Piecewise Nano Size

Overview
Students will practice graphing piecewise functions. These piecewise functions are linear, exponential and quadratic functions. The lesson starts with a blurb about an application of nano-sized wires created by a chemistry lab at UNC-CH. Students then create a graph from a piecewise function and continue to duplicate the graph using horizontal shift transformations to see what possible nanowire shapes would look like.

Key Search Words
Piecewise function, linear, exponential, quadratic, evaluate, interval, transformation, horizontal shift, morphology (shape or appearance of a structure)

Learning Objectives
- Students will be able to graph piecewise functions with the support of a table 100% of the time.
- Students will be able to create horizontal shift transformations of piecewise graphs.

Curriculum Alignment
- Interpret the structure of expressions. Interpret expressions that represent a quantity in terms of its context (NC.M3.A-SSE.1)
- Understand the concept of a function and use function notation. Use function notation to evaluate piecewise defined functions for inputs in their domains, and interpret statements that use function notation in terms of a context. (NC.M3.F-IF.2)

Classroom time required
Warmup (10 minutes) - optional
Introduction of Application (5 minutes)
Complete handout (35 minutes)
Exit Ticket (10 minutes)

Materials & Technology
- Pencils (for students to write on the handout)
- Piecewise Nano Size Handout for each student
- Exit Ticket (see **Assessment/Check for Understanding**)

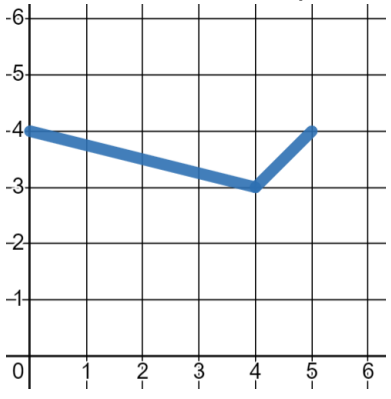
Teacher Preparation for Activity
Print a class set of the handout

Student Preparation for Activity
Prerequisites:

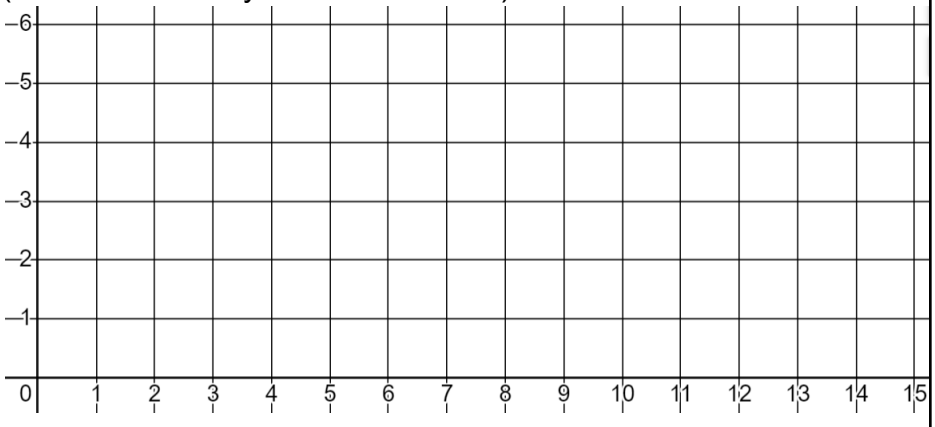
Previously, students should have been introduced to graphing piecewise functions. These functions should include linear, exponential, and quadratic functions.

Suggested Warm-up:

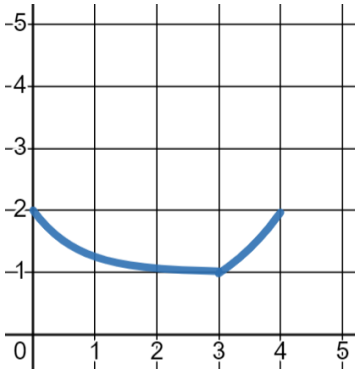
1.The graph is a piecewise function of two linear equations.



Recopy the graph, then duplicate it two more times (transformation by a horizontal shift).



2. The graph is a piecewise function of two exponential equations.



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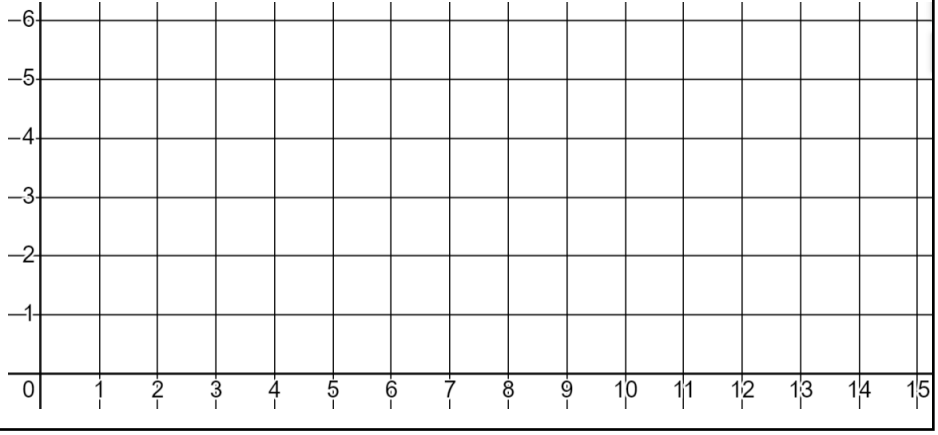
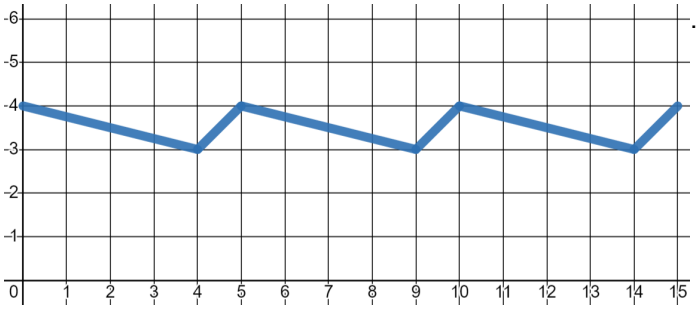
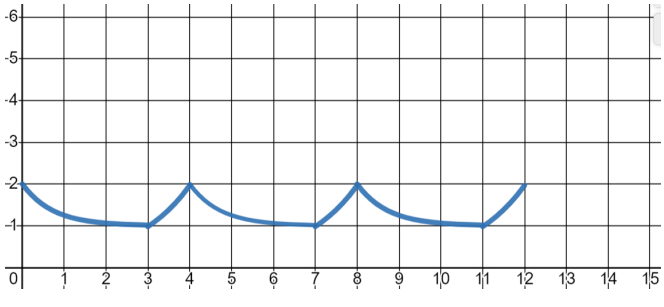


Answers:

1.



2.



Procedure

1. Warmup (suggested): Have students complete the answers to the warmup at the beginning and review answers.
2. Handout
    a. Give two minutes for students to read the box on the top of the front to themselves.
    b. Read the box out loud.
    c. As a class, have students complete a KWL chart about what was just read. (Know/Want-to-Know/Learned)
    d. Some background information:
        i. *Nanowires* are made of molecules that have silicon (Si) which is an atom.
        ii. *Morphology* is the shape or appearance of a structure.

iii. *Encoding Morphology* is what the lab programs the software to make (in ideal conditions with perfect positions of the molecules) whereas the *Engraving Si* (silicon) is the actual image that has been made.
iv. The goal is to maximize the number of electrons to pass through the wire. By changing the *morphology* or 'shape', it is possible to change the flow of the electrons.
v. While nanowire shape is the focus of this lesson, there are other structures that the lab is experimenting with - silicon plates (think 2mm square solar panel glass).

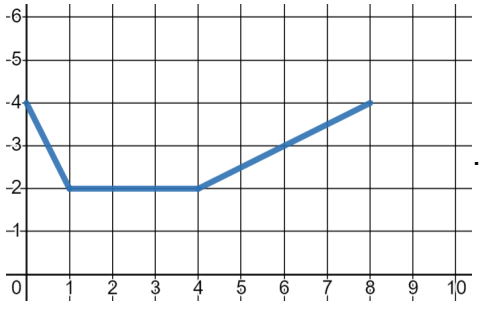
e. "Your Task" - students are to complete the three problems on the handout. Students might need some guidance to get them started with question #1. Students are to have their piecewise graph checked BEFORE translating the graph using horizontal shifts. There is a place for a stamp to confirm if each answer is correct.

3. For students who finish early, they can use Desmos.com to check their answers (see Differential section).

Differentiation

Extension for Students Who Finish Early

- Using Desmos (https://www.desmos.com/calculator)
  - Students can graph their piecewise functions on the online Desmos graphing calculator.
  - The format of each part: y = equation {# < x < #} *For example, y = -3x + 5 {0<x<1}*
  - The equations for the transformed graph will need to be modified for the horizontal shifts.
- Give students this graph and have them create the piecewise function:



Answer: $f(x) = \begin{cases} -2x + 4; & 0 \le x \le 1 \\ 2 \quad ; & 1 < x < 4 \\ \frac{1}{2}x \quad ; & 4 \le x \le 8 \end{cases}$

Support for Students Who May Need More Help

- Have a pre-read activity of the introductory passage (such as a vocabulary activity for the following words: *nano, solar, orientations, silicon, morphology, engraved).*
- Reading the passage out loud (see Procedures 2b).
- Have students identify each equation as "linear", "exponential", or "quadratic"
- Suggest that students use the tables to help them determine the points needed for the graphs of each piece.

Assessment/Check for Understanding

Handout (see appendix). There are parts on the handout that require students to acquire teacher confirmation before moving on to the next part.

Supplemental resources

Information on solar energy:

- Video on how solar cells work: https://www.youtube.com/watch?v=L_q6LRgKpTw (Lesics)
- Video on how solar panels work: https://www.youtube.com/watch?v=xKxrkht7CpY (TED-Ed)
- Video on Growth of Nanowires: https://www.youtube.com/watch?v=0YFxg8tqT9k (U of Cambridge)

Author comments

- This is not an introductory lesson. It is to be completed after students have learned and practiced piecewise functions.
- Note: Problem 1's graph does not begin and end at the same point. The answer key has a vertical line (in orange) that would connect the end of each graph to the beginning of the repeated graph. This is a probable shape if a computer was following the equations of the function.
- While translations of the graph are not a requirement for NC Math 3, the repetition of the graphs is a great connection with the building of the nano-sized structures.

Sources

- Guidance on how to use a KWL Chart: https://www.youtube.com/watch?v=PvF0ON4olOc
- Cahoon Group at UNC-CH http://cahoon.chem.unc.edu/research/

Appendices

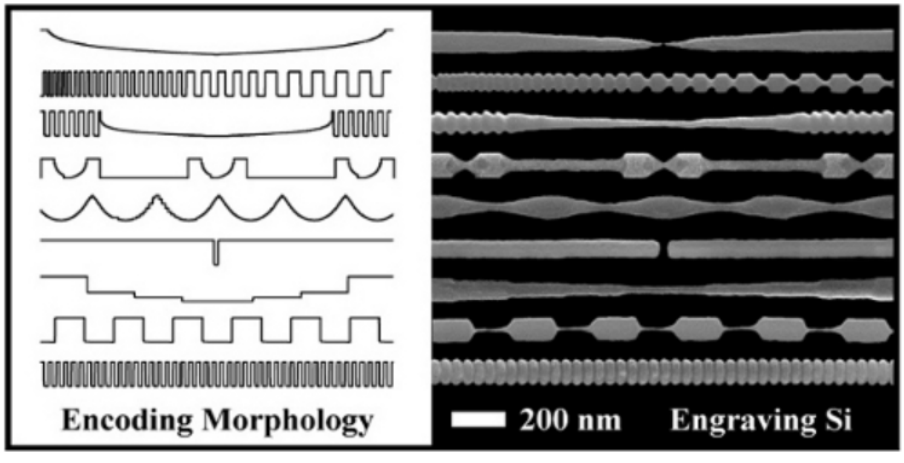
Handout and Teacher Answer Key

Piecewise Nano Size Name _____

You have probably seen solar panels before. They tend to be flat window-sized materials that are often laid on a roof or on the ground at an angle. Their purpose is to convert the sun's rays to energy so you can run electronics and heat water. Scientists are trying to find other ways to use solar energy to generate chemical reactions.

The Cahoon Lab at UNC-CH builds nano-sized structures to convert water and gases into fuel sources by using sunlight. For example, the research is determining whether nanowires can reliably break down excess carbon dioxide (CO_2) molecules into useful fuels. The lab experiments with different orientations to determine the most efficient shape for electron travel ("electricity") and chemical reactions.

Some shapes they have created on silicon nanowires are pictured here:



Cahoon Labs
Chemistry Department
University of North Carolina
Chapel Hill

Your task: The lab has reached out to you for help with more nano orientations. Given each set of equations, graph the piecewise functions.

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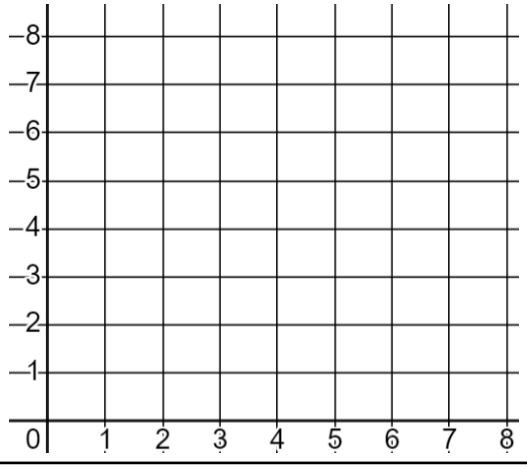
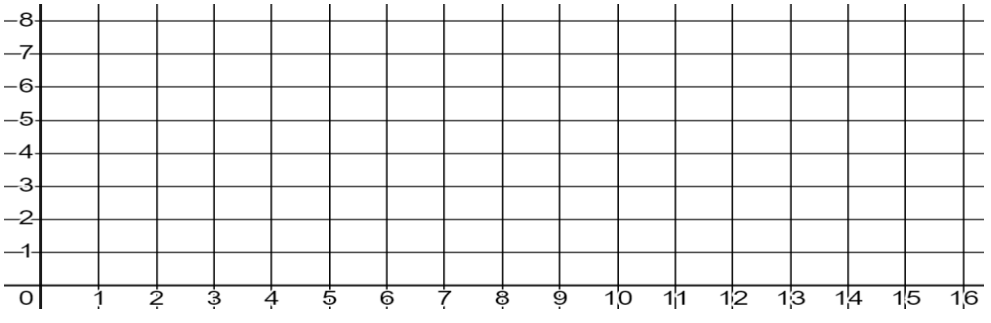
interval	equation

interval	equation



Teacher's stamp confirming the above piecewise graph is correct.

To see what the nanowire would look like, repeat the graph next to the original function. (horizontal shifts)



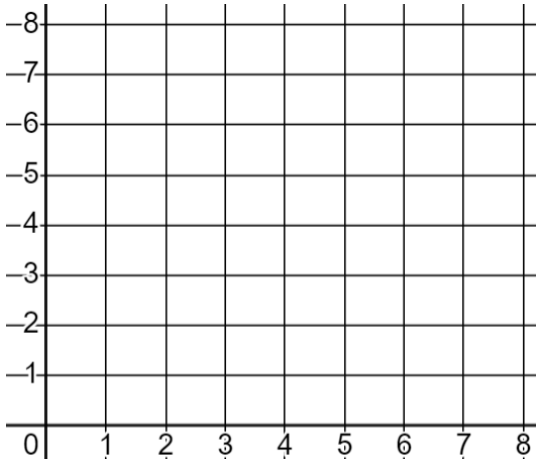
2.

$$f(x) = \begin{cases} -3x + 4; & 0 \le x < 1 \\ 1 \ ; & 1 \le x \le 3 \\ x - 2; & 3 < x \le 6 \end{cases}$$

interval	equation

interval	equation

interval	equation



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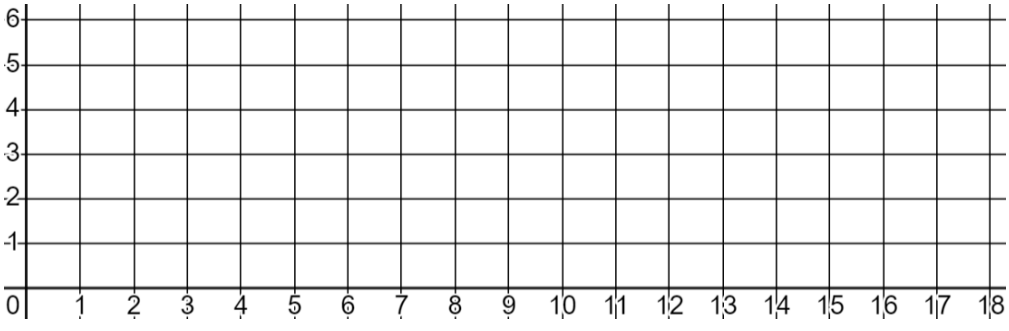


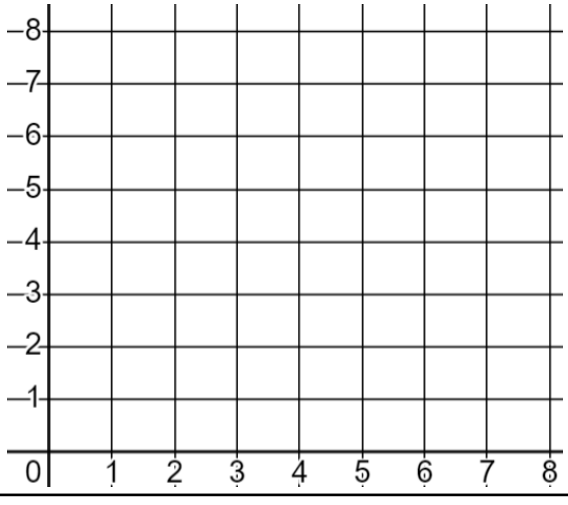
3.

$$f(x) = \begin{cases} -x + 4; & 0 \le x \le 2 \\ (x-3)^2 + 1; & 2 < x < 4 \\ x - 2; & 4 \le x \le 6 \end{cases}$$

interval	equation

interval	equation

interval	equation



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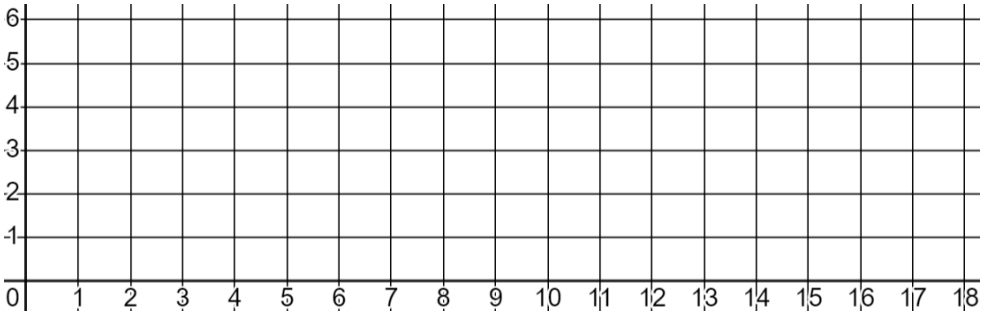

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Teacher Answer KEY

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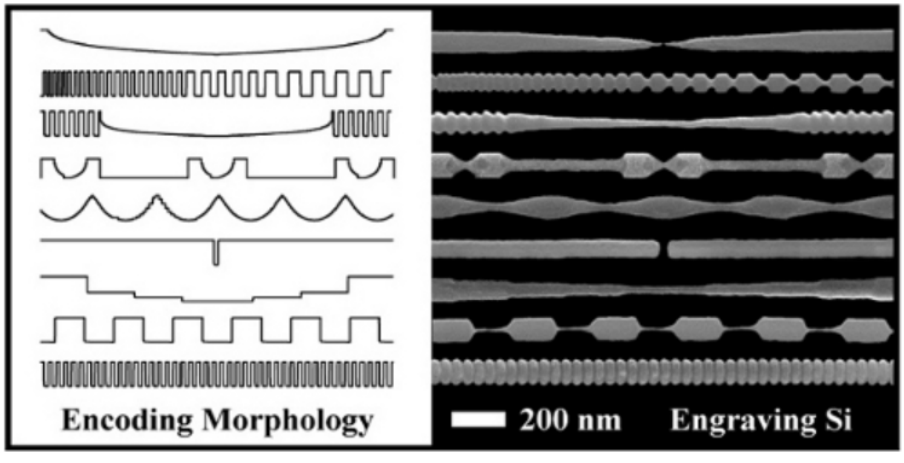

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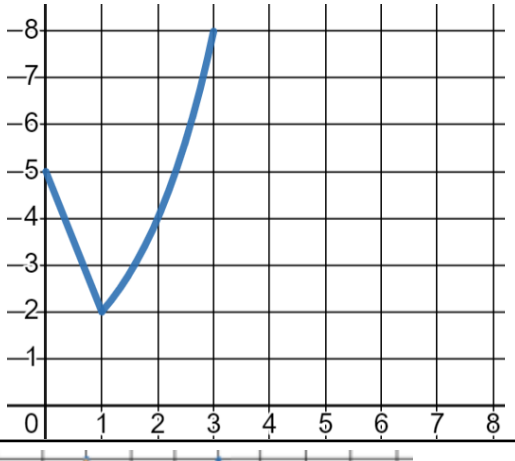
interval	equation
0	6
1	3

interval	equation
1	2
1.5	2.8
2	4
3	8



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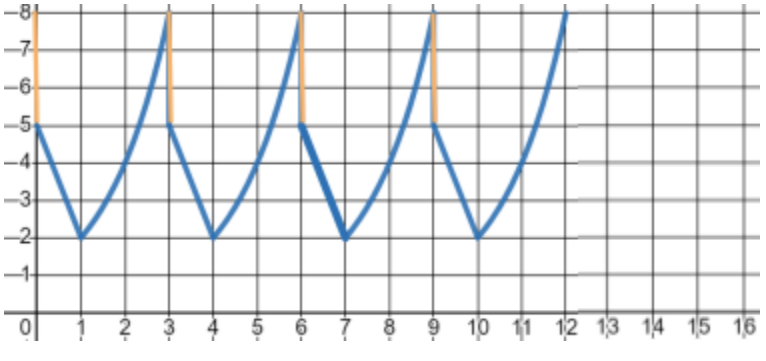

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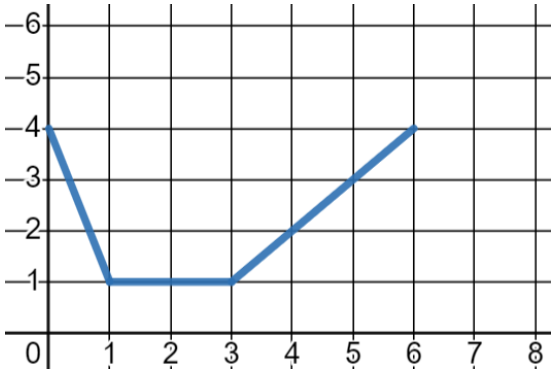
interval	equation
0	4
1	1

interval	equation
1	1
2	1
3	1

interval	equation
3	1
4	2
5	3
6	4



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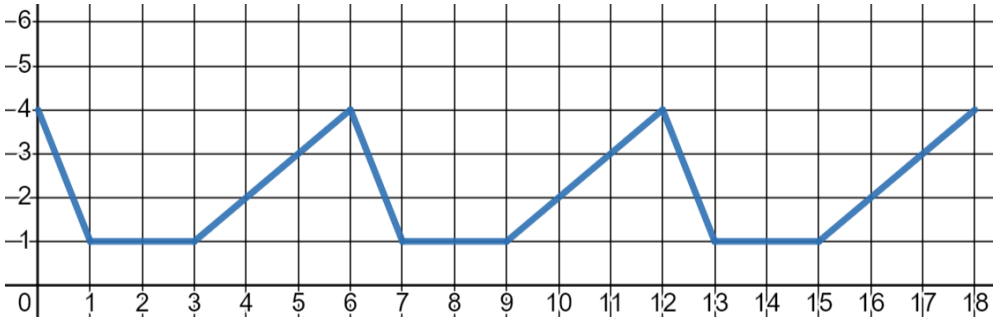

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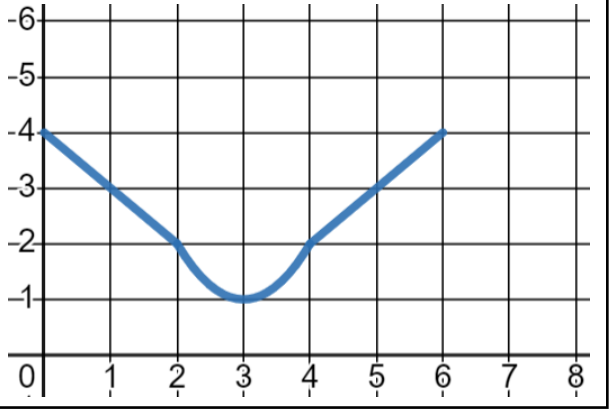
interval	equation
0	4
1	3
2	2

interval	equation
2	2
3	1
4	2

interval	equation
4	2
5	3
6	4



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