Chapter 11. A Sling Psychrometer and Relative Humidity: A Structured-Inquiry Activity

Think About This!

How does your comfort level differ on a warm day in summer from a similarly warm day in autumn? Sometimes summer temperatures in the mid or upper eighties in a city, like Washington D.C. along the Potomac River, will be very uncomfortable, but the same temperatures in the autumn will feel more comfortable. What might explain the difference?

Purpose

To have students construct and use a sling psychrometer to measure the wet-bulb and dry-bulb temperatures, and then use a chart to determine relative humidity based on the wet-bulb and dry-bulb readings.

Objectives for the Learner (Essentials of Inquiry)

Conceptual Theme: To develop a basic understanding of the relationship between the temperature and the amount of moisture that the air can absorb and how this relationship changes as temperature varies.

Content: Developing a basic understanding of how a sling psychrometer is used to determine relative humidity and how to read a chart to determine this relationship. In addition, the student will establish a basic understanding of dew point. Further, providing the student additional and basic understandings of other factors that constitute the study of meteorology.

Skills: The focus is using laboratory equipment, making careful observations, reading a relative humidity chart, recording data, making conclusions, and describing and communicating results.

Scientific Habits of Mind: The importance of careful observations, respect for data, verifying results, and using equipment safely.

Materials

2 non-mercury thermometers

15 cm (6 in.) wooden dowel

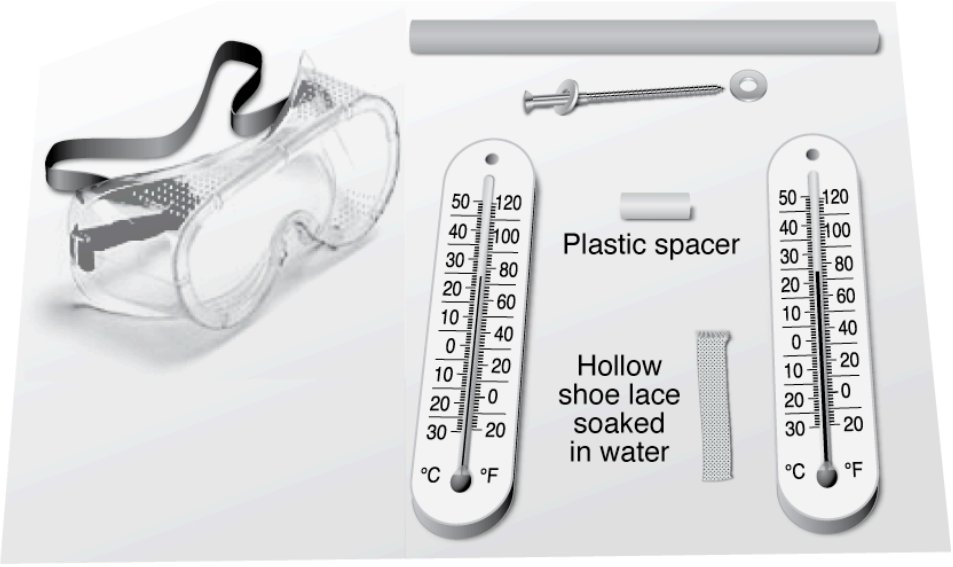
5 cm (2 in.) wood screw

2 washers

1 cm (0.5 in.) plastic spacer (such as a section of plastic drinking straw)

5 cm (2 in.) section of hollow shoe lace that has been soaked in water

Safety glasses



Preparation

A sling psychrometer can be used to find relative humidity, which is expressed as a percentage. It is computed by multiplying the amount of moisture in the air at a given temperature, dividing by the maximum amount of moisture the air could contain at that same temperature, and then multiplying the quotient by 100. The dew-point temperature is always lower than the dry-bulb temperature, unless the air is saturated, in which case they are identical. Also, the wet-bulb temperature is higher than the dew-point temperature, except when the air is saturated; in that case, the two are equal. Dew point is the temperature at which water vapor starts to *condense* out of air that is cooling, whereas wet-bulb temperature represents how much moisture the air can *evaporate*.

A sling psychrometer consists of two thermometers. One is a wet bulb and the other is a dry bulb. To make a wet-bulb thermometer, wrap a piece of white, porous cloth (a hollow white shoelace is ideal) which has been soaked in water around the bulb of one of the thermometers and secure it with a rubber band or twine.

Use a screw to attach the thermometers to the wooden dowel, with the spacer between the thermometers and the washers between the screw head and top thermometer and the bottom thermometer and dowel, in order that they can be circulated (slung) around a point, allowing air movement across each bulb (Figure 11-1). Safety glasses should be worn while twirling the sling psychrometer.

NOTE: *There are other ways to construct a sling psychrometer, such as looping a short cord through the holes in the thermometers to use for swinging. Inexpensive psychrometers are also available through commercial sources.*

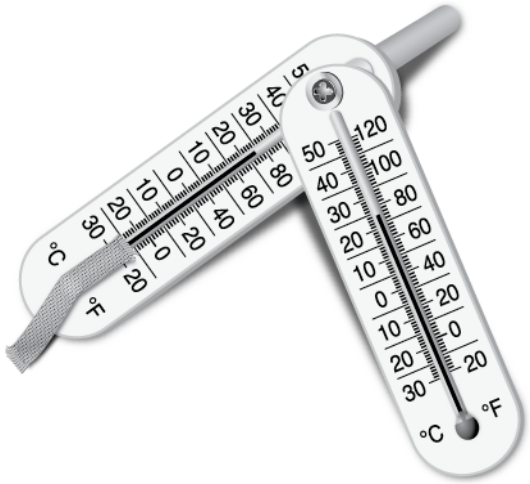


Figure 11-1. Assembled psychrometer.

Examining Results

After twirling the sling psychrometer for 10 to 20 seconds, take readings (in °C) from both thermometers and record the results.

Next, use the relative humidity chart to determine the relative humidity of the air.

NOTE: *This activity is important to familiarize the learner with the process of using tables and graphs to interpret data.*

Relative Humidity Table

You may use Table 11-1 below to determine relative humidity. The numbers in the center of the chart represent relative humidity in percentages. Relative humidity is determined by finding the differences in degrees between the dry-bulb and wet-bulb readings on the horizontal scale at the top, and then reading off where this column intersects the horizontal row containing the dry-bulb temperature reading. In this example, the dry-bulb temperature is 20 °C and the wet-bulb temperature is 14 °C. The difference between

Table 11-1. Relative Humidity (%)

Dry-Bulb Temp.,°C	Dry-Bulb Temperature Minus Wet-Bulb Temperature (Dry-Bulb Depression), °C														
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20
2	84	68	52	37	22	8									
4	85	71	57	43	29	16	3								
6	86	73	60	48	35	24	11								
8	87	75	63	51	40	29	19	8							
10	88	77	66	55	44	34	24	15	6						
12	89	78	68	58	48	39	29	21	12						
14	90	79	70	60	51	42	34	26	18	10					
16	90	81	71	63	54	46	38	30	23	15					
18	91	82	73	65	57	49	41	34	27	20	7				
20	91	83	74	66	59	51	44	37	31	24	12				
22	92	83	76	68	61	54	47	40	34	28	17	6			
24	92	84	77	69	62	56	49	43	37	31	20	10			
26	92	85	78	71	64	58	51	46	40	34	24	14	5		
28	93	85	78	72	65	59	53	48	42	37	27	18	9		
30	93	86	79	73	67	61	55	50	44	39	30	21	13	5	
32	93	86	80	74	68	62	57	51	46	41	32	24	16	9	
34	93	87	81	75	69	63	58	53	48	43	35	26	19	12	5
36	94	87	81	75	70	64	59	54	50	45	37	29	21	15	8
38	94	88	82	76	71	66	61	56	51	47	39	31	24	17	11
40	94	88	82	77	72	67	62	57	53	48	40	33	26	20	14
42	94	88	83	77	72	67	63	58	54	50	42	34	28	21	16
44	94	89	83	78	73	68	64	59	55	51	43	36	29	23	18

NOTE: Because relative humidity charts tend to vary slightly in percentage relating to relative humidity, You may wish to compare this chart with those found in Earth science books or other meteorology publications.

the two readings (dry-bulb depression) is 6 °C. According to the table, when the dry-bulb depression is 6 °C and the dry-bulb temperature is 20 °C, the relative humidity is 51 percent.

To convert Celsius to Fahrenheit, use the following formula:

$$F = (9/5) \times C + 32.$$

See Appendix V for additional references.

Conclusion

Based upon the data that you generated with the activity, what major conclusion did you make?

The main conclusion that the student should draw from this activity is that it is sometimes necessary to use tables and charts to convert the data to find the final answer.

Going Further

Repeat the procedure several times or over several days. Graph and compare the results.

Challenge

Examine the relationships between relative humidity and temperature by checking the relative humidity of warm air versus cooler air.

For example, cold air outside could be measured and compared with warm air inside. On warm days an air-conditioned room could be compared with outside air.

Background for the Teacher

Whirling the wet-bulb thermometer causes the water on the wet cotton to evaporate. This evaporation cools the bulb of the wet-bulb thermometer. The drier the ambient (surrounding) air, the more evaporation (and associated cooling) can take place. This is why you feel more comfortable on a day with lower humidity. If the humidity is lower, more evaporation of perspiration from your skin can occur. Thus, you'll feel cooler even though the dry-bulb temperature may be exactly the same as that on a more humid day.