The Art of Performing Demonstrations in the Classroom

Students of today's generation have grown up surrounded by an extremely interactive and stimulating world, computers and computer generated games are the norm in almost very house hold across America and the days of standing inform of a class of students and telling them about science will no longer work, you have got to reach out and grab students attention with stimulating and interactive demonstration on a daily basis. From what I have discoed from my 14 years in the classroom is that students who are constantly exposed to daily demonstrations become higher level thinks and develop better question skills, they become more involved and are more excited about the class. Students look forward to each class in anticipation of what is going to happen next.

Why do demonstrations?
- To arouse curiosity and stimulate student interest.
- To show the application of concepts and to reinforce the learning process.
- Demonstrations are fun, and they bring a positive atmosphere to your classroom.

What makes a good demonstrator?
- Someone who is enthusiastic and love what they are doing
- Someone who has a sense of humor
- Someone who can be a "showman" or is comfortable in front of large groups

Important notes for all
Even if you have seen a demonstration yourself, it will be new to the students.

Do not be afraid to make a fool out of yourself, your students already believe that you do that everyday so now have lessen up and have fun with each demo. As much as we hate to say it is so, teaching is showmanship and you cannot be afraid to 'ham it up.

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Boiling Water in a Paper Cup

A paper Dixie cup is filled half way with water and then placed on a ring stand. Students are asked what they think will happen to the cup and the water if you place a bunson burner under the cup and begin heating the water. After students discuss what they think will happen, the demonstration is conducted. The cup will not burn and the water will begin to boil. The water has a boiling point that is lower than the combustion point of the paper cup. Boiling is a cooling process and removes the heat from the paper so it can't get hot enough to burn until all the water has boiled off. Native Americans used to weave boiling pots out of reeds and leaves.

Dollar Drop

This is a great demonstration that I use to make a point about the proper way to operate a stopwatch and who should be the timer during an experiment in order to eliminate as much error as possible. A dollar is dropped between the open fingers of a student. As the dollar bill is released, the student is to catch the falling bill with their fingers. It is almost impossible as long as the student does not get a jump-start. The reaction time of the student is not quick enough to overcome the acceleration of gravity. Try dropping the dollar bill between your fingers and you always catch it. How come? Because you know when you let go! I use this demonstration to discuss the importance of proper timing during lab activities. The person operating the lab equipment should also be the timer because they are the only individual who knows the precise moment the activity begins.

Hoop Pull

A piece of chalk or a pen is balanced on the top of an embroidery hoop that is balanced on a flask. The hoop is to be removed so that the object (chalk) falls into the container. The secret is the pull the hoop out and not push the hoop out. To do this demonstration, one has to swing at the hoop missing the near side and grabbing the far side as one swings across his/her body. The demonstration makes the observers "believe" the demonstrator is hitting the hoop off the set-up but in reality s/he is pulling it. A volunteer is asked to come up and repeat the demonstration and inevitably (if the demonstrator has successfully tricked the audience) hits the wrong side of the set-up causing the object to shoot into the air. This demonstrates the concept of inertia in several different ways.

Windbag

Experiment: One Breath Bag - Windbag

Here's the challenge: How many breaths would it take to blow up an 8-foot long bag? Depending on the size of the person, it may take anywhere from 10 to 50 breaths of air. However, with a little practice you will be able to inflate the bag using only one breath!

Materials:
The "bag" is actually a long plastic bag in the shape of a tube. While you can purchase "Windbags" from toy stores that sell science experiments, you can make your own long bag using a product called a Diaper Genie refill. It's part of a diaper system that parents use to store diapers. A Diaper Genie refill is commonly available at any major department store.

Experiment:

1. Tie a knot in one end of the bag. Invite a friend to blow up the bag keeping track of the number of breaths it takes. Then, let all of the air out of the bag. Explain to your friend that you can blow up the bag in one breath.
2. Have your friend assist you by holding onto the closed end of the bag. Hold the open end of the bag approximately 10 inches away from your mouth. Using only one breath, blow as hard as you can into the bag. Remember to stay about 10 inches away from the bag when you blow.
3. Quickly seal the bag with your hand so that none of the air escapes. Tie a slipknot in the end of the bag, or let the air out and try again.

How it works:
The long bag quickly inflates because air from the atmosphere is drawn into the bag from the sides along with the stream of air from your lungs. Here's the technical explanation: In 1738, Daniel Bernoulli observed that an area of low atmospheric pressure surrounds a fast moving stream of air. In fact, the faster the stream of air moves, the more the air pressure around the moving air drops. When you blow into the bag, higher pressure air in the atmosphere forces its way into the area of low pressure created by the stream of air from your lungs. In other words, air in the atmosphere is drawn into the long bag at the same time that you are blowing into the bag.

Additional Information:
Fire fighters use this principle to quickly and efficiently force smoke out of a building. Instead of placing the fans up against the doorway or window, a small space is left between the opening and the fan in order to force a greater amount of air into the building. Fire fighters call it "Positive Air Flow.

Heavy Weight Champ

Two different sized masses are tied to a 1-meter string. A large mass such as a 1 kg or 0.5 kg mass is tied to one end and a small 0.05 kg (50g) mass is tied to the other end. The apparatus is setup such that the small mass is held in one hand and a long rod is held in the other hand. The string runs horizontally from the small mass over the rod and then horizontal to the large mass. The idea is that the small mass is released allowing the system including the large mass to begin falling. Students are asked to predict what will happen to the system once the small mass is released, or better yet, to predict whether or not the large mass will pull the whole system to the floor? The answer is that as the large mass falls, it begins pulling the small mass towards the rod but the small mass also begins to fall giving the small mass angular momentum around the rod. The small mass quickly wraps itself around the rod causing the system to stop falling. This demonstration can be used to illustrate several different concepts in physics including free fall, gravity, angular momentum, and conservation of angular momentum.

Jug-of-Fun

This is a MUST DO demonstration. Methanol has a lot of stored chemical potential energy and this demonstration is designed to release the energy from the methanol within a large container. Pour a small amount of methanol (approximately 100 mL) into a large 5-gallon water jug. Spin and shake the jug several times in an effort to vaporize the alcohol inside of the jug. Pour any remaining liquid from the jug. Drop a match inside the jug to observe very impressive results as the energy stored in the methanol is released inside of the jug with a spontaneous reaction.

I like to use this demonstration to talk about the modern combustion engine. The energy released from the methanol takes many different forms including light, sound, heat, and mechanical energy. Combustion engines are relatively inefficient since they are really only designed to take advantage of the mechanical energy and not the other forms of energy. The experiment cannot be repeated with the same jug for some time because the oxygen has been used during the reaction and the jug will need to sit so more oxygen can diffuse back into the jug. A modern engine has valves that are designed to push the" bad air" out and pull in new fresh air so the reaction can start again. Turn the jug upside down and a small amount of liquid will pour out, this liquid is water from the reaction.

WARNING! The jug cannot be used repeatedly year after year, the quick release of energy causes rapid expansion of the plastic jug and over time small cracks will appear in the jug weakening the container. It is advisable that the jug be replaced yearly and any time small surface cracks can be seen.

Gummi Bear Demo

This is another must do demonstration that could be used as an introduction to a variety of topics. I like to use this demonstration leading into discussions of energy. This demonstration produces a LOT of smoke and should be done in a well-ventilated room or better yet, under a fume hood. Clamp a 25 x 150 mm Pyrex test tube vertically up a ring stand. Pour in about 10-15 grams of potassium chlorate ($KClO_3$) Using a Bunsen burner, play with the flame around the bottom of the test tube until the potassium chlorate begins to melt. Place the burner back on the table and drop a gummy bear into the test tube, STEP BACK QUICKLY. NOTE: The teacher should be wearing goggles and the students should be at least 10-15 feet away. The potassium chlorate is a strong oxidizing agent. The reaction is extremely exothermic with a beautiful violet blue flame. The sugar in the gummy bear reacts with the oxygen given off from the potassium chlorate to create carbon, carbon dioxide, water, and a ton of energy.

$2\ KLO_3$ -----> $2\ KCl + 3\ O_2$ and $3\ O_2 + C_{12}H_{22}O_{11}$ -----> $9C + 3\ CO_2 + 11\ HOH$ + Energy

The size of a Joule

A joule is a very abstract concept. One demonstration I like to do in order to give students a visual of a joule of energy is to drop a 0.1 kg (100 gram) mass at a height of 1 meter onto a can. The can is dented and then the demonstration is repeated with a 1 kg mass that has ten times the energy resulting in 10 times the damage.

Number "1" Water Bottle

This is just a fun demo to have sitting around the room. A 2-liter soda bottle has a small pin-size hole near the bottom of the container. The bottle is filled with water and a small amount of dye is added to the water to give the water a yellow color. Place the top back on the bottle to seal the system and prevent air from entering into the bottle. As long as the top is in place, the water remains inside the bottle. If the cap is removed, the water will pour out of the hole at the bottom of the container since air is now allowed to enter the system. A label is placed on the bottle to create curiosity among the students, I like to use:

Warning!

Striped Skunk (Mephitis mephitis) **Urine**

Not for use in normal indoor rooms, must be used in well-ventilated rooms or outside only. If container is opened inside, evacuate room and allow it to air out for 2-3 days before re-entering. Do not get on hands or clothing, Urine will stain clothing and skin as well as causing extreme odor that cannot be washed off. If urine gets on clothing, it is best to dispose of clothing by placing the clothing in a sealed container. If urine gets on skin, immediately flush with water and scrub with dish soap, any odor will remain for several days

Swinging Lights

Purpose:
Compare alternating and direct current.

Materials:
Two bi-colored LEDs
Wire
Batteries and battery holder
5 watt X *600* ohm resistor

By swinging a bi-colored LED in a circle, you can make the distinction between AC current and DC current. Caution: swinging objects have been known to collide with objects that have not been cleared from their path. Make two LEDs as follows: solder one end of an extension cord to a terminal on the LED to make the AC current LED. Solder the other end of the cord to a 5-watt resistor, and then solder the resistor to the other end of the LED. Plug it into wall outlet; do not touch bare wire if you forgot to wrap ends. To make the DC current LED, connect two wires to the DC current LED and attach the bare ends of the wires to two 1.5-volt dry cells.

Book and Paper Drop

A book and piece of paper are dropped together to show air resistance. The paper can be held in different positions, flat or vertical, and then dropped the same time as a book. When the paper is held flat the book hits the floor first because the effect of air resistance is greater on the paper. In the upright position the paper is less effected by the air resistance and should tie with the book. Try crumpling the paper and dropping it at the same time as the book and again the two should tie.
An uncrumpled piece of paper can be placed on top of a book and dropped. The book pushes the air out of the way and the paper falls with the book. Students will ask to see the situation reversed, book on top of the paper, and to their amazement the paper and book fall just as fast as before. I am always amazed at the number of students that think that the book should float in the second situation.

Chain Saw

Purpose:
• Demonstrate centripetal force and rotational inertia

Materials:
Toilet bowl chain
Drill with a speed of at least *2000 rpm's*
Sound disk mounted on a drill

Make a wooden disk to hold a circular chain on a lathe. If you do not know *how to* use a lathe, ask *someone* who teaches industrial technology to give you a hand. The disk should be made in such a way that the chain fits snugly on a cut groove. The disk should be mounted on a drill bit adapter. When the chain is placed on the disk, hold the drill at a slight angle so that the disk and chain are not perpendicular to the floor but close to it. Pull the trigger, let the drill rev up, turn the drill so that it is perpendicular to the floor, and then jerk quickly away from the chain. The chain will roll across the floor and if anything is in the way like books (hint, hint), the chain will jump over them until it bangs into the wall.

Explanation: Each link in the chain has a velocity that is the same as its neighbor's speed but in a different direction. Because each link tries to move in its own direction, it will cause the link following behind to change its path of motion. The net effect is that every link wants to go straight but there is a net acceleration perpendicular to motion, centripetal force.

Egg Throw

Purpose:
• Show the relationship *between* impulse *(force* though time) and change in *momentum*.

An egg can be thrown into a *sheet* as hard as possible and it will not crack; however if you lightly toss the egg at the wall, it breaks apart.

Explanation: The change in *momentum* of the egg is equal to the impulse, the time that the *force* is applied. With the *sheet, the force* is applied through a longer time and hence the *force* is smaller than the wall, which applies a large *force* in a short time.

Electric Pickle

A pickle is used as a salt bridge and "electrocuted" with AC current. WARNING: High voltage electricity can cause electrocution or death! This device is plugged into a 110 AC outlet, the pickle and the leads CAN NOT be touched unless the cord is removed from the outlet. After the smoke clears, unplug the pickle and as an added finale, take a bite out of the pickle.

Hooter Tubes

A long cardboard tube is fitted with a stainless steel screen, the screen is heated with a blowtorch and once the heat is removed the tube begin to sing like a whale. Air is pulled through the tube and as the screen cools it, the resulting vibrations create a standing wave in the tube.

Singing Rods

An aluminum rod (36" x 1/4") is used to create a standing wave. Hold the rod in the center by one hand and then using the other hand, tightly grab the rod and slide away from the center. The finger should slip on the rod setting up a vibration that leads to a standing wave and the rod begins to sing. A small amount of resin can be used to help your finger slip and slide along the aluminum rod. Try holding the rod at the 1/4 point, the 1/8 point, and if possible the 1/16 point. Note the change in pitch.

Water Rockets

Purpose:
• Demonstrate Newton's Third Law and conservation of momentum.

Materials:
Toy water rockets
Two- or three-liter soda bottle
Rubber stopper
Long rubber *hose*
Compressed air

Toy water *rockets* can be purchased at almost any toy *store*. Basically, fill the *rocket* with a small amount of water, then pump it up with air, and watch it go! I have discovered a new twist to this old toy. Take a long *hose* and insert a rubber stopper in *one* end, then attach the *other* end to an air jet. The stopper has to fit into the soda bottle, take a soda bottle (not glass) and fill half way or less with water. Place the rubber stopper into the soda bottle and hold tight. Have *someone* turn on the air, hold on as long as you can and say the following chant as you let go "DUCK!!" Caution: My *room* has *some* rather large unexplained holes in the ceiling, do not aim straight up!!

Explanation: For *every* action there is an equal but *opposite reaction*. As particles *escape* out of the *bottom* of the *rocket,* thrust is produced from the *pressure* inside the container. Thrust is the *reaction* from the particles pushing off the top of the container that propel the *rocket* in the *opposite* direction. Water and air push the *rocket,* and the *rocket* pushes air and water. A *good* question to ask the students is: "Why did I add the water and air instead of just air?" The answer has to do with *conservation* of *momentum* and can be difficult to explain. The *velocity* and mass coming out of the container is equal to the *velocity* and mass of the container. Air alone has a small mass compared to the mass of the water.

Scud Missile

Purpose:
• Demonstrate Newton's Third Law
• Put a hole in the wall and *become* the students' favorite teacher

Materials:
2 liter or 3 liter soda bottle
Launch pad or
5 gallon distilled water container and cap
Launch system spark plug *100-200 feet* of wire tesla *coil*

This is truly *one* of my *favorite* demonstrations. I heard about this demonstration from my department head that had seen George Haugue do it in his "normal" exciting manner. My department head looked at me, smiled, and said, " This is one demonstration I will never tell you how to do, it is forbidden." It was that *moment* that I know I had to find out what the scud missile was, and I had to do it. Take a two- or three-liter soda and wrap it with scotch tape. Then fill it with *oxygen* gas. Pour a small amount of denatured alcohol into the container and cap it. Leave the container sit for at least *24* hours. Make a launch pad to aim the missile at about a *30°* angle or more. It is best to do this *outside*. (If not, aim at a lab safety chart in the *room* for a few laughs.) When you are ready to launch the scud, take the cap off and place the missile on the launch pad. Have students move to the opposite side of the *room* if you are doing this indoors. (I do not recommend doing this indoors.) Ignite the *rocket using* a "long" flint stick *(12* inches long or *more)*. Caution: Do not reuse scuds!!

New Twist (Danger!). For those who are more daring, the same demonstration can be performed with a five-gallon container. Make sure you wrap the container with lots of scotch tape (several rolls). The five-gallon jug can only be done *outside!!* Build a launch pad that 1S anchored to the ground very securely: then attached a spark plug at the point where the mouth of the jug will sit when on the launch pad, but not inside the jug. Attach a long wire that 1S at least *100 feet* in length to the spark plug, and ignite the *opposite* end of the wire with a tesla *coil*. A couple of my launched containers are still in space on their way to Pluto! I love serendipity!

The Oreo Cookie

This demonstration is comparable to the famous Thermite demonstration but is somewhat safer. The demonstration brings up a very interesting discussion on the use of various fire extinguishers used in years past and the correct use of these extinguishers. The question before the demonstration becomes, "What happens to a fire if you spray it with CO_2?" We have all been taught that carbon dioxide is the ultimate weapon in extinguishing a fire, this is not true.

A block of dry ice is set-up such that it has a cavern large enough to hold a pile of magnesium in its center. The block of dry ice is placed on a demonstration table and the cavern is filled with magnesium turnings. A second block of dry ice stands ready to be placed over the reaction once it begins. Using a torch, begin heating the magnesium until it ignites; quickly cover the first block of dry ice with the second. The blocks of dry ice glow orange and then red until the reaction is complete. The reaction demonstrates that given enough heat, CO_2 converts to carbon and oxygen. The oxygen is used in the reaction to convert the magnesium into magnesium oxide.

$2\ Mg + CO_2 \text{ -----> } 2MgO + C$

Leaky Faucet

A large faucet like apparatus is built using PVC irrigation tubing and is attached to a large container capable of holding dry ice and water. My apparatus was made out of a two-liter soda bottle and a large plastic container glued together. The top can be opened to drop in the dry ice and then sealed. Fill half of the container with water and then add some dry ice. Make sure you seal the container after you drop in the dry ice. Using a soap (bubble) solution, dip a cup on the end of the faucet and bubbles will begin forming and falling from the faucet. CO_2 is denser than air so the bubbles fall to the floor.

Balloon in flask

This demo works best by setting it up ahead of time and then asking a student to replicate the activity without telling the student how it was done. A small amount of water (1 mL) is placed in an Erlenmeyer flask, which is then heated to a boil. The heat is turned off and then quickly a balloon is placed over the top of the flask. Soon, the balloon begins to expand into the flask as the air in the flask cools; the flask can be placed in a water bath to speed up the results. The explanation is that the hot water vapor created by the boiling water expanded and took up more volume than the cool air.

Similar experiments using the same principle: Sucking an egg into a flask, crushing a can, crushing a soda can.

Floating Soda Can

Diet Dr. Pepper and regular Dr. Pepper are placed in an aquarium of water. Diet Dr. Pepper floats and regular Dr. Pepper sinks. Regular Dr. Pepper is denser than Diet Dr. Pepper. The question becomes, which can has the greater buoyant force acting on it? Since the regular Dr. Pepper sinks, it displaces more water than the Diet Dr. Pepper and has the greater buoyant force acting on it. Most individuals think that the can that floats has a greater buoyant force but they fail to understand that the buoyant force is equal to the volume of water displaced. An object that floats displaces a volume of fluid equal to the weight of the object. An object that sinks displace a volume of fluid equal to its volume creating a buoyant force that is less than the weight.

Magic Air Bubble

Stopper the end of a long glass tube, and then fill the tube about half way with colored water. Fill the rest of the tube with ethanol or methanol and then stopper the other end. Begin turning the tube end over end. As the two liquids mix, attractive forces between the molecules will cause a reduction in total volume as the two liquids mix and the mixture will take up less space.

Coin on Hanger

A coin is balanced on a metal coat hanger, which is then swung around. To the amazement of all, the coin remains on the hanger. The hanger applies an inward force that pushes the coin inward or as we should say the coin experiences a centripetal force not a centrifugal force, which is a fictitious outward force that does not exist.

Grease fire

Another MUST DO demonstration. Attach a small iron ring and a small aluminum pie pan to the ring stand. Fill the dish with wax paraffin and heat the paraffin to melting point, then ignite the melted parifin and remove the heat from below. Using a wash bottle, squirt the fire; a huge fireball will rise from the paraffin. Students should be 6 meters away from this demonstration. This is a great example of why you should never put water on a grease fire at home. The water atomizes the grease causing it to ignite spontaneous.

