# B15 · The generator effect and Lenz’s law

Student notes - follow the slides, fill the blanks, work the questions

Explain how motion in a field separates charge, use ΔV = Blv, and apply Lenz’s law.

Name: _____ Date: _____

## Slide 1 of 8 · A moving rod separates charge

The generator effect runs the motor effect backward: _____.
Pulling a rod through a field pulls its _____ through the field too. Each feels a force.

Right hand: fingers along the _____, thumb along the rod’s _____ (in B14 the thumb pointed along the current). The palm shows the force on a _____ charge.
_____ it for electrons.

The electrons gather at one end, so that end is _____. The other end is _____.

Reverse the velocity or the field, and the polarity _____.

**Example.** A horizontal metal rod is pulled straight down the page through a magnetic field that points into the page. Which end of the rod, left or right, becomes positive?

Work:

Answer: _____

**Try it.** A vertical rod is pulled to the right through a magnetic field that points out of the page. Which end, top or bottom, becomes positive, and how does this compare with the field into the page?

Work:

Answer: _____

Sketch (draw and label the diagram):

## Slide 2 of 8 · How large is the potential difference?

ΔV is the potential difference between the _____ of the rod. ΔV = _____. B is the field (T), l is the rod length (m), v is the speed (m/s).

Faster rod, longer rod or stronger field: a _____ ΔV. 1 T × 1 m × 1 m/s = _____. Example: (0.250 T)(0.40 m)(3.0 m/s) = _____.

The equation is _____ on the data sheet. Write the rearranged form, such as v = _____, before the numbers.

For ratio questions, _____ the change factors. Never add them.

**Example.** A rod of length 0.60 m moves at right angles to a magnetic field of 0.150 T and to its own length. The potential difference between its ends is 0.90 V. What is the speed of the rod? (ΔV = Blv)

Work:

Answer: _____

**Try it.** A rod moving through a field produces a potential difference ΔV. A second rod has twice the length, moves at half the speed, and is in a field three times as strong. What is its potential difference? A. ΔV/3 B. ΔV C. 3ΔV D. 6ΔV

Work:

Answer: _____

## Slide 3 of 8 · Closing the circuit

The rod slides on two _____ (parallel metal bars) with a _____ (a part that uses electrical energy, like a lamp) joining the ends. The rod acts like a _____.

Conventional current leaves the _____ end, goes round the circuit and returns to the _____ end. Inside the rod it goes from negative to positive.

Find the ends first (right hand, then reverse). Then _____ the current: clockwise or counterclockwise.

Reverse the velocity or the field, and the current _____.

**Example.** A rod slides on two rails. A resistor joins the right-hand ends of the rails, and the magnetic field points into the page. When the rod is pulled to the right the top end is positive and the current is clockwise. Now the rod is pulled to the left. Does conventional current go clockwise or counterclockwise?

Work:

Answer: _____

**Try it.** Same rails and rod, but the field now points out of the page and the rod is pulled to the right. Does conventional current go clockwise or counterclockwise, and which end of the rod is positive?

Work:

Answer: _____

Sketch (draw and label the diagram):

## Slide 4 of 8 · A magnet and a coil

A coil can do it too. When a magnet and a coil move _____ to each other, the electrons in the coil feel a force. This is electromagnetic _____. Michael _____ discovered it in 1831.

Current flows only _____ they move. A magnet held still gives _____ current.

Reverse the motion or the pole, and the current _____.

Faster, a stronger magnet or more turns gives _____ current. Four times the turns gives about _____ the current.

**Example.** Pushing the south pole of a bar magnet into a coil at a steady speed deflects the meter needle to the right. Predict the needle for (a) pulling the same pole out at the same speed, (b) pushing the north pole in at the same speed, (c) pushing the south pole in twice as fast, and (d) holding the magnet still inside the coil.

Work:

Answer: _____

**Try it.** Pushing the south pole into a coil at a steady speed gives a deflection of 2 divisions to the right. Predict the needle if the same pole is pushed in at half the speed into a coil with four times as many turns.

Work:

Answer: _____

## Slide 5 of 8 · Motors and generators

A motor and a generator are the same device used both ways. Motor: electricity in, _____ out. Generator: motion in, _____ out.

Name the energy change: motion to _____, or the reverse.

A generator joined to a lamp is _____ to turn. Its current is in a field, so it feels a force that _____ the turning.

With nothing connected there is no _____, so no force. The extra _____ you do goes into the lamp’s energy.

**Example.** A hand-cranked generator is easy to turn when its wires are not connected to anything, and noticeably harder when it is connected to a lamp that lights. Explain why it is harder when connected, and where the extra energy goes.

Work:

Answer: _____

**Try it.** A small toy motor is spun by hand with its two wires joined to a lamp, and the lamp lights. Is the device acting as a motor or a generator? Name the energy change.

Work:

Answer: _____

## Slide 6 of 8 · Lenz’s law: the force opposes the motion

A moving magnet makes currents in a conductor. A current made by motion in a field, with no battery, is an _____ current. It feels a _____, and the force acts on the magnet.

Lenz’s law: the force from an induced current _____ the motion that caused it. A magnet falling feels a force _____.

Chain: motion → _____ → _____ → slower fall. No current means _____ force. A better conductor carries a _____ current.

The force always opposes the motion. It takes energy _____.

In air the magnet falls 0.30 m in _____. In the aluminium tube it takes _____.

**Example.** Three rods of the same size, one plastic, one aluminium and one copper, each have a ring magnet dropped over them from the same height. Copper conducts better than aluminium; plastic is an insulator. Order the rods from fastest fall to slowest and explain.

Work:

Answer: _____

**Try it.** A pendulum with a strong magnet at its end swings between two aluminium blocks and is moving to the right through its lowest point. What is the direction of the magnetic force on the magnet right now, what happens to the swing over time, and does this force’s direction change when it swings back to the left?

Work:

Answer: _____

## Slide 7 of 8 · Lenz’s law for a coil: which way the current goes

An induced current turns a coil into a _____. By Lenz’s law, that magnet _____ the motion that caused the current.

Step 1: which way is the magnet _____? Step 2: which pole opposes that? A magnet moving closer must be _____, so the near end is the _____ pole. A magnet moving away must be _____, so the near end is the _____ pole.

Step 3: the field inside a coil points toward its _____ end. Grip a wire on the _____ of the coil with the right hand, thumb along the conventional current. The fingers inside the coil show the field.

Thumb up puts the field inside to the _____. Thumb down puts it to the _____. Reverse the motion and the pole and the current both _____.

**Example.** A coil is joined to a meter in a closed circuit. The north pole of a bar magnet is pushed toward the right end of the coil. (a) Which pole does the right end of the coil become? (b) Which way does the conventional current go in the wires on the front of the coil, up or down? (c) The magnet is then pulled back out. What happens to the pole and to the current?

Work:

Answer: _____

**Try it.** NEW, for teacher review: The south pole of a bar magnet is pushed toward the left end of a coil in a closed circuit. Which pole does the left end of the coil become, and which way does the conventional current go in the wires on the front of the coil?

Work:

Answer: _____

Sketch (draw and label the diagram):

## Slide 8 of 8 · Method: how to find an induced voltage and its direction

Step 1: list v, B and l with units: _____, _____, _____. All at _____.

Step 2: ΔV = _____. Keep every digit. The unit is _____.

Step 3: right hand, then reverse for electrons. They gather at the _____ end. The other end is _____.

Step 4: current leaves the _____ end. Step 5: _____: the force on the rod _____ v. Reverse v or B, and every direction _____.

**Example.** A 0.40 m rod is pulled to the right at 3.0 m/s through a field of 0.250 T that points into the page. The rod is part of a closed circuit with a resistor on the right. Find the potential difference, the positive end, the direction of the current and the direction of the force on the rod.

Work:

Answer: _____

**Try it.** A 0.60 m rod is pulled to the left at 2.0 m/s through a field of 0.500 T that points into the page. The rod is part of a closed circuit with a resistor on the right. Find the potential difference, the positive end, the direction of the current and the direction of the force on the rod. Write each step number beside your work.

Work:

Answer: _____

# B15 · practice

The generator effect and Lenz’s law | Questions 1-2 of 8

Constants from the Alberta Physics 30 data sheets: $k = 8.99 \times 10^{9}\ N \cdot m^2/C^2$, $e = 1.60 \times 10^{-19}\ C$, electron mass $m_e = 9.11 \times 10^{-31}\ kg$, proton mass $mp = 1.67 \times 10^{-27}\ kg$, $g = 9.81\ m/s^2$.

Easy · B15-N01. What is the difference between the motor effect and the generator effect?

Work:

Final answer (with unit and sign): _____

Easy · B15-N02. A vertical rod is pulled to the right through a magnetic field that points into the page. Which end of the rod becomes positive?

A. The top end
B. The bottom end
C. The left end
D. Neither end

Work:

Final answer (with unit and sign): _____

# B15 · practice

The generator effect and Lenz’s law | Questions 3-4 of 8

Easy · B15-N03. A 0.80 m rod moves at 5.0 m/s at right angles to a field of 0.040 T and to its own length. Find the potential difference between its ends.

Work:

Final answer (with unit and sign): _____

Medium · B15-N04. A 0.50 m rod moves at 12 m/s at right angles to a 0.25 T field. What potential difference appears between its ends?

Work:

Final answer (with unit and sign): _____

# B15 · practice

The generator effect and Lenz’s law | Questions 5-6 of 8

Medium · B15-N05. A magnet is pushed into a coil and the meter shows a current. List three changes that would make the current larger.

Work:

Final answer (with unit and sign): _____

Medium · B15-N06. Why is a generator harder to turn when it is connected to a lamp?

A. The induced current gives a magnetic force that opposes the motion.
B. The lamp makes the magnet heavier.
C. The lamp removes the magnetic field.
D. The coil stops being a conductor.

Work:

Final answer (with unit and sign): _____

# B15 · practice

The generator effect and Lenz’s law | Questions 7-8 of 8

Challenging · B15-N07. A magnet is dropped from rest through 0.30 m in air. Find the free-fall time. Then compare it with 2–3 s for the same magnet inside a vertical aluminium tube. Use g = 9.81 m/s². Give the free-fall time in seconds.

Work:

Final answer (with unit and sign): _____

Challenging · B15-N08. A magnet is dropped through a plastic tube, an aluminium tube and a copper tube of the same size. Rank the fall times from shortest to longest and explain.

Work:

Final answer (with unit and sign): _____