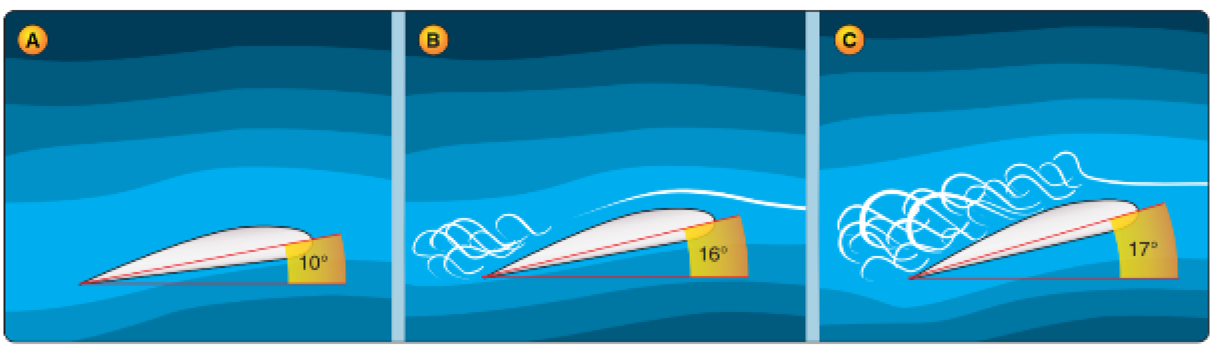
VII.D. ACCELERATED STALLS

References: Airplane Flying Handbook, Risk Management Handbook, Stall and Spin Awareness Training (AC 61-67), POH/AFM

KNOWLEDGE

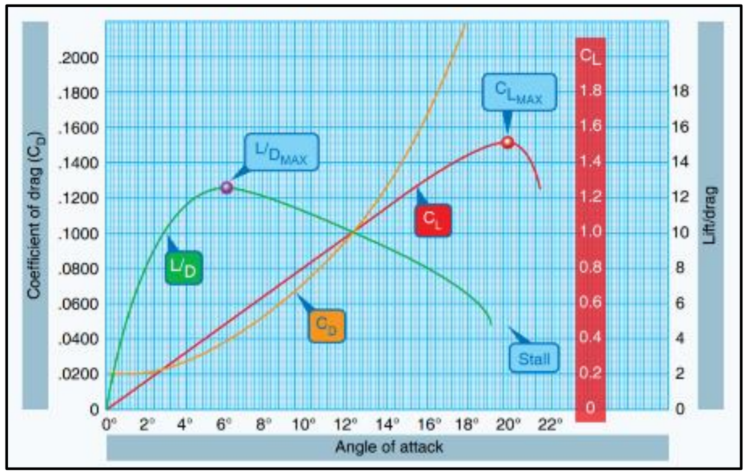
The applicant demonstrates understanding of:

1. **Aerodynamics**
   A. Why an Aircraft Stalls
      i. Basically…
         a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
            - This happens when the wing exceeds its critical angle of attack (AOA)
               a The critical AOA varies, but is usually around 15-20^{o} in a general aviation aircraft
               b Remember, AOA is the angle between the chord line of the wing and the relative wind
            - A stall can occur at any airspeed, in any attitude, with any power setting
      ii. More Specifically…
         a. Airflow Over the Wing
            - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in graphic below)
            - As AOA increases, the airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in graphic below)
            - As AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift, and leading to airflow separation and a stall (C in graphic below)
               a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of the airflow from the wing's surface



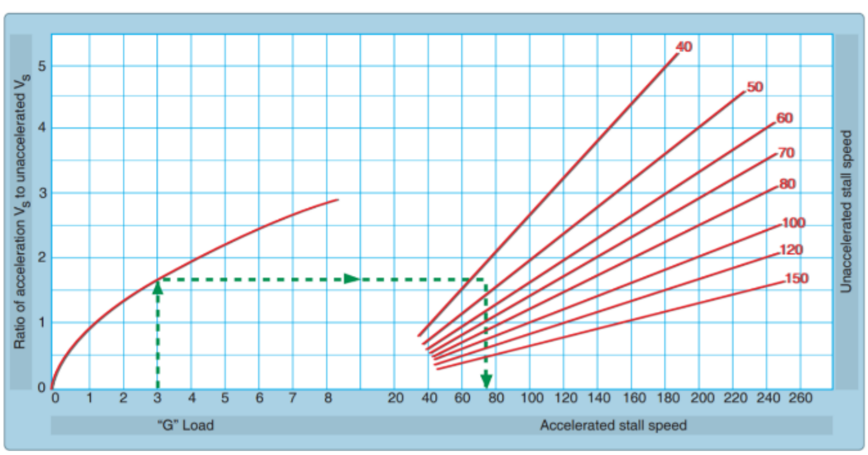
         a. The Critical Angle of Attack/C_{LMAX}
            - The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
            - C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
               a Determined by wind tunnel tests and based on airfoil design and AOA
            - Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly
   B. Stall Characteristics
      i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips
         a. By having the root stall first, aileron effectiveness is maintained at the wingtips, maintaining controllability of the aircraft

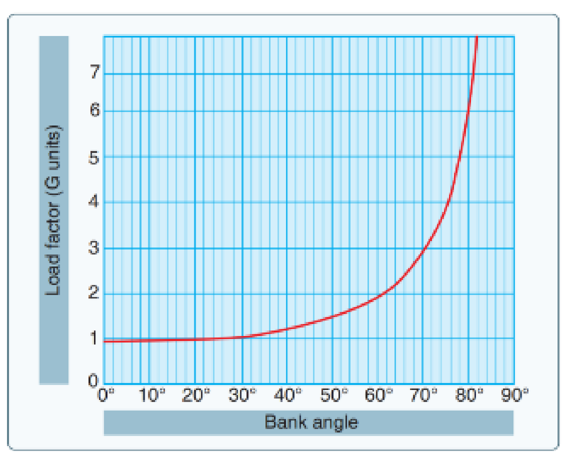
ii. Various design can be used to accomplish this:
   a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
      - Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
      - These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip
   b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than it would otherwise stall



C. What is an Accelerated Stall?
   i. At the same gross weight, configuration, CG location, power setting, and environmental conditions, a given plane will stall at the same indicated airspeed provided the plane is at 1G (steady state unaccelerated flight)
   ii. However, the plane can also stall at a higher indicated airspeed when subject to a load factor > 1G
      a. Ex. Turning, pulling up, or other abrupt changes to the flight path
   iii. Stalls encountered when the G-load, or load factor, exceeds 1G are called Accelerated Stalls

D. Increased Load Factor Increases Stall Speed
   i. Load factor is the ratio of the total load acting on the aircraft to the gross weight of the aircraft
      a. Expressed in terms of Gs
   ii. The stall speed increases in proportion to the square root of the load factor
      a. An aircraft with a stall speed of 50 knots can be stalled at 100 knots by inducing a load factor of 4Gs
   iii. Anything that puts Gs on the aircraft increases the load factor and therefore the stall speed
      a. Pulling out of a steep descent, steep turns, aggressive control inputs, etc.
   iv. Bank Angle and Load Factor
      a. Increased load factors are a characteristic of all turns
      b. Tremendous loads are imposed on an airplane as the bank is increased beyond 45°
         - At a 60° bank, a load factor of 2 Gs is imposed on the airplane structure
         - At approx. 63° of bank the stall speed is increased by approximately ½
      c. Example: Entering a turn, increased back pressure is required to maintain altitude
         - Another way of saying this is that the wings must produce additional lift to maintain altitude (increased load factor)
            a Remember, in a turn the vertical component of lift is split into a horizontal & vertical component





- The additional lift comes from added back pressure which increases AOA
    - a The flight path/relative wind remain the same, while pitch is increased leading to a higher AOA
- If at any time during the turn the AOA becomes excessive, the aircraft will stall

v. Aggressive Pull ups and Load Factor
   a. Recovering too aggressively from a steep descent can quickly and significantly increase load factor, and AOA can quickly exceed critical AOA
   b. Ex. If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate change to the flight path
      - AOA changes abruptly from quite low to very high, but even though the nose has been raised, the aircraft continues its trajectory downward for some amount of time (load factor is increased)
      - Since AOA is suddenly increased while the flight path remains the same, the aircraft can reach the critical AOA at a speed much higher than the published stall speed

C. Hazards of Accelerated Stalls
   i. Significant load factor increases can be imposed when pulling out of steep dives or in steep turns
      a. Can result in structural damage at high airspeeds
      b. Mitigation: Stay at/below V_A & use smooth control inputs to limit G-forces
   ii. Accelerated stalls tend to occur at higher airspeeds and to be more aggressive due to the higher airspeeds
      a. Can catch a pilot off guard
      b. A prolonged accelerated stall may result in a spin or other departure from controlled flight
      c. Mitigation: Understand accelerated stalls, and recognize & recover promptly

2. Stall Characteristics and Impending Stall and Full Stall Indications

A. Stall Characteristics
   i. Most wings are designed to stall progressively outward from root to tip
      a. This is done by designing the wings with *washout* - the wingtips have less angle of incidence (AOI) than the wing roots
         - AOI - Angle between the chord line of the wing and longitudinal axis of the airplane
         - This design allows the tips of the wings to have a lower AOA than the wing roots
      b. This is done so the ailerons are still effective at high AOA's and the plane has more stable stalling characteristics

B. Approach to Stall Indications
   i. A good technique is to announce the Indications as you recognize them
      a. Stall Warning Horn
      b. Reduced Control Effectiveness
      c. Buffet
      d. Stall
      e. Be alert, accelerated stalls can occur more suddenly than the pilot is used to. The approach to stall indications may come very quickly
   ii. Sight
      a. Attitude of the airplane
         - Increasing pitch attitude
         - In an accelerated stall, pitch attitude may not be as noticeable as in a power-on or power-off stall
   iii. Sound
      a. Stall warning horn
   iv. Kinesthesia (The sensing of changes in direction or speed of motion)
      a. Probably the most important and best indicator to the trained pilot
      b. If developed, it will warn of an approaching stall

- There won't be as much mushing or sinking but the excessive back pressure at a relatively high speed and high load factor should be a sign of an impending stall

v. Feel
   a. Due to the relatively high speeds, control pressures won't become less effective like in other stalls
   b. Buffeting, uncontrollable pitching or vibrations just before the stall
   c. Excessive back pressure at relatively high airspeeds and high load factors
      - The resulting force will push the pilot into the seat, increase wing loading, and decrease speed

C. Full Stall Indications
   i. Because of design variations, the stall characteristics for all aircraft can't be specifically described; however, the most notable indications for GA aircraft are the elevator control position and a high descent rate
      a. An aircraft will stall during a coordinated steep turn exactly as it does from straight flight, except that the pitching and rolling actions tend to be more sudden
         - Tend to be more rapid/severe as they occur at higher airspeeds and lower than normal pitch
         - Slipping - Tends to roll rapidly toward the outside of the turn (Outside wing stalls 1^{st})
         - Skidding - Tends to roll rapidly toward the inside of the turn (Inside wing stalls 1^{st})
         - Coordinated - Both wings stall simultaneously, just like straight and level

3. Factors and Situations that can Lead to an Accelerated Stall and Actions that can be taken to Prevent it

A. Improperly executed steep turns, stall and spin recoveries, and pullouts from steep dives
   i. Although often demonstrated in steep turns, an accelerated stall may be encountered any time excessive back pressure is applied and/or AOA is increased rapidly
   ii. Basically, anything that increases G-loading on the aircraft

B. Use smooth control inputs, avoid aggressive control inputs

C. Be aware of stall speeds with excessive G-loads on the aircraft and how G-loads affect the aircraft's ability to fly

4. Fundamentals of Stall Recovery

A. Recovery - Disconnect, Pitch, Roll, Thrust, Stabilize, Configure (perform each step as appropriate)
   i. Disconnect: Autopilot is likely already disconnected
   ii. Pitch: Elevator pressure should be released
      a. Reduce the AOA and eliminate the stall warning
   iii. Roll: Use coordinated aileron and rudder pressures to level the wings
   iv. Thrust: Adjust power as necessary
      a. If a high airspeed already exists, additional power may not be necessary
         - Power may even need to be reduced depending on the airspeed and attitude
      b. If a spin were to develop, power should be taken to idle
   v. Stabilize: Return to the desired flight path
   vi. Configure: Likely no changes applicable, but establish the desired configuration

B. Poor recovery procedures may result in a secondary stall, a spin, or a continuation of the accelerated stall
   i. Release excessive back pressure, add power, and use coordinated control pressures

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Factors and Situations that Could Lead to Inadvertent Accelerated Stall, Spin, and Loss of Control

A. Most frequently, an accelerated stall would occur during improperly executed steep turns, stall and spin recoveries, and pullouts from steep dives
   i. Although often demonstrated in steep turns, an accelerated stall may actually be encountered any time excessive back pressure is applied and/or the angle of attack is increased rapidly

B. Use smooth control inputs, avoid aggressive control inputs
C. Be aware of stall speeds with excessive G-loads on the aircraft and how G-loads affect the aircraft's ability to fly

2. Range and Limitations of Stall Warning Indicators

A. Buffet: Tends to occur prior to the stall horn
   i. May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
B. Stall Horn: Designed to provide warning of an approaching stall and time for stall recovery
   i. Per 23.207
      a. Clear & distinct stall warning with the flaps and gear in any normal position, in straight and turning flight
      b. Warning must begin at least 5 knots above stall speed and continue until the stall occurs
      c. Must provide the pilot time to take action to avert the stall
C. Stall Characteristics
   i. Can vary by aircraft – consider your aircraft
   ii. Generally, nose and/or wing drop, consistent rate of descent, etc.
D. Stall indications and horns have different operational ranges and limitations
   i. Reference the POH for specific information
   ii. Ex: Uncoordinated flight may inhibit airflow at the stall indicator

3. Stall Warning During Normal Operations

A. Recover
B. The first thought is not how and why is this happening, the first reaction is to recover/fix the problem
   i. When safe, then you can figure out how it happened

4. Stall Recovery Procedure

A. Disconnect, Push, Roll, Thrust, Stabilize, Configuration
B. Failure to reduce AOA
   i. Without reducing AOA, the aircraft will remain in a stall and altitude will continue to decrease
      a. Since the basic cause of a stall is always an excessive AOA, the cause must be eliminated
C. Failure to use max power
   i. The primary consequence of not max performing is an increased loss of altitude, or a secondary stall
      a. The stall can be broken by decreasing the AOA, but without power the aircraft will not be able to climb
         - Likely leads to a secondary stall
   ii. Power is essential to regaining airspeed and establishing a climb or at least level flight
D. Failure to use coordinated aileron and rudder to return to straight flight
   i. Stall + Uncoordinated Yaw = Spin. Worst case, an uncoordinated recovery can induce a stall
      a. Maintain coordinated flight during all stall recoveries to prevent spinning the aircraft
   ii. Best case, straight and level flight is regained but at the cost of additional drag due to uncoordinated flight
      a. This leads to decreased performance, likely resulting in additional altitude lost
E. Full Stall
   i. Improper recovery procedures can aggravate the stall and lead to a more stalled condition, creating a more difficult situation to recover from
   ii. Follow the same steps – relax the back pressure enough to break the stall, add full power, and reestablish straight and level flight with coordinated input

5. Secondary Stalls, Cross-Control Stalls, & Spins

A. Secondary Stalls
   i. Occurs after recovery from a preceding stall
      a. Pilot does not sufficiently reduce AOA or attempts to recover using power only
   ii. Perform the stall recovery procedure again
   iii. Prevent secondary stalls with proper recovery procedures (Push, Roll, Thrust, Stabilize)
B. Cross-Controlled Stalls
   i. Aileron and rudder in opposite directions can lead to a cross-controlled stall

   - ii. May have little to no warning of the impending stall - Release the crossed-controls and recover
   - iii. Prevent cross-controlled stalls by maintaining coordination
- C. Spins
   - i. Stall + Yaw (or uncoordinated flight)
      - a. Recover at the first sign of a stall
      - b. Maintain coordination to prevent a spin
   - ii. In the case a spin develops, recover using PARE
      - a. Power idle, Ailerons neutral, Rudder opposite the spin, Elevator forward

6. Effect of Environmental Elements on Aircraft Performance

- A. Turbulence
   - i. Can increase the stall speed
      - a. Sudden changes in relative wind, and/or aggressive control inputs to maintain altitude can lead to exceeding the critical AOA and a stall
      - b. In moderate to severe turbulence or strong crosswinds, use a higher-than-normal approach speed
   - ii. Slow Flight: When flying below minimum drag speed (L/D_{MAX}) the aircraft exhibits speed instability
      - a. If disturbed by turbulence and airspeed decreases, total drag increases, leading to further loss of speed
      - b. Total drag continues to rise, and airspeed continues to fall
- B. Microbursts
   - i. Can induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm
   - ii. At a high AOA/power and slow speed, there is minimal ability to climb, especially in the case of a microburst
      - a. Stalls: Instinct can be to pitch excessively to counter the descent and avoid ground contact
         - In the case of potential ground contact, increase pitch to minimize sink while avoiding a stall
         - Stalling makes the problem far worse than it already is
   - iii. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common
      - a. The best risk mitigation starts with effective planning
   - iv. In the case of a microburst follow the POH procedures
   - v. Aviation Weather Handbook (FAA-H-8083-28)
      - a. Recognizing and avoiding microbursts, and strategies for successful escape
- C. Atmospheric Conditions
   - i. Pressure Altitude: Altitude above the standard 29.92" Hg plane ($1{,}000(29.92 - \text{Altimeter}) + \text{Elev}$)
      - a. Higher Pressure (lower pressure altitude): Better engine performance (more combustion)
      - b. Lower Pressure (higher pressure altitude): Poorer performance
   - ii. Density Altitude: Pressure altitude corrected for nonstandard temperature
      - a. $120(°\text{C} - 15°\text{C}) + \text{PA}$ (approximation)
      - b. Lower temperatures (the air is more compressed): Improves performance
      - c. Higher temperatures (the air is less compressed): Degrades performance
   - iii. Humidity: Although not directly accounted for on the performance charts, humidity decreases performance

7. Collision Hazards

- A. Per the ACS: Complete no lower than 3,000' AGL
- B. Minimum Altitudes for Stalls
   - i. Single Engine Aircraft
      - a. Recommended that stalls are practiced at an altitude allowing recovery no lower than 1,500' AGL
      - b. An average spin rotation in a single engine aircraft loses about 500' of altitude. This altitude allows for recovery from a spin within two turns + 500' (3 full rotations before reaching the ground)
   - ii. Multi Engine Aircraft
      - a. Recommended that stalls are practiced at an altitude allowing recovery no lower than 3,000' AGL
      - b. An average spin rotation in a multi engine aircraft loses about 1,000' of altitude. This altitude allows for recovery from a spin within two turns + 1,000' (3 full rotations before reaching the ground)

C. Collision Avoidance
    i. Clearing Procedures
        a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
        b. Prior to any turn: Clear in the direction of the turn
        c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind
    ii. Scanning
        a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
            - Each movement should not exceed 10º, each area should be observed for at least one second
        b. Divide attention between flying and scanning for aircraft
    iii. Operation Lights On
        a. Voluntary FAA safety program
        b. Turn on landing lights during takeoff and when operating below 10,000', day or night
    iv. Right-of-Way Rules (FAR 91.113)
        a. An aircraft in distress has the right-of-way over all other traffic
        b. Converging Aircraft
            - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
            - If the aircraft are different categories:
                a Basically, the less maneuverable aircraft has the right-of-way
                    1. Balloons, gliders, and airships have the right of way over airplanes
                b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
        c. Approaching Head-on: Each pilot shall alter course to the right
        d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
        e. Landing
            - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
                a Do not take advantage of this rule to force an aircraft off the runway which has already landed
            - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
                a Don't take advantage of this rule to cut in front of another aircraft

D. Terrain
    i. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
    ii. Day vs Night flying over terrain
        a. Be extra vigilant at night, when terrain may be impossible to see until it is too late

E. Obstacles and Wire Strike
    i. Antenna Towers
        a. Numerous antennas extend over 1,000'-2,000' AGL
            - Most are supported by guy wires which can extend 1,500' horizontally from the structure
    ii. Overhead Wires (may not be lighted)
        a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
            - Lakes, highways, railroad tracks, etc.

F. Minimum Safe Altitudes (FAR 91.119)
    i. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
    ii. Over Congested Areas: 1,000' above the highest obstacle within 2,000'

G. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

8. Distractions, Task Prioritization, SA & Disorientation

A. Distractions
    i. They're dangerous
        a. Remove distractions from view or, if a person, explain the situation and ask them to stop

   - ii. Focus on performance & clear for traffic
      - a. If distracted, recognize the problem, and fix it
   - iii. Sterile cockpit
   - iv. Fly first! Aviate, Navigate, Communicate
- B. Situational awareness (SA) & Disorientation
   - i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
   - ii. Maintain SA
      - a. Starts with preflight planning
      - b. Know what's coming next and stay ahead of the airplane
      - c. Divide attention between inside and outside references
      - d. If SA is lost, admit it and fix the problem
   - iii. Disorientation can be caused by, or lead to, an upset
      - a. Push: Apply forward pressure to unload the plane
      - b. Roll: Roll aggressively to the nearest horizon
      - c. Thrust: Adjust as required
      - d. Stabilize: Return to a safe flight condition
   - iv. Lack of Visual References
      - a. Trust the instruments
      - b. For more details, see II.B. Visual Scanning & Collision Avoidance and II.M. Night Operations
- C. Task Prioritization
   - i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
   - ii. Understand what tasks need to be accomplished and when
   - iii. Recognize when you are getting behind and find a way to catch up
   - iv. Proper task management can help prevent distractions, loss of SA, and disorientation
   - v. Safety is the number one priority – Aviate, Navigate, Communicate

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Select an entry altitude that will allow the task to be completed no lower than 3,000' AGL.
3. Establish the configuration as specified by the evaluator.
4. Set power appropriate for the configuration, such that the airspeed does not exceed V_A or any other applicable POH/AFM limitation.
5. Establish and maintain a coordinated turn in a 45° bank, increasing elevator back pressure smoothly and firmly until an impending stall is reached.
6. Acknowledge the cues at the first indication of a stall (e.g., aircraft buffet, stall horn, etc.).
7. Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
8. Configure the airplane as recommended by the manufacturer and accelerate to V_X or V_Y.
9. Return to the altitude, heading, and airspeed specified by the evaluator.