Lesson 11: Building a Trundle Wheel

Goals

- Create a trundle wheel and use it to calculate the length of the classroom.
- Explain (orally and in writing) how a trundle wheel is used to measure long distances.

Lesson Narrative

This lesson is optional. In the second lesson of the 4-lesson sequence, students build a trundle wheel, a device used to measure walking distances. First, they learn about a trundle wheel and discuss how such a device works (MP5). Then, students use paper plates to make a usable trundle wheel and practice using it to measure distances in the classroom.

Students can either use the same-sized paper plates or different groups can use different-sized paper plates. The use of different-sized plates allows for more mathematical discussion about how diameter and circumference of the plates affect how we report the distance being measured (MP6).

As with all lessons in this unit, all related standards have been addressed in prior units. This lesson provides an optional opportunity to go deeper and make connections between domains.

Alignments

Building On

- 7.G.B.4: Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

Addressing

- 7.G.B.4: Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.
- 7.RP.A: Analyze proportional relationships and use them to solve real-world and mathematical problems.

Instructional Routines

- MLR2: Collect and Display
- MLR7: Compare and Connect

Required Materials

Index cards
Measuring tools
Metal paper fasteners
brass brads
Paper plates
Tape

Required Preparation

To build the trundle wheel, each group of 3–4 students will need 1 paper plate, a metal paper fastener, something long object to use as the handle, an index card, and tape.

Ideally, have three different sizes of paper plates for different groups to work with (typical sizes are 6–12 inches) to help reinforce the point that the size of the plate affects how many "clicks" (rotations) it takes to measure the same distance.

There are many options for how to make the handles. A yardstick or meter stick with a hole on one end is most convenient. Alternatively, you can tape two rulers together or cut pieces of sturdy cardboard or foam core that are about 1.5 inches wide by 30 inches long, and poke a hole centered at one end.

Student Learning Goals

Let's build a trundle wheel.

11.1 What Is a Trundle Wheel?

Optional: 10 minutes
In the previous lesson, students tried using simple methods and tools to measure long distances. In this activity, they learn that a trundle wheel is a tool used in real-world situations to measure such distances. From an image and a description of what a trundle wheel looks like, students think about how the tool works and how they could build one. Students think about the tasks for which a trundle wheel is an appropriate measuring tool (MP5). This builds on work students did in an earlier unit, when they learned about the relationship between the circumference of a wheel and the distance it travels.

Building On

- 7.G.B.4

Instructional Routines

- MLR2: Collect and Display

Launch

Keep students in the same groups of 3–4 from the previous lesson. Explain to students that a trundle wheel is a measuring device composed of a handle, a wheel, and a device that clicks each time the wheel completes on rotation. Give students 5 minutes of quiet work time followed by whole-class discussion.

Access for English Language Learners

Writing, Speaking: MLR2 Collect and Display. While groups are working on this activity, listen to student conversations and document phrases from conversations or students' written work that describe sources of error and the meaning of circumference. Display phrases for the class to consider when responding to questions posed during the synthesis. Press for student use of mathematical language during the discussion.
Design Principle(s): Support sense-making

Anticipated Misconceptions

Students may not remember the relationship between the circumference of a wheel and the distance traveled by the wheel. Remind students of this idea from previous lessons.

Student Task Statement

A tool that surveyors use to measure distances is called a trundle wheel.

1. How does a trundle wheel measure distance?
2. Why is this method of measuring distances better than the methods we used in the previous lesson?
3. How could we construct a simple trundle wheel? What materials would we need?

Student Response

Answers vary. Possible responses:

1. You push the wheel, and as it turns it keeps track of the number of rotations. If we know the circumference of the wheel, we can multiply by the number of rotations to find the distance we walked.
2. The circumference does not change, it is constant, and each rotation follows the next without any gaps. Strides can be slightly different from step to step, and if we use a measuring tape, there might be a gap between iterations.

3. We need a wheel, a handle, and a way to keep track of and count rotations.

Activity Synthesis

The goal of this discussion is for students to remember the connection between the circumference of a wheel and the distance the wheel travels during one rotation, so that they are prepared to use a trundle wheel to measure distances in the next activity. Invite students to share their ideas about how to build a trundle wheel and ask them how their design will allow them to measure distances.

Consider asking the following questions:

- "What information about the wheel do we need to know? What quantities should we measure?"
- "Why is it important to have a clicking device? What information does the device give us?"
- "If we have a wheel that has diameter 25 cm and we count 11 clicks to go across the classroom, what is the length of the room?" (Answer: $25\pi \cdot 11$ or between 8 and 9 m.)

We can measure distance by counting the rotations of the wheel and multiplying by the circumference of the wheel. The construction of the trundle wheel allows us to easily count the rotations as we walk.

11.2 Building a Trundle Wheel

Optional: 25 minutes
In this activity, students build a trundle wheel and use it to measure distances in the classroom. The trundle wheels need to be stored in the classroom for use in the next lesson. If it is not feasible to store a trundle wheel from every group of 3–4 students, have them combine to form larger groups before building the wheels. Each student should still get a chance to practice measuring with the trundle wheel.

It is suggested that students build their trundle wheels using a paper plate as the wheel, two rulers taped together end to end as the handle, a metal paper fastener, and an index card taped to the wheel to produce an audible "click" when it hits the handle. There are many other ways to build a trundle wheel. If this fits into the culture of the class, students can use other designs and materials, e.g., students could use a bike with a playing card in the spokes to count rotations.

Addressing

- 7.G.B.4
- 7.RP.A

Instructional Routines

- MLR7: Compare and Connect

Launch

Keep students in the same groups, or if necessary, combine them to form larger groups. Discuss how to build the trundle wheel and distribute the supplies. Give students 15 minutes of group work time to build and try out their trundle wheels, followed by whole-class discussion.

Anticipated Misconceptions

Students may need some trial and error in building working trundle wheels, in particular for placing the clicking device. Encourage them to try out their design and then revise it as necessary.

Student Task Statement

Your teacher will give you some supplies. Construct a trundle wheel and use it to measure the length of the classroom. Record:

1. the diameter of your trundle wheel
2. the number of clicks across classroom
3. the length of the classroom (Be prepared to explain your reasoning.)

Student Response

Answers vary. Possible solutions:

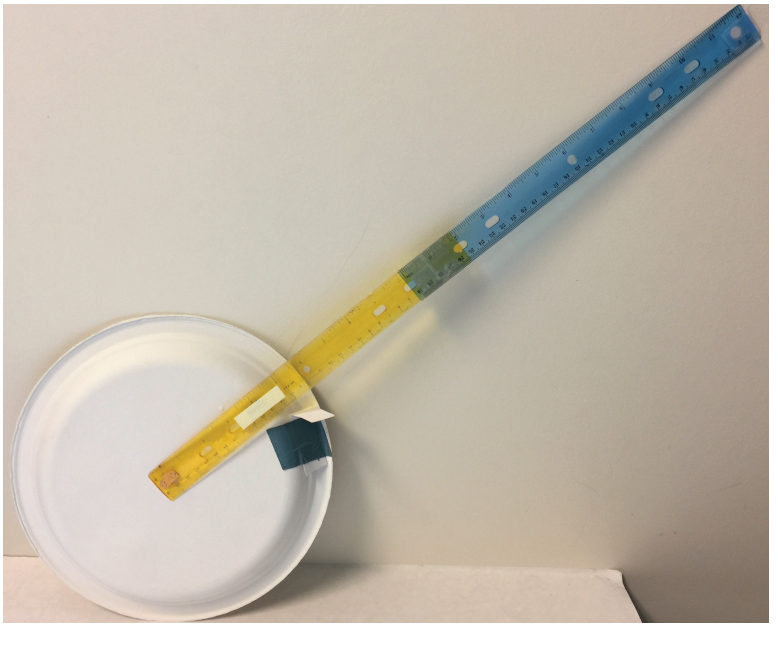

Plate radius is 13 cm. Diameter is $2\pi \cdot 13$ or 81.7 cm. 1 click corresponds to 81.7 cm. If we count 20 clicks on the path, then the distance of the path is $20 \cdot 81.7$ or about 16 m.

Activity Synthesis

The goal of this discussion is for students to double-check that their trundle wheels work correctly and their results are reasonable. Invite one group that used each size of paper plate to demonstrate how their wheel works by walking across the classroom and counting the

"clicks." Record the data for all to see and discuss how these groups' calculations for the length of the classroom compare, which may include the following points:

- The group with the smaller plate had a larger number of clicks and vice versa.
- Each group needs to multiply their number of clicks by the circumference of their wheel.
- The circumference of the wheel can be found by multiplying the diameter times π or the radius times 2π.
- Should we report our answer in terms of π or use an approximation?
- Are the groups' answers for the length of the classroom pretty close or very different?
- Is it possible to count half rotations of the wheel?

Access for Students with Disabilities

Representation: Develop Language and Symbols. Display or provide charts with important terms and vocabulary. Invite students to suggest language or diagrams to include that will support their understanding and memory of: formula for circumference, rotation and the relationship between circumference of a wheel and the distance traveled.
Supports accessibility for: Conceptual processing; Memory

Access for English Language Learners

Representing, Conversing: MLR7 Compare and Connect. Rearrange groups of students so that they are seating with another group that used the same size paper plate to build their trundle wheel. Invite groups to share their solutions and reasoning for the length of the classroom with each other. Ask, "What is the same and what is different?" about how they used their trundle wheel to measure the classroom. This will help students to consider precision when measuring and use mathematical language as they converse.
Design Principle(s): Maximize meta-awareness; Cultivate conversation