

Basic functions and transformations

Lesson #4

MAT 1375 Precalculus

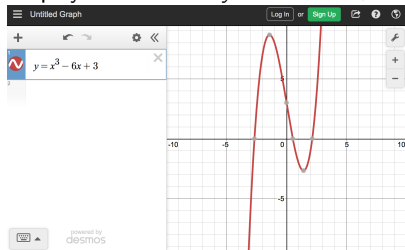
New York City College of Technology CUNY



Introduction to desmos

Download the desmos app or go to www.desmos.com (click on "Graphing Calculator")

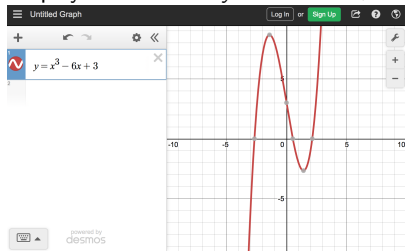
- Display the function $y = x^3 - 6x + 3$



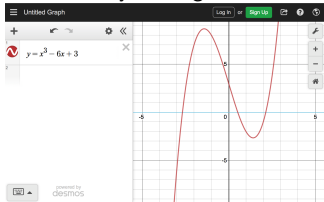
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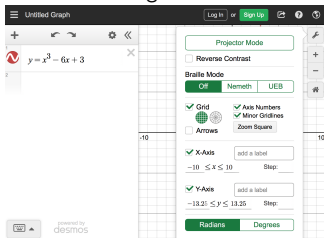
- Display the function $y = x^3 - 6x + 3$



- Change scale by zooming in or out
Zoom axis by holding "shift" + zoom axis

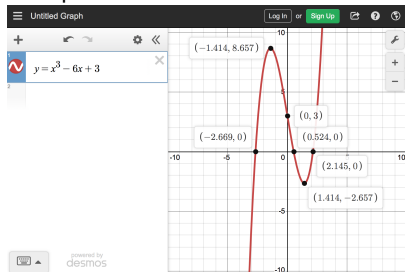


Or under settings: X-Axis and Y-Axis



Introduction to desmos

- Find points of interest



Approximate coordinates found by clicking

local maximum: $(x, y) \approx (-1.414, 8.657)$

local minimum: $(x, y) \approx (1.414, -2.657)$

x-intercepts or roots or zeros:

$(x, y) \approx (-2.669, 0)$

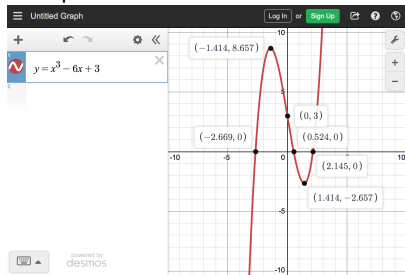
$(x, y) \approx (0.524, 0)$

$(x, y) \approx (2.145, 0)$

y-intercept: $(x, y) = (0, 3)$

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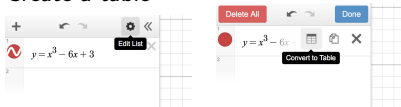
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- Create a table



Find function values for specified inputs x :

$$f(17) = 4814$$

x	$x^3 - 6x + 3$
-2	7
-1	8
0	3
1	-2
2	-1
17	4814

Extrema, roots, and y-intercept with desmos - exercises

Find all maxima, minima and specify if they are local or global. Find the roots and the y-intercept.

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

3 $f(x) = x^2 - 7x^3$

5 $f(x) = 5$

2 $f(x) = -2x^4 + 7x^2 - 2$

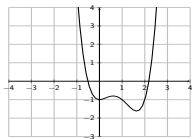
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roots: $(x, y) \approx (-0.513, 0)$

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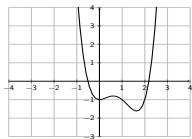
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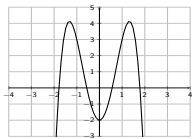
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global max: $(x, y) \approx (-1.323, 4.125)$

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local min: $(x, y) = (0, -2)$

roots: $(x, y) \approx (\pm 1.785, 0)$

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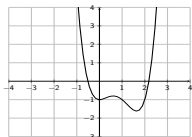
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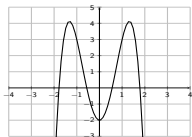
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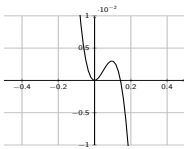
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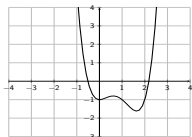
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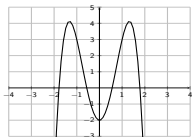
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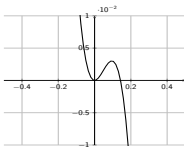
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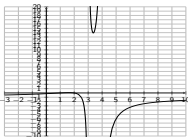
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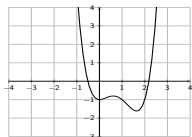
$(x, y) = (2, 0)$

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Extrema, roots, and y-intercept with desmos - exercises

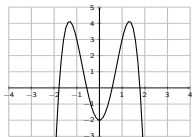
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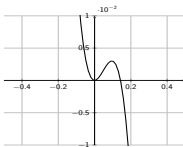
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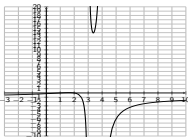
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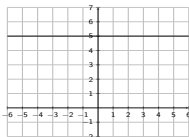
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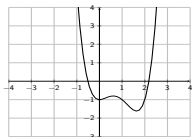
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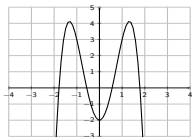
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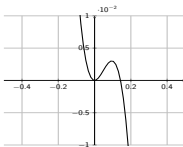
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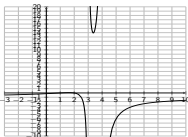
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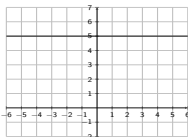
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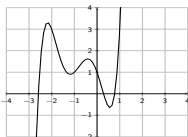
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local min: $(x, y) \approx (0.57, -0.647)$
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 $(x, y) \approx (0.285, 0)$
 $(x, y) \approx (0.776, 0)$
y-intercept: $(x, y) = (0, 1)$

Basic Functions

Use desmos to explore the graphs of the basic functions below. Memorize their graphs!

Graphs of basic functions

$$y = mx + b$$

$$y = x^2$$

$$y = |x|$$

$$y = \frac{1}{x}$$

$$y = c$$

$$y = x^3$$

$$y = \sqrt{x}$$

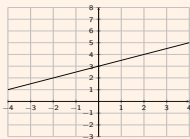
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Basic Functions

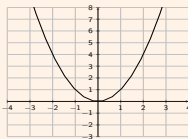
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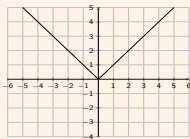
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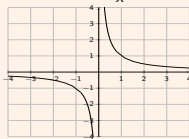
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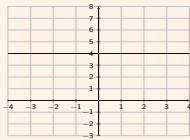
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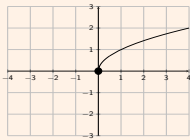
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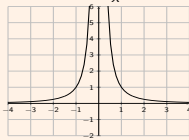
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$$y = \sqrt{x}$$



$$y = \frac{1}{x^2}$$

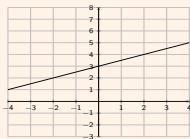


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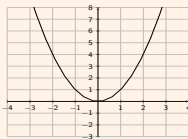
Graphs of basic functions

$$y = mx + b$$



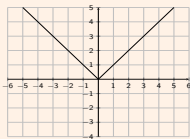
$$D = \mathbb{R}$$

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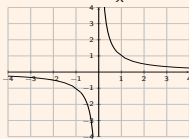
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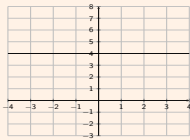
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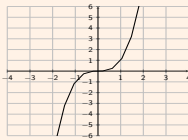
$$D = \mathbb{R} - \{0\}$$

$$y = c$$



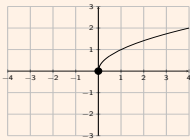
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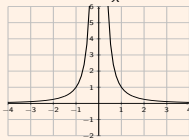
$$D = \mathbb{R}$$

$$y = \sqrt{x}$$



$$D = [0, \infty)$$

$$y = \frac{1}{x^2}$$



$$D = \mathbb{R} - \{0\}$$

Transformations: shift left/right/up/down, reflection, stretch/compress

- Explore with desmos:
- $y = \sqrt{x} + a$ (shift the slider a up and down)
 - $y = \sqrt{x+a}$
 - $y = -\sqrt{x}$ and $y = \sqrt{-x}$
 - $y = x^3 + 2$ and $y = a \cdot (x^3 + 2)$ and $y = (a \cdot x)^3 + 2$

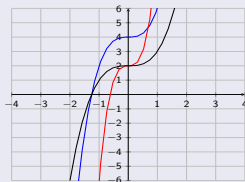
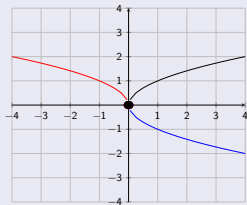
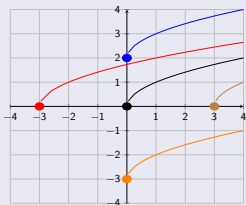
Transformations: shift left/right/up/down, reflection, stretch/compress

- Explore with desmos:
- $y = \sqrt{x} + a$ (shift the slider a up and down)
 - $y = \sqrt{x+a}$
 - $y = -\sqrt{x}$ and $y = \sqrt{-x}$
 - $y = x^3 + 2$ and $y = a \cdot (x^3 + 2)$ and $y = (a \cdot x)^3 + 2$

Summary of graph transformations

For $a > 0$, the graph of $y = f(x)$ is

- shifted **up/down** by $y = f(x) \pm a$
- shifted **left/right** by $y = f(x \pm a)$
- reflected about the **x-axis** by $y = -f(x)$
- reflected about the **y-axis** by $y = f(-x)$
- **stretched away** ($a > 1$) or **compressed towards** ($0 < a < 1$) the x-axis by $y = a \cdot f(x)$
- **compressed towards** ($a > 1$) or **stretched away** ($0 < a < 1$) the y-axis by $y = f(a \cdot x)$



Transformations - exercises

Use sliders in desmos to explore how the graph differs from a basic graph.

1 $f(x) = (x + 2)^2 + 3$

Use $y = (x + a)^2 + b$

with sliders a and b .

3 $f(x) = \frac{1}{x-3} - 2$

5 $f(x) = \sqrt{-x + 2}$

2 $f(x) = -|x - 4|$

4 $f(x) = 2 \cdot (x + 4)^3$

6 $f(x) = -\left(\frac{1}{x^2} + 3\right)$

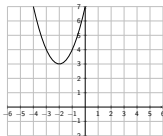
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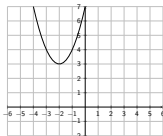
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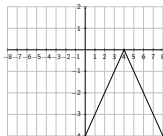
Use $y = (x + a)^2 + b$

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shift up by 3, left by 2

2 $f(x) = -|x - 4|$



shift right by 4, reflect down

3 $f(x) = \frac{1}{x-3} - 2$

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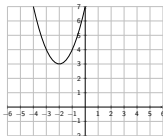
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Transformations - exercises

Use sliders in desmos to explore how the graph differs from a basic graph.

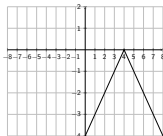
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Use $y = (x + a)^2 + b$
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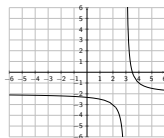
shift up by 3, left by 2

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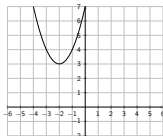
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Transformations - exercises

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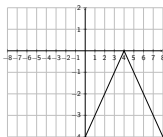
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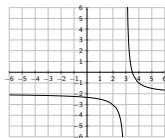
shift up by 3, left by 2

2 $f(x) = -|x - 4|$



shift right by 4, reflect down

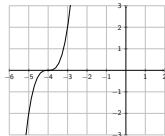
3 $f(x) = \frac{1}{x-3} - 2$



shift right by 3, down by 2

5 $f(x) = \sqrt{-x + 2}$

4 $f(x) = 2 \cdot (x + 4)^3$



shift left by 4,
stretch away from x-axis

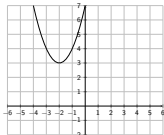
6 $f(x) = -\left(\frac{1}{x^2} + 3\right)$

Transformations - exercises

Use sliders in desmos to explore how the graph differs from a basic graph.

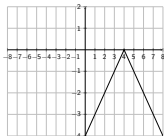
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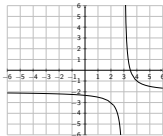
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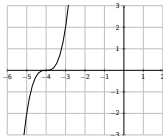
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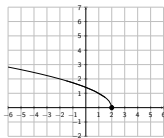
shift right by 3, down by 2

4 $f(x) = 2 \cdot (x + 4)^3$



shift left by 4,
stretch away from x-axis

5 $f(x) = \sqrt{-x + 2}$



reflect to the left,
shift right by 2

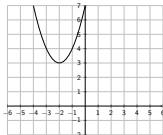
6 $f(x) = -\left(\frac{1}{x^2} + 3\right)$

Transformations - exercises

Use sliders in desmos to explore how the graph differs from a basic graph.

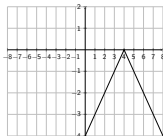
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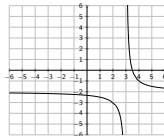
shift up by 3, left by 2

2 $f(x) = -|x - 4|$



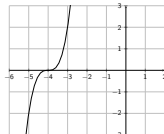
shift right by 4, reflect down

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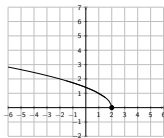
shift right by 3, down by 2

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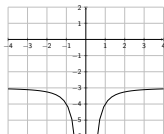
shift left by 4,
stretch away from x-axis

5 $f(x) = \sqrt{-x + 2}$



reflect to the left,
shift right by 2

6 $f(x) = -\left(\frac{1}{x^2} + 3\right)$

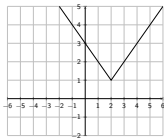


reflect down,
shift down by 3

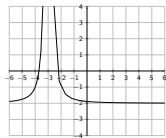
Transformations - exercises

Find a possible formula for the graph displayed below.

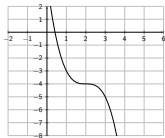
1



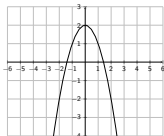
3



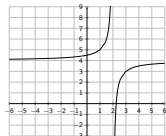
5



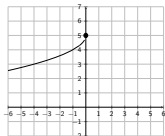
2



4



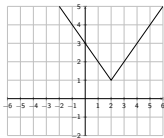
6



Transformations - exercises

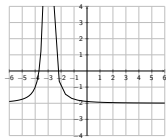
Find a possible formula for the graph displayed below.

1

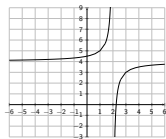


$$f(x) = |x - 2| + 1$$

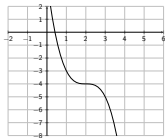
3



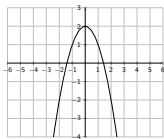
4



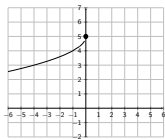
5



2



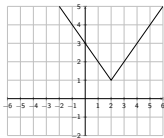
6



Transformations - exercises

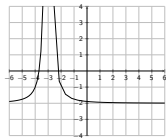
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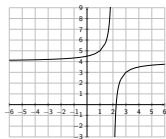


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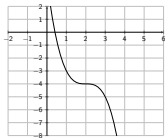
3



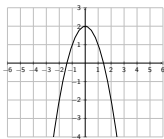
4



5

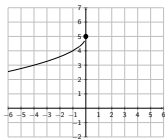


2



$$f(x) = -x^2 + 2$$

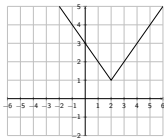
6



Transformations - exercises

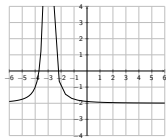
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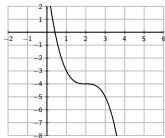
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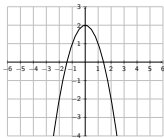


$$f(x) = \frac{1}{(x+3)^2} - 2$$

5

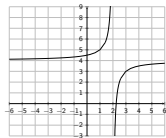


2

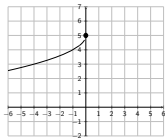


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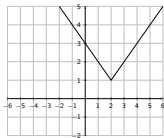
6



Transformations - exercises

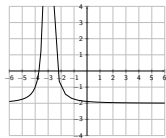
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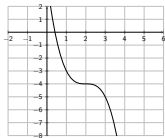
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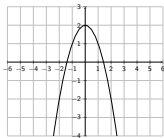


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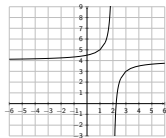


2



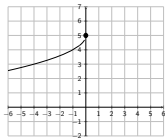
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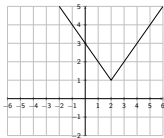
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Transformations - exercises

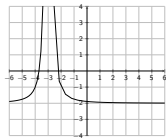
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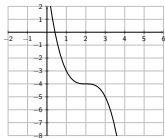
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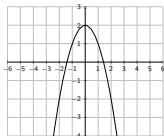
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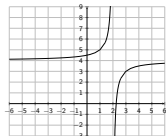
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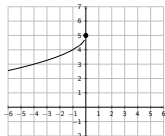
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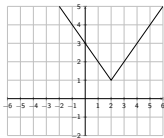
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Transformations - exercises

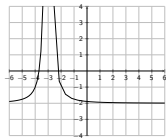
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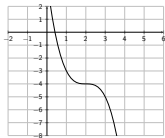
$$f(x) = |x - 2| + 1$$

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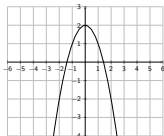
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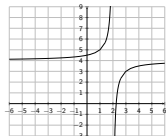
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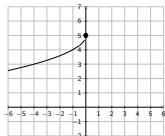
$$f(x) = -x^2 + 2$$

4



$$f(x) = -\frac{1}{x-2} + 4$$

6



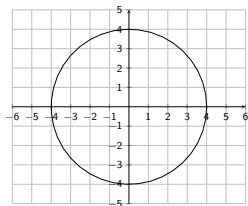
$$f(x) = -\sqrt{-x} + 5$$

Function vs. relation with desmos - exercises

Graph $x^2 + y^2 = 16$

Function vs. relation with desmos - exercises

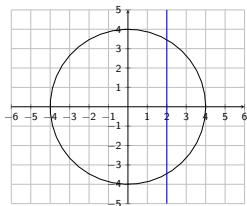
Graph $x^2 + y^2 = 16$



Circle with center $(0, 0)$ and radius 4
Is this the graph of a function?

Function vs. relation with desmos - exercises

Graph $x^2 + y^2 = 16$



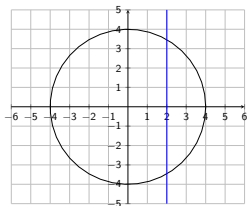
Circle with center $(0,0)$ and radius 4

Is this the graph of a function?

No! ✗ Use Vertical Line Test!

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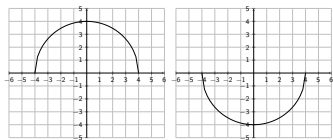
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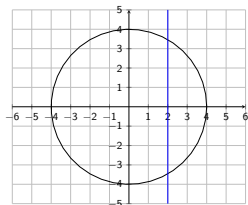
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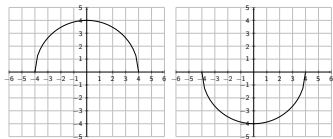
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Use the vertical line test to determine if the given equation is a function or a relation.

❶ $x^2 + 2y^2 = 8$

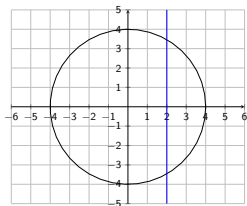
❸ $y + x + y^2 = 1$

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❹ $3x^2 + y^3 + 5xy = 7$

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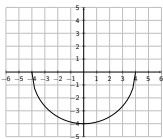
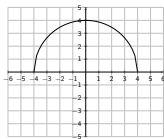
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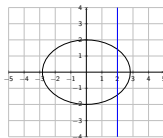
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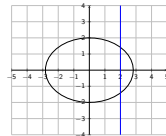


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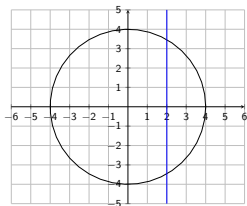
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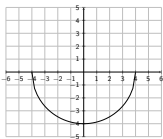
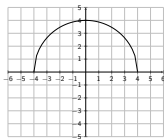
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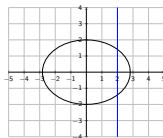
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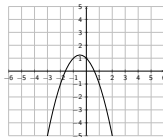
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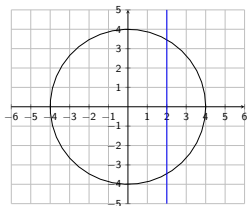


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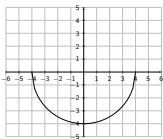
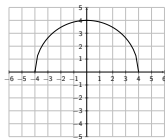
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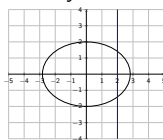
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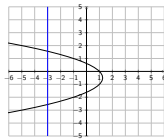
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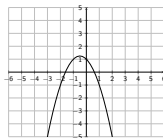
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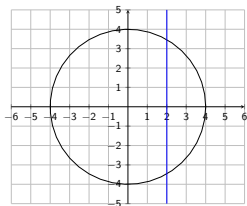


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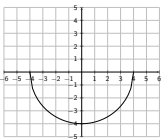
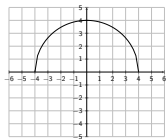
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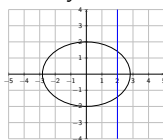
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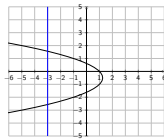
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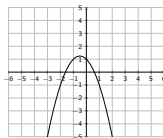
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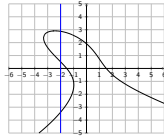
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Domain and range with desmos - exercises

Find the domain and range of the function.

1 $f(x) = x^4 - 3x^2 - 3$

3 $f(x) = 2 + \sqrt{3 - x}$

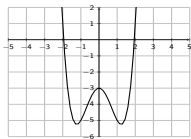
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Domain: $D = \mathbb{R}$

Range: $R = [-5.25, \infty)$

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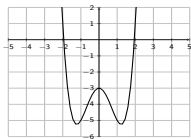
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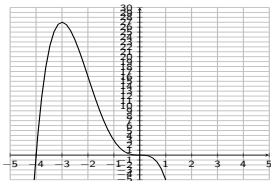
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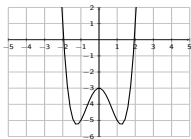
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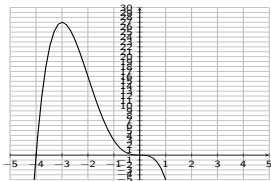
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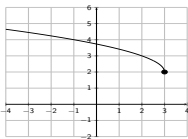
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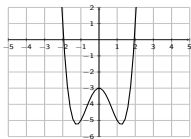
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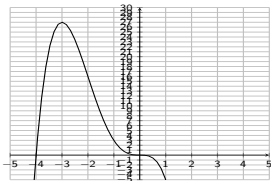
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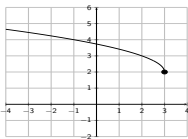
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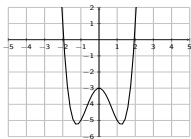
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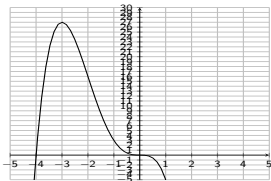
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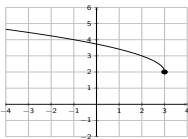
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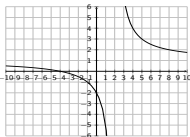
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Domain: $D = \mathbb{R} - \{2\}$
Range: $R = \mathbb{R} - \{1\}$
Note: $f(2)$ is undefined

