GENERAL

algebra 2 conic sections study guide

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Algebra 2 Conic Sections Study Guide

When you're tackling Algebra 2, one of the most exciting and visually engaging topics is conic sections. These curves—circles, ellipses, parabolas, and hyperbolas—appear in everything from satellite orbits to architectural arches. This study guide is designed to give you a clear, step by step understanding of each type of conic, how to derive their equations, and how to solve real world problems using them. By the end, you'll feel confident tackling any conic section question that appears on your tests, quizzes, or exams.

Why Conic Sections Matter in Algebra 2

Conic sections are more than just textbook examples; they're the foundation of many modern technologies. Understanding their properties helps you:

- Predict the path of projectiles and satellites.
- Design optical devices like telescopes and lenses.
- Analyze financial models that use quadratic functions.
- Explore relationships between geometry and algebra.

Mastering conic sections also sharpens your analytical skills, preparing you for higher level mathematics, physics, and engineering courses.

1. The Four Classic Conics

Conic sections arise when a plane cuts a cone at different angles. Each cut produces a distinct curve:

1.1 Circle

A circle is the set of all points that are a fixed distance (the radius) from a center point. Its algebraic form is simple and symmetrical.

1.2 Ellipse

An ellipse generalizes a circle by having two focal points. The sum of the distances from any point on the ellipse to the foci remains constant.

1.4 Parabola

A parabola is the locus of points equidistant from a fixed point (the focus) and a fixed line (the directrix). Its "U" shape is familiar from projectile motion.

1.5 Hyperbola

A hyperbola consists of two separate curves that mirror each other. Each point on a branch has the absolute difference of distances to two foci equal to a constant.

2. Standard Forms and Key Parameters

For each conic, there is a standard algebraic equation that reveals its essential characteristics. Below are the

standard forms, along with the meaning of each parameter.

2.1 Circle

Standard Equation: $(x – h)^2 + (y – k)^2 = r^2$

- (h, k) – Center of the circle.
- r – Radius.

2.2 Ellipse

Standard Equation (horizontal major axis): $((x – h)^2 / a^2) + ((y – k)^2 / b^2) = 1$

- a – Semi major axis length.
- b – Semi minor axis length.
- c = " $(a^2 – b^2)$ – Distance from center to each focus.

2.3 Parabola

Standard Equation (vertex at origin, opening right): $y^2 = 4px$

- p – Distance from vertex to focus (also to directrix).
- Vertex: (0, 0).
- Focus: (p, 0).
- Directrix: x = –p.

2.4 Hyperbola

Standard Equation (horizontal transverse axis): $((x – h)^2 / a^2) – ((y – k)^2 / b^2) = 1$

- a – Distance from center to vertices.
- b – Distance related to asymptotes.
- c = " $(a^2 + b^2)$ – Distance from center to foci.

3. Transformations and Graphing Techniques

Real world problems often present conics in non standard forms. Learning how to shift, stretch, or rotate equations is essential for accurate graphing and analysis.

3.1 Translation (Shifting)

Adding or subtracting constants inside the parentheses moves the graph horizontally or vertically.

Example: $(x – 3)^2 + (y + 2)^2 = 25$ shifts the circle 3 units right and 2 units down.

3.2 Scaling (Stretching/Compressing)

Multiplying terms outside parentheses changes the size of the graph.

Example: $4(x – 1)^2 + (y – 2)^2 = 1$ stretches the ellipse horizontally.

3.3 Rotation (When Needed)

Rotation is less common in Algebra 2 but can be handled using trigonometric substitutions. Most high school problems keep axes aligned.

4. Deriving Equations from Geometry

Often you'll be given a geometric description and must translate it into an algebraic equation. Below are step by step methods for each conic.

4.1 Circle from Center & Radius

1. Identify the center (h, k) and radius r.
2. Insert them into $(x – h)^2 + (y – k)^2 = r^2$.
3. Simplify if necessary.

4.2 Ellipse from Foci & Major Axis

1. Find the distance between foci 2c.
2. Determine the major axis length 2a (often given or derived from other points).
3. Compute b = " ($a^2 – c^2$).
4. Plug into the standard equation.

4.3 Parabola from Vertex & Focus

1. Locate the vertex (h, k) and focus (h + p, k) (or (h, k + p) if vertical).
2. Calculate p as the distance between them.
3. Use $y^2 = 4p(x – h)$ for horizontal orientation or $x^2 = 4p(y – k)$ for vertical.

4.4 Hyperbola from Foci & Transverse Axis

1. Find c as half the distance between foci.
2. Determine a as half the transverse axis length.
3. Compute b = " ($c^2 – a^2$).
4. Insert into the standard hyperbola equation.

5. Common Algebraic Manipulations

Conic equations can appear in various algebraic forms. Here's how to convert them into standard forms.

5.1 Completing the Square

When you see quadratic terms in x and y together, you can complete the square to isolate them into a perfect square.

1. Group like terms: $Ax^2 + By^2 + Dx + Ey + F = 0$.
2. Divide by coefficients to make the quadratic coefficient 1.
3. Move constant terms to the other side.
4. Add and subtract the square of half the coefficient of the linear term.
5. Rewrite as a squared binomial.
6. Repeat for the other variable.

5.2 Factoring Quadratic Expressions

Sometimes the equation can be factored into a product of linear terms, revealing the conic's nature quickly.

5.3 Using the Discriminant

The discriminant 9B Ò +" b D C from the general quadratic equation can indicate the conic type:

- 9B Ò b arabola.
- 9B â b ‡— W&&öÆ à
- 9B b VÆÆ— 6R ÷" 6—&6ÆR †6—&6ÆR –b Ò " æB 2 Ò 'à

6. Practice Problems & Solutions

Practice is the key to mastery. Below are representative problems for each conic, followed by detailed solutions.

6.1 Circle Problem

Problem: Find the equation of the circle that passes through the points (1, /2), (4, /6), and (7, /2).

Solution:

1. Assume the circle's equation: $(x – h)^2 + (y – k)^2 = r^2$.
2. Plug each point to create three equations:
3. $(1 – h)^2 + (2 – k)^2 = r^2$
4. $(4 – h)^2 + (6 – k)^2 = r^2$
5. $(7 – h)^2 + (2 – k)^2 = r^2$

6.2 Ellipse Problem

Problem: Determine the equation of the ellipse with foci at (0, /0) and (8, /0) and a major axis length of 12.

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