**⚡ Station 3: “Power the Arm” – Voltage & Energy Transfer**

**Standard:** HS-PS3-3  
**Objective:** Use a **multimeter** to measure voltage in a circuit designed to “power” a part of the rover.

Goal:

You will **build a simple LED circuit**, use a **multimeter** to measure energy flow (voltage), and **engineer a modification** that lets the LED turn on **only when a condition is met**—just like powering a robotic arm on a rover!

**Materials Needed:**

* Coin battery (CR2032 or similar)
* LED light
* Alligator clips or wire leads
* Paperclip (for a manual switch)
* Multimeter (with voltage and continuity modes)
* Optional: Resistor, tilt switch, or pressure sensor

📝 **Student Directions:**

**Step 1: Build a Basic Circuit**

1. Connect the **positive (+)** side of the coin battery to the **long leg (anode)** of the LED using wire or clips.
2. Connect the **short leg (cathode)** of the LED to the **negative (-)** side of the battery to complete the circuit.
3. Insert a **paperclip** between the circuit as a simple switch—pressing it completes the connection.

💡 **Tip:** If the LED doesn’t light, check your connections or reverse the LED legs.

**Step 2: Use the Multimeter**

1. **Measure Voltage Across the LED**
   * Set your multimeter to DC voltage (V⎓).
   * Place the red probe on the positive LED leg and black on the negative.
   * Record the voltage:

🔋 Voltage across LED: \_\_\_\_\_\_\_ V

1. **Test Continuity of the Wires**
   * Switch your multimeter to continuity mode (🔔 symbol).
   * Touch both probes to each end of a wire.
   * If it beeps, the wire conducts electricity well.
2. **(Optional) Measure Resistance of Components**
   * Set your multimeter to Ω (ohms).
   * Test any resistors or other parts (like a pressure switch).
   * Record the resistance value.

**Step 3: Engineering Challenge – Conditional Power**

Your goal: **Modify your circuit** so the **LED turns on only when the “arm” moves** or when a specific condition is met.

Choose one idea:

* Use a **tilt sensor** or a hanging paperclip that shifts when tilted
* Use a **pressure switch** (e.g., foil layers that connect only when pressed)
* Use your **paperclip switch** to close when a part of the rover moves

Sketch or describe your design:

🛠 My design idea: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**💬 Reflection Questions:**

* How does energy transfer from the battery to the LED in your circuit?  
  → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* What happened when you changed the materials or added a switch?  
  → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Why might a real robotic arm need conditional circuits like this?  
  → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

turns on only when the “arm” reaches a certain position (e.g., tilt or pressure sensor).

**⚡ Station 3: “Power the Arm” – Voltage & Energy Transfer**

**NGSS Standard:** HS-PS3-3  
*Design, build, and refine a device that works within given constraints to convert one form of energy into another.*

**✅ ITEEA STEL Standards – High School**

**STEL 1E** – *Technological systems use inputs, processes, outputs, and feedback to solve problems.*  
→ Students build circuits that require inputs (battery or sensor), processes (voltage flow and switching), and outputs (LED lighting) that simulate robotic system logic.

**STEL 2E** – *Technological systems are made up of interactive parts.*  
→ The activity explores how sensors, power, and switches work together to control output in a circuit—like a robotic arm controller.

**STEL 7F** – *Technological products and systems can be used to apply energy in a variety of ways.*  
→ Learners observe energy conversion from stored chemical energy (battery) to electrical energy and finally to light and heat in the LED.

**STEL 8F** – *Design involves a set of steps that can be performed in different sequences and repeated as needed.*  
→ Students plan, build, and iterate on their circuit design—especially during the conditional power challenge.

**STEL 11F** – *Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.*  
→ Learners sketch, measure, and test their circuits, refining as needed to solve the real-world challenge of conditional power transfer.

**✅ Common Core Math Standards – High School**

**CCSS.MATH.CONTENT.HSN.Q.A.1** – *Use units to understand problems and guide the solution.*  
→ Students use voltmeters, resistance measurements, and understand units such as volts and ohms.

**CCSS.MATH.CONTENT.HSN.Q.A.3** – *Choose a level of accuracy appropriate to limitations on measurement.*  
→ Learners interpret voltage readings from multimeters and understand how small differences can impact energy flow.

**CCSS.MATH.CONTENT.HSA.CED.A.2** – *Create equations in two or more variables to represent relationships.*  
→ Students may explore voltage-resistance-current relationships (Ohm’s Law: V=IRV = IRV=IR) as they modify their circuits.

**CCSS.MATH.PRACTICE.MP4** – *Model with mathematics.*  
→ Students relate measured voltage values to the physical behavior of their circuit components.

**CCSS.MATH.PRACTICE.MP5** – *Use appropriate tools strategically.*  
→ Students use multimeters to evaluate and troubleshoot circuits, developing fluency with measurement tools in applied STEM contexts.

**✅ Summary:**

This hands-on activity emphasizes **practical engineering design**, **energy conversion**, and **real-world applications** (like robotic systems) by integrating:

* ITEEA STEL standards for systems thinking, modeling, and energy use
* NGSS performance expectations around energy transfer
* Common Core Math practices related to measurement, units, and modeling