Using Quadratics Equations
To find the Parabolas of a Suspension Bridges

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Overview

The expeditionary mathematics can be employed to build bridges between "Urban Youth" and engineering application of algebra and geometry. Suspension bridges are used to span large distances. More can be learned more about these bridges at the following website: **http://www.goldengate.org.**

When the main (curved) cables are attached to the deck by vertical cables they will end up in the shape of a parabola. Assume that we need to build a bridge that spans 2400 feet. The two towers, 165 feet tall each, are placed 400 feet from either side. The lowest point of the main cable is reached in the center of the bridge at 10 feet. Vertical suspension cables are placed at 25-foot intervals.

Activity
How many feet of cable are needed to connect the deck to the main cables between the two towers? What is the length of the main cable? Show all your work.

Rationale

The philosophy of hands - on math permeates both the teachers' preparation and their high school classrooms. The change to a new view of mathematical learning is a journey that began with the teachers themselves experiencing a profound change in their relationship to mathematics. As teachers learned to construct their own solutions to problems, they became aware of the personal nature of learning. Using manipulative materials and sketches to solve problems, increased their confidence in their own problem-solving strategies. Recently, and as early as the 1990's, teachers realized that substantive changes in math would not be implemented simply by changing textbooks or by mandate from the administration. A major shift in instructional focus required that teachers develop new skills, behaviors, and beliefs.

As teachers developed new understandings about math, they became aware that previously they had been "feeding" a set of pre-established procedures to the students and training students to "parrot back" these procedures. That form of instruction was seen as teacher centered. To reorient the instructional process toward being more student centered, teachers needed practice in stepping away from center stage and using class time to focus instead on students' exploration of

math concepts. This meant that some instructional practices needed to be modified, and teaching and learning was now the norm. Teachers, to meet the needs of each student, used constructivist-teaching methods.
Rather than focusing on calculations and repetition of drill and practice, mathematics class time has become an exploration of concepts using hands-on models. The bulk of class time is devoted to student problem-solving work in cooperative teams. When several teams have devised a solution, students demonstrate their own mathematical reasoning by illustrating their team's solution.

Using constructivist-teaching methods

Learning does not mean simply receiving and remembering a transmitted message; instead, "educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding" (Mathematical Sciences Education Board, 1989, p. 58). To help students learn mathematics, teachers must become aware of how children have constructed mathematics from their experiences both in and out of school and learn more about what it means for students to construct mathematical knowledge. Three basic tenets of constructivism are:

1. Knowledge is not passively received but is actively created or invented (constructed) by students. Students construct new mathematical knowledge by reflecting on their physical and mental actions.
2. Learning reflects a social process in which students interact, discuss, and even argue their ideas, with themselves and with others, in the process of understanding a particular concept.
3. The National Council of Teachers of Mathematics, in the Assessment Standards for School Mathematics (1995), emphasized the importance of having an alignment (consistency) between the tools used for instruction in the classroom and for assessment. Most recently, the *NCTM Principles and Standards for School Mathematics* (2000) stated, "electronic technologies — calculators and computers — are essential tools for teaching, learning, and doing mathematics."

The Use of Technology in the Learning and Teaching of Mathematics

The appropriate use of instructional technology tools is integral to the learning and teaching of mathematics and to the assessment of mathematics learning.

Technology has changed the ways in which mathematics is used and has led to the creation of new and expanded fields of mathematical study. Thus, technology is driving change in the content of mathematics programs, in methods for mathematics instruction, and in the ways that mathematics is learned and assessed. A vital aspect of such change is a teacher's ability to select and use instructional technology to develop, enhance, and extend students' understanding and application of mathematics. (See NCTM Position Statement at http://www.nctm.org/about/position_statements/position_statement_13.htm.

Calculators and the Education of Youth

The National Council of Teachers of Mathematics recommends the integration of calculators into the school mathematics program at all grade levels. Research and experience support the potential for calculator use to enhance the learning and teaching of mathematics. Calculator use has been shown to enhance cognitive gains in areas that include number sense, conceptual development, and visualization. Such gains can empower and motivate all teachers and students to engage in richer problem-solving activities.

Westinghouse High School

The Westinghouse High School mathematics curriculum explores mathematics from both a theoretical and a life-application perspective. Real world situations and experiences are brought into the classroom through structured learning experiences using technology, TI 83 graphing calculators and field trips. This method of the study of mathematics also leads to the student's ability to think logically and solve problems. It develops thought patterns and mental discipline appropriate to life in a technological age.

As science and technology have come to influence all aspects of life from health and environment to financial affairs and national defense, so mathematics has come to be of vital importance to the educational agenda of our nation. Mathematics is the foundation of science and technology. The analytical skills inherent in mathematics are necessary for almost anything a person will do in today's society.

To prepare students to cope with the technological, information-based society of the 21st century, schools will have to raise the level of education in general, and mathematics instruction in particular. Everyone will need mathematics to function well in the work place and in society.

This unit offers a very different approach to the area of mathematics. Students develop the expertise in mathematics necessary to succeed at the college level or in a skilled job area. Applied mathematics learning is designed to make mathematics useful and meaningful for the students through the use of a more hands-on approach. Laboratory – site visit - activities should be included to apply the skills learned in the classroom to practical problems.

Cooperative and constructivist learning will govern the teaching strategy for this unit. Students in urban settings have different learning styles and social skills that will be addressed in this unit. Hands – on approach, team projects and open – ended questions will challenge both student and instructor to maintain a sense of focus and objectivity. At Westinghouse High School, an urban school where 99% of the student population is African Americans performing at below basic skills, a systemic overhaul is required to improve the teaching and learning of mathematics. As students work on bridge design and the mathematics of the main cable, in cooperative work groups, they will apply not only mathematical principles but also social problem-solving strategies. They will discover their "way," which may not be universally embraced, but will be very engaging and challenging.

Using TI 83 Plus, students will be required to program the calculator the length of the main cable, suspenders, and distances from the tower. Some students may get hooked on this project and work from its beginning to completion. This combination of algebra, geometry, working as a team, and having a thematic project will give the students a sense of learning, while having fun.

The specific strategy of the unit will appeal to many different learning styles and may, in fact, give female students a scientific and engineering sense of the built environment that they would not ordinarily have in a traditional mathematic curriculum. This is true for many of the male students, too. The hope is that many students will find the project interesting and will essentially teach themselves. A secondary objective is that students will develop an in-depth cognitive assimilation of mathematics, and in due course look for the “math” in their world. Much of the emphasis will be on the procedural knowledge that many students come to geometry with but lack a deeper conceptual understanding, and very few, if any, have an understanding of how to apply what they have learned.

Many urban students come to school often with different academic needs. The traditional seat time is not the best educational method for these students. Tactile learning, integrated with hands–on and minds–on activities will facilitate the production of deeper thinkers – a “Habit of Mind” for inquiry, asking questions and finding solutions. Research has suggested that many students in urban setting are often low achievers and require alternative teaching and learning methods.

The Learning Styles of Low Achievers

Seven learning style traits discriminate between high-risk students and dropouts, and students who perform well in school. Most low achievers and dropouts need but are not limited to the following:

- Frequent opportunities for mobility
- Reasonable choices of how, with which resources, and with whom to learn

- A variety of instructional environments, materials, and sociological groupings rather than routines and patterns
- To learn during late morning, afternoon, or evening hours
- Informal seating (e.g., beanbag chairs and cushions)
- Soft illumination—bright or fluorescent light may contribute to hyperactivity
- Introduction to materials with tactile or visual resources, reinforced with visual or kinesthetic resources; or an introduction to materials with kinesthetic or visual resources, reinforced with visual or tactile resources

Underachievers tend to have poor auditory memory. If they learn visually, it usually is through pictures, drawings, graphs, symbols, comics, and cartoons rather than text. Although low achievers often want to do well in school, their inability to remember facts through lecture, discussion, or reading contributes to their low performance in traditional schools where introductory instruction is usually teachers talking and students listening or reading (Dunn 1988). Although low achievers learn differently from high achievers and the gifted, they also learn differently from each other.

How Does Culture Contribute to Achievement?

Research by Milgram, Dunn, and Price (1993) reveals that opportunity substantially influences an individual's development of specific talents. For example, if access to creative activities, information, or role models is not readily available, fewer adolescents will develop giftedness in that domain. Thus, in cultures that respect science, higher percentages of students gifted in science will develop. The same finding holds firm across other domains. Most U.S. communities support athletics financially, but rarely hesitate to eliminate programs in music, art, and drama when funds are scarce. In addition, few advanced science opportunities are available to elementary school and middle school students.[1]

Developing Conceptual and Procedural Knowledge – Through Applied Learning

An underlying mission is to accelerate student learning and enable students to become change agents of their own academic development through Habits of Mind - the complete integration of technology, authentic learning projects within the mathematics curriculum coupled with sciences and applied learning. In this unit the students will be able to gain a greater conceptual understanding of how to apply procedural knowledge.

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[1] http://ascd.org/publications/books/1996dunn/chapter1.html

Mathematical Abilities Definitions

- *Conceptual understanding*

Students demonstrate conceptual understanding in mathematics when they provide evidence that they can recognize, label, and generate examples of concepts; use and interrelate models, diagrams, manipulatives, and varied representations of concepts; identify and apply principles; know and apply facts and definitions; compare, contrast, and integrate related concepts and principles; recognize, interpret, and apply the signs, symbols, and terms used to represent concepts. Conceptual understanding reflects a student's ability to reason in settings involving the careful application of concept definitions, relations, or representations of either.

- *Procedural knowledge*

Students demonstrate procedural knowledge in mathematics when they select and apply appropriate procedures correctly; verify or justify the correctness of a procedure using concrete models or symbolic methods; or extend or modify procedures to deal with factors inherent in problem settings. Procedural knowledge encompasses the abilities to read and produce graphs and tables, execute geometric constructions, and perform non-computational skills such as rounding and ordering. Procedural knowledge is often reflected in a student's ability to connect an algorithmic process with a given problem situation, to employ that algorithm correctly, and to communicate the results of the algorithm in the context of the problem setting.

- *Problem solving*

Students demonstrate problem solving in mathematics when they recognize and formulate problems; determine the consistency of data; use strategies, data, models; generate, extend, and modify procedures; use reasoning in new settings; and judge the reasonableness and correctness of solutions. Problem-solving situations require students to connect all of their mathematical knowledge of concepts, procedures, reasoning, and communication skills to solve problems.[2]

The Project

Students will choose a suspension bridge and use the quadratic equations to determine the parabola, cables and suspension lengths using the TI 83 Plus calculator. Outlined below is a detailed example of a lesson that the instructor will use to teach and demonstrate the principles of applied learning.

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[2] National Center for Education Statistics
Institute of Education Sciences, U.S. Dept. of Education
http://nces.ed.gov/nationsreportcard/mathematics/abilities.asp

Suspension Bridges site:
Suspension bridges, for site visits are the bridges spanning the Monongahela River from Station Square and the South Side to downtown Pittsburgh, including the historic Smithfield Street Bridge (1881), the Panhandle RR Bridge (1903), the Liberty Bridge (1928), the South 10th Street Bridge (1921), the Birmingham Bridge (1977) and, near the horizon, the twin black spans of the Hot Metal Bridge (1877) and Mon Con RR Bridge (1877). Students can learn more about this bridge at the following website:
http://pittsburgh.about.com/library/pictures/bridges/uc_bridge-2.htm

Figure 1 Towers of suspension bridge

Figure 2 parabolas from the towers of suspension bridge

(Note: The students as part of their research must verify all dimensions. The dimensions given here are for demonstration purposes only.)

When the main (curved) cables are attached to the deck by vertical cables they will end in the shape of a parabola. Assume that we need to build a bridge that spans 2400 feet. The two towers, 165 feet tall each, are placed at 400 feet from either side. The lowest point of the main cable is reached in the center of the bridge at 10 feet. Vertical suspension cables are placed at 25-foot intervals.

How many feet of cable are needed to connect the deck to the main cables between the two towers? Show all your work.

Objectives

Pittsburgh has more bridges than any other city in the country. I thought it might be nice to take advantage of this fact and use what students see, in both the natural and built environment. What I saw was a "teachable moment," using the students' neighborhoods, cities and surroundings to develop this task. For many people this is not a new task, but the connection with the technology, expeditionary learning and constructivist learning may make the task rich and interesting to students and instructors.

What This Task Accomplishes

Students will develop a strategy, most likely using a quadratic function, to determine cable length as a function value. This task is particularly well suited to use the quadratic format that is based on a transformation point of view rather than the general format.

What the Student Will Do

Students will need to spend some time understanding all the details of this problem in the context of a suspension bridge. They should develop a mathematical model and then apply this model toward a solution for this problem. Students may do a background investigation at the suggested websites or other websites. Students may also simulate this problem by writing a computer or calculator program. Geometry and spatial sense are fundamental components of mathematics learning. They offer ways to interpret and reflect on our physical environment and can serve as tools for the study of bridges and the structures that support them.

As the study of the relationships among shapes and their properties becomes more abstract, students should come to understand the role of definitions and theorems and be able to construct their own proofs. For example, students in high school should be able to prove that the area of a triangle formed by vertices that bisect the sides of a larger triangle equal one-fourth of the area of the larger triangle.

Principles and Standards (NCTM) call for geometry to be learned using concrete models, drawings, and dynamic software. With appropriate activities and tools and with teacher support, students can make and explore conjectures about geometry and reason carefully about geometric ideas.

Strategies

Time Required for Task

1. Six weeks
2. 40 to 60 minutes per class time
3. Four to six field trips 2 hours each

Concepts to be Assessed and Skills to be developed

- Problem–solving
- Mathematical modeling
- Quadratic functions
- Using a coordinate system
- Choosing an appropriate domain
- Determining function values

Suggested Materials

Graphing paper, (programmable) calculators or computers, spreadsheets

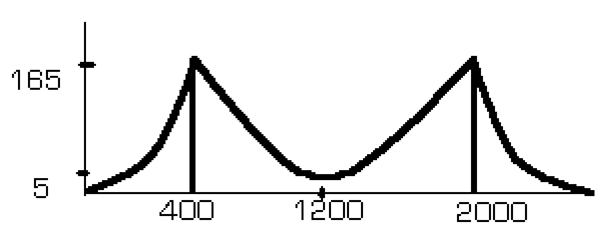
Teaching Tips and Possible Solutions

Alert students how to determine if cables are used to suspend road decks on bridges. Often at each point several vertical cables connect the bridge with the main cables. Students should take this into account. You could ask additional questions such as:

- How many miles of cable will be needed?
- If we put cables at 50 foot intervals would that halve the total amount of cable?
- What is the increase in the amount of cable needed if the lowest point of the main cable is 20 feet above the bridge's center?

Presented below are two different ways to solve this problem. In the student papers there is also a very nice solution using a computer program.

First Scenario: $0.0002422x^2 - 0.58125x + 356.768$



The parabola in this case is on the domain [400, 2000]. We can find the formula for this parabola easily by using the transformation model. Then with simple algebra it can be expanded to the general formula, such as the one above.

This goes as follows: $y = a(x - h)^2 + k$

Where *(h, k)* is the vertex of the parabola (here that is (1200,10) and *a* is a measure of the curvature of the parabola)? Expanding this form gives:

$y = ax^2 - 2ahx + (ah^2 + k)$, which is the general form.

$$y = ax^2 + bx + c$$

It is obvious that for the bridge problem *b* and *c* are expressed in *a, h*, and *k*, and thus are parameters that are complex and difficult to give any meaning for a bridge. However, the general formula works very well for accelerated motion, where *a* represents the acceleration, *b* the initial velocity, and *c* the initial distance. In the above example we need one point on the curve to calculate the value of *a*. In our case that could be (400,165).

The formula above is then derived as follows:

$y = a(x - 1200)^2 + 10$

$165 + a(400 - 1200)^2 + 10$

$155 = a(800)^2$

$a = \frac{155}{800^2} = 0.0002422$

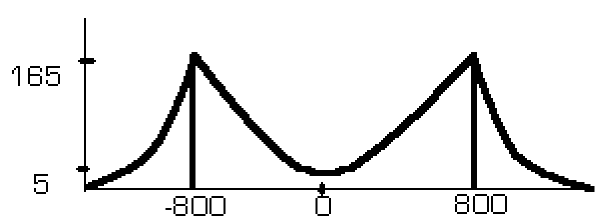
$so:$

$y = 0.0002422(x - 1200)^2 + 10$

$y = 0.0002422(x^2 - 2400x + 1440000) + 10$

$y = 0.0002422x^2 - 0.58125x + 358.768$

Second Scenario: $0.0002422x^2 + 10$



Rather than finding out how our parabola was moved from the origin, we can move our origin to a convenient place. *This requires an adjustment in the domain* otherwise the conditions are altered. By moving the origin horizontally under the vertex, we essentially make $h = 0$

The domain is now adjusted to [–800,800] and the new vertex is (0,10), therefore the formula that will help us capture the exact same parabola is:

$y = ax^2 + k$, which, in this example, becomes: $y = ax^2 + 10$, and since we need a point on the parabola to calculate *a*, we can use (–800,165) for this purpose. The result is:

$$165 = a(800)^2 + 10$$
$$155 = a(800)^2$$
$$a = \frac{155}{800^2} = 0.0002422$$
$$so:$$
$$y = 0.0002422x^2 + 10$$

Therefore, both formulas describe the same parabola, however on different domains.

Attached is a spreadsheet that illustrates this in increments of 25. The cables are doubled on either side for stable construction and we do not have any cables at the towers, so the total cable is about 4 x 3800 ft = 15,200 ft or about 3 miles of cable.

Rubrics and Benchmarks

Novice
This student makes a correct picture of the given situation. Possible vertex coordinates and a quadratic function are given without explanation. The student appears to find a distance that is unrelated to the problem.

Apprentice
This student makes a correct picture of the given situation. The student applies strategies that belong to linear functions. It is not clear where some of the numbers come from. The student extrapolates an incorrect strategy to an interesting way to find the cable length on both sides of the bridge. Although this is very inventive, it does not relate to this problem at all.

Practitioner
This student develops an appropriate mathematical model for this problem, but quadratic function is not stated explicitly. A model is used appropriately to

calculate function values. Total cable length is calculated appropriately. It appears that the term “squared” is not used appropriately here.

Expert Sample 1
This student creates a very thorough and clear solution employing a self-designed computer program. Nothing is left for interpretation. This work is like scenario 1 in the Teaching Tips and Possible Solutions section above.

Expert Sample 2
A very clear and thorough solution equivalent to scenario 2 in the Teaching Tips and Possible Solutions section is created. Nothing is left for interpretation. This student makes a clear link with previous learning and demonstrates overtly working with a model.

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Petroski, Henry, *Engineers of Dreams: Great Bridge Builders and the Spanning of America*, Vintage Books, 1996. A history of five engineers who have built bridges

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Salvadori, Mario and Tempel, Michael. (1983) *Architecture and Engineering: An Illustrated Teacher's Manual on Why Building Stand up*. New York, New York Academy of Science --Manual for teachers.

Student Reading List

John Carol, and Rieth, Elizabeth, *Bridges: Amazing Structures to Design, Build & Test*, and Williamson Publishing 1999. Bridges from all around the world and construction techniques used to build them.

Kaner, Etta, *Bridges*, Kids Can Press, 1997. A guide to hand-on building of models.

Student Web Site List

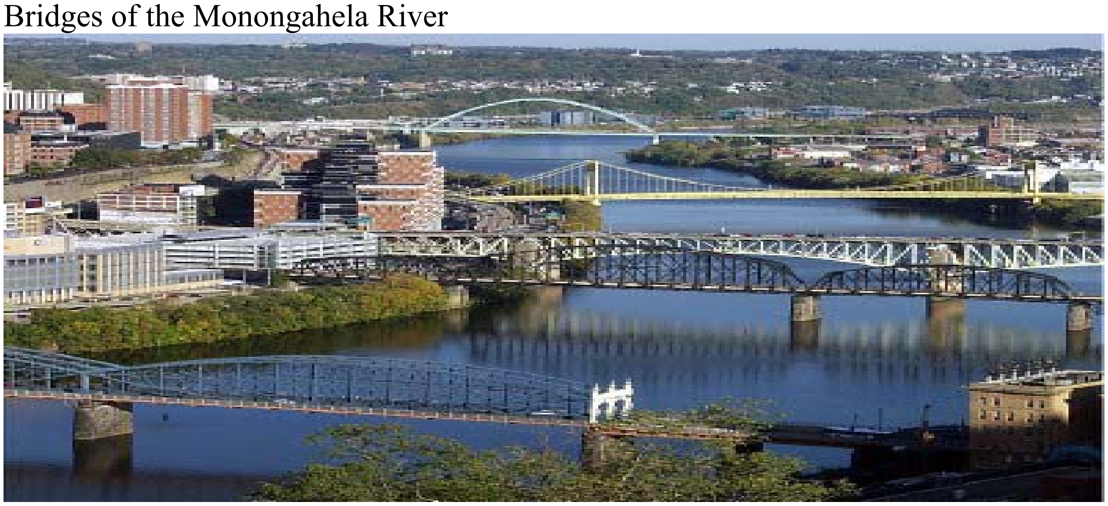
Pittsburgh's Bridges
by Walter C. Kidney, Clyde Hare

APPENDIX: A

Pittsburgh - "City of Bridges"

If you like bridges, then you'll love Pittsburgh! We're affectionately known as the City of Bridges for good reason - over 1900 bridges exist in Allegheny County alone

Bridges of the Monongahela River



Bridges spanning the Monongahela River from Station Square and the South Side to downtown Pittsburgh, include the historic Smithfield Street Bridge (1881), the Panhandle RR Bridge (1903), the Liberty Bridge (1928), the South 10th Street Bridge (1921), the Birmingham Bridge (1977) and, near the horizon, the twin black spans of the Hot Metal Bridge (1877) and Mon Con RR Bridge (1877).

6th Street Bridge - Roberto Clemente Bridge

The Sixth Street Bridge, renamed the Roberto Clemente Bridge in 1999, is one of three identical "sister" bridges built across the Allegheny River, connecting Pittsburgh to the North Shore. It, like most downtown Pittsburgh river bridges, is painted golden yellow (the official city colors are Black and Gold). The unique U-shaped building at the far end of the bridge is the historic Fulton building, recently restored as a luxury Marriott Renaissance Hotel.

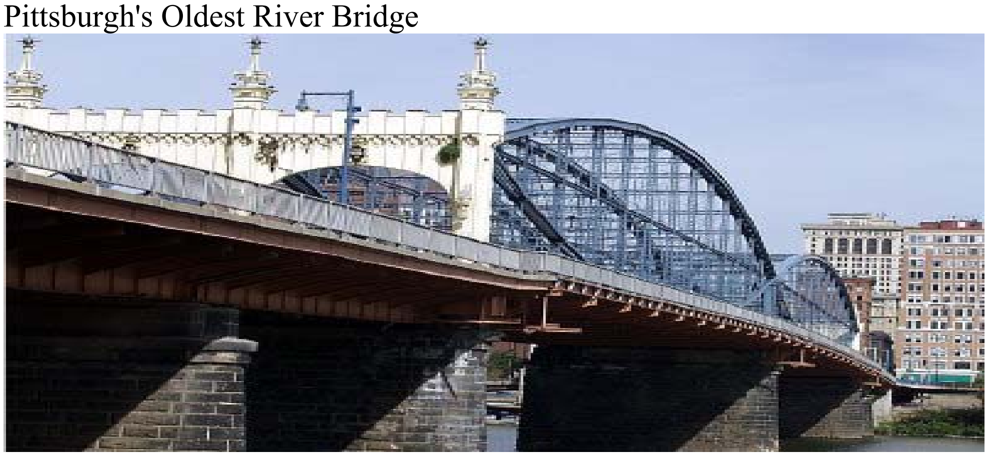
Allegheny River Bridges at Downtown Pittsburgh

The bridges which cross the Allegheny river near downtown Pittsburgh and the Point include the Ft. Duquesne Bridge (1969), the identical Sixth (1928), Seventh (1926), and Ninth Street Bridges (1928), the Fort Wayne Railroad Bridge (1904), the Veteran's Bridge (1987), and the Sixteenth Street Bridge (1923).

The Three Sisters - Sixth, Seventh & Ninth Street Bridges

The Sixth (Roberto Clemente), Seventh, and Ninth Street bridges are called the "Three Sisters" - the only identical trio of bridges in the United States. All three replaced former bridges, but the story of the Roberto Clemente (Sixth Street) Bridge is the most interesting - the original Sixth Street bridge burned in the late 1800's because the sparrows nests in the beams caught fire from the steamboat smoke stacks.

Pittsburgh's Oldest River Bridge



The Smithfield Street bridge (1883) is considered by most to be Pittsburgh's most historically significant bridge for several reasons: 1) it replaced two bridge structures by well-known bridge engineers, Lewis Wernwag and John A. Roebling (creator of the Brooklyn Bridge); 2) it was the first American use of the lenticular (lens-shaped) truss design; and 3) it was one of the first major bridges in the US built primarily with steel, and is probably the oldest extant major steel truss remaining. The graceful Smithfield Street Bridge is also the oldest remaining river bridge in Allegheny County and has been designated a National Historic Civil Engineering Landmark.

APPENDIX: B

Instructional Unit The Parabola:

Instructional Unit
The Parabola: An Algebraic Approach

Teaching Notes:

In this lesson students look at the directrix and the focus of a parabola. This lesson has direct connections to Day 1. However, instead of finding the parabola from the directrix and focus, the students will be finding the directrix and focus of a known parabola. No technology is stressed in this lesson. However, algebraic manipulation tools may be helpful for some students that have difficulty performing tasks like completing the square.

Introduction:

Prior to this lesson, we have looked at the parabola's equation in standard polynomial form. That is, y = ax^2 + bx + c. Now we will look at simply the standard form of the parabola equation.

The Definition:

A parabola is the set of points equidistant from a line called the directrix, and a fixed point called the focus. The focus is not on the directrix.

Standard Form Equation: (x - h)^2 = 4c(y - k)
Vertex: (h, k)
Axis of Symmetry: x = h
Focus: (h, k+c)
Directrix: y = k - c
Opens: up if c > 0 / down if c < 0

Examples:

1. Find the directrix and focus of this parabola:
(x - 5)^2 = 12(y + 2)
Solution:
This equation is already in standard form, so simply use the information provided above.

Value of "c": 3 Vertex: (5,-2)
Axis of Symmetry: $x = 5$
Focus: (5,1)
Directrix: $y = -5$
Opens: up

2. Find the directrix and focus of this parabola:
$2x^2 - 4x + y + 4 = 0$
Solution:
This equation needs to first be written in standard form by completing the square.
$2x^2 - 4x + y + 4 = 0$
$2x^2 - 4x + 2 + y + 4 = 2$ (add 2 to both sides)
$2(x^2 - 2x + 1) + (y + 4) = 2$ (grouping and factoring)
$2(x - 1)^2 = -y - 2$ (factoring)
$(x - 1) 2 = -(1/2)(y + 2)$
Value of "c": -1/8 Vertex: (1,-2)
Axis of Symmetry: $x = 1$
Focus: (1,-17/8)
Directrix: $y = -15/8$
Opens: down

Additional Teaching Notes:

Some students may require some additional examples. Probably the most difficulty will be encountered while "completing the square", so it may be necessary to spend some time reviewing this concept.

Homework Problems:

Find the directrix and focus of this parabola:

1. $y = x2 + 5$
2. $(x - 4) 2 = 2(y - 1)$
3. $3x2 + 12x - 5y + 7 = 0$
4. $y = x2 - 6x + 5$
5. $y = -2x2 + 5x - 3$

Solutions to Homework Problems:

1. Focus: (0,-19/4) Directrix: y = -21/4
2. Focus: (4,3/2) Directrix: y = 1/2
3. Focus: (-2,-7/12) Directrix: y = -17/12
4. Focus: (3, -15/4) Directrix: y = -17/4

Study Guide and Practice for Algebra I
NAME: ________________________________

Material Covered

- Quadratic Functions
- Compute an input-output table from a quadratic equation
- Graph a quadratic equation by plotting the points in an input-output table
- Find the zeroes and vertex of a quadratic function from the graph or the input-output table
- Solve quadratic equations by graphing and finding the zeroes.

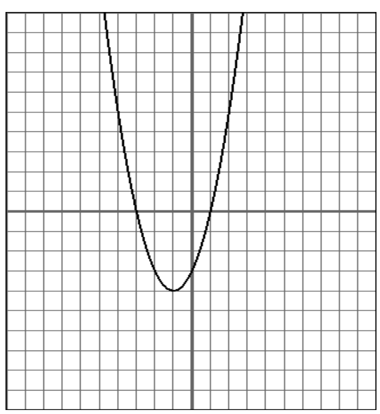
Calculators

Calculators will be permitted, but will not be required. No problems will require use of the graphing features of the TI-83. You may use any type of calculator if you do not have a TI-83.

Practice Problems for Algebra I Quiz on Quadratics

Based on the given information, identify the zeroes and the vertex.

a. For this graph:



Zeroes (x values):

Vertex (x and y values):

b. For this table (ask for graph paper and make a graph if it helps):

x	y
–3	5
–2	0
–1	–3
0	–4
1	–3
2	0
3	5

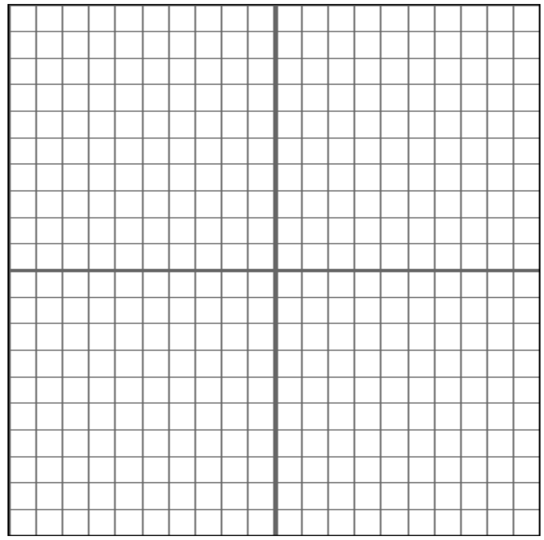
Zeroes (x values):

Vertex (x and y values):

2. Do the following for $y = x^2 + x - 6$.

a. Make the table and graph.

x	y	(Calculations)
–4		
–3		
–2		
–1		
0		
1		
2		
3		
4		



b. Find the zeroes (x values):

c. Find the vertex (x and y values):

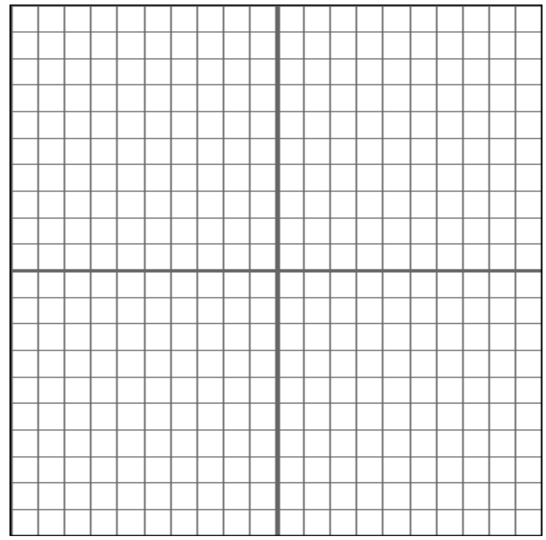
3. Solve the equation $x^2 + 3 = -4x$. Remember, there may be no solutions, 1 solution, or 2 solutions.

a. Rewrite the equation so 0 is on one side of the = sign:

b. Replace 0 with y.

c. Complete the table of values and graph the new equation from step (b)

x	*y*	(Calculations)
–4		
–3		
–2		
–1		
0		
1		
2		
3		
4		



Solution(s) if there are no solutions, write “no solutions”:

d. Check the solution(s) in the original equation. If the check fails, go back and find the mistake and fix it. If you found two solutions, you must check both of them.

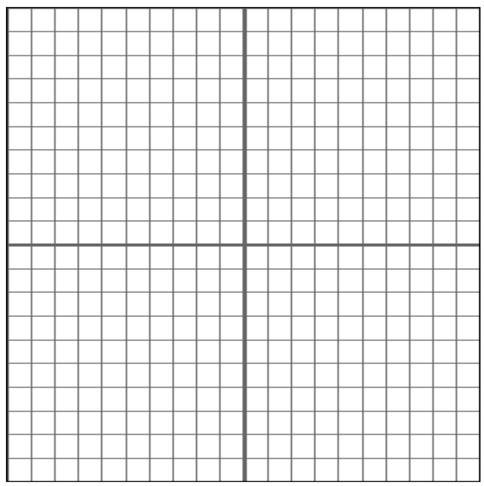
4. Solve the equation $x^2 + 2x = -4$

a. Rewrite the equation so 0 is on one side of the = sign:

b. Replace 0 with *y*.

c. Complete the table of values and graph the new equation from step (b)

x	y
–4	
–3	
–2	
–1	
0	
1	
2	
3	
4	

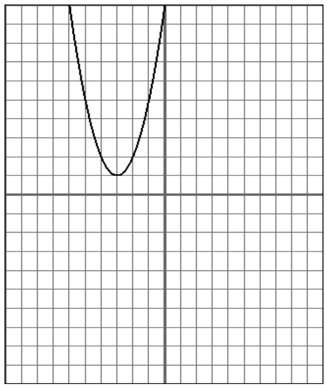


Solution(s):

d. Check the solution(s) in the original equation. If the check fails, go back and find the mistake and fix it. If you found two solutions, you must check both of them.

5. Based on the given information, identify the zeroes and the vertex.

a. For this graph:



Zeroes (x values):

Vertex (x and y values):

b. For this table (ask for graph paper and make a graph if it helps):

x	y
–3	12
–2	5
–1	0
0	–3
1	–4
2	–3
3	0
4	5

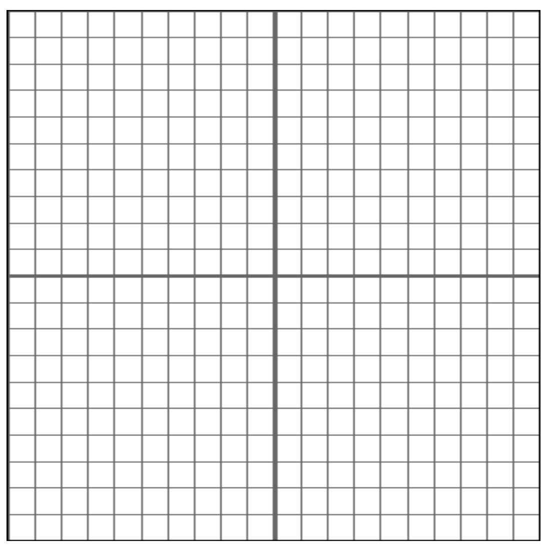
Zeroes (x values):

Vertex (x and y values):

6. Do the following for $y = 2x^2 + x - 3$.

a. Make the table and graph.

x	y	(Calculations)
–4		
–3		
–2		
–1		
0		
1		
2		
3		
4		



b. Find the zeroes (x values):

a. Find the vertex (x and y values):

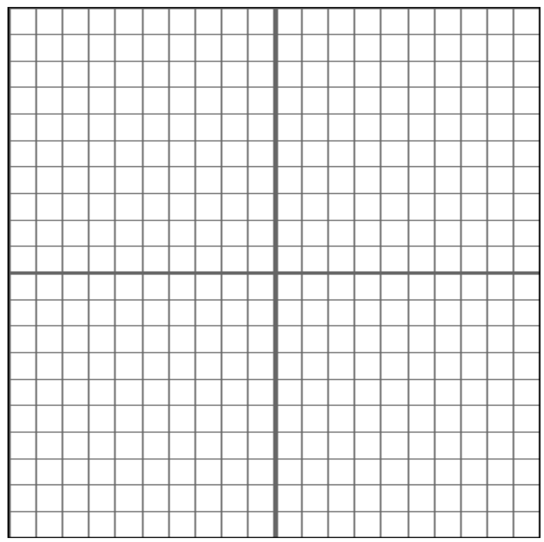
7. Solve the equation x2 + 3 = – x. Remember, there may be no solutions, 1 solution, or 2 solutions.

a. Rewrite the equation so 0 is on one side of the = sign:

b. Replace 0 with y.

c. Complete the table of values and graph the new equation from step (b)

x	y	(Calculations)
–4		
–3		
–2		
–1		
0		
1		
2		
3		
4		



Solution(s) if there are no solutions, write "no solutions":

d. Check the solution(s) in the <u>original</u> equation. If the check fails, go back and find the mistake and fix it. If you found two solutions, you must check <u>both</u> of them.

APPENDIX: C

Content Standards

The Pittsburgh Public Schools have adopted Mathematics Standards that are used throughout the entire district. All seven of the math standards used by my school district, Pittsburgh Public Schools, are addressed in the unit and are listed below. Students are to take measurements, perform calculations and come up with theoretical predictions, which are later verified. The Mathematics Standards describe what students should know and be able to perform at or above grade level. They reflect the increasing complexity and sophistication that students are expected to achieve as they progress through school. The lessons and tasks in this paper, adhere to the following standards:

1. All students use numbers, number systems, and equivalent forms (including numbers, words, objects and graphics) to represent theoretical and practical situations.
2. All students compute, measure, and estimate to solve theoretical and practical problems, using appropriate tools, including modern technology, such as calculators and computers.
3. All students apply the concepts of patterns, functions and relations to solve theoretical and practical problems.
4. All students formulate and solve problems and communicate the mathematical processes used and the reasons for using them.
5. All students understand and apply basic concepts of algebra, geometry, probability and statistics to solve theoretical and practical problems.
6. All students evaluate, infer and draw appropriate conclusions from charts, tables and graphs, showing the relationship between data and real world situations.
7. All students make decisions and predictions based upon the collection, organization, analysis and interpretation of statistical data and the application of probability.

Glossary

A. Content Standards Specific information on what students are expected to know and be able to do for the nine academic goals. Content standards describe the knowledge and skill expected of students at important developmental stages. Standards are not curriculum, but guide the development of curriculum.