youcubed at Stanford University

Patterns and Functions Unit

This unit was created by Math for America Fellows Yekaterina Milvidskaia and Tiana Tebelman who teach 8th Grade Mathematics at Vista Magnet Middle School in Vista, CA.

This unit contains 15 lessons (including a quiz and an assessment). The lessons are based on classes that are 84 minutes long.

The goal of this unit is to show students the importance of looking for patterns and why there is a need to generalize them, especially if there is a very large figure number. Through this unit, students will have to make sense of and look for structure in the patterns. Students will learn to justify their reasoning mathematically and visually. They will be asked to construct mathematical arguments and challenge the reasoning of others. In this unit students will learn about functions and relations and different ways to represent them. Lastly, this unit will give students the foundation they need to be successful with linear functions, which is one of the most important concepts in Math 8. By the end of this unit students will understand various ways to represent functions and know how to create a general rule.

This unit addresses three essential questions:
1. Why do mathematicians look for patterns?
2. Why do I need to generalize a pattern?
3. What are different ways that I can represent a function?

The Math 8 Common Core State Standards addressed are:
Functions: F.A.1, F.A.2, F.A.5
Mathematical Practices (MPS) 1, 2, 3, 6, 7, 8

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

General Structure for Daily Lessons

General Structure for Guiding Question (GQ) Quick Write

Each lesson will begin with a GQ Quick Write. Students will write down the GQ and then reflect on the GQ independently (typically 5 minutes). It is important to explain to students that they are writing down their initial ideas and opinions on the question. The students are not expected to know how to fully or correctly answer the question yet. After the students have reflected individually, you can have students pair-share with a partner and finally have students share with the whole class. The GQ should be revisited toward the end of the lesson for further reflection. Often times we ask students to add their new ideas or what they learned that day to their initial reflection.

General Structure for the Patterns and Problems

1) Independent Work (typically 5-7 minutes): Students will begin working independently. Students should write down their initial ideas or questions that they have about the problem. They are expected to come to their group with something to share or a question to ask.

**Note: If students have already worked on the pattern or problem, then they don't need to do more independent work in class. Instead they can begin with the group work right away.*

2) Group Work (10-15 minutes before 1st class presentation): Students should work in groups of 3-4 students to collaborate on the pattern or problem. Before the group work begins, the teacher should review expectations for group work. While students are sharing their ideas and working through the problems, the teacher walks around to each group and takes note of the different methods and misconceptions that students have. During group work, the role of the teacher is to be an observer and a questioner. The teacher should not be giving out hints or solutions.

3) Whole Class Student Presentations (typically 10-15 minutes):

The teacher should select student presenters that have various solutions and ways of thinking about the problem. These solutions do not need to be the correct solutions but rather presentations that would provide a thought provoking mathematical discussion. We recommend that the teacher selects students who have more tedious or messy solutions to present first, followed by students who have more simple or elegant solutions. This will help value the more tedious or messy solutions first, while allowing students to appreciate the more simple or elegant solutions later.

During whole class presentations the student presenters can write their solution on a whiteboard, SMART board, etc. or show their work under a document camera. It is important that the students explain their reasoning and thought process. While students are presenting the rest of the class should take notes on their ideas and be ready to ask clarifying questions or comments after the

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

presentation is finished. After a presentation it is a good idea to have other students paraphrase this group's ideas or strategies.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Homework Questions

The following questions are used throughout the unit. They are assigned on a daily basis for students to reflect upon what they learned in class.

Part 1: Written Response Questions

**Your responses to these questions should be very detailed! Please write in complete sentences on the left hand side of your homework notebook.*

1. What were the main mathematical concepts or ideas you learned today or that we discussed in class today?

2. What was the big mathematical debate about in class today? What did you learn from the debate?

3. What new vocabulary words or terms were introduced today? What do you believe each new word means? Give an example/picture of each word.

4. How did you or your group approach today's problem or problem set? Was your approach successful? What did you learn from your approach?

5. Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem?

6. What connections can you make between today's task and tonight's homework questions?

7. What questions do you still have about _____? If you don't have a question, write a similar problem and solve it instead.

8. How is _____ similar or different to _____?

9. What would happen if you changed _____?

10. What were some of your strengths and weaknesses in this unit? What is your plan to improve in your areas of weakness?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 1

Guiding Question:
Why do mathematicians look for patterns?

Lesson Objective:
Students will be able to make sense of the Border Problem and appreciate various methods of figuring out the total number of border squares. Students will look for structure and use this structure to figure out the total number of border squares in other figures.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Border Problem Introduction
4. Border Problem Part 1 a and Part 1 b

Homework:
Part 1: Written Response Questions
#4 How did you or your group approach today's problem or problem set? Was your approach successful? What did you learn from your approach?
#5 Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem?
#7 What questions do you still have about the Border Problem? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
The Border Problem Part 1 c & d
c) How many colored squares are in figure 1×10^6?
d) How can you determine how many colored squares will be in any figure?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

The Border Problem Introduction

Teacher's Script for the Border Problem Introduction:

- Without counting one by one, how many squares are in the colored border of the 10 x 10 grid? (Don't allow students to talk or write any ideas)
- Turn to your partner and talk to each other about what you got and how you figured it out.
- How many squares are there?
- Did any of you get a different answer?
- How many of you got 40 the first time? Can you explain how you got 40?
- Did any of you get 38 the first time? Can you explain how you got 38?
- Let's see some different methods for getting 36.
- How many of you understand _____'s method? Can you paraphrase it?
- How about a different method?
- How are these methods alike and different?

  Various Methods:

  - (4 x 10) - 4
  - 10 + 9 + 8 + 8
  - 10+ 10 +8 +8
  - (10 x 10)-(8 x 8)
  - 4 x 8+4

  If students do not come up with some of these methods, teacher can write them down ask students to explain how the expression relates to the diagram.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 1: The Border Problem Part 1 a & b

a) How many colored squares are in figure 6? Explain how you know.

b) How many colored squares are in figure 1,006? Explain how you know.

Example of a Square Border :

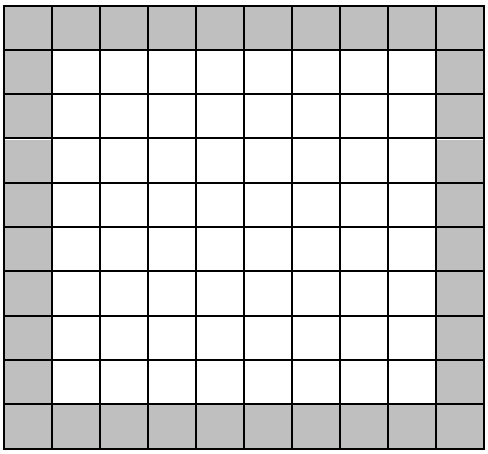


Figure 10

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 1 Homework: The Border Problem Part 1 c & d

c) How many colored squares are in figure 1×10^6? Explain how you know.

d) How can you determine how many colored squares will be in any figure? Justify your ideas.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 2

Guiding Question:
How are the different methods for figuring out the number of border squares similar and/or different to each other?

Lesson Objective:
Students will look for structure in the Border Problem and use this structure to figure out the total number of border tiles in other figures. Students will begin to generalize how to figure out the total number of squares for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework Border Problem Part 1 c & d
4. Border Problem Part 2 a and Part 2 b

Homework:
Part 1: Written Response Questions
#4 How did you or your group approach today's problem or problem set? Was your approach successful? What did you learn from your approach?
#5 Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem?
#7 What questions do you still have about the Border Problem? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
The Border Problem Part 2 c
c) If you have 256 squares can you use all of them to make a square border? If you can, what is the side length of the square? Explain your thinking with justification.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 2: The Border Problem Part 2 a & b

a) If you have 64 squares can you use all of them to make a square border? If you can, what is the side length of the square? Explain your thinking with mathematical justification.

b) If you have any number of squares, how can you determine if you can make the square border using all of the squares?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 2 Homework: The Border Problem Part 2 c

c) If you have 256 squares can you use all of them to make a square border? If you can, what is the side length of the square? Explain you thinking with mathematical justification.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 3

Guiding Question:
How did I determine if I could use all 256 squares to make a square border?

Lesson Objective:
Students will be able to make sense of Pattern 4.0 and look for structure in how the pattern is growing. Students will begin to generalize how to determine the total number of squares for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework
4. Pattern 4.0 Parts a, b, c
5. Pattern 4.0 Part d
6. Number Transformer Challenge (#1 ,#2)

Homework:
Part 1: Written Response Questions
#4 How did you or your group approach today's problem or problem set? Was your approach successful? What did you learn from your approach?
#5 Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem?
#7What questions do you still have about Pattern 4.0? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
Pattern 4.1

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

The Number Transformer Challenge

Teacher's Script for the Number Transformer Challenge:

- We will provide the class one clue at a time to solve the challenge. Your goal is to use the least amount of clues possible.
- The clue will show a number going into the "Number Transformer Machine." In the machine the number is transformed through a series of mathematical operations and the resulting number will come out. Your challenge is to figure out how the original number is being transformed in the machine. Every original number I show you will be transformed using the same mathematical operations.

Directions:

- Show the students the first clue. Have them individually brainstorm what mathematical operations transformed the original number into the resulting number. Have students share their ideas with their group. Teacher can record various methods on the board.
- Teacher asks the following questions after each clue:
  "Would you like to see another clue or are we ready to vote on how the original number is being transformed?"
- Then have the students vote. If students would like to see another clue, show them the next clue on the next PowerPoint slide. If the majority has agreed upon how the original number is being transformed, then test your method on the following slide by showing them the original and having them predict the resulting number.

Misconceptions: Students don't understand that the same mathematical operations are transforming the original number.

*Comment: When the first clue is shown, it is a great opportunity for students to think flexibly.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 3: Pattern 4.0

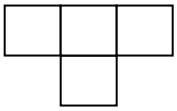


Figure 1

Figure 2

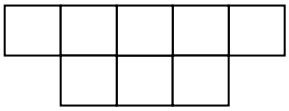


Figure 3

Figure 4

a) How do you see the pattern growing?

b) How many squares will be in Figure 10?

c) How many squares will be in Figure 100?

d) How can you figure out how many squares will be in any figure?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 3 Homework: Pattern 4.1 (Discussed in class on Day 4)

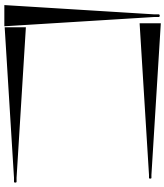


Figure 1

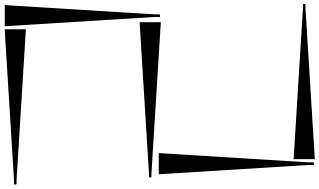


Figure 2

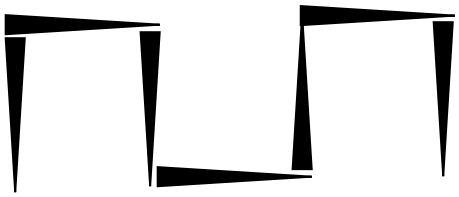


Figure 3

a) How do you see the pattern growing?

b) How many toothpicks are in figure 7?

c) How many toothpicks are in figure 507?

d) How can you figure out how many toothpicks will be in any figure?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 4

Guiding Question:
How did I see the pattern growing? (Pattern 4.1)

Lesson Objective:
Students will be able to make sense of Pattern 4.1 and look for structure in how the pattern is growing. Students will begin to generalize how to determine the total number of toothpicks for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework Pattern 4.1 Parts a, b, c
4. Pattern 4.1 Part d
5. Number Transformer Challenge (#3, #4)

Homework:
Part 1: Written Response Questions
#4 How did you or your group approach today's problem or problem set? Was your approach successful? What did you learn from your approach?
#5 Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem? (Reflect on Pattern 4.1)

Part 2: Mathematical Questions
Pattern 4.2

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 4 Homework: Pattern 4.2 (Discussed in class on Day 5)

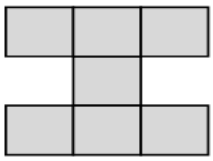


Figure 1

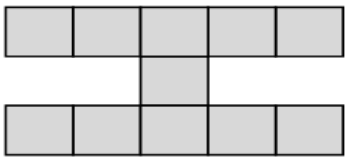


Figure 2

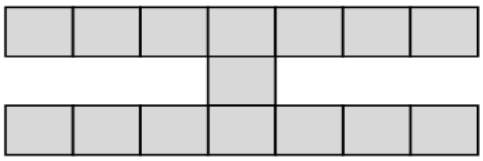


Figure 3

a) How do you see the figure growing?

b) How many squares are in figure 8?

c) How many squares are in figure 808?

d) How can you figure out how many squares will be in any figure?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 5

Guiding Question:
How did I see the pattern growing? (Pattern 4.2)

Lesson Objective:
Students will be able to make sense of Pattern 4.2 and look for structure in how the pattern is growing. Students will begin to generalize how to determine the total number of squares for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Watch Pattern Video (What is a mathematical proof?)
4. Debrief Homework Pattern 4.2 Parts a, b, c
5. Pattern 4.2 Part d
6. Number Transformer Challenge (#5)

Homework:
Part 1: Written Response Questions
#7 What questions do you still have about Number Transformer Challenge? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
Stair-like Structure Problem a, b, c

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 5 Homework: The Stair-like Structure Problem Part a, b, & c

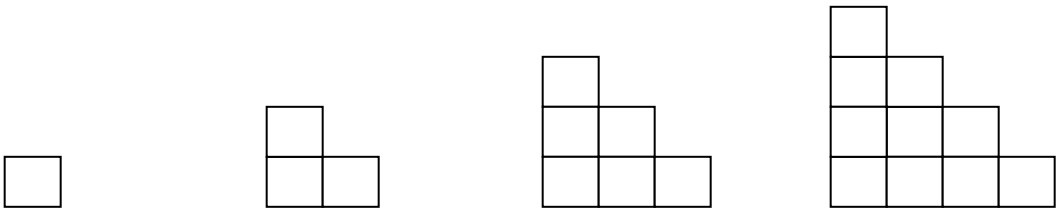


Figure 1 Figure 2 Figure 3 Figure 4

a) How do you see the pattern growing?

b) How many squares are in figure 10? Explain how you know.

c) How many squares are in figure 55? Explain how you know.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 6

Guiding Question:
How many squares would be in figure 1,000 of the Stair-like Structure Problem?

Lesson Objective:
Students will be able to make sense of the Stair-like Structure Problem and look for structure in how the pattern is growing. Students will begin to generalize how to determine the total number of squares for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework Stair-like Structure Problem a, b, c
4. Number Transformer Challenge (#6)

Homework:
Part 1: Written Response Questions
#5 Describe in detail how someone else in class approached a problem. How is their approach similar or different to the way you approached the problem?
#7 What questions do you still have about the Stair-like Structure Problem? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
Stair-like Structure Problem d & e

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 6 Homework: The Stair-like Structure Problem Part d & e

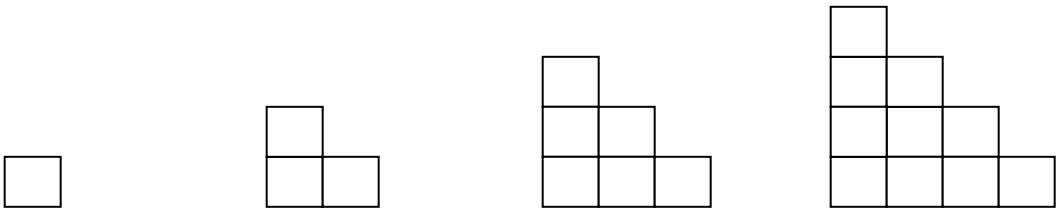


Figure 1 Figure 2 Figure 3 Figure 4

d) Can you use 190 squares to make a stair-like structure? Mathematically justify your answer.

e) How can you figure out how many total squares are in any figure?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 7

Guiding Question:
How can I make a general rule for the Stair-like Structure Problem?

Lesson Objective:
Students will be able to make sense of the Stair-like Structure Problem and look for structure in how the pattern is growing. Students will generalize how to determine the total number of squares for any figure in this pattern.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework Stair-like Structure Problem d & e
4. Generalize Stair-like Structure Problem
5. Number Transformer Challenge (#7)

Homework:
Part 1: Written Response Questions
#1 What were the main mathematical concepts or ideas you learned today or that we discussed in class today?
#7 What questions do you still have about the Stair-like Structure Problems? If you don't have a question, write a similar problem and solve it instead.

Part 2: Mathematical Questions
Stair- Like Structure Problem f

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 7 Homework: The Stair-like Structure Problem Part f

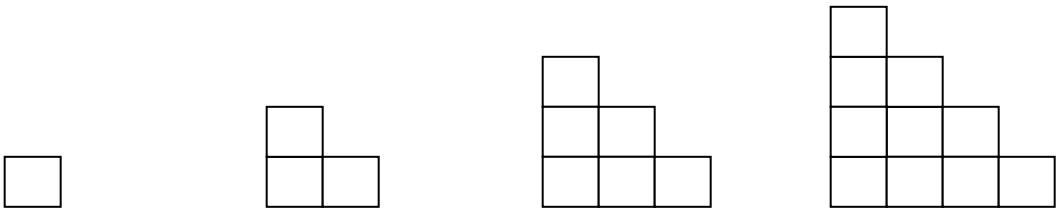


Figure 1 Figure 2 Figure 3 Figure 4

f) If you have 1,478 squares, can you make a stair-like structure using all of the squares?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 8

Guiding Question:
Why do we want to find a general rule for a pattern?

Lesson Objective:
Students will be able to generalize a rule when given a set of inputs and outputs in the Number Transformer Challenge and in an input-output table. Students will recognize the similarities between the Number Transformer Challenge and the input-output table.

Math Standards/Practices:
Introduction to F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework Stair-like Structure Part f
4. Number Transformer Challenge (#8)
5. Silent Board Game (input-output table)

Homework:
Day 8 Homework Worksheet

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 8: The Table Challenge Problem Part 1

Directions: This table represents clues from the Number Transformer Challenge. The original number is called the input and the resulting number is called the output.

Your challenge is to work collaboratively with your group members to fill in the missing inputs or outputs. Then answer the follow-up questions below.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)			2				10	

a) If the number 10 was the input, what would the output be?

b) Describe the pattern between the input and output values in words.

c) Write a general rule or equation to find the output (y) given any input (x).

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 8: The Table Challenge Problem Part 2

Directions: This table represents clues from the Number Transformer Challenge. The original number is called the input and the resulting number is called the output.

Your challenge is to work collaboratively with your group members to fill in the missing inputs or outputs. Then answer the follow-up questions below.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)	11			2				

a) If the number -7 was the input, what would the output be?

b) Describe the pattern between the input and output values in words.

c) Write a general rule or equation to find the output (y) given any input (x).

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 8 Homework Worksheet

A .1. Look for the pattern then fill in the following Input-output table.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)				2			14	

2. Write the pattern between the input and output values in words.

3. Write a general rule or equation to find the output (y) given any input (x).

B.1. Look for the pattern then fill in the following Input-output table.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)				-5				3

2. Write the pattern between the input and output values in words.

3. Write a general rule or equation to find the output (y) given any input (x).

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 9

Guiding Question:
What connection can you make between the input-output table and the Number Transformer Challenge?

Lesson Objective:
Students will see the connection between the Number Transformer Challenges and the input-output tables. Students will learn the definition of a function and a relation and understand the difference between them.

Math Standards/Practices:
F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework
4. Day 9 Problem Part 1 & 2
5. What is a Relation?
6. What is a Function?

Homework:
Day 9 Homework Worksheet

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 9 Problem Part 1

Does this input-output table represent numbers that have gone through a Number Transformer Machine? Why or why not?

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)	-12	-8	-4	0	4	8	12	16

Day 9 Problem Part 2

Does this input-output table represent numbers that have gone through a Number Transformer Machine? Why or why not?

Input (x)	-3	-2	-1	0	1	2	2	3
Output (y)	-2	-1	0	1	2	3	4	5

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 9 Homework Worksheet

A .1. Look for the pattern then fill in the following input-output table.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)				-2			4	

2. Write the pattern between the input and output values in words.

3. Write a general rule or equation to find the output (y) given any input (x).

B.1. Look for the pattern then fill in the following Input-output table.

Input (x)	-3	-2	-1	0	1	2	3	4
Output (y)	9				1			16

2. Write the pattern between the input and output values in words.

3. Write a general rule or equation to find the output (y) given any input (x).

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 10

Guiding Question:
How can I determine if an input-output table represents a function?

Lesson Objective:
Students will demonstrate their understanding of how to work with and generalize patterns. They will also reflect on the relationship between input-output tables and the Number Transformer Challenges. Students will review how to determine if a relation is a function or not.

Math Standards/Practices:
F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework
4. Unit 4 Quiz

Homework:
Part 1: Written Response Questions
#10 What were some of your strengths and weaknesses in this unit? What is your plan to improve in your areas of weakness?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Function Unit Quiz Version A

Section 1: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

1. Is the following relation a function? Explain why or why not.

Input (x)	1	2	3	4	5
Output (y)	2	5	8	11	14

Circle one: **Yes** or **No**

Explain:

2. Is the following relation a function? Explain why or why not.

Input (x)	-1	-1	0	1	1
Output (y)	9	7	5	3	1

Circle one: **Yes** or **No**

Explain:

3. In the Number Transformer Challenge Freddy was given the following clues. He thinks that the pattern is multiplying the input by 4 and subtracting 3 to get the output. Is he correct? Why or why not?

3 → ☐ → 9

-2 → ☐ → -11

Circle one: **Yes** or **No**

Explain:

4. Describe the pattern that you noticed between the input and the output in the table below. You can describe the pattern in words or with a general rule.

Input (x)	-2	-1	0	1	2
Output (y)	-5	-2	1	4	7

5. Explain in detail how the Number Transformer Challenge, the Input-Output tables, and the pattern problems (with squares and toothpicks) are all related and connected to each other. What similarities and differences do you notice between them?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 2: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

Directions: Use the following pattern to answer the questions below.

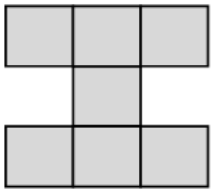


Figure 1

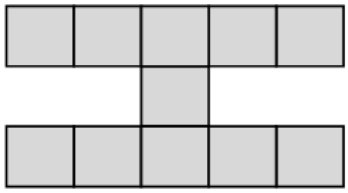


Figure 2

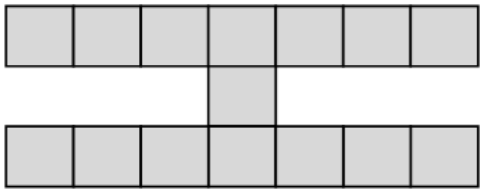


Figure 3

6. How many squares are in figure 11? Show your work and explain your ideas (2 points).

7. How many squares are in figure 1,234? Show your work and explain your ideas (2 points).

8. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas. (1 point)

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Function Unit Quiz Version B

Section 1: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

1. Is the following relation a function? Explain why or why not.

Input (x)	-1	-1	0	1	1
Output (y)	9	7	5	3	1

Circle one: **Yes** or **No**

Explain:

2. Is the following relation a function? Explain why or why not.

Input (x)	1	2	3	4	5
Output (y)	2	5	8	11	14

Circle one: **Yes** or **No**

Explain:

3. In the Number Transformer Challenge Sue was given the following clues. She thinks that the pattern is multiplying the input by 4 and subtracting 3 to get the output. Is she correct? Why or why not?

3 → ☐ → 9

-2 → ☐ → -5

Circle one: **Yes** or **No**

Explain:

4. Describe the pattern that you noticed between the input and the output in the table below. You can describe the pattern in words or with a general rule.

Input (x)	-2	-1	0	1	2
Output (y)	-7	-3	1	5	9

5. Explain in detail how the Number Transformer Challenge, the Input-Output tables, and the pattern problems (with squares and toothpicks) are all related and connected to each other. What similarities and differences do you notice between them?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 2: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

Directions: Use the following pattern to answer the questions below.

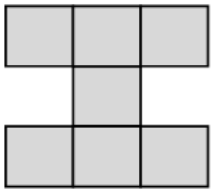


Figure 1

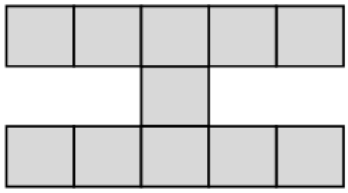


Figure 2

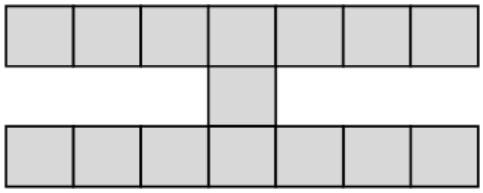


Figure 3

6. How many squares are in figure 13? Show your work and explain your ideas (2 points).

7. How many squares are in figure 1,001? Show your work and explain your ideas (2 points).

8. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas. (1 point)

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 11

Guiding Question:
How are the input-output tables, equations, and the number transformer challenges related?

Lesson Objective:
Students will make connections between the input-output tables, algebraic equations, the Number Transformer Challenges and written descriptions of a general rule.
Students will compare various functions that are represented in a different way (algebraically, numerically in tables, or by written descriptions).

Math Standards/Practices:
F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.A.2: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework
4. Day 11 Function Sort
5. Error Analysis

Homework:
Part 1: Written Response Questions
#7 What questions do you still have about Functions? If you don't have a question, create a representation of a function instead.
#8 How is the input-output table similar or different to an equation/general rule?

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 11 Function Sort

Directions:

- Pass out materials.
- Students cut out the various representations. There are 4 pieces for each representation.
- Students work with your group members to match up the various representations.
- Use four different colors to color code the matching representations.
- Students should be ready to show and justify your ideas and strategies to the class.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

$y = 4x - 1$ $y = 3x$

$y = x + 4$ $y = x^2$

Add 4 to the input to get the output.

Multiply the input by itself to get the output.

Multiply the input by 3 to get the output.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Multiply the input by 4 then subtract 1 to get the output.

Input (x)	1	2	3	4
Output (y)	3	7	11	15

Input (x)	1	2	3	4
Output (y)	3	6	9	12

Input (x)	1	2	3	4
Output (y)	1	4	9	16

Input (x)	1	2	3	4
Output (y)	5	6	7	8

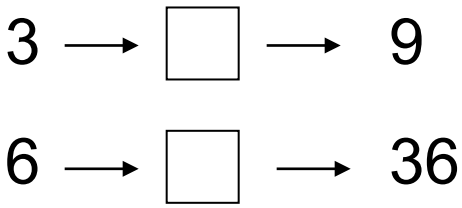
5 → ☐ → 9

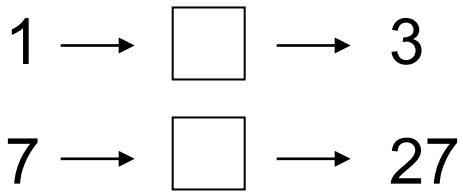
10 → ☐ → 14

0 → ☐ → 0

1 → ☐ → 3

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman





Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 11 Error Analysis Problem

Isaiah answered the questions below, but some of his answers are correct and some of them are incorrect. Which answers do you agree with? Which answers do you disagree with? Explain your reasoning.

Directions: Which of the following input-output tables represent a function?

Input (x)	-2	-1	0	1	2
Output (y)	-3	-1	1	3	5

Isaiah's Answer: Yes, this table represents a function.

Your Response: I _____ (agree/disagree) with Isaiah because _____

_____.

Input (x)	-1	-1	0	1	2
Output (y)	4	5	6	7	8

Isaiah's Answer: Yes, this table represents a function.

Your Response: I _____ (agree/disagree) with Isaiah because _____

_____.

Input (x)	-2	-1	0	1	2
Output (y)	-10	-5	0	5	217

Isaiah's Answer: No, this table does not represent a function.

Your Response: I _____ (agree/disagree) with Isaiah because _____

_____.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 12

Guiding Question:
How can you represent a pattern in an input-output table?

Lesson Objective:
Students will make connections between the input-output tables, algebraic equations, the written descriptions of a general rule, graphs, mapping diagrams, and pattern problems. Students will compare various functions that are represented in a different way (algebraically, graphically, numerically in tables, or by written descriptions).

Math Standards/Practices:
F.A.2: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework
4. Day 12: Mega Sort

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Day 12 Mega Sort

Directions:

- Pass out materials.
- Students cut out the various representations. There are 4 pieces for each representation.
- Students work with your group members to match up the various representations.
- Use four different colors to color code the matching representations.
- Students should be ready to show and justify your ideas and strategies to the class.

*Through this activity students will be exposed to mapping diagrams and discrete graphs for the first time. They will need to figure out what these representations mean and then work together to match up the various representations that describe the same function.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

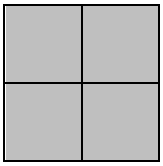


Figure 2

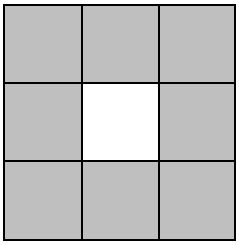


Figure 3

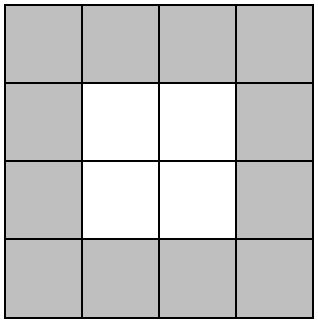


Figure 4

Figure 1

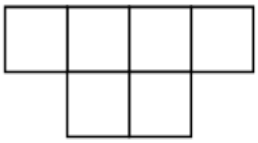


Figure 2

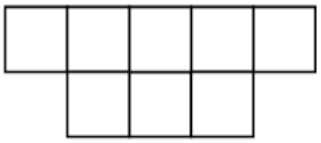


Figure 3

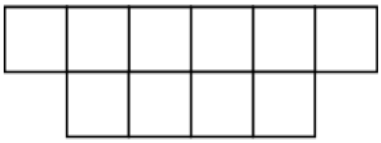


Figure 4

Figure 1

Figure 2

Figure 3

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

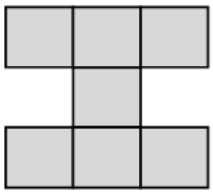


Figure 1

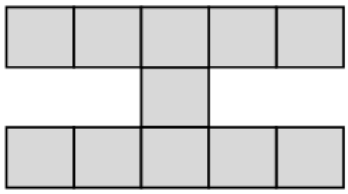


Figure 2

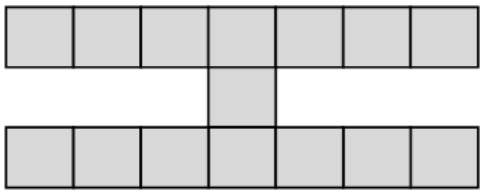


Figure 3

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

$y = 2x + 2$

$y = 4x + 3$

$y = 4x - 4$

$y = 2x + 1$

Multiply the figure number by 4 and then subtract 4 to get the total number of squares.

Multiply the input by 2 then add 1 to get the output.

Multiply the figure number by 4 then add 3 to get the total number of squares.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Multiply the input by 2 then add 2 to get the output.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

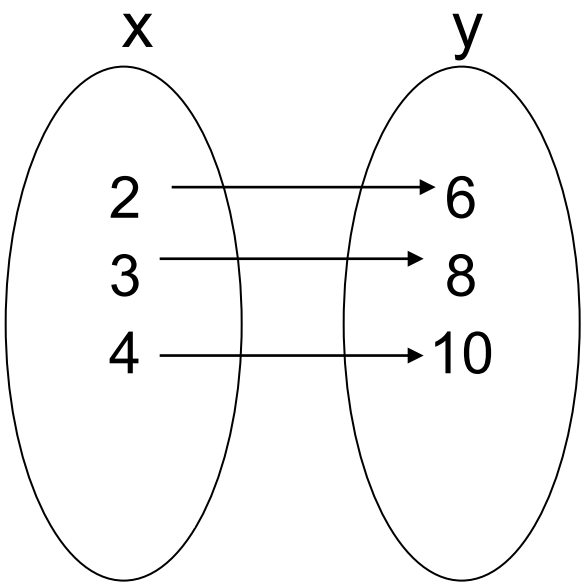
Input (x)	1	2	3	4
Output (y)	0	4	8	12

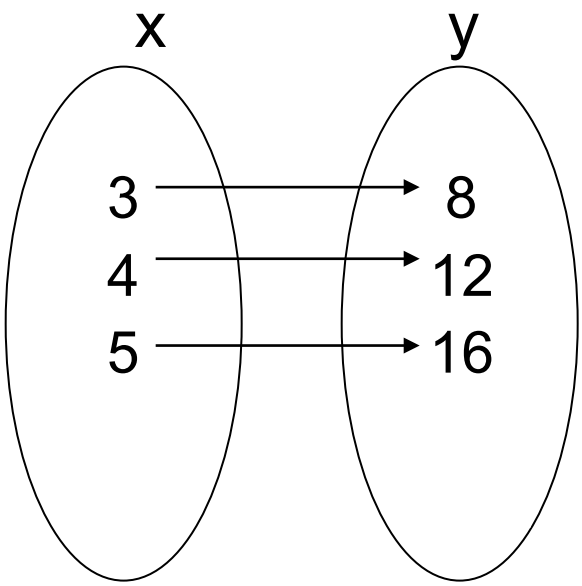
Input (x)	0	1	2	3
Output (y)	3	7	11	15

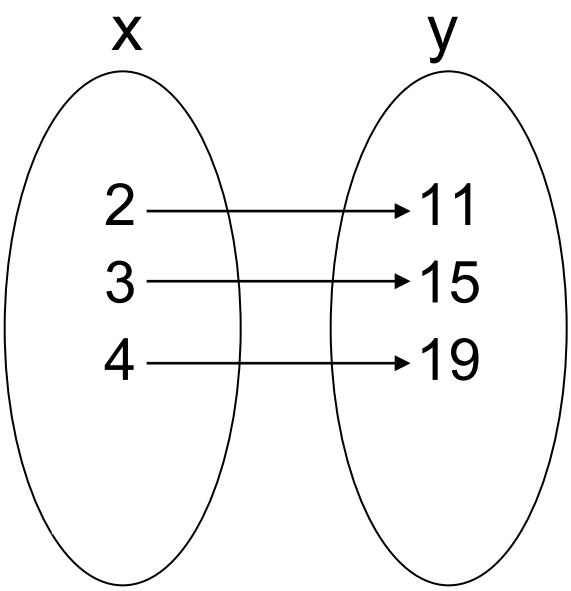
Input (x)	2	4	6	8
Output (y)	5	9	13	17

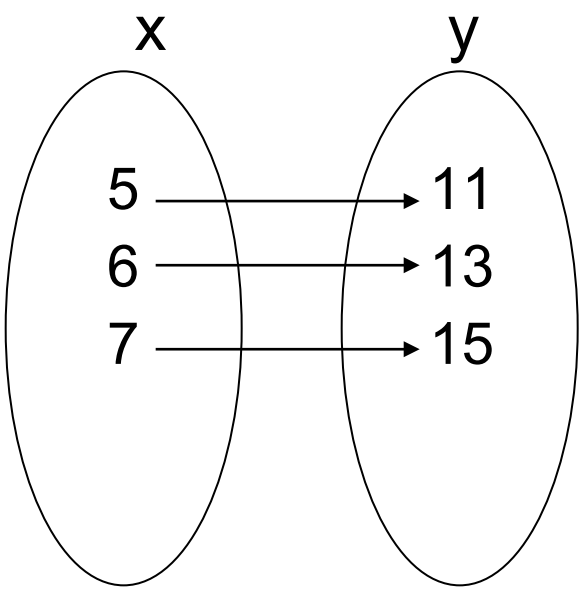
Input (x)	1	3	5	7
Output (y)	4	8	12	16

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

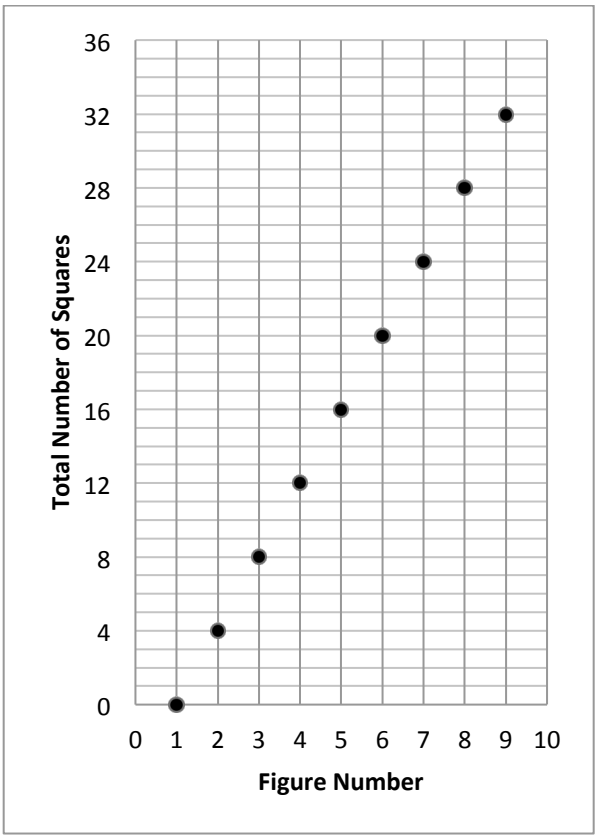


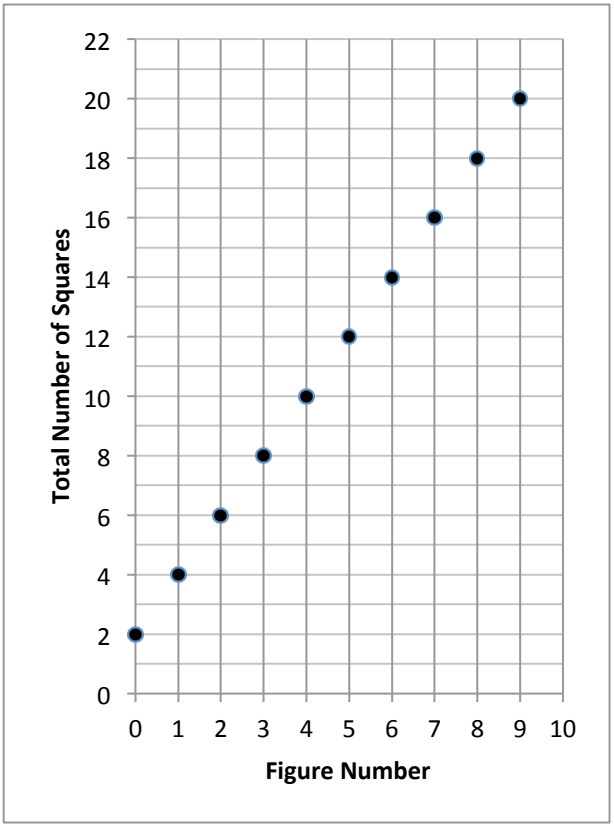




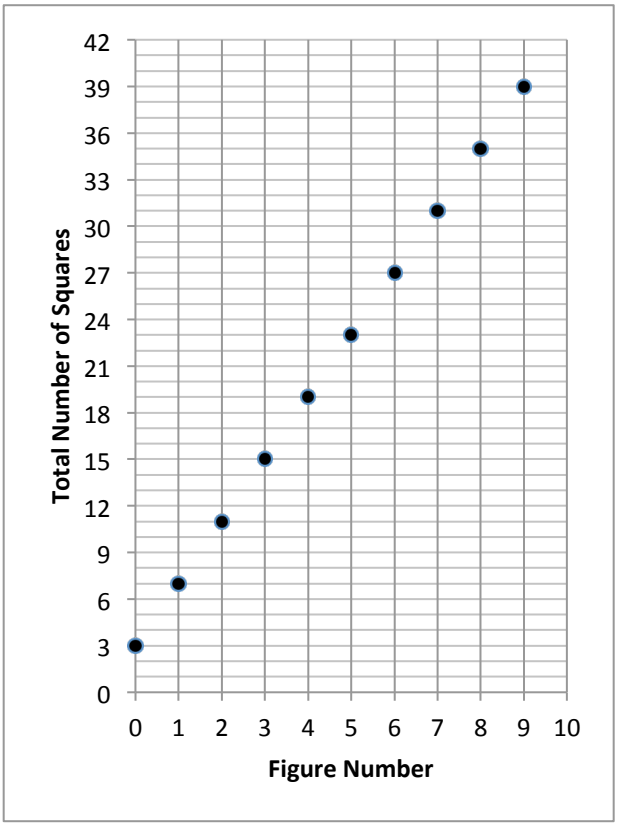


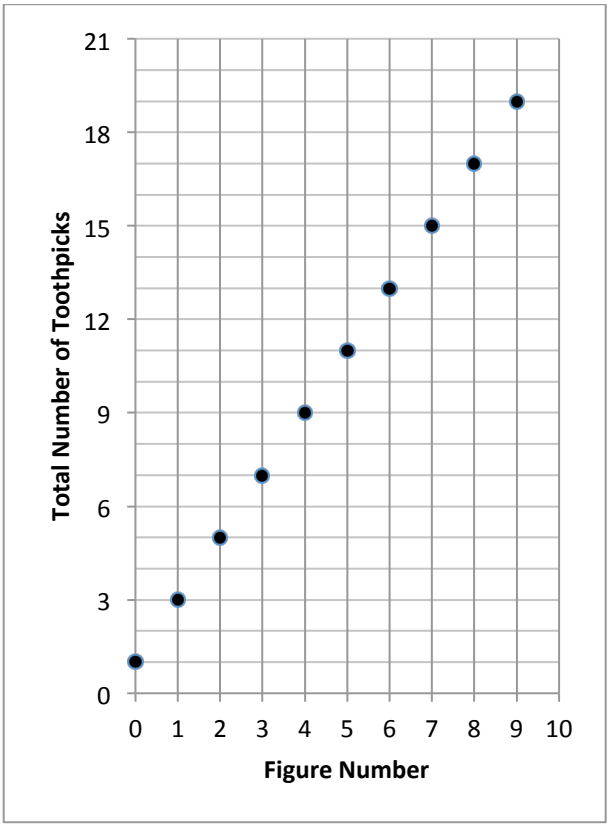
Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman





Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman





Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 13

Guiding Question:
What are the important features of a graph?

Lesson Objective:
Students will understand how to interpret a graph and describe the relationship between two quantities. Students will create a graph that exemplifies a situation that has been described in words.

Math Standards/Practices:
F.B.5: Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.
MP.1: Make sense of problems and persevere in solving them.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.6: Attend to precision.

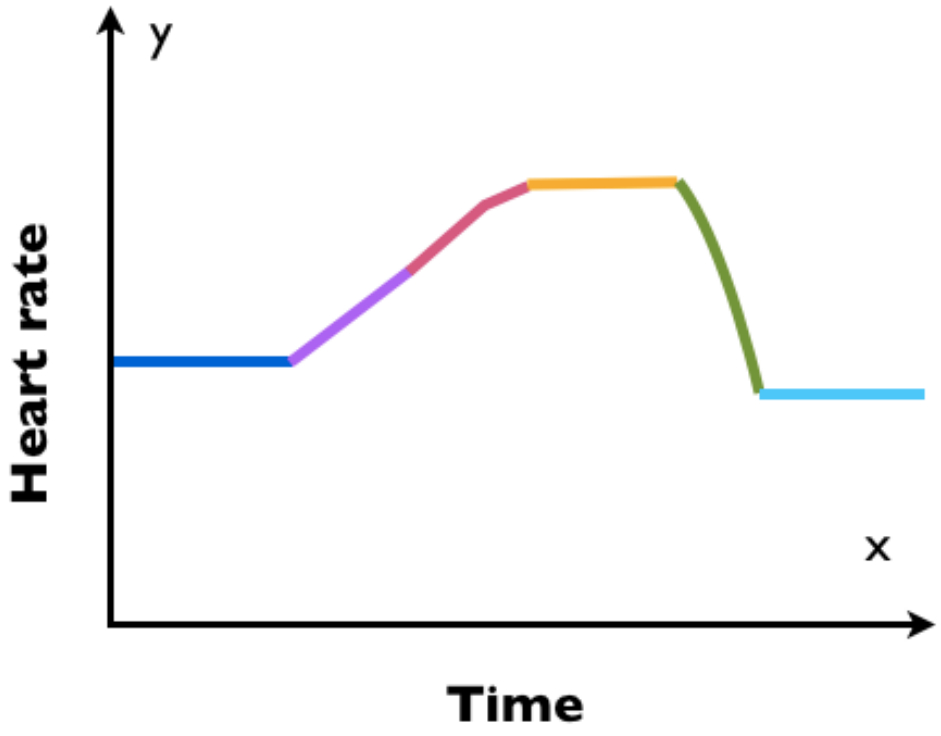
Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Day 13 Problem Part 1 (Analyze the graph and write a story)
4. Day 13 Problem Part 2 (Create a graph)

Homework:
Day 13 Homework Worksheet

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 13 Problem Part 1: Analyze the Graph

Directions: Write a story to match the graph.



Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 13 Problem Part 2: Create a Graph

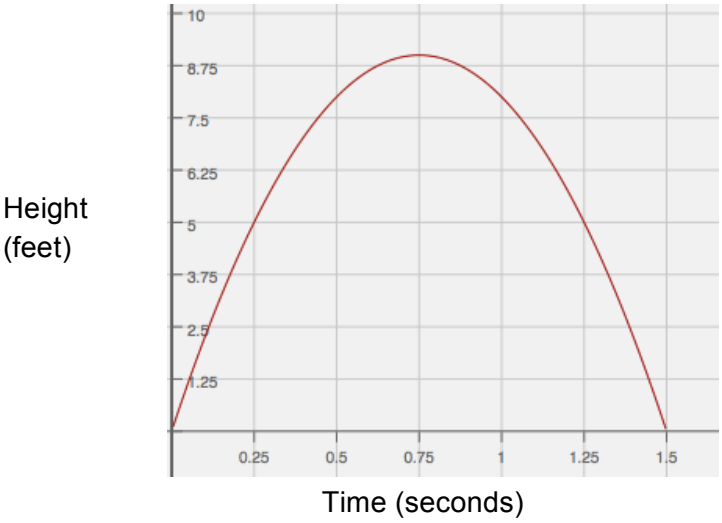
Directions: Create a graph for the situation below. Label the x and y axis.

In San Diego, the air temperature was constant for several hours in the morning. Then the temperature rose steadily for several hours. It stayed the same temperature for most of the day before dropping sharply after sunset.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 13 Homework Worksheet

1. The graph below shows the height of an object over time. Write a detailed story to describe the situation.



2. Create a graph that accurately models the situation below. Make sure that you label each axis appropriately.
Situation: The height of grass of a well-maintained lawn during growing season.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 14

Guiding Question:
What are different ways that I can represent a function?

Lesson Objective:
Students will be able to make sense of a new pattern and look for structure in how the pattern is growing. Students will begin to generalize how to figure out the total number of squares for any figure in this pattern.
Students will make connections between the input-output tables, algebraic equations, the written descriptions of a general rule, graphs, mapping diagrams, and pattern problems. Students will compare various functions that are represented in a different way (algebraically, graphically, numerically in tables, or by written descriptions).

Math Standards/Practices:
F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.A.2: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Debrief Homework (Worksheet)
3. Day 14 Problem Part 1
4. Day 14 Problem Part 2

Homework:
Function Unit Review Sheet

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Accountability Quiz

* We suggest that the accountability quiz is used with Day 14 Problem Part 1 and 2.

Directions:

- For Day 14 Problem Part 1 use the general structure for daily lesson for group work.
- When a group is finished with Part 1, the group members will make sure that each student understands the group's solution and can answer the teacher's questions.
- When the group is ready, one student will call the teacher over for an Accountability Quiz.
- Teacher quizzes each student using the following script.

Teacher Script for Part 1 (Accountability Quiz)

- _____ (Student name) can you explain how your group figured out question ___?
- If a student does not correctly or thoroughly answer the teacher's question, then the teacher tells the group that they need to discuss this question further and that the teacher will come back to quiz them again when they are ready.
- When the group has passed the Accountability Quiz then the will receive Day 14 Problem Part 2.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 14 Problem Part 1

Directions: Use the following pattern to answer the questions below.

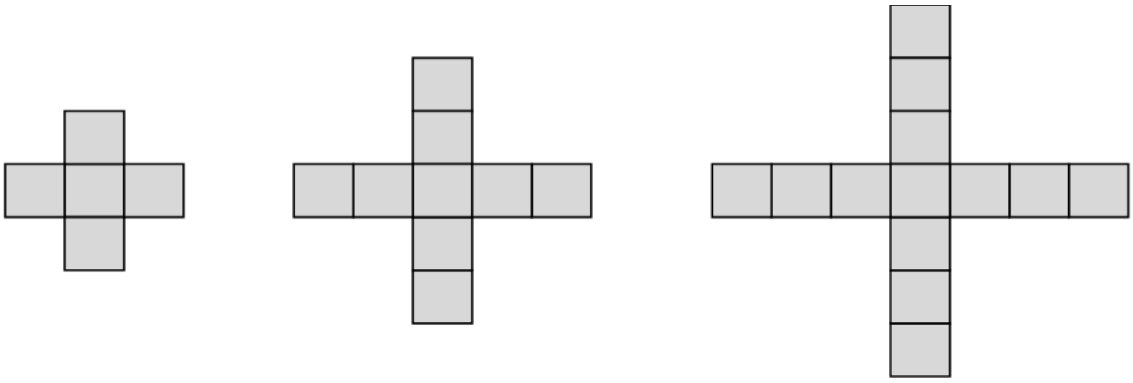


Figure 1 Figure 2 Figure 3

1. How do you see the pattern changing and growing? Explain your ideas visually and with words.

2. How many squares are in figure 10? Show your work and explain your ideas.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

3. How many squares are in figure 6,789? Show your work and explain your ideas.

4. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 14 Problem Part 2

Question: Which of the following representations match with the pattern between the figure number and the total number of squares? Choose all that apply. You may assume that the input (x) represents the figure number and the output (y) represents the total number of squares.

Pattern: Use the pattern from Day 14 Problem Part 1

Section 1: Input-Output Table

A.

Input (x)	2	4	6	8
Output (y)	9	17	25	33

Answer and Explanation:

B.

Input (x)	1	3	5	7
Output (y)	4	12	20	28

C.

Input (x)	4	5	6	7
Output (y)	17	21	25	29

Section 2: Equation

A. $y = 4x$

Answer and Explanation:

B. $y = 4(x + 1) - 3$

C. $y = 4x + 1$

Section 3: Written Description

A. To find the output (y), multiply the input (x) by 4 and add 1.

Answer and Explanation:

B. To find the total number of squares in the figure, multiply the figure number by 4.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

C. To find the output (y), add the input (x) to itself 4 times

Section 4: Number Transformer Challenge

A. 10 → ☐ → 41
100 → ☐ → 410

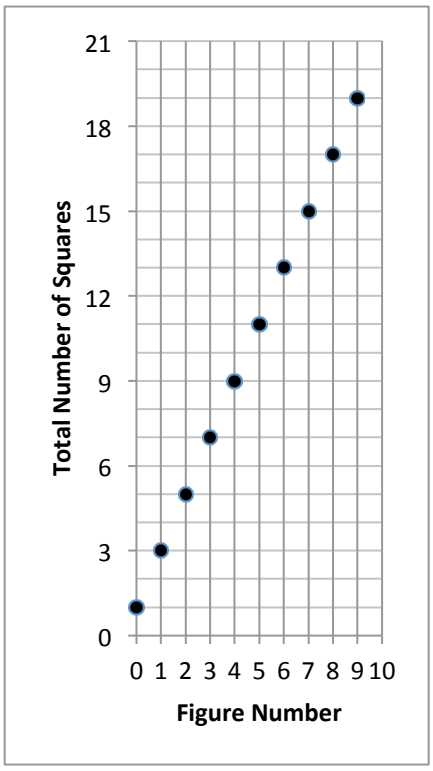
Answer and Explanation:

B. 9 → ☐ → 37
11 → ☐ → 45

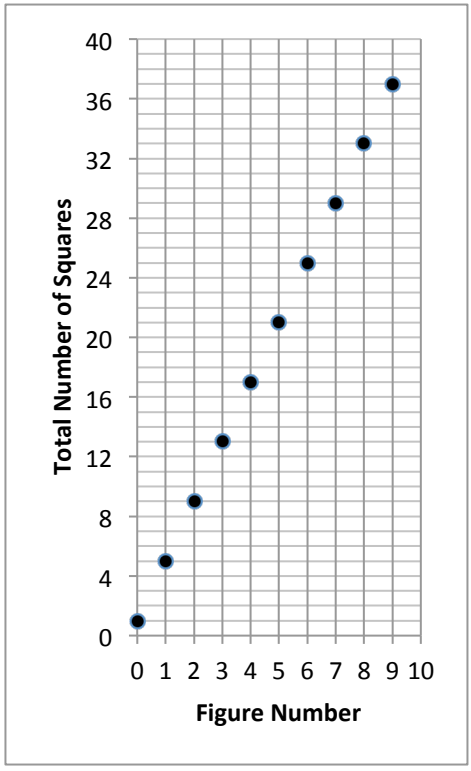
C. 1 → ☐ → 4
2 → ☐ → 8

Section 5: Graphs

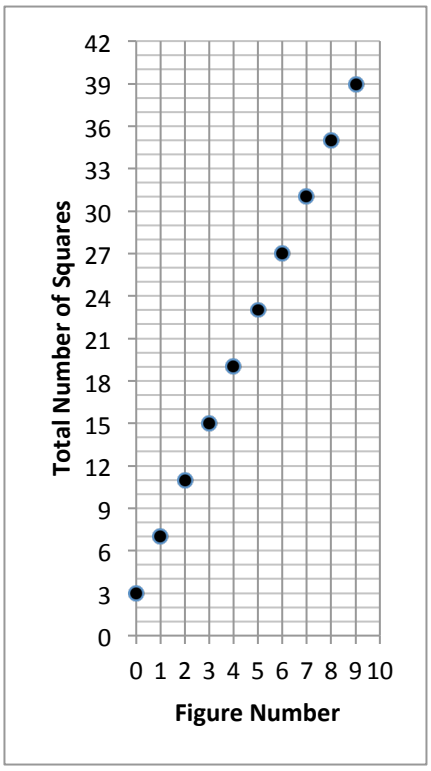
A.



B.



C.



Answer and Explanation:

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Function Unit Review Sheet

Section 1: Functions (F.1 and F.5)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

1. Is the following relation a function? Explain why or why not.

Input (x)	1	2	3	3	4
Output (y)	1	3	5	5	9

Circle one: **Yes** or **No**
Explain:

2. Is the following relation a function? Explain why or why not.

Input (x)	-3	-1	0	1	3
Output (y)	7	7	7	7	7

Circle one: **Yes** or **No**
Explain:

3. Create a graph that accurately models the situation below. Make sure that you label the x and y axis.

Situation: A car travels at a steady speed along the freeway until it slows down on the off ramp. Then it comes to a stop at the traffic light. When the light turns green the car continues at a constant speed on the street.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 2: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

Directions: Use the following pattern to answer the questions below.

Figure 1

Figure 2

Figure 3

Think about how you see the pattern growing and changing before you answer these questions:

6. How many squares are in **figure 12**? Show your work and explain your ideas.

7. How many squares are in **figure 2,000**? Show your work and explain your ideas.

8. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Day 15

Guiding Question:
Why do mathematicians look for patterns?

Lesson Objective:
Students will demonstrate their understanding of how to work with and generalize patterns. Students will show how to determine if a relation is a function or not. Students will match various function representations with a given pattern. Students will understand how to interpret a graph and describe the relationship between two quantities. Students will create a graph that exemplifies a situation that has been described in words.

Math Standards/Practices:
F.A.1: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.A.2: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
F.B.5: Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.
MP.1: Make sense of problems and persevere in solving them.
MP.2: Reason abstractly and quantitatively.
MP.3: Construct viable arguments and critique the reasoning of others.
MP.7: Look for and make use of structure.
MP.8: Look for and express regularity in repeated reasoning.

Activities:
1. Guiding Question Quick Write
2. Record Homework
3. Function Unit Assessment

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Function Unit Test Version A

Section 1: Functions (F.1 and F.5)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

1. Is the following relation a function?
Explain why or why not.

Input (x)	1	2	2	3	4
Output (y)	1	3	5	7	9

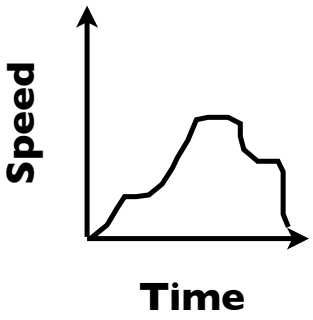
Circle one: **Yes** or **No**
Explain:

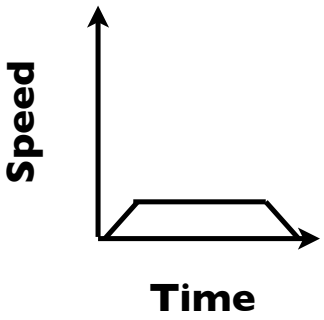
2. Is the following relation a function?
Explain why or why not.

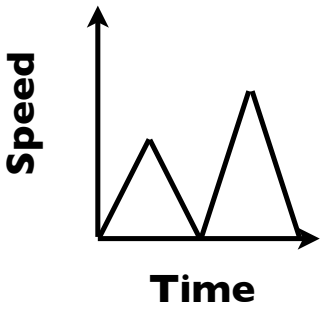
Input (x)	-2	-1	0	1	2
Output (y)	4	2	0	-2	-4

Circle one: **Yes** or **No**
Explain:

3. Match each of the following situations with one of the graphs below.
A group of students went on three different rides at an amusement park.
A) Merry-Go-Round
B) Roller Coaster
C) Extreme Elevator Drop







4-5. Create a graph that accurately models the situation below. Make sure that you label the x and y axis.
Situation: A car speeds at a steady rate along the freeway until an police officer pulls it over and gives the driver a ticket. The car then resumes its journey along the freeway at a more responsible speed.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 2: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

Directions: Use the following pattern to answer the questions below.

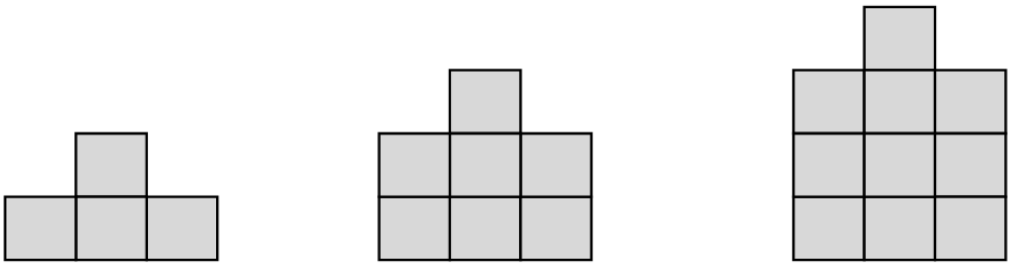


Figure 1 Figure 2 Figure 3

6. How many squares are in **figure 9**? Show your work and explain your ideas (1 point).

7. How many squares are in **figure 400**? Show your work and explain your ideas (2 points).

8. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas. (2 points)

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 3: Functions (F.2)

F.2 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Question: Which of the following representations match with the pattern between the figure number and the total number of squares? Choose all that apply. You may assume that the input (x) represents the figure number and that the output (y) represents the total number of squares in each figure.

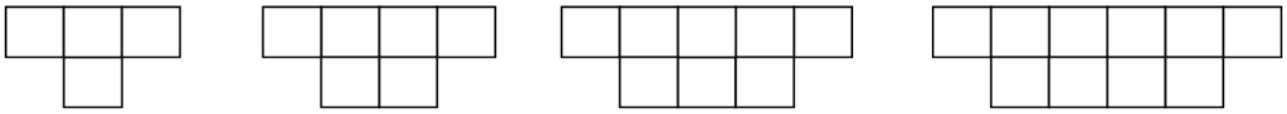


Figure 1 Figure 2 Figure 3 Figure 4

Section 1: Input-Output Table

A.

Answer and Explanation:

Input (x)	2	4	6	8
Output (y)	6	10	14	18

B.

Input (x)	1	3	5	7
Output (y)	4	12	20	28

C.

Input (x)	4	5	6	7
Output (y)	16	25	36	49

Section 2: Equations

Answer and Explanation:

A. $y = 4x$

B. $y = 2x + 2$

C. $y = 2(x + 2) - 2$

Section 3: Written Description

A. Multiply the input (x) by 2 then add 2 to get the output (y).

Answer and Explanation:

B. To find the output (y), multiply the

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

input (x) by 3.

C. Multiply the input (x) by 2, then add the input (x) to get the output (y).

Section 4: Number Transformer Challenge

A. 10 → ☐ → 20

100 → ☐ → 200

Answer and Explanation:

B. 1 → ☐ → 3

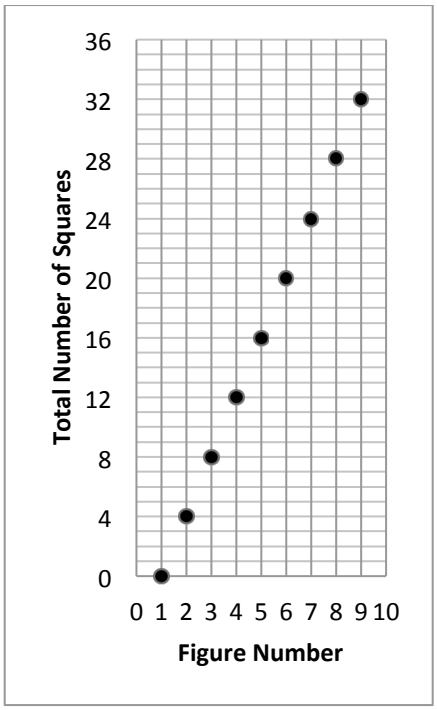
7 → ☐ → 21

C. 20 → ☐ → 42

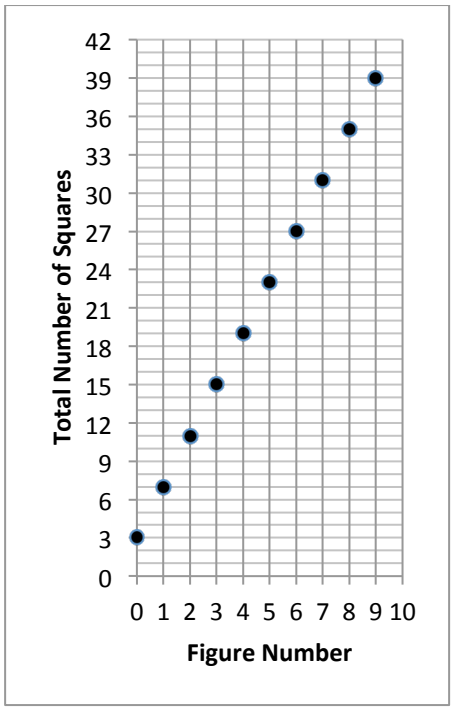
30 → ☐ → 62

Section 5: Graphs

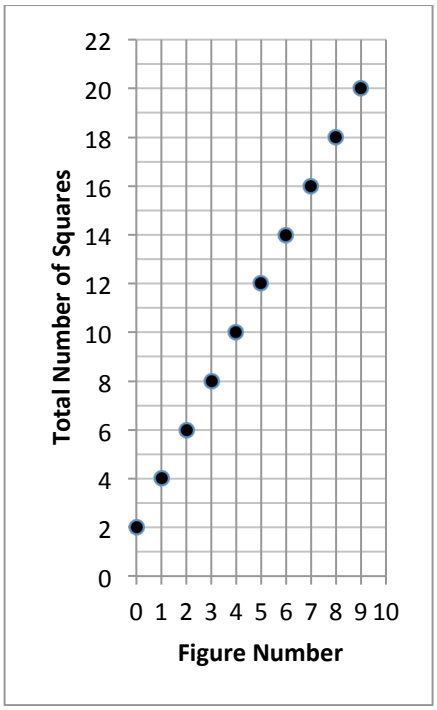
A.



B.



C.



Answer and Explanation:

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

youcubed at Stanford University

Function Unit Test Version B

Section 1: Functions (F.1 and F.5)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
F.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

1. Is the following relation a function?
Explain why or why not.

Input (x)	1	2	3	4	4
Output (y)	1	3	5	7	9

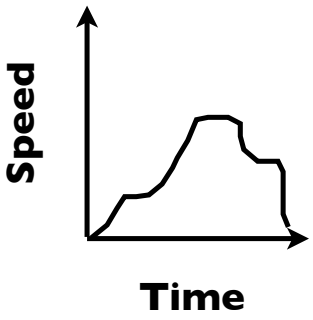
Circle one: **Yes** or **No**
Explain:

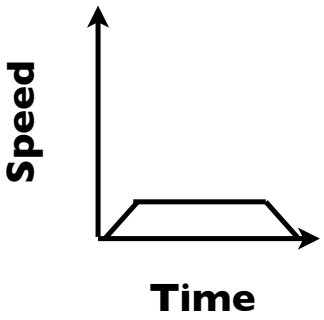
2. Is the following relation a function?
Explain why or why not.

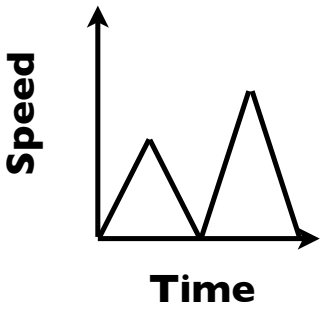
Input (x)	-2	-1	0	1	2
Output (y)	2	1	0	-1	-2

Circle one: **Yes** or **No**
Explain:

3. Match each of the following situations with one of the graphs below.
A group of students went on three different rides at an amusement park.
A) Extreme Elevator Drop
B) Roller Coaster
C) Merry-Go-Round







4-5. Create a graph that accurately models the situation below. Make sure that you label the x and y axis.
Situation: A car speeds at a steady rate along the freeway until an police officer pulls it over and gives the driver a ticket. The car then resumes its journey along the freeway at a more responsible speed.

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 2: Functions (F.1)

F.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

Directions: Use the following pattern to answer the questions below.

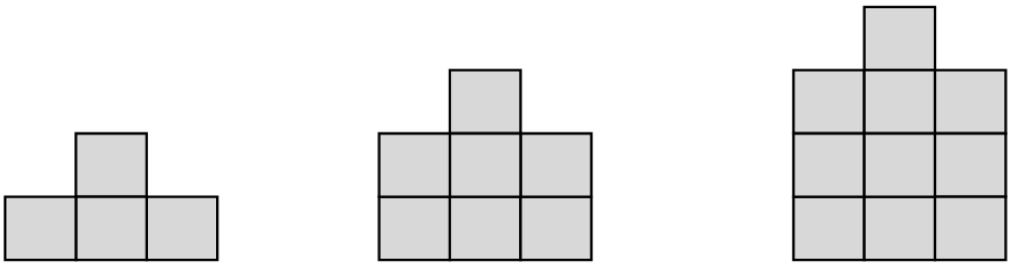


Figure 1 Figure 2 Figure 3

6. How many squares are in **figure 8**? Show your work and explain your ideas (1 point).

7. How many squares are in **figure 300**? Show your work and explain your ideas (2 points).

8. What pattern can you use to find out how many squares will be in any figure of this pattern? What is a general rule for this pattern? Explain your ideas. (2 points)

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

Section 3: Functions (F.2)

F.2 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Question: Which of the following representations match with the pattern between the figure number and the total number of squares? Choose all that apply. You may assume that the input (x) represents the figure number and that the output (y) represents the total number of squares in each figure.

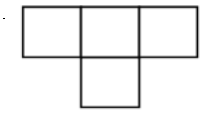


Figure 1

Figure 2

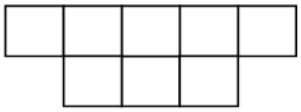


Figure 3

Figure 4

Section 1: Input-Output Table

A.

Answer and Explanation:

Input (x)	4	5	6	7
Output	16	25	36	49

B.

Input (x)	1	3	5	7
Output	4	12	20	28

C.

Input (x)	2	4	6	8
Output	6	10	14	18

Section 2: Equations

Answer and Explanation:

A. $y = 2x + 2$

B. $y = 4x$

C. $y = 2(x + 2) - 2$

Section 3: Written Description

A. Multiply the input (x) by 2 then add 2 to get the output (y).

Answer and Explanation:

B. To find the output (y), multiply the

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman

input (x) by 3.

C. Multiply the input (x) by 2, then add the input (x) to get the output (y).

Section 4: Number Transformer Challenge

A. 10 → □ → 20

100 → □ → 200

Answer and Explanation:

B. 20 → □ → 42

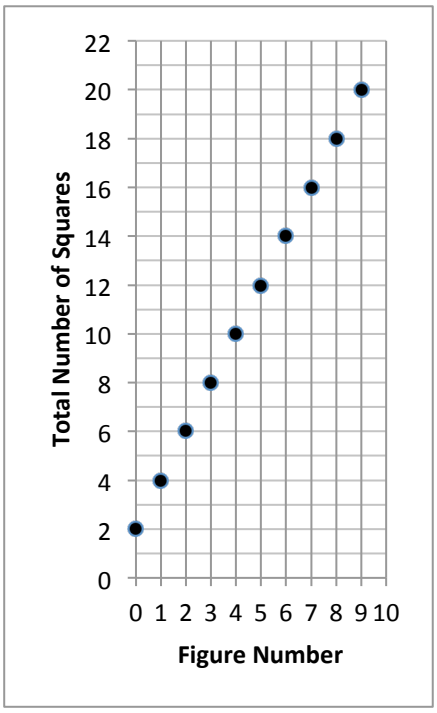
30 → □ → 62

C. 1 → □ → 3

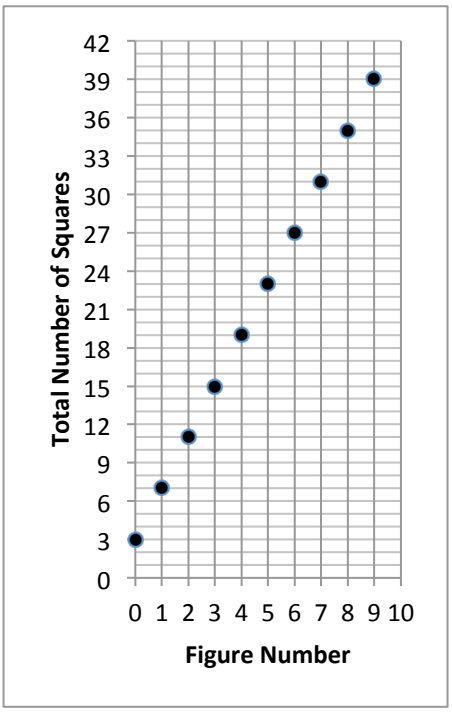
7 → □ → 21

Section 5: Graphs

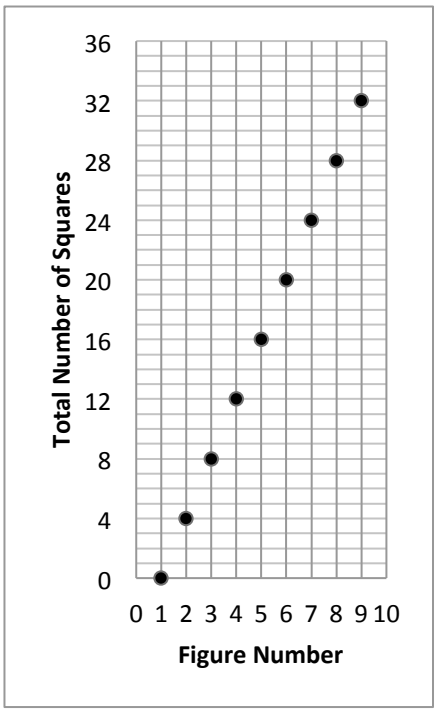
A.



B.



C.



Answer and Explanation:

Licensed under Creative Commons Attribution 3.0 by Yekaterina Milvidskaia and Tiana Tebelman