I.F. PERFORMANCE & LIMITATIONS

References: Weight and Balance Handbook, Airplane Flying Handbook, Pilot's Handbook of Aeronautical Knowledge , Risk Management Handbook, POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Preflight Action Requirements** (this is not part of the ACS, but it is applicable and important to this section)
   - A. FAR 91.103: Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include:
     - i. For a flight under IFR or a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternatives available if the planned flight cannot be completed, and any known traffic delays of which the pilot in command has been advised by ATC;
     - ii. For any flight, runway lengths at airports of intended use, and the following takeoff and landing distance information:
       - a. For civil aircraft for which an approved Airplane or Rotorcraft Flight Manual containing takeoff and landing distance data is required, the takeoff and landing distance data contained therein
2. **Performance and Limitations Charts**
   - A. Airplane performance is found in Section 5 of the POH (Performance and Limitations)
     - i. Supplement 4, for the DA20 (any charts not shown in the supplement are found in Chapter 5)
   - B. Using the performance charts, and the accompanying instructions, we can calculate
     - i. Cruise Performance
     - ii. Stall Speeds based on airplane configuration
     - iii. Wind Components (Crosswind and Headwind)
     - iv. Takeoff Distance and Landing Distance
     - v. Climb Performance (In cruise and takeoff configurations as well as Balked Landing)
     - vi. True Airspeed
     - vii. Maximum Flight Duration (Pressure Altitude is combined with RPM to find % bhp, KTAS, GPH)
   - C. To make use of these charts we need to know the Pressure Altitude (PA)
     - i. Pressure Altitude – The altitude indicated when the altimeter setting window is set to 29.92
       - a. PA = 1,000(29.92-Current Altimeter Setting) + Elevation
         - EX: Altimeter = 30.42 and Elevation = 808, so PA = 308'
         - EX: Altimeter = 29.84 and Elevation = 808, so PA = 888'
     - ii. From Pressure Altitude we can compute Density Altitude (DA)
       - a. DA: Pressure Altitude corrected for non-standard temperature (Directly related to performance)
       - b. DA = 120(Current Temperature-15°C) + PA
         - EX: Temp = 23°C and PA = 308', so DA = 1,268'
         - EX: Temp = 03°C and PA = 308', so DA = -1,132
         - This is a good estimate of DA, the equation is not perfect
   - D. Using the Charts (This is tailored to the Diamond 20 Performance Charts)
     - i. Using the Pressure Altitude, start at the temperature at the bottom of the chart and move up to the PA
       - a. From there, move straight across until reaching the next stage of the chart
         - Once you reach the next step, mirror the trend line, and move straight across to the next stage
     - ii. This is done until we reach the performance number
   - E. How the Charts Work
     - i. The charts account for the various factors that affect the performance criteria you're trying to obtain

        a. Ex: On takeoff, the chart requires temperature, pressure altitude, weight, wind (head or tailwind), etc.
    ii. The charts also represent how each factor affects the performance criteria
        a. Ex: For takeoff, a headwind will decrease runway required, and a tailwind will increase runway required

3. Factors Affecting Performance

A. Atmospheric Conditions
    i. Atmospheric Pressure
        a. Under standard conditions at sea level, the average pressure is approx. 14.7 lbs. per sq. in
        b. Since air is a gas, it can be compressed or expanded
        c. Air density effects performance: As density increases, performance increases and vice versa
    ii. What Changes Air Density (DA)?
        a. Barometric Pressure, Temperature, Altitude, and Humidity
            - Density varies directly with pressure - As pressure increases, density increases and vice versa
            - Density varies inversely with temperature – As temp increases, density decreases and vice versa
            - Density varies inversely with altitude - As altitude increases, density decreases and vice versa
            - Density varies inversely with humidity – As humidity increases, density decreases and vice versa
    iii. How it affects Performance
        a. As the air becomes less dense, it reduces:
            - Power, since the engine takes in less air
            - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
            - Lift, because the thin air exerts less force on the airfoils

B. Pilot Technique
    i. Different techniques can change aircraft performance
        a. Ex: Climbing at speeds other than those published in the POH
            - This negates any climb performance data you may have calculated from the charts
    ii. A simple way to fix this is to fly by the book

C. Aircraft Configuration
    i. The configuration of the aircraft can have a large effect on performance
        a. Gear, whether retracted or extended, can significantly influence drag
        b. Flaps increase lift but also increase drag. Different flap settings may have larger effects on lift and/or drag influencing the aircraft's performance
        c. Use the charts and information in the POH to determine the aircraft's performance capabilities in various configurations

D. Airport Environment
    i. Different airport environments can affect the performance of the aircraft in various ways
        a. Inclined or declined runways can adjust takeoff and landing distance
        b. Hills, mountains, trees, buildings, etc. can affect wind patterns creating changing winds and at times up or down drafts
        c. High altitude airports greatly decrease performance
            - Also, at high altitudes, true airspeed is increased. Even though you're flying an approach at a normal indicated airspeed, you are moving much faster than you would be at sea level. This greatly affects landing distances

E. Loading
    i. Weight and Flight Performance
        a. A heavier gross weight will result in:
            - Higher takeoff speed, longer takeoff run, reduced rate and angle of climb, lower maximum altitude, shorter range, reduced cruise speed, reduced maneuverability, higher stall speed, higher approach and landing, longer landing roll, excessive weight on the nose or tail wheel

- Climb and cruise performance is reduced which can lead to:
  - a Overheating in climbs, added wear on engine, and increased fuel use

ii. Weight and Structure
  a. Structural failures which result from overloading may be catastrophic, but they often affect structure progressively making it difficult to detect or repair
  b. An airplane is certified to withstand certain loads on its structure based on the category
    - If gross weight and load factors limits are observed, the total load will remain in limits
    - If the max gross weight is exceeded, load factors within the load factor limits can cause damage
  c. The results of routine overloading are cumulative and may result in failure later during normal ops

F. Weight and Balance
  i. A stable and controllable plane may have very different characteristics when overloaded
    a. Weight distribution has the most effect, but gross weight also adversely affects stability
  ii. An airplane with forward loading
    a. The aircraft acts heavier than it is, and consequently slower than the same airplane with a further aft center of gravity
      - Nose up trim is needed which requires the tail surfaces to produce a greater down force. This adds to the wing loading, increasing the total lift required from the wings
    b. Requires a higher angle of attack, which results in more drag and, in turn, produces a higher stalling speed
    c. The airplane is more controllable (the longer arm from the CG makes the elevator more effective)
  iii. An airplane with aft loading
    a. With aft loading, the aircraft acts lighter than it is
    b. The aircraft requires less nose down force allowing for a faster cruise speed
      - Faster cruise because of reduced drag (smaller AOA and less down deflection of stabilizer)
      - The tail surface is producing less down force, relieving the wing of loading and lift which results in a lower stall speed
        - a Although the stall speed is lower, recovery from a stall becomes progressively more difficult as the CG moves aft
  iv. The CG and the Lateral Axis
    a. Unbalanced lateral loading (more weight on the right or left side of the aircraft centerline) may result in adverse effects
      - This can be caused by fuel imbalance, people, baggage, etc.
    b. Compensate for any imbalance with trim (if available), or constant control pressure
      - This places the aircraft in an out-of-streamline condition, increasing drag, and decreasing efficiency
  v. Weight and Controllability
    a. Generally, an airplane becomes less controllable as the CG moves aft
      - The elevator has a shorter arm and requires greater deflection for the same result
      - Stall recovery is more difficult because the plane's tendency to pitch down is reduced
        - a If the CG moves beyond the aft limit, stall and spin recovery may become impossible
    b. As the CG moves forward, the airplane becomes more nose-heavy
      - Although the aircraft is more controllable, since the arm between the CG and elevator is larger, the aircraft may become so nose heavy that the elevator may not be able to hold up the nose, particularly at low airspeeds (takeoff, landing, glides)
        - a On landing the elevator may not be able to produce sufficient force to lift the nose wheel during the flare, in extreme cases a safe landing could be impossible

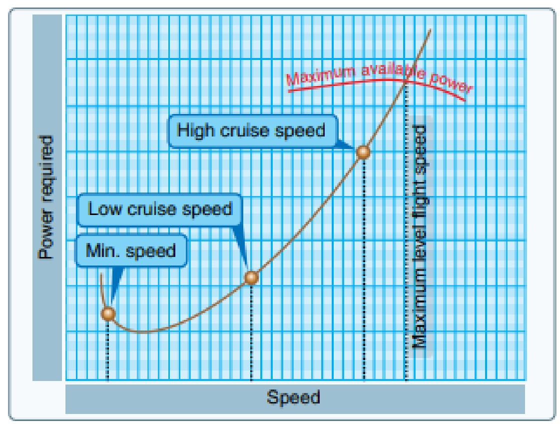
G. Effects of Weight and Balance over the course of the Flight
  i. During the flight the weight and balance of the aircraft will change based on any weight that is moved or lost

a. The most common example is the en route fuel burn
- As fuel is burned, weight is lost in the fuel tanks and the center of gravity will change
  - a Whether it moves forward or backward depends on the location of the fuel tanks
- To compensate for the changing fuel, calculate the center of gravity at the fuel level for departure, and calculate the center of gravity with empty tanks
  - a If the center of gravity stays within limits throughout the transition from full (or departure level) tanks to empty tanks, there will be no center of gravity problem en route

b. If for any reason the weight or balance will change en route (EX: passengers, baggage, fuel etc.) ensure the center of gravity remains within limits to preclude a potential loading emergency in flight

4. Aerodynamics

A. Straight-and-Level
- i. To maintain straight-and-level, lift must equal weight and thrust must equal drag
- ii. Parasitic drag dominates at high speed, induced drag at low speed (pictured, top right)
- iii. Max level flight speed is obtained when power required equals max power/thrust available (lower right picture)
- iv. Min level flight speed is not defined by thrust/power requirements since stall occurs first (lower right picture)



B. Climb Performance
- i. Kinetic Energy (KE): Energy of speed
  - a. Directly proportional to the square of airspeed
  - b. $KE = \frac{1}{2} \times m \times v^2$
    - m = mass, v = velocity
- ii. Potential Energy (PE): Stored energy, Altitude
  - a. Directly proportional to the altitude
  - b. $PE = m \times g \times h$
    - m = mass, g = gravity, h = height
- iii. Power & Thrust
  - a. Thrust: Force or pressure exerted on an object (pounds or newtons)
  - b. Power: Measurement of the rate of performing work or transferring energy (horsepower or kilowatts)
    - The motion (KE and PE) a force (thrust) creates when exerted on an object over a period of time
- iv. Positive climb performance occurs when an aircraft gains PE by increasing altitude
  - a. Two factors contribute to gaining altitude:
    - Factor One: Aircraft uses excess power above what's required to maintain level flight
    - Factor Two: Aircraft converts airspeed (KE) to altitude (PE)

C. Angle of Climb (AOC)
- i. Comparison of altitude gained relative to distance traveled
  - a. V_X is used for max AOC performance
- ii. Max AOC occurs at the airspeed and AOA combination resulting in maximum excess *thrust*
  - a. This combination differs amongst aircraft types
    - Jet: Approximately L/D_{MAX}
    - Propeller Plane: Below L/D_{MAX} and just above stall speed

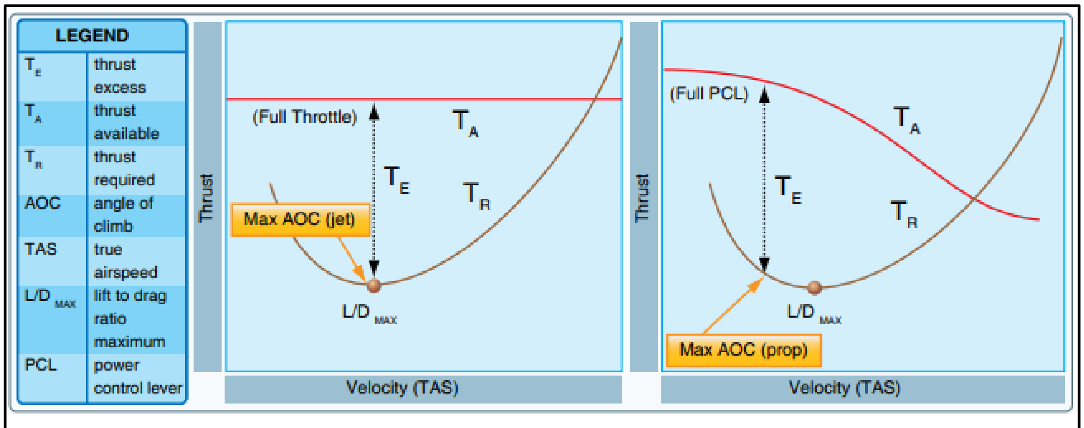


Figure 11-8. *Comparison of maximum AOC between jet and propeller airplanes.*

D. Rate of Climb (ROC)
   a. Comparison of altitude gained relative to the time needed to reach that altitude (V_Y)
ii. Max ROC occurs at the airspeed and AOA combination resulting in maximum excess *power*
   a. Combination differs amongst aircraft types
      - Jet: Airspeed > L/D_{MAX} and AOA < L/D_{MAX} AOA
      - Propeller Plane: Airspeed and AOA combination close to L/D_{MAX}

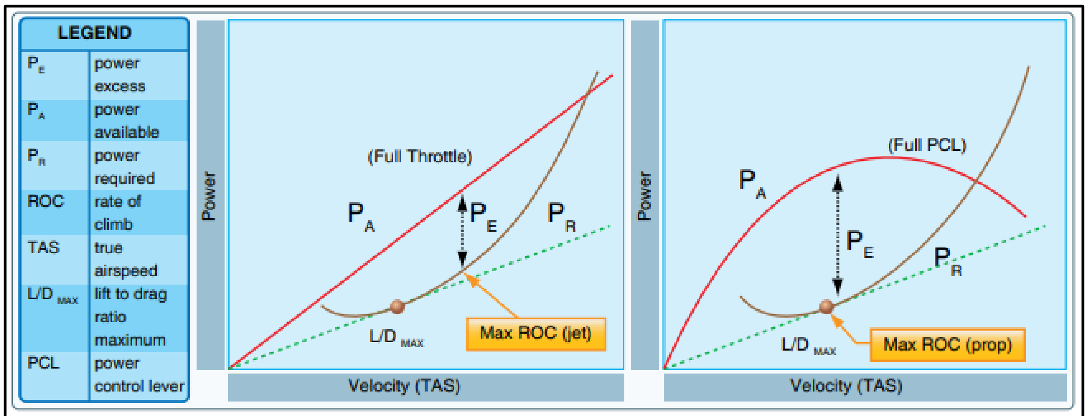


Figure 11-9. *Comparison of maximum ROC between jet and propeller airplanes.*

E. Climb Performance Factors
i. Weight, altitude, and configuration affect excess thrust & power and therefore climb performance
   a. Increased weight/altitude and lowering the flaps/gear decrease excess thrust & power
ii. Weight
   a. Added weight means the aircraft must fly at a higher AOA to maintain a given altitude & speed
      - Increases drag requiring additional thrust
      - Additional thrust = less reserve thrust to climb
iii. Altitude (pictured, right)
   a. Climb performance diminishes with altitude
      - Increases power required & decreases power available
   b. As altitudes increases, max AOC/ROC & min/max level flight speeds converge at the absolute ceiling
      - At the absolute ceiling, there is no excess power and

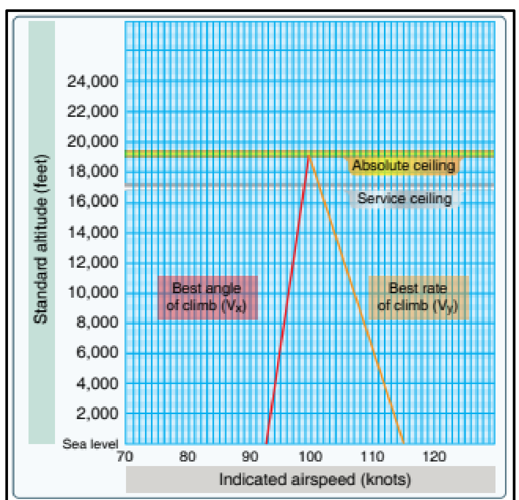
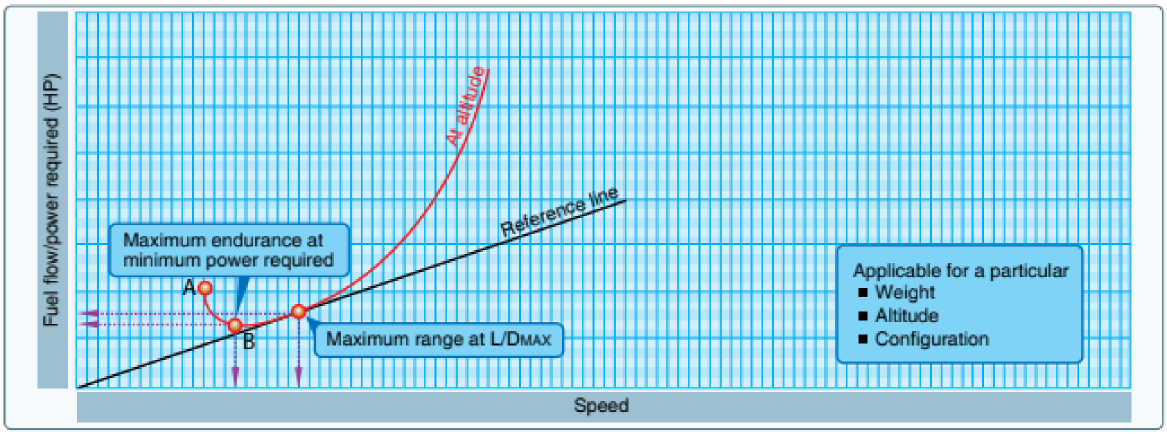


Figure 11-10. *Absolute and service ceiling.*

only one speed allows level flight

F. Range Performance



i. The ability to convert fuel into flying distance
ii. Range versus Endurance
   a. Range involves the consideration of flying distance
   b. Endurance involves the consideration of flying time
iii. Maximum Endurance (Time)
   a. If max endurance is desired, the flight condition must provide minimum fuel flow (point B in the chart)
   b. Point A (low speed, high fuel flow) is takeoff and climb
   c. As airspeed increases, power and fuel requirements decrease due to aerodynamic factors up to Point B
   d. Beyond Point B, you must pay to go faster (more airspeed requires more power at the cost of fuel)
iv. Maximum Range
   a. Costs aside, max range is the flight condition providing max NM per pound of fuel (or specific range)
      - Specific Range = NM / pounds of fuel
         - a Ex: Specific range of 1.89 means for every pound of fuel, the aircraft could fly 1.89 miles
   b. Obtained at L/D_{MAX} and varies with gross weight, altitude, and configuration
      - As fuel is burned, gross weight changes, and therefore optimum altitude, airspeed, & power changes
      - L/D_{MAX} occurs at a specific AOA & lift coefficient, irrespective of weight
         - a Changes in weight alter the specific airspeed and power required to attain L/D_{MAX}
      - To maintain maximum range, optimum conditions must be maintained
   c. Headwinds & Tailwinds
      - Theories say that speeding up in a headwind & slowing in a tailwind helps achieve max range
      - May be true in many cases, but there are many variables to every situation – no catch all rule
   d. Reciprocating engine aircraft experience little, if any, variation in specific range up to absolute altitude

RISK MANAGEMENT

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

1. Use Performance Charts, Tables, and Data

A. Ensure you understand how to properly use the performance charts
   i. Improperly used, they're worthless and dangerous - the pilot has no real grasp on the aircraft's performance abilities based on the conditions

2. Airplane Limitations

A. Understand the limitations of the aircraft and do not exceed them
B. It's a great idea to consistently review the aircraft limitations

        i. Not only to ensure you don't exceed them, but also so that you're aware if they are exceeded and can take the proper action
    C. Weight and Balance
        i. Always calculate any expected changes in weight and balance en route while on the ground
            a. Always find the center of gravity at takeoff and with empty tanks to ensure the center of gravity will not ever be out of limits
            b. Understand how the aircraft performance will change as the center of gravity moves
            c. An out of balance center of gravity is never something to mess around with – don't exceed limitations

3. Possible Differences between Calculated Performance and Actual Performance
    A. Use the performance charts and relate them to the airport information (runway lengths, climb rates vs obstacles in the area, etc.)
        i. The charts will provide performance for all phases of flight
        ii. Remember, the charts don't make an allowance for pilot proficiency or mechanical deterioration
            a. Does the airplane have problems that may limit performance?
    B. There is always the possibility of changing weather resulting in useless original calculations
        i. Just because the plane will perform well now doesn't mean it will perform well later
        ii. Plan ahead and be aware that as conditions change so does the aircraft performance. Stop and reassess the aircraft capabilities if necessary.

SKILLS

The applicant demonstrates the ability to:

1. Compute the weight and balance, correct out-of-center of gravity (CG) loading errors and determine if the weight and balance remains within limits during all phases of flight.
2. Demonstrate use of the appropriate aircraft manufacturer's approved performance charts, tables and data.