

VIII.B. Level Turns

References: FAA-H-8083-3

Objectives	The student should develop knowledge of the elements related to establishing and maintaining a level turn.
Key Elements	<ol style="list-style-type: none">1. Increased Back Pressure (HCL/VCL)2. Coordination (Adverse Yaw)3. Control Pressures
Elements	<ol style="list-style-type: none">1. Flight Controls2. How Turning Works3. Integrated Flight Method4. Level Turning5. Trim Procedure6. Overcoming Tenseness and Over-Controlling
Schedule	<ol style="list-style-type: none">1. Discuss Objectives2. Review material3. Development4. Conclusion
Equipment	<ol style="list-style-type: none">1. White board and markers2. References3. Model Airplane
IP's Actions	<ol style="list-style-type: none">1. Discuss lesson objectives2. Present Lecture3. Ask and Answer Questions4. Assign homework
SP's Actions	<ol style="list-style-type: none">1. Participate in discussion2. Take notes3. Ask and respond to questions
Completion Standards	The student has the ability to turn at varying degrees of bank, maintaining altitude and airspeed.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

Level turns sound boring and simple, but there is a lot more to turning than you might think, and a strong grasp on this will make many other maneuvers considerably easier.

Overview

Review Objectives and Elements/Key ideas

What

A level turn is a turn at a specified angle of bank in which altitude and airspeed are maintained.

Why

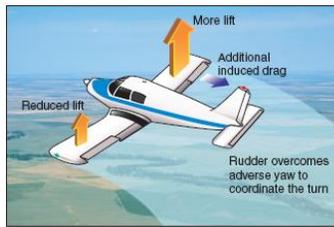
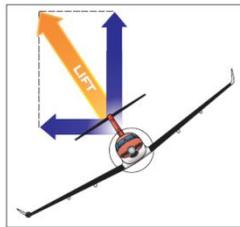
The ability to understand and fly a level turn is essential to the building of every pilot's skill set. Level turns are the building blocks to many more difficult maneuvers and will help the pilot in his or her control of the airplane.

How:

1. Flight Controls

- A. All four primary controls are used in coordination when making turns
 - i. Ailerons - Bank the wings and determine the rate of turn at any given airspeed
 - ii. Elevator - Moves the nose up or down in relation to the pilot, and perpendicular to the wings
 - a. It sets the pitch attitude in the turn and "pulls" the nose around the turn
 - iii. Throttle - Provides thrust which may be used for airspeed
 - iv. Rudder - Offsets any yaw effects developed by the other controls (Does not turn the airplane)

2. How the Turn Works



- A. Changing the direction of the wing's lift to either side causes the airplane to be pulled that direction
 - i. This is done by applying coordinated aileron and rudder to bank the airplane
- B. Lift
 - i. In straight and level flight, the total lift is acting perpendicular to the wings and the Earth
 - a. As the plane is banked, lift becomes the resultant of two components
 - Vertical Component (VC) - Continues to act perpendicular to Earth and opposes gravity
 - Horizontal Component (HC) - Acts parallel to the Earth's surface and opposes inertia (or Centrifugal Force)
 - VC/HC act at right angles to each other (shown in the picture above); total lift acts perpendicular to the banked wings
 - The horizontal component of lift is what actually turns the airplane, not rudder
 - ii. Angle of Attack must be increased when turning
 - a. This is required because part of the vertical lift has been diverted to horizontal lift

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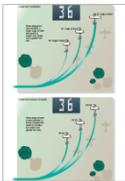
- b. Thus, total lift must be increased to compensate for this loss
 - Total lift is perpendicular to the banked wings

C. Adverse Yaw

- i. When applying aileron to bank the aircraft, the aileron that is lowered produces greater drag than the aileron that is raised
 - a. The wing associated with the lowered aileron is producing more lift which equates to greater induced drag, creating a yawing motion in the opposite direction of the turn
 - To counteract this and remain coordinated, rudder pressure must be applied in the direction of the turn

D. Rate of Turn

- i. The rate of turn is dependent on airspeed and the horizontal component of lift (bank angle)
 - a. Horizontal Component of Lift (bank angle)
 - The greater the bank angle, the greater the rate of turn
 - The rate of turn at a given airspeed is dependent on the horizontal component of lift
 - a. The horizontal component of lift varies in proportion to the bank angle
 - 1. As bank angle increases, the horizontal component of lift increases
 - a. Therefore, the steeper the angle of bank, the higher the rate of turn

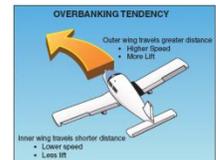


b. Airspeed

- As airspeed increases, the aircraft's rate of turn decreases due to inertia
 - a. The higher the airspeed of an aircraft, the greater the inertia
 - 1. The greater the inertia, the more the aircraft desires to continue straight ahead and therefore the slower the rate of turn
 - b. At a given angle of bank, a higher true airspeed will make the radius of the turn larger

E. Overbanking Tendency

- i. As the radius of a turn becomes smaller, a significant difference develops between the speed of the inside wing and the speed of the outside wing
 - a. The wing on the outside of the turn travels a longer circuit than the inside wing, yet both complete their respective circuits in the same length of time
 - Therefore, the outside wing must travel faster than the inside wing; as a result, it develops more lift
 - The differential between the lift of the inside and outside wings tends to further increase the angle of bank
 - b. In a shallow turn (less than 20°), the excess lift generated by the outside wing is less than the force generated due to the airplane's inherent lateral stability and there is a tendency for the airplane to return to level flight
 - c. As a shallow bank changes to a medium bank (20° - 45°) and the radius of turn decreases, the airspeed of the wing on the outside of the turn increases in relation to the inside wing, but the force created exactly balances the force of the inherent lateral stability of the airplane so that, at a given speed, no aileron pressure is required to maintain that bank
 - d. As the radius decreases further (when the bank progresses from a medium bank to a steep bank (> 45°)), the lift differential overbalances the lateral stability, and counteractive pressure on the ailerons is necessary to keep the bank from steepening the turn
 - Because the outside wing is developing more lift, it also has more induced drag
 - a. This causes a slight slip during steep turns that must be corrected with the use of rudder



F. Coordination

- i. The ball in the turn and slip indicator will be displaced whenever the airplane is skidding or slipping
- ii. In proper coordinated flight, there is no skidding or slipping

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- iii. Step on the ball to center it and maintain coordinated flight
- iv. Uncoordinated flight results in decreased performance (excess drag)

3. Integrated Flight Method (Learn Outside, then Inside)

- A. To establish the desired angle of bank, the pilot should use outside visual references as well as the attitude indicator
 - i. Outside References
 - a. The angle formed by the raised wing and the horizon, the top of the cowling and the horizon
 - b. Reference the pitch of the airplane with the horizon
 - The higher the bank, the more pitch necessary to maintain level flight
 - Teach the student the different pitch pictures for varying banks
 - ii. Inside References
 - a. The attitude indicator will be used to ensure the angle of the wings in relation to the horizon
 - Use this to learn to judge the angle of bank based on outside references

4. Level Turning

- A. Before turning, Clear the Area in the direction of the turn
- B. Entering the Turn
 - i. Simultaneously move the controls and rudder pressure in the desired direction
 - a. The speed the plane rolls into the bank depends on the rate and amount of control pressure
 - b. The amount of bank depends on how long the ailerons are deflected
 - ii. Rudder pressure must be enough to keep the ball of the inclinometer centered
 - a. If it is not centered, step on the ball to re-center
 - b. **CE** - Uncoordinated use of the flight controls
 - iii. Establishing the Bank
 - a. Use the angle made by the cowling or wings and the horizon
 - This will provide some indication of the approximate degree of bank
 - iv. Posture in the Turn
 - a. This is important as it will affect the alignment of outside visual references
 - There is a tendency to lean away from the turn to remain upright in relation to the ground
 - a Do not do this, allow yourself to roll with the airplane
 - v. Maintaining Altitude
 - a. Total lift must be increased so that vertical lift will remain equal to weight
 - Increase total lift by applying enough elevator back pressure to maintain altitude
 - More bank = more back pressure
 - b. Use the horizon as a reference to maintain level flight
 - Just as in straight and level flight
 - c. Since the seats are to either side of the airplane's centerline, the position of the nose in relation to the horizon will be different in turns to the left than in turns to the right
 - In a turn to the left, the nose may appear level or slightly high
 - In a turn to the right, the nose may appear low
 - vi. Power
 - a. As lift is increased, drag is also increased
 - The increase in drag may result in a decrease in airspeed
 - If necessary add power to maintain airspeed (usually noticeable above 30° of bank)
- C. In the Turn
 - i. Maintaining Bank
 - a. Once the desired angle of bank is established, aileron and rudder pressures should be released

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- This will stop the bank from increasing since the control surfaces will be neutral (in a medium turn)
 - a In a shallow turn aileron pressure will be required in the direction of the turn
 - b In a steep turn, aileron pressure will be required opposite the turn direction
 - b. **CE** - Faulty attitude and bank control
 - ii. Maintaining Altitude
 - a. The back elevator pressure should not be released and may need to be increased
 - Throughout the turn, cross check the references and occasionally include the altimeter to check pitch attitude
 - a **CE** - Failure to cross-check and correctly interpret outside and instrument references
 - b. Adjustments
 - If bank angle is too high or low, reestablish the desired bank using the ailerons
 - If climbing/descending, adjust the pitch attitude in relation to the horizon
 - a Then recheck the altimeter/VSI to determine if altitude is being maintained
 - b Once an attitude is established that maintains the altitude, maintain that attitude by making corrections in relation to the horizon
 - 1. Just as in straight-and-level flight - Adjust the pitch attitude of the airplane to maintain the reference on the horizon
 - c. Once the necessary adjustments have been made trim the airplane for level flight
 - d. Throughout the turn, cross-check the outside references, altimeter and VSI to determine whether or not the pitch attitude is correct
 - **CE** - Failure to cross-check and correctly interpret outside and instrument references
 - e. **CE** - Faulty attitude and bank control
 - iii. Power
 - a. Throughout the maneuver cross-check the airspeed indicator, if the airspeed has decreased more than 5 knots add power
 - Due to the increased lift, increased drag may slow the airplane (usually applicable above 30° of bank)
 - iv. Summary
 - a. During all turns, the ailerons, rudder and elevator are used to correct minor variations in pitch and bank just as they are in straight-and-level flight
- D. Rolling Out
- i. Similar to a roll in except control pressures are used in the opposite direction
 - a. Aileron and rudder are applied toward the high wing
 - ii. Lead the rollout by approximately $\frac{1}{2}$ the bank angle (this is a very slow roll out)
 - a. If you have 30° of bank start the rollout 15° before your desired heading
 - iii. As the angle of bank decreases, elevator pressure should be released smoothly to maintain altitude
 - a. When the airplane is no longer banking, the vertical component of lift increases
 - b. Remove the trim if necessary
 - iv. Power should be reduced back to maintain airspeed in straight flight
 - v. As the wings become level, the control pressures should be gradually/smoothly released
 - a. The airplane returns to straight-and-level flight
 - vi. Attention should be directed to visual references and attitude and heading indicator to determine the turn has stopped

5. Trim Procedure

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- A. The airplane is designed so that the primary flight controls (rudder, aileron, elevator) are streamlined with the non-movable airplane surfaces when the airplane is cruising straight and level at normal weight and loading
 - i. If the airplane is out of that balanced condition, one or more of the control surfaces is going to have to be held out of its streamlined position by continuous control input
 - a. Trim tabs relieve the pilot of this requirement
 - If the airplane is trimmed properly and the air is smooth, straight and level flight requires almost no application of control pressure
 - B. Trimming the Airplane
 - i. Set the power
 - ii. Set the pitch
 - iii. Let the airspeed stabilize
 - iv. Trim the airplane for the current airspeed
 - a. Method
 - Establish and hold the airplane in the desired attitude using the primary flight controls
 - a. Proper attitude should be established with reference to the horizon and then verified by reference to the flight instruments
 - Then apply trim to relieve whatever pressure was required
 - a. The airplane attitude must be established and held first, then control pressures trimmed out so that the airplane will maintain the desired flight attitude in “hands off” flight
 - As previously discussed, if power changes, the pitch attitude to maintain level flight will change, and the aircraft will have to be re-trimmed
 - v. **CE** - Faulty trim procedure
 - a. Use trim frequently and in small amounts
 - b. Trying to fly the airplane with trim is a common fault in basic flying technique
 - Establish the desired attitude, then trim the aircraft (establish first, trim second)
 - Do not trim to establish the desired attitude (trim first, establish second)
 - v. **CE** - Faulty trim procedure
 - a. Use trim frequently and in small amounts
 - b. Trying to fly the airplane with trim is a common fault in basic flying technique
 - Establish the desired attitude, then trim the aircraft (establish first, trim second)
 - Do not trim to establish the desired attitude (trim first, establish second)
 - C. Any control pressure the pilot feels should be a result of deliberate pilot control input during a planned change in airplane attitude
 - i. It should not be a result of pressure being applied by the airplane because the pilot is allowing it to assume control
- 6. Overcoming Tenseness and Over-Controlling**
- A. Signs of over-controlling
 - i. Control movements rather than control pressures
 - a. Jolty, large movements of the flight controls
 - b. White knuckles (look for the death grip)
 - c. Overall nervousness
 - B. Prevention
 - i. Point out the over-controlling and demonstrate the correct light/fingertip grip and pressures desired
 - ii. If over-controlling is consistent, place a wooden pencil on top of the middle and ring finger and under the index and pointer finger of the hand the student uses to fly
 - a. If the student starts the death grip, the force of the pencil on the middle/ring finger will be a reminder to relax, if the student continues to tighten their grip the pencil will break
 - C. **CE** - Application of control movements rather than pressures

Common Errors:

- Failure to cross-check and correctly interpret outside and instrument references

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- Application of control movements rather than pressures
- Uncoordinated use of the flight controls
- Faulty attitude and bank control

Conclusion:

Brief review of the main points

In a level turn, we establish and maintain our bank angle and pitch attitude in relation to the horizon. The airplane's attitude is confirmed by referring to flight instruments and its performance. If the airplane performance, as indicated by flight instruments, indicates a need for correction, a specified amount of correction should be applied with reference to the horizon. Then the airplane's attitude and performance are rechecked by referring to the flight instruments.

PTS Requirements:

To determine that the applicant:

1. Exhibits instructional knowledge of the elements of level turns by describing:
 - a. Effect and use of flight controls.
 - b. The Integrated Flight Instruction method.
 - c. Outside and instrument references used for pitch, bank, yaw, and power control; the crosscheck and interpretation of those references; and the control procedure used.
 - d. Trim procedure.
 - e. Methods that can be used to overcome tenseness and over controlling.
2. Exhibits instructional knowledge of common errors related to level turns by describing:
 - a. Failure to cross-check and correctly interpret outside and instrument references.
 - b. Application of control movements rather than pressures.
 - c. Uncoordinated use of flight controls.
 - d. Faulty altitude and bank control.
3. Demonstrates and simultaneously explains level turns from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to level turns.

