Warm Up

Simplify each expression. Write the step(s) you used.

1. $a^4 * a^5$

2. $(a^3)^7$

3. $(a^2 b)^9$

4. $\dfrac{a^8}{a^6}$

Unit 8
Lesson 4
Graphing Exponentials and Properties of Exponents

TODAY

- SWBAT use properties of exponents to simplify a problem
- SWBAT create graphs and determine end behavior and intercepts of nonlinear functions.
- SWBAT determine the rate of change of a graph
- **N-RN.A.1** Students will investigate the meaning of exponents through patterns. Understand and use the properties of integer exponents. Verify that the properties of integer exponents hold for rational exponents as well.
- **F-IF.C.7.e** Students will graph functions given by an equation and show characteristics such as, but not limited to, intercepts, maxima, minima, and intervals of increase or decrease. Find the intercepts, maxima, and minima from the graphing calculator either graphically or in table form. Produce the graph and identify key features of the parent function of an exponential function by hand. Produce the graph of an exponential function which is given in symbolic form. Understand parameters introduced into a function alter the shape of the graph of the parent function. Compare the exponential function to its parent function.
- **F-IF.B.6** Students will calculate the average rate of change of quadratic, absolute value, piecewise-defined or step functions over specified intervals. Determine the average rate of change from a table, an algebraic representation/equation or a graph. Interpret the average rate of change of a function in context. Estimate the average rate of change from a graph. Interpret what the average rate of change means in terms of the context it is in.

Properties

- $a^m * a^n = a^{m+n}$ add exponents
- $(a^m)^n = a^{mn}$ multiply exponents
- $(ab)^m = a^m b^m$ distribute exponent.
- $\dfrac{a^m}{a^n} = a^{m-n}$ subtract exponents

Write out what needs to be done

1. $y^4 * y^8$

2. $(a^7)^5$

Write out what needs to be done

3. $(a^2 b^3 c^5)^4$

4. $\dfrac{x^9}{x^4}$

Simplify

5. $3x^3 * 2x^4$

6. $(2a^2)^3$

Simplify

7. $(3a^4b^2c^4)^3 * a^2b^5$

8. $\dfrac{x^8y^3z^2}{x^5y}$

Simplify

9. $5y^4 * y^2 * 8y^9$

10. $(3x^4)^2 * 2x^4$

Simplify

11. $(5a^3b^6c^9)^2 * a^4b^3c$

12. $\dfrac{x^5y^2z}{x^5y}$

Graphing

- $f(x) = 3^x$
- Make a table and draw the graph.

x				
y				

- Find the intercepts
- Find the rate of Change from 1 to 3.

Graphing

- $f(x) = -(2)^x$
- Make a table and Draw the graph.

x				
y				

- Find the intercepts
- Find the rate of Change from 0 to 3.

Graphing

- $f(x) = -2(3)^x$
- Make a table and Draw the graph.

x				
y				

- Find the intercepts
- Find the rate of Change from 0 to 2.

Graphing

- $f(x) = 3(4)^x$
- Make a table and Draw the graph.

x				
y				

- Find the intercepts
- Find the rate of Change from 1 to 2.

Graphing

- A $65,000 car depreciates in value by 10% each year. What function represents the value of the car after t years? What is the real-world meaning of year 0?

Graphing

- An initial investment of $1,000 grows at 5% per year. What function represents the value of the investment after t years? What is the real-world meaning of year 5?

Graphing

- A $65 video game in value by 60% each year. What function represents the value of the car after t years? What is the real-world meaning of year 3?

Graphing

- An initial investment of $15,000 grows at 6% per year. What function represents the value of the investment after t years? What is the real-world meaning of year 20?

No Calculators

1. Simplify $3r^2 \cdot 4r^7 \cdot 5r^9$.

2. Simplify $\frac{6^7}{6^3}$.

3. Simplify $(3x^2y^4)^3(xy)^2$ showing all work.

4. If there are initially 1500 bacteria in a culture, and the number of bacteria triples each hour, the number of bacteria after t hours can be found using the formula $N = 1500(3^t)$. How long will it take the culture to grow to 40500 bacteria?
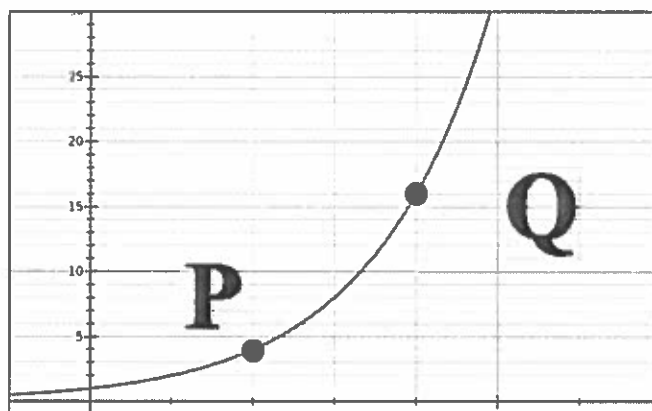
5. Holly is reviewing the change in the value of an investment.

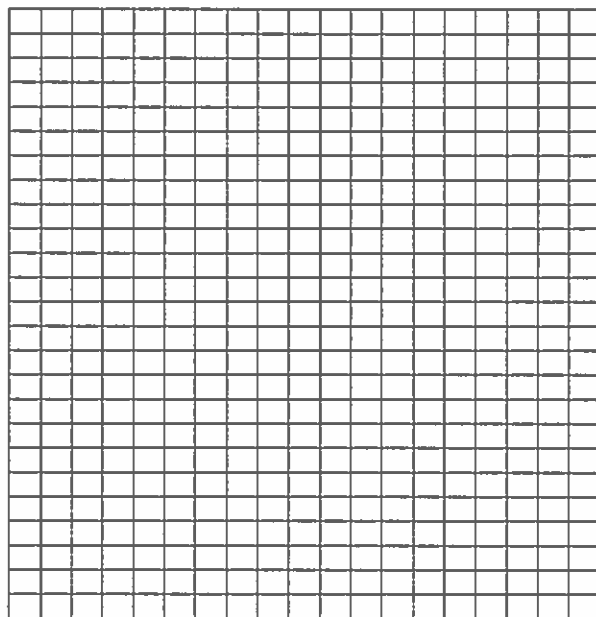 | Time (decades) | 0 | 1 | 2 | 3 |
   |---|---|---|---|---|
   | Value ($1000s) | 8 | 4 | 2 | 1 |

   What type of function can Holly use to model this data? Why is this type of function a good model for the data? Write the function.

6. An initial investment of $5,000 grows at 7% per year. What function represents the value of the investment after t years?

7. About 10^2 taxpayers live in City A. Last year, the state collected about 10^5 dollars in taxes from these taxpayers.

   a. On average, how much did each taxpayer in City A pay in taxes last year? **(1 point)**

   b. City B has 10^5 taxpayers and collected 10^7 dollars in taxes. On average, did a resident of City B pay more or less than a resident of City A in taxes? Explain. **(2 points)**

8. The graph shows the distance, d, a motorcycle is traveling over time, t. What is the average rate of change between points P and Q?

9. Graph $y = -(3)^x$, identifying any intercepts and end behavior.

10. A student claimed that the function shown in the table is exponential. Do you agree or disagree? Explain. Write a function.

y	1	4	16	64	256
x	0	1	2	3	4

11. The maximum height reached by a racquet ball is given by $h(x) = 6(0.5)^x$ where h is the measured in feet and x is the bounce number. What does it means when $x = 0$ and when $x = 2$?

Calculator Use Section

12. The population of a town is currently 2750 people and is expected to double every 5 years. How many people will be living there in 20 years?

13. For which natural number value of x greater than 1 does 8^x first exceed x^8?

    A.   7   **B.**   8   **C.**   9   **D.**   10

14. In 2000, 1000 grams of radium were stored. The half-life of radium is 1,620 years. How many grams of radium remain after 8100 years? Remember, half-life is the amount of time it takes for half of the amount of a substance to decay.

15. Each year the local country club sponsors a bowling tournament. Play starts with 512 participants. During each round, half the players are eliminated. How many players remain after 3 rounds?

16. The population of a sample of bacteria quadruples every 3 minutes. Using a_0 to represent the initial population of the sample, Grant wrote the equation $a_t = a_0(4^{3t})$ to predict the population after a_t after t minutes.

    a. Complete the table of values below and use it to show that Grant's equation is incorrect. **(2 points)**

Time	0 minutes	3 minutes
Population	19	

    b. Write an equation that will accurately predict the population a_t after t minutes of a sample of bacteria that doubles every 3 minutes. **(1 point)**

17. You deposited $500 in an account that pays 4% interest compounded yearly. Find the balance of the account after 7 years.

18. A realtor estimates that a certain new house worth $175,000 will gain value at a rate of 2% per year. Make a table that shows the worth of the house for years 0, 1, 2, 3, and 4. What is the real-world meaning of year 0? Write a function for the data.

19. The following data set represents the value of land that was purchased in 1980. Let t be the number of years since 1980 and v be the value of the land.

Year, t	2000	2001	2002	2003	2004
Value, v	35,000	36,750	38,587.50	40,516.875	42,542.71875

a. Write an exponential model for the value of the land t years after 2000. Does this model represent exponential growth or decay? Explain. (2 points)

b. What is the approximate value of the land in the year 2010? (1 point)

c. Use the exponential model you created and draw the graph of the function using the correct labels and scales. (3 points)