

SCIENCE ACTIVITY

## Three-Axis Control

The Wright Brothers were the first to develop a fully controllable airplane. They understood that flying machines needed to be controlled on three-axis – pitch, roll and yaw – in order for flight to be safe.

**Pitch** is the motion of the airplane as its nose points up or down. To control the pitch of their first glider, they used a wing mounted on the front of their glider. The Wrights called this wing their “front rudder.” Today movable control surfaces called elevators are used to control the up and down motion of the airplane around its lateral axis. In modern aircraft, the force of air on an upward deflected elevator causes the airplane’s tail to drop and the nose to rise. The elevator on the Wrights’ glider was in the front, what Wilbur called a “happy accident of design.” In later years, Orville noted, “we retained the elevator in the front for many years because it absolutely prevented a nose dive such as that in which Lilienthal and many others since have met their deaths.” Today this arrangement featuring a small wing ahead of a large wing is known as a “canard” configuration. Canard is the French word for duck, a nickname used because of the similarity to the flying profile of the bird. Around 1910, the elevator and rudder were located together at the tail, because engines, for engineering reasons, needed to be placed at the front of the airplane. **Click here for a demonstration of pitch.**

**Pitch demonstration:** <http://www.grc.nasa.gov/WWW/Wright/airplane/pitch.html>

**Roll** is the tilting motion of the airplane around its longitudinal axis, when one wing rises or falls in relation to the other. Wing warping was the method used by the Wrights to control roll. This process involves raising the front, or leading edge of one side of the wing while dropping the leading edge of the other side of the wing. For example, to raise the right side of the wing, a pilot manipulates cables to twist the leading edge of the right side of the wing upward. This increases its lift and angle of attack, which is the angle at which the air strikes the wing. Meanwhile, the left side of the wing drops because cables simultaneously decrease the angle of attack and lift on the left. Today, movable control surfaces located on the trailing edge of each wingtip called ailerons (a’-luh-ronz) control roll. Click here for a demonstration of roll.

**Roll demonstration:** <http://www.grc.nasa.gov/WWW/Wright/airplane/roll.html>

**Yaw** is the twisting motion around a plane’s vertical axis as the nose turns left or right. Rudders control yaw. The force of air on a rudder deflected to the right causes the tail of the airplane to move to the left, forcing the nose to move to the right. Although airplanes bank because of the action of ailerons, a movable rudder is necessary to help the airplane make the turn. Click here for a demonstration of yaw.

**Yaw demonstration:** <http://www.grc.nasa.gov/WWW/Wright/airplane/yaw.html>