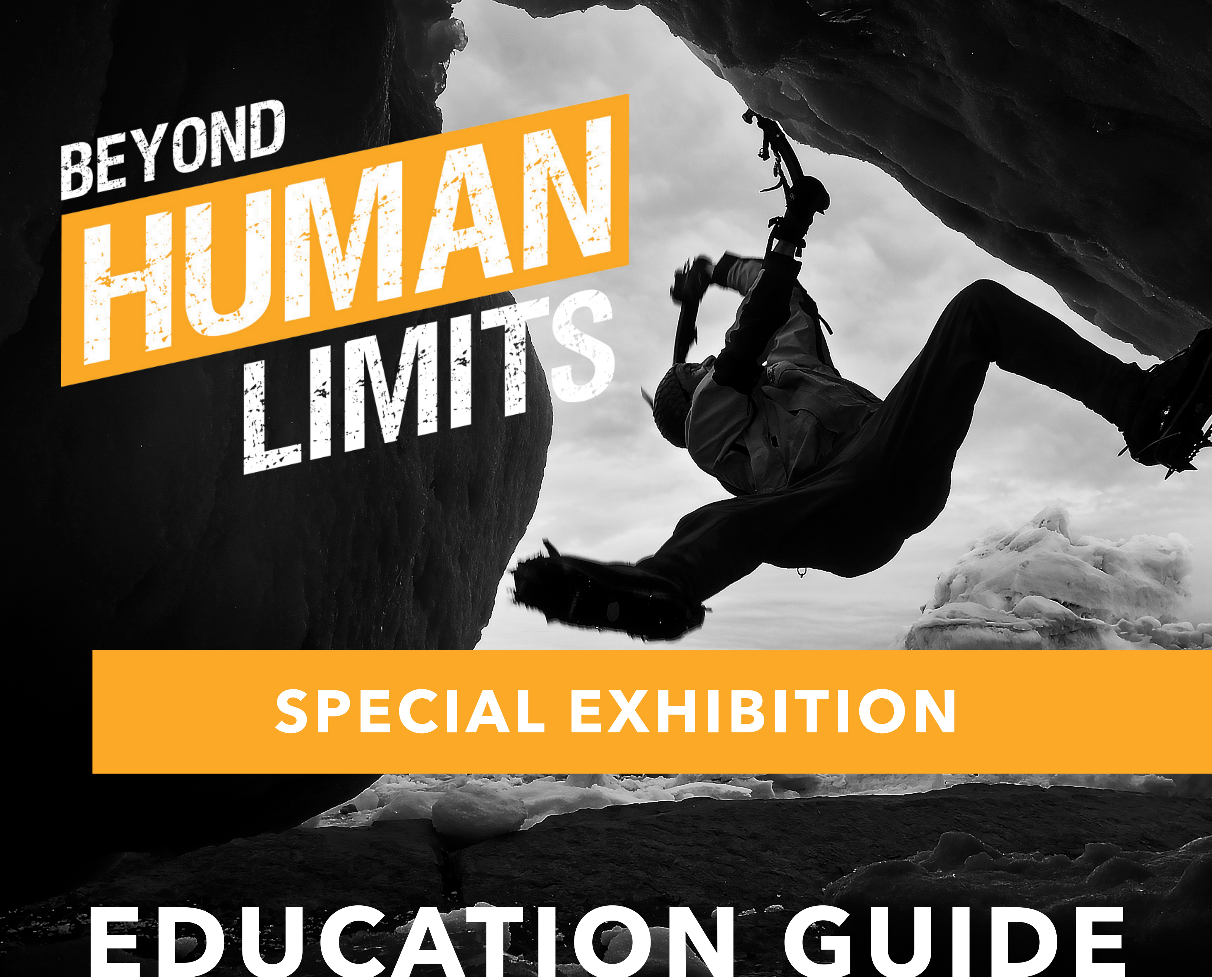


BEYOND HUMAN LIMITS

SPECIAL EXHIBITION

EDUCATION GUIDE

LESSON PLANS

K TO GRADE 12

This educator's guide is a companion to the traveling exhibition Beyond Human Limits and will provide information and tools to assist educators in creating rich learning experiences in relation to the exhibiton.

The exhibition Beyond Human Limits focuses on science related to extreme sports. In this high-energy exhibition students experience the thrill of extreme sports in exciting challenges, interactive exhibits and immersive environments. They explore the technology, creativity and innovation inherent to these sports. They meet passionate athletes and hear their incredible stories, and take in the artistry, motivation and thoughtfulness that go into everything they do.

This guide gives an overview of the topics covered in the exhibition, which are organized by thematic zones. Lesson plans to be completed either before, or after visits to the exhibition are proposed for each theme. This guide also presents online educational resources to support additional in-depth investigations of the exhibition themes.

Beyond Human Limits takes visitors inside the minds and bodies of extreme athletes to explore the psychology, physiology, and physicality of some of the most extreme activities in the world.

Extreme sports can be hard to define, since they are always changing as skills and equipment evolve. They have inherent risk – a mistake can mean serious injury. These activities usually involve high levels of technical skill, intense physical and mental exertion, and the use of specialized gear. They also commonly involve exhilarating speeds, breathtaking heights, or profound depths, and a variety of uncontrolled environmental variables.

By presenting facts and real stories, the exhibition will help dispel myths and stereotypes commonly associated with extreme sports and the people who participate in them. The exhibition will illustrate that participation in extreme sports requires skill, training, and smart decision-making.

The entrance introduces the main theme and topics of the exhibition. A definition of extreme sports is presented and visitors are encouraged to test their balance in an immersive sensory experience that plunges them into the action!

ZONE 2: INSIDE THE MIND AND BODY

This zone ties together scientific content that is featured throughout the exhibition. A central multimedia theatre experience brings visitors inside the mind and body of extreme athletes to explore what happens before, during, and after their extreme feats. Visitors can interact more deeply with this content in complementary exhibits surrounding the theatre. They are encouraged to understand the potential consequences of extreme sports, explore their knowledge of first aid, and test their concentration abilities. A key misconception about extreme sports is dispelled in this zone when visitors learn that dopamine, not adrenaline, guides extreme athletes’ motivation and success.

As well as learning about extreme athletes, visitors learn more about themselves. They use questionnaires, activities, and quizzes to find out about their own personality and physical characteristics. Visitors can compare their sensation-seeking personality scores to those of extreme athletes and researchers featured throughout the exhibition.

A series of immersive spaces transport visitors to the locales of extreme sports – soaring high above the earth, sliding through icy or snowy terrain, being on and under the water, scaling high rock cliffs and mountains, and trekking over the ground. Large scale photos, bright colours, and other design elements surround visitors with the sights and sounds of the five distinct environments. These environmental treatments provide a backdrop for visitors to:

- Experience the sports through physical and multimedia challenges, including opportunities to compete with other visitors;
- "Meet" athletes, researchers, and rescuers that participate in or contribute to the understanding of extreme sports;
- Experiment with interactive exhibits to better understand the underlying physics and physicality of the sports.

This zone encourages visitors to reflect on their experiences in the exhibition by envisioning the future of extreme sports, creating a personalized vision board and reflecting on some of the inspiring messages heard throughout the exhibition.

PROPRIOCEPTION TRAINING

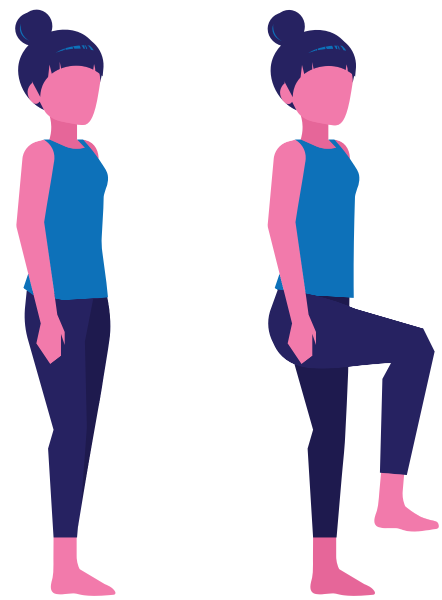
Activity Description:
These four exercises will allow students to explore their own proprioception and awareness of their bodies. By repeating and practising these exercises, students will be able to enhance their proprioception.

Materials:
- Padded floor mats
- Stopwatches

Procedure:

EXERCISE 1: TABLE TOP
1. Get on all fours on a padded surface in table-top position.
2. Make sure your back is flat and your neck is aligned with your spine.
3. While looking at the floor, raise and extend your right arm and your left leg at the same time.
4. Hold for 3-5 seconds and repeat on the other side. Repeat 10 times on each side.
5. For advanced students: hold for 20 seconds and do the exercise with closed eyes.

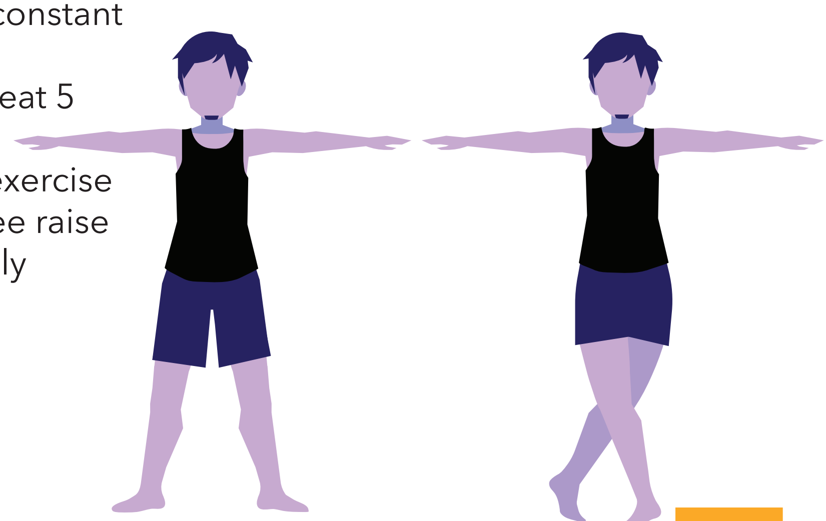
EXERCISE 2: SINGLE LEG



1. Stand with feet hip distance apart.
2. Raise your knee to a 90-degree angle and hold for 3-5 seconds.
3. Return foot to the floor. Repeat 5 times on each leg.
4. For advanced students: perform this exercise with eyes closed and hold for 10 seconds, 10 times on each leg.

EXERCISE 3: CROSSOVER WALK

1. Stand with feet hip distance apart.
2. Begin walking to your right by crossing your left leg over the right, then back to starting position.
3. Continue stepping sideways in a constant motion for about 10 metres.
4. Repeat in the other direction. Repeat 5 times each direction.
5. For advanced students: perform exercise at a faster rate and with a high knee raise as you cross over your leg, naturally twisting your hips.



EXERCISE 4: SQUAT JUMP

1. Stand up straight with your knees slightly bent and feet shoulder-width apart.
2. Squat down until your thighs are parallel to the floor by pushing hips back, keeping back flat and head facing forward.
3. Explode upwards, reaching as high as you can with your hands as your feet leave the floor.
4. Land in the same position you started in. Swing your arms back and jump again right away.
5. Repeat 5-10 times on each side.

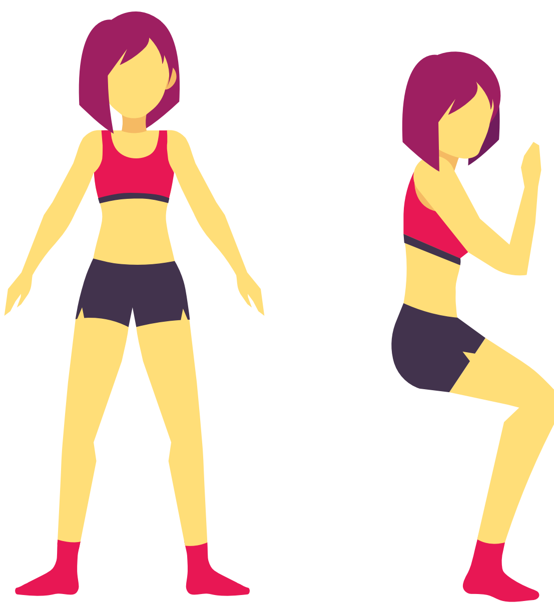


Exhibit Description:
This activity relates to the Body Sense Challenges exhibit where visitors test their sense of their body in space through a series of physical challenges. This exhibit demonstrates that extreme athletes must have a highly-developed sense of the position of their body and limbs in space – called proprioception – in order to execute precise movements such as jumps, flips and dives.

Background Information:
Proprioception refers to the body's ability to sense movement within joints and joint position. This ability enables us to know where our limbs are in space, and in relation to each other, without having to look and explains how athletes are able to have such awareness of their bodily movements without looking at the action as it occurs. It is important in everyday movements but especially so in complicated sporting movements when precise coordination is essential.

Just as your foot is aware of the location of the step beneath it, an athlete's quadriceps and hamstrings know just when and how to contract to stabilize around the knee to perform specific athletic movements. Without this inner sense of timing and accuracy, the rate of injury would be incredibly high, and simple movements would require an enormous amount of cognitive energy.

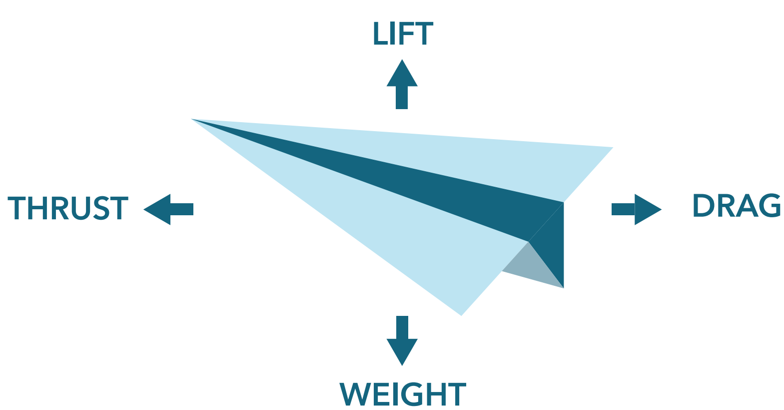
Activity Description:
Building paper airplanes will allow students to explore the forces of flight.

Exhibit Description:
This activity relates to the Wingsuit Design exhibit where visitors learn about the science, physics and forces behind humans gliding through the air.

Background Information:
Paper airplanes are actually great examples of gliders, as they are not powered after they are launched. There are four forces involved in flight: weight, lift, drag and thrust. Weight is the force of gravity pulling down on your plane. To be able to fly you need enough lift to counteract the force of gravity. When in flight, lift is greater than weight. Thrust is the force that propels the plane forward. In gliders, the only thrust that the aircraft experiences is before it is actually in flight.
Drag is the force that is caused by air friction, and acts against thrust, slowing the aircraft. When students are designing and re-thinking their aircraft have them consider the following:

> Weight: Can we make the airplane lighter?
> Thrust: Can we add a stronger 'engine'?
> Drag: Can we make a more aerodynamic design?
> Lift: Can we design wings that will provide more lift?

4 FORCES OF FLIGHT



Materials:
- Sheets of paper
- Scissors
- Rulers
- Tape

Procedure:
1. Have students research plane designs, and find simple instructions.
2. Students will then build their planes. Encourage them to build more than one each and to keep their planes.
3. Set up a ‘test’ zone in your classroom. Students take their planes to the test zone and throw them.
4. Have students then modify their planes to see if they can get them to glide further, or faster.

Activity Description:
This activity is designed to get students thinking about what happens when air moves. Sometimes it is difficult to think about air and what it does because it is invisible. The air cannon is a way to "see" air as it moves objects within its "blast zone". In this experiment, students will combine an empty plastic container with a fog machine and be able to create and see swirling vortexes of smoke!

Material:
- Large plastic container with a lid
- Utility knife
- Fog machine

Procedure:
1. Trace and then cut out a circle of plastic from the bottom of the container. The cut doesn't need to be perfect but the more centered and circular the hole is, the better your smoke rings will be. You could smooth and round it with a little sandpaper.
2. Place the fog machine at the hole in the bottom of the container and fill the container. It won't take long to fill with smoke. Remove the fog machine.
3. Point the hole away from you and tap in the center of the lid to generate rolling smoke rings.

EXPLORE IN MORE DEPTH:

- You can change the size of the rings by changing the size of the hole.
- What might happen if you use a hole that's not round?
- The plastic lid may be too stiff to generate rings easily.
  A substitute might be a couple layers of plastic wrap held on and pulled snug using rubber bands.

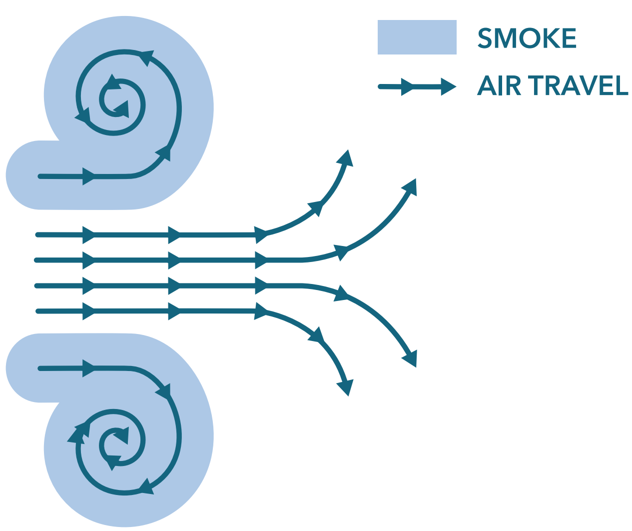
Exhibit Description:
This activity relates to the Flying Simulator exhibit where visitors feel as if they are gliding as they lie on a structure and experience a wingsuit flight.

Background Information:
A vortex is a spinning flow of fluid or gas. Water going down the drain or the air in a tornado, form vortices in the shape of funnels.

The air cannon vortex is a donut shape or, mathematically, a torus. The air in the donut rolls from the centre to the edge. This vortex of air is generated because the air leaving at the center of the hole is traveling faster than the air leaving around the edge of the hole. The air keeps its shape since the surrounding air is relatively slow moving (and under higher pressure).

That swirling or vortex motion can be observed if a little smoke is in the container before giving the lid a tap. This activity demonstrates that air occupies space and the rolling smoke rings are an added bonus.

MOVEMENT OF THE TORUS



Activity Description:
Students get to build a ramp out of materials of their choice. The goal of the ramp is to allow objects to travel as far off of the ramp as possible. Lead a discussion in which students realize that they could create ramps with different functions in mind: for example, to make objects move fast, to hold a lot of weight, or to hold large objects. Be sure to emphasize that they will build ramps with distance in mind.

Based on the level of your students, you can decide the procedure by which students will determine the distance traveled by the objects. For example, students could plot out the distance using colored stickers. Students could then measure the distance traveled with rulers, math cubes, or other appropriate tools.

After each group has tested out its ramps, allow them to test their design against the "record" previously established by the prototype ramp. Ask each group the following questions as a way to evaluate their understanding of the activity:

- Did you use more than one material for the ramp?
- Do you think the surface of the ramp affected your results?
- Do you think the angle of the ramp affected your results?
- How would you want to alter your ramp to allow items to move slower? To move faster?

Materials:

Objects to roll down the ramp, such as:

- Matchbox cars
- Cans of various sizes
- Marbles
- Tongue depressors – to act as a snowboard

A variety of building materials, such as:

- Carpet samples
- Hard foam pieces
- Foam wrap
- Wood
- Plywood
- Rubber treads
- PVC pipe
- Brick
- Masking tape
- Cardboard
- Fabric samples

Exhibit Description:
This activity relates to the Slope Slide exhibit where visitors experiment with flexible tracks and position them at different angles to create an ideal slope.

Activity Description:
Scientists have a special term for the balancing point of an object. They call it the center of mass. Mass is actually defined as the measure of an object's resistance to a change in speed. The center of mass is relatively easy to find for a rectangle or circle or triangle. What about an object with a complicated outline? Can you find the center of mass for any shape?

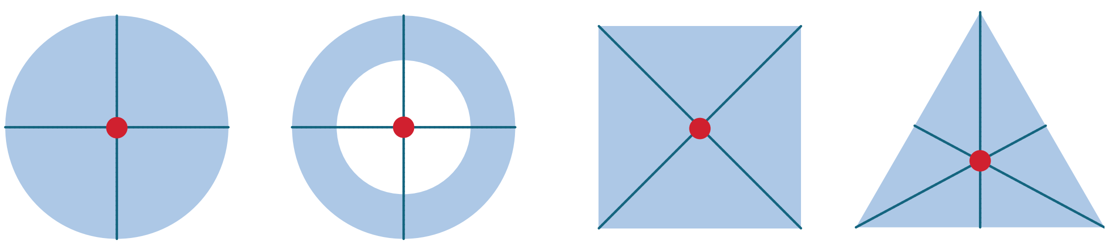


Figure 1: Centre of mass for some simple geometric shapes (red dots).

ACTIVITY #1: Finding the center of a rectangle

Materials:
- Ruler
- Pencil
- Scissors
- Heavy card stock paper or thin cardboard (side of a cereal box)

Procedure:
1) Use the ruler to draw a rectangle on the piece of card stock or cardboard.
2) Cut out the rectangle.
3) Use a ruler to find the center of the rectangle and mark it with a dot. (The easiest way to do this is simply to align the ruler so that it connects two opposite corners, then draw a line. Do this to the other pair of opposite corners. The point where these lines cross is the center.)
4) Place the center dot of your rectangle right on the tip of the balance point (nail or pencil or whatever). Does it balance? If not, move it around until you get it to balance. How far off were you?

ACTIVITY #2: Finding the center of circles and triangles

Materials:

- Ruler
- Pencil
- Scissors
- Heavy card stock paper or thin cardboard (side of a cereal box)
- Something circular that you can trace around (CD, large can, plate, bowl, etc.)

Procedure:

For a circle:

1) Place the circular object on your cardboard and trace around it with the pencil.
2) Cut out the circle.
3) Place the ruler across the circle and move it up and down until you find the widest place. Draw a line across the circle at this widest point.
4) Turn the circle a bit then repeat this process. Find the widest place and draw a line.
5) Repeat this process several more times, turning the circle a bit then drawing a line at the widest point. These lines should all intersect at a single point - the center point.
6) Check your center point with the balance stand. How accurate were you?

For a triangle:

1) Draw a triangle on a piece of heavy card stock paper or a piece of thin cardboard. It doesn't have to be a right triangle or an equilateral triangle. Just draw three lines that form a triangle.
2) Cut out your triangle.
3) Use the ruler to find the center of each edge. (If you are using card stock it's thin enough to fold in half.) Mark the centers of each side with a pencil dot.
4) Use the ruler as a straight edge (don't have to measure) to make a connecting line between each center dot and the angle that is directly opposite to it. The place where these three lines meet will be the center of the triangle.
5) Place the triangle on the balance stand and see if it will balance on that center dot.
6) Try another triangle that looks a lot different from your first one.

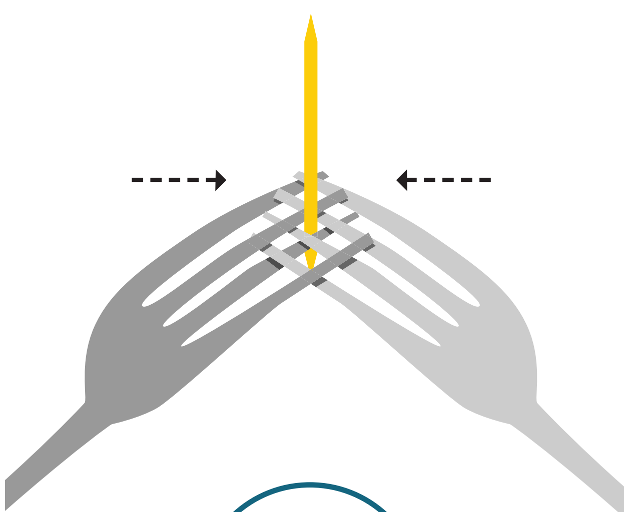
THINK ABOUT THIS:

How many objects or machines can you think of that depend in some way on a center dot? (For example, CDs have that center hole). What would happen to each of these if the hole were off-centre?

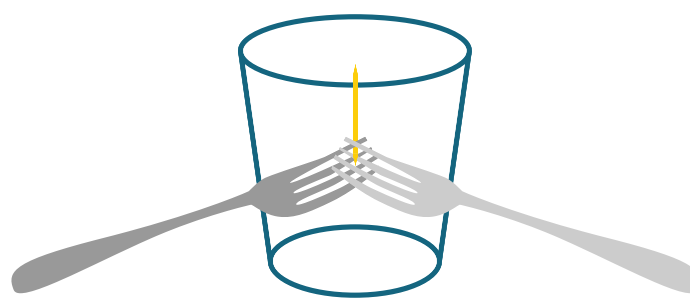
ACTIVITY #3: A Fork Balancing Act

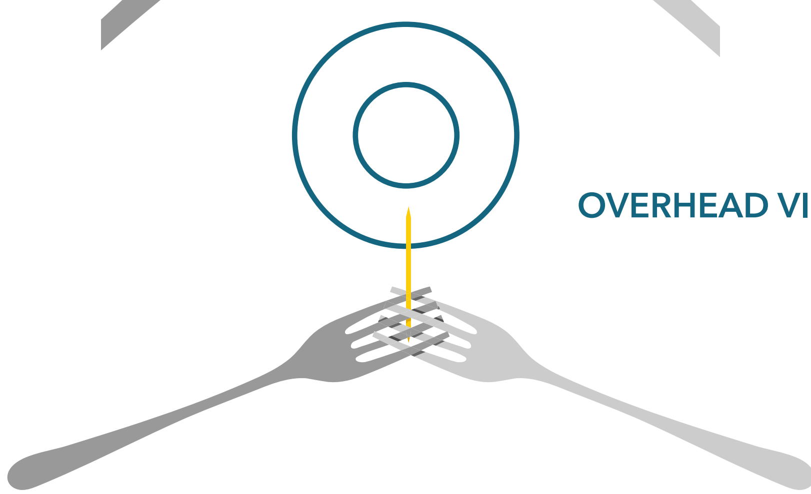
Materials:
- Two forks
- Toothpick
- Glass

Procedure:
1) Put the two forks together so that their tines interlock.
2) Wedge the toothpick into a crack where the forks intersect.
3) Rest the toothpick on the edge of a glass or other object.



SIDE VIEW





OVERHEAD VIEW

ACTIVITY #4: Can You Stand Up?

Materials:
- Chair
- Volunteer

Procedure:
1) Tell your volunteer to sit in the chair, with his/her back against the back of the chair and hands in lap.
2) Place your pinky finger on his/her forehead. (You can use any finger - it does not have to be the pinky.)
3) Tell your volunteer to stand up. Use your finger to keep his/her head from tilting forward.
4) Your volunteer will probably not be able to stand up.

When you are standing, your center of mass (somewhere in your abdomen) is directly over your feet. When you are seated, your center of mass is above the seat of the chair, not over your feet.

In order to stand up you need to move your center of mass from over the chair to over your feet. To accomplish this, you need to lean forward. Strangely enough, the amount of force needed to keep someone from leaning forward is not all that much. You can exert this force with one finger.

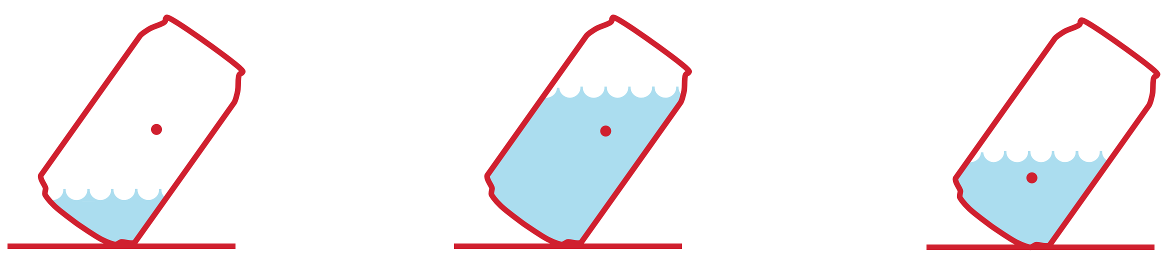
ACTIVITY #5: The Leaning Can

Materials:

- Empty pop can (with angular section between the side and the bottom)
- Water

Procedure:

1) Start by trying to balance the empty can. (If you happen to have a full can, try to balance that as well. Prove to yourself that neither will balance.)
2) Pour water into the can until it is about 1/3 full. Try to balance it again. If it does not balance, add or subtract water until the can balances.
3) If you have balanced the can well, you will be able to push the can gently and get it to roll around in a circle!



If the can has too little water, the weight of the can itself will be the most significant factor in the center of mass, causing the center of mass to be too far away from the base.

If the can has too much water, the center of mass will again be to one side of the balancing point, causing it to topple over.

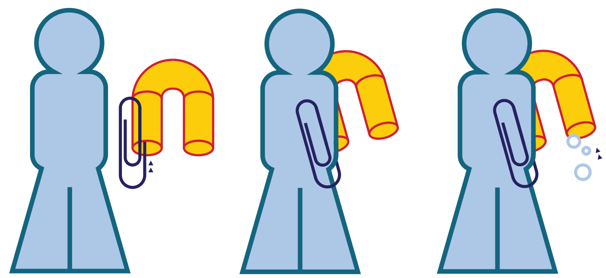
If the can has just the right amount of water in it, the center of mass will be directly over the base.

Exhibit Description:
This activity relates to the Balance Challenge exhibit where visitors test their balance by using a balance board.

Activity Description:
This experiment takes a few minutes to set up and is a great way to demonstrate the principle of buoyancy.

Materials:

- Empty plastic bottle (pop bottle)
- Drinking straw
- Small paper clip
- Playdough or reusable adhesive putty
- Thick foil or foil pan
- Scissors
- Water



Procedure:

1. Cut out your diver using the same shape and size indicated below. Lightly sketch the diver on the foil before cutting out. Note: That is a small paper clip. The diver should be approximately 1.5″ tall.
2. Cut the straw and position it on the paper clip. Each end should be secured by the ends of the paper clip.
3. Slowly slide the straw onto the diver. The diver should look like it's wearing a scuba tank.
4. Place a small piece of playdough or putty on the diver's feet.
5. Fill a glass with water and put the diver in. This is to test to make sure it floats. It should float as shown above. If it doesn't float, your straw may have a hole in it. Try again with a new straw.
6. Fill the large bottle with water. Make sure to fill it to the top, otherwise the experiment won't work. Carefully place the diver into the bottle and screw on the lid.
7. Squeeze the bottle and watch as the diver sinks to the bottle. Stop squeezing and the diver will float back to the top.

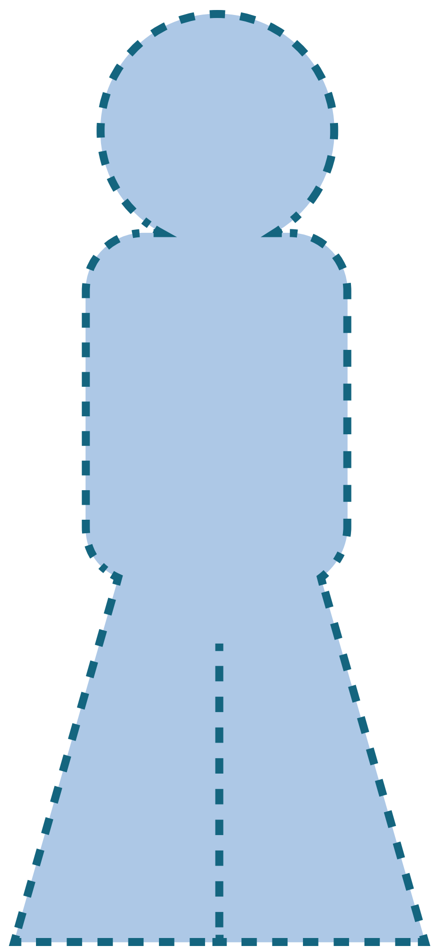


Exhibit Description:
This activity relates to the One Breath Challenge exhibit where visitors slow down, learn about freediving, and practice some breathing exercises. When they are ready, visitors take the plunge and challenge themselves!

Background Information:
This experiment is also referred to as the Cartesian Diver Experiment. It is a simple way to explore density and how it impacts whether an object will float or sink.

The straw on the bottle diver has an air bubble inside of it. When you squeeze the sides of the bottle, you increase the pressure pushing on the air bubble in the straw. This compresses the air allowing water to fill the straw. This causes a decrease in volume of the air bubble and increases the density of the diver, as water fills that space. This causes it to sink to the bottom of the bottle.

By releasing the pressure when you stop squeezing the bottle, you allow the air bubble to expand back to its normal/original size, and so the bottle diver will float to the top of the bottle once again.

Activity Description:
Students explore the concept of how gravity affects balance by creating their own gravity measuring device.

Exhibit Description:
This activity relates to the Spin, Flip and Roll exhibit where visitors explore the role of gravity and rotational forces as extreme athletes flip and rotate through the air.

Background Information:
Every time you fall down you are experiencing the pull of gravity. Gravity is defined as the force that pulls everything on earth toward the center of the earth. Sir Isaac Newton, rumored to have discovered gravity when he saw an apple fall from a tree, wrote mathematical formulas that proved the truth of experiments previously performed by Galileo centuries earlier. Newton's Law of Universal Gravitation, published in 1687, states that 'any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them'.

Anything that has mass has a gravitational pull. The more massive an object is, the stronger its gravitational pull. Earth's gravity is what keeps you on the ground and what causes objects to fall. Gravity is what holds the planets in orbit around the Sun and what keeps the Moon in orbit around Earth. The closer you are to an object, the stronger its gravitational pull. Gravity is what gives you weight and creates the force that pulls on all of the mass in your body.

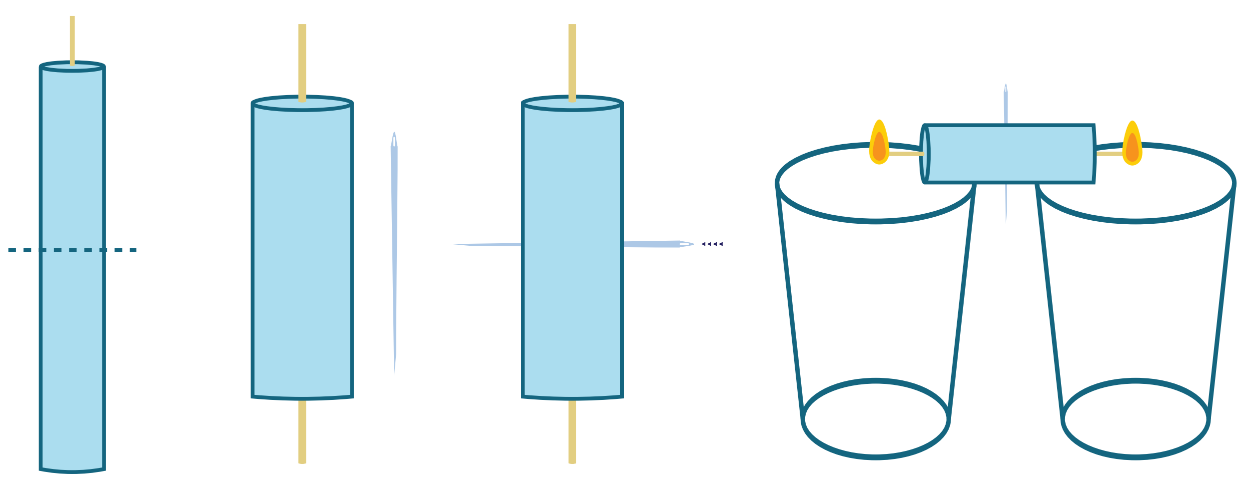
Materials:
- Long candle
- A needle
- Two glasses
- Two saucers
- Knife

Procedure:

1. Cut off the bottom half of a long candle to expose the wick at both ends.
2. Push a needle through the center of the candle along its horizontal axis.
3. Use the needle to balance the candle on the lip of the two glasses.
4. Place the saucers under each end of the candle so they catch the wax as it melts.
5. Light both ends of the candle.
6. Observe and note what happens!

Conclusion:

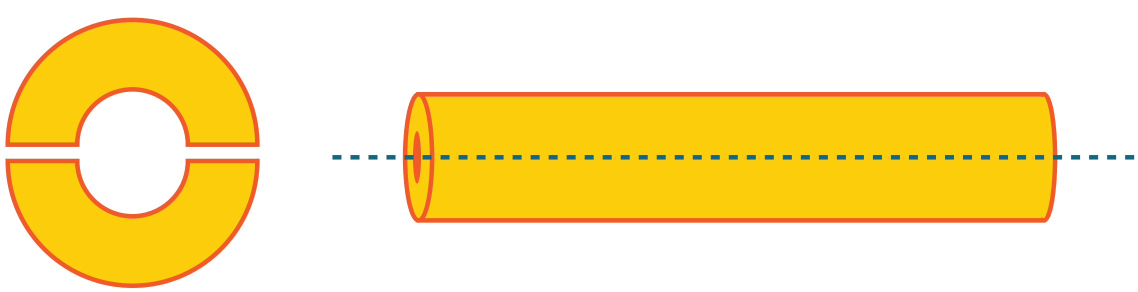
Gravity will pull the heavy end down and cause it to drip more wax, thus making the other end heavier and causing the candle to oscillate between the two ends as the weight changes.



Activity Description:
The goal of this experiment is to build a roller coaster for marbles using foam pipe insulation. This will be used to investigate how much of the gravitational potential energy of a marble at the starting point is converted to the kinetic energy of the marble at various points along the track.

Materials:
- At least two 6′ (183 cm) sections of 1.5″ (about 4 cm) diameter foam pipe insulation
- Glass marbles
- Utility knife
- Masking tape
- Tape measure
- Bookshelf, table, or other support for roller coaster starting point
- Stopwatch
- Scale for weighing marble

Procedure:
1. Cut the foam pipe insulation in half (the long way) to make two U-shape channels.
2. To make a roller coaster track, tape two (or more) lengths of the foam U-channel together, end-to-end. The joint between the two pieces should be as smooth as possible.
3. You can make the track as simple or as complex as you would like. You can add curves, loops, and additional uphill and downhill sections. You will find that one requirement is that the starting point be the highest point on the track.



Challenges:

- In order to measure the velocity of the marble, you will need a way to measure how much distance the marble travels during a measured time interval.
- Measure the height of the starting point for the track.
- Measure the mass of the marble.
- Calculate the gravitational potential energy of the marble at the starting point.
- Run a single marble down the track 10 separate times.
- From your velocity measurement and the mass of the marble, calculate the kinetic energy of the marble.
- Repeat the velocity measurement at various points on the track by cutting the track and allowing the marble to continue on in a straight line on a smooth surface. Use your striped measuring stick and stopwatch to measure the velocity of the marble.
- Does the marble's kinetic energy ever equal or exceed its initial gravitational potential energy?

Exhibit Description:

This activity relates to the Parkour exhibit where visitors are encouraged to crawl, fall, balance, jump, vault and roll to trace the footsteps of a parkour athlete and learn what the sport is about – the training, the movements and the state of mind involved.

Training and an understanding of proper body mechanics can minimize bodily impacts and the chance of injury.

Background Information:

Potential energy comes in many forms. In the case of a roller coaster, the stored energy is called "gravitational potential energy," since it is the force of gravity that will convert the potential energy into other forms. The amount of gravitational energy can be calculated from the mass of the object (m, in kg), the height of the object (h, in m), and the gravitational constant (g = 9.8 m/s2). The equation is simply: gravitational potential energy = mgh.

Kinetic energy is the energy of motion. The amount of kinetic energy an object has is determined by both the mass of the object and the velocity at which it is moving. The equation for calculating kinetic energy is: kinetic energy = 1/2 mv2, where m is the mass of the object (in kg) and v is the velocity of the object (in m/s).

You have probably noticed that the first hill on the roller coaster is always the highest. This is because not all of the potential energy is converted to kinetic energy. Some of the potential energy is "lost" in other energy conversion processes.

Because some of the potential energy is dissipated to friction, sound, and vibration of the track, the cars cannot possibly have enough kinetic energy to climb back up a hill that is equal in height to the first one. The way that physicists describe this situation is to say that energy is conserved in a closed system like a roller coaster. That is, energy is neither created nor destroyed; there is a balance between energy inputs to the system (raising the train to the top of the initial hill) and energy outputs from the system (the motion of the train, its sound, frictional heating of moving parts, flexing and bending of the track structure, etc.).

You can investigate the conversion of potential energy to kinetic energy with this experiment. You use foam pipe insulation to make a roller coaster track. For the roller coaster itself, you use marbles. By interrupting the track and allowing the marble to continue on a smooth, level surface, you can measure the velocity of the marble at different points along the track.

From the velocity and the mass of the marble, you can calculate the marble's kinetic energy at the different track locations.

For each track configuration, you should try at least 10 separate tests with the marble to measure the kinetic energy. How much of the marble's gravitational potential energy will be converted to kinetic energy?

Need ideas on how to build your roller coaster? Here are some tricks to try:

Loops

- Swing the track around in a complete circle and attach the outside of the track to chairs, table legs, and hard floors with tape to secure in place.
- Loops take a bit of speed to make it through, so have a partner hold it while you test it out before taping.
- Start with smaller loops and increase in size to match your entrance velocity into the loop.
- Loops can be used to slow a marble down if speed is a problem.

Camelbacks

- Make a hill out of track in an upside-down U-shape. This is good for show, especially if you get the hill height just right so the marble comes off the track slightly, then back on without missing a beat.

Corkscrew

- Start with a basic loop, and then spread apart the entrance and exit points. The further apart they get, the more fun it becomes.
- Corkscrews usually require more speed than loops of the same size.

Pretzel

- Make a very loose knot that resembles a pretzel. Bank angles and speed are the most critical, with rigid track positioning a close second.
- If you are having trouble, make the pretzel smaller and try again. You can bank the track at any angle because the foam is so soft.
- Use lots of tape and a firm surface (bookcases, chairs, etc).

Activity Description:
Fill a bucket half-full with water. Grasp the handle and swing it over your head in a circle in the vertical direction. Try spinning around while holding the handle out in front of your chest to swing it in the horizontal plane. Vary your spin speed to find the minimum!

Exhibit Description:
This activity relates to the Spin, Flip and Roll exhibit where visitors explore the role of gravity and rotational forces as extreme athletes flip and rotate through the air.

Background Information:
In this activity, the force that keeps the water in the bucket is called centripetal force, not to be confused with centrifugal force. Some may think the force in play is centrifugal force, as the spinning of the bucket generates a force on the water that is keeping it inside the bucket. Like a passenger in a car that is going around a curve. The passenger is 'pushed' to the side of the car in the opposite direction of the curve. Although this would be simple enough, centrifugal force is an inertial force, also called a fictitious force, that is directed away from the axis of rotation that appears to act on all objects when viewed in a rotating frame of reference. Using Newton's laws of motion and real forces, the force acting on the water is centripetal, for if it was not acting on the bucket, the bucket would travel in a straight line. In order to keep the water moving in a circular path, a centripetal force is needed (in this case provided by the handle of the bucket and your arm). Centripetal force is a force that makes a body follow a curved path. When centripetal force becomes small enough, gravity takes over, and with this experiment, you get wet! Sir Isaac Newton described it as "a force by which bodies are drawn or impelled, or in any way tend, towards a point as to a centre."

Activity Description:
In this activity, students are introduced to the biomechanical characteristics of helmets, and are challenged to incorporate them into designs for helmets used for various applications such as rock climbing.

The use of helmets helps to protect the brain and neck during a crash or fall. To do this effectively, helmets must have some sort of crushable material to absorb the collision forces and a strap system to make sure the protection stays in place.

Exhibit Description:
This activity relates to the Climb It! Challenge exhibit where visitors of all ages test their climbing ability on a simulated-rock climbing wall.

The exhibit provides visitors with an opportunity to learn about and test the materials and mechanisms used in providing passive and active fall protection when climbing.

Background Information:
Rock climbing, a branch of the wider sport of mountaineering, involves an element of risk. This is one of its attractions. In the approximately 120 years since the inception of rock climbing as a sport, the equipment used to protect participants from death or injury has developed from extremely rudimentary to scientifically sophisticated.

Engineers use scientific principles and other background information to design and create useful things that we use and depend upon every day.

One effective way to prevent head injury from these accidents is to use helmets.

Helmets generally consist of two parts: an impact protection system to absorb the force and a strap system to keep the protective layer in place.

Often three layers are used together to provide impact protection.

1. The outer layer is generally a hard shell or a micro-shell made of fiberglass, Lexan or ABS plastic. This shell serves many purposes: it distributes the force of the collision over a large area, it allows the helmet to slide, thereby causing a slower deceleration, it provides a shield against penetration, and it holds the middle layer together.
2. The middle layer is usually a crushable liner that absorbs the shock of collision. This layer is often made of expanded polystyrene, also known as EPS.
3. The inner layer, which may be more segmented, helps to ensure proper fit and comfort.

Materials List:

- Poster board (approx. 20 x 30 in)
- Markers, colored pencils, etc.
- Two or more example helmets
- EPS (expanded polystyrene) or Styrofoam (approx. 10 in2)
- PET (polyester terephthalate, such as cutting the plastic from a pop bottle to lay flat)
- 5-pound weight
- Scissors
- Masking tape

Procedure:

PART 1

People who design and manufacture helmets must know how to make a helmet protective, functional and marketable at the same time.

- In groups, consider the following: all helmets contain the same basic parts to protect the head in an accident. However, helmets are not all alike. They may differ depending on who will use them and for what purpose.
- Determine the purpose of a helmet.
- Pass around examples of bicycle helmets so that the students can identify the parts.
- Describe the parts of the helmet and discuss the purpose of each part.
    - Hard and slick shell
    - Crushable liner
    - Padding layer
    - Strap system
    - Vents

To reinforce the purpose of the hard shell, conduct the following experiment:

- From shoulder height, drop the 5-pound weight onto a piece of EPS.
- Pass the EPS around the class and have students note the deformation.
- Tape the flat plastic piece onto the EPS.
- Drop the weight from shoulder height onto the combination of EPS and PET.
- Pass the combination around the class and have the students note the deformation.
- Think about the helmet characteristics that are designed for a certain application. By adding these characteristics to the basic helmet, the proper design can be determined for an application.
- Pass out Worksheet A: Helmet Design Project (2 pages) and assign each group one of the design challenges.
- Have students brainstorm ideas and complete the worksheet.

PART 2

- Have students prepare a two-minute poster presentation on their designs. Require the posters to include the helmet designs and that students be prepared to discuss the choices they made.
- Finish with a discussion about how students approached the problem like engineers. At each stage of the project, what engineering role were they performing?

Adapted from: https://www.teachengineering.org/activities/view/bicycle_helmet_activity

Activity Description:
Do the following six exercises as a circuit. Perform as many repetitions as possible of one move for 30 seconds, rest for 30 seconds, and then move on to the next move. When you are finished the last exercise, start with the first move again. Do 3 or 4 circuits total. The entire workout should take you 18 to 24 minutes.

SQUAT JUMP
With your feet hip width apart, squat until your thighs are parallel to the floor, and then jump as high as you can. Allow your knees to bend 45 degrees when you land, pause in deep squat position for 1 full second, and then jump again.

WALKING SINGLE-LEG STRAIGHT-LEG DEADLIFT REACH
Stand with your feet hip width apart and your arms hanging to the side of your thighs. Lift your right leg behind you. Keeping your lower back naturally arched, bend forward at your hips and lower your torso until it is nearly parallel to the floor while you reach your opposite hand to the floor. Return to the starting position, take two steps forward, then repeat the movement with the opposite leg.

SIDE LUNGE
Stand with your feet about twice your shoulder width apart. Keeping your right leg straight, push your hips back and to the left. Then bend your left knee and lower your body until your left thigh is parallel to the floor. Your feet should remain flat on the floor at all times. Pause for 2 seconds, and then return to the starting position. Complete all repetitions and switch sides.

SCISSOR BOX JUMP
Place your left foot on a bench with your right foot on the floor. In one movement, jump up and switch leg positions in midair. At the bottom position, pause for 1 second before alternating to the other leg.

SINGLE-LEG HIP RAISE
Lie face up, arms out to your sides at 45 degree angles, left foot flat on the floor with that knee bent, and your right leg straight. Raise your right leg until it is in line with your left thigh. Then squeeze your glutes and push your hips up - your lower back will elevate. Pause, and return to the starting position.

ALTERNATING DROP LUNGE
Stand with your feet hip width apart, hands on hips. Keep your chest and eyes up, shoulders squared. Cross your right leg behind your left, and bend both knees, lowering your body until your left thigh is nearly parallel to the floor. Return to start and repeat, switching sides.

Exhibit Description:
This activity relates to the Climb It! Challenge exhibit where visitors of all ages test their climbing ability on a simulated-rock climbing wall.

They can test their strength, agility and flexibility, and explore how lower body strength is one aspect of the fitness necessary for extreme climbing.

http://www.menshealth.com/fitness/leg-workout-without-weights

Activity Description:
How do you know the right amount of filler to add to give a strong composite? Is it possible to add too much? Changing the proportions not only affects the properties of the final material, but also affects the overall cost, and can affect how easy the material is to work with. But, how does the amount of filler affect the strength of the composite? In this activity, you are going to try out three different mixes of Plaster of Paris (the matrix) and millet seeds (the filler). Each mixture needs a mixing bowl and a mold. The quantities for each mix are shown in the table.

Mix	Plaster of Paris	Millet seed
A	8.5oz	2.5oz
B	5oz	1.7oz
C	6oz	0.8oz

Exhibit Description:
This activity relates to the Be Creative! exhibit where visitors can mix and match equipment, as well as athlete heads, torsos and lower bodies to create amusing sport combinations, and may even be inspired to dream up a new extreme sport.

Visitors are prompted to play with the ideas of evolution, innovation and creativity as they pertain to the development of new extreme sports.

Background Information:
Composites are made by physically combining two or more materials. Many composite materials are used to provide strength and rigidity while using thinner, lighter components. However, they are also being developed for their ability to provide specific combinations of properties and functions, not simply for their mechanical properties.

Materials:
- Plaster of Paris
- Millet Seeds
- Water
- Mold

Procedure:

1. To make one of the mixes, you should first measure out the correct quantities of Plaster of Paris and millet seeds. Mix these thoroughly in your mixing bowl. Always mix the dry seeds and powder first.
2. Add a little water while stirring, until you have a mixture that is like porridge or thick yogurt. For each 3.4oz of Plaster of Paris, you will probably need 1.7oz of water.
3. Spoon the mixture into a mold and leave it to harden.
4. Repeat steps 1 to 3 for each of the different mixes you are going to use.
5. To remove the hardened sample from the mold, peel off or cut the adhesive tape so you can open the mold first, then carefully lift the sample out.
6. Test each of the samples in turn: the diagram shows a possible arrangement for testing.
7. Which of the samples is strongest? Which is weakest?
8. Scientists and engineers often refer to the “volume fraction” of filler in a composite. This is the volume of filler divided by the total volume of “filler plus matrix”. What was the volume fraction of the strongest sample?
9. Based on your results, how does the volume fraction of filler affect the strength of the composite? How well does this reflect the properties of “real-life” composite mixes?

Safety:
Plaster of Paris gets hotter as it sets. Wear eye protection when measuring out or mixing with water, and wash any splashes off skin as soon as possible.

Activity Description:
Plywood is a laminar composite – it is built up in layers – and the orientation of the grain in plywood can change from one layer to the next.

You are going to make and test three different plywood arrangements.

Exhibit Description:
This activity relates to the Be Creative! exhibit where visitors can mix and match athletes heads, torsos and lower bodies to create amusing sport combinations, and may even be inspired to dream up a new extreme sport.

Visitors are prompted to play with the ideas of evolution, innovation and creativity as they pertain to the development of new extreme sports.

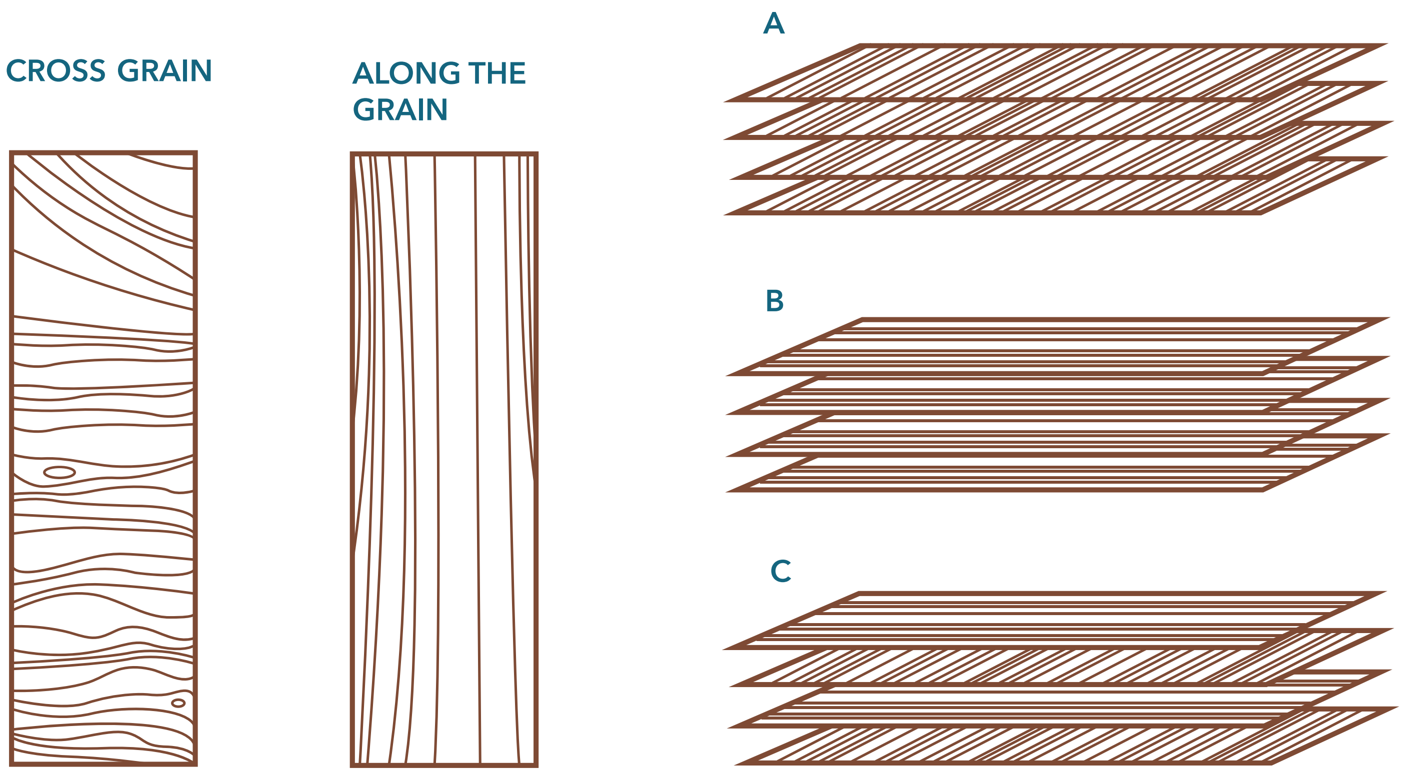
Background Information:

Procedure:

1. Plywood is made using layers of veneer. In each layer, the strip of veneer will either be aligned along the grain or across the grain. The three combinations you are going to compare are:

   A: four strips, all cut across the grain
   B: four strips all cut along the grain
   C: four strips, with two cut across the grain and two along the grain, and layered with alternating grain directions.

2. Find out which combination(s) of veneer you are going to use then collect your pieces of veneer.
3. Stick the layers together using PVA glue. Label the top layer of each plywood combination.
4. Leave the plywood samples to dry thoroughly before you test them. You will need to store them under something heavy to keep them flat.
5. Before you test your samples, gently try to flex each one, to see which gives the most flexibility and which is most rigid.
6. Carefully load each sample in turn until it starts to crack. Which sample is strongest?
7. How does the grain direction in different layers affect the strength of the plywood?


CROSS GRAIN
ALONG THE GRAIN
A
B
C