1.3: Temperature and Time

Learning Objectives

1. State the freezing and boiling points of water on the Celsius and Fahrenheit temperature scales.
2. Convert temperatures and times using conversion formulas.
3. Perform arithmetic calculations on temperature and time.
4. Solve application problems using temperature and time.

Introduction

Turn on the television any morning and you will see meteorologists talking about the day's weather forecast. In addition to telling you what the weather conditions will be like (sunny, cloudy, rainy, muggy), they also tell you the day's forecast for high and low temperatures. A hot summer day may reach 100° in Philadelphia, while a cool spring day may have a low of 40° in Seattle.

If you have been to other countries, though, you may notice that meteorologists measure heat and cold differently outside of the United States. For example, a TV weatherman in San Diego may forecast a high of 89°, but a similar forecaster in Tijuana, Mexico —which is only 20 miles south— may look at the same weather pattern and say that the day's high temperature is going to be 32°. What's going on here?

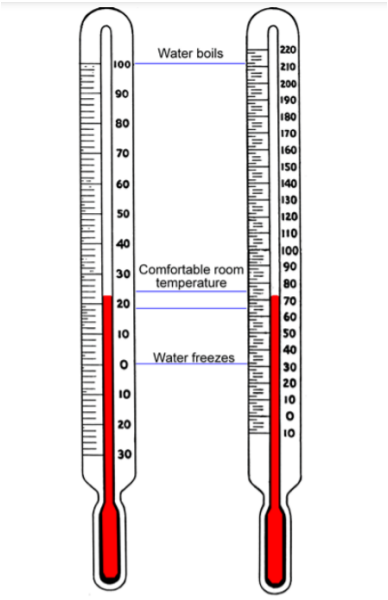
The difference is that the two countries use different temperature scales. In the United States, temperatures are usually measured using the **Fahrenheit** scale, while most countries that use the metric system use the **Celsius** scale to record temperatures. Learning about the different scales— including how to convert between them—will help you figure out what the weather is going to be like, no matter which country you find yourself in.

Measuring Temperature on Two Scales

Temperature

Temperature is used to describe the level of heat or cold of an object or environment.

Fahrenheit and Celsius are two different scales for measuring temperature.

A thermometer measuring a temperature of 22° Celsius is shown here.		A thermometer measuring a temperature of 72° Fahrenheit is shown here.
On the Celsius scale, water freezes at 0° and boils at 100°.		On the Fahrenheit scale, water freezes at 32° and boils at 212°.
If the United States were to adopt the Celsius scale, forecast temperatures would rarely go below -30° or above 45°. (A temperature of -18° may be forecast for a cold winter day in Michigan, while a temperature of 43° may be predicted for a hot summer day in Arizona.)		In the United States, forecast temperatures measured in Fahrenheit rarely go below -20° or above 120°. (A temperature of 0° may be forecast for a cold winter day in Michigan, while a temperature of 110° may be predicted for a hot summer day in Arizona.)
Most office buildings maintain an indoor temperature between 18°C and 24°C to keep employees comfortable.		Most office buildings maintain an indoor temperature between 65°F and 75°F to keep employees comfortable.

Try It 1.3.1

A cook puts a thermometer into a pot of water to see how hot it is. The thermometer reads 132°, but the water is not boiling yet. Which temperature scale is the thermometer measuring?

Answer

The thermometer is using Fahrenheit. Water boils at 212° on the Fahrenheit scale, so a measurement of 132° on a Fahrenheit scale is legitimate for hot (but non-boiling) water.

Converting Between the Scales

By looking at the two thermometers shown, you can make some general comparisons between the scales. For example, many people tend to be comfortable in outdoor temperatures between 50°F and 80°F (or between 10°C and 25°C). If a meteorologist predicts an average temperature of 0°C (or 32°F), then it is a safe bet that you will need a winter jacket.

Sometimes, it is necessary to convert a Celsius measurement to its exact Fahrenheit measurement or vice versa. For example, what if you want to know the temperature of your child in Fahrenheit, and the only thermometer you have measures temperature in Celsius measurement? Converting temperature between the systems is a straightforward process as long as you use the formulas provided below.

Temperature Conversion Formulas

To convert a Fahrenheit measurement to a Celsius measurement, use this formula.

$$C = \frac{5}{9}(F - 32) \tag{1.3.1}$$

To convert a Celsius measurement to a Fahrenheit measurement, use this formula.

$$F = \frac{9}{5}C + 32 \tag{1.3.2}$$

How were these formulas developed? They came from comparing the two scales. Since the freezing point is 0° in the Celsius scale and 32° on the Fahrenheit scale, we subtract 32 when converting from Fahrenheit to Celsius, and add 32 when converting from Celsius to Fahrenheit.

There is a reason for the fractions $\frac{5}{9}$ and $\frac{9}{5}$, also. There are 100 degrees between the freezing (0°) and boiling points (100°) of water on the Celsius scale and 180 degrees between the similar points (32° and 212°) on the Fahrenheit scale. Writing these two scales as a ratio, $\frac{F^\circ}{C^\circ}$, gives $\frac{180^\circ}{100^\circ} = \frac{180^\circ \div 20}{100^\circ \div 20} = \frac{9}{5}$. If you flip the ratio to be $\frac{C^\circ}{F^\circ}$, you get $\frac{100^\circ}{180^\circ} = \frac{100^\circ \div 20}{180^\circ \div 20} = \frac{5}{9}$. Notice how these fractions are used in the conversion formulas.

The example below illustrates the conversion of Celsius temperature to Fahrenheit temperature, using the boiling point of water, which is 100° C.

Example 1.3.1

The boiling point of water is 100°C. What temperature does water boil at in the Fahrenheit scale?

Solution

A Celsius temperature is given. To convert it to the Fahrenheit scale, use Equation 1.3.2.

$$F = \frac{9}{5}C + 32$$

Substitute 100 for C and multiply.

$$F = \frac{9}{5}(100) + 32$$

$$F = \frac{900}{5} + 32$$

Simplify $\frac{900}{5}$ by dividing numerator and denominator by 5.

$$F = \frac{900 \div 5}{5 \div 5} + 32$$

$$F = \frac{180}{1} + 32$$

Add 180 + 32.

$$F = 212$$

Answer: The boiling point of water is 212°F.

Example 1.3.2

Water freezes at 32°F. On the Celsius scale, what temperature is this?

Solution

A Fahrenheit temperature is given. To convert it to the Celsius scale, use Equation 1.3.1.

$$C = \frac{5}{9}(F - 32)$$

Substitute 32 for F and subtract.

$$C = \frac{5}{9}(32 - 32)$$

Any number multiplied by 0 is 0

$$C = \frac{5}{9}(0)$$

$$C = 0$$

Answer: The freezing point of water is 0°C.

The two previous problems used the conversion formulas to verify some temperature conversions that were discussed earlier—the boiling and freezing points of water. The next example shows how these formulas can be used to solve a real-world problem using different temperature scales.

Example 1.3.3

Two scientists are doing an experiment designed to identify the boiling point of an unknown liquid (remember different liquids have different boiling point). One scientist gets a result of 120°C; the other gets a result of 250°F. Which temperature is higher and by how much?

Solution

One temperature is given in °C, and the other is given in °F. To find the difference between them, we need to measure them on the same scale.

What is the difference between 120°C and 250°F?

Use the conversion formula to convert 120°C to °F. (You could convert 250°F to °C instead; this is explained in the text after this example.)

$$F = \frac{9}{5}C + 32$$

Substitute 120 for C.

$$F = \frac{9}{5}(120) + 32$$

Multiply.

$$F = \frac{1080}{5} + 32$$

Simplify $\frac{1080}{5}$ by dividing numerator and denominator by 5.

$$F = \frac{1080 \div 5}{5 \div 5} + 32$$

Add 216 + 32.

$$F = \frac{216}{1} + 32$$

You have found that 120°C = 248°F.

$$F = 248$$

To find the difference between 248°F and 250°F, subtract.

$$250^\circ F - 248^\circ F = 2^\circ F$$

Answer: 250°F is the higher temperature by 2°F

You could have converted 250°F to °C instead, and then found the difference in the two measurements. (Had you done it this way, you would have found that 250°F = 121.1°C, and that 121.1°C is 1.1°C higher than 120°C.) Whichever way you choose, it is important to compare the temperature measurements within the same scale, and to apply the conversion formulas accurately.

Try It 1.3.2

Tatiana is researching vacation destinations, and she sees that the average summer temperature in Barcelona, Spain is around 26°C. What is the average temperature in degrees Fahrenheit?

Answer

Tatiana can find the Fahrenheit equivalent by solving the equation $F = \frac{9}{5}(26) + 32$. The result is 78.8° Fahrenheit, which rounds to 79° Fahrenheit.

Time

Time

Time is used to describe the amount of existence between events.

Time is universal--everyone uses the same measurements of time. Some of the common units (along with their abbreviations) for time are listed in the following table.

Unit Conversion Table
1 minute (min) = 60 seconds (sec)
1 hour (hr) = 60 minutes
1 day (da) = 24 hours
1 week (wk) = 7 days
1 year (yr)= 52 weeks

Example 1.3.4

Convert 2,016 hr to weeks.

Solution

Looking in the unit conversion table under *time*, we see that $1\text{ wk} = 7\text{ da}$ and that $1\text{ da} = 24\text{ hr}$. To convert from hours to weeks, we must first convert from hours to days and then from days to weeks. We need two unit fractions.

The unit fraction needed for converting from hours to days is $\frac{1\text{ da}}{24\text{ hr}}$. The unit fraction needed for converting from days to weeks is $\frac{1\text{ wk}}{7\text{ da}}$.

$$\begin{aligned} 2{,}016\text{ hr} &= \frac{2{,}016\text{ hr}}{1} \cdot \frac{1\text{ da}}{24\text{ hr}} \cdot \frac{1\text{ wk}}{7\text{ da}} && \text{Divide out common units.} \\ &= \frac{2{,}016\ \cancel{\text{hr}}}{1} \cdot \frac{1\ \cancel{\text{da}}}{24\ \cancel{\text{hr}}} \cdot \frac{1\text{ wk}}{7\ \cancel{\text{da}}} \\ &= \frac{2{,}016 \cdot 1\text{ wk}}{24 \cdot 7} && \text{Simplify} \\ &= 12\text{ wk} \end{aligned}$$

Thus, $2{,}016\text{ hr} = 12\text{ wk}$.

Try It 1.3.3

Your employer tracks your accumulated vacation time in hours. You want to take a two week vacation and have accumulated 412 hours of paid time off. Do you have enough hours for your vacation?

Answer

To solve this we need to covert 412 hours to weeks.

The unit fraction needed for converting from hours to days is $\frac{1\text{ da}}{24\text{ hr}}$. The unit fraction needed for converting from days to weeks is $\frac{1\text{ wk}}{7\text{ da}}$.

$$\begin{aligned} 412\text{ hr} &= \frac{412\text{ hr}}{1} \cdot \frac{1\text{ da}}{24\text{ hr}} \cdot \frac{1\text{ wk}}{7\text{ da}} && \text{Divide out common units.} \\ &= \frac{412\ \cancel{\text{hr}}}{1} \cdot \frac{1\ \cancel{\text{da}}}{24\ \cancel{\text{hr}}} \cdot \frac{1\text{ wk}}{7\ \cancel{\text{da}}} \\ &= \frac{412 \cdot 1\text{ wk}}{24 \cdot 7} && \text{Simplify} \\ &= 2.5\text{ wk} \end{aligned}$$

Thus, $412\text{ hr} = 2.5\text{ wk}$.

Yes, you have enough time for a 2.5 week vacation.

Try It 1.3.4

According to the Global Web Index Survey, the average US resident between 16-64 years of age spent 144 minutes per day on social media in 2021. How many days is that per year? Assume the year has 365 days.

Answer

To solve this we need to multiply 144 minutes per day by 365 days to get the total minutes per year.

$144 * 365 = 52{,}560$minutes for the whole year.

The unit fraction needed for converting from minutes to hours is $\frac{1\text{ hr}}{60\text{ min}}$. The unit fraction needed for converting from hours to days is $\frac{1\text{ da}}{24\text{ hr}}$.

$$
\begin{aligned}
52,560\ \text{min} &= \frac{52,560\ \text{min}}{1} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{da}}{24\ \text{hr}} && \text{Divide out common units.} \\
&= \frac{52,560\ \cancel{\text{min}}}{1} \cdot \frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}} \cdot \frac{1\ \text{da}}{24\ \cancel{\text{hr}}} \\
&= \frac{52,560 \cdot 1\ \text{da}}{60 \cdot 24} && \text{Simplify} \\
&= 36.5\ \text{wk}
\end{aligned}
$$

Thus, $52{,}560\ \text{min} = 36.5\ \text{da}$

The average American spends 36.5 days a year on social media.

Summary

Temperature is often measured in one of two scales: the Celsius scale and the Fahrenheit scale. A Celsius thermometer will measure the boiling point of water at 100° and its freezing point at 0°; a Fahrenheit thermometer will measure the same events at 212° for the boiling point of water and 32° as its freezing point. You can use conversion formulas to convert a measurement made in one scale to the other scale. Time is universal and is measured in seconds, minutes, hours, days, weeks and years.
