



Teacher's Notes for
Rocket Lab

GroundStation Canada presentation of the H.R. MacMillan Space Centre

Program description: What goes up doesn't necessarily come down. How does it get "up there" in the first place? In this live demonstration, students will learn the basic principles of rocketry and take part in a lively discussion about motion. Footage of past and present rocket missions will be shown, along with demos of various types of rockets from simple to complex. This program illustrates Newton's Laws of Motion with visuals and audience participation demonstrations.

Advance preparation: Studies have shown that people, especially children, learn better when they feel secure in their surroundings and know what is expected of them. We recommend that you orient your students to the main areas of our facility, make sure the purpose of the field trip is clear, and link the field trip to the students' learning in the classroom. For a map of our facility and more suggestions for a successful field trip download the Orientation Package on our website www.spacecentre.ca.

These "Teacher's Notes" are designed to help you prepare your students further and include enrichment activities that can be done before or after your visit. *These activities cover topics related to those in your program and are therefore not necessarily the same.*

Curriculum connections: Grades 6, 9 and 11

Earth and Space Science and Physical Science IRP Connections:

L=Rocket Lab, A=Teacher Guide activities

It is expected that students will:

Grade 6	
identify the different types of forces	
describe the relationships among forces, motion, and mass	
describe the history of piloted and unpiloted flight	
identify the human and technological requirements for space exploration	
evaluate piloted space exploration in comparison with unpiloted exploration	
Grade 9	
analyze relationships between force, motion, and mass	

Grade 11	
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describe some recent advances in space technology	
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Newton's First Law: Objects at rest will stay at rest and objects in motion will move in a straight line at constant speed unless acted upon by a force.

Newton's Second Law: Force is equal to mass times acceleration ($F=ma$)

Newton's Third Law: For every action there is always an opposite and equal reaction.

Activity One (A) – Balloon Rocket
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Objective: Students will build balloon rockets to explore aspects of Newton's First and Third Laws of Motion.

Materials: balloons (long & narrow)
plastic straws (milk shake size are best)
tape
fishing line
stopwatch
metre sticks/measuring tapes

What to do:

1. On large poster paper, write Newton's Laws of motion for the students to read.
2. With students working in groups of 3-5, have each group tie one end of their fishing line to an anchored object at one end of the classroom, several feet off the floor, and then stretch it across to the other side of the room.
3. Have each group thread their straw onto the fishing line and then have a student hold the other end of the fishing line as tight as possible, parallel to the ground.
4. Ask each group to blow up a balloon one third full of air and then hold it so that the air will not escape. Have the students carefully tape the balloon to the straw so that the length of the balloon is parallel to the straw.
5. Once all the groups are ready, have them all line up with their balloons at one end of their fishing line, give a countdown, let the nozzles go, and watch their balloons (rockets) fly along the fishing lines.
 - a) Use a stopwatch to record the duration of the flight.
 - b) Measure the distance of the flight with a metre stick.
 - c) Repeat the launch two more times and record the above information.
 - d) Average the results of the three launches and record.
6. Repeat the activity with the following modifications:
 - a) Fill the balloon with two thirds of air.
 - b) Fill the balloon completely with air.
7. Create a chart/table on the chalkboard and have each group fill in their results for 1/3, 2/3, and full. Using this information, discuss the following questions with the class:

- a) Did all the teams obtain the same data? How can we explain the differences?
- b) When did the balloon rockets go the farthest? What caused this? How can we test these ideas? (answer: more air = greater force for longer duration)
- c) Why did the balloon rockets stop? (answer: force of friction between the line and the straw)
- d) If there were no friction between the straw and the line, and no wall in the way, how would the balloon rocket behave? (answer: it would keep accelerating along the line until all the fuel was gone and then it would continue at the same speed forever)
- e) Which Law(s) of motion have we explored in this activity? Explain. (answer: Laws #1 & #3)

Activity One (B) – Two-stage Balloon Rocket

Objective: Students will use balloon rockets to investigate how rockets can achieve greater altitudes by using the technology of staging.

Materials: Balloon Rocket materials from Activity One (A)
Styrofoam coffee cups and clothes pegs

What to do:

1. Have students complete steps 1-3 from Activity One (A).
2. Have each group of students cut a coffee cup in half so that the lip of the cup forms a continuous ring.
3. Have the students inflate one balloon about three quarters full and squeeze its nozzle shut. Pull the nozzle through the coffee cup ring, twist the nozzle, and secure it closed with a clothes peg. Inflate a second balloon, ensuring the front end of this balloon extends through the ring a short distance. As the second balloon inflates it will press against the nozzle of the first balloon, thus taking over the job of the clothes peg. Then, using a clothes peg, clip the nozzle of the second balloon shut.
4. When all the groups are ready, have them take their two-stage balloon rockets to one end of the line, remove the clothes pegs from both balloons but continue to hold the nozzle of the second balloon. Do a countdown, and have the students blast off their rockets.
5. Have the students try this activity several times and compare the results with those achieved with the single-stage rockets in Activity One (A).

Going further:

Challenge the students to try other launch arrangements such as side-by-side balloons and three-stage rockets.

Ask the students to try and fly a two-stage balloon rocket without the fishing line as a guide, having them consider how the balloons could be modified to make this work.

Activity Two – Bean Bag Demo

Objectives: Students will learn about Newton's Third Law.
Students will learn how Newton's Third Law applies to rockets.

Materials: Flat dolly cart or a large skateboard or a chair on castors.
12 bean bags.

What to do:

- 1) Explain to the students that one person will sit on the cart (skateboard or chair) and throw bean bags off in the same direction. Then ask the students to predict what will happen.
- 2) Have a student sit on the cart, skateboard, or chair with the bean bags.
- 3) Have the student throw the bean bags.
- 4) Compare the results with the predictions.

What happened:

As the student throws the bean bags away they exert a force on the bean bag that creates an equal and opposite reaction; the student rolls backwards.

Going further:

Have the student repeat the experiment. Carefully note how fast the student moves and how fast the bean bag moves. Have students formulate a reason for the different accelerations.

Answer: Let's assume that the student threw the bean bag with 5 N of force and the bean bag has a mass of 1 kg. The bag's acceleration would then be 5 m/s^2 . Newton's Third Law states that 50 N of force also acted on the student. If the student has a mass of 50 kg then the student's acceleration would be 0.1 m/s^2 . The forces are the same but the accelerations are different because they have different masses.

$$m_{\text{bag}} a_{\text{bag}} = m_{\text{student}} a_{\text{student}}$$

In other words, the mass of the bag multiplied by the acceleration of the bag is equal to the mass of the student multiplied by the acceleration of the student.

Going further:

Use a medicine ball in place of the bean bags and see how the results differ.

Answer: Same as above but now the student's acceleration will be larger because of the greater mass of the medicine ball.

Background Information – How Rockets Work

Rockets (and the space shuttle) use Newton's Third Law to maneuver in space. When the rocket fires, it "throws" mass out with a large acceleration that causes an equal and opposite reaction, and the space shuttle accelerates in the opposite direction.