Task Model 1

Response Type: Matching Table

DOK Level 1

F-IF.B.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

Evidence Required:
1. The student interprets key features of a graph or a table representing a function modeling a relationship between two quantities.

Tools: Calculator

Version 3 Update: Retired TM1a example stem 2.

Prompt Features: The student is prompted to identify true statements regarding key features of a given graph of a function that models a relationship between two quantities. The statements will be in the context of the relationship being modeled. Key features include the following:

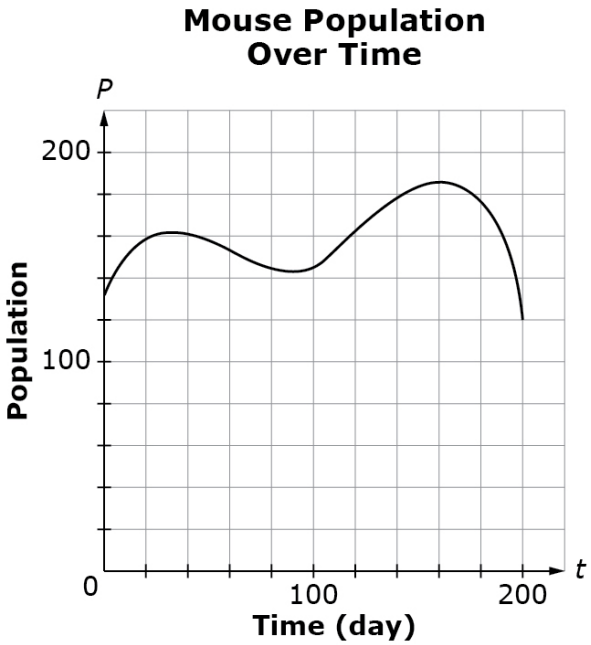
- intercepts
- intervals where the function is increasing or decreasing, positive or negative
- relative maximums and minimums
- symmetries
- asymptotes or end behavior
- periodicity

Stimulus Guidelines:

- Item difficulty can be adjusted via these example methods, but is not limited to these methods:
  - The graph or table represents a function with either one relative maximum or minimum (e.g., quadratic).
  - The graph or table represents a function with multiple relative maximums or minimums.

TM1a
Stimulus: The student is given a graph representing a function that models the relationship between two quantities in a real-world situation familiar to 15- to 17-year-olds, e.g., temperature change over time, or population change over a period of time.

Example Stem: This graph shows the population of mice in a study, modeled as a function of time. The study begins on day 0 and ends on day 200.



Determine whether each statement is true according to the graph. Select True or False for each statement.

Task Model 1

Response Type: Matching Table

DOK Level 1

F-IF.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

Evidence Required:
1. The student interprets key features of a graph or a table representing a function modeling a relationship between two quantities.

Tools: Calculator

Version 3 Update: Retired TM1a example stem 2.

Statement	True	False
The mouse population was decreasing between day 40 and day 80.		
The least number of mice during the study was 130.		
The mouse population was at its greatest around day 160.		
There are two intervals of time where the mouse population is decreasing.		

Rubric: (1 point) The student correctly selects true or false for each of the interpretations of key features of the graph (e.g. T, F, T, T).

Response Type: Matching Table

Task Model 1

Response Type: Hot Spot

DOK Level 1

F-IF.B.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

Evidence Required:
1. The student interprets key features of a graph or a table representing a function modeling a relationship between two quantities.

Tools: Calculator

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

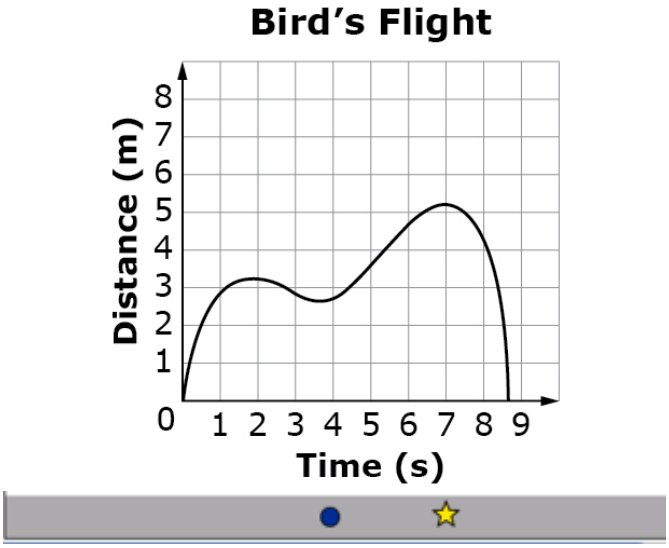
Prompt Features: The student is prompted to identify points on a given graph that correspond to key features of events within a contextual situation. The graph is the representation of a function modeling the contextual situation. Key features include the following:

- intercepts
- intervals where the function is increasing or decreasing, positive or negative
- relative maximums and minimums
- symmetries
- asymptotes or end behavior
- periodicity

Stimulus Guidelines: (same as TM1a)

TM1b
Stimulus: The student is given a graph representing a function that models the relationship between two quantities in a real-world situation familiar to 15- to 17-year-olds, e.g., temperature change over time, or population change over a period of time.

Example Stem: A bird flies out of its nest. This graph represents the distance it flies from its nest (in meters) as a function of time (in seconds).



Drag the star to mark the point on the graph that represents the bird's greatest distance from its nest. Then drag the circle to mark the point that represents the bird's return to its nest.

Interaction:
The student drags the star and circle to the correct points on the graph.

Rubric: (1 point) The student correctly identifies the point representing the bird's farthest distance from the nest and the point where the bird returns [e.g., approximately (7, 5.2) and (8.7, 0)].

Response Type: Hot Spot

Task Model 2

Response Type: Graphing

DOK Level 2

F-IF.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

Evidence Required:
2. The student sketches graphs showing key features given a verbal description of a relationship between two quantities that can be modeled with a function.

Tools: Calculator

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 sketch a graph (or points on a graph) showing key features given a verbal description of a relationship between two quantities. Key features include the following:

- intercepts
- intervals where the function is increasing or decreasing, positive or negative
- relative maximums and minimums
- symmetries
- asymptotes or end behavior
- periodicity

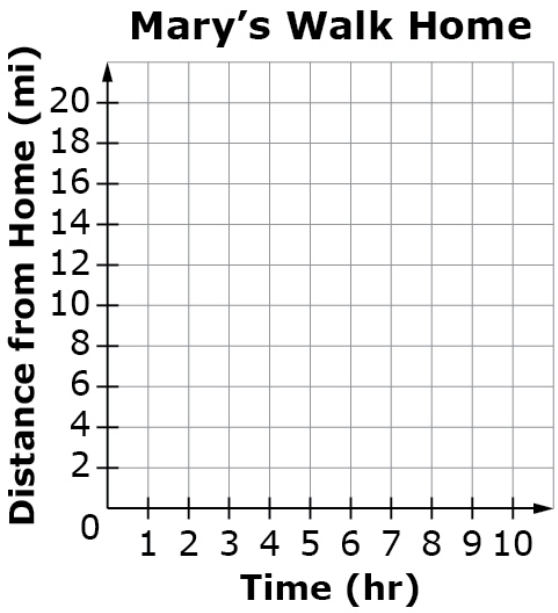
Stimulus Guidelines:

- Item difficulty can be adjusted via these example methods, but is not limited to these methods:
  - A linear relationship that includes
    - a rate and an intercept, or
    - two intercepts.

TM2
Stimulus: The student is presented with a contextual situation, familiar to 15- to 17-year-olds, where a function can model a relationship between two quantities.

Example Stem 1: Mary is 10 miles from her home.

- She is returning home, walking at a constant speed of 2 miles per hour.
- Her distance from home can be modeled as a function of time.



Use the Add Point and Connect Line tools to graph Mary's distance from home as a function of time.

Task Model 2

Response Type: Graphing

DOK Level 2

F-IF.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

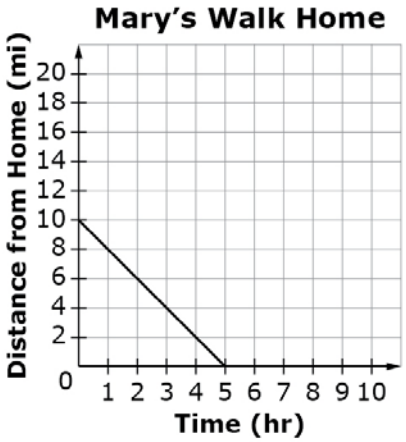
Evidence Required:
2. The student sketches graphs showing key features given a verbal description of a relationship between two quantities that can be modeled with a function.

Tools: Calculator

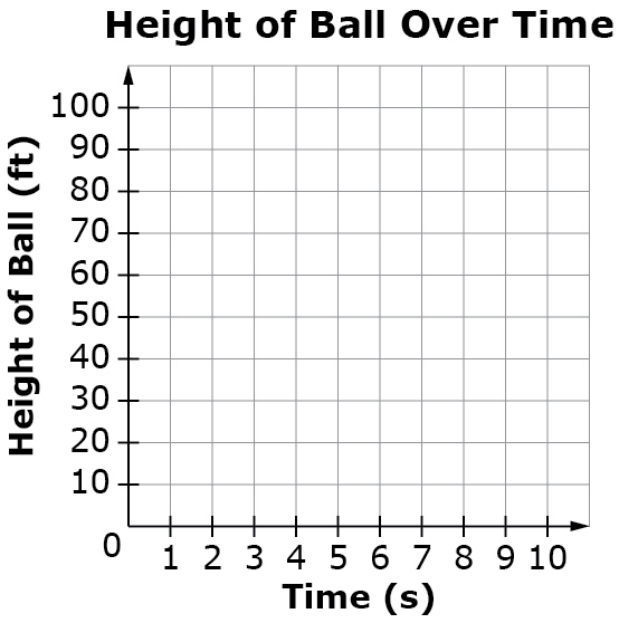
Accessibility Note:
Graphing items are not currently able to be Brailled. Minimize the number of items developed to this TM.

Interaction: The student uses the Add Point tool to place points on the grid, and the Connect Line tool to connect the points.

Rubric: (1 point) The student creates the graph correctly (e.g., see below).



Example Stem 2: A ball is on the ground. Jon kicks the ball into the air at $s = 0$. Assume that the height of the ball can be modeled as a quadratic function with respect to time. It reaches a maximum height of 64 feet and lands on the ground 4 seconds later.



Use the Add Point tool to plot the points on the grid that represent

- when John kicks the ball,
- the ball at its highest point, and
- when the ball lands on the ground.

Interaction: The student uses the Add Point tool to place points on the grid.

Task Model 2

Response Type: Graphing

DOK Level 2

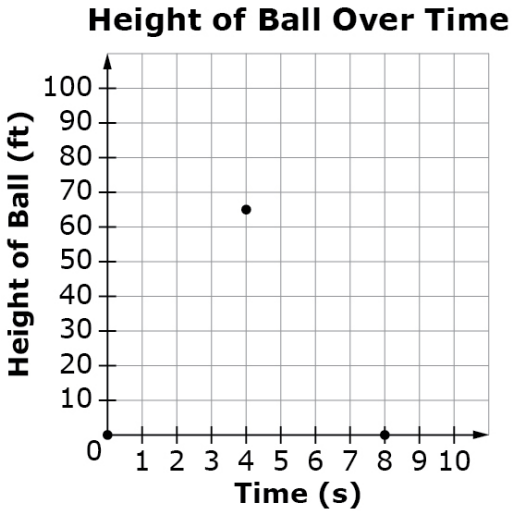
F-IF.4
For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.*

Evidence Required:
2. The student sketches graphs showing key features given a verbal description of a relationship between two quantities that can be modeled with a function.

Tools: Calculator

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

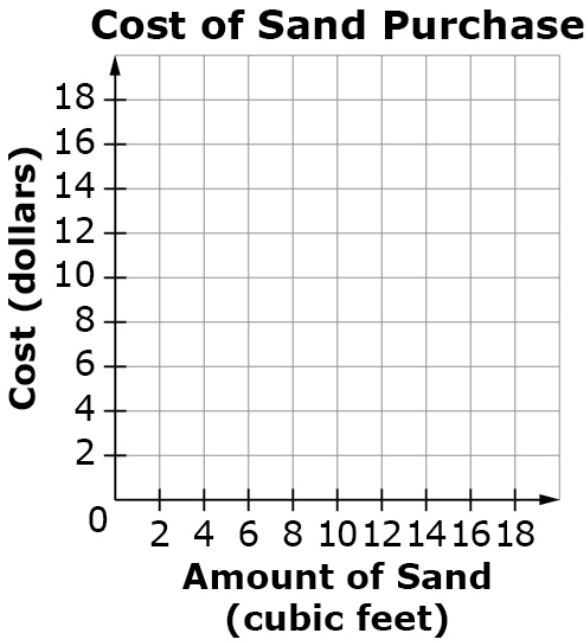
Rubric:
(1 point) The student plots the points correctly (e.g., see below).

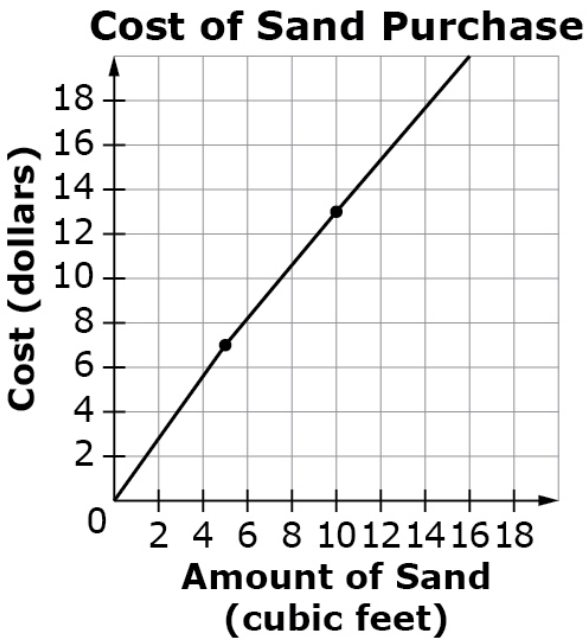


Example Stem 3: A company is building a playground and needs to buy sand. The cost of sand is a function of the amount of sand purchased.

- The first 5 cubic feet cost $1.50 per cubic foot.
- An amount greater than 5 cubic feet and less than or equal to 10 cubic feet costs $1.25 per cubic foot.
- An amount over 10 cubic feet costs $1.00 per cubic foot.

Use the Add Point and Connect Line tools to create a graph to show the total cost of the sand (in dollars) as a function of the amount of sand purchased (in cubic feet).



Task Model 2 **Response Type: Graphing** **DOK Level 2** **F-IF.4** For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* **Evidence Required:** 2. The student sketches graphs showing key features given a verbal description of a relationship between two quantities that can be modeled with a function. **Tools:** Calculator **Accessibility Note:** Graphing items are not currently able to be Brailled. Minimize the number of items developed to this TM.	**Interaction:** The student uses the Add Point tool and Connect Line tool to graph the linear segments of a piecewise function on the grid. **Rubric:** (1 point) The student creates the graph correctly (e.g. see below).  **Response Type:** Graphing

Task Model 3

Response Type: Multiple Choice, single correct response

DOK Level 2

F-IF.5
Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*

Evidence Required:
3. The student relates the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

Tools: Calculator

Prompt Features: The student is prompted to relate the domain of a function to its graph and to the quantitative relationship it describes.

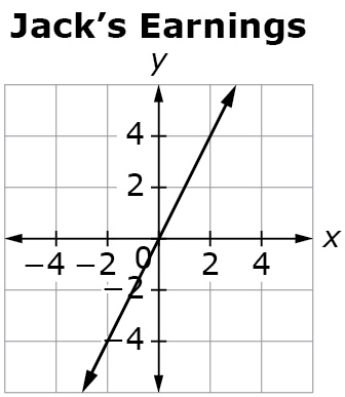
Stimulus Guidelines:

- The graphs must represent linear, quadratic, and other polynomial functions defined by a context and apply appropriate labels and scales.
- Item difficulty can be adjusted via these example methods, but is not limited to these methods:
  - Representing a linear function
  - Representing a quadratic function
  - Representing an exponential function
  - Representing a trigonometric function

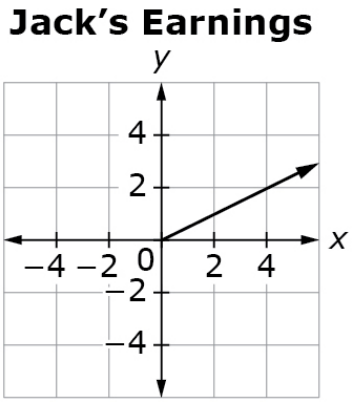
TM3a
Stimulus: The student is presented with four graphs of a function in the coordinate plane, with the graphs in various intervals of positive and negative *x*-values.

Example Stem: Select the graph that correctly represents the amount of money, *y*, Jack earns doing chores for *x* hours at $2 per hour.

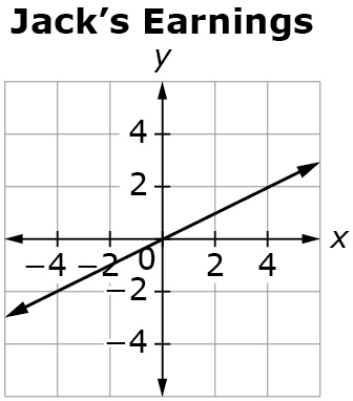
A.



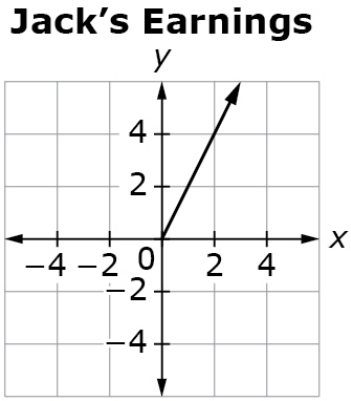
B.



C.



D.



Rubric: (1 point) The student identifies the correct graph (e.g., D).

Response Type: Multiple Choice, single correct response

Task Model 3 **Response Type: Multiple Choice, single correct response** **DOK Level 2** **F-IF.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.* **Evidence Required:** 3. The student relates the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. **Tools:** Calculator	**Prompt Features:** The student is prompted to select the correct statement describing the domain a function modeling a contextual situation. **TM3b** **Stimulus:** The student is presented with a contextual situation, and asked to identify the domain of the function modeled by the given situation. **Example Stem:** Billy buys light bulbs in packs of 8 for $20. The shipping cost is $10 regardless of the number of packs bought. Billy has only $120 to spend. If n is the number of packs of lightbulbs bought, then the cost per lightbulb, C, can be modeled as a function of n. Select the statement that correctly describes the domain of the function. A. The domain is the set of all **real numbers** $1 \leq n \leq 6$. B. The domain is the set of all **real numbers** $1 \leq n \leq 5$. C. The domain is the set of all **integers** $1 \leq n \leq 6$. D. The domain is the set of all **integers** $1 \leq n \leq 5$. **Rubric:** (1 point) The student correctly selects the statement describing the domain or range of the function (e.g., D). **Response Types:** Multiple Choice, single correct response

Task Model 3

Response Type: Multiple Choice, multiple correct response

DOK Level 2

F-IF.5
Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*

Evidence Required:
3. The student relates the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

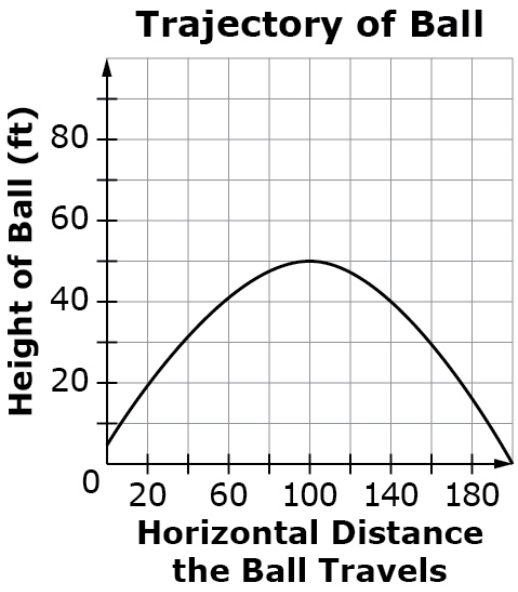
Tools: Calculator

Version 3 Update:
Retired the first example stem for TM3c. Added new TM3d.

Prompt Features: The student is prompted to select the correct statement describing the domain or range of a function modeling a contextual situation.

TM3c
Stimulus: The student is presented with a description and graph of contextual situation, and asked to identify all values that are in the domain of the function modeled by the given situation.

Example Stem: Sue hits a ball from a height of 4 feet. The height of the ball above the ground is a function of the horizontal distance the ball travels until it comes to rest on the ground. Consider this complete graph of the function.



Select **all** values that are in the domain of the function as shown in the graph.

A. –5 feet
B. 0 feet
C. 60 feet
D. 220 feet

Rubric: (1 point) The student correctly selects the values that are within the domain (e.g., B, C).

Response Types: Multiple Choice, multiple correct response

Task Model 3

Response Type: Matching Table

DOK Level 2

F-IF.5
Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*

Evidence Required:
3. The student relates the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

Tools: Calculator

Version 3 Update:
Retired the first example stem for TM3c. Added new TM3d.

Prompt Features: The student is prompted to select an appropriate domain of a function modeling a contextual situation.

TM3d
Stimulus: The student is presented with an equation and several descriptions of contextual situations, and asked to identify appropriate values of the domain of the function modeled by the given situations.

Example Stem: Consider the function $f(x) = 10x + 25$. Identify an appropriate domain for the function if it is used to model each of the following contexts.

	An interval of real numbers	**A subset of the integers**
The total value $f(x)$ in cents of a handful of x dimes and 1 quarter.		
The amount of water $f(x)$ in a tank that starts with 25 gallons of water and is being filled by a hose at 10 gallons per hour after x hours.		
The total money raised $f(x)$ if x people donate \$10 each and one person donates \$25.		

Rubric: (1 point) The student correctly identifies the appropriate kind of domain (integers, reals, integers).

Response Types: Matching Table

Task Model 4

Response Type: Multiple Choice, single correct response

DOK Level 2

F-IF.6
Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

Evidence Required:
4. The student calculates and interprets the average rate of change of a function presented symbolically or as a table and estimates the rate of change of a function from a graph.

Tools: Calculator

Version 3 Update:
Retired TM4b.

Prompt Features: The student is prompted to calculate the average rate of change of a given function over the specified interval, in terms of a context.

Stimulus Guidelines:

- Item difficulty can be adjusted via these example methods, but is not limited to these methods:
  - The function is presented as a table.
  - The function is presented symbolically as a linear equation.
  - The function is presented symbolically as a quadratic or exponential equation.

TM4a
Stimulus: The student is presented with a function in symbolic form, representing a context familiar to 15- to 17-year-olds.

Example Stem: Craig records the number of minutes, *m*, it takes him to mow *n* lawns in a table.

n	1	2	3	4	5	6
m(*n*)	33	64	89	109	124	139

Select the average amount of time per lawn it takes Craig to mow the **first 4 lawns**. Round to the nearest minute per lawn.

A. 25 minutes per lawn
B. 27 minutes per lawn
C. 33 minutes per lawn
D. 74 minutes per lawn

Rubric: (1 point) The student identifies the correct value for the average rate of change (e.g., B).

Response Types: Multiple Choice, single correct response

Task Model 4 **Response Type: Equation/Numeric** **DOK Level 2** **F-IF.6** Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph. **Evidence Required:** 4. The student calculates and interprets the average rate of change of a function presented symbolically or as a table and estimates the rate of change of a function from a graph. **Tools:** Calculator **Version 3 Update:** Retired TM4b.	**Prompt Features:** The student is prompted to calculate the average rate of change of a given function over the specified interval, in terms of a context. **Stimulus Guidelines:** • Item difficulty can be adjusted via these example methods, but is not limited to these methods: ○ The function is presented as a table. ○ The function is presented symbolically as a linear equation. ○ The function is presented symbolically as a quadratic or exponential equation. **TM4c** **Stimulus:** The student is presented with a nonlinear function in symbolic form. **Example Stem:** During the first years of growth the height of a tree can be modeled with the function $h = -t^2 + 12t + 10$, where *t* is the time in years since being planted and *h* is the height in inches**.** Enter the average rate of change, in inches per year, from year 1 to year 5. **Rubric:** (1 point) The student enters the correct answer for the average rate of change given the units (e.g., 6). **Response Type:** Equation/Numeric