**Station 2: “Force Finder” – Newton’s Second Law Lab**

**Standard:** HS-PS2-1
**Objective:** Measure mass and acceleration to apply **F = ma**.

**Goal:**

You’re testing how the **mass of a moving object (a mini rover)** and its **acceleration** are related to the **net force** acting on it. You’ll roll a rover down a ramp, **measure time and distance**, and calculate acceleration and force using physics formulas.

 **Student Directions:**

**Materials Needed:**

* Ramp (books + board or foam ramp)
* Small “rover” (toy car or weighted container with wheels)
* Stopwatch
* Ruler or measuring tape
* Washers or coins (for adding mass)
* Calculator
* Data sheet or notebook

**Student Directions:**

**Step 1: Set Up the Ramp**

* Place your ramp on a stable surface. Measure the **length of the ramp** (distance the rover will travel from top to bottom).
📏 Record distance (d): \_\_\_\_\_\_\_ cm or meters

**Step 2: Test with Starting Mass**

* Put your rover at the top of the ramp.
* Get ready with your **stopwatch**.
* Let it go and **time how long it takes** to reach the bottom.
⏱ Record time (t): \_\_\_\_\_\_\_ seconds

**Step 3: Repeat with More Mass**

* Add 1–2 washers or coins to your rover to increase mass.
* Repeat the test. Do this **at least 3 times** with different masses.
* Each time, record the time it takes and keep the ramp angle the same.

**Step 4: Calculate Acceleration**

Use the formula:

Where:

* aaa = acceleration
* ddd = distance traveled down the ramp
* ttt = time measured

💡 Use a calculator and show your work!

**Step 5: Calculate Force**

Next, use the formula:

Where:

* FFF = Force
* mmm = Mass of rover (use total mass including added washers—estimate in kg if possible)
* aaa = Acceleration from the last step

📝 Record in a chart:

| **Trial** | **Mass (kg)** | **Time (s)** | **Acceleration (m/s²)** | **Force (N)** |
| --- | --- | --- | --- | --- |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |

**💬 Discussion Prompts:**

* What happened to the **acceleration** when the mass increased?
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Did the **net force** increase or stay the same? Why do you think that happened?
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* How did using a **stopwatch or measuring tools** help improve the accuracy of your calculations?
→ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**🎯 Station 2: “Force Finder” – Newton’s Second Law Lab**

**NGSS Standard:** HS-PS2-1
*Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.*

**✅ ITEEA STEL Standards – High School**

**STEL 1E** – *Technological systems use energy, information, and physical resources to achieve goals.*
→ Students gather physical data (mass, distance, time) and convert that into useful information (acceleration, force) to understand energy and motion.

**STEL 4E** – *Troubleshooting and testing help refine technological systems.*
→ Students repeat trials, adjust masses, and use time measurements to improve data quality and system accuracy.

**STEL 6F** – *Creativity in design leads to innovative solutions.*
→ Students design and adapt testing setups using basic materials (books, ramps, cars) to explore fundamental laws of motion.

**STEL 8F** – *Design involves steps such as testing and refining.*
→ This lab mirrors the engineering process: measure, test, calculate, adjust, and reflect.

**STEL 11F** – *Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.*
→ Newton’s 2nd law is mathematically modeled, tested through experiment, and evaluated by students using their own data.

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

**CCSS.MATH.CONTENT.HSN.Q.A.1** – *Use units to understand problems and guide solutions.*
→ Students work with correct units (kg, m/s², N), showing dimensional understanding.

**CCSS.MATH.CONTENT.HSN.Q.A.2** – *Define appropriate quantities for descriptive modeling.*
→ Time, mass, acceleration, and force are used to model physical systems.

**CCSS.MATH.CONTENT.HSN.Q.A.3** – *Choose a level of accuracy appropriate to limitations on measurement.*
→ Students consider measurement precision when using stopwatches and rulers, and record data with appropriate significant figures.

**CCSS.MATH.CONTENT.HSA.CED.A.2** – *Create equations in two or more variables to represent relationships.*
→ Students apply a=2dt2a = \frac{2d}{t^2}a=t22d​ and F=maF = maF=ma to create equations from observed data.

**CCSS.MATH.PRACTICE.MP4** – *Model with mathematics.*
→ Students model real-world physical motion mathematically through Newton’s laws.

**CCSS.MATH.PRACTICE.MP5** – *Use appropriate tools strategically.*
→ Rulers, stopwatches, and calculators are selected and applied for measurement and calculation tasks.

**✅ Summary**

This activity connects physics and engineering through Newton’s Second Law, enabling students to:

* Apply **STEM practices** by measuring and analyzing real motion data
* Follow **design and testing principles** from ITEEA standards
* Use **Common Core-aligned math** to solve and reflect on motion-based equations