Chapter 3 Basic Flight Maneuvers

**The Four Fundamentals:**

* Straight and level flight
* Turns
* Climbs
* Descents

**Effect and use of the flight controls:**

* The pilot is considered the referenced center of effect as flight controls are used
* **With The Pilot’s Hands**

1. **Apply back pressure =** nose rotates back relative to pilot around the pitch(lateral) axis
2. **Increase forward Pressure =** nose rotates forward around pitch axis
3. **Right pressure/ deflection on ailerons =** clockwise rotation (roll) and right wing down
4. **Left Pressure =** counterclockwise rotation and left wing down

* **With the Pilot’s feet**

1. **Forward Pressure Right Rudder =** Yaw right
2. **Forward Pressure Left Rudder =** Yaw left

* Flight controls have resistance to pilot input based on the current airspeed

**Attitude Flying**

* **Pitch Attitude:** Angle between longitudinal axis and natural horizon
* **Bank Attitude:** Angle formed by the lateral axis
* **Angular Difference:** Attitude relative to the airplane’s direction of flight (NOT relative to natural horizon)

1. **Pitch Control:** Involves use of the elevator
2. **Bank Control:** Involves use of the ailerons
3. **Power Control:** Control of the Thrust setting
4. **Trim Control:** used to relieve the control pressures held by the pilot
5. **Yaw Control:** used to cancel out yaw induced changes

**Integrated Flight Instruction**

* Student should be focused on the outside of the plane 90% of the time.

**Straight-and-Level Flight**

* Use the wingtips for level reference instead of the nose
* The pitch attitude for level flight is first obtained by sitting properly, selecting a nose reference point and keeping it in a fixed position relative to the horizon.
* “**Increase the back pressure**” or “**Increase pitch attitude**” = raise the nose
* “**Decrease pitch attitude**” = lower the nose
* Constant or increasing engine power means constant or increasing airspeed respectively
* Pitching moments can also be generated by extension or retraction of flaps, landing gear etc…
* **Common Errors**

1. Attempting to use improper pitch and bank reference points for attitude
2. Forgetting the location of preselected reference points on subsequent flights
3. Attempting to use flight instruments instead of the natural horizon
4. “Chasing” the flight instruments instead of adhering to attitude principles
5. Mechanically jerking the flight controls instead of using smooth pressure
6. Not scanning outside the cockpit for air traffic, weather, terrain etc
7. A tight palm grip which results in overcontrolling of the airplane.
8. Habitually flying with one wing low or only using the rudder for direction
9. Failure to make timely and measured control inputs against deviations
10. Inadequate attention to sensory inputs in developing feel for the plane

**Trim Control**

* Improper trim produces tension and fatigue and distracts the pilot
* Usually all light GA planes have a trim wheel for elevator trim
* When available the rudder should be trimmed first
* Rudder -> Elevator -> Ailerons
* If airspeed is varying get to level flight first with pitch trim and then Rudder -> Ailerons

**Level Turns**

* Controlled by banking the plane
* **Bank Left =** lower left wing = raise left aileron
* **Bank Right =** lower right wing = raise right aileron
* **Procedure**

1. Bank plane and add enough power or pitch to compensate for loss of lift
2. Neutralize controls to stop bank from increasing
3. Use the opposite stick to return the plane to level
4. Neutralize controls again and reduce power or pitch for increase of lift

* The horizontal component of lift moves the plane toward the banked direction
* The elevator pitches the nose up or down relative to pilot and perpendicular to wings
* Pitch up to maintain altitude or increase engine power
* The vertical fin keeps the aft end of the plane behind the front end
* The throttle can also increase airspeed and tighten the turn
* Rudder is used to offset adverse yaw caused by differential lift and the propeller
* **Shallow Turn (angle < 20 degrees):** Will return to neutral due to lateral stability if not held
* **Medium Turn(20-45 degrees):** Airplane remains at a constant bank angle without pilot input
* **Steep Turn(angle > 45 degrees):** Pilot must apply opposite flight control to prevent overbanking
* **Adverse Yaw:** The high wing produces more lift and, by consequence more drag, than the low wing when the plane is banked leading to a yaw action toward the high wings side. This must be counteracted by the pilot using the rudder to coordinate the turn.
* **Slip:** When the plane moves towards the inside of the turn (slipping due to gravity)
* **Skid:** When the plane is heading outwards on the turn (skidding out of the turn circle)
* **Turn Radius**
  + When a plane is held at a constant bank angle a higher airspeed will lead to a slower turn and larger turn radius. A lower airspeed leads to a faster turn and smaller turn radius.
  + **Lift Dissymmetry:** Both wings turn with the same angular rate, but this means that the wing onoutside of the turn radius is moving faster than the wing on the inside. This means that the outside wing has a higher airspeed and by consequence more lift and drag than the inside wing, leading to a roll tendency that must be corrected by the pilot to prevent overbanking. The drag will also causes a slight slip at high bank angles, which must be corrected with the rudder.
* **Establishing a Turn**
  + In most small airplanes the engine cowling is flat and can be used for vertical reference.
  + Pilot must be seated properly and not leaning during a turn to maintain visual references.
  + The pilot’s seat is usually left of the longitudinal axis of the plane making it appear as though the **nose** of the plane drops during right turns and raises during left turns. The **pilot** appears to lower during a left turn and raise during a right turn.
  + If the nose starts to move before the bank is started the rudder is being applied too soon
  + If the banks starts before the nose starts turning, the rudder is applied too late
  + If the nose moves up or down when entering a bank, excessive or insufficient elevator back pressure is being applied.
  + Back pressure on the elevator should be maintained to keep the vertical component of lift the same
* If a steep turn loses altitude the procedure is to reduce the bank angle then apply elevator. Warning: only applying the elevator will lead to overbanking.
* Additional power and trimming can be used to aide a turn over 30 degrees following the increase of drag
* Rollout should be started ½ the amount of bank before reaching the desired heading
* Stick input usually lead to person cross-coupling controls leading to diving when turning right and climbing when turning left
* **Common Errors in level turns**
  + Failure to clear in the direction of turn for air traffic.
  + Gaining or losing altitude
  + Not holding the bank angle constant
  + Attempting to execute the turn by only instrument reference
  + Leaning away from the direction of the turn
  + Insufficient feel of slips and skids
  + Trying to maintain the bank angle by only referencing the nose
  + Excessive rudder in the direction of the turn
  + Failure to coordinate controls

**Climbs and Climbing Turns**

* Plane changes its flightpath to climb attitude
* Excess lift must be developed to overcome weight leading to more drag, decreasing airspeed.
* Climb rate is limited by excess thrust available
* **Normal Climb (Cruise Climb):** Performed at a manufacturer recommended speed; typically, higher than rate of best climb. Better cooling, visibility and control than others.
* **Best Rate of Climb (VY):** Produces the most altitude over a given timespan. Used when departing the runway until free of obstructions and ready for cruise climb configuration.
* **Best Angle of Climb (VX):** Performed at an airspeed that gives the most altitude gain over a distance and a steep climb. Used to clear obstacles.
* As altitude increases so does the airspeed for best angle of climb, but the speed for best rate of climb decreases.
* **Establishing a climb:**
  + First apply small back pressure and apply climb power while referencing the wingtips for power climb attitude.
  + Counteract the excess pitching motion caused by increased slipstream caused by the power increase
  + On special airplanes you may need to advance the propellor and/or cowl flaps into climb configuration
  + As power decreases, advance the throttle setting to maintain manufacture specified climb speeds
* The propellor typically rotates counterclockwise from the pilot’s position. As a climb is performed, lift dissymmetry on the prop moves the center of lift to the right. This asymmetric condition is called **P-factor.**
* **P-factor:** Is caused by increasing angle of attack on the descending blade of the prop and can lead to some effects such as,
  + A left yaw moment that needs to cancelled by pilot rudder input.
  + Increased antitorque of the propeller causing a left banking moment
* Pilot should typically use right rudder and aileron control to counteract P-factor
* As airspeed decreases during a climb the pitch attitude will tend to do the same.
* Pilot should apply nose up trim during the climb
* To stop climbing, pilot needs to level off at an altitude 10 percent the rate of climb before the target is reached.
* When the airplane stops climbing maintain the climb power until cruise airspeed is reached and trim the plane for cruise flight both in pitch and power.

**Climbing Turns**

* **Factors to consider first:**
  + With constant power the same pitch and attitude can’t be maintained in a bank as in a straight climb.
  + Degree of bank can’t be too steep as it would decrease rate of climb
  + Need to maintain a constant turn rate and airspeed.
  + At a constant power setting the plane will climb at a shallower angle
* All the same effects during a turn an climb are present and interact during a climbing turn i.e. adverse yaw, overbanking tendency, reduction of lift and airspeed.
* **Common Errors in Climbing and Climbing Turns:**
  + “Chasing the airspeed”
  + Aggressive elevator
  + Inappropriate rudder pressure
  + Allowing the plane to yaw during the climb
  + Fixating on the airplanes nose resulting in climbing one wing low
  + Failure to coordinate controls to initiate the turn after starting to climb
  + “Slip” due to poor turn coordination
  + Not keeping pitch or bank angle constant
  + Aggressive forward elevator when leveling-off

**Descents and Descending turns**

* Plane changes from level to descent attitude and weight is no longer only perpendicular to the flight path.
* Lift decreases and so does induced drag.
* **Partial Power Descent (Cruise or en route descent):** The normal method of losing altitude.
  + Target descent rate should be **500 feet per minute (fpm).**
* **Descent at Minimum Safe Airspeed:** Nose high and power assisted.
  + Typically used for clearing obstacles during landing approach to a short runway.
  + Airspeed is usually no greater than **1.3 VSO.** Steeper than normal descent angle and excessive power may be required.
* **Emergency Descent:** Typically, high drag, and high airspeed descent that loses altitude fast.
  + Usually specified in the AFM/POH procedures and feature required configurations of the airplane.

**Glides**

* Plane loses altitude without engine power
* Pilot must balance gravity and lift.
* To level off from a powered descent, use **10 percent** of the descent rate as the lead point to begin raising the nose.
* **Glide ratio:** The distance the plane travels compared to the altitude it loses
* **Best glide speed occurs at best AOA for highest Lift over Drag ratio (L/DMAX)**
* Weight does not affect the max distance the plane can glide but does increase the airspeed of best glide as it increases.
* Tailwind makes the plane glide further, but headwind makes the plane glide for shorter.
* If the propellor is lost, slight left rudder may be needed because of P-factor and control surfaces may become slower acting.
* **Minimum sink speed maximizes time in the air during a glide and is typically a few knots less than best glide speed.**
* **To enter a glide:** Close the throttle, advance propellor lever forward if you can and maintain altitude until best glide speed is reached, then you can pitch down.