Unit 5 Airplane Performance and Weight and Balance

5.0 Using charts and graphs

- Understand clearly what is required (landing roll distance, weight, etc)
- Analyze the chart or graph to determine the variables involved, incl labeled axes of the chart and labeled lines within the chart
- Plug in given data
- Determine the value in question

5.1 Density Altitude

- DA is a measure of air density expressed in terms of altitude
    - Air density varies inversely with altitude (air is denser at low altitudes than high)
    - Density altitude != air density. They are inversely related.
    - Temp, humidity, and barometric pressure also affect air density
        - Scale of air density to altitude is established by a standard temp/pressure, which is 15C at sea level and 29.92
        - When temp/pressure are not standard (which is extremely common), the DA is not the same as true altitude
    - DA is pressure altitude corrected for nonstandard temp. In a sense, DA is the altitude at which the airplane "feels" like it's flying at - on a hot and humid day, the DA might be 2500 ft while the elevation is at sea level. At high elevation airports, high DA may degrade performance to the point where takeoff is difficult or impossible.
- Must know how barometric pressure, temp, and humidity affect density altitude.
    - As barometric pressure increases -> air is more compressed -> DA deccreases
    - Temp increases -> air expands -> pressure drops -> DA increases
    - Humidity increases -> air becomes less dense, since a given volume of moist air weighs less than the same volume of dry air, since water vapor is less dense than dry air. -> less dense air means lower pressure. Lower pressure means higher DA.
- DA varies directly with temp and humidity, and inversely with barometric pressure. Cold, dry air and high pressure = low DA. Warm, humid air and low pressure = high DA
- Pressure altitude is based on standard temp. Warm air results in higher DA.
- Primary reason for computing DA is because of airplane performance. High DA reduces performance - less climb performance and longer takeoff roll. Props have less efficiency because there is less air to move.
    - However, the same IAS is used for takeoffs and landings regardless of altitude or air density b/c the ASI is also directly affected by air density.

5.2 DA Computations

- How to find DA: first, find the pressure altitude, which is the indicated altitude when the altimeter is set to 29.92 (height above the standard datum plane). Then, adjust for the temperature to convert pressure altitude to density altitude.

    - The chart in the left side of figure 8 is WRONG!!! You must use the flight computer!!!
- Using Figure 8:
    - Adjust indicated altitude to pressure altitude by using the right side of the chart by adding or subtracting the conversion factor.
    - Use a flight computer to apply the temperature to the pressure altitude. On an E-6B, line up the air temp with the pressure altitude and read the DA opposite the arrow in the DA window.

5.3 Takeoff Distance

- Conditions that reduce airplane takeoff and climb performance: high altitude, high temps, high humidity
- Takeoff distance performance is displayed in the a/c operating manual either in chart form or on a graph.
- If it is a graph, it is usually presented in terms of DA. Thus, one must first adj the airport elevation for nonstandard temp and pressure.
    - Figure 40 - graph used in the exam. The first section on the left uses outside air temp and pressure altitude to find DA. The curved line on the left portion is standard atmosphere, which you use when the question calls for standard temp.
    - The second section takes the weight in pounds into acct
    - The third portion takes headwind/tailwind into account
    - The 4th section takes obstacles into account.
    - Go straight up from OAT to pressure temp, then horizontally across to the ref line. Then, follow the trendline approximately to the weight, then horizontally across to the next ref line. Then the trendlines to the wind component; then horizontally to the next section and so forth. The final set of axes shows the distance to takeoff and clear obstacles.

5.4 Cruise Power Settings

- Cruise power settings are found in Figure 35.
- Based on 65% power
- Can adjust for temps, standard day, ISA-20C, ISA+20C. (ISA is international standard atmosphere)
- Values are found in the table based on various pressure altitudes, including engine RPM, manifold pressure, fuel flow in gal per hr, and true airspeed

5.5 Crosswind Components

- Airplanes have a limit to the amount of direct crosswind in which they can land. When the wind is quartering, a crosswind component chart can be used to determine the crosswind component.
- The variables on the chart (figure 36) are angle b/w wind and runway, and wind velocity.

- The angles are the angle that the wind is to the runway, with 0 degrees being head on and 90 degrees being exactly perpendicular. Find the arc (or location between the arcs of your total wind, then drop straight down or across to find crosswind or headwind.

5.6 Landing Distance
- Req'd landing distances differ at various altitudes and temps due to changes in air density, but IAS for landing is the same in all situations.
- If an emergency situation requires a downwind landing, expect a longer rollout, higher groundspeed at touchdown, and a greater possibility of overshooting the desired touchdown point.
- Figure 37 gives landing distances; works the same way as Figure 40 (takeoff distances)
- Must distinguish b/w landing distances with or without obstacles.
- Landing distance table: has been computed for landing without wind, at standard temp, and at pressure altitude. Notes include info for adjusting for nonstandard conditions.

5.7 Weight and Balance Definitions
- Empty weight - consists of the airframe, engine, and all items of operating equipment permanently installed in the a/c, incl optional special equipment, fixed ballast, hydraulic fluid, unusable fuel, and undrainable (or in some aircraft, all) oil
- Standard weights have been established for numerous items involved in w/b computations. For example, std weight for avgas is 6 lb/gal
- The CG is the point of balance along the a/c's longitudinal axis.
  - By multiplying the weight of each component and its arm (distance from the reference datum, an arbitrary point), the moment is determined. The CG is the sum of moments div by the weight.

5.8 CG Calculations
- Basic formula for w/b is Weight x Arm = Moment
- Moment = torque in a statics problem.

5.9 CG Graphs
- The loading graph (top graph in Figure 34) - pretty self-explanatory, match the weights on the y-axis to the moment/1000 on the x-axis, add all the moments.
- Bottom graph - cg moment envelope chart - make sure the sum of moments + total weight is within the red lines for the operating category.

5.10 CG Tables
- Use tables to determine weight and cg. Determine the total moments using the charts; remember that weight x arm = moment for values in between. Then use figure 33 to check if the cg is within limits.

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Missed Questions 9

9. Winds aren't mentioned in the problem and aren't guaranteed to improve takeoff performance

11. Miscalculated. Must use actual calculations to interpolate.

12. Miscalculated.

17. Didn't follow the graph precisely enough
18. Use the percent difference between lines to interpolate.
22. Follow the graph more precisely.
27. Selected wrong choice with correct calculation.
55. Misread the graph.
68. Recalculate completely after adjustments.