Applications

1. a. $\frac{10}{3}$, or about 3.3 m/s (The exact answer is 3.33333. . . m/s.)

   b. 30 seconds

   c. At $\frac{10}{3}$ meters per 1 second, Hoshi walks $50\left(\frac{10}{3}\right)$ meters or $166\frac{2}{3}$ meters (approximately 167 meters) in 50 seconds.

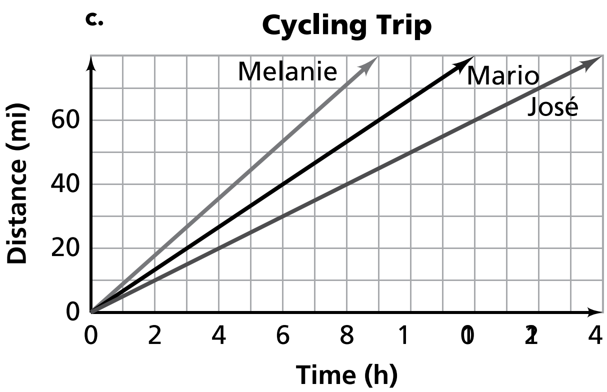
   d. $d = \frac{10}{3}t$

2. Mira's; Milo's walking rate is about 2.7 m/s and Mira's is 3 m/s.

3. a. Jose: $15 \div 3 = 5$ mph;
   Mario: $21 \div 3 = 7$ mph;
   Melanie: $27 \div 3 = 9$ mph

   b. Jose: $7 \times 5 = 35$ mi;
   Mario: $7 \times 7 = 49$ mi;
   Melanie: $7 \times 9 = 63$ mi

   c.



   d. Jose: about 33 mi; Mario: about 46 mi; Melanie: about 59 mi

   e. Jose: 14 hours; Mario: 10 hours; Melanie: about 7.75 hours

   f. The faster the cyclist, the steeper the graph.

   g. Let t = the number of hours and d = the number of miles. Jose: $d = 5t$; Mario: $d = 7t$; Melanie: $d = 9t$

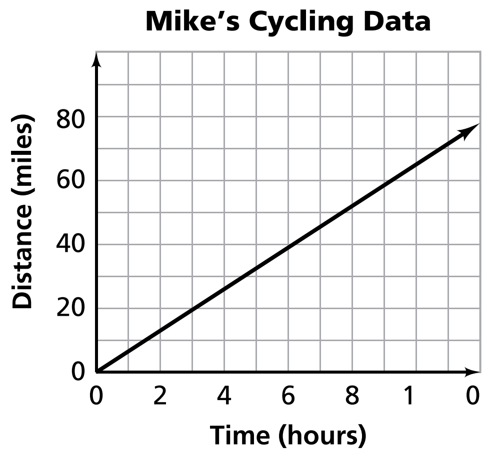
   h. Jose: 32.5 mi; Mario: 45.5 mi; Melanie: 58.5 mi

   i. The rate shows up in the equation as the number being multiplied by t.

   j. All three relationships between distance cycled and time are proportional. They are all of the form $d = rt$. The value of r is the constant of proportionality.

4. a. $d = 6.5t$

   b.



   Answers will vary. Students may say that they looked at the range of numbers needed for time and for distance and then decided on a reasonable scale.

   c. The table can be extended by adding 6.5 miles every hour (or 3.25 miles for a half-hour) to show 7 and $9\frac{1}{2}$ hours. On the graph, the distances at these points may be approximated. In the equation, the values of 7 and $9\frac{1}{2}$ can be substituted for t, which gives the answers of 45.5 mi and 61.75 mi.

   d. The table can be extended by increments of 1 hour or greater to show values of d that are close to 100 mi and 237 mi. On the graph, the times at these points may be approximated after the graph has been made. In the equation, the values of 100 mi and 237 mi can be substituted for d, which gives the approximate answers 15.4 hours and 36.5 hours.

   e. Answers will vary. Possible answer: If the value is already shown in the table or graph, then these representations would be easy to use. If the values are far from those shown in the table or graph, or if you need an exact amount, it is easier to use an equation to get the answer.

f. In decreasing order, the bikers' speeds are Melanie's, Mario's, Mike's, and Jose's. In the tables, this can be found by comparing the distance biked after 1 hour or by finding the difference between any two consecutive distances for times that vary by 1 hour. In the graphs, the steepness of the line gives this information. In the equations, the bikers' rates can be compared by noting the number by which t is multiplied.

5. a. 7.5 mph

b. Alicia's graph would be steeper than Mike's graph. In decreasing order of steepness, the lines would be Melanie's, Alicia's, Mario's, and Jose's. These lines will all go through (0, 0).

6. a. Plan A: no initial donation and then \$3/km; Plan B: The sponsor always donates \$5 no matter how far the participant walks; Plan C: \$2 initial donation and then \$1.50/km (or \$2 initial donation and \$3 every 2 km)

b. Plan A is \$3/km; Plan B is \$0/km except for the initial charge; Plan C is \$1.50/km.

c. the initial donation for each pledge plan

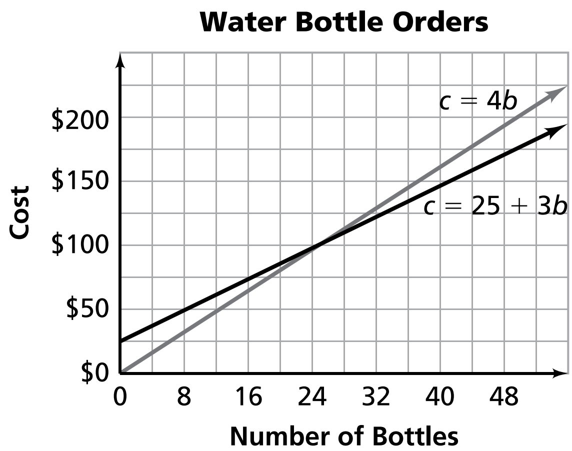
d. Answers will vary. Sample answers: Plan A: (0, 0) (2, 6); Plan B: (0, 5) (4, 5); Plan C: (0, 2) (4, 8) Each point represents the amount of money that is pledged for a certain distance in km walked. For Plan A, (0, 0) represents that walking 0 km will give you \$0 and (2, 6) represents that walking 2 km will give you \$6. The points in Plans B and C represent similar situations.

e. The relationship between amount of money and distance walked for Sponsor A is proportional. The relationships for Sponsors B and C are not proportional because the sponsors donate an amount in addition to the money donated per kilometer.

7. a. Fill It Up: $c = 4b$

Bottles by Bob: $c = 25 + 3b$ (where c is the cost and b is the number of water bottles)

b. Independent variable: number of water bottles; Dependent variable: cost



c. If fewer than 25 water bottles are ordered, Fill It Up has the better offer. If more than 25 are ordered, Bottles by Bob has the better offer. If exactly 25 water bottles are ordered, the companies have the same offer. To decide which company is better, you could look at the point where the lines intersect each other; after this point, the line for Fill It Up is higher than the line for Bottles by Bob.

d. The costs are equal at 25 water bottles. This is where the lines cross.

8. B

Note: The point (0, 5) means that 0 caps cost \$5, which doesn't make sense.

9. a. (10, 85) and (3, 60.5); if you substitute 10 for t in the equation, you will get 85. You can apply the same process to (3, 60.5).

b. The coordinate pair (10, 85) represents that after 10 seconds, the cyclist has gone 85 meters from his home. The point (3, 60.5) represents that after 3 seconds, the cyclist has gone 60.5 meters from his home.

10. a. Similarities: In Tables 1 and 2, the x-values increase by one; this isn't true in Tables 3 and 4.

Differences: In Table 1, the value of y doesn't change at all; in Tables 2, 3, and 4, it does. In Table 2, the y-values decrease and then increase; in Table 3, the y-values increase; and in Table 4, they decrease. In Tables 1, 3, and 4, as the x-values go up by 1, the y-value changes at a constant rate; this isn't true in Table 2.

Note: The patterns in Tables 1, 3, and 4 are similar in that, as x goes up by 1, the y-values change by the following patterns: 0, 0, 0 . . . in Table 1; 3, 3, 3, . . . in Table 3; and −1.5, −1.5, −1.5, . . . for Table 4. So, the data in Tables 1–3 are linear.

The graph of Table 2 is nonlinear. (Actually, its graph is a parabola; it is in fact quadratic.) Its table indicates this nonlinearity by the nonconstant rate of change between y-values as x increases by 1.

b. Tables 1, 3, and 4 represent linear relationships. The change in the y-value is the same for each unit change in the x-value, and the graph forms a straight line.

c.

Table 1

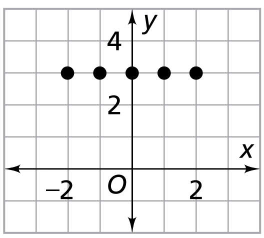


Table 2

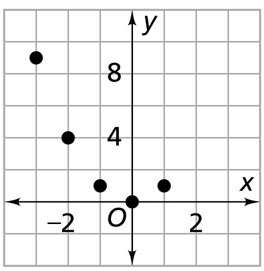


Table 3

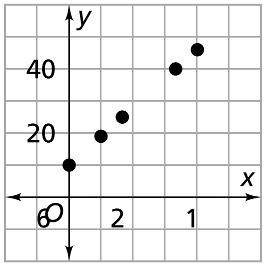
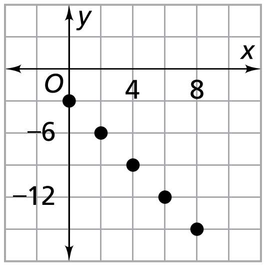


Table 4



d. Table 1: $y = 3$;

Table 3: $y = 3x + 10$;

Table 4: $y = -1.5x - 3$; In Table 1, the y-value is 3 for any x-value. In Table 3, the x-value increases by 3 for every y increase of 1. When $x = 0$, $y = 10$. In Table 4, the y-value decreases by 1.5 as the x-value increases by 1. The y-value is −3 when $x = 0$.

11. a. $t = 30 - 5h$; The variable t represents the temperature in degrees Fahrenheit, which will be 30° minus the 5° per hour (h) that the temperature is expected to drop.

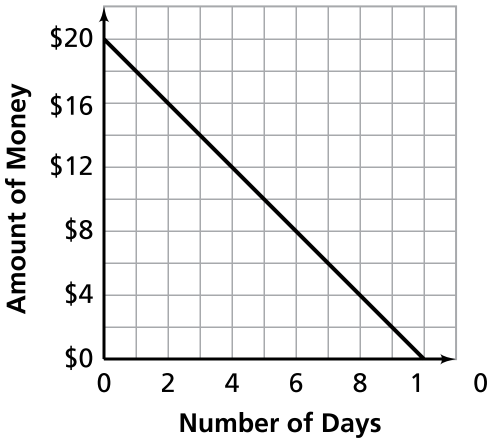
b. This is a linear relationship. The constant rate of change is −5.That is, as the hours increase by 1, the temperature decreases by 5.

12. a. \$20; In the table, "Day 0" represents the start of camp, when Jamal has been at camp for 0 days.

b. \$2; As the number of days increases by 1, the amount of money left decreases by \$2.

c. Yes; as the values for the days go up by 1 unit, the values for the money left go down by a constant amount.

d. **Jamal's Money**



e. $M = -2d + 20$, where M is the money left, d is the number of days, the 20 is the starting amount in Jamal's wallet, and the -2 is the rate at which the money in Jamal's wallet is decreasing.

13. Graph 1: $y = -x$ and Graph 2: $y = -x$

Note: Students are not expected to be fluent at finding the equation from a given graph at this stage.

14. a. Answers will vary. Possible answers:

i. A cable company charges a family a \$100 start-up fee and then \$50 per month. The relationship between months that the family has had cable and the total amount they have to pay is linear and positive.

ii. Another cable company charges a \$100 installation fee and no monthly fee. The relationship between months that the family has had cable and the total amount they have to pay to the cable company would be linear with zero rate of change, because no matter how many months they have cable, they would never pay more than \$100.

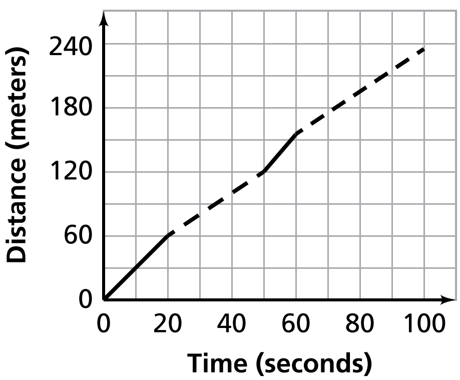
iii. If the family has \$1,000 in their account to pay the first cable company, the amount of money in that account decreases at a constant rate.

b. Again, answers will depend on the answers to part (a). For the examples above, the first equation is $y = 100 + 50x$, the second equation is $y = 100$, and the third equation is $y = 1{,}000 - 50x$.

Connections

15. a. His rate started out at 3 m/s for the first 20 seconds, and then slowed down to 2 m/s for the next 30 seconds; he sped up to 3.5 m/s for the next 10 seconds and then walked at a rate of 2 m/s for the last 40 seconds.

b. **Jelani's Walking Race**



16. a. $2 + (-3 \times 4) = -10$

b. $(4 + -3) \times -4 = -4$

c. $-12 \div (2 + -4) = 6$

d. $(8 \div -2) + -2 = -6$

17. a. True; using the Distributive Property, 20 groups of 410 is the same as 20 groups of 400 plus 20 groups of 10.

b. True; using the Distributive Property, 20 groups of 308 is the same as 20 groups of 340 minus 20 groups of 32.

c. True; using the Distributive Property.

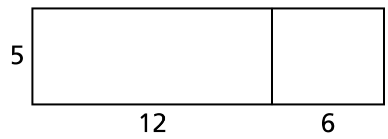
d. Not true; the Distributive Property is not applied correctly. Multiplication should be distributed over addition, not addition distributed over multiplication.

18. a. 6

b. x and 2

c. x

19. a.



b. Area equals $5 \times 12 + 5 \times 6$ or 90 units^2.

20. a. Unit Rate: 3 dollars per T-shirt or $\frac{1}{3}$ T-shirt for $1. Equation: $C = 3t$ (C = cost, t = number of T-shirts) or $t = \frac{1}{3}C$.

b. Unit Rate: 0.23 video games for $1 or 1 video game for $4.43. Equation: $C = \frac{31}{7}v$. (C = cost, v = number of video games) or $v = \frac{7}{31}C$.

c. Unit Rate: 6 tbsp of sugar for one glass or 1 tbsp sugar for $\frac{1}{6}$ glass. Equation: $S = 6g$ (S = total amount of sugar, g = number of glasses) or $g = \frac{1}{6}S$.

21. a. $2{,}292 \div 23.66 = 96.87$ hours

b. $2{,}292 \div 23.56 = 97.28$ hours. So, if his average speed was 0.1 less, it would have taken about 0.41 hours = 41% of 60 minutes, or about 25 minutes longer, to complete the race.

22. a. 41 minutes 56.23 seconds = 2,516.23 seconds, and 10,000 m $\div$ 2,516.23 s $\approx$ 3.974 m/s

b. 86 minutes 52.3 seconds = 5,212.3 seconds, and 20,000 m $\div$ 5,212.3 s $\approx$ 3.837 m/s

23. Possible answer: The relationship between the number of batches b of juice and the number of cups w of water is linear. The relationship between the number of batches b of juice and the number of cups j of juice is also linear. The equations that represent these linear relationships are $w = 3b$, and $j = 5b$.

Note: Other linear relationships in this table include $w = \frac{3}{2}c$, $j = \frac{5}{2}c$, $j = \frac{5}{3}w$, $b = \frac{1}{3}w$, $b = \frac{1}{5}j$, and $b = \frac{1}{2}c$. Students are not as likely to see these relationships unless they look at the equations or graphs of *all* relationships between pairs of variables.

24. a. 9 cups of soda water; Possible explanation: The recipe calls for 3 times as much pineapple juice as orange juice and half as much soda water as pineapple juice. For 6 cups of orange juice, there would be 18 cups of pineapple juice, and 9 cups of soda water.

b. 2 cups of orange juice and 3 cups of soda water; Possible explanation: Look at the row in the table that shows the recipe for 12 cups of pineapple juice, and divide each number by 2.

25. For about the first 3 seconds, John ran at a constant rate of l m/s. He then paused for a second and slowly increased his rate for about 3 seconds to run 3 meters, then ran at a constant rate of 2 m/s for one second, paused for 3 seconds, and finished the race at a rate of 3 m/s. He did not run at a constant rate for the entire race.

26. a. No, it is not linear; there is not a constant rate of change. There are 4 different rates of change represented in the graph.

b. Yes; a person starts off walking for 5 seconds at a constant rate, stops for 3 seconds, then walks at a constant rate for 2 seconds, and then walks a little faster at a constant rate.

27. a. At 70 seconds, about 20 milliliters has been lost, so an estimated time that the 100-ml container would be full is $70 \times 5 = 350$ seconds, or 5 minutes and 50 seconds.

b. The relationship between water loss and time is fairly close to linear, but it is not exactly linear. It isn't linear since the rate is not constant. For example, the time is going up by even intervals of 10 seconds. The patterns of change in the water loss for the first few values are $5 - 2 = 3$ and $8.5 - 5 = 3.5$. Since 3 is not equal to 3.5, there is no constant rate.

28. Answers will vary. Possible answer: The difference might be the scale the students used on their axes. Maybe one of Denise's intervals equals two of Takashi's intervals on the *t*-axis.

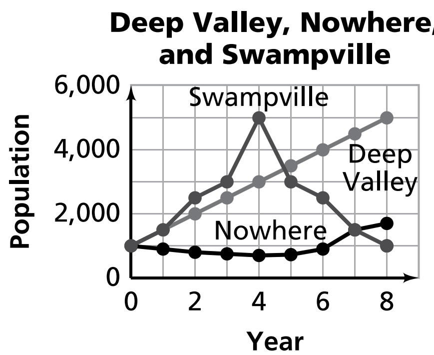
29. Answers will vary. Possible answers: This could mean that no more water was lost after a certain time, perhaps because the faucet stopped leaking. Or, if *v* refers to the volume collected in the measuring container, the container might have overflowed, so no more water could be collected.

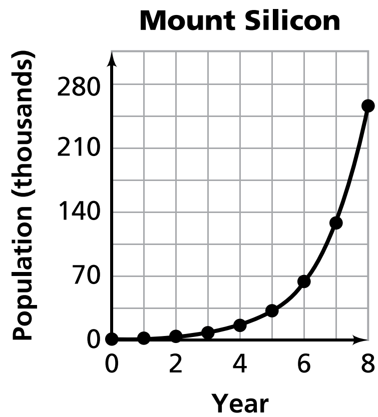
Extensions

30. a. For Deep Valley, as the number of years increased, the population increased at a constant rate of 500. Nowhere's population gradually decreased at a nonconstant rate and then made a quick increase. Swampville's population increased at a nonconstant rate until the fourth year, and then decreased at the same rate it had increased. Mount Silicon's population doubled each year.

b. Deep Valley's population growth represents a linear relationship because it increased at the constant rate of 500 for each year.

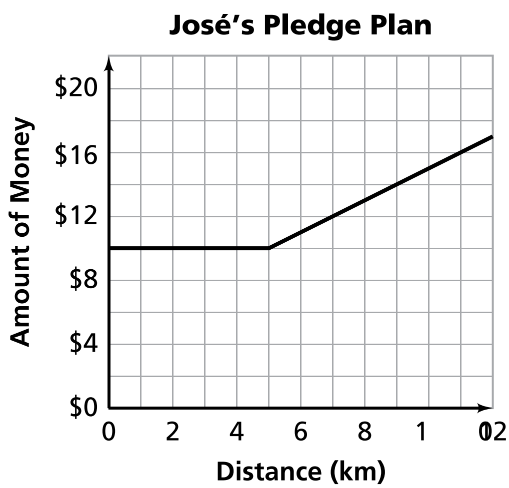
c. The populations of Deep Valley, Nowhere, and Swampville are somewhat close and may easily be represented on the same graph. Putting Mount Silicon on the same vertical scale is difficult because its population increased so rapidly. Ranges will vary; students should support their choices. The horizontal scales are the same on the graphs shown below.





d. Answers will vary. Possible answer: The tables may be more appropriate if you want to know the precise population of a city at a certain time. The graphs give a picture of the population over time at a quick glance, and they show overall trends better than tables do.

31. a.



b. For the first 5 km, this part of the graph looks like Leanne's—a horizontal line that intersects the y-axis at 10 and is parallel to the x-axis. After 5 km, it goes straight up to the right at a constant rate of $l/km, so it is slightly less steep than Gilberto's graph, which is $2/km.

32. Answers will vary.

a. Possible answer: (4, $40). This coordinate would mean that to make 4 T-shirts, it would cost $40.

b. Possible answer: (1, $30), where 1 is the number of T-shirts made and $30 is the cost for making those T-shirts. This point lies above the line because the cost exceeds that of the original equation. In the original equation, it would cost $25 to make 1 T-shirt.

c. Possible answer: (1, $15), where 1 is the number of T-shirts made and $15 is the cost of making those T-shirts. This point lies below the line because the cost is less than that of the original equation, which is $25 for 1 T-shirt.

33. Answers will vary.

a. Possible answer: He is planning to ask his sponsors for a $20 donation and $3/km. How much money could he earn from each donor by walking 5 km?

b. Possible answer: He is planning to ask her donors for 25¢/km. How far would he have to walk to earn $3 from each donor?

c. Possible answer: He is planning to walk at 4 km/h. How far can he walk in 3 hours?