**The Four Forces**

**Before we get really involved with flight we need to take a look at the four forces: lift, weight (gravity), drag and thrust. These four forces act with each other and against each other.**

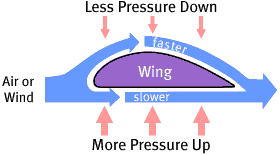
**Lift is the force that causes a plane to rise. It is the wings of the airplane that give it lift. Lift is caused by air movement and air pressure. If you are not sure how this works, here is a quick review of Bernoulli's Principle, which explains how air pressure produces lift.**

**Weight: The earth's gravity pulls down on the plane. This is the plane’s weight. The lift needs to be greater than the weight of the plane if the plane is to take off.**

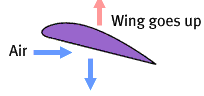
**Thrust is the force that moves the airplane forward. Engines provide thrust for airplanes, unless of course it is a glider. The engine's thrust keeps the plane moving forward and the air flowing over the wings keep the plane in the air.**

**Drag is caused by the wind or air against the plane. Drag can slow a plane down. The shape of the airplane is important in telling how much drag there will be. The more streamlined the plane is the less drag it will have. An aerodynamic plane has little drag. If there is more thrust than drag then the plane speeds up. If there is less thrust than drag, the plane slows down. If they are the same then the plane flies at a constant speed.**

**Review of Bernoulli's Principle**

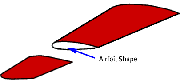


**The air above the wing moves faster than the air below it. Slower air has higher pressure than faster air, so the air pressure pushing up on the bottom of the wing is greater than the pressure pushing down. When this happens the wing moves up and we have lift.**

**The shape representing wings (purple colour) is called** ***airfoil***.

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**LOW PRESSURE**



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| --- |
| http://www.homestead.com/~site/Scripts_Shapes/shapes.dll?CMD=GetRectangleGif&r=255&g=255&b=255 |

**HIGH PRESSURE**

**Cross-section of**

**Airplane Wing**

**airfoil shape**

**Airplane Wings**

**· Airplanes are designed with thin wings and a smooth surface.**

**· An airplane requires an engine and propellers to achieve lift and thrust.**

**· Airplanes have adopted unique features such as winglets, slats and flaps to stabilize the wings and improve lift.**

**· A plane lowers the flaps on the trailing edge of the wing to achieve lift.**

**· Attached to the wings are the inside flaps that make the airplane fly more slowly and the outside ailerons that make the plane turn.**

**· On an airplane there are slots that can be opened on the top of the wing to increase the speed of air moving over the upper surface of the wing, increasing lift.**

**· A pilot is able to change the direction of an airplane by controlling the elevators and ailerons of an aircraft.**

**· When landing a plane a pilot uses wing flaps and slats to increase drag.**

**· An aircraft has tails that work like a bird's, helping it to brake and steer.**

**· An airplane pilot has instruments to help them navigate the airplane.**

**LOW PRESSURE**



**HIGH PRESSURE**

**Bird's Wing**

**airfoil shape**

**Bernoulli's Principle at work !**

**Bird Wings**

**· Bird's wings are naturally thin with feathers creating a smooth surface.**

**· Birds are different from airplanes in that they are able to get lift, thrust, and propulsion from their wings.**

**· When birds glide or soar their feathers allow them to maintain an optimum combination of lift and drag forces.**

**· A bird's skeletal system is designed so that it can easily fly through the air. The shoulder joints are designed so that the inner wings are held at a proper angle to obtain the greatest lift.**

**· A bird's body is designed to be very aerodynamic helping to reduce drag.**

**· Birds have feathers attached to a movable finger bone called the alula, found on the front of each wing. The alula adjusts air flows aiding in lift.**

**· By changing the shape of their wings and tail, birds can change the direction of their flight.**

**· When landing birds will spread their feathers apart, lower their legs, and increase their angle of approach to land safely.**

**· Birds have well developed organs that aid in navigation.**