LESSON 1

The Path of a Ball's Flight

LEARNING OBJECTIVES

- Today I am: collecting data on a ball toss.
- So that I can: graph the data and make predictions.
- I'll know I have it when I can: tell the difference between quadratic functions and other functions.

Opening Exploration

Source: Adapted from the UCLA Curtis Center

In this activity, you will model the path of an object in projectile motion. To do this, several students will line up at regular intervals about 2 feet from the wall. One student will then throw a ball between the wall and the line of students. Students in the line will mark where the ball passes them on the wall. Then each participant will measure the height at which the ball passed them and record the resulting data in the chart on the next page.

1. In the space below, sketch what you believe the path of the ball will be.

2. Is there anything special about the path of the ball?

3. **Directions**

- Ten to twelve students will stand at regular intervals along the length of a wall and about 2 feet from the wall.

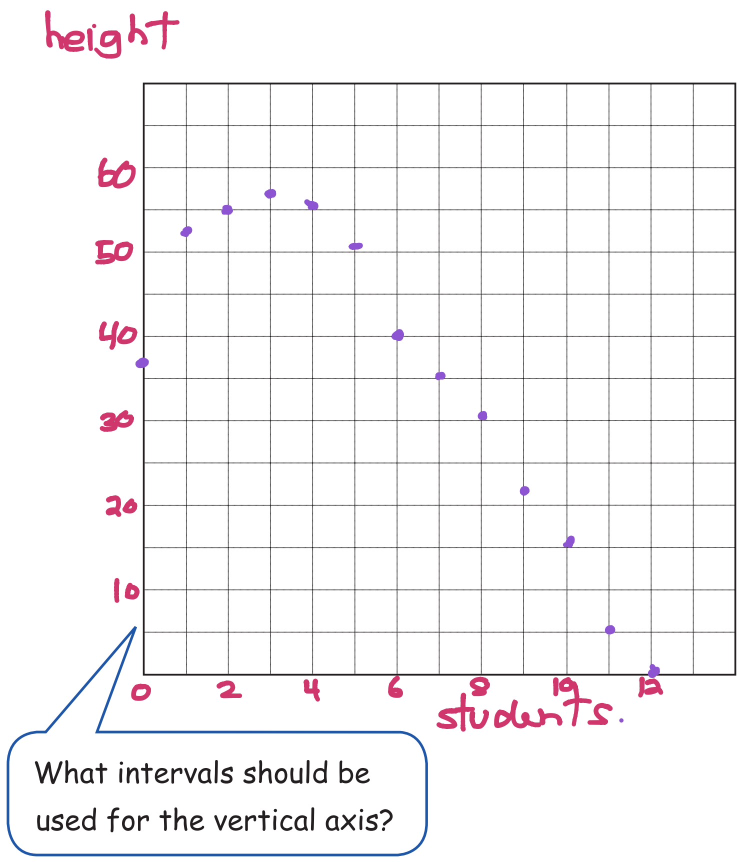
- A ball is then tossed between the students and the wall. (The student who tosses the ball may need to practice several times to get the ball to the desired distance, while not hitting the ceiling or any other students.)

- The students along the wall place a post-it note on the wall to indicate the height of the ball as it passed. Remember to watch the wall directly in front of you and ***not*** watch the ball as it is moving across the wall.

- The vertical distance from the ground to the marker is measured and recorded in the table on the next page.

4. Collect and graph the data.

Approximate horizontal position (x)	**Approximate vertical distance (y) in inches**
0	37
1	52
2	55
3	57
4	56
5	51
6	40
7	35
8	30
9	22
10	15
11	5
12	0



5. Does it make sense to connect the data points with a smooth curve? Explain your thinking.

6. How close was your sketch of the graph in Exercise 1 to the actual graph in Exercise 4? Why is that?

Analyzing the Data and Graph

7. What does this graph physically represent?

Relationship between height and horizontal position.

8. Does this appear to be a function? Justify your answer.

Yes, it passes the vertical line test.

9. Does it appear to be a linear function? Exponential function? Or something else? Justify your answer.

It's not a line but a curve. (Quadratic Function)

10. What are some important values on this graph? Why do you think they're important?

minimum maximum vertex, intercepts (y- and x-)

11. What are some important characteristics of this graph? Explain your thinking.

Symmetric, up-side down, U-shape.

12. As with exponential, linear, and piecewise functions, this function has a special name. Its name is a quadratic function. The shape of the graph is called a parabola.

$y = x^2$

$y = ax^2 + bx + c$

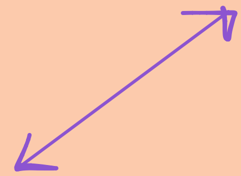
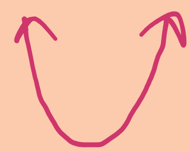
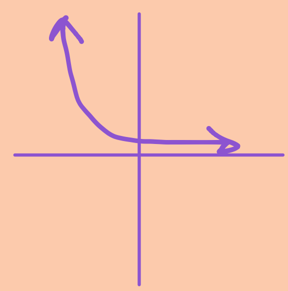
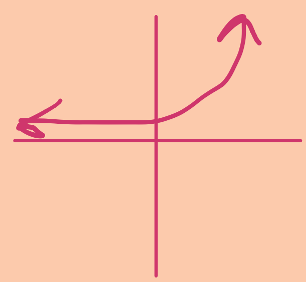
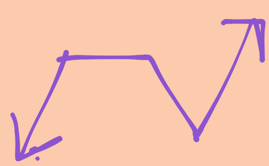
13. As with other graphs, you can use the graph to make predictions about the height of the ball at other positions. What do you think the height of the ball would be if someone stood between . . .

A. position 1 and position 2?

B. position 7 and position 8?

14. Complete the Lesson Summary on the following page by sketching an example graph for each type of function and writing two characteristics of each one.

Lesson Summary

Function	Characteristics	Sketch of the Graph
Linear (including growth, decay and horizontal lines)	• x- and y-intercepts • $y = mx + b$ • m = slope, b = y-inter	
Quadratic	• U-shape, has symmetry • Opens up or down	
Exponential Decay	• Rapid decrease • $y = a \cdot b^x$ $0 < b < 1$	
Exponential Growth	• Rapid increase • $y = a \cdot b^x$ $b > 1$	
Piecewise	• Made up of several functions • inc, dec, constant	

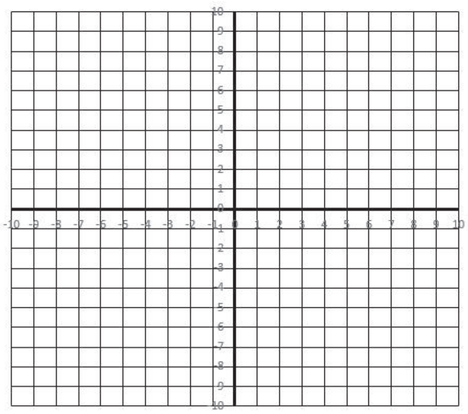
NAME: ______________________ PERIOD: ____________ DATE: ____________

Homework Problem Set

Graph the data in each problem and determine if the graph is showing exponential growth, exponential decay, linear growth, linear decay or a quadratic.

1.

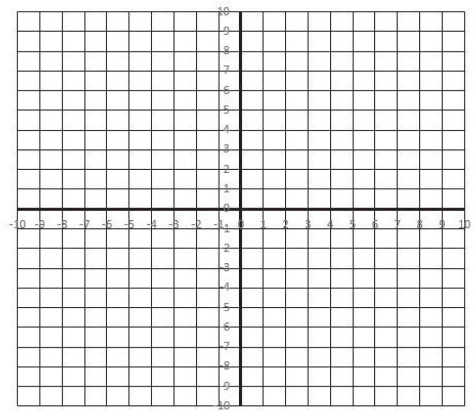
x	y
−3	8
−2	4
−1	2
0	1
1	0.5



This is a ______________________ function.

2.

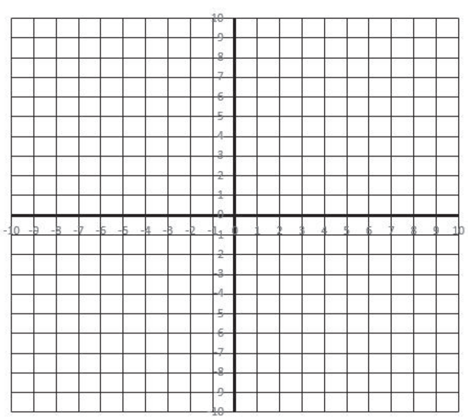
x	y
−2	6
−1	0
0	−2
1	0
2	6



This is a ______________________ function.

3.

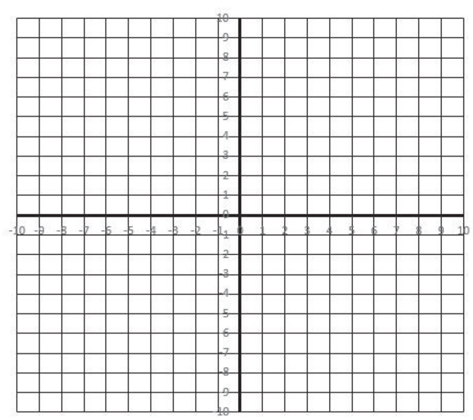
x	y
−2	−6
−1	−4
0	−2
1	0
2	2



This is a ______________________ function.

4.

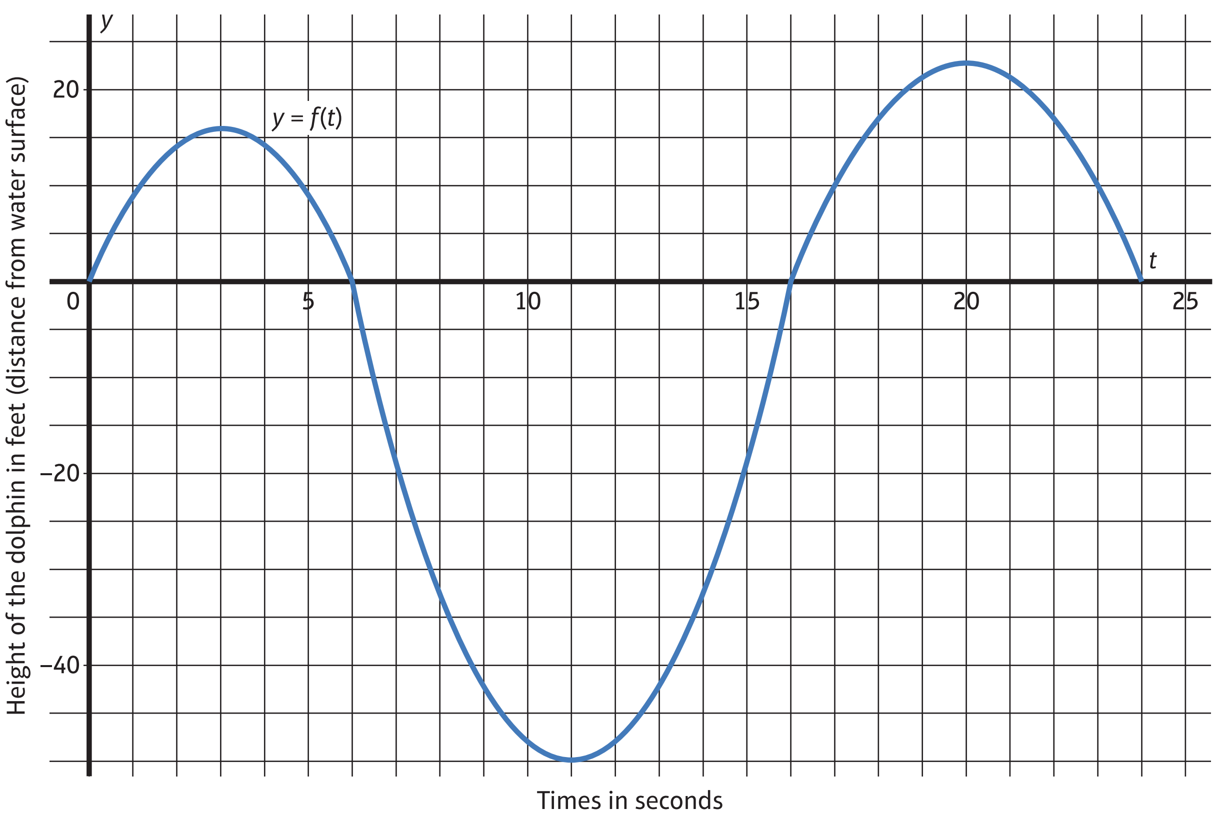
x	y
−1	0.5
0	1
1	2
2	4
3	8



This is a ______________________ function.

5. How could you use the tables (without the graphs) to tell if a function is exponential, linear or quadratic?

6. In a study of the activities of dolphins, a marine biologist made a 24-second video of a dolphin swimming and jumping in the ocean with a specially equipped camera that recorded one dolphin's vertical position with respect to time. This graph represents a piecewise function, $y = f(t)$, that is defined by quadratic functions on each interval. It relates the dolphin's vertical distance from the surface of the water, in feet, to the time from the start of the video, in seconds. Use the graph to answer the questions below.



A. Describe what you know for sure about the actions of the dolphin in the time interval from 0–6 sec. Can you determine the horizontal distance the dolphin traveled in that time interval? Explain why or why not.

B. For which times does $f(t) = 0$? Explain what they mean in the context of this problem. (Hint: You should have multiple answers.)

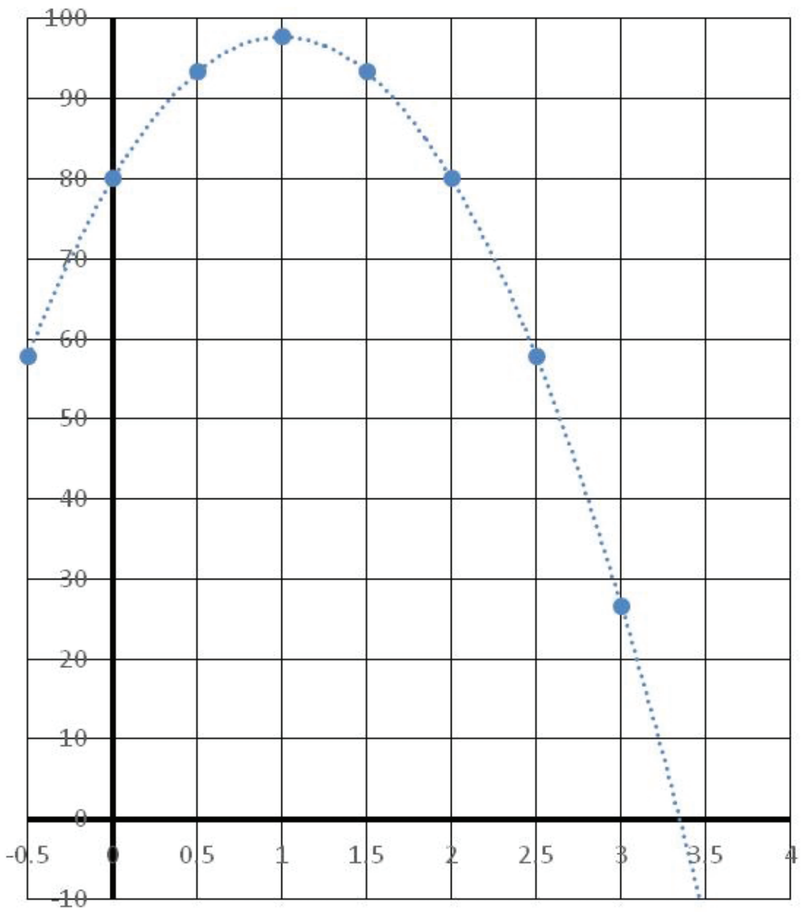
C. How long in seconds was the dolphin swimming under water in the recorded time period? Explain your answer or show your work.

D. Estimate the maximum height, in feet, that the dolphin jumped in the recorded 24-second time period. Explain how you determined your answer.

E. Locate the point on the graph where $f(t) = -50$, and explain what information the coordinates of that point give you in the context of this problem.

7. Pettitte and Ryu each threw a baseball into the air.

The vertical height of Pettitte's baseball is represented by the graph $y = P(t)$ below. P represents the vertical distance of the baseball from the ground in feet, and t represents time in seconds.

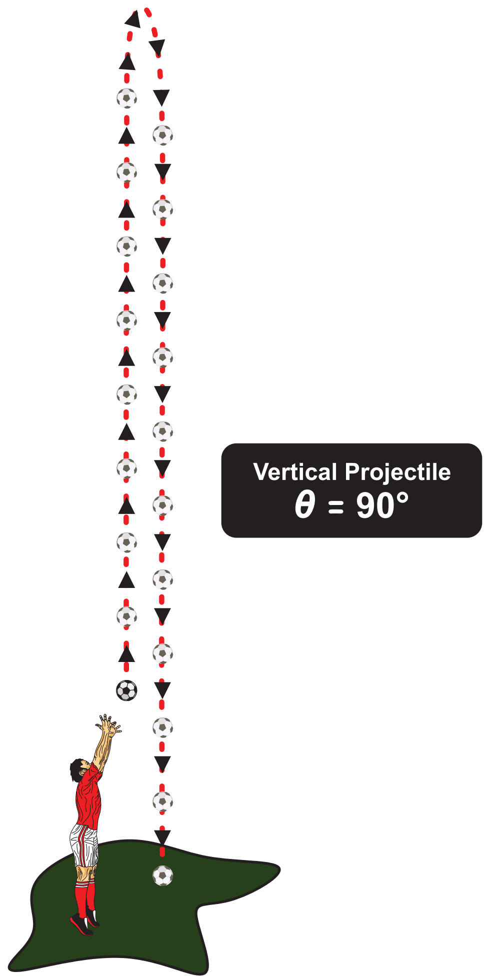


The vertical height of Ryu's baseball is represented by the table values $R(t)$ below. R represents the vertical distance of the baseball from the ground in feet, and represents time in seconds.

t	$R(t)$
0	86
0.5	98
1	102
1.5	98
2	86
2.5	66
3	38
3.3	0

A. Whose baseball reached the greatest height? Explain your answer.

B. Whose ball reached the ground fastest? Explain your answer.



C. Pettitte claims that his ball reached its maximum height faster than Ryu's. Is his claim correct or incorrect? Explain your answer.

D. Find $P(0)$ and $R(0)$ values and explain what they mean in the problem. What conclusion can you make based on these values? Did Ryu and Pettitte throw their baseballs from the same height? Explain your answer.

E. Ryu claims that he can throw the ball higher than Pettitte. Is his claim correct or incorrect? Explain your answer.

Spiral REVIEW—Average Rate of Change

In previous modules, you calculated the average rate of change using the formula $\frac{f(x_1) - f(x_2)}{x_1 - x_2}$.

8. What other common name do we call this formula?

Determine the average rate of change for each function and given points in Problems 9–16.

9. $f(x) = 3x + 2$ for $x_1 = 3$ and $x_2 = -1$.

10. $f(x) = -x - 3$ for $x_1 = 0$ and $x_2 = -4$.

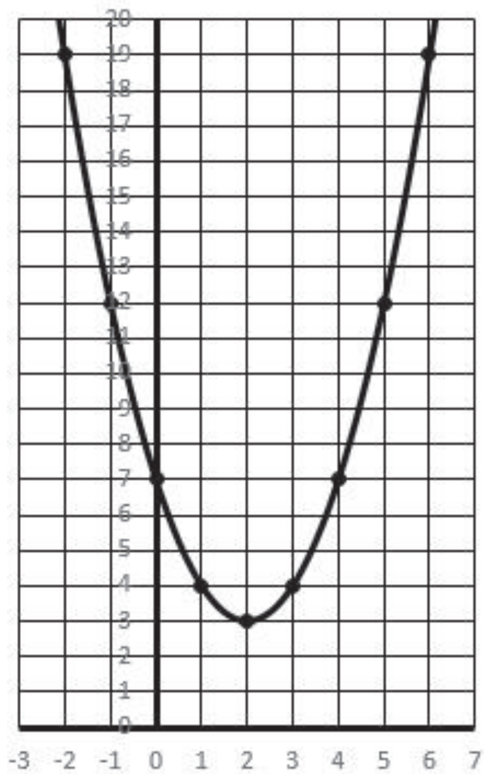
11. $f(x) = 3x^2 + 2$ for $x_1 = 0$ and $x_2 = 2$.

12. $f(x) = -x^2 - 3$ for $x_1 = -1$ and $x_2 = 1$.

13. $f(x) = 3(x - 1)^2 + 2$ for $x_1 = 0$ and $x_2 = 2$.

14. $f(x) = -(x + 2)^2 - 3$ for $x_1 = -1$ and $x_2 = 1$.

15. Use the graph for $x_1 = 0$ and $x_2 = 4$.



16. Use the graph for $x_1 = -1$ and $x_2 = 2$.