Lesson 1: YOU’RE PILOTING A PLANE!

► Begin the presentation with “Lesson 1: You’re Piloting a Plane!”

Introduce yourself and the program. A suggested personal introduction:

“Hello, my name is ________________ , and I am a ________________ (position title) at Aerojet Rocketdyne. I will be visiting your class once every month to speak to you about space exploration and space travel. We will learn about the basics of aerodynamics, rocket propulsion, and spaceflight to the space station, the moon, and future missions to Mars!”

► Tell the students that in the coming months you (or another volunteer) will not only be discussing with them the scientific principles that govern space flight, but will perform some simple experiments with them to demonstrate these principles.
■ While addressing historical developments that led to flight as we know it today, this lesson introduces students to scientific principles of flight. Various activities help reinforce students’ understanding of these principles and the associated engineering designs allowing for manned flight. Optional experiments, found at the end of this lesson plan, provide extra opportunities for older students to develop their knowledge of flight principles.

MATERIALS NEEDED

• DVD/Presentation
• Projector screen/TV
• Vocabulary List
• Pre-made (preferably pre-tested) paper airplanes
• 2”x8” strip of paper

► See lesson to assess total equipment needs.

LESSON OUTLINE (NOTE: total time of videos is almost 4 minutes)

Introduction
Lesson Concepts
Vocabulary
Flight: History and Overview
• Flight is Natural
• Paper Flying Machines
• History of Flight
• Modern Airplane Wing
• Aerojet Rocketdyne JATO
Applying What We Have Learned
Let’s Review
Experiments

INTRODUCTION

For centuries people have wondered exactly what it takes to fly. While modern flight technologies, such as airplanes and rockets, have existed for barely 100 years, people have been thinking about flight throughout history. Famed artist Leonardo Da Vinci designed flying machines that drew upon principles of flight nearly 500 years ago! Da Vinci is so important to flight history that
part of the International Space Station is named after him!

LESSON CONCEPTS

- The properties of air and vacuum
- Principles of lift

VOCABULARY

Dense: Mass packed tightly together
Density: The ratio of an object's mass compared to volume
Drag: Backward force of flight
Gravity: The force that tends to draw all bodies together
Force: Causes an object to alter its movement
Lift: Upward force of flight
Mass: The amount of matter in a body
Thrust: Forward force of flight
Vacuum: A volume of space that is essentially empty of matter
Volume: A three-dimensional space
Weight: Downward force of flight

► Ask students what they already know about flight and airplanes or other relevant topics. Here are some questions you might ask:

- Have you ever flown on a jet airplane?
- What types of things or creatures are able to fly?

FLIGHT HISTORY AND OVERVIEW

Flight is Natural

People have always been interested in flying. There seems to be a lot of freedom and joy in
flying. Wings by themselves cannot make a person fly. The muscles used to flap wings must be strong enough to really lift a body into the air. The heavier the animal, the stronger the muscles have to be to fly. No human being can lift his or her weight by using his or her muscles to flap wings.

**Paper Flying Machine**

There are several types of paper flying machines or airplanes.

♦ **Paper Airplane Experiment**

**Experiment Concepts**
Observing how the shape and velocity of a paper airplane affects its flight pattern

**Experiment Materials**
- 5 pre-tested paper airplanes

**Experiment Instructions**
1. Ask students what they notice about different paper airplanes. Do they all fly the same, or do they fly differently?
2. Bring out the pre-made paper airplanes. Ask for five volunteers. Give one plane to each volunteer and instruct them to hold onto the plane until you tell them to fly it. Instruct them how to fly each one.
   a. Easy Glider (Nakamura Lock): Throw lightly and straight ahead. Could also throw at an up angle
   b. Stunt Show (Swashbuckler): Throw a little harder, but not too hard. Throw at an up or down angle.
   c. Dart (Headhunter): Throw fast and straight. (Try to pick a target and hit it across the room – not another student.)
   d. Cruiser (Space Cruiser): Hold plane on the back like you’re doing a sock puppet. Push the plane slowly at any angle.
   e. Vortex (Hurricane): Hold like a football with pointer finger on the back edge. Throw it like a football and try to get a little flick with your finger at the end.
3. Before letting them launch, ask for predictions. Make them justify their predictions with specific observations. Instruct all students to pay close attention to the way each of the planes fly. Launch each plane one by one (wait until one lands/crashes until you move to the next one). When they are all done, have a class discussion about how they flew differently and why they flew differently.

Tell the story of Icarus and Daedalus. Ask the students whether they think they could fly like Icarus. Why? Why not?

One of the most famous flying stories is over 2,500 years old and originated in ancient Greece! Icarus and his father, Daedalus, an inventor, were imprisoned on an island near Crete. With no boat to leave the island, Daedalus decided to build wings for himself and for his son. Using light wood, he built the skeleton of a wing, covered it in wax, and covered the wax with feathers. He and Icarus used these wings to rise into the air and fly away from the island. Daedalus reached land about 500 miles away, but Icarus, enjoying his ability to fly, soared too high. Approaching the sun, he found the heat melting the wax. The feathers on his wings loosened, fell off, and then Icarus fell to his death.

Can You Fly? Experiment

Experiment Concepts
- Gravity
- Force
- Mass

Experiment Instructions
1. If room and class size allow, instruct students to stand up.
2. If you are speaking to a larger crowd, students can stay seated and do this exercise.
3. Explain to them that you are conducting a very “important” experiment.
4. Proceed to ask students to flap their arms like wings, to try to fly.
5. This is a great exercise to get kids moving and aware of their surroundings before other experiments begin.

Experiment Explanation
Gravity keeps humans on the ground and causes objects to fall to the ground. But when birds, bats, and insects beat their wings against the air to fly, they don’t fall! Having wings alone can’t make a person, or even a bird, fly. What counts is the amount of power generated by the muscles used to flap wings. The larger the mass of the animal, the stronger the muscles must be to allow it to fly. Humans have neither wings nor strong muscles to lift us into the air. Most animals that have wings have the muscles necessary to lift themselves into the air. Others do not, like penguins or chickens. Man made objects that have wings, like airplanes, need some sort of engine to get into the air. What do you suppose helps get these objects into the air? What sort of “muscles” or force do airplanes use?

The First Plane Flight

Sir George Cayley, an Englishman, was responsible for the very first human flight in a plane-shaped craft - a glider. He designed the glider in 1799 and built it in 1849. Sir George Cayley asked a local ten year-old boy to fly the three-winged glider for him. The gliding machine carried the boy aloft on at least one short flight.

The Beginning of Powered Flight – The Wright Brothers

The first primitive airplane was flown by the Wright brothers in 1903. A gasoline engine with a propeller attached pushed rapidly moving air over the airplane’s two wings and provided both the forward thrust and rapidly moving air flow over the airplane wings, providing the lift needed to get
Wright Flyer 1 into the air. Advanced versions of the Wright Flyer eventually allowed for flights of up to one-half hour. From this modest early beginning, we have developed airplanes that can carry hundreds of people, at speeds over 500 miles per hour, half way around the world without refueling!

► Talk to the students about the Wright brothers and their accomplishment. Ask the students if they know how their airplane generates the lift to get off the ground.

► Show video about early flight attempts.

♦ How an Airplane Wing Provides Lift Experiment

Experiment Concepts
- Wing principle

Experiment Materials
- 2 x 8 inch strip of paper for each student

Experiment Instructions
1. Hold the paper between your thumb and forefinger.
2. Blow gently over the paper.
3. Ask students to observe what happens.

Experiment Explanation
The paper is surrounded by air pressing equally on all surfaces. Since the pressure is equal on all surfaces of the paper, the pressure does not tend to cause the paper to move. Gravity pulls the paper strip toward the Earth. When you blow over the top of the paper, the rapidly moving air creates a low pressure area on top of the paper. The relatively higher air pressure below the paper forces the paper up, just as higher air pressure under an airplane wing forces the airplane wing up.

Airplane Styles
Throughout history, people have invented machines to help them fly. Some common examples are shown here – older military, planes that land on water, new and increased speed military planes and even residential planes.

Modern Airplane Wing

► Talk to the students about the Modern Airplane Wing picture. Ask them to come up with observations about the wing and discuss their observations.

► Talk about how the Airflow works around the wing.
All things that fly need air. Air has the power to push/pull on birds, balloons, kites, planes, etc. Airplanes need both wings and air to fly. On an airplane, the wings are shaped to move the air faster over the top of the wing. When air moves faster, the air pressure decreases - the pressure above is less than the pressure below. The difference in pressure creates a force on the wing that lifts it up.

▶ Talk about the forces of flight: Lift, Drag, Weight and Thrust.

Aircraft Carriers
The airplanes on a carrier need to get into the air quickly because there is very little space to take off.

▶ Ask the students how the airplanes get up to speed and if there are other ways they can think of that accomplish that same goal of providing thrust needed to help a plane take off quickly.

▶ Talk about JATO as one way to solve that issue.
Aerojet-General Corporation began by making Jet-Assisted Takeoff (JATO) rockets in World War II (August 16, 1941). JATO rockets provided an extra boost for aircraft taking off from short runways. The rockets used tar-based propellant. These rockets usually were attached to the airplane and were used to burn just once.

► Show video of JATO Launch.

So at Aerojet Rocketdyne we make rockets for all kinds of things, including airplanes. We have talked about one goal for jet propulsion on an airplane.

► Ask the students to think of any other reasons why jet propulsion might be useful for airplanes. Show slide and video of F-22 takeoff.
Aerojet Rocketdyne provided the one piece monolithic F22 Boom Structures on this F22 Raptor. These titanium one piece welded structures attach the leading wing to the body of the airplane. The F22 Raptor’s role was a stealth air superiority fighter.

**Show the video about the Sound Barrier.**

Breaking the sound barrier is a precise moment which has high concentrations of Stress Loads on the airplane. In the early days, folks thought the planes would break apart when they hit the Sounds limit. US Air Force Captain, Chuck Yeager, proved that theory wrong on October 14, 1947.

**LET’S REVIEW**
QUIZ THE TEACHER (Q & A)

► Hand out index cards to the class and ask them to write down three things they learned today about airplanes and flight.

► Have them name a few things that engineers can improve upon to get different results (such as smoother flights, take off sooner).

► If you and your teacher have set a meeting for the next presentation, let students know what they will be exploring next session:

“Today we learned how airplanes fly and how we can make them better using things like rockets. In the next session, ‘You’re Launching a Rocket!’ your class will learn about the planning, science, and preparation that go into building and launching rockets for space missions.”

► Thank class.

♦ ADDITIONAL EXPERIMENTS (time-permitting):

♦ Floating Rocks Experiment

Experiment Concepts

• Density

Experiment Materials

• Clear bowl (filled with water)
• Small piece of wood
• Pumice rock

Experiment Instructions

1. Show the class the pumice stone and the piece of wood.
2. Take a class survey: Will each object float or sink?
3. Hand objects to volunteer and ask the student to drop the piece of wood into a bowl of water.
4. Ask how many students were right about the wood piece.
5. Ask volunteer to drop the pumice stone into the water.
6. Ask how many students were right about the pumice stone.

Experiment Explanation

The reason the pumice floats is because of density. Because volcanic pumice is so much less dense than ordinary rock, it floats. Ask students, which would weigh more, a pound of lead or a pound of feathers. If students understand the concept of density, they will answer that both objects weight the same, lead just occupies less volume.
♦ **Popcorn(y) Science I Experiment**

**Experiment Concepts**
- **Density**

**Experiment Materials**
- Clear bowl of water
- 1 cup uncooked popcorn kernels
- 1 cup cooked popcorn

**Experiment Instructions**
1. Drop the uncooked popcorn in the bowl and allow students to watch popcorn sink.
2. Ask students what happened to the popcorn and why.
3. Explain that you are dropping a similar amount of popcorn into the bowl; the only difference is that it is cooked.
4. Allow students to take guesses as to what will happen.
5. Drop cooked popcorn into the bowl.
6. Lead students through a discussion about what just happened in the activity.

**Experiment Explanation**
The popcorn's density changed, allowing the cooked popcorn to float while the uncooked popcorn sinks. Ask students about the relationship between size and density.

♦ **Popcorn(y) Science II Experiment**

**Experiment Concepts**
- **Density**

**Experiment Materials**
- Popcorn popper
- Uncooked popcorn
- Oil
- Scale
- Measuring cup

**Experiment Instructions**
1. Have a volunteer carefully measure and record the amount and weight of popcorn that is put into the popper.
2. While you talk about density, let the popcorn pop.
3. When finished, have a volunteer carefully measure and record the weight and the volume of the popcorn.
4. At the end of the experiment, share popcorn with the class.

**Experiment Explanation**
Ask the class the following questions to guide them through a discussion about the relationship between density and weight.

- Has the total weight changed? (No)
- Has the total volume changed? (Yes)
- What do you notice?

♦ **Spin-a-Round Experiment**

**Experiment Concepts**
- Gravity

**Experiment Materials**
- 1 large glass jar
- 1 small rubber ball

**Experiment Instructions**
1. Place the ball on top of the table, and then place the jar over the ball so that the ball is inside the mouth of the canning jar.
2. Start spinning the jar around in a circular motion (keeping it on the table).
3. Once the ball starts spinning inside the jar lift it from the table top. The ball is lifted from the table and will continue to spin inside the jar until it loses its speed.

**Experiment Explanation**
This works because the ball spinning inside the jar is trying to escape, but the jar itself forces the ball to stay inside the wall of the jar. Due to the force of the spin or speed, the ball will continue to spin until it loses its speed and gravity will pull it back to earth and the ball will fall from the jar.

♦ **Full of Hot Air Experiment**

**Experiment Concepts**
- Density
- Volume

**Experiment Materials**
- Large dry cleaner’s bag
- Hot air gun (hair dryer)
- Tape

**Experiment Instructions**
1. Have a helper hold the bag open while you blow hot air into the bag. (Be careful not to melt the bag). As the air in the bag heats up, it will start to lift on its own.
2. Hold the bag by the opening until the air in it is good and warm — then release it. It should rise up to the ceiling and float for several seconds.
3. While the bag may tip over and spill the air out, you can prevent this by placing a few strips of
tape around the opening of the bag to weight the open end down.

**Experiment Explanation**

Heating a gas reduces its density. Heating the air increases the energy of the gas molecules. This causes the molecules to vibrate more so that each one takes up more space. Since you can fit fewer molecules in a given volume, the density of the gas is decreased. When you heat the air in a balloon, you decrease its density relative to the cool air around the outside of the balloon. This difference in density causes the balloon to want to float up through the dense cold air.