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UNIT 4 | SECTION B | LESSON 1 | PRESENTATION

THEORIES OF LIFT

LEARNING OBJECTIVES

At the end of this lesson, students will be able to:

- **Summarize why the development of lift is such a complicated concept.**
- **Explain how lift is created.**
- **Analyze three misconceptions about lift.**



THE GREAT LIFT CONTROVERSY

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CONTROVERSY



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WARM-UP

You are a scientist attending an international conference on aerodynamics. The purpose of the conference is to establish, once and for all, the accepted theory on how lift is produced. Your job is to convince the participants that your theory of lift production is the correct one.

- Read the theory of lift assigned to your team.
- As a group, prepare a brief explanation of the assigned theory.
- Following the presentations, vote on which of the five theories of lift you find most plausible. Be prepared to explain your reasoning.



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LIFT FAILS

Why is creating lift so important to aircraft designers?



VIDEO



What types of problems did these early designers have?

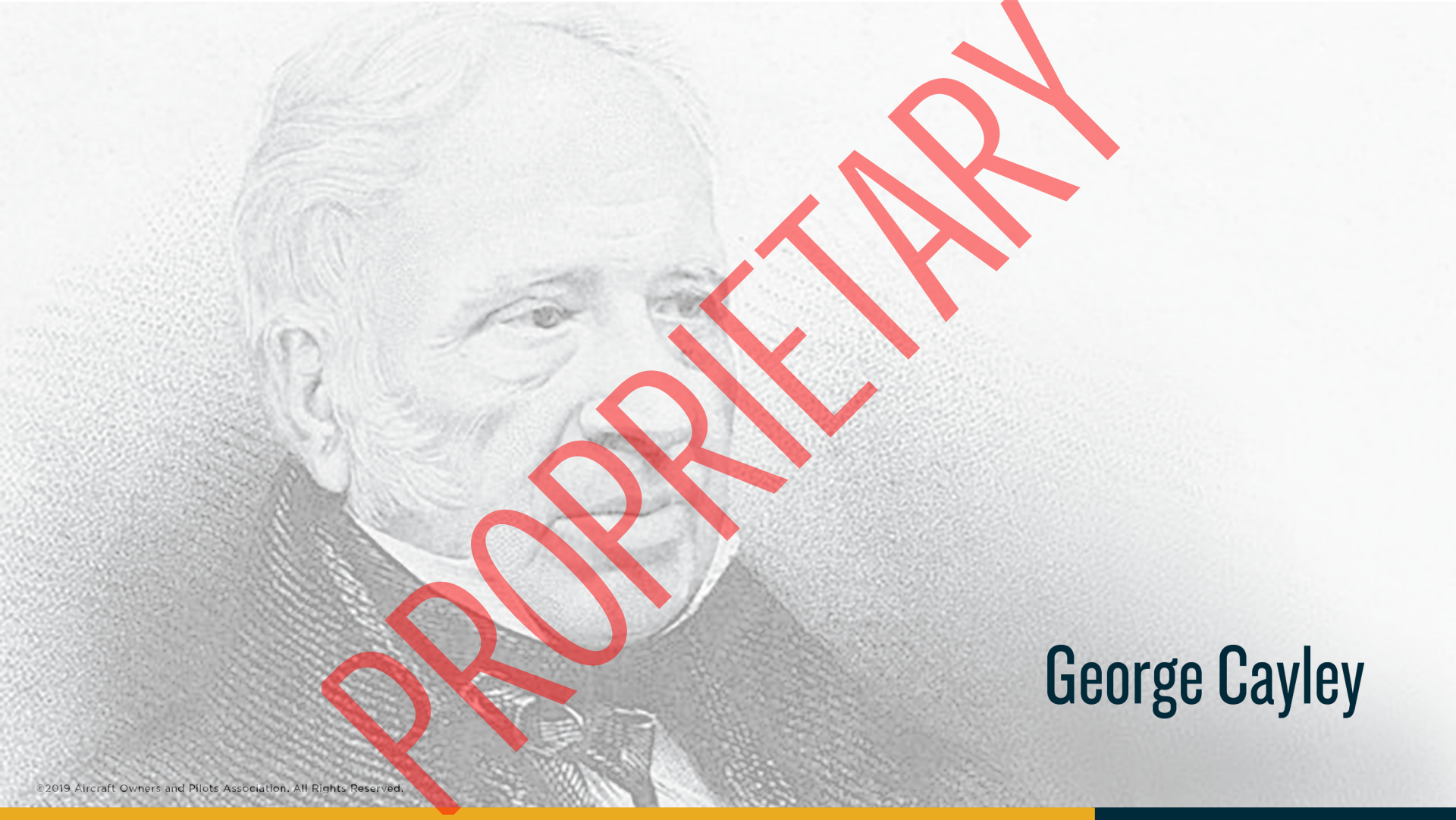
Why do you think it was so difficult to create successful aircraft?

Why are we still working to develop a precise understanding of lift today?

LIFT IS COMPLICATED



What theories of lift might be used to explain what you see in this video?



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George Cayley

GEORGE CAYLEY

- Cayley was credited for being the first researcher to apply methods and tools of science and engineering to the research of flight.
- He was considered the first person to understand the four forces of flight.
- He was doing his work in the late 1700s to mid-1800s.
- Cayley designed and built his first glider model in 1804.

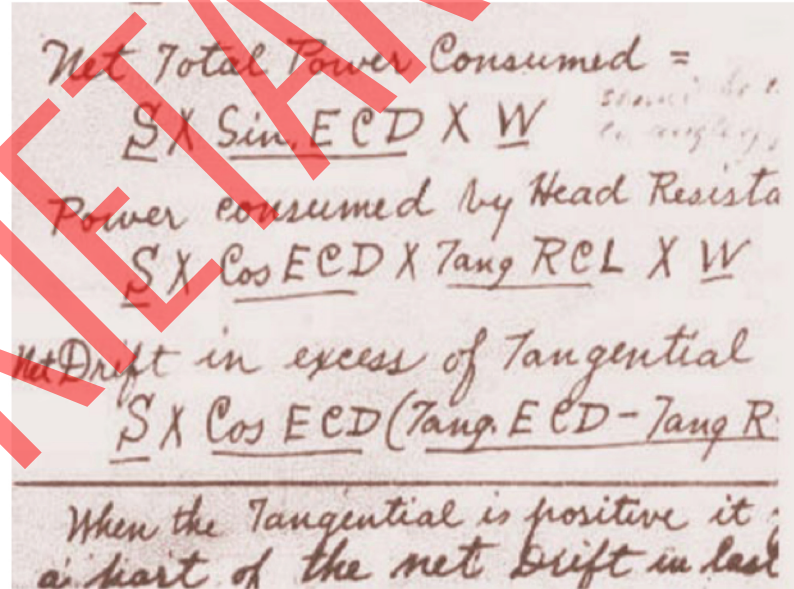
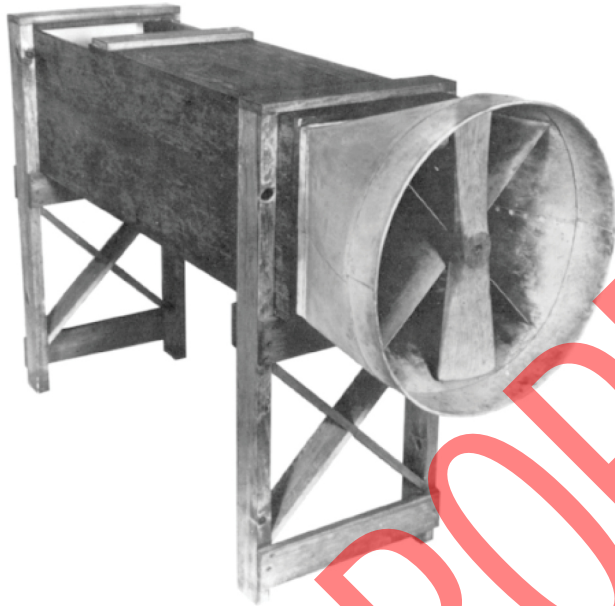
Cayley's first
glider - 1804





The Wright Brothers

WRIGHT BROTHERS



Replica of the Wright brothers' wind tunnel and some of their handwritten formulas

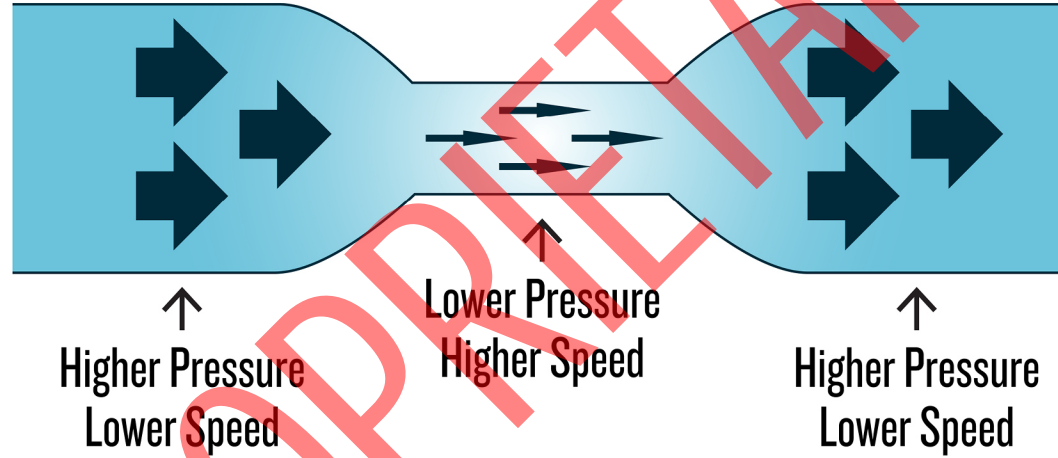
DANIEL BERNOULLI



1700-1782

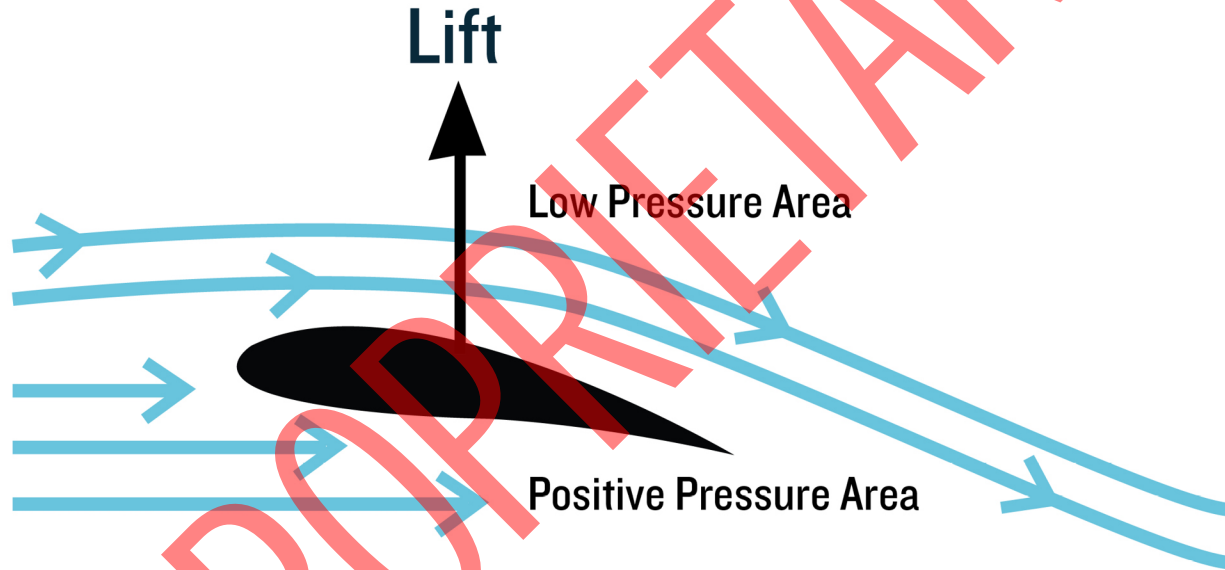
- Swiss mathematician and physicist
- Explained how the pressure of a moving fluid (liquid or gas) varies with its speed

BERNOULLI'S PRINCIPLE



- Venturi - Smaller piece of tube between two wider ones, creating a restricted flow
- Pressure is lower where the tube is narrow and the speed of the gas is faster

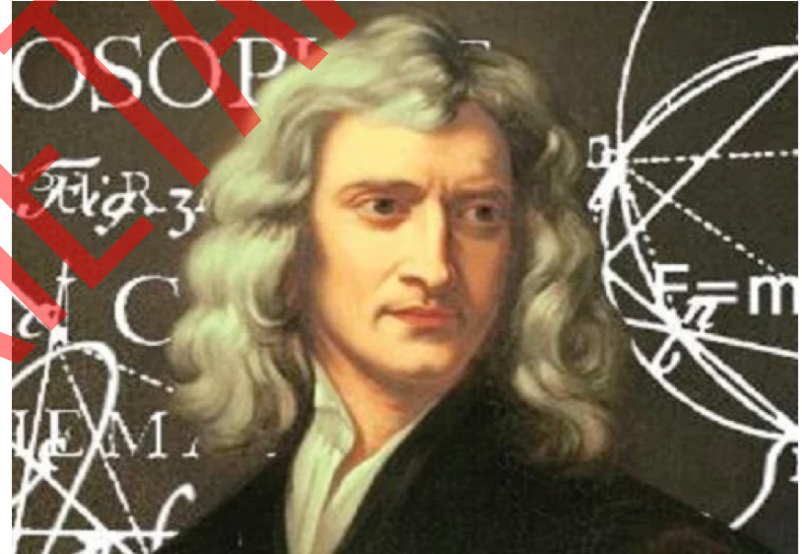
CREATING LIFT WITH BERNOULLI



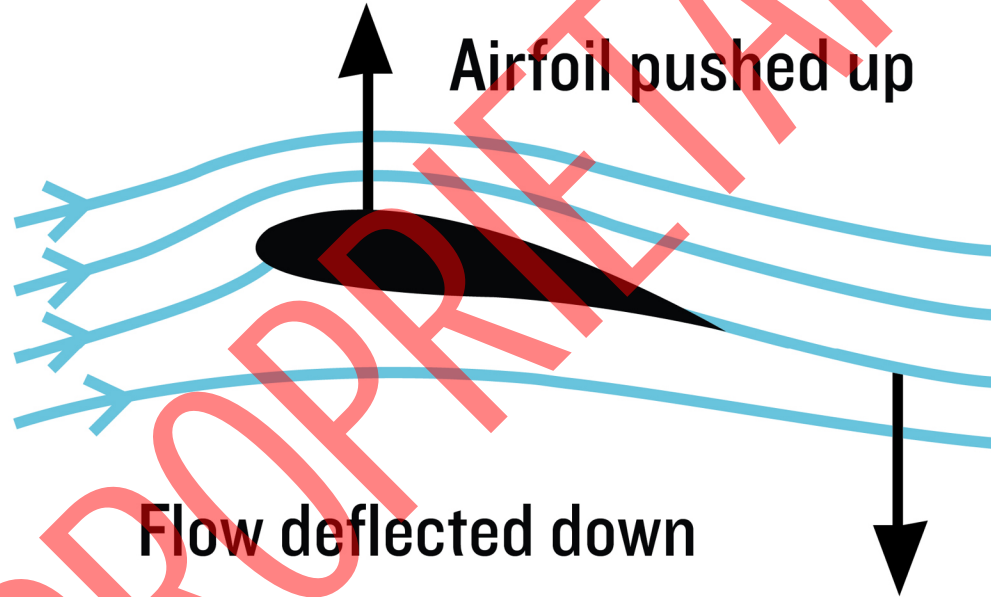
Faster airflow over the top of the wing creates lower pressure.

SIR ISAAC NEWTON

- **Third Law of Motion states that for every action, there is an equal and opposite reaction.**
- **When air traveling across the top of an airfoil bends down, the action results in an upward force on the airfoil.**



GENERATING LIFT WITH NEWTON



The downward deflected airflow results in lift.

FLOATING BALL DEMONSTRATION



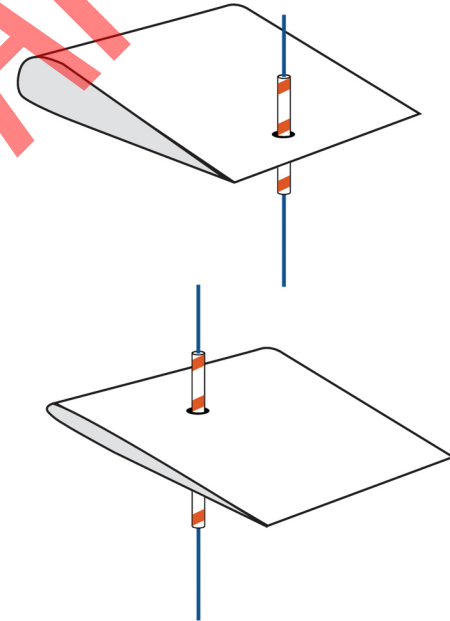
What principle does this demonstration illustrate?

MAGIC BALLOONS EXPERIMENT



What principle does this demonstration illustrate?

AIRFOIL DESIGN EXPERIMENT



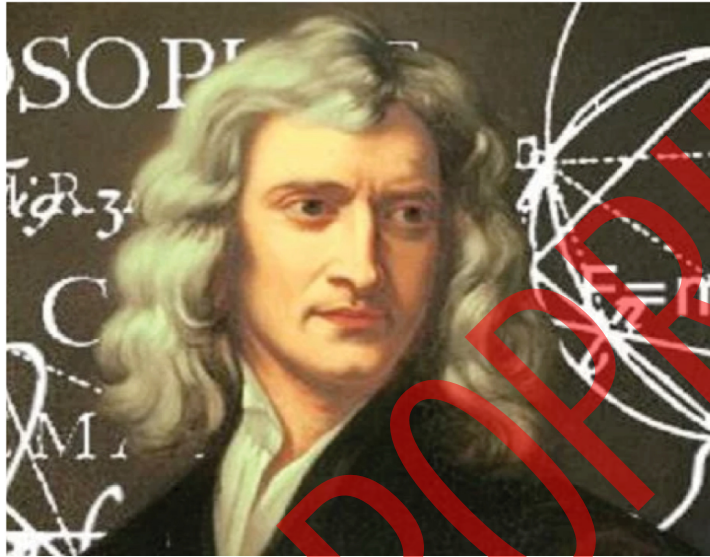
What principle does this demonstration illustrate?

THE TRUTH ABOUT LIFT

Watch this video to learn about which of the five theories are truly responsible for creating lift.



THE WINNERS ARE...



NEWTON

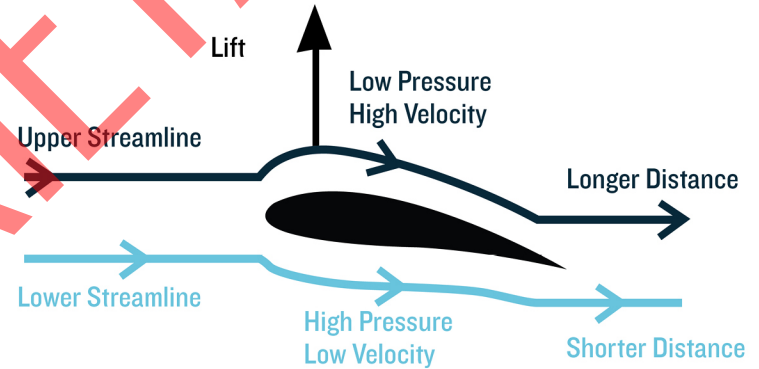


BERNOULLI

LONGER PATH OR EQUAL TRANSIT TIME THEORY

NO!

- Theory says molecules of air flowing over the top of a wing must travel faster than the molecules of air flowing beneath the wing in order to meet at the trailing (back) edge.
- It is based on the false idea that molecules of air arriving at the leading edge (front) of the wing at the same time must also arrive at the trailing edge of the wing at the same time.

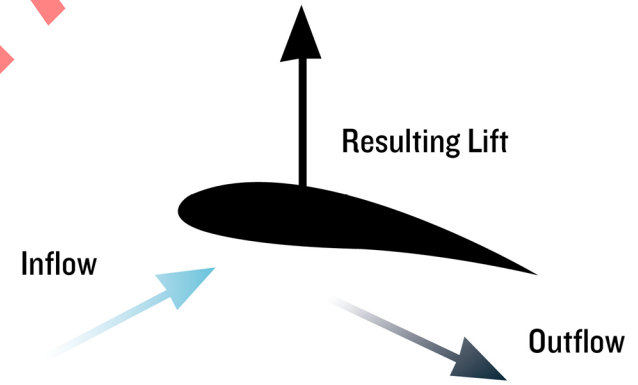


“Longer Path” or “Equal Transit” Theory

SKIPPING STONE THEORY

NO!

- Theory says lift is produced because air hitting the underside of the wing is deflected downward, pushing the wing up in a simple action-reaction cycle much like the one produced by skipping a flat stone across the surface of the water.
- But it does not accurately reflect the physical properties of the fluid (air) through which the wing is moving. This theory also ignores the role of other surfaces, including the upper surface of the wing, in producing lift.

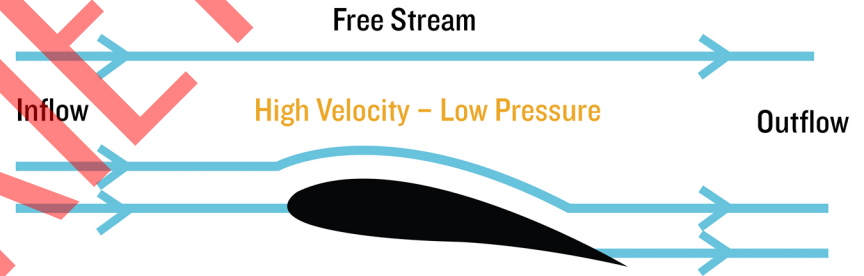


“Skipping Stone” Theory

VENTURI THEORY

NO!

- Suggests that air flowing over the top of a cambered wing surface is compressed, as in a Venturi tube, and therefore moves more quickly than air that is not compressed.



“Venturi” Theory

- The primary problem with this theory is that it is based on an incorrect assumption that the top wing surface acts as a Venturi tube. Without compressing the air from both sides, as in a tube, the air flow does not produce the velocity field needed to explain lift.

FORMATIVE ASSESSMENT

- On a piece of paper *without your name*, write a paragraph explaining how lift is created.
- Your teacher will collect the papers, mix them up, and hand them back out to you.
- “Grade” the explanation you receive by writing comments either reinforcing or correcting the explanation.

Your teacher will review the correct answer with the class.

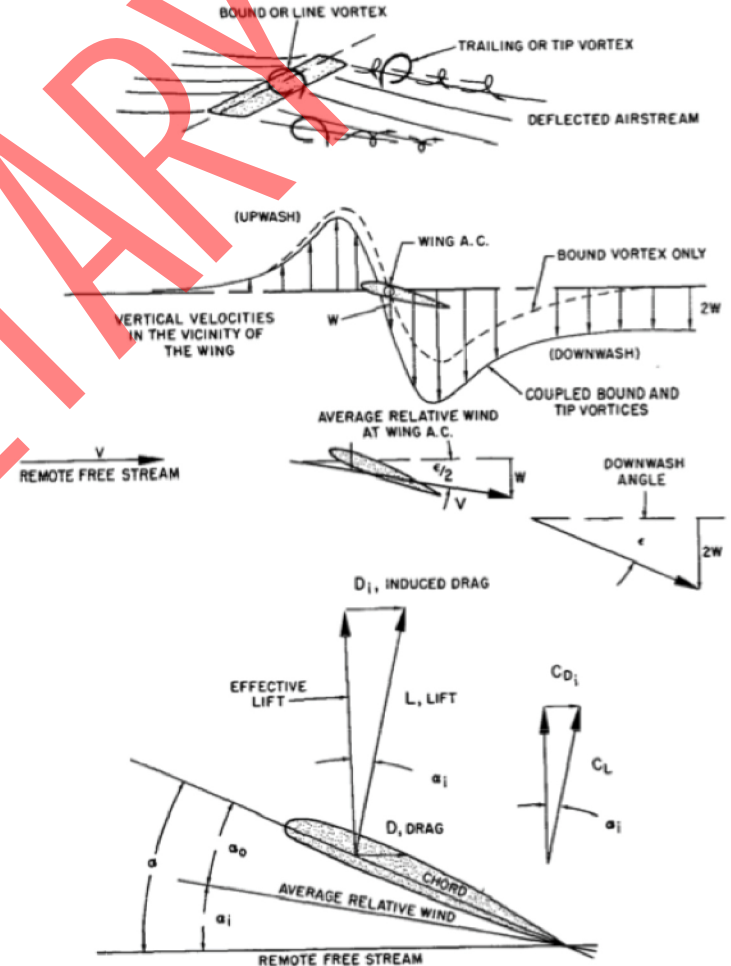
Be sure to write your name on the work you graded and return it to the teacher for credit.



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IT'S COMPLICATED

- Lift is a complicated phenomenon that doesn't lend itself to a simple explanation.
- The flow around an airfoil is complex and involves us trying to visualize movements that aerospace engineers normally calculate with computers running complex math equations.
- But we do know that, at subsonic speeds, it is a combination of Bernoulli's Principle and Newton's Third Law.



PRIVATE PILOT KNOWLEDGE TEST QUESTION

Which statement relates to Bernoulli's principle?

- A. For every action, there is an equal and opposite reaction.
- B. An additional upward force is generated as the lower surface of the wing deflects air downward.
- C. Air traveling faster over the curved upper surface of an airfoil causes lower pressure on the top surface.

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PRIVATE PILOT KNOWLEDGE TEST ANSWER

Which statement relates to Bernoulli's principle?

- A. For every action, there is an equal and opposite reaction.
- B. An additional upward force is generated as the lower surface of the wing deflects air downward.
- C. **Air traveling faster over the curved upper surface of an airfoil causes lower pressure on the top surface.**

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EVALUATE

Using what you have learned about lift, create a storyboard and a script for a YouTube video that explains why each of the three incorrect theories of lift are in error.

- Equal Transit/Longer Path
- Skipping Stone
- Venturi

"CS2C: Fun with Storyboards" by Kenneth Chan



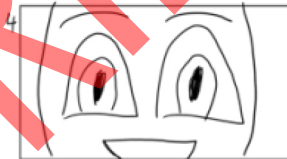
1 Establishing shot of classroom. One student snoring. One sits up in alarm over assignment.



2 Student feels overwhelmed. Voiceover: "I've never done this!" Camera pans slowly to make space.



3 Ideas surrounded by blurry thought bubble. Brainstorm may also be video montage surrounded by blurry frame.



4 Moment of clarity. "Aha!" Ding or chimes; lightbulb moment.



5 Working in a dark dorm room. Sounds of clock ticking and pencil scratching on paper.



6 Proudly shows off finished storyboard. Wipes sweat off brow. Victory music. Zoom in on storyboard.



7 Submitting via Coursework. Fade out as if ending.



8 Back to the classroom. Keep as similar as possible to original. "Elaborate on your storyboards!"



9 Back to the drawing board. Looking haggard but determined. Fade out.

YOUTUBE VIDEO

- Goal** To educate new pilots about the incorrect theories of lift.
- Role** You are a flight instructor in a collegiate flight school program.
- Audience** The target audience is student pilots.
- Situation** To prepare the new student pilots for the rigorous flight training program at your college, you need to help them understand how lift really works. There has been a lot of misinformation spread over the years that uses the incorrect theories of lift to train new pilots.

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