



When it comes to your local weather report, it's easy to understand what the Weatherperson means by the terms temperature and wind speed. During the summertime, you will often hear about 'humidity', which is the amount of moisture carried by the air. This term also makes a lot of sense!

When the air is carrying a lot of moisture on a 'humid' hot summer's day, it feels very uncomfortable. Your body is trying to cool off by perspiring. Because the air is already carrying a lot of moisture, there is no place for your perspired water to easily go. So you start to over-heat and feel wet all over!

Air can carry water vapor, and warm air can carry a lot more water vapor than cold air. That's why your skin feels wet and clammy in the summer, and you often have problems with dry skin during the winter. Because the amount of water and air humidity depends on temperature, your Weatherperson will often use the term 'dew point' to tell you what to expect when you step outside!

When the air temperature is close to a critical temperature called the **dew point**, water vapor begins to condense out of the air as droplets. The windshield of your car will have beads of water all over, and if this happens inside your house, your windows will cloud up with drops of moisture. That is why for some locations, indoor air conditioners have to have a 'dehumidifier' to remove moisture from the air so that it doesn't condense on the cooler panes of window glass.

For large masses of air, millions of droplets of moisture can form in every cubic centimeter and you see a cloud begin to appear.

The diagram above shows what happens to an 'air mass' with a dew point temperature of 58°F as it rises to cooler altitudes. Nothing happens if the dew point temperature is below the air temperature. But when the local air temperature equals or is larger than the dew point, the cloud appears.

Sometimes, the local temperature near the ground can be slightly above the dew point. When this happens, the air remains clear, but droplets of water can form on cooler windows or on cars. When the local ground temperature is below the dew point, droplets will condense in the air and you get ground fog!

Dew point temperature can be a confusing idea when you first work with it, but it is such a common and practical idea that you will hear about it on your local weather report, especially during the spring, summer and fall!

The dew point temperature is very complicated to calculate exactly because it depends on the local atmospheric pressure and temperature, and the amount of water vapor in the air. There are some ways to estimate dew point temperature that give a rough idea of what to expect. The following formula is one of these methods:

$$T_{\text{dewpoint}} = T_{\text{air}} - \frac{100 - P}{5}$$

A general rule-of-thumb is that, if the humidity of the air is 60% you will feel uncomfortable ( $P = 60$ ). If the outside temperature on a hot summer's day is  $90^{\circ}\text{F}$  ( $T_{\text{air}}=90^{\circ}\text{F}$ ) then the dew point temperature is  $82^{\circ}\text{F}$ . If the humidity of the air approaches 100%, then for this example the dew point temperature equals the air temperature and droplets of moisture will start to form.

**Problem 1** – A Marathon runner finishes the race and gets into her car. The outdoor temperature is  $75^{\circ}\text{F}$  and the humidity is 80%. Explain why her actions may be dangerous if she immediately drives away, and a simple remedy.

**Problem 2** - It's a warm sunny day and the air is rather humid with a dew point of  $75^{\circ}\text{F}$ . The ground temperature is  $85^{\circ}\text{F}$ . If the air temperature decreases at a rate of  $3.5^{\circ}\text{F}/1000$  feet (called the wet lapse rate), at what altitude will a cloud begin to appear?

**Problem 3** – On a comfortable summer day, the humidity is only 20% and the outside temperature is  $80^{\circ}\text{F}$ . At what altitude might clouds start to form overhead if the air temperature is decreasing at a 'dry' lapse rate of  $5.5^{\circ}\text{F}/1000$  feet?

**Common Core Math Standards:**

**Grade 6** – CCSS.Math.Content.6.RP.A.3b Solve unit rate problems including those involving unit pricing and constant speed. For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?

**Grade 7** – CCSS.Math.Content.7.RP.A.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks  $\frac{1}{2}$  mile in each  $\frac{1}{4}$  hour, compute the unit rate as the complex fraction  $\frac{1/2}{1/4}$  miles per hour, equivalently 2 miles per hour.

**Problem 1** – A Marathon runner finishes the race and gets into her car. The outdoor temperature is  $75^{\circ}\text{F}$  and the humidity is 80%. Explain why her actions may be dangerous if she immediately drives away, and a simple remedy.

Answer: The dew point temperature is  $T = 75 - (100-80)/5 = 71^{\circ}\text{F}$ . As she expels moist air from her lungs, the humidity inside the car steadily increases and the dew point temperature rises from  $71^{\circ}\text{F}$  to  $75^{\circ}\text{F}$ . Then the inside of her windows begin to fog up as water condenses on their surfaces. This makes it harder for her to see outside and creates a dangerous situation.

A remedy is to first turn on the car air conditioner, which will condense the remaining moisture in the air onto the cooling pipes. Then turn on the heater which will warm the windows and evaporate the moisture droplets on the windows. With the AC still on, this moisture will also condense on the cooling pipes, resolving the situation. Typically this takes only a minute or two for an average-sized car.

**Problem 2** – It's a warm sunny day and the air is rather humid with a dew point of  $75^{\circ}\text{F}$ . The ground temperature is  $85^{\circ}\text{F}$ . If the air temperature decreases at a rate of  $3.5^{\circ}\text{F}/1000$  feet, at what altitude will a cloud begin to appear? Answer: The rising air near the ground has to drop in temperature by  $85^{\circ}\text{F} - 75^{\circ}\text{F} = 10^{\circ}\text{F}$ . It is decreasing by  $3.5^{\circ}\text{F}$  every 1000 feet, so the dew point temperature of  $75^{\circ}\text{F}$  will be reached at an elevation of  $10^{\circ}\text{F}/3.5^{\circ}\text{F} = \mathbf{2857}$  feet.

**Problem 3** – On a comfortable summer day, the humidity is only 20% and the outside temperature is  $80^{\circ}\text{F}$ . At what altitude might clouds start to form overhead if the air temperature is decreasing at a 'dry' lapse rate of  $5.5^{\circ}\text{F}/1000$  feet?

Answer: First use the dew point formula to calculate  $T_{\text{dewpoint}}$ . For  $P=20$  and  $T_{\text{air}}=80^{\circ}\text{F}$  we get  $T_{\text{dewpoint}}=80 - (100-20)/5$  so  $T_{\text{dewpoint}}=64^{\circ}\text{F}$ .

Next, calculate the altitude from the lapse rate. The difference between the ground temperature and the dew point temperature is  $80^{\circ}\text{F} - 64^{\circ}\text{F} = 16^{\circ}\text{F}$ . The altitude will be  $A = 16^{\circ}\text{F}/(5.5^{\circ}\text{F}/1000\text{feet}) = \mathbf{2909}$  feet.