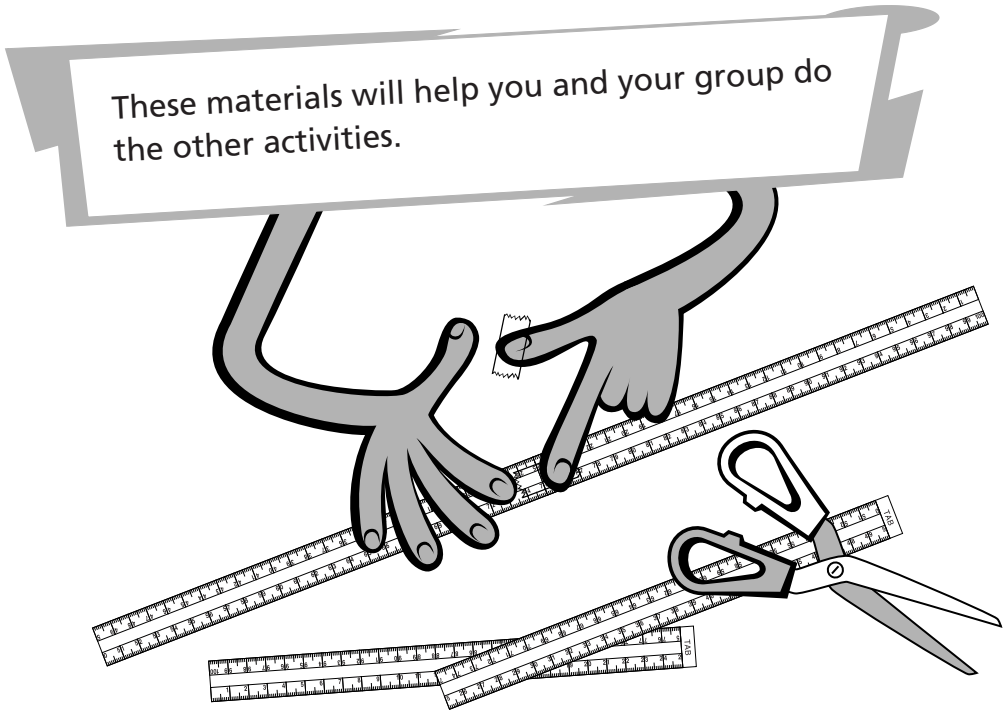
Tools You Can Make and Use



Activity 21 Stride Ruler

This activity introduces people to a tool they can use to estimate distances: their own two feet.

Activity 22 Paper Dice

People can use this template to fold their own dice from paper. These paper dice can be used to play Boxed In! *and* Pig.

Activity 23 Make-It-Yourself Meterstick

With this activity, people can make the metersticks they need for various other activities.

Activity 24 Centimeter Ruler

People can use copies of this page on card stock to make their own centimeter rulers.

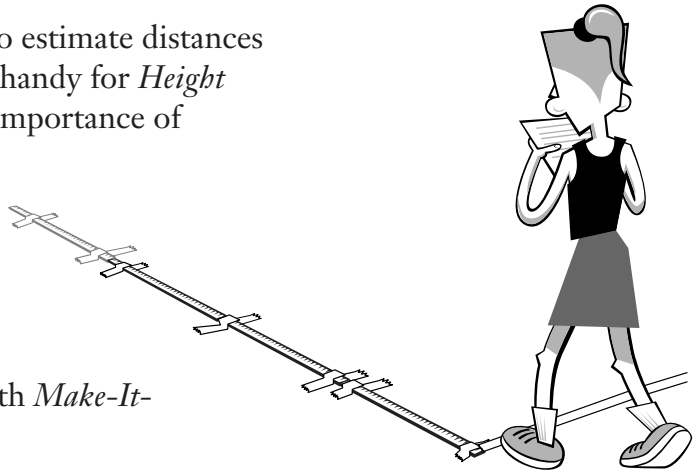
Grid Paper

Copy this page whenever you need graph paper for your group.

ACTIVITY 21

Stride Ruler

After doing this activity, people will be able to estimate distances using their own two feet. This tool comes in handy for *Height Sight* (page 138). *Stride Ruler* introduces the importance of estimates and offers practice in measuring, an important skill for middle schoolers.



Preparation and Materials

For the entire group, you will need:

- 4 metersticks (you can make your own with *Make-It-Yourself Meterstick*, page 199)
- tape (any kind)
- calculators (1 per 3 or 4 people)

For each person, you will need:

- a copy of *Stride Ruler*

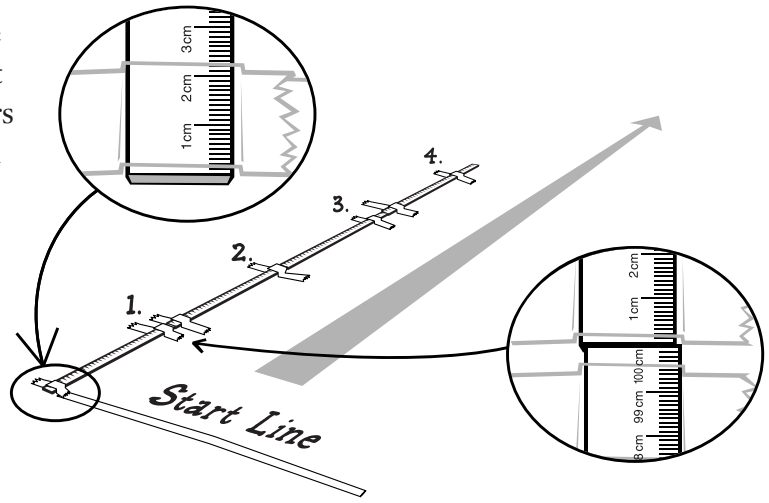
Before beginning this activity, lay the metersticks end to end in a straight line on the floor, placing the "zero" end of one against the "100" end of the next. Tape them securely to the floor, and then tape a "Start Line" on the floor at the zero-cm mark on the first meterstick. This is where people will line up their toes before starting forward.

Planning chart

Measuring 10 steps	15 minutes
Calculating the length of a step	5 minutes
Making *Make-It-Yourself Metersticks* (optional)	20 minutes

Using This Activity

Tips for using *Stride Ruler* start on page 190. If your group does *Stride Ruler* just before *Height Sight* (page 138), members will immediately see why this is a useful way to measure a distance.



The Math Explorer
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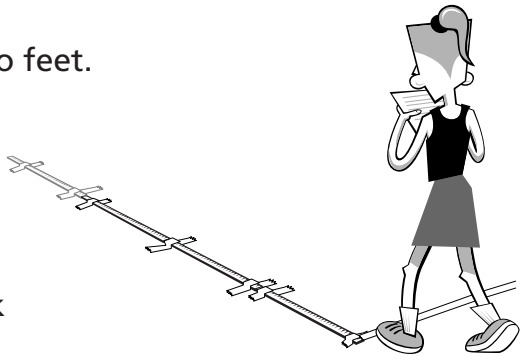
Explorer's Notebook

Stride Ruler



You can measure a distance using only your own two feet.

What Do I Do?

Step 1 Put your toes just behind the "Start Line." Take 10 "baby steps" forward, walking right next to the line of metersticks. (In "baby steps," you walk heel to toe, so that the heel of one foot touches the toes of the other foot.)

Step 2 After your tenth step, stop and look at where the toes of your forward foot are. What's the measurement in centimeters (cm) on the meterstick? Write that number down.

Position of my toes after 10 baby steps = _____ cm

Step 3 Now look to see how many metersticks you walked past. For every meterstick you walked past, add 100 cm to the measurement in Step 2. Write down your answer in centimeters.

Length of 10 baby steps in centimeters = _____ cm

Step 4 To find the length of just one step, divide your total measurement by 10.

$$\frac{\text{Length of 10 steps in cm}}{10} = \text{\_\_\_\_\_ cm} = \text{Length of 1 step in centimeters}$$

Step 5 Now you have a tool that will help you estimate the distance between any two points. Simply walk in baby steps and count your steps. Then use this formula:

Number of baby steps × Length of baby steps = Distance in centimeters

Helping Your Group with *Stride Ruler*

Have each person follow the instructions in *Stride Ruler* on page 189 to measure the length of 10 steps and then compute the average length of 1 step.

Measuring Steps

You may have to show people what "baby steps" are. Simply walk heel to toe.

If possible, help each member of the group read his or her measurement from the metersticks and count how many metersticks were walked past. People need to add 100 cm to their measurement for each meterstick they walked past. Sometimes people forget that *each* meter is 100 cm.

Some people may want to use a calculator to divide by 10. Others may realize that dividing by 10 is easy: just move the decimal point one place to the left. Let group members make this discovery on their own.

Why Measure Ten Steps?

You might ask people if they know why they went to the trouble of measuring 10 steps if all they really want to know is the length of 1 step.

There are two good reasons. First, no measurement is exact; there's always some error. In a sense, every measurement you make is an estimate, no matter how carefully you measure.

Second, the length of each baby step you take will be slightly different. By measuring the length of 10 steps and dividing by 10, your longer and shorter steps balance out to give you the length of an average baby step. Because you have measured 10 steps, you divide any measurement error by 10, giving you a more accurate measurement.

After Completing *Stride Ruler*

Explain to group members that they now have a tool that will help them estimate distance. By counting the number of baby steps from one point to another, they can make a reasonable estimate of the distance between the points.

To give it a try, ask everyone in the group to count how many baby steps it takes to walk a certain distance—the length of the room, for example. Chances are everyone will get a different number of steps.

Convert Baby Steps to Centimeters

Now have people convert their measurements in baby steps to measurements in centimeters. They can do this by following the formula in Step 5 of the *Stride Ruler* instructions. Or you can introduce them to *dimensional analysis*, which is a simple method for figuring out how to convert from one measurement system to another, without memorizing any formulas. See *Where's the Math?* on page 193 for details.

Conversion Challenges

After group members have successfully used baby steps to measure a distance, you might challenge them to convert from centimeters to other systems of measurement.

Convert Centimeters to Inches

Ask people to convert the average length of their baby step in centimeters into inches. Tell them that there are 2.54 cm per inch, or 2.54 cm/in.

Some people won't know how to convert centimeters to inches. They may know that they have to either divide by 2.54 cm/in. or multiply by it, but not know which.

Here's an easy way to help them figure it out. Have them take a look at a ruler marked in both centimeters and inches. Ask, "Will there be more inches than there were centimeters, or fewer?" Most people will realize that there will be fewer inches than centimeters because an inch is longer than a centimeter. Therefore, when centimeters are converted to inches, the answer will be a smaller number.

Now ask, "If you multiply by 2.54 cm/in., do you get a larger number or a smaller number?" Multiplying by 2.54 cm/in. results in a larger number, which they have just told you is wrong. That means the right choice is to divide by 2.54 cm/in.

To convert centimeters to inches, divide the length in centimeters by 2.54 cm/in.

People can use a calculator to do the calculation—and then check their answer by marking out their step in centimeters, and measuring it in inches.

Convert Steps to Miles

Ask people to figure out how many baby steps they would have to take to walk a mile (mi).

Explain that there are

63,360 in./mi 160,934 cm/mi

5280 ft/mi

You may have to lead your group through this calculation. You can use the tool of *dimensional analysis*. (See *Where's the Math?* on page 193.) Or follow these steps:

- Take the number of centimeters per mile—160,934 cm/mi.
- Figure out exactly what you want the answer to be, in terms of which unit is where. You want to know how many baby steps there are in a mile. So, you want an answer that is in baby steps per mile, or baby steps/mi. That means you want "baby steps" to be on the top in your answer (in the *numerator*) and "miles" to be on the bottom (in the *denominator*).
- Figure out how you can write down what you already know to put baby steps in the numerator and miles in the denominator:

$$\frac{\textbf{1 baby step}}{\textbf{20 cm}} \times \frac{\textbf{160,934 cm}}{\textbf{1 mi}}$$

- Multiply these numbers as you would multiply any fractions (multiplying the numerator by the numerator and the denominator by the denominator). Because you have centimeters in both the numerator and the denominator, this unit cancels out, leaving you with:

$$\frac{\textbf{160,934 baby steps}}{\textbf{20 mi}}$$

- Divide 160,934 by 20, and you get 8046.7 baby steps/mi.
- Round the answer to 8047 baby steps/mi.

When converting from one unit of measurement to another, it's always important to pay attention to the units of measurement. Including the units provides a way to double-check an answer.

Estimation Challenges

Once people in your group know the length of their stride, they can use that number to make other estimates. Here are some things they can try:

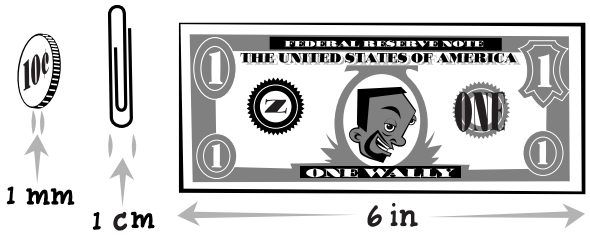
- They can use their stride rulers to measure the distance between two points in the room (or outside). Have them compare results.
- As a research project, they can figure out the distance they walk to school, between classes, or to the store.

Other Handy Ways to Estimate

Tell people in your group that a centimeter is about the width of their little finger. Ask them if they can suggest any other ways to use their bodies or common objects to measure distance.

There are many possible answers to this question. Here are just a few:

- A jumbo paper clip is about 1 centimeter wide.
- A dollar bill is about 6 inches long.
- A dime is just a little more than 1 millimeter thick.
- This page is about 30 centimeters long.



Where's the Math?

At school, students may get the idea that math and science are always very precise. In math class, there is usually a precise answer. But in everyday life, you often need only an estimate. You might describe an estimate as a well-informed guess—an answer that may not be exactly right, but is close enough for your purposes.

Here's an example you might share with your group. Suppose you decide to go to the movies Saturday night. You want to figure out how much money you'll need for the movie and a drink and some popcorn. You don't need to know the amount down to the penny—but you do need to know *about* how much money to take with you. Is 5 dollars too little? Is 20 dollars too much? When you figure out how much money you need for the movie, you are making an estimate.

Many mathematical problems require precise answers, but even in math class, estimation can help a student. It's always useful to estimate an answer before doing the precise calculation. Then a student can check his or her answer against the estimate. If the two are very different, the student knows to double-check his or her calculations.

Where's the Math?

You can show members of your group a tool that will help them figure out how to convert from one measurement system to another, without memorizing any formulas. This tool is known as *dimensional analysis*.

Converting from one unit of measurement (such as baby steps) to another (such as centimeters) requires a *conversion factor*. In the *Stride Ruler* activity, people figured out a conversion factor for baby steps to centimeters. Their conversion factor is the number they calculated in Step 4: the length of one baby step in centimeters.

Ask group members how they might write that number as a fraction. Here are two ways:

$$\frac{\textbf{20 cm}}{\textbf{1 baby step}} \qquad \frac{\textbf{1 baby step}}{\textbf{20 cm}}$$

Both ways are correct. You might want to point out that these fractions are both equal to 1. (Remember, any number divided by itself equals 1. So, a fraction in which the top and bottom are equal—whether it's $\frac{2}{2}$, or $\frac{3}{3}$, or $\frac{20\text{ cm}}{1\text{ baby step}}$—is equal to 1.)

Ask your group what happens when you multiply a number by 1. (You get the number you started with.) So, multiplying by one of these conversion factors won't change the number—but it will change the units!

The key to converting from one unit of measurement to another is this: pay attention to the units! (That may sound obvious, but lots of people don't do it!) When you multiply fractions, the units act just as numbers do. So, if you have the same unit on the top of one fraction and on the bottom of the other, they cancel out.

Suppose the length of the room is 25 baby steps when measured by someone whose baby step is 20 cm long.

$$\frac{\textbf{20 cm}}{\textbf{1 baby step}} \times \textbf{25 baby steps} =$$

$$\frac{\textbf{20 cm}}{\textbf{1 baby step}} \times \frac{\textbf{25 baby steps}}{\textbf{1}} =$$

$$\frac{\textbf{20 cm} \times \textbf{25 baby steps}}{\textbf{1 baby step}}$$

The baby steps cancel out, and the result is

$$\frac{\textbf{20 cm} \times \textbf{25}}{\textbf{1}} = \textbf{(20} \times \textbf{25) cm = 500 cm}$$

What will happen if you use the other fraction, $\frac{1\text{ baby step}}{20\text{ cm}}$?

$$\frac{\textbf{1 baby step}}{\textbf{20 cm}} \times \textbf{25 baby steps} =$$

$$\frac{\textbf{1 baby step} \times \textbf{25 baby steps}}{\textbf{20 cm}}$$

Look at the units. You'll see that they don't cancel out, so this can't be the right answer!