KIBO Mark-and-Measure!

Experiment, measure, and record with the KIBO Free Throw Extension. As students mark each landing spot, a pattern emerges.

Materials:

- KIBO-10 kit (or greater) per group, with wheels and motors inserted
- KIBO Free Throw Extension per group
  - Provide 2 rubber bands and one ball to each group
- Sticker sheet for each group
- Measuring tape for each group
- Data Collection Sheet per group

Preparation:

- Tape a large (appx 4'x4') area of paper in a central area of the floor. Each group will sit around the edges of this area with their KIBOs.
- Scan the program BEGIN -> THROW -> END into each KIBO.
- Consider setting up roles for this activity: Free Throw Manager, Measurer, and Data Recorder. Students can change roles during the activity.

Introduction:

- Demonstrate the activity in a group introduction. Each group starts their KIBO at a set point around the floor paper. They will choose options for their Free Throw, then throw the ball. They will mark where it lands on the paper by placing a sticker, and then measure and record the distance the ball traveled.
- Engage the students in a discussion about the different Free Throw settings they can change in this activity: the stopper position, which affects the **trajectory**; and which hoop the ball is placed in, which affects the **leverage**.
  - Note: the data collection sheet does not include an entry for number of rubber bands. Changing the number of rubber bands has a large impact on the ball's travel distance, so the balls may not even land on the paper if the students change the number of bands.

> ***Trajectory***: the path of travel of the ball.
>
> ***Leverage***: the extra force delivered by a longer throwing arm (the lever).

- If measuring tapes are a new tool for the students, introduce these during the initial group time as well.
  - Note: students will mark their ball's landing spot with a sticker, and *then* measure from the sticker to their KIBO to find the distance.

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Activity (individual or group work):

Note: Because all balls are landing in a central area, having each group take turns launching and measuring can avoid collisions and conflict.

1. Each group chooses options for their throw attempt.
    - Choose Free Throw settings (number of rubber bands, arm stopper position, long or short basket)
2. Record the choices on the data collection sheet.
3. Load the ball into the Free Throw and run the program.
4. If the ball lands on the paper area, mark the spot with a sticker.
5. Using measuring tape, measure the distance from the front of the group's KIBO to the sticker, and record on the data sheet.
6. Repeat from Step 1, changing the options to vary the throw.

Discussion / Technology Circle:

- Have students share their findings in a Technology Circle. Ask the students: What do you notice about the pattern of stickers? What effect did changing the Free Throw options have?

Standards Addressed:

NGSS (Engineering Design)	K-2-ETS1-3: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
NGSS (Forces and Interactions)	K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
NGSS (Energy)	4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.
Common Core Math Standards	CCSS.MATH.CONTENT.K.MD.A.1: Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. CCSS.MATH.CONTENT.1.MD.A.2: Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. CCSS.MATH.CONTENT.2.MD.A.1: Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

KIBO Mark-and-Measure Data Collection Sheet

Which arm Stopper?	Which throwing Hoop?	Distance Measured
1 2	Short Long	
1 2	Short Long	
1 2	Short Long	
1 2	Short Long	