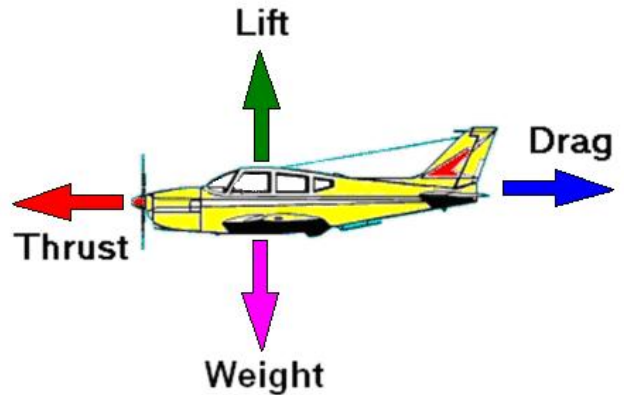


Student Worksheet for Ep. 1: Flying Machines

Overview: You're going to build several different flying machines and observe the balance between the four aerodynamic forces to get you thinking about how and why things fly.

What to Learn: The four fundamental forces on an airplane are lift, weight, thrust, and drag. There's a balance between lift and weight, as well as between thrust and drag. Too heavy of an aircraft, and it can't sustain flight in the Earth's gravitational field. If the engine's too small to generate enough thrust in the Earth's atmosphere, then it's not going anywhere. Any flying object must deal with finding a balance between these four forces.



Materials:

- Several sheets of paper
- Paper clips
- Tape and scissors
- Measuring tape
- Stopwatch

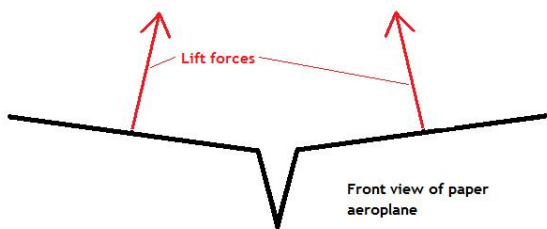
Lab Time:

You're about to build several different flying machines! We're going to start with something pretty basic.

1. Start with a single sheet of paper, hold it up, and then let it go. Record your observations in the data table.
2. Now fold over one of the edges about an inch, and then let it go again. Was there a difference? Record this in your data table.
3. Fold over the edge again, so now there are two folds on your sheet of paper. Hold it up and let it go. Any difference?
4. Fold over the edge a third time, creasing well. Hold it up and let it go. Any difference?
5. Clip 2 large paperclips (or 5-6 small) onto the folded edge to increase the weight. Hold it up and let it go. Was there any difference now?
6. Now you try... see how you can fold, roll, cut, tape, split, curl, and tuck to make the perfect flying machine, but remember, only change one thing at a time so you know which change had which effect on your design. You can use string, rubber bands, straws, toothpicks, and add passengers (jelly beans or popcorn kernels).
7. Track your results in your data table, just like a real scientist!

Flying Machines Data Table

Type of Airplane	Time Aloft <i>(units?)</i>	Distance Traveled <i>(units?)</i>	Observations
<i>Single sheet of paper</i>			
<i>Paper with one fold</i>			
<i>Paper with two folds</i>			
<i>Paper with three folds</i>			
<i>Paper with two folds and ___ paper clips</i>			



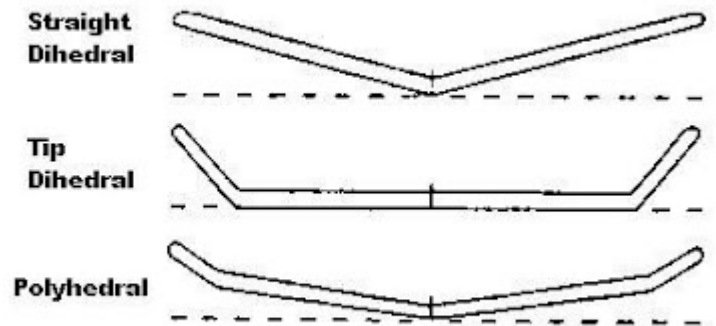
Tip: If your flying machine doesn't work right, see if you can figure out exactly it *is* doing (or not doing), and then take a more careful look at how it's constructed. Focus on watching what happens when you make small changes, and try to change only one thing at a time.

Exercises:

1. If your plane takes a nose dive, you should try
 - a. changing the elevators by pinching the edges
 - b. change the dihedral angle
 - c. change how you throw it
 - d. all of the above

2. What are the four forces that act on every airplane in flight?

3. Draw a quick sketch of your plane viewed from the front with a positive dihedral.



4. If you were designing your own “Flying Paper Machine Kit”, what would be inside the box?

5. What keeps an airplane from falling?