.

4. Answer: 0.168 N

Easy · B14-X02. A charge of 24.0 C passes through a wire in 8.0 s. Find the current in amperes.

1. Givens: q = 24.0 C; t = 8.0 s. Question: I.

2. I = q ÷ t.

3. I = 24.0 ÷ 8.0 = 3.00 A.

4. Answer: 3.00 A

Easy · B14-X03. Two long parallel wires carry currents in the same direction. What do the wires do?

A. They repel each other.
B. They do not affect each other.
C. They attract only if the currents are different sizes.
D. They attract each other.

1. Givens: two parallel wires, currents in the same direction. Question: attract or repel.

2. Each wire makes a field at the other. The right-hand rules give a force on each wire toward the other wire.

3. Currents in the same direction attract. Currents in opposite directions repel.

4. Answer: D. They attract each other.

Medium · B14-X04. A wire 0.150 m long carries 2.5 A at right angles to a magnetic field. The magnetic force on it is 0.0450 N. Find the size of the field, in tesla.

1. Givens: L = 0.150 m; I = 2.5 A; F = 0.0450 N; angle 90°. Question: B.

2. F = ILB, so B = F ÷ (IL).

3. B = 0.0450 ÷ ((2.5)(0.150)) = 0.120 T.

4. Answer: 0.120 T

Medium · B14-X05. A horizontal wire of mass 3.00×10^{-3} kg and length 0.100 m is held up by a magnetic force from a horizontal field of 0.200 T at right angles to the wire. Use g = 9.81 m/s². Find the current in amperes.

1. Givens: m = 3.00×10^{-3} kg; L = 0.100 m; B = 0.200 T; g = 9.81 m/s²; the wire is held still, so the net force is zero. Question: I.

2. The upward magnetic force balances the weight: ILB = mg.

3. I = mg ÷ (LB) = $(3.00 \times 10^{-3})(9.81) \div ((0.100)(0.200))$ = 1.47 A.

4. Answer: 1.47 A

Medium · B14-X06. A wire carries conventional current to the right across the page. The magnetic field points into the page. Which way is the magnetic force on the wire?

A. Up the page
B. Down the page
C. Into the page
D. To the left

1. Givens: current to the right; field into the page. Question: the force direction.

2. Right hand: fingers along the field (into the page), thumb along the current (right). The palm faces up the page.

3. The force is up the page.

4. Answer: A. Up the page

Challenging · B14-X07. A wire 0.300 m long is in a field at right angles to it. A graph of the force on the wire against the current is a straight line through (1.00 A, 0.15 N) and (4.00 A, 0.42 N). Find the size of the field, in tesla.

1. Givens: L = 0.300 m; points (1.00 A, 0.15 N) and (4.00 A, 0.42 N). Question: B.

2. Slope = (0.42 − 0.15) ÷ (4.00 − 1.00) = 0.0900 N/A.

3. F = (LB)I matches y = mx, so the slope = LB.

4. B = slope ÷ L = 0.0900 ÷ 0.300 = 0.300 T.

5. Answer: 0.300 T

Challenging · B14-X08. A graph of magnetic force on a wire against current is a straight line that does not pass through the origin: the force is 0.020 N when the current is zero. Give a reason for this and say what it means for the slope.

1. Givens: the force-current line has an intercept of 0.020 N. Question: why, and what it means for the slope.

2. With no current there is no magnetic force, so something else is acting on the wire. Likely reasons: the weight of the wire, or a spring or balance reading that was not zeroed.

3. The intercept does not change the slope. The slope is still LB, so you can still find B from it.