Supplementary Density Altitude Guide

Step-By-Step Example Problem -

In addition to the quick example problem given in the video lecture, a detailed step-by-step example is provided for reference when trying to calculate your own location's density altitude.

Step 1:

To begin, first locate your nearest airport on this site: https://en.allmetsat.com/metar-taf/africa.php. Using the Lilongwe International Airport for this example problem, you will pull up a page very similar to the one found in Figure 1. The values you'll need to take note of are the elevation (m), highlighted in the orange box, the pressure (hPa), highlighted in the red box, and the temperature (C), highlighted in the blue box.

Figure 1 - Web page of relevant airport data for calculating density altitude

As you can see, the airport elevation is at 1,229 meters above sea level, and the recorded pressure and temperature for a few hours ago was 1,020 hPa and 21 C.

Step 2:

Next, you'll need to calculate a pressure altitude using the pressure and elevation values obtained from step 1. Using the pressure recorded, 1,020 hPa, you can find the altitude correction value using the Pressure Altitude table from the appendix. (**Note** You may also use the linear interpolation equation, Equation 1, to find a more accurate pressure altitude correction) Using the Pressure Altitude chart in the appendix, we find that 1020 hPa lies between 1019.30 and 1022.69 hPa and so the altitude correction lies between -50.3 to -78.3 meters (-165 and -257 feet). Using Equation 1, where the pressures are the x-values and the resultant altitude corrections are the y-values, the appropriate altitude calculation for a pressure of 1020 hPa is found to be -56.08 meters or -184 feet. This means that the pressure altitude at the Lilongwe Airport for just a few hours ago was approximately (1,229 - 56.08) or 1172.92 meters (3848.2 feet.)

$$y = (y_0 * (x_1 - x) + y_1 * (x - x_0)) \div (x_1 - x_0) \tag{1}$$

Pressure altitude is the altitude at which the equivalent standard atmospheric pressure would indicate. This means that if the pressure recorded was exactly 1013.25 hPa, this would represent a pressure altitude the exact same as the airport's natural elevation. However, if a higher pressure were recorded, such as 1020 hPa, the pressure altitude would record as lower than the natural elevation pressure. This is due to the fact that pressure should generally decrease with height and so a higher pressure would indicate a lower altitude, and vice versa.

Step 3:

Convert the ***elevation*** of the airport to feet so that you can do a linear interpolation of the ISA Temperature chart in the appendix in order to find your $T_{standard\ air\ temp.}$ value. 1,229 meters is equal to approximately 4,032 feet. Again using Equation 1, use the linear interpolation formula to find the appropriate standard air temperature from the chart. Looking at the chart, 4032 feet is between 4000 and 5000 feet which indicates a potential range of 7.1 to 5.1 air temperature. Taking feet as your x-variable in Equation 1 and the air temperature as your y-variables, you'll find that the $T_{standard\ air\ temp.}$ value is equal to approximately 7.04 or just 7 C.

Step 4:

You now have all of the information that you need to fill in the Density Altitude Equation that was mentioned in class and can again be found in the Appendix! Be careful to ensure that your pressure altitude term is in feet when inputting into the final equation! Though we've used both throughout this process, the Density Altitude Equation is formulated to use feet.

You can see that the Density Altitude Equation now equals:

$$\rho_{density\ altitude} = 3848.2 + (120 * (21 - 7)) \tag{2}$$

Which then becomes

$$\rho_{density\ altitude} = 5523.87\, feet = 1683.68\, meters \tag{3}$$

It was covered in lecture, but remember that the density altitude is simply the altitude in which an equivalent air density is found in the standard atmospheric model. This is the altitude value which will have the greatest effect on your aircraft performance as density is a direct component of the lift equation.

These concepts can be difficult to understand, so do not be concerned if you are still confused on the exact meanings of pressure or density altitudes. For more information on these principles, check out the link below:

- A good video that explains both pressure and density altitude. Do note, however, that the equation he uses to find the pressure altitude is a rule of thumb, not an exact calculation.
    - https://www.youtube.com/watch?v=ThdDxTdJUnc

Appendix -

Whenever you may need to calculate the density altitude for your flying location, these materials and equations can be helpful for finding these density altitudes:

Density Altitude Equation:

$$\rho_{density\ altitude} = p_{pressure\ altitude} + (120 * (T_{ambient\ air\ temp.} - T_{standard\ air\ temp.}))$$

International Standard Atmosphere (ISA) Temperature Chart:

Altitude (feet)	ISA Temperature (Celsius)
0	15.0
1000	13.0
2000	11.0
3000	9.1
4000	7.1
5000	5.1
6000	3.1
7000	1.1
8000	-0.8
9000	-2.8
10000	-4.8
11000	-6.8
12000	-8.8
13000	-10.8
14000	-12.7
15000	-14.7
16000	-16.7
17000	-18.7
18000	-20.7
19000	-22.6
20000	-24.6

Pressure Altitude Chart:

Note: Remember that this chart is used in addition to the elevation provided in Step 1 to calculate a pressure altitude.

Method for Determining Pressure Altitude			
Altimeter Setting			Altitude Correction
Inches Hg	Millibars	Hectopascals (hPa)	Feet
28.00	948.19	948.19	1824
28.10	951.58	951.58	1727
28.20	954.96	954.96	1630
28.30	958.35	958.35	1533
28.40	961.73	961.73	1436
28.50	965.12	965.12	1340
28.60	968.51	968.51	1244
28.70	971.89	971.89	1148
28.80	975.28	975.28	1053
28.90	978.67	978.67	957
29.00	982.05	982.05	863
29.10	985.44	985.44	768
29.20	988.83	988.83	673
29.30	992.21	992.21	579
29.40	995.60	995.60	485
29.50	998.98	998.98	392
29.60	1002.37	1002.37	298
29.70	1005.76	1005.76	205
29.80	1009.14	1009.14	112
29.90	1012.53	1012.53	20
29.92	1013.21	1013.21	0
30.00	1015.92	1015.92	-73
30.10	1019.30	1019.30	-165
30.20	1022.69	1022.69	-257
30.30	1026.08	1026.08	-348
30.40	1029.46	1029.46	-440
30.50	1032.85	1032.85	-531
30.60	1036.24	1036.23	-622
30.70	1039.62	1039.62	-712
30.80	1043.01	1043.01	-803
30.90	1046.39	1046.39	-893
31.00	1049.78	1049.78	-983