

# Section 2

## Matters of Scale

In this section, students explore the concept of scale and the relationships between scales. The “big idea” of this section is for students to recognize the value of a scale with common reference points and regular intervals to which numbers are assigned as a means for measuring and comparing temperatures.

After familiarizing themselves with temperatures in Celsius and Fahrenheit, students construct a qualitative rank ordering based on subjective measures of temperature generated by the class. Students also construct their own temperature scale using fixed points for reference. They use e-mail to share their temperature scales with their partner class.

Next, students examine the relationship between the Fahrenheit and Celsius scales, initially making estimates about the formula for conversion and then determining the actual formula. They use a spreadsheet application to test their formulas.

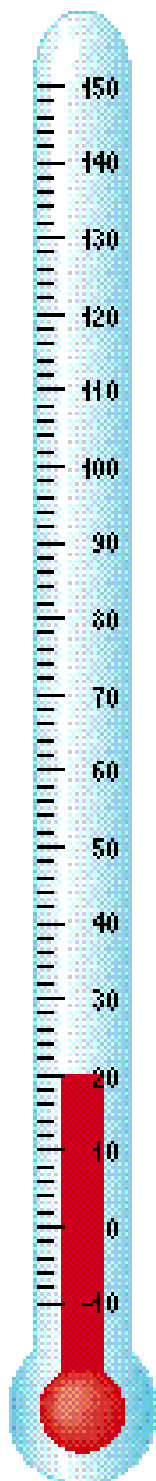
Finally, students compare temperatures in Celsius and Fahrenheit with readings on their own scales and develop rules for making conversions.

**DRAFT**



# Reading Celsius and Fahrenheit Scales

How do Fahrenheit temperatures compare with Celsius temperatures? This activity will help students begin to get a feel for the relationship between the two scales and give them practice in reading temperatures on both scales.



## math goals

- Students learn to read Celsius and Fahrenheit thermometers with intervals representing 1 and 2 degrees, respectively.
- Students match Fahrenheit and Celsius temperatures.
- Students explore signed numbers as a way to represent temperatures above and below zero.
- Students add and subtract signed numbers (integers).
- Students look for patterns and discuss rules.

## ongoing assessment

This activity offers several occasions to assess students' ability to read temperature scales accurately.

1. [Reproducible Masters 5](#) through [7](#) will test students' understanding of how to determine numeric intervals on a scale.
2. [Reproducible Master 8](#) will demonstrate how accurately students can record and match Fahrenheit and Celsius temperatures.
3. The student activity explained in [Background Information](#) will allow you to assess students' abilities to add and subtract signed numbers.

## advance preparation

Make 10 copies of [Reproducible Master 6](#) (Celsius Thermometer) and 10 copies of [Reproducible Master 7](#) (Fahrenheit Thermometer). The thermometers should be colored as explained in the [Background Information](#) section and posted around the room.

### materials

- overhead from [Reproducible Master 5](#) (Comparing Fahrenheit with Celsius)
- 1 copy of [Reproducible Master 8](#) (Matching Temperatures) for each student
- 1 copy of [Reproducible Master 9](#) (What's the Temperature?) for each student
- 1 Fahrenheit–Celsius thermometer for each group

## what students do

1. Students practice finding temperatures on a Fahrenheit scale and relating them to Celsius temperatures.

Using an overhead projector and a transparency of [Reproducible Master 5](#) (Comparing Fahrenheit with Celsius), ask volunteers to show on the Fahrenheit scale an appropriate temperature for each of the following (students may not use any temperature that is a multiple of 10):

- warm enough to swim outside
- cold enough to see breath
- too cold for shorts
- too hot for a sweater
- good for ice skating outdoors

After students name and point to the Fahrenheit temperature, ask them to read the corresponding Celsius temperature. Invite students to suggest other temperatures, and continue the activity until you are satisfied that students understand how to read both scales.

2. Individually or in pairs, students read each of the 20 paper thermometers and record the temperatures on their copy of [Reproducible Master 8](#) (Matching Temperatures).

Check to see that students have correctly read the temperatures. Resolve any disagreements through discussion.

3. Using [Reproducible Master 8](#) (Matching Temperatures), students match each Fahrenheit to a Celsius temperature and write the matching pairs at the bottom of the page.

Check the correctness of students' matches and discuss the strategies they used. Some

## Teachers' Teacher A

There were both fringe benefits and surprises for me when students began to keep records of temperatures in the classroom. Some students who had only digital clocks at home had to learn to read the analog clock on our wall so that they could record the time the temperature was taken. I noticed several students helping others learn to read “the big hand” and “the little hand.”

Students disagreed surprisingly often about the temperature readings, because some of them counted each mark on the Fahrenheit scale as 1 degree when it actually was 2 degrees. I had not expected them to have so much trouble with this, and I found they really benefited from the practice they got by taking readings several times each day.

To give them extra practice, I put thermometers around the room—some in ice water, one in hot water, one near the window, one in the fish tank, and so on. I had students read the thermometers and record their readings in both Celsius and Fahrenheit.

# Stories .....

## Teacher B

My students had no previous experience working with positive and negative numbers. I used [Reproducible Master 9](#) (What's the Temperature?) as an introduction to writing equations with positive and negative numbers. The students used the number line (the thermometer) to solve the problems. Then we went back through the equations and looked for patterns in the way the students solved them.

*On December 25, 1995, the highest U.S. temperature was 86 in Honolulu, Hawaii. The lowest U.S. temperature was 108 degrees lower, in West Yellowstone, Montana. What was the temperature in West Yellowstone?*

$$86 - 108 = ?$$

For example, for the first problem students found 86 on the thermometer (number line). Then they counted down 108 degrees on the thermometer and landed on  $-22$ . Later, when we looked at the equation, I asked them to think about how they might solve this without using the number line. Many students noticed that since it is subtraction, we are trying to find the difference: 22. Since the larger number is being taken away, the result is negative:  $-22$  degrees.

I felt students were now ready to solve equations using colored chips to represent positive and negative numbers. We spent some class time and a lot of homework time on this over the next several weeks.

students, for example, may simply put both scales' temperatures in ascending order; others may match 0 degrees Celsius to 32 degrees Fahrenheit and work upward and downward from there; and still others may refer to the overhead transparency or to an actual thermometer.

- Without referring to their reproducible masters or thermometers, students vote on the reasonableness of various events when the temperature is given in degrees Celsius.

Ask students: Is it reasonable to

- go swimming at the beach at 30 degrees Celsius?
- water a garden at 26 degrees Celsius?
- wear a wool scarf at 11 degrees Celsius?
- turn on a heater at 40 degrees Celsius?
- go snowboarding at 21 degrees Celsius?
- turn on an air conditioner at 32 degrees Celsius?

- Students begin to take daily classroom temperature readings.

Direct students, in groups, to place their thermometer in a spot in the room where they expect to find considerable variation in room temperature. Encourage the groups to devise a process whereby group members read and record the temperature at the same time each day. (Students can, if feasible, take the temperature more than once each day; later in the unit, they will graph the temperature in different ways to discern patterns of change.)

- The class carries out the signed number exercise on [Reproducible Master 9](#), described at the end of this activity.

## background information

### Setting Up the Activity

Color the paper thermometers ([Reproducible Masters 6](#) and [7](#)) to show the following temperatures (equivalent temperatures on the two scales are shown side by side):

°Fahrenheit	°Celsius
28.5	-2
91.5	33
55.5	13
96	35.5
69	20.5
50	10
5	-15
60	15.5
95	35
32	0

Post the thermometers around the room at random (do not put matching temperatures side by side).

### Reading Temperature Scales

At first, some students may have difficulty reading scales when the intervals are greater than 1 degree. Ample opportunities for practice, especially when students have plenty of occasions to verify readings by working with a partner, will accustom students to paying attention to different scales.

In this way, students become alerted to common errors that occur in taking readings. It is important for students to realize that errors easily creep into any data collection process, and that they must always be on guard to catch as many as they can.

## student activity

A thermometer is a useful image for helping students understand the addition and subtraction of signed numbers.

Challenge students to find the new temperature when you give them a starting temperature and tell them how many degrees and in what direction (up or down) the temperature changed.

For example:

$$-30 + 2 = -28$$

It was 30 below until it warmed up 2 degrees. Then it was 28 below.

$$-20 - 5 = -25$$

It was 20 below. When it got 5 degrees colder, the thermometer read 25 below 0.

$$7 - 17 = -10$$

It started out at 7 degrees. Then the temperature dropped 17 degrees and the thermometer read 10 below zero.

The questions on [Reproducible Master 9](#) (What's the Temperature?) provide further practice in working with signed numbers. To extend this exercise, use your Internet browser to access the *USA Today* Weather Index at the following:

<http://www.usatoday.com/leadpage/indexusa.htm#wdex>

It has links to high and low temperature data that can be used to construct additional problems reflecting the most recent weather. Some students may want to explore and analyze these differences as part of a final project.

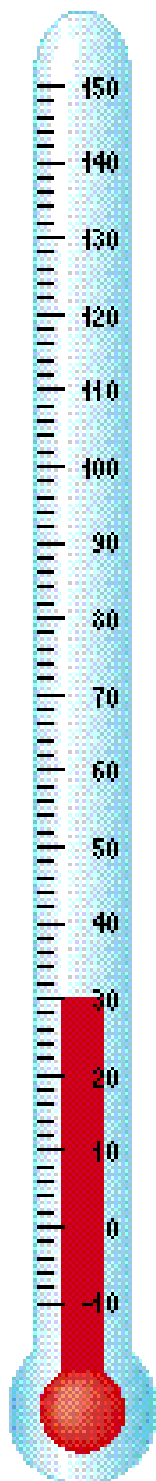
**DRAFT**





# Make Your Own Temperature Scale

How were the temperature scales we now use created? In this activity, students make their own quantitative temperature scale using fixed reference points. Students then rank qualitative statements about temperature from hottest to coldest. They compare the relative temperature differences between personal experiences such as “I put on a sweater” and “I go swimming” and place their statements onto their scales.



## math goals

- Students list statements that are measured by temperature, and rank order them.
- Students review how Fahrenheit and Celsius created their temperature scales.
- Students make and calibrate their own temperature scales by identifying fixed reference points.
- Students find differences and use other operations.
- Students measure distances and divide them into equal intervals.
- Students assign temperatures to events.

## ongoing assessment

Students’ work in this activity will provide you with information about their understanding of how a scale is constructed, as well as how numbers on a scale relate to students’ own physical perceptions and associations.

## advance preparation

### materials

[Reproducible Master 10](#) (Make Your Own Scale)

## what students do

1. Students work in groups to generate a list of statements that describe different temperatures.

Examples of statements might include the following:

- I need to sleep under a blanket
- We turn on the heat in our house
- We run through the water sprinkler
- “I need to wear a sweater.

Make a class list of as many of students’ ideas as possible.

2. Each student rank orders the class list of qualitative temperature statements.

Ask students to save their lists so that they can share them with their partner class.

3. Students discuss the differences in their ordering of similar statements.

Ask students: Are there statements that can be put in many places on the scale? If, for example, students choose “Ice cream drips down my cone” as a statement, help them see that ice cream melts at any temperature above freezing but might melt faster at a hotter temperature, and thus the statement can be put in different places. Be sure to ask students to explain their reasoning and tell their classmates what the temperature of the statement is on their own scale.

4. Students discuss Gabriel Fahrenheit and Anders Celsius and the temperature scales they created.

See [Background Information](#) for more about Fahrenheit and Celsius. Ask students how these two scientists created their scales.

## Teachers'

### Teacher A

My kids were very excited to make their own scales like the famous scientists did. Some students chose really wild numbers as the numbers they added to their scales. BreeAnn thought that the day and year of her birthday would make perfect numbers for the scale. She chose 13 (for the thirteenth of October) as her low point (the freezing point of water) and 1986 as the top end of her scale (body temperature). She created 12 intervals, making the task of determining the size of the interval difficult  $[(1986-13)/12]$ . She found out pretty quickly that this made her task very hard and she chose a new set of numbers!

### Teacher B

Students came up with a lot of ideas to describe a range of outdoor temperatures:

Your dog starts to pant.	You don't want to go outside.
You can see your breath.	The tar on the street bubbles.
You need to put on a sweater.	The car won't start.
You can't dig a hole in the ground.	Grass turns brown.
You open all the car windows.	The street looks like it has sky in it.
You can fry an egg on the sidewalk.	Ice cream drips down your cone.
You sleep without any covers.	Snow melts when it hits the ground.

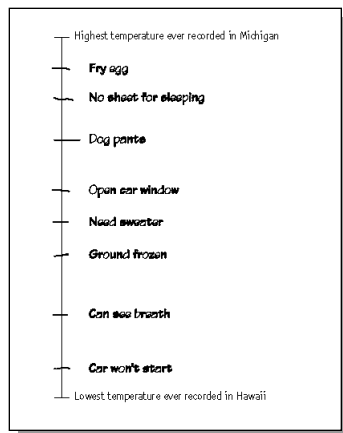
We talked about which ones to keep. We wanted to have a good range, so we chose “You can fry an egg on the sidewalk” as the hottest and “The car won’t start” as the

## Stories .....

coldest. Because some students didn't have dogs, we decided to change the statement to "Dogs start to pant." We also went with "You need to put on a sweater," "Snow melts when it hits the ground," and "You open all the car windows," because we thought these statements represented a good range of temperatures. Students rejected "You don't want to go outside" and "Grass turns brown" because they could be interpreted as either very hot or very cold. I enjoyed watching the class work together to make such good decisions.

## Teacher C

An example from my class is shown below:



I was surprised to see that students found so many ways to order these eight statements. Yet students each had a good reason for doing it the way they did. Students also personalized their scales with several of their own statements, and so we ended up with quite a variety to look at and discuss.

Students should recognize that both of them chose certain fixed points around which they created their scales.

Ask students: Are any of the temperature statements that the class listed useful for making a temperature scale? Help students realize that the qualitative temperature statements they ranked would not suffice to define a scale, because they do not refer to any one fixed point in temperature.

5. Students use [Reproducible Master 10 \(Make Your Own Scale\)](#) to create their own temperature scale.

Explain to students that they can assign any numbers they choose to the high and low marks on the scale. They then mark equal intervals between the two points, using rulers. (See [Background Information](#) for more about [Reproducible Master 10](#).)

Discuss with students how to determine the size of their intervals. Students should divide the difference between their high and low temperature points by the number of intervals they have marked to determine the size (in degrees) of each interval. They may find they need to adjust the numbers on their scales (as Fahrenheit did) to make the intervals whole numbers.

6. Students name their scales.

Students might decide to imitate Fahrenheit and Celsius by naming their scales after themselves, or students might come up with an entirely fanciful name. Remind them that they should refer to temperatures on their personal scales in the following manner: "29 degrees Keishon."

7. Students apply qualitative temperature statements from the list made earlier to their personal temperature scales.

## background information

### The Development of Thermometers and Temperature Scales

The historical highlights in the development of thermometers and their scales given here are based on “Temperature,” by T. J. Quinn, and “Heat,” by James M. Cork.

One of the first attempts to make a standard temperature scale occurred about 170 AD, when Galen, in his medical writings, proposed a standard “neutral” temperature composed of equal quantities of boiling water and ice; on either side of this temperature were 4 degrees of heat and 4 degrees of cold, respectively.

The earliest devices used to measure temperature were called thermoscopes. These consisted of a glass bulb having a long tube extending downward into a container of colored water, although supposedly Galileo, in 1610, used wine. Some of the air in the bulb was expelled before placing it in the liquid, causing the liquid to rise into the tube. As the remaining air in the bulb was heated or cooled, the level of the liquid in the tube would vary, reflecting the change in the air temperature. An engraved scale on the tube allowed for a quantitative measure of the fluctuations.

The air in the bulb is referred to as the *thermometric medium*—that is, the medium whose property changes with temperature. In 1641, the first sealed thermometer that used liquid rather than air as the thermometric medium was developed for Ferdinand II, grand duke of Tuscany. His thermometer used a sealed alcohol-in-glass device, with 50 “degree” marks on its stem but no “fixed point” used to zero the scale. These were referred to as spirit thermometers.

Robert Hook, curator of the Royal Society, in 1664 used a red dye in the alcohol. His scale, for which every degree represented an equal increment of volume equivalent to about  $1/500$  part of the volume of the thermometer liquid, needed only one fixed point. He selected the freezing point of water. By scaling it in this way, Hook showed that a standard scale could be established for thermometers of various sizes. Hook’s original thermometer became known as the standard of Gresham College and was used by the Royal Society until 1709. (The first intelligible meteorological records used this scale.)

In 1702, the astronomer Ole Roemer of Copenhagen based his scale upon *two* fixed points: snow (or crushed ice) and the boiling point of water. With this thermometer, Roemer recorded the daily temperatures at Copenhagen in 1708–1709.

It was in 1724 that Gabriel Fahrenheit, an instrument maker of Daanzig and Amsterdam, used mercury as the thermometric liquid. Mercury's thermal expansion is large and fairly uniform, it does not adhere to the glass, and it remains a liquid over a wide range of temperatures. Its silvery appearance makes it easy to read.

Fahrenheit described how he calibrated the scale of his mercury thermometer:

Placing the thermometer in a mixture of salt ammoniac or sea salt, ice, and water a point on the scale will be found which is denoted as zero. A second point is obtained if the same mixture is used without salt. Denote this position as 30. A third point, designated as 96, is obtained if the thermometer is placed in the mouth so as to acquire the heat of a healthy man. (D. G. Fahrenheit, *Phil. Trans. [London]* 33, 78, 1724)

On this scale, Fahrenheit measured the boiling point of water to be 212. Later he adjusted the freezing point of water to 32 so that the interval between the boiling and freezing points of water could be represented by the more rational number 180. Temperatures measured on this scale are designated *degrees Fahrenheit*.

In 1745, Carolus Linnaeus of Upsula, Sweden, described a scale in which the freezing point of water was zero and the boiling point 100, making it a centigrade (100-step) scale. Anders Celsius (1701–1744) used the reverse scale, in which 100 represented the freezing point and zero the boiling point of water, still, of course, with 100 degrees between the two defining points. In 1948, the term *degrees centigrade* was dropped for this scale and replaced by *degrees Celsius*. Temperatures measured on a centigrade scale, with the freezing point of water as zero, are designated *degrees Celsius*.

## Comparing Relative Temperatures

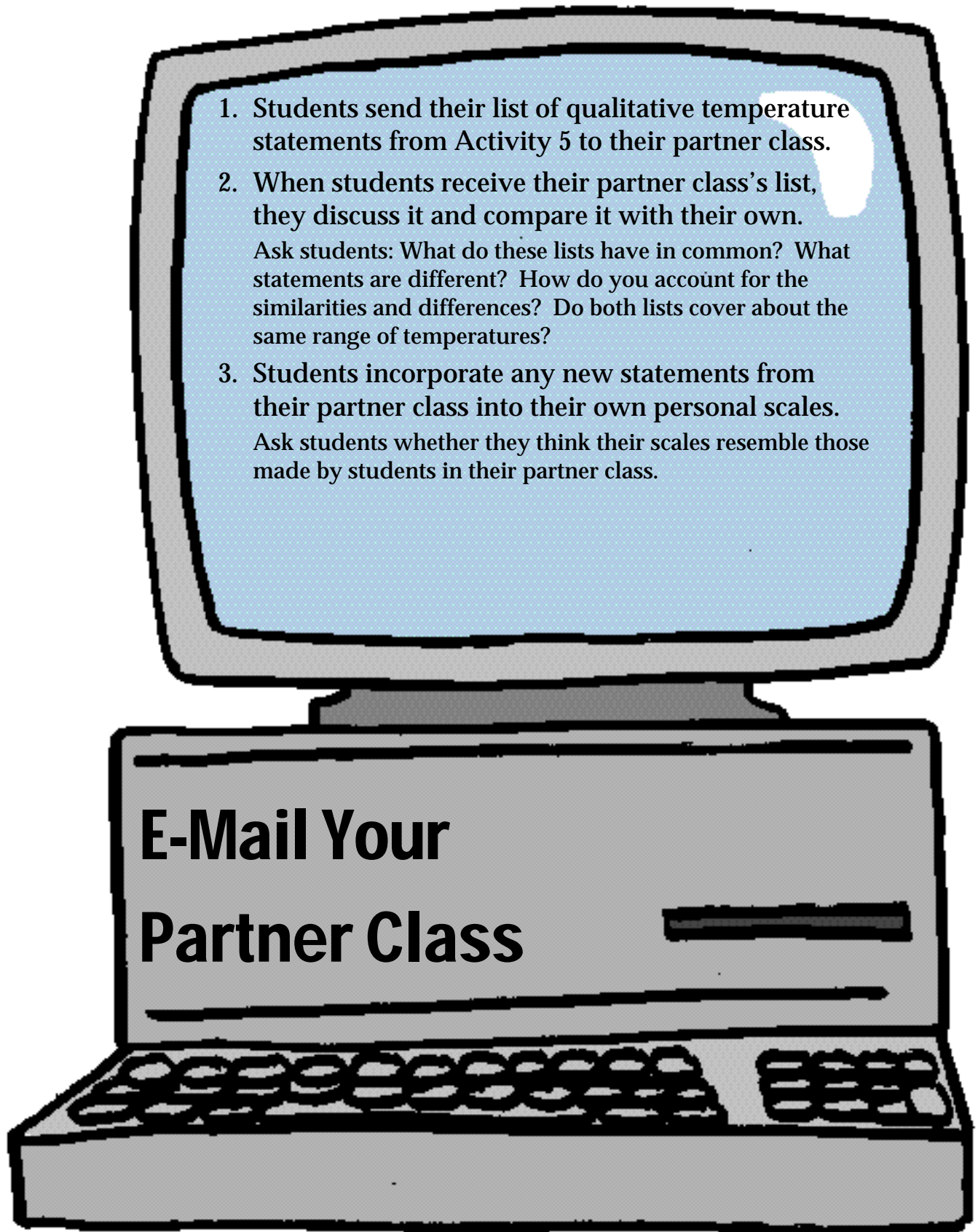
Until about 300 years ago, nobody had used numbers to measure temperature differences. Before then, a person could say, for example, that today is warmer than yesterday, but no one could say for sure exactly how much warmer. In this activity, students develop their own ways to describe changes in temperature without using numbers. Focus their attention on the relative values of the qualitative measures they generate and how these relate to the hottest and coldest outdoor temperatures students have experienced. These maximum and minimum temperatures serve as benchmarks, like the boiling and freezing points of water on conventional scales. Students will discover in Activity 6 that these two points are useful benchmarks for converting between any two scales.

## Personal Scales

This activity provides students with a simple way to go through the scientific process of making a scale. Ask students to imagine that someone took a tube of mercury to Hawaii on the coldest day ever and marked it to show how high the mercury reached. Also, the same tube was taken to Michigan on the warmest day ever, and another mark was made to show the highest point the mercury reached on that day. [Reproducible Master 10](#) (Make Your Own Scale) shows the distance between those two points. Now, like Mr. Fahrenheit and Mr. Celsius, each student can choose any number at all for those two points as well as decide how many intervals to have in between. In this way, students will produce a variety of scales that are equally valid as measuring instruments. By comparing the scales they make, students can see that the size of a degree varies according to the range of numbers assigned to the two reference points.

## Reproducible Master 10

The length of the segment between the two points on [Reproducible Master 10](#) is 6.25 inches, which corresponds to 16 degrees Fahrenheit per inch (the highest recorded temperature in Michigan is 112 degrees Fahrenheit, which occurred on July 13, 1936, and the lowest temperature ever recorded in Hawaii is 12 degrees Fahrenheit, which occurred on May 17, 1979). Students can choose to mark their intervals in a variety of ways: 5 intervals of 1.25 inches, 25 .25-inch intervals, 50 .125-inch intervals, and so on.



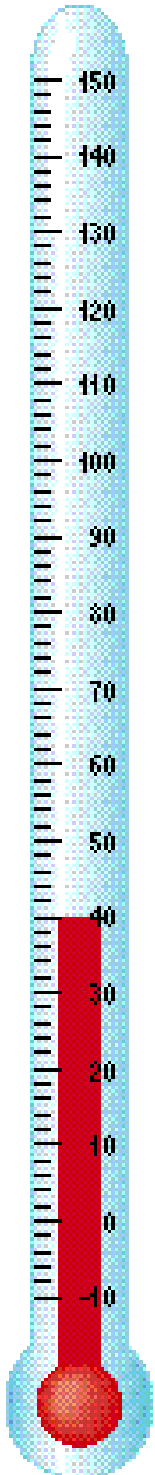
**DRAFT**





# Making a Rule to Convert Between Fahrenheit and Celsius

How does the Celsius scale compare with the Fahrenheit scale? In this activity, students make graphs of the linear equation of the two scales. They hypothesize about the formula for conversion between scales and determine the actual numerical formula for conversion. Using a spreadsheet application, they test the formula they have determined.



## math goals

- Students identify and describe mathematically significant patterns in data sets.
- Students use ratios to describe the relationship between two scales.
- Students graph number pairs on a coordinate system.
- Students discuss properties of their graph, such as slope and intercepts.
- Students use the slope of the line to informally develop and describe a rule for converting between Fahrenheit and Celsius scales.
- Students translate an informal rule into a formula using a spreadsheet.
- Students create spreadsheets for converting between Celsius and Fahrenheit and describe the rule.

## ongoing assessment

As students do the spreadsheet activities, you will be able to observe their problem-solving strategies and their ability to use the spreadsheet to check their rules. To obtain a record of their work, have students print their spreadsheet each time they fill up a page with test formulas.

## advance preparation

Make an overhead transparency of graph paper with axes, as on page 50.

### materials

spreadsheet (ClarisWorks, Data Wonder, Excel)

graph paper

1 copy of [Reproducible Masters 11](#) and [12](#) (What's the Relationship?) for each student

## what students do

1. In pairs, students do the spreadsheet exercise described on pages 51 and 52 ([Reproducible Masters 11](#) and [12](#)).

They look for patterns in the relationship between temperatures shown on two thermometers and start to develop a formula for converting from one scale to the other.

2. Students are introduced to a coordinate system for representing the relationship between Fahrenheit and Celsius.

On the graph paper transparency, draw a horizontal line 10 blocks down from the top. Mark intervals along this line to represent Fahrenheit degrees between  $-40$  and  $50$ . At  $0$  Fahrenheit, draw an intersecting perpendicular line to represent Celsius degrees, with  $0$  Celsius at the point of intersection.

Show students how to plot pairs of Fahrenheit and Celsius temperatures, using these whole number coordinates:  $(-40, -40)$ ,  $(-31, -35)$ ,  $(-22, -30)$ ,  $(-13, -25)$ ,  $(-4, -20)$ ,  $(5, -15)$ ,  $(14, -10)$ ,  $(23, -5)$ ,  $(32, 0)$ ,  $(41, 5)$ , and  $(50, 10)$ .

Challenge students to spot a pattern in the plotted points. When students notice the straight line, draw it on the transparency.

Help students notice the step pattern consisting of 5 grid squares Celsius to every 9 grid squares Fahrenheit. Start at one of the points you plotted and count 9 squares horizontally and 5 vertically to arrive at the next plotted point.

Introduce the concept of a ratio by explaining that since there are 5 Celsius degrees for every 9 Fahrenheit degrees, the ratio of Celsius to Fahrenheit is 5:9. For

## Teachers' Teacher A

I was pleased with the way students became engrossed in the spreadsheet activity. We went to the computer lab and students worked in pairs to enter Fahrenheit temperatures. Even students who lacked a good sense of how the two temperature scales relate were, by the end of the period, making formulas that approximated the Fahrenheit-to-Celsius conversion. Many students began with a simple subtraction ( $C = F - 32$ ) and moved on to more sophisticated formulas [ $C = F - 32 * 1/2$  and  $C = F - 32 * (5/9)$ ]. Initially, most of their efforts were trial and error, but as time went on, they were able to use the results of their conversions to better hone their formulas.

# Stories .....

## Teacher B

I introduced my students to the coordinate graph by starting to graph temperatures. I drew two axes and asked students to help me to label them. They chose to label the  $x$ -axis as degrees Fahrenheit and the  $y$ -axis as degrees Celsius.

Then we determined the scale we would use. Most students suggested that each box on the graph paper should represent 1 degree, because they felt it would be too hard to place the intermediate points otherwise.

I asked students to call out some ordered pairs and graphed them. Then I asked individual students to come up to the overhead and mark other points.

While those students were marking points, I asked the others whether they noticed a pattern appearing. It was not long before students recognized that the graph was going to be a straight diagonal line. When each student had marked a point, we connected all of the points and saw that the graph was indeed a straight line.

Then we practiced using the graph to convert between Fahrenheit and Celsius. Here are some of the equations I asked students to solve:

$$10^{\circ}\text{F} = \underline{\quad}^{\circ}\text{C}$$

$$10^{\circ}\text{C} = \underline{\quad}^{\circ}\text{F}$$

$$80^{\circ}\text{F} = \underline{\quad}^{\circ}\text{C}$$

$$50^{\circ}\text{F} = \underline{\quad}^{\circ}\text{C}$$

every 5 degrees of change in a Celsius temperature, the Fahrenheit temperature changes 9 degrees; for every 1 degree of change in Celsius, the change in Fahrenheit is  $\frac{9}{5}$  (or 1 and  $\frac{4}{5}$ )—nearly 2 degrees. Conversely, the ratio of Fahrenheit to Celsius is 9:5. For every 1 degree change in Fahrenheit, the corresponding change in Celsius is  $\frac{5}{9}$  of a degree—a little more than one-half.

3. Students use the line to find other pairs of temperatures and check their results by looking at a dual-scale thermometer.
4. Students develop a formula for converting between Fahrenheit and Celsius. They use a spreadsheet to test their formula.

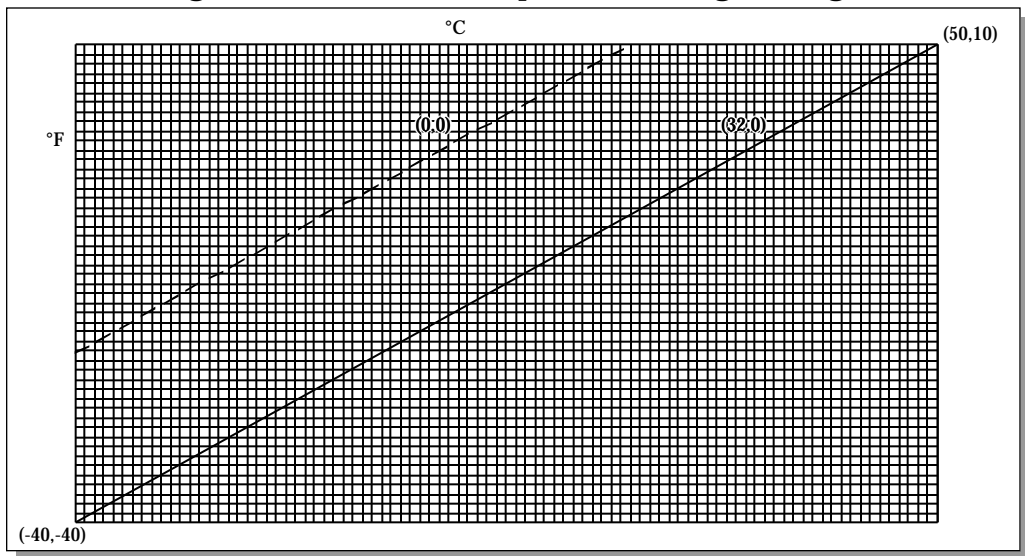
It may take a bit of work, but students now have all the tools necessary to figure out the formula. Help them to remember both that the Fahrenheit scale adds 32 degrees to the Celsius scale and that each Fahrenheit degree corresponds to a fraction of a Celsius degree. Encourage students to explain the formula in statements like the following: “You have to take 32 away from the Fahrenheit temperature. Then you multiply the number by  $\frac{5}{9}$  to get the Celsius temperature.” The formula works out to be  $C = (F - 32) * \frac{5}{9}$  which can be translated into the spreadsheet formula  $= (A1 - 32) * \frac{5}{9}$ . This formula, if entered in cell B1, will convert any Fahrenheit temperature entered in cell A1 and display it in cell B1.

5. Students find rules for converting between their own scales and either Fahrenheit or Celsius.

## background information

### Graphing the Linear Equation of Degrees Fahrenheit vs. Degrees Celsius

This graph of the linear equation shows the *relationship* of degrees Fahrenheit to degrees Celsius. Students can use the graph to determine the ratio of degrees Fahrenheit to degrees Celsius by choosing a point where Fahrenheit and Celsius intersect at a pair of whole numbers and then another point where they intersect. Using this information, students can determine that for every 5 degrees the Celsius temperature changes, the Fahrenheit temperature changes 9 degrees.



### Ratios

A ratio is a relationship between two quantities of the same measure. Usually, ratios are used to describe parts of a whole collection (e.g., the ratio of one make of car to all of the makes of cars in the parking lot). Ratios are usually expressed in fractional form ( $\frac{3}{52}$  Ford) or using colon notation (3:52 Ford).

Technically speaking, the relationship of degrees Fahrenheit to degrees Celsius is not a perfect ratio, because the scales do not intersect at zero. Nevertheless, as shown with the linear equation graph above, 9 degrees Fahrenheit is equivalent to 5 degrees Celsius. In other words, for every nine units of change on the X-axis, there is a corresponding five units of change on the Y-axis.

## Spreadsheets

Spreadsheets are an advantage to students because they accurately perform a series of calculations that would be tedious for students to carry out. They also serve as a record of the results of the calculations.

Students use a spreadsheet application to test their rules for converting from Fahrenheit to Celsius and from Celsius to Fahrenheit. They test their rules by inputting the rule into a cell and then testing the conversion for many numbers. For example, most spreadsheets use a system of letters and numbers in order to reference other cells in the “worksheet.” The columns are referred to with letters and the rows with numbers. To input a formula, select a cell by clicking on it and type an =. This lets the program know that you are inputting a formula. The formula should be typed with normal arithmetic symbols. Order of operations is followed during calculation. The following formula in Cell B1 would take the number typed into Cell A1 and convert it into a Celsius temperature:

$$=(A1 - 32) \div 9*5$$

If your students need practice developing both their spreadsheet skills and their ideas about formulas, you might want to present them with the Spreadsheet Student Activity detailed in the next section.

## Spreadsheet Student Activity

This activity provides students with some experience working with simple functional relationships on spreadsheets. The activity is designed to be used prior to work on Activity 6 in which students work with the more complex functional relationship between the Fahrenheit and Celsius scales.

On [Reproducible Masters 11](#) and [12](#) (What’s the Relationship?), students encounter four inaccurate thermometers. The temperature readings of each faulty thermometer can be described as a function of the temperature reading of the accurate thermometer. That is, the relationship between the inaccurate thermometer and the accurate one is always the same.

In advance of the activity, you will need to set up four spreadsheet templates—one for each problem from [Reproducible Masters 11](#) and [12](#).

## Section 2: Matters of Scale

1. The first new thermometer always reads  $7^{\circ}\text{F}$  more than the classroom thermometer. So, the spreadsheet template might look like this:

	A	B
1	Classroom	New #1
2		$A2 + 7$

2. The second new thermometer always reads  $12^{\circ}\text{C}$  less than the classroom thermometer. The formula for the new thermometer is  $A2 - 12$ .
3. The third new thermometer always reads 3 times the Fahrenheit temperature reading on the classroom thermometer. The formula for the new thermometer is  $A2 * 3$ .
4. The fourth new thermometer always reads 2 times plus 10 the Celsius reading on the classroom thermometer. The formula for the new thermometer is  $2 * A2 + 10$ .

The formula (or relationship) should be hidden from students. One way to do this is to “hide” it in a cell at the very bottom of the spreadsheet.

## Converting Between Fahrenheit and Celsius

Using the ratio of degrees Fahrenheit to degrees Celsius and the linear equation, students should be able to get an idea of the approximate rule for conversion. It might help students to shift the linear equation over so that the line goes through the point 0,0. In this case, students will probably find it less difficult to express the rule. Once they are able to define the conversions as being  $F = \frac{9}{5} * C$  and  $C = \frac{5}{9} * F$ , ask them how they can alter the formula to make the line go through the point 32,0. They should be able to recognize that adding 32 to the result of  $\frac{9}{5} * C$  will shift the line. The Celsius to Fahrenheit conversion is a bit tougher, as 32 must be subtracted from the Fahrenheit temperature *before* it is multiplied by  $\frac{5}{9}$ .

# Section 2 Assessment

Students use the [Section 2 Quiz](#), found at the end of the collection of Reproducible Masters, for this assessment.

## Assessment Goals

The items in this assessment test students' ability to read scales and describe relationships between them. To perform well on this assessment, students must be able to

- read temperature scales accurately,
- determine numeric intervals for two different scales,
- add and subtract signed numbers,
- record and match temperatures in two different scales, and
- express relationships between two scales in words or in mathematical expressions.

## Answer Key

- Scale A ranges from 0 to 1,000 in intervals of 50 degrees; Scale B ranges from -1,000 to 1,000 in intervals of 100 degrees.
- 2a. 800. 2b. 600.
- 3a. 800. 3b. 900.
- 4a. 1,000. 4b. 2,000.
- 5a. 1 degree in Scale A. 5b. It is twice as big as one degree in Scale B.
6. 50, 100; 100, 50.
- 7a. Answers appear in boldface:

Scale A	Scale B
1,000	1,000
<b>850</b>	700
775	<b>550</b>
<b>725</b>	450
700	<b>400</b>
500	<b>0</b>
<b>450</b>	-100
250	-500
<b>0</b>	-1,000

- 7b. Answers will vary.
8.  $A = B \div 2 + 500$ ;  $B = 2 * A - 1,000$ ; students may describe either or both processes in words.

**[Go to  
Section 3](#)**

**DRAFT**