Traveling Science Shows

Post-Show

MOTION & MACHINES

After the Show

We recently presented a Motion and Machines show at your school, and thought you and your students might like to continue investigating this topic. The following activities are designed to review and extend the ideas covered in the show.

Please remember to use appropriate safety measures for all activities. An adult instructor should always supervise students during experiments.

Visit us online at www.fi.edu/TSS or contact us at tss@fi.edu.

THING-A-MA-JIG

FOR GRADES 1-8

Rube Goldberg, an American cartoonist, was famous for designing machines that performed very simple, everyday tasks through a complicated series of events. You can find numerous examples of his inventions in books and online. Not only are his inventions entertaining, they also illustrate how machines help us do work. In this activity, students will engineer a machine to complete a task in the style of Rube Goldberg. Be sure to emphasize safety precautions as students construct and test their designs.

EQUIPMENT

Tape
Scissors
Balls
Blocks
Assorted everyday objects such as: coffee cans, string, spools, ramps, bags, balloons, etc.

PROCEDURE

1. Research Rube Goldberg machines and find one example you like. How does it work? How many simple machines does it use?

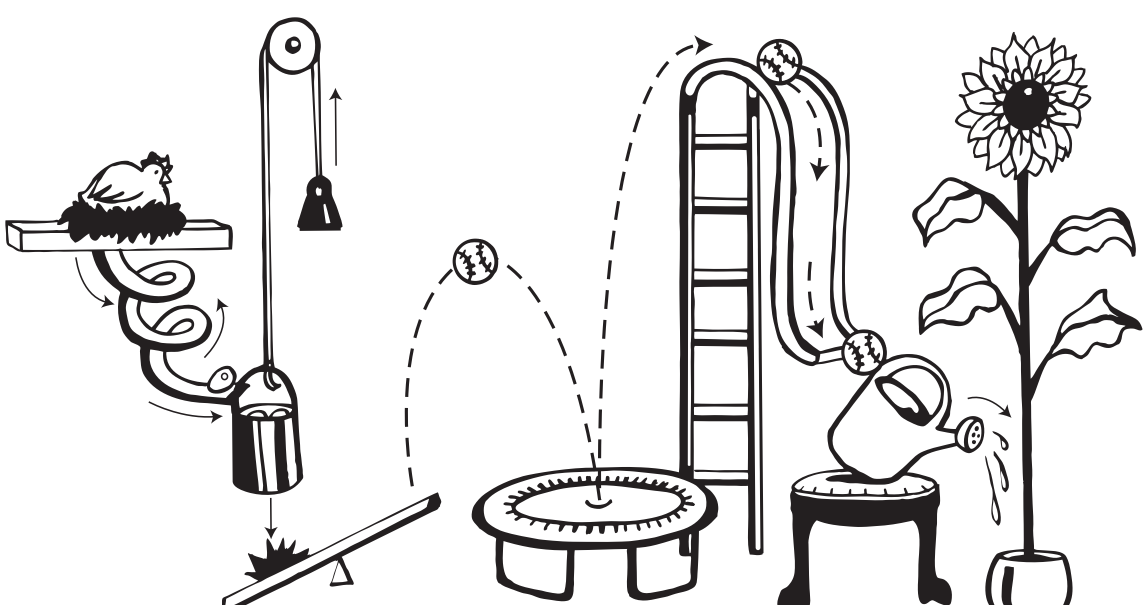
2. Pick a simple task. For instance, make a pencil mark on a piece of paper at least 6 feet away from the start, or make a ping-pong ball land in a cup 10 feet away.

3. Build a machine that uses a chain reaction to accomplish the task. Does your machine do work? How does it change the direction or amount of force needed to do work?

4. Experiment and have fun!

WHY?

In the show, we explored a variety of simple machines. Machines help us do work by changing the direction or amount of force needed, resulting in a force that moves an object over some distance. A complex machine, such as a Rube Goldberg design, is a system of simple machines that work together.



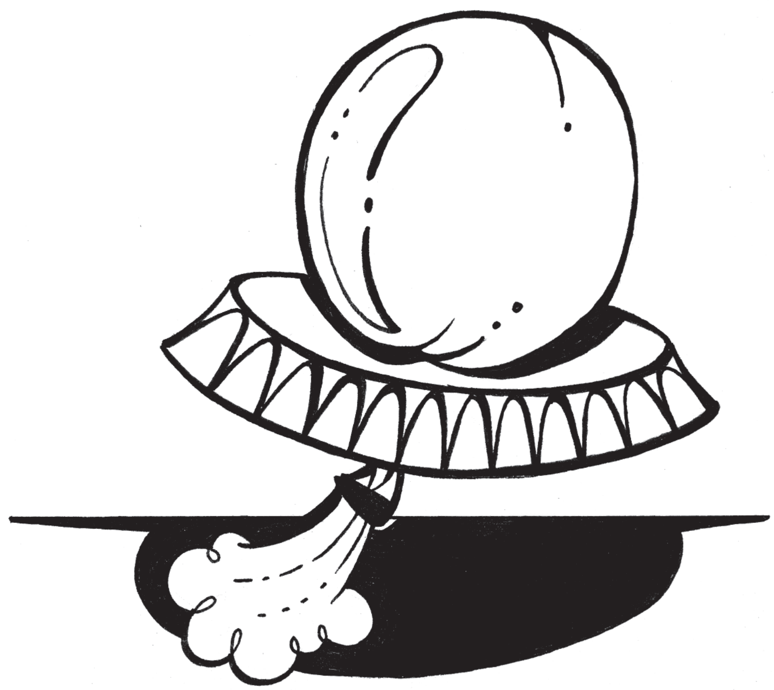
BUILD A HOVERCRAFT

FOR GRADES 1-4

During the show, we built a hovercraft, a machine that uses air to push off the ground. The hovercraft illustrates all three of Newton's Laws of Motion, as well as the forces of friction and gravity. In this activity, students will build a small version of a hovercraft.

EQUIPMENT

Paper plate
Pencil
Balloon



PROCEDURE

1. Using the pencil, poke a hole in the center of the paper plate. Push the neck of the balloon through the hole, leaving the body of the balloon on the other side.

2. Blow up the balloon. Hold the neck of the balloon closed while you turn the plate over, so that the balloon is now on top.

3. Let go of the balloon and quickly put the plate flat on the table. What happens? Why?

4. Experiment with your hovercraft. How many pennies can it hold on the plate before it is unable to hover? How can you make it go farther? Can you design a way to steer it?

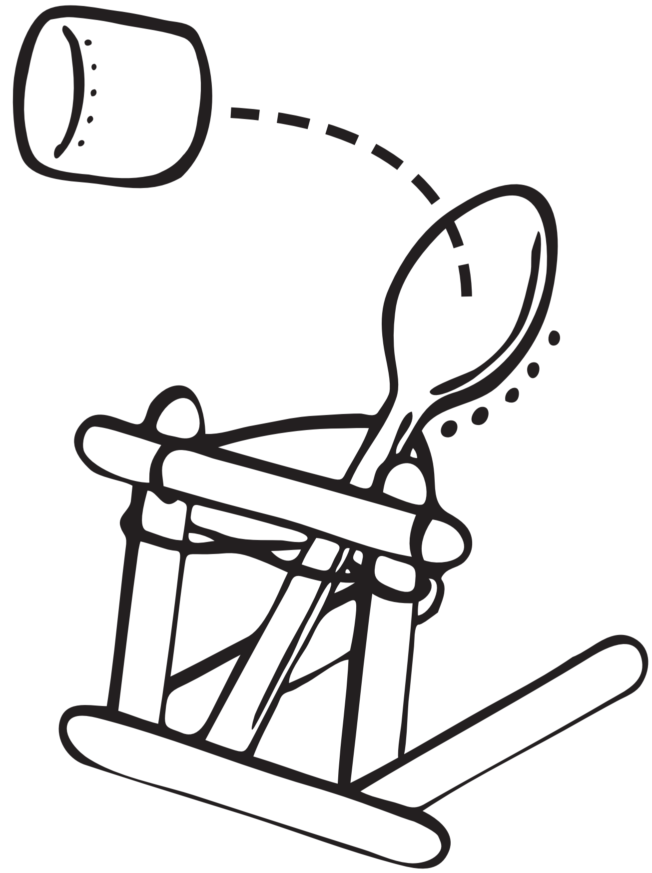
WHY?

Newton's First Law (the Law of Inertia) tells us that the stream of air acts as the unbalanced force that accelerates the hovercraft upwards and over the table. Air coming down from the balloon pushes the hovercraft up into the air, according to the Third Law (Action-Reaction). Because the paper plate has little mass, only a small amount of air is needed to accelerate the hovercraft, just as the Second Law predicts. A layer of air between the hovercraft and the table reduces the amount of friction, allowing the hovercraft to move more easily. When the air stream stops, gravity pulls the hovercraft back down to the table.

CRAZY CATAPULTS

FOR GRADES 5-8

During the show, we learned how machines are designed to use Newton's Laws to do work. Machines do all kinds of work, from transportation to construction to flinging marshmallows through the air. In this activity, students design and test catapults. Be sure to emphasize safety precautions as students use their catapults.



EQUIPMENT

Marshmallows or cotton balls
Masking tape
Meter sticks
Plastic spoons
Rubber bands
Assorted building materials (such as string, cups, craft sticks, toothpicks, etc.)

PROCEDURE

1. Study the picture of the catapult above. Does it do work?
   How does the motion of the projectile demonstrate Newton's First and Second Laws?

2. Form small groups of 3 to 4 students. In your groups, build a catapult that launches a marshmallow or cotton ball. During launching, only one hand may be used to hold or fire the catapult.

3. What are the variables that affect the catapult's range and accuracy? As you experiment, try to test one aspect of your design at a time, while keeping others the same.

4. Explain and demonstrate the finished catapults. Have a competition and measure their range. Alternatively, set up a target and test their accuracy.

WHY?

A catapult is similar to a lever in that it consists of a bar that pivots about a fulcrum. Catapults work by storing tension, as in a twisted rubber band or a flexed plastic spoon. When you release the tension, the stored energy turns into kinetic energy and propels the projectile forward. This is an example of work because the catapult is applying a force over a distance, resulting in motion.

MORE INFORMATION…

We've provided the following information to help refresh your memory about the topics we covered during the show, and to deepen your understanding about motion and machines.

Sir Isaac Newton: An English physicist, mathematician, and astronomer who developed the three laws of motion and described universal gravitation. A popular myth claims that Newton discovered gravity when an apple fell from a tree and hit him on the head. Actually, he postulated that the force that makes things fall and the force that holds planets in their orbits might be the same force.

Force: A push or pull that one body exerts on another. Two forces are balanced when they are equal in size but opposite in direction, like in a game of Tug-of-War. Unbalanced forces occur when one force is greater than the other, resulting in motion.

Gravity: A force that pulls objects together. Massive objects, like the Sun, exert a great deal of gravity. The gravitational force between the Sun and the Earth keeps our planet in orbit, just as the gravitational force between Earth and your body keeps pulling you towards the center of the Earth. In a vacuum (without the effects of air resistance), gravity causes objects to fall at the same rate regardless of their mass. Gravity is not affected by sideways motion. Hence, a ball dropped straight down from the roof of a building will hit the ground at the same time as a ball thrown straight forward from the same height.

Friction: A force that opposes motion between two surfaces that are touching. When two things rub against each other, friction is generated. Different surfaces create more or less friction. An ice rink, for instance, is slippery because it produces less friction against your feet than a concrete sidewalk.

Acceleration: Any change in an object's velocity (speed and direction), including speeding up, slowing down, or changing direction. Acceleration is caused by unbalanced forces, as stated in Newton's First Law.

First Law of Motion: A body at rest will stay at rest unless an unbalanced force acts on it, and a body in motion will stay in motion with the same velocity (speed and direction) unless an unbalanced force acts on it. The first law is often referred to as the law of inertia. Inertia is resistance to acceleration, and increases as the mass of the object increases.

Second Law of Motion: The force required to accelerate an object depends on the mass of the object and how much you want to accelerate it. In other words, if you have two objects and give them both the same amount of force, the lighter one will accelerate more. This can also be expressed with the equation Force = Mass x Acceleration.

Third Law of Motion: "For every action, there is an equal and opposite reaction." Every time you exert a force on an object, it exerts a force of equal strength in the opposite direction. For instance, if you push on a wall, it pushes back on you. Usually, friction between the floor and your shoes keeps you in place. If, however, you push on a wall while wearing roller skates, you will feel the Third Law in action as you go rolling backwards!

Work: Applying force over a distance to move a mass. If there is no mass involved, or no motion, then no work is done. In other words, if you hold a ton of bricks over your head, you are not doing work because the bricks are not moving. However, if you move a feather two inches, then you are doing work because the feather has mass and you have moved it. The amount of work done equals the amount of force applied times the distance the object moves.

Simple Machines: Anything that makes work easier. In general, machines help us do work by changing the direction or amount of force needed to do work. Complex machines are collections of simple machines that work together.

Wheel and Axle: The wheel changes the amount of force needed by reducing the friction created. By using a wheel that rolls over the ground instead of rubbing against it, less friction is produced and the work is easier. A gear is a modified wheel.

Lever: A bar that pivots about a fulcrum. A lever can change the direction or amount of force needed. If the fulcrum is at the center of the lever, then the job is no easier. If the fulcrum is placed closer to the load being lifted, you do not have to push as hard to do the work. You do, however, have to push farther.

Inclined Plane: A sloped ramp. The inclined plane gives us the same mechanical advantage that the lever does; that is, we don't have to push as hard, but we do have to push farther. Two variations of the inclined plane are the wedge and the screw.

Pulley: A rope running through the grooved rim of a wheel. A fixed pulley changes the direction of the work being done, but does not reduce the force needed to move the load. A movable pulley does provide this advantage. For every movable pulley attached to an object, you decrease the force needed by one-half. Once again, this means that you increase the distance you must pull.

Mechanical Advantage: The factor by which a machine multiplies the force put into it. When a machine has a mechanical advantage greater than one, it makes it easier for us to do work with less force.

MORE RESOURCES...

The Franklin Institute: On your next field trip, check out Sir Isaac's Loft, an interactive exhibit that blends Newton's Laws and art. Then visit Amazing Machine to explore historical and everyday machines. Download exhibit guides at http://www.fi.edu/teacherresources/.

Force, Motion and Energy: Visit http://www.fi.edu/msp/force/index.html for a collection of relevant teaching resources. You'll find lesson plans, games, videos, and more!