How can we design fun moving toys that other kids can build?
Learning Set 2: What causes the motion of our toy to change?
Math Lesson 2.3: How do different surfaces affect the motion of our toys?

Lesson Overview (45 min) Note: May take 30 minutes more if the launchers are built by the students.	**Lesson DQ:** How do surfaces made of different materials affect the motion of our toys? **Lesson Snapshot** 1. Introduction: Revisit the balloon rocket investigation and review the "fair test" process. 2. Planning Investigation: Students plan an investigation to determine the impact that two different materials (which cause different amounts of friction when in contact with a moving toy) have on the motion of toy cars. Review with students that friction is a force that results from two surfaces in contact with each other and which resists motion. 3. Conducting Investigation: Each group of two to three students will launch cars and observe and record the distance the cars travel on two different materials, for example, poster board (or floor tile) and a towel (or carpet). 4. Wrap Up: Students record their observations, then share observations and post any new questions to the DQB. . **Learning Performance** Students will develop predictions about the interaction between objects and the surfaces they are in contact with to plan and conduct an investigation that explains the effect of an unbalanced force on the motion of objects(cause and effect, structure and function). **Building toward PE(s)** **3-PS2-1** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. **Math Standards** **Measurement and Data -** Represent and interpret data. CCSS.MATH.CONTENT.3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. **Math Competency Statement** I can generate data by measuring lengths to the nearest centimeter.
Materials and Prep	***Materials*** • Matchbox car • Materials and instructions for building toy car launcher • Poster board (or floor tile) • Towel • 2 Sheets of plain chart paper • 3 Sheets of graphing chart paper • Measuring tape • Tape • Student Sheet: Recording Observations ***Embedded Language Supports*** • Realia to support listening and speaking about science ideas • Use of multiple domains • Explicit support for engaging in student investigation • Discourse moves from WIDA ***Preparation*** • Determine whether you (the teacher) or your students will construct the toy car launchers • Construct sample of toy car launcher - collect shoe boxes to make launchers • Pre-assign student groups/partners (recommended) • Identify an open area to set up the toy car launcher stations (hallway, clear section of the classroom, a vacant room, etc.). At each station, secure 2-3 measuring tapes to the floor end to end in front of the launcher to use for measuring distance. If space and materials are available, teacher can set up multiple stations per material.

Lesson Component	**How to Implement**

What are Kids Figuring out?	**Students are figuring out that** toy cars move different distances when the same initial force is applied but the cars come in contact with surfaces made of different materials (different structures causing different frictional forces). **Look Fors** 1. Look for students using peers' observations of the structure of the surfaces as evidence to predict the amount of friction that will act on the moving car. 2. Look for students communicating the need to control variables as they conduct the investigation with their group. "You have to pull back the launcher the same amount each time." " Where should we start to measure?" 3. Look for students explaining that friction is a force that results from two surfaces in contact with each other and which resists motion.
1 Introduction (10 min)	**Introduction: Revisit balloon rocket investigation and fair tests and introduce the Driving Question, "*How do different surfaces affect the motion of our toy cars?* "** 1. Review with students the investigation of different string textures and the balloon rocket from the previous day's lesson. Lead students in a discussion to recall what happened with the distance the balloon rocket traveled when it was placed on different types of string (e.g., *What happened when the balloon rocket was placed on the smooth string? The rough string? Why did the distance the balloon traveled change with the different strings?*). Ask students how the distance the balloon rocket traveled was impacted by the interaction of the textured string and the moving rocket (friction). 2. Review with students the meaning of friction as posted on the DQB or interactive word wall in Lesson 3.2: ***Friction is a contact force that acts between a moving object and the surface it is in contact with. Friction can change the direction or speed of motion of an object.*** Introduce the Driving Question, "*How do different surfaces affect the motion of our toys*?" Inform students that they will now plan their own investigation to determine how friction impacts the motion of toy cars using the "fair test" process they discussed in the balloon rocket investigation.
2 Planning Investigation (10 min)	**Planning Investigation: Design toy car investigation of friction** 1. Brainstorm with students the different types of materials (materials that create a lot of friction or very little friction) they could use to test how the motion of the toy car is affected. Show students the toy car and possible materials (towel, carpet, tile floor or poster board), have them describe the texture of surfaces of the different materials and compare them to the strings from the previous lesson. 2. Remind students that they are planning an investigation to answer the question: ***How do different surfaces affect the motion of our toy cars?*** Write this question on the board and have students find it on their Recording observations student sheet (or write it in their science notebooks). 3. Ask students, "*How do you think each material will affect the motion of the car?*" Tell students to *turn-and-talk* to their partner and make predictions about what they think. Students can record their predictions on the Student Sheet: Recording Observations. 4. Demonstrate for students how the toy car launcher works. Ask students, "What do you think will happen if I pull the rubber band back farther? "What will happen if I pull the rubber band a shorter distance?" Allow student volunteers to test their ideas by pulling back on the rubberband and describing the force that they feel at different positions in order to figure out that the amount they "pull back" on the rubber band will cause a different force on the car. 5. Ask students, "In a fair test, do you think it is important that the rubber band be pulled the same distance for each trial for each surface?" Have students explain why or why not. Students should reach the conclusion that the rubber band should be stretched the same amount each time in order for the investigation to be considered a fair test. 6. Ask students what other ideas they have related to making sure they conduct a fair test.

Remind students of the jumping investigation in squirrels; they may discuss **measuring the same way each time**.

7. Divide students into groups of three. Assign the group members one of the following roles: (1) student to launch the car, (2) student to measure the distance travelled in centimeters (using measuring tape), and (3) student to record observations (**Optional: Students can change roles as they rotate through the stations)**.
8. Once the toy car launchers are built or distributed, explain to the students that they will be launching their toy car on various materials located at different stations. Tell students that each group will record observations and measure how far each toy car travels on each material (1 smooth surface and 1 rough surface).

Discourse Move: Help a student clarify his/her thinking
During the discussion of students' predictions of motion, use questions to help clarify students' thinking and help them make connections between the structure of the surfaces and the amount of friction they will exert. Support all students to articulate their thinking, "What I think I heard you say is…" "What were you thinking about that helped you make that prediction?" What did you mean when you said the surface was rough? Can you describe it with more details?

3
Conducting Investigation
(15 mins)

Conducting Investigation: Make observations
Distribute the Student Sheet: Recording Observations to students. Have students discuss with their group their prediction of how the car will move on each surface. Instruct students to write their predictions on the Student Sheet: Recording Observations

1. Model for students how to complete the chart on the observation sheet by demonstrating launching a toy car on one of the materials. Have 2-3 rough and smooth surface testing stations set up in the room. Each group will test at one smooth and one rough testing station using their own launcher.****It is important to stress to students the importance of launching their car as soon as they reach their station as they only have 3 minutes at each station.**** Inform students of the signal you will use to inform them it is time to switch stations.
2. Remind students of expectations for working together in their group: (1) make sure all group members are actively involved in the task, (2) make sure everyone has a chance to share their ideas, and (3) show that you value the ideas of all group members by listening, asking questions, and talking together.

4
Wrap Up
(10 min)

Wrap Up: Share out recorded observations

1. Have the student recorder share his/her recorded observations with the group to check for agreement about how they described what happened when the car was launched. Group members can suggest changes and corrections. Groups should then share their data with the class. As they share, record data on a class chart and ask each group to identify any similarities or differences between their data and the data from other groups.
2. Emphasize the idea of patterns in the data rather than looking at individual data points. Support students to make causal connections between the patterns in the data and the texture of the surfaces by comparing their prediction with the data. **Suggested Prompt:** "How does your data compare with your prediction?" Why is it important to look at the pattern rather than one piece of data as evidence?
3. Wrap up by asking students, "What are they noticing? What are they wondering about? What new questions do they have?" Post any new questions to the DQB.

Assessing Student Learning

Formative Assessment
Look Fors
1. Look for students using peers' observations of the structure of the surfaces as evidence to predict the amount of friction the materials will exert.
2. Look for students communicating the need for variables to be controlled as they conduct

the investigation with their group. “You have to pull back the launcher the same amount each time.” “ Where should we start to measure?”

3. Look for students explaining that friction is a force that results from two surfaces in contact with each other and which resists motion.

Evidence Statement

- Student predictions describe a relationship between the texture of the surface and the motion of the toy car. “I think the toy car will slow down and stop on the towel because it has a rough surface and there is more force pushing in the direction opposite the motion of the car.” “I think the toy car will roll farther and straighter on the floor because it has a smooth surface and has less force pushing against the motion of the car.”
- Students’ investigations explore how different surfaces can apply forces that can slow and stop a toy’s movement.
- Student observations include numerical measurements and describe speed and direction of the motion of the toy car on each surface.

Assessment Description

Student predictions and observation charts can be evaluated as a formative assessment of the lesson.

Individual Assessment Option

Ask students to write a sentence describing what they noticed about how different amounts of friction impact the distance a toy car moves.