III.D. Performance and Limitations

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to airplane performance and limitations as required in the necessary ACS/PTS.
Key Elements	1. Density 2. Density Altitude 3. Airplane Performance
Elements	1. Determining Weight and Balance 2. Atmospheric Conditions and Performance 3. Performance Charts 4. Determining the Required Performance is Attainable 5. Exceeding Airplane Limitations
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 student has the ability to calculate the airplane's performance based on the current or expected conditions of a flight and decide whether or not the performance will suffice.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

How exciting would it be to find out first hand, that the airplane actually doesn't have the ability to takeoff from a certain runway and that it also doesn't have the ability to clear the obstacle at the departure end?

Overview

Review Objectives and Elements/Key ideas

What

The Performance and Limitations section of the POH contains the operating data for the airplane; that is, the data pertaining to takeoff, climb, range, endurance, descent, and landing.

Why

The use of the operating data for the airplane is mandatory for safe and efficient operations

How:

1. **Determining Weight and Balance**
   - A. CG = Total Moment divided by Total Weight
     - i. Begin with the empty weight and make a list of everything that will be loaded in the airplane
       - a. People, items, fuel, etc. (note the weights of everything as well)
       - b. Be sure the weight of what you want to load is within the maximum weight limits
         - If the total weight is too high, remove items/people to get within weight limits
     - ii. Calculate the Moments of each item
       - a. To find the moments, use the graph or multiply the weight by the arm with the information in the POH
         - The weight/moment of the airplane are found in the weight and balance documents
     - iii. Then calculate the CG – (Total Moment/Total Weight)
       - a. *For the DA20, compare the Total Weight and Total Moment on the graph in supplement 4
     - iv. Use the chart in Supplement 4 to determine whether the airplane is within limits
2. **Atmospheric Conditions and Performance**
   - A. Atmospheric Pressure
     - i. Though air is light, it has mass and is affected by gravity and therefore it has a force
     - ii. Under standard conditions at sea level, the average pressure exerted is approx. 14.7 lbs. per sq. in
     - iii. Since air is a gas, it can be compressed or expanded
     - iv. Density of the air has significant effects on the airplane's performance
       - a. As the density of the air increases, airplane performance increases and vice versa
   - B. What Changes Air Density (DA)?
     - i. Barometric Pressure, Temperature, Altitude, and Humidity all affect air density
       - a. Density varies directly with pressure - As pressure increases, density increases and vice versa

b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
- More specifically: For a given volume of atmospheric air, as humidity increases some of the dry air is replaced by water vapor
  a The molecular weight of dry air is approximately 29 grams/mol, while the molecular weight of water vapor (H_20) is about 18 grams/mol
    1. Grams/mol = Molar mass
  b As the proportion of water in the atmosphere (humidity) increases, the density (weight / volume) of the particular volume of air decreases

C. How it affects Performance
  i. As the air becomes less dense, it reduces:
    a. Power, since the engine takes in less air
    b. Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
    c. Lift, because the thin air exerts less force on the airfoils
D. High altitude, high temperature airports may not allow safe operation
  i. Always be aware of the density altitude and accompanying performance when planning a flight
  ii. If necessary, delay until the performance is attainable, or reduce weight to attain the performance

3. Performance 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 (Chart in which the Pressure Altitude is combined with RPM to find % bhp, KTAS, GPH)
C. In order to make use of these charts we need to know the Pressure Altitude (PA)
  i. Pressure Altitude (PA) – 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: PA corrected for non-standard temperature (Directly related to airplane performance)
    b. DA = 120(Current Temperature-15^{o}C) + PA
      - EX: Temp = 23^{o}C and PA = 308’, so DA = 1,268’

- EX: Temp = 03°C and PA = 308', so DA = -1,132
- This is a very good estimate of DA, the equation is not perfect

D. *Once we have PA, we can start at the temperature at the bottom of the chart and move up to the PA
   i. From there, we move straight across until we reach the next stage of the chart
      a. Once we reach the next step, follow the trend line and then move straight across
E. This is done until we reach the performance number

4. Determining the Required Performance is Attainable

A. Use the performance charts and relate them to the airport information (runway lengths, etc.)
   i. The charts will provide performance for all phases of flight
   ii. But, remember, the charts don't make 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

5. Exceeding Airplane Limitations

A. Operating Limitations are in Chapter 2 of the POH
   i. The limits here establish the boundaries in which the airplane can be safely operated
   ii. Adverse Effects
      a. Attempting to takeoff or land without enough runway
         - Can result in a crash into an obstacle or over-running the runway also damaging the plane
      b. Attempting to clear an obstacle that the airplane performance will not allow at a certain weight
         - Can result in crashing into the obstacle
      c. Not having enough fuel to reach the airport of intended landing
         - Can result in an emergency landing, or ditching
      d. Using the wrong type of fuel
         - Can result in detonation, causing significant damage to the engine, as well as engine failure
      e. Exceeding the structural/aerodynamic limits (overweight or outside CG limits)
         - Can result in airplane damage or structural failure
         - Airplane control may be hampered and stall speeds may be affected
      f. Exceeding the maximum crosswind component (20 knots)
         - This will greatly increase the difficulty of the landing, possibly resulting in a crash
         - The airplane may not have the ability to stay aligned with the runway, resulting in a crash or departing the landing surface

Conclusion:

Brief review of the main points

It is very important that before every flight, the pilot ensures the airplane can produce the required performance depending on the airport and atmospheric conditions.

PTS Requirements:

To determine that the applicant exhibits instructional knowledge of the elements related to performance and limitations by describing:

1. Determination of weight and balance condition.
2. Use of performance charts, tables, and other data in determining performance in various phases of flight.
3. Effects of exceeding airplane limitations.
4. Effects of atmospheric conditions on performance.
5. Factors to be considered in determining that the required performance is within the airplane's capabilities.