

Parabolas: Parts, Equations & Analysis

Conic Sections Worksheet · Grade 10–12

Name: _____

Date: _____

Learning Objectives

- Identify the vertex, focus, directrix, and axis of symmetry of a parabola
- Write the standard equation of a parabola opening vertically or horizontally
- Determine the direction a parabola opens based on the sign of p

Problems

1. A parabola has its vertex at the origin, opens upward, and has $p = 2$. State the coordinates of the focus.

$$(x - 0)^2 = 4(2)(y - 0)$$

2. Write the equation of the directrix for a parabola with vertex at the origin and focus at $(0, -5)$.

3. A parabola opens to the right with vertex at the origin and $p = 3$. Write its standard equation.

$$y^2 = 4px$$

4. Identify the direction in which the parabola given below opens, and state whether p is positive or negative.

$$(y - 4)^2 = -8(x - 1)$$

5. Find the vertex, focus, and directrix of the parabola given below.

$$(x - 3)^2 = 8(y + 2)$$

6. Find the vertex, focus, and directrix of the parabola given below.

$$(y + 1)^2 = -12(x - 5)$$

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7. Write the standard equation of the parabola that has vertex at (4, -3), opens downward, and has $p = 5$.

$$(x - h)^2 = 4p(y - k)$$

8. A parabola has its vertex at (-2, 6) and its directrix at $x = 1$. Write the standard equation of this parabola.

$$(y - k)^2 = 4p(x - h)$$

9. Rewrite the equation in standard form, then find the vertex, focus, and directrix.

$$x^2 - 6x - 4y + 1 = 0$$

10. Rewrite the equation in standard form, identify all parts of the parabola (vertex, focus, directrix, axis of symmetry, and direction of opening), and describe how the graph would look.

$$y^2 + 10y - 8x + 41 = 0$$

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Parabolas: Parts, Equations & Analysis — Answer Key

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Answer Key

1. Answer: Focus: (0, 2)

- For a vertical parabola opening upward, the focus is at $(h, k + p)$.
- With $h = 0$, $k = 0$, and $p = 2$, the focus is at $(0, 0 + 2) = (0, 2)$.

2. Answer: $y = 5$

- The focus is at $(0, -5)$, so $p = -5$ (parabola opens downward).
- The directrix is the horizontal line $y = k - p = 0 - (-5) = 5$.
- Therefore the directrix is $y = 5$.

3. Answer: $y^2 = 12x$

- For a horizontal parabola opening to the right, use $(y - k)^2 = 4p(x - h)$.
- With $h = 0$, $k = 0$, and $p = 3$: $y^2 = 4(3)x = 12x$.

4. Answer: Opens to the left; p is negative

- The equation is in the form $(y - k)^2 = 4p(x - h)$, which represents a horizontal parabola.
- Since $4p = -8$, we get $p = -2$, which is negative.
- A negative p in a horizontal parabola means it opens to the left.

5. Answer: Vertex: (3, -2); Focus: (3, 0); Directrix: $y = -4$

- The equation is $(x - h)^2 = 4p(y - k)$, so $h = 3$ and $k = -2$. Vertex = $(3, -2)$.
- $4p = 8$, so $p = 2$.
- Focus = $(h, k + p) = (3, -2 + 2) = (3, 0)$.
- Directrix = $y = k - p = -2 - 2 = -4$.

6. Answer: Vertex: (5, -1); Focus: (2, -1); Directrix: $x = 8$

- The equation is $(y - k)^2 = 4p(x - h)$, so $h = 5$ and $k = -1$. Vertex = $(5, -1)$.
- $4p = -12$, so $p = -3$.
- Focus = $(h + p, k) = (5 + (-3), -1) = (2, -1)$.
- Directrix = $x = h - p = 5 - (-3) = 8$.

7. Answer: $(x - 4)^2 = -20(y + 3)$

- For a vertical parabola, use $(x - h)^2 = 4p(y - k)$.
- Since it opens downward, $p = -5$.
- Substituting $h = 4$, $k = -3$, $p = -5$: $(x - 4)^2 = 4(-5)(y - (-3)) = -20(y + 3)$.

8. Answer: $(y - 6)^2 = -12(x + 2)$

- The directrix is a vertical line $x = 1$, so this is a horizontal parabola.

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- Vertex is at $(-2, 6)$. The directrix $x = 1$ is to the right of the vertex, so the parabola opens left.
- Distance from vertex to directrix: $|(-2) - 1| = 3$, so $p = -3$.
- Equation: $(y - 6)^2 = 4(-3)(x - (-2)) = -12(x + 2)$.

9. Answer: $(x - 3)^2 = 4(y + 2)$; Vertex: $(3, -2)$; Focus: $(3, -1)$; Directrix: $y = -3$

- Group and complete the square: $x^2 - 6x = 4y - 1$.
- Add 9 to both sides: $x^2 - 6x + 9 = 4y - 1 + 9 = 4y + 8$.
- Factor: $(x - 3)^2 = 4(y + 2)$.
- Vertex = $(3, -2)$; $4p = 4$, so $p = 1$.
- Focus = $(3, -2 + 1) = (3, -1)$; Directrix = $y = -2 - 1 = -3$.

10. Answer: $(y + 5)^2 = 8(x - 2)$; Vertex: $(2, -5)$; Focus: $(4, -5)$; Directrix: $x = 0$; Axis: $y = -5$; Opens right

- Rearrange: $y^2 + 10y = 8x - 41$.
- Complete the square: $y^2 + 10y + 25 = 8x - 41 + 25 = 8x - 16$.
- Factor: $(y + 5)^2 = 8(x - 2)$.
- Vertex = $(2, -5)$; $4p = 8$, so $p = 2$.
- Focus = $(h + p, k) = (2 + 2, -5) = (4, -5)$.
- Directrix = $x = h - p = 2 - 2 = 0$.
- Axis of symmetry is the horizontal line $y = -5$.
- Since $p > 0$, the parabola opens to the right, enclosing the focus at $(4, -5)$.

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