# Applications

**1.** In parts of the United States, wolves are being reintroduced to wilderness areas where they had become extinct. Suppose 20 wolves are released in northern Michigan, and the yearly growth factor for this population is expected to be 1.2.

**a.** Make a table showing the projected number of wolves at the end of each of the first 6 years.

**b.** Write an equation that models the growth of the wolf population.

**c.** How long will it take for the new wolf population to exceed 100?

**2.** This table shows the growth of the elk population in a state forest.

**a.** The table shows that the elk population is growing exponentially. What is the growth factor? Explain how you found it.

**Growth of Elk Population**

| Time (yr) | Population |
|---|---|
| 0 | 30 |
| 1 | 57 |
| 2 | 108 |
| 3 | 206 |
| 4 | 391 |
| 5 | 743 |

**b.** Suppose this growth pattern continues. How many elk will there be after 10 years? How many elk will there be after 15 years?

**c.** Write an equation you could use to predict the elk population $p$ for any year $n$ after the elk were first counted.

**d.** In how many years will the population exceed one million?

**3.** Suppose there are 100 trout in a lake and the yearly growth factor for the population is 1.5. How long will it take for the number of trout to double?

**4.** Suppose there are 500,000 squirrels in a forest and the growth factor for the population is 1.6 per year. Write an equation you could use to find the squirrel population $p$ in $n$ years.

**5. Multiple Choice** The equation $p = 200(1.1)^t$ models the exponential growth of a population. The variable $p$ is the population in millions and $t$ is the time in years. How long will it take this population to double?

**A.** 4 to 5 years **B.** 5 to 6 years **C.** 6 to 7 years **D.** 7 to 8 years

**In Exercises 6 and 7, the equation models the exponential growth of a population, where *p* is the population in millions and *t* is the time in years. Tell how much time it would take the population to double.**

**6.** $p = 135(1.7)^t$

**7.** $p = 1{,}000(1.2)^t$

**8. a.** Fill in the table for each equation.

$y = 50(2.2)^x$

| $x$ | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| $y$ | | | | | | |

$y = 350(1.7)^x$

| $x$ | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| $y$ | | | | | | |

**b.** What is the growth factor for each equation?

**c.** Predict whether the graphs of these equations will ever cross.

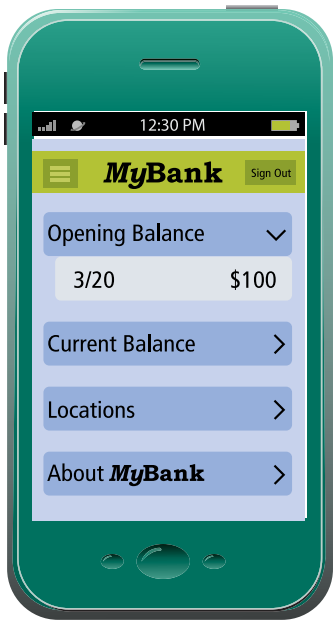
**d.** Estimate any points at which you think the graphs will cross.

**9.** Maya's grandfather opened a savings account for her when she was born. He opened the account with \$100 and did not add or take out any money after that. The money in the account grows at a rate of 4% per year.

**a.** Make a table to show the amount in the account from the time Maya was born until she turned 10.

**b.** What is the growth factor for the account?

**c.** Write an equation for the value of the account after any number of years.



**Find the growth rate associated with the given growth factor.**

**10.** 1.4 **11.** 1.9 **12.** 1.75

**Find the growth factor associated with the given growth rate.**

**13.** 45% **14.** 90% **15.** 31%

**16.** Suppose the price of an item increases by 25% per year. What is the growth factor for the price from year to year?

**17.** Currently, 1,000 students attend Greenville Middle School. The school can accommodate 1,300 students. The school board estimates that the student population will grow by 5% per year for the next several years.

**a.** When will the population outgrow the present building?

**b.** Suppose the school limits its growth to 50 students per year. How many years will it take for the population to outgrow the school?

**18.** Suppose that, for several years, the number of radios sold in the United States increased by 3% each year.

**a.** Suppose one million radios sold in the first year of this time period. About how many radios sold in each of the next 6 years?

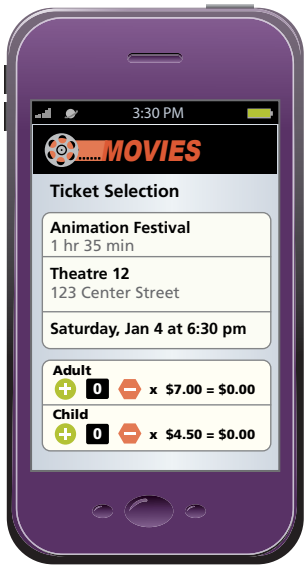
**b.** Suppose only 100,000 radios sold in the first year. About how many radios sold in each of the next 6 years?

**19.** Suppose a movie ticket costs about $7, and inflation causes ticket prices to increase by 4.5% a year for the next several years.

**a.** How much will a ticket cost 5 years from now?

**b.** How much will a ticket cost 10 years from now? 30 years from now?

**c.** How many years will it take for the cost of a ticket to exceed $26?



**20.** Find the growth rate (percent growth) for an exponential function represented by the equation $y = 30(2)^x$.

**21. Multiple Choice** Ms. Diaz wants to invest \$500 in a savings bond. At which bank would her investment grow the most over 8 years?

**A.** Bank 1: 7% annual interest for 8 years

**B.** Bank 2: 2% annual interest for the first 4 years and 12% annual interest for the next four years

**C.** Bank 3: 12% annual interest for the first 4 years and 2% annual interest for the next four years

**D.** All three result in the same growth.

**22.** Oscar made the following calculation to predict the value of his baseball card collection several years from now:

$$\text{Value} = \$130 \times 1.07 \times 1.07 \times 1.07 \times 1.07 \times 1.07$$

**a.** What initial value, growth rate, growth factor, and number of years is Oscar assuming?

**b.** If the value continues to increase at this rate, how much would the collection be worth in three more years?

**23.** Carlos, Latanya, and Mila work in a biology laboratory. Each of them is responsible for a population of mice.

| | | |
|---|---|---|
| The growth factor for Carlos's population of mice is $\frac{3}{8}$. | The growth factor for Latanya's population of mice is 3. | The growth factor for Mila's population of mice is 125%. |

**a.** Whose mice are reproducing fastest?

**b.** Whose mice are reproducing slowest?

# Connections

**Calculate each percent.**

**24.** 120% of \$3,000 **25.** 150% of \$200 **26.** 133% of \$2,500

**For Exercises 27–30, tell whether the pattern represents exponential growth. Explain your reasoning. If the pattern is exponential, give the growth factor.**

**27.** 1 1.1 1.21 1.331 1.4641 1.61051 1.771561

**28.** 3 5 $8\frac{1}{3}$ $13\frac{8}{9}$ $23\frac{4}{27}$

**29.** 3 $4\frac{2}{3}$ $6\frac{1}{3}$ 8 $9\frac{2}{3}$ $11\frac{1}{3}$

**30.** 2 6.4 20.5 66 210

**31.** A worker currently receives a yearly salary of \$20,000.

**a.** Find the dollar values of a 3%, 4%, and 5% raise for this worker.

**b.** Find the worker's new annual salary for each raise in part (a).

**c.** Joanne says that she can find the new salary with a 3% raise in two ways:

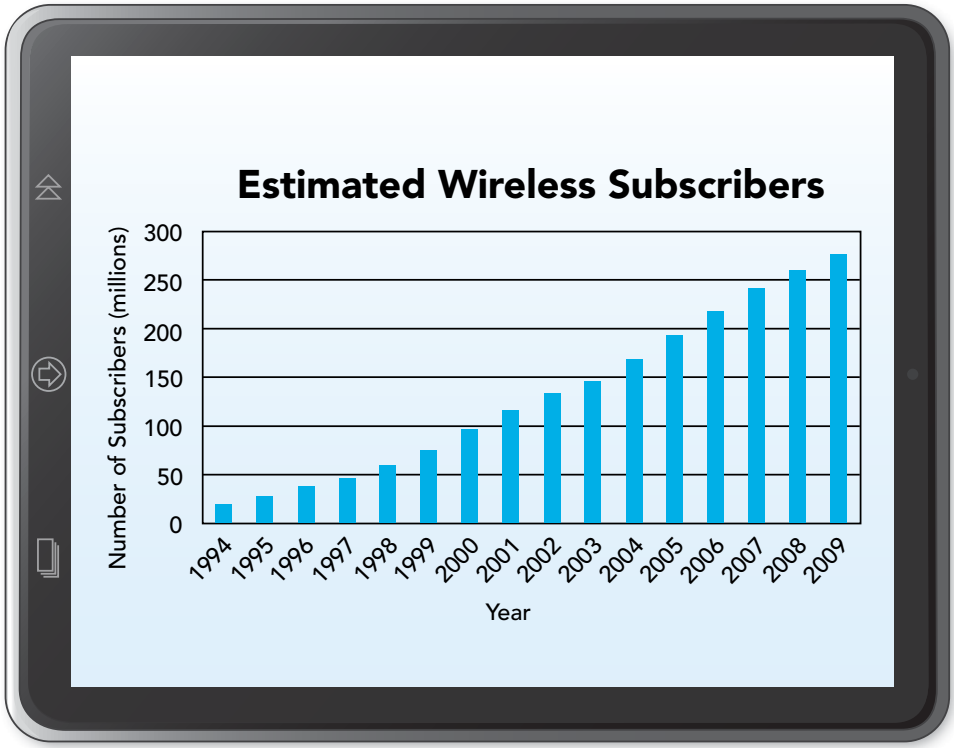
**Method 1**
Add \$20,000 to (3% of \$20,000).

OR

**Method 2**
Find 103% of \$20,000.

Explain why these two methods give the same result.

**32.** The graph shows the growth in the number of wireless subscribers in the United States from 1994 to 2009.




**a.** What do the bars in the graph represent?

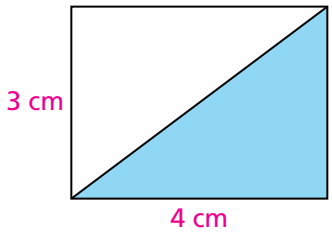
**b.** What does the implied curve represent?

**c.** Describe the pattern of change in the total number of subscribers from 1994 to 2009. Could the pattern be modeled by an exponential function or a linear function? Explain.

**d.** The number of subscribers in 2010 was 300,520,098. In 2011, the number was 322,857,207. Do these numbers fit the pattern you described in part (c)? Explain.

**e.** If the U.S. population in 2010 was approximately 308 million, what might explain the number of subscriptions from 2011?

**33.** Refer to the drawing below.




**a.** What is the length of the diagonal? What is the area of the shaded region?

**b.** Arturo enlarges the drawing to 110% of this size. Make a copy of the drawing on grid paper. What is the length of the diagonal in the enlarged drawing? What is the area of the shaded region?

**c.** Arturo enlarges the enlargement to 110% of its size. He continues this process, enlarging each new drawing to 110% of its size. After five enlargements, what will be the length of the diagonal and the area of the shaded region?

**d.** Arturo and Esteban are wondering if each enlargement is similar to the original figure.

**Auturo's Conjecture**

All the rectangles are similar because the ratio new width : new length is always 3 : 4. This ratio is the same as the ratio of the width to the length in the original figure.

**Esteban's Conjecture**

In part (a), the ratio diagonal length : area was different from the same ratio in part (b). Therefore, the figures are not similar.

Which conjecture do you think is correct? Explain. Why is the other conjecture incorrect?

**34.** Kwan cuts lawns every summer to make money. One customer offers to give her a 3% raise next summer and a 4% raise the summer after that.

Kwan says she would prefer to get a 4% raise next summer and a 3% raise the summer after that. She claims she will earn more money this way. Is she correct? Explain.

**35.** After graduating from high school, Kim accepts a job with a package delivery service, earning $\$9$ per hour.

**a.** How much will Kim earn in a year if she works 40 hours per week for 50 weeks and gets 2 weeks of paid vacation time?

**b.** Write an equation showing the relationship between the number of weeks Kim works $w$ and the amount she earns $a$.

**c.** Kim writes the following equation: $9{,}000 = 360w$. What question is she trying to answer? What is the answer to that question?

**d.** Suppose Kim works for the company for 10 years, receiving a 3% raise each year. Make a table showing how her annual income grows over this time period.

**e.** When Kim was hired, her manager told her that instead of a 3% annual raise, she could choose to receive a $\$600$ raise each year. How do the two raise plans compare over a 10-year period? Which plan do you think is better? Explain your answer.

**36.** Which represents faster growth, a growth factor of 2.5 or a growth rate of 25%?

**37.** Order these scale factors from least to greatest.

130% $\frac{3}{2}$ 2 1.475

**38.** Christopher made a drawing that measures $8\frac{1}{2}$ by 11 inches. He needs to reduce it so it will fit into a space that measures $7\frac{1}{2}$ by 10 inches. What scale factor should he use to get a similar drawing that is small enough to fit? (Do not worry about getting it to fit perfectly.)

**39.** **a.** Match each growth rate from List 1 with the equivalent growth factor in List 2 if possible.

**List 1**

20%, 120%, 50%, 200%, 400%, 2%

**List 2**

1.5, 5, 1.2, 2.2, 4, 2, 1.02

**b.** Order the growth rates from List 1 from least to greatest.

**c.** Order the growth factors from List 2 from least to greatest.

# Extensions

**40.** In Russia, shortly after the breakup of the Soviet Union, the yearly growth factor for inflation was 26. What growth rate (percent increase) is associated with this growth factor? We call this percent increase the *inflation rate*.

**41.** In 2000, the population of the United States was about 282 million and was growing exponentially at a rate of about 1% per year.

**a.** At this growth rate, what will the population of the United States be in the year 2020?

**b.** At this rate, how long will it take the population to double?

**c.** The population in 2010 was about 308 million. How accurate was the growth rate?

**42.** Use the table to answer parts (a)–(d).

**a.** One model of world population growth assumes the population grows exponentially. Based on the data in this table, what would be a reasonable growth factor for this model?

**b.** Use your growth factor from part (a) to write an equation for the growth of the population at 5-year intervals beginning in 1955.

**c.** Use your equation from part (b) to predict the year in which the population was double the 1955 population.

**d.** Use your equation to predict when the population will be double the 2010 population.

**World Population Growth**

| Year | Population (billions) |
|---|---|
| 1955 | 2.76 |
| 1960 | 3.02 |
| 1965 | 3.33 |
| 1970 | 3.69 |
| 1975 | 4.07 |
| 1980 | 4.43 |
| 1985 | 4.83 |
| 1990 | 5.26 |
| 1995 | 5.67 |
| 2000 | 6.07 |
| 2005 | 6.46 |
| 2010 | 6.84 |

**For Exercises 43–45, write an equation that represents the exponential function in each situation.**

**43.** A population is initially 300. After 1 year, the population is 361.

**44.** A population has a yearly growth factor of 1.2. After 3 years, the population is 1,000.

**45.** The growth rate for an investment is 3% per year. After 2 years, the value of the investment is \$2,560.

**46.** Suppose your calculator did not have an exponent key. You could find $1.5^{12}$ by entering:

$1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5 \times 1.5$

**a.** How could you evaluate $1.5^{12}$ with fewer keystrokes?

**b.** What is the fewest times you could press ✕ to evaluate $1.5^{12}$?

**47.** Mr. Watson sold his boat for \$10,000. He wants to invest the money.

**a.** How much money will Mr. Watson have after 1 year if he invests the \$10,000 in an account that pays 4% interest per year?

**b.** Mr. Watson sees an advertisement for another type of savings account:

"4% interest per year compounded quarterly."

He asks the bank teller what "compounded quarterly" means. She explains that instead of giving him 4% of \$10,000 at the end of one year, the bank will give him 1% at the end of each 3-month period (each quarter of a year).

If Mr. Watson invests his money at this bank, how much will be in his account at the end of one year?

**c.** Mr. Watson sees an advertisement for a different bank that offers 4% interest per year *compounded monthly*. (This means he will get $\frac{1}{12}$ of 4% interest every month.) How much money will he have at the end of the year if he invests his money at this bank?

**d.** Which account would have the most money at the end of one year? Explain.

**Growth of \$10,000 Investment at 4% Interest Compounded Quarterly**

| Time (mo) | Money in Account |
|---|---|
| 0 | \$10,000 |
| 3 | \$10,100 |
| 6 | \$10,201 |
| 9 | \$10,303.01 |