

# Exponential Decay

Name: \_\_\_\_\_

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## Q Quick Review

**Exponential decay** multiplies by a factor between 0 and 1 each equal time period. The model is  $y = a(1 - r)^t$ , where  $a$  is the initial value and  $r$  is the decay rate. A 12% decay rate uses multiplier 0.88 because 88% remains. Half-life is a special decay model: if a quantity halves every  $h$  units, use  $y = a \left(\frac{1}{2}\right)^{t/h}$ .

## PRACTICE

Model or evaluate each exponential decay situation.

- A bike originally costs \$500 and loses 20% of its value in one year. What is its value after that year? \_\_\_\_\_
- A device has value 1000 and loses 5% during one period. What value remains? \_\_\_\_\_
- A computer depreciates by 15% each year. What multiplier should be used? \_\_\_\_\_
- A decay model uses multiplier 0.72. What percent decay rate does that represent? \_\_\_\_\_
- A sample starts at 80 grams and goes through two half-lives. How much remains? \_\_\_\_\_
- A medicine amount starts at 200 mg and halves twice. How much remains? \_\_\_\_\_
- A machine value is modeled by  $10000(0.9)^t$ . What is the value when  $t = 3$ ? \_\_\_\_\_
- A car value is modeled by  $V(t) = 30000(0.85)^t$ . Estimate  $V(4)$ . \_\_\_\_\_
- A phone starts at value 500 and depreciates by 18% each year. Write the decay model. \_\_\_\_\_
- A radioactive sample starts at 80 grams and has a half-life of 4 days. How much remains after 12 days? \_\_\_\_\_
- The model  $A(t) = 120(0.5)^t$  uses time in days. What is the half-life? \_\_\_\_\_
- The model  $A(t) = 120(0.5)^{t/6}$  uses time in hours. What is the half-life? \_\_\_\_\_
- A machine loses 5% of its value each year. What multiplier belongs in the yearly decay model? \_\_\_\_\_
- A sample starts at 640 grams and is multiplied by 0.5 each hour. How much remains after 3 hours? \_\_\_\_\_
- A car starts at value 900 and keeps 80% of its value each year. What is the value after 2 years? \_\_\_\_\_
- Is  $y = 50(0.93)^t$  an exponential growth model or an exponential decay model? \_\_\_\_\_
- A product loses 10% of its value each year. What fraction of the original value remains after  $t$  years? \_\_\_\_\_
- A model is  $A(t) = 200e^{-0.04t}$ . Does it represent exponential growth or decay? \_\_\_\_\_
- A substance decays by 40% each time period. What percent remains after one period? \_\_\_\_\_
- Can an exponential decay model with a positive starting value ever become negative? \_\_\_\_\_

## ◆ Word Problems

- A radioactive sample of 80 g has a half-life of 4 days. How much remains after 12 days?  
\_\_\_\_\_
- A car worth \$30,000 depreciates by 15% each year. Estimate its value after 4 years.  
\_\_\_\_\_
- A phone originally costs \$900 and loses 18% of its value each year. Estimate its value after 3 years.  
\_\_\_\_\_
- A medicine amount starts at 200 mg and halves every 5 hours. How much remains after 15 hours?  
\_\_\_\_\_



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## Answer Keys

- |                       |                        |
|-----------------------|------------------------|
| 1. \$400              | 13. 0.95               |
| 2. 950                | 14. 80                 |
| 3. 0.85               | 15. 576                |
| 4. 28%                | 16. decay              |
| 5. 20                 | 17. $0.9^t$            |
| 6. 50                 | 18. decay              |
| 7. 7290               | 19. 60%                |
| 8. $\approx \$15,660$ | 20. no                 |
| 9. $y = 500(0.82)^t$  | 21. 10 g               |
| 10. 10                | 22. $\approx \$15,660$ |
| 11. 1 day             | 23. $\approx \$496$    |
| 12. 6                 | 24. 25 mg              |

### Step-by-Step Tutor Notes

1. Losing 20% leaves 80% of the value, so use multiplier 0.80:  $500(0.80) = 400$ .
2. Focus on the main idea of the problem, then simplify carefully. A 5% loss leaves multiplier 0.95, so  $1000(0.95) = 950$ . So the answer is 950.
3. Work one inverse operation at a time and keep both sides balanced. Subtract the decay rate from 1:  $1 - 0.15 = 0.85$ . After simplifying, the answer is 0.85.
4. Compare the change in output to the change in input, because slope is a rate of change. The missing part is  $1 - 0.72 = 0.28$ , so the decay rate is 28%. So the requested value is 28%.
5. Use the clue in the question first, then let the arithmetic finish the job. Two half-lives leave one fourth of the original amount:  $80(0.5)^2 = 20$ . So the answer is 20.
6. Work one inverse operation at a time and keep both sides balanced. Halving twice means multiply by  $(\frac{1}{2})^2$ , so  $200(\frac{1}{2})^2 = 50$ . After simplifying, the answer is 50.
7. Move carefully through the arithmetic; one clean operation usually unlocks the next one. Multiply by 0.9 three times:  $10000(0.9)^3 = 7290$ . After simplifying, the answer is 7290.
8. Put the given value into the expression first, then simplify from the inside out. Substitute  $t = 4$ :  $30000(0.85)^4 \approx 15660$ . That confirms the final answer is  $\approx \$15,660$ .
9. The multiplier is  $1 - 0.18 = 0.82$ , so the model is  $y = 500(0.82)^t$ .
10. This is a good place to slow down, check the notation, and simplify cleanly. Twelve days is 3 half-lives, so  $80(\frac{1}{2})^3 = 10$  grams. So the answer is 10.
11. Each increase of 1 in  $t$  multiplies the amount by 0.5, so the half-life is 1 day.
12. When  $t = 6$ , the exponent is 1, so the amount has been halved after 6 hours.
13. Start with the definition the problem is testing, then apply it directly. A 5% loss means 95% remains, so the multiplier is 0.95. So the answer is 0.95.
14. Start with the definition the problem is testing, then apply it directly. The model is  $640(0.5)^t$ . At  $t = 3$ ,  $640(0.5)^3 = 80$ . So the answer is 80.
15. Start with the definition the problem is testing, then apply it directly. Keeping 80% means multiplier 0.8, so  $900(0.8)^2 = 576$ . So the answer is 576.
16. Take it one clear step at a time and keep the original question in mind. The multiplier 0.93 is between 0 and 1, so the model shows decay. So the answer is decay.
17. Each year leaves 90% of the previous value, so the remaining fraction is  $0.9^t$ .
18. Use the clue in the question first, then let the arithmetic finish the job. The exponent coefficient is negative, so the model decreases over time. So the answer is decay.
19. This is a good place to slow down, check the notation, and simplify cleanly. If 40% is lost, the remaining percent is  $100\% - 40\% = 60\%$ . So the answer is 60%.
20. No. It can get closer and closer to zero, but multiplying by a positive decay factor keeps it positive.
21. Use the given numbers to build the model, then finish the calculation. Twelve days is three half-lives, so  $80(\frac{1}{2})^3 = 10$  g.
22. Name the quantities first so the model is easy to read. The car keeps 85% each year, so  $V = 30000(0.85)^4 \approx 15660$ .
23. Set up the model from the story, then calculate carefully. The multiplier is 0.82. Then  $900(0.82)^3 \approx 496$ .
24. Use the given numbers to build the model, then finish the calculation. Fifteen hours is three half-lives, so  $200(\frac{1}{2})^3 = 25$  mg.



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