AIRPLANE PERFORMANCE (chapter 4)

DENSITY ALTITUDE

1. Density altitude is a measurement of the density of the air expressed in terms of altitude.

    a. Air density varies inversely with altitude; i.e., air is very dense at low altitudes and less dense at high altitudes.

    b. Temperature, humidity, and barometric pressure also affect air density.

        1) A scale of air density to altitude has been established using a standard temperature and pressure for each altitude. At sea level, standard is 15°C and 29.92" Hg.

        2) When temperature and pressure are not at standard (which is almost always), density altitude will not be the same as true altitude.

2. You are required to know how barometric pressure, temperature, and humidity affect density altitude. Visualize the following:

    a. As barometric pressure increases, the air becomes more compressed and compact. This is an increase in density. Air density is higher if the pressure is high, so the density altitude is said to be lower.

        1) Density altitude is increased by a decrease in pressure.

        2) Density altitude is decreased by an increase in pressure.

    b. As temperature increases, the air expands and therefore becomes less dense. This decrease in density means a higher density altitude. Remember, air is normally less dense at higher altitudes.

        1) Density altitude is increased by an increase in temperature.

        2) Density altitude is decreased by a decrease in temperature.

    c. As relative humidity increases, the air becomes less dense. A given volume of moist ~ air weighs less than the same volume of dry air. This decrease in density means a higher density altitude.

        1) Density altitude is increased by an increase in humidity.

        2) Density altitude is decreased by a decrease in humidity.

3. Said another way, density altitude varies directly with temperature and humidity, and inversely with barometric pressure:

    a. Cold, dry air and higher barometric pressure = low density altitude.

    b. Hot, humid air and lower barometric pressure = high density altitude.

4. Pressure altitude is based on standard temperature. Therefore, density altitude will exceed pressure altitude if the temperature is above standard.

5. The primary reason for computing density altitude is to determine airplane performance.

   a. High density altitude reduces an airplane's overall performance.

   b. For example, climb performance is less and takeoff distance is longer.

   c. Propellers have less efficiency because there is less air for the propeller to get a grip on.

   d. However, the same indicated airspeed is used for takeoffs and landings regardless of altitude or air density because the airspeed indicator is also directly affected by air density.

DENSITY ALTITUDE COMPUTATIONS

1. Density altitude is determined most easily by finding the pressure altitude (indicated altitude when your altimeter is set to 29.92) and adjusting for the temperature.

   a. The adjustment may be made using your flight computer or a density altitude chart. This part of the FM test requires you to use a density altitude chart.

2. When using a density altitude chart (see Figure 8 Appendix 1),

   a. Adjust the airport elevation to pressure altitude by adding or subtracting the conversion factor for the current altimeter setting.

   b. To adjust the pressure altitude for nonstandard temperature, plot the intersection of the actual air temperature (listed on the horizontal axis of the chart) with the pressure altitude lines that slope diagonally upward. Move left horizontally from the intersection to read density altitude on the vertical axis of the chart.

   c. EXAMPLE: Outside air temperature 90°F Altimeter setting 30.20" Hg Airport elevation 4,725 ft.

Referring to Figure 8 Appendix 1, you determine the density altitude to be approximately 7,400 ft. This is found as follows:

1) The altimeter setting of 30.20 requires a -257 altitude correction factor.

2) Subtract 257 from field elevation of 4,725 ft. to obtain pressure altitude of 4,468 ft.

3) Locate 90°F on the bottom axis of the chart and move up to intersect the diagonal pressure altitude line of 4,468 ft.

4) Move horizontally to the left axis of the chart to obtain the density altitude of about 7,400 ft.

5) Note that while true altitude (i.e., airport elevation) is 4, 725 ft., density altitude is about 7,400 ft.

6) Finally, note that you may determine the effects of temperature changes on density altitude simply by following the above chart procedure and substituting different temperatures.

TAKEOFF DISTANCE

1. Conditions that reduce airplane takeoff and climb performance are

   a. High altitude

   b. High temperature

   c. High humidity

2. Takeoff distance performance is displayed in the airplane operating manual either

   a. In chart form or
   b. On a graph

3. If a graph, it is usually presented in terms of density altitude. Thus, one must first adjust the airport elevation for nonstandard pressure and temperature.

   a. In the graph used on this exam (see Figure 41 Appendix 1), the first section on the left uses outside air temperature and pressure altitude to obtain density altitude.

      1) The curved line on the left portion is standard atmosphere, which you use when the question calls for standard temperature.

   b. The second section of the graph, to the right of the first reference line, takes the weight in pounds into account.

   c. The third section of the graph, to the right of the second reference line, takes the headwind or tailwind into account.

   d. The fourth section of the graph, at the right margin, takes obstacles into account.

   e. EXAMPLE: Given an outside air temperature of 15°C~ a pressure altitude of 5,650 ft., a takeoff weight of 2,950 Ib., and a headwind component of 9 kt., find the ground roll and the total takeoff distance over a 50-ft. obstacle. Use Figure 41 on page 156.

   f. The solution to the example problem is marked with the dotted arrows on the graph. " Move straight up from 15°C (which is also where the standard temperature line begins) to the pressure altitude of 5,650 ft. and then horizontally to the right to the first reference line. It is not necessary to adjust for weight because the airplane is at maximum weight of 2,950 Ib. Continuing to the next reference line, the headwind component of 9 kt. means an adjustment downward in the wind component section (parallel to the guidelines). Finally, moving straight to the right gives the ground roll of 1,375 ft. The total takeoff distance over a 50-ft. obstacle, following parallel to the guideline up and to the right, is 2,300 ft.

CRUISE POWER SETTINGS

1. Cruise power settings are found by use of a table (see Figure 36 Appendix 1) .

   a. It is based on 65% power.

   b. It consists of three sections to adjust for varying temperatures:

      1) Standard temperature (in middle)
      2) ISA -20°C (on left)
      3) ISA +20°C (on right)

c. Values found on the table based on various pressure altitudes and temperatures include

1) Engine RPM

2) Manifold pressure (in. Hg)

3) Fuel flow in gal. per hr. (with the expected fuel pressure gauge indication in pounds per square inch)

4) True airspeed (kt. and MPH)

2. The FAA test questions gauge your ability to find values on the chart and interpolate between lines (see Figure 36 Appendix 1).

a. EXAMPLE: A value for 9,500 ft. would be 75% of the distance between the number for 8,000 ft. and the number for 10,000 ft.

b. EXAMPLE: At a pressure altitude of 6,000 ft. and a temperature of 26°C and with no wind, a 1,000-NM trip would take 71.42 gal. of fuel (1,000 + 161 kt. = 6.21 hr.) (6.21 hr. x 11.5 gph = 71.42 gal.).

CROSSWIND COMPONENTS

1. Airplanes have a limit to the amount of direct crosswind in which they can land. When the wind is not directly across the runway (i.e., quartering), a crosswind component chart may be used to determine the amount of direct crosswind. Variables on the crosswind component charts are

a. Angle between wind and runway
b. Wind velocity

NOTE: The coordinates on the vertical and horizontal axes of the graph will indicate the headwind and crosswind components of a quartering wind.

2. Refer to the crosswind component graph, which is Figure 37 Appendix 1.

a. Note the example on the chart of a 40-kt. wind at a 30° angle.

b. Find the 30° wind angle line. This is the angle between the wind direction and runway direction, e.g., runway 18 and wind from 210°.

c. Find the 40-kt. wind velocity arc. Note the intersection of the wind arc and the 30° angle line.

1) Drop straight down to determine the crosswind component of 20 kt.; i.e., landing in this situation would be like having a direct crosswind of 20 kt.

2) Move horizontally to the left to determine the headwind component of 35 kt.; i.e., landing in this situation would be like having a headwind of 35 kt.

3) EXAMPLE: You have been given 20 kt. as the maximum crosswind component for the airplane, and the angle between the runway and the wind is 30°. What is the maximum wind velocity without exceeding the 20-kt. crosswind component? Find where the 20-kt. crosswind line from the bottom of the chart crosses the 30° angle line, and note that it intersects the 40-kt. wind velocity line. This means you can land an airplane with a 20-kt. maximum crosswind component in a 40-kt. wind from a 30° angle to the runway.

LANDING DISTANCE

1. Required landing distances differ at various altitudes and temperatures due to changes in air density.

    a. However, indicated airspeed for landing is the same at all altitudes.

2. Landing distance information is given in airplane operating manuals in chart or graph form to adjust for headwind, temperature, and dry grass runways.

3. It is imperative that you distinguish between distances for clearing a 50-ft. obstacle and distances without a 50-ft. obstacle at the beginning of the runway (the latter is described as the ground roll).

4. See Figure 38 Appendix 1 for an example landing distance graph. It is used in the same manner as the takeoff distance graph discussed previously in figure 41 Appendix 1.

5. Refer to Figure 39 Appendix 1, which is a landing distance table.

    a. It has been computed for landing with no wind, at standard temperature, and at pressure altitude.

    b. The bottom "notes" tell you how to adjust for wind, nonstandard temperature, and a grass runway.

        1) Note 1 says to decrease the distance for a headwind. Note that tailwind hurts much more than headwind helps, so you cannot use the headwind formula in reverse.

    c. EXAMPLE: Given standard air temperature, 8-kt. headwind, and pressure altitude of 2,500 ft., find both the ground roll and the landing distance to clear a 50-ft. obstacle.

        1) On the table (Figure 39) for 2,500 ft., at standard temperature with no wind, the ground roll is 470 ft. and the distance to clear a 50-ft. obstacle is 1,135 ft.

These amounts must be decreased by 20% because of the headwind (8 kt./4 x 10% = 20%). Therefore, the ground roll is 376 ft. (470 x 80%) and the distance to clear a 50-ft. obstacle is 908 ft. (1, 135 x 80%).