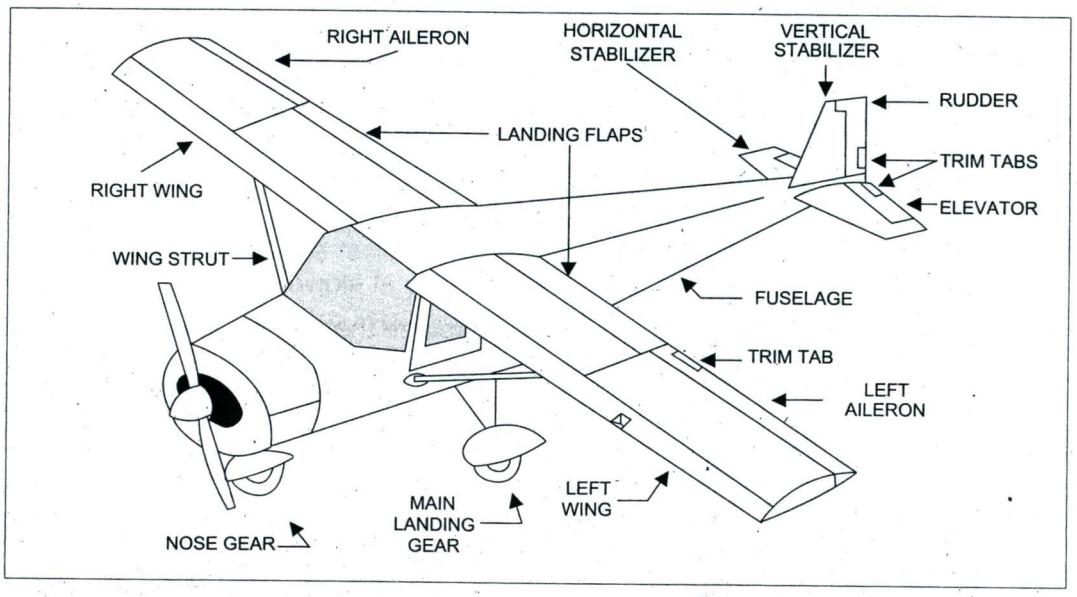
AIRPLANES: HOW THEY FLY

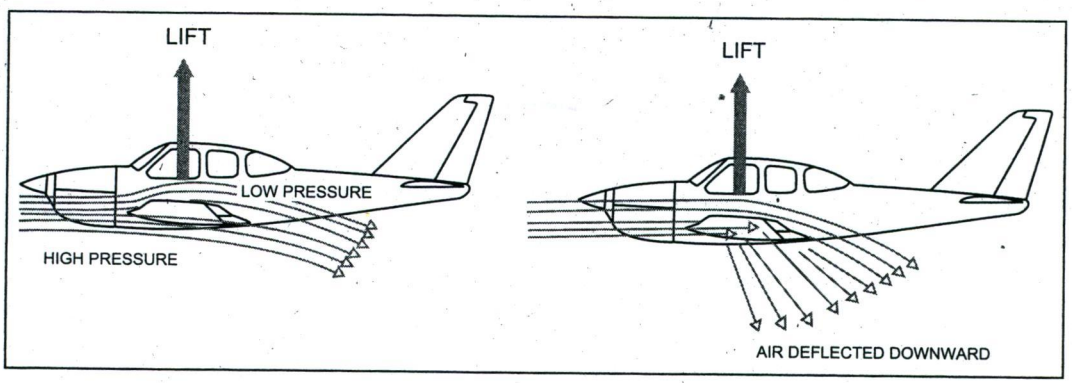
The purpose of the next six pages is to introduce you to the parts of the airplane and to aerodynamics, i.e., the forces acting on the airplane in flight. Remember, this is technical material that will make more sense as you begin your flight lessons.

3.1 THE AIRPLANE

The first figure below is a high-wing aircraft, such as a Cessna 152. On low-wing airplanes, such as the Beech Skipper and the Piper Tomahawk, the wings are affixed to the bottom rather than the top of the fuselage, as indicated in the second figure below.

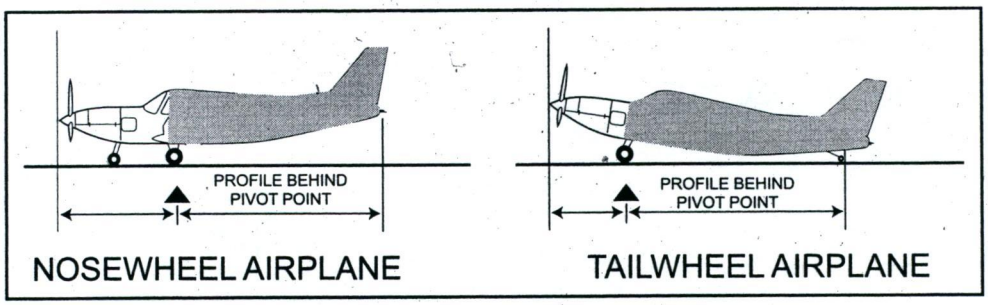


1. ***Wing*** -- Provides lift by creating a low pressure area on the top of the wing and a high pressure area on the bottom. The top of the wing is curved, which provides a longer distance for air to flow over the wing than under the wing. As the air on top of the wing travels a greater distance in the same amount of time, it moves faster than the air flowing under the wing, which results in less pressure on top than on the bottom of the wing. At the same time, the bottom of the wing deflects air downward, which also produces lift.



2. ***Fuselage*** -- The main component of the airplane. Its function is to act as a carrier for the wings and tail section. It also is designed to produce a limited amount of lift.
3. ***Horizontal stabilizer*** -- This structure, located in the rear of the airplane, is designed to provide continuous longitudinal (from front to rear) stability. It prevents uncontrolled up and down movements of the nose (pitching).

4. ***Elevator*** -- A movable part on the rear of the horizontal stabilizer. It is used to move the airplane about the lateral axis. It provides the input of pitch and helps control altitude. Note the axes of rotation are discussed and illustrated on page 16.
5. ***Vertical stabilizer*** -- This surface provides directional (right or left) stability. It acts like a weathervane. It prevents uncontrolled left or right movements of the nose (yawing).
6. ***Rudder*** -- This surface, which is connected to the vertical stabilizer, moves the airplane around its vertical axis and is used to yaw (move the tail to the left or right) the airplane.
7. ***Rudder and elevator trim tabs*** -- These small, movable surfaces decrease control pressures and help to establish hands-off flight (i.e., when the airplane will almost fly by itself). All airplanes have elevator trim tabs controlled from the cockpit.
8. ***Right and left ailerons*** -- These surfaces, located on the outside trailing edges of the wings, control the airplane around its longitudinal axis, i.e., the degree of bank, or whether one wing is higher or lower than the other wing (rolling).
9. ***Aileron trim tab*** -- This small movable section of one or both ailerons permits adjustment so the wings remain level; i.e., you can compensate for more weight on either side of the airplane. Not all airplanes have Aileron trim tabs.
10. ***Landing flaps*** -- These surfaces are located on the inside trailing edges of the wings. They can be extended to provide greater wing area at slower speeds. This provides more lift and drag and allows an airplane to land, take off, or fly at slower speeds.
11. ***Main landing gear*** -- The component of the airplane that touches the runway first during a normal landing. It is designed to take large loads and impacts.
12. ***Nose gear*** -- This component is designed to steer the airplane on the ground. It is not designed for excessive impacts or loads. However, it is designed to carry the weight of the forward portion of the airplane.
13. ***Nosewheel* (tricycle) vs. *tailwheel* (conventional)** -- Nosewheel airplanes have the "third" wheel in front of the main landing gear (i.e., under the nose) as pictured below. Nosewheel airplanes have much better handling (because there is less airplane behind the pivot point) and visibility characteristics while taxiing. Almost all new airplanes are nosewheel design.
    a. Tailwheel airplanes have the "third" wheel under the tail. Tailwheel airplanes can land on much rougher terrain and, consequently, are used by bush pilots. In a tailwheel airplane, this gear supports the weight of the rear portion of the airplane.



14. ***Retractable landing gear*** -- Retracting the gear reduces drag and increases airspeed without the need for additional power. The landing gear normally retracts into the wing or fuselage through an opening which may be covered by doors after the gear is retracted. The smooth door will provide for the unrestricted flow of air across the opening that houses the gear. The retraction or extension of the landing gear is accomplished either electrically or hydraulically by landing gear controls from within the cockpit. Warning indicators are usually provided in the cockpit to indicate whether the wheels are extended and locked, or retracted. In nearly all airplanes equipped with retractable landing gear, a system is provided for emergency gear extension in the event landing gear mechanisms fail to lower the gear.

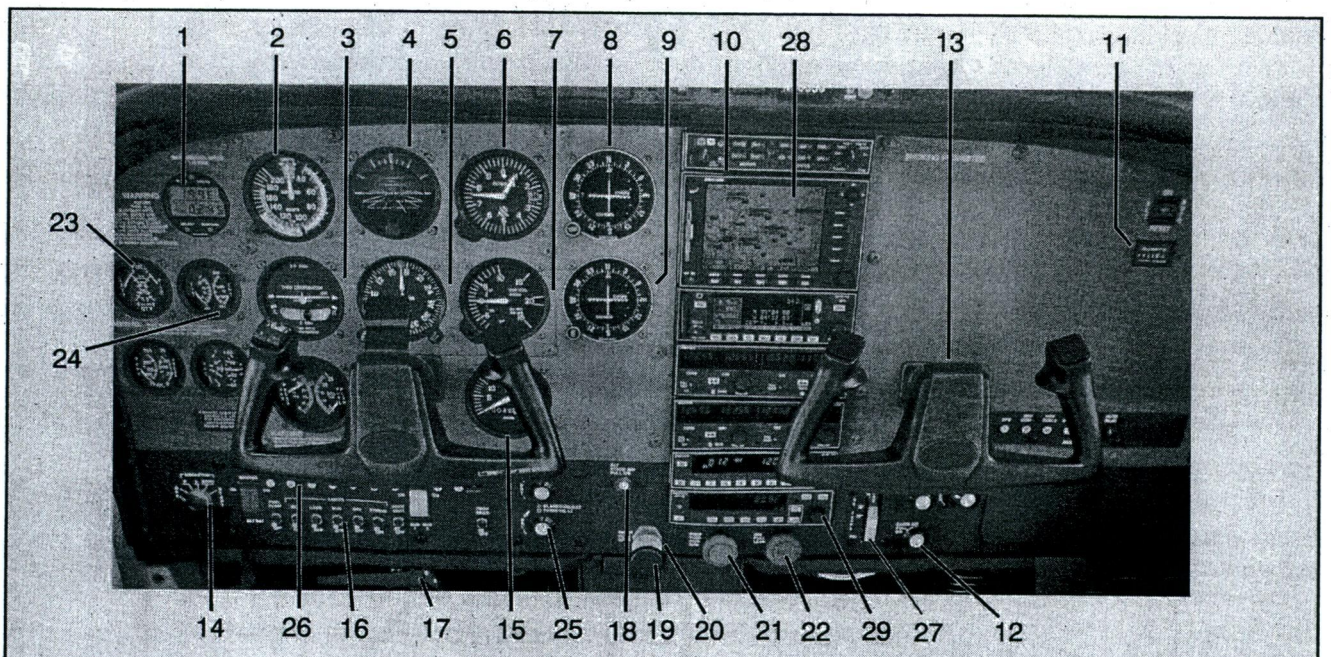
3.2 CATEGORIES OF AIRCRAFT

A. The four categories of aircraft and their subdivision into classes are listed below.

1. ***Airplanes***
   a. Single-engine land
   b. Multiengine land
   c. Single-engine sea
   d. Multiengine sea
2. ***Gliders***
3. ***Rotorcraft***
   a. Gyroplanes -- Thrust is provided by a pusher propeller and lift by an unpowered rotorblade.
   b. Helicopter -- Rotorblade is powered to obtain lift and thrust.
4. ***Lighter-than-air***
   a. Airship
   b. Gas balloon
   c. Hot air balloon

3.3 INSIDE THE AIRPLANE

The following is a diagram of a Cessna instrument panel. It may contain more equipment than is found in some trainer-type airplanes used by student pilots.

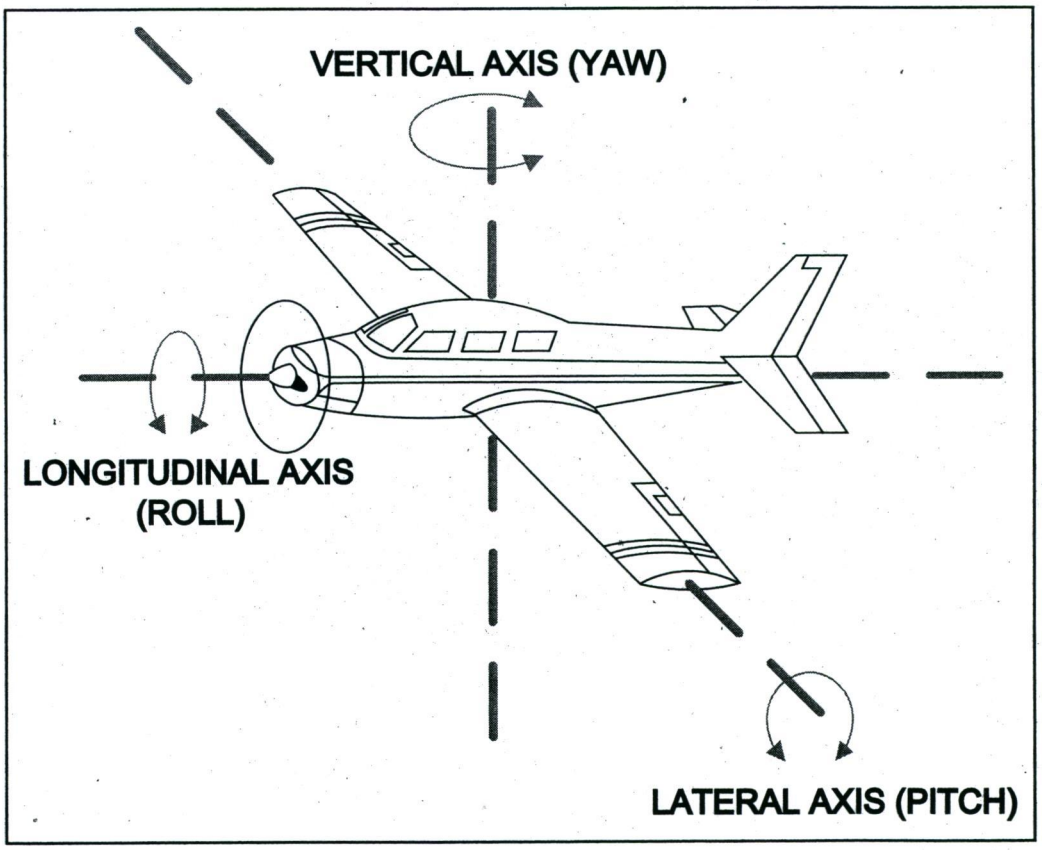


1. CLOCK
2. AIRSPEED INDICATOR
3. TURN COORDINATOR
4. ATTITUDE INDICATOR
5. HEADING INDICATOR
6. ALTIMETER
7. VERTICAL SPEED INDICATOR (VSI)
8. NAV 1 INDICATOR
9. NAV 2 INDICATOR
10. AVIONICS
11. HOBBS METER
12. TEMPERATURE CONTROL
13. CONTROL YOKE
14. MAGNETO SWITCH
15. TACHOMETER
16. ELECTRICAL SWITCHES
17. PARKING BRAKE
18. ALTERNATE STATIC SOURCE
19. THROTTLE
20. FRICTION LOCK
21. PROPELLER CONTROL
22. MIXTURE CONTROL
23. FUEL QUANTITY GAUGES
24. ENGINE INSTRUMENTS
25. LIGHT DIMMER CONTROLS
26. CIRCUIT BREAKER PANEL
27. FLAP CONTROL LEVER
28. G.P.S.
29. AUTO PILOT

3.4 AXES OF ROTATION

A. The airplane has three axes of rotation around which it moves. See the illustration below.

1. ***Lateral (pitch) axis*** -- an imaginary line from wingtip to wingtip
   a. Rotation about the lateral axis is called **pitch** and is controlled by the elevator.
   b. The rotation is similar to a seesaw. The bar holding the seesaw is the lateral axis.
   c. The angle between the airplane's nose and the horizon is known as the airplane's **pitch attitude**.
2. ***Longitudinal (roll) axis*** -- an imaginary line from the nose to the tail
   a. Rotation about the longitudinal axis is called **roll** and is controlled by the ailerons.
   b. The rotation is similar to a barbecue rotisserie, in which the spit is the longitudinal axis.
   c. The angle between the airplane's wings and the horizon is known as the airplane's bank.
3. ***Vertical (yaw) axis*** -- an imaginary line extending vertically through the intersection of the lateral and longitudinal axes
   a. Rotation about the vertical axis is called **yaw** and is controlled by the rudder. This rotation is referred to as directional control or directional stability.
   b. The rotation is similar to a weather vane, in which the post holding the vane is the vertical axis.

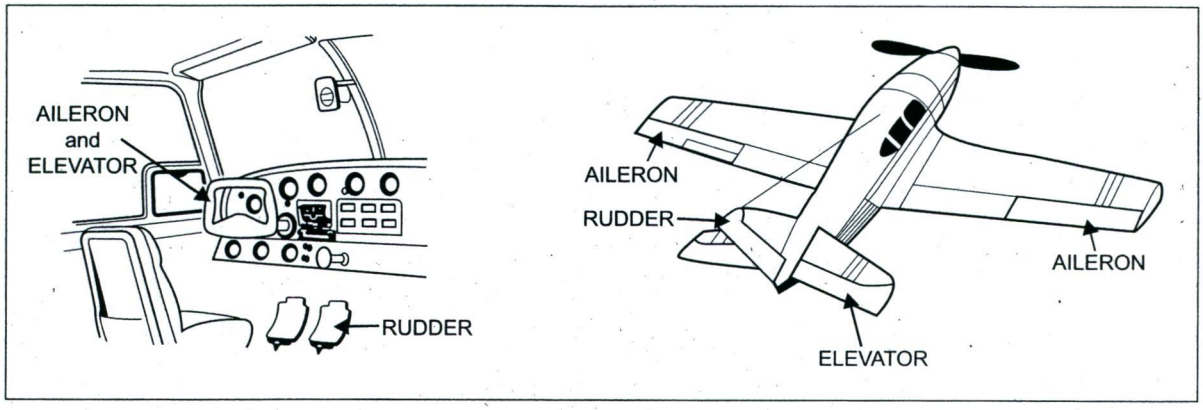


B. The airplane can rotate around one, two, or all three axes simultaneously. Think of these axes as imaginary axles around which the airplane turns, much as a wheel would turn around axles positioned in these same three directions.

3.5 FLIGHT CONTROLS AND CONTROL SURFACES (ILLUSTRATED BELOW)

A. ***Primary Flight Controls.*** The airplane is controlled by deflection of flight control surfaces. These are hinged or movable surfaces with which the pilot adjusts the airplane's attitude during takeoff, flight maneuvering, and landing (airplane attitude refers to whether the airplane is pointing up, down, etc.). The flight control surfaces are operated by the pilot through connecting linkage to the rudder pedals and a control yoke.

1. The **control yoke** is similar to the steering wheel of a car. However, you can push and pull it in addition to turning it. The push/pull movement controls the third dimension in which airplanes move (up and down). Remember, a car can only go straight or turn (move in two dimensions), but an airplane can go straight, turn, or move up and down.



2. The **rudder** is attached to the vertical stabilizer. Controlled by the rudder pedals, the rudder is used by the pilot to control the direction (left or right) of yaw about the airplane's vertical axis for minor adjustments. It is NOT used to make the airplane turn, as is often erroneously believed. Banking the airplane makes it turn. See "How Airplanes Turn" on the following page.
3. The **elevators** are attached to the horizontal stabilizer. The elevators provide the pilot with control of the pitch attitude about the airplane's lateral axis. The elevators are controlled by pushing or pulling the control yoke.
4. The outboard movable portions of each wing are the **ailerons**. The term "aileron" means "little wing" in French. Ailerons are located on the trailing (rear) edge of each wing near the outer tips. When deflected up or down, they in effect change the wing's camber (curvature) and its angle of attack. This changes the wing's lift and drag characteristics.
   a. Their primary use is to bank (roll) the airplane around its longitudinal axis. The banking of the wings results in the airplane turning in the direction of the bank, i.e., toward the direction of the low wing.
   b. The ailerons are interconnected in the control system to operate simultaneously in opposite directions of each other. As the aileron on one wing is deflected downward, the aileron on the opposite wing is deflected upward.
   c. The ailerons are controlled by turning the control yoke.

B. ***Secondary Flight Controls.*** In addition to primary flight controls, most airplanes have another group called secondary controls. These include trim devices of various types and wing flaps.

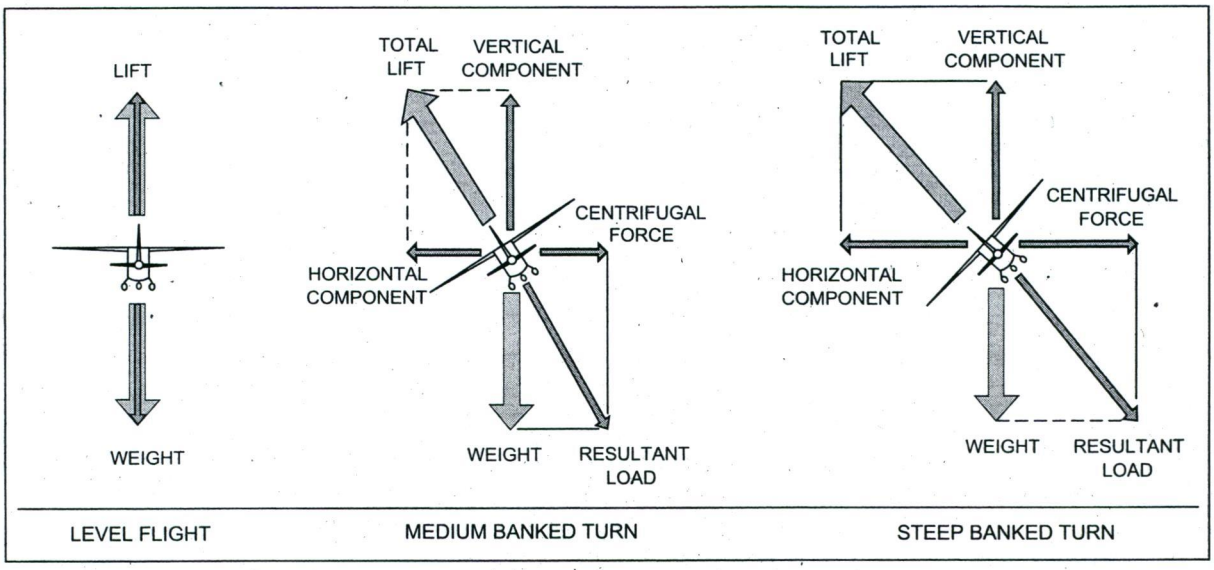
1. **Trim tabs** are commonly used to relieve the pilot from maintaining continuous pressure on the primary controls when correcting for an unbalanced flight condition caused by changes in aerodynamic forces or weight.
2. **Wing flaps** are installed on the wings of most airplanes. Flaps increase both lift and drag and have three important functions:
   a. First, they permit a slower landing speed, which decreases the required landing distance.

b. Second, they permit a comparatively steep angle of descent without an increase in speed. This makes it possible to safely clear obstacles when making a landing approach to a small field.

c. Third, they may also be used to shorten the takeoff distance and provide a steeper climb path.

3.6 HOW AIRPLANES TURN

A. The lift produced by an airplane's wings is used to turn the airplane. When banked, the horizontal component of lift turns the airplane.



1. Until a force acts on the airplane, it tends to fly straight ahead due to inertia.
   a. Inertia is the phenomenon observed when moving objects continue to move in the same direction; i.e., they tend not to turn unless acted upon by an outside force.
2. When the airplane begins to turn, centrifugal force pulls the airplane away from the turn, i.e., tends to make it fly straight ahead.
3. The horizontal component of lift (in a bank) counteracts the centrifugal force.
   a. Therefore, the greater the bank, the sharper the turn or the greater the rate of turn because more of the total lift goes into the horizontal component.
4. The rudder does not turn the airplane. It controls the yaw about the vertical axis.
   a. This permits the "coordination" of the rudder and ailerons.
   b. **Coordinated flight** is when the airplane goes "straight ahead" through the relative wind.

B. In a bank, the total lift consists of both horizontal lift (counteracting centrifugal force) and vertical lift (counteracting weight and gravity).

1. Therefore, given the same amount of total lift, there is less vertical lift in a bank than in straight-and-level flight.
2. Thus, to maintain altitude in a turn, you must
   a. Increase back pressure on the control yoke (for a higher angle of attack to produce more lift), and/or
   b. Increase power.

C. The turn is stopped by decreasing the bank to zero (i.e., wings level).