Lesson Plan: The Flight Challenge - Engineering for Lift and Accuracy Subject: Engineering, Aerodynamics, Design Thinking Ages: 9-13 (Optimized for 11-year-olds, with adaptations) Time Allotment: 60-75 minutes

Materials Needed

- Several sheets of standard printer paper (per participant)
- Paper clips (5-10 per participant)
- A pair of scissors
- A tape measure
- Masking tape (for creating a starting line and targets)
- Paper and pencil for planning and recording results
- Optional: A small hole punch, staples

Learning Objectives

Building on our understanding of the Engineering Design Process and structural forces, by the end of this lesson, learners will be able to:

- Apply the five steps of the Engineering Design Process to solve an aerodynamics challenge.
- Define and explain the four forces of flight: Lift, Gravity (Weight), Thrust, and Drag.
- Modify a design based on test results to achieve a different goal (shifting from distance to accuracy).
- Demonstrate an understanding of iteration (the "Improve" step) by making and justifying changes to their design.

Lesson Structure

Part 1: Review & Introduction (10 minutes)

Review of Previous Lessons
Educator asks: "In our first two engineering challenges, we used a powerful five-step process. Who can name those steps?" (Guide them to recall: Ask, Imagine, Plan, Create, Improve). "Then, with our bridges, we learned about two invisible forces that all structures have to deal with. What were they?" (Tension and Compression). "We discovered that using triangles was the secret to controlling those forces and building a strong bridge."

The Hook
Educator says: "So far, all of our creations have been designed to stay perfectly still. Today, we're going to do the opposite. We are leaving the world of static structures and entering the world of aerodynamics. Your challenge is to engineer a vehicle that flies! But just like with bridges, there are invisible forces we need to understand and control to be successful."

State the Challenge & Objectives
Educator says: "Your mission involves two 'Asks.' First, you will engineer a paper airplane that flies the maximum possible distance. Then, you will have to re-engineer your plane to land on a specific target. To succeed, we'll need to learn about the four forces of flight and become experts at the most important step in our process: 'Improve'."

Part 2: Body of the Lesson (40 minutes)

I Do: Introduce the Four Forces of Flight (10 minutes)
Educator explains: "Instead of just two forces, flying things have to balance four. They are always in a

tug-of-war."

- **Gravity (Weight):** "We already know this one. It's the force pulling everything down." (Drop a piece of paper).
- **Thrust:** "This is the force that pushes things forward. For a jet, it's the engine. For our planes, what will create the thrust?" (Our throwing arm!).
- **Drag:** "This is air resistance, the force that slows things down." (Drop a flat sheet of paper and a crumpled ball of paper at the same time. The crumpled ball falls faster because it has less drag). "Sleek, pointed shapes usually have less drag."
- **Lift:** "This is the magic! It's the upward force that fights gravity." (Hold a strip of paper just under your bottom lip and blow over the top of it. The paper will rise). "When air moves faster over the top of a wing than the bottom, it creates an upward push called lift. Big, wide wings are great at creating lift."

We Do: Plan for Distance (5 minutes)
Educator facilitates a group brainstorm:

- "Our first 'Ask' is to fly for maximum distance. Thinking about the four forces, what kind of design should we imagine?"
- "Do we want a lot of lift to stay in the air longer, or do we want very little drag to cut through the air faster? What's the trade-off?"
- "Take 3 minutes to 'Plan.' Draw a design for a 'Distance Glider.' Label where you think the wings will create lift and the nose will reduce drag."

You Do: Create, Test, and Improve for Distance (15 minutes)
Educator designates a starting line. "Alright, aeronautical engineers! You have 10 minutes to 'Create' your distance gliders and test them. After each throw, think: 'How can I 'Improve' this?' Maybe a fold needs to be sharper, or maybe you need to add a paperclip to the nose to change its balance. This is called iteration."

- Learners build their planes.
- They test them, measuring the distance of their best flight.
- **Formative Assessment:** The educator circulates, asking questions:
  - "What happened on that flight? Did it stall and go straight up, or did it dive into the ground?"
  - "How could you change the drag on your plane?"
  - "What do you think adding a paperclip to the back would do? Let's form a hypothesis and test it!"

You Do Part 2: Re-Engineer for Accuracy (10 minutes)
The educator places a target (e.g., a piece of paper or hoop) about 10-15 feet away. "New 'Ask,' engineers! Distance doesn't matter anymore. Your new goal is accuracy—landing on or as close to that target as possible. You have 10 minutes to go back to the 'Imagine,' 'Plan,' and 'Improve' steps. How will you modify your existing plane to make it more accurate?"

- Learners modify their planes. They might add weight to the nose for a more direct flight path, bend the wingtips up (winglets) for stability, or even create a whole new design.
- They test and iterate for accuracy.

Part 3: Conclusion (10-15 minutes)

Final Test and Showcase

Educator says: "Time for the official flight tests!"

- First, each learner gets two official attempts for the **Distance Challenge**. Record the best distance.
- Next, each learner gets two official attempts for the **Accuracy Challenge**. Measure the distance from the center of the target.
- Celebrate all designs and flights, especially those that show clever modifications.

Recap and Reflect
Educator leads a final discussion to connect all three lessons:

- "What was the biggest difference between designing for distance versus designing for accuracy?"
- "Let's name the four forces of flight again. How did you try to increase lift or decrease drag?"
- "Today, the 'Improve' step was our main activity. How is this different from the marshmallow tower or the bridge? Why is constant improvement so important for an engineer?"
- "Think about our whole journey: from a simple tower, to a strong bridge using triangles and forces, to a flying machine that balances four different forces. You see how engineering knowledge builds on itself to let you solve more and more complex problems."

Educator reinforces the takeaway: "You were true engineers today. You didn't just build something once; you tested it, analyzed the results, and improved it over and over. This cycle of iteration is how engineers create everything from faster cars to spacecraft that can land on a target millions of miles away."

Assessment & Success Criteria

- **Formative (During the lesson):** Learner makes intentional modifications to their plane after test flights and can explain their reasoning, even if it's simple (e.g., "It kept diving, so I added a paperclip to the back").
- **Summative (End of lesson):** The learner's understanding is demonstrated by:
    - Successfully creating and flying a paper airplane.
    - Verbally identifying at least two of the four forces of flight (e.g., "I wanted less drag, so I made the nose pointy").
    - Describing at least one specific change they made to their plane to improve its performance for either distance or accuracy.

Differentiation and Extension

- **For Younger or Struggling Learners (like Troy):**
    - **Scaffolding:** Provide 2-3 simple, pre-designed paper airplane folding instructions. Focus on one modification at a time, such as "Let's see what happens when we just add one paperclip to the nose."
    - **Success Criteria:** Success is folding a plane, testing it, and explaining what happened on the flight ("It went really fast!" or "It turned to the left.").
- **For Advanced Learners (like Vienna):**
    - **Extension:** Challenge them to design a plane that does a specific acrobatic maneuver, like a loop-the-loop. This requires a deep understanding of control surfaces (elevators and rudders). Ask them to create a chart to track their modifications and the resulting flight distances to analyze the data.
    - **Success Criteria:** Success includes creating a high-performing design and being able to explain the trade-offs they made using specific vocabulary (e.g., "I increased the wingspan to get more lift, but that also increased the drag, so I had to make the fuselage sleeker.").

- **Follow-Up Activity:** Introduce new materials like cardstock, straws, and tape to build more complex gliders or "unconventional aircraft." This brings back the material constraints from the first two lessons.