



Forces

Grades 3-5

Exhibit Guide

Dear Educator,

Welcome to the Imagination Station's field trip resource! With the assistance of area K-12 educators, the Imagination Station has created learning guides to help structure a field trip that aligns directly to the concepts you are teaching in the classroom.

Students will explore forces with three Imagination Station exhibits: the High Wire Cycle, the Giant Lever and the Tennis Ball Launcher.

Your Forces Exhibit Guide contains:

- Introduction- suggestions for using the guide, with key concepts included
- State Standards Alignment for both Ohio and Michigan
- Chaperone Page(s)- tips for facilitating exhibit explorations with students
- Student Data Recording Pages that guide your students through exhibit-based explorations
- Post-Visit Activity to do back in the classroom

How to Use This Guide:

- Review the guide.
- Customize the guide for your needs. You can have your students complete the entire guide or just a particular component, depending on your field trip objectives.
- Print off sufficient copies of the Student Data Recording Pages for each student.
- Print off copies of the Chaperone Pages for each of the chaperones.
Divide your class into groups of 5-7 students and assign a chaperone to each group.
- Review the guide and your expectations with your students and prepare for a day of fun science learning at Imagination Station!
- Science Suggestion: Use this guide in combination with a science notebook so students can record observations and data throughout the day.

Ohio's New Learning Standards

GRADE 2 PS:**Topic: Change in Motion****Forces change the motion of an object.**

The change in motion of an object is related to the size of the force.

Some forces act without touching, such as using a magnet to move an object or objects falling to the ground.

Motion can increase, change direction or stop depending on the force applied.

GRADE 5 PS:**Topic: Light, Sound and Motion****The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.**

Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t).

Earth pulls down on all objects with a gravitational force. Weight is a measure of the gravitational force between an object and the Earth.

Any change in speed or direction of an object requires a force and is affected by the mass* of the object and the amount of force applied.

*While mass is the scientifically correct term to use in this context, the NAEP 2009 Science Framework recommends using the more familiar term "weight" in elementary grades.

Michigan Grade Level Content Expectations

Science Processes:

S.I.P.E.1 and S.I.P.M.1 Inquiry involves generating questions, conducting investigations and developing solutions to problems through reasoning and observation.

S.IA.E.1 and S.IA.M.1 Inquiry includes an analysis and presentation of findings that lead to future questions, research and investigations.

S.RS.E.1 and S.RS.M.1 Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision-making and the application of science throughout history.

Physical Science:

P.FM.E.2 Gravity: Earth pulls down on all objects with a force called gravity. With very few exceptions, objects fall to the ground no matter where the object is on the Earth.

P.FM.E.3 Force: A force is either a push or a pull. The motion of objects can be changed by forces. The size of the change is related to the size of the force. The change is also related to the weight (mass) of the object on which the force is being exerted. When an object does not move in response to a force, it is because another force is being applied by the environment.

P.FM.E.4 Speed: An object is in motion when its position is changing. The speed of an object is defined by how far it travels in a standard amount of time. *

P.EN.E.1 Forms of Energy: Heat, electricity, light and sound are forms of energy.

P.FM.M.2 Force Interactions: Some forces between objects act when the objects are in direct contact (touching), such as friction and air resistance, or when they are not in direct contact (not touching), such as magnetic force, electrical force and gravitational force.

P.FM.M.4 Speed: Motion can be described by a change in position relative to a point of reference. The motion of an object can be described by its speed and the direction it is moving. The position and speed of an object can be measured and graphed as a function of time.

* Revised expectations.

Inclined Planes

Discover how inclined planes can be used to help us do work.

Materials:

Cardboard tube (paper towel, toilet paper or wrapping paper)

Paper cups, various sizes

Tape

Miscellaneous small objects: marbles, ping pong balls, paper clips, metal washers, buttons, cotton balls, etc.

An inclined plane is a simple machine with no moving parts. It is simply a sloping, slanting surface that is used to move objects up and down.

Procedure:

1. Turn a cup upside down on a flat surface. Rest one end of a tube on the bottom of the cup and tape it in place. The other end should be resting on the table.
2. Place the objects, one at a time, into the tube. Observe: Do the objects roll down? Using the chart, record the objects and if they rolled down the tube in your investigations.

Object	Did the object roll?	Why or why not did the object roll down the tube?

3. If you use an inclined plane to transport these materials, which ones would you transport?

Design your own investigation:

Now that you have observed how different objects behave on the inclined plane, think of some variables you would change and do some further testing.

- Try using larger tubes
- Try using different kinds of tubes
- Try changing the angle of the tube

Use a stopwatch, protractor or ruler to take some measurements like speed and angle.

Create a chart to record your results and start testing. How do your new results compare with your initial investigation?

High Wire Cycle

1. Think about the High Wire Cycle as a teeter-totter that has been turned upright. In a typical teeter-totter, the fulcrum is the point where the lever pivots or turns. Where is the fulcrum on the High Wire Cycle?

2. The load is what is lifted. On a typical teeter-totter, this is the person who ends up in the air. Where is the load on the High Wire Cycle?

3. The effort is the force (push or pull) that makes the load move. Where is the effort on the High Wire Cycle? In other words, what keeps the person riding the High Wire Cycle from flipping over?

4. Make a simple drawing of the High Wire Cycle. Identify the fulcrum, load and effort.

High Wire Cycle

Back in the Classroom:

1. The High Wire Cycle is a Class One Lever because the fulcrum lies between the weight and the load. Can you name two other simple machines that are considered Class One Levers?

2. What do you think would happen if the load (the rider) weighed more than 275 pounds?

With a partner, determine the center of gravity of a pencil.

- Measure the length of your pencil in centimeters and record it in the table below under Pencil 1.
- Point your index fingers in front of you about 4 inches apart.
- Have your partner rest a pencil on top of your pointed fingers.
- Slowly slide your index fingers together until they meet. Your fingers will meet under the pencil's center of gravity.
- Measure the center of gravity and record it in centimeters for Pencil 1 in the table below. The center of gravity is the distance from the end of the pencil to where it is balanced.
- Find a pencil of a different length. Do you think this pencil will have the same center of gravity as Pencil 1. Why or why not?
- Repeat steps 1 through 5 with your second pencil. Record your results under Pencil 2 in the chart below.

Trial	Length of Pencil	Center of Gravity (measurement from the end of the pencil to where it balanced)
Pencil 1		
Pencil 2		
Pencil 3		

3. What do you notice about the relationship between the length of the pencil and the center of gravity?

Giant Lever

This large exhibit is actually a simple machine! After completing the High Wire Cycle activity, you know that a fulcrum is a fixed point where a lever pivots and turns. The longer the lever, the easier it is to move a load.

1. Make a simple drawing of the Giant Lever. Locate the fulcrum and mark this point on your drawing. Place a star on the side of the Giant Lever that you predict will win in a game of tug-of-war if an equal number of people are on each side.
2. Now test your hypothesis (educated guess) with a game of tug-of-war! Make sure you have an equal number of people on each side of the lever.
3. Which side won? Mark this on your drawing.
4. Test again! Have the groups switch sides and play again.
5. Which side won? Mark this second trial on your drawing.

Back in the Classroom:

1. Did the side win that you predicted? Why or why not?
2. Simple machines make work easier. Did the Giant Lever make work easier for one group? Why or why not?

3. How could you change the exhibit so that neither side would have an advantage?

Ball Launcher

1. Draw a sketch of the Ball Launcher. Observe it in operation several times.

2. Draw arrows to explain the FLOW OF ENERGY through the exhibit. In other words, draw arrows to show how objects move through the Ball Launcher.

3. What force is acting on the bowling ball when it is falling?

4. What pushes the tennis ball into the air?

Back in the Classroom:

1. Look at your sketch of the Ball Launcher exhibit. Imagine if the tennis ball was replaced by another bowling ball. Do you think the bowling ball will travel as high as the tennis ball? Why or why not?

2. What do you think would happen to the tennis ball if you dropped the bowling ball from HIGHER in the air?

Dear Chaperone,

We're glad you're here! Thank you for volunteering to be a chaperone on your school's visit to the Imagination Station. This page explains field trip procedures and offer tips on how to facilitate an Imagination Station Exhibit Guide.

The Imagination Station requires students and chaperones to remain together at all times. Group size should be 7 students or less per one adult.

Student Names:

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

Schedule for the day:

Lunch Time:

Demonstration Time(s):

Departure Time:

Imagination Station Exhibit Guides:

- Students should fill out the their Data Recording pages while at the science center. The 'Back in the Classroom' section of the Data Recording pages can be completed when the students return to school.
- It should take about 1 hour to complete the activities.
- For older students, remind them to return their Data Recording pages to their teacher.
- For younger students, collect the Data Recording pages and hand them to the teacher at the end of the day.
- Have fun! A field trip is a great chance to interact with young people and see the wonder of science through their eyes.
- Ask open-ended questions. You don't have to be the science expert! Tell students to look up information when they return to the classroom or ask an Imagination Station Team Member about a specific exhibit.
- If a student is struggling with a portion of the Data Recording Sheet, ask questions like 'What have you done so far?' or 'What were you thinking about doing next?' These types of questions can help a student work through challenges and find their own solutions.

Visitor Guide

Attractions

High Wire Cycle – This thrill ride hovers over 18 feet above the ground, suspended on a 1-inch cable with a 275 pound counterweight that enables any person to defy gravity.
• You must be 54" to ride

BOYO – Using science similar to that of the classic yo-yo, a rider is propelled up to 13 feet in the air using his or her own strength and some basic science principles.
• You must be 54" to ride

Simulator Theater – Over The Edge!

Experience every turn, jolt, twist and drop. With HD visuals, surround sound and a responsive platform, you have an adventure without leaving your seat!

- Imagination Station members ride FREE! You must have a token to ride. Tokens are \$2 and available at Simulator entrance or Visitor Service.
- You must be 42" to ride.
- Elevator available. Please contact a team member.

Demonstrations

Extreme Science Theater

Interactive demonstrations with an exciting EXTREME twist! Check monitors located at Visitor Service or at elevators for times.

Learning Worlds

Eat It Up! – This Learning World is focused on nutrition and exercise and tells the story of how the choices you make affect your body. Eat Smart. Play Hard. Have Fun.

Energy Factory – Get a glimpse into the abstract world of oil refining and solar energy.

Flex Space – This ever-changing space features some of the best exhibitions from North America and great experiences that we've created right here at Imagination Station.

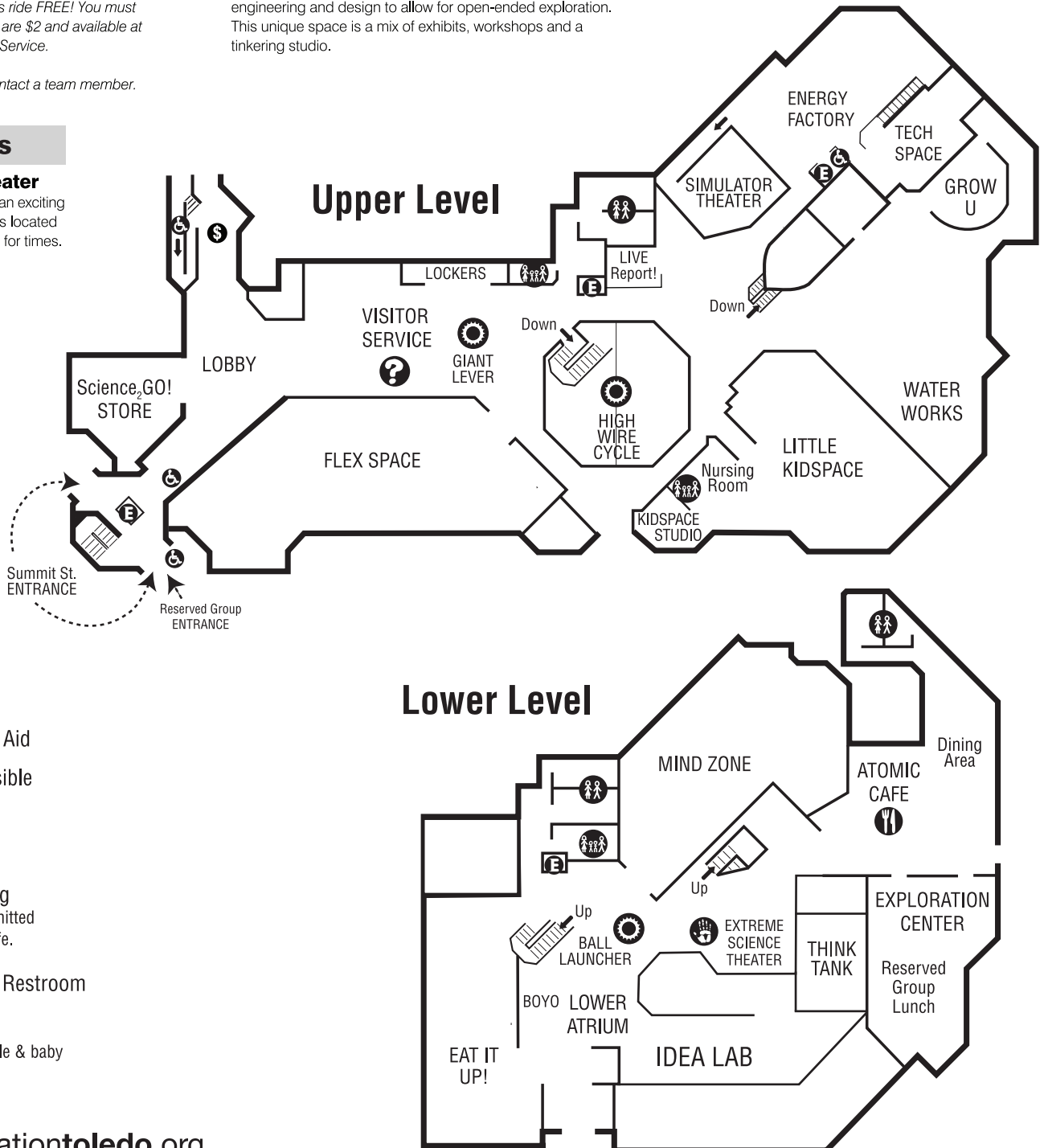
Grow U – Let Mother Nature be your guide as you take on FARM 101: Know It to Grow It.

IDEA Lab – This Learning World combines science, art, engineering and design to allow for open-ended exploration. This unique space is a mix of exhibits, workshops and a tinkering studio.

Little KIDSPACE™ – Our littlest adventurers (kindergarten and under) can hop aboard our fire truck, shop in the grocery store or climb on our favorite tree house while learning science fundamentals.

Mind Zone – Home to the Distorted Gravity Room, discover how the mind processes, interprets and creates illusions and perceptions.

Water Works – Discover the slippery science of water and explore nature's most powerful resource.



- ⚙️ FORCES Exhibits
- ❓ Information
Lost Persons/First Aid
- ♿ Wheelchair Accessible
- E Elevator
- 👤 Demonstration
- 🍽 Restaurant/Vending
Food & beverages permitted
only in Atomic/H2O Cafe.
- 🚻 Men's & Women's Restroom
- 👨👩👦 Family Restroom
Special needs accessible & baby
changing facilities.

High Wire Cycle

Student Data Recording Page Questions:

1. Think about the High Wire Cycle as a teeter-totter that has been turned upright. In a typical teeter-totter, the fulcrum is the point where the lever pivots or turns. Where is the fulcrum on the High Wire Cycle?
2. The load is what is lifted. On a typical teeter-totter, this is the person who ends up in the air. Where is the load on the High Wire Cycle?
3. The effort is the force (push or pull) that makes the load move. Where is the effort on the High Wire Cycle? In other words, what keeps the person riding the High Wire Cycle from flipping over?
4. Make a simple drawing of the High Wire Cycle. Identify the fulcrum, load and effort.

IN THE KNOW

Gravity works to your advantage on the High Wire Cycle as you take a ride across a one-inch thick wire nearly 18 feet above the ground! Note: Students must be 54" tall to ride the High Wire Cycle.

Simple machines make work easier by changing the size or direction of the force. There are many different types of simple machines, including levers, inclined planes, wedges, wheel and axles, pulleys and gears.

A lever is a bar that rests on a turning point or fulcrum that is used to lift a load. The High Wire Cycle is a great example of a Class One Lever. This means that the fulcrum lies between the load and the effort.

A quick reminder of the terms:

- The fulcrum is the point where the lever pivots and turns. For the High Wire Cycle, this is the point where the bike meets the cable.
- The load is the thing being lifted. In this case, it is the High Wire Cycle rider.
- The effort is the force (push or pull) that makes the load move. A 275-pound weight is the effort on the High Wire Cycle.

Activity:

While students are completing the activity or if they are struggling to identify fulcrum, load and effort, use these tips to assist them:

- Students should identify the fulcrum as the point where the cable meets the bike on the High Wire Cycle. Have students think about the point where the bike rocks.
- Have students imagine what would happen if the High Wire Cycle (complete with rider) was placed on the ground like a teeter-totter. This will probably make it easier for students to visualize the effort (the 275 pd. weight) and load (the rider).

Giant Lever

Student Data Recording Page Questions:

This large exhibit is actually a simple machine! After completing the High Wire Cycle activity, you know a fulcrum is a fixed point where a lever pivots and turns. The longer the lever, the easier it is to move a load.

1. Draw a rough sketch of the Giant Lever. Locate the fulcrum and mark this point on your drawing. Place a star on the side of the Giant Lever that you predict will win in a game of tug-of-war if an equal number of people are on each side.
2. Test your hypothesis with a game of tug-of-war! Make sure you have an equal number of people on each side of the lever. Which side won? Mark this on your drawing.
3. Test again! Have the students switch sides and play again. Which side won? Mark this second trial on your drawing.

IN THE KNOW

This exhibit allows students to experience mechanical advantage in a fun and engaging way. Simple machines make work easier. We use the word 'work' in a lot of different ways. Physicists have a very specific way of defining work. Work occurs when an object moves in the direction that a force is exerted.

In mathematical terms, this means $WORK = FORCE \times DISTANCE$.

In regards to the Giant Lever, this means that if we increase the distance (i.e. the location of the rope from the fulcrum) then we can decrease the force exerted and still get the same amount of work (i.e. winning the tug of war). Conversely, we would have to increase our effort (pull A LOT harder) to make up for the fact that our distance from the fulcrum is much shorter on the other side of the lever.

Here is how one side wins again and again...

The leverage that one side has over the other is known as mechanical advantage. One rope is 6 feet from the fulcrum while the other is 2 feet. This means on the side further from the fulcrum, because the distance is 3 times greater, the force needs to be only 1/3 as much to equal the work on the other side. This makes it far easier for one side to win, again and again.

Make sure the students try the tug-of-war multiple times with your group switching sides each time. It should be clear to students by the end that one group is not stronger than the other. The lever, a simple machine we use everyday, is making work easier!

Ball Launcher

Student Data Recording Page Questions:

1. Draw a sketch of the Ball Launcher. Observe it in operation several times.
2. Draw arrows to explain the FLOW OF ENERGY through the exhibit. In other words, draw arrows to show how objects move through the Ball Launcher.
3. What force is acting on the bowling ball when it is falling?
4. What pushes the tennis ball into the air?

IN THE KNOW

This exhibit offers students a great opportunity to observe the flow of energy through a closed system. Interactions with the Tennis Ball Launcher deal with energy in two forms, kinetic and potential.

- Kinetic energy is energy of motion, the energy an object has when it is moving.
- Potential energy is the energy an object has based on its relative position or chemical composition.

For example, a boulder at the top of a hill has a lot of potential energy. When the boulder is rolling down the hill, it has kinetic energy. Lastly, when it sits at the base of the hill, it has no kinetic energy (it's not moving) or potential energy (it's not likely to).

Activity

It is great if students can understand that energy travels from the bowling ball through the narrowing tubes to the tennis ball. Because the tubes narrow, the air is forced to move faster. This fast moving air forces the tennis ball high into the air.

Gravity can be a difficult concept for some of the younger grades. This is the force that 'pushes' the bowling ball down.

The bowling ball has its greatest potential energy when it is pulled to its highest point. It has no potential energy when it is done falling.

Encourage students to pull the bowling ball to different heights before releasing it. Does this have an impact on how far the tennis ball travels?