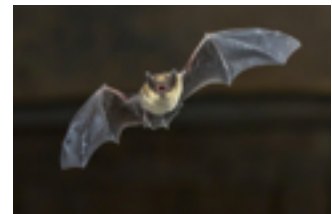


The Principles of Flight:

4 Forces of Flight

What is Flight? How do planes, birds and other objects move through the air? What gets an object/organism off the ground and allows it to remain up in the air?



Force

A **force** is a push or pull that causes an object to **move** or **change direction**.

There are 4 Forces that act upon things that fly:

- 1) Lift
- 2) Thrust
- 3) Drag
- 4) Weight (gravity)

Before Reading Further:

Answer the following on a piece of paper:

Think & Predict

From what you know about these terms, how might they affect flight.

How does *lift* affect flight?

How does *thrust* affect flight?

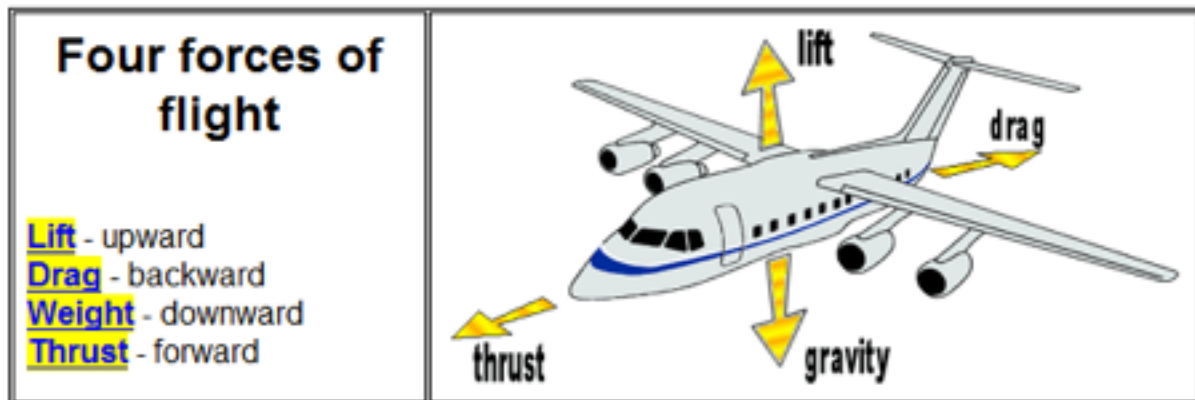
How does *drag* affect flight?

How does *weight* affect flight?

Let's use an airplane to discuss these forces:

When an airplane flies, the wing is designed to provide enough **Lift** to overcome the airplane's **Weight**, while the engine provides enough **Thrust** to overcome **Drag** and move the airplane forward. The **Thrust** of a rocket engine overcomes the **Weight** of the object to move the rocket forward.

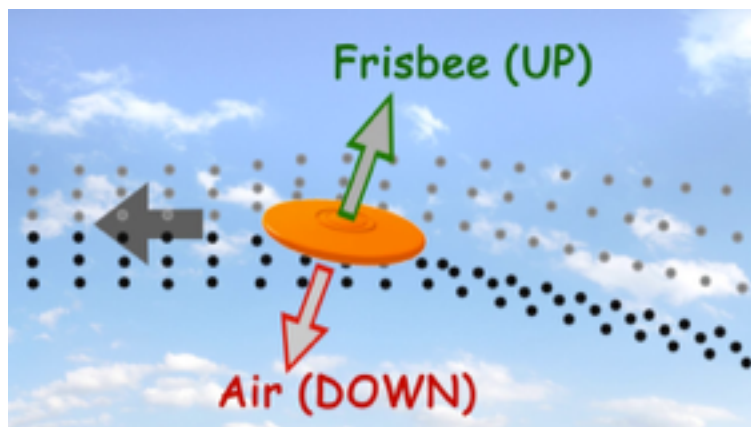
Increasing the **weight** of an aircraft affects the amount of **lift** needed. In turn, a larger wing would provide more **lift**, but that would increase the amount of **drag** and therefore increase the amount of **thrust** needed. *The forces of flight are interconnected, and a change in one affects the others.*



<https://youtu.be/aLJzEI5st8s>

Imagine This:

You are throwing a Frisbee outside with a friend... As the Frisbee flies through the air, **lift** holds it up. You gave the Frisbee **thrust** with your strong arm when you threw it. **Drag** created from the air made the Frisbee slow down while the **weight (gravity)** of the Frisbee brought it back to the ground and in reach for your partner to catch it (NASA).



Lift

Lift is the force that acts at a right angle to the direction of motion through the air (upward). Lift is the force behind elevation. Lift is created by differences in air pressure. Lift is the opposite force to gravity or weight.

A bird's wings flap up and down to give it lift. A plastic bag can get lift from the wind blowing across a parking lot.



For birds and airplanes, lift is caused by air moving around their wings creating pressure that keeps them up. Lift keeps airplanes in the sky, while thrust gives them power to move forward. Airplanes use airfoils to create lift using Bernoulli's Principle: The faster air flows, the less pressure it has.

Thrust

Thrust is the force that makes an airplane move forward, and a rocket move up. Thrust acting on an airplane is created by an engine or propellers. Engines power the plane to give it thrust when flying in the air. Without thrust, the airplane would fall to the earth. It is thrust that moves the plane, bird or object through the air. Opposite to thrust is drag, caused by air resistance. If thrust is greater than drag, the plane will slowly accelerate and be able to fly.

Remember the frisbee? It was the power of your throw that thrust the frisbee through the air.



Drag

Drag is the force that acts opposite to the direction of motion. Drag is caused by friction and differences in air pressure. Drag is the force that tries to resist (stop) the direction of motion (which is caused by thrust).



Drag is trying to slow down the flying object. Drag is caused by the weight of the air around the object. Drag increases with velocity (speed). Ever walk through really deep water? If you try to walk through the water, the faster you walk, the harder it becomes to move.

By making something more *aerodynamic*, you reduce the drag, allowing an object/organism to go faster and be more energy efficient.

Aerodynamic:

The study of how air moves around a solid object. The more aerodynamic a flying object is, the better it will fly.

By studying the motion of air around an object we are able to measure the forces of lift, which allows an aircraft to overcome gravity, and drag. Everything moving through the air (including airplanes, rockets, and birds) is affected by aerodynamics.

Can you think of any objects that need to be aerodynamic?

Did you think of a race car or maybe even a professional swimmer or runner? Did you think of the vehicles we drive around everyday? What about a bike helmet? Or wind turbines that provide power?

Let's examine a golf ball. Golf balls have their unique shape with hundreds of dimples on them is to improve their aerodynamics and create more lift. The way the air travels around the ball is impacted by it's design. Due to this design, golf balls can travel farther after being hit with great force (thrust).



Weight (gravity)

Weight works against thrust. Weight acts in a downward direction toward the centre of the earth. Weight is the force of gravity. Gravity is the downward force of attraction which applies to every object or mass in the Universe. Gravity becomes stronger when the mass of an object is greater. Compare dropping a piece of paper from shoulder height next to a frisbee when thinking about the gravitational affects on different objects. The weight of a rocket, or airplane is always pulling it down, so in order for these aircrafts to fly, they must have more thrust than weight.

Weight and lift operate in opposite directions when a plane is flying through the air. If lift is more than weight, the plane will rise. If you have a role reversal, the plane will not fly.



CONGRATULATIONS,

You have completed:

Principles of Flight Booklet

Next :

Complete these Review Assignment
on a separate piece of paper.

Review Assignment:

- 1) Write the definition and provide an example for each force of flight.
- 2) Describe the relationship between the 4 forces (lift, weight, thrust and drag) that are required in order to create flight.

2b) Pick one statement from each force below.

Describe using your new knowledge from this booklet to **explain** your reasons in **detail**.

3) Create a **diagram** that will demonstrate your explanation.

Choose one of the statements for each below then describe in detail how each statement is true:

1. LIFT

- a. Lift must be greater than weight for a plane to take off
- b. Lift must be less than weight for a plane to take off

2. THRUST

- a. Thrust must be greater than drag for a plane to take off
- b. Thrust must be less than drag for a plane to take off

3. LIFT

- a. Lift must be greater than weight for a plane to land
- b. Lift must be less than weight for a plane to land

4. THRUST

- a. Thrust must be greater than drag for a plane to land
- b. Thrust must be less than drag for a plane to land