

# Does It Break Down, and Is It Worth It? Two Cup Datasets

**Learning target:** I can graph and calculate from data about how fast different cup materials break down and how much energy they use per use, and I can explain what the numbers do and do not tell us about which material is better.

Data and graphing

About 45 min

Individual

MS-PS1-3 · practice

MS-ETS1-3 · practice

data analysis

independent practice

Name

Date

Period

Directions

Both datasets on this sheet are teaching datasets: the numbers were invented to be realistic, not measured in a real test. Part A asks you to graph and interpret breakdown data. Part B asks you to compare single-use and reusable cups by the energy each one takes. Show every calculation, write units on every number, and when a question asks what the data do not tell you, be specific.

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

## Part A: How fast does each cup break down?

A materials lab put identical-sized cups of three materials into an industrial composter kept at 58 °C, moist, with air moving through it. A fourth sample, a PLA cup, was buried in a sealed bin of dry soil at 20 °C with no air flow to imitate a landfill. Every 30 days a cup was removed, cleaned and weighed. The table shows the percent of the starting mass that remained.

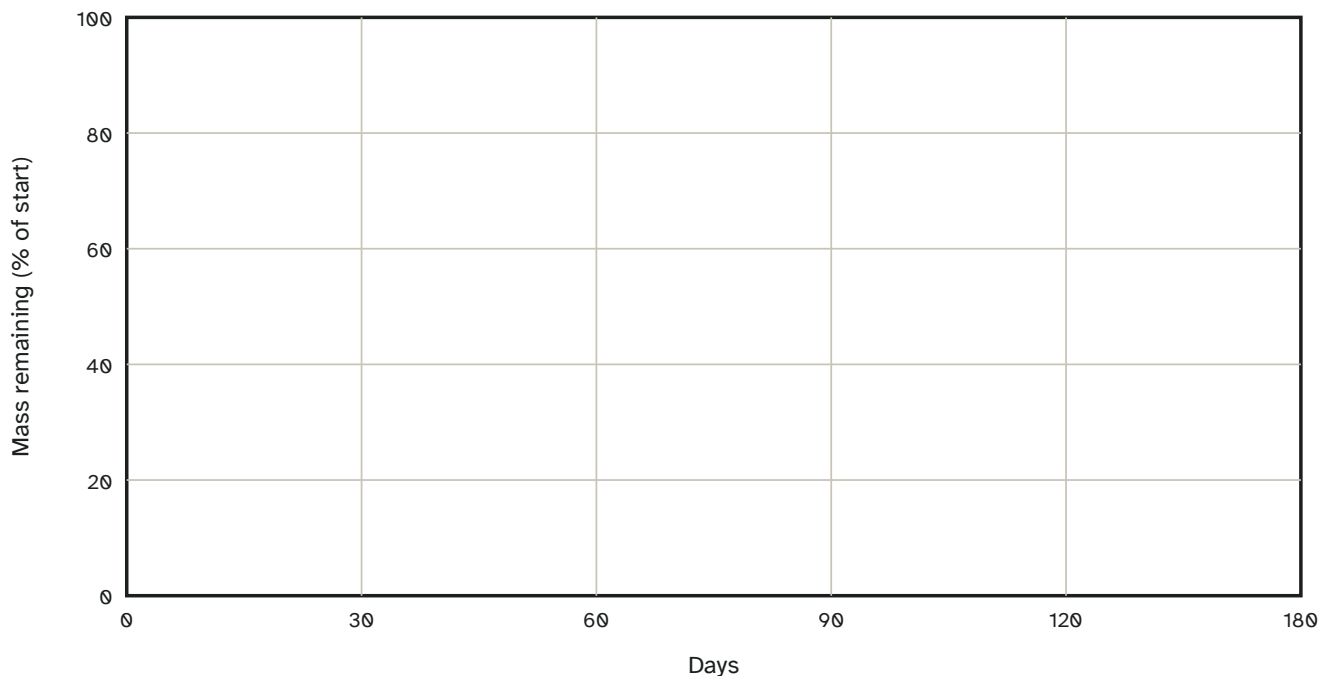
### Percent of starting mass remaining (teaching dataset)

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

| Day | Paper cup, composter (%) | PLA cup, composter (%) | PET cup, composter (%) | PLA cup, landfill bin (%) |
|-----|--------------------------|------------------------|------------------------|---------------------------|
| 0   | 100                      | 100                    | 100                    | 100                       |
| 30  | 62                       | 88                     | 100                    | 99                        |
| 60  | 31                       | 61                     | 99                     | 99                        |
| 90  | 12                       | 34                     | 99                     | 98                        |
| 120 | 4                        | 15                     | 99                     | 98                        |
| 180 | 1                        | 6                      | 99                     | 97                        |

Simulated data for teaching. The pattern matches published findings: paper and PLA break down in hot industrial compost over weeks to months; PET does not; PLA in a cool, dry, airless landfill barely changes.

## Mass remaining versus days



1. Calculate the percent of mass the PLA cup in the composter lost by day 90 and by day 180. Show your work.

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2. Find the average rate of mass loss, in percent per day, for the PLA cup in the composter between day 30 and day 90. Then find the same rate for the paper cup. Which broke down faster during that interval?

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3. Describe the shape of each of the four lines on your graph in one phrase each. Which two lines are nearly flat, and what does a flat line mean here?

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4. The PLA cup in the landfill bin lost 3 percent of its mass in 180 days. If it kept losing mass at that same rate, how many days would it take to lose all 100 percent? Convert your answer to years. Then give one reason the real answer might be even longer.

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5. A cup maker's advertisement says its PLA cups are 'biodegradable.' Using numbers from two different columns, explain what that word does and does not promise. Then explain what one fact about a town would decide whether switching from PET to PLA cups would reduce the cups sitting in its landfill.

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Part B: Single-use or reusable? Counting energy per use

The same lab estimated how much energy it takes to make one cup of each kind, from the natural resource to the finished cup, and how much energy one wash in a dishwasher uses. A single-use cup is used once. A reusable cup is used many times and washed after each use. Energy is given in megajoules (MJ); one megajoule is roughly the energy in a small snack bar.

Energy to make and to wash one cup (teaching dataset)

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

| Cup                              | Natural resource       | Energy to make one cup (MJ) | Energy per wash (MJ) |
|----------------------------------|------------------------|-----------------------------|----------------------|
| Single-use PET                   | petroleum              | 0.5                         | not washed           |
| Single-use PLA                   | corn                   | 0.6                         | not washed           |
| Reusable polypropylene (plastic) | petroleum              | 15                          | 0.1                  |
| Reusable stainless steel         | iron and chromium ores | 30                          | 0.1                  |

Simulated values chosen to be realistic in size and order; a real life-cycle study would also count water, transport and what happens at the end.

6. Complete the table with the total energy, in MJ, for each number of uses. For single-use cups, every use is a new cup. For reusable cups, count the cup once plus one wash per use. Show one full calculation below the table.

| 10 uses                                          | 50 uses | 100 uses |
|--------------------------------------------------|---------|----------|
| Single-use PET (0.5 MJ per cup)                  |         |          |
| Reusable polypropylene (15 MJ + 0.1 MJ per wash) |         |          |
| Reusable steel (30 MJ + 0.1 MJ per wash)         |         |          |

7. The break-even point is the number of uses at which a reusable cup has used the same total energy as the same number of single-use PET cups. Calculate the break-even number of uses for the polypropylene cup and for the steel cup. Show your work. (Hint: each use of a reusable cup saves 0.5 MJ on a new PET cup but costs 0.1 MJ for a wash.)

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8. A student buys a reusable polypropylene cup, uses it 20 times, and loses it. Calculate the energy used by that cup and by 20 single-use PET cups. Which choice used less energy, and what does that say about when 'reusable' is actually better?

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9. Suppose a school has to choose between the PLA cup and the steel cup for its cafeteria. List two things the energy dataset tells you and two important things it does not tell you. Then explain why someone who only looked at Part A, or only at Part B, could reach the wrong decision.

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### Rates and break-even, step by step

A rate is a change divided by the time it took. For q2, subtract the later percent from the earlier percent, then divide by the number of days between them; the unit is percent per day. For q7, think of each use as a small contest: the reusable cup saves the 0.5 MJ that a new PET cup would have cost, but spends 0.1 MJ on a wash, so each use gains 0.4 MJ on the single-use option. Divide the energy it took to make the reusable cup by 0.4 MJ per use to find how many uses pay it back.

### The fuel in the tank

Nearly all gasoline sold in the United States is E10, about one tenth ethanol by volume. Real reference values, rounded: a liter of gasoline releases about 32 MJ when burned; a liter of ethanol releases about 21 MJ. Calculate the energy in one liter of E10 (0.9 L gasoline plus 0.1 L ethanol) and the percent less energy it carries than pure gasoline. Then write three sentences: what this means for how far a car goes on a tank, why that is not by itself a reason to reject ethanol, and what other information (land, water, the energy to grow and distill the corn) you would want before judging corn ethanol fairly.