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Mathematics

Quarter 1 - Module 8: Finding the Equation and Solving Problems Involving Quadratic Function

AIRs - LM

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Quarter 1 - Module 8: Finding the Equation and Solving Problems Involving Quadratic Function
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Development Team of the Module

Authors: Glieza A. Laña and Maryknoll B. Lisboa
Editor: SDO La Union, Learning Resource Quality Assurance Team
Content Reviewers: Philip R. Navarette and Jocelyn G. Lopez
Language Reviewers: Teresa A. Villanueva and Cleofe M. Lacbao
Illustrator: Ernesto F. Ramos Jr. and Christian Bautista
Design and Layout: Dana Kate J. Pulido

Management Team:

Atty. Donato D. Balderas Jr.
Schools Division Superintendent
Vivian Luz S. Pagatpatan, Ph D
Assistant Schools Division Superintendent
German E. Flora, Ph D, *CID Chief*
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Erlinda M. Dela Peňa, Ph D, *EPS in Charge of Mathematics*
Michael Jason D. Morales, *PDO II*
Claire P. Toluyen, *Librarian II*

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Department of Education – SDO La Union
Office Address: Flores St. Catbangen, San Fernando City, La Union
Telefax: 072 – 205 – 0046
Email Address: launion@deped.gov.ph

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Quarter 1 - Module 8: Finding the Equation and Solving Problems Involving Quadratic Function

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.

Target

A quadratic function is one of the form $f(x) = ax^2 + bx + c,$ where a, b and c are real numbers and a is not equal to zero. The application of quadratic function can be seen in many different fields like physics, industry, and business and in variety of mathematical problems. So far you have learned how to find the roots of quadratic equations and to graph quadratic function. In this module, you will reverse the process and learn how to write equations using (a) table of values (b) graph c) zeros.

After going through this module, you are expected to attain the following objectives:

Learning Competencies

- Determines the equation of a quadratic function given: (a) a table of values; (b) graph; (c) zeros **(M9AL-Ij-1)**
- Solves problems involving quadratic functions **(M9AL-Ii-j-2)**

Subtasks

1. Find the solution of the quadratic function given the table of values, graph and zeros of quadratic functions.
2. Apply the properties of quadratic functions in solving problems involving real life situation.

Before going on, check how much you know about this topic. Answer the pretest on the next page in a separate sheet of paper.

Pre-assessment

Direction: Choose the letter of the correct answer and write it on a separate sheet of paper.

1. Which of the following equations represents a quadratic function?
   A. $y = 3 + 2x^2$
   B. $2y^2 + 3 = x$
   C. $y = 3x - 22$
   D. $y = 2x - 3$
2. What is the standard form of the quadratic function $f(x) = x^2 + 2x - 1$?
   A. $f(x) = (x + 1)^2 + 1$
   B. $f(x) = (x + 1)^2 - 2$
   C. $f(x) = (x + 1)^2 + 2$
   D. $f(x) = (x + 1)^2 - 1$
3. What is $f(x) = -3(x + 2)^2 + 2$ when written in the form $f(x) = ax^2 + bx + c$?
   A. $f(x) = -3x^2 + 12x - 10$
   B. $f(x) = -3x^2 + 12x + 10$
   C. $f(x) = 3x^2 - 12x + 10$
   D. $f(x) = -3x^2 - 12x - 10$
4. What are the zeros of the quadratic function $y=x^2-2x-3$?
   A. 1, 3
   B. -1, 3
   C. 1, -3
   D. -1, -3
5. What happens to the graph of $y = x^2 - 3$ if obtained by sliding the graph of $y = x^2$?
   A. 3 units downward
   B. 3 units upward
   C. 3 units to the right
   D. 3 units to the left
6. What is the nature of the zeros of $y = -2x^2 + 4x - 3$?
   A. real and unequal zeros
   B. real and equal zeros
   C. no real zeros
   D. equal and not real
7. What is an equation of a quadratic function whose zeros are twice the zeros of $y = 2x^2 - x - 10$?
   A. $f(x) = 2x^2 - 20x + 20$
   B. $f(x) = x^2 - x - 20$
   C. $f(x) = 2x^2 - 2x - 5$
   D. $f(x) = 2x^2 - 2x - 10$
8. Which of the following shows the zeros of the quadratic function $y=x^2+x-12$?
   A. 2, 6
   B.-2, 6
   C. 3,4
   D. 3,-4
9. Richard predicted that the number of mango trees **x** planted in a farm could yield $y = -20x^2 + 2800x$ mangoes per year. How many trees should be planted to produce the maximum number of mangoes per year?
   A. 60
   B. 70
   C. 80
   D. 90

10. The path of an object when it is thrown can be modeled by $S(t) = -16t^2 + 8t + 4$ where S in feet is the height of the object t seconds after it is released. What is the maximum height reached by the object?
    A. 3 ft
    B. 4 ft
    C. 5 ft
    D. 6 ft
11. The product of two consecutive negative integers is 1122. What are the numbers?
    A. -30 and -31
    B. -31 and -32
    C. -33 and -34
    D. -34 and -35
12. You have a 500-foot roll of fencing and a large field. You want to construct a rectangular playground area. What is the largest area?
    A. 15,625 ft^2
    B. 15,626 ft^2
    C. 15,627 ft^2
    D. 15,628 ft^2
13. An object is launched from ground level directly upward at 39.2 m/s. For how long is the object at or above a height of 34.3 meters?
    A. 34. 1 m
    B. 34. 2 m
    C. 34. 3 m
    D. 34.5 m

For numbers 14-15: An object is launched directly upward at 64 feet per second (ft/s) from a platform 80 feet high.

14. What will be the object's maximum height?
    A. 140 feet
    B. 141 feet
    C. 143 feet
    D. 144 feet
15. When will it attain this height?
    A. 1 second
    B. 2 seconds
    C. 3 seconds
    D. 4 seconds

Jumpstart

Activity 1. Where do you belong?

Directions: Copy the table below in your answer sheet and write the letter of the given equation in the table.

a. $y = x2 - 1$
b. $y = x$
c. $2x^2 - 2x + 1 = y$
d. $3x-1 + y = 0$
e. $y = (2x+ 3) (x- 1)$
f. $y = x^3 + 1$
g. $2^2 + x = y$
h. $y = 3x + 2x$
i. $3x + x^2 = y$
j. $2x(x - 3) - y = 0$

Quadratic Function	Not Linear nor Quadratic	Linear Function

Discover

Finding the Equation of a Quadratic Function

We can determine the equation of a quadratic function using the three methods: (a) table of values (b) graph and (c) zeros. Let us find out how to use these methods as we go on with this module.

A. Using the table of values

Assuming you are given table of values that represents a parabola, you can create system of three equations. Create the equations by substituting the ordered pair for each point into the general form of the quadratic equation, $ax^2 + bx + c$. Simplify each equation, then use the method of your choice to solve the system of

equations for a, b and c. Finally substitute the values you found for a, b, and c into general equation to generate the equation for your parabola.

Example 1. Given table of values, determine the quadratic function.

$$f(x) = ax^2 + bx + c$$

x	0	-1	2	3	4
y	c	a+b+c	4a+2b+c	9a+3b+c	16a +4b+c

First difference	a+b	3a+b	5a+b	7a+b
Second difference	2a	2a	2a	

1. Equate 2a with the second difference in the table of values to find a
   2a = 4 ⟶ a = 2
2. Equate a+b with the first difference in the table of values and use the value a to find b.
   a + b =-3 ⟶ 2+b = -3 ⟶ b = -5
3. To find c, locate the ordered pair where x equals zero.
   c=-12

   The quadratic function is $f(x)=2x^2-5x-12$.

Example 2. Given the following table of values, determine the quadratic function.

x	1	2	3
y	5	11	19

You are given three points along a parabola, you can find the quadratic equation that represents that parabola by creating a system of three equations. The following are the steps to follow:

1. Substitute the first pair of values into the general form of the quadratic equation: Solve for *a*.	$f(x) = ax^2 + bx + c$ $5 = a(1)^2 + b(1) + c$ simplifies to $a = -b - c + 5$
2. Substitute the second ordered pair and the value of *a* into the general equation. Solve for *b*	$11 = (-b - c + 5)(2)^2 + b(2) + c$ simplifies to $b = -1.5c + 4.5$.

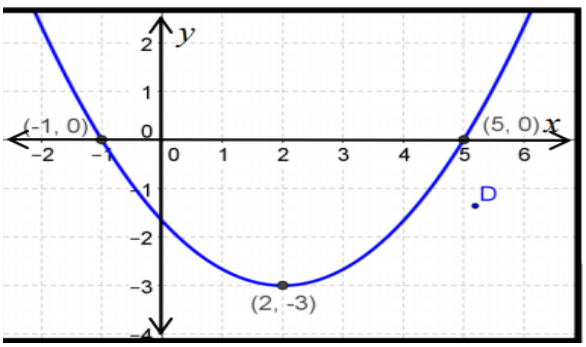
3. Substitute the third ordered pair and the values of *a* and *b* into the general equation. Solve for *c*.	19 = -(-1.5c + 4.5) - c + 5 + (-1.5c + 4.5)(3) + c simplifies to c = 1.
4. Substitute any ordered pair and the value of *c* into the general equation. Solve for *a*.	For instance, you can substitute (1, 5) into the equation to yield $5 = a(1)^2 + b(1) + 1$, which simplifies to a = -b +4
5. Substitute another ordered pair and the values of *a* and c into the general equation. Solve for *b*.	For example, $11 = (-b + 4)(2)^2 + b(2) + 1$ simplifies to b = 3.
6. Substitute the last ordered pair and the values of *b* and *c* into the general equation. Solve for *a*.	The last ordered pair is (3, 19), which yields the equation: $19 = a(3)^2 + 3(3) + 1$. This simplifies to a = 1.
7. Substitute the values of *a*, *b* and *c* into the general quadratic equation.	The equation that describes the graph with points (1, 5), (2, 11) and (3, 19) is $x^2 + 3x + 1$.

B. Graph

The graph of a quadratic function $y = ax^2 + bx + c$ is called **parabola.** Parabola is the locus of points in the plane that are equidistant from both the directrix and the focus. Parabola is like an umbrella, it could open upward or downward depending on the value of quadratic term ax^2. Usually – ax^2 creates a parabola that opens downward and ax^2 creates a parabola that opens upward. The vertex of the parabola is the point where the graph attains its minimum point if opens upward and maximum point if opens downward.

Study the illustrative examples presented below.

Example 1. Find the equation of the quadratic function determined from the graph below.



Solution:

The vertex of the graph of the quadratic function is (2,-3). The graph passes the point (5,0). By replacing x and y with 5 and 0, respectively, and h and k with 2 and -3 respectively, we have

$$y = a(x-h)^2 + k$$
$$0 = a(5-2)^2 + (-3)$$
$$0 = a(3)^2 - 3$$
$$3 = 9a$$
$$a = \frac{1}{3}$$

Thus, the quadratic equation is $y = \frac{1}{3}(x-2)^2 - 3$ or $y = \frac{1}{3}x^2 - \frac{4}{3}x - \frac{5}{3}$

Example 2. Express $y = 3x^2 - 4x + 1$ in the form $y = a(x - h)^2 + k$ form and give the values of h and k.

Solution:

$y = 3x^2 - 4x + 1 \qquad y = (3x^2 - 4x) + 1$

$y = 3(x^2 - 4x) + 1$ ⟶ Group together the terms containing x

$y = 3\left(x^2 - \frac{4}{3}x\right) + 1$ ⟶ Factor out a. Here a=3

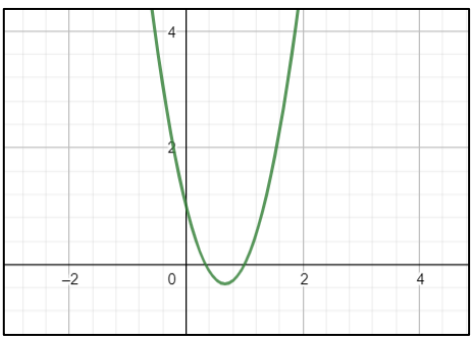
$y = \left[x^2 - \frac{4}{3}x + \left(\frac{2}{3}\right)^2\right] + 1 - \left(\frac{2}{3}\right)^2$ ⟶ Compete the expression in parenthesis to make it a perfect square trinomial by adding the constant. $3(4/3/3)^2=3(2/3)^2=3(4/9)=4/3)$ and subtracting the same value from the constant term.

$y = 3\left(x^2 - \frac{4}{3}x + \frac{4}{9}\right) + 1 - \frac{4}{9}$ ⟶ Simplify and express the perfect square trinomial as the square of a binomial

$y = 3\left(x - \frac{2}{3}\right)^2 - \frac{1}{3}$ ⟶ Hence, $y=3x^2-4x+1$ can be expressed as $y=3(x - \frac{2}{3})^2 - \frac{1}{3}$

In this case, $h = \frac{2}{3}$ and $k = \frac{1}{3}$.

We can graph the function as shown below.



C. Zeros

If r_1 and r_2 are the zeros of a quadratic function, then $f(x) = a\ (x- r_1)\ (x - r_2)$ where *a* is a nonzero constant that can be determined from other point on the graph. Also, you can use the sum and product of the zeros to find the equation of the quadratic function.

Example 1: Find an equation of a quadratic function whose zeros are -3 and 2.

Solution: Since the zeros are $r_1 = -3$ and $r_2 = 2$, then

$f(x) = a(x- r_1) (x - r_2)$

$f(x) = a[x - (-3)](x - 2)]$

$f(x) = a(x + 3)(x - 2)$

$f(x) = a(x^2 + x - 6)$ where a is any nonzero constant.

Example 2: Find an equation of a quadratic function with zeros $\frac{3 \pm \sqrt{23}}{3}$.

Solution: A quadratic expression with irrational roots cannot be written as a product of linear factors with rational coefficients. In this case, we can use another method. Since the zeros are $\frac{3 \pm \sqrt{23}}{3}$ then,

$x = \frac{3 \pm \sqrt{23}}{3} \rightarrow 3x = 3 \pm \sqrt{2} \rightarrow 3x - 3 = \pm\sqrt{2}$

Square both sides of the equation and simplify $\rightarrow$ $9x^2 - 18x + 9 = 2$

$9x^2 - 18x + 7 = 0$

Thus, the equation of a quadratic function is $f(x) = 9x^2 - 18x + 7$

Solving Problems Involving Quadratic Equations

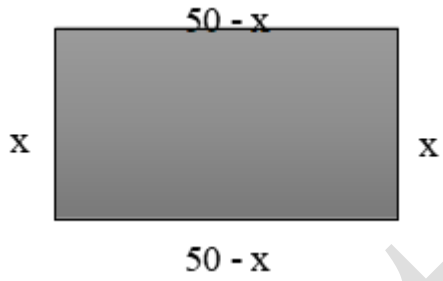
To solve for problems involving quadratic equation, concepts associated with quadratic functions particularly the maximum point and the minimum point of the graph. Most real-life problems involve concepts of maxima-minima. Consider the examples below:

Example 1. A rectangular garden will be enclosed by 100 m of fencing materials. Find the greatest possible area that the materials can enclose?

Representation: The problem asks for the maximum area that can be enclosed using 100m of fencing materials.

Let x = length of one side of the rectangular garden, then

$\frac{100-2x}{2}$ *or* $50 - x =$ the length of the other side adjust to it



Equation:

Express the area (A) as function of x,

$A = x(50 - x)$

$A = -x^2 + 50x$

Solution:

Here a = -1, thus the graph opens downward and the vertex gives the maximum value at a given value of x.

To find the vertex, you can choose between completing the square or using the vertex formula. By completing the square,

$A = -x^2 + 50x$

$= -(x^2 - 50x)$

$= -(x^2 - 50x + 625) + 625$

$= -(x - 25)^2 + 625$

The vertex is at (25, 625). It means that the maximum area that can be enclosed from 100m of fencing materials is $625m^2$.

The length of one side is x = 25m
The length of the other side 50 – x, or 25m

It indicates that the largest area for 100m fencing materials can be given by a square of side 25m.

Example 2: $f(x) = 2x^2 + 10x - 7$

$-2(x^2 - 5x) - 7$ ⟶ Factor the coefficient

$-2\left(x^2 - 5x + \frac{25}{4}\right) + \frac{25}{4} - 7$ ⟶ $\left(\frac{5}{2}\right)^2 = \frac{25}{4}$; add and subtract

$-2(x - \frac{5}{2})^2 + \frac{11}{2}^2$ ⟶ Factor $\left(x^2 - 5x + \frac{25}{4}\right)$

The vertex of the graph of this function is at $(\frac{5}{2}, \frac{11}{2})$. The value of k or the y- coordinate of the vertex gives the maximum or minimum value depending on the opening of the graph.

Therefore, the equation has a maximum value of $\frac{11}{2}$ at x = $\frac{5}{2}$.

REMEMBER:

The following are the steps to solve problems involving quadratic functions particularly maximum or minimum value:

1. Rewrite the unknowns using a single variable.
2. Write the equation of quadratic function in a general form.

3. Choose the appropriate method for the problem
    a. Complete the square and find (h, k)
    b. Use the vertex formula: V

    $V = (\frac{-b}{2a}, \frac{4ac-b^2}{4a})$
4. The value of k gives the maximum value or minimum value of the function at the given value of h.

Explore

Activity 3

Directions*:* The table of values below describes a quadratic function. Find the equation of the quadratic function by following the given procedure. Write your answer on your answer sheet.

x	-3	-2	-1	0	1	2	3
y	24	16	10	6	4	4	6

Steps	Solutions
A. Substitute 3 ordered pairs (x,y) in $y = ax^2 + bx + c$	
B. What are the three equations you came up with?	
C. Solve for the values of a, b and c.	
D. Write the equation of the quadratic function $y = ax^2 + bx + c$.	

Activity 4: Step by Step!

Directions: *Transform the given quadratic functions into the form $y = a(x - h)^2 + k$ by following the steps below. Write your answer on your answer sheet.*

1. $y = x^2 - 4x - 10$ 2. $y = 3x^2 - 4x + 1$

Steps	Task
1. Group the terms containing x	
2. Factor out a	
3. Complete the expression in parenthesis to make it a perfect square trinomial.	
4. Express the perfect square trinomial as square of a binomial	
5. Give the value of h	
6. Give the value of k	

Deepen

Activity 5: Hit the Mark!

Directions: Analyze and solve the problem carefully. Write your answer on your answer sheet.

A company of cellular phones can sell 200 units per month at Php2,000.00 each. They found out that they can sell 50 more cellphone units every month for each Php100.00 decrease in price.

a. How much is the sales amount if cellphone units are priced at Php2000.00?
b. How much would be their sales if they sell each cellphone unit at Php 1600.00?
c. What is the equation for the revenue function?
d. What price per cell phone unit gives them the maximum monthly sales?
e. How much is the maximum sale?

Great job! You have understood the lesson. Are you now ready to summarize?

Gauge

Post-Assessment

Directions*:* Choose the letter of the correct answer and write it on a separate sheet of paper.

1. Which of the following equations represents a quadratic function?
   A. $9y^2 + 3 = x$
   B. $y = 2x^2 – 7x + 1$
   C. $y = 3x - 8^2$
   D. $y = 3x – 3$
2. What is the quadratic function that this table of values represents?

x	-2	-1	0	1	2
y	5	0	-3	-4	-3

   A. $y = 3x^2 −2x−2$
   B. $y = 2x^2 −2x–3$
   C. $y = −2x^2 +3x−2$
   D. $y = −3x^2 +2x$

3. What is the value of y in the equation $y = x^2 + 2x + 7$ if $x = 2$?
   A. 13
   B. 14
   C. 15
   D. 16
4. What is the value of y in the equation $y = 2x^2 + 2x + 2$ if $x = -1$?
   A. – 2
   B. –1
   C. 1
   D. 2
5. Which quadratic function opens downwards and has a vertex (0, – 3)?
   A. $y = (x + 3)^2$
   B. $y = -(x + 3)^2$
   C. $y = x^2 - 3$
   D. $y = -x^2 - 3$
6. Which of the following represents a quadratic function opening downwards?
   A. $y = 3x^2(x - 1)$
   B. $y = - 3x(x - 1)$
   C. $y = - 3x^2(x - 1)$
   D. $y = 3x(x - 1)$
7. Which of the following table of values represents a quadratic function?
   A.

x	-2	-1	0	1	2
y	-3	-1	1	3	5

   B.

x	-2	-1	0	1	2
y	-1	0	1	2	3

   C.

x	-2	-1	0	1	2
y	5	2	1	2	5

   D.

x	-2	-1	0	1	2
y	-7	0	1	2	9

8. Which ordered pairs represent a quadratic function?
   A. (-4,9), (-3,8), (-2,7), (-1,6), (0,5)
   B. (-4,-9), (-3,-8), (-2,-7), (-1,-6), (0,5)
   C. (-4,-11), (-3,-4), (-2,1), (-1,4), (0,5)
   D. (-4,69), (-3,32), (-2,13), (-1,6), (0,5)
9. What is the vertex of the quadratic equation $f(x) = (x + 1)^2 - 2$?
   A. (1, -2)
   B. (-1, 2)
   C. (1, -2)
   D. (-1, -2)
10. What is the axis of symmetry of the quadratic function $f(x) = (x + 3)^2 + 2$?
   A. x = 3
   B. x = -3
   C. x = 2
   D. x = -2

11. What is the product of the zeros of quadratic function $y = -3x^2 – 2x + 5$?
    A. 5/3
    B. -5/3
    C. 3/5
    D. -3/5
12. A ball is thrown straight up from the top of a 128 foot tall building with an initial speed of 32 feet per second. The height of the ball as a function of time can be modeled by the function $h(t) = –16t^2 + 32t + 128$. How long will it take for the ball to hit the ground?
    A.1 sec
    B. 2 sec
    C. 3 sec
    D. 4 sec
13. A ball is thrown straight up from the top of a 288 foot tall building with an initial speed of 48 feet per second. The height of the ball as a function of time can be modeled by the function $h(t) = –16t^2 + 48t + 288$. When will the ball reach a height of 320 feet?
    A.1 sec
    B. 1.5 sec
    C. 3 sec
    D. 4 sec
14. A rocket is launched straight up from the top of a 24 foot tall building with an initial speed of 92 feet per second. The height of the rocket as a function of time can be modeled by the function $h(t) = –16t^2 + 92t + 24$. How long will it take for the rocket to hit the ground?
    A.5 sec
    B. 6 sec
    C. 7 sec
    D. 8 sec
15. A ball is hit straight up in the air from a height of 4 feet with an initial speed of 64 feet per second. The height of the ball as a function of time can be modeled by the function $h(t) = –16t^2 + 64t + 4$. When will the ball reach a height of 52 feet?
    A. 2 sec
    B. 3 sec
    C. 4 sec
    D. 5 sec

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For inquiries or feedback, please write or call:

Department of Education – SDO La Union
Curriculum Implementation Division
Learning Resource Management Section
Flores St. Catbangen, San Fernando City La Union 2500
Telephone: (072) 607 - 8127
Telefax: (072) 205 - 0046
Email Address:
launion@deped.gov.ph
lrm.launion@deped.gov.ph