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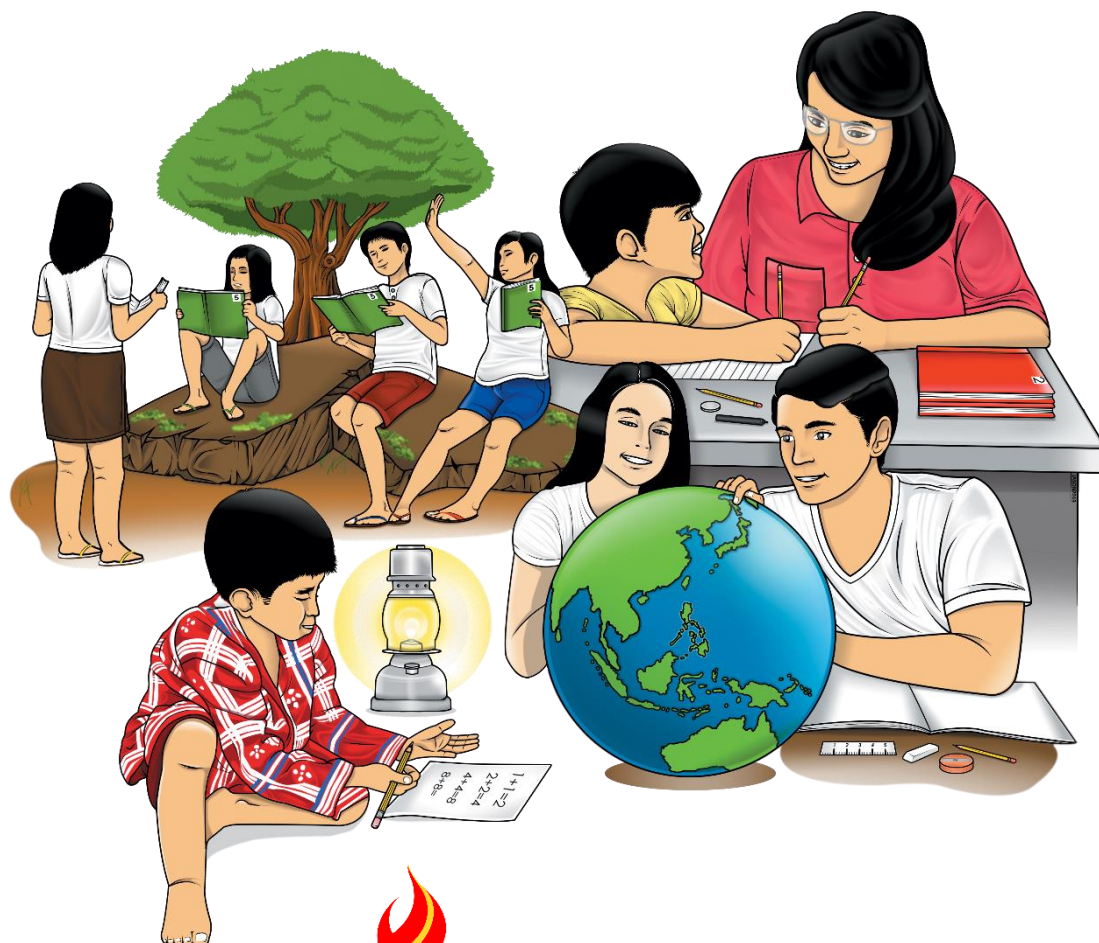
Statistics and Probability

Quarter 4 – Module 21:
Calculating the Slope and
Y-Intercept of a Regression Line

ALTERNATIVE DELIVERY MODE
ADM

Statistics and Probability – Grade 11
Alternative Delivery Mode
Quarter 4 – Module 21: Calculating the Slope and Y-Intercept of a Regression Line
First Edition, 2021

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

In the previous modules, you've learned about independent and dependent variables and how these variables are related. You also learned about scatter plots that can help you better understand statistical data. Furthermore, you calculated correlation coefficient and analyzed existing relationships between variables.

This module will introduce you to concepts about regression analysis and the regression line. Also, you will master calculating the slope and y-intercept of the regression line as well as using the computed values to create a regression equation. Later, you will interpret the calculated slope and y-intercept of the regression line.

After going through this module, you are expected to:

1. identify the slope and y-intercept from the equation of the regression line;
2. calculate the slope and y-intercept of the regression line; and
3. formulate the equation of the regression line.

Before you proceed to the lesson, make sure to answer first the questions in the next page (*What I Know*).
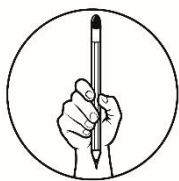
What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which straight line is used to predict the value of y (dependent variable) for a given value of x (independent variable)?
   a. approximation point
   b. approximation line
   c. regression form
   d. regression line

2. What term refers to the steepness of the regression line?
   a. domain
   b. range
   c. slope
   d. y-intercept

3. What indicates the location where the regression line intersects the y-axis?
   a. domain
   b. range
   c. slope
   d. y-intercept

4. How do you determine the slope from an equation of a regression line?
   a. Look for the constant.
   b. Look for the numbers, then divide.
   c. Look at the number after the plus sign.
   d. Look at the number attached to the x-variable.

5. How do you find the y-intercept from an equation of a regression line?
   a. Look for the constant.
   b. Look for the numbers, then divide.
   c. Look at the number after the plus sign.
   d. Look at the number attached to the x-variable.

6. In the regression equation $\hat{y} = 2 + x$, what is the slope?
   a. 3   b. 2   c. 1   d. 0

7. In the equation $\hat{y} = 2 + x$, what is the y-intercept?
   a. 3   b. 2   c. 1   d. 0

8. What is the y-intercept in the regression equation: $\hat{y} = -4x - 5$?
   a. 5   b. 4   c. -4   d. -5

9. What is the slope in the regression equation: $\hat{y} = -2x + 7$?
   a. 7   b. 2   c. -2   d. -7

10. What is the slope (b) and y-intercept (a) in the equation: $\hat{y} = 5 - \frac{2}{3}x$?

    a. $b = 5$; $a = \frac{2}{3}$ c. $b = -\frac{2}{3}$; $a = 5$

    b. $b = -5$; $a = \frac{2}{3}$ d. $b = \frac{2}{3}$; $a = 5$

Consider the following data for nos. 11-15.

x	1	2	3	4	5	6	7
y	4	5	1	6	7	10	7

11. What is the $\sum y$ of the given data on the table?

    a. 28   b. 40   c. 1120   d. 1600

12. What is the $\sum xy$ of the given data on the table?

    a. 148   b. 184   c. 185   d. 785

13. What is the slope (b) of the regression equation based on the data above?

    a. 0.89   b. 1.37   c. 1.98   d. 2.14

14. What is the y-intercept (a) of the regression equation based on the given data set?

    a. 0.89   b. 1.37   c. 1.98   d. 2.14

15. What is the equation of the regression line based on the given data?

    a. $\hat{y} = 2.14 + 0.89x$ c. $\hat{y} = 2.14 - 0.89x$

    b. $\hat{y} = 0.89 + 2.14x$ d. $\hat{y} = 0.89 - 2.14x$

Lesson 1

Slope and Y-Intercept of a Regression Line

One important application of statistics is that it allows us to predict one variable from other variables. For example, you might want to predict the amount of income from the number of years spent studying. This can be done through regression analysis. Regression analysis mathematically describes the relationship between independent variables and a dependent variable.

In this module, you will start to explore and learn about regression analysis. First, you need to recall important terms related to regression analysis by answering the next activity.

What's In

Jumbled Letters

Based on the given definition, rearrange the letters to form the correct word. Write your answers on a separate sheet of paper.

1. | L | S | P | O | E |

   Shows the steepness of a line and represents the rate of change in *y* as *x* changes

2. | R | E | E | I | T | T | N | P | C |

   A point where the line crosses or intersects the horizontal or vertical axis

3. | N | E | R | A | L | I |

   A type of regression that finds the best-fit line to represent a bivariate data set

4. | A | N | D | M | I | O |

   The x-values which represent the independent variable

5. | Q | A | E | N | O | I | T | U |

   The algebraic expression of a regression line

Since you recalled these important words, you are now ready to learn about regression analysis.

One type of regression is linear regression. Linear regression consists of finding a best-fitting straight line on a scatter plot of sample data. The slope and y-intercept of the regression line play an important role in analyzing a set of data. The slope indicates the steepness of a regression line and the y-intercept indicates the location where it intersects the y-axis. The slope and the y-intercept define a linear relationship between two variables and can be used to estimate an average rate of change.

Now, you will learn how to calculate the slope and y-intercept of the regression line. Start your progress by answering the next activity.

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

What's New

Step Yes, Step Do!

Read the given situation, follow the instructions, and fill in the missing values. Then, answer the guide questions that follow.

A teacher believes that excellence is a fruit of hard work and persistence. That's why she wants to prove if the number of students' absences is related to their general average. On her gathered data, the recorded number of absences and general average in the recent semester are shown on the table.

	Number of Absences *(x)*	General Average (*y*)
1	1	98
2	2	90
3	3	86
4	5	87
5	7	85
6	9	85
7	10	78

The teacher decided to use linear equations to describe the relationship of the two variables. She wants to see if two pairs of points will result in the same or approximately the same equations since the points came from a similar set of data. For the two pairs of data, she used the absences and general average of Students 1 and 7 and Students 1 and 4, respectively. Her computations were as follows:

Step 1. Using the given data as points, find the slope (*m*) using algebraic method.	
Use the points (1, 98) and (10, 78). $$m = \frac{y_2 - y_1}{x_2 - x_1}$$ $$m = \frac{78 - 98}{10 - 1}$$ $$m = \frac{-20}{9}$$ $$m = -2.22$$	Use the points (1, 98) and (5, 87). $$m = \frac{y_2 - y_1}{x_2 - x_1}$$ $$m = \frac{\underline{\quad} - 98}{\underline{\quad} - 1}$$ $$m = \frac{\quad}{\quad}$$ $$m = \underline{\quad}$$

Table 1. Some Branches of Biology

Name	**Focus**
Botany	Plants
Zoology	Animals
Anatomy	structure of living things
Taxonomy	classification of living things
Cytology	cells, their structure and functions

Step 2. Find the y-intercept using the slope (m), the point (1, 98), and the slope-intercept form of a line ($y = mx + b$).	
$y = mx + b$ $98 = (-2.22)(1) + b$ $98 = -2.22 + b$ $b = 98 + 2.22$ $b = 100.22$	$98 = mx + b$ $98 = (\_\_\_\_)(1) + b$ $98 = \_\_\_\_ + b$ $b = 98 + \_\_\_\_$ $b = \_\_\_\_$
Step 3. Write the equation of the line. Substitute the value of m and the value of b in $y = mx + b$.	
$y = -2.22x + 100.22$	$y = \_\_\_\_x + \_\_\_\_$

Guide Questions:

1. Compare the slope solved using the points (1, 98) and (10, 78) with the slope solved using (1, 98) and (5, 87). Are the two slopes equal?

2. Compare the y-intercept solved using the points (1, 98) and (10, 78) with the y-intercept solved using the points (1, 98) and (5, 87). Are the computed y-intercepts equal?

3. Are the two equations of the line equal or unequal? Why?

4. Do you think the teacher can describe the relationship of the given variables using the two equations he just computed? Why?
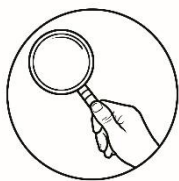
What is It

In the previous activity, <u>unequal</u> slopes and y-intercepts are solved because two different pairs of points are used. Since the slopes and y-intercepts are unequal, two different equations are obtained using the algebraic method.

Whenever there are more than two points of data, it is usually impossible to find one line that passes through all points. However, a best-fit line that is a good approximation of the data can usually be found. This best-fit straight line used to predict the value of y for a given value of x is called the regression line.

For statistics, there is a simpler way to find the equation of the best-fit line. The equation of the best-fit line is also called <u>*equation of the regression line*</u> or simply <u>*regression equation.*</u>

> The equation of the regression line is <u>$\hat{y} = bx + a$</u>
>   where: b = slope of the regression line
> a = y-intercept of the regression line

Examples:
   a. $\hat{y} = 2x + 3$ $b = 2$; $a = 3$; The slope is 2 and y-intercept is 3.
   b. $\hat{y} = \frac{x}{2} - 1$ $b = \frac{1}{2}$; $a = -1$; The slope is $\frac{1}{2}$ and y-intercept is -1.

       As shown in the activity, the slope and y-intercept can be easily determined from the equation of a regression line.

       In real life, however, students need to calculate the slope and y-intercept from the raw data. The y-intercept and slope can be solved using the step-by-step solution and formulas for finding the slope and y-intercept.

       The steps in calculating the slope and y-intercept from a given set of data are the following:

Step 1: Make a data table with four columns ($x, y, xy, and x^2$). Note the sample size, n.

Step 2: List the data for x and y. Multiply x and y to get xy. Square x to get x^2. Complete the table.

Step 3: Find the sum of $x, y, xy, and x^2$ by adding the values in each column.

Step 4: Substitute the solved values into the corresponding formula.

The slope (*b*) can be calculated using the following formula:

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

The y-intercept (*a*) can be calculated using the following formula:

$$a = \frac{(\sum y) - b(\sum x)}{n}$$

Let us solve the given situation in the previous activity (*Step Yes, Step Do!*) using these steps.

By doing Steps 1 and 2, you will make this four-column data table.

	Number of Absences *(x)*	General Average (*y*)	xy	x^2
1	1	98	98	1
2	2	90	180	4
3	3	86	258	9
4	5	87	435	25
5	7	85	595	49
6	9	85	765	81
7	10	78	780	100
	$\sum x = 37$	$\sum y = 609$	$\sum xy = 3111$	$\sum x^2 = 269$

From the table of data, you will be able to determine the sum of *x, y, xy, and* x^2. These are the values that will be substituted into the formula to calculate the slope and y-intercept.

$$n = 7 \qquad \sum x = 37 \qquad \sum y = 609 \qquad \sum xy = 3111 \qquad \sum x^2 = 269$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{7(3111) - (37)(609)}{7(269) - (37)^2}$$

$$b = \frac{21,777 - 22\,533}{1883 - 1369}$$

$$b = \frac{-756}{514}$$

$b = -1.47$ ⟵ This is the slope.

$$a = \frac{(\sum y) - b(\sum x)}{n}$$

$$a = \frac{609 - (-1.47)(37)}{7}$$

$$a = \frac{609 + 54.39}{7}$$

$$a = \frac{663.39}{7}$$
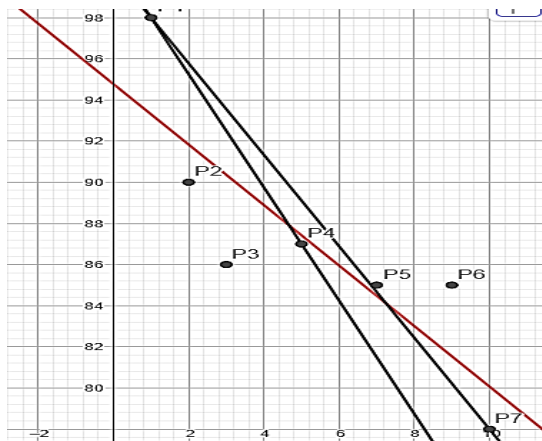
$a = 94.77$ ◄━━━ This is the y-intercept.

Therefore, the equation of the regression line is $\hat{y} = -1.47x + 94.77$.

From the previous activity (*Step Yes, Step Do!*), we obtained two equations of the line by using two different pairs of points. Using those steps, you will be able to determine the slope and y-intercept. Also, you will find the equation of the best-fit line.

Best-Fit Line

This graph shows the number of absences (*x*) and general average (*y*). The two computed lines in the previous activity are shown here. This also shows the best-fit line obtained from calculating the slope and y- intercept.

By simply looking at the graphs of the lines, you can see that only one line will be best fit. That is the line with equation $\hat{y} = -1.47x + 94.77$.
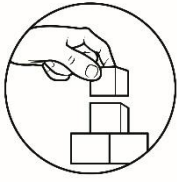
Activity 1.1 Start with a and b

From each regression line, identify the y-intercept (a) and the slope (b).

Regression Equation	Y-Intercept (a)	Slope (b)	Regression Equation	Y-Intercept (a)	Slope (b)
1. $\hat{y} = 5 + 4x$	____	____	6. $\hat{y} + 2 = x$	____	____
2. $\hat{y} = 3 - 2x$	____	____	7. $\hat{y} - 3x = \frac{1}{4}$	____	____
3. $\hat{y} = \frac{1}{2} + x$	____	____	8. $\hat{y} - 3 + 4x = 0$	____	____
4. $\hat{y} = -1 - 3x$	____	____	9. $\hat{y} - 1 - 2x = 0$	____	____
5. $\hat{y} = 2 + \frac{2x}{3}$	____	____	10. $\hat{y} + \frac{1}{2} + 5x = 0$	____	____

Activity 1.2 Then, Follow Me!

Study and follow the steps. Then, apply those steps in the next activity.

X	y	xy	x^2
1	4	4	1
2	3	6	4
3	8	24	9
4	6	24	16
5	12	60	25
6	10	60	36
7	8	56	49
$\sum x =$ _____	$\sum y =$ _____	$\sum xy =$ _____	$\sum x^2 =$ _____

Find the slope, y-intercept, and regression equation for the given data.

From the given table, list the values that must be substituted into the formula on a separate sheet of paper.

$n =$ ____ $\sum x =$ ____ $\sum y =$ ____ $\sum xy =$ _____ $\sum x^2 =$ _____

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{7(234) - (28)(51)}{7(140) - (28)^2}$$

$$b = \frac{1,638 - 1,428}{980 - 784}$$

$$b = \frac{210}{196}$$

$b=1.07142 \text{ or } 1.07$ ◀—— This is the slope.

$$\boldsymbol{a} = \frac{(\sum \boldsymbol{y}) - \boldsymbol{b}(\sum \boldsymbol{x})}{\boldsymbol{n}}$$

$$a = \frac{51 - 1.07(28)}{7}$$

$$a = \frac{51 - 29.96}{7}$$

$$a = \frac{21.04}{7}$$

$a = 3.0057 \text{ or } 3.00$ ◀—— This is the y-intercept.

Therefore, the equation of the regression line is $\hat{y} = \boldsymbol{1.07x + 3.}$

Activity 1.3 Connect and Complete

Copy the given table on a sheet of paper. Complete the missing tabular values to calculate the slope and y-intercept. Then, solve for the slope and y-intercept using the given formulas below.

X	y	xy	x^2
1	98		1
2	90	180	
3	86		
5	87	435	25
7	85	595	
9	85		81
10	80		
$\sum x =$	$\sum y =$	$\sum xy =$	$\sum x^2 =$

Solve for the slope and y-intercept. Show your complete solutions.

a. What is the slope (*b*)?

$$\boldsymbol{b} = \frac{\boldsymbol{n}(\sum \boldsymbol{xy}) - (\sum \boldsymbol{x})(\sum \boldsymbol{y})}{\boldsymbol{n}(\sum \boldsymbol{x^2}) - (\sum \boldsymbol{x})^2}$$

b. What is the y-intercept (*a*)?

$$\boldsymbol{a} = \frac{(\sum \boldsymbol{y}) - \boldsymbol{b}(\sum \boldsymbol{x})}{\boldsymbol{n}}$$

c. What is the regression equation?

Activity 1.4 Compute on Your Own

Using the given data, make a table of values on a separate sheet of paper.

X	y	xy	x^2
5	40		
12	28		
20	17		
8	32		
15	24		
25	1		
$\sum x =$	$\sum y =$	$\sum xy =$	$\sum x^2 =$

Solve for the slope and y-intercept. Then, find the equation of the regression line. Show your complete solutions.

What I Have Learned

Fill in the blanks to complete the statements. Copy and answer on a separate sheet of paper.

1. Make a _____ with four columns (x, y, xy, and x^2).

2. Take note of the _____ (n) of the data set.

3. List the data for x and y. _____ x and y to get xy.

4. Square x to get x^2. _____ the table.

5. Find the_____ of x, y, xy, and x^2 by adding the values in each column.

6. _____ the solved values into the corresponding formula.

7. The _____ can be computed using the formula below:

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

8. The y-intercept (a) can be calculated using the formula: _____.
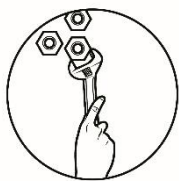
What I Can Do

Make a process flowchart showing the steps and formulas in calculating the slope and y-intercept from a given set of data. Show your imagination and creativity. Use long bond paper.

Rubric for Creative Process Flowchart

Standards	4	3	2	1
Steps	The flowchart includes all steps.	The flowchart is missing one step.	The flowchart is missing two steps.	The flowchart is missing more than two steps and is confusing.
Vocabulary	The flowchart is accurately labeled and detailed.	The flowchart is labeled and detailed.	The flowchart is labeled and has some details.	The flowchart is not labeled and lacks detail.
Readability	The overall appearance of the flowchart is pleasing, easy to interpret, and logically set up.	The overall appearance of the flowchart is somewhat pleasing, logically set up, and easy to interpret.	The overall appearance of the flowchart is pleasing and easy to interpret, but not logically set up.	The flowchart is difficult to interpret and not logically set up.
Imagery	Images used to show each step are relevant and add visual quality to the flow chart.	Images used to show each step are relevant and add some visual quality to the flow chart.	Images used to show each step are somewhat relevant and add some visual quality to the flow chart.	Images used are irrelevant and do not add visual quality to the flow chart.
Task Completion	Fully achieved the purpose of the task	Accomplished the task	Completed most of the task	Attempted to do the task but with no success

Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. What is the set of statistical method used to describe the relationship between independent variables and a dependent variable?
   a. regression analysis
   b. regression equation
   c. regression form
   d. regression line

2. What can be computed using the formula: $b = \frac{n(\sum xy)-(\sum x)(\sum y)}{n(\sum x^2)-(\sum x)^2}$?
   a. domain
   b. range
   c. slope
   d. y-intercept

3. What can be computed using the formula: $a = \frac{(\sum y)-b(\sum x)}{n}$?
   a. domain
   b. range
   c. slope
   d. y-intercept

4. In the regression equation $\hat{y} = 1 + 2x$, what is the slope?
   a. 3
   b. 2
   c. 1
   d. 0

5. In the given equation $\hat{y} = 1 + 2x$, what is the y-intercept?
   a. 3
   b. 2
   c. 1
   d. 0

6. In the regression equation $\hat{y} = -3 + 2x$, what is the slope?
   a. 3
   b. 2
   c. −2
   d. −3

7. In the given equation $\hat{y} = -3 + 2x$, what is the y-intercept?
   a. 3
   b. 2
   c. −2
   d. −3

For nos. 8-15, use the given data table below.

x	1	2	3	4	5	6	7
y	2	6	4	8	12	10	12

8. What is the $\sum x$ of the given data table?
   a. 24
   b. 26
   c. 28
   d. 30

9. What is the $\sum y$ of the given data table?
   a. 50
   b. 54
   c. 58
   d. 60

10. What is the $\sum xy$ of the given data table?
    a. 212   b. 252   c. 262   d. 272

11. What is the $\sum x^2$ of the given data table?
    a. 140   b. 141   c. 161   d. 184

12. What is the slope (b) of the regression equation based on the data table?
    a. 0.83   b. 0.93   c. 1.07   d. 1.64

13. What is the y-intercept (a) of the regression equation based on the given data set?
    a. 0.83   b. 0.93   c. 1.14   d. 1.67

14. What is the equation of the regression line based on the given data?
    a. $\hat{y} = 1.14 + 1.64x$ c. $\hat{y} = 0.83 + 0.93x$
    b. $\hat{y} = 1.64 + 1.14x$ d. $\hat{y} = 0.93 + 0.83x$

15. Which of among the choices is the equation of a regression line based on the data table below?

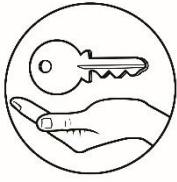| x	2	4	6	8	10	12	14
y	20	15	12.5	11.8	7.5	4	2

    a. $\hat{y} = 15 + 2.47x$ c. $\hat{y} = 21.97 + 1.45x$
    b. $\hat{y} = 15 - 2.47x$ d. $\hat{y} = 21.97 - 1.45x$
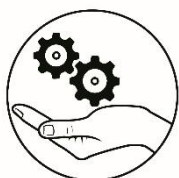
Additional Activities

Now, it is time to reflect. Answer the following questions honestly.

- What concepts have you learned?
  I learned that _____
  _____
  _____
  _____

- Why is slope and y-intercept important in finding the regression equation?
  The slope and y-intercept are important because _____
  _____
  _____
  _____

- What is the importance of following steps in doing computations?
  I learned _____
  _____
  _____

What I Know

1. D	9. C
2. C	10. C
3. D	11. B
4. D	12. C
5. A	13. A
6. C	14. D
7. B	15. A
8. D	

What's In

Jumbled Letters

1. slope
2. intercept
3. linear
4. domain
5. equation

Assessment

1. A	9. B
2. C	10. C
3. D	11. A
4. B	12. D
5. C	13. C
6. B	14. A
7. D	15. D
8. C	

What's New

Step Yes, Step Do!

Step1: $87.5 - \frac{11}{4} - 2.75$

Step2: 100.75

Step 3: $- 2.75X + 100.75$

Note: Guide questions will depend on student.

What I have learned

1. Make a data table with four columns $(x, y, xy,$ and $x^2)$.
2. Take note of the sample size (n) of the data set.
3. List the data for x and y. Multiply x and y to get xy.
4. Square x to get x^2. Complete the table.
5. Find the sum of x, y, xy, and x^2 by adding the values in each column.
6. Substitute the solved values into the corresponding formula.
7. The slope can be computed using the formula.
8. The y-intercept (a) can be calculated using the formula in "What is It".

Activity 1.3 Connect and Complete

x	y	xy	x²
1	98	**98**	1
2	90	180	**4**
3	86	**258**	**9**
5	87	435	25
7	85	595	**49**
9	85	**765**	81
10	80	**800**	**100**
$\Sigma x = 37$	$\Sigma y = 611$	$\Sigma xy = 3,131$	$\Sigma x^2 = 269$

a. The slope is − 1.34.
b. The y-intercept is 94.38.
c. The regression equation is $\hat{y} = -1.34x + 94.38$.

Activity 1.4 Compute on Your Own

x	y	xy	x²
5	40	200	25
12	28	336	144
20	17	340	400
8	32	256	64
15	24	360	225
25	1	25	625
$\Sigma x = 85$	$\Sigma y = 142$	$\Sigma xy = 1517$	$\Sigma x^2 = 1483$

The slope is − 1.77. The y-intercept is 48.8. The regression equation is
$\hat{y} = -1.77x + 48.8$.

What's More

1.1 Start with a and b
1. 5; 4
2. 3; -2
3. $\frac{1}{2}$; 1
4. - 1; -3
5. 2; $\frac{2}{3}$
6. -2; 1
7. $\frac{1}{4}$; 3
8. 3; -4
9. 1; 2
10. $-\frac{1}{2}$; -5

1.2 Then, Follow Me!

$n = 7$	$\Sigma x = 28$	$\Sigma y = 51$	$\Sigma xy = 234$	$\Sigma x^2 = 140$

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