

Four Forces of Flight Principle

Respective blueprint	Flying Machine Framework
Description	Learn how helicopters fly and describe the forces affecting an aircrafts' flight.
Learning Objectives	<p>After this lesson, students should be able to:</p> <ul style="list-style-type: none"> • Describe how objects are pulled downwards because of the gravitational attraction between them and the earth • Describe the forces that impact flight • Use the weight formula (W)
Related curricular subject(s)	Physics, Engineering
Prerequisites / preparatory actions for teachers	Make sure that students are familiar with the meaning of forces and Newton's 2nd Law of Motion.
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Age of students	12 – 15 years old (depending on the physics established curricula)
Duration	1-2 hours
Level of difficulty	Intermediate

Step by step description of the tasks

Step 1: How do helicopters work?

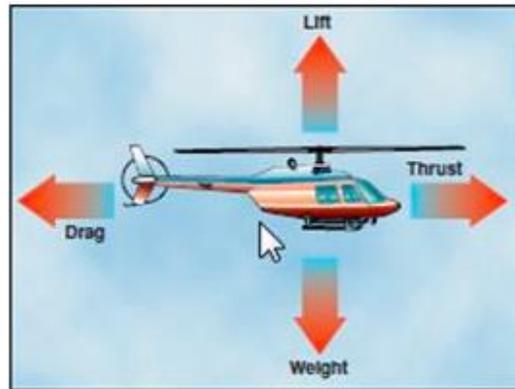
In basic terms, an actual helicopter is a type of aircraft that creates lift (an upward force of air) with horizontally spinning rotor blades. These rotor blades are sometimes referred to as simply rotors or blades. The rotors spin clockwise to generate lift.

Step 2: How many forces act on a helicopter in flight?

Helicopters (and airplanes) fly because they are able to generate a force called **Lift** which normally moves the helicopter upward. The forward motion of the helicopter generates lift through the air. This motion is produced by the **Thrust** of the engine(s).

The figure below is a simple diagram of the four forces acting on a helicopter.

Thrust, Lift, Drag and Weight. Drag is the force produced by the resistance of the air to the forward motion of the helicopter. Swish your hand rapidly side-to-side and you will feel that resistance on your hand.



Forces acting on a helicopter in flight

Source: faasafety.gov

Weight is the force created by the pull of gravity toward the centre of the earth. You will feel the effect of this force if you jump up from the floor. Your weight will force you back down.

Step 3: Explain the flight of bodies by comparing the forces acting on them (thrust, weight)

- When the **Thrust** produced by the engine(s) is greater than the force of **Drag**, the airplane moves forward.

As Newton's 2nd Law indicates:

$$\Sigma F_x = \text{Thrust} - \text{Drag}$$

If

$$\text{Thrust} > \text{Drag}$$

→ Airplane moves forward



- When the forward motion is enough to produce a force of **Lift** that is greater than the **Weight**, the helicopter moves upward.

As Newton's 2nd Law indicates:

$$\Sigma F_y = \text{Lift} - \text{Weight}$$

If

$$\text{Thrust} > \text{Drag}$$

→ Airplane moves upward

Step 4: How can helicopters fly without wings?

Unlike airplanes, helicopters don't have super-long wings to control the aircraft in flight. The propeller is connected to an engine, which provides thrust. As it spins, the airfoil-shaped propeller blades force the air over the top to speed up, decreasing pressure, while the air underneath keeps its higher pressure. The high-pressure air pushes up on the blades, lifting the helicopter into the air.

Some helicopters have stumpy wings to help stabilize direction and airflow, but most of the magic happens in the helicopter's rotor blades at the top of the vehicle.

The rotor blades have a distinct shape and orientation that pushes denser air underneath to create lift, much like an airplane's wings. Mainly, **the faster those blades spin and generate lift**, the higher the helicopter can climb in the air.

Assessment activities

Assessment Activity 1:

Q1: The force that propels a flying machine in the direction of motion:

- Weight
- Lift
- **Thrust**
- Drag

Q2: Which force works opposite of lift?

- **Weight**
- Lift
- Thrust
- Drag

Q3: Which force acts opposite to the direction of motion?

- Weight
- Lift
- Thrust
- **Drag**

Q4: The force that propels a flying machine in the direction of motion:

- Weight
- Lift



- Thrust
- Drag

Q5: Which part of a helicopter provides the lift?

- Engine
- Wheels
- Blades

Q6: For a balloon to rise, the combined weight of the balloon and the air that fills it must be ___ the weight of the air it displaced.

- the same
- less than
- more than

Assessment Activity 2:

Teachers should ask their students to construct the plane using the blueprint, and then either showing their models and explaining what they did, or having a discussion altogether about the principles they have just learned.

Assessment Activity 3:

Teachers could ask their students to make a small presentation of the first helicopter and airplane ever invented, pointing out their main differences.

References

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