**📊 STATION 2: "Motion Math" – Measure Acceleration & Momentum**

**NGSS Connection: HS-PS2-1 & HS-PS2-2**
**Student Directions:**

**🧪 Set Up:**

**STEP 1: Choose your projectile:**

* + Start with a cotton ball (light mass).
	+ You'll test different masses later!

**STEP 2: Set up your launcher** (from Station 1 or use the same kind):

* + Make sure it’s stable and ready to fire in a straight line.

**STEP 3: Mark a start line** and use tape or a ruler to create a **measuring track** (at least 2 meters long if possible).

**⏱️ Collect Motion Data:**

**STEP 4: Measure Distance:**

* + Use a tape measure or ruler to mark where the projectile lands.
	+ Record how far it traveled (meters or centimeters).

**STEP 5: Measure Time:**

* + Use a stopwatch or timer to record how long the projectile is in motion (from launch to landing).
	+ Have one student time while another launches.

**STEP 6: Repeat 3 times** for accuracy. Then change mass (e.g., small eraser, aluminum foil ball, or coin) and repeat.

**✏️ Do the Math:**

**STEP 7: Estimate Average Speed (v):**

**Calculate Acceleration (a):**
Use this formula:

**Calculate Momentum (p):**
First, record the estimated mass of your object in kg (e.g., 0.01 kg for a cotton ball). Then:



 **Data Table Example:**

| **Object** | **Mass (kg)** | **Distance (m)** | **Time (s)** | **Speed (m/s)** | **Acceleration (m/s²)** | **Momentum (kg·m/s)** |
| --- | --- | --- | --- | --- | --- | --- |
| Cotton Ball | 0.01 |  |  |  |  |  |
| Heavier Object | 0.05 |  |  |  |  |  |

 **Reflection Prompts:**

**1. How did changing the mass of the projectile affect the speed and momentum?**
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**2. Was more pull-back (tension) always better for distance or speed? Why or why not?**
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**3. What patterns do you notice in how mass, speed, and momentum are connected?**
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

📊 **Station 2: "Motion Math" – Measure Acceleration & Momentum**
**NGSS**: 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.
**NGSS**: HS-PS2-2 – Use mathematical representations to support the claim that the total momentum of a system is conserved.

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

**STEL 1H** – Energy can be used to do work using many technologies.
→ Students observe energy transfer from potential to kinetic energy during projectile launches and examine how changes in energy affect motion and force.

**STEL 3I** – Technological systems are designed to achieve specific goals.
→ Learners measure system outputs (speed, distance, momentum) to evaluate how their launcher system performs under changing variables like mass and tension.

**STEL 4G** – The process of experimentation and iteration is used to solve problems and improve designs.
→ Through repeated trials, students test various masses and conditions, analyze the results, and refine their understanding of acceleration and momentum.

**STEL 5G** – Data is used to improve technological systems.
→ Students collect and analyze motion data (distance, time, speed), using it to draw conclusions about force, motion, and mass relationships.

**STEL 8G** – The design process is a purposeful, iterative approach to problem solving.
→ Students not only launch but revise how they launch — adjusting variables to improve consistency and performance in motion-based tasks.

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

**CCSS.MATH.CONTENT.HSN.Q.A.1–3** – Use units and quantitative reasoning to solve problems.
→ Students measure time, distance, mass, and apply appropriate formulas (v = d/t, a = Δv/Δt, p = mv) using correct units (m/s, m/s², kg·m/s).

**CCSS.MATH.CONTENT.HSA.CED.A.1–2** – Create and solve equations to represent relationships between quantities.
→ Students model projectile motion using equations and interpret how variables interact in Newtonian mechanics.

**CCSS.MATH.CONTENT.HSS.ID.B.6** – Represent data on two quantitative variables and describe how variables are related.
→ Students can create scatter plots or line graphs to compare projectile mass with speed or momentum.

**CCSS.MATH.CONTENT.HSS.ID.C.7** – Interpret the slope and intercept of a linear model in context.
→ Students analyze how variations in mass or angle relate to speed or momentum, interpreting patterns in their data.

💡 **Summary:**
This station immerses students in real-world applications of Newton’s laws by combining engineering-based launching devices with rich data collection and math analysis. Students practice interpreting motion mathematically while learning the impact of variable changes on acceleration and momentum. The task builds essential STEM skills in problem-solving, experimentation, and analytical reasoning.