

Working with Fahrenheit & Celsius Temperature Scales

“Walking quickly from the parking lot toward the terminal, I felt so warm I had to remove my jacket. The airport thermometer read 28 degrees. Driving home later that night, I got caught in a snowstorm. The guy on the local radio station said a moist air mass would bring more snowfall during the night as temperatures hovered around 30.”

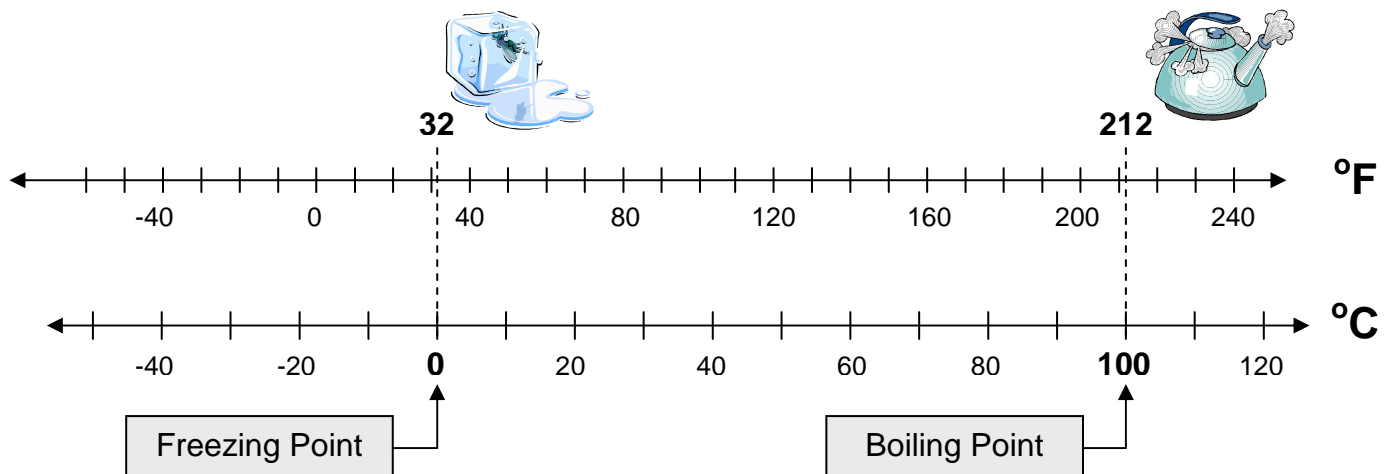
How would you make sense of this riddle?

Consider this fact: If you cross the border into Canada, you will see road signs showing distances in kilometers and newspapers listing temperatures in degrees Celsius. As it turns out, a similar situation exists almost everywhere elsewhere in the world. The United States is the only industrialized nation that does not depend widely on the metric system of measurement.

Not too many years ago there was a plan in the U.S. to convert to the metric system. In 1975, Congress passed an act to encourage the voluntary conversion from the English system to the metric system in all aspects of American life and commerce. A second piece of legislation was passed in 1988 to promote metrification, again voluntarily. But the process of converting to metric remains incomplete. While many U.S. businesses and virtually all scientists have made the change to metric in order to keep pace with global standards, the cultural side of U.S. life remains largely rooted in the old system of weights and measures. In time this will change as more Americans become familiar with metric measurement and learn to use it out of necessity.

Even in the U.S., the metric system is part of the language of science and math. In scientific publications that still use the English system you will almost always see the metric equivalents given next to the English units of measure. Whether you are a scientist, a student, a writer, or a business person, sometimes it is necessary to convert between English and metric when working with data or preparing reports. Such is often the case when reporting temperatures.

Both units of temperature measurement – degrees Fahrenheit ($^{\circ}\text{F}$) in the English system and degrees Celsius ($^{\circ}\text{C}$) in the metric system – are based on the freezing and boiling points of pure water at sea level. The relationships are shown in the scale diagram below.



The Fahrenheit scale designates the freezing point as 32 °F and the boiling point as 212 °F. Notice that there is a difference of 180 °F between these two values.

The Celsius scale is based on a more logical arrangement in which the freezing point is set at 0 °C and the boiling point at 100 °C. Because this is a difference of 100 degrees, the Celsius scale is often referred to as the centigrade scale.

Look at the two scales for a moment. What is the only temperature that has the same numerical reading on both scales?

Because 100 degrees of measure on the Celsius scale is exactly equal to 180 degrees of measure on the Fahrenheit scale, one unit °C is equal to 1.8 units °F. This ratio comes into play when making the conversion from Celsius to Fahrenheit and vice versa. The applicable equations are as follows:

Change Fahrenheit to Celsius: $^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$

Change Celsius to Fahrenheit: $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$

Example 1: Change 25 °F to Celsius. $^{\circ}\text{C} = (25 - 32) / 1.8 = -3.9^{\circ}\text{C}$

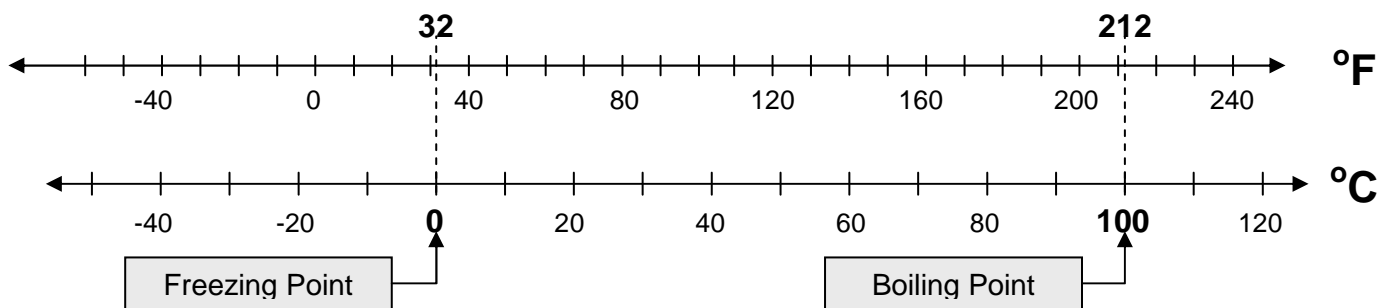
Example 2: Change 112 °C to Fahrenheit. $^{\circ}\text{F} = (1.8 \times 112) + 32 = 233.6^{\circ}\text{F}$

When you have side-by-side temperature scales, as in the diagram provided, you can obtain approximate temperature conversions by eye. The resulting answer is close enough for many purposes. However, there will be times when greater precision is needed. At other times, the temperature values will lie outside the range of the temperature scale diagram. In those cases the only recourse is to use the conversion equations.

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 & **Celsius**
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Practice

Fill in the missing temperature values in the tables below.



1. Give a reasonable answer of temperature in degrees Fahrenheit based on your knowledge, then make a close estimate of the equivalent Celsius temperature using the temperature scale diagram.

Room temperature	°F	°C
Morning temperature on a cold day in January	°F	°C
Maximum temperature on a July beach day	°F	°C
Temperature at noon on a brilliant October day	°F	°C

2. Use the diagram to estimate the missing temperature values.

The average surface temperature of Earth	57 °F	°C
The average surface temperature of Mars	°F	-63 °C
The record low temperature on New Hampshire's Mt. Washington	-47°F	°C
The boiling point of water in Denver	°F	94 °C
The boiling point of rubbing alcohol (isopropanol)	82.5 °F	°C
The freezing point of dry ice (carbon dioxide)	°F	-78.5 °C

3. Use the two temperature conversion equations to change the listed temperatures to °F or °C, as required, to the nearest degree.

The average surface temperature of Venus	864 °F	
The average surface temperature of Titan, Saturn's largest moon		-179 °C
The maximum daytime surface temperature of Mercury		427 °C
The maximum daytime surface temperature of Earth's moon	253 °F	
The approximate maximum temperature in Earth's upper atmosphere		1,700 °C

Change Fahrenheit to Celsius: $^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$

Change Celsius to Fahrenheit: $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$

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Teachers' Notes

Objectives: Students will learn about the English and metric temperature scales and will perform conversions between degrees Fahrenheit and degrees Celsius.

Grade Level: Middle/High

NSES: A3, A4, A5, A6, B4, D4, D6, E5, F10, G4, G5

NHSCF: 1a, 2a, 2b, 2c, 4a, 4b, 5g, 6d

Key Concepts

The United States lags the rest of the industrialized world in adopting the metric system of measurement. However, the scientific community and a large number of U.S. businesses are wholly dependent on the metric system, as their work must conform to globally accepted standards. Despite the apparent reluctance of the American general public to embrace the metric system, full metrification is probably inevitable if the U.S. is to remain economically competitive. For more on the historical context, visit <http://ts.nist.gov/ts/htdocs/200/202/lc1136a.htm#history>.

Answer to riddle: The person telling the story is about to fly home from abroad. The country he is leaving uses the Celsius scale. His home country, the United States, uses the Fahrenheit scale.

The Fahrenheit temperature scale is part of the English system of weights and measures. The Celsius (centigrade) scale is its metric equivalent. Both systems are calibrated to the freezing and boiling points of water. One unit on the Celsius scale is exactly equal to 1.8 units on the Fahrenheit scale. This ratio is present in the two equations for converting temperatures from one measurement system to the other. An important difference between the two scales is that only the Celsius scale starts with the zero point set to the freezing temperature of water.

For most people born and raised in the U.S., metric measurement is not intuitive. Americans are conversant with feet, pounds, and degrees Fahrenheit, but not sure of themselves when it comes to using meters, kilograms, and degrees Celsius. The only way to overcome this lack of familiarity is to begin using the metric system.

With respect to instruction, the Celsius scale is a good place to start. Many students are curious about Celsius measurement, already having encountered Celsius temperatures in their experiences and travels, if not previously in school. Like all aspects of the metric system, the Celsius scale is both *logical* and *systematic*. While some students may be put off by having to learn a different system, in time they will come to appreciate the simplicity and beauty of metric measurement.

Instruction in the metric system becomes increasingly important by the day. Many publications in both print and electronic media – especially those related to the sciences, technology, and international affairs – report facts and figures only in metric units of measure. The trend toward metric continues.

Extension Activity

Teacher divides the class into small groups and presents each group with a series of items or locations (targets) having widely varying temperatures. Students in each group then estimate the temperature of each target and record all estimates in a data table. Teacher distributes Fahrenheit laboratory thermometers. Students measure the actual Fahrenheit temperatures and record the data. Students then estimate the equivalent Celsius temperatures without use of calculators or other aids and record their estimates in the table. Teacher distributes Celsius thermometers. Students measure the actual Celsius temperature of each target and record their measurements. When all data have been recorded, students in each group determine the total average difference between their initial estimates and actual Fahrenheit temperatures. They repeat this calculation for the differences between estimated and actual Celsius temperatures. Winning groups are those with the lowest average differences.

Suggested Targets:

*cold tap water
hot tap water
lukewarm tap water
chilled antifreeze
ambient indoor temperature
ambient outdoor temperature
interior of refrigerator
interior of freezer
room heating radiator
air conditioner outlet vent*

ANSWER KEY

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1. Give a reasonable answer of temperature in degrees Fahrenheit based on your knowledge, and then make a close estimate of the equivalent Celsius temperature using the temperature scale diagram.

Room temperature	<i>Sample Responses</i>	70 °F	21 °C
Morning temperature on a cold day in January		0 °F	-18 °C
Maximum temperature on a July beach day		90 °F	32 °C
Temperature at noon on a brilliant October day		50 °F	10 °C

2. Use the diagram to estimate the missing temperature values.

The average surface temperature of Earth	57 °F	14 °C
The average surface temperature of Mars	-81 °F	-63 °C
The record low temperature on New Hampshire's Mt. Washington	-47 °F	-44 °C
The boiling point of water in Denver	201 °F	94 °C
The boiling point of rubbing alcohol (isopropanol)	82.5 °F	28 °C
The freezing point of dry ice (carbon dioxide)	-109 °F	-78.5 °C

3. Use the two temperature conversion equations to change the listed temperatures to °F or °C, as required, to the nearest degree.

The average surface temperature of Venus	864 °F	462 °C
The average surface temperature of Titan, Saturn's largest moon	-290 °F	-179 °C
The maximum daytime surface temperature of Mercury	801 °F	427 °C
The maximum daytime surface temperature of Earth's moon	253 °F	123 °C
The approximate maximum temperature in Earth's upper atmosphere	3,100 °F	1,700 °C