Please Note

These pdf slides are configured for viewing on a computer screen.

Viewing them on hand-held devices may be difficult as they require a "slideshow" mode.

Do not try to print them out as there are many more pages than the number of slides listed at the bottom right of each screen.

Apologies for any inconvenience.

Linear and quadratic graphs

Numeracy Workshop

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STUDYSmarter
Learning, Language and Research Skills

Introduction

These slides introduce the *cartesian plane* and the features of *linear* and *quadratic graphs*.

Drop-in Study Sessions: Monday, Wednesday, Thursday, 10am-12pm, Meeting Room 2204, Second Floor, Social Sciences South Building, **every week.**

Website: Slides, worksheet, solutions.

www.studysmarter.uwa.edu.au → Numeracy and Maths → Online Resources

Email: *geoff.coates@uwa.edu.au*

A coordinate system: The Cartesian Plane

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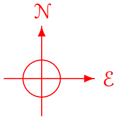

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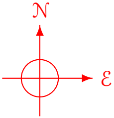

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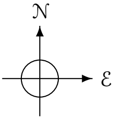

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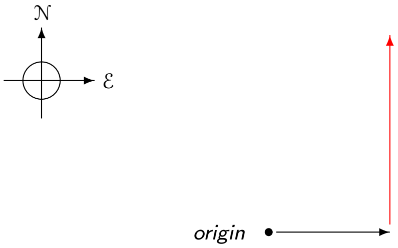

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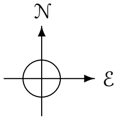

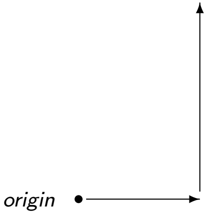

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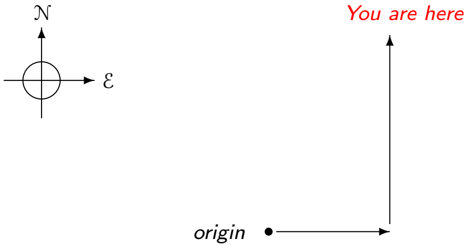
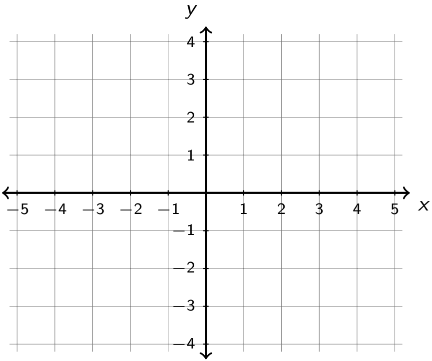


The Cartesian Plane

The most commonly used two-dimensional coordinate system is the Cartesian plane.



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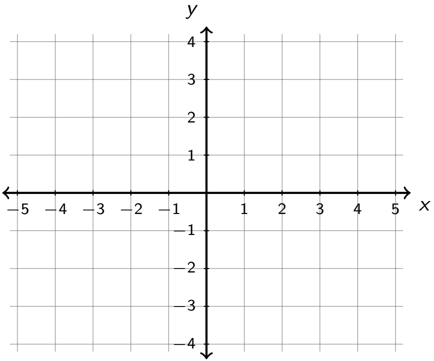
We specify points in the Cartesian plane as an ordered pair (x, y).



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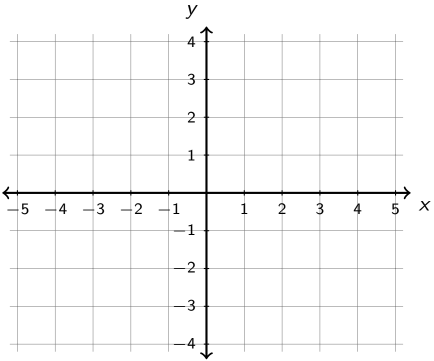

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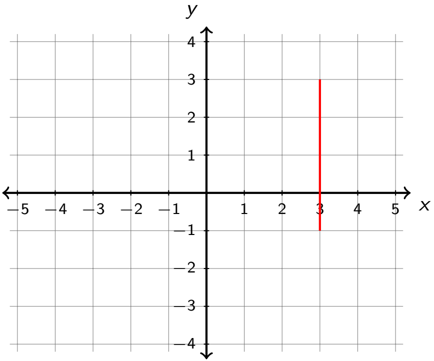

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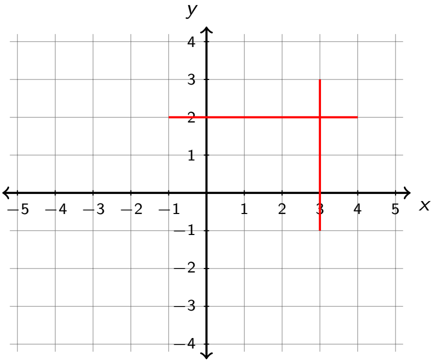

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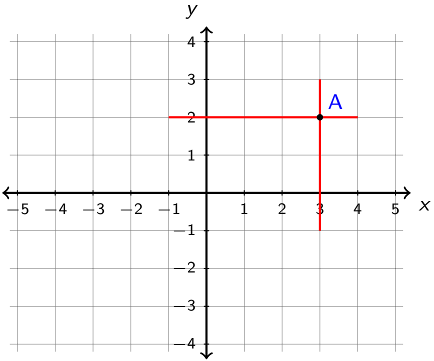

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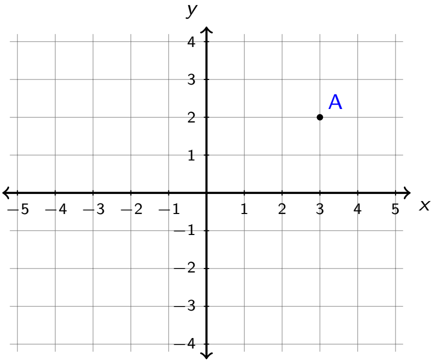
Examples: A: $(3, 2)$ B: $(-1, 4)$



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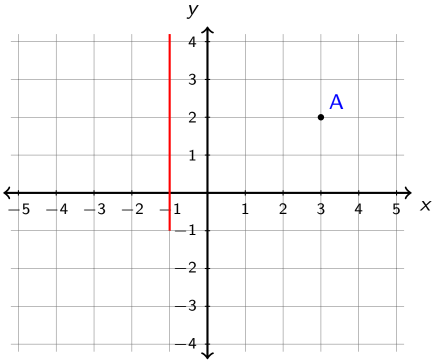

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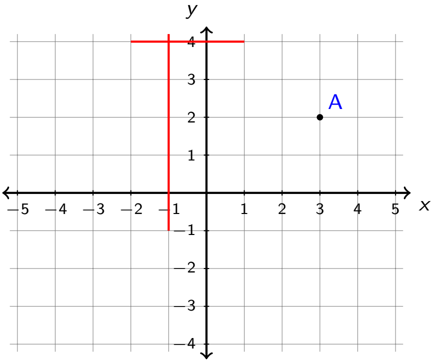

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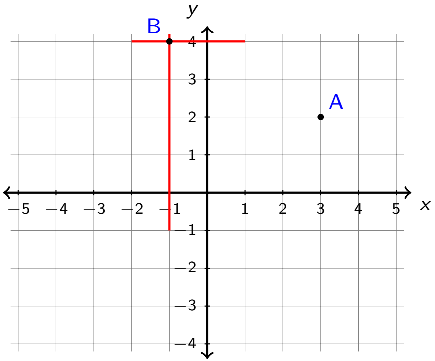

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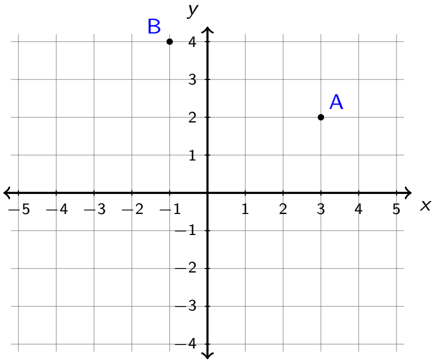

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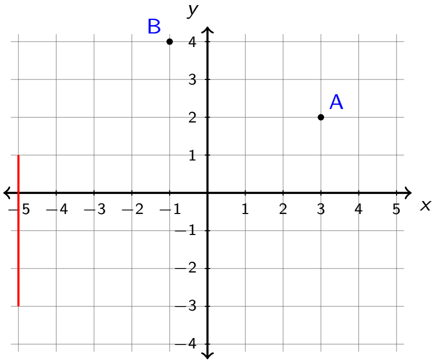

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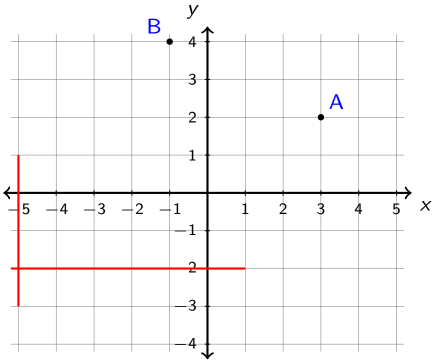

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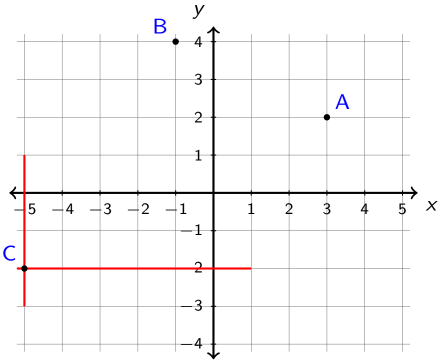

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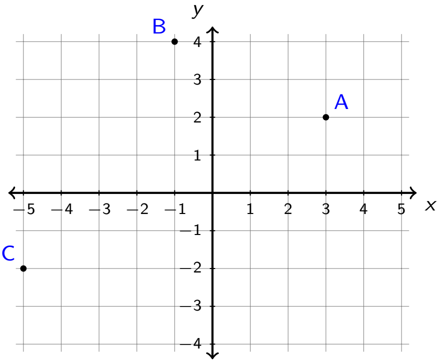

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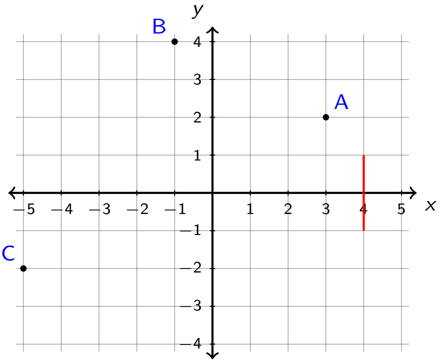

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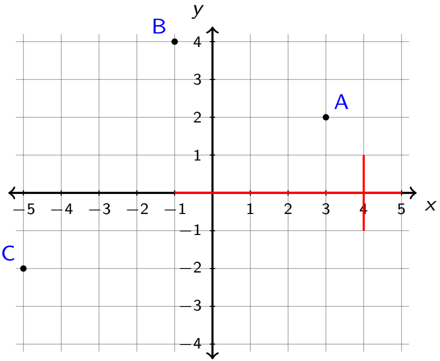

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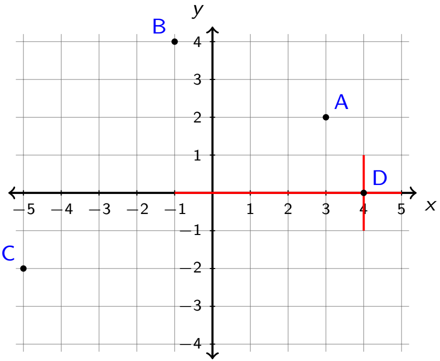

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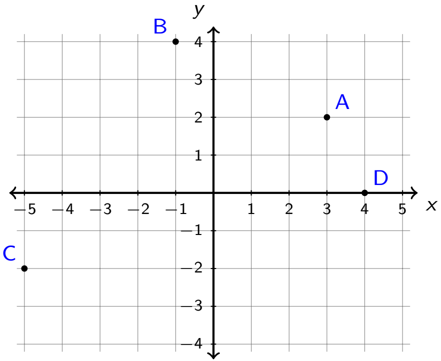

Equations and Relationships

An equation which involves two variables is a mathematical way to express the relationship that exists between them.

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$$y = x^2$$

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The above equation says, that whatever number x is, y is always the square of this number.

So, y and x are **fixed to each other** in some way.

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It is convenient sometimes to plot all the points (x, y) which satisfy an equation.

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$$x = 3 \quad \Rightarrow \quad y = 3^2 = 9 \quad \to \quad (x, y) = (3, 9)$$

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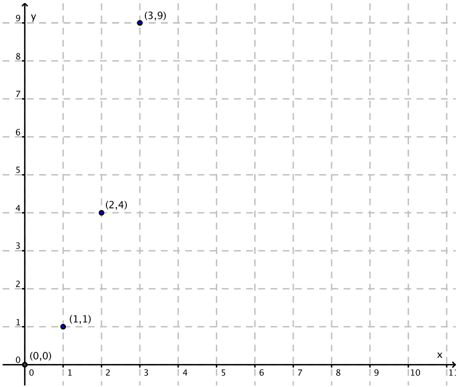
$$x = 3 \quad \Rightarrow \quad y = 3^2 = 9 \quad \rightarrow \quad (x, y) = (3, 9)$$

By feeding values through our relationship, we obtain points which we can display in the Cartesian plane!

Graph the points:

$$\{(0,0),(1,1),(2,4),(3,9)\}$$



Equations and Relationships

Graphing a few points of a relationship draws only a piece of the mathematical relationship.

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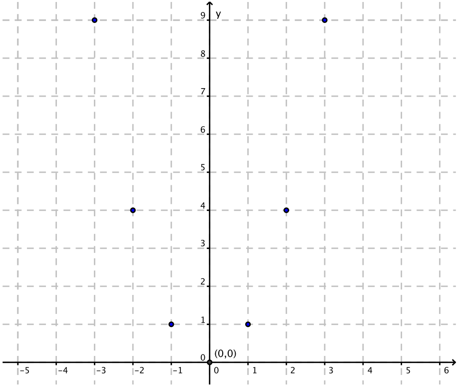
The relationship becomes smooth as we plot more and more values.

Equations and Relationships



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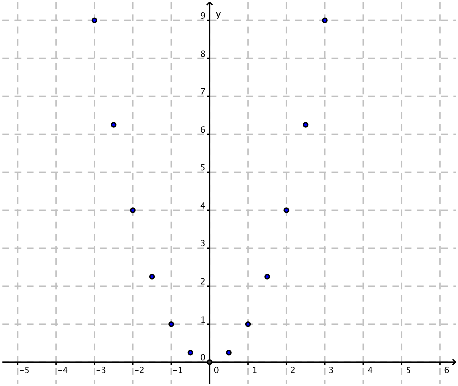

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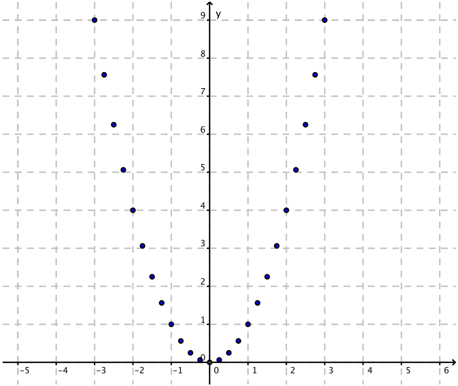

Equations and Relationships

To get a smooth curve, we need to plot infinitely many points!

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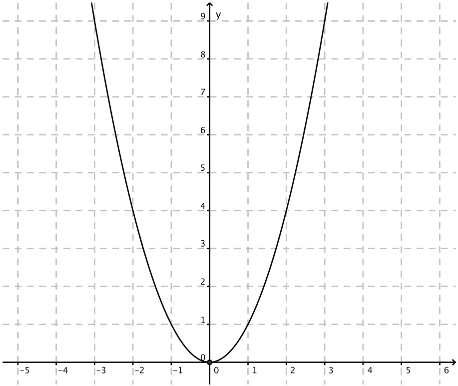
$\boxed{\text{This smooth curve is called the } \textbf{graph} \text{ of the function.}}$

Equations and Relationships

The graph of $y = x^2$:



Equations and Relationships

We have seen that mathematical relationships have a shape when plotted on the Cartesian plane.

A graph is useful, because **it represents the function completely**.

Linear equations

A mathematicial relationship of the form

$$y = mx + c$$

will produce a linear (straight line graph).

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variables

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Linear equations

$$y = 2x + 1$$

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Here, $m = 2$.

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$$x = 1 \quad \Rightarrow \quad y = 2 \times 1 + 1 = 3$$

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$$x = -3 \quad \Rightarrow \quad y = 2 \times -3 + 1 = -5 \quad \rightarrow \quad (x, y) = (-3, -5)$$

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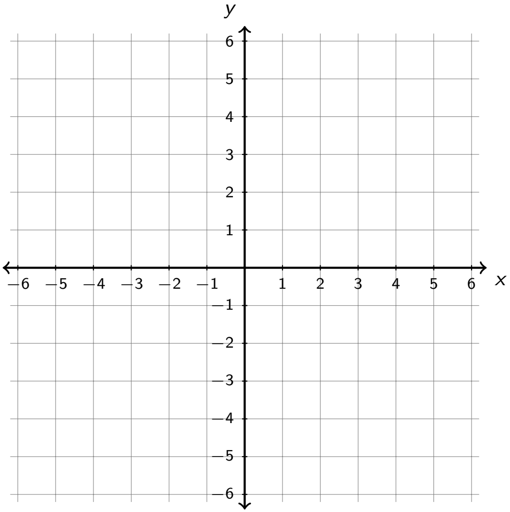
$$x = 2 \quad \Rightarrow \quad y = 2 \times 2 + 1 = 5 \quad \rightarrow \quad (x, y) = (2, 5)$$

$$x = -3 \quad \Rightarrow \quad y = 2 \times -3 + 1 = -5 \quad \rightarrow \quad (x, y) = (-3, -5)$$

Now plot these points on the Cartesian plane.

Linear equations

$$y = 2x + 1$$



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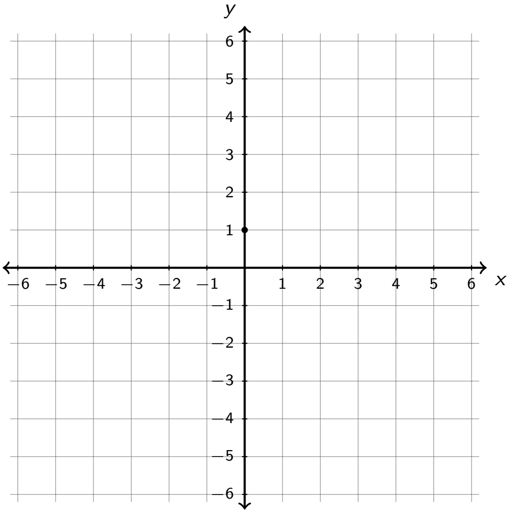

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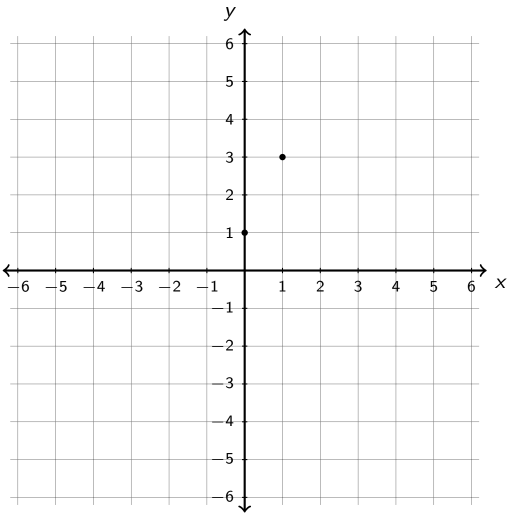

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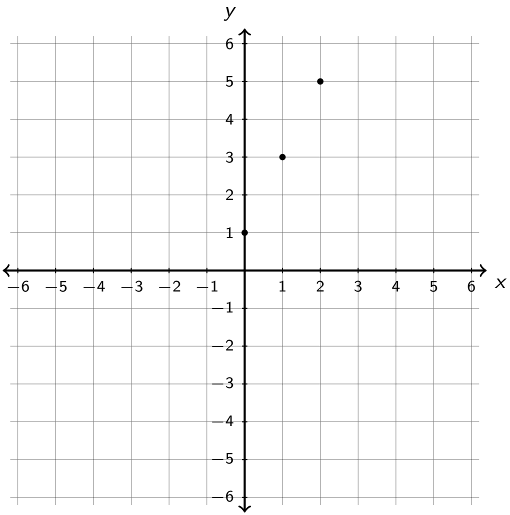

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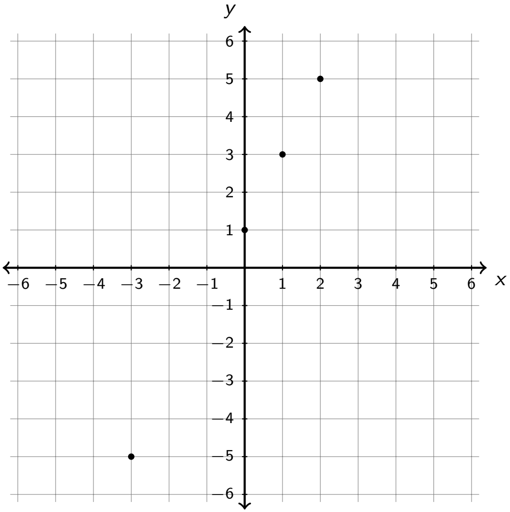

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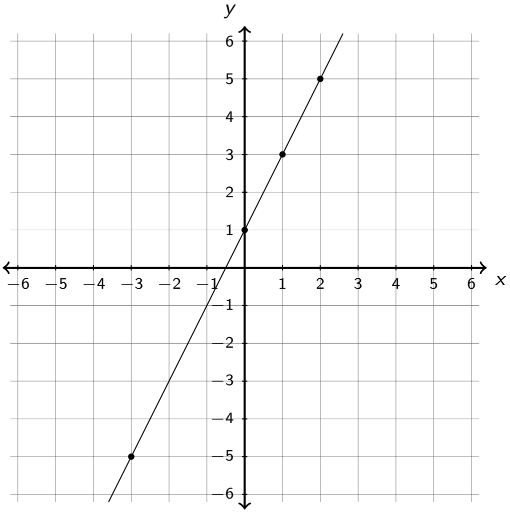

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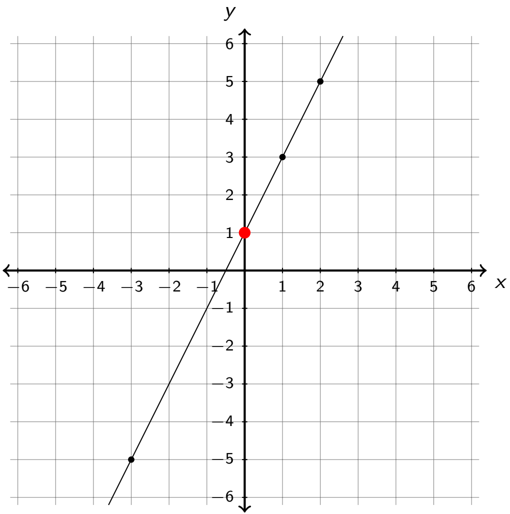

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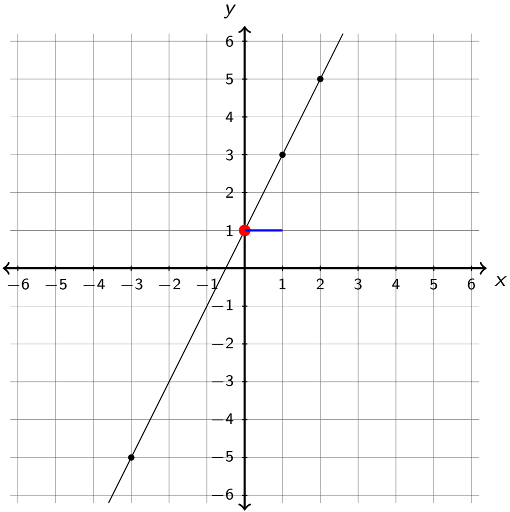

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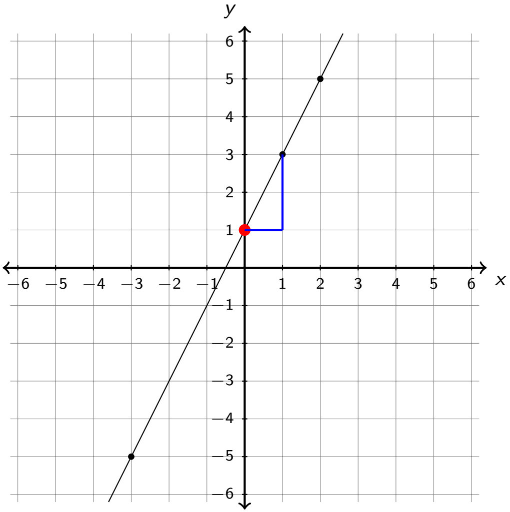

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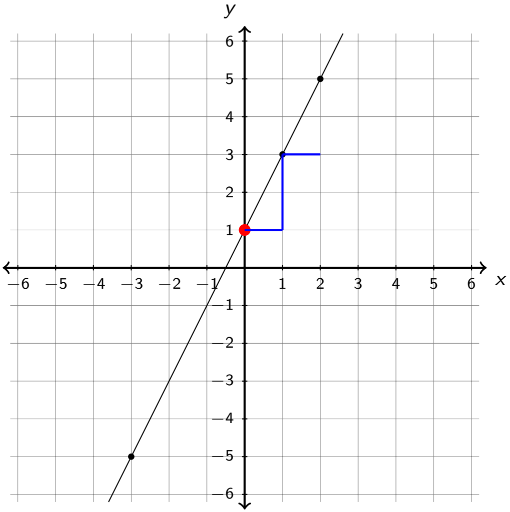

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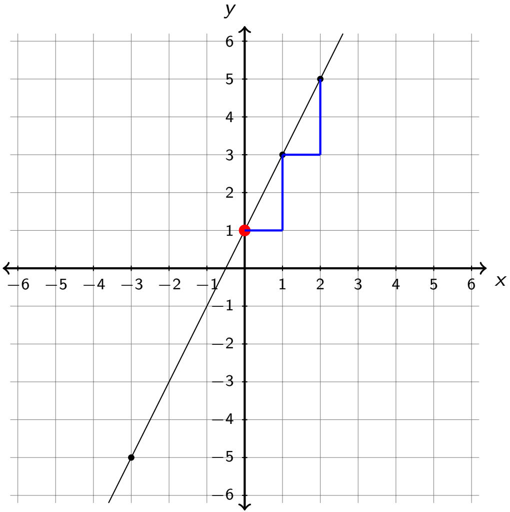

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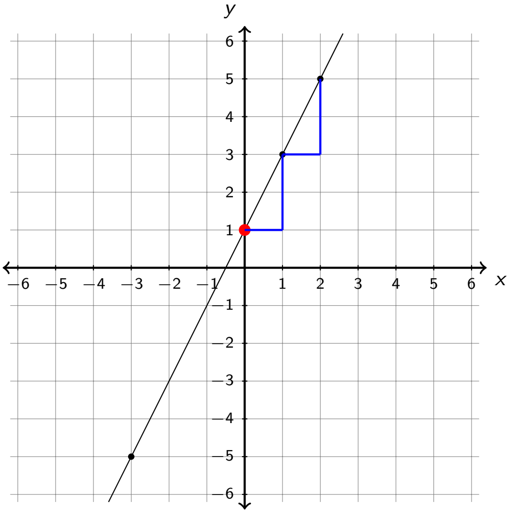

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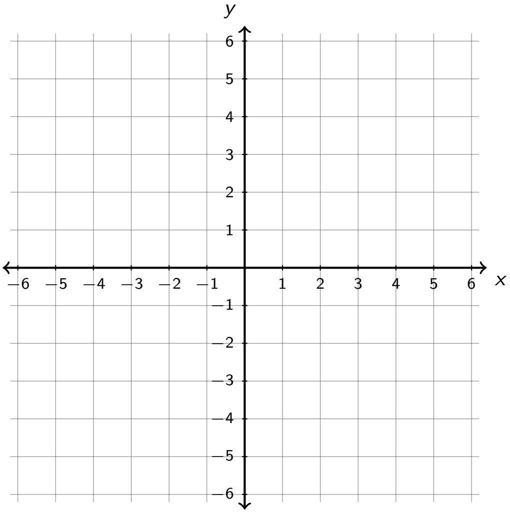

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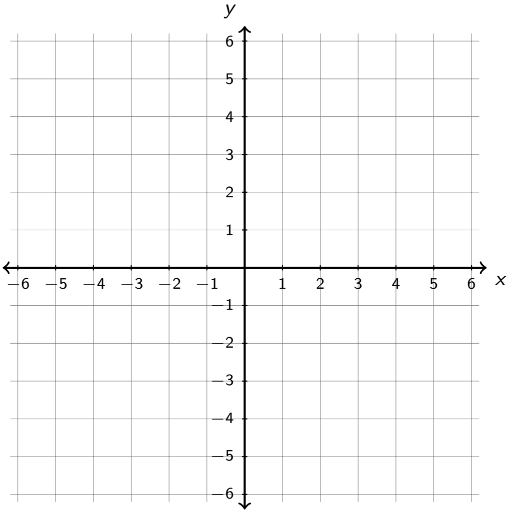

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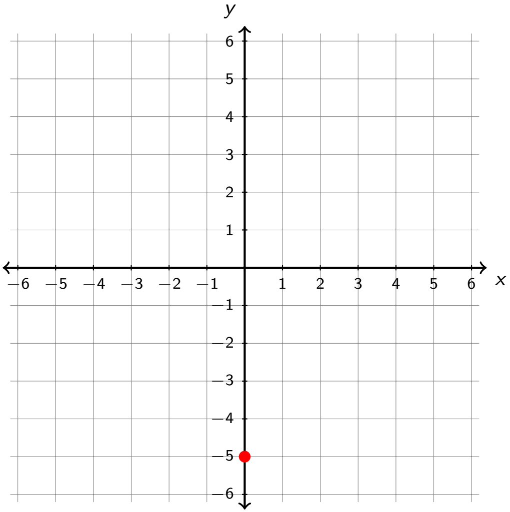

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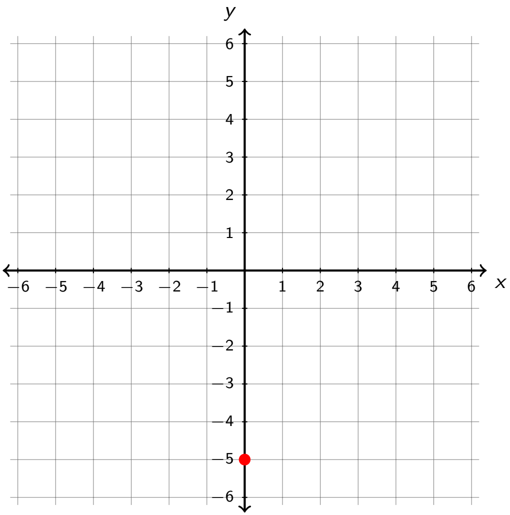

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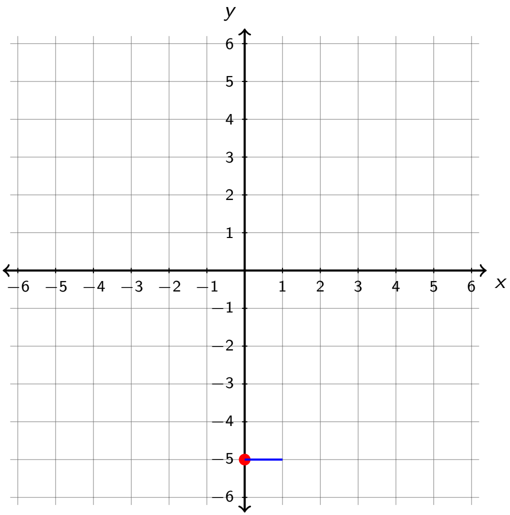

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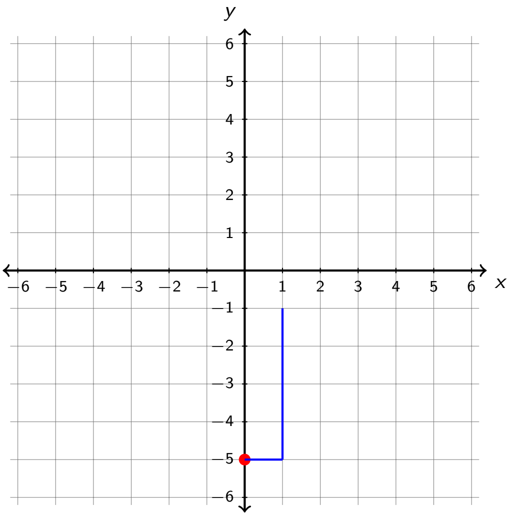

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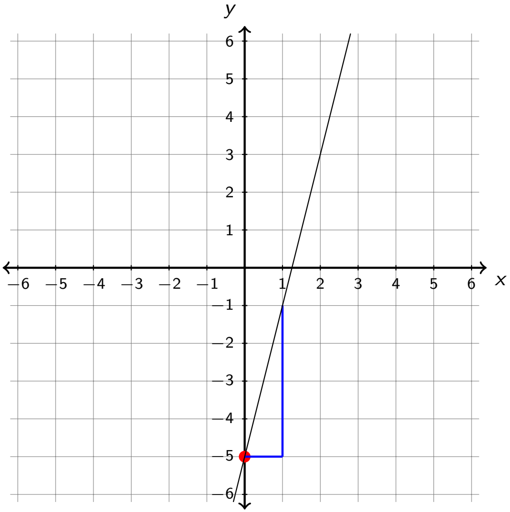

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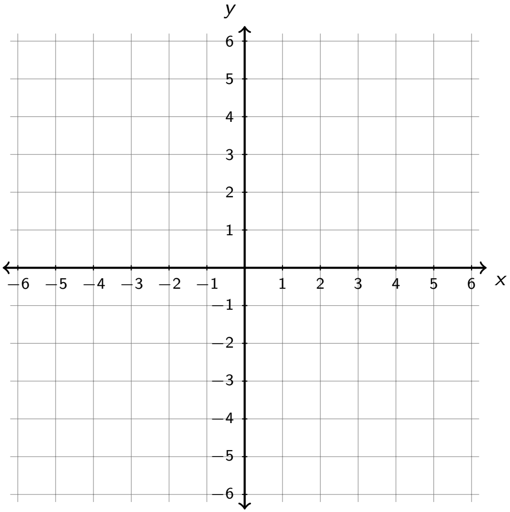

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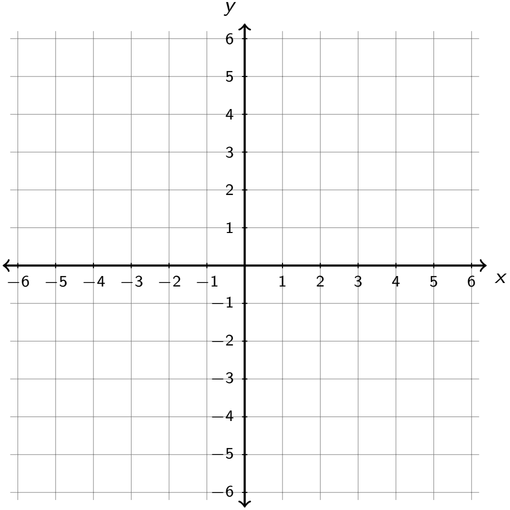

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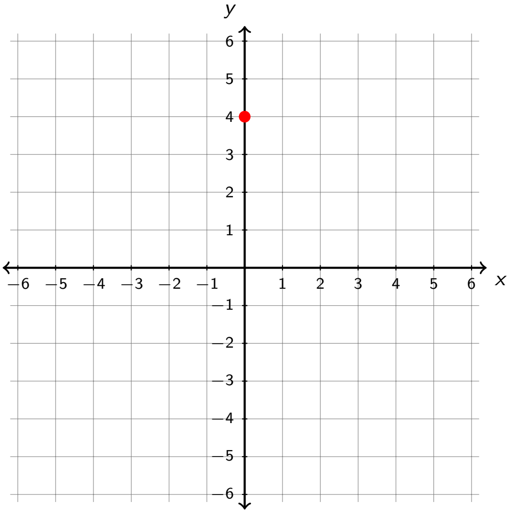

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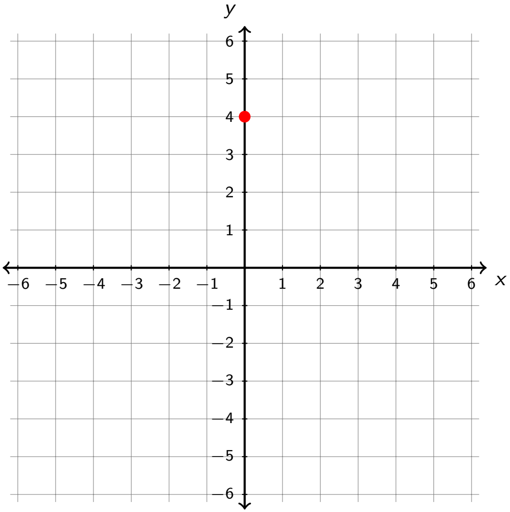

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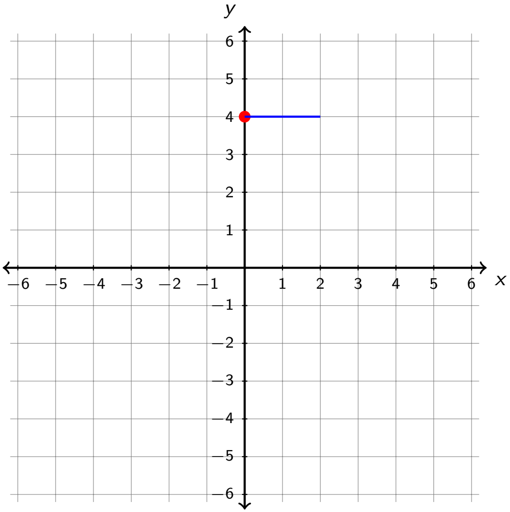

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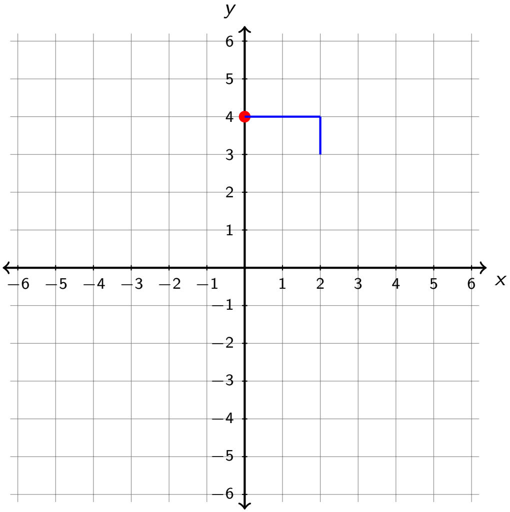

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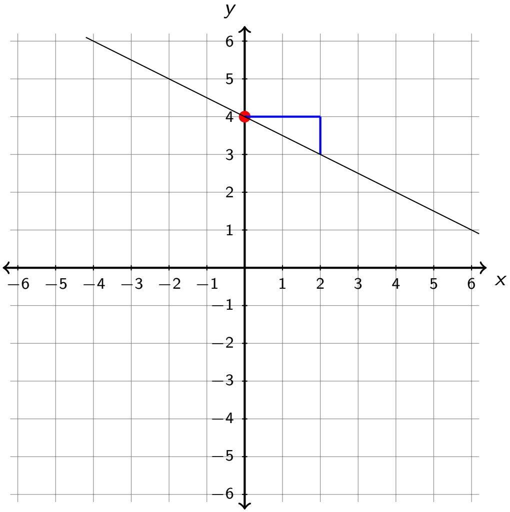

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Have a go at rearranging them!

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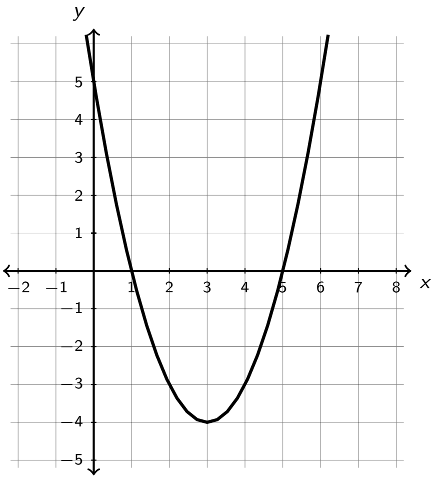
These functions take on the shape of a parabola when we graph them.

Properties of quadratic functions

A quadratic function has four properties of interest.



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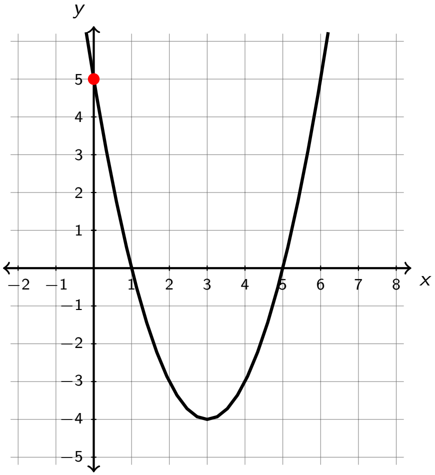

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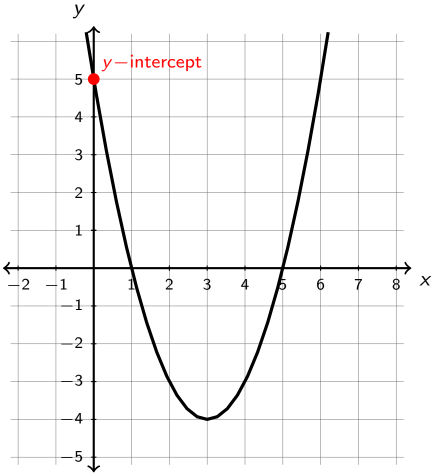

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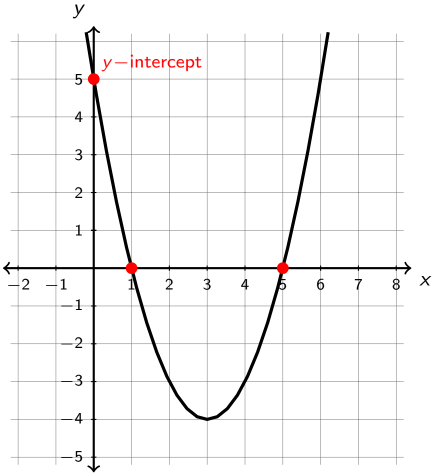

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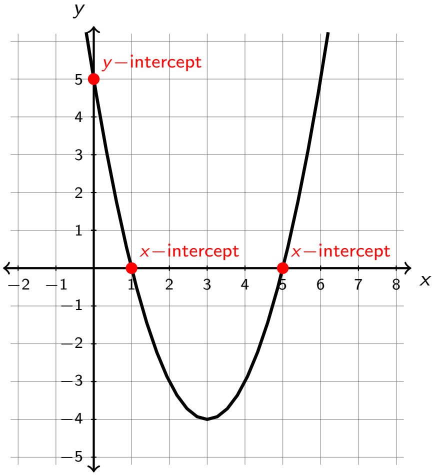

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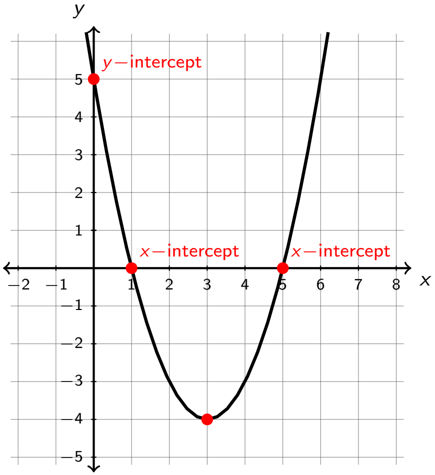

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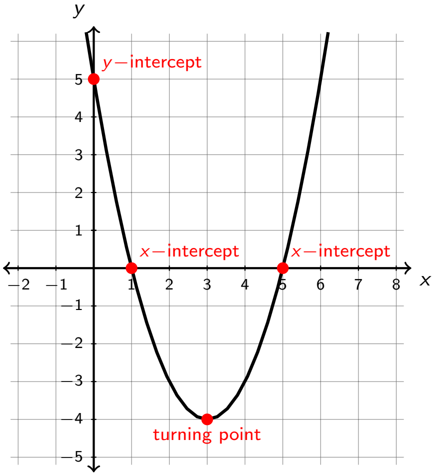

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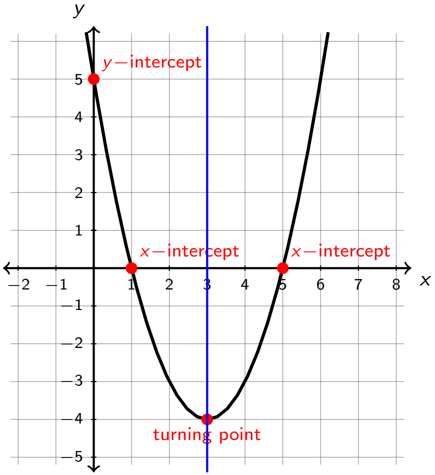

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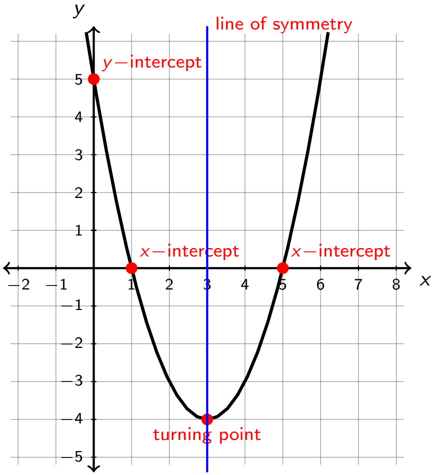

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Converting from one form to another requires algebraic manipulation which we won't discuss in this workshop.

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$y = x^2 - 2x + 5$	smile	$(0, 5)$	

Quadratic Functions: Standard Form

$$y = ax^2 + bx + c$$

In standard form, the sign of a determines whether it's a smile or frown, the $y-$intercept is $(0, c)$ and the line of symmetry is $x = \dfrac{-b}{2a}$.

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We have the $x-$value of the turning point because we have the line of symmetry.

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Equation		$y-$intercept	line of symmetry
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = \ -1$

We have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute this $x-$value into the equation:

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = -1$

We have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute this $x-$value into the equation:

$$y = 2(-1)^2 + 4(-1) - 5$$

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = -1$

We have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute this $x-$value into the equation:

$$y = 2(-1)^2 + 4(-1) - 5 = 2 - 4 - 5 = -7$$

Quadratic Functions: Standard Form

Equation		y−intercept	line of symmetry
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = -1$

We have the $x-$value of the turning point because we have the line of symmetry.

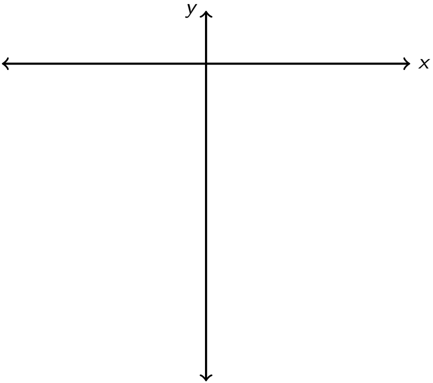
To find the $y-$coordinate of the turning point we simply substitute this $x-$value into the equation:

$$y = 2(-1)^2 + 4(-1) - 5 = 2 - 4 - 5 = -7$$

So, the turning point is $(-1, -7)$.

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry	turning point
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = -1$	$(-1, -7)$



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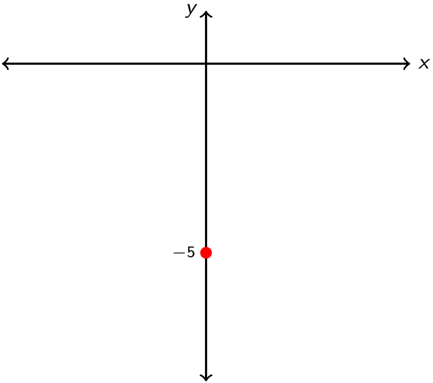

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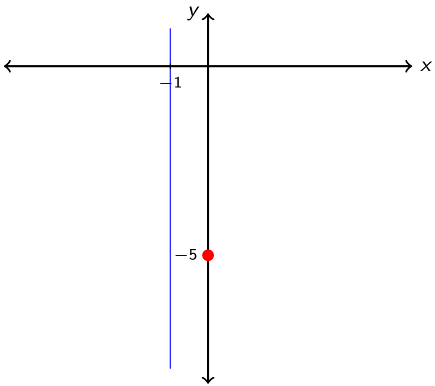

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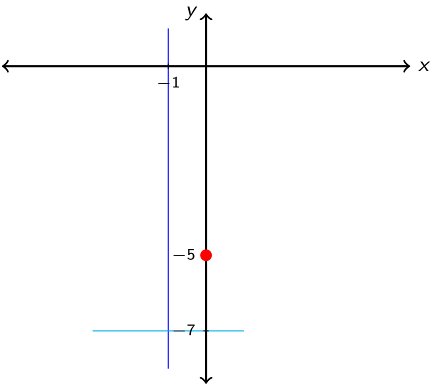

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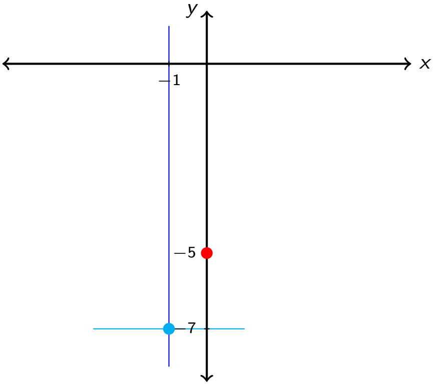

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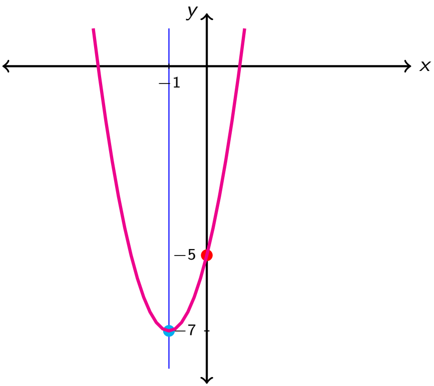

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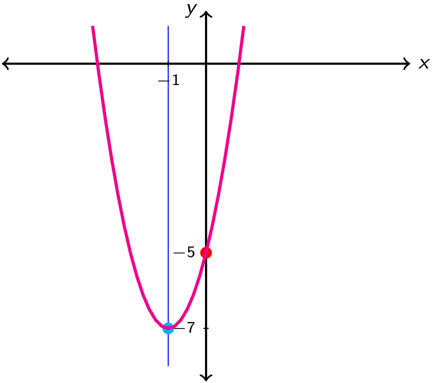

We now know that this quadratic has two $x-$intercepts.

Quadratic Functions: Standard Form

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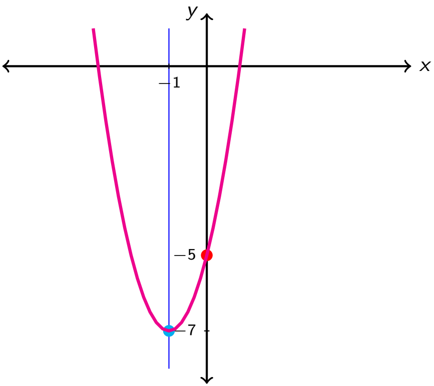
$y = 2x^2 + 4x - 5$	smile	$(0, -5)$	$x = -1$	$(-1, -7)$



We now know that this quadratic has two $x-$intercepts. If we need the exact values we have to either factorize the quadratic or use the quadratic formula.

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

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

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

$$y = (1)^2 - 2(1) + 5 = 4$$

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$

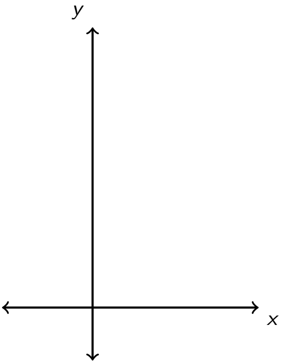
To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

$$y = (1)^2 - 2(1) + 5 = 4$$

So, the turning point is $(1, 4)$.

Quadratic Functions: Standard Form

Equation		$y-$intercept	line of symmetry	turning point
$y = x^2 - 2x + 5$	smile	$(0, 5)$	$x = 1$	$(1, 4)$



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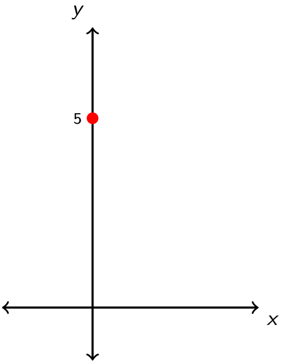

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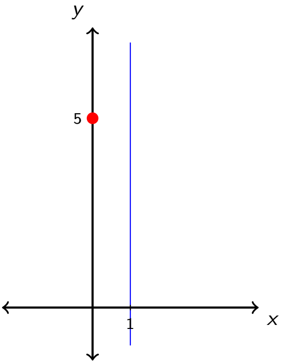

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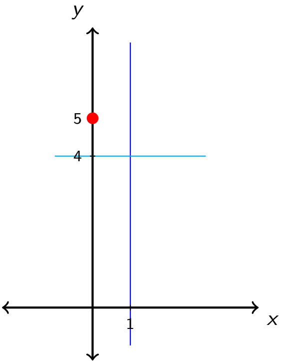

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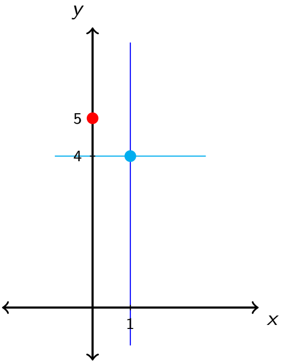

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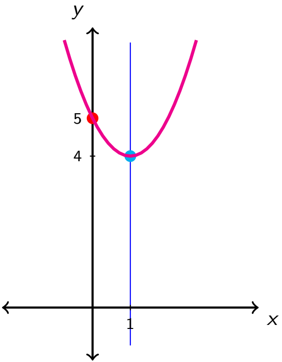

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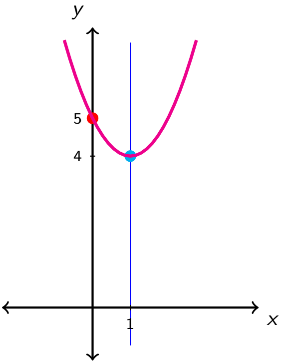

We can now see that this graph has no $x-$intercepts (which can also be discovered via the the quadratic formula).

Quadratic Functions: Factored Form

$$y = d(x - e)(x - f)$$

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In factored form, the sign of d determines whether it's a smile or frown, the $x-$intercepts are $(e,0)$ and $(f,0)$, which means that the line of symmetry is $x = \dfrac{e+f}{2}$.

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In factored form, the sign of d determines whether it's a smile or frown, the $x-$intercepts are $(e, 0)$ and $(f, 0)$, which means that the line of symmetry is $x = \dfrac{e + f}{2}$.

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Equation	smile/frown	$x-$intercepts	line of symmetry
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Quadratic Functions: Factored Form

$$y = d(x-e)(x-f)$$

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Equation	smile/frown	$x-$intercepts	line of symmetry
$y = 2(x-1)(x-3)$	smile		

Quadratic Functions: Factored Form

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Equation	smile/frown	$x-$intercepts	line of symmetry
$y = 2(x-1)(x-3)$	smile	$(1,0),\ (3,0)$	$x = \dfrac{1+3}{2} = 2$
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	

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$y = 2(x-1)(x-3)$	smile	$(1,0),\ (3,0)$	$x = \dfrac{1+3}{2} = 2$
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = \dfrac{2+4}{2} = 3$

Quadratic Functions: Factored Form

$$y = d(x - e)(x - f)$$

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$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = \dfrac{2+4}{2} = 3$
$y = 2(x-3)(x+3)$	smile	$(3,0),\ (-3,0)$	

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$y = -(x - 2)(x - 4)$	frown	$(2, 0),\ (4, 0)$	$x = \dfrac{2 + 4}{2} = 3$
$y = 2(x - 3)(x + 3)$	smile	$(3, 0),\ (-3, 0)$	$x = \dfrac{3 + -3}{2} = 0$

Quadratic Functions: Factored Form

$$y = d(x-e)(x-f)$$

In factored form, the sign of d determines whether it's a smile or frown, the $x-$intercepts are $(e,0)$ and $(f,0)$, which means that the line of symmetry is $x = \dfrac{e+f}{2}$.

Equation	smile/frown	$x-$intercepts	line of symmetry
$y = 2(x-1)(x-3)$	smile	$(1,0),\ (3,0)$	$x = \dfrac{1+3}{2} = 2$
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = \dfrac{2+4}{2} = 3$
$y = 2(x-3)(x+3)$	smile	$(3,0),\ (-3,0)$	$x = \dfrac{3+-3}{2} = 0$
$y = -2(x+3)^2$			

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$y = -2(x+3)^2$	frown	$(-3,0)$	

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$y = -2(x+3)^2$	frown	$(-3,0)$	$x = -3$

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$

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$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

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

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

$$y = -(0-2)(0-4) = -(-2)(-4) = -8$$

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

$$y = -(0-2)(0-4) = -(-2)(-4) = -8$$

So, the $y-$intercept is $(0,-8)$.

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

As before, we have the $x-$value of the turning point because we have the line of symmetry.

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

As before, we have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

As before, we have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

$$y = -(3-2)(3-4)$$

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

As before, we have the $x-$value of the turning point because we have the line of symmetry.

To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

$$y = -(3-2)(3-4) = -(1)(-1) = 1$$

Quadratic Functions: Factored Form

Equation		$x-$intercepts	line of symmetry	$y-$intercept
$y = -(x-2)(x-4)$	frown	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$

As before, we have the $x-$value of the turning point because we have the line of symmetry.

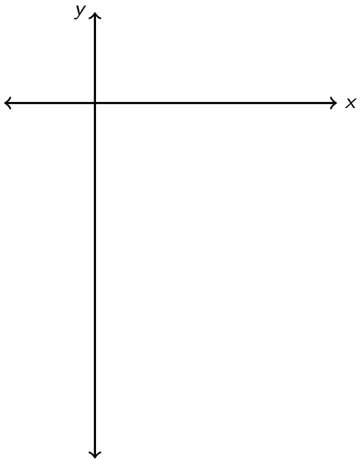
To find the $y-$coordinate of the turning point we simply substitute the $x-$value into the equation:

$$y = -(3-2)(3-4) = -(1)(-1) = 1$$

So, the turning point is $(3,1)$.

Quadratic Functions: Factored Form

Equation		$x-$intercepts	l. o. s.	$y-$intercept	t. p.
$y = -(x-2)(x-4)$	smile	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$	$(3,1)$



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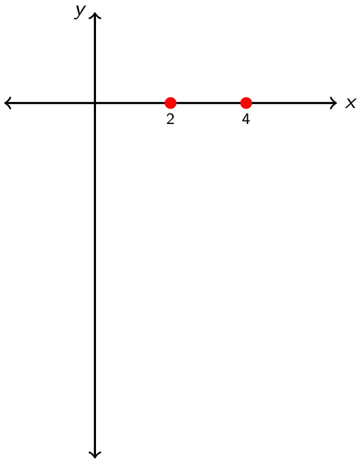
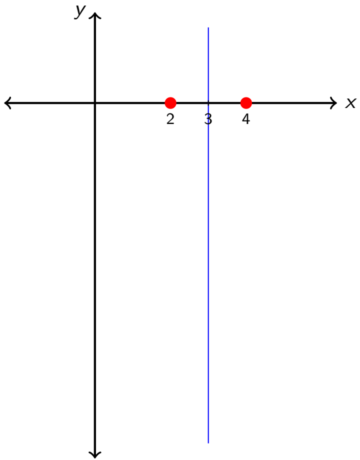
$y = -(x-2)(x-4)$	smile	$(2,0)$, $(4,0)$	$x = 3$	$(0,-8)$	$(3,1)$



Quadratic Functions: Factored Form

Equation		$x-$intercepts	l. o. s.	$y-$intercept	t. p.
$y = -(x-2)(x-4)$	smile	$(2, 0)$, $(4, 0)$	$x = 3$	$(0, -8)$	$(3, 1)$



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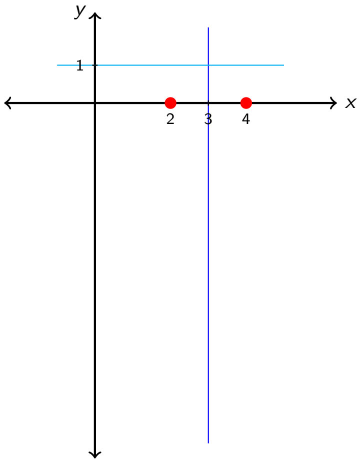
$y = -(x-2)(x-4)$	smile	$(2,0),\ (4,0)$	$x = 3$	$(0,-8)$	$(3,1)$



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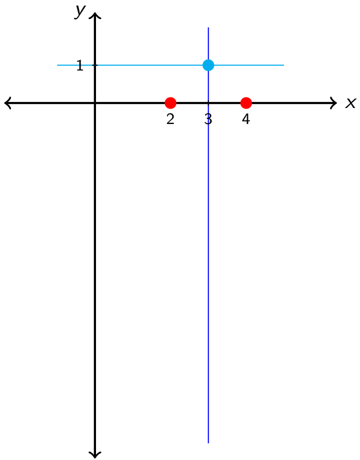
Equation		$x-$intercepts	l. o. s.	$y-$intercept	t. p.
$y = -(x-2)(x-4)$	smile	$(2,0)$, $(4,0)$	$x = 3$	$(0,-8)$	$(3,1)$



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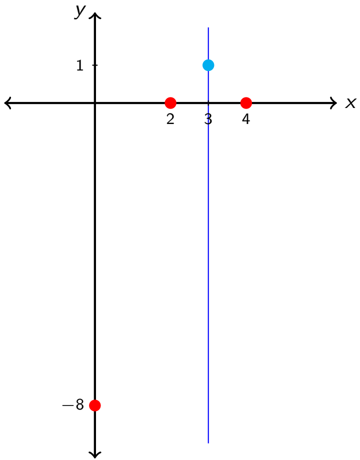

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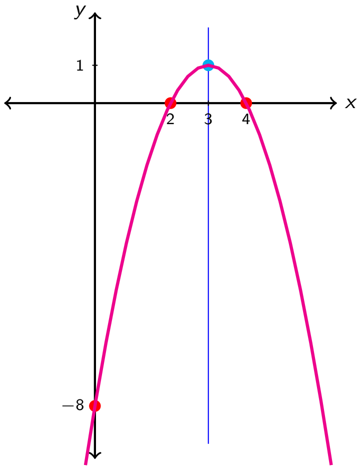

Quadratic Functions: Turning Point Form

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Quadratic Functions: Turning Point Form

$$y = g(x - h)^2 + k$$

In turning point form, the sign of g determines whether it's a smile or frown, the turning point is (h, k) and the line of symmetry is $x = h$.

Quadratic Functions: Turning Point Form

$$y = g(x-h)^2 + k$$

In turning point form, the sign of g determines whether it's a smile or frown, the turning point is (h, k) and the line of symmetry is $x = h$.

Equation	smile/frown	turning point	line of symmetry

Quadratic Functions: Turning Point Form

$$y = g(x-h)^2 + k$$

In turning point form, the sign of g determines whether it's a smile or frown, the turning point is (h, k) and the line of symmetry is $x = h$.

Equation	smile/frown	turning point	line of symmetry
$y = 3(x-1)^2+4$			

Quadratic Functions: Turning Point Form

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$y = 3(x-1)^2+4$	smile		

Quadratic Functions: Turning Point Form

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Equation	smile/frown	turning point	line of symmetry
$y = 3(x-1)^2+4$	smile	$(1, 4)$	

Quadratic Functions: Turning Point Form

$$y = g(x-h)^2 + k$$

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Equation	smile/frown	turning point	line of symmetry
$y = 3(x-1)^2+4$	smile	$(1,4)$	$x = 1$

Quadratic Functions: Turning Point Form

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Equation	smile/frown	turning point	line of symmetry
$y = 3(x-1)^2+4$	smile	$(1, 4)$	$x = 1$
$y = -2(x-2)^2-5$			

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

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$y = (x+5)^2+1$	smile	$(-5, 1)$	$x = -5$
$y = -(x+3)^2$	frown	$(-3, 0)$	

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Equation		turning point	line of symmetry
$y = 3(x-1)^2 + 4$	smile	$(1, 4)$	$x = 1$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

Quadratic Functions: Turning Point Form

Equation		turning point	line of symmetry
$y = 3(x-1)^2 + 4$	smile	$(1, 4)$	$x = 1$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

$$y = 3(0-1)^2 + 4$$

Quadratic Functions: Turning Point Form

Equation		turning point	line of symmetry
$y = 3(x-1)^2 + 4$	smile	$(1, 4)$	$x = 1$

The $y-$intercept isn't obvious in this form but we can find it by substituting $x = 0$ into the equation:

$$y = 3(0-1)^2 + 4 = 3(-1)^2 + 4 = 7$$

Quadratic Functions: Turning Point Form

Equation		turning point	line of symmetry
$y = 3(x-1)^2+4$	smile	$(1,4)$	$x=1$

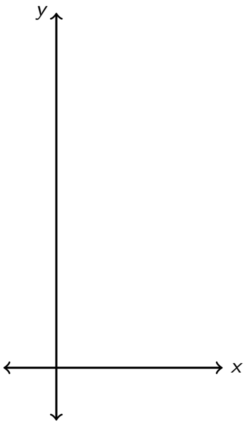
The $y-$intercept isn't obvious in this form but we can find it by substituting $x=0$ into the equation:

$$y = 3(0-1)^2+4 = 3(-1)^2+4 = 7$$

So, the $y-$intercept is $(0,7)$.

Quadratic Functions: Factored Form

Equation		turning point	line of symmetry	$y-$intercept
$y = 3(x-1)^2 + 4$	smile	$(1, 4)$	$x = 1$	$(0, 7)$



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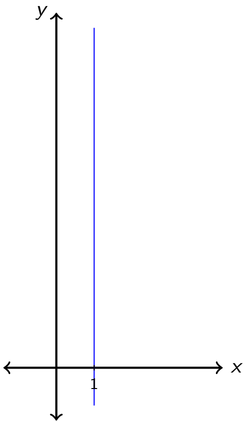

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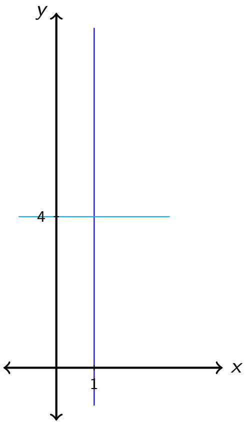

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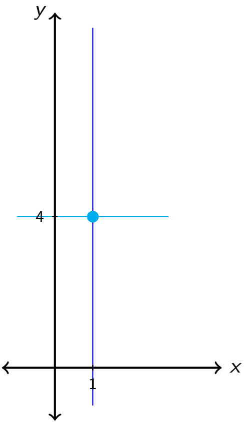

Quadratic Functions: Factored Form

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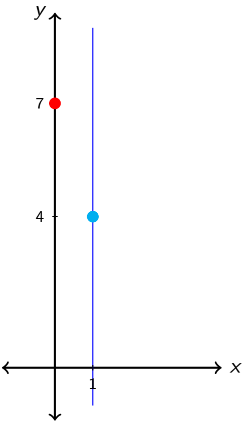

Quadratic Functions: Factored Form

Equation		turning point	line of symmetry	$y-$intercept
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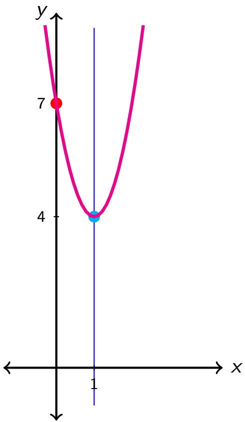

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