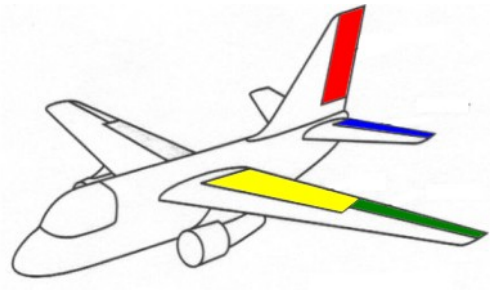
# Forces and Flight

(This activity is partly based on "The Paper Airplane Book" by Seymour Simon)

- Airplanes use forces by moving air to fly
- Flowing air makes **drag forces** (against motion) that depend on the shape and orientation of the object.
- Some of the drag from moving air is converted to an upward **lift force** when the nose is tilted up
- Airplanes use movable flaps to control lift and drag forces and to make turns.



## Part 1: Drag and Lift

1. Drop, from standing, at the same time, a flat sheet of notebook paper and a crumpled up piece of paper.

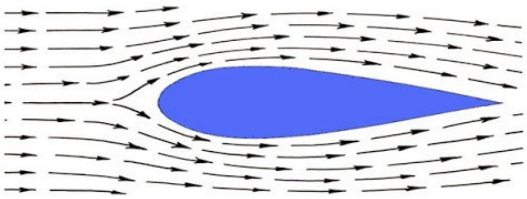
Which one hits the ground first? _____

Discuss: What forces are acting on the falling paper? In which direction?
Which force is the same for both the flat sheet and the crumpled blob? Which is different?

2. How else could you fold the paper to make it fall as fast as possible? Try different shapes. When testing two shapes always start the bottom of the objects at the same height.

What is the best shape you could find for hitting the ground first?

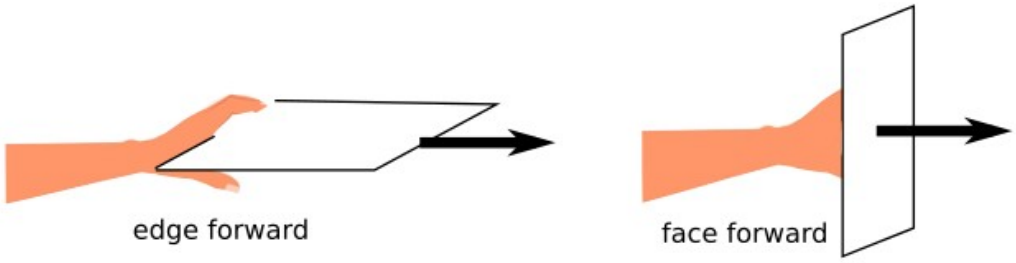
Air resistance (or **drag**) is a force that acts **against the direction of movement**. The strength of air resistance depends on the shape of the moving object. "Stream-lined" shapes (narrower in front and wider in the middle) help decrease drag.



Discuss: What man-made or natural objects can you think of that have a streamlined shape? Why is it helpful for them to have that shape?

3. Now let's see how the orientation of an object can change the drag force.

Hold a sheet of **cardstock** edge-forward, and try pushing it rapidly through the air. Now try holding the cardstock with the flat face forward and pushing it again.

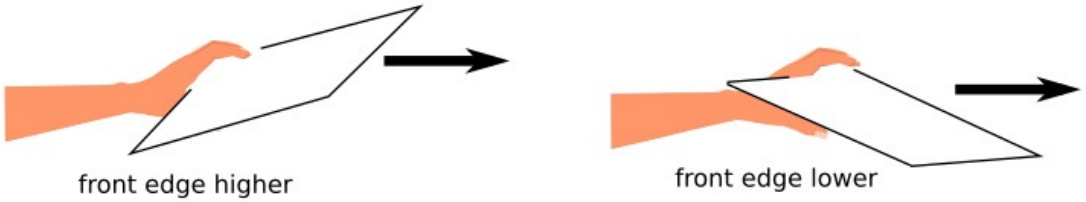



In which direction did you feel more drag pushing back from the air? (Circle one)

4. Now try holding the back edge of your cardstock. Tilt it so the front edge is slightly higher and try pushing it forward.

In addition to the backward drag force, does the sheet also experience an upward or downward force? Which way does the front end of the cardstock bend?

upward downward




5. Now try pushing it forward with the front edge tilted downward.

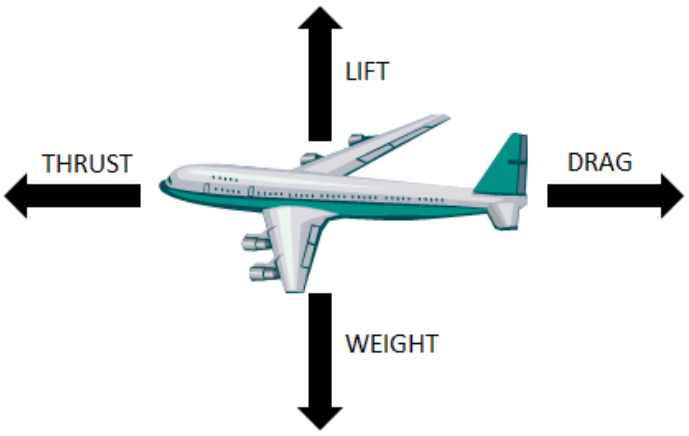
Is there an upward or downward push from the drag force on the sheet? Which way does the front end bend?

upward downward

The **lift force** pushes up on an airplane and prevents it from falling. Tilting the airplane nose up will result in a lift force from the air that flows past it.

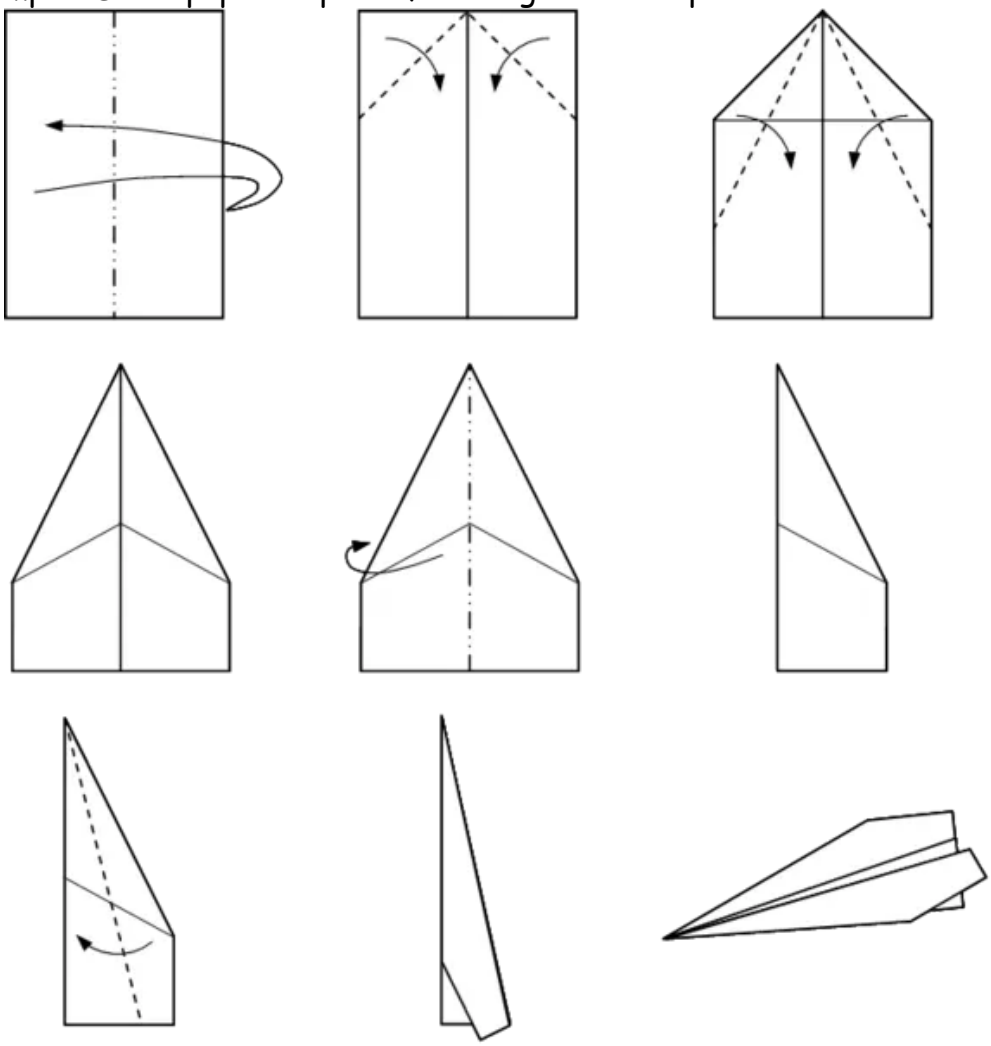
Discuss: What would happen to an airplane if it stopped moving. Would it still feel a lift force?

There are 4 types of forces acting on a flying airplane (or bird):
1) **Gravity** (weight) pulls down.
2) **Lift** forces pushes up.
3) **Drag** forces push backward.
4) **Thrust** is a force that pushes the plane forward. This can be produced by propellers or jets.



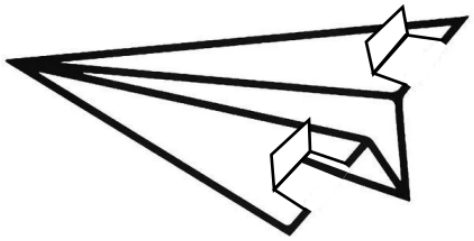

## Part 2: Paper Airplanes

1. Make a simple "Dart" paper airplane following these steps:



Use a piece of tape to secure the top of the plane so that it doesn't open.
2. Try out your paper airplane. Get a sense of how far it flies.

3. Cut ½" wide flaps in the back of each airplane wing.



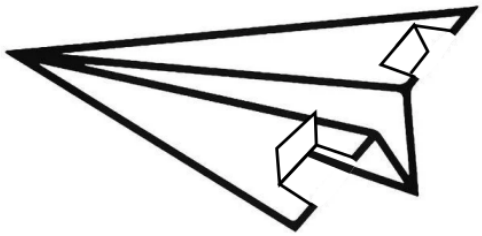
Make a prediction: how will the plane's flight change if you tilt both flaps **very slightly** up?
(Hint: hold the plane loosely in the middle and try pushing on the flaps with your finger. Think about what that force will do to the plane.)

Test your prediction. What did the plane do?
Nose tipped up Tail tipped up

In addition to slightly increasing the lift of the plane, the upward tilted flaps also increase what other force? Drag gravity thrust

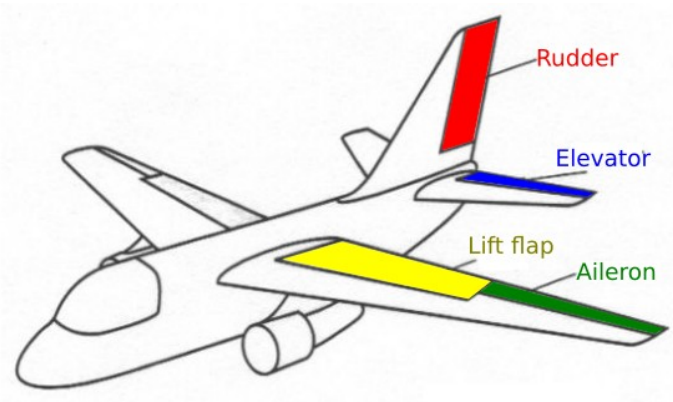
Discuss: What happens if you turn the flaps up too far? Why?

Now predict what will happen if you push both flaps downward:
Test your prediction. Were you right?



Finally, predict what will happen to the plane if you tilt one flap slightly up and one slightly down.

Were you right?




Real airplanes control their flight with movable flaps on the wing and tail.
**Lift flaps** on the wings help increase lift during take-off and landing.
**Aileron** flaps at the edge of the wing allow the plane to roll left or right.
**Elevator flaps** at the back of the tail let the pilot point the plane's nose up and down to change the height of the plane.