# How Long Has This Been Left?

## Topic

Study of the rate of temperature loss

## Introduction

An object that cannot maintain its own temperature (e.g., a dead body, a hot beverage, an ice cube) will gradually become the same temperature as its surroundings. The rate at which a warm object cools to the same temperature as its surroundings (and the rate at which a cold objects warms to the same temperature as its surroundings) depends on the difference in the two temperatures – the temperature gradient. When a person dies, he no longer generates heat, and his temperature begins to drop to that of the surroundings. Forensic examiners, therefore, can use the temperature of the body, together with the temperature of the surroundings, to judge the time of death (within certain limits). More mundane objects also follow the same pattern of heat loss and, in the first part of this experiment, you will study the rate at which a cup containing a hot beverage loses heat in two places with at least a 10°C difference in temperature. In the second part of the experiment, you will use your data on the rate of heat loss at a particular location to help you calculate the time since your teacher poured boiling water into a cup in this location.

## Time required

Part A: about 2 hours
Part B: 15 minutes (plus preparation time for the teacher)

## Materials

*For Part A:*
2 small cups or mugs (capacity 150 – 200 ml)
200 ml boiling water
2 thermometers (–10°C to 110°C)
2 sheets of graph paper
2 pencils
2 watches or clocks with second hand

*For Part B:*
cup or mug (similar to the ones used in Part A) containing boiling water
thermometer (–10°C to 110°C)
watch showing the correct time (synchronize with your teacher or supervisor)
pencil
30 cm ruler

## Safety note

**Be careful with hot liquids.**

## Procedure

You will need a partner for this experiment. Your teacher has an important role to play in Part B.

*Part A: Temperature gradients*

1. Select two places (X and Y) with different ambient temperatures. Place X should be about 10°C warmer than place Y.
2. Decide who is going to take the temperature readings in place X (person X) and who is going to take them in place Y (person Y). Make two copies of data table A on the next page (one each). (If you do not have a partner, you could repeat the readings in the other location.)
3. Person X takes the temperature of place X and enters the reading in data table A on the next page for room temperature at this location. Person Y does the same for place Y.
4. Person X pours 100 ml boiling water into the cup at place X, places the thermometer in the water, and enters the thermometer reading in data table A for time 0. Person Y does the same at place Y.
5. Person X takes the temperature of the water every minute for the first 10 minutes, every 5 minutes for the next 40 minutes, and every 10 minutes thereafter. Person X enters the readings in data table A. Person Y does the same at place Y.
6. Combine your results on one copy of data table A. Use your readings to plot graphs of temperature against time for places X and Y. An example graph is shown in diagram 1 on page 6.01–4.

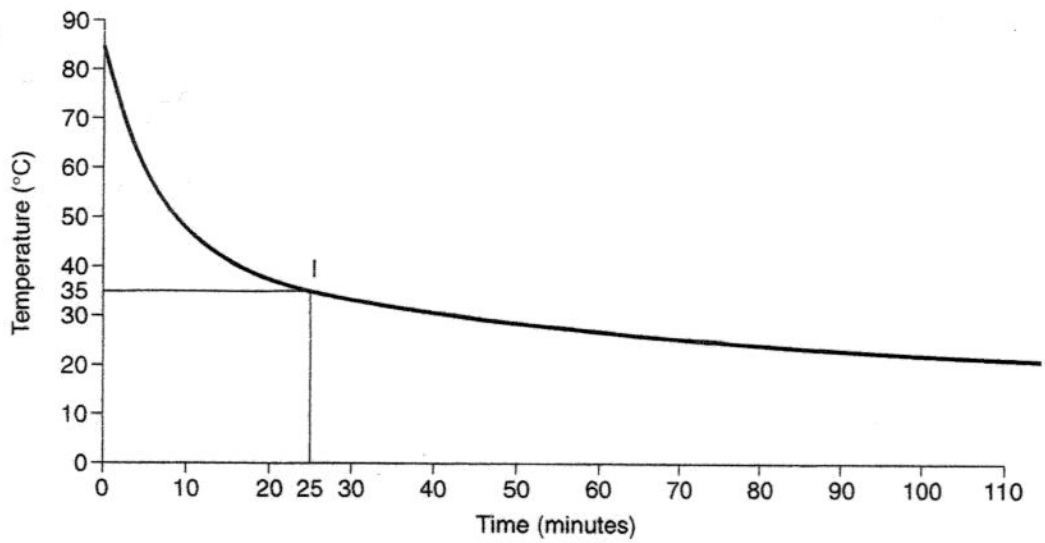
*Part B: Discover how long since the drink was made*

The teacher should pour boiling water into the cup or mug, noting the time ($T_0$) at which he did this. The teacher then places the cup in either location X or location Y.

1. Look in locations X and Y to find the cup.
2. Use the thermometer to take the temperature of the water in the cup. Record the time at which you take the reading. Enter the temperature and time ($T_1$) in data table B on page 6.01–4.
3. Using the graph from Part A for the location of the cup, find the point on the vertical axis of the graph represented by the temperature of the water from data table B. Draw a horizontal line linking this point to the line of the graph (point I in diagram 1 on page 6.01–4).
4. Draw a vertical line from point I to the horizontal axis of the graph. The point at which this line touches the horizontal axis gives the number of minutes since the water was poured. Enter this value (T) in data table B.
5. Ask your teacher what time ($T_0$) he poured the water into the cup. Enter this value in data table B.
6. Calculate the number of minutes between $T_1$ and $T_0$. Enter this value in data table B.

## DATA TABLE A

| Location X | | Location Y | |
|---|---|---|---|
| Room temperature ..... °C | | Room temperature ..... °C | |
| Time (minutes) | Temperature (°C) | Time (minutes) | Temperature (°C) |
| 0 | | 0 | |
| 1 | | 1 | |
| 2 | | 2 | |
| 3 | | 3 | |
| 4 | | 4 | |
| 5 | | 5 | |
| 6 | | 6 | |
| 7 | | 7 | |
| 8 | | 8 | |
| 9 | | 9 | |
| 10 | | 10 | |
| 15 | | 15 | |
| 20 | | 20 | |
| 25 | | 25 | |
| 30 | | 30 | |
| 35 | | 35 | |
| 40 | | 40 | |
| 45 | | 45 | |
| 50 | | 50 | |
| 60 | | 60 | |
| 70 | | 70 | |
| 80 | | 80 | |
| 90 | | 90 | |
| 100 | | 100 | |
| 110 | | 110 | |
| 120 | | 120 | |




*Example of graph of temperature versus time*

| DATA TABLE B | |
|---|---|
| Location of cup (X or Y) | |
| Temperature | ..... °C |
| Time at which temperature of the water taken ($T_1$) | |
| Time at which teacher poured the water ($T_0$) | |
| $T_1 - T_0$ | ..... minutes |
| Time measured from graph (T) | ..... minutes |

## Analysis

*Part A: Temperature gradients*

1. What can you say about the graphs drawn using data from the two locations?
2. Which graph demonstrates more rapid cooling?

*Part B: Discover how long since the drink was made*

1. Was the number of minutes measured from the graph the same as the number of minutes that had actually elapsed since the teacher poured the hot water?

## Want to know more?

See Section 10: Our Findings