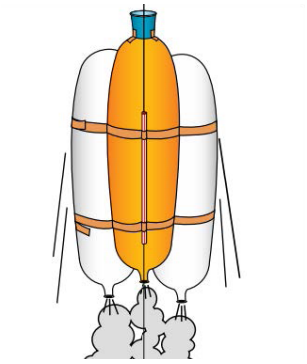
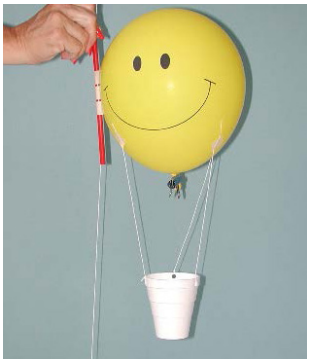
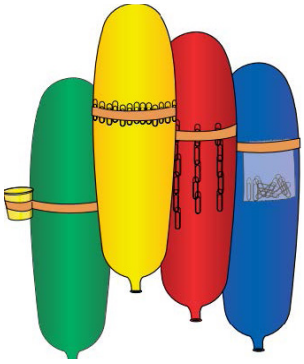
MR. LIFTER: UP WE GO!

USING A "ROCKET" TO LIFT WEIGHT - INSTEAD OF A WING

OBJECTIVE – Students will be able to construct balloon-powered rockets to determine the amount of initial thrust needed to launch the rocket to the classroom ceiling. Students will be able to extend critical thinking and creativity to see if additional weights affect performance and engineer a way to get the greatest payload possible to the classroom ceiling.







NATIONAL STANDARDS –

Next Generation Science Standards (www.nextgenscience.org):

Disciplinary Core Idea Progressions

Physical Science Progression

- PS2.A: Forces and Motion
- PS3.C: Relationship between energy and forces

Crosscutting Concepts

- Systems and system models
- Cause and effect
- Scale, proportion, and quantity
- Stability and change
- Structure and function

Science and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations (for science) and designing solutions (for engineering)

BACKGROUND

Please visit "Make a Balloon Rocket" (https://youtu.be/KMX7zgaLC0w) by SciShow Kids for an idea of how to construct the basic rocket. Note: This rocket in the video travels horizontally and the rocket in this lesson travels vertically.

Heavy lift launchers are a major part of NASA's research program because it is necessary that heavy payloads be lifted into orbit. The payloads include large satellites used for scientific purposes, station module replacements, supplies for the International Space Station, as well as departure stages that help propel spacecraft carrying people to the Moon and Mars. NASA has had many designs for the heavy lift launcher. The Ares V is one that never completely came to fruition, but definitely was at the

forefront of the heavy lifters that we have today (http://www.spacelaunchreport.com/ares5.html).

It is extremely challenging for NASA to launch heavy payloads to orbit. The rockets have to have a massive amount of thrust from powerful engines and lots of propellants. There is definitely a market for commercial space companies to fulfill this need and there will continue to be a need for heavy lifters in the future.

ROCKET SCIENCE 101

Teaching children about the mathematics of gravity

- Please see the **"Rocket Science 101"** insert at the beginning of this publication for rocket background information.

- Depending upon the class, teachers might only want to approach this from Newton's third law, "…for every action there is an equal and opposite reaction."

- For students in the upper grade levels who are ready for it, the **Educational Brief, Microgravity: Fall into Mathematics** may help with some history about gravity. The eight page brief covers the lives of Galileo Galilei, Isaac Newton, and Albert Einstein as well as several mathematical formulae developed covering gravity and microgravity. The NASA brief is located at the following link: https://er.jsc.nasa.gov/seh/Fall_Into_Mathematics.pdf.

MATERIALS

a. Large binder clips (one per "launch zone")
b. Fishing line or smooth string (one per "launch zone")
c. Meter Stick (one per "launch zone" for measuring)
d. 3 Balloons per group (long balloons work better from a party store or look online for balloons labeled 524 or 5" x 24")
e. Masking tape (1 meter)
f. String (1 meter)
g. Two straight drinking straws
h. Small 3 oz bathroom cup (1 per team)
i. Sandwich sized fold-over plastic bag (1 per team: holds materials but can also be used in design. How ever, do not mention use in design. This is part of the creativity element.)
j. Scissors
k. Paper clips (small ones, about 25-30 per group)
l. Balloon hand pumps (optional)

Tips for Management of Lesson

- Prep the classroom by setting up "launch zones" where you have the fishing line already connected to the ceiling. You can easily use binder clips tied to the fishing line to attach the fishing line to the metal frame that supports the ceiling tiles if you have a suspended ceiling. Make sure the fishing line reaches the floor and that you have open space around the "launch zone".
- You can assign teams or tables to a specific "launch zone" to help with the testing traffic.
- Explain how to use the straw as a guide for the rockets before construction begins on the balloon rocket. Show the students that the fishing line is fed through the straw to guide it up the line when the balloon is released.
- Mention that it is extremely important that one person holds the end of the fishing line taut to the floor. If the line has slack, the balloon rocket will not work as efficiently.
- Keep a small supply of replacement balloons. Some will have a small pinhole from the factory. ****Most importantly:** Try not to give too much information to the students. This is a lesson in creativity and problem solving. Explain the challenge and how to use the straw for stability and mention that they can use all or part of the materials provided to them. There are three balloons to use, but only three.

PROCEDURE

1. Show students a balloon and ask if they know what it is called. When they inform you that it is a balloon, tell them that it might look like a balloon, but it is actually a rocket engine.
2. Blow up the balloon and hold it closed. Have the students predict what might happen if you let it go.
3. Release the balloon and talk about the reaction. Facilitate a conversation on why the balloon went out of control around the classroom and how we could possibly harness that release of energy.
4. Discuss how a balloon is like a rocket using the background information provided. Show the video,"Make a Balloon Rocket" (https://youtu.be/KMX7zgaLC0w) from SciShow Kids to give an idea of how a horizontal rocket launch works. Also mention the special class of heavy lifters that NASA is currently looking for from the commercial world.
5. Divide your class into teams of two or three students and explain the design challenge:

   NASA is looking for a new commercial space company to design the next heavy lifter to propel heavy payloads into orbit. Your team is challenged to design and build the most efficient heavy-lift rocket. Each team has received identical parts to construct your rocket. The team that can lift the greatest payload (paper clips) into space (the ceiling) will be declared the winner.

6. Provide each team with an identical kit of building materials (3 balloons, 1 meter of string, 1 meter of masking tape, a 3 oz drinking cup, and 2 straight straws all in a sandwich sized plastic fold-over bag). The materials are not to be touched until after they have sketched their design. Mention that they can use any or all of the materials, but no more will be given to the team. Also, mention that the materials may be manipulated in any way, but they will not be replaced with new materials.
7. Review the launching procedure, including the assigned "launch zone". Mention again how the straw guides the rocket up the fishing line and that it must be held taut to the floor when launched. Remind students that there are only three balloons for each team. The teams can launch as many times as they would like, but each time should improve the amount of paper clips lifted up to "space".
8. Pass out the Student Data Sheet and have students follow the Engineering Design Process to sketch and build

their heavy lifter rocket as well as record data during the testing process. Make sure to remind them that they will not be able to touch materials or build until a sketch has been created.

9. Be sure to set a limit for the amount of time for the building and testing. Once the testing has ended, bring the class back together for a conclusion discussion.

10. Engage the class in the following conversations from NASA's Heavy Lifting Lesson (Rocket Heavy Lifting):

a. Why is NASA so supportive of commercial space companies?

- NASA's space efforts are aimed at expanding our horizons in space. Although their space rockets are easily capable of launching communications, weather, and Earth resources satellites, NASA continually looks beyond. NASA explores, and when it pioneers a new technology, it seeks to turn over continued development to U.S.commercial interests. That way, NASA can focus on and advance to the next new horizon. NASA's current new horizons include the first permanent bases on the Moon and the first human expeditions to Mars. These are demanding challenges. When they are met, commercial space companies will follow, permitting NASA to move on to even greater challenges.

b. Why is it so important to construct efficient heavy-lift vehicles?

- Traveling into space is a very difficult and expensive endeavor. Huge rockets and tremendous amounts of propellants are required to accomplish the job. With some rockets, launch costs were approximately $20,000 per kilogram of payload delivered into Earth's orbit. If that cost were to continue, imagine staying at a space hotel where it would cost about $10,000 for a half liter bottle of drinking water! Improving heavy-lift rockets (lighter rocket structures, more propellant efficient engines, etc.) will enable us to accomplish much more in space at far more reasonable costs!

11. Allow time for students to share their designs and discoveries. Consider having a showcase of rockets!
a. Have each team describe their design to the class. How many balloons did they use? How many paper clips did their rocket carry to the ceiling? How did they attach the paper clips to the balloon? What problems did they encounter? How did they solve those problems?

MR. LIFTER

Engineering Design Process Student Data Sheet

Name _____ Date _____

Ask: How can you design a Heavy Lift Launch Vehicle that can carry a payload (paper clips) to space (the ceiling) with the supplies that you are given?

_____

_____

_____

Imagine: From the supplies given, what could you use to hold paper clips?

_____

_____

Plan: Sketch your idea for how to build the launch vehicle below. Make sure to label the materials.

Create and **Experiment**: Collaborate with your team and build the launch vehicle. Experiment using the chart below. Measure and record the distance Mr. Lifter travels when you add the following payload.

1 paper clip	_____	cm
3 paper clips	_____	cm
5 paper clips	_____	cm
7 paper clips	_____	cm

Improve: How could you innovate your original design to carry more mass?

_____

_____

Before continuing to the next step of the Mr. Lifter Design Challenge write a brief summary of your launch vehicle using correct science and technology terms (e.g., lift, payload, mass, thrust).

_____

_____

******Continue onto the reverse side of the paper for the "Mr. Lifter Rocket Mission Report".**

MR. LIFTER
ROCKET MISSION REPORT

Team Member Names:

_____

_____

_____

_____

_____

Flight Test	Predict How Much Mass Your Rocket Will Lift 1 Paper Clip = 2g	Actual Mass Lifted
1.		
2.		
3.		
4.		
5.		

Make a sketch of your best rocket

Describe your first rocket.

_____

_____

_____

_____

How did you change your rocket to make it carry more mass?

_____

_____

_____

_____

What other ways could you change your rocket to improve it?

_____

_____

_____

_____