GENERAL

algebra ii notes chapter 6 quadratic functions and

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Algebra II Notes Chapter 6: Quadratic Functions and Their Applications

Welcome to Chapter 6 of your Algebra II journey—Quadratic Functions and Their Applications. This section is a cornerstone of algebra, bridging the gap between linear concepts and the more complex world of polynomial behavior. Whether you're a high school student tackling the state curriculum or an adult learner brushing up on math fundamentals, these notes will give you a clear, step by step understanding of quadratic functions, their graphs, and real world uses.

What Are Quadratic Functions?

A quadratic function is a polynomial of degree two, usually written in the form **f(x) = ax² + bx + c**, where *a*, *b*, and *c* are constants and *a* "` .0The graph of a quadratic function is a parabola, opening upward if *a* is positive and downward if *a*is negative. Quadratics appear in countless contexts—from projectile motion to economics—making them a vital tool in both science and everyday life.

Key Features of a Quadratic Graph

- Vertex – The highest or lowest point on the parabola, depending on the direction of opening.
- Axis of Symmetry – A vertical line that divides the parabola into two mirror image halves.
- Y Intercept – The point where the graph crosses the y axis, occurring when x = 0.
- X Intercepts (Roots) – The points where the graph crosses the x axis, found by solving f(x) = 0.
- Direction of Opening – Determined by the sign of coefficient a.

Standard Form vs. Vertex Form

Quadratic functions can be expressed in two primary algebraic forms:

1. Standard Form: f(x) = ax² + bx + c
2. Vertex Form: f(x) = a(x - h)² + k, where (h, k) is the vertex.

Transitioning between these forms is essential for graphing and solving equations. The vertex form immediately reveals the vertex and axis of symmetry, while the standard form is often the starting point for algebraic manipulation.

Finding the Vertex

The vertex can be found using the formula *h = -b/(2a)* for the x coordinate, then substituting back into the function to obtain *k = f(h)*. Alternatively, completing the square transforms the standard form into vertex form directly.

Completing the Square: A Step by Step Guide

1. Start with f(x) = ax² + bx + c.
2. Factor out a from the first two terms: f(x) = a(x² + (b/a)x) + c.
3. Add and subtract (b/2a)² inside the parentheses: f(x) = a[(x + b/2a)² - (b/2a)²] + c.
4. Rewrite as f(x) = a(x + b/2a)² + [c - a(b/2a)²], giving the vertex form f(x) = a(x - h)² + k.

Completing the square is not only useful for graphing but also for solving quadratic equations when factoring is difficult.

Factoring Quadratic Functions

When the quadratic can be expressed as a product of two binomials, factoring is often the quickest way to find the roots:

f(x) = a(x - r •)(x - r ,) where *r* • and *r* , are the x intercepts.

Factoring is most effective when the leading coefficient *a* equals 1. For other values of *a*, the "ac method" or "grouping" techniques are useful.

Quadratic Formula

When factoring is impossible, the quadratic formula provides a universal solution:

f(x) = 0 !Ò x = [-b ± " (b² - 4ac)] / (2a)

The discriminant *9B Ò +" Ò* F Ó indicates the nature of the roots:

- 9B â b Two distinct real roots.
- 9B Ò b öæR &V Â F÷V le root (the vertex lies on the x axis).
- 9B b Two complex conjugate roots.

Graphing Quadratics: A Practical Approach

1. Identify the vertex using the formula or completing the square.
2. Determine the axis of symmetry: x = h.
3. Plot the y intercept at (0, c).
4. Find the x intercepts using factoring or the quadratic formula.
5. Sketch the parabola, ensuring symmetry about the axis.

Using graphing technology can confirm your hand drawn graph, but understanding the underlying shape is essential for problem solving.

Applications of Quadratic Functions

Quadratics are ubiquitous in real world scenarios. Here are several common applications:

- Projectile Motion – The height of a thrown object follows h(t) = -16t² + v €t + h €.
- Economics – Profit functions, cost functions, and revenue functions often involve quadratic relationships.
- Physics – Parabolic trajectories in optics and mechanics.
- Engineering – Design of parabolic reflectors and bridges.
- Business – Optimizing production levels to maximize profit.

Optimization Problems Using Quadratics

Optimization frequently involves maximizing or minimizing a quadratic function. The vertex provides the extremum point. For example:

Problem:A rectangular garden is to be surrounded by a fence. The cost per foot of fence is $3, and the area must be 200 /sq /ft. Find the dimensions that minimize cost.

Solution: Let the length be *L* and width *W*. Constraints: *LW = 200* and perimeter *2(L + W)*. Express cost as *C = 3·2(L + W) = 6(L + W)*. Using *W = 200/L*, we get *C(L) = 6(L + 200/L)*. This is a quadratic in terms of *L + 200/L*, which can be minimized by completing the square or calculus. The optimal shape is a square: *L = W = " 200 "H 14.14 /ft*

Real World Data Fitting

Quadratic regression is used to fit data that follows a parabolic trend. In statistics, the least squares method yields a

best fit quadratic equation. This technique is valuable in physics experiments, economic forecasting, and biological growth studies.

Common Mistakes to Avoid

1. Confusing the sign of a – A positive a opens upward; negative opens downward.
2. Forgetting to factor out a when completing the square.
3. Misinterpreting the discriminant – A negative discriminant indicates no real roots.
4. Ignoring the domain and range constraints of real functions.
5. Overlooking the axis of symmetry when sketching the graph.

Practice Problems

Test your understanding with these problems. Solutions are provided afterward.

Find the vertex of $f(x) = 2x^2 - 8x + 5$.

Factor the quadratic $f(x) = x^2 + 7x + 12$.

Solve $3x^2 - 12x + 9 = 0$ using the quadratic formula.

Sketch the parabola for $f(x) = -x^2 + 4x - 3$ and identify all key features.

A ball is thrown upward from a height of 5 /ft with an initial velocity of 20 /ft/s. Its height is given by $h(t) = -16t^2 + 20t + 5$. Find the maximum height and the time it takes to reach that height.

1. Vertex: h = -b/(2a) = -(-8)/(2·2) = 2; k = f(2) = 2(4) - 8(2) + 5 = 8 - 16 + 5 = -3. Vertex: (2, -3).
2. Factor: x² + 7x + 12 = (x + 3)(x + 4).
3. Quadratic formula: 9B Ò ,Ó ">" Ò Ks;s' Ò CB Ò , Ò 3c° x = [12 ± " 36]/(2·3) = [12 ± 6]/6. Solutions: x = 3 and x = 1.
4. Graphing: Vertex at (2, -3), y intercept at (0, -3), x intercepts at (1, 0) and (3, 0). Parabola opens downward.
5. Maximum height: Vertex (t, h) occurs at t = -b/(2a) = -20/(2·(-16)) = 20/32 = 0.625 /s. Height: h(0.625) = -16(0.625)² + 20(0.625) + 5 "H 15.625 /ft.

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