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Paper Airplane Engineering! Exploring Forces that Impact Flight

For teachers: Depending on which questions you ask, this activity can engage students in

- *NGSS Cross Cutting Concepts: Patterns, Cause & Effect, Structure & Function.*
- *NGSS Science & Engineering Practices: Asking Questions, Defining Problems, Planning & Conducting Investigations, Using Models, Evaluating Data, and Designing Solutions*

This can be a simple do & think activity, or it can be expanded into a formal lesson, with data collection, testing of variables (different types of paper, different plane designs; use of flaps to impact direction & loft; addition of weight such as paper clips, etc.). Basic do-at-home instructions below, followed by lesson extensions.

Materials needed: A piece of paper! Options could include trying different types of paper such as scratch paper, newsprint, wax paper, brown bag paper

Link to simple plane folding video:

https://www.youtube.com/watch?v=gZQI1Z_viNg

Goals of activity: Students become engineers as they observe how their planes fly and explore ways that modifications impact how the plane flies. Can they make it fly further? Hit a specific target? Do a 'trick'? As they make changes to the shape or weight of a paper plane, they are exploring forces that impact flight: lift, gravity/weight, drag, and thrust -- whether or not they use the vocabulary words! And they engage in engineering, by looking at where there are failures and testing strategies to improve their plane's performance.

Flight Engineering at Home

Materials needed: A piece of paper! Options could include trying different types of paper such as scratch paper, newsprint, wax paper, brown bag paper

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Engage: Setting the stage: Introduce the phenomena of airplane flight – How do airplanes fly?

A few questions to get us thinking about flight (*Discuss as a class via zoom, or with a parent at home, or respond in a science journal*)

- Have you seen an airplane in the sky? What kind of plane?
- What do you notice about planes?
- Have you ever been on an airplane?
- What other things have you seen flying in the sky?
- Why can airplanes fly but cars don't?

Explore: Let's explore what it takes to get a big, heavy airplane full of people off the ground. We'll use paper airplanes as a model, to help us better understand how planes fly.

- Get a piece of paper. Hold your hand out, palm up, and place the sheet of paper on your hand. What holds it in place?
- What happens if you let go of the piece of paper?
- Squat down, with your arm stretched out in front of you. Place the paper on your palm again. What happens to the paper as you stand up? Try standing slowly, then again faster. What do you notice?

Now that we have some ideas about forces that affect our paper, let's fold it into an airplane. Follow these steps to make a basic DART design.

Link to simple plane folding video:

https://www.youtube.com/watch?v=gZQI1Z_viNg

- Clear a space in your room or outdoors where it is safe to launch your paper plane. Give it a few tries. What do you notice?
- How far does your plane fly? Can you make a simple change to get it to fly farther? (examples of things you could try: add a paperclip or penny or some tape to impact the weight; fold flaps that you can bend up or down on the back of the wings)

Explain: What did you notice about the different forces that were acting on your paper plane? What kinds of changes did you try?

- What made it go forward? What helped it to go up?
- What made it go down, or left/right?

- Did you try adding flaps to the back? What happened if you folded them up? Down? One up, one down?
- Did you try adding any weight, like a paperclip or a penny?

Adults working with students can prompt discussion with questions such as the following, encouraging students to look for patterns, or cause-effect connections:

- “What do you notice about your plane’s shape?”
- “Why do you think (your plane nosedived or went up, or went off course, etc.) that happened?”
- “What could you try adjusting? What will you change and how do you think it will change how the plane flies?”
- Do you notice a pattern when _____” (the back flap is tilted up or down, side flaps are added, a paper clip is added, etc)?
- Advanced: After discussing forces that impact flight (lift/gravity or weight, thrust/drag) discuss: “What force do you notice affecting how your plane flies?” Do you need more lift? More or less drag to stabilize?

Elaborate & Iterate: Now that you’ve experimented a bit, take one of these challenges:

- How far can you make your plane fly? What helps it to fly far?
- What material works best for a paper plane – try materials you have around the house (wax paper, brown paper bag, wrapping paper, newspaper)
- Can accurate can you make your plane fly? Place a shirt or socks on the ground for a landing strip – can you land your plane on the landing strip? What helps it to hit a specific target?
- What tricks can your plane do? How can you make it fly like a corkscrew? Can you make the nose go up and do a circle in the air without crashing on the ground?
- What challenges can you think of?

For a more formal lesson version: TK-Grade 2 Flight Testing Procedure:

1. Each student will get one paper airplane. They will stand on the launch line and when you say “3, 2, 1, go” they can release their planes on “go”.
2. Do a second launch, same procedure.
3. Ask students what they noticed. Did they get lift? Did their plane nosedive, or go to the side, or did it glide nicely straight and far?
4. Now ask the students to think about one way they can change (modify) their plane to get it to fly farther. What happens if you fold the back flap down a bit? What happens if you fold it up a bit? How about if you add a paper clip?
5. Do a third launch, with the modified plane. Ask the students to compare the modified plane to their first launch. How did it change?
6. If there’s time they can try one more modification and one last launch.
7. Students place a tally mark on the Flight Log poster to show how far their plane traveled. They can take their plane with them and continue their experiments at home.

If there’s time and you’d like to wow your group, you can demonstrate how folding one flap up and one flap down can allow your plane to fly in a corkscrew!

Grades 3-5 Flight Testing Procedure:

1. Show the students there are 3 plane designs to choose from. Each student can select a plane, and a challenge: they can go for distance or accuracy! Why do they think their plane design will work best for the challenge they have selected?
2. Students taking the distance challenge, line up at the “runway”. Students taking the accuracy challenge line up near the number grids on the blacktop. They will stand on the launch line and when you say “3, 2, 1, go” they can release their planes on “go”.
3. Do a second launch, same procedure -- make sure no one is “on the runway” when planes are launched!
4. Ask students what they noticed. Did they get lift? Did their plane nosedive, or go to the side, or did it glide nicely straight and far?
4. Now ask the students to think about one way they can change (modify) their plane to get it to fly farther or fly more accurately. Let them make a modification to test. What happens if you fold the back flap down a bit? What happens if you fold it up a bit? How about if you add a paper clip?
5. Do a third launch, with the modified plane. Ask the students to compare the modified plane to their first launch. How did it change?
6. If there’s time they can try one more modification and one last launch.
7. Students place a tally mark on the Flight Log poster to show how far their plane traveled, or on the accuracy log. Which model of plane can go the farthest? Which model is able to most accurately land on a target?

If there’s time and you’d like to wow your group, you can demonstrate how folding one flap up and one flap down can allow your plane to fly in a corkscrew! They will want to try it too so be sure to allow time if you show this trick!

Background information for presenters:

Force: a push or pull acting on an object

There are four main forces acting on airplanes in flight.

Gravity: The force that pulls objects toward the center of the Earth. You can demonstrate this by dropping an object and observing that it falls down toward the

Earth. **Weight** is the measure of the force of gravity acting on the mass of an object.

The larger the mass of an object the stronger the pull of gravity it exerts.

Lift: The force that opposes the force of weight (gravity) and moves an object off the ground. Objects achieve lift when there is a change in the air pressure above and below the object (this is why airplane wings have a curved front edge). One way to increase the Lift of a paper airplane is to change its shape so that the flow of air changes.

Thrust: The force that propels an object to move. In aviation Thrust is created using machines such as propellers or jets. Ways to increase Thrust of a paper airplane include stabilizing the plane's flight by adding a paperclip to the nose or frame, adding mass, or throwing with greater force.

Drag: Is the force opposite of Thrust. Drag resists motion. It is caused by friction or air resistance. Think of the feeling of water pushing against your hand when you move your hand under water, or of a parachute. Drag can be increased, or used to change the path of the plane (curving up, down, right or left) by cutting slits or flaps in the paper and folding flaps or wings up or down.

Paper airplane tricks and tips:

To get a paper plane to fly in a corkscrew pattern, fold one back flap slightly up and another slightly down.

Folding up sides of wings can cause plane to fly left or right

Folding two back flaps down can cause the plane to nosedive; folding two back flaps up can cause the plane to nose up and then stall/fall backwards.