



Thrust, Air Pressure Rockets and Newton's 3rd Law

DESCRIPTION

This lesson connects a series of activities to examine thrust and Newton's 3rd Law applied to rockets and cars propelled by air pressure.

OBJECTIVES

Students will:

- Investigate Newton's third law of motion using thrust produced by falling water, balloon powered rockets and racing cars.
- Explore the action-reaction principle by constructing a balloon-powered pinwheel
- Demonstrate how several stages of a rocket can operate in steps to propel a rocket.

NASA SUMMER OF INNOVATION

UNIT

Physical Science- Forces and Motion

GRADE LEVELS

4th – 6th

CONNECTION TO CURRICULUM

Science and Mathematics

TEACHER PREPARATION TIME

60 minutes

LESSON TIME NEEDED

4 hours

Complexity – Moderate

NATIONAL STANDARDS

National Science Education Standards (NSTA)

Science as Inquiry

- Skills necessary to become independent inquirers about the natural world

Physical Science

- Position and motion of objects
- Motions and forces
- Properties of objects and materials

Science and Technology

- Abilities of technological design
- Understanding about science and technology

Common Core State Standards for Mathematics (NCTM)

Number and Operations

- Understand the place value system
- Generalize place value understanding for multi-digit whole numbers

Measurement and Data

- Convert like measurement units within given measurement system
- Represent and interpret data

MANAGEMENT

The activities in this lesson should be done with cooperative groups of two to three students. Safety practices should be reviewed and observed during the activities.

Teacher will need to gather aluminum cans (or have students bring them in). For the Rocket racers, each team will need a Styrofoam tray (about 3/16" thick). You may request donations from your local supermarket. Other management considerations can be found in the activity pdf's.

CONTENT RESEARCH

The NASA Rockets – Educator Guide has great background information on rockets and their history. The guide also discusses Newton's Laws of Motion very clearly.

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html>

Key Terms:

- **Force-** a push or a pull exerted on an object.
- **Thrust** – when a system expels or accelerates mass in one direction the accelerated mass will cause a proportional but opposite force on that system.
- **Newton's 1st Law of Motion-** Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force.
- **Newton's Second Law of Motion-** The second law relates force, acceleration, and mass: $f = m \times a$. The force produced on the Newton car is directly proportional to the mass of the expelled bottle times its acceleration.
- **Newton's 3rd Law of Motion** – states that every action has an equal and opposite reaction.
- **Stages** - Two or more rockets stacked on top of each other in order to reach a higher altitude or have a greater payload capacity.
- **Microgravity-** An environment that imparts to an object a net acceleration that is small compared to that produced by Earth at its surface.

Misconceptions –

- **Inertia-** The most common misconception is that sustaining motion requires a continued force. (*Newton's first law of motion declares that a force is not needed to keep an object in motion.*) *A book in motion on the tabletop does not come to a rest position because of the absence of a force; rather it is the presence of a force - friction - that brings the book to a rest position.*

LESSON ACTIVITIES

Pop Can Hero Engine

Small student teams will construct water-propelled engines out of soft drink cans and investigate ways to increase the action-reaction thrust produced.

http://www.nasa.gov/pdf/153414main_Rockets_Pop_Can_Hero.pdf

Rocket Pinwheel

Student teams construct a balloon-powered pinwheel to explore Newton's third law, the action-reaction principle.

http://exploration.grc.nasa.gov/education/rocket/TRCRocket/rocket_pinwheel.html

Balloon Staging

Two inflated balloons are joined in a way simulate a multistage rocket launch as they slide along a fishing line on the thrust produced by escaping air.

http://exploration.grc.nasa.gov/education/rocket/TRCRocket/balloon_staging.html

MATERIALS

- 4 empty aluminum soft drink cans per team (pull tabs in intact)
- Carpenter's nails of different sizes (6, 12, 16D)
- String (about 50cm)
- Water tub (large plastic storage tub, small kiddie pool, sink, etc.)
- Water
- Towels
- Rulers, Meter stick
- Sticker or bright permanent marker
- Wooden pencil with an eraser on one end
- Sewing pin
- 4-5" Round balloons
- Flexible soda straw
- Plastic tape
- Balloons
- 2 long party balloons (not round balloons)
- Nylon monofilament fishing line (any weight)
- 2 Plastic straws (non-bendable)
- Styrofoam cup
- Masking tape
- Scissors
- Styrofoam food trays
- Small plastic stirrer (round)
- Sandpaper

Rocket Races

Student teams construct racing cars from Styrofoam food trays and power them with the thrust of an inflated balloon.

http://www.nasa.gov/pdf/153417main_Rockets_Rocket_Races.pdf

ADDITIONAL RESOURCES

- This video introduces students to Isaac Newton's Laws of Motion and demonstrates how they apply to space flight. Using the microgravity environment of Earth orbit, Space Shuttle astronauts conduct simple force and motion demonstrations in ways not possible on Earth.

http://www.nasa.gov/audience/foreducators/topnav/schedule/program_descriptions/Newton_in_Space_5-8.html

- More on Newton's Laws from NASA website.

<http://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/dynamicsoflight.html#lawofmotion>

DISCUSSION QUESTIONS

- How do the concepts explored in these activities relate to NASA and its exploration of space? *Newton's Laws govern in part the launch of rockets into space: inertia must be overcome in each activity and with rockets, the acceleration of a rocket is determined by its mass and the force applied to it, and rockets launch do to the principle of action/reaction*
- Do all three of Newton's Laws of Motion apply to the activities performed in this lesson? *Yes, all three laws apply: Inertia must be overcome for an object to move (1st Law), an object's acceleration is determined by its mass and the force applied to it (2nd Law), and all four activities involve motion due to the action/reaction principle (3rd Law).*
- Why is the staging of rockets particularly useful to lifting equipment into space? *A large first stage rocket once exhausted and is released to return to the Earth. The upper stages are able to reach much higher altitudes because they do not have to carry the expired engines and empty propellant tanks (less mass) that make up the first stage. Space rockets are often designed with three or four stages that each fire in turn to send a payload into orbit.*

ASSESSMENT ACTIVITIES

Pop Can Hero- Ask teams to state their experiment hypotheses, explain their procedures, and present their results. Make a list of ways one can increase the number of can rotations. Have teams submit their data sheets with written conclusions.

Rocket Pinwheel – Have students explain Newton's third law of motion as demonstrated by the rocket pinwheel.

Staging- Student teams should explain the performance of their "staged" rockets versus a single balloon rocket.

Rocket Racer- Review student Rocket Racer Data Sheets and Design Sheets. Have students write an explanation of Newton's third law of motion using their rocket racers as examples.

ENRICHMENT

Each activity includes extensions to allow students to continue their learning experiences.