## 📍 Station 4: Engineering Optimization Challenge

**NGSS: HS-ETS1-3** – Evaluate solutions based on constraints

### 🎯 Goal: Improve one of your circuits to reduce energy loss and increase performance.

**Materials:**

* Any previously used circuit
* Optional: buzzer, motor, second battery
* Multimeter
* Stopwatch (for timing response)

### 🛠️ Student Directions:

🧠 **Step 1: Choose a Circuit to Improve**

1. Pick one of your designs from another station.
2. Identify problems like dim lights, overheating, or low power.

🔧 **Step 2: Make Modifications**  
Try one or more of the following:

* Reduce resistance
* Use parallel layout
* Add a more powerful battery
* Add a motor or buzzer for multifunctional output

📓 **Test & Record Results:**

| **Change Made** | **Outcome** | **Better/Worse?** |
| --- | --- | --- |
|  |  |  |

### 💬 Reflection Prompts:

1. How did your design change improve circuit performance?  
   → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What trade-offs did you have to consider (e.g., cost, heat)?  
   → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## 🏁 Wrap-Up Challenge: Circuit Speedway Blueprint

Create a blueprint for a racing garage system that uses at least **two energy conversions**.

* Label input energy, output energy, components used.
* Optional: Add switches, sensors, or safety features.

**Sketch & Describe Below:**  
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
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**NGSS: HS-ETS1-3 – Evaluate solutions based on constraints**

### ✅ **ITEEA STEL Standards – High School**

**STEL 1E** – Technological systems use energy, information, and resources to achieve goals.  
→ Students identify inefficiencies and redesign their circuits to **improve energy use and output**.

**STEL 2E** – Technological decisions should consider efficiency, safety, and sustainability.  
→ Students weigh options like adding batteries vs. reducing resistance, reflecting **real-world trade-offs**.

**STEL 3E** – Systems thinking involves understanding how parts interact within a system.  
→ Students modify a component (resistor, battery, layout) and observe how the **entire system’s performance** changes.

**STEL 4E** – Troubleshooting and problem-solving help identify failures and improve designs.  
→ This challenge is **rooted in identifying performance issues**, proposing solutions, and evaluating success.

**STEL 5E** – Engineering design involves testing and refining solutions.  
→ Students apply **iterative testing**, refining their circuits to reduce energy loss and meet design goals.

**STEL 6E** – Modeling and prototyping represent technology solutions.  
→ Modified circuits act as **physical models** for evaluating system performance and energy optimization.

**STEL 7E** – Design constraints affect outcomes.  
→ Students evaluate performance against constraints like **heat, power, space, or cost**, simulating real engineering contexts.

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

**CCSS.MATH.CONTENT.HSN.Q.A.1–3** – Use units to describe quantities like voltage, current, and resistance.  
→ Students measure and interpret energy performance using **multimeters and appropriate units**.

**CCSS.MATH.CONTENT.HSA.CED.A.1** – Create equations and inequalities to model constraints and solutions.  
→ Students may use **Ohm’s Law (V = IR)** or power equations to compare old and new setups.

**CCSS.MATH.CONTENT.HSA.REI.B.3** – Solve equations as part of a system.  
→ Students might solve for unknowns like current or resistance as part of testing circuit efficiency.

**CCSS.MATH.PRACTICE.MP2** – Reason abstractly and quantitatively.  
→ Students analyze trade-offs (e.g., battery power vs. LED brightness) and back their decisions with numeric data.

**CCSS.MATH.PRACTICE.MP4** – Model with mathematics.  
→ Circuit optimization is a **real-world modeling scenario**, requiring design modification and data-driven evaluation.

**CCSS.MATH.PRACTICE.MP5** – Use appropriate tools strategically.  
→ Multimeters, stopwatches, and comparison tables are all used for **strategic measurement and analysis**.

### ✅ Summary

This activity blends **engineering design principles** from NGSS and ITEEA with **quantitative analysis and systems modeling** from Common Core Math. Students experience a real-world engineering cycle: **problem identification, solution testing, performance measurement, and optimization**—preparing them for future STEM careers.