# What is a Möbius Strip?

OVERVIEW

## ESSENTIAL QUESTION

What is a Möbius strip, how do you create one, and what can it represent?

## OVERVIEW

*In this lesson, students will use geometry vocabulary and the scientific method to explore and define a Möbius strip. Music by renowned author Neil Gaiman introduces the idea of the Möbius strip. Students create basic geometric models, practice making and evaluating predictions through observations, and use mathematical vocabulary to articulate their findings, including face, edge, orientable/non-orientable, and properties.*

A Möbius strip, also known as a Möbius band or Möbius loop, is a fascinating geometric figure with only one side and one edge. To create a Möbius strip, take a strip of paper (or any other flat material) and twist it 180° before closing the ends to form a loop. The result is a surface that appears to have no distinct "inside" or "outside."

A Möbius strip is a continuous, seamless loop. An unbroken line drawn along the surface of a Möbius strip from start to finish will cover both sides of the loop without ever lifting the marker. For example, imagine a Möbius strip created out of a 10-inch strip of paper with one black side and one white side. If an ant were to travel along the Möbius strip, it would journey a total of 20 inches to return to its initial point, with its path including 10 inches of black paper and 10 inches of white paper.

Discovered concurrently, but independently, by the German mathematicians August Ferdinand Möbius and Johann Benedict Listing in 1858, the Möbius strip has been inspiring mathematicians, scientists, and artists alike ever since.

In 2023, internationally renowned author Neil Gaiman ventured into the world of music with his first album *Songs of Life*. The album features tracks composed of music performed by Australia's FourPlay String Quartet and poetry and prose performed by Gaiman. On a track titled "Möbius Strip", Gaiman reflects on learning to create the loop from his grandfather, sharing directions for the listener to create their own. Gaiman told NPR, "That Möbius strip idea just took me back to the point where now I'm a grandfather and I have grandkids. And that's the kind of thing that I love being able to do with them . . . It felt like a perfect metaphor for the shape of a life [where] you are always traveling this Möbius strip."

Neil Gaiman has been honored for his work with countless awards, including both the Newbery and Carnegie Medals. A prolific creator, some of his most notable works include the comic book series *The Sandman* and the novels *Good Omens*, *Stardust*, *American Gods*, *Coraline*, and *The Graveyard Book*.

## OBJECTIVES

Upon completion of this lesson, students will:

### 1. KNOW (KNOWLEDGE):

- How to create a Möbius strip
- The properties of a Möbius strip
- Geometry vocabulary: face, edge, orientable/non-orientable, properties
- How to use the scientific method to make and verify predictions
- How a Möbius strip can symbolize real-world events

### 2. MASTERY OBJECTIVE:

- Students will be able to define a Möbius strip by discovering its properties through a series of experiments and observations.

## ACTIVITIES

### MATERIALS REQUIRED FOR THIS LESSON:

1. Scissors (one for each student)
2. Marker (one for each student)
3. Tape (two pieces for each student)

### MOTIVATIONAL ACTIVITY

1. Display **Image 1, Works by Neil Gaiman**. Ask students:
    - Are you familiar with any of these books? Do you know who wrote them?
2. Explain to students that all of these books were written by Neil Gaiman, an internationally renowned author who has written novels and comics that have been adapted into plays, TV series, and films.
3. Inform students that Neil Gaiman expanded his portfolio to include music when he debuted his first album *Signs of Life* in 2023 with Australia's FourPlay String Quartet. The music can be described as a blend of classical and folk music stylings paired with poetry and prose.

4. Play **Clip 1, "Möbius Strip."** Instruct students to consider what the song might be about as they listen. Then ask students:

    - Who are some of the people mentioned in the song?
    - What do the lyrics describe the people doing?

## PROCEDURE

1. Distribute **Handout - Lesson Vocabulary**. Pre-teach the vocabulary that will be used throughout the lesson. Work together with students to create meaningful context for each word as needed. Then ask students to draw a picture in the last column of the Math Vocabulary table. (*Example: Hold up a rectangular object [such as a plastic pencil case] and ask students how many **faces** the object has. Using the same object, ask students to identify where the **edges** of the object are. Discuss **properties** by looking at a familiar shape; ask students: how do I know this is a triangle? [because it has three sides]. Discuss **orientable** by considering a compass; no matter how you stand or sit in the classroom, North will always be in the same location.*)

2. Distribute **Handout - Möbius Strip Activity Packet**. Inform students that they will be investigating the geometric figure, and the subject of Gaiman's song, called a Möbius strip through a series of short experiments.

3. Read page 1 of the handout with students. Inform students that they will come back to this page after completing each experiment to fill in the properties table.

4. **Part 1 of Handout:** Display **Image 2, Möbius Strip and Loop Models**. Tell students to rip off the last page of the packet, and follow along with the directions on page 2 to create a model of a loop and a Möbius strip.

5. **Part 2 of Handout**: Divide students into groups and instruct them to complete the experiments on pages 3-7. You may wish to stop after each experiment to review the results and fill in the properties table together as a class. Encourage students to refer back to the vocabulary sheet when explaining their findings.

6. After completing the properties table, ask students to return to the vocabulary sheet and create a definition for loop and Möbius strip.

7. **Part 3 of Handout:** Using the Möbius strip created in Part 1, instruct students to complete the transformation activity on pages 8-9. Display **Image 3, Cutting a Möbius Strip** and model for students how to cut along the center of the Möbius strip. (*To begin, you'll need to cut a small slit, then insert your scissors into the slit and continue cutting all the way around.*)

## SUMMARY ACTIVITY

1. Display **Image 4, Conclusions and Connections 1**. Inform students that they will examine lyrics from Neil Gaiman's "Möbius Strip" and share their connections to today's activity with the class. Then ask students:

    - What part of our experimentation today do these lyrics connect to?
    - How can the scientific method help determine whether or not something is truly impossible?

2. Display **Image 5, Conclusions and Connections 2**. Then ask students:

    - What part of our experimentation today do these lyrics connect to?
    - Is the transformation of the shape truly "magic"? What properties of the shape may explain how it is able to transform in such a way?

3. Display **Image 5, Conclusions and Connections 2**. Then ask students:

    - What might be the meaning behind these lyrics from "Möbius Strip"?
    - What do you think the Möbius strip can be used to represent in real life?

## EXTENSION ACTIVITIES

1. Show students the artwork **Moebius Strip II** (https://www.artchive.com/artwork/moebius-strip-ii-red-ants-maurits-cornelis-escher-1963/#:~:text=M%C3%B6bius%20Strip%20II%20is%20a,mathematicians%20and%20artists%20since%201858). Explain to students that the artist, M.C. Escher was inspired by mathematics and regularly used mathematical principles in his artwork. Ask students to interpret the artwork then create their own Möbius strip-inspired art.

2. Ask students to research what a Möbius strip can be used for in real life.

STANDARDS

## NEXT GENERATION SCIENCE STANDARDS

*Energy*

4-PS3-3: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.

4-PS3-2: Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

4-PS3-1: Use evidence (e.g., measurements, observations, patterns) to construct an explanation.

## COMMON CORE STATE STANDARDS

*Geometry*

CCSS.Math.Content.4.G.A.2: Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles.

*College and Career Readiness Anchor Standards for Reading*

Reading 1: Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

Craft and Structure 4: Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

Integration of Knowledge and Ideas 7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

*College and Career Readiness Anchor Standards for Speaking and Listening*

Presentation of Knowledge 4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

*College and Career Readiness Anchor Standards for Language*

Vocabulary Acquisition and Use 4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

## RESOURCES

### VIDEO RESOURCES

- “Möbius Strip”

### HANDOUTS

- Handout - Lesson Vocabulary
- Handout - Möbius Strip Activity Packet
- Handout - Möbius Strip Activity Packet (Teacher’s Guide)