Spacegate Station

The Science of Flight

Resource Content

The Science of Flight - Curriculum Lesson Plan

Grade Band: Middle School (6–8)
Focus Areas: Forces of Flight, Aerodynamics, Engineering Design, Motion & Stability
Episode Length: 8 minutes
Learning Objectives: After viewing this episode, students will be able to:

- Identify and describe the four forces of flight: lift, weight, drag, and thrust.
- Explain how wing shape and air pressure differences create lift.
- Describe how control surfaces (elevator, ailerons, rudder) allow an aircraft to maneuver
- Analyze how forces interact to influence aircraft motion and stability.
- Connect aerodynamics concepts to NASA research and real-world engineering applications

Lesson Procedure

1**. Engage (10 minutes) MS-PS2-2, SC.6.P.13.1**

- Video Segment: *00:00:08 – 00:01:29* (Introduction + NASA context)
- Play opening clip (Aurora introduction through explanation of purpose)
- Distribute Guided Notes – Section 1

Discussion Prompt (Whole Class): What do you think makes it possible for something as heavy as an airplane to fly?

Teacher Focus: Activate prior knowledge about motion and forces and emphasize importance of scientific investigation and NASA research

2. Explore (15 minutes) MS-PS2-2, SC.6.P.13.3

- Video Segment: *00:01:29 – 00:05:02* (Four forces of flight)
- Students complete Guided Notes – Sections 1–3
- Key Content Covered
    - Weight (gravity) and Lift (upward force from wings)
    - Drag (air resistance) and Thrust (forward motion)

Optional Group Task: Students create a Force Diagram showing how the four forces interact

3. Explain (15 minutes) MS-PS2-4, SC.7.P.11.2

- Video Segment: *00:05:02 – 00:05:56* (Transition to control surfaces)
- Video Segment: *00:05:56 – 00:07:45* (Control surfaces explained)
- Students complete Guided Notes – Section 4

Discussion Questions:

- Why must lift be greater than weight for flight?
- How does drag affect an aircraft's performance?
- Why are control surfaces essential for safe flight?

4. Elaborate (20 minutes) MS-ETS1-2, SC.6.P.13.1

Part A: Engineering Design Challenge (10–15 min)

- Students design a paper airplane or wing model
- Goal: Reduce drag or increase lift

Part B: Application Discussion

- Video Segment: *00:01:10 – 00:01:22* (NASA planetary flight context revisit)
- Discuss:
    - How flying on another planet might differ
    - Why NASA studies aerodynamics beyond Earth

Higher-Order Questions:

- Which force is hardest to manage and why?
- How might engineers reduce drag in aircraft design?
- How could different atmospheres affect flight?

5. Evaluate (10 minutes) MS-PS2-2, SC.6.P.13.3

Student Tasks:

1. List the four forces of flight and explain each one
2. Identify which force opposes thrust
3. Describe how wings create lift
4. Explain how one control surface affects airplane movement
5. Reflection Prompt:
    - What is one new concept you learned about flight, and why is it important?

Instructional Notes: Reinforce the idea that balanced vs. unbalanced forces determine motion. Use diagrams to visualize forces acting on aircraft and Encourage real-world connections (planes, drones, rockets).

Differentiation: Support: Provide labeled diagrams of forces and aircraft parts. Extension: Have students research aircraft used on Mars or other planets. ELL Support: Pre-teach vocabulary (lift, drag, thrust, control surfaces)

Guided Notes

Word Bank

ailerons	forward motion	thrust
atmosphere	lift	thrust
atmosphere	lower	upward
axis	performance	weight
control surfaces	planets	weight
drag	pressure	wings
drag	resistance	
elevator	rudder	

SECTION 1 — Introduction to Aerodynamics

1. Aerodynamics is the study of how objects move through the _____.
2. Airplanes must overcome four forces of flight: lift, _____, drag, and thrust.
3. _____ is the force caused by gravity pulling an object downward.
4. _____ is the upward force that opposes weight.
5. _____ is the force that pushes an aircraft forward.
6. _____ is the force that resists motion through the air.

SECTION 2 — How Lift Works

7. Lift for an airplane comes from its _____.
8. Wings are curved on top and flatter on the bottom, causing differences in air _____.
9. Faster-moving air over the top of the wing creates _____ pressure.
10. This pressure difference causes the wing—and the airplane—to move _____.

SECTION 3 — Drag and Thrust

11. _____ increases the faster an object moves through the air.
12. Narrow or rounded shapes usually create less _____.
13. _____ is the force opposite of drag.
14. Jet engines or propellers provide the _____ needed to move forward.

SECTION 4 — Control Surfaces

15. _____ are parts of an aircraft that allow it to turn, climb, and descend.
16. The _____ controls movement up and down (pitch).
17. The _____ control banking left or right (roll).
18. The _____ controls left and right nose movement (yaw).
19. These surfaces work together to help the pilot steer along each _____ of rotation.

SECTION 5 — Real-World Applications

20. Understanding aerodynamics helps NASA design vehicles for other _____.
21. Knowledge of flight forces helps engineers improve aircraft _____ and safety.
22. Aerodynamics applies to airplanes, rockets, kites, and anything moving through the _____.

Guided Notes Answer Key

SECTION 1

1. atmosphere
2. weight
3. weight
4. lift
5. thrust
6. drag

SECTION 2

7. wings
8. pressure
9. lower
10. upward

SECTION 3

11. drag
12. resistance
13. thrust
14. forward motion

SECTION 4

15. control surfaces
16. elevator
17. ailerons
18. rudder
19. axis

SECTION 5

20. planets
21. performance
22. atmosphere

Glossary of Terms

Aerodynamics: The study of how air moves around objects and how forces affect motion through the air.

Ailerons (Roll Control): Control side-to-side tilting or banking of the aircraft

Air Pressure: The force exerted by air on surfaces; differences in pressure create lift.

Atmosphere: The layer of gases surrounding Earth through which aircraft move.

Axis (of Rotation): An imaginary line around which an object rotates (pitch, roll, yaw axes).

Balanced Forces: Forces that are equal in size and opposite in direction, resulting in no change in motion.

Control Surfaces: Parts of an aircraft that allow it to steer and change direction.

Drag: The force of air resistance that opposes motion through the air.

Efficiency: How effectively a system uses energy to perform work (e.g., minimizing drag).

Elevator (Pitch Control): Controls up-and-down movement of the aircraft nose

Energy Transfer: The movement of energy from one place to another (e.g., engines producing thrust).

Energy: The ability to do work or cause change.

Engineering Design: The process of solving problems by creating and improving technologies.

Force: A push or pull acting on an object that can change its motion.

Gravity: The force that pulls objects toward Earth, responsible for weight.

Jet Engine: A machine that produces thrust by expelling high-speed air from the back of an aircraft. (described in episode narration)

Lift: The upward force that opposes weight and allows an object to rise into the air.

Model: A simplified representation used to explain or test how something works.

Motion: A change in position of an object over time.

Performance: How well a system (such as an aircraft) operates under certain conditions.

Planets: Celestial bodies that may have different atmospheres affecting how flight works.

Pressure Difference: A variation in air pressure that causes movement, such as lifting a wing upward.

Propeller: A rotating blade that produces thrust by pushing air backward. (described in episode narration)

Prototype: An early version of a design used for testing and improvement.

Resistance: A force that slows down motion; drag is a type of resistance.

Rudder (Yaw Control): Controls left-and-right movement of the aircraft nose.

Stability: The ability of an aircraft to maintain controlled flight.

Thrust: The forward force that pushes an aircraft through the air.

Unbalanced Forces: Forces that are not equal, causing an object to accelerate or change direction.

Weight: The force of gravity pulling an object downward toward Earth.

Wing (Airfoil): A shaped surface designed to create lift by changing air pressure above and below it.

Higher-Order Discussion Questions

1. Systems Thinking — Interacting Forces 00:01:29 – 00:02:02
Which of the four forces of flight do you think is the most challenging for engineers to manage, and why?

2. Human Impact — Engineering Decisions 00:03:07 – 00:03:29
Why is it important for aircraft designers to understand drag and lift when creating new planes?

3. Cause and Effect — Planetary Exploration 00:01:10 – 00:01:22
How might flying on another planet (like Mars) differ from flying on Earth?

4. Cross-Disciplinary Understanding — NASA Research 00:00:55 – 00:01:22
Why does NASA study aerodynamics even for missions that don't involve airplanes?

5. Data Interpretation — Wing Shape 00:03:10 – 00:03:21
Why do you think wing shape matters so much for lift?

6. Ethical Decision-Making — Safety in Design 00:05:04 – 00:05:18
What responsibilities do engineers have when designing aircraft for public use?

7. Engineering and Technology — Innovation 00:03:38 – 00:04:08
If you could design a new aircraft feature to reduce drag, what would it be?

8. Language and Science — Clear Communication 00:02:29 – 00:02:52
Why must pilots and engineers use precise vocabulary when discussing aircraft movement?

9. Real-World Application — Transportation 00:03:38 – 00:04:08
How does understanding aerodynamics help improve everyday transportation (cars, trains, drones)?

10. Reflection — Personal Learning 00:07:56 – 00:08:12
What is one idea from this episode that changed how you think about flight?

Higher Order Discussion Questions Teacher Answer Key

1. Systems Thinking — Interacting Forces MS-PS2-2, SC.6.P.13.1

Teacher Sample Answer: Drag is often the most challenging force to manage because it increases as speed increases and depends heavily on an aircraft's shape. Engineers must balance reducing drag while maintaining lift and stability.

2. Human Impact — Engineering Decisions MS-ETS1-2, SC.6.P.13.3

Teacher Sample Answer: Designers must understand lift and drag to ensure planes can take off efficiently and remain in the air safely. If lift is too low or drag is too high, the aircraft may not perform well or could become unsafe.

3. Cause and Effect — Planetary Exploration MS-PS2-2, MS-ETS1-2 , SC.7.E.6.4

Teacher Sample Answer: Flight would differ because planets may have different gravity and atmospheric density. For example, lower gravity might make lift easier, but a thin atmosphere would reduce lift, making flight more difficult overall.

4. Cross-Disciplinary Understanding — NASA Research MS-ETS1-2, SC.7.E.6.4

Teacher Sample Answer: NASA studies aerodynamics because spacecraft, landers, and drones must still move through atmospheres. Understanding airflow helps ensure safe landing, movement, and exploration on other planets.

5. Data Interpretation — Wing Shape MS-PS2-2, SC.6.P.13.1

Teacher Sample Answer: Wing shape controls how fast air moves above and below the wing. Faster air above creates lower pressure, which causes lift. Without this shape,

6. Ethical Decision-Making — Safety in Design MS-ETS1-2, SC.6.P.13.3

Teacher Sample Answer: Engineers must ensure aircraft are safe, reliable, and thoroughly tested. They must consider how failures in control systems or forces could affect passengers and prioritize safety over cost or speed.

7. Engineering & Technology — Innovation MS-ETS1-2, SC.6.P.13.1

Teacher Sample Answer: I would design smoother, more streamlined surfaces or adaptive wings that adjust shape during flight. This would reduce air resistance and improve efficiency.

8. Language & Science — Clear Communication SEP Constructing Explanations / Communicating Information, SC.6.N.1.1 (scientific communication skill support)

Teacher Sample Answer: Precise vocabulary ensures that instructions and explanations are clearly understood. Miscommunication could lead to misunderstandings about aircraft movement or safety procedures.

9. Real-World Application — Transportation MS-PS2-2, SC.6.P.13.1

Teacher Sample Answer: Aerodynamics helps reduce drag, making vehicles more fuel-efficient and faster. Streamlined shapes allow cars and trains to move through air more easily, saving energy.

10. Reflection — Personal Learning SEP: Engaging in Argument from Evidence, SC.6.N.1.1

Teacher Sample Answer: I used to think flight depended mainly on engines, but now I understand that lift and air pressure differences are just as important as thrust.

Science of Flight – Exit Ticket

Name: _____ Period: _____ Date: _____

Part 1 – Multiple Choice (Concept Check)

1. Which force pulls an airplane downward toward Earth?
☐ A. Lift
☐ B. Drag
☐ C. Weight
☐ D. Thrust

2. Which force must be greater than weight for an airplane to take off?
☐ A. Drag
☐ B. Lift
☐ C. Thrust
☐ D. Resistance

3. What is the force that opposes motion through the air?
☐ A. Lift
☐ B. Thrust
☐ C. Drag
☐ D. Gravity

4. Which aircraft part controls up-and-down movement (pitch)?
☐ A. Rudder
☐ B. Ailerons
☐ C. Elevator
☐ D. Wings

Part 2 – Short Response (2–3 sentences each)

5. Explain how wing shape helps create lift.

6. Describe how thrust and drag work together during flight.

7. Why are control surfaces important for safe flight?

8. Imagine you are designing a new airplane. What is ONE change you would make to improve performance, and which force are you trying to affect? Explain why.

9. What is one idea you learned about flight that changed your thinking? Why is it important?

Exit Ticket Teacher Answer Key

Part 1 – Multiple Choice

1. C – Weight

- *Explanation:* Weight is caused by gravity pulling objects downward.

2. B – Lift

- *Explanation:* Lift must be greater than weight for an aircraft to rise into the air.

3. C – Drag

- *Explanation:* Drag is the force that resists motion through the air.

4. C – Elevator

- *Explanation:* The elevator controls pitch (up/down movement of the plane).

Part 2 – Short Response

5. Wing Shape and Lift – Sample Answer:
Wings are curved on top and flatter on the bottom, causing air to move faster over the top. This creates lower pressure above the wing, which lifts the airplane upward.

Acceptable Elements:

- Curved wing shape (airfoil)
- Faster air over top
- Lower pressure above / higher below
- Upward lift force

6. Thrust vs Drag – Sample Answer: Thrust pushes the airplane forward, while drag slows it down by resisting motion. For an airplane to keep moving forward, thrust must be greater than drag.

Acceptable Elements:

- Thrust = forward force
- Drag = resistance
- Relationship must be balanced/unbalanced

7. Control Surfaces – Sample Answer: Control surfaces allow the pilot to steer the airplane and control its direction. Without them, the aircraft would not be able to turn, climb, or descend safely.

Acceptable Elements:

- Steering / control function
- Movement (pitch, roll, yaw)
- Safety importance

8. Design Question – Sample Answer: I would design smoother wings to reduce drag because less air resistance would allow the airplane to move faster and use less fuel.

Scoring Guidance:

- **3 points:** Clear design idea + correct force + explanation
- **2 points:** Idea + partial explanation
- **1 point:** Idea only
- Acceptable forces: drag, lift, thrust, weight

9. Reflection – Sample Answer: I learned that lift comes from air pressure differences, not just engines. This is important because it shows how flight depends on the interaction of forces, not just power.

Scoring Guidance:

- Accept any thoughtful, accurate response
- Look for:
    - Concept understanding
    - Personal connection
    - Explanation of importance

Science of Flight Lab: Paper Airplane Engineering Challenge

Title: How Do Design Changes Affect Flight Performance?

Grade Band: Middle School (6–8)

Time: One class period (45–60 minutes)

Standards Alignment

NGSS:

- **MS-PS2-2:** Investigate how forces affect motion
- **MS-ETS1-2:** Evaluate and improve design solutions

Florida B.E.S.T.:

- **SC.6.P.13.1:** Effects of forces on motion
- **SC.6.P.13.3:** Balanced/unbalanced forces

Learning Objective: Students will investigate how **aerodynamic design changes affect flight distance and stability** by modifying paper airplanes to adjust lift, drag, and thrust.

Essential Question

How do changes in airplane design affect how far and how well it flies?

Materials (per group of 2–3 students)

- 3–4 sheets of paper
- Ruler or measuring tape
- Stopwatch (optional)
- Paper clips (optional, for weight)
- Data table (provided below)
- Pencil

Name: _____ Period: _____ Date: _____

Title: How Do Design Changes Affect Flight Performance?

Learning Objective: Investigate how **aerodynamic design changes affect flight distance and stability** by modifying paper airplanes to adjust lift, drag, and thrust.

Essential Question: How do changes in airplane design affect how far and how well it flies?

Materials 3–4 sheets of paper

- Ruler or measuring tape
- Stopwatch (optional)
- Paper clips (optional, for weight)
- Data table (provided below)
- Pencil

Procedure

Part A – Build & Test (Baseline) (15 min)

1. Students fold a **basic paper airplane** (see model sheet).
2. Measure and mark a **launch line**.
3. Launch plane **3 trials** from the same spot using consistent force.
4. Record **distance flown** and **observations**.

Part B – Modify Design (15–20 min)

Redesign their airplane to test one change:

Choose ONE variable:

- Wing size (bigger/smaller)
- Wing shape (curved vs flat folds)
- Weight (add paper clip)
- Nose design (sharp vs blunt)

1. Build a **new version**
2. Predict how the change will affect flight
3. Test 3 trials again

Part C – Compare & Analyze (10–15 min)

- Compare original vs modified design
- Identify which forces were affected (lift, drag, thrust, weight)
- Complete analysis questions

Student Data Table

Trial	Original Distance (m)	Modified Distance (m)	Observations
1			
2			
3			

Questions

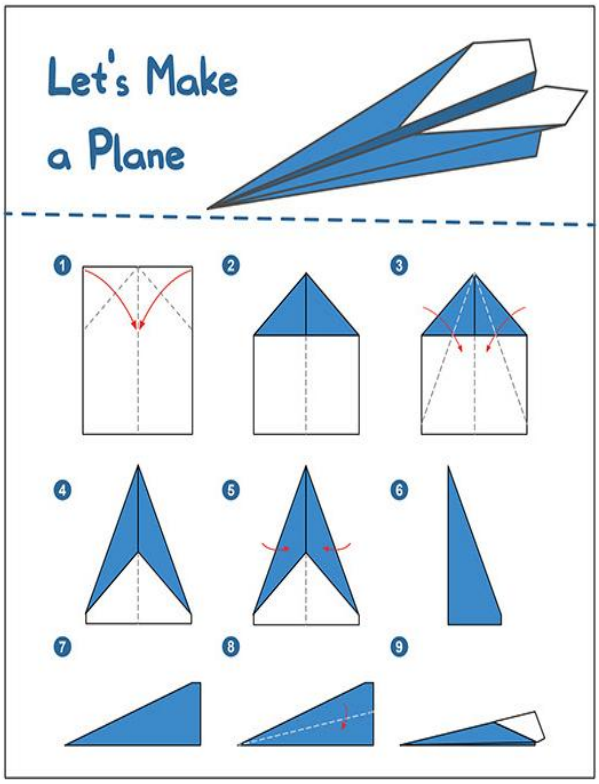
1. What change did you make to your airplane?

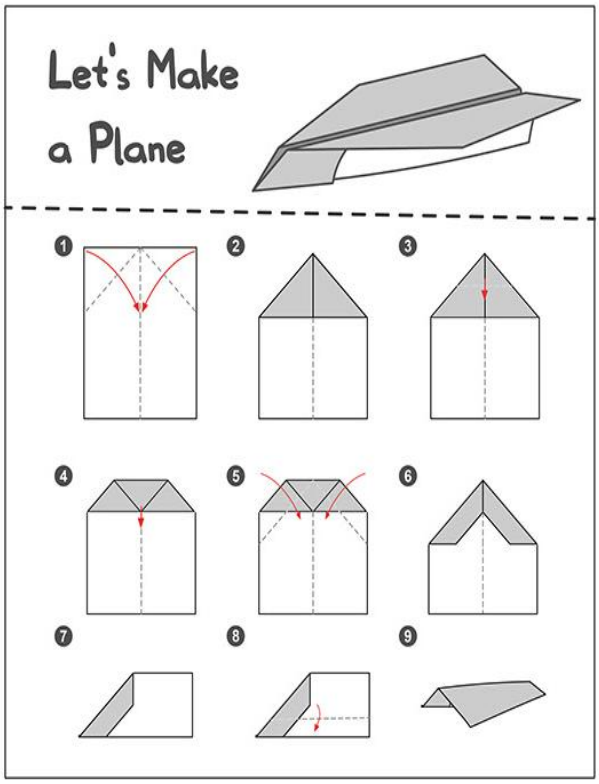
2. How did your design affect flight distance?

3. Which force did your design change the most (lift, drag, thrust, weight)? Explain.

4. Which design worked best and why? Use evidence from your data.

5. How could you improve your airplane further?


Let's Make
a Plane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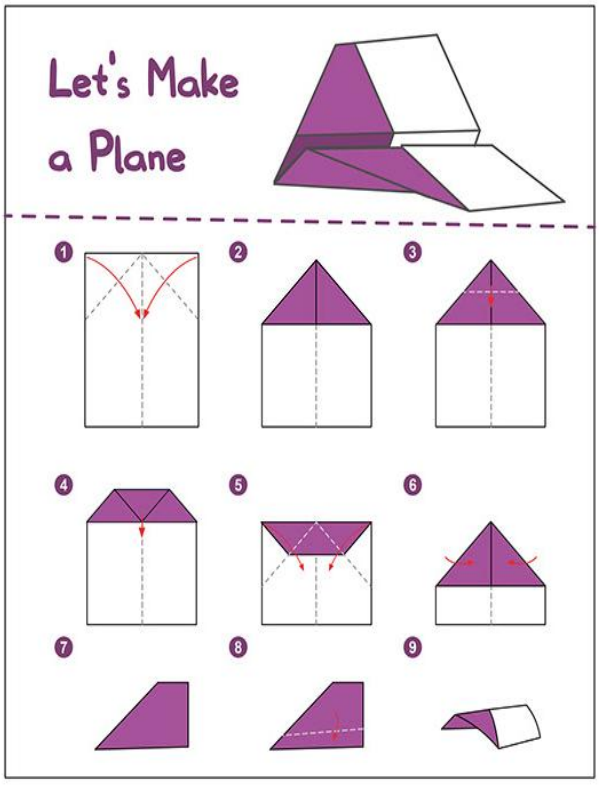
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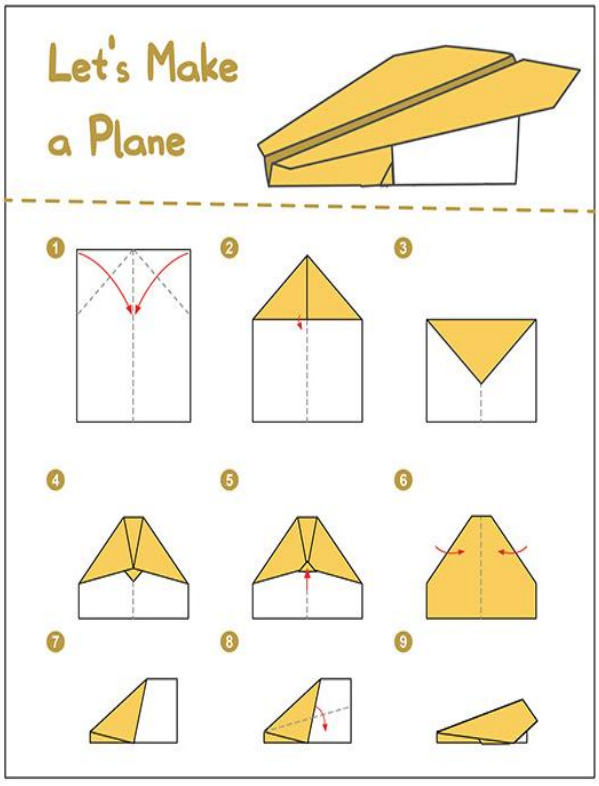
Let's Make
a Plane

Teacher Answer Key

Expected Results

- Larger wings → Increased **lift**, longer flight (but possibly more drag)
- Added weight → Increased **weight**, may increase stability but reduce lift
- Sleek design → Reduced **drag**, increased distance
- Curved wings → Improved **lift**

Sample Answers

1. Design Change
I added a paper clip to increase weight.

2. Effect on Distance
The airplane flew shorter distances but was more stable.

3. Force Explanation
My change affected weight because adding a paper clip increased the downward force. This made it harder for lift to overcome gravity.

4. Best Design
The original design worked best because it had less drag and better lift, allowing it to fly farther based on the data.

5. Improvements
I would try making longer wings to increase lift and improve flight distance.

Scoring Rubric (Quick)

Criteria	3 = Proficient	2 = Developing	1 = Beginning
Data Collection	Complete & accurate	Partial	Minimal
Force Explanation	Clear + correct force reasoning	Partial understanding	Incorrect
Use of Evidence	Uses data to justify	Some reference	No evidence
Design Thinking	Thoughtful improvement	Basic idea	Limited effort

Teacher Tips

- Demonstrate **consistent launch technique** (same angle/force)
- Emphasize **fair testing (controlled variable)**
- Connect observations directly to **forces of flight**
- Encourage iteration if time allows

NGSS Alignment (Middle School)

MS-PS2-2 — Forces and Motion
Episode Connection*:* Four forces of flight; how forces interact to produce motion.

MS-PS2-4 — Motion and Stability
Episode Connection*:* How lift, drag, thrust, and weight determine aircraft movement.

MS-ETS1-2 — Engineering Design
Episode Connection*:* NASA research, designing wing shapes, improving aircraft performance.

MS-ESS2-6 — Weather & Atmosphere (supporting)
Episode Connection*:* Air pressure differences around wings.

Science & Engineering Practices (SEPs)

- **Developing and Using Models:** Forces of flight diagrams, wing airflow models.
- **Analyzing and Interpreting Data:** Understanding pressure differences and drag.
- **Constructing Explanations:** Explaining how lift works.
- **Engaging in Argument from Evidence:** Evaluating which force is most important.
- **Asking Questions and Defining Problems:** Engineering challenges in aircraft design.

Florida B.E.S.T. Science Standards Alignment

SC.6.P.13.1 — Forces and Motion
Episode Connection*:* Four forces of flight; motion changes based on force interactions.

SC.6.P.13.3 — Balanced and Unbalanced Forces
Episode Connection*:* Lift vs. weight; thrust vs. drag.

SC.7.P.11.2 — Energy Transfer
Episode Connection*:* Jet engines, thrust, and energy in motion.

SC.7.E.6.4 — Human Exploration and Technology
Episode Connection*:* NASA research on aerodynamics for planetary missions.