



# Coffee Conundrum

## Exponential Decay

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<b>Grade Level</b>	11th Grade	<b>Time Frame</b>	2-3 class period(s)
<b>Subject</b>	Mathematics	<b>Duration</b>	150 minutes
<b>Course</b>	Algebra 2		

### Essential Question

How is exponential decay applicable to the real world?

### Summary

Students explore exponential functions by investigating exponential decay.

### Snapshot

#### Engage

Students quickly simulate an exponential decay function and discuss its properties.

#### Explore

Students investigate exponential decay using Newton's Law of Cooling.

#### Explain

Students share their results from the investigation.

#### Extend

Students research other uses of exponential decay.

#### Evaluate

Students present their findings and their solution to the Coffee Conundrum.

## Standards

*Oklahoma Academic Standards for Mathematics (Grades 9, 10, 11, 12)*

**A2.F.1.4:** Graph exponential and logarithmic functions. Identify asymptotes and x- and y-intercepts using various methods and tools that may include graphing calculators or other appropriate technology. Recognize exponential decay and growth graphically and algebraically.

## Attachments

- [Coffee Conundrum Handout.docx](#)
- [Coffee Conundrum Handout.pdf](#)
- [Lesson-Slides-Coffee-Conundrum.pptx](#)

## Materials

- Six-sided dice (one for each person)
- Coffee Conundrum Handout (attached)
- Writing utensils
- Classroom display for a computer of some kind
- Access to a graphing utility (Excel, GoogleSheets, etc.)

## Engage

Display for the students the question: If each of us rolled a six-sided die and had to sit out when we rolled a one, how many people would still be standing after five rounds? Allow students time to guess and justify their answers.

Conduct the experiment. Provide all but one student with a six-sided die. The student without one will record for the class. Then have everyone stand up. Everyone rolls their die, and if they roll a one, they sit down. The recorder should record how many people are still standing after each round. Take note of how many people are still standing after five rounds but continue until fewer than three students are standing.

While the recorder inputs the data into the graphing utility, ask the rest of the class for predictions. What will the graph look like?

After the data is inserted, note the shape of the graph. Compare it to what you have seen previously with exponential functions. Fit a line to the data and note its equation.

### Teacher's Note

A connection could be made here to exponent rules. Remember that anything with a negative exponent can move to the denominator to make the exponent positive. The base of the "exponential" part here (the part with the variable exponent) is less than one in this case, which is what it generally takes for an exponential function to decay.

The most well known application of exponential decay is probably the decay of radioactive elements, but we are going to investigate a more familiar concept today.

## Explore

Split students into groups of two or three. Provide each group with the "Coffee Conundrum Handout." Allow students time to work through the problem, providing assistance for students who struggle but not guiding them outright. Some good questions to ask might be:

- What do you think you need to do to solve the problem?
- Does your group agree?
- What have you tried so far?
- How did you get that?
- What is the goal of this question?

### Teacher's Note

Students should, in theory, use the information given to find the constant  $k$  for each thermal mug. Then, students can use a graphing utility (or their own calculations) to compare the three mugs. If students are not comfortable solving for  $k$  algebraically, encourage them to guess-and-check using a calculator or other tools.

## Explain

Students should be prepared to explain why they chose the mug they did in the handout. This explanation could be in any (reasonable) format. Allow each group to present their solution, and then ask the class to vote for one mug, based on these arguments.

## Extend

Using the Internet, student groups will research further applications of exponential decay and present their findings.

## Evaluate

Student presentations for the Coffee Conundrum could be used as an evaluation. Additionally, students may reflect on their new understanding of exponential functions using the strategy, [I Used to Think... But Now I Know](#).

## Resources

- I Used to Think . . . But Now I Know Instructional Strategy. K20 Center. (n.d.). Copyright 2015, Board of Regents of the University of Oklahoma. Retrieved from <https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f50639f2>