NON-INTUITIVE DEMOS TO MAKE STUDENTS THINK
NSTA National 2000

A SPOOL AND NEWTON'S LAWS

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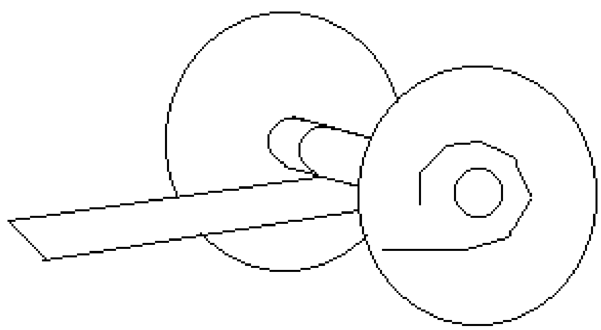
Nearly everyone is familiar with the concept of Newton's Second Law which states that when a force acts on an object the object will accelerate in the direction of the force. Newton's Second law does not seem to work with a spool of thread. Nearly everyone has tried to grab the loose end of a piece of thread and found the spool roll in the opposite direction. This occurs because your pull is not the only force on the spool. To show what happens if you force is the only force obtain a large spool. Instead of thread or string, I have wound mine with a wide ribbon to keep it moving straight. I wind the ribbon on the spool as shown and ask students to predict which way the spool will roll if I pull the ribbon horizontally. Most students will say that it will roll away from me. I then pull it gently and watch the spool move in my direction and roll up the ribbon. A number of students then respond that it is because I pulled gently so I repeat the experiment but this time pull very rapidly. It will still come towards me.



It is possible to make the spool roll away from you but not by pulling straight. You have to pull up so that the gravity and friction also become important and produce a resultant away from you. There is one special angle that you can pull up in which the spool does not roll away from or to you but just sits there and unwinds but you usually need to find this by trial and error.

A JOLY PHOTOMETER

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A photometer is a device for measuring the relative intesitive of two different light sources. This one was invented by a physicist named Joly, hence a Joly photometer. It can also be used to get students to think. It is simple to make cut a piece of aluminum foil the size of a paraffin block. Sandwich it in between two paraffin blocks and use a rubber band to hold the two blocks together. To use as a thought provoking activity hold the block in front of the class and ask them what they observe (a dark piece of paraffin on the bottom and a light piece on the top). Then ask them how to get the dark piece on the top. Most students will simply say to turn it over. Turn it over quickly and notice that the dark piece is still on the bottom. Turn it over several more times and not the dark piece is still on the bottom. Keep the student focused on the question – How do we get the dark piece on the top? Students will often try and explain what is happening rather than answering the question. Eventually someone will suggest shining a light from the bottom.

PISTOLS AT 20 PACES

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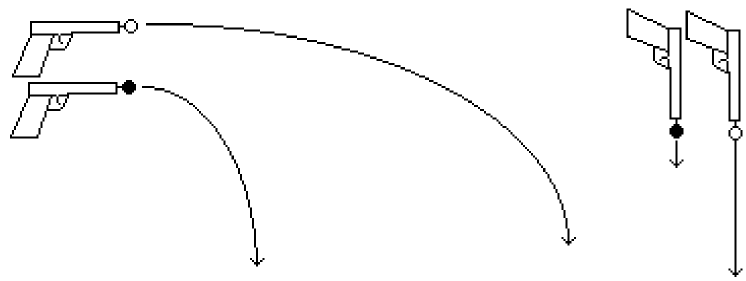
A couple of toy dart pistols can be used to explain a great deal about mechanics, gravity and Newton's laws. Tape a light rubber ball onto a toy dart and a similar sized steel ball bearing onto a second dart. Load the two darts into two identical toy dart guns. Ask the students which dart will land first if the two dart guns are simultaneously fired horizontally. When both darts hit the floor at the same time but at vastly different distances away, you can discuss the independence of the horizontal and vertical motions. Then stand on a chair and ask the students which dart will hit the ground first if they are simultaneously fired vertically down. It surprises many people who know a little science that the lighter dart always hits first. While gravity will always increase the speed of the darts as they move down, the lighter dart, because it leaves the gun with the greatest velocity will always be moving the fastest.



WORK AND ENERGY IN A BLOW GUN

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It is always difficult to show that kinetic energy is equal to $mv^2/2$. Students seem to think linearly and so the dependence of the energy on the square of the velocity is a difficult concept. Cut jumbo soda straws in lengths of 2,4,6,8 inches. Obtain a piece of wooded dowel just small enough to fit inside the straw and then cut into 2 inch lengths. Take two, 2 inch straws and insert a dowel into each. Hold the straws horizontal and blow both at the same time to show that with equal energies the straws obtain equal velocities. (They have equal energies because equal amounts of work have been applied. Equal work because the pressure of your breath applies the same force for the same distance in each straw). Next ask student to predict the velocity of a straw that has twice as much energy (or work). Repeat the experiment with a 2 inch straw and a 4 inch straw. Note the dowel in the 4 inch straw does NOT go twice as far. It usually is less than 50% farther. The 6 inch dowel will send the dowel about 1 2/3 as far and it takes the 8 inch dowel to make the dowel go twice as far. In other works, the dowel must have 4 times the energy (same force for four times the distance) to go twice as fast.

WEIGHING A FINGER

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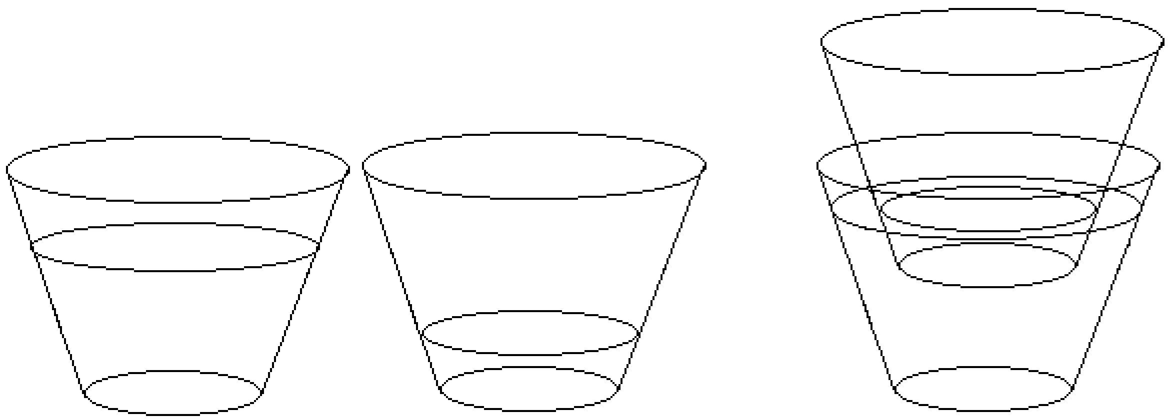
Place a hexagonal pencil on a flat surface. Place a 12 inch ruler on the pencil so that it is balanced and not touching the table on either side (like a teeter-totter). Place a clear plastic glass at each end of the ruler. Fill one glass to within 1/2 inch of the top with water. Slowly pour water into the second glass until it is just slightly heavier than the first glass. Ask your students what they think will happen when you put your finger in the glass that is slightly lighter. Demonstrate the reaction by putting one finger into the lighter glass of water. Be careful not to touch the rim of the glass. Ask your students if they can explain why the balance tips. By sticking your finger in the lighter glass you increase the volume that the glass is holding by an amount equal to the volume of your finger. The increase in volume makes the glass heavier and it tips the balance to that side. Now ask what will happen when you remove your finger!

ARCHIMEDES' PRINCIPLE

The formal statement of Archimedes' Principle, usually means very little to students who are learning science and why things float or sink. The following demo is a nifty way to catch students' attention. Start with two clear plastic disposable tumblers. Fill one nearly to the top then ask the students if they think that the empty second glass will float in the first glass filled with water. Most will agree that it can and will be pleased that they were correct when you demonstrate it to them. Then pour about 1/3 of the water into the second glass and repeat the question again. Will the glass I/3rd filled float in the glass that is 2/3rds filled? Again, most will agree that it will. When it is demonstrated, the cup does float as expected. Finally, pour another third of the first cup into the second and repeat the question. Will the second cup which is now 2/3rds filled be able to float in the first cup that is now only 1/3rd filled? Most of the students will agree that it will not but watch the surprise on their faces when you actually try it!



This demonstration can really help with an understanding of Archimedes' principle if a line is drawn at the starting level of the water in the first cup. Because the disposable tumblers are so light no appreciable water will be displaced when the second empty tumbler is placed on top of the water and floated. Therefore, the water level remains basically in the same place. During the second try when the second cup is 1/3rd filled, students should be able to observe that the water in the first cup is displaced (rises) to its original position AND that the second cup will sink until its water level is essentially equal to the original mark and the water in the first cup. Finally, when the second cup is filled with 2/3rds of the original water, students should notice again that the water in the first cup will rise to its original level and the second cup should sink until its water level is even with the water level in the first cup.

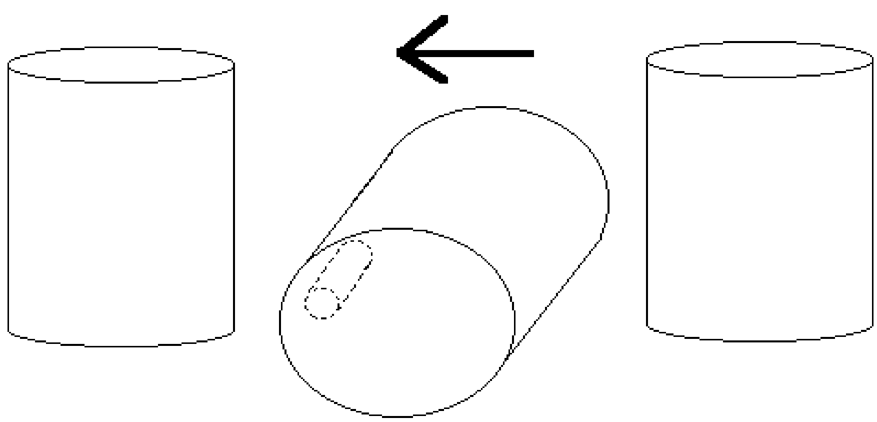
This is a good vivid example that floating objects are buoyed up with a force equal to the weight of the water that they displace. Since the disposable tumblers are nearly weightless compared to the water that we are working with, the weight of the floating object is equal to the weight of water it contains. Therefore, it always floats so that the water level inside is equal to the water level outside. Since the volume of water that has been removed from the first cup is the difference between the present water level and the original mark, the water will always rise to its original level when the other glass is floated on top.

BATTERY OPERATED CANS

This is a great demonstration that provides a chance for teachers to talk about science and the way that it works. All you need is three coffee cans (or similar round cans) with tops to keep students from seeing inside. Mark the outsides of two of the cans with a strip of tape running from top to bottom and place them about 50 cm apart. Ask the students to observe what happens when you place the third can on its side midway between the other two. When you put it down, it rolls towards one of the cans. Next ask the Students to c what will happen when you turn both of the original upright cans around 180 degrees. Then put the third can down and let them observe it roll in the opposite direction. Ask them to predict what might happen if one of the two upright cans faces one way and the other faces the opposite way. Put the third can down and let them see that it does not move in any direction.

Ask the students to develop a theory as to why the can moves the way it does. Ask then to think of some other experiments that might be helpful in figuring it out. Try some of then if you have time. After the students have some hypothesis as to how things are working, give them the hint: "It is battery operated." See if some students have to change their minds.

Explain to students that this is really the scientific process. Scientists make (1) observations of things. They try and figure out what is happening. They try and make several other observations. From these observations they try and (2) predict what is going to happen. After they have taken a number of observations they try and (3) form a theory to explain their observations. Finally they (4) test the theories. Your students may have developed more than one theory as to how things are working (although I think most will be convinced that magnets are involved some how). Scientists also often develop more than one theory to explain what has been observed. (PS. Scientists test their theories to see if they are WRONG. Scientists do NOT prove things correct, they try and disprove things.)



How do scientists choose between theories? The one that best explains what has been observed is generally the accepted one. If two or more theories explain the observations equally well then Ockham's Razor is used. This is the idea that if two, theories equally explain the facts then the simplest theory is generally more likely valid. Ask student if there might be an even simpler explanation of their observations. Then perform the ultimate experiment and take the lid off the can that has rolled back and forth and show them how things have worked. Inside have a AAA battery (thus battery operated) glued to one side. The teacher has simply set the can down so that the battery inside has made the can roll in a desired direction.