

How Things Fly

Chris Ramsell
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Chris.Ramsell@KLA-Tencor.com

The Main concepts are:

- Newton's 3rd Law: For every force there is an equal and opposite force
- Bernoulli principle: As the velocity of air goes up, air pressure goes down.
- Airplanes and Helicopters create lift by pushing air down.
- Rockets don't need air. They create upward thrust by pushing the fuel down.
- Key words: Gravity, Lift, thrust, drag,

What to do

Q: What is a Force ? Get some answers from the kids. **A:** Yes, it is a push or a pull.

Forces cause things to move (accelerate).

Show cup on a table. It is not moving. **Q:** Are there any forces on the cup ? If the kids say no, then move the cup off the table and let it drop on the floor. Now ask are there any forces on the cup.

A: Yes, the force of Gravity pulls the cup down, but the table creates a force in the opposite direction that pushes the cup up. When those two forces are in the opposite direction, but the same strength (magnitude) then the two forces cancel, and the cup does not move. Make this more clear by showing bigger and smaller arrows. Which ones cancel and which ones don't ?

4 Forces on an Airplane

An airplane is nearly the same as the cup. Gravity pulls it down, so we need to create some force to push it up. That force is called Lift. Show a diagram of the 4 forces on an airplane: Gravity, Lift, Thrust, and Drag. Let's see each one of these forces.

Drag

Drag is the force back on you as you push through the air. Do you ever notice the air moving around you ?? Imagine a very windy day, where the wind is so strong that it is pulling you back. Or imagine trying to run in the swimming pool. The drag from water is much stronger than the drag from air, because water is more dense than air.

Show the Drag Tank. 10 gallon aquarium full of water. Kids get to move different shapes through the water to see which ones have the least drag.

Action and Reaction

- Kids throw a ball. Try not to step back
- Catapult on frictionless wheels. Launch a racquet ball to the right, and the cart should move to the left. Newton's 3rd Law says that for every force there is an equal and opposite force. We call this Action (a force) and Reaction.
- Show the propeller mounted on a stick that rotates around a horizontal peg. When the propeller pushes the air down, the air pushes the motor up. This is just how a helicopter works. Show the puddle jumper.

Thrust

Mount the "propeller on a stick" the vertical peg so that it can rotate around the peg. Now the propeller points horizontal so the motor will spin around.

Balloon on a string (continuous momentum)

Lift

Bernoulli's Principle:

- Remind kids about Air Pressure. **Q:** What creates air pressure ? **A:** Molecules hitting on a surface.
- Show box of atoms to show a gas (optional).
- Use straw to blow air between two cans. The cans should come together.
- Diagram of an airfoil. Longer path over the top creates lower pressure than the bottom.
- Use shop vac as a blower to show the floating beach ball. Streamers on a stick show that the high velocity air is flowing over the top of the ball.

Angle of attack

Show a diagram that illustrates direction of the air flow, and angle of the plate relative to air flow.

Q: Have you ever stuck your hand out the window of a car when you were driving real fast ?

Show Angled plate experiment with Blower. Streamers show that air bends down and travels under the wing. Change the angle to cause more or less upward force.

Q: What will happen to the air as a wing swoops over the air at some small angle ? **A:** The air under the wing will be pushed down. Show a diagram of an airplane from the front. Arrows show the air under the wing is being pushed down. **Q:** If the air is pushed down, then what is the force on the airplane ?

A: The wing is pushed up. This upward force is the lift.

Actually we know that Bernoulli's Principle and the Angle of Attack explanation are really the same. We know this because as the wing presses the air down (more air is crammed into the same volume) the air pressure must increase. The air that flows over top of the wing also bends down, leaving some unfilled volume. This is the source of the low pressure above the wing.

Optional: Control Surfaces

Why do airplanes have tails ? Show horizontal tail & vertical tail. Use rocket mounted on a peg. Air blows past using the shop vac. Compare 2 rockets. One has fins mounted at the front. The other has fins mounted on the back. The rocket with fins on the front is not stable. The rocket with fins on the back is stable.

Water bottle rocket.

Air pressure inside the pop bottle pushes the water out the bottom. If the water is pushed down, then the rocket will be pushed up.

Review

Airplane: Wings push the air down, so air pushes the airplane up

Helicopter: Blades push the air down, so the air pushes the helicopter up

Rocket: Fuel burns & creates high pressure that pushes the fuel down, so fuel pushes the rocket up.

Equipment needed

Cup

Arrows to show force

Mouse trap catapult on wheels

Dowel to trip mouse trap

String + Straw + clamps

Foot ball or basket ball

Atoms in a Box

Diagram of air around an airfoil

2 cans on dowel rollers

Shop Vac

Beach Ball

Stick with streamers

Puddle Jumper

Angled plate

Laptop

Diagrams

Water bottle rocket

Air pump

Hose & Bucket

Laptop

Consumables

Straws (with paper cover)

String

Balloons

How Things Fly

Forces

- What is a force ?
- Cup
- 4 forces on an airplane

Drag

- Examples: Wind, swimming pool,
- Fan
- Aquarium

Action & Reaction

- Examples
- Throw a ball
- Catapult
- Propeller on a stick
- Puddle Jumper (helicopter)

Thrust

- Propeller on a stick
- Balloon on a string

Lift

- Diagram of an Airfoil
- Bernoulli's principle
- Two cans
- Beach Ball

Angle of attack

- Diagram
- Flat plate
- Wing tip Vortex Photos

Water Rocket