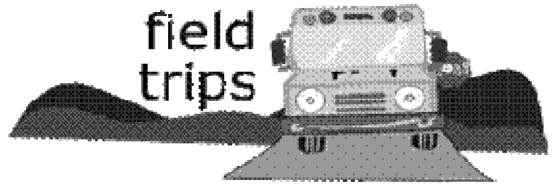

9-12 Force & Motion TEACHER GUIDE

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 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 it everything, select just a few areas to spend your day. You will see less, but you will learn more.

COSI Exhibits related to Force & Motion

COSI is a great place to learn about force and motion. Below are descriptions of exhibits related to force and motion. Push, pull, shove, roll and fly your way into science with these cool experiences. You will find them in Gadgets, Ocean, Big Science Park, Space, and the hallways. You may want to consider making a reservation for one of the following experiences to enhance your explorations of force & motion. All shows require 3 weeks advance notice.

The Gadgets LIVE Show – This dynamic demonstration includes potential and kinetic energy, force and motion, and explosions! Caution: Science can be LOUD! Reservations for up to 200 people at select times.
The Gadgets Café – Your group can spend some time in the Gadgets Café taking stuff apart or trying out our science menu. Reservations available for groups of 6 or less.

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BIG SCIENCE PARK

Big Science Park is strictly Big Fun for your head and body as big experiments await your exploration. Big Science Park fosters the spirit of learning by putting you into the experiments, so you become a part of the science. As in all of the exhibition areas, there is no food, drink, or smoking in Big Science Park. Some great exhibits for your students to explore include:

- The Centripetal Generotor will allow you and your students to feel *inertia, friction, gravity, and centripetal force* in action. As the 'Rotor spins, your body is forced against the walls, so when the floor drops below you, your body remains suspended. Young children can focus on the idea of gravity, and a push or pull. This is experience is open weather permitting. Certain restrictions apply.

- The Granite Sphere- Are you strong enough to move a 2,500-pound object? Give the granite sphere a push and see how reducing friction can make things easier to move. The inch of water under the sphere allows for the sphere to roll easily than it would if it were in contact with the ground.

- The Giant Lever - Get a body-on understanding of simple machines as you lift a 2437-pound (1105.4 kg) 1961 Mercury Comet! This is a class-1 lever, with a fulcrum between the load and the effort. Try both ropes. Which one is easier? Which one takes longer?

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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 of water through laminar streams, eroding sand, and other activities, and 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, revealing the modern means for understanding the sea. Based on real ocean exploration technology, the "D.S.B. Poseidon" uses submersibles sonar to explore the scientific side of Ocean. Caution: It is likely that your students will get wet. Encourage them to take care not to get others wet in the process. Exhibits include:

The Cartesian Diver 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 the air is removed, the BC will deflate. This decreases the divers overall volume, making him/her more dense than the surrounding water. Can you get COSI's diver to go up and down? How about remain neutrally buoyant (the middle)?

Erosion Table As water is pulled by gravity to lower levels, it exerts a force of change upon the surface on which it travels. This force of change is called erosion. The erosion table demonstrates fluvial (water) erosion on landmass. Where does the sand go? Where is sand washed away faster? Slower? Why? Are there any areas that have no sand? Where? How would you explain this observation? What ideas do you have to stop the flow of water? What do you think will happen when the water is blocked? (Make and share predictions.) Have students construct a dam with the sand and compare their predictions with their observations about the dam.

Ball Fountains You will notice that the ball is spinning. The moving water sticks to the bottom of the ball and then is thrown from the top of the ball. The thrown water moves in one direction, causing the ball to move in the other direction. This is an example of Newton's Third Law of Motion: For every action, there is an equal and opposite reaction.

Laminar Flow The water coming out of the water cannons is an example of laminar flow. Notice that this water is much less turbulent than the water in your kitchen sink. Does if feel or look different than other streams of water you have seen? How is it different?

Water Jets Notice water popping up from the floor. Pumps push the water up and gravity pulls it back down. What else doe you notice? Does the water spray out or stick together? What makes it do that?

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GADGETS

Admired for their ability to change how we do things, gadgets are tangible proof of how creativity advances technology. The Gadgets exhibition area contains a variety of exhibits that allow guests to explore the building blocks of more complex gadgets: pulleys, gears, lasers, and electric circuits. Guests can examine the inner workings of everyday gadgets by taking them apart in the Gadgets Café. The café is an inventor's paradise that offers the tools necessary to investigate the gadgets we use daily. Force and motion exhibits include:

- Pulley Chairs - An example of a simple machine that makes life easier. Each chair has a different number of pulleys, so you can try them all and feel the difference. If there are more pulleys, you expend less effort.

- Air Cannon - Have some fun with the Air Cannon in the back of Gadgets. Toss a ball in and turn the handle to launch. Air from the compressor will push the ball. Try two or five or ten balls. What happens?

- Flying Propellers -Control the speed of the flying propellers, causing them to rise, fall, or hover on a pole that reaches the ceiling. The faster the propeller spins, the more air it pushes down, causing lift.

- Newton's Nozzles - Balance a ball inside a path of airflow. Air is pushing up on a ball. Since the ball is curved, the air travels over top of the ball. This action holds the ball in place. This is an excellent demonstration of Newton's third law: for every action there is an equal and opposite reaction.

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SPACE

How big is the universe? What drives humanity to the stars? These are questions that have piqued the curiosity of many, and whose answers change as we gain more information about the universe. *Space* offers opportunities to think about these questions while at the same time relive some of history's great space explorations. Enter the exhibit through the Black Hole, a cool spinning sensory experience, or sit in the Living Room and watch the history of space travel. Please ask students to use caution in the tunnel.

Overhead Thrusters Listen for the hissing sound. This is the sound of air being pushed through the thruster's nozzles, causing thrust. Thrust is the primary means of acceleration in space. In space, propellant is pushed through a nozzle instead of air. Thrust from the air being forced through the nozzles causes the thruster to move. The thruster has inertia. Inertia refers to an object's tendency to keep moving or the resistance to changes in motion. Until an outside force (air resistance, friction, collision) acts upon the thruster, it will continue to move. These thrusters will eventually stop on their own due to drag. The primary forces are air resistance (drag) and friction. In space, however, there is little gas, which means, little drag. To stop a thruster here or in space, apply thrust in opposite direction. How do Newton's laws of motion relate to this exhibit? Newton's first law of motion (objects in motion tend to stay in motion) explains why the thruster continues to fly after the thrust is disengaged. The thruster will continue to fly until some force opposes that motion. Newton's second law (force = mass * acceleration) dictates the rate at which the thruster will accelerate when a force is applied either from thrust or air friction. Newton's third law (every action has an equal and opposite reaction) is demonstrated by the simultaneous push the thruster exerts on the fuel (air) and push the fuel exerts on the thruster.

The Rocket Launch exhibit invites guests to "fuel up" a rocket by charging a projectile with compressed air. Guests then perform their own countdown and release the miniature rocket, watching it arc 25 feet up to the ceiling. Rockets go because of Newton's Third Law: For every action there is an equal and opposite reaction. Spent fuel escapes the rocket through a hole called the nozzle. This is the action. The rocket moves away from the spent fuel, in effect pushing against it. This is the reaction. The more spent fuel the rocket leaves behind, and the faster the spent fuel moves, the faster the rocket will fly. Notice that the rocket does not push against the launch pad, the air, or anything else except its own fuel. This is the reason rockets can work in outer space.

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Standards

Grade 9 Physical Science

12. Explain how an object's kinetic energy depends on its mass and its speed ($KE=\frac{1}{2}mv^2$).
13. Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight (mg where m is the object's mass and g is the acceleration due to gravity) and height (h) above a reference surface ($PE=mgh$).
22. Demonstrate that any object does not accelerate unless an unbalanced force acts on it.
24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
25. Demonstrate the ways in which frictional forces constrain the motion of objects.

Grade 10 Scientific Inquiry

4. Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence from investigations.

Grade 12 Physical Science

8. Describe how the observed wavelength of a wave depends upon the relative motion of the source and the observer (Doppler effect). If either is moving towards the other, the observed wavelength is shorter; if either is moving away, the observed wavelength is longer.

Resources

www.howstuffworks.com - Just about everything you've ever wanted to know is described at this informative and understandable website.

http://www.exploratorium.edu/snacks/iconmagnetism.html Some cool activities from the Exploratorium related to magnetism.

http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=4&DocID=405
A lesson on gravity and other forces related to the launch of an object.

http://www.mos.org/sln/Leonardo/InventorsToolbox.html
Description of simple machines

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Vocabulary Words

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

Acceleration: The time rate of change of velocity with respect to magnitude or direction.
Force: A push or pull on an object. You can observe a force when something flies, falls, spins, drops, rolls or stops.
Gravity: The earth's pull on things.
Mass: A measure of quantity of matter in an object.
Newton's First Law of Motion- An object in motion will stay in motion unless acted upon by an outside force, or things will keep on doing what they are doing until something stops them. This is also known as inertia.
Newton's Second Law of Motion: Force =Mass x acceleration, which translates to this: the more mass an object has, the more you have to push it. The harder you push an object, the farther it will go. Newton's Third Law of Motion: When you push on an object, it pushes back, and is often referred to as action and reaction. This is not the same as cause & effect.
Speed: how far something goes in a certain amount of time.
Velocity: How fast and in what direction something is going.
Weight: The amount of gravitational pull on an object.

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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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 force and motion 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.

Exploring Pendulums
http://www.sciencenetlinks.com/lessons.cfm?Grade=6-8&BenchmarkID=4

Fast Cars/ Slow Riders
http://www.pbs.org/wgbh/nova/teachers/activities/2208_fastcars.html

Wright Brothers Flying Machines
http://www.pbs.org/wgbh/nova/teachers/activities/3015_wright.html

Top Gun Over Moscow
http://www.pbs.org/wgbh/nova/teachers/activities/2315_topgun.html

Forces & Motion
http://school.discovery.com/lessonplans/programs/forcesandmotion/

Forces, Motion, Energy & Electricity
http://school.discovery.com/lessonplans/programs/motionforces/

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After Your Visit/Assessment

Use the following activity 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.

Rubber band Rockets!

Objective: Design, construct and fly a rubber band rocket that will travel the greatest distance possible.

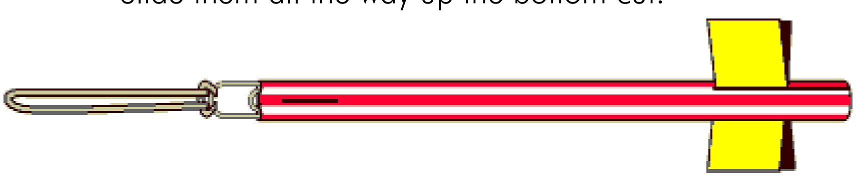
Materials: Plastic straws
- Scissors
- Paper clips
- Paper
- Staples and stapler
- Rubber Bands

Procedure:

1. Cut a regular size plastic drinking straw in half.
2. Slide a paper clip into one end of the straw then staple through the plastic to hold the clip in place.

3. Loop a rubber band onto the one end of the paper clip.

4. Make a one-inch cut through the bottom of the rocket. Cut out two paper fins (1" by ½"). Slide them all the way up the bottom cut.



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Procedure (con't):

5. Staple through the plastic to secure the fins. Bend the fins around so they are equally spaced.

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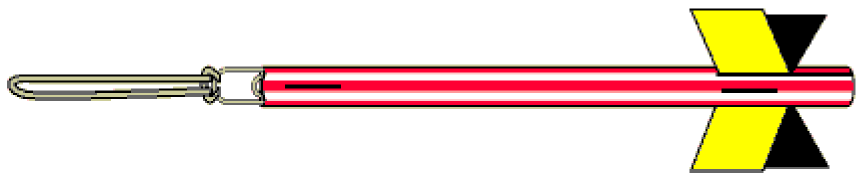

Hold the straw rocket below the fins as you prepare to launch. Try launching the rocket a few times.

Possible Interactive Questions:

What happened? How far did it go?
What would you change about the design to make it go faster? Higher? Further?
What would you change about the way you launched it?
What did you notice about the different times you launched your rocket . . . did it fly the same distance or the same way each time? Why or why not?

What's Going On?

Like the flight of Robert Goddard's first liquid fuel rocket in 1926, the straw rocket gets its upward thrust from its nose end rather than its tail. Regardless, the rocket's fins still provide stability, guiding the rocket upward for a smooth flight. If a steady wind is blowing during flight, the fins will steer the rocket towards the wind in a process called 'weather cocking.' On NASA rockets, active controls steer during flight to prevent weather cocking and to aim them on the right trajectory. Active controls include tilting nozzles and various forms of fins and vanes.