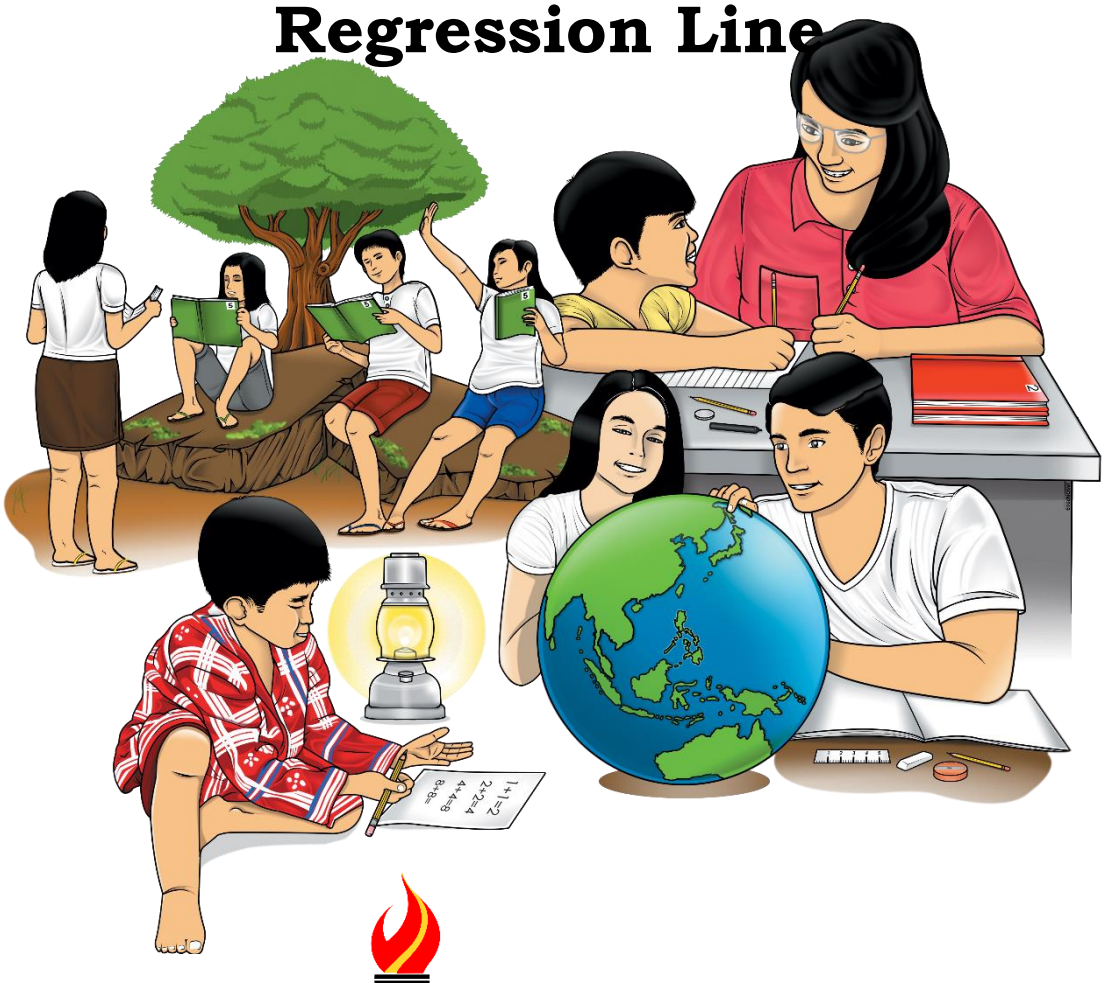
Senior High School

DepED
DEPARTMENT OF EDUCATION

Statistics and Probability

Quarter 4 – Module 22: Interpreting the Calculated Slope and Y-Intercept of the Regression Line



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Quarter 4 – Module 22: Interpreting the Calculated Slope and Y-Intercept of the Regression Line
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Secretary: Leonor Magtolis Briones
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Development Team of the Module

Writer: Joe Victoria B. Daelo
Editors: Jerome A. Chavez, Nestor N. Sandoval, Jos Garry S. Villaverde, and Pelagia L. Manalang
Reviewers: Josephine V. Cabulong, Rey Mark R. Queaño, Mary Joy B. Talavera, Ermelo A. Escobiñas,Michelle Anne L. Acesor, Regicelle D. Cabaysa, Jerome A. Chavez, Luzviminda Cynthia Richelle F. Quinter and Generosa F. Zubieta
Illustrator: Jeewel L. Cabriga and Joe Victoria B. Daelo
Layout Artist: Ronnjemmele A. Rivera and Edna E. Eclavea
Management Team: Francis Cesar B. Bringas
Job S. Zape, Jr.
Ramonito Elumbaring
Reicon C. Condes
Elaine T. Balaogan
Fe M. Ong-ongowan
Gerlie M. Ilagan
Antonio P. Faustino Jr.
Imelda C. Raymundo
Generosa F. Zubieta
Louie L.Fulledo

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Department of Education – Region 4A CALABARZON

Office Address: Gate 2 Karangalan Village, Brgy. San Isidro, Cainta, Rizal
Telefax: 02-8682-5773/8684-4914/8647-7487
E-mail Address: lrmd.calabarzon@deped.gov.ph

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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

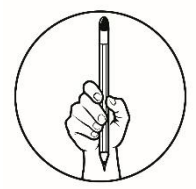
In the previous module, you started to learn about regression analysis specifically linear regression. You calculated the slope and y-intercept from given data values using statistical formulas. Furthermore, you found the equation of the regression line that shows relationships between an independent variable and a dependent variable.

This module will help you master how to interpret the calculated slope and y-intercept of a regression line. Also, you will learn to make interpretations based on real-life scenarios typical in statistics problems and research applications. Then, you will progress to formulating predictions about dependent variables based on independent variables.

After going through this module, you are expected to:

1. determine the relationship between variables based on the slope;
2. interpret the computed slope and y-intercept of the regression equation; and
3. realize the relevance of the y-intercept based on given 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. What does slope represent?
   a. predicted value of y
   b. predicted value of y when $x = 0$
   c. variation around the line of regression
   d. estimated change of y per unit change in x

2. What does y-intercept represent?
   a. predicted value of y
   b. predicted value of y when $x = 0$
   c. variation around the line of regression
   d. estimated change of y per unit change in x

3. What is the relationship between independent variable x and the dependent variable y if the regression equation has a negative slope?
   a. There is no relationship.
   b. There is a positive relationship.
   c. There is a negative relationship.
   d. Relationship cannot be determined.

4. What is the relationship between independent variable x and the dependent variable y if the regression equation has a positive y-intercept?
   a. There is no relationship.
   b. There is a positive relationship.
   c. There is a negative relationship.
   d. Relationship cannot be determined.

5. Which variable/s is/are most likely to have a negative relationship?
   I. Monthly family income and floor area of family's house
   II. Number of student absences and academic performance
   a. I only
   b. II only
   c. both I and II
   d. neither I nor II

For numbers 6 to 9, consider the following situation:
Mrs. Cruz is a hardworking government employee who does her job with all honesty and compassion. She knows the value of every cent she's earning, that is why she is saving money for her retirement. The equation $y = 500x + 12{,}000$ models her retirement savings where y is her total savings in pesos and x is the number of months.

6. What is the y-intercept?
   a. 12,000 b. 500 c. – 500 d. – 12,000

7. What does the y-intercept mean?
   a. Joanne started with 500 in her account.
   b. Joanne started with 12,000 in her account.
   c. Each month, Joanne saves additional 500.
   d. Each month, Joanne saves additional 12,000.

8. Based on the given equation, what is the slope?
   a. 12,000 b. 500 c. – 500 d. – 12,000

9. What does the value of the slope indicate?
   a. Joanne started with 500 in her account.
   b. Joanne started with 12,000 in her account.
   c. Each month, Joanne saves additional 500.
   d. Each month, Joanne saves additional 12,000.

For numbers 10 to 13, consider the following situation:
Nathan sells restaurant discount cards as part of a fund raiser to support health workers during the pandemic. The equation y = -10x + 500 models his selling where y is the total number of cards and x is the number of days.

10. Based on the given equation, what is the slope?
    a. 500 b. 10 c. – 500 d. – 10

11. What does the value of the slope indicate?
    a. Nathan starts with 500 cards to sell.
    b. Nathan is selling 500 cards over 10 days.
    c. Nathan earns 500 pesos for every 10 cards he sells.
    d. There is a decrease of 10 cards daily on the total number of cards.

12. Based on the given equation, what is the y-intercept?
    a. 500 b. 10 c. – 500 d. – 10

13. What does the y-intercept mean?
    a. Nathan starts with 500 cards to sell.
    b. Nathan is selling 500 cards over 10 days.
    c. Nathan earns 500 pesos for every 10 cards he sells.
    d. There is a decrease of 10 cards daily on the total number of cards

14. Kyell collects shoes. The equation $y = 3x + 122$ models the number of pairs of rubber shoes he has in his collection after x months. What is the interpretation of the slope?
    a. Kyell collects additional 3 pairs of rubber shoes each month.
    b. In 3 months, Kyell will have 122 more pairs of rubber shoes.
    c. Kyell starts his collection with 122 pairs of rubber shoes.
    d. Kyell collects 122 pairs of rubber shoes every 3 months.

15. An employer uses the equation $y = 9x + 100$ to determine how much to pay his employees for the holidays. In the equation, y is the total money paid and x is the number of hours the employees worked. What is the meaning of the y-intercept??
    a. a pay bonus for employee
    b. the pay for a really good work
    c. the amount of money earned each hour
    d. the number of hours needed to earn overtime pay

Lesson 1 Interpreting the Slope and Y-Intercept

You already learned how to solve for the slope and y-intercept of a regression line using certain formulas. One common issue in learning about the equation of a regression line is when you see the slope as a mere number, but you have no idea what it represents based on a real situation.

In this module, you will learn how to interpret the slope and y-intercept to calculate the slope and y-intercept of the regression equation. First, check your readiness for this lesson by doing this activity.

What's In

Reveal the Key Word!

To decode the key word, determine the slope of each regression equation. Then, write the letter that corresponds to the value of the slope. Afterwards, supply the key word you formed in the blank on the following sentence.

In regression analysis, the slope is the heart and soul of the equation because it tells you how much _____ to expect in the *y* based on the *x*.

Slope						
Keyword						
Regression Equation	$\hat{y} = 5 + 4x$	. $\hat{y} = 6 - 2x$	$\hat{y} = \frac{1}{2} + x$	$\hat{y} = -1 - 3x$	$\hat{y} = \frac{1}{2} - 5x$	$\hat{y} = 2x - 2$

A = 1	B = -1	C = 4	D = -4	E = 2	F = 3	G = -5
H = -2	I = 5	J = $\frac{1}{2}$	K = $-\frac{1}{2}$	L = 6	M = -6	N = -3

For you to be able to interpret the slope and y-intercept, it is important that you have mastered skills in identifying the slope and y-intercept of a regression equation. Furthermore, you should be able to compute the values of the slope and y-intercept to make accurate inferences based on a given context or situation.

Since you were able to determine the slope in the previous activity, you can now begin with our lesson on interpreting the slope and y-intercept.

What's New

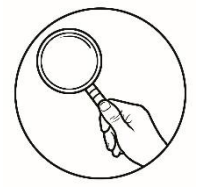
Is It Positive or Negative?

Draw a plus sign (+) if the trend of relationship between y and x is positive and draw a minus sign (−) if the trend of relationship between y and x is negative based on the slope of the regression equation.

Regression Equation		Regression Equation	
1. $\hat{y} = 5 + 4x$	____	6. $\hat{y} = x - 2$	____
2. $\hat{y} = 3 - 2x$	____	7. $\hat{y} = 3x - \frac{1}{4}$	____
3. $\hat{y} = \frac{1}{2} + x$	____	8. $\hat{y} = -3 + 4x$	____
4. $\hat{y} = -1 - 3x$	____	9. $\hat{y} = 1 - 2x$	____
5. $\hat{y} = 2 + \frac{2x}{3}$	____	10. $\hat{y} = \frac{1}{2} + 5x$	____

Guide Questions:

1. Were you able to determine the trend of relationships between variables? How?
2. Which value in the regression equation did you use to determine the trend of relationships?
3. What difficulties did you experience in determining the trend of relationships between variables?



What is It

As shown in the activity, you need to consider the slope of the regression equation to determine the relationship between variables x and y.

Recall: $\hat{y} = bx + a$

- $\hat{y}$ = predicted values of y
- a as the y-intercept of the regression equation
  It is the value of y when x is equal to 0.
- b as the slope of the regression equation
  It is the estimated rate of change of y per unit change in x.

Based on the slope, you can determine the relationship between the variables and then, interpret its meaning related to the situation. The sign of the slope (b) is used to identify the trend or direction of relationship between the dependent and independent variable.

Relationship	Interpretation
A positive slope means a positive relationship between variables *x and y*.	When x-values increase, y-values also increase. *OR* When x-values decrease, y-values also decrease.
A negative slope means a negative relationship between variables *x and y*.	When x-values decrease, y-values increase. *OR* When x-values increase, y-values decrease.
A zero slope means no relationship between variables *x and y*.	There is no relationship between x and y-variables.

The y-intercept can also be interpreted to determine its relevance on a specific situation.

- Substitute the value of *y* into the equation.
- Analyze if the values of the dependent and independent variables depict a possible situation between the two variables.

Note: Unlike the slope which is easily determined, analysis of the situation is needed to determine if the y-intercept is relevant with respect to the situation.

Look at the following examples.

Example 1: A biologist wants to study the relationship between the number of trees per square meter (*x*) and the number of birds per square meter (*y*). She came up with the equation of the regression line:

$$\hat{y} = 3x + 4$$

Slope and Y-Intercept	Interpretation
The slope is 3. The positive slope indicates a positive relationship between x and y.	For every additional tree, you can expect an average of 3 additional birds per square meter.
The y-intercept is 4.	It means that the average number of birds per square meter in an area with no (0) trees is 4. This value is relevant because the number of trees can be 0 and it is possible to have a bird in an area without trees.

Example 2: A survey was done to know the relationship between the age in years of a young person (x) and the time in minutes a person can run one mile (y). Data from children between the ages of 8 and 15 were collected. The regression equation is

$$\underline{\hat{y} = -x + 15}$$

Slope and Y-Intercept	Interpretation
The slope is -1. The negative slope indicates a negative relationship between x and y.	From the situation, as a young person ages 1 year, his run time decreases by 1 minute.
The y-intercept is 15.	This is not relevant because a zero-year-old child cannot run one mile. It is also stated in the problem that the domain is between 8 and 15. The age of a person cannot be 0. Thus, getting the y-intercept is a violation to the problem but not on the regression equation.

Try to apply what you have learned by answering the next activities.

What's More

Activity 1.1 Fill in the Blanks

Fill in the missing words to complete the paragraph. Rewrite on a separate sheet of paper.

Cream Line Creamery is a local ice cream store in Tayabas City that donates portion of their profit in maintaining the cultural heritage of the city. The store clerk keeps records of the temperature and how many ice cream cups it sells in a day. The equation of the regression line for the situation is:

$$\hat{y} = 1.1415x - 29.8934$$

The slope is _____. The slope means that for every one unit increase of _____, we expect that on average _____ will increase by _____.

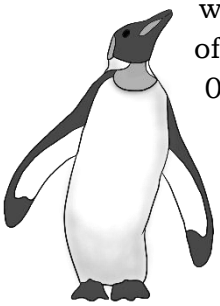
The y-intercept is _____. The y-intercept means that if _____ is zero, then we expect on average _____ to be _____. Does the y-intercept have a practical interpretation? _____

Activity 1.2 Ask and Answer

Read and analyze the situation. Answer the questions that follow.

1. A study was done to see the relationship between the time in years it takes to complete a college degree (x) and the amount of money spent in pesos (y). The equation of the regression line was found to be $y = 25{,}142 + 14{,}329x$.
   a. What is the slope?
   b. What does it mean?
   c. What is the y-intercept?
   d. What does it mean?
   e. Is the y-intercept relevant?

2. Data were collected on the depth of a dive of penguins and the duration of the dive. The following regression equation somehow summarizes the data, where x is the duration of the dive in minutes and y is the depth of the dive in yards. The equation for the regression line is $y = 0.015 + 2.915x$.



   a. What is the slope?
   b. What does it mean?
   c. What is the y-intercept?
   d. What does it mean?
   e. Is the y-intercept relevant?

Activity 1.3 It's Important to Interpret

Identify the slope and state the relationship. Interpret the slope and y-intercept.

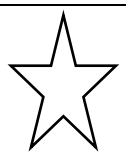
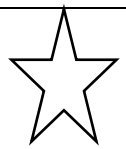
1. A counsellor has collected data on the number of times per year a SHS student goes out on a date (x) and the number of hours a student spends in doing homework per week (y). She came up with the equation of the regression line: $y = 30 - 0.2x$.
Slope: _____ Interpretation:
2. The police wanted to investigate the relationship between the number of criminals a person knows (y) and the number of times the person has been arrested (x). The equation was found to be $y = 8x + 0.4$. Slope: _____ Interpretation:
3. A school nurse was researching the relationship between the number of cigarettes a person smokes per day (x) and the number of days the person is sick per year (y). The nurse came up with the regression equation: $y = 1.2x + 6$. Slope: _____ Interpretation:

4. A study was done to look at the number of a certain type of fossil based on its distance from a water source in meters (x). The equation of the regression line is $y = 24 - 1.4x$. Slope: _____ Interpretation:
5. When smoking cigarettes, one by-product is carbon monoxide. Data were collected to determine if the carbon monoxide emission (y) can be predicted by the nicotine level (x) of the cigarette. Variables are measured in milligrams. The regression equation is $y = 3 + 10.3x$. Slope: _____ Interpretation:

In this next activity, carefully analyze each described situation based on the discussion on determining the relevance of the y-intercept.

Activity 1.4 Realizing Relevance

Shade the star if the y-intercept is not relevant. Then, explain the reason for its relevance or non-relevance based on the situation on a separate piece of paper.

1. A counsellor has collected data on the number of times per year a SHS student goes out on a date (x) and the number of hours a student spends in doing homework per week (y). She came up with the equation of the regression line: $y = 30 - 0.2x$.	
2. The police wanted to investigate the relationship between the number of criminals a person knows (y) and the number of times the person has been arrested (x). The equation was found to be $y = 8x + 0.4$.	
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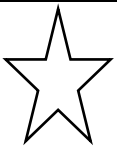
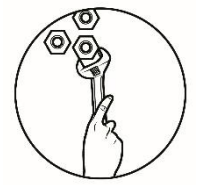
5. When smoking cigarettes, one by-product is carbon monoxide. Data were collected to determine if the carbon monoxide emission (y) can be predicted by the nicotine level of the cigarette (x). Variables are measured in milligrams. The regression equation is $y = 3 + 10.3x$.	

What I Have Learned

Complete the statements on what you have learned.

- The _____ of the regression equation is the value of y when x is equal to 0.
- The slope of the regression equation is the estimated _____ of y per unit change in x.
- The_____ of the slope (b) is used to identify the relationship between the dependent and independent variable.
- A positive slope means that when x-value increases, y-value _____.
- A negative slope means that when x-value increases, y-value _____.
- A zero slope means that there is no _____ between the variables.
- The y-intercept can also be interpreted to determine the _____ on a specific situation.



What I Can Do

Tuition Investigation

Investigate the relationship between school year and the cost of tuition fees of the university or college of your choice. Make a data table for the past ten (10) years and compute the slope and y-intercept. Analyze the relationship between year and tuition fee cost. Make interpretations about the slope and y-intercept based on the situation.

Rubric for Performance Task (Tuition Investigation)

Standards	**4**	**3**	**2**	**1**
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 of 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 containing data for the past 10 years or more	Data table containing data for the past 8 to 9 years	Data table containing data for the past 5 to 7 years	Data table containing data for less than 5 years
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
Communication of Ideas and Interpretations	Communicated ideas and analysis effectively, raised interesting interpretations, and went beyond expectations	Communicated ideas and analysis effectively	Communicated ideas and analysis	Unable to finish the investigation and was unable to communicate ideas and analysis

Assessment

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

1. What does y-intercept represent?
   a. predicted value of y
   b. predicted value of y when $x = 0$
   c. variation around the line of regression
   d. estimated change of y per unit change in x

2. What does slope represent?
   a. predicted value of y
   b. predicted value of y when $x = 0$
   c. variation around the line of regression
   d. estimated change of y per unit change in x

3. What is the relationship between independent variable x and the dependent variable y when the regression equation has a positive slope?
   a. There is no relationship.
   b. There is a positive relationship.
   c. There is a negative relationship.
   d. Relationship cannot be determined.

4. What is the relationship between independent variable x and the dependent variable y when the regression equation has a negative y-intercept?
   a. There is no relationship.
   b. There is a positive relationship.
   c. There is a negative relationship.
   d. Relationship cannot be determined.

5. Which variable/s is/are most likely to have a positive relationship?
   I. Monthly family income and floor area of family's house
   II. Number of student absences and academic performance
   a. I only
   b. II only
   c. both I and II
   d. neither I nor II

For numbers 6 to 9, consider the following situation:

Mrs. Cruz is a hardworking government employee who does her job with all honesty and compassion. She knows the value of every cent she's earning, that is why she is saving money for her retirement. The equation $y = 600x + 10{,}000$ models her retirement savings where y is her total savings in pesos and x is the number of months.

6. Based on the given equation, what is the slope?
   a. 600 b. 10,000 c. – 600 d. – 10,000

7. What does the value of the slope mean?
   a. Joanne started with 600 in her account.
   b. Joanne started with 10,000 in her account.
   c. Each month, Joanne saves additional 600.
   d. Each month, Joanne saves additional 10,000.

8. What is the y-intercept?
   a. 600 b. 10,000 c. – 600 d. – 10,000

9. What does the y-intercept indicate about the situation?
   a. Joanne started with 600 in her account.
   b. Joanne started with 10,000 in her account.
   c. Each month, Joanne saves additional 600.
   d. Each month, Joanne saves additional 10,000.

For numbers 10 to 13, consider the following situation:

Nathan sells restaurant discount cards as part of a fund raiser to support health workers during the pandemic. The equation y = -15x + 720 models his selling where y is the total number of cards and x is the number of days.

10. Based on the given equation, what is the slope?
    a. 15 b. 720 c. – 15 d. – 720

11. What does the value of the slope indicate?
    a. Nathan starts with 720 cards to sell.
    b. Nathan is selling 720 cards over 15 days.
    c. Nathan earns 720 pesos for every 15 cards he sells.
    d. There is a decrease of 15 cards daily on the total number of cards.

12. Based on the given equation, what is the y-intercept?
    a. 720 b. 15 c. – 15 d. – 720

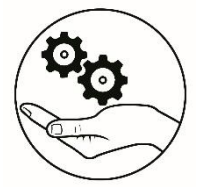
13. What does the y-intercept mean?
    a. Nathan starts with 720 cards to sell.
    b. Nathan is selling 720 cards over 15 days.
    c. Nathan earns 720 pesos for every 15 cards he sells.
    d. There is a decrease of 15 cards daily on the total number of cards.

For numbers 14 – 15, consider the following situation.

Lindsey loves hair accessories. The equation $y = 4x + 65$ models the number of different hair accessories she owns after x months.

14. What is the interpretation of the y-intercept?
    a. Lindsey buys 65 hair accessories every 4 months.
    b. Lindsey purchases additional 4 hair accessories each month.
    c. In 4 months, Lindsey will have 65 additional hair accessories.
    d. Lindsey starts her collection by owning 65 different hair accessories.

15. What is the interpretation of the slope in the given situation?
    a. Lindsey buys 4 hair accessories each month.
    b. In 4 months, Lindsey will have 65 hair accessories.
    c. Lindsey began her collection by owning 65 hair accessories.
    d. Lindsey purchases 65 hair accessories in the span of 4 months.



Additional Activities

Now, it is time for reflection. Answer the following questions honestly.

- What concepts have you learned about interpreting the calculated slope and y-intercept? Complete the sentence below.
  I learned that _____
  _____
  _____

- Relevance is a concept discussed in our lesson. What is the relevance of learning in your daily life? Give at least three (3) specific experiences.
  _____
  _____
  _____

Answer Key

What I Have Learned

- The y-intercept of the regression equation is the value of y when x is equal to 0.
- The slope of the regression equation is the estimated rate of change of y per unit change in x.
- The sign of the slope (b) is used to identify the relationship between the dependent and independent variable.
- A positive slope means that when x-value increases, y-value increases.
- A negative slope means that when x-value increases, y-value decreases.
- A zero slope means that there is no relationship between the variables.
- The y-intercept can also be interpreted to determine the relevance on a specific situation.

Assessment

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

What's New

Is it Positive or Negative?

1.	+	6.	+
2.	–	7.	+
3.	+	8.	+
4.	-	9.	-
5.	+	10.	+

What's In

Reveal the Keyword

4;-2;1;-3;-5;2 C-H-A-N-G-E

What I Know

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

What's More

1.1 Fill in the blanks

The slope is 1.1415. The slope means that for every one unit increase of temperature, we expect that on average the number of ice cream cups sold will increase by 1.1415.

The y-intercept is - 29.8934. The y-intercept means that if the temperature is zero, then we expect on average the number of ice cream cups sold to be - 29.8934. Does the y-intercept have a practical interpretation? No.

1.2 Ask and Answer

1.

a. 14,329
b. This means that for every additional year, amount of money spent increases by 14,329.
c. 25,142
d. If the time in years is 0, you would have spent 25,142.
e. It does not make sense because the years it takes to complete a college degree cannot be zero.

2.

a. 2.915
b. If the duration of the dive increases by 1 minute, we predict the depth of the dive will increase by approximately 2.915 yards.
c. 0.015
d. If the duration of the dive is 0 second, then we predict that the depth of the dive is 0.015 yards.
e. It does not make sense because the dive in minutes cannot be zero. Also, 0.015 in yards is too shallow for a dive.

What's More

1.3 It's Important to Interpret

1. Slope: -0.2

   Interpretation: There is a negative relationship between the number of times per year a SHS student goes out on a date and the number of hours a student spends in doing homework per week. It means that for every "date" a student makes for a year, the number of hours that he does homework in a week decreases by 0.2 hour.

2. Slope: 8

   Interpretation: It means that there is a positive relationship between the number of criminals a person knows and the number of times the person has been arrested. This also means that for every arrest of a person, there is an additional 8 number of criminals that he knows.

3. Slope:1.2

   Interpretation: There is a positive relationship between the number of cigarettes a person smokes per day and the number of days the person is sick. It means that for every cigarette that a person smokes, the number of days the person is sick per year will be increased by 1.2 or 1 day.

4. Slope: -1.4

   Interpretation: There is a negative relationship between the distance of fossil from a water source and the number of these fossils. It means that for every meter distance, there is a decrease of 1.4 or 1 fossil.

5. Slope: 10.3

   Interpretation: There is a positive relationship between the nicotine level and carbon monoxide emission when smoking cigarettes. This means that there is additional 10.3 mg of carbon monoxide for every 1 g of nicotine.

1.4 Realizing Relevance

1. y – intercept: 30
   It makes sense because the number of "dates" in a year can be zero. It means that if a student does not go on a date, he will consume 30 hours of doing his homework in a week.

2. y-intercept: 0.4
   This makes sense in the context of the problem since we can round down 0.4 to 0. It means that if a person has never been arrested, he does not know a criminal.

3. y-intercept: 6
   This makes sense in the context of this problem. If a person doesn't smoke, the number of days he will be sick is 6 days. Since correlation does not imply causation, it does not necessarily mean that if a person does not smoke, he will not be sick.

4. y-intercept: 24
   This makes sense because the distance can be 0. If the distance is 0, there could be 24 fossils.

5. y-intercept=3
   This makes sense because it is possible to have no nicotine like e–cigarette and herbal cigarettes. If there is no nicotine, the carbon monoxide will be 3 mg.

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For inquiries or feedback, please write or call:

Department of Education - Bureau of Learning Resources (DepEd-BLR)

Ground Floor, Bonifacio Bldg., DepEd Complex
Meralco Avenue, Pasig City, Philippines 1600

Telefax: (632) 8634-1072; 8634-1054; 8631-4985

Email Address: blr.lrqad@deped.gov.ph * blr.lrpd@deped.gov.ph