**NGSS Middle School Standards for the Build Your Own Circuitry Game Unit**

The **Build Your Own Circuitry Game kit** introduces middle school students to **electricity, circuits, and engineering design**. This unit aligns with **Next Generation Science Standards (NGSS) for Middle School**, particularly in **Physical Science (PS) and Engineering Design (ETS).**

**NGSS Middle School Standards Covered**

**Physical Science (PS) – Energy and Electricity**

* **MS-PS2-3:** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
	+ **Connection:** Students investigate **how different materials (conductors and insulators) affect circuit performance** and explore **the impact of circuit configurations on voltage and resistance.**
* **MS-PS3-2:** Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
	+ **Connection:** Students **explore stored energy in electrical systems (such as batteries) and how potential energy is converted into electrical energy to power their game.**
* **MS-PS3-3:** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
	+ **Connection:** Students **examine resistance in circuits and how electrical energy converts into heat, light, and sound in their game components.**
* **MS-PS3-5:** Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
	+ **Connection:** Students **observe energy transfer in their circuit, such as electrical energy powering an LED or buzzer.**

**Engineering, Technology, and Application of Science (ETS)**

* **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.
	+ **Connection:** Students **design their circuitry game by establishing functional requirements, such as how many LEDs, buzzers, or switches to include.**
* **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
	+ **Connection:** Students **experiment with different circuit configurations (series vs. parallel) to optimize their game’s performance.**
* **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each.
	+ **Connection:** Students **use multimeters to measure voltage and resistance, comparing circuit performance to refine their design.**
* **MS-ETS1-4:** Develop a model for iterative testing and modification of a proposed object, tool, or process to optimize performance.
	+ **Connection:** Students **test, troubleshoot, and improve their circuit-based game through multiple iterations.**

**Key Concepts Covered in Middle School**

✔ **Electricity & Circuits:** **Understanding current, voltage, and resistance through hands-on circuit building.**
✔ **Energy Transfer:** **Exploring how electrical energy is converted into light, sound, and motion.**
✔ **Ohm’s Law & Circuit Behavior:** **Applying Ohm’s Law to predict circuit behavior.**
✔ **Series vs. Parallel Circuits:** **Investigating the advantages and disadvantages of different circuit types.**
✔ **Troubleshooting & Optimization:** **Using multimeters and systematic problem-solving to refine circuit performance.**
✔ **Engineering Design Process:** **Designing, building, testing, and improving an interactive game.**

**NGSS High School Standards for the Build Your Own Circuitry Game Unit**

The **Build Your Own Circuitry Game kit** aligns with **Next Generation Science Standards (NGSS) for High School**, particularly in **Physical Science (PS) and Engineering Design (ETS).**

**NGSS High School Standards Covered**

**Physical Science (PS) – Energy and Electricity**

* **HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
	+ **Connection:** Students analyze **how conductors, insulators, and circuit materials impact electrical current flow and resistance** in their game design.
* **HS-PS3-1:** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) is known.
	+ **Connection:** Students **measure voltage, current, and resistance using Ohm’s Law to predict and model energy transfer in circuits.**
* **HS-PS3-2:** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles and energy associated with the relative position of particles.
	+ **Connection:** Students **explore how electrical energy is converted into light (LEDs), sound (buzzers), and motion in circuit components.**
* **HS-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
	+ **Connection:** Students **design and optimize circuits that convert electrical energy into interactive game elements, such as lighting up LEDs or triggering a buzzer.**
* **HS-PS3-5:** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
	+ **Connection:** Students **explore how electric fields influence charge flow and component behavior in circuits.**

**Engineering, Technology, and Application of Science (ETS)**

* **HS-ETS1-1:** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
	+ **Connection:** Students **evaluate how circuit design affects efficiency and functionality, relating to real-world applications of electrical systems.**
* **HS-ETS1-2:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
	+ **Connection:** Students **break down circuit design challenges into wiring, power distribution, and troubleshooting tasks.**
* **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics.
	+ **Connection:** Students **optimize their game’s electrical system for efficiency and reliability, balancing power distribution, component choice, and performance.**
* **HS-ETS1-4:** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems.
	+ **Connection:** Students **could use circuit simulation software to model and test their designs before physical construction.**

**Key Concepts Covered in High School**

✔ **Circuit Design & Behavior:** **Understanding series and parallel circuits and their impact on electrical current.**
✔ **Energy Transfer & Efficiency:** **Applying energy conservation principles to circuit components.**
✔ **Ohm’s Law & Electrical Calculations:** **Using Ohm’s Law to determine voltage, resistance, and current.**
✔ **Troubleshooting & Optimization:** **Refining circuit designs for efficiency and performance.**
✔ **Engineering Design Process:** **Applying iterative design to enhance electrical systems.**
✔ **Real-World Applications:** **Exploring careers in electrical engineering, electronics, and game design.**

**NGSS Elementary Standards for the Build Your Own Circuitry Game Unit**

The **Build Your Own Circuitry Game kit** aligns with **Next Generation Science Standards (NGSS) for Elementary School**, particularly in **Physical Science (PS) and Engineering Design (ETS).**

**NGSS Elementary Standards Covered**

**Physical Science (PS) – Energy & Electricity**

* **PS3.B: Conservation of Energy and Energy Transfer**
	+ **4-PS3-2:** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
		- **Connection:** Students **explore how electrical energy moves through circuits and is converted into light (LEDs) and sound (buzzers) in their game.**
* **4-PS3-4:** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
	+ **Connection:** Students **design and build circuits that transform electrical energy into sound and light, troubleshooting to improve functionality.**
* **PS4.A: Wave Properties**
	+ **1-PS4-1:** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
		- **Connection:** Students **use buzzers to explore how electrical signals create vibrations that produce sound.**
* **PS1.A: Structure and Properties of Matter**
	+ **2-PS1-3:** Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
		- **Connection:** Students **assemble and disassemble circuit components, understanding how different configurations affect the performance of their game.**

**Engineering, Technology, and Application of Science (ETS)**

* **K-2-ETS1-1:** Ask questions, make observations, and gather information to define a simple problem that can be solved through the development of a new or improved object or tool.
	+ **Connection:** Students **observe how circuits work, identify issues in their designs, and improve their game board through hands-on learning.**
* **K-2-ETS1-2:** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a problem.
	+ **Connection:** Students **draw and label circuit schematics to plan their game board design.**
* **3-5-ETS1-1:** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
	+ **Connection:** Students **design their circuitry game with specific constraints, ensuring it functions correctly within the given materials.**
* **3-5-ETS1-2:** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
	+ **Connection:** Students **experiment with different circuit designs (series vs. parallel) to optimize their game’s performance.**

**Key Concepts Covered in Elementary School**

✔ **Electricity & Energy Transfer:** **Understanding how circuits move electrical energy.**
✔ **Circuit Components & Functionality:** **Exploring LEDs, buzzers, and switches.**
✔ **Engineering Design Process:** **Planning, testing, and improving a functional circuit game.**
✔ **Observation & Measurement:** **Using tools like multimeters to measure voltage and resistance.**
✔ **Problem-Solving & Critical Thinking:** **Troubleshooting faulty circuits and refining game designs.**