

Coffee and Corpses

Exponential Decay

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Grade Level	10th – 11th Grade	**Time Frame**	150 minutes
Subject	Mathematics	**Duration**	2-3 class periods
Course	Algebra 2		

Essential Question

How is exponential decay applicable to the real world?

Summary

Students explore exponential functions by investigating exponential decay. Students should already have an introduction to exponential equations before starting this lesson.

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 discuss the possible uses of exponential decay in everyday life.

Evaluate

Students research other uses of exponential decay.

Standards

ACT College and Career Readiness Standards - Mathematics (6-12)

F702: Build functions for relations that are exponential
F707: Exhibit knowledge of logarithms

Oklahoma Academic Standards Mathematics (Algebra 2)

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

Attachments

- Choice A—Coffee and Corpses - Spanish.docx
- Choice A—Coffee and Corpses - Spanish.pdf
- Choice A—Coffee and Corpses.docx
- Choice A—Coffee and Corpses.pdf
- Choice B—Coffee and Corpses - Spanish.docx
- Choice B—Coffee and Corpses - Spanish.pdf
- Choice B—Coffee and Corpses.docx
- Choice B—Coffee and Corpses.pdf
- Choice C—Coffee and Corpses - Spanish.docx
- Choice C—Coffee and Corpses - Spanish.pdf
- Choice C—Coffee and Corpses.docx
- Choice C—Coffee and Corpses.pdf
- Handout—Coffee and Corpses - Spanish.docx
- Handout—Coffee and Corpses - Spanish.pdf
- Handout—Coffee and Corpses.docx
- Handout—Coffee and Corpses.pdf
- Lesson Slides—Coffee and Corpses.pptx

Materials

- Lesson Slides
- Coffee and Corpses handout (attached; one per student)
- Choices A, B, and C documents (attached; one each to hang up in the classroom)
- Six-sided dice (one for each person)
- Writing utensils
- Classroom display for a computer of some kind
- Access to a graphing utility (graphing calculator, Desmos Studio, Excel, Google Sheets, etc.)
- Paper or personal white board

Engage

Teacher's Note: Preparation

Prior to the beginning of the lesson, print out the attached **Coffee and Corpses handout** for every student. This will be a handout they can refer back to throughout the lesson.

Use **Lesson Slides** to guide the lesson.

Show **slides 3–4** and review the essential question and lesson objective before beginning the activity.

Show **slide 5**. Using the Think-Pair-Share strategy, ask students to think about the following question on their own: *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?* Ask students to write their predictions on a piece of paper or personal white board.

Next, have students pair up with another student next to them to discuss their predictions.

After partner groups have had enough time to discuss their predictions, call on groups to share their predictions to the whole group and justify their answers.

Teacher's Note: Digital Dice

If you prefer students to use a digital version of dice for this activity, you can use the CPM Probability Generators and select the dice option.

Ask students to participate in the following experiment:

1. Provide all but one student with a six-sided die.
2. Ask the student without a die to record for the class.
3. Have everyone stand up.
4. Ask everyone to roll their die.
5. Tell the class that anyone who rolls a "one" must sit down.
6. Ask the Recorder to note how many people are still standing after each round.
7. Take note of how many people are still standing after five rounds.
8. Continue the activity until fewer than three students are standing.
9. While the recorder inputs the data into the graphing utility, ask the rest of the class for predictions.
10. Have them describe what they think the graph will look like.
11. After the data is inserted, note the shape of the graph.
12. Compare it to what you have seen previously with exponential functions.
13. 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 and greater than zero, which, in this case, means it is exponential decay.

Announce to students that while the most well-known application of exponential decay is probably the decay of radioactive elements, the class is going to investigate a more familiar concept.

Explore

Show **slide 6**. Split students into groups of two. Provide each student with the **Coffee and Corpses handout.**

Display **slide 7** and tell students to read the first paragraph of the **Coffee and Corpses handout** silently.

Instruct students to work through the problem with their partner. 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. Provide assistance to students who struggle with the concept but avoid giving them answers directly.

Explain

Teacher's Note: Voting

Print and hang the attached **Choices A, B, and C** documents around the room. Space the posters out so that students can move to their choice of mug for the coffee shop.

Show **slide 8**. Present the students with the following question: *Based on the information provided and your mathematical reasoning, which mug do you believe Moondoe's Coffee should buy and why?* Give students a couple minutes to wrap up their investigation and organize their thoughts and work. Students should be prepared to explain why they chose the mug they did. 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.

When the class votes, ask the students to physically move to the poster on the wall that labels their choice. Students should be prepared to explain why they made their choice.

Have students return to their seats then move through **slide 9 to 12** as you discuss the example with the students. At this point, dive a little deeper into what an exponential decay is, what it looks like, a general equation, and an example. What you put in the box will vary from teacher to teacher depending on what the students already know and what you are trying to demonstrate on this particular topic. In the example, try to include a real-world scenario because that will help lead them into the next activity.

Extend

Go to **slide 13**. Play the *K20 ICAP: Coffee and Corpses* video to introduce the death scene investigator. The death scene investigator will expand how the math of this lesson directly impacts his career. The professional will then give one example of exponential decay in real-life that has not already been mentioned in this lesson.

After the video is finished, move to **slide 14** to present the students with the following question: *How do employers use exponential decay in their everyday life and why is it important?* As a whole class discuss the question and the importance of understanding that math is used outside the four walls of a classroom.

Instruct students to use an electronic device to research further applications of exponential decay.

Teacher's Note: Gathering Research

Consider having students use instructional strategies such as the 5W Cube, Claim Evidence Reasoning (CER), or 3-2-1 to gather and organize their research.

Evaluate

Go to **side 15**. Have the students find a partner they have not worked with today. Instruct them to discuss and present the research they found about exponential decay and the importance of it. Once they have discussed their findings, they will use the strategy I Used to Think... But Now I Know to reflect on their learning and wrap up the lesson. Use already established classroom procedures for students to turn in their research.

Resources

- Brewer, L. A. (n.d.). Steaming hot coffee. [Digital Image]. Creative Commons. https://search.creativecommons.org/photos/44e1a23e
- Free Images Live. (n.d.). 1877 Lucky dice. [Digital Image]. Creative Commons. https://www.freeimageslive.co.uk/free_stock_image/luckydicejpg
- Giangrandi.Ch. (n.d.). Learn exponents online. [Virtual Image]. https://www.ixl.com/math
- K20 Center. (n.d.). 3-2-1. Strategies. https://learn.k20center.ou.edu/strategy/117
- K20 Center. (n.d.). 5W cube. Strategies. https://learn.k20center.ou.edu/strategy/81
- K20 Center. (n.d.). Claim, evidence, reasoning (CER). Strategies. https://learn.k20center.ou.edu/strategy/156
- K20 Center. (n.d.). CPM probability generators. Tech tools. https://learn.k20center.ou.edu/tech-tool/2317
- K20 Center. (n.d.). I used to think . . . but now I know. Strategies. https://learn.k20center.ou.edu/strategy/137
- K20 Center. (n.d.). Think-pair-share. Strategies. https://learn.k20center.ou.edu/strategy/139