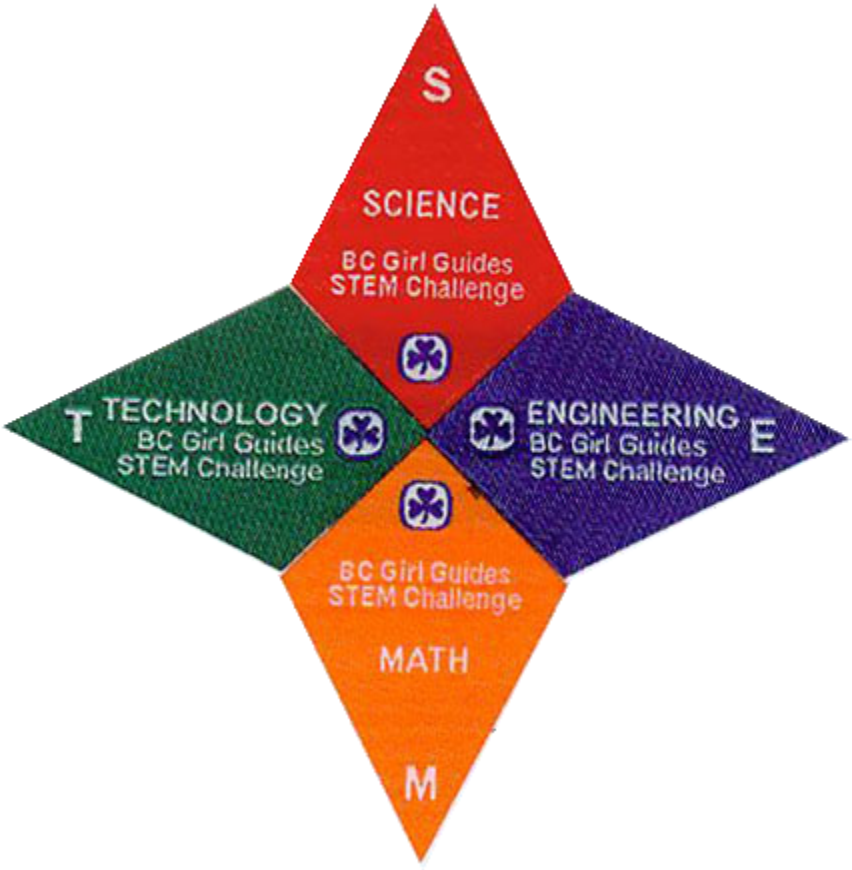

Math

STEM Challenge

BC Program Committee
September 2010

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Chapter 1

Introduction

- *About This Challenge*

Welcome to the new, updated Science, Technology, Engineering and Math Challenge from the BC Program Committee. This is a four-part challenge: one booklet, and one ribbon crest, for each of Science, Technology, Engineering and Math. Do just the parts that interest you, or tackle all four and proudly display the complete crest on your camp blanket.

The STEM Challenge is an update of the Science in a Box and Girls Exploring Technology (GET) challenges that were launched by the BC Program Committee several years ago. In the STEM Challenge booklets, you will find two or three categories of activities:

- Replacement Activities. Some of the activities in the original challenges are too complex for many groups to actually do; some require specific equipment that is difficult to find or no longer available; some are just so great that you've done them over and over. The Replacement Activities in the new STEM challenge provide fresh, new approaches to these activities.
- New Activities. Because you just can't get enough STEM, these activities provide a whole new set of things for you to experiment with.
- Obsolete Activities: In some cases, activites outlined in the older resources are just no longer workable for one reason or another. In these cases, we'll give you some suggestions for other things you can do instead.

As you work on the challenge, please remember: We'd love to hear from you! Please feel free to let us know what activities you've done and what you thought of the STEM Challenge.

Sincerely,

The BC Program Committee

BC Council

About This Challenge

Objectives

To have fun experimenting with mathematics, logic and problem-solving.

You're Kidding, Right?

"Seriously, *math*? As part of the girls' program? Come on--we want these girls to stay in Guiding, after all!"

Well, yes, we're serious. And we really believe it can be done. Of course, we're not talking about "doing" math like in school—you'll notice none of the activities in this booklet include multiplication drills or worksheets of algebra word problems. Nobody wants that at Brownie camp. But let's look at math in another way: rather than seeing it as just a bunch of numbers and arcane symbols, think of it as a process of logical thinking and creative problem-solving. Even those word problems many of us disliked so much in school were just a way of training our brains to work through a problem or a process to achieve a goal. In that light, adding some math to the program isn't just something that *can* be done—it's something that *should* be done, and that probably is being done already in some way or other. Don't believe it? Have you ever:

- Cooked with the girls? Recipes are all about measuring, counting, adding, multiplying and following prescribed steps toward an end result. Just like an algebra problem, only much tastier.
- Gone camping/touring/hiking/etc., and had to figure out how many tents/vehicles/packages of trail mix/etc. you would need? That's math with a practical application, which is always the most interesting kind.
- Played card games or board games? Games that require counting and adding, like cribbage, have very obvious connections to math, and strategy games like chess, checkers, *Risk* or *The Settlers of Catan* (to name just a few) take plenty of logical thinking. Jigsaw puzzles count, too—there is a lot of geometry and spatial awareness involved in putting together a jigsaw puzzle.

These are just a few ways that you can, and probably have, helped your girls develop math-related skills. This booklet provides lots more.

The activities in this booklet are pretty broad in scope, and many are only distantly related to the kind of math you did in school. We have done that intentionally: we recognize that math is not everyone's favourite subject, and hardly anyone's first thought in planning a fun, engaging program for a meeting or a camp. Therefore, we've included a range of activities in the hope that there is something in here that everyone can see themselves doing with the girls. As much as possible we've made the activities active and interactive, and for good measure we've thrown in some puzzles and board games that would be good for gathering time at the start of a meeting or for quiet time at camp. In many cases, we've also provided suggestions for increasing the "Math Factor", if you really want to emphasize the math-related skills behind the activities. So read on, dive in and do some math with your girls!

Earning the Crest

To earn the ribbon crest for this part of the STEM Challenge, you need to complete a specific number of activities, depending on your branch of Guiding. You can select these activities from this booklet, or you can choose activities from the original Science in a Box and GET challenge materials that are related to this part of the STEM Challenge. However, you are not limited to the activities in these resources! Feel free to use ideas from the Internet, books or magazines, other Guiders or people in your community, or any other resources.

The Program Committee has produced a variety of program resources that include STEM activities. Look for these resources in your District or on the *BC Girl Guides website*:

- Eco-Pak booklet and CD
- CSI Challenge booklet
- Branch-specific Instant Meeting booklets

As long as the activities are challenging for your group and fit the objectives of this part of the STEM Challenge, go ahead and use them. (And if you come across something really cool, please let us know so we can add it to any future STEM-related challenges!)

Required Activities

Branch	Number of Activities Required
Sparks	3
Brownies	4
Guides	5
Pathfinders	6
Rangers	8
Adults	8

Ordering the Crest

When you have completed this portion of the challenge, you can order the crest by sending an email to the BC Program Committee at *program@bc-girlguides.org*. Please specify which portion of the challenge you have completed and the number of crests you need. Please allow four to six weeks for delivery.

A Word About Program Connections

Each activity in this booklet includes a list of program connections--areas of the girls' regular program that the STEM challenge meets the requirements for. These program connections are intended as guidelines to help you fit the STEM challenge into your regular program planning. In some cases, the challenge activity is very similar to an activity in the program area; in other cases, the challenge activity could be used as an alternative to activities mentioned in the program area. In all cases, remember that the girls' program is intended to be flexible: if an activity meets the objectives of the program area, and if it is interesting and challenging for the girls, by all means give them credit for it as part of their program requirements.

The lists of program connections is also not exhaustive. If you find another progam area that is covered by an activity in this booklet, don't hesitate to give the girls credit for it.

You may notice that very few of the activities include explicit program connections for Rangers. The Ranger program encourages in-depth exploration of topics of interest. Many of the activities in this booklet, on the other hand, are relatively short and simple—so that busy Guiders can easily incorporate them into unit meetings—and offer only a very superficial taste of the subject matter. That makes it difficult to draw direct connections between these activities and the Ranger program. However, because the Ranger program is also very flexible and self-directed, Rangers can certainly take any of these activities and expand or combine them to meet the objectives of one of the program areas. Rangers who are working in units can also plan and lead any of these activities for younger girls.

Chapter

2

Replacement Activities

- *Butterfly Symmetry*

The activities in this section are intended as replacements for or updates to activities in the Science in a Box Challenge booklet.

Butterfly Symmetry

Butterflies are a natural example of symmetry: their right and left wings are mirror images of each other. Make your own symmetrical butterfly in this simple craft activity.

Replacement or update for:

- Science in a Box Experiment #12: Butterfly Beauties

What you need:

- Construction paper in a variety of colours
- Pencil
- Scissors
- Glue
- Craft stick

What to do:

1. Fold a sheet of construction paper in half lengthwise. Draw a butterfly wing on it, placing it so the fold is where the butterfly's body would be.
2. Cut out the wing, without cutting the fold. When you unfold it, you should have two identical wings attached in the middle.
3. Fold another sheet of construction paper, in a different colour, in half lengthwise. Then fold it in half lengthwise again.
4. Cut out a random shape that starts at one end of the folded edge and ends a little bit higher up the fold. Do not cut the fold itself. When you unfold your shape, you should have two identical, symmetrical shapes.
5. Position one of your shapes on each wing, in the same place on each wing. Trace around them with the pencil to mark where they should go.
6. Dab a little glue onto the back of the shape, then glue it into the positions you marked.
7. Continue adding different shapes until your butterfly looks how you want it to. Just remember: the goal is to make each wing the mirror image of the other.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM; Key to the Living World; Key to the Arts
- Guides: Discovering You (Discover Your Creativity); Plants and Animals badge; Naturalist badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM); My Music, Movies and More! (The Arts from A to Z)

Chapter 3

New Activities

- *Chinese Abacus*
- *Bubble Pictures*
- *Sudoku*
- *What's the Rule?*
- *How Much Water?*
- *Licence Plate "Tengo"*
- *What's Your Shape?*
- *Flexagons*
- *Sundial*
- *Go Shopping!*
- *Mathematical Card Trick*
- *Chess Games*

This is a selection of new activities for you to try.

Chinese Abacus

For centuries before the days of cheap digital calculators, people used abacuses (abaci?) to do calculations. Build your own, and use it to add up your cookie revenue!

What you need:

- Large piece of corrugated cardboard
- Scissors
- Ruler
- Pen or pencil
- Glue
- 6 bamboo skewers, 30 cm long
- 12 red pony beads (or colour of your choice)
- 30 white pony beads (or colour of your choice)

What you should know before you begin:

The quantities and instructions given here are for each abacus. If you are planning on making more, you will need to multiply the quantities accordingly.

What to do:

1. Cut two pieces of cardboard 20 x 27 cm. The ridges of the cardboard should run parallel to the long side of both pieces.
2. Cut one of the pieces cross-wise into nine equal pieces, each 20 x 3 cm.
3. Stack three of your small pieces on top of each other. Glue the stack together, then glue the stack along the top edge of the remaining large piece of cardboard. Make sure all the edges are lined up, and make sure the ridges of the cardboard run parallel to the long side of the large piece of cardboard.
4. Do the same with three more small pieces and the bottom edge of the large piece of cardboard.
5. Stack the remaining three pieces on top of each other, glue them together, and glue them across the large piece about 1/3 of the way down from the top stack.
6. Push a skewer through one of the cardboard ridges in the top stack.
7. Thread two red beads onto the skewer, then push the skewer through a ridge in the middle stack.
8. Thread five white beads onto the skewer and push the skewer through a ridge in the bottom stack. The skewer should run parallel to the long edges of the piece of cardboard.
9. Repeat with all six skewers. There should be two red beads and five white beads on each skewer.

How it works:

Lay your abacus on a flat surface with the red beads at the top. Starting from the right-hand side of your abacus, the white beads on each skewer are worth multiples of 10. Specifically, the white beads on the right-most skewer are each worth 1, the white beads on the second skewer from the right are worth 10, the white beads on the third skewer are worth 100, and so on up to 100,000 on the left-most skewer.

The red beads on each skewer are worth five times the white beads: again starting on the right, the red beads are worth 5, 50, 500, 5000, etc.

To set the abacus to zero:

1. Lay the abacus on a flat surface with the red beads at the top.
2. Move all the red beads to the top of the top section. Move all the white beads to the bottom of the bottom section.

To show a number, for example 24, on the abacus:

1. Break the number up into single digits. For example, 24 becomes 2 tens (20) and 4 ones (4).

2. On the right-hand skewer (the "ones" skewer), move four white beads up to represent the 4 ones.
3. On the second skewer from the right (the "tens" skewer), move two white beads up to represent the 2 tens (20).

To show 37:

1. Break 37 up into single digits: 3 tens (30) and 7 ones (7).
2. On the "ones" skewer: move one red bead down to make 5, and move two white beads up to make 2 (5+2=7).
3. On the "tens" skewer: move three white beads up to make 3 tens (30).

To show 193:

1. Break 2 up into single digits: 2 hundreds (200), 9 tens (90), and 3 ones (3).
2. On the "ones" skewer: move three white beads up to make 3.
3. On the "tens" skewer: move one red bead down to make 50, and move four white beads up to make 40 (40+50=90).
4. On the "hundreds" skewer: move two white beads up to make 200.

How to increase the Math Factor:

To add two numbers together, e.g., 24 and 32:

1. Show the first number on the abacus. For example, show 24 by moving four white beads up on the "ones" skewer and two white beads up on the "tens" skewer.
2. Move more beads to represent the second number. Use the red beads if necessary to show totals that are greater than five. For example, to add 32 to the 24 you already have, you need to show a total of 6 on the "ones" skewer (4+2=6), so move one red bead down and leave only one white bead up.
3. Move three more white beads up on the "tens" skewer. You should now have five "tens" and six "ones", which gives you the total of 56.

Can you figure out how to subtract using your abacus?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things); Inventing badge; Heritage Home Skills badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM, From Dinosaurs to Vintage Cars)

Bubble Pictures

Use coloured bubble solution to investigate the geometry of bubbles.

What you should know before you start:

You can use either store-bought or homemade bubble solution for this experiment. Recipes for homemade solution are plentiful and varied; typically they are a mixture of one part liquid dish soap and three to five parts water, often with a bit of glycerin or sugar added to make the bubbles a little longer-lasting. Experiment a bit to find the formula that works best for you.

What you need:

- Bubble solution
- Small plate
- Tempera paint powder
- Spoon
- Straw
- Paper

What to do:

1. Pour some bubble solution into a plate.
2. Stir in tempera powder to make a thick paint. You need a good, intense colour for good bubble pictures, so you are aiming for the thickest, brightest colour that you can still blow bubbles with. You can use more than one colour in a plate for multi-coloured bubble pictures.
3. Put one end of the straw into the bubble paint and blow through it to make bubbles in the plate.
4. Gently touch the paper to the bubbles in the plate. Don't squash the paper down; you just want to pop the bubbles onto the paper.

How to increase the Math Factor:

Take a good look at your bubble picture.

- What shape are the bubbles?
- How do the shapes change when two bubbles of the same size touch?
- If a big bubble touches a small bubble, what happens?
- What happens when three bubbles touch? Four? More?
- When three or more bubbles meet, what angle is formed where their walls meet? (Measure it with a protractor, if you have one.) Is this angle always the same?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM; Key to the Arts
- Guides: Discovering You (Discover Your Creativity); Science badge; Art Production badge; Creative Craft badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM); My Music, Movies and More! (The Arts from A to Z)

Sudoku

These popular puzzles are a great way to practice your logical thinking skills. Sudoku puzzles are good gathering or quiet-time activities.

What you should know before you start:

You can find books of sudoku puzzles virtually anywhere paperbacks are sold--bookstores, drug stores, grocery stores, newsstands...There are also plenty of websites with free sudoku puzzles (many with solutions) that you can play online or print out; a quick search on "sudoku" will turn up dozens of sites. For younger girls, look for the smaller 4x4 or 6x6 puzzles.

The same sources are often good for tutorials and tips on solving sudoku puzzles, if you need some pointers to get you started.

What you need:

- Sudoku puzzle with an appropriate level of difficulty
- Pencil or pen

What to do:

1. Try to solve the sudoku puzzle. For added excitement (?), time yourself.

How to increase the Math Factor:

Make blank sudoku grids and get the girls to create their own sudoku puzzles for their friends.

If you've already got the hang of standard sudoku, try one of the many variants (giant sudoku, jigsaw sudoku); or try a kakuro puzzle instead.

What else you can do with this:

Even very young kids can do Sudoku! Instead of grids of numbers, use simple pictures. You'll need four copies of each of four pictures. Arrange the pictures in a grid so that each picture shows up only once in each row and column. Then remove one picture from each row and column. Ask the girls to figure out which picture is missing from the empty spaces.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things)
- Pathfinders: Exploring a Theme (Everything Comes from STEM, Puzzle Me)

What's the Rule?

This is a great game for filling gaps in a camp or event schedule. Keep a collection of small objects handy and pull it out when you're waiting for a meal, waiting for the rest of your group to arrive, waiting for a bus, waiting for the rain to stop...

What you need:

- 15-20 small objects: crayons, paper clips, bottle caps, bandanas, shoes, coins, pocket lint--whatever you have handy

What to do:

1. One person selects a few objects according a rule that she makes up. For example, she might choose things that are yellow, or things that are longer than her pinky finger. She puts her selected objects in a group separate from the rest of the objects, but she does not disclose her rule for choosing them.
2. Everyone else in the group tries to guess the rule.
3. If the guessers need hints, they can ask if one of the remaining objects could go into the selected group. The person who did the selecting can only answer "Yes" or "No".
4. When someone guesses the rule, put all the objects back together. The person who guessed the rule then gets to select objects based on her own rule.

How to increase the Math Factor:

If you don't have a bunch of random objects, or if you're in an environment where you can't all see the objects, you can play a similar game using numbers:

1. One person thinks of a rule, then gives three sets of numbers that obey that rule. For example, if her rule is "Pick a number, and add seven to it to get the second number", she might say "9 and 16", "27 and 34", and "3 and 10".
2. Everyone else tries to guess the rule. If needed, they can suggest other sets of numbers that they think fit the rule. The rule-maker can only answer "Yes" or "No".
3. The first person to guess the rule is the next rule-maker.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: You and Others (Build Skills in Communication); Beyond You (Try New Things)
- Pathfinders: Creating Your Future (We're a Team); Exploring a Theme (Everything Comes from STEM, Puzzle Me)

How Much Water?

Climate change and resource conservation are hot topics these days. Combine them with a mathematical challenge to find out how much water you use when you shower.

What you need:

- Shower
- Large bucket
- Stopwatch or timer
- Measuring cup

What to do:

1. Next time you take a shower, time yourself to see how long you spend in the shower.
2. Figure out the flow rate of your shower: turn the shower on and hold the bucket up under the shower head for 30 seconds.
3. Use the measuring cup to measure the number of litres of water in the bucket (1 cup = 250 mL; 4 cups = 1 litre). Multiply that amount by 2. The result is the flow rate of your shower in litres per minute.
4. Multiply the flow rate you figured out in Step 3 by the length of your shower that you timed in Step 1. That's how many litres of water you use every time you shower.
5. Multiply that by the number of showers you have in a week, then by the number of weeks in a year (52). How many litres of water do you send down the shower drain every year?
6. How much water would you conserve if you cut two minutes off the time you spend in the shower? What about if you shut the water off while you lather your hair?

How to increase the Math Factor:

Figure out how much water your family uses in a week for bathing/showering, flushing, laundry and dishes:

1. Figure out the flow rate of the kitchen and bathroom faucets, using the method you used in the shower. (If a large bucket won't fit under the faucet, use a smaller one and only run the water for 10 seconds. Then multiply the amount of water by 6 to get the flow rate in litres per minute.) If you can't figure out the flow rates, use these approximate numbers:
   - Standard shower head: approximately 30 litres per minute
   - Low-flow shower head: approximately 10 litres per minute
   - Faucet (opened full): approximately 15 litres per minute
2. Find out how much water your clothes washer and dishwasher use every time you run a load. Look in the user's manual, check out the manufacturer's website, or if you have EnergyStar appliances, look up the brand name and model on the EnergyStar website (*www.energystar.gov*). (The information is given in imperial units, so you'll have to convert them to metric.) Note: in many cases, water usage for these appliances is given per cycle. To figure out how much water is actually used per load, you need to multiply by the number of cycles (e.g., one wash cycle plus one rinse cycle.) If you can't find the information, use these average numbers from the City of Vancouver website (*http://vancouver.ca*):
   - Standard dishwasher: 57 litres per load
   - EnergyStar dishwasher: 45 litres per load
   - Standard clothes washer: 150 litres per load
   - EnergyStar clothes washer: 75 litres per load
3. Find out how much water your toilet uses every time you flush it. Most toilets have a little sticker somewhere near the back of the seat telling you this. If you can't find it, use these averages:
   - Standard toilet: 20 litres per flush
   - Low-flow toilet: 6 litres per flush

4. Ask everyone in your family to time themselves every time they run a faucet. (You might have better luck with this if you put a small clock or watch near each faucet, with a sheet of paper and a pen so everyone can write down the time right away.) Add up the total number of minutes each faucet is running during the week, then multiply that by the flow rate you've figured out for that faucet.
5. Count the number of times your family runs the clothes washer or dishwasher, and multiply the total by the water usage you've found out for your appliances.
6. Ask everyone in your family to count the number of times they use the toilet every day of the week. (The average, by the way, is four times per person, per day). Again, a piece of paper and a pen near the toilet might help. Add up the total number of flushes, and multiply that by the number of litres per flush.
7. Add everything up. Does the number surprise you? Where can you cut back? Remember, this only includes indoor water use. How much more do you use outside for watering the garden, washing the car or filling the kiddie pool?

What else you can do with this:

If you want to adapt this activity for younger girls or for girls who are absolutely not going to do all the calculations, you can use small objects like buttons, pennies, large beans, etc. to represent the water--one button/penny/bean for each litre of water. Use the average water use numbers given above, and invent a game or activity that suits your group or theme. For example:

- Ask the girls to collect pennies (or other coins--this will take a lot of pennies!) every time they use water during a week: 75 cents for each shower, 10 cents every time they wash their hands or flush the toilet, one or two cents a day for the water they drink. Use the pennies for CWFF funds.
- Play a relay race to demonstrate water supply and demand: one person is the User, one person is the Drain, and everyone else is a Pipe. The Pipes form a line (or two, if you have lots of girls) with one end of the line near the User and the other end near a large pile or bag of beans/buttons, which represents a reservoir or other water supply. Give the user, say, 50 beans or buttons to start out with, representing 50 litres of water. Every few seconds, the User calls out a water use, e.g., "Shower!" "Toilet!" "Dishwasher!" "Hand washing!" and so on. Each time she does, the Drain takes away the appropriate number of litres of water (beans) from the User's pile. Meanwhile, the Pipes must pass water from the reservoir to the User, one bean at a time. Can they keep the User supplied with water? Expand the game by adding multiple users, imposing water restrictions, increasing or decreasing the number of Pipelines, and so on. You could even have one person act as nature's water cycle, collecting water from the Drain and "raining" it back into the reservoir. Does the reservoir ever run dry?

Program connections:

- Sparks: Exploring and Experimenting Keeper; In My Community Keeper
- Brownies: Key to STEM; Key to the Living World
- Guides: Beyond You (Learn About Our Environment); Conservation badge; Water badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM, Our Environment)
- Rangers: Environment, Outdoors and Camping (Falling from the Sky, Our Local Environment)

Licence Plate "Tengo"

Kind of like Bingo, except that instead of trying to make a straight line on a grid of numbers, you're trying to make ten out of the numbers on vehicle licence plates. This is a good game for long road trips, but you can play it any time you have a variety of licence plates around (when you're waiting around in a parking lot for parents to pick girls up after camp, for example). House numbers and phone numbers work just as well.

What you need:

- Licence plates

What to do:

1. Use any mathematical operation you like (addition, multiplication, etc.) to make ten from the numbers on a licence plate.
2. The (completely arbitrary) rules we suggest: You must use all the numbers on the licence plate, and no others, and you must use them in the order they appear. (Feel free to modify these rules as you see fit!) The math you use can be as simple or as advanced as you like. For example:

If a licence plate has these numbers:	You can make ten like this:
325	3 + 2 + 5 = 10
286	2 x 8 - 6 = 10
272	2 x (7 - 2) = 10
321	3^2 + 1 = 10

Program connections:

- Brownies: Key to STEM
- Guides: Beyond You (Try New Things)
- Pathfinders: Exploring a Theme (Everything Comes from STEM, Puzzle Me)

What's Your Shape?

You may have heard of people being "pear-shaped" or "apple-shaped", both of which refer to someone's waist and hip measurements. But did you know you can also classify people as squares or rectangles? Try this experiment to find out which one you are.

What you need:

- Tape measure, ideally at least 180 cm (6 feet) long
- Partner

What to do:

1. Measure your partner's height. You can measure in centimetres or inches, whichever you prefer, as long as you use the same units in the next step as well.
2. Ask your partner to stretch her arms out to the sides. Measure the distance from one fingertip to the other.
3. Compare the two measurements. If they are nearly the same, your partner is a square. If one measurement is longer than the other, she is a rectangle.
4. Switch places and do it again.

How to increase the Math Factor:

Survey your unit or your family. How many people are rectangles and how many are squares? Do you see any patterns—for example, does a person's age or gender help predict whether they'll be a square or a rectangle?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things); Body Works badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Flexagons

You might not have heard the name, but you might have seen one. A flexagon is a strip of paper folded up in a special way to make a flat shape—often hexagonal (six-sided), but not always. The shape has two surfaces: a front and a back. If you pinch, fold, and unfold (or flex, hence the name) the flexagon in just the right way, you reveal another surface that was hidden before.

What you should know before you start:

There are lots of flexagon patterns to try; some are fairly simple to make, while others are very complex. Look for books of flexagon templates (they can be hard to track down, but they do exist; your local bookstore may be able to order one for you), or search the Internet. A good site is The Flexagon Portal (*http://flexagon.net*). Print out a pattern you like (the Trihexaflexagon Classic is a good one to start with) and follow the directions to fold.

What you need:

- Flexagon pattern and folding instructions
- Scissors
- Glue

What to do:

1. Cut out the flexagon pattern and follow the instructions for making it.
2. Flex and fold it to discover the hidden surfaces. Try drawing pictures on each surface to see how they change as you flex your flexagon.

What else you can do with this:

Young girls might find the rectangular flexagon (*www.artistbooks.com/flexagons/flexmake.html*) a little easier to make, and older girls will enjoy this one too. It has four book-like surfaces on which you can draw pictures to fit any theme. Some ideas for things to put in your flexagon book:

- A calendar, with three months on each surface.
- The life cycle stages of a butterfly or other insect (egg, larva, pupa, adult).
- Instructions for four different knots.
- Lists of gear to put in a backpack for hiking in each of the four seasons.
- The Promise, Law, and Motto, plus what WAGGGS stands for.
- Menus or recipes for four different camp meals.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM; Key to the Arts
- Guides: Beyond You (Try New Things); Creative Craft badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM, Puzzle Me)

Sundial

Use the sun and some simple materials to make your own sundial.

What you should know before you start:

If you don't have a convenient piece of pavement to set up your sundial on, you can use small rocks instead of sidewalk chalk to mark the hours on dirt, outdoor carpeting or short grass.

What you need:

- Modelling clay
- Long pencil or similar dowel
- Compass
- Watch
- Sidewalk chalk
- Ruler

What to do:

1. Roll the modelling clay into a ball and poke the end of the pencil into it so it stands at about a 45° angle. This is the pointer, or *gnomon*, of your sundial.
2. Set the pointer in a sunny spot on your driveway or front walk. If you use the driveway, keep your sundial to the side so it doesn't get run over when your parents come home from work.
3. Use the compass to find North, and turn the gnomon so that it is pointing North.
4. Keep checking your watch. Every hour on the hour, use the ruler and sidewalk chalk to draw a line along the gnomon's shadow, starting at the base of the gnomon and going out about 30 cm. Mark the hour at the outside end of the line. Depending on the clouds and what time you start, it might take a couple of days to mark all the daylight hours.
5. Your sundial is complete! Practice telling time with it—can you tell time to the nearest 15 minutes, or even more accurately than that?

How it works:

As the earth rotates, the sun appears to move across the sky. As the sun moves, so does the shadow of the gnomon—in one hour, the shadow will move through an arc of 15°. At noon, when the sun is directly in the south, the gnomon's shadow will be pointing due north (0° on your compass); at 1:00 p.m., it will be pointing to 15°. By 6:00 p.m., when the sun is in the west, the shadow will be pointing due east, or 90° on your compass.

How to increase the Math Factor:

You might notice some inaccuracy in the time your sundial tells you, or in the direction of the sun at various times of day as shown by your compass. There are a couple of reasons why that might be:

- The path that the sun follows through the sky changes during the year. As the days pass by, you might notice that your sundial is becoming less accurate, because the sun is not in exactly the same position at noon today as it was on the same day last week. This error is small and comes on gradually, but if you have your sundial set up for several weeks you might notice it.
- The sun's path is based on geographic directions—that is, when the sun is directly in the south, the gnomon's shadow points toward the geographic north pole, or *true north*. Your compass, however, points to the magnetic north pole, which is not in the same place. This difference is called *magnetic variation* or *magnetic declination*, depending on who you ask. The difference can be quite significant; in most of BC, the declination is between 20° and 25° East (meaning that the magnetic north pole is east of true north).

See if you can figure out how to correct these errors and make your sundial more accurate.

Program connections:

- Sparks: Exploring and Experimenting Keeper; Going Outside Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Explore the Outdoors and Nature, Try New Things); Science badge, Astronomy badge
- Pathfinders: Let's Take It Outside (Finding Your Way); Exploring a Theme (It's About Time, Galactic Adventures, Everything Comes from STEM)
- Rangers: Environment, Outdoors and Camping (Engineering and the Outdoors)

Go Shopping!

If you have a camp, sleep-over, or similar event coming up, get the girls involved with the planning, budgeting and shopping for it.

What you should know before you start:

This activity works well if you can split it up over a couple of meetings—one to do the planning, and another to do the shopping. When you give the girls a budget to work with for their planning, it might be an idea to keep a little money back so that you have some reserves in case certain supplies are more expensive than expected when you go do the shopping.

What you need:

- Event plan and budget
- Fliers or price lists from grocery store, craft store, etc., depending on what you are planning
- Paper and pens or pencils
- Calculators (optional)

What to do at the planning meeting:

1. Divide the girls up into small groups. Assign each group a small part of the event to plan (e.g., one meal for a camp, snacks for a hike, a craft activity for a sleep-over, etc.). Give each group fliers or price lists from stores appropriate to the meal/activity they are planning.
2. Give each group a budget for their meal/activity. Make sure they are aware of any other limitations on what they can plan (e.g., nut-free meals or snacks, light-weight supplies, etc.)
3. Each group must figure out what they will eat/do, how much of all the supplies they will need, and how much it will all cost (based on prices in the fliers).

Note: Make sure you give lots of time and adult support for this. The girls may need to try a few different ideas before they come up with something that will work with the budget. Suggestions and assistance from an adult who has done it before will help prevent the whole process from breaking down in frustration.

4. Make a detailed shopping list, including prices, of everything required for the meal/activity.

What to do at the shopping meeting:

1. Hold your next meeting at the store(s) where you will buy the supplies. Make sure each group brings their list from the planning meeting.
2. Remind the girls how much money they have to spend.
3. Buy all the supplies for the meal/activity. As you shop, pay close attention to the actual prices of supplies, and compare them to the ones you used for budgeting. If one item is more expensive than expected, can you save somewhere else, or substitute something less expensive? If you have kept some money back as a reserve, make sure the girls understand that it is to be used only if absolutely necessary—the first goal is to stay within their means and stick to the budget.

How to increase the Math Factor:

The planning part of this activity can be quite complex and is best suited to older girls. If you want to adapt this activity for younger girls, or if you want to focus on the budgeting and math aspects, you could:

- Do the planning yourself and the shopping with the girls. Give them a list, tell them how much money they can spend and have them keep a running total as you shop. If the total creeps up over the budget, get them to decide what to do without or suggest alternatives to reduce costs.
- Skip the planning altogether. Instead of shopping for an event, try shopping for toys to donate to your local Christmas Bureau or women's shelter. Again, give the girls a budget, have them keep a running total as they shop,

and make them decide what they can afford to buy. If they choose something that needs accessories, like batteries, they must include the accessories in their budget too.

Program connections:

- Sparks: In My Community Keeper; Going Camping Keeper
- Brownies: Key to I Can; Key to STEM; Key to Camping
- Guides: You and Others (Learn How to Plan); Discovering You (Understand How to Be Responsible); Beyond You (Try New Things); Event Planning badge; Life Skills badge
- Pathfinders: Creating Your Future (Event Planning, Find Your Inner Leader); Let's Take It Outside (Camping, Here We Come); On My Own (Skills for Around the Home, Moneywise); Exploring a Theme (Everything Comes from STEM)
- Rangers: Leadership and Management (Financial Responsibility); Environment, Outdoors and Camping (Mmmm Dinner)

Mathematical Card Trick

Many card tricks are based on mathematics. Some are simple, like this one; others are considerably more complex. If you like this one, look for others in books of magic tricks or on the Internet.

What you need:

- 21 playing cards, all different
- An audience

What to do:

1. Lay out three cards face-up in a row, going from left to right. Lay the next three in the next row, overlapping the first row and again going from left to right. Continue until you have laid out all 21 cards in three columns of seven cards each.
2. Ask a volunteer from your audience to pick one of the cards, without telling you what it is. She should just point to the column that it is in.
3. Pick up each column in turn, making sure that the second column you pick up is the one your volunteer has pointed to.
4. Holding the stack of cards face-down, lay them out again row by row in three columns of seven cards each, exactly as you did in step 1.
5. Ask your volunteer to find her card again and point to the column it is in (not to the card itself).
6. Repeat steps 3-5 one more time.
7. Gather up the cards column-by-column again, making sure the column your volunteer has pointed to is the second one.
8. Holding the stack face-down, count out 10 cards, turning them face-up as you count. Hold up the 11th card and ask your volunteer if this is the card she picked.

How to increase the Math Factor:

Figure out why the chosen card always ends up as the 11th card in the stack.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things)
- Pathfinders: Exploring a Theme (Puzzle Me, Everything Comes from STEM)

Chess Games

Chess is a great game for teaching critical-thinking and problem-solving skills, which are fundamental skills for any future mathematician (or anyone else, for that matter). If your girls are chess players already, or if you're up for the job of teaching them, go ahead and play a full game of chess. But if that's too much, try out some of these simpler games that use chess pieces.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things)
- Pathfinders: Exploring a Theme (Puzzle Me, Everything Comes from STEM)

Battle of the Pawns

In this game, you play with just the pawns. The goal is to get one of your pawns all the way across the board from your side to your partner's.

What you should know before you start:

In chess, the player with the white pieces always goes first. Decide who gets them by putting one piece of each colour behind your back and asking your partner to choose a hand.

What you need:

- Chess board
- All the pawns
- Partner

What to do:

1. Set the pawns up as you would for a regular chess game: all the white pawns on the second row (called a rank) of the chess board, and all the black pawns facing them on the seventh row (rank). In other words, leave one blank row at each end of the board and set the pawns up on the next row.
2. Taking turns with your opponent, advance your pawns across the board. Try to get one pawn all the way across to your partner's end of the board. Pawns can move as follows:
   - Pawns can move only forwards, not backwards or sideways.
   - Pawns can move diagonally only to capture your opponent's pawn. If your opponent's pawn is one square ahead and to the right (or left) of your pawn, you can move diagonally onto that square and take her pawn.
   - On any pawn's first move (i.e., when it leaves its starting position), it can move forward one square or two squares. After that, that pawn can move only one square at a time.
   - Pawns can capture "*en passant*": if you move a pawn two squares forward from its starting position, and if your opponent's pawn could have captured it if you had moved it only one square forward, she can still capture it. She can move her pawn diagonally and take your pawn, exactly as if you had moved it only one square forward. capture the pawn as if taking it "as it passes" through the first square. However, your opponent must make the *en passant* capture on her very next turn, or she loses the opportunity to do so.
   - You cannot skip a turn.
3. The game ends when one of these things happens:
   - One player's pawn reaches the other side of the board.
   - Neither player has a legal move left. (But note: if you have a legal move, you must take it. You cannot skip a turn to avoid making a move you don't want to make.)

Rook's Maze

In this game, only the rooks (castles) can move. Other pieces are on the board to make an obstacle course for the rooks as they move from one corner of the board to the other.

What you should know before you start:

In chess, the player with the white pieces always goes first. Decide who gets them by putting one piece of each colour behind your back and asking your partner to choose a hand.

What you need:

- Chess board
- Chess pieces, including one white rook, one black rook, and a variety of other pieces
- A partner

What to do:

1. Place the rooks in diagonally-opposed corners of the board.
2. Place the other pieces around the board in random locations. The more pieces you have, the more challenging this game is.
3. Taking turns with your partner, try to move your rook from your corner to your partner's corner. Rooks can move as follows:
    - Rooks can move up and down (vertically) and side to side (horizontally). They cannot move diagonally.
    - Rooks can cross one or more squares in a single move, as long as they are not blocked by another piece.
    - Rooks can stop on squares of either colour.
    - Rooks can capture an opponent's piece by landing on the square occupied by that piece.
    - Rooks cannot move past one of their own pieces; they must stop before it.
4. The game ends when one player's rook has reached the opposite corner.

Knights to the Rescue!

Two knights race to reach the Queen first. It's a contest, though, so each knight must make sure he does not get captured by the other!

What you should know before you start:

In chess, the player with the white pieces always goes first. Decide who gets them by putting one piece of each colour behind your back and asking your partner to choose a hand.

What you need:

- Chess board
- One white knight (horse) and one black knight
- One queen (either colour)
- Partner

What to do:

1. Place the knights in diagonally-opposed corners of the board. Set the queen on a square near the middle of the board, or in one of the remaining corners.
2. Taking turns with your partner, try to get your knight to the queen the fastest. Knights can move as follows:
    - Knights always move in an L-shape: two squares forward or back and one square to either side (or two squares to the side and one square forward and back).
    - Knights can stop on a square of either colour.
    - Knights can pass over other pieces of either colour.
    - A knight captures an opponent's piece by stopping on the square occupied by that piece.
3. The game ends when one knight rescues (or captures) the queen, or when one knight captures the opponent's knight.

What else you can do with this:

To make this game even more challenging, use two knights each. Put them in the corners of the board, put the queen in the middle, then try to capture your opponent's knights as you race to rescue the queen.