Essential Question: How can we represent an exponential function that shows an increase or decrease over time?

Do Now: Read and solve the following word problems.
(a) The radio station $\mathrm{Z}-100$ is sponsoring a contest. The prize begins as a $\$ 1000$ gift card to Roosevelt Field Mall. Once a day, the disc jockey announces a name, and the person has 15 minutes to call in and claim the prize. If the person does not call within the allotted time, the prize increases by $10 \%$ per day. How much will the gift card be worth if no one wins after 3 days?

| Number of Days <br> Passed | Mathematical Expression | Prize Money |
| :---: | :---: | :---: |
| 0 | Initial Value of the Prize | $\$ 1000$ |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |

(b) Leo purchases a car for $\$ 26,499$. The car depreciates (loses value) at a rate of $18 \%$ annually. What will Leo's car be worth after 3 years?

| Number of Years | Mathematical Expression | Car's Worth |
| :---: | :---: | :---: |
| 0 | Initial Value | $\$ 26,499$ |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |



Exponential Growth occurs when a quantity increases by the same rate, $r$, in each unit of time, $t$.

Exponential Decay occurs when a quantity decreases by the same rate, $r$, in each unit of time, $\boldsymbol{t}$.

The value of the quantity at any given time can be calculated as a function of the rate and the original amount.


Let's look at the Do Now...which situation represents exponential growth? exponential decay?

| Exponential Model |
| :--- |
| What is the value of the prize money <br> after 3 days have passed? |
|  |


| Exponential Model |
| :--- |
| What is the value of Leo's car after 3 <br> years? |

## Examples:

1. A sculpture was valued at $\$ 1200$ in the year 1990. Since then it has been appreciating at a rate of $8 \%$ per year.
a) Write an exponential function to model this situation.
b) Complete the table of values that shows the increase in value over time. Round to the nearest dollar.

| $t$ (time in yrs) | 0 | 5 | 10 | 15 | 20 |
| :---: | :--- | :--- | :--- | :--- | :--- |
| $\boldsymbol{y}$ (value in \$) |  |  |  |  |  |

c) Sketch a graph of the function with the indicated window.

Window:
$x$-min: 0
$x$-max: 40
xscl: 5
y-min: 1,200
y-max: 30,000
yscl: 150

Think About This?

What do the window settings mean in the context of the problem?
d) How much is the sculpture worth now to the nearest dollar?
2. Mr. Rogers purchased machinery for his farming operation for $\$ 175,000$. It is expected to depreciate at a rate of $9 \%$ per year.
a) Write an exponential function to model this situation. What will be the value of the piece of machinery in 10 years?
b) Sketch a graph of the function with the indicated window.

## Window:

$x$-min: 0
$x$-max: 20
xscl: 5
y-min: 20,000
y-max: 175,000
yscl: 10,000

c) Approximately, how many years will it take for the combine to be worth $\$ 50,000$ ?
3. Maria's parents invested $\$ 14,000$ in a CD account earning $6 \%$ per year compounded annually. How much money will there be in the account after 10 years?
4. In 2000, 2200 students attended Polaris High School. The enrollment has since been declining $2 \%$ annually. If this trend continues, how many students will be enrolled in 2019?
5. Ms. Arnold received a job as a teacher with a starting salary of $\$ 55,000$. According to her contract, she will receive a $1.5 \%$ increase in her salary every year. Write an exponential function that can be used to find S, Ms. Arnold's salary after tyears. How many years will it take for Ms. Arnold to reach a minimum salary of $\$ 60,000$ ?

If a relationship grows over time, it can be represented by an Exponential Growth model, $\qquad$ , where $\mathbf{1 + r}$ represents the
$\qquad$
$\qquad$ between successive function values when $\boldsymbol{t}$
increases by 1.
If a relationship decreases over time, it can be represented by an Exponential
Decay model, $\qquad$ , where 1 - $r$ represents the
$\qquad$
$\qquad$ between successive function values when $\boldsymbol{t}$
increases by 1 .

Read each word problem below. Use an exponential growth or decay model to solve.

1. A fully inflated raft containing 4500 cubic inches of air loses $6.6 \%$ of its air every day.
a) After 5 days, how much air remains in the raft? Round to the nearest cubic inch.
b) How much air was lost?
2. The current enrollment of the Roslyn Middle School is expected to increase over the next five years. Each year the population is expected to increase by about $3.2 \%$ from the previous year. How many more students are expected to be enrolled in year 5 than in year 4 if the current enrollment is 850 students?
3. In a particular state, the population of black bears has been decreasing at the rate of $0.75 \%$ per year. In 1990, it was estimated that there were 400 black bears in the state. If the population continues to decline at the same rate, what will the population be in 2020?
4. Camilo purchased a rare coin from a dealer for $\$ 300$. The value of the coin increases $5.5 \%$ each year. How many years will it take for the coin to increase in value by $\$ 100$ ?
5. Elise is buying a new car for $\$ 42,500$. As time goes by, the value of the car will decrease. It's worth can be estimated using the equation $y=42,500(0.91)^{x}$ in which $y$ represents the value of the car over $x$ years.
a) What is the depreciation rate, $\boldsymbol{r}$, of this particular car? Express your answer as a percent.
b) Create a table of values that shows the car's value over a period of 20 years.

Round all values to the nearest dollar.

| Number of Years Passed | Value of the Car <br> (rounded to the nearest dollar) |
| :---: | :---: |
| 0 | $\$ 42,500$ |
| 4 |  |
| 8 |  |
| 12 |  |
| 16 |  |
| 20 |  |

c) Using your table of values, create a graph over the interval $0 \leq x \leq 20$.
d) What will Elise's car be worth after 15 years?


