Heights of Traffic Cone Stacks:

$$h = c(1.5) + 16.5$$

In this equation, h = height in inches of the stack and c = number of cones in the stack.

Two things to note here. First, looking at the graph, if we extend the line, it no longer intersects the origin as it should for proportional relationships. Second, the equation does not adhere to the correct form. The extra 16.5 shatters the form of $y = kx$ necessary for a proportional equation.

Skill Check Answers

1. c. and d. **2.** a. and b. **3.** $6.02

4.5 Exercises

✔ CONCEPT CHECK

1. A variable quantity A is _____ to a variable quantity b when there exists an invariant, k (the constant of proportionality), such that $A = kb$.

2. The length of a spring will always be proportional to the _____ on the spring.

3. Setting two equivalent fractions equal to one another and solving is often referred to as _____.

4. When two quantities are proportional, they are connected by an _____ formula.

5. If a relationship is proportional, the graph of the corresponding values will be a line that passes through the _____, and the slope of that line is the constant of proportionality.

PRACTICE

Find the constant of proportionality.

6. $3y = 12x$

7. $7a = 35b$

8. $4r = 36s$

9. $5h = 55w$

Solve.

10. A force of 500 newtons stretches a spring by 2 meters.

a. What is the constant of proportionality?

b. How much force would be needed to stretch the spring 5 meters?

11. A force of 70 newtons stretches a spring by 5 meters.

a. What is the constant of proportionality?

b. How long would the spring stretch if a force of 42 newtons was used?

12. A force of 240 newtons stretches a spring by 4 meters.

a. What is the constant of proportionality?

b. How much force would be needed to stretch the spring 7.5 meters?

13. A force of 125 newtons stretches a spring 5 meters.

a. What is the constant of proportionality?

b. How long would the spring stretch if a force of 225 newtons was used?

APPLICATIONS

14. If a model car is an S scale model car, then for every 1-inch length on the model, the corresponding part of the actual car is 64 inches long. Find the constant of proportionality for the length of the scale model to the length of the actual car.

15. On a map for a local community park, the scale indicates that every inch of length on the map corresponds to 48 inches of length of the park. Find the constant of proportionality for the scale of the map to the actual park.

16. The scale on a map of a town center indicates that one inch on the map is equivalent to 60 inches in the town center. Find the constant of proportionality for the length on the map to the length in the town center.

17. For an HO scale model train, each inch of length of the on the model train corresponds to 87 inches on the actual train. Find the constant of proportionality for the length on the model train to the length on the actual train.

18. The scale given on a blueprint of a city park indicates that each inch on the blueprint is equivalent to 8 feet of the actual park. If a path in the park is 160 feet long, how long is the path on the blueprint?

19. For a G scale model train, each inch of length of the model train is equivalent to 25 inches of length on the actual train. If a real boxcar is 665 inches long, how long is the G scale model of the boxcar?

20. At Minimumdus, an outdoor museum in Klagenfurt, Austria, each building replica is a scaled version of the original with a ratio of 1 : 25. If the actual Taj Mahal is 73 meters tall, how tall is the replica at Minimundus?

21. A Cuda Dragster car model has a scale of 1 : 25. If the tire height of the model is 1.06 inches, what is the height of the life-size tire?

22. The Clarksville football team outscored its opponents 5 : 3 last season. If their opponents scored 78 points, how many points did Clarksville score?

23. The scale of a map is 1 in. = 11.9 miles. How many inches will be drawn on the map to represent 30.9 miles?

24. Find the actual width of a building if the model of the building is 5 cm wide by 58.7 cm long and the actual length of the building is 140.9 m.

25. The ratio of outdoor swimmers to indoor swimmers at the recreation center is 3 : 2. If the center has 55 swimmers altogether, how many of them are indoor swimmers?

26. On a globe model of the Earth, one centimeter is equivalent to 650 kilometers on the actual Earth. The straight-line distance from Juneau, AK, to Orlando, FL, is approximately 5215 kilometers. What would the distance between the two cities be on the globe model?

27. You are packing to move and need to pack your collection of paperback novels. The moving company you hired requires that small boxes weigh no more than 45 pounds. You weigh a few of your books and determine that 4 novels weigh approximately 3.6 pounds. If you have 125 novels, approximately how many boxes will you fill with books?

28. A contest is being held to guess the number of candies in a jar where the winner will receive a $50 gift card. You make an educated guess that the jar holds 17 ounces of candy and experiment with a pack of candy you purchased yourself to determine that 20 individual candies weigh 0.15 ounces. Using this information, how many candies would you guess are in the jar?

29. A wedding planner is assembling small gift bags for an upcoming wedding reception. The couple set aside $240 of their wedding budget for the gifts, $120 of which is specifically for chocolates. The planner found chocolate hearts that are sold in packs of 8 for $2.50 per pack. How many chocolate hearts can the wedding planner purchase for the gift bags?

30. A general goods store at a campsite needs to restock their inventory of fire starters. The store's distributor sells boxes of 12 fire starter kits for $16. If the store's budget for ordering fire starters is $260, how many fire starter kits can be purchased? (**Hint:** You can only purchase whole boxes.)

31. While packing up donations for distribution, a worker at a donation center forgot to write the number of T-shirts that were packed into a box before sealing it with tape. Instead of unpacking the box, the worker weighed a few T-shirts and discovered that a stack of four T-shirts weighs an average of 550 grams. The worker also estimates that the weight of the contents of the box is 16 550 grams. Approximately how many T-shirts are in the box?

32. A local food bank received a shipment of 3 large boxes each containing 12-count individual mac and cheese dinners. Employees determine that each of the 12-count dinner boxes weighs 25 pounds and each of the large boxes weighs 100 pounds. How many individual dinners were received?

33. A coffee roasting company offers a blend made of coffee beans from Brazil, Colombia, and Peru in a ratio of 4 : 5 : 2. The company pays \$3.50/lb for the beans from Brazil, \$4.00/lb for the beans from Colombia, and \$4.50/lb for the beans from Peru. If the production steps (such as roasting, packaging, and shipping), cost the company an additional \$3.00 per pound, what is the total cost of producing one pound of the coffee blend?

34. Instructions for a chemical procedure state to mix salt, baking soda, and water in a 4 : 5 : 21 ratio by mass. How many grams of water would be required to make a mixture that contains 60 grams of salt?

35. A screen printing company finds that for each T-shirt it produces, 40% of the cost is for materials, 50% is for labor, and 10% is for advertising. If a batch of 100 shirts required \$180 in materials, what was the total cost of producing one shirt in the batch?

36. You want to estimate the number of sheets of office paper that you have on your desk. You know the following.

1. The standard pack of paper contains 500 sheets and is 52 millimeters high.
2. The height of the stack you have is 20 millimeters.

Use the fact that the height of a stack is proportional to the number of sheets of paper in it to find the number of sheets in your stack.

37. You need to determine how many cans a machine can produce in half an hour. You know that the average amount of cans produced in a 6-hour shift is 3000. Use the fact that the number of cans produced is proportional to time to find the number of cans that is produced in half an hour.

38. The following table contains the amount of simple interest paid on a loan in relation to the length of the loan.

Length of the Loan (years)	1	2	3	4	5	6
Interest (\$)	70	140	210	280	350	420

Is the interest proportional to the length of the loan? If it is, find the constant of proportionality. If not, explain why.

39. The following table contains the amount of simple interest paid on a loan in relation to the length of the loan.

Length of the Loan (years)	1	2	3	4	5	6
Interest (\$)	308.39	635.80	983.40	1352.45	1744.25	2160.22

Is the interest proportional to the length of the loan? If it is, find the constant of proportionality. If not, explain why.

40. Consider the distance covered by a car moving at a constant speed.

Time (minutes)	3	5	10	15	20
Distance (miles)	2.4	4	8	12	16

Is the distance proportional to the time spent? If it is, find the constant of proportionality. If not, explain why.

41. Consider the weight of a bottle of milk in relation on the amount of milk in the bottle.

Amount of Milk (milliliters)	300	400	550	750
Weight (grams)	800	900	1050	1250

Is the amount of milk proportional to the weight of the bottle? If it is, find the constant of proportionality. If not, explain why.

42. The air temperature in Anchorage, Alaska, during a day in 2022 is shown in the table.

Hours after Midnight	3	6	9	12	15
Temperature (°C)	1	2	3	5	6

Is the temperature proportional to the number of hours passed after midnight? If it is, find the constant of proportionality. If not, explain why.

43. The table shows the amount of flour needed to make a loaf of bread.

Flour (grams)	400	1200	1600	2800
Bread (loafs)	1	3	4	7

Is the amount of flour proportional to the number of loafs of bread baked? If it is, find the constant of proportionality. If not, explain why.

44. The growth of a child during the first 6 months of life is shown in the following table.

Age (months)	1	2	3	4	5	6
Height (centimeters)	55	58	61	64	67	70

Is the height of the child proportional to the age of the child? If it is, find the constant of proportionality. If not, explain why.

45. The temperature of water heated over a span of 8 minutes is shown in the table.

Time (minutes)	1	2	4	6	8
Temperature (°C)	30	40	60	80	100

Is the temperature of the water proportional to the time it was heated? If it is, find the constant of proportionality. If not, explain why.

46. The following table shows the amount of water needed to fill a cylindrical tank depending on the tank's diameter.

Diameter (meters)	1	2	3	4	5
Volume of Water (liters)	1570	6280	14,140	25,130	39,270

Is the volume proportional to the diameter of the tank? If it is, find the constant of proportionality. If not, explain why.

4.5 PROJECT

WHY ARE CELLS SO SMALL?

The germ theory of disease is the fundamental theory of medicine that says infectious diseases are caused by microscopic organisms called pathogens. The theory wasn't accepted until the end of the 19th century, in part because pathogens are invisible to the naked eye.

A main type of pathogen is bacteria (singular, bacterium). These are one-celled (or unicellular) living organisms present almost everywhere on Earth.

In this project, we will explore one possible reason that bacteria are so small.

In order to simplify matters, let's assume we are going to study a bacterium that is perfectly spherical.

Biologists believe that the ability of a bacterium to obtain resources (such as food) is proportional to its radius. They also believe that the bacterium's need (or demand) for resources is proportional to the square of its radius. If the demand for resources is less than or equal to the ability to obtain resources, then the bacterium is able to sustain itself.

The table below contains the values for the ability to obtain resources (A) and the demand for resources (D) for a hypothetical bacterium. Units are omitted for clarity.

Radius (R)	**Ability (A)**	**Radius Squared (R^2)**	**Demand (D)**
1.5	0.75	2.25	0.45
2	1	4	0.8
2.5	1.25	6.25	1.25

1. Assume that A is proportional to R; that is, $A = k_1R$ for a constant of proportionality k_1. Determine the value of k_1.

2. Assume that D is proportional to R^2; that is, $D = k_2R^2$ for a constant of proportionality k_2. Determine the value of k_2.

3. When the radius doubles from 1.5 to 3.0, how many times does the ability to obtain resources increase by?

4. Determine the demand (D) from a radius of $r = 3$. How many times larger is that than the demand (D) when the radius is equal to 1.5?

5. How can these numbers help explain why most unicellular organisms are usually small?