NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE™

Engineering Design Challenge – Flight Suits

Students will practice using the Engineering Design Process as they develop an understanding of how flight suits help protect the crew while in flight and during ejection.

Learning Objectives:

The students will:

- Gain a basic understanding about protective flight equipment.
- Learn about the Engineering Design Process (EDP)
- Work in teams to design, build and test a "flight suit" for a raw egg with the given materials.

Purpose:

Students will work in teams to understand the science and technology behind flight suits. They will learn about the effects of different materials and how specific suits function for different aircraft. Students will learn about the Engineering Design Process (EDP) and how it is a vital aspect in the research and development for flight and space suits. Students may learn about the early history of flight suits.

Background:

Flight suits have been around since the early construction of aircraft. During the time of WWI when airplanes began flying higher and faster, flight suits became one of the most important aspects for a pilot's protection. Pilots used to wear leather jackets and thick wool coats to deter the cold weather of high altitudes. In the 1920s, flight suits and airplanes started to incorporate oxygen masks so that pilots were able to function in high altitude. It was not until the 1950s when flights suits started to become more practical and useful to the pilot. During experimental and space research, flight and space suits became one of the main focuses of discussion. Researchers started to ask questions on how flight and space suits could protect the pilot or astronaut from the elements. From these discussions and questions, developers and innovators started to create flight suits that could withstand high altitudes within our atmosphere and developed modern space suits that protect astronauts from the elements. To learn more about the history, science, and technology of flight and space suits, look for the Resources section.

Grade Level: 6 - 8

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

Earth & Space Science
7.ESS.2: Thermal energy & atmosphere can effect environments
7.ESS.3: Atmosphere has different properties

Ohio Learning Standards/Technology (2017)
Design & Technology
6-8.DT.1.f.: Give examples of trade-offs in design
6-8.DT.2.a.: Apply a design process to solve a problem
6-8.DT.2.c.: Explain the effects of innovation
6-8.DT.2.e.: Identify and explain importance of effective designs
6-8.DT.3.a.: Collaborate as a team to solve problem
6-8.DT.3.b.: Explain how innovation can be transferred to another field
6-8.DT.3.c.: Evaluate teams effectiveness

Materials Required:

- Eggs
- Packing peanuts
- Packing bubble-wrap
- Empty cardboard tubes of various sizes
- Variety of small cardboard boxes
- Wood glue and/or hot glue guns
- Various types of tape
- Scissors
- 5x5 fabric scraps
- Medium to thick string (24 in.)

Procedure:

A. Warm-up

1. Review the science and technology behind flight and space suits.

2. Divide the students into groups of four or five (or more depending on size of class).

3. Students should receive all supplies to make flight suits for their eggs.

4. Review with students the attached sheet on the Engineering Design Process (EDP) *(page 4)* and how flight and space suits go through development stages.

B. Activity

1. Team's mission is to create and test an effective flight suit for their (egg) pilot while simultaneously applying an engineering design process.

2. Teams will choose the type and amount of materials necessary to accomplish their task

3. Teams will then decide what type of flight suit they are building and what materials are needed to protect their pilot.

4. Test each team's design success by "flying" their pilot, while contained in the protective suit.

5. Determine if the suit is flight worthy by dropping their (egg) pilots from a maximum height equal to the top rung of a step ladder. Drop the egg three times, if possible.

5. If their pilot doesn't crack the suit is acceptable. If not, you have ***two more tries*** to develop a suit design until egg doesn't crack.

C. Wrap up

1. Team of students should prepare a presentation on the design and efficacy of their flight suits. All parts should be described and explained. The presentations could involve drawings, dioramas, PowerPoint slides, etc.

2. Review any necessary information regarding the science and technology of flight and space suits.

Assessment/Evaluation:

The students should be evaluated on their class and team participation, listening skills and ability to follow verbal instructions, especially when they are involved with their design process.

Extension:

Consider adding a "cost" constraint to the activity.

Visit the National Museum's Virtual Tour on our website or visit the National Museum of the USAF to see actual flight and space suits on exhibit.

Resources/References:

History of Flight Suits:

https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196432/aircrew-combat-shirt-and-trousers/

https://carterny.com/history-of-the-flight-suit-and-how-nomex-material-changed-the-industry/

https://www.stephanh.com/2017/06/22/history-flight-suits/#:~:text=The%20Early%20Days%20of%20Aviation,-For%20every%203%2C000&text=The%20first%20concept%20for%20flight,protect%20pilots%20from%20the%20cold.&text=In%20the%201920s%2C%20flight%20suits,offered%20no%20protection%20against%20electrocution!

Science behind Flight Suits:

https://adventure.howstuffworks.com/wingsuit-flying.htm#:~:text=The%20typical%20wingsuit%20design%20accomplishes,the%20airfoil%20semirigid%20through%20flight.

https://www.wired.com/story/how-much-power-does-it-take-to-fly-in-a-real-life-jet-suit/

https://www.nytimes.com/2000/08/22/science/high-tech-suits-help-pilots-avoid-gravity-s-perils.html

https://www.explainthatstuff.com/howplaneswork.html

History of Space Suits

https://www.nasa.gov/audience/forstudents/k-4/stories/history-of-spacesuits-k4.html

https://web.mit.edu/16.00/www/aec/spacesuit.html

https://www.businessinsider.com/spacesuit-design-history-timeline-changes-nasa-2018-3

Science begin Space Suits

https://www.nasa.gov/audience/forstudents/nasaandyou/home/spacesuits_bkgd_en.html

https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-spacesuit-58.html

https://science.howstuffworks.com/space-suit.htm

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THE ENGINEERING DESIGN PROCESS

It is important to note that the *Engineering Design Process (EDP)* is flexible. There are as many variations of the model as there are engineers and engineering teams. Since this is a cycle, there is no official starting or ending point. You can focus on one step, move back and forth between steps, work on one of two steps, then pass the project to another team or begin again to refine the flight suit.

Step 1: Introduce the *Engineering Design Process:*

ASK: What is the problem? How have others approached it? What are your constraints or limits?
IMAGINE: What are some solutions? Brainstorm ideas. Choose the best one.
PLAN: Draw a diagram. Make list of materials you will need.
CREATE: Follow your plan and create something. Test it out!
IMPROVE: What works? What doesn't? What could work better? Test it out!

Step 2: Explain the task: Students are tasked with developing a flight suit for an egg (pilot). Students will conduct the testing of this experiment by dropping the egg in its flight suit from a ladder.

Step 3: ASK: What is the problem? Develop a flight suit that will protect the egg (pilot). How have others approached it?
What are your constraints? May only use the materials provided. (You may also want to include other materials not listed on page one—such as paper clips, different weight papers, etc.)

Step 4: IMAGINE: What are some solutions? Brainstorm ideas. Choose the best one. Encourage students to think "outside the box."

Step 5: PLAN: Draw a diagram. Make list of materials you will need.

Step 6: CREATE: Follow your plan and create a flight suit. Test each suit by dropping the egg from any height on the ladder. Make note of damage or no damage.

Step 7: IMPROVE: If the design does not work on the first test. Ask questions such as: What works? What doesn't? What could work better?

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NAME:_____

DATE:_____

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STUDENT /TEAM WORKSHEET

Flight suit—Design 1

Design 1	Trial 1	Trial 2	Trial 3
No damage (Y or N)			

Flight suit—Design 2

Design 2	Trial 1	Trial 2	Trial 3
No damage (Y or N)			

Flight suit—Design 3

Design 3	Trial 1	Trial 2	Trial 3
No damage (Y or N)			