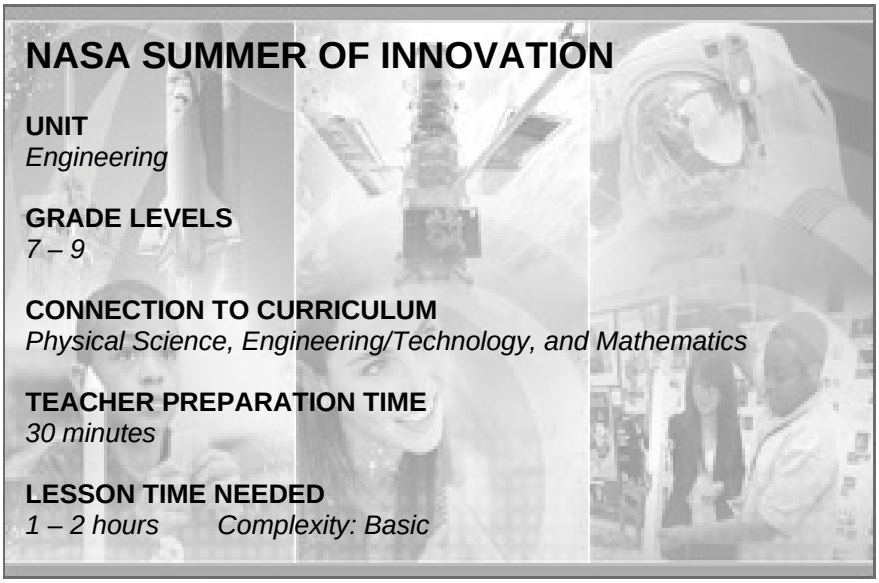
Heavy Lifting Air Engines

LESSON DESCRIPTION
Students use balloons to demonstrate concepts applied by jet and rocket engines to supply thrust for movement.

OBJECTIVES
Students will
• Observe how unequal pressure creates power
• Explain that air power can help airplanes fly
• Construct a working model of an air engine
• Construct balloon-powered rockets to launch the greatest payload possible to the classroom ceiling



NASA SUMMER OF INNOVATION

UNIT
Engineering

GRADE LEVELS
7 – 9

CONNECTION TO CURRICULUM
Physical Science, Engineering/Technology, and Mathematics

TEACHER PREPARATION TIME
30 minutes

LESSON TIME NEEDED
1 – 2 hours *Complexity: Basic*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
•Abilities necessary to do scientific inquiry
Physical Science
•Position and motion of objects
•Motions and forces
Science and Technology
•Abilities of technological design

Principles and Standards for School Mathematics (NCTM)
•Math as Problem Solving
•Measurement
•Number and Operations
•Data Analysis and Probability
• Reasoning and Proof
•Communication
•Connections
•Representations

National Technology Standards (ITEA)
•Creativity and Innovation
•Research and Information Fluency
•Critical Thinking, Problem Solving, and Decision Making

MANAGEMENT

These are simple activities with minimal setup and background requirements. The teacher will need to divide the students into working teams and supply each with a set of materials. A fishing line test track will need to be strung across the room on which to "fly" the balloon air engines. To slip the fishing line through the straw each time the teacher may wish to devise a clipping system so there is no need to tie off or continue to hold the string with each test.

Air Engines serves as an introductory activity to Heavy Lifting, which requires a vertical track from floor to ceiling.

Vectoring requires a cardstock duplication of an F–15 aircraft from page 56 of the Exploring the Extreme Educators Guide.

MATERIALS

- Large binder clips (one per launch pad)
- Fishing line or smooth string
- Long balloons (see note on next page about sources)
- Bathroom size (3 ounce) paper cup
- 2 straight drinking straws
- 50 small paper clips
- Sandwich size plastic bag
- Masking tape
- Balloon hand pumps (optional)
- Wooden spring-type clothespins (optional)

Vectoring

- One 8- by- 10-inch F–15 ACTIVE template on page 56, photocopied on cardstock, 1 per student
- 1 balloon per student
- 1 flex-neck bendable plastic straw
- 1 small rubberband per student
- 1 pair of scissors per student
- Tape
- Three 8-inch pieces of string per student
- One copy of the Student Work Sheet per student
  Instructions and Student Worksheet

CONTENT RESEARCH

This activity simply demonstrates laws of motion and imbalanced forces.

> Newton's first law states that every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force. This is normally taken as the definition of inertia.
>
> The second law explains how the velocity of an object changes when it is subjected to an external force. The law defines a force to be equal to change in momentum (mass times velocity) per change in time. For an object with a constant mass **m**, the second law states that the force **F** is the product of an object's mass and its acceleration **a**:
>
> $$F = m * a$$
>
> The third law states that for every action (force) in nature there is an equal and opposite reaction.

Once the balloon is filled with air, there is a difference in air pressure between the outside and the inside of the balloon. The inside of the balloon has higher pressure than the outside of the balloon. The air on the inside of the balloon equalizes with the air on the outside of the balloon when the balloon is released. Energy is generated as air equalizes from high pressure areas to low pressure areas.

LESSON ACTIVITIES

Air Engines: The students will use an inflated balloon to exert the forces to propel it down a fishing line test track. Long narrow balloons (not the type used for "balloon animals") are preferred.
Vectoring: Students will use the concepts from Air Engines and apply vectoring or directional steering of the air that leaves the balloon using a bendable straw.
Heavy Lifting: As the track shifts to a vertical lift, the second law of motion becomes more apparent as added mass requires more force or thrust to create the same acceleration and/or distance traveled. Students add weight to their balloon rocket and make adjustments to their design to lift the greatest amount of weight at the greatest distance.
While paper clips are approximately a gram weight, if scales are available with small mass increments an added skill of measurement and quantifying your results is added to the outcomes.

RELATED RESOURCES
Air Engines:
http://www.nasa.gov/pdf/205700main_Air_Engines.pdf
NASA Educators Aeronautics Guide:
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Aeronautics.html
NASA Rocket Guide—Heavy Lifting:
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Heavy_Lifting.html
Exploring the Extreme Guide:
http://www.nasa.gov/pdf/62553main_Exploring.the.Extreme.Guide.pdf
Making Future Commercial Aircraft Quieter:
http://www.nasa.gov/centers/glenn/about/fs03grc.html
Glenn Research Center "Newton's Laws":
http://www.grc.nasa.gov/WWW/K-12/airplane/newton.html

DISCUSSION QUESTIONS
1. Why does the balloon and straw move along the fishing line? *The escaping air creates an imbalance force with a reacting motion in the opposite direction.*
2. Are there ways that you might control the flight of the balloon without a guiding line? *Consider design modifications that control the flow of air out and along the balloon's structure.*
3. The first activity runs the balloon and straw horizontally. How did you change your design to run it vertically?
    a. What is required as you add a payload and increase the mass to be lifted by the flight? *Answers will vary. Distribution of the mass, the amount of force required to lift the additional mass, etc.*
4. Elaborate on your designs to create a means of adding multiple balloon engines and staging the engines to add distance or thrust. *Answers will vary.*

ASSESSMENT ACTIVITIES
Air Engines: The teacher will establish task accomplishment criteria for which mission is accomplished or not. There should be observations made during the process to empower the students to make changes to their designs to become successful at some level. Criteria such as distance traveled (vertically or horizontally), the amount of mass transported, time related to the speed of the balloon ($R = {}^{D}/_{T}$), etc.

ENRICHMENT
Added extensions that may or may not be easily accomplished should be related to the extremes of the outcomes for the regular missions. Qualities of flight may be identified related to the criteria: steady flight, spiraling flight, and lifting the greatest mass of payload or comparing the mass of the payload to the mass of the engines used to lift the payload.