

Timing the Spread: Dye, Temperature and the Shape of the Curve

Learning target: I can organize, graph and calculate with spreading-time data, describe the shape of the relationship between temperature and spreading, and explain it with the average motion of particles.

Data and graphing

About 45 min

Individual

MS-PS1-4 · practice

MS-PS3-4 · supports

data analysis

independent practice

writing

Name

Date

Period

Directions

Part A gives a class's results from timing how long one drop of dye takes to spread evenly through still water at six temperatures. You will calculate means, decide what to do with an unusual trial, graph the means and describe the shape of the graph. Part B gives results from a second test in which the water could not flow at all. Show every calculation. Round means to the nearest whole minute.

You will need: This worksheet, Pencil, Ruler, Calculator (optional)

Part A: Dye in still water

A class filled tall 250 mL graduated cylinders with 200 mL of water at six temperatures (the teacher prepared and poured all the water), let each cylinder sit until the water was still, and added one drop of blue food dye to the center without stirring. They recorded the time until the color looked even from top to bottom against a white card. Each temperature was tested three times with fresh water.

Time for one drop of dye to spread evenly in a tall cylinder of still water (200 mL) (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

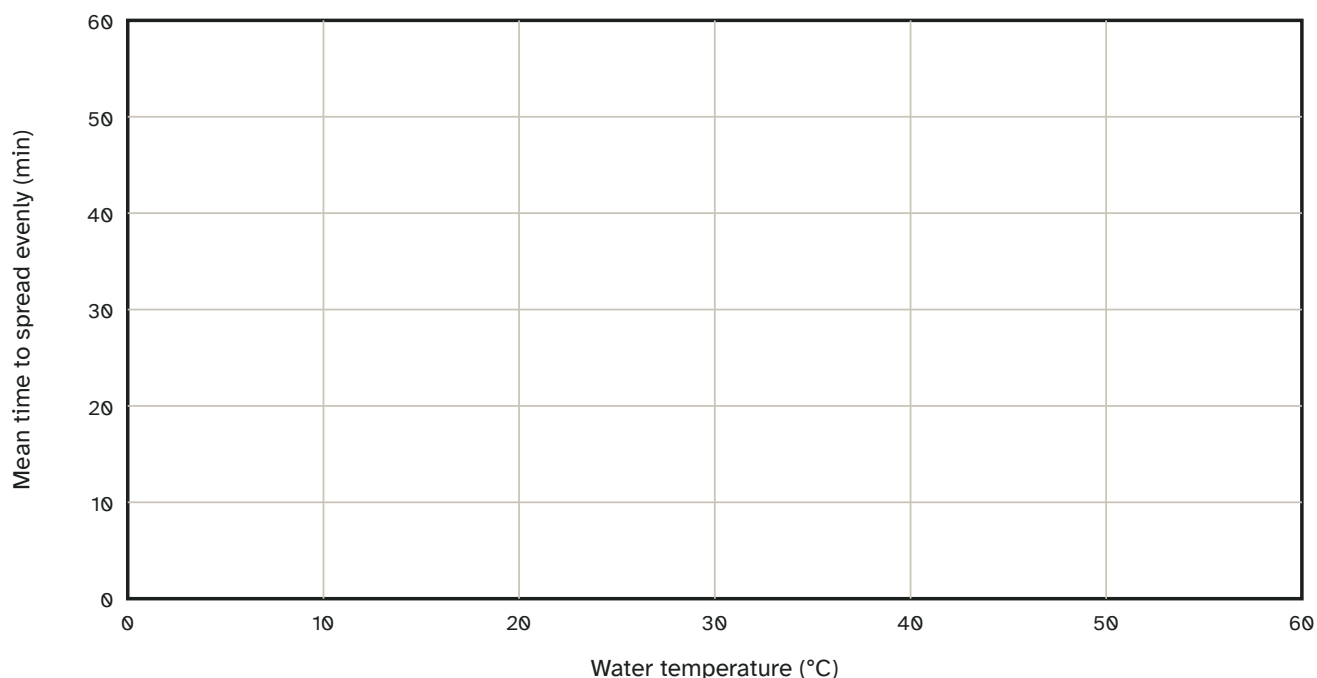
Water temperature (°C)	Trial 1 (min)	Trial 2 (min)	Trial 3 (min)	Mean (min)
5	58	55	55	
15	41	38	41	
25	30	33	30	
35	26	24	12*	
45	21	22	20	
55	18	19	20	

A teaching dataset; the times are realistic for this setup but were not measured in a real class. *During trial 3 at 35 °C, a student bumped the table two minutes after the drop.

1. Calculate the mean time for each temperature and write it in the last column of the table. Show your calculation for 5 °C here.

2. Should trial 3 at 35 °C be included in the mean? Explain your decision using what bumping the table would do to the water, and write the mean you used.

Mean spreading time at each water temperature



3. Describe the shape of your graph in one or two sentences. Is it a straight line? Where is it steepest?

4. By how many minutes did the mean time drop between 5 °C and 15 °C? Between 45 °C and 55 °C? Show both subtractions.

5. How many times longer did the dye take to spread at 5 °C than at 55 °C? Show the division and round to one decimal place.

6. Use your graph to estimate the mean spreading time at 30 °C. Mark the point on your graph.

7. A student notices the time drops about 2 minutes for each 10 °C near 50 °C and predicts: 'At 95 °C the dye will take about 11 minutes, and at 150 °C it will spread in 0 minutes.' Give **two** reasons this prediction does not hold up.

Part B: Dye in a gel

Some of the spreading in a cylinder comes from gentle currents in the water. To remove them, a researcher used dishes of agar gel, a firm jelly that is almost entirely water but cannot flow. She placed one drop of dye on each dish, making a colored spot 5 mm across, covered the dishes, and kept them at four temperatures. After 6 hours she measured the width of the colored circle.

Width of the colored circle in agar gel after 6 hours (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Gel temperature (°C)	Width of colored circle after 6 hours (mm)
5	14
20	17
35	19
50	22

A teaching dataset; the widths are realistic for a food dye in agar but were not measured in a real lab. Every spot started 5 mm across.

8. How many millimeters wider than the starting 5 mm spot did the circle become at 5 °C, and at 50 °C? About how many times as much did it widen at 50 °C as at 5 °C?

9. Why did the researcher use a gel instead of plain water? What does Part B show that Part A by itself could not?

10. Write a claim that answers: **How does water temperature affect how fast dye spreads, and why?** Support it with at least two numbers from Part A and one from Part B, and explain the pattern using the motion of particles. Use the words *on average* and *diffusion*.

Steps for a mean

To find a mean, add the trials and divide by how many you added. For 15 °C: $41 + 38 + 41 = 120$, and $120 \div 3 = 40$ minutes. If you leave out a trial, divide by the number of trials you kept. For the graph, put each temperature on the bottom axis and go straight up to the mean time; check your points by reading them back off the axes.

Is it the particles or the stickiness?

Warm water is also less 'sticky' than cold water: it flows more easily. Scientists say its viscosity is lower. Both faster particles and lower viscosity help dye spread faster in warm water. Design a test that could show whether temperature still matters when stickiness is held the same, for example by comparing water with a liquid that is thicker at the same temperature. Say what you would keep the same, what you would change, what you would measure, and what result would show that particle speed matters on its own.