Principles of Flight

There are four major forces acting on an aircraft:

- Gravity
- Lift
- Drag
- Thrust

Gravity

Gravity is the downward force that keeps the airplane on the ground or pulls the airplane toward Earth while in flight. Gravity acts on all objects according to their mass. Airplanes should be as light as possible to reduce the effects of gravity.

Lift

Lift is the upward force created by the curved shape of the wing. The aircraft will climb only when lift is greater than gravity.

Drag

An aircraft pushes air aside as it flies along. The air pushes back and slows the plane down. This air resistance is called drag. The faster an airplane flies, the greater the drag. Fast planes have a streamlined shape that minimizes drag so they fly through the air easily.

Thrust

Thrust is the force that must be created to overcome the force of drag. Gliders are always in a gradual descent and thus use gravity to provide thrust. Even when rising in a thermal, gliders are descending. It is like slowly walking down an escalator that is going up quickly. Powered airplanes use either jet or piston engines to produce thrust.

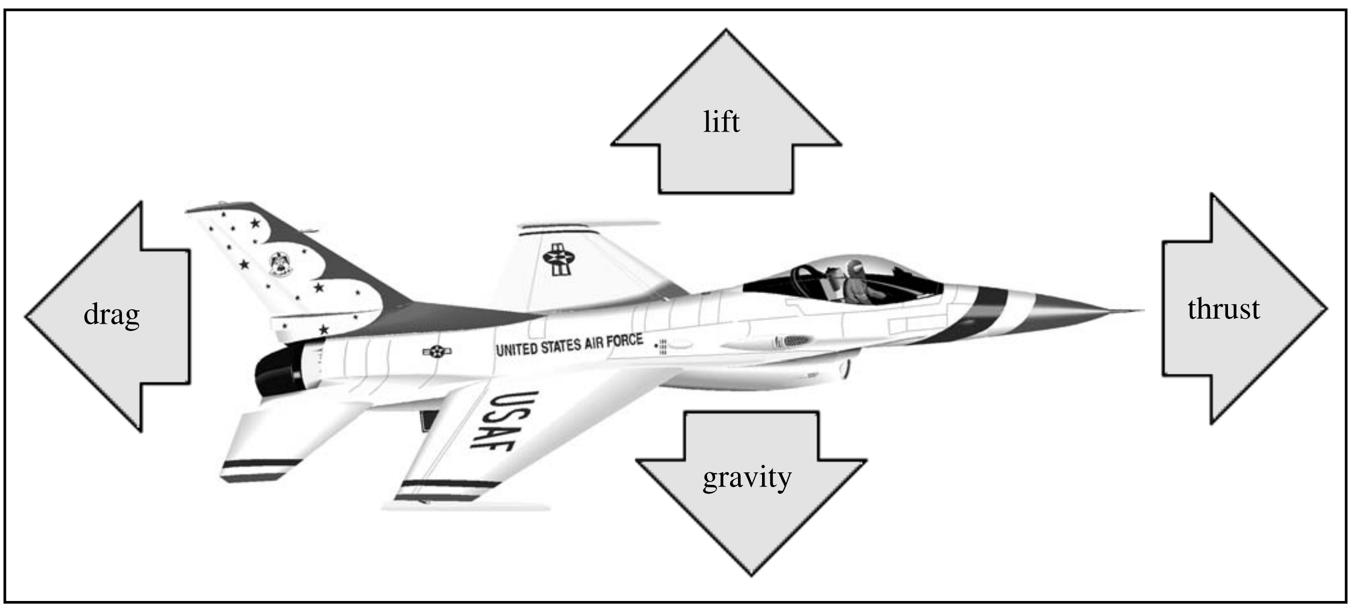

Figure 24: Four forces affect an airplane.

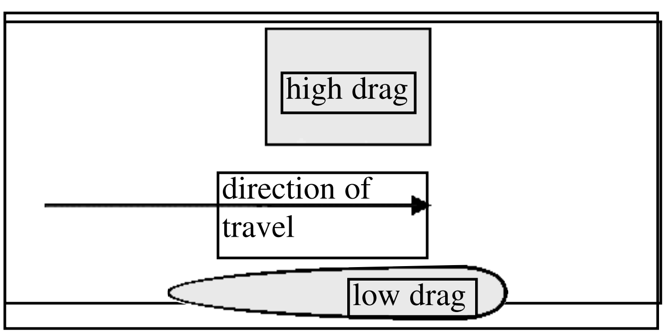

Figure 25: The amount of drag is determined by the size and shape of the object. A streamlined object creates less drag.

What Is a Sailplane?

Many people consider the terms "glider" and "sailplane" to have the same meaning. Others define a glider as motorless like the ones used in World War II. These planes were towed to great heights and released so they could glide silently behind enemy lines with troops and equipment. Sailplanes are usually towed into the air by a rope attached to a light, powered airplane. The sailplane is released about 2,000 feet above ground and it uses rising air to gain altitude.

Landing a sailplane is very similar to landing a powered plane except the pilot has only one chance. As a pilot of powered planes, I hate to think of how many times I have aborted a bad approach for landing, added power, and come around again to do it right.

While writing this book, I had the opportunity to go for my first ride in a glider and actually take over the controls. There is no engine noise, just the sound of the air flowing over the wings. Time passed quickly as I practiced soaring and making 360-degree turns to the right and to the left. Flying it was more difficult than I expected, but it was very rewarding.

What is Soaring?

Soaring is motorless flight using a sailplane and the naturally atmospheric condition of rising air to gain altitude. Thrust is provided by gravity; a glider is constantly descending, even in a mass of upward moving air. After the sailplane has the airspeed required for the wings to produce lift, any excess vertical lift is used to gain more altitude or increase airspeed. There are three main types of rising air available to the soaring pilot.

Thermals occur when the Sun heats the ground. Heat is radiated to the air forcing it to rise in a vertical column. A

Figure 40: Instrument panel in a glider

glider pilot can circle in this mass of rising air and gain altitude as quickly as 1,000 to 8,000 feet per minute.

Upward air currents also form where wind (air) is forced up by the slope of a hill or mountain. By following the ridge, the glider pilot can fly great distances without the need to circle to gain altitude.

If a strong wind blows over mountains, a mountain wave can form. This wave can rise or fall by as much as 2,000 feet per minute.

Instrumentation

Many types of instruments are available to a glider pilot, but every plane has at minimum the instruments described below.

- An altimeter measures the distance above sea level.
- An airspeed indicator measures the speed through the air.
- A magnetic compass shows the direction in which the plane is flying.
- A variometer is a sensitive vertical speed indicator used to tell the pilot how fast the plane is rising or falling.
- A 3" piece of red yarn attached to the canopy shows the pilot the relative air flow of the glider and helps the pilot carve good turns.

Glider Design

Dihedral Wings

A dihedral wing is more stable than a horizontal wing. Dihedral wings are self-correcting and minimize side slip when a disturbance causes a wing to lower such as in turbulence.

Wing Location

A high wing is very stable but is slow to respond to pilot commands. A low wing is unstable but quick to respond to pilot commands. A compromise design places the wing in the middle of the fuselage. Mounting the wing on top is usually the best method for gliders.

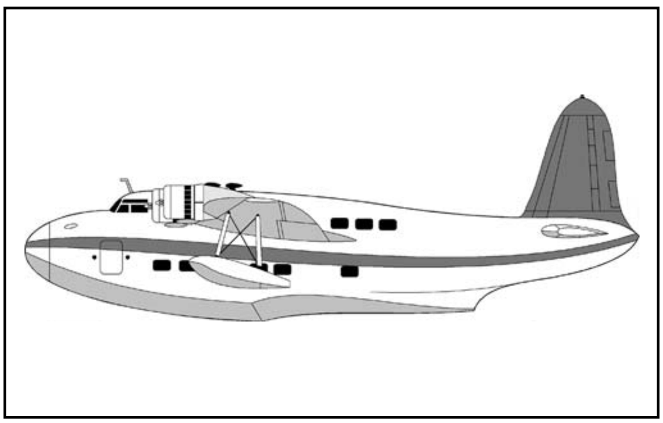

Figure 41: A middle wing is mounted in the middle of the fuselage.

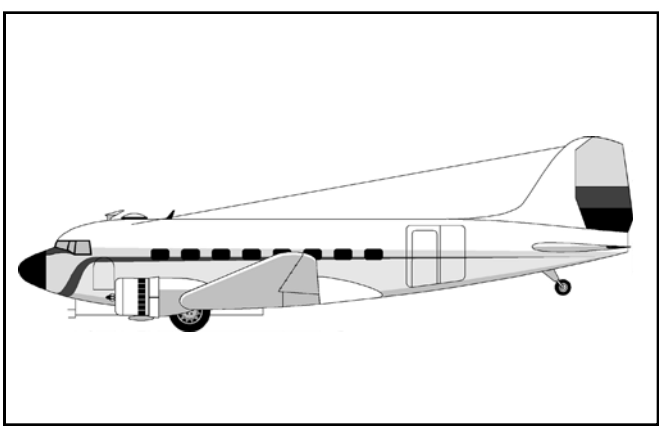

Figure 42: A low wing is placed at the bottom of the fuselage.

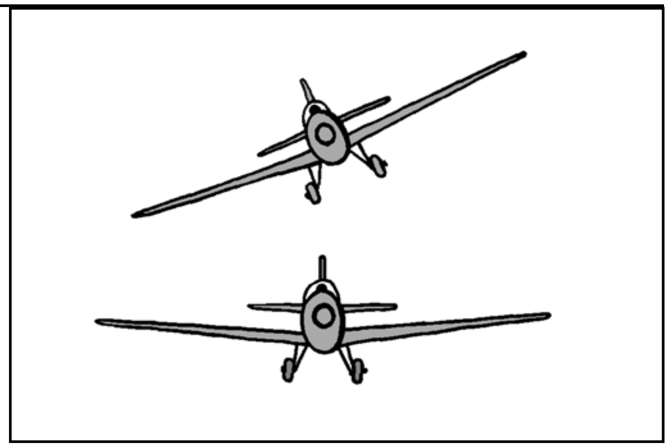

Figure 43: A dihedral wing will correct itself.

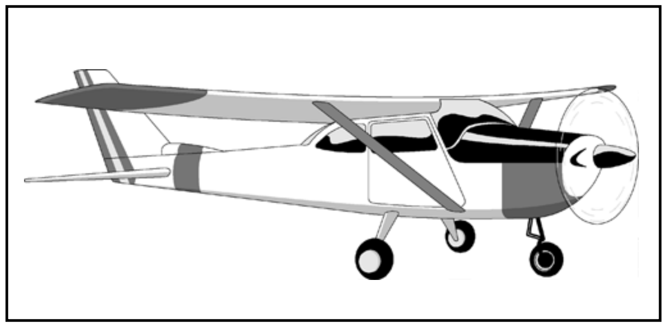

Figure 44: A high wing is located at the top of the fuselage.

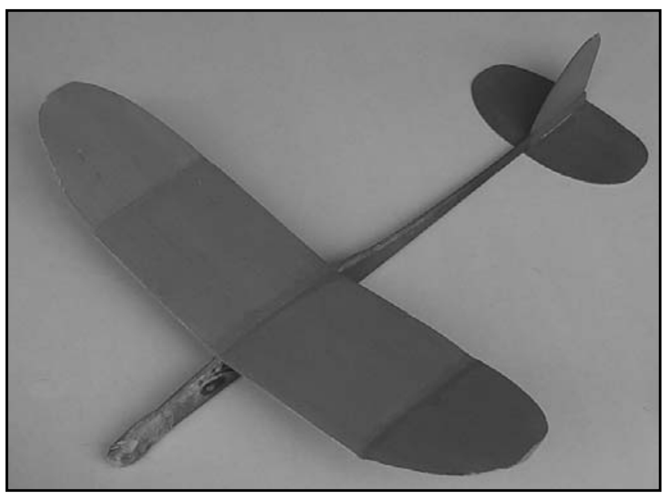

Figure 45: This big wing glider is described later in this book.

Challenge #2

Designing

Challenge

You will design and build a glider from a limited supply of materials. The goal is to stay in flight as long as possible.

Your instructor may provide specifications different from those described in this book.

Procedure

To complete the glider, follow these steps:

1. Complete the technical report.
2. Brainstorm solutions.
3. Make a rough sketch.
4. Make a full-size drawing.
5. Make a cardboard mock-up.
6. Construct the glider prototype.
7. Trim the glider.
8. Evaluate the glider.

Materials Required

- 11" x 17" graph paper
- Thin cardboard

Equipment Required

- Ruler
- Pencil
- Hobby knife
- Balsa wood

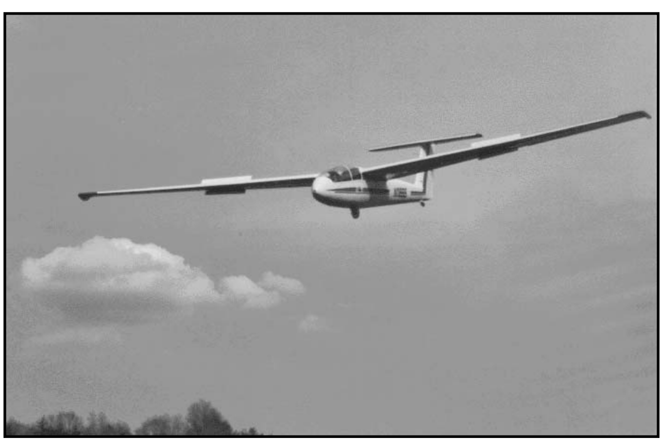

Figure 62: A glider is about to land. Gliders have spoilers instead of flaps on top of the wings to reduce lift .

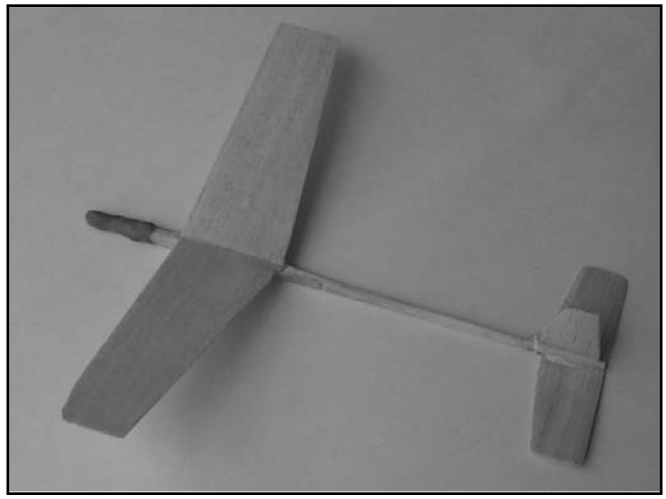

Figure 61: Step-by-step construction method is shown for this design of balsa glider (see Figure 74).

Optional Equipment

- Drafting tools
- Computer and CAD program

Specifications

Instructions are provided for a glider that flies very well. You may choose to design and build a glider of your design.

1. The glider must be constructed from the materials provided.
2. There are no minimum dimensions for any part.
3. Modeling clay may be used to balance the glider.

Materials

Every student has the same amount of materials to use in the construction of the glider. The fuselage, wing, horizontal stabilizer, and vertical stabilizer may be constructed from any of the pieces of balsa wood supplied.

Step 7

Trim Your Glider

Trimming is the process of adjusting the control surfaces of the model glider so that it flies correctly. To adjust the control surface, dampen the aileron, rudder or elevator surface, and gently bend the wood. To dampen the wood, blow on the surface. After the wood dries, it will keep its new shape.

The glider should be evaluated for construction quality immediately after completion and before it is test flown.

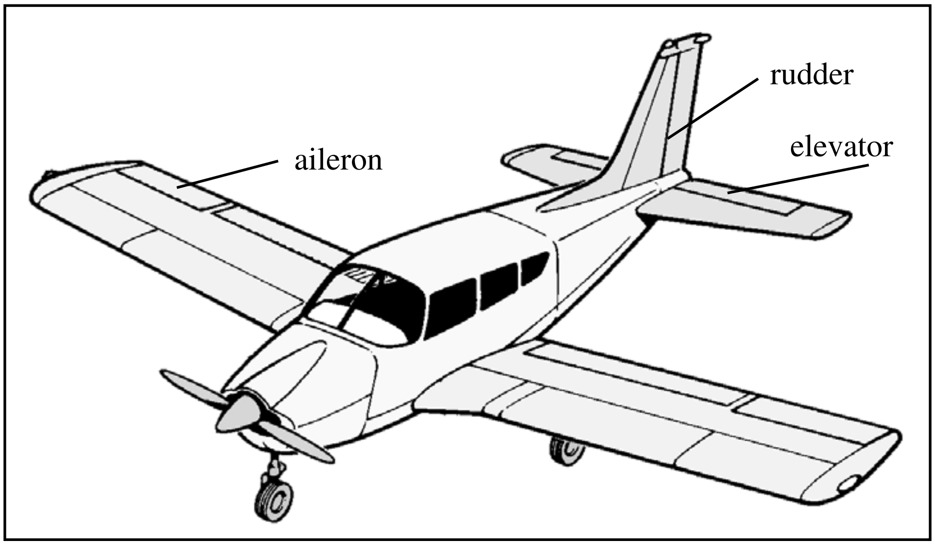

Figure 93: Control surfaces

Adjusting the Center of Gravity

Adjust the center of gravity before the glider is flown. The center of gravity can be changed by adding or removing modeling clay at the nose of the glider.

The glider should balance at the midpoint or slightly in front of the midpoint of the wing.

If the center of gravity is too far forward, the plane is nose heavy and it will dive. If the center of gravity is too far toward the rear, the plane is tail heavy and the glider will stall and loop.

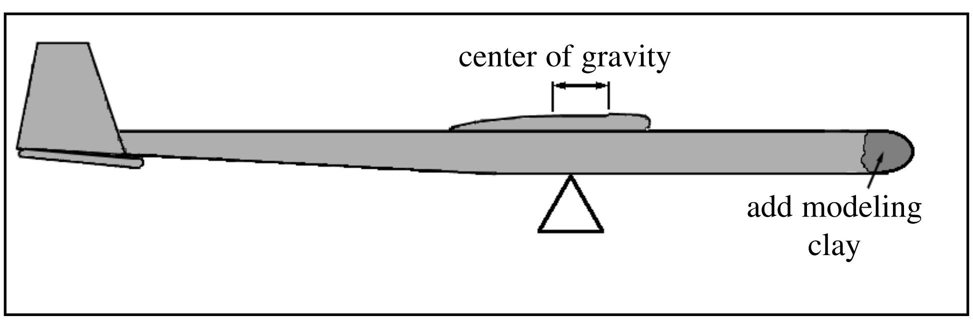

Figure 94: Add modeling clay to the nose until the the glider balances at a point 1/4 to 1/2 of the wing width (chord).

Challenge #3

After Whitewings and small balsa gliders have been mastered, it is time to fly a much larger model. These gliders, if properly trimmed, can make flights of more than two minutes in duration.

Construction steps and trimming are similar to those for the small wing glider.

Specifications

Fuselage

The fuselage is made from 1/4" x 1" x 18" balsa with a tight grain. Cut the fuselage on an angle starting 3-1/2" from the tip of the nose. The fuselage should be 3/8" wide at the tail end. Sand the fuselage smooth and mount the wing so the leading edge is 3-1/2" from the tip and has 1/16" positive incidence. Add modeling clay to the nose to ensure the center of gravity is located in the middle of the wing.

Wing

The polyhedral wing is made from 3/16" x 4" x 18" balsa. Sand or plane the airfoil so that the high point is 1/3 the chord from the leading edge. You can see the location of the high point as a line drawn on the wing in Figure 105. The wing is cut, scored, bent, and glued as in the small model. The second bend is 3-1/2" from the tip.

Horizontal Stabilizer

The horizontal stabilizer is made from 1/16" x 3" x 6" balsa. Round the leading edge and taper the trailing edge. Attach it to the bottom of the fuselage with stab tilt. The horizontal stabilizer should be at the same angle as the wing.

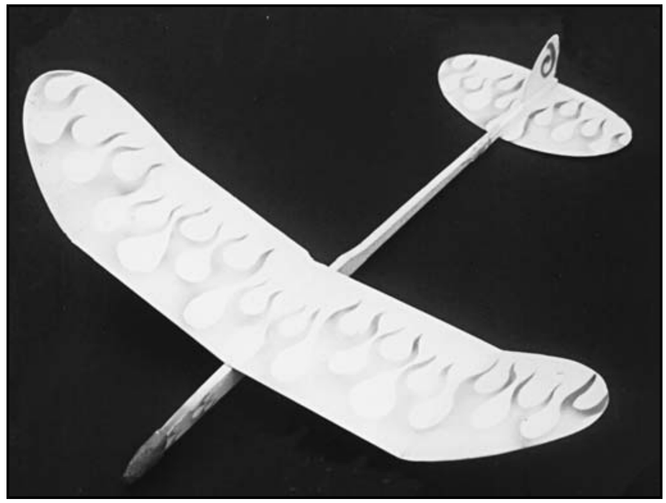

Figure 103: Big wing glider

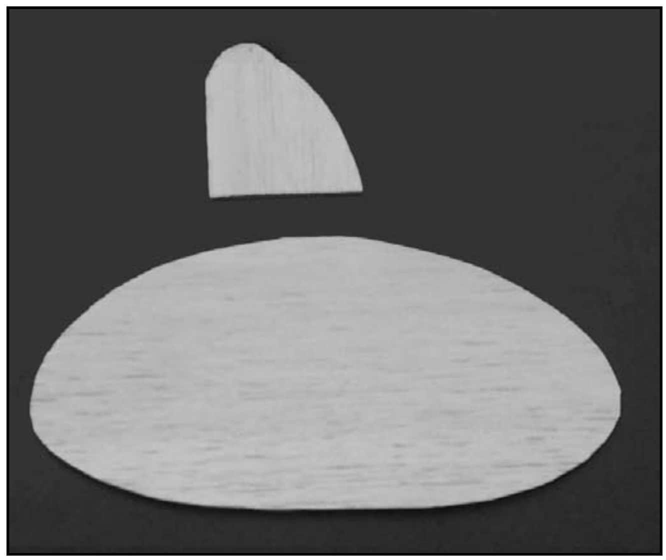

Figure 104: Horizontal and vertical stabilizer cut out

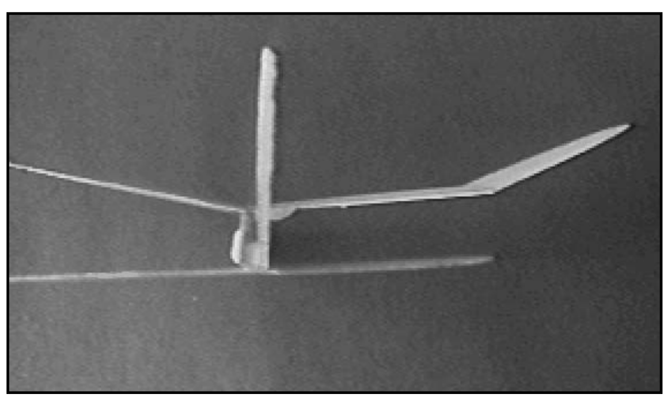

Figure 105: Stab tilt for a right-handed person, showing the horizontal stabilizer on an angle