Four Forces of Flight

Suggested Grades: 3–8

Activity Overview

In this activity, you will explore the basics behind all four forces of flight. You will witness the effects of gravity on two different balls (weight), the thrust provided by an inflated balloon, the drag created by air resistance and the lift produced by your hands in a stream of air.

If you look at Figure 1, you can see the four forces that act on an airplane. A force can be thought of as a pushing or pulling motion in a specific direction. By controlling the four forces of flight, an airplane can move in any direction.

Time: 30 minutes

Materials:

- Two balls of similar size but different weights (for example, tennis ball and baseball)
- Two pieces of paper
- Uninflated balloon
- Fan
- Timer such as a stopwatch or a timer app on a phone
- Umbrella
- Balloon inflator pump (optional)
- Kitchen scale (optional)

STEPS

1. Place one ball in each hand so you can compare the weights. You should notice that one ball weighs more than the other.
2. If you have a scale, weigh the balls to confirm that they are different weights.
3. Hold the two balls at arm's length and at equal height. If you drop them at the same time, which one do you think will hit the ground first, the lighter or the heavier ball?
4. Drop them at the same time and see if you were right. Was your prediction correct?
5. Take two pieces of paper and scrunch one of them into a tight ball, leaving the other untouched. Remember, both sheets of paper weigh the same. Based on the what you observed when you dropped the two balls, make a guess about which piece of paper will hit the ground first.

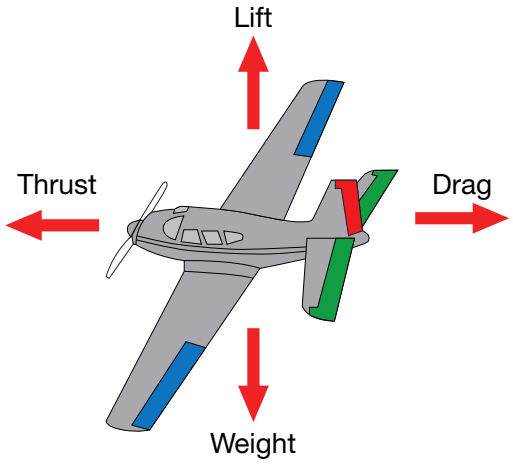
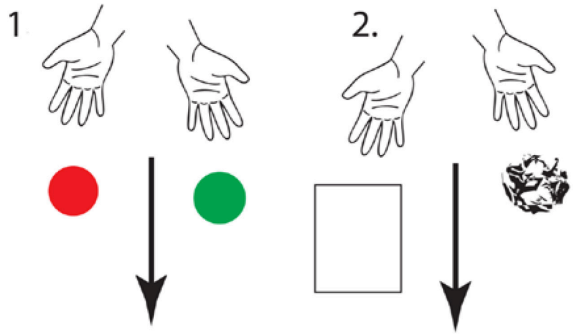


Figure 1. The four forces of flight.

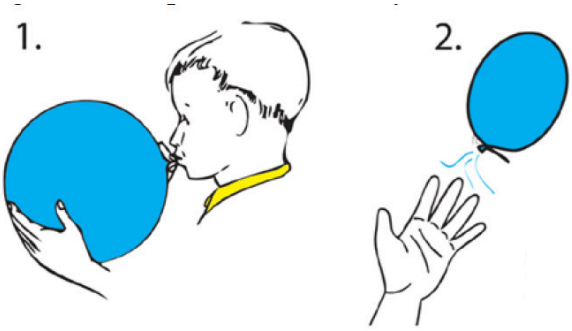
FLIGHT LOG ENDORSEMENT CODE: 4FFA20

6. As before, hold the two pieces of paper and drop them at the same time, noting which one landed first.



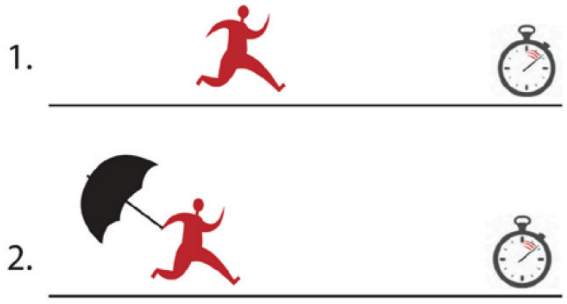
THRUST

1. Inflate the balloon using reither four breaths or four pumps from a balloon pump.
2. Let go of the balloon while someone uses the timer to measure the length of time the balloon is in flight.
3. Why do you think the balloon flew through the air? As the air comes out of the balloon, it creates thrust that moves the balloon in the direction opposite of the air coming out.
4. Repeat the experiment multiple times with various levels of inflation (more or less breaths or pumps), recording the number of breaths and the flight time for each trial. Think of the air like gas in an airplane—the more you have, the farther it can fly.



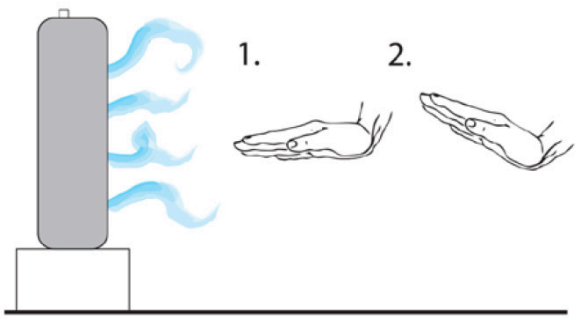
DRAG

1. In your card (or other large area) mark two points between which you can safely run.
2. Run at a steady pace from one point to the other while someone times your run.
3. Run again at the same pace as before, but this time hold the open umbrella behind you. Have someone time how long the run takes with the umbrella.
4. Did the umbrella slow you down? Without the umbrella, the main drag was the air resistance against your body as you ran. With the umbrella open, it provided a much larger surface area that also had to be pulled through the air. This created additional drag, which meant that you had to work harder to run.



LIFT

1. Using the box fan, hold one hand flat against the blowing stream of air. You should be able to feel the air blowing, but it shouldn't be pushing your hand up and down. In other words, it's not creating lift.
2. Now, tilt the front of your hand slightly upward. You should feel it start to rise. This is lift!



Background Information

Every vehicle, whether it is a car, truck, boat, airplane, helicopter, rocket or even a kite, is affected by four opposing forces: thrust, lift, drag and weight. It is the job of the vehicle's designer to harness these forces and use them in the most advantageous way possible, providing the vehicle's operator with an efficient way to control the vehicle. For example, a rocket needs to overcome the effects of weight and drag, while a kite needs to balance all four forces.

- **Thrust:** Think of thrust as the driving force that is produced by an aircraft's propulsion system, or engine. The direction of the thrust dictates the direction the aircraft will move.

- **Lift:** Lift occurs when a solid object changes a moving flow of gas. The flow is turned in one direction, and the lift is generated in the opposite direction. Because air is a gas and the molecules are free to move around, any solid surface can deflect a flow of gas. For an aircraft wing, both the upper and lower surfaces contribute to the flow turning since gases will flow both above and below a wing. Because the air moving over the top of a curved wing tends to go faster than the air under the wing, there is also less pressure at the top of curved wings and more pressure below the wings, allowing the wing to lift into the air.

- **Drag:** Drag is produced any time a solid object tries to pass through a liquid or gas. In the case of an aircraft, drag is simply the resistance of the air against the aircraft. If an aircraft wants to slow down, one way it can do this is to use flaps. With a flap causing more drag, thrust is lessened, and the aircraft can slow down. You might have seen this if you have ever been on a commercial aircraft flight and watched the flaps move up during landing.

- **Weight:** Weight is a force that is always directed toward the center of Earth due to gravity. The amount of the weight is the sum of all the airplane's parts and payload, which is the sum of all the fuel, people and cargo.

National Aeronautics and Space Administration

NASA Headquarters
300 E. Street, SW
Washington, DC 20546

www.nasa.gov

EP-2024-11-635-HQ