Chapter 4: Civil Engineering Applications of the Quadratic Function

Part 1 – Background Information

Before you work with specific examples within the Civil Engineering field, first take some time to learn about the origins and applications of quadratic equations. Go to the Algebra II moodle page to find the links to the documents below. You will receive points for reading through both articles.

- 101 Uses of a Quadratic Equation: Part 1
- 101 Uses of a Quadratic Equation: Part 2

Part 2 – Applied Problems for Bridges and Arches

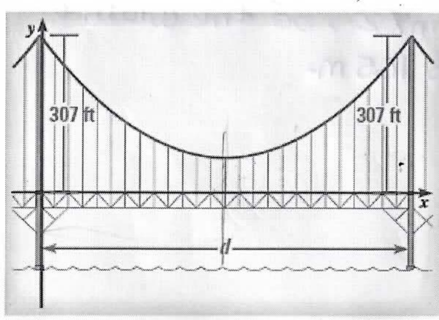
Please complete each problem thoroughly, showing all work and giving explanations about your strategies used to solve the problem.

Tacoma Narrows Bridge

The Tacoma Narrows Bridge in Washington has two towers that each rise 307 feet above the roadway and are connected by suspension cables as shown. Each cable can be modeled by the function

$$y = \frac{1}{7000}(x - 1400)^2 + 27$$

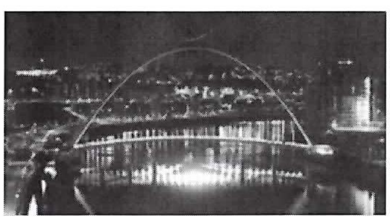
where x and y are measured in feet. What is the distance d between the two towers?



Not drawn to scale

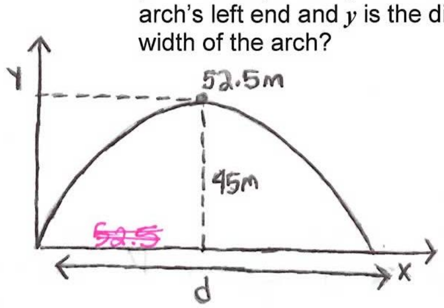
The function $y=\frac{1}{700}(x-1400)^2+27$ is in vertex form. The coordinates of the vertex are (1400,27), Using vertex form $y=a(x-h)+k$ where ~~h~~ h is the x coordinate and k is the y coordinate. The vertex of the two towers is 1400, therfore 1400 x 2 = 2800. So d = 2800ft.

Arch of the Gateshead Millennium Bridge



Please go to the Gateshead Millennium Bridge link on the Algebra 2 moodle page to learn more about the design of the world's first and only tilting bridge. Click on the virtual tour and read about the design.

The arch of the Gateshead Millennium Bridge, in Europe, forms a parabola with equation $y = -0.016(x - 52.5)^2 + 45$ where x is the horizontal distance (in meters) from the arch's left end and y is the distance (in meters) from the base of the arch. What is the width of the arch?



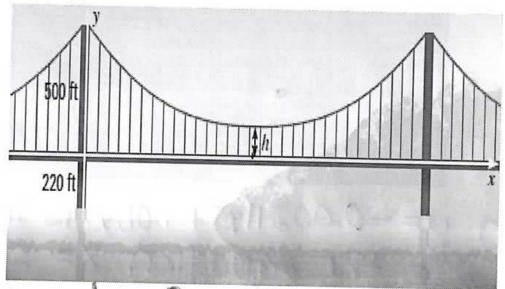
The equation $y=-0.016(x-52.5)+45$ is a quadratic function in vertex form. Vertex form, $y=a(x-h)+k$, states that h is the x coordinate and the k is the y coordinate. The distance is 52.5m x 2 . So the width of the arch is 105 m.

Golden Gate Bridge

Each cable joining the two towers on the Golden Gate Bridge in San Fransico, California can be modeled by the function

$$y = \frac{1}{9000}x^2 - \frac{7}{15}x + 500$$

where x and y are measured in feet. What is the height h above the road of a cable at its lowest point?



The equation $y = \frac{1}{9000}x^2 - \frac{7}{15}x + 500$ is in Standard form, to find the vertex, use the equation $x = \frac{-b}{2a}$.

$a = \frac{1}{9000}$

$b = -\frac{7}{15}$

$$x = \frac{\frac{7}{15}}{2\left(\frac{1}{9000}\right)} = \frac{\frac{7}{15}}{\frac{2}{9000}} = \frac{7}{15} \cdot \frac{9000}{2} = \frac{63000}{30} = 2100$$

$x = 2100$ft. After solving for x, substitute for x in the origional equation $y = \frac{1}{9000}x^2 - \frac{7}{15}x + 500$.

$y = \frac{1}{9000}(2100)^2 - \frac{7}{15}(2100) + 500$

Then solve.

$y = 10$

The vertex is $(2100, 10)$ so $h = 10$ft.

Arch of Sydney Harbor Bridge

The arch of the Sydney Harbor Bridge in Sydney, Australia can be modeled by $y = -0.00211x^2 + 1.06x$ where ***x*** is the distance (in meters) from the left pylons and **y** is the height (in meters) of the arch above the water, as shown below. For what distance ***x*** is the arch above the road?

The equation $y = -0.00211x^2 + 1.06x$ is in standard form. To find the vertex use the equation $x = \frac{-b}{2a}$

$a = -0.00211$
$b = 1.06$

$$x = \frac{-1.06}{2(-0.00211)} = 251.2\text{m}$$

Then Substistee 251.2m into the equation

$y = -0.00211(251.2)^2 + 1.06(251.2)$

$y = 133$

vertex $(251.2, 133)$

$52 = -0.00211x^2 + 1.06x$

The y valve is 52 so set $y = 52$ then put the equation into standar form

$y = -0.00211x^2 + 1.06x - 52$ $\quad \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Then I have to use the quadratic equation

$a = -0.00211$ $b = 1.06$ $c = -52$

$$x = \frac{-1.06 \pm \sqrt{1.06^2 - 4(-.00211)(-52)}}{2(-0.00211)}$$

$$x = \frac{-1.06 \pm \sqrt{1.1236 - .43888}}{-.00422}$$

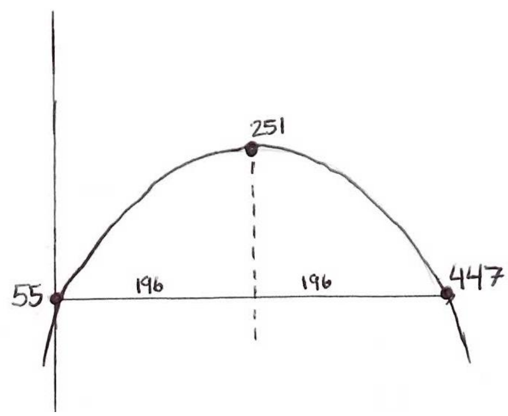
$$x = \frac{-1.06 \pm \sqrt{.68472}}{-.00422}$$

$x = -55.1$ or $x = 447.3$

$251.2 - 447.3 = 196.1$

$196.1 \times 2 = 392.2$

$447.3 - 392.2 = 55.1$



447.3 is the "right" number So, if I take the vertex and the "right" number I will get one half of the road be where, the arch is above the road, 196.1.

Then, I will take 196.1 and multiply it by 2.

Finally, I subtract 392.2 from 447.3 to get the "Left" number

Then, I write the inequality

$x > 55$

$x < 447$