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I. Model Problems

A **linear model** is a linear equation that represents a real-world scenario. You can write the equation for a linear model in the same way you would write the slope-intercept equation of a line. The y -intercept of a linear model is the quantity that does not depend on x . The slope is the quantity that changes at a **constant rate** as x changes. The change must be at a constant rate in order for the equation to be a linear model.

Example 1 A machine salesperson earns a base salary of \$40,000 plus a commission of \$300 for every machine he sells. Write an equation that shows the total amount of income the salesperson earns, if he sells x machines in a year.

The y -intercept is \$40,000; the salesperson earns a \$40,000 salary in a year and that amount does not depend on x .

The slope is \$300 because the salesperson's income increases by \$300 for each machine he sells.

Answer: The linear model representing the salesperson's total income is $y = \$300x + \$40,000$.

Linear models can be used to solve problems.

Example 2 The linear model that shows the total income for the salesperson in example 1 is $y = 300x + 40,000$. (a) What would be the salesperson's income if he sold 150 machines? (b) How many machines would the salesperson need to sell to earn a \$100,000 income?

(a) If the salesperson were to sell 150 machines, let $x = 150$ in the linear model; $300(150) + 40,000 = 85,000$.

Answer: His income would be \$85,000.

(b) To find the number of machines he needs to sell to earn a \$100,000 income, let $y = 100,000$ and solve for x :

$$y = 300x + 40,000$$

$$100,000 = 300x + 40,000$$

$$60,000 = 300x$$

$$x = 200$$

Write the linear model.

Substitute $y = 100,000$.

Subtract.

Divide.

Answer: To earn a \$100,000 income the salesperson would need to sell 200 machines.

You can also use the standard form to write a linear model. Use this form if you are analyzing two quantities that increase at different rates.

Example 3 At a school play, children's tickets cost \$3 each and adult tickets cost \$7 each. The total amount of money earned from ticket sales equals \$210. Write a linear model that relates the number of children's tickets sold to the number of adult tickets sold.

Let x = the number of children's tickets sold
and y = the number of adult tickets sold

The amount of money earned from children's tickets is $3x$.

The amount of money earned from adult tickets is $7y$.

The total amount of money earned from ticket sales is $3x + 7y$, which is equal to \$210.

Answer: $3x + 7y = 210$.

Example 4 In the ticket sales example above, how many children's tickets were sold if 24 adult tickets were sold?

If 24 adult tickets were sold, $y = 24$. Substitute $y = 24$ into the linear model above:

$$3x + 7y = 210$$

$$3x + 7(24) = 210$$

$$3x + 168 = 210$$

$$3x = 42$$

$$x = 14$$

Write the linear model.

Substitute $y = 24$.

Simplify.

Subtract.

Divide.

Answer: 14 children's tickets were sold.

II.

Practice

Solve.

1. Lin is tracking the progress of her plant's growth. Today the plant is 5 cm high. The plant grows 1.5 cm per day.
 - a. Write a linear model that represents the height of the plant after d days.
 - b. What will the height of the plant be after 20 days?
2. Mr. Thompson is on a diet. He currently weighs 260 pounds. He loses 4 pounds per month.
 - a. Write a linear model that represents Mr. Thompson's weight after m months.
 - b. After how many months will Mr. Thompson reach his goal weight of 220 pounds?
3. Paul opens a savings account with \$350. He saves \$150 per month. Assume that he does not withdraw money or make any additional deposits.
 - a. Write a linear model that represents the total amount of money Paul deposits into his account after m months.
 - b. After how many months will Paul have more than \$2,000?
4. The population of Bay Village is 35,000 today. Every year the population of Bay Village increases by 750 people.
 - a. Write a linear model that represents the population of Bay Village x years from today.
 - b. In approximately many years will the population of Bay Village exceed 50,000 people?

5. Conner has \$25,000 in his bank account. Every month he spends \$1,500. He does not add money to the account.
- Write a linear model that shows how much money will be in the account after x months.
 - How much money will Conner have in his account after 8 months?
6. A cell phone plan costs \$30 per month for unlimited calling plus \$0.15 per text message.
- Write a linear model that represents the monthly cost of this cell phone plan if the user sends t text messages.
 - If you send 200 text messages, how much would you pay according to this cell phone plan?
7. Ben walks at a rate of 3 miles per hour. He runs at a rate of 6 miles per hour. In one week, the combined distance that he walks and runs is 210 miles.
- Write a linear model that relates the number of hours that Ben walks to the number of hours Ben runs.
 - Ben runs for 25 hours. For how many hours does he run?
8. A salesperson receives a base salary of \$35,000 and a commission of 10% of the total sales for the year.
- Write a linear model that shows the salesperson's total income based on total sales of k dollars.
 - If the salesperson sells \$250,000 worth of merchandise, what is her total income for the year, including her base salary?
9. Amery has x books that weigh 2 pounds each and y books that weigh 3 books each. The total weight of his books is 60 pounds.
- Write a linear model that relates the number of 2 pound books to the number of 3 pound books Amery has.
 - If Amery has 10 3-pound books, how many 2-pound books does he have?

- 10.** Max sells lemonade for \$2 per cup and candy for \$1.50 per bar. He earns \$425 selling lemonade and candy.
- Write a linear model that relates the number of cups of lemonade he sold to the number of bars of candy he sold.
 - If Max sold 90 bars of candy, how many cups of lemonade did he sell?

III. Challenge Problems

- 11.** A bacteria population doubles every minute. Explain why this population growth cannot be modeled using a linear equation.
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- 12.** Kara used the linear model $y = 20,000 + 0.3x$ to predict her total salary from achieving total sales of x . What is her base salary? What percent commission does she earn?
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13. Correct the Error

Question: The model $2x + 5y = 85$ can be used to model how much money Tim spent on x sodas and y sandwiches. If he bought 15 sodas, how many sandwiches did he purchase?

Solution:

$$2x + 5(15) = 85$$

$$2x + 75 = 85$$

$$2x = 10 \text{ or } x = 2$$

Tim bought 2 sandwiches.

What is the error? Explain how to solve the problem.

IV. Answer Key

1. $y = 5 + 1.5d$; 35 cm
2. $y = 260 - 4m$; 10 months
3. $y = 350 + 150m$; 11 months
4. $y = 35,000 + 750x$; 20 years
5. $y = 25,000 - 1,500x$; \$13,000
6. $y = 30 + 0.15t$; \$60
7. $3x + 6y = 210$; 20 hours
8. $y = 35,000 + 0.1k$; \$60,000
9. $2x + 3y = 60$; 15 2-pound books
10. $2x + 1.5y = 425$; 145 cups
11. The rate of increase is not constant
12. Base salary = \$20,000. 30% commission
13. The student switched x and y . Correct answer is $y = 11$.