### **NGSS Middle School Standards for the Measurement Unit**

The **STEM 101 Tool Kit: Use Tools for Measurement** introduces students to essential measurement skills in both the **imperial and metric systems** while incorporating concepts from **physical science, engineering, and technology.** Below are the **Next Generation Science Standards (NGSS) for middle school (Grades 6-8)** that align with this unit.

### **NGSS Middle School Standards Covered**

#### **Physical Science (PS) – Measurement, Forces, and Energy**

* **MS-PS1-2:** Analyze and interpret data on the properties of substances before and after they interact to determine if a chemical reaction has occurred.
	+ **Connection:** Students **develop measurement accuracy and precision, which are essential for analyzing materials in scientific experiments.**
* **MS-PS2-2:** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
	+ **Connection:** Students **measure distances and use rulers, calipers, and other tools to analyze forces and motion.**
* **MS-PS3-1:** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and the speed of an object.
	+ **Connection:** Students **use measurement tools to collect and analyze data related to motion, energy, and physical properties.**
* **MS-PS3-5:** Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.
	+ **Connection:** Students **measure voltage and continuity using a multimeter, helping them understand energy transfer.**

#### **Engineering, Technology, and Application of Science (ETS) – Engineering & Precision Measurement**

* **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.
	+ **Connection:** Students **apply precise measurement techniques in hands-on projects that require accuracy.**
* **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 **compare different measurement tools (ruler vs. digital caliper) to determine accuracy.**
* **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution.
	+ **Connection:** Students **use collected data from various measurement tools to improve accuracy and precision in real-world applications.**

### **Crosscutting Concepts – Patterns, Systems, and Data Analysis**

* **Patterns:**
	+ **Connection:** Students **identify patterns in measurement and learn how consistency ensures accuracy in real-world applications.**
* **Scale, Proportion, and Quantity:**
	+ **Connection:** Students **compare and convert between metric and imperial systems.**
* **Systems and System Models:**
	+ **Connection:** Students **use a multimeter to measure voltage and continuity, understanding electrical systems.**
* **Stability and Change:**
	+ **Connection:** Students **learn how small measurement errors can lead to system failures in engineering and technology.**

### **Key Middle School Concepts Covered**

✔ **Measurement & Precision:** **Using rulers, digital calipers, and multimeters to measure accurately.**
 ✔ **Metric & Imperial Systems:** **Understanding and converting between different units of measurement.**
 ✔ **Scientific Inquiry & Data Collection:** **Analyzing measurements to support scientific claims.**
 ✔ **Technology & Engineering Practices:** **Using tools for voltage testing, continuity testing, and other applications.**
 ✔ **Problem-Solving & Critical Thinking:** **Applying measurement skills to real-world STEM challenges.**

### **NGSS High School Standards for the Measurement Unit**

The **STEM 101 Tool Kit: Use Tools for Measurement** teaches students **precision measurement skills** using **imperial and metric systems**, digital calipers, rulers, and multimeters. These skills align with **high school NGSS standards in physical science, engineering, and technology.**

### **NGSS High School Standards Covered**

#### **Physical Science (PS) – Measurement, Forces, and Energy**

* **HS-PS1-3:** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
	+ **Connection:** Students **use precise measurement tools to analyze physical properties of materials.**
* **HS-PS2-1:** Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among net force, mass, and acceleration.
	+ **Connection:** Students **measure distances, force, and mass to calculate acceleration using measurement tools.**
* **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 **use multimeters to measure voltage and continuity, applying energy transfer concepts.**
* **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 **use multimeters to test electrical properties, reinforcing concepts of electrical fields and forces.**

#### **Engineering, Technology, and Application of Science (ETS) – Engineering & Precision Measurement**

* **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 **use measurement accuracy to design solutions for real-world STEM challenges.**
* **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 **use measurement techniques to ensure precision in engineering projects.**
* **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 **evaluate different measurement tools (digital calipers vs. rulers) for accuracy and reliability.**
* **HS-ETS1-4:** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem.
	+ **Connection:** Students **analyze measurement data and apply mathematical reasoning to optimize solutions.**

### **Crosscutting Concepts – Patterns, Systems, and Data Analysis**

* **Patterns:**
	+ **Connection:** Students **analyze measurement patterns to ensure precision in engineering and technology.**
* **Scale, Proportion, and Quantity:**
	+ **Connection:** Students **convert between metric and imperial systems and analyze proportional measurements.**
* **Systems and System Models:**
	+ **Connection:** Students **measure electrical continuity and voltage using multimeters to understand electrical systems.**
* **Stability and Change:**
	+ **Connection:** Students **evaluate how minor measurement errors affect system performance.**

### **Key High School Concepts Covered**

✔ **Precision Measurement:** **Using rulers, digital calipers, and multimeters accurately.**
 ✔ **Metric & Imperial Conversions:** **Applying mathematical principles to measurement systems.**
 ✔ **Scientific Inquiry & Data Analysis:** **Using measurement data to support claims and solve problems.**
 ✔ **Engineering & Technology Applications:** **Applying measurement in electrical testing, system design, and troubleshooting.**
 ✔ **Problem-Solving & Critical Thinking:** **Using measurement tools to ensure reliability in STEM projects.**

### **NGSS Elementary Standards for the Measurement Unit**

The **STEM 101 Tool Kit: Use Tools for Measurement** teaches elementary students **precision measurement skills** using **imperial and metric systems, rulers, digital calipers, and multimeters.** This unit aligns with **NGSS standards in physical science, engineering, and mathematics** at the elementary level.

### **NGSS Elementary Standards Covered**

#### **Physical Science (PS) – Measurement, Forces, and Energy**

* **2-PS1-1:** Plan and conduct an investigation to describe and classify different materials by their observable properties.
	+ **Connection:** Students **use measurement tools to classify materials by length, width, and electrical properties.**
* **3-PS2-4:** Define a simple design problem that can be solved by applying scientific ideas about magnets.
	+ **Connection:** Students **test continuity using a multimeter, exploring how electrical circuits work.**
* **4-PS3-4:** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
	+ **Connection:** Students **measure voltage with a multimeter to understand energy transfer in electrical circuits.**

#### **Engineering, Technology, and Application of Science (ETS) – Engineering & Precision Measurement**

* **K-2-ETS1-1:** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
	+ **Connection:** Students **observe and measure objects to improve accuracy in engineering projects.**
* **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 **use measurement accuracy to ensure success in hands-on projects.**
* **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 **compare ruler measurements to digital caliper accuracy to determine the best tool for the task.**
* **3-5-ETS1-3:** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
	+ **Connection:** Students **analyze measurement errors and refine their techniques for better accuracy.**

### **Crosscutting Concepts – Patterns, Systems, and Data Analysis**

* **Patterns:**
	+ **Connection:** Students **identify patterns in measurements to ensure consistency.**
* **Scale, Proportion, and Quantity:**
	+ **Connection:** Students **learn how to measure accurately and compare different unit systems.**
* **Systems and System Models:**
	+ **Connection:** Students **test electrical continuity and voltage using multimeters to understand basic circuits.**
* **Cause and Effect:**
	+ **Connection:** Students **observe how small measurement errors affect project outcomes.**

### **Key Elementary Concepts Covered**

✔ **Using Measurement Tools:** **Rulers, tape measures, digital calipers, and multimeters.**
 ✔ **Metric & Imperial Systems:** **Learning to convert between units.**
 ✔ **Scientific Inquiry & Data Collection:** **Using precise measurements to test predictions.**
 ✔ **Engineering Applications:** **Applying measurement in hands-on projects.**
 ✔ **Critical Thinking & Problem-Solving:** **Understanding how measurement accuracy affects results.**