School Based Activities

Activity 1: Water Rocket

For safety reasons, this activity is best done as a teacher demonstration. Launch only from an outdoor area well away from buildings, never lean over the rocket, stand back as far as possible when pumping up the rocket, and ensure that spectators are at least 20 metres from the launch area.

Background information

Gravity forces the resting rocket down towards the ground.

The bike pump compresses air in the bottle. The compressed air pushes against the sides of the bottle and the surface of the water. Finally, the larger stopper is pushed out and the air and water escapes from the opening.

Air pressure in the bottle is unbalanced when the rubber stopper gives way. The pressure at the top of the bottle is unopposed and pushes the bottle up.

Water adds mass to the rocket. Without water the rocket does not go far. The momentum of the water expelled from the rocket causes an equal and opposite thrust in the direction the rocket is pointed. At blastoff the rocket has maximum force but is not moving very fast. The rocket accelerates as the water escapes.

What you need

- Plastic bottle – 2 litre PET
- Larger stopper – rubber or cork, diameter same as inner diameter of neck of plastic bottle

- Copper tubing – 0.5 cm outer diameter, about 5 cm long
- Plastic tubing – 0.5 cm inner diameter, about 2 metres long
- Smaller stopper/cork – outer diameter 0.5 cm
- Water proof glue

- Bricks to provide firm launch pad and to support rocket, or
- 3 x plastic fins, glued to side of bottle (see illustration)

- Bike pump with inflation needle attached
- Water

What to do:

1. Drill a 0.5cm hole in the centre of the larger stopper

2. Tightly glue the copper tube into the hole in the larger stopper. Leave about half of the copper tubing protruding from the top of the larger stopper.

3. Tightly glue one end of the plastic tubing to the copper tubing. Push the plastic tubing down until it's flush with the top of the larger stopper.

4. Coat the end of the inflation needle with glue and push it through the small stopper/cork. Ensure that the thread for attaching the needle to the pump protrudes above the small stopper/cork.

5. Tightly glue the small stopper/cork into the remaining end of the plastic tubing.

Source: http://www.kidscanmakeit.com/SC0002.htm

6. If using plastic fins, glue these to the side of the bottle (see illustration).

7. Let the glue dry overnight.

Remember: Safety first when launching the rocket!

8. Fill the bottle about 1/3 full of water.

9. Fit the larger stopper firmly into the bottle.

10. Place the rocket on the launch pad.

11. Attach the bike pump to the valve needle.

12. Put on safety glasses. Make sure that everyone is at least 20 metres back and that the rocket is aimed safely.

13. Pump! When the air pressure is high enough, the larger stopper will release, the water and air will shoot out and the rocket will launch. If this doesn't happen, be careful. The rocket is pressurized and will take off when you jiggle it.

14. Try the rocket with different amounts of water and air. A rocket with just air does not go far. Add a cone to the nose of the rocket and see if it goes further.

Activity 2: CD Hovercraft

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Background Information:

To move an object across a table, we have to keep pushing it because the object rubs against the table and causes friction. Friction is the force that resists the movement of an object and makes it slow down.

In this activity, a thin layer of air is created between the CD and the table. This means that there is hardly any friction, so the hovercraft slides around easily. When the air runs out, the CD comes back into contact with the table.

What you need:

- Balloon
- CD
- Spout from water or juice bottle
- Glue

What to do:

1. Glue the spout over the centre of the CD. You can use craft glue, or a hot glue gun. Masking tape or duct tape would work too, but be sure the seal is air tight.
2. Push the spout down so that it is closed and no air can pass through.
3. Blow up the balloon. Don't tie it! Carefully stretch it so that it is over the spout.
4. Hold the bottom of the balloon in place with one hand. With the fingers of the other hand, carefully pull open the spout. Watch what happens!

The air in the balloon is forced out through the drinking spout. It creates a blanket of air and an almost frictionless surface, like a hovercraft. The CD is propelled by the balloon, and moves randomly across a smooth surface (floor).

When your 'hovercraft' stops, just blow the balloon up again for more fun!

Note: It is possible to replace the CD with a clean inverted polystyrene meat tray. Make a hole in the middle and carefully glue the drink bottle spout over it as above.

Activity 3: Playing Bernoulli Ball

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Background information:

Bernoulli's principle says that the faster air flows over the surface of something, the less the air pushes on that surface. Therefore, air that is moving at higher speed produces lower pressure than air that is moving at slower speed.
The air from the hair dryer flows upwards, hits the bottom of the ball, slows down, and creates a region of high-pressure air, which holds the ball up by balancing the pull of gravity. As the air moves around the ball it speeds up and creates a pocket of low air pressure that keeps the ball suspended.

When the ball moves to the side of the air column, the slower moving air on the outer side of the ball creates a region of higher pressure. This pushes the ball back into the lower pressure region at the centre of the air stream.

What you need:

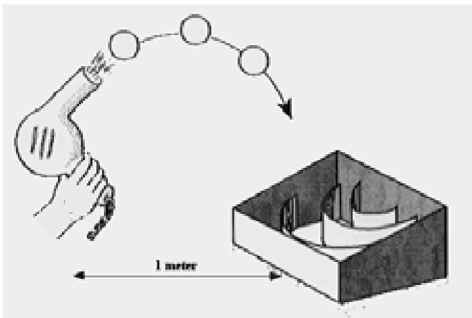
- Hair dyer with a cylindrical nozzle
- Polystyrene ball, 4-5 cm in diameter
- Two cardboard boxes of different sizes

What to do:

1. The player sits in a chair or on a stool, holding the hair dryer about 1 metre away from the target box.
2. Place cardboard boxes inside each other to serve as the target. Alternatively, cut and shape cardboard into curved sections and place in box, as illustrated below. If you position the back of the box against a wall, you won't have to chase as many stray balls.
3. Scores for each part of the target are:
   Inner box – 3 points; Outer box – 1 point; Outside of boxes – 0 points
4. Use the hair dryer on the cold, low-speed setting.
5. Each player is allowed five practice shots and five shots for official score.
6. To start the game, turn the dryer on and point the nozzle straight up. Place the polystyrene ball in the airstream about 30 cm above the nozzle.
7. The player shoots the ball by smoothly tilting the dryer so that the ball falls out of the airstream and continues on a curved path towards the target.
8. If the ball hits the dryer, the player gets to try again.

Questions:

1. Why does the ball stay in the air steam when the dryer is pointed straight up?
2. Does the ball fall out of the air stream as soon as you start to tilt the dryer?
3. Why does the ball leave the airstream when you continue to tilt the hair dryer?
4. After playing the game, do you have any suggestions for someone who has never played it?



Source: http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/newton/jumbojet2.html

Activity 4: Whirlpool in a Bottle

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Background information:

This activity demonstrates the formation of a vortex in a body of water that is draining from its base. The vortex makes it easier for air to come into the bottle and allows the water to pour out faster. If you look carefully, you will be able to see the hole in the middle of the vortex that allows the air to come up inside the bottle. If you do not swirl the water and just allow it to flow out on its own, then the air and water have to take turns passing through the mouth of the bottle.

What you need:

- Two 2-litre PET soft drink bottles
- Washer
- Electrical tape
- Water
- Food dye
- Stopwatch

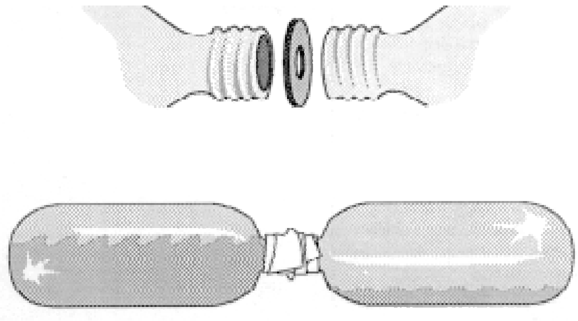
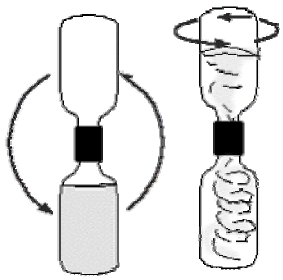


Image: http://www.exploratorium.edu/snacks/vortex.html

What to do:

1. Remove caps from the two bottles.
2. Fill one of the bottles two-thirds full of water.
3. Add a couple of drops of food dye.
4. Tape the bottles together with the washer between them. Make sure the electrical tape seals the bottles well to prevent leakage.
5. Place your bottles in a vertical position, so that all the water flows into the bottom bottle.
6. Invert your bottles and time how long it takes for the water to flow from the top to the bottom bottle. Carefully watch the motion of the water.
7. Record the time and describe the motion of the water.
8. Repeat Step 6. This time, swirl the top bottle a few times as you invert it. Time how long it takes for the top bottle to empty, and carefully watch the motion of the water.
9. Record the time and describe the motion of the water.



Results:

- Time recorded when the bottle was emptied without swirling it first: ______

  Describe the motion of the water: ________________________________

- Time recorded when the bottle was emptied after swirling the water: _____

  Describe the motion of the water: ________________________________

- Conclusion: What is the effect of a vortex on a body of water? __________

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Activity 5: Orbits of the Planets

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Background information:

Johannes Kepler (1571-1630) developed several laws to describe his observations of the orbits of the planets. His laws state, among other things, that planets that are distant from the Sun will have a slower orbital velocity (speed) than planets that are closer to the Sun.

Kepler's work has contributed to a more general law describing the motion of spinning and turning objects known as the Conservation of Angular Momentum. This law explains why a ball rolling around the Gravity Well in the *Sci-Quest* exhibition goes faster as it moves towards the centre, why an ice skater spins faster when her arms are at her sides, and why a whirlpool or cyclone spins fastest near its centre.

Detailed information on the planets of the Solar System is available from NASA at http://nssdc.gsfc.nasa.gov/planetary/factsheet/index.html
An animation showing the orbits of the inner planets is at http://www.ac.wwu.edu/~stephan/Astronomy/planets.html
For more information, search the Internet for 'Kepler' and 'Conservation of Angular Momentum'
(eg. http://csep10.phys.utk.edu/astr161/lect/history/kepler.html)

Source: NASA

What to do:

Complete the table below. You will be able to obtain the information you need by consulting an astronomy book or searching the Internet. Be sure to clearly indicate the units that you are using for distance and velocity.

Name of Planet	Distance from Sun	Orbital Velocity
Mercury		
Venus		
Earth		
Mars		
Jupiter		
Saturn		
Uranus		
Neptune		
Pluto (dwarf planet)		

Kepler was correct!

Planets that are closer to the Sun have a ☐ faster ☐ slower orbit than planets that are further away from the Sun.

Activity 6: Hundreds and Thousands

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Background information:

You may be familiar with getting zapped while getting out of a car, or zapping yourself or someone else after walking on carpet. These incidents involve static electricity. When you rub certain materials together, you can separate charges. If the static electricity is strong enough, you can see and/or hear a spark moving from one object to another as it discharges.

Discharging occurs when the charged object loses its electricity to an object that is in contact with the Earth.

There are two types of charges: positive charge and negative charge.

- When two materials have the same charge (positive and positive or negative and negative), they repel each other.
- When two objects have different charges (positive and negative and vice versa), they attract each other.
- Charged objects attract neutral objects (objects that have no charge).

In this activity, when the wool is rubbed on the plastic lid, some electrons are transferred from the wool to the lid. Electrons have a negative charge, so the lid becomes negatively charged.

The ‘Hundreds and Thousands’ have a neutral charge and so are attracted to the negatively charged lid. After some time, the lid starts to lose its charge, so the ‘Hundreds and Thousands’ drop back down.

By rubbing your finger across the top of the lid, the negative charge on the lid is discharged through your finger to the Earth. The ‘Hundreds and Thousands’ therefore drop back down into the container.

What you need:

- ‘Hundreds and Thousands’
- Shallow (1 or 2 cm) container with a clear plastic lid (eg a small take away food container)
- Woollen clothing or cloth

What to do:

1. Put a small amount of ‘Hundreds and Thousands’ into the container.
2. Put the lid on the container and charge the lid by rubbing it with a woollen cloth. Observe what happens.
3. Gently move a finger across the lid and observe what happens.

Questions:

1. Why do the ‘Hundreds and Thousands’ stick to the lid?
2. Why do they sometimes fall back down?
3. What happens when you move your finger across the container?

Activity 7: Ruler Guitar & Rubber Band Guitar Δ

Background information:

When a string is attached to the sound box of a guitar, its vibrations cause the sound box and the surrounding air to vibrate at the same frequency. This is called resonance, and results in a louder sound.

The faster a string vibrates, the shorter the wavelength and the higher the frequency of the sound waves. This causes a higher pitched sound.

- A tight string produces higher-pitched sounds, while a lower-tension string produces lower-pitched sounds.
- A heavier string produces slower vibrations and therefore a lower pitch.
- A shorter string vibrates at a higher frequency and produces a higher pitch. Guitar players play different notes by pressing a string against the neck of the guitar. This shortens the length of the string and produces a higher pitch.

What you need:

- Wooden ruler
- Shoe box
- Small wooden sticks
- Rubber bands of various sizes
- Pair of scissors

What to do:

Ruler Guitar

1. Hold the ruler on a table with half its length over the edge. Pluck the end of the ruler and listen to the sound.

2. Now move the ruler so there is only a short length over the edge of the table and pluck it again. Then try the same thing with a long length of ruler over the edge of the table.

3. As you move the ruler, what happens to the sound? If more of the ruler is over the edge of the table, does the sound become higher or lower? Why does this happen?

Rubber Band Guitar

1. Cut a hole in the middle of a shoe box.

2. Stretch several rubber bands of various lengths and thicknesses across the top of the box. Leave a gap of about 1cm between each rubber band.
   Pluck the rubber bands in turn to hear what sound they make.

3. Make a bridge by inserting two wooden sticks about 1.5cm square under the rubber bands on each side of the hole in the box.
   Compare the sound that the rubber bands make before, and after, the bridge is installed. Why is there a difference?

source: http://www.iit.edu/~smile/ph9301.html
Image: http://www.teachersdomain.org/resources/phy03/sci/phys/mfe/zmguitar/index.html

Activity 8: Good Vibrations

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Background information:

When objects vibrate, they do so with a resonant (or natural) frequency that is determined by the size and shape of the object. Large objects produce vibrations that have a long wavelength, which make low pitch sounds. Small objects produce vibrations that have a short wavelength, which make high pitch sounds.

What you need:

- Mailing tubes of various shapes
- Pieces of PVC pipe of various lengths
- Wine glasses – at least eight
- Water
- Rubber thong

What to do:

Mailing Tube Whackers

1. Whack the ends of mailing tubes of various sizes with a rubber thong to produce sounds of different pitch. With both ends of the tube open, the wavelength of the sound produced is twice the length of the tube.
2. Put a lid on one end of a tube. The wavelength now produced is four times the length of the tube and the sound is an octave lower than when both ends of the tube are open.
3. Arrange the mailing tubes, with and without lids, from lowest pitch to highest pitch. Can you play a simple tune?

PVC Pipe Whackers

1. Whack the ends of pieces of PVC pipe of various lengths with the rubber thong.
   Short pipes make a sound of s _ _ _ _ wavelength and h _ _ _ pitch.
   Long pipes make a sound of l _ _ _ wavelength and l _ _ pitch.
2. Arrange the pieces of pipe from lowest pitch to highest pitch. Try to play a simple tune.

Singing Wine Glasses

1. Place eight wine glasses in a row on a table.
2. Put some water in each wine glass. Put very little water in the left hand glass, a little more in the next one, and so on.
3. Wet your finger and run it around the rim of each glass to make it ‘sing’. Adjust the amount of water in each glass to make the eight notes of an octave. Lots of water will decrease the amount of the glass that vibrates, thereby producing a sound of shorter wavelength and higher pitch.

Get some friends together to form an orchestra using the mailing tubes, PVC pipes and wine glasses!

Activity 9: Robotic Arm

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Background information:

This activity uses air pressure to remotely lift a lid on a container. This is similar to the hydraulic systems used in industry for remotely controlled machinery, except that oil rather than air would normally be used to transfer the force to its destination.

What you need:

- A bamboo rod
- A length of 3mm plastic tubing
- A film canister
- Icy pole stick
- Masking tape
- Strong glue
- 2 x 25ml hydraulic rams /syringes
  Students need to be cautioned that they must never touch a syringe that they find. It should be reported to the local council for collection and proper disposal.

What to do:

1. Tape the hydraulic rams/syringes to each end of the bamboo rod.
   Make sure that the piston on hydraulic ram/syringe 2 is pushed in and that the piston on hydraulic ram/syringe 1 is pulled out.

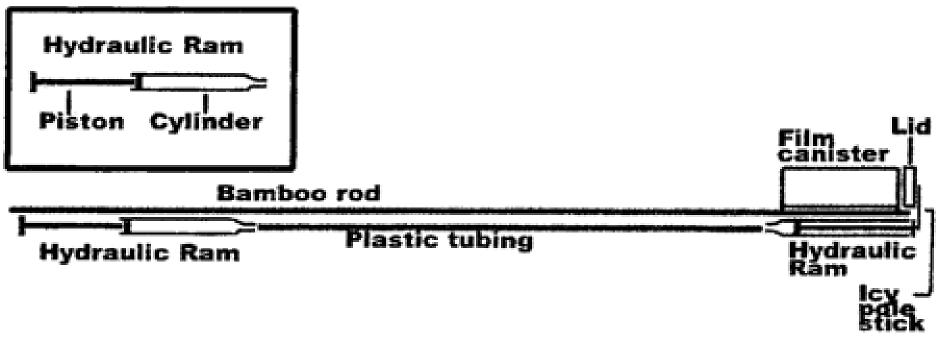
2. Cut the plastic tubing to length and attach each end to the hydraulic rams/syringes.

3. Securely tape the film canister next to hydraulic ram/syringe 2, taping around rod, canister and syringe. The robotic arm works best when the canister lid is parallel to the top of the piston on hydraulic ram/syringe 2.

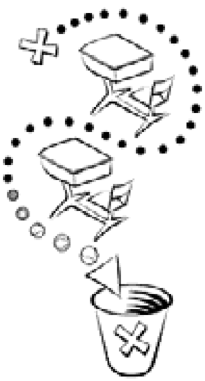
4. Connect the canister lid to the end of the piston of hydraulic ram/syringe 2 by gluing the icy pole stick to them both. Make sure that the film canister lid is just sitting on top of the canister, rather than snapped on tightly.

5. Operate the robotic arm by pushing in and pulling out the piston on hydraulic ram/syringe 1. You should be able to lift and replace the lid on the film canister, and you may be able to use the lifted lid and canister as 'fingers' to remotely pick up a small object.

Hydraulic ram/syringe 1 ↓ **Hydraulic ram/syringe 2** ↓



Activity 10: Robot Trail



Background information:

This activity demonstrates interactions between a 'robot' and its 'controller'.

- Robots can't think for themselves, but follow very precise instructions, using a predetermined vocabulary (program).
- Robots are often used in space missions. Earth-based controllers must rely on the robot's video cameras for visual orientation.
- Robots may be able to send data from sensors to the controller.
- If the controller is on Earth and a robot is on a distant space craft or planet, there will be a time delay between the transmission and receipt of instructions. From Earth to Mars the delay is from 8.8 to 41.9 minutes.

What you need:

Cardboard box, blindfold, basketball, rubbish bin

What to do:

NB. Be sure that courses are safe and that there are sufficient people on hand to prevent the 'robot' from falling over obstacles. Robots must proceed slowly!

1. Find a partner. Decide who will be the robot and who will be the controller.
2. If time allows, make a square 'robot head' out of a cardboard box. This is to be fitted over the head of the student who is to be the robot so that they can't see. Alternatively, a blindfold can be used.
3. The 'robot' is to carry a basketball around a pre-determined course and put it in a bin or other container. The controller must tell the robot how to avoid obstacles and complete the course, and the robot must follow the directions of the controller exactly. The robot can't talk or ask questions.
4. The robot and the controller switch roles.

5. Discuss your success or otherwise. Which commands caused problems? Make up an agreed list of commands that would help the robot to function. You might like to precisely define some commands, eg. the length of a 'step', how many degrees in a 'half turn' etc.
6. Both complete the course again. Was the list of commands useful?

7. Make up a new obstacle course. Draw a map of the course.
8. This time, the controller must sit facing away so that they can't see the robot or the obstacle course, but the robot can see. The controller uses the map to give directions, which the robot must follow exactly. The controller can question the robot about their location; the robot answers yes/no.
9. You could pretend that the controller is on Earth and the robot is on a space craft 3 million kilometres away. This would cause a 10 second delay between when directions are given and received.
10. Challenge another robot/controller pair of students to a competition to complete an obstacle course that the other pair has devised.

Source: http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/newton/nasa.html