NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE™

Engineering Design Challenge: Create a Flying Machine

Students will learn about forces and motion while practicing the engineering design process as a team to design their own flying machine to meet a specific challenge.

LESSON PLAN

Learning Objectives:

The students will:

- Work cooperatively in teams to create appropriate designs for their aircraft
- Apply Newton's Laws of Motion
- Build a team aircraft within a given set of parameters
- Test and run simulations of the "flight"
- Re-design as necessary
- Compete in a final challenge

Purpose:

This class is designed to give students the opportunity to practice, design and understand the aspects of building an airframe. Students will learn about Newton's Laws of Motion and the other forces that effect flight. They will learn how to design their own model airframes using different materials. This will teach the students creative and innovative ways to solve problems while simultaneously learning about the science behind early and modern aircraft.

Introduction:

Airframes all abide by scientific theories that are still difficult to comprehend but scientists speculate that there are certain reasons as to why this occurs. They speculate that laws, effects, and principles of nature all make up this scientific theory of flight. First we want to discuss the four forces that effect flight. These are thrust, drag, weight, and lift. Thrust is a force that moves an aircraft in the direction of the motion, drag is the force that acts opposite of motion, weight is the force caused by gravity, and lift is the force that holds the airplane in the air. All of these forces are composed of different scientific theories that play a role into the way they operate. Newton's Laws of Motion are one of the primary components to these theories. There are three Newton's laws that act upon an airframe and its ability to fly. Each one of these laws encapsulates the methods of force and motion that acts upon an object within nature. These laws are critical to understand when constructing an airframe. Many scientists and engineers still work to find the most efficient and effective way to build an airframe while abiding by these scientific theories. For more information on Newton's laws and aircraft theories, see the **Resources** topic below.

Grade Level: 8 – High School

Ohio Learning Standards/Science (2018)
Expectation of Learning
Nature of Science

Physical Science
8.PS.1: Force due to external field
8.PS.2: Forces can change motion

High School Physical Science
PS.FM.1: Motion
PS.FM.2: Forces
PS.FM.3: Dynamics

Ohio Learning Standards/Technology (2017)
Design & Technology
6-8.DT.2.b.: Invention is process of turning ideas
6-8.DT.2.c.: Process of modifying system
6-8.DT.2.e.: Identify & explain effective designs
6-8.DT.3.a.: Collaborate as a team
6-8.DT.3.c.: Evaluate effectiveness of team
9-12.DT.2.b.: Implement design process
9-12.DT.4.a.: Evaluate project solutions
9-12.DT.4.b.: Interpret testing data/information

Materials Required:

- Basic propulsion system for each team consisting of a rubber-band powered propeller mounted on a balsa wood stick
- Straw for each "line" with monofilament fish line (20+ ft.) threaded through the straw as the trajectory
- Multiple chairs or poles for each line as the anchors for the monofilament fish line
- Paper, craft sticks, straws, string, Styrofoam plates, cups, bubble wrap, balloons, paper clips, etc. Each team should have the same materials.
- Tape measure
- Tape, scissors, glue
- Safety glasses
- Caution tape

Procedure:

A. Warm-Up

1. Divide the students into groups of three (or more depending on size of class).

2. Review the Purpose and Introduction section to the class so they understand the reasoning behind their experimentation.

B. Activity

1. Prepare a flying area with fishing line strung between two poles, stands or chairs about 18 - 20 feet apart. **NOTE**: Multiple flying areas should be constructed.

2. Before attaching the line, be sure to thread the line through straws.

3. One piece of tape should be placed on the floor, perpendicular to the direction of the fishing line and about 15 feet feet away from the first pole (starting point).

4. Each team of students should then be given a box with identical materials **(stated in Materials Required).**

5. A timeframe of 30 minutes should be set for each group to design and test an airframe.

6. Students will then test each launch by starting from one pole and waiting until the airframe comes to a complete stop.

7. The goal is to reach exactly at the top of the 15 feet spot on the floor. If the team is short of or goes over the 15 feet mark, they need to go back and re-design.

8. Each team is allowed to build and retest as often as necessary within the allotted 30 minute time frame.

9. If more than one team achieves the 15 feet mark after the allotted timeframe, then allow those teams, with the same design, to fly again to determine the winner.

Assessment/Evaluation:

Teams will be evaluated on their observations and questioned for their strategies for their airframe.

Resources:

Newton's Laws of Motion:
https://www.grc.nasa.gov/www/k-12/airplane/newton.html
https://www.britannica.com/science/Newtons-laws-of-motion
https://www.nasa.gov/sites/default/files/atoms/files/bernoulli_principle_k-4.pdf

Bernoulli Principle and Newton's laws:
https://www.grc.nasa.gov/WWW/K-12/airplane/bernnew.html

Four Forces of Flight:
https://www.nasa.gov/audience/foreducators/k-4/features/F_Four_Forces_of_Flight.html#:~:text=The%20four%20forces%20are%20lift,made%20the%20Frisbee%20slow%20down.

Lift :
https://www.discoverhover.org/infoinstructors/guide8.htm

Drag:
https://www.grc.nasa.gov/WWW/k-12/VirtualAero/BottleRocket/airplane/drag1.html#:~:text=Drag%20is%20the%20aerodynamic%20force,(even%20the%20engines!).&text=Drag%20is%20generated%20by%20the,the%20object%20and%20the%20fluid.

Weight:
https://science.howstuffworks.com/transport/flight/modern/airplanes2.htm#:~:text=Every%20object%20on%20Earth%20has,is%20drawn%20toward%20the%20Earth.

Thrust:
https://www.nasa.gov/sites/default/files/atoms/files/bernoulli_principle_k-4.pdf