UNIT: Measurement

“Field Forces” – Electromagnetic Arm Assist

OBJECTIVE:

Investigate how electric or magnetic fields interact with objects.

GOAL:

You will build a simple electromagnet, explore how well it can lift or move magnetic objects, and measure its electrical properties using a multimeter. Then, you’ll reflect on how electromagnets could help move parts in a robotic arm.

Materials:

* Iron nail (3–4 inches)
* Insulated copper wire (about 3 feet)
* AA battery (or 9V battery for stronger field)
* Electrical tape or alligator clips
* Paperclips, small metal objects
* Compass (optional)
* Multimeter (for voltage and resistance)

STUDENT DIRECTIONS:

**Step 1: Build Your Electromagnet**

1. **Wrap the Wire**
   * Tightly coil the wire around the nail, leaving about 3 inches of wire free on each end.
   * Try to make the coils neat and close together (this increases the strength).
2. **Connect to Power**
   * Tape one wire end to the positive (+) terminal of the battery.
   * Quickly touch and hold the other wire end to the negative (–) terminal.
   * ⚠️ **Only connect for short intervals (10–15 seconds)** to prevent the wire from overheating!
3. **Test It**
   * Try to pick up paperclips or attract small metal objects.
   * Move a compass near your electromagnet—does the needle react?

**Step 2: Measure the Electromagnetic Properties**

1. **Voltage Across Your Coil**
   * Set your multimeter to DC Voltage (V⎓).
   * Connect probes to both wire ends *while connected to the battery*.
   * Record the voltage:
     + Coil Voltage: \_\_\_\_\_\_\_\_\_\_\_ V
2. **Resistance of the Coil**
   * Disconnect the battery.
   * Set the multimeter to resistance (Ω).
   * Connect probes to each wire end of the coil.
   * Record resistance:
     + Coil Resistance: \_\_\_\_\_\_\_\_\_\_\_ Ω

**Engineering Reflection:**

* What variables seemed to make your electromagnet stronger?

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* How could a robotic arm use this kind of electromagnetic system to pick things up?

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* What might limit how strong your electromagnet can be?

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**Extension Challenge (Optional):**

Can you increase the strength of your magnet by:

* Adding more coils?
* Using a larger nail?
* Using more batteries?

Test and compare results—record your changes and findings below.

Standards Alignment

NGSS: HS-PS3-5 STEL: STEL 1E, STEL 2E, STEL 7F, STEL 8F, STEL 11F CCSS: CCSS.MATH.CONTENT.HSN.Q.A.1, CCSS.MATH.CONTENT.HSN.Q.A.3, CCSS.MATH.CONTENT.HSF.IF.C.7, CCSS.MATH.PRACTICE.MP2, CCSS.MATH.PRACTICE.MP5