2. Sketch graphs of these three quadratic relations on the same set of axes.

a) $y = (x - 9)^2$ **b)** $y = (x + 2)^2$

c) $y = (x - 5)^2$

3. Sketch graphs of these three quadratic relations on the same set of axes.

a) $y = x^2 + 8$ **b)** $y = x^2 - 5$

c) $y = x^2 - 10$

4. Sketch the graph of each parabola. Label at least three points on the parabola. Describe the transformation from the graph of $y = x^2$.

c) $y = x^2 - 5$ **d)** $y = (x - 8)^2$

e) $y = -\frac{1}{2}x^2$

g) $y = x^2 + 0.5$

Connect and Apply

6. Write an equation for the quadratic relation that results from each transformation.

a) The graph of $y = x^2$ is translated 6 units upward.

b) The graph of $y = x^2$ is translated 4 units downward.

7. Write an equation for the quadratic relation that results from each transformation.

a) The graph of $y = x^2$ is translated 7 units to the left.

b) The graph of $y = x^2$ is translated 5 units to the right.

c) The graph of $y = x^2$ is translated 8 units to the left.

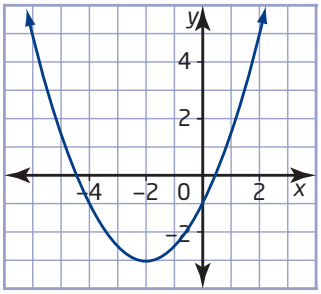
d) The graph of $y = x^2$ is translated 3 units to the right.

Communicate Your Understanding

C1 Why is the vertical line through the vertex called the axis of symmetry? Illustrate with an example.

C2 When describing the transformation from $y = x^2$ to $y = 2x^2$, you say that it has been stretched vertically by a factor of 2, instead of compressed horizontally. Explain why vertical stretches are used in descriptions.

C3 Which equation is correct for the graph shown? Explain your reasoning.



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

B $y = \frac{1}{3}(x + 2)^2 - 3$

C $y = \frac{1}{2}(x + 2)^2 - 3$

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

Practise

For help with questions 1 and 2, see Example 1.

1. Copy and complete the table for each parabola. Replace the heading for the second column with the equation for the parabola.

Property	$y = a(x - h)^2 + k$
Vertex	
Axis of symmetry	
Stretch or compression factor relative to $y = x^2$	
Direction of opening	
Values x may take	
Values y may take	

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

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

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

d) $y = \frac{1}{2}(x + 1)^2 + 5$

e) $y = (x - 7)^2 - 3$

f) $y = -(x - 1)^2 + 7$

g) $y = 2(x - 4)^2 - 5$

h) $y = -3(x + 4)^2 - 2$

2. Sketch each parabola in question 1.

For help with questions 3 to 7, see Example 2.

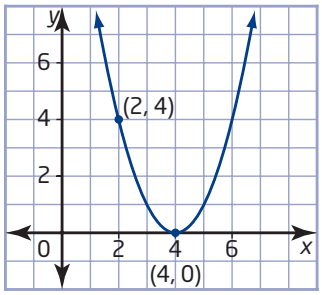
3. Write an equation for the parabola with vertex at (2, 3), opening upward, and with no vertical stretch.

4. Write an equation for the parabola with vertex at (−3, 0), opening downward, and with a vertical stretch of factor 2.

5. Write an equation for the parabola with vertex at (4, −1), opening upward, and with a vertical compression of factor 0.3.

6. Write an equation for each parabola.

a)



b)