Parabolas: Standard Form & Key Features

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 given its key features
- Determine the orientation and direction of opening of a parabola from its equation or given information

Problems

1. Identify whether the parabola opens vertically or horizontally, and state which equation form applies:

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

2. A parabola has its vertex at the origin and its focus at (0, 4). State the value of p and the direction the parabola opens.

3. Find the equation of the directrix for a parabola with vertex at the origin and focus at (0, 4).

4. Write the standard equation of the parabola with vertex at the origin and focus at (3, 0).

5. Identify the vertex, value of p, and direction of opening for the parabola given below:

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

6. Find the coordinates of the focus for the parabola given below:

$$(x+3)^2 = 12(y-1)$$

7. Write the standard equation of the parabola with vertex at (2, -1) and directrix at y = -4.

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8. A parabola has vertex at (-1, 3) and focus at (-1, -2). Find the equation of the parabola, the directrix, and the axis of symmetry.

9. Convert the equation below to standard form, then identify the vertex, focus, and directrix:

$$x^2 - 6x - 8y + 1 = 0$$

10. Convert the equation below to standard form, then find the vertex, focus, directrix, and axis of symmetry, and describe the direction the parabola opens:

$$y^2 + 10y - 4x + 13 = 0$$

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Parabolas: Standard Form & Key Features — Answer Key

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Answer Key

1. Answer: Vertical (opens up or down); this is the vertical form

- The squared term is on the x variable, which means the parabola opens vertically.
- It opens upward when p > 0 and downward when p < 0.

2. Answer: p = 4; opens upward

- The focus is at (0, 4), which is directly above the vertex at (0, 0).
- The distance from the vertex to the focus is p = 4, and since the focus is above the vertex, the parabola opens upward.

3. Answer: y = -4

- Since p = 4 and the parabola opens upward, the directrix is below the vertex.
- The directrix is at y = -p, so y = -4.

4. Answer: y^{2} = 12x

- The focus is at (3, 0), which is to the right of the vertex, so the parabola opens to the right and uses the horizontal form.
- p = 3, so 4p = 12.
- The standard equation is y^2 = 12x.

5. Answer: Vertex (1, 2); p = -2; opens left

- The equation is in horizontal form (y - k)^2 = 4p(x - h), so vertex is (h, k) = (1, 2).
- 4p = -8, so p = -2.
- Since p is negative in a horizontal parabola, it opens to the left.

6. Answer: Focus at (-3, 4)

- Vertex is at (h, k) = (-3, 1) and 4p = 12, so p = 3.
- The parabola opens upward, so the focus is p units above the vertex.
- Focus = (-3, 1 + 3) = (-3, 4).

7. Answer: (x - 2)^{2} = 12(y + 1)

- The directrix is y = -4 and the vertex is at (2, -1). The distance from vertex to directrix is p = -1 - (-4) = 3.
- Since the directrix is below the vertex, the parabola opens upward.
- 4p = 12, so the equation is (x - 2)^2 = 12(y + 1).

8. Answer: (x+1)^{2} = -20(y-3); directrix: y = 8; axis: x = -1

- Focus is below the vertex, so the parabola opens downward. p = 3 - (-2) = 5, so p = -5.
- 4p = -20.

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- Equation: (x + 1)^2 = -20(y - 3).
- Directrix is p units above the vertex: y = 3 + 5 = 8.
- Axis of symmetry passes vertically through the vertex: x = -1.

9. Answer: (x-3)^{2} = 8(y+1); vertex (3,-1); focus (3,1); directrix y = -3

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

10. Answer: (y+5)^{2} = 4(x+3); vertex (-3,-5); focus (-2,-5); directrix x = -4; axis y = -5; opens right

- Rearrange: y^2 + 10y = 4x - 13.
- Complete the square: add 25 to both sides: (y + 5)^2 = 4x - 13 + 25 = 4x + 12.
- Factor: (y + 5)^2 = 4(x + 3).
- Vertex is (-3, -5); 4p = 4 so p = 1.
- Since p > 0 in horizontal form, parabola opens right.
- Focus = (-3 + 1, -5) = (-2, -5); Directrix: x = -3 - 1 = -4; Axis of symmetry: y = -5.

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