Lesson 9.3.1 and 9.3.3 Class Package

Name: Date: Period:

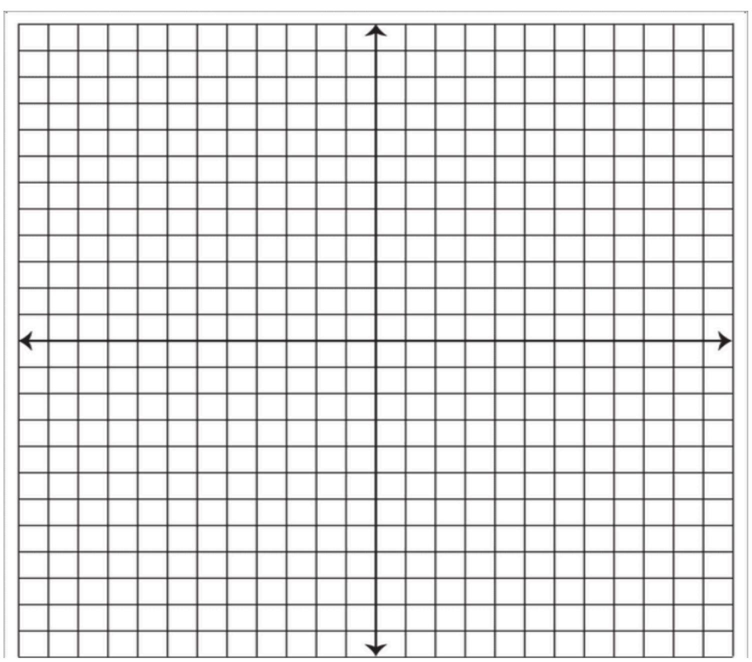
Lesson Objective:

- Students will use tables, graphs, and equations to determine average rates of change from a context, and they will determine when a function is increasing and decreasing. They will also learn about the motion of an object under the force of gravity.
- Students will apply what they know about transforming functions to write equations for graphs of piecewise-defined functions.

9-73. WATER BALLOON VELOCITY

Sasha used video footage from the water balloon contest in Chapter 5 and an app to record the approximate heights at specific times of Maggie's balloon. Her data is shown in the table at right. Maggie's balloon reached a maximum height of 90.75 feet (30.25 yards). How quickly did her balloon rise and fall? That is, what was the balloon's velocity (speed) during different times of its flight? Complete the parts below to answer these questions.

a. Graph the data approximately to scale. Add a curve to your graph to model the data. What is the shape of the curve? Is this what you expected?



Time (sec)	Height (feet)
0	0
0.5	34.2
1.0	60.3
1.5	78.4
2.0	88.4
2.5	90.5
3.0	84.6
3.5	70.7
4.0	48.8
4.5	18.8

b. **Average rate of change** is calculated by determining the slope between two points on a graph. For example, calculate the average rate of change of the balloon between t=0.5sec and t =1.0 sec. Write your answer with its units. What does it mean in the context of the balloon launch?

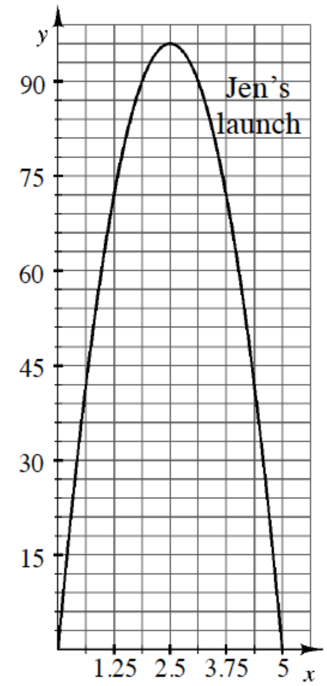
c. Choose two points from the table and use them to calculate the approximate velocity of the balloon 1.75 seconds after it was launched. Does the balloon seem to be speeding up or slowing down as it goes higher?

d. Maggie's balloon landed after approximately 4.8 seconds. When did it reach its maximum height? Choose a pair of points and calculate the approximate velocity of the balloon just after it reached its maximum height. Be sure to include units in your answers.

e. What happened to the velocity of the balloon just before and just after it reached its maximum height? Does this make sense? Explain.

f. What do you predict the velocity of the balloon will be just before it hits the ground? Why? Test your prediction by calculating the approximate velocity of the balloon at the end of its flight.

9-74. Sasha has a graph from Jen's balloon launch and knows that Jen's balloon reached a maximum height of 96 feet (32 yards) and landed after approximately 4.9 seconds. Sasha made a new graph with time (seconds) on the x-axis and the height of the balloon (feet) on the y-axis. Use the graph to estimate the average rate of change when:

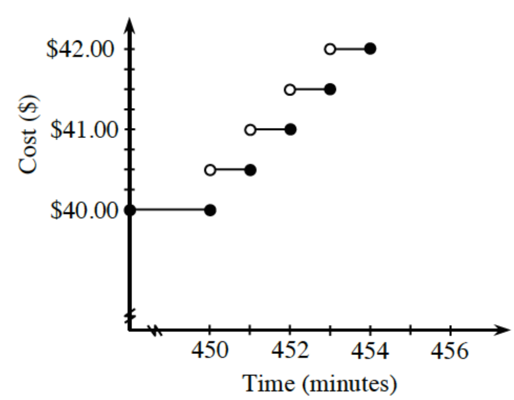


a. t = 2 seconds	b. t = 2.5 seconds
c. t = 4 seconds	d. t = 0.1 seconds

e. When is the height of Jen's balloon increasing? When is it decreasing? How can you tell?

Often a situation cannot be described using a single function. When multiple functions are used to describe a situation, the function is called a **piecewise-defined function**.

9-102. The Horizon Phone Company offers a basic monthly voice plan where customers pay a low monthly fee, but they must pay extra if their calls exceed the maximum number of minutes.The graph at right shows how the plan works.



a. Describe the plan in detail. How many minutes are included in the monthly fee? What is the charge for extra minutes?

b. Write an equation for the first piece of the graph. What is its domain?

c. Use the graph and your description of the plan to write equations for the second and third pieces of the graph. Write the domain for each piece.

d. Does the graph represent a functional relationship? Explain.

e. This kind of piecewise-defined function is called a **step function**. Why do you think it has that name? What other situations can be modeled with step functions?

9-103. Draw a complete graph of each of the following piecewise-defined functions. It may help to make a table first.

a. $f(x) = \begin{cases} 3 & -4 \le x \le -2 \\ -1 & -2 < x \le 2 \\ 5 & 2 < x \le 5 \end{cases}$	b. $f(x) = \begin{cases} 2x - 5 & x \le 1 \\ (x-3)^2 + 1 & x > 1 \end{cases}$