

### Vocabulary and Core Concept Check

- COMPLETE THE SENTENCE** In the exponential growth function  $y = a(1 + r)^t$ , the quantity  $r$  is called the \_\_\_\_\_.
- VOCABULARY** What is the decay factor in the exponential decay function  $y = a(1 - r)^t$ ?
- VOCABULARY** Compare exponential growth and exponential decay.
- WRITING** When does the function  $y = ab^t$  represent exponential growth? exponential decay?

### Monitoring Progress and Modeling with Mathematics

In Exercises 5–12, identify the initial amount  $a$  and the rate of growth  $r$  (as a percent) of the exponential function. Evaluate the function when  $t = 5$ . Round your answer to the nearest tenth.

- $y = 350(1 + 0.75)^t$
- $y = 10(1 + 0.4)^t$
- $y = 25(1.2)^t$
- $y = 12(1.05)^t$
- $f(t) = 1500(1.074)^t$
- $h(t) = 175(1.028)^t$
- $g(t) = 6.72(2)^t$
- $p(t) = 1.8^t$

In Exercises 13–16, write a function that represents the situation.

- Sales of \$10,000 increase by 65% each year.
- Your starting annual salary of \$35,000 increases by 4% each year.
- A population of 210,000 increases by 12.5% each year.
- An item costs \$4.50, and its price increases by 3.5% each year.
- MODELING WITH MATHEMATICS** The population of a city has been increasing by 2% annually. The sign shown is from the year 2000. (See Example 1.)
  - Write an exponential growth function that represents the population  $t$  years after 2000.
  - What will the population be in 2020? Round your answer to the nearest thousand.



- MODELING WITH MATHEMATICS** A young channel catfish weighs about 0.1 pound. During the next 8 weeks, its weight increases by about 23% each week.
  - Write an exponential growth function that represents the weight of the catfish after  $t$  weeks during the 8-week period.
  - About how much will the catfish weigh after 4 weeks? Round your answer to the nearest thousandth.



In Exercises 19–26, identify the initial amount  $a$  and the rate of decay  $r$  (as a percent) of the exponential function. Evaluate the function when  $t = 3$ . Round your answer to the nearest tenth.

- $y = 575(1 - 0.6)^t$
- $y = 8(1 - 0.15)^t$
- $g(t) = 240(0.75)^t$
- $f(t) = 475(0.5)^t$
- $w(t) = 700(0.995)^t$
- $h(t) = 1250(0.865)^t$
- $y = \left(\frac{7}{8}\right)^t$
- $y = 0.5\left(\frac{3}{4}\right)^t$

In Exercises 27–30, write a function that represents the situation.

- A population of 100,000 decreases by 2% each year.
- A \$900 sound system decreases in value by 9% each year.
- A stock valued at \$100 decreases in value by 9.5% each year.

30. A company profit of \$20,000 decreases by 13.4% each year.
31. **ERROR ANALYSIS** The growth rate of a bacterial culture is 150% each hour. Initially, there are 10 bacteria. Describe and correct the error in finding the number of bacteria in the culture after 8 hours.



$$b(t) = 10(1.5)^t$$

$$b(8) = 10(1.5)^8 \approx 256.3$$

After 8 hours, there are about 256 bacteria in the culture.

32. **ERROR ANALYSIS** You purchase a car in 2010 for \$25,000. The value of the car decreases by 14% annually. Describe and correct the error in finding the value of the car in 2015.



$$v(t) = 25,000(1.14)^t$$

$$v(5) = 25,000(1.14)^5 \approx 48,135$$

The value of the car in 2015 is about \$48,000.

In Exercises 33–38, determine whether the table represents an *exponential growth function*, an *exponential decay function*, or *neither*. Explain. (See Example 2.)

33.

| x  | y   |
|----|-----|
| -1 | 50  |
| 0  | 10  |
| 1  | 2   |
| 2  | 0.4 |

34.

| x | y  |
|---|----|
| 0 | 32 |
| 1 | 28 |
| 2 | 24 |
| 3 | 20 |

35.

| x | y  |
|---|----|
| 0 | 35 |
| 1 | 29 |
| 2 | 23 |
| 3 | 17 |

36.

| x | y   |
|---|-----|
| 1 | 17  |
| 2 | 51  |
| 3 | 153 |
| 4 | 459 |

37.

| x  | y   |
|----|-----|
| 5  | 2   |
| 10 | 8   |
| 15 | 32  |
| 20 | 128 |

38.

| x | y   |
|---|-----|
| 3 | 432 |
| 5 | 72  |
| 7 | 12  |
| 9 | 2   |

39. **ANALYZING RELATIONSHIPS** The table shows the value of a camper  $t$  years after it is purchased.

| t | Value    |
|---|----------|
| 1 | \$37,000 |
| 2 | \$29,600 |
| 3 | \$23,680 |
| 4 | \$18,944 |

- a. Determine whether the table represents an exponential growth function, an exponential decay function, or neither.
- b. What is the value of the camper after 5 years?

40. **ANALYZING RELATIONSHIPS** The table shows the total numbers of visitors to a website  $t$  days after it is online.

| t        | 42     | 43     | 44     | 45     |
|----------|--------|--------|--------|--------|
| Visitors | 11,000 | 12,100 | 13,310 | 14,641 |

- a. Determine whether the table represents an exponential growth function, an exponential decay function, or neither.
- b. How many people will have visited the website after it is online 47 days?



In Exercises 41–48, determine whether each function represents *exponential growth* or *exponential decay*. Identify the percent rate of change. (See Example 3.)

41.  $y = 4(0.8)^t$       42.  $y = 15(1.1)^t$
43.  $y = 30(0.95)^t$       44.  $y = 5(1.08)^t$
45.  $r(t) = 0.4(1.06)^t$       46.  $s(t) = 0.65(0.48)^t$
47.  $g(t) = 2\left(\frac{5}{4}\right)^t$       48.  $m(t) = \left(\frac{4}{5}\right)^t$

In Exercises 49–56, rewrite the function to determine whether it represents *exponential growth* or *exponential decay*. (See Example 4.)

49.  $y = (0.9)^t - 4$       50.  $y = (1.4)^t + 8$
51.  $y = 2(1.06)^{9t}$       52.  $y = 5(0.82)^{t/5}$
53.  $x(t) = (1.45)^{t/2}$       54.  $f(t) = 0.4(1.16)^{t-1}$
55.  $b(t) = 4(0.55)^{t+3}$       56.  $r(t) = (0.88)^{4t}$

In Exercises 57–60, write a function that represents the balance after  $t$  years. (See Example 5.)

57. \$2000 deposit that earns 5% annual interest compounded quarterly
58. \$1400 deposit that earns 10% annual interest compounded semiannually
59. \$6200 deposit that earns 8.4% annual interest compounded monthly
60. \$3500 deposit that earns 9.2% annual interest compounded quarterly

61. **PROBLEM SOLVING** The cross-sectional area of a tree 4.5 feet from the ground is called its *basal area*. The table shows the basal areas (in square inches) of Tree A over time. (See Example 6.)

| Year, $t$       | 0   | 1   | 2     | 3     | 4     |
|-----------------|-----|-----|-------|-------|-------|
| Basal area, $A$ | 120 | 132 | 145.2 | 159.7 | 175.7 |



Tree B

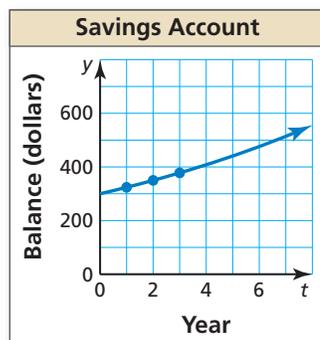


Growth rate: 6%

Initial basal area:  $154 \text{ in.}^2$

- a. Write functions that represent the basal areas of the trees after  $t$  years.
  - b. Graph the functions from part (a) in the same coordinate plane. Compare the basal areas.
62. **PROBLEM SOLVING** You deposit \$300 into an investment account that earns 12% annual interest compounded quarterly. The graph shows the balance of a savings account over time.

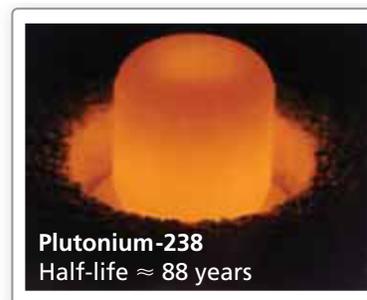
- a. Write functions that represent the balances of the accounts after  $t$  years.
- b. Graph the functions from part (a) in the same coordinate plane. Compare the account balances.



63. **PROBLEM SOLVING** A city has a population of 25,000. The population is expected to increase by 5.5% annually for the next decade. (See Example 7.)



- a. Write a function that represents the population  $y$  after  $t$  years.
  - b. Find the approximate monthly percent increase in population.
  - c. Graph the function from part (a). Use the graph to estimate the population after 4 years.
64. **PROBLEM SOLVING** Plutonium-238 is a material that generates steady heat due to decay and is used in power systems for some spacecraft. The function  $y = a(0.5)^{t/x}$  represents the amount  $y$  of a substance remaining after  $t$  years, where  $a$  is the initial amount and  $x$  is the length of the half-life (in years).



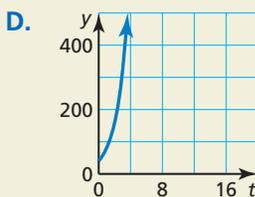
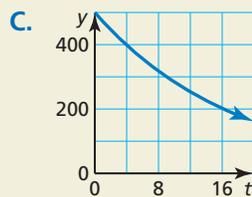
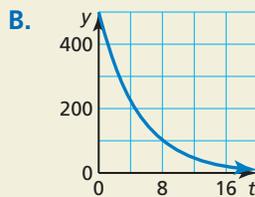
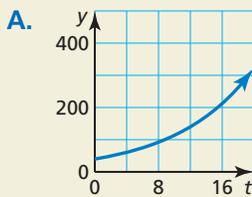
- a. A scientist is studying a 3-gram sample. Write a function that represents the amount  $y$  of plutonium-238 after  $t$  years.
  - b. What is the yearly percent decrease of plutonium-238?
  - c. Graph the function from part (a). Use the graph to estimate the amount remaining after 12 years.
65. **COMPARING FUNCTIONS** The three given functions describe the amount  $y$  of ibuprofen (in milligrams) in a person's bloodstream  $t$  hours after taking the dosage.
- $$y \approx 800(0.71)^t$$
- $$y \approx 800(0.9943)^{60t}$$
- $$y \approx 800(0.843)^{2t}$$
- a. Show that these expressions are approximately equivalent.
  - b. Describe the information given by each of the functions.

66. **COMBINING FUNCTIONS** You deposit \$9000 in a savings account that earns 3.6% annual interest compounded monthly. You also save \$40 per month in a safe at home. Write a function  $C(t) = b(t) + h(t)$ , where  $b(t)$  represents the balance of your savings account and  $h(t)$  represents the amount in your safe after  $t$  years. What does  $C(t)$  represent?

67. **NUMBER SENSE** During a flu epidemic, the number of sick people triples every week. What is the growth rate as a percent? Explain your reasoning.

68. **HOW DO YOU SEE IT?** Match each situation with its graph. Explain your reasoning.

- A bacterial population doubles each hour.
- The value of a computer decreases by 18% each year.
- A deposit earns 11% annual interest compounded yearly.
- A radioactive element decays 5.5% each year.



69. **WRITING** Give an example of an equation in the form  $y = ab^x$  that does not represent an exponential growth function or an exponential decay function. Explain your reasoning.

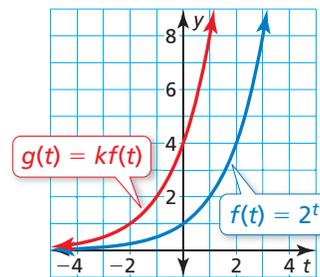
70. **THOUGHT PROVOKING** Describe two account options into which you can deposit \$1000 and earn compound interest. Write a function that represents the balance of each account after  $t$  years. Which account would you rather use? Explain your reasoning.

71. **MAKING AN ARGUMENT** A store is having a sale on sweaters. On the first day, the prices of the sweaters are reduced by 20%.

The prices will be reduced another 20% each day until the sweaters are sold. Your friend says the sweaters will be free on the fifth day. Is your friend correct? Explain.



72. **COMPARING FUNCTIONS** The graphs of  $f$  and  $g$  are shown.



- Explain why  $f$  is an exponential growth function. Identify the rate of growth.
- Describe the transformation from the graph of  $f$  to the graph of  $g$ . Determine the value of  $k$ .
- The graph of  $g$  is the same as the graph of  $h(t) = f(t + r)$ . Use properties of exponents to find the value of  $r$ .

## Maintaining Mathematical Proficiency

Reviewing what you learned in previous grades and lessons

Solve the equation. Check your solution. (Section 1.3)

73.  $8x + 12 = 4x$

74.  $5 - t = 7t + 21$

75.  $6(r - 2) = 2r + 8$

Find the slope and the y-intercept of the graph of the linear equation. (Section 3.5)

76.  $y = -6x + 7$

77.  $y = \frac{1}{4}x + 7$

78.  $3y = 6x - 12$

79.  $2y + x = 8$