B15 · Extra practice, worked solutions

The generator effect and Lenz’s law | Diploma-style set of 8

Easy · B15-X01. A metal rod 0.500 m long moves at 4.0 m/s at right angles to a magnetic field of 0.300 T. Find the potential difference across its ends, in volts.

1. Givens: l = 0.500 m; v = 4.0 m/s; B = 0.300 T. Question: ΔV.

2. ΔV = Blv.

3. ΔV = (0.300)(0.500)(4.0) = 0.600 V.

4. Answer: 0.600 V

Easy · B15-X02. A rod 0.300 m long moves through a field of 0.150 T at right angles. The potential difference across it is 0.45 V. Find the speed of the rod, in m/s.

1. Givens: l = 0.300 m; B = 0.150 T; ΔV = 0.45 V. Question: v.

2. ΔV = Blv, so v = ΔV ÷ (Bl).

3. v = 0.45 ÷ ((0.150)(0.300)) = 10.0 m/s.

4. Answer: 10.0 m/s

Easy · B15-X03. The north pole of a bar magnet is pushed toward a coil that is part of a closed circuit. Which statement is correct?

A. The induced current makes a field that pulls the magnet in faster.

B. No current is induced, because the magnet is not touching the coil.

C. The current flows only after the magnet stops.

D. The induced current makes a field that opposes the motion, pushing the magnet away.

1. Givens: a magnet pushed toward a closed coil. Question: what the induced current does.

2. Lenz’s law: the induced current makes a force that opposes the motion that caused it.

3. So the coil pushes back on the magnet. This is why you have to do work to make electricity.

4. Answer: D. The induced current makes a field that opposes the motion, pushing the magnet away.

Medium · B15-X04. A rod 0.400 m long moves at right angles to a field of 0.500 T. At 3.0 m/s the potential difference across it is 0.600 V. Find the speed that gives a potential difference of 1.5 V.

1. Givens: l = 0.400 m; B = 0.500 T; target ΔV = 1.5 V. Question: v.

2. ΔV = Blv, so v = ΔV ÷ (Bl).

3. v = 1.5 ÷ ((0.500)(0.400)) = 7.50 m/s.

4. Check: 1.5 V is 2.50 times 0.600 V, and the speed is 2.50 times 3.0 m/s.

5. Answer: 7.50 m/s

Medium · B15-X05. A rod moves to the right through a magnetic field that points into the page. Which end of the rod becomes positive?

A. The bottom end
B. The top end
C. The right end, in front of the motion
D. Neither end; the rod stays neutral

1. Givens: v to the right; B into the page. Question: which end is positive.

2. Right hand for positive charge: fingers into the page (B), thumb to the right (v). The palm faces up the page.

3. The force on the positive charges is up the page, so they move to the top end, which becomes positive. The bottom end is negative.

4. Answer: B. The top end

Medium · B15-X06. A wire of length 1.20 m moves at 15 m/s at right angles to a field of 75 mT. Convert the field to tesla first. Find the potential difference across the wire, in volts.

1. Givens: l = 1.20 m; v = 15 m/s; B = 75 mT = 0.0750 T (1 mT = 0.001 T). Question: ΔV.

2. ΔV = Blv.

3. ΔV = (0.0750)(1.20)(15) = 1.35 V.

4. Answer: 1.35 V

Challenging · B15-X07. The north pole of a bar magnet is released above a closed copper ring and falls toward it. Which statement describes the force of the ring on the magnet?

A. It points downward, helping the fall.

B. It is zero, because copper is not magnetic.

C. It points sideways.

D. It points upward, opposing the fall.

1. Givens: a magnet falling toward a closed ring. Question: the force of the ring on the magnet.

2. The motion makes an induced current in the ring. Lenz’s law: the force on the magnet opposes the motion that caused the current.

3. The magnet is falling down, so the force on it is up. The magnet falls more slowly than it would without the ring.

4. Answer: D. It points upward, opposing the fall.

Challenging · B15-X08. A rod slides on two rails. Explain why a current flows only when the rails are joined by a circuit, and why pulling the rod gets harder when the circuit is closed.

1. Givens: a rod on rails, pulled through a field. Question: why a current needs a closed circuit, and why pulling gets harder.

2. The motion pushes charge to the ends of the rod, so there is a potential difference $\Delta V = Blv$. Charge can only flow around if there is a complete loop.

3. When there is a current, the rod is a current-carrying wire in the field, so it feels a magnetic force. By Lenz’s law that force opposes the motion.

4. So you must push harder, and do work, to keep the rod moving. That work becomes the electrical energy.