

Power to Fly

**Session Time:** 5, 45-minute sessions

Lesson Summary

In this lesson students will explore the four forces of flight and explain how the different types of engines help aircraft to stay in the air.

Lesson Standards

NGSS

- MS-ETS1-1

ITEEA

- STEL-2N
- STEL-2R

Learner Goals

The learner will:

- Explain how energy can be used to do work, using many processes.
- Define power systems used to drive and provide propulsion to other technological products and systems.
- Explain the relationship between the power source and the other parts of a vehicle and how the vehicle interacts with the environment.

Teacher Background

There are four forces that work on an airplane when it is in flight. These are lift, gravity (expressed as weight), thrust and drag. Lift is produced by a combination of Bernoulli's principle and Newton's third Law of Gravity. Newton's Third Law states that for every reaction there is an equal and opposite reaction. Therefore, as the wing pushes air downward an upward reaction force (lift) is created. At the same time, Bernoulli's principle which states that an increase in speed of a fluid (air) causes a decrease in pressure is in effect. The shape of the wing and the angle of attack cause air to move faster over the top surface, decreasing pressure and contributing to lift.

Misconceptions

- **Mass and weight are the same thing.**
 - Correction: Mass is the amount of material in an object and weight is the force of gravity on an object. The further you go from the center of an object (ex. Earth), the less the force of gravity. However, on Earth, that change is minimal. As you move into space then the impact of gravity is less. A common example given is that the moon is $1/6^{\text{th}}$ the size of the earth, therefore its pull of gravity is only $1/6^{\text{th}}$ of that of Earth. Therefore, if you weighed 120 pounds on Earth, you would weigh 20 pounds on the Moon, but your mass would be the same.

Vocabulary

Drag – force caused by air; it acts in the opposite direction to an object moving through the air; created by all parts of the airplane.

Lift – created by an object (such as wings) moving through the air (or other fluid)

Gravity – the force that pulls objects towards the ground (center of the Earth).

Thrust – the forward force which pushes the airplane through the air. It is used to overcome the drag and is generated by the engines.

Weight – the force of gravity on an object.

Lesson Preparation

Materials: Teacher

- Power to Fly Presentation
- Computer
- Projector
- Video Link: [Flight Failures](#)
- Video Link: [Forces of Flight](#)
- Video Link: [Aircraft Systems - 03 - Engine](#)
- Video Link: [How Jet Engines Work](#)

Materials: Student

Per Student or Pair

- 1 Plastic Propeller - [amazon link](#)
- 1 Small Craft stick
- 1 Helicopter shape on cardstock
- Tape
- 1 Small paper clip
- 3 Size 33 Rubber bands – [amazon link](#)
- Student Think Sheet A
- Student Think Sheet B
- Student Think Sheet C

Advanced Preparation

- Laminate instructions for creating rubber band helicopter.
- Copy student think sheets for each student
- Print Helicopter templates and cut apart (students can cut outlines of helicopters).
- Check links to videos.

Lesson Plan

ENGAGE

DAY ONE

Slide 2

1. Tell students that in the previous lesson you learned about the power to drive vehicles in general. Now we are going to look in detail at the power to fly a plane.
2. Briefly discuss the objectives.

Slide 3

1. Explain to students that they are going to watch a video of early flight attempts. After the video they will be asked to list some of the things that went wrong.
2. Show [Flight Failures Video](#).

**ASK:**

What things went wrong? *Accept all reasonable answers*

Slide 4

1. Show [Flight Failures Video](#).

**ASK:**

- a. Ask: What is required to get this jet in the air? *A lot of power to overcome gravity's impact due to mass of plane*
- b. What brought it up to speed so quickly? *A powerful engine*

Part 1: Forces of Flight

Slide 5

1. Explain to students that in order to understand how the power systems work, first we have to understand the four forces of flight.
 - a. Show short video Forces of Flight.
 - i. As each force comes up, stop the video and ask students to describe the force and the direction it is applied.
 1. **Lift** – created by wings pushing against the air, usually in an upward direction.
 2. **Drag** – force caused by air; it acts in the opposite direction to an object moving through the air; created by all parts of the airplane.
 3. **Thrust** – the forward force which pushes the airplane through the air. It is used to overcome the drag and is generated by the engines.
 4. **Gravity** – the force that pulls objects towards the ground (center of the Earth). Note: in this video the downward force is labeled weight instead of gravity. Explain to the students that weight is a measurement and that gravity is the force. Therefore, when they label this force they should write gravity.
2. Distribute Student Think Sheet A: Forces of Flight. Students identify the four forces on Student Think Sheet A and write a description for each one.

Slide 6

1. Explain to students that they will now explore the four forces of flight with a rubber band helicopter. *(This can be done individually or in pairs)*
2. Review the materials that will be used.

Slides 7 -9

1. Walk the students through each step in building the helicopter. *(See presentation and Student Think Sheet A for instructions)*

Slide 10

1. Answers to questions:
 - a. How was energy stored in this helicopter? *When the rubber band is twisted.*
 - b. How was power provided to move the helicopter? What force is this? *The energy is released from the rubber band to the propeller. Thrust*
 - c. How was lift produced? *The propeller provides lift by moving the air around it.*
 - d. How was drag produced? *The "helicopter" cut out pushes against the air creating drag.*
 - e. How did the flight change as you added more rubber bands? Why? *The power was increased allowing the helicopter to fly higher.*
 - f. What force would be impacted if you cut the body of the helicopter thinner or shorter? *Weight (gravity)*
 - g. What impact do you think this would have on the overall flight of the helicopter? *Depending on how much you cut it, it would either not go as high and as long or it would not fly at all.*
 - h. Cut your helicopter body and test it. What did you observe? Explain why you think this happened. *Answers will vary depending on shape it was cut.*

Part 2: Engine Types

Slide 11

1. Show: [Aircraft Systems - 03 - Engine](#) use first 1:33 min. (Need to cut this clip)
2. Stop at the following times and ask the questions listed below.

Video Time Stamps and Questions:

- a. 00:34
 - o Why is an engine referred to as a "power plant"? *It powers the other systems.*
 - o What are some of these systems? *Electricity, vacuum suction and heat*
- b. 00:52
 - o What are the two types of engines? *Reciprocating and turbine*
- c. 1:12
 - o What happens to fuel inside the cylinders of a reciprocating engine? *Fuel and air are mixed, compressed and ignited.*
- d. 1:32
 - o What causes the propeller to turn to produce thrust? *Fuel air mixture explodes moves pistons forward, causing crank shaft to rotate, as crank shaft turns it turns the propeller producing thrust.*

Slide 12

1. Watch Pratt & Whitney Video "[How Jet Engines Work](#)" Stop at each of the following times and ask the questions listed below.
2. Stop at the following times and ask the questions listed below.

Video Time Stamps and Questions:

3.
 - a. 0:49
 - What is the first step? *A big fan pulls air from the outside and around the engine, then sucks air into the core.*
 - b. 1:20
 - What happens to the air in the core? *It is run through a series of fans that get smaller and smaller compressing (squeezing) the air. The compressed air is then mixed with jet fuel.*
 - c. 1:30
 - What happens in the combustor? *The air and fuel mixture meet a flame and shoots out the back of the engine.*
 - d. 1:50
 - How does this air produce thrust? *The air spins a turbine which scoops up heated air and spins the shaft connected to the fan at the front of the engine. The excess air from the combustor blows out the back of the engine producing thrust.*

EXPLAIN

DAY THREE

Slide 13

1. Distribute Student Think Sheet B.
 - a. Students will label each aircraft with the four forces of flight and an arrow showing the direction of force and will explain how thrust is produced in each one.
2. Distribute Student Think Sheet C.
 - a. Students compare and contrast each type of propulsion system presented from the videos. Answers are provided attached to Student Think Sheet C.



Formative Assessment

The questions asked within Explore and Explain serve as the Formative Assessment.

ELABORATE

DAY THREE

Slide 14

1. Refer back to the lesson on energy and the different type of vehicles. Assign one to each group. Ask students to list all the things in each one that require power. (Engine, radio, instruments, lights, climate control, pressure, kitchen, Audio/visual systems, Wi-Fi, etc.)
2. Groups share. Write list on the board or on a piece of chart paper. If students missed some add those by asking leading questions.
3. Groups research how planes get the power for these. (generators, etc.)

EVALUATE

DAY FOUR

Slide 15

1. Explain to students that they will complete the first few steps in the engineering design Process by designing their own "flying vehicle"
2. Review the steps in the Engineering Design process. (see slide). They will complete the first four steps. Explain that the research part will be using what they have learned from this lesson.

Slide 16

1. Distribute Student Think Sheet D.
2. Discuss the problem and design criteria.
3. Point out that the reasoning parts will be filled out on the back of the think sheet.
4. Explain to students that their designs will be graded based on the criteria listed.

REFERENCES

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