



## Jet Propulsion

### LESSON THEME

To build a model to demonstrate how thrust is created in a jet engine

### OBJECTIVES

Students will

- Investigate how thrust is created in a jet engine
- Design a model jet engine
- Construct a model jet engine from materials provided
- Observe how their model jet engine operates

## NASA SUMMER OF INNOVATION

### UNIT

*Physical Science—Aeronautics*

### GRADE LEVELS

4 – 6

### CONNECTION TO CURRICULUM

*Science, Mathematics, and Technology*

### TEACHER PREPARATION TIME

2 hours

### LESSON TIME NEEDED

2 hours

*Complexity : Advanced*

## NATIONAL STANDARDS

### National Science Education Standards (NSTA)

#### *Science as Inquiry*

- Understanding of scientific concepts
- An appreciation of “how we know” what we know in science
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

#### *Physical Science Standards*

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

#### *Science and Technology Standards*

- Abilities of technological design
- Understanding about science and technology

#### *History and Nature of Science Standards*

- Science as a human endeavor

### Common Core State Standards for Mathematics (NCTM)

#### *Operations and Algebraic Thinking*

- Use the four operations with whole numbers to solve problems
- Generate and analyze patterns

#### *Operations and Algebraic Thinking*

- Analyze patterns and relationships
- Write and interpret numerical expressions
- Analyze patterns and relationships

### ISTE NETS Performance Indicators for Students (ISTE)

#### *Creativity and Innovation*

- Create original works as a means of personal or group expression
- Use models and simulations to explore complex systems and issues

#### *Communication and Collaboration*

- Contribute to project teams to produce original works or solve problems

#### *Research and Information Fluency*

## MANAGEMENT

Student data sheet, Part 1, is out of date and needs to state the scientific method. Each station can have a separate data sheet with a student data table listing independent variables and the dependent variable and contain a table for data collection. Then have students compute the range, mean, and median distances of each jet engine test. Graph, plotting averaged numerical data, and make a picture representation (line graph).

Stations need the following:

- Intake Station has one fan. Include instructions on how to build a simple anemometer device used to measure wind speed in m/s units.
- Compression Station has one and two fans. Fan speed is an independent variable (low, medium, and high). Include instructions on how to build a simple anemometer device used to measure wind speed in m/s units.
- Combustion Station can have different-size balloons. Measure the circumference of each inflated balloon, and calculate expansion of air (volume).

## CONTENT RESEARCH

### Key Concepts:

- Parts of a Jet Engine (Jet engines come in a variety of shapes and sized with the specifics usually dictated by the speed of the aircraft.)
  - Engine: The engine is the part of the aircraft that provides the power for takeoff and landing and sustains flight.
  - Air intake (intake): This is the front section of a jet engine that brings free-stream air into the engine.
  - Compressor: The compressor is made with many rotary blades attached to a shaft. The blades spin at high speed and compress or squeeze the air before it enters the combustion section.
  - Fuel line (burner or combustion section): The compressed air is then sprayed with fuel, an electric spark lights the mixture, and the burning gases expand.
  - Turbine: The gases produced in the combustion chamber move through the turbine and spin its blades. The turbines are linked by a shaft to turn the blades in the compressor.
  - Nozzle(s): The rear section of a jet engine tailpipe through which the exhaust gases escape.

### Misconceptions:

A jet engine is an air-breathing engine. It will not operate in the vacuum of space. A rocket engine is not an air breathing engine. A rocket carries oxygen into space by burning fuel through combustion (or burning). A liquid propulsion rocket engine has a fuel tank and oxygen tank (oxidizer). A solid propulsion rocket engine has solid propellant that is a mixture of fuel and oxidizer.

## MATERIALS

### Part 1

#### Intake Station

- Small desk fan
- One sheet of paper
- Intake Station Directions

#### Compression Station

- Butcher paper
- Two desk fans that are the same size
- Twenty 6-inch lengths of string
- Twenty 5-by-7-inch index cards
- Tape
- Two markers
- Compression Station Directions

#### Combustion Station

- Flask, medium size
- Balloon
- Can of Sterno, Matches, or lighter
- Tongs
- Combustion Station Directions

### Part 2

- One cardboard paper towel core per student
- One flexible straw per student
- One 12-by-12-inch sheet of aluminum foil per student
- Four paper circles 1-1/2 inches in diameter per student
- One small (1-inch) paper clip per student
- One 3-oz. paper cup per student
- One pair of scissors per student
- Tape
- Glue (not glue sticks)
- One copy of the Student Work Sheet Part 2 for each student

## LESSON ACTIVITIES

Have students complete data sheets that apply the Scientific Method. At each station students should

- Describe the experiment (Research Question)
- Predict what will happen before doing the experiment (Hypothesis)
- Conduct the experiment (Experiment)
- Record your observations (Data Collection)

Option: The teacher demonstration of an operational jet engine can be done using inexpensive, locally obtained, recycled materials.

[http://www.nasa.gov/pdf/382712main\\_ETE\\_Lesson\\_1\\_Jet\\_Propulsion.pdf](http://www.nasa.gov/pdf/382712main_ETE_Lesson_1_Jet_Propulsion.pdf)

## ADDITIONAL RESOURCES

The Beginner's Guide to Aeronautics Homepage

<http://www.grc.nasa.gov/WWW/K-12/airplane/index.html>

Airplane parts—turbine engines

<http://www.grc.nasa.gov/WWW/K-12/airplane/turbine.html>

Beginners Guide to Propulsion

<http://www.grc.nasa.gov/WWW/K-12/airplane/bgp.html>

Fact sheets and interactive jet engine simulator

<http://www.grc.nasa.gov/WWW/K-12/airplane/ngnsim.html>

The Courage to Soar Educator Guide

[http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The\\_Courage\\_to\\_Soar.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Courage_to_Soar.html)

Aeronautics Educator Guide

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Aeronautics.html>

- Air Engine activity

## DISCUSSION QUESTIONS

- What did you observe at station 1 with the paper and the fan? Did this match your prediction? *The paper that is held in front is blown away from the fan. The paper held in the back is sucked in towards the fan.*
- What was your prediction for what would happen if the air had been moving into the front fan instead of being still? What actually happened? *The air speed increases when the air behind the fan is blown into the fan rather than being still.*
- What happened to the balloon at station 3? Why do you think this happened? What would happen if the air was enclosed in a tube that didn't expand instead of inside a balloon? *The balloon inflated because the air inside was heated. Heated air expands. If this had taken place in a tube, the air would have been forced out the end of the tube.*
- All these stations demonstrate the processes that take place inside the various parts of a jet engine. In what order do you think they take place? Why? *The proper order of the stations is intake, compression, and combustion. There is an additional step of using a turbine to move the air out of the engine. This was not demonstrated. According to one NASA engineer, a shorthand way to remember the steps is "suck, squeeze, burn, and blow."*
- Describe the function of each part of the jet engine and state the scientific concepts that occur.
  - *Air inlet (also intake): The air intake brings ambient or outside air into the engine. The compression section moves the air through a series of fans that compress, or squeeze, the air causing it to increase in speed. The combustion section heats the air by burning fuel. This causes the air to expand very rapidly and significantly increases its speed again. Finally, the turbine forces the heated, expanding air out the back of the engine, creating thrust.*
  - *Compressor: The compression section moves the air through a series of fans that compress, or squeeze, the air causing it to increase in speed.*

- *Fuel line: The combustion section has fuel lines that supplies fuel that is sprayed into the airstream. The air is mixed with fuel and then ignited. The burning fuel heats the air producing hot expanding gases.*
- *Turbine: The turbine forces the heated, expanding air out the back of the engine, creating thrust.*
- *Jet nozzle: The jet nozzle is the exhaust duct of the jet engine. This is the jet engine part which actually produces the thrust.*

### **ASSESSMENT ACTIVITIES**

- Conduct a class discussion where students share their findings about how a jet engine works.
- Assess the Jet Propulsion Work Sheet that describes the function of each part of the jet engine.
- Using their jet engine model, take a blank sheet of paper and draw a jet engine cross section and then describe the function of each part.

### **ENRICHMENT**

“How does a jet engine work?” Web site

<http://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/engines.html#enginework>

This Web site contains

- How a Jet Engine Works video
- History of the jet engine
- Parts of a jet engine
- Types of jet engines