What Goes Up…Must Come Down: Projectile flight

NASA SUMMER OF INNOVATION

UNIT
Physical Science- Force and Motion

GRADE LEVELS
4th – 6th

CONNECTION TO CURRICULUM
Science and Mathematics

TEACHER PREPARATION TIME
2 hours

LESSON TIME NEEDED
5 hours *Complexity: Moderate*

DESCRIPTION
This lesson connects activities to examine the projectile flight, trajectory and stability of rockets using multiple rocket designs.

OBJECTIVES
Students will:

- Explore the motion of a projectile
- Describe, draw, and calculate the approximate path of a thrown tennis ball
- Investigate rocket stability and range as they design, construct and fly several rockets types
- Explore the concept of terminal velocity
- Measure the acceleration environments created by different motions.

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

Common Core State Standards for Mathematics (NCTM)
Operations and Algebraic Thinking
- Write and interpret numerical expressions

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

Expressions and Equations
- Apply and extend previous understandings of arithmetic to algebraic expressions

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. Foam trays may be donated by grocery stores' meat departments.

CONTENT RESEARCH

An object that is thrown, shot, or otherwise propelled into the air is a **projectile**. The path the projectile follows through the air is known as its **trajectory** and the path of the trajectory is a **parabola**. If no forces other than **gravity** act on the object, its trajectory can be easily and accurately determined. When a rocket launches, stability is an important issue. The NASA Rockets – Educator Guide has a thorough background on rockets and their history.
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html

Key Concepts:

- **Projectile-** An object that is thrown, shot, or otherwise propelled into the air.
- **Trajectory-** The path the projectile follows through the air is known as its trajectory
- **Terminal velocity-** The maximum speed an object reaches during freefall.
- **Acceleration**- is the rate at which an object's velocity is changing. The change can be in how fast the object is moving, a direction change, or both.

LESSON ACTIVITIES

Museum in a Box: Ball Launcher

A parabolic or trajectory flight path is the same path that would be taken by an object in free fall, such as a thrown baseball, tennis ball or cannonball fired into the air. Several forces affect how far a thrown baseball or tennis ball can travel. Students will measure distance (range) and time of flight then calculate the height the ball flew using an algebraic equation.
http://files.me.com/peggymaher/205rwc

3…2…1 Puff!

Students will construct small "indoor" paper rockets, determine their flight stability, and launch them by blowing air through a drinking straw.
http://www.nasa.gov/pdf/153413main_Rockets_3_2_1_Puff.pdf

Pop! Rockets

A rocket with a triangular cross section is made from three rocket-shaped strips (or a single piece) of card stock paper and launched with the Pop! Rocket Launcher.
http://www.nasa.gov/pdf/295791main_Rockets_Pop_Rockets.pdf
http://www.nasa.gov/pdf/295790main_Rockets_Pop_Rocket_Launcher.pdf

Foam Rocket

Student teams will construct rockets made from pipe insulating foam and use them to investigate the trajectory relationship between launch angle and range in a controlled investigation.
http://www.nasa.gov/pdf/295787main_Rockets_Foam_Rocket.pdf

Accelerometers

This activity provides students with the plans for making a one-axis accelerometer that can be used to measure acceleration in different environments ranging from +3 g to -3 g. Students are then challenged to use their accelerometers to measure various accelerations.
http://www.nasa.gov/pdf/315949main_Microgravity_Accelerometers.pdf

MATERIALS

- Tape Measure
- Stop Watch
- Chuckit Ball Launcher with ball
- Photo C-9B Aircraft
- Photo C-9B Flight
- Trajectory Ball Launcher
- Data Collection Sheets
- 8.5 x 11 paper
- Eye protection
- Drinking straws
- Paper rocket plans
- Card-stock paper
- Glue stick
- Penny
- Pop! Rocket Launcher

Foam rockets (each)

- 30 cm length polyethylene foam pipe insulation (for ½" pipe)
- Rubber bands (size 64)
- Styrofoam food tray
- 3-8" plastic cable ties
- 75 cm string
- Meters stick
- Press tack
- Washer or nut
- Experiment data sheet

Accelerometer (each)

- Lightweight poster board (any color)
- 3 "drilled egg" lead fishing sinkers, 1 ounce size
- Masking tape
- Rubber band, #19 size
- 4 small paper clips
- Scissors
- Straightedge
- Ballpoint pen, pencil
- Pattern Hot glue (low temperature)

ADDITIONAL RESOURCES

U-tube video of NASA's Weightless Wonder airplane flying parabolic flight:
http://www.youtube.com/watch?v=2V9h42yspbo
For more on the subject on acceleration (with animations) see:
http://www.physicsclassroom.com/mmedia/kinema/acceln.cfm
A good resource on the subject of freefall and acceleration due to gravity.
http://www.physicsclassroom.com/class/1dkin/u1l5a.cfm
Why do astronauts float in space?
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Why_Do_Astronauts_Float.html

DISCUSSION QUESTIONS

- What factors affect the flight of a projectile near the Earth? *Mass of the object, the amount of thrust initially applied, the angle of launch, wind speed and direction, drag of the air, and gravity.*
- What factors change as rockets speed toward orbit hundreds of miles above Earth? *Mass is reduced as fuel is used, thrust will change a multiple stages are used, wind ceases above a certain altitude, drag decreases as air thins with altitude, gravity decreases slightly with altitude.*
- See discussion questions in the Student Data sheets.

ASSESSMENT ACTIVITIES

Ball Launcher- *Answers will vary for the following questions.*

- Did the student participate as an active member of his/her team?
- Did the student record all required data?
- Was the data entered as appropriate?
- Did the student complete all of the required calculations?

There are other assessment questions as well as student data sheets in the lesson.

3-2-1 Puff + Pop Rockets + Foam Rockets

- Have students write and illustrate a paragraph that describes their improvements to their rockets and how these affected their experimental results.
- Have the students draw pictures of their rockets flight path.

Accelerometer-

Test each accelerometer to see that it is constructed and calibrated properly. Collect and review the student sheets.

ENRICHMENT

- See "Extensions" section of 3-2-1 Puff activity, Pop Rockets and Foam Rockets.
- Take the accelerometer to an amusement park and measure the accelerations on approved rides. Note: Parks may not allow accelerometers on all rides.