"Rocket Science 101"

Background

Without the mighty *Saturn V* rockets, there could have been no *Apollo* program and no humans on the Moon. Without the smaller, cheaper *Delta II* rockets, *Mars Global Surveyor*, *Pathfinder*, *Mars Odyssey* and now the MER missions would not have been affordable. Weight, cost, thrust, power... all these are critical to the exploration of our Cosmos. This set of Activities will expose young people to some fundamentals of rocket science, and some key principles of physics.

Simple balloon rockets, for example, offer great opportunities to explore the Laws of Motion. These laws were first expressed by the English scientist, Sir Isaac Newton (1642-1727).

1. 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 an unbalanced force. (I.e., If something is at rest [not moving], it will stay at rest unless something pushes or pulls on it—that is, exerts a force on it. Also, if something is moving in a straight line at a constant speed, it will continue to move that way unless something pushes or pulls on it.)

2. Newton's Second Law

Force is equal to mass times acceleration.

$$\mathbf{F = ma}$$

(I.e., If you push or pull on something, that force can change the object's speed and/or direction. The greater the force, the greater can be the resulting change in the object's speed and/or direction. But, for a given force, you will have less effect on a massive object than a less massive one.)

3. Newton's Third Law

For every action there is always an opposite and equal reaction. (Which translates as: if you push on something, it will "push back" with an equal amount of force)

Newton's Laws applied to the motion of rockets

To summarize, an *unbalanced force* must be exerted for a rocket to lift off from a launch pad or for a spacecraft to change *speed* or *direction* (First Law). The amount of thrust (force) produced by a rocket engine will be determined by the rate at which the mass of the rocket fuel burns and the speed of the gas escaping from the rocket (Second Law) OR if you push or pull on something, that force can change the object's speed and/or direction. The harder you push or pull, the greater the effect! The reaction, or motion, of the rocket is equal to and in the opposite direction to the action, or thrust, from the engine (Third Law).

In its simplest form, a rocket is a chamber enclosing gas under pressure. A small opening at one end of the chamber allows the gas to escape, and by so doing provides a thrust which propels the rocket in the opposite direction. There's a strong similarity between the mightiest rocket and a humble balloon. The air inside a fastened balloon is compressed by the rubber walls. The air pushes back so that inward and outward forces balance: the balloon does not move. When the nozzle is released, air escapes through it in one direction and the balloon is propelled in the opposite direction.

Objectives

- ➢ Participants will explore aspects of Newton's First and Third Laws of Motion.
- ➢ Participants will be able to describe the launch and cruise phases of the MER mission in terms of Newton's First and Third Laws of Motion.
- ➢ Participants will conduct controlled rocketry experiments and analyze the MER mission in terms of the principles of rocketry.

Materials for each team of 3 or 4

- several balloons which, when fully inflated, are 3 to 5 inches in diameter and 1-2 feet long (party time!)
- several plastic drinking straws (milk shake size)
- strong adhesive tape
- nylon fishing line
- stopwatch or timer
- metric measuring tape or meter sticks
- Rocket Science Worksheet (one per participant)

Materials for all participants

- Large printed signs of Newton's Laws of Motion

Vocabulary (use the WORDSEARCH in `Kid's Corner` for an interactive vocabulary game)
acceleration
action/reaction
balanced
force
friction
launch
orbit
payload
rocket

Implementing the activity

Engage
Show participants a video of a rocket or Space Shuttle being launched and continuing up into orbit. (Most NASA mission films will show this. See also `COUNTDOWN TO MARS`, the first "To Mars with MER" program.) Have participants note any changes they observe in the rocket's speed and direction. Allow time for discussion and sharing of personal experiences with real or model rockets and/or launches. Ask them if they think they might ever want to become "rocket scientists."

Explore

Procedure

1. Explain to participants that they are going to become junior flight engineers for NASA, working in small “Rocket Science Teams”, and that their mission is to investigate how rockets work. This will involve some fun experiments with rockets made from balloons and, in the process, testing Newton’s famous “Laws of Motion.” Place Newton’s “Laws of Motion” on a chalkboard or other display medium. This Activity will illustrate two of these laws.
2. Demonstrate the experimental procedure as outlined on Worksheet 1.1.A. Hand out materials, and answer any questions. Then allow the “Rocket Science Teams” time to construct their rockets and complete the experiment, recording data on individual worksheets as well as collecting all the teams’ results on a group data sheet or chalkboard.
3. Discuss the results of the balloon rocket experiments with participants. In particular, ask the following:

- Did all teams obtain the same data? How can they/we explain the differences?
- When did the balloon rockets go the farthest? What caused this? (A greater *unbalanced force* was applied for a longer period of time.) How could they test their ideas?
- Why did the balloon rockets stop? (There was a counter-acting force called *friction* between the string and the straw.)
- If there were no friction between the straw and the nylon string, and no wall in the way, how would the balloon rockets behave? (They would keep accelerating until all the fuel was gone because there would continue to be an unbalanced force on the balloon.)
- If there were no friction between the straw and nylon string, no wall in the way, and no air resistance acting against the deflated shell of the balloon, how would the rockets behave after they ran out of fuel? (They would keep going at the final speed they had when the fuel ran out.)
- Which of Newton’s “Law(s) of Motion” does this activity illustrate and why?

Expand/Adapt/Connect

Research (using print or on-line sources) the Delta II rockets chosen by NASA for recent Mars missions, and for MER. When were these rockets designed and built? Have they been used on other space missions? What are their strengths and limitations?

Suggested URLs