H.R. MACMILLAN SPACE CENTRE

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	
describe some recent advances in space technology	

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

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.

$$\mathbf{m}_{\text{bag}}\ \mathbf{a}_{\text{bag}} = \mathbf{m}_{\text{student}}\ \mathbf{a}_{\text{student}}$$

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.

Aim How does Newton's 3rd law propel rockets?
Obj: design balloon rockets. Apply Newton's 3 laws to rocketry
Materials: balloons, paper clips, straws, tape, fishing line, string, scissors, paper

I. Types of Balloon Rockets:

1. *Tracked balloon rocket*: This rocket is guided to its target by fishing line
2. *Self-guided balloon rocket:* This rocket has structures attached to the balloon that control its flight.
3. *Multi-stage balloon rocket:* This rocket uses 2 balloons. The 2nd balloon does not fire until the first one is nearly deflated.

II. The First Challenge

1. Choose a type of balloon rocket to build. Higher number is more challenging & will receive more points for success.

2. Practice & modify your design to make a better rocket. Your goal is for your rocket to reach a target. You may change rocket types if you wish. Sketch your final design below.

3. Inflate your balloon. Sketch the forces acting on the balloon below.

4. Why don't these forces move the balloon?

5. Fire your rocket to hit the target. How did your rocket compare to the others?

III. The Second Challenge

1. How can you determine how fast your rocket flew?
2. Velocity = distance / time.
3. Write a procedure below showing how to determine your rocket's velocity. Follow that procedure, and record its velocity.

IV The Third Challenge

1. How large a payload of paper clips can be carried to the light fixture?
2. Devise a way to attach paper clips to your rocket.
3. Run your experiment & record the maximum payload below:

V The Fourth Challenge-The Conclusion Questions

1. Sketch your rocket in flight. Show all the forces acting on it using arrows and labeling the arrows.

2. Whose rocket was the most accurate? Whose was the fastest? Whose could lift the greatest payload?

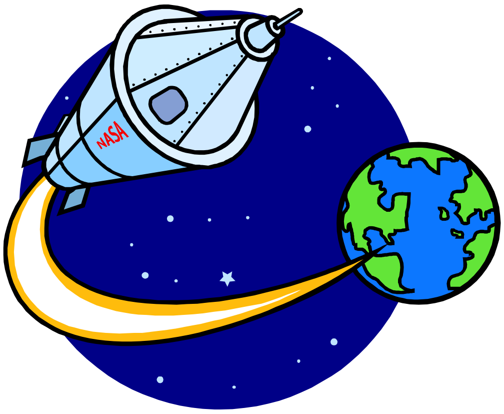
3. Hypothesize reasons for #2.

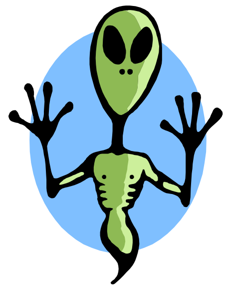
4. How does this lab demonstrate Newton's 1st law of motion?

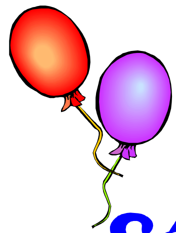
5. How does this lab demonstrate Newton's 2nd law of motion?

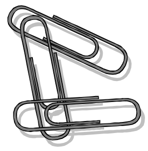
6. How does this lab demonstrate Newton's 3rd law of motion?

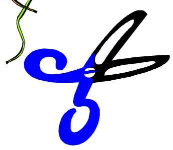
Balloon rockets











Your task

Use the equipment given to make a **balloon rocket**.

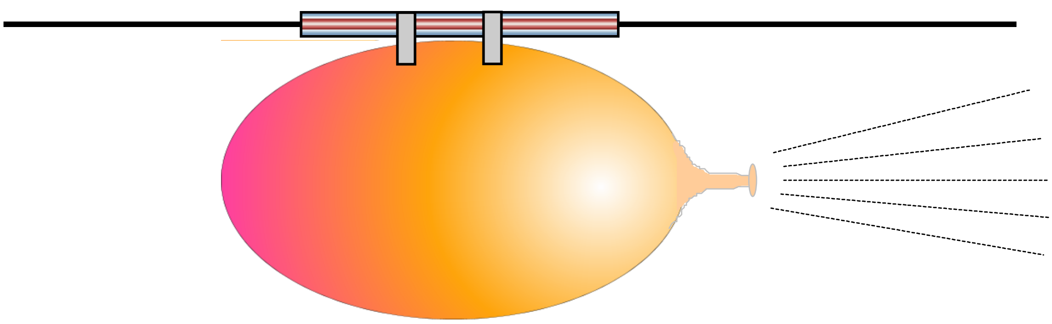
Your rocket should travel **as far as possible** along the string guideline.

Equipment provided

- 1 rocket testing facility (a 2m test string)
- 4 balloons *
- 4 drinking straws *
- 4 paper clips *
- Sellotape *
- Scissors *
- 2 A4 sheets of card

Rules

❶ Use the starred equipment to make a balloon rocket like the one shown below.
Test it on your **rocket testing facility**.



❷ Now use the other bits provided, in any way you want, to make the rocket go further.

Judging

The winner is the rocket that travels **the furthest** (however quickly or slowly).

www.creative-chemistry.org.uk

Teacher Guide for Balloon Rockets

Contents:

Activity notes
Technicians' notes

Activity notes

This is easy and fun. The main problem is how to stop the air coming out of the balloon too fast. This is where the drinking straws and paper clips help. The string must be taut, and free of knots. Nearly all groups will burst some balloons in the building and testing stages, so have some extras handy. We usually make it a timed exercise (how long depends on how they are getting along with the problem). Beware of howls of protest when the students remember it doesn't matter how fast it goes, only how far!

Balloon Rockets

Technicians' notes

Per group of students:

4 x balloons
4 x drinking straws
4 x paper clips
1 x roll of Sellotape
1 x pair of scissors
2 x A4 sheets of card
2m of string

In the lab:

Spare string and balloons

www.creative-chemistry.org.uk

Elizabeth Zewe
GIPSE Poster Assignment 2001

Balloon Rocket Race Track

Can you regulate the speed, direction and distance of a flying balloon?

Background information: This is a great activity to do with 5th through 8th graders before or after covering motion. Students may use an inquiry approach or already have an understanding of measuring motion and familiarity with the following concepts. Older students can work with the formulas.

* Speed is related to time and distance S= D/T
* Velocity is the measurement of an object's speed and direction.
  Change in velocity = $\frac{\text{final velocity - starting velocity}}{\text{time}}$
* Acceleration is a change in velocity
* The relationship between potential and kinetic energy
* The relationship between force, friction, mass, and acceleration. (Newton's Three Laws of Motion)

Students will use inquiry to explore the nature of a speeding balloon on a string track. They will make the track to be used, make predictions, observe events, take measurements, record data, use charts, interpret data, write conclusions from their observations and share their findings.

PA State Standards:

- 3.1.7 B: Applying models to predict specific results and observations
- 3.1.7 E: Describe the effect of making a change on one part of a system on the system as a whole
- 3.2.7 A: Answer "What if" questions based on observation,
- 3.2.7 B: Design controlled experiments, recognize variables, and manipulate variables as well as interpret data and produce solutions
- 3.2.7 C: Identify and use the elements of scientific inquiry to solve a problem and communicate appropriate conclusions from the experiment
- 3.4.7 C: Identify and explain the principles of force and motion in an object based on its position, direction, and speed

- 3.7.7 A: Describe the safe use of tools and techniques to answer questions and solve problems
- 3.7.7 B: Use appropriate instruments to study, measure and record objects

Materials:

student groups of three to four
chairs to tie off the line
scissors
tape
meter sticks or measuring tape
paperclips, small washers
straws
a spool of fishing string per group
goggles
balloons of two sizes ten of each per group
yarn
stopwatches
lab sheet and pencils
scales

- **Remind students to be careful with the scissors, flying and bursting balloons. Goggles are a good precaution against flying materials.**

Follow-up activity and assessments: Students write a paragraph and prepare a short oral report to share their findings with the class. Students can also have a contest where they create a balloon rocket that can travel a given distance or speed set by the teacher.

Lesson Procedure for the Teacher:

Raise student interest:

Inflate a balloon and hold it up for the class. Ask these questions noting student responses:

1. "What will happen if I let go?" Let the balloon fly.

2. "Why did that happen?"

3. Discuss the recent topic of the class, measuring motion or brainstorm ideas.

4. "How can we measure (or make it easier to record) the speed, distance or acceleration of the balloon?" Let the class brainstorm, recording the ideas on the board. Make note of the changing direction of the balloon for the class if they do not.

5. One student should suggest a track of some kind; if not, you hint toward the idea.

6. Tell them that they are about to make a balloon racetrack and pass the lab sheet out. Younger students may need to read it orally as a class; older students read it through then follow procedures.

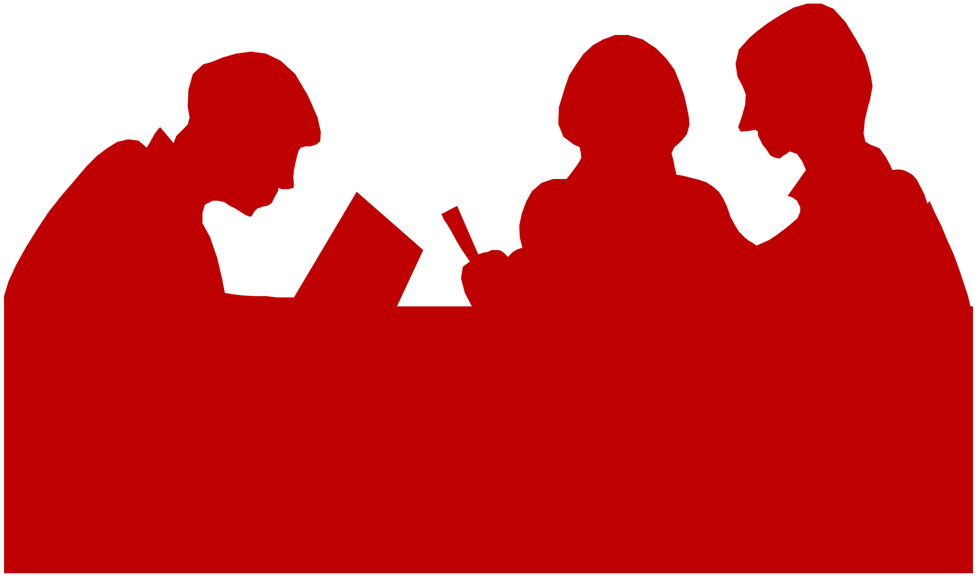
7. As students work, check for cooperative behavior by all members of the groups.

8. Check students' use of safety precautions and appropriate use of lab materials.

9. Give minimal aid to students when necessary. Let them explore and solve the problems that they encounter.

10. The following rubric is a suggestion. Make changes to suite your class and needs. Each item is worth 2pts.

11. If there is time at the close of the lab, have students share their findings. If there is not time, the next day students can share their paragraphs on their findings and attempt to complete the follow-up contest below.



Rubric Outline

Student Will:

1. **Cooperation**:
    - ❖ participate in all the steps of the lab
    - ❖ observe the lab safety procedures
    - ❖ treat the members of his/her group with respect

2. **Measurement:**
    - ❖ use meter sticks to accurately measure length and distance
    - ❖ use a balance to accurately measure masses of small objects

3. **Working track**
    - ❖ construct a balloon car that will travel on the track
    - ❖ construct a track on which the balloon car will travel freely

4. **Changing variable**
    - ❖ create at least three variable changes that will effect the motion of the balloon car

5. **Record observations**
    - ❖ identify changes in the movement of the balloon
    - ❖ enter each new variable and the resulting event

6. **Neat**
    - ❖ complete a legible lab sheet

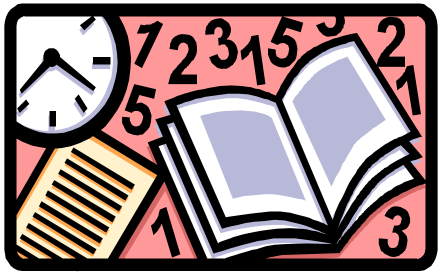
7. **Make Predictions**
   - write predictions on lab sheet

8. **Complete Table**
   - enter data into corresponding section of lab sheet
   - draw accurate diagrams of three different set ups

9. **Interpret data**
   - answer questions using the data collected

10. **Communicates Findings**
    - write a paragraph describing the findings and share with the class

Follow-up activity and alternative assessments: Students write a paragraph and prepare a short oral report to share their findings to the class. Students can also have a contest where they create a balloon rocket that can travel a given distance or speed set by the teacher. Students can also graph various their results and conclusions taken from the data collected.



Scoring Rubric Chart

Student Name	Cooper	Measure	Track	Variable	Observe	Neat	Predict	Table	Interp	Comm	Total

Elizabeth Zewe
GIPSE Poster Assignment 2001

Balloon Race Track

Can you regulate the speed, direction, and distance of a flying balloon?

Name____ Date_____

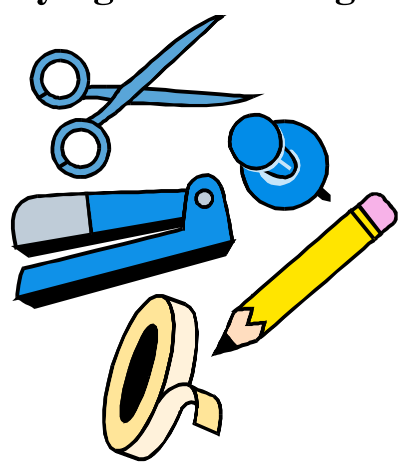
Materials:

student groups of three to four
chairs to tie off line
scissors
scales
paperclips, small washers

a spool of fishing string per group
stopwatches
balloons of two sizes ten of each per group
pencils
meter sticks or measuring tape

straws
tape
goggles

*****Be careful with the scissors, flying and bursting balloons. Wear goggles.**



Procedures:

1. Cut a length of fishing line the length of the classroom. Attach one end of the line to a chair or a table.

2. Inflate the balloon.

3. With tape, attach the balloon under the straw so that the neck of the balloon is parallel to the end of the straw

4. Hold the straw so the neck of the balloon faces you. Thread the free end of the fishing line through the straw.

5. Measure the distance from the end of the balloon to the attached end of the fishing line. Record in meters or centimeters.

6. Inflate the balloon and pinch shut the neck. Hold the free end of the fishing line so it is tight.

7. Release the balloon. Record the time and distance that it travels.

8. Calculate the speed of the balloon and record it in your data table.

9. Now, create at least three different ways to change the movement of the balloon. Record the variable change in your data table. If you have an idea but do not see the supplies needed, ask the teacher.

Draw your new setups below.

Set-up 1 **Set-up 2** **Set-up 3**

Write observations for each trial below

Trial	Strg. lng	Variable chan	Distanc	Time	Speed	

Answer the following questions.

1. What variables did you change on your balloon rocket?

2. Were your predictions accurate? Why or why not?

3. What produced the lowest and the highest speeds?

4. What created the greatest change in the distance traveled?

5. Write a paragraph describing how you changed the speed of your balloon rocket. Include the changing of variables and the effects on speed, mass, acceleration and friction. Be prepared to discuss with the class your data, conclusions, and any abnormal events.

You will be grades on the following. Each number is worth **2 points.**

1. Cooperation
2. Use of measurement
3. Creation of a working track
4. Changing variables
5. Recording data
6. Neatness
7. Completion of table
8. Use complete sentences
9. Making predictions
11. Writing a clear paragraph to share conclusions

Elizabeth Zewe

Answer Key

10. Draw your new setups below.

Setup 1. Setup 2 Setup 3

Answers will vary. Check students art for accuracy

Answers will vary; check student's data for accuracy

Tr	Strg	Varia	Dis	Ti	Sp

Task Analysis: Answer the following questions. Answers will vary.

1. What variables did you change on your balloon rocket?
   Answers will vary. Accept any reasonable effort
2. Were your predictions accurate? Why or why not?
   Answers will vary. **Accept any reasonable answers**
3. What produced the lowest and the highest speeds?
   Answers will vary. Check student answer with data

4. What created the greatest change in the distance traveled?
   Answers will vary. Check student answer with data

5. Write a paragraph describing how you changed the speed of your balloon rocket. Include the changing of variables and the effects on speed, mass, acceleration and friction. Be prepared to discuss with the class your data, conclusions and any abnormal event.
   Answers will vary. Check student's answers for use of collected data and reasonable data analysis.

Elizabeth Zewe
GIPSE Poster Assignment 2001

Forces, Motion, and Energy Unit

<u>Science Insights Exploring Matter and Energy</u>

Scott Foresman - Addison Wesley 1999

Chapter 1: Studying Science
- 1.1 Science Skills and methods
- 1.2 Measuring With Scientific Units
- 1.3 Graphing
- 1.4 Science Tools and Technology
  - Activity 1 how do you make a microbalance?

Chapter 2: Motion and Energy
- 2.1 Motion
- 2.2 Acceleration
- 2.3 Energy of Motion
  - Activity 2 how can you change the speed of a rocket?

Chapter 3: Forces and Motion
- 3.1 Forces, Motion, and Gravity
- 3.2 First Law of Motion
- 3.3 Second Law of Motion
- 3.4 Third Law of Motion
- 3.5 Universal Forces
  - Activity 3 Do heavier objects fall faster than light objects?

Chapter 4 Forces in Fluids
- 4.1 Fluid Pressure
- 4.2 Buoyancy
- 4.3 Forces in Moving Fluids
  - **Enhanced Activity Balloon Rocket Race Track**

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