

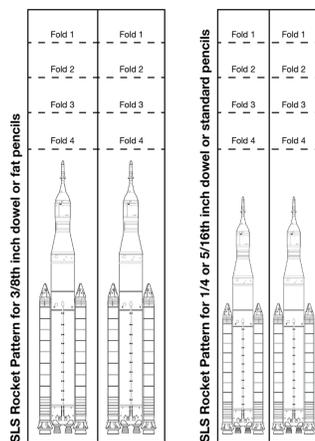
**BIOLOGY RESEARCH****TITLE:** EXPLORING PHYSICAL SCIENCE**TOPIC:** 3...2...1...PUFF! – UNDERSTANDING ROCKET STABILITY AND MOTION**GRADE LEVEL:** High School (Grades 10 & 12)**DURATION:** 4 - 5 days (45 min periods)**STANDARDS:****Next Generation Science Standards (NGSS):****MS-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to improve models.**MS-ETS1-1.** Define a simple design problem reflecting a need that includes specified criteria for success and constraints on materials, time, or cost.**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.**Common Core Math Standards:****CCSS.MATH.CONTENT.7.RP.A.2.D.** Use proportional relationships to solve multistep ratio and percent problems.**3-Dimensional Learning**

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions. Developing and Using Models. Planning and Carrying Out Investigations. Analyzing and Interpreting Data. Using Mathematical and Computational Thinking. Constructing Explanations. Engaging in Argument from Evidence. Obtaining, Evaluating, and Communicating Information.	<b>PS2.A: Forces and Motion</b> <ul style="list-style-type: none"> <li>The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion</li> </ul>	<b>Patterns.</b> Graphs, charts, and images can be used to identify patterns in data.  <b>Cause and Effect.</b> Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.  <b>Systems and System Models.</b> Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems.

**RESOURCES/MATERIALS:****Teacher resource:** <https://www3.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20.pdf> (pages 42 - 47)

Paper (8.5 x 11 inches), scissors, tape, straws, ruler, meter stick, pencils/dowels - for rocket construction

SLS rocket patterns from NASA resources

**DIFFERENTIATION:**

- Provide vocabulary support for key concepts (e.g., thrust, drag, COM, COP).
- Scaffolded guidance for students requiring additional support, including step-by-step instructions for rocket building and data analysis.

**BACKGROUND INFORMATION**

This is a Biology research class, where students study scientific inquiry, focusing on life sciences and conducting a year-long research project on fruit flies. They engage in activities involving scientific reading, writing, data analysis, and presentation. This physical science component will allow students to practice inquiry and design skills through hands-on investigations, strengthening their research and scientific inquiry abilities.

This lesson connects physics principles such as stability, thrust, and motion to biological systems by having students design and build paper rockets using NASA's PSIM resources (pages 42-47). Students will explore the concepts of center of mass (COM) and center of pressure (COP) in the context of both rocket flight and biological systems, such as the motion of animals in different environments. For example, bird flight relies on similar principles of stability and aerodynamic forces, while fish swimming through water parallels fluid dynamics in rocket motion. Students will make connections to how physics concepts by understanding biological motion and adaptations in various ecosystems.

**LEARNING OUTCOMES**

**Goal:** Students will use scientific design or inquiry to design paper rockets, test their stability, and investigate how modifications impact their flight distance.

**Instructional Objectives:**

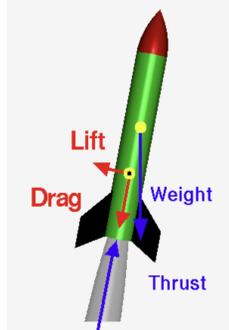
- Conduct background research and develop an appropriate hypothesis
- Design and conduct an experiment to test the hypothesis
- Draw conclusions from the results of the experiment

**LESSON OUTLINE****Engage**

- **Introduction to Rocket Stability**
  - **Teacher will** show students images and videos of rockets (using PSIM page 42).
  - **Teacher will** discuss the importance of stability for rocket launches and space missions.
- **Model Rocket Construction:**
  - **Teacher will** demonstrate how to build a paper rocket using the instructions from page 43 of the PSIM guide.
    - **Video options:**
      - <https://www.youtube.com/watch?v=AweP9Rbryhs>
      - <https://www.youtube.com/watch?v=0hThMoHB88w>
  - **Teacher will** explain the importance of center of mass (COM) and center of pressure (COP) in rocket stability.
- **Class Discussion:**
  - **Students will** think about and share ways the concept of COM/COP relates to biological systems, such as how fish or birds maintain stability in water and air.

**Possible student misconceptions:**

**The directions of thrust, lift, drag, and weight.** Lift and drag are defined based on the direction of the rocket's movement relative to the air. Drag is opposite the direction of motion, and lift is perpendicular to the direction of motion. Normally, this does not cause any confusion because we think about objects that fly horizontally (like a paper airplane), so lift points up. However, if a rocket is launched vertically, then lift points sideways and not up.



Real rockets provide continuous thrust by burning fuel, which is expelled out the back end of the rocket. According to Newton's third law of motion (for every action, there is an equal and opposite reaction), since the fuel is pushed out the back of the rocket, the rocket must be pushed forward. This concept also applies to certain toy rockets, like model rockets, water bottle rockets, and baking soda/vinegar rockets, all of which expel some sort of fuel. However, the paper rockets in this project do not carry any fuel. They are propelled forward by one initial puff of air from the straw, but after that, do not produce any thrust on their own.

The rockets have fins that, at first glance, might seem like they act like wings and generate lift if you launch the rocket horizontally. However, the fins are very small and their primary purpose is to keep the rocket stable and prevent it from tumbling—not to provide lift.

**NASA: Rocket Stability**

<https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/rocket-stability/>

**NASA: Rocket Stability Condition**

<https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/conditions-for-rocket-stability/>

**Explore**

- Safety Precautions: Review safety procedures, such as wearing eye protection and ensuring no rockets are aimed at others.
- **Rocket Building: Students will** work in groups to design and build their rockets using the materials provided (as detailed on page 42 of the PSIM guide).
- *Stability Test:* Perform the drop test (PSIM page 43). Students will test their rockets for stability and make adjustments as necessary (e.g., changing fin size or location).

**Explain**

- **Rocket Launch: Students will** conduct three launch trials (PSIM page 46). They will measure the distance traveled in each trial and record the data in their Rocket Test Report.
- **Data Analysis:** Students calculate the average distance traveled and reflect on how their rocket design impacted the flight stability and distance.
- **Discussion:** Students will discuss their findings and relate their results to the concepts of thrust, drag, and Newton's third law of motion (PSIM page 45). They will also consider how these principles can apply to biological movement, such as bird flight or fish swimming.

**Data Collection:**

<p><b>ROCKET 1</b> Flight Distance (in cm)</p> <p>Flight 1 <input type="text"/></p> <p>Flight 2 <input type="text"/></p> <p>Flight 3 <input type="text"/></p> <p>Average Distance <input type="text"/></p>	<p>Make notes about the flights here.</p>
<p><b>ROCKET 2</b> Flight Distance (in cm)</p> <p>Distance Prediction <input type="text"/></p> <p>Difference between your prediction and the average flight distance <input type="text"/></p> <p>Flight 1 <input type="text"/></p> <p>Flight 2 <input type="text"/></p> <p>Flight 3 <input type="text"/></p> <p>Average Distance <input type="text"/></p>	<p>Make notes about the flights here.</p>
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### Elaborate and Evaluate

- **Design Improvements:** Students will modify their rocket design based on their results (e.g., adjusting fin size or the rocket's length). They will then repeat the launch process, comparing their modified rocket's performance to their original design.
- **Group Presentations:** Each group presents their data, discussing how their design changes affected rocket stability and flight distance (*Formative Assessment*)

**Summative Assessment:** Students will complete a written lab report (PSIM page 46) summarizing their experiment, including their hypothesis, data, and conclusions. Students should also include reflections on how rocket stability concepts can be applied to biological systems.