Recommended time, 1 hour

Curves, Arcs, and Circles

Parts Needed	CS Topics	Cross-Curricular Connections
 Marker Extension Set	Models & Visualization, Engineering Design Process	Science: NGSS 3-5-ETS1–3 (engineering design process)

Overview

Using engineering ingenuity, we'll explore ways to modify KIBO's movement and see what impact this has on the drawings we can make with the Marker Extension Set. In this inquiry-based lesson, students will gain familiarity using the Marker Extension Set.

Learning Goals

Students will:

- Change KIBO's movement paths by changing KIBO's wheels.
- Describe different kinds of curved shapes.
- Understand how to draw curves with KIBO's Marker Extension Set.

Preparation and Materials

Provide **large sheets of paper** or **erasable mats**.

Prepare some **videos of examples of circular motion**: planets in their orbits, birds circling, or dancers around a maypole.

You'll also need **materials for students to use to modify their KIBO wheels**. Provide round container lids (plastic yogurt lids work great!), sturdy cardboard for them to cut circles from, scissors, and masking tape. Any other makerspace materials are welcome too!

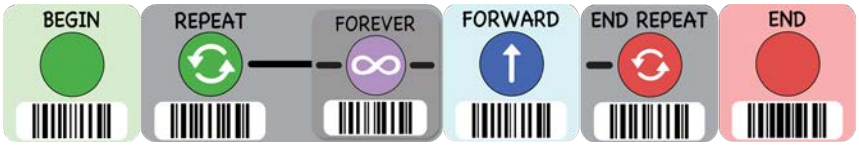
INSPIRE: Changing KIBOs Path

"Today we will experiment with changing KIBO's wheels to make KIBO travel on curved paths. We'll be able to make KIBO travel in long arcs and circles, and we will try to make KIBO draw different sized circles. I'll show you one way to change how KIBO travels; you can experiment to find more."

Remind the students of the Engineering Design Process, and the importance of testing and revising. Explain that when engineers make small changes in their designs, they can sometimes cause big changes in how their creations work.

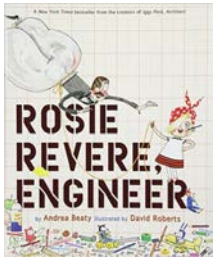
Demonstrate a KIBO with two wheels of different sizes. For this demonstration, you can use a cardboard circle, yogurt lid, or other sturdy circle that is slightly larger than KIBO's wheel; tape this circle to one of KIBOs wheels so that the two wheels are of different sizes.

Scan and run this program:



Ask the students what they notice. Explain to them that this is one way to make KIBO move in a circle, and that they will be able to look for other ways too.

CONNECT: Read *Rosie Revere, Engineer*



Read the book *Rosie Revere, Engineer* by Beaty and Roberts. This book shows the importance of imagination and persistence in an engineer's work. Rosie engages in the Engineering Design Process as she tests and improves her creation.

ENGAGE: Circular KIBO Paths

Allow students to experiment freely with modifications to KIBOs wheels to cause KIBO to travel in circular paths and to draw curved lines with the attached markers.

This is primarily an engineering and building activity, where students will learn that when KIBO has two different sized wheels, KIBO will curve toward the side with the smaller wheel. A more significant difference between wheel sizes will lead to a tighter curve. But students should experiment freely without being directed only toward this particular outcome.

The students can use a "forward forever" program like the one demonstrated during the INSPIRE section. They may also want to explore the impact of wheel sizes with different programs. For example, the SPIN command can behave in unexpected ways with different sized wheels.

Some things students might explore:

- Attaching KIBO's circular stage platform to a side motor socket, to create a very large wheel
- Cutting circular shapes from craft materials and recycle supplies, then attaching those in various ways to KIBOs wheels
- Experimenting with different shaped wheels (oval or square wheels!)
- Changing marker arm placement (does a pen on the inside of the curve work differently than on the outside?) or chains of multiple markers (does a long "tail" of markers behave differently on a curved path?)

Tip: If KIBO's two wheels are very different sizes, the markers may not contact the paper reliably. However, solving this can be an interesting engineering challenge too! Can students find other ways to attach the markers?

Throughout this inquiry process, ask your students to notice the impact of their changes and the drawings that KIBO is making. Encourage them to record their observations in their journals/ notebooks.

Challenge: For students who would like to personalize their KIBOs, they can decorate their KIBOs in ways that represent the curved movements they've created. Refer back to the opening conversations and videos where you explored different real-world things that move in circles. Can students decorate their KIBOs to look like one of the circle-moving things they brainstormed?

REFLECT: What Curves Did We Create?

At the closing meeting, groups should share the engineering modifications they experimented with. They might share something that worked well, or share something that they tried that didn't work or that really surprised them. If any groups decorated their KIBOs, they can share the decorations too.

Then, lead the class in a Gallery Walk to visit all of the drawings made by the curved KIBOs. Ask students to share anything they notice about the drawings. Encourage them to observe the different sizes of circles and arcs that KIBO created with wheels of different sizes.

To emphasize a math and geometry connection, guide students in using precise terms for the shapes they see, such as "circle", "arc", "oval", etc.

After the lesson is complete, collect and save the drawings for creating the gallery in Grade 3, Lesson 8.

