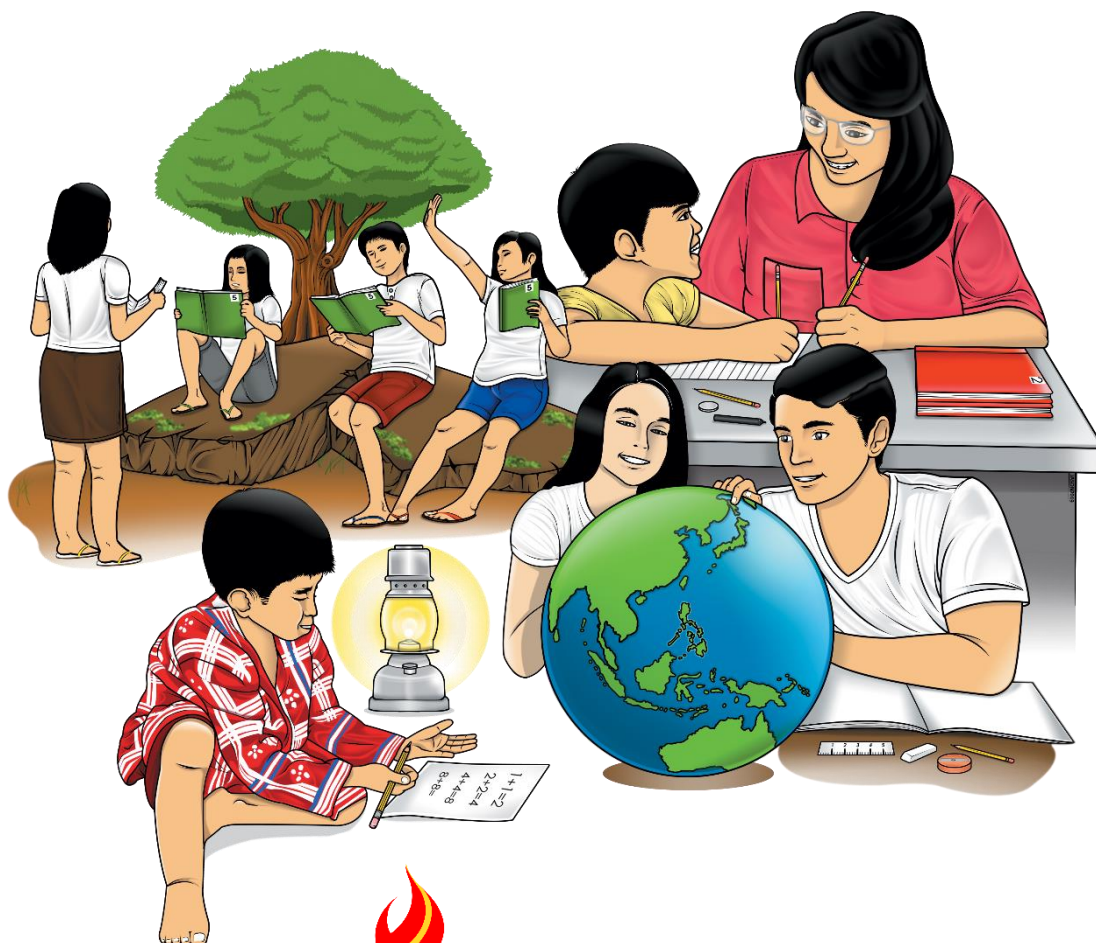


# Statistics and Probability

## Quarter 4 – Module 24: Solving Problems Involving Regression Analysis

4



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**Statistics and Probability – Grade 11**  
**Alternative Delivery Mode**  
**Quarter 4 – Module 24: Solving Problems Involving Regression Analysis**  
**First Edition, 2021**

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**Statistics and  
Probability**  
**Quarter 4 – Module 24:**  
**Solving Problems Involving  
Regression Analysis**

## **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***

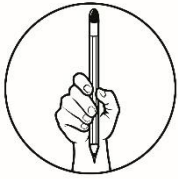
In the previous modules, you have learned about calculating the slope and y-intercept of a regression line and formulating regression equations based on a given set of data. You made interpretations from the calculated values of the slope and y-intercept. Then, you predicted the values of the dependent variable based on the values of the independent variable. All the learnings you have gained in the previous modules will help you in the mastery of this lesson.

In this module, you will apply the knowledge and skills you acquired in solving problems involving regression analysis. Furthermore, you will be computing and making accurate predictions about variables observed in real-life situations.

After going through this module, you are expected to:

1. find the regression equation from word problems;
2. compute the predicted values based on real scenarios; and
3. solve regression analysis problems from real-life situations.

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. Chrishell wants to know if the distance a person kicks a soccer ball affects how well she will do on her Math test. What is the dependent variable  $y$ ?
  - a. how far a person kicks the soccer ball
  - b. how well she does on Math test
  - c. who the person is
  - d. the type of soccer ball
2. Based on the situation in no. 1, what is the independent variable  $x$ ?
  - a. how far a person kicks the soccer ball
  - b. how well she does on Math test
  - c. who the person is
  - d. the type of soccer ball
3. If the regression equation is  $\hat{y} = -3 + 4x$ , what is the slope?
  - a. 3
  - b. -3
  - c. 4
  - d. -4
4. If the regression equation is  $\hat{y} = -3 + 4x$ , what is the y-intercept?
  - a. 3
  - b. -3
  - c. 4
  - d. -4
5. If the regression equation is  $\hat{y} = -3 + 4x$ , how would you predict the value of the dependent variable if the value of the independent variable is 7?
  - a. Solve for  $x$  using the slope formula.
  - b. Solve for  $y$  using the slope formula.
  - c. Substitute  $\hat{y} = 7$  into  $\hat{y} = -3 + 4x$  and solve.
  - d. Substitute  $x = 7$  into  $\hat{y} = -3 + 4x$  and solve.

For numbers 6 to 10, refer to the given situation below.

*A group of friends traveled by car. They recorded the number of miles driven as shown below.*

Time driving	0	1	2	3	4	5	6
Total distance	0	55	120	188	252	307	366

6. What is the independent variable  $x$ ?
  - a. time driving
  - b. total distance
  - c. date of travel
  - d. number of friends

7. What is the dependent variable  $y$ ?
- a. time driving
  - b. total distance
  - c. date of travel
  - d. number of friends
8. Based on the data, the equation of the regression line is  $\hat{y} = 61.93x - 1.79$ . What is the slope?
- a.  $b = - 1.79$
  - b.  $b = 1.79$
  - c.  $b = - 61.93$
  - d.  $b = 61.93$
9. Based on the data, the equation of the regression line is  $\hat{y} = 61.93x - 1.79$ . What is the y-intercept?
- a.  $a = - 1.79$
  - b.  $a = 1.79$
  - c.  $a = - 61.93$
  - d.  $a = 61.93$
10. Based on the linear regression equation  $\hat{y} = 61.93x - 1.79$ , how far will the group of friends travel after 10 hours of driving?
- a. 615.7
  - b. 617.5
  - c. 651.7
  - d. 671.5

For numbers 11 to 15, refer to the situation described below.

*A potato chips manufacturer is interested in estimating how sales are influenced by the price of their potato chips. They randomly chose 6 towns with similar characteristics and offered bags of potato chips at different prices, then collected the following data:*

Price (in pesos)	70	80	90	100	110	120
Number of potato chip bags	100	90	90	40	38	32

11. What is the estimated slope of the regression equation?
- a. 213.2
  - b. 1.56
  - c.  $- 1.56$
  - d.  $- 213.2$
12. What is the y-intercept of the regression equation?
- a.  $- 213.2$
  - b. 213.2
  - c.  $- 1.56$
  - d. 1.56
13. What is the regression equation based on the data given?
- a.  $\hat{y} = 213.2 + 1.56x$
  - b.  $\hat{y} = - 213.2 + 1.56x$
  - c.  $\hat{y} = 213.2 - 1.56x$
  - d.  $\hat{y} = - 213.2 - 1.56x$
14. What is the average number of potato chips sold if the price of a bag of potato chips is ₱ 95?
- a. 56
  - b. 65
  - c. 67
  - d. 76

15. What is the average number of potato chips sold if the price of a bag of potato chips is ₱88?
- a. 56
  - b. 65
  - c. 67
  - d. 76

## Lesson

# 1

## Regression Analysis: Problem Solving

By now, you already know that regression analysis can be used in making estimations and predictions. Specifically, linear regression allows us to make predictions when a variable ( $y$ ) is dependent on a second variable ( $x$ ) based on the regression equation of a given set of data. This also holds true in real-life situations.

One of the most common uses of regression is in college application and admission. Universities and colleges can use regression techniques to predict future academic performances based on each student applicant's requirements. In this module, you will learn how to solve regression analysis problems based on real-life situations.

If you experience any difficulty in answering the activities, you may ask the assistance of your teacher/facilitator. To better prepare for solving regression analysis problem, let us first recall the regression equation, its slope, and  $y$ -intercept. Also, practice predicting values of  $y$  (dependent variable) from  $x$  (independent variable) by substituting  $x$  into regression equations. In answering the next activity, you can recall and practice the said concepts about regression analysis..





## What's In

### Completing the Table

Complete the missing values for the slope, y-intercept, independent variable ( $x$ ), and dependent variable ( $y$ ) based on each regression equation.

Regression Equation	slope (b)	y-intercept (a)	x	y
1. $\hat{y} = 3x + 8$	3	8	2	14
2. $\hat{y} = -2x + 9$	-2		7	
3. $\hat{y} = 7x + 2.5$		2.5	6	
4. $\hat{y} = 3.5x + 1.5$			10	
5. $\hat{y} = -1.5x + 6$		6	2	
6. $\hat{y} = 3.5x + 0.5$				32
7. $\hat{y} = 4.25x + 11$			13	

In the activity, you recalled linear regression concepts specifically the slope, y-intercept, dependent variable ( $y$ ), and independent variable ( $x$ ). Also, you predicted values of  $y$  from given values of  $x$ .

Before you attempt to solve problems involving regression analysis, there are some things you need to know which can be done by following the how-to tips on the second column of the table.

You should know how:	How-to Tips
to identify the independent and dependent variables from a given situation	Complete the statement logically: “_____ depends upon _____.” The first blank contains the dependent variable while the second blank contains the independent variable.
to identify the slope and y-intercept from a regression equation	The number beside $x$ is the slope and the constant number is the y-intercept.
to calculate the slope and y-intercept from a set of given data	Use the formulas: $b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$ $a = \frac{(\sum y) - b(\sum x)}{n}$
to formulate a regression equation based on slope and y-intercept	Recall: $\hat{y} = bx + a$
to predict values of the dependent variable from the independent variable	Substitute $x$ into the regression equation and solve.

You can now apply these tips and your mastered skills in solving regression analysis problems anchored on real-life situations.



## What's New

### Step-by-Step

Follow the step-by-step instructions previously discussed. Read carefully and answer the questions that follow.



Fifteen (15) randomly selected Grade 11 students took a Math Aptitude Test before they started their Statistics and Probability subject. What regression equation best predicts performance in the First Periodical Test in Statistics based on Math Aptitude Test? If a student got a score of 42 on the Math Aptitude Test, what score would the student expect in the First Periodical Test in Statistics?

<i>Math Aptitude Test</i>	38	35	30	28	25	24	20	18	16	15	12	10	8	7	5
<i>First Periodical Test</i>	25	20	17	15	12	15	18	10	12	10	10	10	7	6	5

### Guide Questions:

1. Were you able to solve for the slope of the regression equation? How?
2. Were you able to solve for the y-intercept of the regression equation? How?
3. Were you able to find the regression equation?
4. Were you able to predict the expected score in the First Periodical Test in Statistics based on the Math Aptitude Test score?



## What is It

Before solving for the regression equation being asked in the problem, you need to identify the independent variable ( $x$ ) and dependent variable ( $y$ ).

“\_\_\_\_\_ depends upon the \_\_\_\_\_.”

Which would be assigned as  $x$ ? Math Aptitude Test or First Periodical Test

Which would be assigned as  $y$ ? Math Aptitude Test or First Periodical Test

“Statistics First Periodical Test depends upon the Math Aptitude Test.”

Then, prepare a table of values. (Do this on a separate sheet of paper.)

$x$	$y$	$xy$	$x^2$
$\Sigma x = \underline{\hspace{2cm}}$	$\Sigma y = \underline{\hspace{2cm}}$	$\Sigma xy = \underline{\hspace{2cm}}$	$\Sigma x^2 = \underline{\hspace{2cm}}$

Substitute the solved values to the formula for finding the slope and y-intercept of a regression equation.  $n=15$

*Solution:*

Solving for slope:

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

$$b = \frac{15(4465) - (291)(192)}{15(7141) - (291)^2}$$

$$b = \frac{66,975 - 55,872}{107,115 - 84,681}$$

$$b = \frac{11,103}{22,434}$$

$$b = 0.4949$$

Solving for y-intercept:

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

$$a = \frac{192 - 0.495(291)}{15}$$

$$a = \frac{192 - 144.0159}{15}$$

$$a = \frac{47.9841}{15}$$

$$a = 3.198 \text{ or } 3.2$$

Therefore, the regression equation is  $\hat{y} = 0.4949x + 3.2$

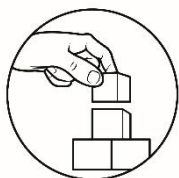
Using this regression equation, we can predict scores in the Statistics Periodical Test given a score in the Math Aptitude Test. If a student got a score of 42 in the Math Aptitude Test, then  $x = 42$ .

*Solution:*

$$\hat{y} = 0.4949(42) + 3.2 = 20.7858 + 3.2 = 23.99 = 24$$

Therefore, if a student got a score of 42 in the Math Aptitude Test, the student would expect a score of **24** in the First Periodical Test in Statistics.

You can now apply this procedure in solving regression analysis problems anchored on real-life situations.



## ***What's More***

### **Activity 1.1 Follow the Steps**

Complete the missing values on the table and compute for the answers on a separate sheet of paper. (For easier computation, use a scientific calculator.)



Survey tests on leadership skills and self-concept were given to student leaders. Both tests used a 10-point Likert scale with 10 indicating the highest scores for each test. The table below contains scores of the student-leaders on the tests. What is the leadership skill of a student-leader whose self-concept is 1.5?

Self-concept (x)	Leadership skill (y)	Xy	x <sup>2</sup>
9.5	9.2	87.40	
9.2	8.8		84.64
6.3	7.3	45.99	
4.1	3.4		16.81
5.4	6.0	32.4	
8.3	7.8		68.89
7.8	8.8	68.64	
6.8	7.0		46.24
5.6	6.5	36.40	
7.1	8.3		50.41
$\Sigma x =$	$\Sigma y =$	$\Sigma xy =$	$\Sigma x^2 =$

Substitute the solved values to the formula for finding the slope and y-intercept of the regression equation.  $n=10$

Solving for slope:

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

$$b = \frac{10(\quad) - (\quad)(\quad)}{10(\quad) - (\quad)^2}$$

$$b = \frac{(\quad) - (\quad)}{(\quad) - (\quad)}$$

$$b = \frac{(\quad)}{(\quad)}$$

$$b = \underline{\quad}$$

Solving for y-intercept:

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

$$a = \frac{(\quad) - (\quad)(291)}{(\quad)}$$

$$a = \frac{(\quad) - (\quad)}{(\quad)}$$

$$a = \frac{(\quad)}{(\quad)}$$

$$a = \underline{\quad}$$

Therefore, the regression equation is \_\_\_\_\_.

From the regression equation, we can now predict the leadership skill scores given the self-concept score. If a student-leader got a score of 1.5 on the self-concept, then  $x = 1.5$ .

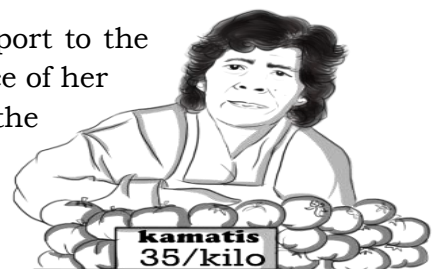
Solution:

Therefore, \_\_\_\_\_

## Activity 1.2 Moving Forward

Read the problem carefully. Answer on a separate sheet of paper.

Aling Maring sells tomatoes in Tayabas Market in support to the local farmers of the City. She decided to change the price of her tomatoes every day for 7 days to see if the change in the price of tomatoes would affect sales. How many kilos of tomatoes may be sold if the price of tomatoes is 35 pesos per kilogram? Her collected data are shown in the table below.



Price per kilo (in pesos)	Number of kilos sold	$xy$	$x^2$
45	30		
50	25		
55	25		
40	40		
52	26		
48	35		
60	15		
$\Sigma x =$	$\Sigma y =$	$\Sigma xy =$	$\Sigma x^2 =$

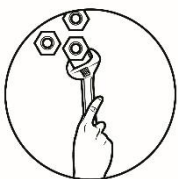
How many kilos of tomatoes may be sold if the price of tomatoes is 35 pesos per kilogram? \_\_\_\_\_



## ***What I Have Learned***

Answer the following questions honestly.

1. What concepts have you learned in this lesson?
2. What techniques did you learn and use in solving regression analysis problems? Cite at least three techniques.
3. What difficulties did you experience in solving linear regression problems?



## ***What I Can Do***

### **My Own Regression Analysis Study**

Studies have found a relationship between the number of hours a student spends studying and his/her overall academic performance. Choose eight modules in any subject that you are currently studying. On a long bond paper, create a table on the hours you spent studying each module and the scores you got on each module's assessment. Find the regression equation based on your own data. Present your table and solutions in an organized but creative manner. Explain the results you got.

*Rubric for Performance Task (My Own Regression Analysis Study)*

<b>Standards</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>
Understanding of Task	Demonstrated substantial understanding of the content, process, and demands of the task	Demonstrated understanding of the process and demands of the task, even though some details may have been overlooked	Demonstrated gaps in understanding the content and demands of the task	Demonstrated little understanding of the content
Completion of Task	Fully achieved the purpose of the task	Accomplished the task	Completed most of the task	Attempted to do the task but with little or no success
Completeness of Data	Data table contains data for eight modules	Data table contains data for seven modules	Data table contains data for five to six modules	Data table contains data for less than five modules
Correctness of Computations	Answers all correct with complete solutions	Answers and solutions mostly correct with minimal errors	Some of the answers correct	Few or none of the answers correct
Creativity and Clarity of Explanation	Creatively and clearly explained data and ideas in effective manner while going beyond expectations	Creatively and clearly explained data and ideas	Clearly explained data and ideas	Unable to finish the task and unable to explain data and ideas



## Assessment

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

1. Chrismae wants to know if the type of gasoline used by a car affects how fast the car can be driven. What is the independent variable  $x$ ?
  - a. what type of gasoline was used
  - b. how much gas was put in the car
  - c. how fast the car can be driven
  - d. how far the car can be driven
2. Based on the situation in no. 1, what is the dependent variable  $y$ ?
  - a. what type of gasoline was used
  - b. how much gas was put in the car
  - c. how fast the car can be driven
  - d. how far the car can be driven
3. If the regression equation is  $\hat{y} = 7 - 5x$ , what is the slope?
  - a. 5
  - b. - 5
  - c. 7
  - d. - 7
4. If the regression equation is  $\hat{y} = 7 - 5x$ , what is the y-intercept?
  - a. 5
  - b. - 5
  - c. 7
  - d. - 7
5. If the regression equation is  $\hat{y} = 7 - 5x$ , how would you predict the value of the dependent variable if the value of the independent variable is 4?
  - a. Solve for  $x$  using the slope formula.
  - b. Solve for  $y$  using the slope formula.
  - c. Substitute  $y = 4$  into  $\hat{y} = 7 - 5x$  and solve.
  - d. Substitute  $x = 4$  into  $\hat{y} = 7 - 5x$  and solve.

For numbers 6 to 10, refer to the given situation below.

*A restaurant sells halo-halo with varied number of ingredients for prices indicated on the data table.*

Number of ingredients	2	3	4	5	6
Price of <i>halo-halo</i>	15	16.5	18	19.5	21



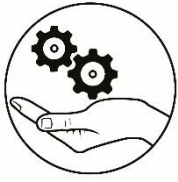
6. What is the independent variable  $x$ ?
- number of ingredients
  - price of *halo-halo*
  - size of *halo-halo*
  - number of *halo-halo* per serving
7. What is the dependent variable  $y$ ?
- number of ingredients
  - price of *halo-halo*
  - size of *halo-halo*
  - number of *halo-halo* per serving
8. Based on the given data, the equation of the regression line is  $\hat{y} = 1.5x + 12$ . What is the slope?
- $b = 1.5$
  - $b = -1.5$
  - $b = 12$
  - $b = -12$
9. Based on the given data, the equation of the regression line is  $\hat{y} = 1.5x + 12$ . What is the y-intercept?
- $b = 1.5$
  - $b = -1.5$
  - $b = 12$
  - $b = -12$
10. Based on the linear regression equation  $\hat{y} = 1.5x + 12$ , how much will *halo-halo* with 10 ingredients cost?
- 24
  - 25.5
  - 27
  - 28.5

For numbers 11 to 15, refer to the situation described below.

*A pastillas manufacturer is interested in estimating how sales are influenced by the price of their pastillas. They randomly chose 6 cities with similar characteristics and offered pastillas jars at different prices, then collected the following data:*

Price (in pesos)	70	80	90	100	110	120
Number of jars sold	100	90	90	40	38	32

11. What is the estimated slope of the regression equation?
- 213.2
  - 213.2
  - 1.56
  - 1.56
12. What is the y-intercept of the regression equation?
- 213.2
  - 213.2
  - 1.56
  - 1.56
13. What is the regression equation based on the data given?
- $\hat{y} = 213.2 + 1.56x$
  - $\hat{y} = 213.2 - 1.56x$
  - $\hat{y} = -213.2 + 1.56x$
  - $\hat{y} = -213.2 - 1.56x$
14. What is the average number of jars sold if the price of a pastillas jar is ₱95?
- 65
  - 78
  - 80
  - 82
15. What is the average number of jars sold if the price of a pastillas jar is ₱88?
- 76
  - 78
  - 80
  - 82



## Additional Activities

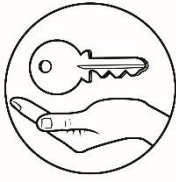
### Real-Life Solving!

$x$	1.4	1.6	1.6	2.0	2.0	2.2	2.4	2.6
$y$	180	184	190	220	186	215	205	240

- The advertising expenditure ( $x$ ) and sales ( $y$ ) in millions of pesos for a retail business on its first eight years of operation are shown in the table above.
  - What is the equation of the regression line?
  - On average, for each million pesos spent on advertising, how does revenue change?
  - Predict the revenue if 3 million pesos is spent on advertising the following year.

$x$	3	4	5	8	10	12	15	17
$y$	20	40	42	98	98	138	130	170

- The table above shows the relationship between the number of chapters and the total number of pages for several books. Find the regression equation and use the regression line to predict how many chapters would be in a book with 220 pages.



## Answer Key

**What I Know**

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

**What's In**

1.  
2. 9; -5  
3. 7; 44.5  
4. 3.5; 1.5; 36.5  
5. -1.5; 3  
6. 3.5; 0.5; 9  
7. 4.25; 11; 66.25

**Completing the Table**

**Assessment**

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

**Additional Activities**

1. a.  $\hat{y} = 119.50 + 42.02x$   
 b. An additional of 42.02 (millions) on revenues for every 1 (million) expenditures  
 c. 245.56 million pesos
2. The regression equation is  $\hat{y} = 10.04x - 0.85$ . There would be 22 chapters.

**What's New**

**Step-by-Step**

1. Were you able to solve for the slope of the regression equation? How? By preparing a table and using the formula for slope
2. Were you able to solve for the y-intercept of the regression equation? How? Using the formula for y-intercept

Math Aptitude Test (x)	Statistics Test (y)	xy	x <sup>2</sup>
38	25	950	1444
35	20	700	1225
30	17	510	900
28	15	420	784
25	12	300	625
24	15	360	576
20	18	360	400
18	10	180	324
16	12	192	256
15	10	150	225
12	10	120	144
10	10	100	100
8	7	56	64
7	6	42	49
5	5	25	25
$\Sigma x = 291$	$\Sigma y = 192$	$\Sigma xy = 4465$	$\Sigma x^2 = 7141$

3. Were you able to find the regression equation? The regression equation is  $\hat{y} = 0.4949x + 3.2$ .
4. Were you able to predict the expected score in the First Periodical Test in Statistics based on the Math Aptitude Test score? If a student got a score of 42 in the Math Aptitude Test, the student would expect a score of **24** in the First Periodical Test in Statistics.

**What's More**

**1.1**

**Follow the Steps**

x	y	xy	x <sup>2</sup>
9.5	9.2	87.4	90.25
9.2	8.8	80.96	84.64
6.3	7.3	45.99	39.69
4.1	3.4	13.94	16.81
5.4	6	32.4	29.16
8.3	7.8	64.74	68.89
7.8	8.8	68.64	60.84
6.8	7	47.6	46.24
5.6	6.5	36.4	31.36
7.1	8.3	58.93	50.41
70.1	73.1	537	518.29

$b = 0.91$

$a = 0.9$

$\hat{y} = 0.91x + 0.9$

The leadership score will be 2.27

**1.2**

**Moving Forward**

x	y	xy	x <sup>2</sup>
4.5	30	1350	2025
50	25	1250	2500
55	25	1375	3025
40	40	1600	1600
52	26	1352	2704
48	35	1680	2304
60	15	900	3600
350	196	9507	17758

$b = -1.14$

$a = 84.78$

$\hat{y} = 84.78 - 1.14x$

The predicted number of kilos of tomatoes is 45 kilos.

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