CESSNA 310

FIGURE 5-1.—The troposphere and stratosphere are the realm of flight.

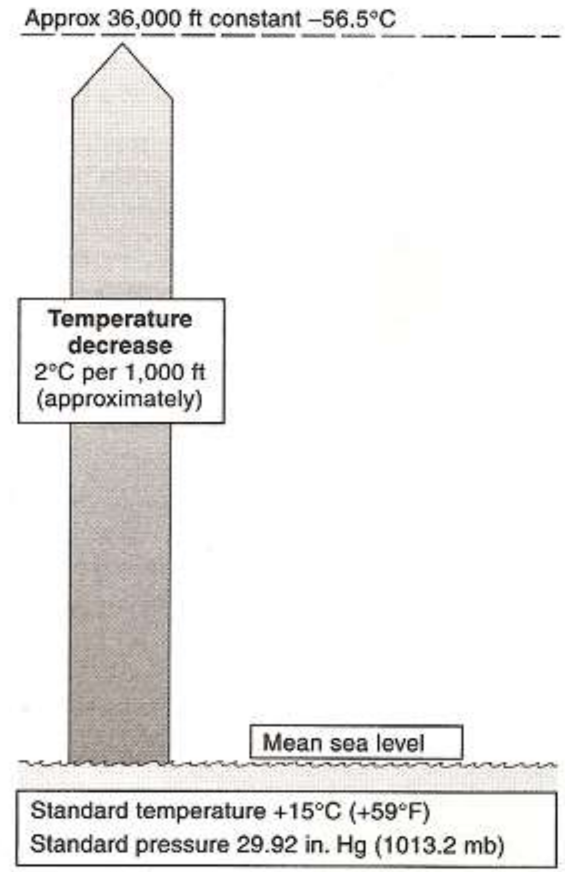


Figure 14-4. The International Standard Atmosphere (ISA)

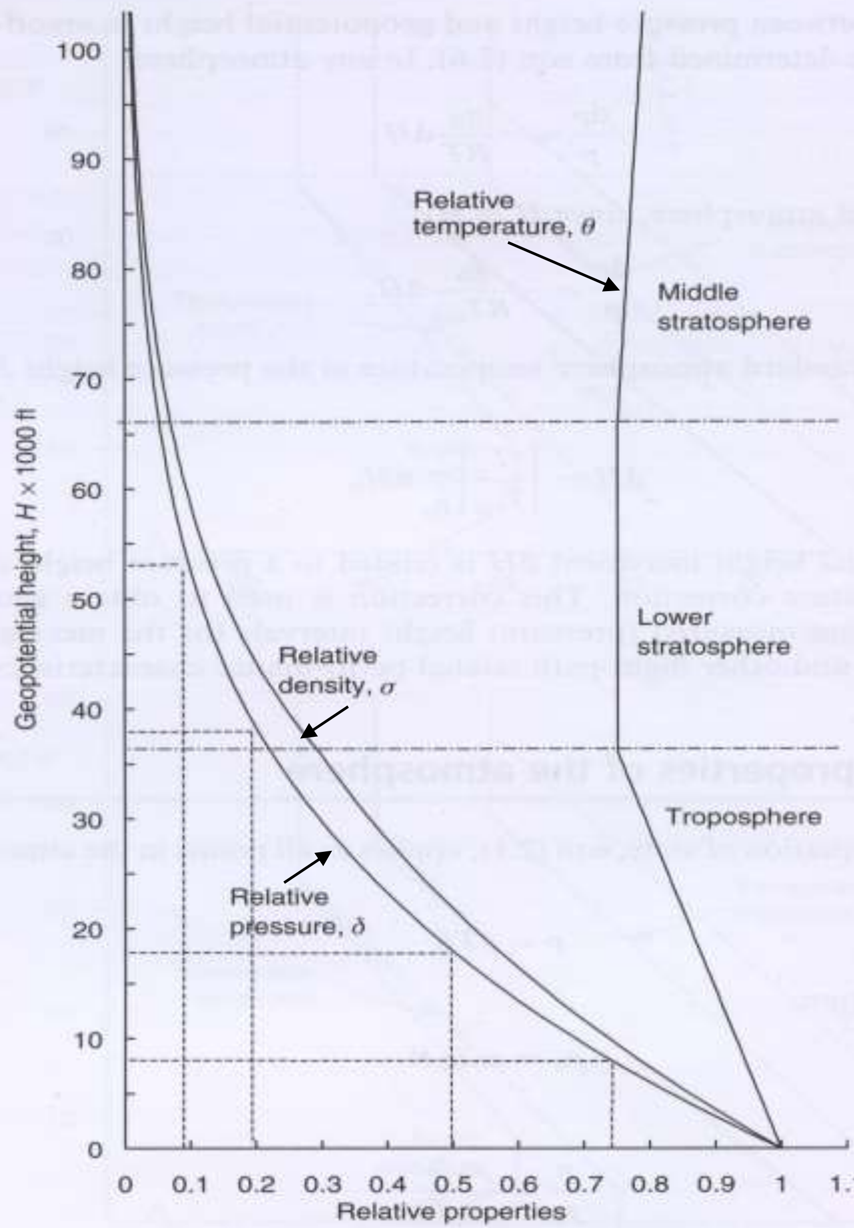
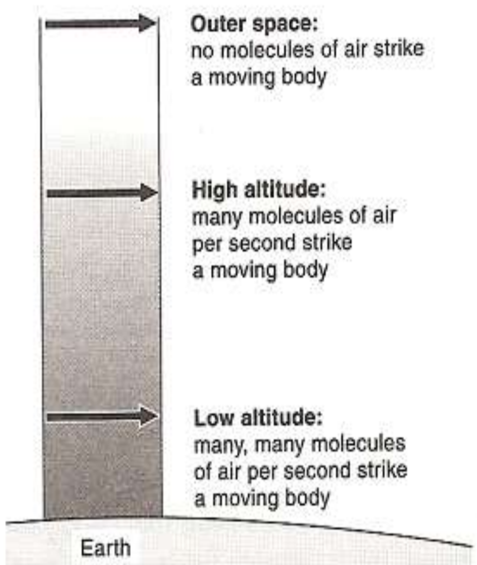
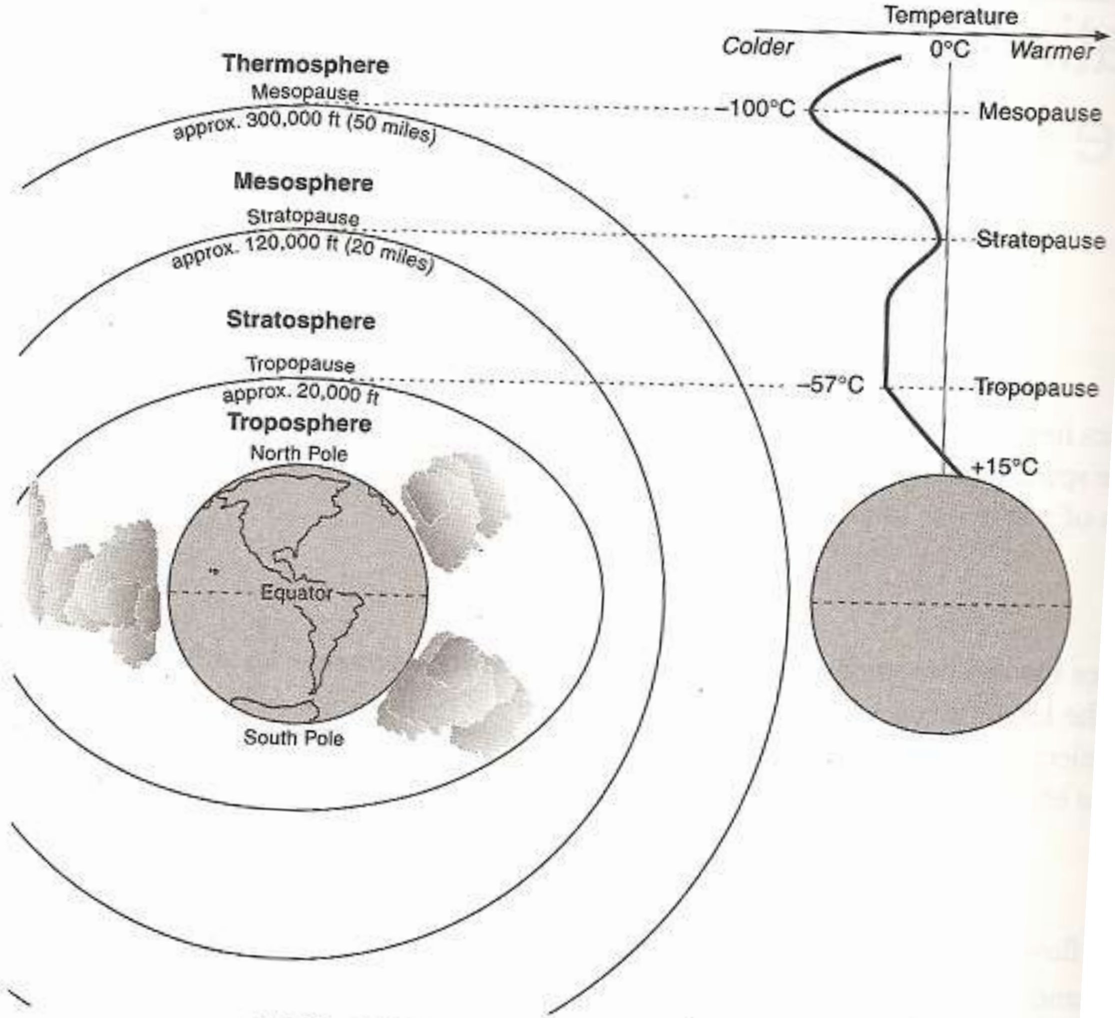


Fig. 2.8 International Standard Atmosphere; relative properties.

Air density decreases with altitude.



The density of air decreases as altitude is gained



The subdivision of the atmosphere is based on temperature

Density altitude is the altitude in the International Standard Atmosphere at which the air density would be equal to the actual air density at the place of observation. "Density Altitude" is the pressure altitude adjusted for non-standard temperature.
Both increase in temperature and increase in humidity cause a reduction in air density. Thus in hot and humid conditions the density altitude at a particular location may be significantly higher than the geometric altitude.
Density altitude can be calculated from atmospheric pressure and temperature (assuming dry air).

$$\mathrm{DA} = 145426\left[1 - \left(\frac{P_0/P_{SL}}{\mathrm{T}/T_{SL}}\right)^{b}\right]$$

where
DA = density altitude
P_0 = atmospheric (static) pressure
P_{SL} = standard sea level atmospheric pressure (1013.25 hpa)
T = true (static) air temperature
T_{SL} = standard sea level air temperature(288.15 K)
b = 0.235

Aircraft manufactures and designer design aircraft using standard atmosphere conditions as the reference point.

Pilots need to adjust these theoretical values of lift, power and thrust to take account of differences between the standard atmosphere and the real atmosphere at a particular time and place. They use charts or aviation computers to say that the real atmosphere at a particular time has the density of the standard atmosphere at a certain altitude, which is likely to be different from the true altitude. The aircraft performs as though it were at the density altitude.

Air density decreases with altitude. At high elevation airports, an airplane requires more runway to take off. Its rate of climb will be less, its approach will be faster, because the true air speed [TAS] will be faster than the indicated air speed [IAS] and the landing roll will be longer.

Density altitude is pressure altitude corrected for temperature. It is, in layman terms, the altitude at which the airplane "thinks" it is flying based on the density of the surrounding air mass.
Too often, pilots associate density altitude only with high elevation airports. Certainly, the effects of density altitude on airplane performance are increasingly dramatic in operations from such airports, especially when the temperature is also hot. But it is important to remember that density altitude also has a negative effect on performance at low elevation airports when the temperature goes above the standard air value of 15° C at sea level. Remember also that the standard air temperature value decreases with altitude.

HEIGHTS TO STANDARD PRESSURE AND TEMPERATURE

Altitude, feet	Pressure, mb	Pressure, inches	Temperature, °C	Temperature, °F	Altitude, feet	Pressure, mb	Pressure, inches	Temperature, °C	Temperature, °F
0	1013.2	29.92	15.0	59.0	26,000	359.9	10.63	−36.5	−33.7
1,000	977.2	28.86	13.0	55.4	27,000	344.3	10.17	−38.5	−37.3
2,000	942.1	27.82	11.0	51.9	28,000	329.3	9.72	−40.5	−40.9
3,000	908.1	26.82	9.0	48.3	29,000	314.8	9.30	−42.5	−44.4
4,000	875.1	25.84	7.1	44.7	30,000	300.9	8.89	−44.4	−48.0
5,000	843.1	24.90	5.1	41.2	31,000	287.4	8.49	−46.4	−51.6
6,000	812.0	23.98	3.1	37.6	32,000	274.5	8.11	−48.4	−55.1
7,000	781.8	23.09	1.1	34.0	33,000	262.0	7.74	−50.4	−58.7
8,000	752.6	22.22	−0.8	30.5	34,000	250.0	7.38	−52.4	−62.2
9,000	724.3	21.39	−2.8	26.9	35,000	238.4	7.04	−54.3	−65.8
10,000	696.8	20.58	−4.8	23.3	36,000	227.3	6.71	−56.3	−69.4
11,000	670.2	19.79	−6.8	19.8	37,000	216.6	6.40	−56.5	−69.7
12,000	644.4	19.03	−8.8	16.2	38,000	206.5	6.10	Constant to	
13,000	619.4	18.29	−10.8	12.6	39,000	196.8	5.81	65,500 feet	
14,000	595.2	17.58	−12.7	9.1	40,000	187.5	5.54		
15,000	571.8	16.89	−14.7	5.5	41,000	178.7	5.28		
16,000	549.2	16.22	−16.7	1.9	42,000	170.4	5.04		
17,000	427.2	15.57	−18.7	−1.6	43,000	162.4	4.79		
18,000	506.0	14.94	−29.7	−5.2	44,000	154.7	4.57		
19,000	485.5	14.34	−22.6	−8.8	45,000	147.5	4.35		
20,000	465.6	13.75	−24.6	−12.3	46,000	140.6	4.15		
21,000	446.4	13.18	−26.6	−15.9	47,000	134.0	3.96		
22,000	427.9	12.64	−28.6	−19.5	48,000	127.7	3.77		
23,000	410.0	12.11	−30.6	−23.9	49,000	121.7	3.59		
24,000	392.7	11.60	−32.5	−26.6	50,000	116.0	3.42		
25,000	376.0	11.10	−34.5	−30.2					

Most density altitude charts and calculators account for the air pressure and temperature, but not for humidity.
Humid air is less dense than dry air,
which means performance will suffer on a humid day.
But these effects are not as great as temperature and air pressure.

All altitudes are measure above Sea Level (MSL) vs Altitude above ground (AGL)

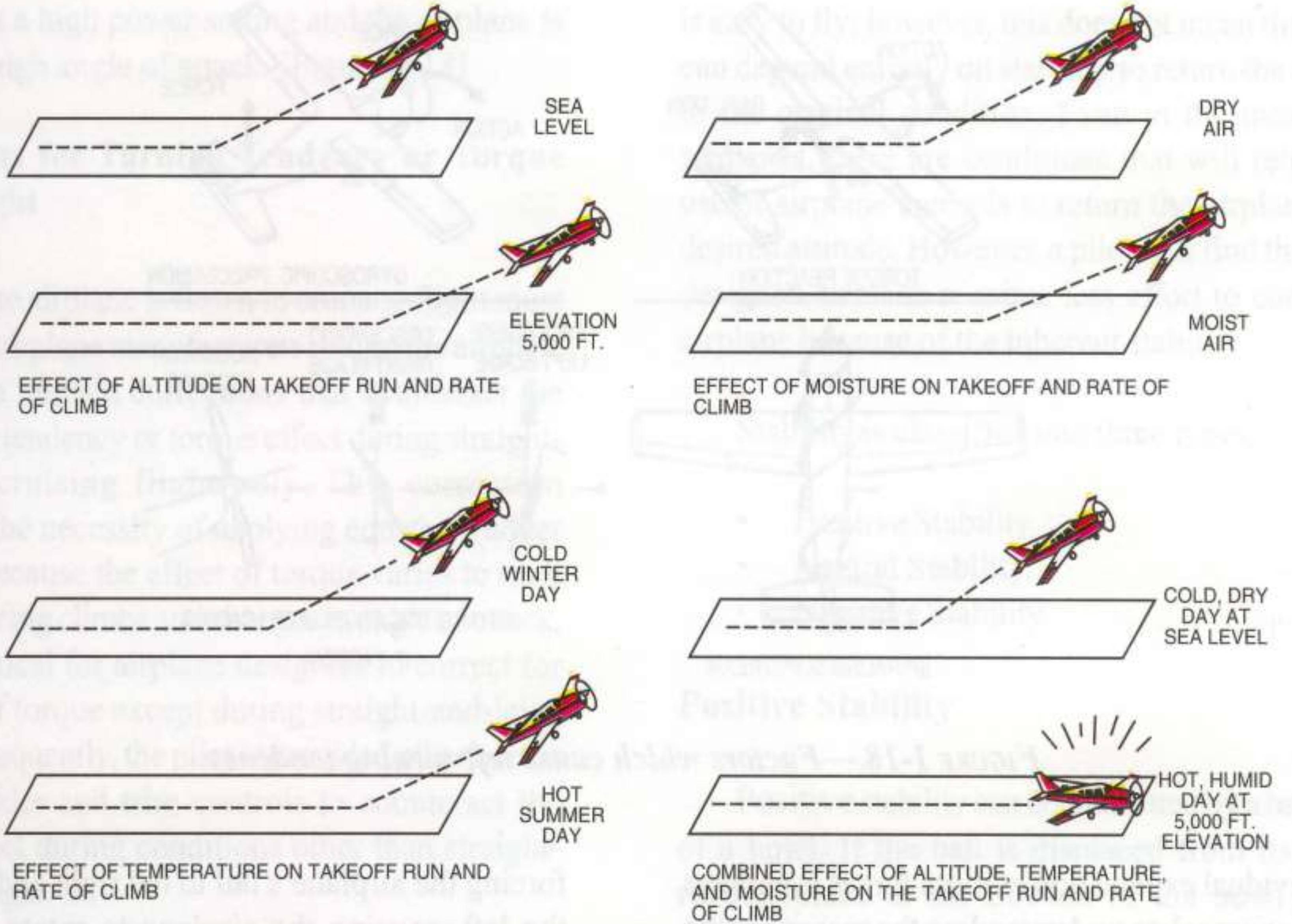


FIGURE 1-17.—Effect of altitude, temperature, and humidity on takeoff run and rate of climb.

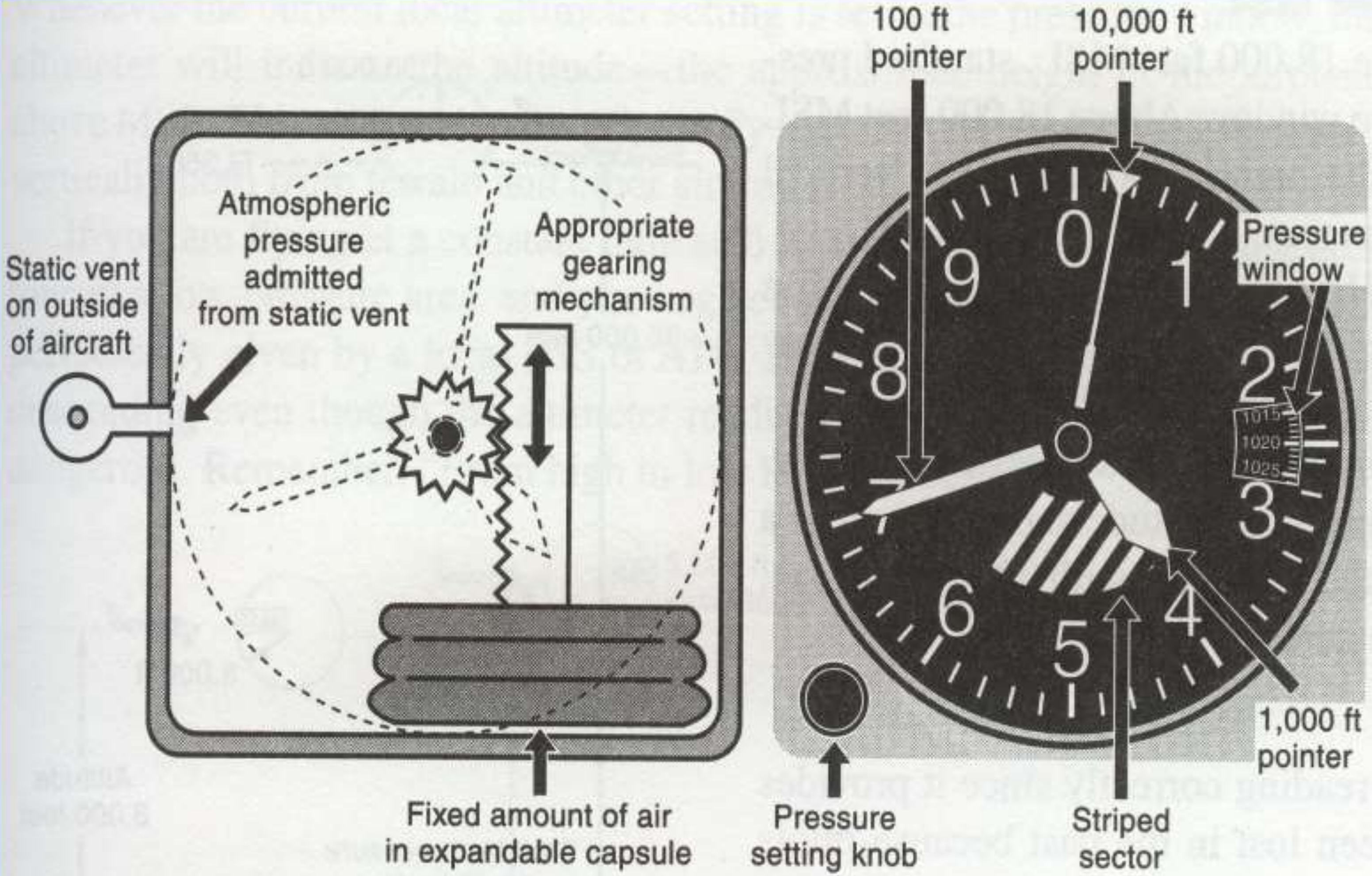


Figure 8-9. The altimeter is a pressure-sensitive instrument

Density Altitude

Interaction between Air pressure, Temperature, Air Moisture and Altitude that impacts all aircraft performance.

Question to ask yourself

At this moment, at this temperature, at this altimeter setting, at this actual altitude and at this relative humidity:

How far from the standard Atmosphere environment will the airplane be operating?

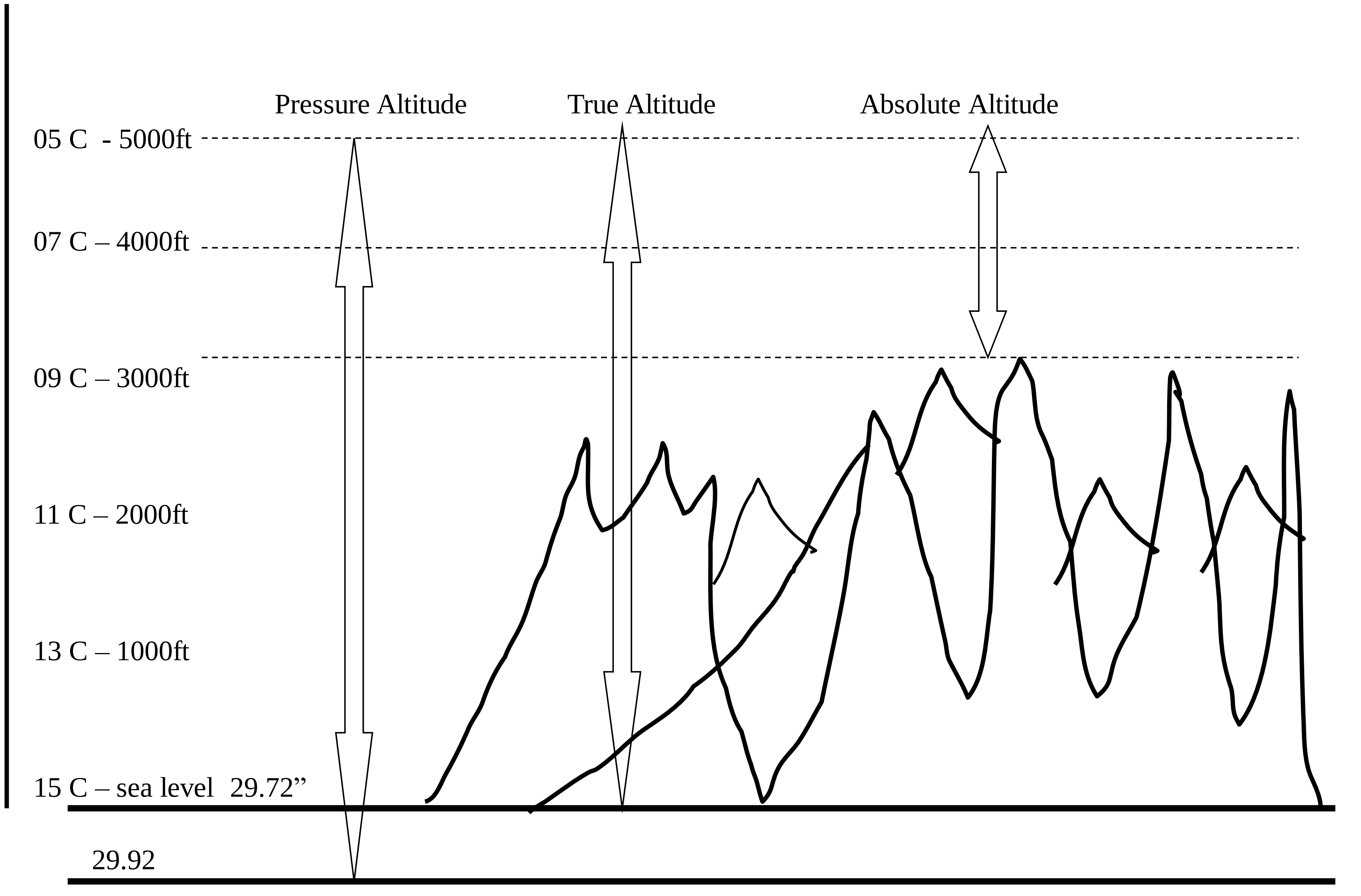
What Altitude does the airplane thinks it is operating at?

The Standard Atmosphere – at Sea level is 59 F or 15 C and a surface pressure of 29.92

Pressure Altitude – is the altitude deviation from the Standard atmosphere

Density Altitude – Airplane and engine performance depends on air density. It is impracticable for you have the equipment necessary to measure air density, so we use two pieces of information already available in the cockpit on which air density depends

1) pressure altitude
2) temperature.



Pressure Altitude
True Altitude
Absolute Altitude
05 C - 5000ft
07 C – 4000ft
09 C – 3000ft
11 C – 2000ft
13 C – 1000ft
15 C – sea level 29.72”
29.92

Pressure altitude within the atmosphere is the altitude in the International Standard Atmosphere (ISA) with the same atmospheric pressure as that of the part of the atmosphere in question.

Presure altitude in feet (ft) from Millibars directly:

$$145366.45\left[1-\left(\frac{\text{Station pressure in millibars}}{1013.25}\right)^{0.190284}\right]$$

For example, if the airfield elevation is $500\ \mathrm{ft}$ and the altimeter setting is $29.32\ \mathrm{inHg}$, then

$$\begin{aligned}\mathrm{PA} &= 500 + 1000 \times (29.92 - 29.32)\\ &= 500 + 1000 \times 0.6\\ &= 500 + 600\\ &= 1100.\end{aligned}$$

Alternatively,

$$\text{Pressure altitude (PA)} = \text{Elevation} + 30 \times (1013 - \text{QNH}).$$

For example, if the airfield elevation is $500\ \mathrm{ft}$ and the QNH is $993\ \mathrm{mb}$, then

$$\begin{aligned}\mathrm{PA} &= 500 + 30 \times (1013 - 993)\\ &= 500 + 30 \times 20\\ &= 500 + 600\\ &= 1100.\end{aligned}$$

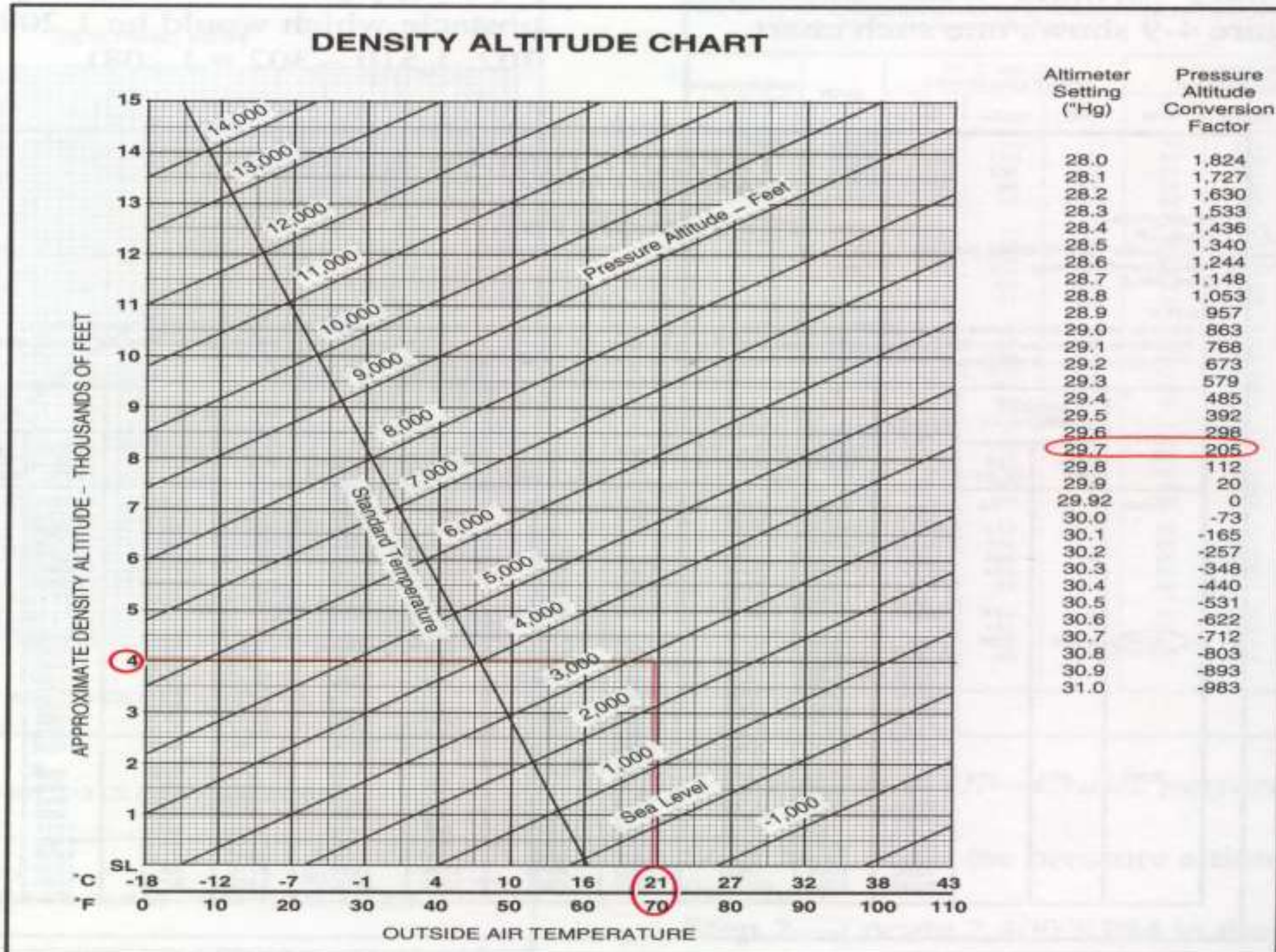


FIGURE 4-8.—Pressure altitude and density altitude chart.

In Class Quiz.

Using the density altitude chart, what is the density altitude if the altimeter reads 5000ft with 28.30 in.Hg in the Pressure window and the true outside air temperature is 90 F?