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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 $\boldsymbol{y = \$300x + \$40{,}000.}$

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:

$y = 300x + 40{,}000$	Write the linear model.
$100{,}000 = 300x + 40{,}000$	Substitute $y = 100{,}000$.
$60{,}000 = 300x$	Subtract.
$x = 200$	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:

$3x + 7y = 210$	Write the linear model.
$3x + 7(24) = 210$	Substitute $y = 24$.
$3x + 168 = 210$	Simplify.
$3x = 42$	Subtract.
$x = 14$	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.

a. Write a linear model that shows how much money will be in the account after x months.
b. 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.

a. Write a linear model that represents the monthly cost of this cell phone plan if the user sends t text messages.
b. 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.

a. Write a linear model that relates the number of hours that Ben walks to the number of hours Ben runs.
b. 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.

a. Write a linear model that shows the salesperson's total income based on total sales of k dollars.
b. 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.

a. Write a linear model that relates the number of 2 pound books to the number of 3 pound books Amery has.
b. 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.

a. Write a linear model that relates the number of cups of lemonade he sold to the number of bars of candy he sold.
b. 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 $y = 11$.