XI.A. Maneuvering During Slow Flight

References: FAA-H-8083-3; POH/AFM

Objectives
To develop an understanding and proficiency in the flight characteristics and degree of controllability of an airplane in slow flight. A “feel” for the airplane at very low speeds should be developed to avoid inadvertent stalls and to operate the plane with precision. In flight, the student should perform the maneuver in varying configurations to PTS standards.

Key Elements
1. Pitch for Airspeed
2. Power for Altitude
3. Coordination

Elements
1. Defining Slow Flight
2. Relationship of Power to Flight Characteristics and Controllability
3. Relationship of the Maneuvering Loads to Flight Characteristics and Controllability
4. Relationship of Weight to Flight Characteristics and Controllability
5. Relationship of the CG to Flight Characteristics and Controllability
6. Relationship of the Maneuver to Critical Flight Situations, such as go-around
7. Slow Flight and the Senses
8. Flight at Minimum Controllable Airspeed

Schedule
1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment
1. White board and markers
2. References

IP’s Actions
1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP’s Actions
1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards
The lesson is complete when the student understands factors affecting flight characteristics and controllability and shows the ability to control the airplane effectively in different configurations of slow flight.
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Instructors Notes:

Introduction:

Attention

When the aircraft is flying at just above the stall speed, there is little margin for error to maintain straight and level flight. This maneuver will greatly improve your piloting skills.

Overview

Review Objectives and Elements/Key ideas

What

Slow flight is flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall.

Why

Maneuvering during slow flight demonstrates the flight characteristics and degree of controllability of an airplane at less than cruise speed. The student must develop the awareness and ability of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

How:

1. Defining Slow Flight
   A. Speed that is less than cruise speed
      i. However, in pilot training, it can be broken down into two distinct elements
         a. The establishment, maintenance of, and maneuvering of the airplane at airspeeds and in configurations appropriate to takeoffs, climbs, descents, landing approaches and go-arounds
            • Below cruise speed
         b. Flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall

2. Relationship of Power to Flight Characteristics and Controllability
   A. When performing slow flight, it is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed
      i. As airspeed decreases from cruise to \( L/D_{MAX} \), total drag and thrust required decrease to maintain a constant altitude
      ii. As airspeed decreases below \( L/D_{MAX} \), additional power (thrust) is required to maintain a constant altitude
         a. Total drag is now increasing because induced drag increases faster (due to higher angle of attack) than parasite drag decreases
         b. This is known as the ‘backside of the power curve’ or the ‘region of reverse command’
            • The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude
   B. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components
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i. In slow flight, thrust no longer acts parallel to and opposite to the flight path and drag.
   a. In slow flight, thrust has two components:
      • One acting perpendicular to the flight path in the direction of lift
      • One acting along the flight path
   ii. Because the actual thrust is inclined, its magnitude must be greater than drag if its component
       acting along the flight path is equal to drag
      a. The forces acting upward (wing lift and the component of thrust) equal the forces acting
         downward (weight and tail down force)
   iii. Wing loading is actually less during slow flight because the vertical component of thrust helps
       support the airplane

C. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over
   them
   i. As airspeed decreases, control effectiveness decreases disproportionately
      a. Loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed
      b. Considerably greater loss as the airspeed is reduced to 10 knots above the stall speed
   ii. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high
       power setting condition
   iii. Large control movements may be required
      a. This does not mean rough or jerky movements

3. Relationship of the Maneuvering Loads to Flight Characteristics and Controllability
   A. Load factor is the ratio of the total load acting on the airplane to the
      gross weight of the airplane
      i. Expressed in terms of G’s
   B. Any increase in the load factor increases the stall speed
   C. Turns
      i. Increased load factors are a characteristic of all banked turns
      ii. Load factor increases at a terrific rate after 45°-50° of bank
         a. At approx 63° of bank the stall speed is increased by
            approximately ½
   D. Stalls
      i. The normal stall will not produce added load factors
         beyond the 1 G of straight and level flight
         a. As the stall occurs, however, this load factor may be
            reduced to zero
         b. In the event the recovery is effected by snapping
            the elevator control forward, negative load factors
            may be produced
         c. During the pull-up following recovery, significant load factors are sometimes induced
            • Abrupt pull-ups at high diving speeds may impose critical loads on airplane structures and
              may produce recurrent or secondary stalls by increasing the angle of attack to that of
              stalling
   E. Spins
      i. A stabilized spin is no different from a stall except for the rotation, so the same load factors apply
   F. Rough Air
      i. Gust load factors increase with increasing speed
      ii. Use \( V_A \)

4. Relationship of Weight to Flight Characteristics and Controllability
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A. The heavier the plane is, the more lift necessary
B. As more lift is required, the angle of attack is increased
   i. This brings us closer to the critical angle of attack, therefore we stall at a higher airspeed

5. Relationship of the CG to Flight Characteristics and Controllability
   A. An airplane with forward loading
      i. “Heavier” and consequently slower than the same airplane with a further aft CG
         a. Nose up trim is required which requires the tail surfaces to produce a greater download which
            adds to the wing loading and the total lift required from the wing to maintain altitude
      ii. Requires a higher angle of attack, which results in more drag and, in turn, produces a higher stalling
           speed
      iii. The airplane is more controllable
   B. With aft loading, the airplane requires less download allowing for a faster cruise speed
      i. Faster cruise because of reduced drag
         a. Reduced drag is a result of a smaller angle of attack and less downward deflection of the
            stabilizer
      ii. The tail surface is producing less down load, relieving the wing of loading and lift required to
          maintain altitude
         a. Results in a lower stall speed
      iii. Recovery from a stall becomes progressively more difficult as it moves aft

6. Relationship of the Maneuver to Critical Flight Situations, such as go-around
   A. The maneuver demonstrates the flight characteristics and degree of controllability of the airplane in
      slow flight
      i. It is of great importance that the pilot know the characteristic control responses of the airplane
         during slow flight
         a. This is necessary to avoid stalls at the slower airspeeds which are characteristic of takeoffs,
            climbs, landings, and go-arounds

7. Slow Flight and the Senses
   A. Visually
      i. As you pitch up, you will be looking at sky
         a. There will be few if any visual references at this point
            • Possibly a couple of clouds
      ii. Hearing
         a. Initially, with the reduction of power, sound will decrease
         b. As you approach the stall, the stall warning horn will sound
         c. When power is reintroduced, obviously the sound of the engine increases
            • Although, the sound of the plane moving through the air stays soft as the plane moving slow
      iii. Feel
         a. As the plane’s speed continues to decrease, the controls will become progressively less
            responsive
            • Larger control movements will be necessary to control the airplane as the air flow over the
              control surfaces has been reduced greatly
         b. Right rudder will be necessary as the plane begins to yaw to the left
            • This is due to the left turning tendencies upon reintroduction of power
            • Again, due to reduced control effectiveness, more right rudder than normal is required
         c. Just prior to stalling the plane will begin to buffet

8. Flight at Minimum Controllable Airspeed
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A. Definition
   i. Flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall

B. Purpose
   i. Demonstrates the flight characteristics and degree of controllability of the airplane at its minimum flying speed

C. Performing The Maneuver
   i. Overview of the Basics
      a. Pitch for Airspeed, Power for Altitude
      b. Use both instrument indications and visual references
         • Important habit of frequent reference to the instruments, especially the attitude indicator
         • A “feel” for the airplane at very low speeds must be developed to avoid inadvertent stalls and to operate the plane with precision
   ii. The Maneuver
      a. Configuration
         • Different configurations can be used in order to develop a feel for the airplane in different situations
            a. The ‘dirtier’ (more flaps) the airplane, the slower we can get
               1. Stall speed is reduced
            b. The ‘cleaner’ the airplane, the faster we will have to remain faster to avoid stalling the airplane
         • CE - Failure to establish specified gear and flap configuration
      b. Begin slowing the airplane by gradually reducing the throttle
         • Maintain altitude as power is lost
            a. The position of the nose in relation to the horizon should be noted and raised as necessary to maintain altitude
         • CE – Inappropriate removal of hand from throttles
            a. Keep a hand on the throttles unless absolutely necessary, in order to make small adjustments
               1. Or large adjustments if you unintentionally stall the aircraft
      c. Retrim the Airplane
         • Retrim as often as necessary to compensate for changing control pressure
            a. This will make the maneuver considerably easier to perform
         • CE – Improper trim technique
      d. Full flaps should be lowered incrementally as the airspeed reaches the allowable flap operation limits
         • Incremental flap application will allow for easier adjustments in pitch attitude to maintain altitude
            a. Lowering the flaps will require nose down pitch to compensate for the ballooning
      e. Gear can be lowered if necessary
      f. Note the feel/sounds
         • As speed decreases, the pilot should note the feel of the flight controls (especially elevator)
         • Also note the sound of the airflow as it lessens
      g. Flight Control Effectiveness
         • Much less effective with the reduction in airspeed
            a. Elevators become less responsive
            b. Flight control inputs are not as smooth to control the airplane (coarse)
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h. Reintroduce power
   • Additional power will be required as airspeed decreases below L/D_{MAX} to maintain altitude
     a. As the airspeed is approaching the specified speed/stalling speed additional power will be required to maintain airspeed and altitude just above the stall
   • The slipstream effect and torque produces a strong yaw
     a. Right rudder is necessary to maintain coordinated flight
        1. This can result in a roll to the right, in which case the ailerons must be used to correct and keep the wings level
           a. Can result in flying cross controlled
     b. CE – Improper correction for torque effect
   • Losing too much speed/using too little power
     a. Losing too much speed/too little power requires further back pressure which may result in a loss of altitude or stall
     b. CE – Unintentional stalls
   • CE – Improper entry technique

i. Establish the desired pitch attitude to maintain airspeed
   • Continually cross check the attitude indicator, altimeter, and airspeed indicator, as well as outside references to ensure that accurate control is being maintained
   • Throughout the maneuver, be proactive in fixing altitude, heading, etc changes
     a. Don’t let the airplane get away
     b. CE – failure to establish and maintain the specified airspeed
     c. CE – Excessive variations of altitude and heading when a constant altitude and heading are specified

j. Maintain straight and level flight and perform required level turns at a constant altitude
   • During turns, the pitch attitude and power may need to be increased to maintain airspeed and altitude
   • Maintaining bank angle
     a. In slow flight, putting in a small amount of bank (5°) results in the airplane wanting to continue banking
        1. Opposite aileron will be necessary to maintain the 5° bank angle
     b. Adverse Yaw
        a. The downward deflected aileron produces more lift and therefore more drag
        b. The airplane will try to yaw toward the outside wing during the turn
           1. The plane must be kept coordinated
   • Extreme Bank
     a. Extreme bank situations, like steep turns, are not used in slow flight
        1. As we increase the bank angle above 30°, we begin to increase the stall speed
           a. Obviously, this is unsafe when we are very close to the stall speed

k. Maintain coordinated flight as climbs/descents or climbing/descending turns are performed
   • Adjust the power to begin the climb or descent, and simultaneously adjust the pitch attitude as necessary to maintain the desired airspeed
     a. You will gain altitude by increasing power and adjusting pitch to maintain airspeed
        1. In some situations you may have to pitch down to maintain airspeed in a climb
     b. CE – Rough and/or uncoordinated use of flight controls

iii. Reestablishment of Cruise Flight
   a. Just like a stall recovery
   • Full Power
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- Nose Down
- Clean Up the airplane
  a. Flaps
  b. Gear (If necessary)

b. Increase the power and lower the nose to begin building airspeed
- Maintain altitude
- Trim the nose down for level flight
  a. If the nose was trimmed up for the maneuver, it will be very difficult to maintain altitude with the additional power

c. Remove the first increment of flaps
- Anticipate the change in lift to maintain altitude
d. As speed increases and the airplane exceeds $V_Y$, remove the second increment of flaps
- Again, anticipate the change in lift to maintain altitude
e. As airspeed increases, right rudder pressure may be reduced

Common Errors:
- Failure to establish specified gear and flap configuration
- Improper entry technique
- Failure to establish and maintain the specified airspeed
- Excessive variations of altitude and heading when a constant altitude and heading are specified
- Rough or uncoordinated use of flight controls
- Improper correction for torque effect
- Improper trim technique
- Unintentional stalls
- Inappropriate removal of hand from throttle

Conclusion:
Brief review of the main points
Understanding the characteristics that affect slow flight and how to perform this maneuver is an extremely important part of a pilot’s training. Slow flight develops the student’s awareness of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

PTS Requirements:
To determine that the applicant:
1. Exhibits instructional knowledge of the elements of maneuvering during slow flight by describing:
   a. relationship of configuration, weight, center of gravity, maneuvering loads, angle of bank, and power to flight characteristics and controllability.
   b. relationship of the maneuver to critical flight situations, such as go-arounds.
   c. performance of the maneuver with selected landing gear and flap configurations in straight-and-level flight and level turns.
   d. specified airspeed for the maneuver.
   e. coordination of flight controls.
   f. trim technique.
   g. reestablishment of cruise flight.
2. Exhibits instructional knowledge of common errors related to maneuvering during slow flight by describing:
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a. failure to establish specified gear and flap configuration.
b. improper entry technique.
c. failure to establish and maintain the specified airspeed.
d. excessive variations of altitude and heading when a constant altitude and heading are specified.
e. rough and/or uncoordinated use of flight controls.
f. improper correction for torque effect.
g. improper trim technique.
h. unintentional stalls.
i. inappropriate removal of hand from throttles.

3. Demonstrates and simultaneously explains maneuvering during slow flight from an instructional standpoint.

4. Analyzes and corrects simulated common errors related to maneuvering during slow flight.
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