Task Model 1
 	
Response Type: Graphing
 	
DOK Level 2
 	
F-IF.C.7
Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
a. Graph linear and quadratic functions and show intercepts, maxima, and minima.
b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.
c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.
e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.
 	
Evidence Required:
1. Students graph functions expressed symbolically and show key features of the graph.
 	
Tools: None
 	
Accessibility Note:
Graphing items are not currently able to be Brailled. Minimize the number of items developed to this TM.
	Prompt Features: The student is prompted to graph a simple function and show key features.
	
	Stimulus Guidelines:
	• Graphs in answer choices must be within a -20 to 20 coordinate grid, unless otherwise specified.
	• Functions must be chosen so that Key Features fit on the grid.
	• Key Features are values that can be interchangeable on a per item basis, e.g., "Which of these is the *x*-intercept of the function?"
	• The Key Feature being tested must correspond to a whole number or a decimal to the tenths place: see Stimulus guidelines within task models.
	• Linear functions will:
	  ○ be in the form of $f(x) = mx + b$
	  ○ $0 \leq m \leq 10$, $0 \leq x \leq 10$, and $0 \leq b \leq 10$
	• Key Features for linear include:
	  ○ slope
	  ○ *x*-intercept
	  ○ *y*-intercept
	• The quadratic function may take the following forms:
	  a) $f(x) = ax^2 + bx + c$
	  b) $f(x) = a(x - h)^2 + k$
	  c) $f(x) = a(x - r_1)(x - r_2)$
	• Key Features for quadratic include:
	  ○ *x*- intercepts and/or *y*-intercept
	  ○ increasing interval and/or decreasing interval
	  ○ positive interval and/or negative interval
	  ○ vertex
	  ○ symmetries
	  ○ end behavior
	• Square Roots functions will:
	  ○ take the form $f(x) = a\sqrt{x - h} + k$
	  ○ *a* is 1 or -1
	  ○ *h* and *k* are single digit integers
	  ○ *h* and *k* must be chosen so that there are *x*- and *y*-intercepts (e.g. not a function like $f(x) = \sqrt{x - 3} + 1$)
	• Cube Roots functions will:
	  ○ have the form $f(x) = a\sqrt[3]{x - h} + k$
	  ○ *a* is 1 or -1
	  ○ *h* and *k* are single digit integers
	• Piecewise functions will:
	  ○ have pieces that are linear, quadratic, square roo
	• Absolute Value functions will:
	  ○ have the form $f(x) = a\|x - h\| + k$
	  ○ *a* is rational
	  ○ *h* and *k* are single digit integers
	• Key Features for square root, absolute value, and piecewise include:
	  ○ *x*- intercepts and/or *y*-intercepts
	  ○ increasing interval and/or decreasing interval
	  ○ positive interval and/or negative interval
	  ○ points on the graph that correspond to relative

Task Model 1

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DOK Level 2

F-IF.C.7
Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

a. Graph linear and quadratic functions and show intercepts, maxima, and minima.
b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.
c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.
e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

Evidence Required:
1. Students graph functions expressed symbolically and show key features of the graph.

Tools: None

Accessibility Note:
Graphing items are not currently able to be Brailled. Minimize the number of items developed to this TM.

- maximum and/or relative minimum values of the function
  - symmetries
  - end behavior
- Polynomials will:
  - be factorable over the rational numbers or written in factored form
- Key Features for polynomials include:
  - *x*- and *y*-intercepts (some polynomials will have only one *x*-intercept, e.g. $f(x) = x^3$-27)
  - points on the graph that correspond to relative maximum and minimum values of the function
  - end behavior
- Logarithmic functions:
  - must be in the form $f(x) = a\log(x \pm h) \pm k$ or $f(x) = a \cdot ln(x \pm h) \pm k$
- Exponential functions:
  - must be in the form $f(x) = b^{x-h} \pm k$
  - where $1 < b \leq 100$, *h* and *k* are single digit integers.
- Key Features for exponential and logarithmic functions include:
  - *x*- and *y*-intercepts
  - end behavior
  - vertical asymptotes
- Functions must be chosen so that requested Key Features exist; for example, some exponential functions do not cross one of the axes, such as $f(x) = 3^{x-1} + 4$, and $f(x) = \log(x - 4) + 2$.
- Item difficulty can be adjusted via these example methods, but are not limited to these methods:
  - Linear, quadratic, absolute value, square root, cube root, polynomials, piecewise, logarithmic, exponential.

TM1a
Stimulus: The student is presented with a function and a coordinate grid.

Example Stem 1: Given a linear function with a slope of $\frac{2}{3}$ and a *y*-intercept of 2:
- Using the Add Arrow tool, draw a line on the coordinate grid to graph the function.
- Place a point on the line representing the *x*-intercept of the function.

Example Stem 2: Given the function $y = \frac{2}{3}x + 2$,
- Using the Add Arrow tool, draw a line on the coordinate grid to graph the function.
- Place a point on the line representing the *x*-intercept of the function.

Example Stem 3: Given the function $y = \frac{1}{2}|2x - 1| + 2$,
- Use the Add Arrow tool to create a graph that represents the function.

Task Model 1

Response Type: Graphing

DOK Level 2

F-IF.C.7
Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

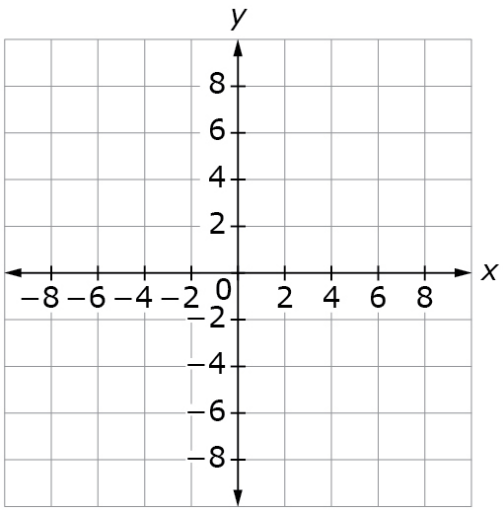
d. Graph linear and quadratic functions and show intercepts, maxima, and minima.
e. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.
f. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.
f. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

Evidence Required:
2. Students graph functions expressed symbolically and show key features of the graph.

Tools: None

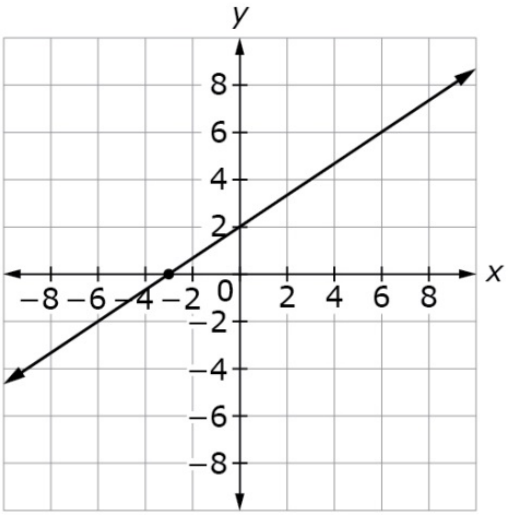
Accessibility Note:
Graphing items are not currently able to be Brailled. Minimize the number of items developed to this TM.

- Place a point on the coordinate grid to show the *y*-intercept of the function.

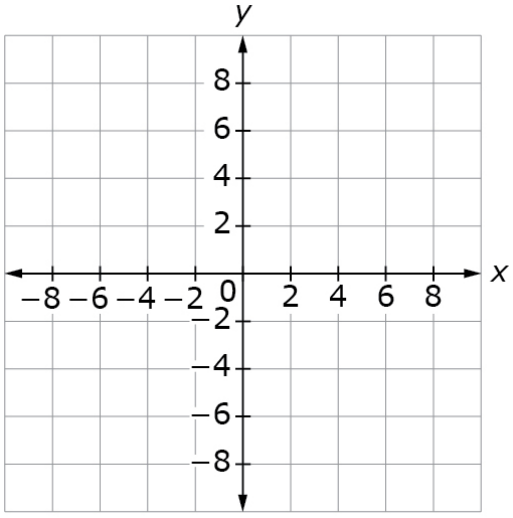


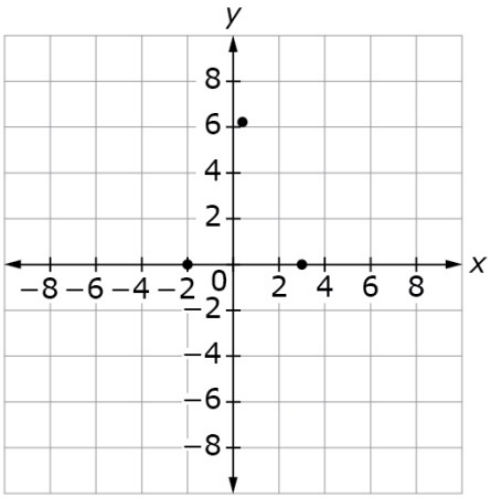
Interaction: The student will graph lines using the Add Arrow tool and/or plot points using the Add Point tool.

Rubric: (2 points) The student graphs the correct line and plots the point at the correct location that represents a key feature [e.g., Example Stem 1, draws a correct line and plots the *x*-intercept located at (-3, 0)].
(1 point) The student graphs the correct line or plots the point at the correct location that represents a key feature [e.g., Example Stem 1, draws a correct line OR plots the *x*-intercept located at (-3, 0)].



Response Type: Graphing

Task Model 1 **Response Type: Graphing** **DOK Level 2** **F-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic functions and show intercepts, maxima, and minima. b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude. **Evidence Required:** 1. Students graph functions expressed symbolically and show key features of the graph. **Tools:** Calculator **Version 3 Update:** Retired example stems 4, 5, and 6.	**Prompt Features:** The student is prompted to graph a complicated function, using the calculator tool, and show key features. **Stimulus Guidelines: (same as TM1a)** **TM1b** **Stimulus:** The student is presented with a function and a coordinate grid. **Example Stem 1:** Given the function $y = -x^2 + x + 6$, • Place a point on the coordinate grid to show each *x*-intercept of the function. • Place a point on the coordinate grid to show the maximum value of the function. **Example Stem 2:** Given the function $y = \sqrt{x+4} - 1$, • Place a point on the coordinate grid to show each *x*-intercept of the function • Place a point on the coordinate grid to show the *y*-intercept of the function. **Example Stem 3:** Given the function $y = \sqrt[3]{x-1} + 2$, • Place a point on the coordinate grid to show the *x*-intercept of the function. • Place a point on the coordinate grid to show the *y*-intercept of the function. [Retired example stems 4, 5, and 6.] **Example Stem 7:** Given the function $y = 8\log(x+4)$, • Place a point on the coordinate grid to show the *x*-intercept of the function. • Place a point on the coordinate grid to show the *y*-intercept of the function. 

	Interaction: The student will graph lines using the Add Arrow tool appropriate to the example stem (single or double) and/or plot points using the Add Point tool. **Rubric:** (2 points) The student plots the correct points that represent each different key feature. (e.g., Example Stem 1, student plots both *x*-intercepts and the maximum value). (1 point) The student correctly plots 1 of 2 key features called (e.g., in Example Stem 1, student plots the maximum value only OR both *x*-intercepts only.)  Note: Both *x*-intercepts represent one key feature so both are required to earn a point. For example, in Example Stem 1 both *x*-intercepts represent one key feature (1 point), and the maximum point represents another key feature (1 point). **Response Type:** Graphing

Task Model 2 **Response Type: Equation/Numeric** **DOK Level 2** **F-IF.C.8a** Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function: a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. **Evidence Required:** 2. Students write a quadratic function defined by an expression in equivalent factored form and completing the square form to reveal zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. **Tools:** None	**Prompt Features:** Students are prompted to rewrite a quadratic to reveal the key features of its graph. **Stimulus Guidelines**: The student is presented with a quadratic function used in a context. The quadratic function is: • given in the form of $ax^2 + bx + c$, • or in factored form if factorable, which is $a(x - r_1)(x - r_2)$ or in completed square form, which is $a(x - h)^2 + k$, where $h = -b/2a$ and $k = c - b^2/4a$ **TM2a** **Stimulus:** The student is presented with a quadratic function. **Example Stem:** Enter an equation for the line of symmetry for the function defined by $f(x) = -8x^2 + 16x + 2$. **Rubric:** (1 point) The student enters the correct equation (e.g., $x = 1$). **Response Type:** Equation/Numeric

Task Model 3

Response Type:
Matching Table

DOK Level 1

F-IF.C.8b
Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function:

b. Use the properties of exponents to interpret expressions for exponential functions. *For example, identify percent rate of change in functions, such as* $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, $y = (1.2)^{t/10}$, *and classify them as representing exponential growth or decay.*

Evidence Required:
3. Students write an exponential function defined by an expression in an equivalent form using the properties of exponents to reveal and explain different properties of the function and to classify them as representing exponential growth or decay.

Tools: None

Prompt Features: The student will use the properties of exponents to interpret expressions for exponential functions.

Stimulus Guidelines:

- Exponential functions will:
  - be given in the form of $f(x) = ab^{(x-h)} + k$
  - h is a single digit integer
  - k is an integer, maximum value of 19
  - a = 1 or -1
  - b is a rational number, maximum value of 9; can be a non-repeating decimal.
- Key Features are values that can be interchangeable on a per item basis, e.g., "Which of these is the growth rate of the exponential function?"
- Key Features include:
  - end behavior
  - rates of growth or decay
- The Key Feature being tested must correspond to a whole number or a decimal to the tenths place: see Stimulus guidelines within task models.
- Item difficulty can be adjusted to these example methods, but are not limited to these methods:
  - Interpreting growth vs. decay
  - Rewriting exponentials

TM3
Stimulus: The student is presented with multiple functions.

Example Stem: Determine whether each function represents exponential growth or decay. Select the correct option for each function.

Function	Growth	Decay
$f(x) = \left(\frac{1}{2}\right)^x$		
$f(x) = \left(\frac{3}{2}\right)^{4x}$		
$f(x) = \left(\frac{7}{8}\right)^{4x}$		
$f(x) = \left(\frac{4}{3}\right)^{\frac{x}{12}}$		
$f(x) = 3\left(\frac{1}{3}\right)^{\frac{x}{12}}$		

Rubric:
(1 point) The student correctly sorts the exponential functions (e.g., Decay, Growth, Decay, Growth, Decay).

Response Type: Matching Table

Task Model 4
 	
Response Type: Matching Table
 	
DOK Level 2
 	
F-IF.C.9
Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*
 	
Evidence Required:
4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions).
 	
Tools: Calculator
	Prompt Features: Students will identify the relationships, common properties, or key features shared between two functions represented in different ways.
	
	Stimulus Guidelines:
	• Functions include: linear, quadratic, square root, cube root, piecewise-linear, absolute value, polynomial, exponential, and logarithmic functions.
	• Key Features are values that can be interchangeable on a per item basis.
	• Key Features include:
	  ○ maximum and minimum values (for quadratic, piecewise-defined, absolute value, and polynomial functions)
	  ○ end behavior (for square root and logarithmic functions: positive *x*-direction only)
	  ○ *x*-intercepts and y-intercepts (for *x*-intercepts, not exponential; for *y*-intercepts, not logarithmic)
	  ○ increasing and decreasing intervals
	  ○ lines of symmetry
	• The Key Feature being tested must correspond to a whole number or a decimal to the tenths place: see Stimulus guidelines within task models.
	• Item difficulty can be adjusted to these example methods, but are not limited to these methods:
	  ○ Functions come in table, graph or written description form.
	
	TM4a
	Stimulus: The student is presented with two functions that must be represented in two different ways. Functions can be represented as a table of values, a graph, a function equation, or a written description.

Task Model 4

Response Type:
Matching Table

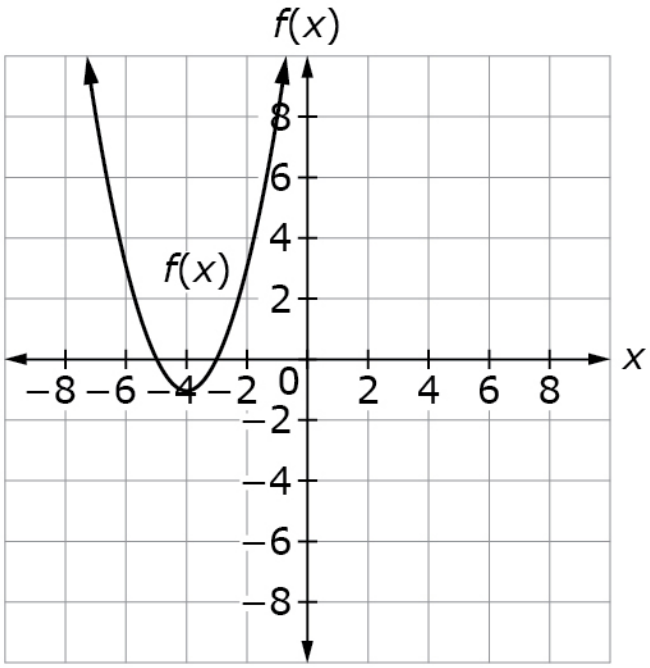
DOK Level 2

F-IF.C.9
Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*

Evidence Required:
4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions).

Tools: Calculator

Example Stem: The graph represents $f(x)$ and the table shows some values of another quadratic function $g(x)$.



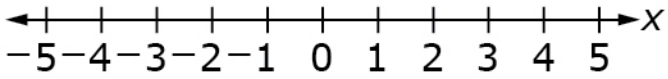
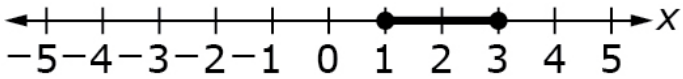
x	−4	−3	−2	−1	0	1	2	3	4	5	6
$g(x)$	0	−9	−16	−21	−24	−25	−24	−21	−16	−9	0

Select whether each statement is True or False about the given functions.

Statement	True	False
The minimum value of $f(x)$ is greater than the minimum value of $g(x)$.		
The value of x when $f(x)$ is at its minimum is less than the value of x when $g(x)$ is at its minimum.		

Rubric:
(1 point) The student correctly identifies each statement as True or False (e.g., TT).

Response Type: Matching Table

Task Model 4 **Response Type:** **Hot Spot** **DOK Level 2** **F-IF.C.9** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.* **Evidence Required:** 4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions). **Tools:** Calculator **Accessibility Note:** Hot Spot items are not currently able to be Brailled. Minimize the number of items developed to this TM.	**Prompt Features:** Students will select sections on a number line that represent an interval where two graphs have a shared key feature. **Stimulus Guidelines: (same as TM4a)** **TM4b** **Stimulus:** The student is given two different functions (square root, cube root, piecewise-defined, or absolute value) and a number line representing the *x*-axis, and asked to indicate where the functions have a shared key feature. **Example Stem:** In which interval(s) on the *x*-axis are the functions $f(x) = \frac{1}{2}\lvert 2x\rvert + 2$ and $g(x) = -2x^2 + 12x - 16$ increasing? Click the interval(s) on the number line that represents where **both** functions are increasing.  **Interaction:** The student will click on intervals on the number line using Hot Spots. **Rubric:** (1 point) The student clicks on the correct intervals (e.g., [1, 3]).  **Response Type:** Hot Spot

Task Model 4

Response Type: Matching Table

DOK Level 2

F-IF.C.9
Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*

Evidence Required:
4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions).

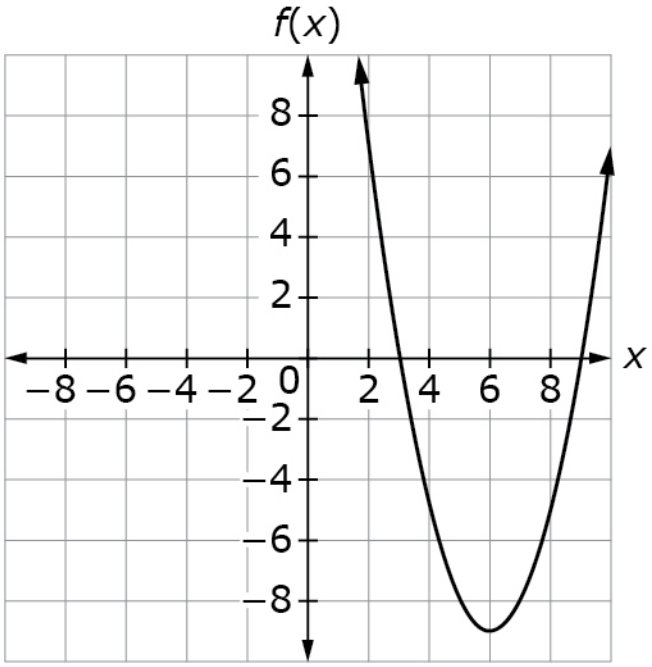
Tools: None

Prompt Features: Students will identify the relationships, common properties, or key features shared between two functions represented in different ways.

Stimulus Guidelines: (same as TM4a)

TM4c
Stimulus: The student is presented with the graph of a quadratic function and a table of equations that may or may not represent the function.

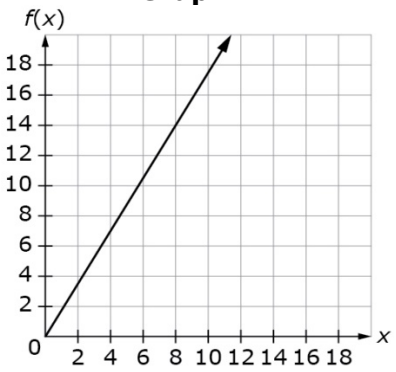
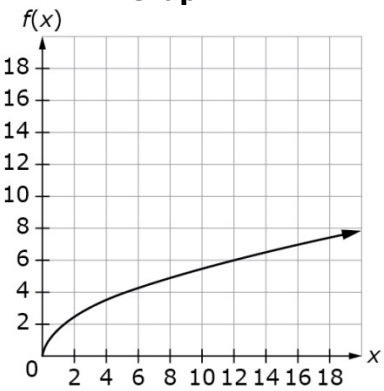
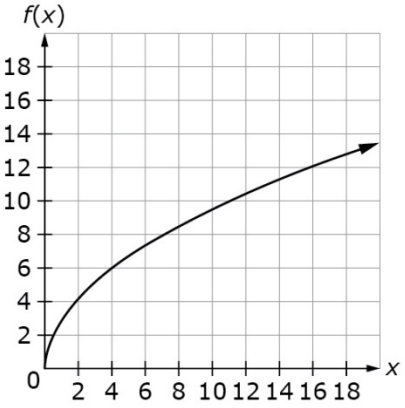
Example Stem: Determine whether each equation in the table represents the graph of the function shown. Select Yes or No for each equation.



Function	Yes	No
$f(x) = (x - 3)(x - 9)$		
$f(x) = (x + 3)(x - 9)$		
$f(x) = (x + 6)(x - 9)$		
$f(x) = (x - 3)^2 - 18$		
$f(x) = (x - 6)^2 - 9$		

Rubric:
(1 point) Student correctly selects the functions that could be represented by the given graph (e.g., YNNNY).

Response Type: Matching Table

Task Model 4 **Response Type: Matching Table** **DOK Level 2** **F-IF.C.9** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.* **Evidence Required:** 4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions). **Tools:** None	**TM4d** **Stimulus:** The student is presented with three functions in various forms (graphs, table of values, etc.) and a matching table that includes the equations of the three functions. **Note:** If tables are given, the ordered pairs should show key features (zeros, etc.). **Example Stem 1:** Select the appropriate box to indicate the match of each graph to its equation. **Graph A**  **Graph B**  **Graph C** 

Task Model 4

Response Type:
Matching Table

DOK Level 2

F-IF.C.9
Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*

Evidence Required:
4. Students compare properties of two functions represented in different ways (e.g., as equations, tables, graphs, or written descriptions).

Tools: None

Equation	Graph A	Graph B	Graph C
$f(x) = x\sqrt{3}$			
$f(x) = 3\sqrt{x}$			
$f(x) = \sqrt{3x}$			

Rubric:
(1 point) The student correctly matches the functions with the graph (e.g., Table A, Table C, Table B).

Example Stem 2: Select the appropriate box to indicate the match of each table of values to its equation.

Table A

x	*f*(*x*)
1	1.73
2	3.46
4	6.92
6	10.38
8	13.84

Table B

x	*f*(*x*)
1	1.73
2	2.45
4	3.46
6	4.24
8	4.90

Table C

x	*f*(*x*)
1	3.00
2	4.24
4	6.00
6	7.35
8	8.49

Equation	Table A	Table B	Table C
$f(x) = x\sqrt{3}$			
$f(x) = 3\sqrt{x}$			
$f(x) = \sqrt{3x}$			

Rubric:
(1 point) The student correctly matches the functions with the table (e.g., Table A, Table C, Table B).

Response Type: Matching Table