9-12 Mathematics TEACHER GUIDE

How to Use your Field Trip Guide

Field Trip Guides provide structure and suggestions on a particular theme within COSI's exhibition areas. This will allow you, your students and your chaperones to be prepared to explore science and discover fun. We suggest you begin by selecting goals for your visit. These goals may include enhancing aspects of your science curriculum, understanding what it means to be a scientist, or showing your students that science learning can be cool and fun! If you have particular curriculum goals, use this Field Trip Guide to connect what you are doing in your classroom with our pre- or post visit activities. We recommend making copies of the Scavenger Hunt for each of your chaperones, so that they can guide the students through the exhibits and help record information. Our Scavenger Hunts are designed to be open-ended, and focus on process skills and scientific thinking. As a result, there may not be one right answer for each of the questions. This means you will NOT find an answer key for any of the scavenger hunts. Instead, you'll find descriptions of the science concepts that we hope you'll experience. If you feel you need more clarification, you can always contact us at fieldtrips@mail.cosi.org.

COSI is a big place. As a result, you may not see everything in one day. Take your time-don't rush, and allow your students to explore the things that they find interesting. All too often kids are pulled away to the next area just as they start to get involved in an experience. Rather than trying to see everything, select just a few areas to spend your day. You will see less, but you will learn more.

COSI Exhibits related to Mathematics

COSI contains a wonderful atmosphere in which to demonstrate just how abundant math is in our daily lives. Mathematics helps us to understand the surrounding world, incorporating data, measurements, and scientific observations. Mathematics is universally applicable offering science both a standard for order and a basis of truth. You will find the proof of math's profusion as you explore Progress, the Cracker Jack Exhibit, Ocean, the Twisted Cord Illusion, Space, and the Foucault Pendulum.

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PROGRESS

Travel through time and interact with the people of the small Mid-western town of Progress and the technology of their time in1898. Around the corner, find yourself generations later in 1962 and see the changes Progress makes. Take a step into the past to explore topics like communication, transportation, and recreation while making meaningful calculations that help predict the future along your way.

Drug Store Look through the objects advertised at the drug store. Observe that in 1962 a toothbrush cost only \$.10 and that a pack of 15 Barbasol razor blades was only \$.25. That same toothbrush today would be \$1.50, how much would the razor blades cost if bought today? We can set up a proportion in relation to the price of the toothbrush, since the price of the razor blades will be computed using the same rate of inflation. For instance: \$.10 is to \$.25 as \$1.50 is to x (x representing the price of the razor blades today). If $.10/.25 = 1.50/x$, then $x=\$3.75$.

None Finer Diner The diner is located in Progress in 1962. Inside there is a jukebox with prices listed: \$.10 to play one song, \$.25 to play 3 songs, and \$.50 to play 7 songs. If it costs \$.25 to play 3 songs, then you are paying about $\$.25/3 = \$.083$ or about 8 cents per song. How much is each song if you play seven songs? What trend do you see in this data, is it increasing linearly or exponentially? Is it possible to determine a rate of change for it?

Inflation As you explore the town of Progress in 1898 and in 1962 look for signs of inflation. Do prices seemed to have increased proportionally among all goods? Which goods increased the most in price? Compare Progress to your home town, which goods have increased in price most dramatically from then to now? Can you think of a reason why?

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CRACKER JACK EXHIBIT

If all the Cracker Jacks ever sold were stacked end-to-end they would wrap around the Earth four times. The circumference of the Earth is approximately 25,000 miles, so they would occupy a distance of about 100,000 miles. There are 5,280 feet per mile, so in feet, the Cracker Jack's would occupy a distance of 5,280,000,000 ft. Since there are 12 inches per foot, they would cover 63,360,000,000 inches.
Try to estimate the total number of trinkets displayed. An easier approach may be to count the number in a certain area then multiply by the number of other areas that seem to contain the same amount.

OCEAN

Poseidon's realm takes two forms in this unique learning environment. On one side of the exhibition, Poseidon reigns majestic over a mythical playground, symbolizing the ancient means for understanding the sea. Here, you can explore the physical nature and mathematical properties of water through laminar streams, eroding sand, and other activities, while at the same time being totally immersed in a theatrical recreation of the ocean's power. On the other side of Ocean, Poseidon is the namesake of an undersea research habitat, now symbolizing the modern means for exploring and understanding the sea. Based on real ocean exploration technology, the "D.S.B. Poseidon" uses submersibles to explore the scientific side of Ocean.

Poseidon Poseidon is at a height of 25 ft. He is perpendicular to his shadow and a right triangle can be created, the angle between Poseidon and the hypotenuse being 60 degrees. Using the tangent trigonometric function, the length of Poseidon's shadow (x) can be computed: $\tan 60° = x/25$ therefore, $x = 25 \times \tan 60°$. The distance from the top of Poseidon's head to the tip of his shadow is equal to the length of the hypotenuse of our right triangle. Since we have the lengths of both of the other edges of the triangle, you can simply use the Pythagorean Theorem.

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Buoyancy Buoyancy is a matter of density. Density is a measure of the amount of mass an object has relative to its volume, the space it takes up. If an object has a density less than the fluid surrounding it, the object will float. Conversely, if the density of the object is greater than that of the fluid, the object will sink. Positive buoyancy occurs when an object is less dense than the fluid around it and the object will float. Negative buoyancy occurs when an object is less dense than the fluid around it and the object will sink. Neutral density occurs when an object maintains its current depth and will neither rise nor sink. Divers will sink when their density is greater than the water surrounding them. This is accomplished with a buoyancy compensator (BC) that they wear. As air is removed from the BC it will deflate, decreasing the diver's overall volume (increasing the density) and the diver will sink. Increasing air to the BC causes it to inflate, increasing the diver's overall volume (decreasing the density) making the diver rise.

JIM Suit The JIM suit was the original diving suit. It was designed in 1965 and named for the first test diver, Jim Garrett. The design of the suit progressed up to the JIM IV. Later on, a new lightweight aluminum suit, the SAM suit (Submersible Atmospheric Mechanism) was created. The one on display in Ocean is a JIM III. The JIM suit is designed to maintain an even pressure of one atmosphere to a depth of 1000 ft. The suit must withstand incredible pressures found at these depths and weighs 800 pounds. It is hinged so that two people lower the top portion while the person to be suited up climbs into the bottom portion. The buoyancy of the atmosphere in the suit enables the diver to move easily once he/she has been lowered into the ocean with a crane. The suit comes equipped with a scrubber to remove $CO2$ from the atmosphere in the suit. Because the suit maintains a constant pressure of one atmosphere, the diver is able to breathe bottled air instead of using mixed gases. The suit also carries a bottle of oxygen to refresh the atmosphere.

Vortex Turbulent flow can create vortices. Turbulent flow can be defined as a flow where all parts of the flowing material do not have the same velocity. A vortex is a circular flow pattern in a fluid. In this exhibit, two primary forces form the water vortex. First, water shoots into the cylinder from an opening inside the bottom edge. This starts the water moving around inside the cylinder. The shape of the cylinder's walls contains the water, keeping it from flying out to the sides. The result is that the water swirls around and tends to move up and away from the center as much as it can inside of the cylinder. Meanwhile, in the center of the cylinder, on the bottom, is a vacuum that causes water suction and pulls the column of water downward. These forces oppose one another (one pulling down in the center, one pushing water up along the outside of the circle) resulting in a V-shaped vortex. Air from the top of the cylinder is pulled down the center of the tube.

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TWISTED CORD ILLUSION

This illusion is located on the Level 2 of COSI. As you observe the picture, do the orange bands appear to curve? They are actually perfectly straight and parallel to each other. Step closer to observe this aspect. Why our brain adds the curvature is not known but the pattern of black segments on the bands seems to add directions for the curve. Try to look at the illusion from different angles, do they bands ever seem to be parallel?

SPACE

Once you enter the dizzying black hole of Space, you can ride in a space capsule, determine your weight on the moon, and maneuver a rover through a Martian landscape. While on your visit, study some of history's great space explorations and the technology that is used today. Observe how mathematics plays a role in the commands used to operate necessary machinery and in determining relative masses and pressures in outer space.

Gravitational Comparison This interactive display demonstrates the weight of a single object, affected by the gravity of three different planets. Guests can lift three bowling balls of the same size to feel the weight of that ball on other planets. They can then view a chart to determine their own weight on these planets. Each of the lines represents a different location; find the slope of each of the lines. Which is the largest? How are the slopes related to the relative weights on each of the planets?

Space Station The space station model houses a number of activities for guests to interact with. There is a Hubble Space Telescope slide show, an astronaut survival game, Saturn Exploration kiosk, History of the Universe interactive timeline, and a Living in Space kiosk that shows movies on the topic of living in space.

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Return to Space While learning about many amazing space capsules, assume that you need to choose two to discuss in class. What is the probability that you will choose the Mercury Redstone and the Molniya? First count the total number of rockets that are discussed, there are 13. Now we need to find the total number of ways to choose two of the rockets. Will order matter, in other words, will it matter which rocket is chosen first and which is chosen second? The order does not matter, so we need to find all the possible combinations of two rockets. If order mattered we would need to find all possible permutations of two. So, we can simply count all possible sets of two or we can use the mathematical formula for combinations:

$$ {}_{n}C_{r} = \frac{n!}{r!(n-r)!} $$

In our situation, we will have

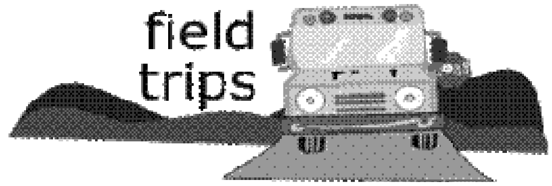
$$ {}_{13}C_{2} = \frac{13!}{2!(13-2)!} = \frac{13!}{2!\times 11!} = \frac{13\times 2}{2\times 1} = 78 $$

Picking the Mercury Redstone and Molniya rockets is just one of these combinations, therefore the probability that these two rockets are picked is 1/78.

THE FOUCAULT PENDULUM

COSI's Pendulum shows guests our recreation of French physicist Jean Foucault's experiment to prove the Earth's rotation on its axis. Knowing Newton's first law of motion, that an object that is free from all outside forces travels at a constant velocity along a straight line path, the only way for the pendulum to trace out the path along the circle is for the Earth to rotate under the pendulum. This pendulum knocks steel balls from their resting place as the pendulum sweeps out the circular path. The period of the pendulum and the length of its cable are connected mathematically. The math formula that shows this is: $Period = 2\times \Pi \times \sqrt{\frac{height}{g}}$

Where g is the acceleration due to gravity and the period is the time it takes the pendulum to swing out and back. By substituting the constants $g=9.8$ m/s^2, $\pi = 3.14$, and rearranging the formula so that it is equal to the height we can easily find the height in meters. Count the seconds it takes for the pendulum to swing out and back, this is equal to the period. Square this result and divide by four and you will end up with the height of our pendulum.



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Vocabulary Words

These are some mathematical terms that you should be familiar with as you explore COSI with your students:

Inflation: A persistent, substantial rise in the general level of prices related to an increase in the volume of money and resulting in the loss of value of currency.
Hypotenuse: Longest side on a right-angled triangle.
Sine: In a right-angled triangle: a ratio of the length of the side opposite a given acute angle to the length of the hypotenuse.
Cosine: In a right-angled triangle: a ratio of the length of the side adjacent to a given acute angle to the length of the hypotenuse.
Tangent: In a right-angled triangle: a ratio of the length of the side opposite a given acute angle to the length of the side adjacent to the same angle.
Density: The mass of a substance divided by the volume occupied by that substance.
Buoyancy: The force that keeps a floating object from sinking.
Combination: Selection of things, the order of these things has no importance.
Permutation: Arrangement of things, the order of these things is considered.
Period: The duration of one complete cycle of a wave or oscillation; the reciprocal of the frequency.
Factorial: The product of a whole number multiplied by every whole number between itself and 0.

Process Skills are the actions that it takes to "do science." These are some of the scientific process skills that your students will be using as they explore the exhibits at COSI.

Observe - Use your senses to gather information.
Measure- Use tools and numbers to quantify objects or phenomena.
Categorize - Place objects into groups based on similarities or differences.
Communicate - Use words, pictures, graphs and diagrams to share your ideas.
Investigate - Follow a scientific method to formulate questions, conduct an experiment.
Apply - Put the information you've gathered to use.
Infer – Make an assumption based on your observations.
Question – Wonder and ask about things and find ways to discover answers.
Predict - Decide what will happen in the future based on your observations.

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Mathematics Standards

Grade 9 Number, Number Sense, and Operations

4. Demonstrate fluency in computations using real numbers.

Grade 9 Measurement

4. Use scale drawings and right triangle trigonometry to solve problems that include unknown distances and angle measure.

Grade 9 Geometry and Spatial Sense

1. Define the basic trigonometric ratios in right triangles: sine, cosine, and tangent.

Grade 9 Patterns, Functions, and Algebra

14. Describe the relationship between slope and the graph of a direct variation and inverse variation.

Grade 9 Data Analysis and Probability

7. Use counting techniques and the Fundamental Counting principle to determine the total number of possible outcomes for mathematical situations.

Grade 10 Number, Number Sense, and Operations

3. Use factorial notation and computations to represent and solve problem situations involving arrangements.

Grade 10 Patterns, Functions, and Algebra

3. Solve equations and formulas for a specified variable.

Grade 11 Measurement

5. Identify, sketch, and classify the cross sections of three-dimensional objects.

Grade 11 Geometry and Spatial Sense

4. Use trigonometric relationships to determine lengths an angle measures.

Grade 12 Measurement

1. Solve problems involving derived measurements.

Grade 12 Geometry and Spatial Sense

3. Relate graphical and algebraic representations of lines, simple curves, and conic sections.

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Classroom Connections

Your visit to COSI should not a one day event, soon to be forgotten. Help your students make connections between the classroom lessons and your field trip by doing activities related to your visit. Before your visit, review the vocabulary words that the students will encounter, and brainstorm things they already know about technology or COSI in general. Give them descriptions of each of the areas and some of your expectations. If possible, review with the chaperones, so they know what to expect. After your visit, have your students draw pictures or write letters of stories about their experience, and list questions they still have that you could explore together.

Below are some lessons that you can use as pre-visit or post-visit activities to help connect your field trip to your classroom experiences and extend your students' learning. Consider doing one activity every day for a week before your visit.

Ultimate Antacid

Objective: Use trig functions to solve a problem

Materials:

- Paper
- Pencil
- Brains (as usual)

Professor Know-It-All has run out of the Hydrochloric Acid that he needs to finish his experiment on creating the Ultimate Antacid!!! Bwahahaha! So the Professor has gotten very sad and is getting a belly-ache, which is ironic, considering what he's working on. But we digress. Suddenly he remembers that he has an HCl reserve, but it is up on a very high, very dusty shelf and our Professor is a very short man. Here is his dilemma: He needs to get a ladder and it is getting late. There are several ladders of different lengths: 40′, 41′, 42′, 43′, 44′, 45′, 46′, 47′ and 48′. The ladders are located in a closet to which the custodians have the only keys and the custodians are leaving in 25 minutes. The closet is exactly 10 minutes away from Professor Know-It-All's lab. The Professor is not a strong man and will only be able to carry one ladder. The distance from the floor to the high, dusty shelf is 40 feet. The high, dusty shelf is perpendicular to the floor. Being a Know-It-All, our Professor knows that to be safe the ladder should be placed at a 75 degree angle from the floor. Given this information, which ladder should our professor get?

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Best Investment
Objective: Use graphs to solve distinguish between exponential and linear relationships, to evaluate problems and to make predictions based upon data

Materials:

- Graph paper
- Pencils
- Rulers
- Blackboard & chalk
- Calculators

Part I:
Imagine you are four years old. A rich aunt wants to provide for your future. She has offered to do one of two things.

Option 1: she would give you $1000 a year until you are 21 (17 years); or
Option 2: she would give you $1 this year, $2 next year, and so on, doubling the amount each year until you were 21.

Predict which option would give you the most money when you would be twenty-one.
To find out the answer, get some graph paper and a ruler. Put money on the left, vertical margin, using units of $5,000. Put years on the horizontal margin, starting with year four to seventeen years. Find the year along the line at the bottom of the graph, then find the amount of money for that year along the left side of the page. Match up these two amounts and place a dot. When you have placed all your dots, draw a straight, solid line to represent option 1: $1000 per year, and a curved, dotted line to represent option 2, $1 the first year and double that amount every year.

Study the graph and answer the following questions:
1. How much money would you have when you were 21 if you chose Option 1? How much would you have if you chose Option 2? Was your prediction correct?
2. If you only received money for ten years, which option would give you the most money? How many years would it be before you had the same amount of money with both options?
3. Why do you think the money in Option 2 increase so rapidly after the fourteenth year? Look at the graph. Option 1 represents a simple, direct relationship and is called a linear relationship. Option 2 shows an exponential relationship in which for every year the amount doubles. Some exponential relationships increase even more than this. Which option is linear? Which option is exponential?

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Population Growth

Year	World Population (in millions)
1650	500
1700	600
1750	700
1800	900
1850	1300
1900	1700
1950	2500
1976	4000
2000	7000

Predict what kind of graph this will be: linear or exponential?
To check your answer, create a graph with the year on the horizontal axis and the world population (in millions) on the vertical axis. Was your prediction correct?

To understand why world population is now growing so fast, we will discuss some issues. This activity will help you understand one of them. Read the four family histories below and answer the questions. It may be helpful to draw a family tree for each one.

Family A: A has one child. If that child has one child, how many grandchildren does A have? If the grand-child has one child, how many great grand-children does A have?

Family B: B has two children and each of them has two children. How many grandchildren does B have? If each grandchild has two children, how many great- grandchildren does B have?

Family C: C has three children and each of them has three children. How many grandchildren does C have? If each grandchild has three children, how many great-grandchildren does C have?

Family D: D has four children and each of them has four children. How many grandchildren does D have? If each grandchild has four children, how many great-grandchildren does D have?

Can you name the pattern or rule that governs these histories?

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After Your Visit/ Assessment

Use the following activities to assess the impact of the visit to COSI on your students' knowledge, attitudes, and perceptions. Use a standard project rubric to assess the product of each of these projects. If you would like, send stories, pictures, or descriptions of your project to COSI c/o Field Trips, 333 W. Broad St., Columbus, OH 43215.

Lunch Time Probability

Objective: Use probability to solve a problem.

Materials:

- Paper
- Pencil

It's lunchtime – YUM! Today's featured items at the café are as follows: fruit choice of grapes, banana or apple; drink choice of OJ, milk or water; entrée choice of steak, sub or salad. How many combos can you have of one fruit, one drink and one entrée?

It's two months later. You've just entered a huge growth spurt and are now buying 4 items of any kind per meal. How many combos of any 4 items can you make?

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Letter Stats

Objective: Gather appropriate information for simple statistical analysis, calculate probability and evaluate results

Materials:

- A book, magazine, or newspaper.
- Worksheets
- Pencil
- Calculator (optional)

This lesson can be introduced by either showing a 5 to 10 minute video clip of the T.V. show "Wheel of Fortune," or by playing the game of Hangman with the class for 5 to 10 minutes.

Are there some letters that we use more than other? Are there some that we hardly use at all? Do you think there may be some mathematical rules that could improve our chances of winning at these word games?

Choose a book or magazine to research our use of letters by choosing a page and a place to begin at random and beginning to tally the letters one at a time, filling out the table provided. Caution: do not "jump around" the page.

Add up the totals, which should come to a grand total of about 300 (more or less, if desired). (Optional:Use a calculator to) Calculate (to 1 or 2 decimal places) the percentage probability of finding each letter. Check accuracy by adding up percents, which should total between 99% and 101% (allowing for rounding).

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1. How many vowels are in the TOP TEN?
2. Which consonants would be the most useful in "Wheel of Fortune"?
   _____, _____, _____, _____, _____, _____
3. Which vowel might be the least useful? ________
4. What percentage of all the letters surveyed were vowels? ________
5. See if you can make ten different words using only the top five letters.

____

____

LETTERS OF THE ALPHABET
(Statistical Conclusions)

TRUE OR FALSE:

1. You should never expect to find the letter Q on "The Wheel Of Fortune."
   T F
2. Almost every word requires a vowel.
   T F