# Straight and Level Flight

## Objective

To ensure the applicant learns the proper methods for performing straight and level flight, as well as has an understanding of the purpose of the flight controls and the factors affecting straight and level flight.


## Purpose

Straight and level flight is the most fundamental flying maneuver, and nearly the entirety of a normal flight is flown during straight and level flight. This maneuver introduces pilots to the primary flight controls, pitch trim, and the basics of managing aircraft attitude.

## Schedule

- **Ground Lesson**: 10 minutes
- **Flight Lessons**
  - **Flight**: 20 minutes - *Introduction to Maneuver*
  - **Flight**: 10 minutes (per lesson) - *Improve Proficiency (Dual)*
- **Debrief**: 10 minutes (*per flight*)

## Equipment

- Airplane Checklist
- Whiteboard / Markers (optional)
- Model Airplane (optional)

## Student Actions

- Ask any questions, receive study material for the next lesson.
- Watch linked video.
- Review listed references.

## Instructor Actions

- Deliver the ground lesson (below).
- Demonstrate the maneuver in flight.
- Debrief after each flight.

## Completion Standards

- **Ground**: Student can explain the purpose and use of the flight controls and the factors affecting straight-and-level flight.
- **Flight**: Student can maintain straight-and-level flight within the following tolerances:
  - Maintains visual scan outside the cockpit while occasionally referencing the flight instruments.
  - Trims the airplane appropriately.
  - Holds heading +/- 10 degrees, altitude +/- 100 feet, airspeed +/- 10 knots.

## References

- ILearn2Fly - “Straight and Level Flight”
  - YouTube - https://www.youtube.com/watch?v=AeirV-y8wew
- FAA-H-8083-3B (Airplane Flying Handbook) - Chapter 3, Page 2-4 [The Four Fundamentals/Effect and Use of Flight Controls], Chapter 3, Page 5-6 [Integrated Flight Instruction], Chapter 3, Page 6-9 [Straight and Level Flight], Chapter 3, Page 10 [Trim Control]
- FAA-H-8083-25B (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 5, Page 1-8 [Forces Acting on an Aircraft/Thrust/Lift/Drag/Weight], Chapter 5, Page 12-13 [Axes of an Aircraft], Chapter 6, Page 2-8 [Flight Controls/Ailerons/Elevator/Rudder], Chapter 6, Page 10-11 [Trim Systems], Chapter 8, Page 3-4 [Altimeter], Chapter 8, Page 8-9 [Airspeed Indicator], Chapter 8, Page 17-18 [Turn Coordinator], Chapter 8, Page 18-19 [Attitude Indicator]
- FAA-S-8081-6D (CFI PTS) - Area VIII Task A

## Ground Lesson Outline

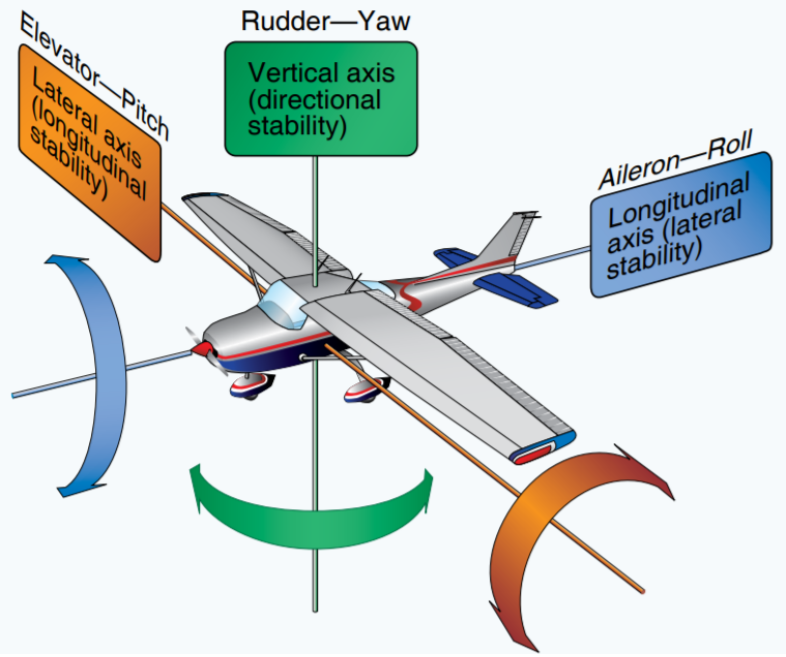
- Introduction to the Four Fundamentals
  - Straight-and-level, Turns, Climbs, and Descents
  - Most airplanes are inherently stable
  - Yaw/Pitch/Roll
  - Airplanes turn by *banking*
- The Primary Flight Controls
  - Ailerons, Elevator, Rudder
- The Elevator Trim
  - Relieving elevator pressure
  - Trim wheel, trim tabs
- Proper Yoke Grip and Overcontrolling
  - One-handed grip
  - Control movements vs control pressures
- How Airplanes Turn
  - Airplanes turn with bank
  - Flight controls are mostly neutral in a constant turn
- Maintaining Straight and Level Flight
  - Heading and Altitude (the altimeter)
- Outside and Inside References
  - Sight picture
  - Attitude Indicator, Heading Indicator/Compass
- The Four Forces
  - Weight, Lift, Thrust, Drag
- Relationship of Thrust to Maintaining Altitude
  - Airplanes don’t climb or descend with elevator alone
  - Tachometer, listening to the engine

## Common Errors

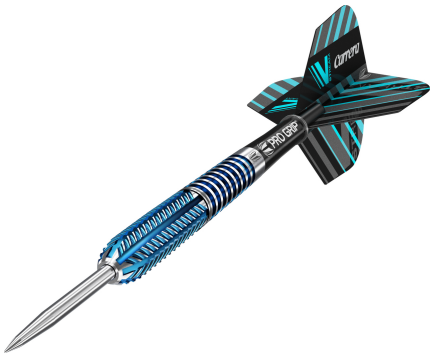
- **Failure to cross-check and correctly interpret outside and instrument references.**
- **Application of control movements rather than pressures.**
- Uncoordinated use of flight controls.
- **Faulty trim procedure.**

# Ground Lesson Content

- **Introduction to the Four Fundamentals** - The *four fundamentals* of flight are **straight-and-level flight, turns, climbs, and descents**. Every flight training curriculum begins with mastering the first fundamental: straight-and-level flight.
    - Most airplanes are inherently stable. The good news for aspiring pilots is that, for the most part, an airplane can be 'flown' without touching the controls at all. Of course, if the airplane is to go where *the pilot* wants it to go, the pilot will need to continuously monitor the airplane and make corrections using the *flight controls*.
    - Straight-and-level flight is the easiest fundamental because it mostly comes down to pointing the airplane at where the pilot wants to fly, and making very small corrections to ensure that the airplane is moving towards the destination and staying at the appropriate altitude.
    - Unlike cars, which turn only left or right in two dimensions, airplanes can move in three dimensions, and rotate around 3 separate axes. The orientation of the airplane is called the *attitude*. The 3 axes of flight are:
        - **Yaw** - *Yaw* is the familiar 'turning' left and right. Rotating around the *vertical axis*.
        - **Pitch** - *Pitch* is the up and down axis. The airplane is rotating around the *lateral axis*, and the nose will be pointing 'uphill' or 'downhill'.
        - **Roll** - *Roll* is somewhat unique to airplanes. **Roll is also often called *bank*.** The airplane is rotating around the *longitudinal* axis. There is no real similarity to cars in this dimension, but it can be thought of as the airplane *leaning* left or right.




    - Airplanes climb and descend in part by increasing or decreasing pitch, however, somewhat unexpectedly, **airplanes do not turn by simply changing yaw. Airplanes turn by banking towards the direction of the turn**, which directs the wings lift force to the side. The vertical tail surface keeps the airplane aligned with the direction of travel, causing the airplane to yaw. This is similar to how the fins or feathers on a dart or arrow keep it flying in the direction it is thrown.



- **The Primary Flight Controls**
  - Airplanes are commonly designed with 3 *primary* flight controls:
    - **Ailerons** - Ailerons move the airplane around its *Roll* axis. **The angle of roll is called the *bank angle* and pilots use the airplane to *bank* in the direction they wish to turn.** Most airplanes control the ailerons with a *yoke*, which is similar to a steering wheel. Turning the wheel left or right causes the airplane to bank left or right.

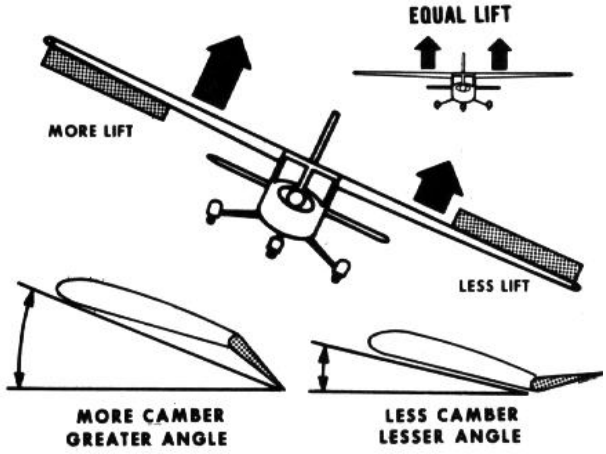
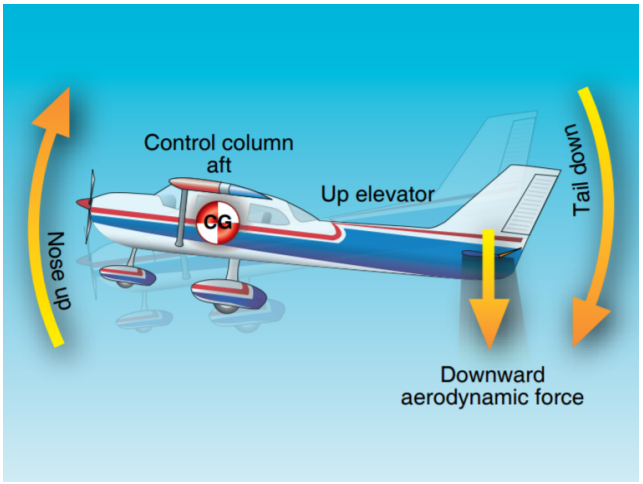
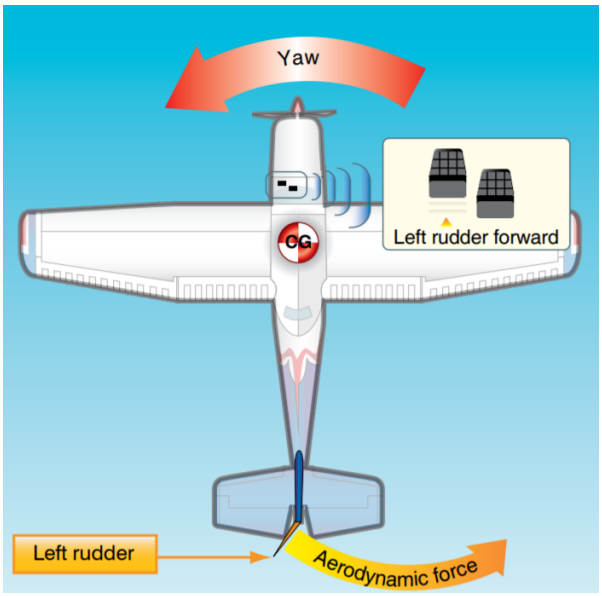



Figure 4–3 Forces Exerted by Ailerons

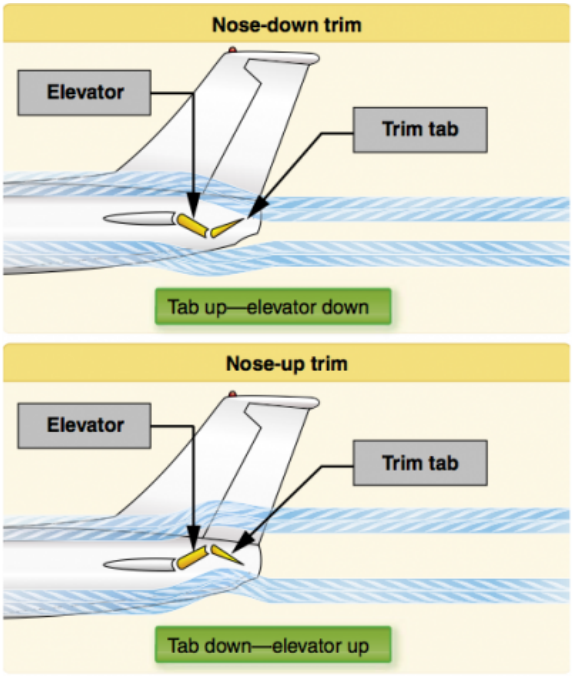
    - **Elevator** - The Elevator moves the airplane around its *Pitch* axis. Pilots can initiate a climb or descent by pulling back or pushing forward on the yoke, respectively.



- **Rudder** - The Rudder moves the airplane around its *Yaw* axis. The rudder is a very mysterious control for most new pilots, because **it is not used to turn the airplane**, as one might expect. The sole purpose of the rudder is to aid the airplane in maintaining a proper (called *coordinated*) flight path during turns made with the ailerons (bank).




- **The Elevator Trim** - In order to hold the nose the proper distance from the horizon and maintain level flight, **new pilots often discover that it may require continuous forwards or backwards elevator pressure on the control yoke**. This is not only uncomfortable, it also requires pilots to devote more attention to maintaining straight and level flight and prevents them from multitasking effectively. There is another, *secondary* flight control, called *pitch trim* or *elevator trim*. These terms are interchangeable, and refer to a control wheel **(the *trim wheel*) which can be used to relieve these control pressures**.
  - The trim mechanism is different on different airplanes, but it usually consists of a small tab, called the *trim tab* on the elevator control surface itself. The trim tab services to 'rebalance' the neutral position of the elevator control and help maintain low control pressures.
  - The trim tab is moved with the *trim wheel*, which when rolled forward moves the trim *nose down*, and when rolled rearwards, moves the trim *nose up*.





- **Proper Yoke Grip and Overcontrolling** - Proper control of the airplane requires that pilots avoid *overcontrolling*. Unlike driving a car, which requires large movements of the wheel, flying an airplane rarely requires large movements, or a lot of force on the controls.
    - Pilots who grip the yoke tightly with both hands often struggle with maintaining straight and level flight or making smooth turns or other maneuvers. Pilots coping with turbulent or bumpy conditions often make the bumpiness *worse* by holding the yoke too firmly.
    - In most situations, pilots should attempt to relax, as **the airplane can be flown mostly with *control pressures*, rather than *control movements***. A one-handed, light grip on the yoke also frees the pilots other hand for manipulating the throttle, or adjusting the radios, etc.

- **How Airplanes Turn** - Although the goal for now is straight and level flight, it is important to understand how airplanes turn. Turning an airplane requires *banking* the airplane towards the desired direction, holding the airplane in the bank until the desired turn is achieved, and then leveling the wings again. For example, to complete a left turn:

- **Step 1** - The pilot applies left aileron input (turns the yoke left) to begin banking the airplane to the left.
- **Step 2** - When a modest bank (usually 30 degrees) is established, the pilot neutralizes the yoke. The airplane will tend to remain in the bank, and begin turning.
- **Step 3** - When the desired turn is accomplished, the pilot applies right aileron input (turns the yoke right) to return the airplane to level flight.

- **Maintaining Straight and Level Flight** - Keeping the airplane in straight-and-level flight is simple. Pilots must manage the airplane so that it is flying in the desired *direction* (called *heading*), and maintaining the desired *altitude*.
  - **Heading** - Maintaining the desired **heading is accomplished by banking**, by **turning the airplane left or right using the ailerons**, as described above. Heading can be maintained by simply aiming the nose of the airplane at prominent visual landmarks.
  - **Altitude** - When established in level flight, **pilots can manage the altitude with pitch**: by climbing or descending by pitching up (pulling back on the yoke), or pitching down (pushing forward on the yoke).
    - Unlike heading, which can be judged visually, it is not usually possible to visually estimate altitude with any accuracy. Therefore, pilots must use an instrument called an *altimeter*, which reports how high the airplane is above sea level.


- **Outside and Inside References** - Pilots use both *outside* (looking out the window) and *inside* (looking at the *flight instruments*) to maintain aircraft attitude. **It is important for pilots to use *both* of these references when flying an airplane**, to prevent optical illusions or poor outside visibility from disorienting the pilot. Comparing multiple independent sources of information about aircraft attitude is called *cross-checking*. The *integrated flight instruction* method recommended by the FAA emphasizes pilots utilizing both outside and inside references from the very beginning of their flying career to develop proper habits of cross-checking these references.
  - **Straight and Level Sight Picture** - Pilots can visually judge their pitch and bank by using something called a *sight picture*. A sight picture is just a familiar appearance of the horizon relative to the airplane's *instrument panel* (dashboard), and is used to judge the *attitude*.
  - Choose a reference point *directly in front of you* on the nose or instrument panel. **When flying straight and level at a given speed, this reference point should always be kept at the same distance from the horizon.** Look left and right and notice that the wing tips are on or near the horizon by the same amount.


- The *inside* reference for pitch and bank is an instrument called the *attitude indicator*, which is also sometimes called an *artificial horizon*.
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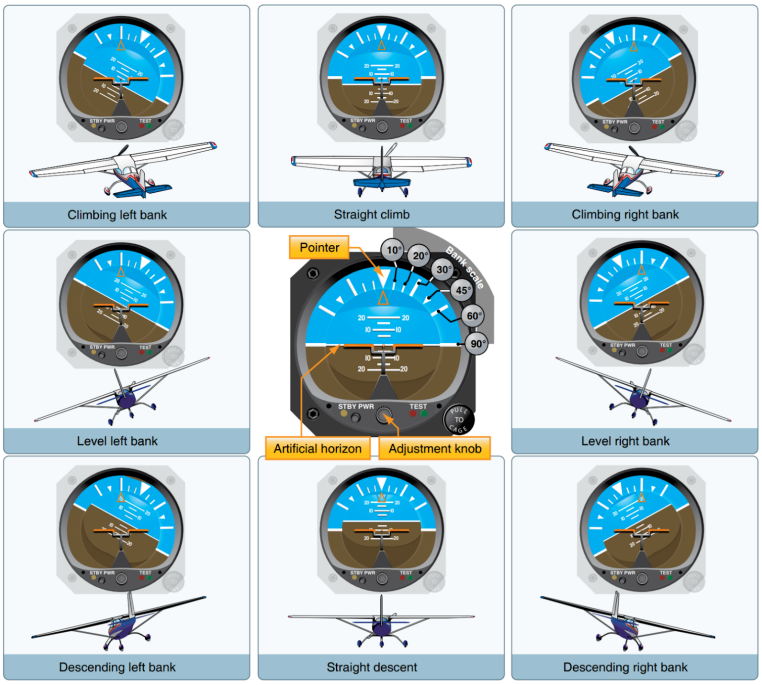
- The attitude indicator is used to back up the out-the-window sight picture for all phases of flight: straight-and-level, climbs, turns, and descents.



- Pilots also judge their heading by using an instrument called a *directional gyro*, which indicates the compass direction (North, South, East, West, etc) the nose of the airplane is pointing.


- **The Four Forces** - Airplanes in straight and level flight are subject to 4 basic forces:
  - **Weight** - *Weight* is the downward force provided by gravity. As an airplane sits stationary on the ground, the only force acting on it is gravity.
  - **Lift** - *Lift* is the upward force provided by the wing. As air flows over and around the wing, it is redirected downward, providing an upward force which during flight balances the downward force of gravity.
  - **Thrust** - *Thrust* is the forward force provided by the engine. Airplanes must move forward to generate lift, and this movement is provided by engine thrust.
  - **Drag** - *Drag* is the rearward force of air resistance, which opposes thrust. Most pilots are already familiar with air resistance… holding a hand out of the window of a moving car is a simple demonstration of drag.

- **Relationship of Thrust to Maintaining Altitude** - Most non-pilots generally understand that "the engine makes the airplane go". Although pilots can use the elevator control to climb, descend, or fly level, without adjusting the *engine thrust*, the airplane may have insufficient power to climb or descend in response to pilot inputs.
  - When an airplane is flying at given speed (called *airspeed*), all of the four forces are in equilibrium, which means that **the thrust precisely equals the drag**. Therefore, a basic task that pilots must accomplish to maintain straight and level flight is managing the engine thrust.
  - Somewhat like a car coasting uphill or downhill, **if the airplane is being held at a given altitude with the control yoke, insufficient power will cause the airplane to slow down, and excess power will cause the airplane to speed up.**
  - Pilots can manage an airplane's thrust by using another instrument, called the *tachometer*. Similar to a car, it indicates how many revolutions per minute (RPM) the propeller is spinning. Higher values equal more power. It is also useful for pilots to use their ears to judge the power setting. **With experience, pilots can develop the ability to judge whether the power setting is too high or low from the engine noise alone.**