Explorations

Math Moves!

Experiencing ratio and proportion

Educator Guide developed by the Science Museum of Minnesota

Inquiry and prolonged engagement are essential to math

Science centers are known for promoting active, "hands-on" inquiry in science. Mathematics can also involve active questioning, constructing, manipulation of objects, and experimenting. Try multisensory active math in Math Moves! Engage your students in curriculum-related, exhibit-based learning, integrating the motivation and energy of free-choice investigation, the fun of discovery and personal meaning-making. Enacting math can be a powerful tool for exploration and understanding.

Table of Contents

In This Guide

Math Moves! Experiencing Ratio and Proportion provides rich, engaging experiences that:

- Encourage children to acquire deep understanding of math concepts.
- Make the practice of math skills surprisingly enjoyable
- Help children identify success with math as personally relevant and rewarding.

The content focus is the broad topic of ratio and proportion, including fractions and the geometric concept of similarity, with exhibits that are:

- **open-ended** to encompass several ways visitors may interact and often more than one math problem to explore
- **conversational** to encourage children and adults to talk with each other about the exhibit activity.
- **accessible** by incorporating audio and written labels in English and Spanish.

When you visit the Math Moves! exhibition:

- Share expectations, plans and schedules for the visit with students and chaperones. Give chaperones copies of any materials given to students. Give chaperones copies of any activities students will do. A chaperone guide (pg. 28) provides guiding questions for chaperones to use with Kindergarten through grade 5 groups. This may also be used to supplement student pages for grades 4–5.
- Encourage students and chaperones to have exploration time at each exhibit. "Play with the exhibit. What do you notice? What are you learning about? What would be interesting for others to do here?"
- Do some preparation activities before your visit. Use suggestions in this guide and the resource list for more ideas.
- Divide your class into small groups (3–4) to work together in the exhibition. For large groups, schedule time in other parts of the museum so each student has access to the exhibits.
- Exhibits are not sequential. You can have students work at one or two of the exhibits or all of them. Give student groups one or two exhibit pages to complete, then share information about "their" exhibits back at school.
- There are two versions of student pages: Level 1 (grade 4–5) and Level 2 (grade 6–8). Review each to see which ones would be most appropriate for your classroom.
- Add your own page(s) or thinking prompts. Use journals or composition notebooks if you use these in classroom work. Bring sturdy cardboard to write on if you plan to use single pages for students.
- Other exhibits about ratio and proportion, besides the ones shown in this guide are also in this area. Ask students to try one of these and report back to the rest of the group about their choice.

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TERC

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ABOUT THIS TOPIC

Math Moves! is about experiencing ratio and proportion. Allowing students to play with ideas of ratio and proportion in tangible ways provides a physical memory and background as a basis for developing abstract patterns, associations, and concepts. This qualitative sense of ratio and proportion can support quantitative competence when they encounter ratios in classroom work.

WHAT IS RATIO?

A comparison of two things. Ratios can also be expressed with fractions, decimals, percents, or words. Ratios also can be written with a colon between the two numbers being compared.

Example: One chaperone is required for every ten students, so for 100 students on the 4th grade field trip, how many chaperones are needed? 10 chaperones for 100 students is the same as 1/10 or 1:10 or one to ten.

WHAT IS PROPORTION?

Proportions are statements that two ratios are equal. Understanding relationships between ratios is known as proportional reasoning. Proportional reasoning is considered the gateway to higher math, including algebra.

In proportion problems there are *two things* that both change at the same rate. If a student knows the amount of dollars & gallons in one situation (e.g., 2 gallons cost $5.40), and either the dollars or the gallons of another situation ($2.70 or 3 gallons), using proportional reasoning allows them to figure out the other quantity (1 gallon or $8.10).

Tables like the ones below help clarify proportional comparisons.

Miles	60		180			
Hours	1	2	3	4	5	

Dollars		3.30				
Pounds	1	2	3	4	5	

Adapted from:
www.homeschoolmath.net/teaching/proportions.php

One of 21 mathematical "Big Ideas" identified by math education researchers includes ratios.

Fractions, Ratios, & Percent

- A comparison of a part to the whole can be represented using a fraction.
- A ratio is a multiplicative comparison of quantities; there are different types of comparisons that can be represented as ratios.
- Ratios give the relative sizes of the quantities being compared, not necessarily the actual sizes. Rates are special types of ratios where unlike quantities are being compared. A percent is a special type of ratio where a part is compared to a whole and the whole is 100. The probability of an event is a special type of ratio.

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CONNECTING WITH THE CLASSROOM

Before Your Visit

Share your expectations with students regarding what they will be doing at the museum. If you plan on using student pages, review the pages with students before the field trip. Clarify any questions students may have.

If you want to use your own guiding questions or have students develop their own questions or activity challenges, use the attached exhibition floor plan (pg. 30) and student activity pages (pg. 10) to inspire or develop questions.

Classroom Activities

These activities allow students to experience ratios with their bodies in the classroom. These are appropriate for all grade levels, and can be done before or after your visit to Math Moves!

WHOLE & HALF

Have students work in pairs. One student will be "whole," the other is "half."

WHOLE holds their hands apart (can be horizontal or vertical—try both). HALF puts one hand half-way between WHOLE's hands. WHOLE can move hands together and apart and HALF needs to adjust accordingly. Switch roles.

Variations:
WHOLE holds hand above floor. HALF places hand between hand and floor.

WHOLE walks along a set distance (about 5 feet), HALF walks half as fast. For an extra challenge, have one person move one quarter as fast or one third as fast.

If you have access to a digital camera, try capturing pairs on video to analyze movements. How close did they come to the goal?

Discuss as a class:
Which partner had to move farthest? Fastest? Explain your thinking.

MOVING TWICE AS FAST

Have students work in pairs. Put 2 pieces of masking tape parallel on the floor, 6–10 feet long. Several pairs can do this concurrently if there is space.

Ask each pair to walk along the taped lines at the same rate. Then student A uses the same rate, but student B needs to walk half as fast, then twice as fast. Switch roles.

Discuss as a class:
How can you tell how fast you were moving? How did you know if you were moving half or twice as fast? What would help you do this?

RATIO HUNT! (For grades 3 and up)

Ask students to quietly move around the classroom to find objects that meet the description given below. How do they know when they have chosen a correct-sized object?

+ Find something that is 3 times longer than your thumb.
+ Find an object that has 2 times the circumference of your arm.
+ Find something that is 1/2 as wide as a piece of paper.
+ Find an object that is 10 times longer than your foot.

Tricky tasks:
+ Find an object that is 1 times longer than your hand.
+ Find an object that is 4.5 times longer than your pinkie.
+ Find an object that has 1/2 the circumference of your head.
+ Find an object that is as big as you.

MATH TALK

Practice "math talk" in daily classroom work. These prompts are excellent for facilitating student interactions at museum exhibits too.

What did you notice?
How are these similar?
How are these different?
What is common?
What is the relationship between _____ and _____.
How are they alike?
What do you see?
What else do you see?
What else?
(Press for details!)

After Your Visit

Review student pages in small groups, then as a whole class. Sharing data and perceptions is important for students to identify patterns in the activities that go beyond individual experiences. Conversations also allow students to process and clarify their ideas. "Compare with another person in your group. How are their choices like yours?"

1. SHADOW FRACTIONS

+ Make your own shadow table with a flashlight and lined paper. Mark measurements on table and perpendicular endpaper.
+ Where do you need to put an object to make its shadow twice as big as the object?
+ Is it the same for all sizes?
+ Share challenges students created at the museum. Do they work on your shadow table?
+ What patterns do students notice?

2. SCALING SHAPES

+ Review the patterns students found, i.e., original number of blocks and number of blocks in a doubled form.
+ What does "doubled" mean when discussing a 3-dimensional form?
+ Brainstorm some ways this information would be useful in life outside math class.

3. BALANCE AND IMBALANCE

+ Ask students to compare their rules about making the bars balance. What similarities do they find?
+ In this activity, students use a lever. Have students make their own levers to investigate the ratios using load and distance from the fulcrum. http://www.msichicago.org/online-science/activities/activity-detail/activities/simple-machines-build-a-lever/browseactivities/0/
+ Making a simple lever with a ruler and paper cups.

4. SENSING RATIOS

+ If students have experience with a piano, or if you can demonstrate with a keyboard or piano, they will notice the same pattern of black and white keys repeating sound patterns as the notes become higher or lower in pitch. What is the pattern? How is this like a musical scale?
+ Investigate what frequencies humans can hear, and what kinds of pitch ratios make up harmonious sounds in music.
  – http://www.musicmasterworks.com/WhereMathMeetsMusic.html
  A mathematical explanation of why some notes sound good to the human ear.
  – http://en.wikipedia.org/wiki/Harmony
  Short explanation about how harmony is defined, and history of harmony in Western music.
+ Explore how different ratios of notes sound.

5. PARTNER MOTION

+ There are 6 different prompts on the graphing screen and 6 images to try out along side the screen. Discuss your students' experiences by using the appropriate discussion prompts below.
+ What did the graph look like on the screen when you and your partner were moving? What was the x-axis *(distance from the sensor/screen)*? What was the y-axis *(showed time elapsed)*?
+ Describe where you and your partner were standing when the ***graph lines crossed.*** OR describe what you had to do to make sure the graph lines ***did not cross.***
+ How does the graph show that you were moving ***twice as fast*** as your partner?
+ How did you move to ***make mountains***? Why are some more steep than others?
+ What shapes/animals did you make? Why are some shapes impossible to make?
+ Ask students to find graphs in the newspaper or on-line that show change over time and discuss them.

6. COMPARING FORMS—CHAIRS

+ What was it like to sit in the large chair? Middle size? Small chair?
+ How did you measure the chairs? What did you find out?
+ If you were building the next size chair larger or smaller, how big would it be? Explain your thinking.

7. COMPARING FREQUENCIES

+ There are numbers on the wheels and on the big circle. What did students notice about the way they worked together?
+ Watch the classroom clock (analog). When the second hand moves around the face, what does the minute hand do? The hour hand? What is the ratio represented on the clock?
+ On the exhibit, there were several photos of applications of this idea. One is a bike with training wheels. Ask students which wheel would go around more times, the big bike wheel or the small training wheel. How does this show ratio?

8. FRACTION TREASURE HUNT.

Discuss:

+ Which exhibits did students find that represent 1/2? How did they show 1/2? Did anyone try to make 1/4 or 1/3? How did they do that? Ask students to compare their findings.

Chairs	Shadow Fractions
Balance and Imbalance	Scaling Shapes
Sensing Ratios	Comparing Frequencies
Partner Motion	

9. CELEBRATE CURIOSITY!

+ After the museum visit, ask students for their ideas about the exhibits in **Math Moves!**
+ Brainstorm: What other kinds of exhibits would help kids "move with math?" How would they design an exhibit to teach math ideas using movement?
+ If you are already teaching about ratio and proportion, ask students what other kinds of activities would they include to help people ***experience*** ratio?

Teacher Resources

Websites

http://illuminations.nctm.org/

Resources for teaching math, includes on-line activities and lesson plans for K–12, with links to more math resources.

http://scimathmn.org/stemtc/

Frameworks for the Minnesota Mathematics and Science Standards, searchable by concept, are resources developed to help teachers translate Minnesota state standards into classroom practice. Each MN standard links to vignettes, misconceptions, resources for students, teachers and parents, assessment, differentiation strategies, correlations to both NCTM and Common Core Standards.

http://www.softschools.com/math/ratios/ratio_coloring_game/

http://www.4kids.org/games/

Ratio games: Single or multi-player games to build ratio recognition skills.

http://www.homeschoolmath.net/teaching/proportions.php

Informal language introduces concepts, including ratio and proportion for adults who work with students.

http://www.bbc.co.uk/skillswise/topic/ratio-and-proportion

Good BBC short video (1 min.) that shows examples of ratio use in computer support, hair salons, construction work. Corresponding lessons, although targeted at adults, give useful real-life examples.

Books

If You Hopped Like A Frog
David M. Schwartz (Author), James Warhola (Illustrator)
ISBN 978-0-590-09857-1

By the author of *How Much is a Million* and *G Is for Googol: A Math Alphabet Book*, this book gives students concrete examples of animal capabilities compared to a child's experiences. E.g. "If you hopped like a frog...you could jump from home plate to first base in one mighty leap!" Challenge students to figure out the ratio.

http://mindfull.wordpress.com/2008/02/24/if-you-hopped-like-a-frog-proportional-reasoning/

Two of Everything
Lily Toy Hong
ISBN 978-0-1530-52002

Based on a Chinese folk tale, this simple story introduces a "magic pot" that doubles everything that goes in. Good introduction to function tables for younger students.

Cut Down to Size at High Noon: A Math Adventure
Scott Sundby
ISBN 978-1-570-911682

Set in the old frontier town of Cowlick, two barbers compete to drive each other out of town, using scale, ratios, and proportion. Grades 1–middle school, introduction to scale.

Common Core State Standards Initiative

http://www.corestandards.org/
Experiences in Math Moves! and the activities described in this Educator Guide can support student learning in the following Standards

Measure lengths indirectly and by iterating length units.

- 1.MD.1. Order three objects by length; compare the lengths of two objects indirectly by using a third object.
- 1.MD.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. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.

Measure and estimate lengths in standard units.

- 2.MD.1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

Develop understanding of fractions as numbers.

- 3.NF.1. Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as the quantity formed by a parts of size 1/b.
- 3.NF.3. Explain equivalence of fractions in special cases, and compare fractions by reasoning about their size.
- Understand two fractions as equivalent (equal) if they are the same size, or the same point on a number line.
- Recognize and generate simple equivalent fractions, e.g., 1/2 = 2/4, 4/6 = 2/3). Explain why the fractions are equivalent, e.g., by using a visual fraction model.

Generate and analyze patterns.

- 4.OA.5. Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself. For example, given the rule "Add 3" and the starting number 1, generate terms in the resulting sequence and observe that the terms appear to alternate between odd and even numbers. Explain informally why the numbers will continue to alternate in this way.

Analyze patterns and relationships.

- 5.OA.3. Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. For example, given the rule "Add 3" and the starting number 0, and given the rule "Add 6" and the starting number 0, generate terms in the resulting sequences, and observe that the terms in one sequence are twice the corresponding terms in the other sequence. Explain informally why this is so.

Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.

- 5.MD.4. Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.
- 5. Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.
    - Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication.
    - Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real world problems.

Understand ratio concepts and use ratio reasoning to solve problems.

- 6.RP.1. Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."
- 6.RP.3. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
    - Solve unit rate problems including those involving unit pricing and constant speed. For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?
    - Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Reason about and solve one-variable equations and inequalities.

- 6.EE.5. Understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true? Use substitution to determine whether a given number in a specified set makes an equation or inequality true.

Math Moves! provides experiences that will help prepare students for the following concepts, but are not directly addressed in the exhibition.

Analyze proportional relationships and use them to solve real-world and mathematical problems.

- 7.RP.1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour.
- 7.RP.2. Recognize and represent proportional relationships between quantities.
    - Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
    - Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
    - Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as t = pn.
    - Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points (0, 0) and (1, r) where r is the unit rate.
- 7.RP.3. Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

Understand the connections between proportional relationships, lines, and linear equations.

- 8.EE.5. Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.
- 8.EE.6. Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation y = mx for a line through the origin and the equation y = mx + b

SHADOW FRACTIONS

1) Use the shapes on the table to make shadows. Compare the size of the shape to its shadow.

Try different places and different shapes.

Draw and label one thing you tried.

2) Place two of the bunnies so their shadows are the same size.

Describe where you put the bunnies in words, as a drawing or in another way.

3) Tree Challenge! Use one tree to make a shadow.

Predict what line you should use for another tree to make the shadows the same size.

Tree #1 is _____ squares tall.

Tree #1 is on line _____.

I predict **tree #2** should be on line _____ for the shadow to be the same size as the shadow of #1.

Tree #2 is _____ squares tall.

	Squares tall	Line#
Tree #1		
Tree #2		_____Predict!

4) Compare the house shadows. Make the shadows all the same size. Fill in the table with your data.

Line #	Small house	Mid-size house	Big house
	2		8
		5	10

Make up a shadow challenge for a friend to try. Try it out with other kids.

SCALING SHAPES

Choose one of the colored block forms. Make a copy.

- How many blocks does your copy use?
- Fill in the table below to find a pattern.
- Double it! Use blocks to make a form twice as big. Count how many blocks you used in doubling.

Are you done yet? Did you double in all three directions? Hint: watch the video!

- Try 2 more shapes and add to the table.

	Shape 1		Shape 2		Shape 3	
	original	doubled	original	doubled	original	doubled
Number of blocks						

BALANCE AND IMBALANCE

Try all of the suggestions on the exhibit.
Use all three balances.

Work with a partner or two to put a weight on one side of the balance beam and then see how many different ways to balance with different blocks on other side. Draw a picture of what you tried and write an equation to show how one side balances the other side. There is space to show three different combinations.

On one side	To balance	On the other side
	=	
Equation	=	

On one side	To balance	On the other side
	=	
Equation	=	

On one side	To balance	On the other side
	=	
Equation	=	

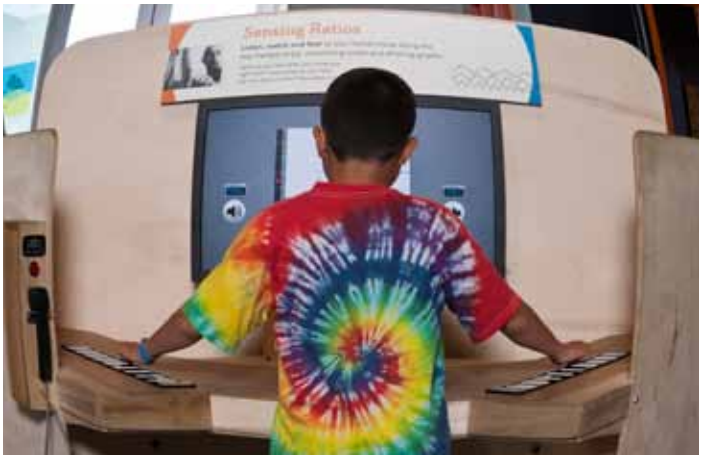
Make up a balance rule for a friend to test. Draw or describe which balance you used. You have three balances to choose from. Have two people try it out.

My balance rule:

SENSING RATIOS

Use the knobs to make different sounds. Make one sound lower than the other.

Write some directions to help someone else do that.



Work together with other students in your group to make a pattern on the screen. What sounds do you make as you each move the knobs?

Our pattern

What do you notice as the pitches (high or low) get closer to each other? Farther apart?

PARTNER MOTION

Watch the graph on the screen as you and a partner move. What do you notice about the graphs?

Predict what the lines will look like if one of the partners moves twice as fast as the other.

Try it! Was your prediction accurate?

Work with a partner and another pair of students. One pair walks and the other observes. Take turns to make sure everyone gets a chance to observe and to walk and make patterns with a partner.

Try one of the ideas on the screen or patterns on the exhibit.

As walker, I felt…

The pattern on the screen looked like…

As observer, I noticed that the walker…

The pattern on the screen looked like…

COMPARING FORMS—CHAIRS

Sit in all three. How does it feel? Compare your ideas with your friends.

Measure the chairs with one or two partners from your group. You can use your body or a tool at the exhibit.

What we used to measure _____

How many units?

Small chair_____

Middle chair _____

Large chair _____

How many people fit in the:

Small chair_____

Middle chair _____

Large chair _____

COMPARING FREQUENCIES

With a partner, put two wheels of different sizes on the big circle. Compare them. Then move one or both to another place on the circle. What do you notice?

Make one go faster than the other. How did you do that?

Draw or describe what you did.

Make a rhythm—draw a picture of your rhythm

FRACTION TREASURE HUNT

Find exhibits that will help you show the fraction ½.

Which ones did you use?

- ☐ 1. SHADOW FRACTIONS
- ☐ 2. SCALING SHAPES
- ☐ 3. BALANCE AND IMBALANCE
- ☐ 4. SENSING RATIOS
- ☐ 5. PARTNER MOTION
- ☐ 6. COMPARING FORMS—CHAIRS
- ☐ 7. COMPARING FREQUENCIES

Draw how one of the exhibits showed ½.

1 

2 

3 

4 

5 

6 

7 

Come up with a representation different from other groups.

Can you find other things in the museum that show ½?

SHADOW FRACTIONS

Place two of the bunnies on the table so their shadows are the same size.

Describe where you put the bunnies in words, as a drawing, or in another way.

Predict other places on the grid where this will happen.

Try it! What did you find out when you tested your prediction?

List 2 more places this relationship will occur if the grid were bigger.

1)

2)

SHADOW FRACTIONS

Use all three trees. Line them up so each shadow is *twice as big* as the next.

Where did you put them?

Tree 1 Size of tree _____ Line #_____

Tree 2 Size of tree _____ Line #_____

Tree 3 Size of tree _____ Line #_____

Move one tree towards the light one square. How many squares do you need to move the others to make all of the shadows the same size

Tree (which one? Circle one) **big** **middle** **small** Moved **1** square

Tree (which one? Circle one) **big** **middle** **small** Moved _____square(s)

Tree (which one? Circle one) **big** **middle** **small** Moved _____square(s)

Try some other combinations.

Small tree	Middle tree	Big tree
1.5		6
2	4	

Draw a picture to show someone how to make the shadow of the small house the same size as the shadow of the middle house.

Write some directions to tell them how to do it.

Share your directions with someone else, and use theirs. Try it!

SCALING SHAPES

Choose one of the colored block forms.

Record the dimensions of the form:

Length _____, width _____, height _____,

and the number of blocks _____ used in the original form.

Double it! Use blocks to make a form twice as big.

Length _____, width _____, height _____,

and the number of blocks _____ used in the original form.

	Shape 1		Shape 2		Shape 3	
	original	doubled	original	doubled	original	doubled
Number of blocks long						
Number of blocks wide						
Number of blocks tall						
Total number of blocks						
Ratio						

Make a shape with the blocks.

Ask a friend to ***double it***. How many blocks did they use? _____

Double it again! How many blocks will they need? _____

What patterns or relationships do you notice?

What is the ratio between the original and the doubled form?

How would you tell someone else to double the form?

BALANCE AND IMBALANCE

Try all of the suggestions on the exhibit.
Use all three balances.

With a partner or two, put a weight on one side of the balance beam and then see how many different ways to balance with different blocks on other side. Show what you tried and write an equation to show how one side balances the other side

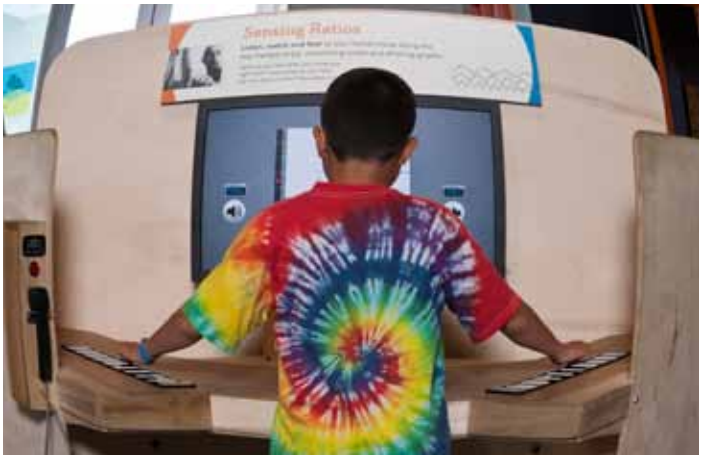
On one side	To balance	On the other side
	=	
Equation	=	
On one side	To balance	On the other side
	=	
Equation	=	
On one side	To balance	On the other side
	=	
Equation	=	

Make up a balance rule for someone else in your group to test. Describe which balance you used. Does it work every time? Have two people test it.

My balance rule:

How many different ways can you make the ratio 5:1?

SENSING RATIOS



Use the knobs to make different sounds. Make one sound lower than the other.

Where do you put the knobs to make the sounds the same? _____

Find another spot. _____

Are there more spots where the sound is the same for both knobs?

Try several pairs. Show the graph they make on the graph below.

With a partner, each of you work one knob and close your eyes. Ask two other students to coach you in making the same sound, frequency or pattern.

PARTNER MOTION

Work with a partner and another pair of students. One pair walks and the other observes. Take turns to make sure everyone gets a chance to observe and to walk and make patterns with a partner.

Try one of the ideas on the screen or patterns on the exhibit.

As walker, I felt…

The pattern on the screen looked like…

As observer, I noticed that the walker…

The pattern on the screen looked like…

PARTNER MOTION—continued

Use **one** of the prompts on the screen (they change for each new turn) and describe what you did by using one of the suggestions below:

Check the one you did and write your explanation below.

☐ Draw your graph and explain how it shows changes of speed.

☐ Describe where you and your partner were standing when the ***graph lines crossed***. OR Describe what you had to do to make sure the graph lines ***did not cross***.

☐ How does the graph show that you were moving ***twice as fast*** as your partner?.

☐ How did you move to ***make mountains***?
Why are some more steep than others?

☐ What shapes/animals did you make?
Why are some shapes impossible to make?

COMPARING FORMS—CHAIRS

Sit in all three. How does it feel? Compare your ideas with your friends.

1) Measure the chairs. You can use your body or a tool at the exhibit.

What I used to measure _____

How many units?

Small chair_____ Middle chair_____ Large chair_____

2) Measure using a different tool.

What I used to measure _____

How many units?

Small chair_____ Middle chair_____ Large chair_____

3) Measure using a third tool.

What I used to measure _____

How many units?

Small chair_____ Middle chair_____ Large chair_____

What do you notice?

How could you predict the units for the middle and large if you know the small?

The 3 chairs are part of a pattern. If you were going to build the next biggest chair, how big would it be? Explain your idea and draw a plan. Be sure to include what pattern you are seeing.

Bonus challenge: Imagine the smallest 5 chairs down the line. What would be the dimensions of that set of chairs?

COMPARING FREQUENCIES

With a partner, put two wheels of different sizes on the big circle. Make one wheel go faster than the other.

Describe how you changed each wheel.

Make one go twice as fast than the other. How did you do that?

What do you think? What do the numbers mean on the wheels?

Make a rhythm—draw a picture of your rhythm.

FRACTION TREASURE HUNT

Find exhibits that will help you show the fraction ½.

Which ones did you use?

- ☐ **1. SHADOW FRACTIONS**
- ☐ **2. SCALING SHAPES**
- ☐ **3. BALANCE AND IMBALANCE**
- ☐ **4. SENSING RATIOS**
- ☐ **5. PARTNER MOTION**
- ☐ **6. COMPARING FORMS—CHAIRS**
- ☐ **7. COMPARING FREQUENCIES**

Draw how one of the exhibits showed ½.

1 

2 

3 

4 

5 

6 

7 

Come up with a representation different from other groups.

Find an exhibit that shows 1/3 or 1/4.

- Encourage students to interact and play with the exhibits, share their discoveries and ideas with the rest of the group.
- Enjoy the exhibit with your group! Share your own discoveries, questions, and "I wonder..."
- Each exhibit component has photos of real-life examples. Ask students if they have ever seen or done any of these things.
- Allow time for student exploration. The suggestions below are guides that encourage exploration of each exhibit. Check with the teacher for their expectations.
- As you visit other parts of the museum, encourage students to find math connections.

1. SHADOW FRACTIONS

Use the questions on the exhibit for students to try. Then try these:

o Find a place where two bunnies' shadows are the same size. Have each child take a turn. Ask each child to describe to the group where they put the bunnies. Look at the lines to help describe where they are. Compare the lines of the bunnies and their shadows. Compare the size of a bunny to the size of its shadow. Where are they are same? Twice as big?

o Make the little tree's shadow twice as big as the big tree's shadow. Describe where you put them.

2. SCALING SHAPES

o Have students try the ideas at the exhibit. *Hint:* watch the video!

o Ask them to count the blocks in their original form.

o Double it! Ask them to count how many blocks they used in doubling.

Hint: if students need help, ask them to start with one block (or one simple form) and copy it. Then start to double in all three directions.

o Compare all of the doubling activities in the group. For example: how many in the original? How many blocks in the doubled form?

o What number patterns do the students notice?

3. BALANCE AND IMBALANCE

o Make them balance! Ask students to try some of the suggestions on the exhibit.

o Try this: Put a block on one side, then ask group members to balance it on the other side as many ways as they can. Can students make up a rule about balancing for the group to test? Does it work for other combinations?

o Is there a pattern? What do the students think it is?

4. SENSING RATIOS

o Ask students to try moving the knobs.

o What do they notice?

o How does the screen show what the knobs are doing?

o Try some of the patterns on the screen. What sounds do you hear? How is one sound different from the other?

o Have two students each work one knob and close their eyes. Ask other students to coach them in making the same sound, frequency or pattern.

5. PARTNER MOTION

There are many ideas to try. Take turns trying out some of the suggestions on screen.

What happens if one partner walks faster than the other? How much faster is it?

6. COMPARING FORMS—CHAIRS

Ask students:

- o What do you notice about the chairs?
- o Sit in all three. How does it feel? Compare your ideas with your friends.
- o Measure the chairs. You can use your body or a tool at the exhibit.
- o How many people fit in the small chair? The middle chair? The large chair?

7. COMPARING FREQUENCIES

o Ask 2 or 3 students to put two wheels of different sizes on the big circle. What clicking do they hear? Move the wheels to other places on the circle. What happens? Take turns to do more.

o Ask:

- o Make one wheel go faster than it did. What did you do to make it go faster?
- o Make one wheel go faster than another wheel. How did you do that?