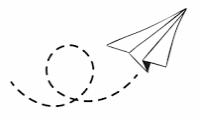
LESSON 1

Name: _____ School: _____



AIRPLANE ENGINEERING – How do they Fly?

Make and Test a Variety of Paper Airplanes

TIME: 30-60 Minutes

MATERIALS:

1. Paper (8.5” x 11” is best)
2. Paper Clips (optional)
3. “Fold’N Fly” paper airplane designs: https://tinyurl.com/mesa-paper-plane

VOCABULARY:

- Aerodynamics
- Drag
- Gravity
- Thrust
- Lift

OBJECTIVE:

Students will build and test a variety of paper airplanes and explore the ***Four Forces of Aerodynamics***.

INTRODUCTION QUESTIONS:

1. When an airplane flies in the sky, how is it possible? How do you think such a large, heavy object can stay in the air?

2. Do you think different physical properties like wing size, weight of the plane, and size of the tail can affect how efficiently it flies? Why or why not?

BACKGROUND INFORMATION:

Aerodynamics *- The properties of a solid object regarding the manner in which air flows around it.*

- Aerodynamics refers to how easily an airplane moves through the air.

Drag – *A type of friction that causes air resistance. It is a force that acts opposite to the relative motion of an object.*

- Drag happens when the air resists the forward motion of an airplane, slowing its velocity. When building a plane, you want to create as little drag as possible.

ACTIVITY!

Demonstration: Hold your hand in front of you so that your hand is in front of you, with the thumb pointing up, as if you are going to shake someone's hand. Notice the amount of air pushing against your hand.

Now turn your palm so that it faces the ground. Your hand will be horizontal and parallel to the ground. Swing your hand back in the same manner, as if you're slicing through the air. You should be able to still feel air, but should also notice that your hand moves more smoothly than when it was turned vertically.

Gravity – *A force that attracts two bodies toward each other. The more mass an object has, the stronger its gravitational pull.*

- Gravity is the force that will pull a paper airplane to the ground.

ACTIVITY!

Demonstration: Put a paper clip on the edge of a piece of paper. When you drop it, how quickly does it fall to the floor? Now remove the paper clip and drop the paper. How does it fall differently?

- When the paper has less mass (without the paperclip), the less it needs to fight against gravity pulling it to the ground.
- How does drag also affect its fall to the ground?

Thrust– *Thrust is a force or a push, when a system pushes or accelerates mass in one direction, there is an equal thrust in the opposite direction.*

- An airplane's engine generates thrust. When flying a paper airplane, the thrust is created by the forward push of the arm.

Lift – *A force that directly opposes the weight of an airplane and holds it in the air.*

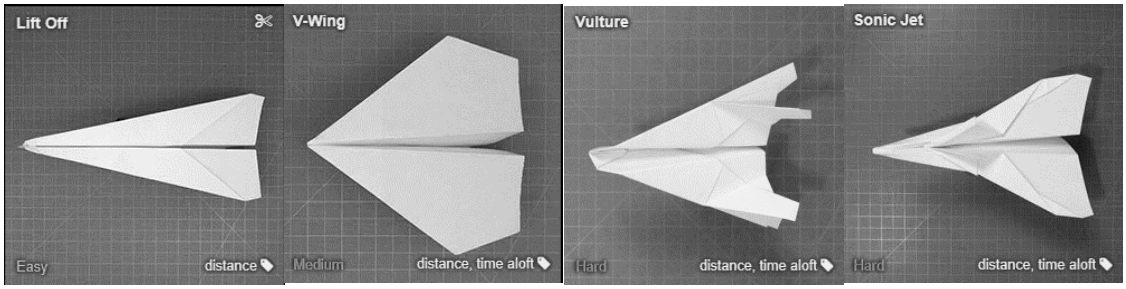
- *An airplane's wings push UP harder than the air above it is pushing down. This means it is the wings that are doing the lifting, not the engines or thrust.*
- *The wings are often slightly curved so the air can move more quickly over the top than the air moves below the wing, creating an upward lift.*

ACTIVITY!

Demonstration:

Fold two different paper airplanes of your own creation and take them outside. Maybe one has large wings and the other has narrow wings. Try some test flights, starting with a smooth steady throw, then gradually increasing the force of your throw (thrust).

- Do you notice a difference when you increase the thrust?
- Did the large winged plane stay in the sky longer, while the one with narrow wings went farther? How does this relate to lift and drag?



BIG ACTIVITY!

NOW LET'S HAVE SOME FUN BUILDING EXPERT PAPER AIRPLANES!

- Check out these online plans and build as many as you'd like: https://tinyurl.com/mesa-paper-plane
- Take your planes outside and create your own testing parameters to test for lift, drag, thrust and aerodynamics.

BACK INSIDE: FOLLOWUP QUESTIONS

1. Describe the testing procedure that you set up. Were you able to measure lift, drag and thrust? How about distance and time?

2. Which airplane flew the farthest? Why?

3. Which airplane flew the fastest? Why?

4. Which plane was your favorite? Why?

Bonus Video (How This Guy Folds and Flies World Record Paper Airplanes):
https://www.youtube.com/watch?v=3BNg4fDJC8A

Have fun exploring the exciting world of physics and the magic of flying! Get some fresh air and exercise!!

"Quite likely the twentieth century is destined to see the natural forces which will enable us to fly from continent to continent with a speed far exceeding that of a bird."

-Simon Newcomb

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LESSON 2

MYSTERY NUMBERS

Read all of the statements in each problem to determine whether the conclusion is true or false.

1	My number and your number are both divisible by 8. Therefore, the sum of our numbers will be divisible by 4.	true false
2	My number is equal to Don's number. Don's number is greater than Donna's number. Your number is less than Donna's number. Therefore, my number is greater than yours.	true false
3	My number has two odd repeating digits. My number's digits add up to less than 10. Therefore, my number must be 33.	true false
4	My number is divisible by 5. Your number is divisible by 3. Therefore, our numbers can't be the same.	true false
5	Tim's number is equal to Scott's. Karen's number is greater than Scott's. Todd's number is less than Tim's. Therefore, Karen's number is greater than Todd's.	true false
6	My number is greater than 15. Your number is less than 20. My number is less than 19. Your number is greater than 13. Therefore, our numbers could be the same.	true false
7	Judy's number is greater than Mario's. Dave's number is less than Jeff's. Jeff's number is equal to Mario's. Judy's number is greater than Dave's. Therefore, Dave's number is greater than Jeff's.	true false
8	My number is a whole number. My number is the square root of your number. Your number is less than four times mine. Therefore, your number is a two-digit number.	true false
9	My number is three more than twice Kum's number. Therefore, three less than half my number is Kum's.	true false

CRITICAL THINKING ACTIVITIES IN PATTERNS, IMAGERY, LOGIC (Secondary)
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LESSON 3

PAPER BRIDGE ENGINEERING CHALLENGE

Can you make a strong bridge using only one sheet of paper?

Goal: Build the strongest free-standing bridge possible, using only one piece of paper

Rules:

- You must only use one sheet of paper (normal 8.5" x 11" paper).
- No other materials may be used.
- Construct the bridge to go across two surfaces, like two thick books or two bricks.
- Test the bridge strength by placing increasing amounts of weight (coins, forks, adding water to a bowl, etc. Anything that is measurable)
  - For example: If, while testing, the bridge collapsed after you put the tenth fork on it, you can say that it was able to hold nine forks!
- Be creative! There are many ways to make this bridge work.

20 MINUTES TO BUILD…. SET A TIMER …. READY?... GO

QUESTIONS:

1. Were you successful with the challenge? Why or why not?

2. How much weight did your bridge hold?

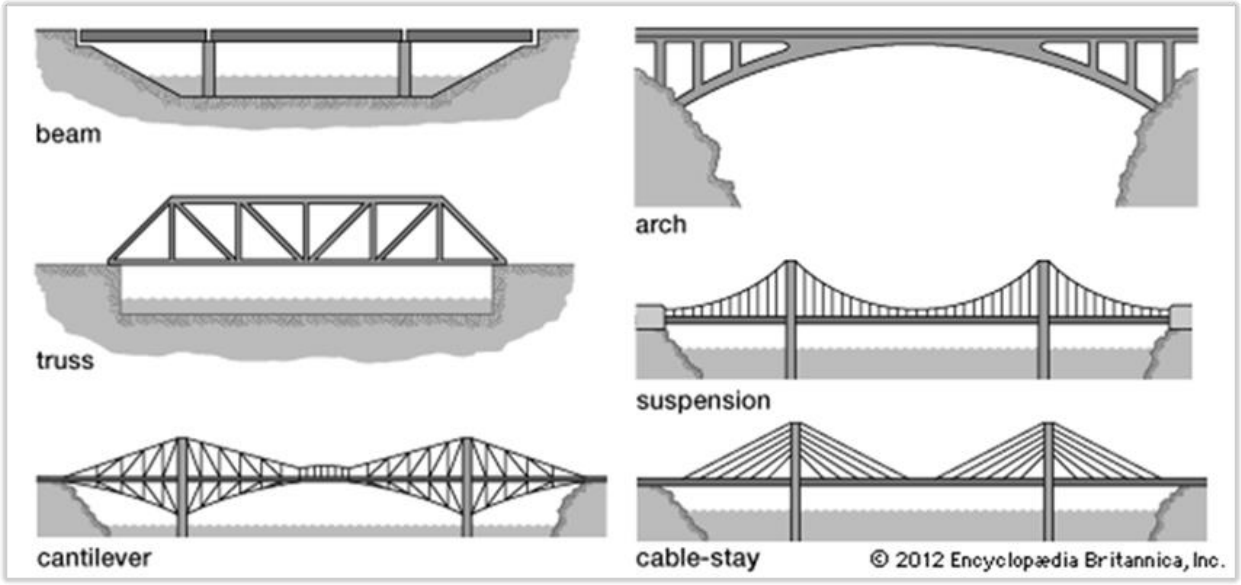
3. What was the most difficult part of the challenge? Why?

4. What did you learn about bridge engineering during your building experience?

LEARN MORE ABOUT BRIDGE ENGINEERING:

Although there are many types of bridges used around the globe, the four most common are the beam bridge, arch bridge, suspension bridge, and draw bridge. Each of these bridges work well for different locations and situations, and it is up to the local engineers to decide which bridge is the best fit. Beam bridges are the simplest design, and consist of a flat deck supported on the ends by abutments. They are great options for crossing over small spans, such as a foot bridge over a stream. Arch bridges are made up of a curved arch supported by abutments on either side. By combining multiple arches side-by-side, these bridges can be used for both shorter and longer spans. Suspension bridges have a deck that hangs below giant suspension cables supported by upright towers. These bridges are especially helpful for crossing great distances, while still leaving room for water traffic below. Seeing as suspension bridges can be very expensive to build, a draw bridge may be a good alternative to keep costs down. Draw bridges work best in low traffic areas, since pedestrians and vehicles must wait as the leaves of the bridge move upwards and downwards to give overhead clearance to passing boats and ships below.

By looking for the basic shapes that make up a bridge, bridge engineers can better understand how forces act on it. Rectangle shapes, such as those that are formed by beam bridges and the ground beneath them, tend to be the weakest of shapes. As weight is added to the top, the beam begins to sag in the middle, causing the top of the beam to undergo compression and the bottom of the beam to undergo tension. If too much weight is added, the beam will tear apart and fail. Arch shapes, found in arch bridges, are more stable than rectangle shapes. The more weight is applied to the top of the arch bridge, the more the arch experiences compression. This squishing force is transferred to the abutments, which pushes back on the arch and prevents it from spreading apart and collapsing. Triangles, such as those seen in suspension bridges, are the most stable of shapes. As weight is added to the deck, the cables experience tension, and this pulling force causes the towers to compress. The towers support most of the weight of the bridge and contribute greatly to its stability.



LESSON 4

Author:
Crystal Chatterton (2018). Rockridge Press, CA

Adapted from:
pages 142-143

Gravity Drop

Level of Difficulty: EASY
From Beginning to End: 30 minutes+
Content: Math, Engineering & Science

Q: Can you make a drop course that will keep a coin, a ping pong ball, a small pom-pom, or something else rolling for 10 seconds or more?

Topics: Learn about **gravity**, experiment with different **angles**, and get a hands-on lesson in **friction** and **momentum** while building a fun tube slide on the wall.

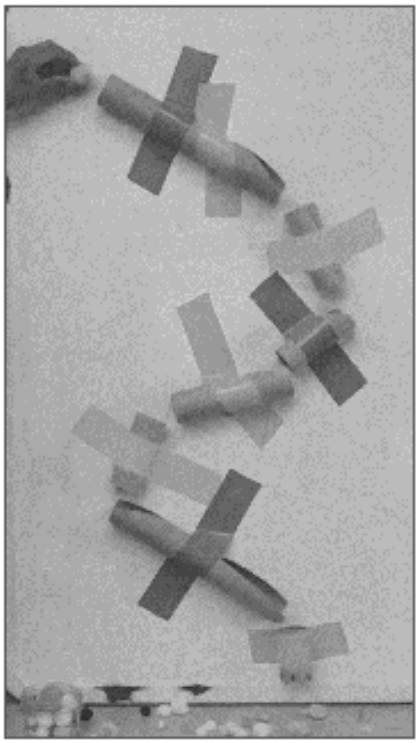
Materials:

- ***pencil & paper***
- ***several cardboard tube from paper towels, toilet paper, or wrapping paper***
- ***other recycled items***
- ***wall-safe tape (like masking or blue painter's tape)***
- ***scissors***
- ***timer/stopwatch***
- ***an item, or several, to drop!***

The Steps:

1. **Use a pencil & paper to sketch out your design for an amazing gravity drop course.**
2. **Tape the cardboard tube & recycling items to the wall using the scissor to trim and cut the tubes as necessary.**
3. **Drop your item through the course and time it with a stopwatch to see how long it takes to get from the top to the bottom.** ☺

Other items you might use: ping pong balls, cut up cereal boxes, construction paper, or other recyclables!



Observations: How long did the item take to get through the course? What can you do it make it go faster? To make it go slower?

Now Try This! Drop heavier or lighter items, like marbles or bouncy balls, through the gravity drop course and compare the results. Are they different? Why?

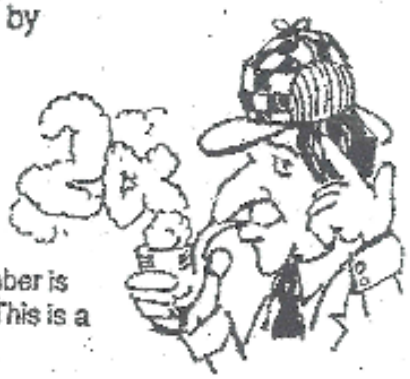
The Hows and Whys

Gravity is a force that pulls objects ot the Earth. Even though gravity constantly pulls the items down, it will travel faster or slower depending on the angles of the cardboard tube. A steeper angle will allow the item to go faster and gain momentum as it rolls through the course.

LESSON 5

INDUCTIVE REASONING

You use *inductive reasoning* if you reach a conclusion by making particular observations.



Example:

If a number is divisible by 4, is it divisible by 2?

Examine some cases: 44, 60, 72, 36

Based on these cases, you should say, "Yes!" In fact, if the number is divisible by 4, then the ones digit is even (divisible by 2). Note: This is a conjecture only, not a proof!

For each statement below, examine five cases. Make a conjecture of "yes" or "no."

	Yes/No
1. If a number is divisible by 2 and 5, is it divisible by 7?	
2. If a number is divisible by 8, is it divisible by 4?	
3. If a number is divisible by 10, is it divisible by 5?	
4. If a number is divisible by 3, is it divisible by 9?	
5. If a number is divisible by 2 and 4, is it divisible by 8?	
6. If a number is divisible by 2 and 4, is it divisible by 6?	
7. If a number is divisible by 2 and 8, is it divisible by 16?	
8. If a number is divisible by 4 and 8, is it divisible by 12?	
9. If a number is divisible by 3 and 4, is it divisible by 12?	
10. If a number is divisible by 5 and 3, is it divisible by 15?	
11. If a number is divisible by 9 and 2, is it divisible by 11?	
12. If a number is divisible by 9 and 2, is it divisible by 18?	
13. If a number is divisible by 2 and 7, is it divisible by 9?	
14. If a number is divisible by 2 and 7, is it divisible by 14?	
15. If a number is divisible by 3 and 6, is it divisible by 18?	