Chapter 10: Exponential Functions

**Lesson 1:** Introduction to Exponential Functions and Equations

**Lesson 2:** Exponential Graphs

**Lesson 3:** Finding Equations of Exponential Functions

**Lesson 4:** Exponential Growth and Decay

**Lesson 5:** Applications of Exponential Functions

**Lesson 6:** Mindful Manipulation of Percents

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Chapter 10: Exponential Functions
Lesson 1
Introduction to Exponential Functions

Exponential functions are similar to other functions that we have discussed. The one major difference is that the ___________ is in the ___________ of the function.

Exponential functions always have a ______________ number other than one or zero as the ____________.

\[ y = a^x \]

It is important to remember, that if an exponential function is in the ___________ of a fraction, we must bring it up to the numerator, by using ___________ exponents.

\[ \left( \frac{1}{2} \right)^x = \_____________ \]

Properties of Exponents

Let’s recall properties of exponents that we learned from the first chapter.

Addition Property of Exponents

When we ________________ expressions that have the same base we can __________ the exponents.

___________________________

Product Property of Exponents

When we take an exponential function that has a ________________ to another ________, we can ____________________ the exponents.

___________________________
Subtraction Property of Exponents

When we ________________ two expressions together that have the same base we can _____________ the exponents.

__________________________

Solving Exponential Equations: Unlike Bases

In order to solve exponential equations, we must force the bases to be the ________________. Once the bases are the same then we set the exponents _____________________ to each other and solve the resulting equation.

To find the same base, we always want to change the base that is the ____________ first. When changing bases, we need to think of ____________.

For example: 125 = ______________

Examples

Complete the following questions. Solve for the missing variable. Answers must be exact (change all decimals to fractions).

1.) $2^{3y-6} = 8$

2.) $4^{x+1} = 8^x$

3.) $(\frac{1}{9})^x = 27^{1-x}$

4.) $\frac{1}{36} = 6^{2x}$
5.) \(4^{x+6} = 32\)  
6.) \(2^{2^2 - 2} = 4\)

7.) \(25^{2x-1} = 125^{3x+4}\)  
8.) \(8^{2x-3} = \left(\frac{1}{16}\right)^{x-2}\)

9.) \(4^{x^2} = 256\)  
10.) \(9^{2x+3} = \left(\frac{1}{27}\right)^{3x+1}\)
11.) Find the x-intercept of the equation \( g(x) = 3^{x+1} - 27. \)

12.) Find point of intersection of the two equations.
\[
f(x) = 4^{3x+5} \quad \text{and} \quad g(x) = 8^{4x-3}
\]

13.) What is the value of \( b \) in the equation \( 4^{2b-3} = 8^{1-b} \)?

\[
(1) \quad \frac{3}{7} \quad (2) \quad \frac{7}{9} \quad (3) \quad \frac{9}{7} \quad (4) \quad \frac{10}{7}
\]

14.) Which of the following represents the solution set to the equation \( 2^{x^2-3} = 64? \)

\[
(1) \quad \{\pm 3\} \quad (2) \quad \{0, 3\} \quad (3) \quad \{\pm \sqrt{11}\} \quad (4) \quad \{\pm \sqrt{35}\}
\]
1.) Solve each of the following exponential equations.

(a) $2^{3x+7} = 16$ \hspace{2cm} (b) $216^{x-2} = \left(\frac{1}{1296}\right)^{3x-2}$

(c) $3^{2x-5} = 27$ \hspace{2cm} (d) $5^{4x-5} = \frac{1}{125}$

2.) Algebraically, determine intersection point of the two exponential functions below.

$y = 8^{x-1}$ \hspace{1cm} and \hspace{1cm} $y = 4^{2x-3}$
3.) Algebraically determine the zeros of the exponential function \( f(x) = 2^{2x-9} - 32 \).

4.) The value of \( x \) in the equation \( 4^{2x+5} = 8^{3x} \) is

(1) 1       (2) 2       (3) 5       (4) -10

5.) If \( 2^{4x+1} = 8^{x+a} \), which expression is equivalent to \( x \)?

(1) \( a - 1 \)       (2) \( 3a - 1 \)       (3) \( \frac{a-1}{15} \)       (4) \( \frac{a-1}{3} \)

6.) Solve for \( x \): \( 2 = 2^{2x+1} \)

\textbf{Challenge Problem:}

7.) Explain how \( \left( \frac{1}{3^2} \right)^2 \) can be written as the equivalent radical expression \( \sqrt[5]{9} \).
Chapter 10: Exponential Functions
Lesson 2
Exponential Graphs

Exponential Functions Basics

Exponential functions have very distinct graphs. It is important to become familiar with the basic shape and look of exponential graphs.

Basic Exponential Functions

________________________ where \( b > 0 \) and \( b \neq 1 \)

Exercise 1: Given the function \( y = 2^x \). Fill in the table below without using your calculator and then sketch the graph on the grid provided.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y = 2^x )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Do you think this is an increasing or decreasing exponential function? Explain.
Exercise 2: Given the function \( y = \left(\frac{1}{2}\right)^x \). Use your calculator to help you, fill out the table below and sketch the graph on the axes provided.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y = \left(\frac{1}{2}\right)^x )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Do you think this is an increasing or decreasing exponential function? Explain.

What is the difference between an increasing exponential function and a decreasing exponential function?
Exercise 3: Based on the graphs and behavior you saw in exercises 1 and 2, state the domain and range for an exponential function of the form $y = b^x$.

**Domain (x-values):**

**Range (y-values):**

Does a graph of an exponential function contain an *asymptote*? What is the asymptote?

Recall: An asymptote is a line that a graph ___________________________ but __________________ crosses.

Exercise 4: Are exponential functions one-to-one? How can you tell? What does this tell you about their inverses?
Exercise 5: Given the function $y = \left(\frac{1}{3}\right)^x + 4$.

(a) How does this function's graph compare to that of $y = \left(\frac{1}{3}\right)^x$? What does adding 4 do to a functions graph?

(b) Determine the y-intercept of this function algebraically. Justify your answer.

(c) Create a sketch of this function, labeling its y-intercept.

(d) Where is the asymptote on this graph? Draw it in.

Exercise 6: Given the function $y = (5)^x - 6$.

(a) How does the graph of this function compare to the graph of $y = 5^x$? Explain in words.

(b) Sketch the function.

(c) Find the equation for the asymptote of this graph.
**Vertical Shifts**

When something is being ________________ to the basic exponential function \( y = b^x \) the graph is being ________________. When something is ________________ from the basic exponential function \( y = b^x \) the graph ________________.

**Exercise 7:** The graph below can be represented by which equation?

1. \( y = 2^x \)
2. \( y = x^2 + 2 \)
3. \( y = 2^{x+1} \)
4. \( y = 2^x + 1 \)

**Exercise 8:** What is the \( y \)-intercept of the graph \( y = 7(2)^x \) ? Explain your thought process.
1.) Which of the following represents an exponential function?

(1) \( y = 3x - 7 \)  
(2) \( y = 7x^3 \)  
(3) \( y = 3(7)^x \)  
(4) \( y = 3x^2 + 7 \)

2.) If \( h(x) = 3^x \) and \( g(x) = 5x - 7 \) then \( h(g(2)) = \)

(1) 18  
(2) 12  
(3) 38  
(4) 27

3.) Which of the following equations represents the graph shown?

(1) \( y = 5^x \)  
(2) \( y = 4^x + 1 \)  
(3) \( y = \frac{1^x}{2} + 2 \)  
(4) \( y = 3^x + 2 \)
4.) Which equation is represented by the graph below?

(1) \( y = 5^x \)

(2) \( y = 0.5^x \)

(3) \( y = 5^{-x} \)

(4) \( y = 0.5^{-x} \)

5.) On the axes below, for \(-2 \leq x \leq 2\), graph \( y = 2^x - 3 \).

6.) Which equation has a higher x-intercept, \( f(x) \) or \( g(x) \)? Explain.

\[ f(x) = x^2 - 16x + 64 \quad g(x) = 2^{x+2} - 128 \]
Chapter 10: Exponential Functions
Lesson 3
Equations of Exponential Functions

Finding Equations of Exponential Functions

One of the skills that you acquired in Common Core Algebra I was the ability to write equations of exponential functions if you had information about the starting value and base (multiplier or growth constant). Let's review a very basic problem.

1) An exponential function of the form $f(x) = a(b)^x$ is presented in the table below. Determine the values of $a$ and $b$ and explain your reasoning.

$$
\begin{array}{c|cccc}
  x & 0 & 1 & 2 & 3 \\
  \hline
  f(x) & 5 & 15 & 45 & 135 \\
\end{array}
$$

$a =$ ________

$b =$ ________

Final Equation: _______________

Explanation:

Finding an exponential equation becomes much more challenging if we do not have output values for inputs that are increasing by unit values (increasing by 1 unit at a time). Let's start with a basic problem.

2) For an exponential function of the form $f(x) = a(b)^x$, it is known that $f(0) = 8$ and $f(3) = 1000$.

(a) Determine the values of $a$ and $b$.

(b) Determine the value of $f(2)$. 

3) An exponential function exists such that \( f(4) = 3 \) and \( f(6) = 48 \), which of the following must be the value of its base? Explain or illustrate your thinking.

(1) \( b = 16 \)  
(2) \( b = 2 \)  
(3) \( b = 6 \)  
(4) \( b = 4 \)

Now, let's work with the most generic type of problem. Just like with lines, \textit{any two (non-vertically aligned) points will uniquely determine the equation of an exponential function}.

4) An exponential function in the form \( y = a(b)^x \) passes through the points (2,36) and (5,121.5). What is the equation? State your final answer in the form \( y = ab^x \).

Let's now get some practice on this with a decreasing exponential function.

5) Find the equation of the exponential function shown graphed below. Be careful in terms of your exponent manipulation. State your final answer in the form \( y = a(b)^x \).
6) A bacterial colony is growing at an exponential rate. It is known that after 4 hours, its population is at 98 bacteria and after 9 hours it is 189 bacteria. Determine an equation in $y = a(b)^x$ form that models the population, $y$, as a function of the number of hours, $x$. Round $a$ to the nearest integer and $b$ to the nearest hundredth. At what percent rate is the population growing per hour? Round to the nearest percent.

7) The table below represents the function $F$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F(x)$</td>
<td>9</td>
<td>17</td>
<td>65</td>
<td>129</td>
<td>257</td>
</tr>
</tbody>
</table>

The equation that represents this function is

- (1) $F(x) = 3^x$
- (2) $F(x) = 3x$
- (3) $F(x) = 2^x + 1$
- (4) $F(x) = 2x + 3$
Chapter 10: Exponential Functions
Lesson 3: Homework
Equations of Exponential Functions

1.) For each of the following coordinate pairs, find the equation of the exponential function, in the form $y = ab^x$ that passes through the pair. Show all work.

(a) $(0,10)$ and $(3, 80)$
(b) $(0, 180)$ and $(2, 80)$

(c) $(2, 192)$ and $(5, 12288)$
(d) $(1, 192)$ and $(5, 60.75)$
2.) Determine the exponential equation in the form \( y = a(b)^x \) that passes through the points \((2,14)\) and \((7,205)\). Round your values for \(a\) and \(b\) to the nearest \textit{hundredth}.

3.) A population of koi fish in a pond was measured over time. In the year 2002, the population was recorded as 380 and in 2006 it was 517. Given that \(y\) is the population of fish and \(x\) is the number of years \textit{since} 2000 complete the following:

   (a) Represent the information in this problem as two coordinate pairs.

   (b) Determine a linear function in the form \(y = mx + b\) that passes through these two points. Do not round your values for \(m\) and \(b\).

   (c) Determine an exponential function of the form \(y = a(b)^x\) that passes through these two points. Round \(b\) to the nearest \textit{hundredth} and \(a\) to the nearest \textit{tenth}.

   (d) Which model predicts a larger population of fish in the year 2000?
4.) Engineers are draining a water reservoir until its depth is only 10 feet. The depth decreases exponentially as shown in the graph below. The engineers measure the depth after 1 hour to be 64 feet and after 4 hours to be 28 feet. Develop an exponential equation in \( y = a(b)^x \) to predict the depth as a function of hours draining. Round \( a \) to the nearest integer and \( b \) to the nearest hundredth. Then, graph the horizontal line \( y = 10 \) and find its intersection to determine the time, to the nearest tenth of an hour, when the reservoir will reach a depth of 10 feet.
Chapter 10: Exponential Functions
Lesson 4
Exponential Growth & Decay

Exponential Growth

Exponential growth is also known as an ________________ exponential function. This is when the original amount is "growing" by a fixed percentage.

Formula: ________________________________

Where

\[ P = __________________ \]

\[ r = __________________ \]

\[ t = _________________ \]

Exercise 1: Louis deposits $400 into a savings account that receives 5% interest per year.
   (a) How much money will be in the account after 7 years?
   
   (b) Use your calculator to determine how long it will take for the money in his account to double. Round to the nearest tenth of a year.
Exercise 2: Which of the following gives the savings $S$ in an account if $250$ was invested at an interest rate of $3\%$ per year?

$(1) \ S = 250(4)^t$ \hspace{1cm}$(2) \ S = 250(1.03)^t$ \hspace{1cm}$(3) \ S = (1.03)^t + 250$ \hspace{1cm}$(4) \ S = 250(1.3)^t$

Exercise 3: Emma's parents deposited $5000$ into a bank account during her freshman year. That account pays $6.5\%$ interest compounded yearly. Determine, to the nearest dollar, the amount in the account 4 years later.

Exercise 4: A movie theatre's matinee ticket price increases $3.2\%$ every year. The price of a ticket in 1998 was $3.50$. How much will the ticket cost in 2015?
Exponential Decay

Exponential decay is also known as a __________________ exponential function. This is when the original amount is "______________" by a fixed percentage.

Formula: ________________________________

Where

\[ P = \quad \text{______________} \]
\[ r = \quad \text{______________} \]
\[ t = \quad \text{______________} \]

The base of all exponential decay functions is always __________ than 1.
(When the exponent is positive)

Exercise 5: If the population of a town is decreasing by 4% per year and started with 12,500 residents, which of the following is its projected population in 10 years? Show the exponential model you use to solve this problem.

(1) 9,230  (3) 18,503
(2) 76    (4) 8,310
Exercise 6: Christopher bought a used truck for $12,000. It depreciates 5.2% each year. What is the value of the truck after 6 years?

Exercise 7: A population, \( p(x) \), of deer in a certain area is represented by the function \( p(x) = 140(0.98)^x \), where \( x \) is the number of years since 2005. How many more deer were there in 2010 than in 2015?

Exercise 8: The stock price of WindpowerInc is increasing at a rate of 4% per week. Its initial value was $20 per share. On the other hand, the stock price of GerbilEnergy is crashing (losing value) at a rate of 11% per week. If its price is $120 per share when Windpower was $20, after how many weeks, to the nearest tenth, will the stock prices be the same? Model both stock prices using exponential functions. Then, find when the stock prices will be equal graphically. Draw a well labeled graph to justify your solution.
Exercise 9: The growth of bacteria in a dish is modeled by the function \( f(t) = 2^{\frac{t}{3}} \). For which value of \( t \) is \( f(t) = 32 \)?

(1) 8  (2) 2  (3) 15  (4) 16

Exercise 10: Given a starting population of 100 bacteria, the formula \( b = 100(2^t) \) can be used to find the number of bacteria, \( b \), after \( t \) periods of time. If each period is 15 minutes long, how many minutes will it take for the population of bacteria to reach 51,200?
1.) If $130 is invested in a savings account that earns 4% interest per year, which of the following is closest to the amount in the account at the end of 10 years?

   (1) $218       (2) $192
   (3) $168       (4) $324

2.) If a radioactive substance is quickly decaying at a rate of 13% per hour approximately how much of a 200 pound sample remains after one day, in pounds?

   (1) 7.1        (2) 2.3
   (3) 25.6       (4) 15.6

3.) Some banks charge a fee on savings accounts that are left inactive for an extended period of time. The equation \( y = 5000(0.98)^x \) represents the value, \( y \), of one account that was left inactive for a period of \( x \) years. What is the \( y \)-intercept of this equation and what does it represent?

   (1) 0.98, the percent of money in the account initially
   (2) 0.98, the percent of money in the account after \( x \) years
   (3) 5000, the amount of money in the account initially
   (4) 5000, the amount of money in the account after \( x \) years
4.) Is the equation $A = 21000(0.88)^t$ a model of exponential growth or exponential decay, and what is the rate (percent) of change per time period?

   (1) exponential growth and 12%
   (2) exponential growth and 88%
   (3) exponential decay and 12%
   (4) exponential decay and 88%

5.) When Rachel was offered a new job she was given two options.

   **Option A:** Earn a $500 raise each year
   **Option B:** Earn a 3.2% raise each year

If you were Rachel, which option would you take? Justify your answer.

6.) In 1950 the Population of Fresh Meadows was 23,000. If the growth rate is 1.7%, what was the population in 1975?
7.) You bought a used truck for $12,300. It depreciates at a rate of 8% a year. What is the worth of the truck after 3 years?

8.) A population of llamas stranded on a dessert island is decreasing due to a food shortage by 6% per year. If the population of llamas started out at 350, how many are left on the island 10 years later?
Chapter 10: Exponential Functions  
Lesson 5  
Applications of Exponential Functions

**Compound Interest:**

Another application of exponential functions is *compound interest*. We use this formula when interest is "compounded" *more than* once per year.

**Formula:** ________________________________

A - represents the amount of money after a certain amount of time

P - represents the ___________________ - or the money that you ___________ with

r - represents the ____________________ - and is ALWAYS represented as a decimal

t - represents the amount of ___________ in YEARS (unless otherwise noted)

n - is the number of times interest is compounded for one year, for example:
    if interest is compounded annually then ______________
    if interest is compounded quarterly then ______________
    if interest is compounded bi-monthly then ______________
    if interest is compounded monthly then ______________

**Examples:**

1.) Louis is saving for his daughter's education. When she was born, he put $5000 into an account earning 2.4% interest compounded *monthly*. If left untouched, in 18 years how much money will be in the account.
2.) How much would $1000 invested at a nominal 2% yearly rate, compounded monthly, be worth in 20 years?

(1) $1485.95  (3) $1033.87
(2) $1491.33  (4) $1045.32

3.) Christopher has $1200 that he wants to invest. One bank offers a nominal rate of 3.25% compounded quarterly. Another bank offers a nominal rate of 3.2% interest compounded monthly. He wants to leave his money in for five years; which bank should he use? Justify your response.

The term ______________ interest rate is used quite frequently. This means in ______________ only. It is known as this because you are effectively earning more than this rate if the compounding period is more than once per year. Due to this, bankers refer to the __________________________, or the rate that would be received if compounded just once per year.
4.) An investment with a nominal rate of 5% is compounded at different frequencies. Give the effective yearly rate, accurate to two decimal places, for each of the following compounded frequencies. Show work.

(a) Quarterly  (b) Monthly  (c) Daily

Compounded Continuously

There are times where something is compounded without interruption; this is known as compounding _______________. There is a special formula these questions.

*Formula:* _______________

A - represents the amount of money after a certain amount of time

P - represents the ____________ - or the amount that you start with

r - represents the ______________ - and is ALWAYS represented as a decimal

t - represents the amount of ____________ in YEARS

5.) The formula for continuously compounded interest is $A = Pe^{rt}$, where $A$ is the amount of money in the account, $P$ is the initial investment, $r$ is the interest rate, and $t$ is the time in years. Using the formula, determine, to the nearest dollar, the amount in the account after 8 years if $750 is invested at an annual rate of 3%.
6.) What amount (to the nearest cent) will an account have after 10 years if $50 is invested at 7.5% interest compounded continuously?

(1) $104.41  
(2) $105.85  
(3) $103.05  
(4) $105.12

7.) If $100 is invested at 8% annual interest compounded continuously, what will the amount be in 3 years?

Half-Life

Another application of exponential functions is the **half-life**. A half-life is usually used when something is ________________. It is the amount of time it takes for something to be half of the ________________ amount.

\[
A = A_0 \cdot \left(\frac{1}{2}\right)^{t/h}
\]

This is the split factor... After a half-life, one pound becomes \(\frac{1}{2}\) pound.
8.) One of the medical uses of Iodine-131 (I-131), a radioactive isotope of iodine, is to enhance x-ray images. The half-life of I-131 is approximately 8.02 days. A patient is injected with 20 milligrams of I-131. Determine, how much will be left in the patient’s body after 10 days. Round your answer to the nearest milligram.

9.) In 2000, Thomas buried 15 kg of Carbon-14 in his backyard. Someone digs it up in the year 13460. Knowing that Carbon-14 has a half life of 5730 years, how much did they find?

10.) A rabbit population doubles every 4 weeks. There are currently 5 rabbits in a restricted area. If t represents the time, in weeks, and P(t) is the population of rabbits with respect to time, about how many rabbits will there be in 98 days?

Double Time Formula:
Chapter 10: Exponential Functions
Lesson 5: Homework
Applications of Exponential Functions

1.) The value of an initial investment $400 at 3% nominal interest compounded quarterly can be modeled using which of the following equations, where \( t \) is the number of years since the investment was made?

(1) \( A = 400(1.0075)^{4t} \)  
(2) \( A = 400(1.0075)^t \)  
(3) \( A = 400(1.03)^{4t} \)  
(4) \( A = 400(1.0303)^{4t} \)

2.) Louis invests $4500 in an account that earns a 3.8% nominal interest rate compounded continuously. If he withdraws the profit from the investment after 5 years, how much has he earned on his investment?

(1) $858.92  
(2) $912.59  
(3) $922.50  
(4) $941.62

3.) An investment that returns a nominal 4.2% yearly rate, but is compounded quarterly, has an effective yearly rate closest to

(1) 4.21%  
(2) 4.24%  
(3) 4.27%  
(4) 4.32%
4.) Kevin wins $500 at a math competition. He wisely decides to invest his money into an account with 3.45% interest compounded quarterly. After 6 years how much money will he have in his account?

5.) Thomas wins $5000. He decides that he wants to invest this amount into an account for 8 years. He looks at two different banks. Bank A offers a 4.5% interest rate compounded quarterly. Bank B offers a 4.3% interest rate compounded continuously. Which bank should he choose? Justify your answers.
6.) An alien radioactive isotope has a half-life of 238 years. If you start with a sample of 8 kg, how much will be left in 100 years? Round to the nearest tenth of a kilogram.

7.) The half-life of an isotope is approximately 8.25 days. If a person starts with 300 mg of the isotope, how much will be left after 12 days? Round to the nearest tenth of a milligram.

8.) Which function represents exponential decay?

(1) \( y = 2^{0.3t} \) \hspace{1cm} (2) \( y = 1.2^{3t} \) \hspace{1cm} (3) \( y = \left(\frac{1}{2}\right)^{-t} \) \hspace{1cm} (4) \( y = 5^{-t} \)
Chapter 10: Exponential Functions
Lesson 6
Mindful Manipulation

Mindful Manipulation of Percents

Percents and phenomena that grow at a constant percent rate can be challenging because unlike linear equations, the ______________ rate indicates a constant ______________ instead of a constant additive effect (linear). Because constant percent growth is so common in everyday life, it's good to be able to mindfully manipulate percents.

Examples:

1) A population of wombats is growing at a constant percent rate. If the population on January 1st is 1027 and a year later is 1070, what is its yearly percent growth rate to the nearest tenth of a percent?

2) Now let's try to determine what the percent growth in wombat population will be over a decade of time. We will assume that the rounded percent increase found in Exercise 1 continues for the next decade.
   (a) After 10 years, what will we have multiplied the original population by, rounded to the nearest hundredth? Show calculation.
   (b) Using your answer from (a), what is the decade percent growth rate?
3) Using the same information from example 1 to find the monthly growth rate to the nearest tenth of a percent? Assume a constant sized month and a constant growth rate over time.

4) If a population was growing at a constant rate of 22% every 5 years, then what is its percent growth rate over a 2 year time span? Round to the nearest tenth of a percent.

(a) First, give an expression that will calculate the single year (or yearly) percent growth rate based on the fact that the population grew 22% in 5 years.

(b) Now use this expression to calculate the percent growth, to the nearest tenth, over 2 years.

5) Last year, the total revenue for Home Style, a national restaurant chain, increased by 5.25% over the previous year. If this trend were to continue, which expression could the company's chief financial officer use to approximate their monthly percent increase in revenue? [Let \( m \) represent months.]

(1) \((1.0525)^m\)  \hspace{1cm} (3) \((1.00427)^m\)

(2) \((1.0525)^{12/m}\)  \hspace{1cm} (4) \((1.00427)^{m/12}\)
6) World oil reserves (the amount of oil unused in the ground) are depleting at a constant rate of 2% per year. We would like to determine what percent decline will be over the next 20 years based on this 2% yearly decline.

(a) Write and evaluate an expression for what we would multiply the initial amount of oil by after 20 years.

(b) Use your answer to (a) to determine the percent decline after 20 years. Be careful! Round to the nearest percent.

7) A radioactive substance's half-life is the amount of time needed for half (or 50%) of the substance to decay. We have a radioactive substance with a half-life of 20 years.

(a) What percent of the substance would be radioactive after 40 years?

(b) What percent of the substance would be radioactive after only 10 years? Round your answer to the nearest tenth of a percent.

(c) What percent of the substance would be radioactive after only 5 years? Round your answer to the nearest tenth of a percent.
Chapter 10: Exponential Functions
Lesson 6: Homework
Mindful Manipulation

1.) An object’s speed decreases by 5% for each minute that it is slowing down. Which of the following is closest to the percent that its speed will decrease over half-an-hour?

(1) 21%  (2) 79%  (3) 48%  (4) 150%

2.) An equation to represent the value of a car after $t$ months of ownership is $v = 32000(0.81)^{t/12}$. Which statement is not correct?

(1) The car lost approximately 19% of its value each month.

(2) The car maintained approximately 98% of its value each month.

(3) The value of the car when it was purchased was $32,000.

(4) The value of the car 1 year after it was purchased was $25,920.

3.) A payday loan company makes loans between $100 and $1000 available to customers. Every 14 days, customers are charged 30% interest with compounding. In 2013, Remi took out a $300 payday loan. Which expression can be used to calculate the amount she would owe, in dollars, after one year if she did not make any payments.

(1) $300(0.30)^{14/365}$  (2) $300(0.30)^{365/14}$  (3) $300(1.30)^{14/365}$  (4) $300(1.30)^{365/14}$
4.) If a bank account doubles in size every 5 years, then by what percent does it grow after only 3 years? Round to the nearest tenth of a percent.

5.) Shana is trying to increase the number of calories she burns by 5% per day. By what percent is she trying to increase per week? Round to the nearest tenth of a percent.

6.) A population of llamas is growing at a constant yearly rate of 6%. At what rate is the llama population growing per month? Please assume all months are equally sized and that there are 12 of these per year. Round to the nearest tenth of a percent.