PAPER AIRPLANE ENGINEERING

OVERVIEW
Airplanes are complex machines, each design is unique, with specific requirements and constraints. The process of designing and building them is involved, and requires testing and evaluation. In this activity, students will learn about the design process by designing, building, and testing an airplane to meet specific performance guidelines.

LEARNING OBJECTIVES
- Discover some of the basic ideas and processes involved in design.
- Design, build, and test a paper airplane that satisfies certain guidelines.

VOCABULARY
- CARGO – Goods carried on an aircraft, ship, or motor vehicle.
- ENGINEER – A person whose job involves designing and building.
- REQUIREMENT - A prominent part or trait. In this case, something a design needs to have.
- CONSTRAINT - A boundary or limitation.

MATERIALS
- Clear tape
- Scissors
- Tape measures and/or yard/meter sticks
- Paper clips
- Airplane Test Data Sheet Handout
- A few paper airplane templates. Use the Paper Airplane Design template provided and research other designs online.

SET-UP
→ Gather paper of different weights and sizes to be used to build the paper airplanes.
→ Choose an area to be the test flight area.
→ Tape a line on the floor where the students can stand and indicate the direction airplanes are thrown.
→ Gather tape measures or yard/meter sticks.

LESSON PLAN
INTRODUCTION
1) Ask students to brainstorm about what design means to them. Some ideas could include:
   - Design is the plan for making something – it could be a picture, technical drawing, blueprint, or description.
   - Design is also the process of figuring out how to build or construct something.
   - Designing involves thinking, imagining, trying things out, and using materials wisely.
2) Discuss the design process:
   - defining a problem
   - identifying requirements and constraints
   - generating ideas, selecting a solution
   - testing the solution(s)
   - making the item
   - evaluating it
   - improving the design
   - presenting the results

3) Engineers who design airplanes always model their design, test it, evaluate it, and then change the design to make it better.

4) Ask students to brainstorm about airplane design requirements and constraints.
   - Examples of requirements:
     - Purpose or type of plane (ex. passenger, cargo, military, private).
     - Efficiency (how well it works or flies).
     - Special capabilities such as being able to land gently or being able to communicate with other planes.
   - Examples of constraints:
     - Project budget or available funding.
     - Time in design process.
     - Maximum size.
     - Available materials.
     - Space to build or use.
     - Human capabilities to use it.

THE CHALLENGE

- Create an airplane that satisfies all of the challenge design guidelines and that travels the furthest.
- Share the following list of guidelines:
  - All parts of the airplane must be made out of paper.
  - Tape may be used to keep parts of the airplane together but no other materials such as rubber bands, paper clips, etc. may be used in the airplane’s design.
  - The airplane may only be flown in the test flight area.
  - The airplane must be able to carry a cargo of at least five paper clips.
- Knowledge check: which of these are constraints and which are requirements? (Hint: only one is a requirement.)

EXPLAIN THE RULES OF THE FLIGHT AREA

- Airplanes may only be flown in the test flight area.
- Throw in one direction only.
- Once it lands, measure and record the distance on the data sheet, pick up your plane and leave the flight test area.
- You can add other rules as needed – for example, limiting how many people can launch or pick up at one time.

DESIGN/TEST/EVALUATE PROCESS

- Ask students to select a template and build it.
- Give your students a tape measure or meter stick. Share if supplies are limited.
- Test the airplane first with no cargo. Then add 5 paperclips and test again.
- Have the teams:
  - Test their designs.
  - Record distance measurements on the data sheet.
  - Make observations about design strength and weaknesses.
  - Record any design changes.
• Encourage students to make sketches of their designs, and to record test results.
• If planes do not meet all of the constraints and requirements, students will need to make adjustments to their design.

WRAP-UP: ANALYZE RESULTS/PRESENT DESIGNS

• Discuss the results.
  o Which designs were the most successful?
  o Which designs were the most consistent (flew about the same distance each time)?
  o Which plane recorded the longest distance?

• Share that students followed a design process very similar to that of engineers. See the design process set up above.
• A sample of reflection questions is listed below. Feel free to use these or develop your own. Be sure to have the students explain the reasoning behind their answers:
  o What went well during the design of your airplane?
  o What problems did you encounter during the design process?
  o How did you make sure that you stayed within the constraints?
  o Were any of the planes perfectly designed? If not, how could the plane be improved?

OPTIONAL EXTENSION

• Challenge students to improve their design and fly their airplanes again.
• Give students additional constraints and/or requirements and have students modify their current design or create a new airplane to satisfy the additional criteria. Some ideas include:
  o Limit the type of paper that the students can use.
  o Do not allow them to use tape or glue.
  o Limit the size of the airplanes.
  o Require them to carry additional cargo.
  o Require a minimum flight distance.
• Have students experiment with their airplane designs to test how many paperclips their plane can fly and/or how far.
• Ask students to draw their airplane design, then label its design features.

FURTHER EXTENSION

In the Museum
During your next visit to The Museum of Flight, take a closer look at some of your favorite aircraft. What do you imagine were the design requirements of each one? What about the constraints?

Other Museum Programs

• Aviation Learning Center (field trip program)
• Fossett Designers (field trip program)
• Aerospace Camp Experience (individual program)
• Amelia’s Aero Club (individual program)
<table>
<thead>
<tr>
<th>Flight</th>
<th>DISTANCE</th>
<th>OBSERVATIONS</th>
<th>CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice Flight #1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(without cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Flight #2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(without cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight #1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(without cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight #2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(with cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight #3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(with cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(with cargo)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Valley fold* in half vertically, crease, then unfold. Flip over.

2. Make a tiny fold to mark the center of the left hand edge.

3. Valley fold the top edge downward, lining it up with the tiny fold from step 2.

4. Fold the top corners inward so that the points meet at the center crease.

5. Fold the top edge downward, crease, then unfold.

6. Fold the top edge downward, crease, then unfold.

7. Remake fold 6, then fold 5 so that the nose is doubled over.

8. Remake fold 1 as a mountain fold* and add creases for the wings. Arrange to match the profile shown.

*A valley fold means folding toward you. A mountain fold means folding away from you.