MSU Science Theatre

Demos

A list of all demos and instructions for how to run them for MSU Science Theatre.

Acetone and Styrofoam

Acetone and Styrofoam is demonstration of a simple chemical reaction that is very portable and effective for stage shows like on the UP trip.

Materials

- Two large opaque containers (**must be made of HDPE to avoid a reaction**)
- Acetone
- Many large pieces of Styrofoam

Safety Precautions

This demo produces a sticky flammable mixture of dissolved Styrofoam and acetone. Please read the Fire Safety section of the Demonstration Safety page before performing this demonstration. Please properly dispose of the accumulated chemical waste, once the container is too full for the demo.

Demonstration

1. Add acetone to one of the containers until it is about 10% full (this should be done ahead of time).
2. Leave the other container empty.
3. Call for a volunteer from the audience.
4. Explain that you will be holding a competition to see who can stuff the most amount of Styrofoam into their container in 60 second.
5. Guide the audience member to the empty container.
6. Start the competition and nonchalantly add Syrofoam to the container. It will dissolve in the acetone and significantly shrink in volume.
7. Eventually the audience will notice that the Styrofoam is disappearing. Then admit to you crimes and explain to the kids how it works.

Bed of Nails

https://www.youtube.com/embed/cWZ-puu1keM

Materials

- Two blast shields
- Bed and blanket of nails
- Wooden foot and back supports
- Wood leg coverings (x2)
- Thick gloves for sleeper (x2)
- Goggles for the sleeper
- Sweatshirt for the sleeper
- Sledgehammer
- Metal cinder block holders (x2)
- Plastic tarp
- One cinderblock for each performance
- One backup cinderblock per 3 performances

Safety Precautions

Science Theatre demonstrators must keep the safety of themselves and their audience in mind at all times. All Science Theatre demonstrators must have read through the Safety Training page. The ST Safety Box with first aid kit, fire extinguisher, etc. should always be available to demonstrators. Always wear safety gloves, glasses, and a labcoat if handling chemicals; always perform potentially dangerous demonstrations at a safe distance from the audience; and always keep a very close eye on any volunteers you call from the audience. Safety is extremely important for this demonstration. If you have an audience member stand on the paper cups, hold their hand to steady their balance and instruct them to step on and off slowly. Ensure proper body support for participant in bed.

Between the box, the wooden coverings, the gloves, and the goggles; the sleeper's entire body should be covered before the cinder block is put down. Keep crowd at a safe distance and behind blast shields. Make sure to tell people not to try this at home! Never invite an audience member to lie on the bed of nails.

Preparation

Make sure the presenter who will be using the sledgehammer has practiced breaking the cinder block so they know how much force to use. Use as little as possible for the safety of the sleeper! Set up the blast shields between where the bed of nails will be and the audience, although you may choose to keep the bed of nails hidden at first for effect. Lay down the tarp behind the blastshield, where you will put the bed.

Demonstration

For young audiences, you may want to introduce the bed of nails with a simple demonstration of pressure. Have an audience member step on one paper cup to demonstrate applying a force to a small surface area. Next, setup an array of at least 36 paper cups and place one of the black wooden leg covers on top of them. Invite another audience member to slowly and carefully step onto the board and stand there. Make sure they step onto the middle of the board, not an edge. The larger surface area of the array of paper cups should sustain their weight.

Next prepare the bed of nails. First get out the bed itself (the bed is the one without the extra wood edge on the base, which are handles) and show it to the audience. Lay the bed of nails down on the tarp. Set up the yellow wooden headrest and footrest.

Before lying down, the sleeper should take the following safety precautions. They may seem like more than is necessary, but safety is extremely important for this demonstration.

- Wear googles
- Wear thick gloves
- Wear sweatshirt

When the sleeper is ready to lie down, follow this procedure:

- Have the sleeper slowly lie down on the bed of nails, place head in headrest, and place feet in footrest.
- Another demonstrator should then slowly hand the sleeper the blank of nails and the sleeper should lower it onto his/her chest and hold it securely by its handles (the extra wood at the edge of the base).
- The other demonstrator should place the two black wooden pieces to cover the sleeper's legs.
- The other demonstrator should use the large black box to cover the sleeper's head and neck.
- The two metal rods should be placed in the center on top of the blanket of nails and the cinder block placed on top of it. Don't leave the cinder block on the sleeper's chest for too long - it's heavy!
- Have the audience count down for you and then break the brick with the sledgehammer. This doesn't take all that much force - make sure you have practiced beforehand! This is helpful so that the sleeper is aware of the timing of the hit.

What to Say

The bed of nails portion of the demonstration can be performed with a little humor, for young audiences. It might go something like this:

> Sleeper: ...yawn...
> Performer: Are you tired?
> Sleeper: Yes, we've done so many demonstrations today. I'm ready to go to bed.
> Performer: Well, you're very lucky, because I've brought a bed with me... put on your pajamas (sweatshirt)... here it is, a bed of nails!
> Sleeper: A bed of nails? I'm not going to sleep on that, it would hurt!
> Performer: No, it won't hurt at all! Back me up, guys, can you explain why it won't hurt?

Make sure the audience can explain the relationship between pressure and surface area

Sleeper: Ok, I guess it doesn't sound that bad. Yah, it doesn't hurt at all! But I'm still cold.
Performer: Well, you're even more lucky to have a friend like me, because I've also brought a blanket of 1000 nails! I know your hands are cold, too, so I've also brought these gloves. I even have a mask (black box) to shut out the light for you.

After all the safety equipment is on, the sleeper can snore loudly

Performer: Ok, he/she's asleep. Now we can try a little experiment. Since he/she's such a good friend of mine and because we're professionally trained scientists, I can try putting a cinder block on top of him. This cinder block is heavy and applies a lot of force, but you all know that it won't create very much pressure because of the large surface area of all the nails. Look, he's still sleeping! I can try applying even more force with a sledgehammer!

Now help the sleeper get off the bed.

Performer: How was your nap?
Sleeper: Great, but I had a strange dream that I was being stepped on by an elephant. Of course, it didn't hurt very much!

Why This Works

Several physics principles are involved here. The force from any one nail is reduced by spreading the weight over many nails. The inertia of the blocks partially protects the person below from the force of impact. The smashing of the blocks absorbs much of the energy of the blow. If there were only one nail, the entire force created by the weight of the body would be distributed over the very small area presented by the tip of the one nail. In this case, the force per unit area, that is, the ratio of the force to the area, would be very great (because the area is small) and would likely result in piercing of the skin, and injury.

Bernoulli's Principle

This is one of our most commonly performed demonstrations. It is easy to perform, easy to understand, and the topic matter is easily adjusted for all grades and age levels.

Materials

- Shop Vacuum/Blower with Hose
- Ribbon Wand
- Beach Ball
- Round-bottom Plastic Bottle
- Optional: Roll of Toilet Paper

Safety Precautions

Please read the Physical Demonstration section of the Demonstration Safety page before performing this demonstration.

Demonstration

Preparation: Blow up the beach ball. Make sure the hose is in the blower side, and plug it in. Make sure that there is a small amount of water in the soda bottle.

1. Choose a volunteer from the audience and have them hold the ribbon wand. Explain to the audience that you will be making the beach ball fly by using the blower, but you want them to guess if the air will be blowing over or under the beach ball. Take a vote to see how many think the air should blow over or under.
2. Turn on the blower on the "LOW" setting. Hold the hose at an angle slightly above 45 degrees, and lift the ball into the air stream. It will lift off into the air, and it will float! Have

the volunteer hold the ribbons first under the ball, and see that the air isn't blowing underneath! Then, have them hold the ribbon wand over the ball to see the ribbons move, and show that the air blows over the ball!

3. Let the volunteer return to their seat. Turn off the blower, and explain the demonstration.
4. Call on a new volunteer, and have them hold the soda bottle in one hand. Turn on the blower on the "HIGH" setting. Holding the hose at about a 70 degree angle, have the volunteer place the rounded side of the bottle into the air stream. It should float in the air! After showing this for a minute, turn off the blower and explain.
5. Optional: To end the show, call up one more volunteer. give them the ribbon wand, and have them hold it sideways, turned towards the audience. put the toilet paper roll on the wand, with the roll over side towards the audience. Turn on the blower on the "HIGH" setting, and aim above the roll a little above a 45 degree angle. The roll will unravel into the audience!/li>

Why This Works

Bernoulli's Principle states that if you have an object inside of a fluid, then the object will move to the part of the fluid that exerts the least amount of pressure upon it. To understand what this means, first look at the beach ball. Before we use the blower, the air is still around the ball. This means that the Air Pressure, or the force the air exerts across all sides of the ball, is equal on all sides. Because it is equal on all sides, the net force will cancel out, leaving the force of gravity as the only force on the ball and pulling it down. When the blower is used, the air above the ball is now moving. The moving air above the ball no longer pushes equally in all directions, and instead pushes mostly in one direction (forward) and weakly in the direction of the ball (downward). The air under the ball is not moving, and so the force it applies on the ball (upward) is now much stronger than the downward force of air from above and the force of gravity. The Lift, or the net upward force, holds the ball up into the moving air stream and keeps it suspended.

The bottle helps to get across how useful this knowledge is. Even though it has more mass to it, we can still get it to hover in the air by using this concept. The curve of the bottle's base allows it to float, much like the curve on a plane's wing will allow it to fly. A plane is able to fly thanks to utilization of this concept, along with a lot of important engineering to make the plane able to ascend, descend and turn in the air.

Binary Counter

This a wooden construction that explains how binary numbers work.

Candy Conflagration

https://www.youtube.com/embed/JSvZ_wuDK9w

This demonstration is an exciting way to show the parts needed for a combustion reaction. There is a lot of possible information to include in this demonstration, making it versatile in the age ranges it can be used with.

Materials

- Test tubes
- Ring stand with ring clamp
- Blowtorch
- Scoopula
- Sodium Chlorate or Potassium PerChlorate salt
- Small candies (Nerds, Sour Patch Kids, Gummy Bears, etc)
- Goggles
- Heat gloves

Safety Precautions

Please read the Fire Safety section of the Demonstration Safety page before performing this demonstration.

Demonstration

1. Using the scoopula, scoop some of the salt into the test tube. fill the test tube no more than a quarter inch with the salt; too much salt and the demonstration won't work as well. Aim the test tube perpendicular to the audience. If you aren't at least 10 feet away from the audience, a blast shield is required.
2. Place some of the candy onto the scoopula, making sure that it is in small enough pieces to fit into the test tube. Set nearby.
3. Ask the audience to name the three things needed for a fire. After you get the answers, explain the purpose of the blowtorch (Heat), candy (Fuel) and salt (Oxygen).
4. Put on the goggles and heat gloves, and start heating the salt with the blowtorch. As you heat the salt, be sure to move the flame of the blowtorch around. If you keep it on one spot for too long, it may melt the glass!

5. When you see that most of the salt is melted, ask the students for a countdown starting at 5. As they countdown, pick up the scoopula, and when they reach one pour the candy into the test tube.
    - If the reaction does not start immediately, continue to heat the test tube until it starts.

6. After it finishes, let the test tube cool for a few minutes, then remove it while still wearing the hot gloves. It can be thrown away.

Why This Works

Chemistry

Combustion Reactions are common reactions where we see heat as a result of the reaction. In order to have a combustion reaction, we need to have a fuel source, an Oxygen source, and a heat source. The fuel source, in this case, is the candy that we add to the test tube. Candy has a lot of sugar in it, and sugars contain a lot of energy in them. Our Oxygen source is the salt that we added at the beginning. Sodium Chlorate and Potassium PerChlorate both have a lot of extra Oxygen stored in them. This extra Oxygen is released when we heat the salt up and melt it. The blowtorch was the heat source, and by providing enough heat for the salt to melt, we can then add in the candy and watch it burn! As it burned, you should see a color to the flame in the test tube. The color is there because of the salt! Sodium gives off an orange flame when heated, and Potassium gives off a purple flame.

Biology

For a combustion reaction you need three things: a heat source, like the blowtorch, an Oxygen source, and a fuel source. The (Per)Chlorate salt was our oxygen source, since it had a lot of extra oxygen stored in it which we released by heating it. The candy that we added was our fuel source for this reaction. Candy has a lot of sugar in it, and that sugar has a lot of energy stored inside of it. The small amount of candy added to the tube would have contained a little more than two Calories of energy in it. We use a capital C on Calories, however, because it actually stands for kilocalories. In other words, our two Calories is actually two thousand calories! Our bodies can use this energy, however, so that we can walk, talk, think and experience the world around us!

Additional Information

The amount of energy released in using 10 Nerds is roughly equivalent to the following:

1. The amount of body heat the average adult produces in 2.5 minutes!
2. The energy needed to run a 120 Watt bulb for 80 seconds!
3. The energy it would take to lift a medium sized tomato 5.8 miles into the atmosphere!
4. The energy needed to lift 10 US dollar bills (any monetary amount, they all weigh the same) from the ground into orbit!
5. The energy needed to lift a honey bee larvae (first born, roughly 0.003-0.009 grams) from the earth to the moon (approximately 230,100 miles)!

Crush the Can

https://www.youtube.com/embed/VfFW_SGjJp0

Materials

- An empty aluminum can
- a small aquarium filled with water
- heat resistant gloves
- propane torch
- a ring to hold the can
- small blast shield

Safety Precautions

Refer to the Demonstration Safety page.

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Preparation

Before the show, fill the aquarium 2/3 or so with water. It's an awkward size and shape, so you'll need a larger sink if you can find one. If one is not at hand, it may be necessary to use a smaller container to collect water which can be poured into aquarium. It would be helpful to assemble the torch by connecting the fuel container to the torch by simply twisting it tightly, but do not turn it on yet. Put the shield in front of the aquarium.

Demonstration

Fill the can with 3 centimeters of water. It is best to listen to the water as you shake the can gently. You should hear and feel some water moving in the can, but not an amount that makes it substantially heavier.

Put the can through the ring. Put on the heat resistant gloves, attach the torch to the fuel container if not yet done and turn the switch on the side of the torch to its "on" position. Holding the can with the ring and the torch with the other, position the torch so that it is aimed toward the bottom of the can, but not your fingers, your body, or the audience. Holding down the trigger of the torch begin to heat the bottom of the can. Try to evenly distribute the heat, not focusing on one spot, so that you do not burn a hole through the can.

Soon the water will begin to boil (maybe a minute or so). You will feel the water boiling, possibly hear it, and begin to see substantial amounts of water vapor leaving the can. Once it begins to boil, wait awhile, maybe 15-30 seconds, continuing to heat evenly. Now putting down the torch, move the can toward the aquarium. In a smooth motion, making sure not to spill any remaining water on the audience, turn the can upside down into the water. The can must be upside prior to entering the water but don't do it too soon. The can will implode if you did it right. Let the can sit in the water. Turn of the torch, detach it from the container and take off the gloves.

What to Say

Ask the audience what they think will happen if you heat a can of water. If the answer is not given, explain that eventually the water will boil and water vapor will fill the can, escaping through the opening. Then ask them what they think will happen if they put a can full of water vapor into a cold container of water. Now begin the demo. As you set up the safety equipment, comment on why you are doing what you are doing-gloves to protect you from the flame, the shield to protect the audience, etc. As the can heats, explain what's going on- the water molecules are gaining energy. When it begins to boil comment of the water vapor (it's not steam) that is escaping. When you are about to turn the can over, comment on the fact that much of the water is now water vapor and has either escaped or has filled the can and is moving around energetically.

After the can implodes, ask what happened. Tell them that when the can was placed in the water, the water vapor condensed into water. Say that this caused a change in pressure that happened so quickly the can imploded. Prior to entering the water, the can was being pushed from the outside by the air and the inside by the water vapor. Once in the water, when the vapor was quickly condensed, only the pressure of the water remained on the can, pushing inward. Because this change happened so suddenly, the can imploded.

Why This Works

When the can is heated it becomes filled with water vapor. This vapor occupies approximately 1000 times more space than it did as a liquid. When you turn the can over into the cool water the water vapor turns back to liquid water very quickly creating a partial vacuum in the can.

Demos

DNA from Strawberries

This is the classic DNA extraction experiment that uses some chemicals to extract a visible amount of DNA from strawberries. Currently there is no documentation for this demo.

Elephant Toothpaste

A classic chemical reaction that is easy and great for all ages.

https://www.youtube.com/embed/x9bKLO2wj6Y

Materials

- 30% Hydrogen Peroxide
- Potassium Iodide (KI) Solution
- 500mL Graduated Cylinder or Erlenmeyer Flask
- Soap
- Food Dye
- 50mL Centrifuge Tube
- Large Clear Bin

Safety Precautions

Please read the Liquid Chemical section of the Demonstration Safety page before performing this demonstration.

This demonstration requires: safety glasses or goggles, rubber or latex gloves.

Demonstration

Preparation

24 hours before the event, be sure to check if there is enough of the KI solution. If there is not, follow these steps to prepare it:

1. Get a 500g bottle of KI. Get a 1L beaker and a hot plate, and start warming 500mL of water on the hot plate set to medium.
2. When the water is hot, add the KI in increments, waiting for the previous addition to dissolve fully until adding more. Once all of it has been added, fill the 500G bottle of KI 2/3 with water, close it and shake it to get the last of the KI from the container. Pour this into the 1L beaker and stir.
3. Fill the KI solution bottles with the still-hot solution, close them, and let them cool to room temperature on a table or counter. Label the bottles with the month and year, and your initials.

Presentation

Note: do NOT handle the chemicals in this show unless you are wearing gloves and goggles.

1. Set out the clear bin with the graduated cylinder in the center. Measure out 100mL of the hydrogen peroxide into the cylinder.
2. Ask the audience if they have ever heard of hydrogen peroxide. Likely they have, and explain that it is sometimes used to clean cuts or for bleaching hair. State that the hydrogen peroxide we are using is ten times stronger than what they have at home, and it can be dangerous, so to not try this at home.
3. Add a small amount of liquid soap to the cylinder, and a couple drops of food dye. After doing so, swirl the cylinder to mix them in and point out that hydrogen peroxide reacts with light, so it is breaking down as we speak.
    - *Note: Be dramatic when saying that it is breaking down! Act like it is exploding the moment you say this, and give the audience a few seconds to laugh at your overreaction.*
4. Point out that it is a slow reaction, and show the catalyst that you will be adding in. Measure out 10mL of the catalyst using the centrifuge tube, and then ask for a countdown. Pour it in at the end of the countdown, and watch as it turns into a big pile of bubbles!
5. Use the rising steam from the reaction to introduce the term "exothermic". Finish by explaining how the catalyst made the reaction faster, using either the Hill Metaphor or the Race Metaphor for younger audiences.

Why This Works

Hydrogen Peroxide (H_2O_2) is a very reactive molecule, and breaks down into water and oxygen gas. When exposed to light it will break down, but this happens very slowly. This is why we include our catalyst, Potassium Iodide (KI). A Catalyst is a molecule that will help another reaction go faster, without being used up in the process. This means that at the end of the reaction, we could get back all of the catalyst that we used in the reaction, which we see as the yellow-brown discoloration in the bubbles.

The Hydrogen Peroxide reaction releases a lot of energy, which we see as the steam that is rising out of the bubbles. This means that this is an Exothermic reaction. A way to explain this is by breaking down the word "exothermic" for the audience. "Exo" they may have heard before, such as an exoskeleton, and it sounds similar to "exit". "Thermic" is similar to "Thermo", like in thermometer, and refers to heat. So by breaking the word down we can see that exothermic means to have heat exit, or leave, the reaction.

Hill Metaphor

Imagine that you are on one side of a big hill. On the other side of this hill is a party that you want to go to, but to get there you have to climb all the way up the hill and all the way down the other side. All of that climbing is going to tire you out, and you'll use up all of your energy before getting to the party. So let's imagine that you find a tunnel that goes right through the hill. This tunnel makes it possible for you to get to the other side pretty quickly, and you won't be tired when you get to the party. When you use the tunnel, does it magically disappear? No! The tunnel is still there, so anyone else who also needs to go over the hill to the party can also use the tunnel to get there!

The "hill" is the amount of energy needed for the reaction to take place, and the "tunnel" is our catalyst that we add. Before adding it, the reaction needs a lot of energy to take place, and so it goes very slowly. Once we add a catalyst though, the reaction can now take this lower energy path, and happens very quickly!

Race Metaphor

Imagine that you are in a race with some of your friends. You are going to run from one end of the park to the other, which both of you know will be tiring. Just before the race though, you get a bicycle to use for the race. By using the bike, do you think you will be faster than your friends? Of course! Not only that, but you will be less tired at the end of the race. When you finish the race, does your bike suddenly disappear? Nope, the bike is still there!

The "race" is the amount of energy needed for the reaction to take place, and the "bicycle" is our catalyst we add. Before adding it, the reaction will take a lot of energy to move forward, and so it goes slowly. Once we add in a catalyst, the reaction can now move much faster!

Additional Information

Catalysts are common in many things, including:

- Catalytic converters in cars to help remove pollutants from car exhaust.
- The Haber Process for adding nitrogen into fertilizer.
- Yeast contain enzymes, which speed up the bread and beer making processes.
- We have enzymes in our digestive tracts, which break down food for us!

Faraday Cage

This is a modification of the Tesla coil demo that adds a Faraday cage for a person to sit in.

Favorite Dixie Cup

This pressure demo using many dixie cups to support the weight of a whole person or audience member. Place 100 dixie cups on a wooden board, then place another board on top and stand on that board. Your weight will be spread across all the cups.

Fire Tornado in a Box

This demo uses a flammable solvent and a fan to create a fire tornado in a wooden box it is good for stage shows.

Flame Tube

https://www.youtube.com/embed/ZI-M4_jMCz0

This demo features our six foot Reuben's Tube, and is a very impressive demonstration on sound waves. this demonstration is a popular request, and is easily adapted to present to a variety of audiences.

Materials

- Flame Tube with hose
- Propane tank
- Speaker with amplifier
- Tone generator with cable
- Headphone jack cable
- Lighters (x2)
- Power strip
- Extension cord
- Optional: Keyboard with cable adapter

Safety Precautions

Read the fire safety section of the Demonstration Safety Page before performing this demonstration.

This demonstration requires: Safety Glasses

This demonstration is sensitive to wind, so do not use outdoors or in a breezy room. In order to present this demonstration, you will need two tables to set up.

Demonstration

Preparation

Set the Flame Tube on the first table, with both sets of feet resting on the same table. On the second table, set the speaker next to the Flame Tube, putting the speaker about half an inch away from the cellophane seal on the side of the tube, or as close as it can get without touching. Next to the speaker, place the amplifier and tone generator. Connect the tone generator cable to the amplifier using the back port labeled "Phono", and the audio cable in the "Aux" port. Put the switch for the ports in the "Phono" position. Make sure the main volume for the speaker is at zero, then plug in the amplifier and tone generator and turn them both on. Connect the propane tank to the flame tube, and before the start of the presentation open the propane tank fully. Attempt to ignite the holes on top of the propane tank once every minute, and once lit let it stand so the flames can grow.

Presentation

1. Explain briefly the setup you are using; A speaker system is set against the Flame Tube, and by turning on the speaker you will put a sound wave through the tube, which we will see as a Transverse wave in the fire. This is because of the sound compressing the propane gas inside the tube.
2. Set the tone generator to 210Hz, and turn up the speaker volume to 1/2 full. The flames will move, creating the wave!
3. Turn down the speaker volume, and name the parts of the wave: Peak (high point), Trough (low point), Node (mid point), Amplitude (height), Frequency (note heard), and Wavelength.
4. Ask the audience what will happen if we turn up the volume. Show that the amplitude increases, and therefore the amplitude is how loud a sound is.
5. Ask the audience to vote on this: If you doubled the frequency (or "went up an octave"), should we see more waves or less waves? After getting responses, set the tone generator to 420Hz and turn the volume up 1/2 full. The number of waves will double! What kind of relationship do frequency and wavelength have?
6. Flip the switch on the back of the amplifier to "Aux". Connect your phone or music player, and select a song to play for them! Songs that work well are:
    - Secrets (OneRepublic)
    - Let it Go (from Frozen)
    - Photograph (Ed Sheeran)
    - Fly Me to the Moon (Frank Sinatra)
    - Iron Man (Black Sabbath)
    - Stay the Night (Zedd, Haley Williams)
    - Bangarang (Skrillex)

- NOTE: Use the two lighters to keep re-igniting the propane while you have a song playing. The music will put out flames as it plays. Only play 30-45 seconds of any one song, so that you can play a few different songs

7. When you finish presenting the Flame Tube, turn off the propane tank and detach it. Place the speaker on its side, and prop the flame tube on it, with a set of feet resting on the speaker. Ignite the propane coming out of the lower end of the tube, and let it burn off until it is time to pack up.

Why This Works

This demonstration introduces Waves, which are a type of oscillation that accompanies an energy transfer. Sound Waves are Compression waves, which travel with an in-and-out motion through a medium. By using the flame tube, we are transforming the compression waves into transverse waves, so to make it easier to identify the different parts of the waves. When we look at the transverse wave we made with the flame tube, we can see that there are high points and low points. The Peak is the high point, and the Trough is the low point, with the mid point of the wave being called the Node. The height of a wave is the Amplitude, which is often shortened to amp. To make a wave taller or shorter, you have to adjust the volume, or amps. The distance from one peak to the next is the Wavelength, which with sound we can recognize it as a note. To change the note heard, you have to increase or decrease the wavelength. The Frequency of a wave is the inverse of the wavelength. A way to think of it is that the frequency is the number of waves per second. If you start at Center C on a piano and go up an octave, you are doubling the frequency of that note. Frequency and wavelength are inverse to each other, so when you double the frequency, you cut the wavelength in half! Likewise, if you cut the frequency in half, you would double the wavelength.

When we listen to music, we know that there are a lot of notes in the music working together or against each other. By playing a song through the Flame Tube, you can see how some notes work together, creating really high flames or easy-to-see waves. You can also see where the notes don't work together, when certain spots in the flame tube get really low flames, or get put out! When the notes are working together, we are seeing constructive interference, or interference that adds onto each other and amplifies. When the notes clash, we are seeing destructive interference, or interference that subtracts from each other and diminishes.

Additional Information

Try to avoid using the Flame Tube at the end of a show, and to not run the Flame Tube for any more than 25 minutes at a time. This is to minimize any fire hazard, and to allow time for the flame tube to empty after a presentation.

Demos

Four Number Trick

Take any four numbers (single digits) and add them together.

Arrange the original four digits in any order to form a four digit number.

Subtract the sum from this four-digit number, and you should get another four digit number.

Hide any one of the four digits in this new number (except a zero) and reveal the other three digits.

How can you determine the value of the hidden number?

Explanation of the Trick

Add up the three digits that were revealed.
Then subtract that sum from the next multiple of 9 and that will be your hidden number.

Why does this work?

When you add up the four digits and subtract from the original number, you will get four digits whose sum is a multiple of nine.

When one number is hidden, you just add up the other three digits and subtract from the next multiple of nine to get the hidden number.

For example,
take the numbers 6 7 1 3
Added together they equal 17.

If you subtract 17 from 6713, you get 6696.
If you hide one of the sixes, and reveal 6, 6, and 9.
You would add up 6+6+9 = 21.
The next multiple of 9 (after 21) is 27.
So 27 - 21 = 6, the hidden number.

If you hide the 9, then the numbers revealed would be 6, 6, and 6.
Add them together and you get 18.
The next multiple of 9 is 27, which would give you a 9.

It doesn't matter what order the numbers are in. In the example above,

Take the same four numbers 6 7 1 3
Added together gives you 17, of course.
But this time subtract 17 from 1376, and you get 1359.

Again the four digits add up to a multiple of 9: 1 + 3 + 5 + 9 = 18.
So if you revealed 1, 5, and 9: add them up to get 15.
Then the next multiple of 9 is 18, so the missing number is 3 (18 - 15).

If the three numbers revealed were 1, 3, and 5 Then that sum is 9.
The next multiple of 9 would be 18, so the hidden number is 9.

Demos

Geiger Counter

Simply explain radioactivity and use the Geiger counter on some of our radioactive objects (such as the uranium orange plates).

Keep Your Balance (aka Magic Spoon)

Magic Spoon (Keep Your Balance) is a simple physics demonstration of torque and lever arms.

Have one person stand on one leg with there arms out. Another person will then try to push gently with a spoon (or just their hand). Pushing close to there shoulder is not very effective, but pushing on their hand or arm causes them to much more quickly lose their balance. The demonstrator then explains the concepts of torque and lever arms.

Liquid Nitrogen

https://www.youtube.com/embed/BlFUjRfDgI8

The Liquid Nitrogen demonstration is one of our most popular demonstrations to be requested. This demonstration requires a lot of practice before being performed, and volunteers must first go through the proper Cryogen Safety training before they are allowed to perform this demonstration.

Materials

- Liquid Nitrogen
- Thermos container for presenting, with lid
- Tongs
- Balloon
- Racquetball (Hollow)
- Flowers OR Bananas
- Nail
- Hammer
- Green Board
- Ladle
- Small Blast Shield
- Cryo gloves and safety glasses/goggles

Safety Precautions

Please read the Cryogentic Demonstration saftey section on the Demonstration Safety page before performing this demonstartion. This demonstration requires the use of cryo gloves, as noted in the demonstrations below. When doing this demonstration, safety glasses or goggles are required at all times. Wear the cryo gloves whenever you are pouring liquid Nitrogen, carrying a liquid Nitrogen container or handling any object that has been submerged or exposed to liquid Nitrogen.

Demonstration

Preparation

Fill the presentation thermos, and put the polystyrene lid on it, making sure it isn't tight. Set up the demonstration area, laying out the different items you need around the thermos on a table. Set a small blast shield in front of the presentation thermos. Blow up the balloon, making sure that it is just slightly too big to fit into the presentation thermos

Balloon

1. Show the balloon to the audience, and ask them for ideas on what will happen if it were put into the liquid Nitrogen.
2. Show that the balloon does not fit into the thermos. Using the ladle, pour liquid nitrogen on top of the balloon while it is on top of the thermos, and it will start to collapse. After pouring one or two scoops onto the balloon, it should fit.
3. After getting the balloon into the thermos, use a pair of tongs to pull it out. Immediately drop it onto the table, and pick it up using your hands (It will be warm enough to handle). As it expands, carefully turn it over in your hands, and blow onto any spots that look frozen to help thaw it out. It should re-expand to the original size!

Banana & Flowers

Banana

1. Show the banana to the audience, and push a nail into the side of it to show that it is a normal banana. Drop the banana into the liquid Nitrogen.
2. As the banana cools and freezes, explain to the audience what is happening to it.
3. After 1-2 minutes, the banana will be sufficiently frozen. While wearing the cryo gloves, pull the banana out of the thermos using the tongs. Drop it on the table.
4. Try to stab the banana with the nail repeatedly, while holding it on the green board. After a few attempts, use the hammer to shatter the banana

Flower

1. Show one of the flowers to the audience, and tap it gently against the blast shield to show that it is a regular flower.
2. While wearing a cryo glove, stick the head of the flower into the liquid Nitrogen for 8-10 seconds. Pull it out, then tap it against the blast shield on the presenter's side. It will

shatter!
3. Repeat the above steps, making sure to take time to explain each part of the demonstration.

Leidenfrost Effect

Note: This demonstration works best either right before or after the Banana & Flower demonstration. Do not perform this demonstration if you have not practiced it. Please use all necessary safety precautions before performing this demonstration.

1. Show the audience your bare hand, and ask them why you wore a glove to handle the banana/Why you didn't wear a glove to handle the balloon.
2. Explain how cold liquid Nitrogen is, and how it is dangerous to handle directly. Ask if you should stick your hand in.
3. Hold your hand directly over the open thermos. Quickly submerge your hand in the container and pull it back out. repeat this process a few times, allowing time between dips to show that your hand is, in fact, intact.
4. Hold one hand directly over the thermos, and have the other holding the ladle. Scoop up a small amount of liquid Nitrogen with the ladle. Have the hand over the thermos open, tilted downward toward the thermos, and pour the liquid Nitrogen onto your hand. It will roll off your hand, and not hurt you!

Racquetball

1. Show the Racquetball to the audience, and bounce it a few times to show that it is elastic. Lock the tongs on it, and put it in the liquid Nitrogen. You might need to use the ladle as well to keep it submerged.
2. While the racquetball is cooling, explain what is happening to the audience
3. After 1-2 minutes, put on the cryo gloves and take the racquetball out. Drop it on the table to show that it has little elasticity, making note of what sound it makes.
4. If you have a back wall that is concrete or similar, throw the ball against the wall to shatter it. If the floor is concrete or there is a metal plate, throw it against it to shatter the ball.

- **Do not throw it against a wood wall or wood floor;** it will bounce off! If there are no sufficiently hard surfaces, then hold the ball on the green board, and hit it hard with the hammer to shatter it.

5. Show one of the shattered pieces to the audience, and have a fellow presenter heat up one of the other pieces to show that it regains elasticity once it is warm again.

Why This Works

Liquid Nitrogen is extremely cold, and sits at about -321 degrees Fahrenheit, or about -196 degrees Celsius. It is very dangerous that it is this cold, which is why we state time and again throughout this write-up to use all necessary safety precautions. The expansion rate of liquid Nitrogen is about 700:1, or for every 1 liter of liquid Nitrogen we have, we will get 700 liters of Nitrogen gas when it warms to room temperature. Please make sure the lid on the container is never tight for this reason, because it can explode if that expanding gas builds up pressure. This is also why this demonstration needs to be performed in a ventilated area.

Balloon

This helps to build the connection between moving molecules and temperature, which was started in the Molecule Dance. When the balloon is at room temperature, the air inside is moving quickly, and takes up a lot of space. As the balloon is cooled by the liquid Nitrogen, the air inside moves much more slowly, as it loses heat to the LN2. This makes the air inside condense, and allows the balloon to "deflate" and fit into the thermos. After pulling it out, the air inside will warm back up and expand the balloon back to its original size.

Banana & Flowers

This shows the effects of heat loss on living organisms, such as ourselves. We know that we have water inside of our bodies, and plants are similar in that they have a lot of water. When the flower or Banana are put inside of the liquid Nitrogen, the water in their cells starts to freeze. Water is unique in that, when it goes from a liquid to solid, it expands. Most of the rest of matter contracts when it goes from a liquid to solid state! When the ice forms in those cells, it causes them to expand as well, and this can break some of the cells as it happens. The frozen water and broken cells become apparent when we pull the plant out of the liquid Nitrogen and shatter it! At the end of the performance, you can show students that the banana and flower petals rapidly wilt and brown when they thaw, due to these broken cells.

Leidenfrost Effect

We need to remember two things to understand this effect. First, that the liquid Nitrogen is extremely cold. Second, that we are extremely hot compared to it. There is an over 400 degree difference (Fahrenheit) between our bodies and the liquid Nitrogen. So, when it first comes in contact with our hand, some of this liquid will instantly turn to gas. The rest of the liquid lands on this gas layer, and rolls across it, never touching us! This effect only works, however, if we do not keep prolonged exposure to the cold liquid. Prolonged exposure allows the gas layer to escape, and that would result in frostbite or worse. Also, this does NOT work for solid-on-solid contact. The solid objects we use are solids at room temperature as well, so they would not create this gas layer, and would quickly freeze to your exposed hand. That is why you need to wear gloves when handling a cold solid.

Racquetball

This demonstration shows how the elasticity of a material is temperature dependent. Many of us heard as kids that you need to "warm up" a rubber band before you use it, and there is some fact to that. A materials elasticity, or how much it can stretch or bounce, is dependent on the temperature of the material. The racquetball we know is elastic at room temperature, but after we put it in the thermos it will start to cool rapidly. Remind students that the racquetball cannot freeze, since it does not have a lot of water in it. What can happen, however, is that the ball will get less and less elastic, to the point where it will not bounce or stretch at all. It is also worth noting that racquetballs are hollow, with air in the center to help with the bounce. We know that air will contract and condense when cooled, so the inside of the ball will have a small vacuum, or empty space, inside of it. This empty space is what causes it to make a loud popping sound when it shatters!

Note: The reason why the ball will not shatter when thrown against a wood surface is because, surprisingly, the wood is too elastic!

Marshmallow Smashies

On of our favorite demonstrations! Students of all ages will love watching the marshmallows in the vacuum flask!

Materials

- Büchner Flask (Vacuum Flask)
- Marshmallows
- Vacuum Pump
- Racquetball
- Partially Inflated Balloon

Safety Precautions

Please see the General Safety section of the Demonstration Safety page before doing this demonstration.

Demonstration

Preparation

connect the vacuum flask to the hose for the pump. Draw faces or animals on the marshmallows that you will use, or set out the ones you plan to use with some markers so you can have volunteers draw on them.

Presentation

1. Show the marshmallows to the audience. If they do not have faces yet, and if you have a younger audience, call up a few volunteers to draw on the marshmallows. Ask the audience or the volunteers to give the marshmallows names.

2. Place the marshmallows inside the vacuum flask, and put the racquetball on top. Ask the audience for ideas on what will happen to the marshmallows if you removed the air inside the flask.
3. Ask for a countdown, and at the end of the countdown turn on the pump. Hold up the flask so the audience can see the marshmallows expanding!
4. The marshmallows will expand for a few seconds, and then stop and start to shrink slowly. When they start to shrink, turn off the pump and pull the racquetball off the top, letting out a loud popping noise and smashing the marshmallows!
5. Show the smashed marshmallows compared to regular sized ones. Ask the audience for ideas on what happened, then explain the demo, using the balloon to show how air will expand in a vacuum.

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Why This Works

This introduces Air Pressure, which is the force of the air applied on everything around it. Air pressure is pretty strong, but we don't normally notice it because our bodies push back against it. Marshmallows also push back, because they have a lot of little air pockets in them. When we put the marshmallows in the vacuum flask and sucked the air out, there was a lot less air pushing on them. We put the marshmallows in a Vacuuum, or an area with a lot of empty space, including no air! The air inside the marshmallows then was able to take up a lot more space, which caused them to expand. However, the marshmallow could only expand so far until the bubbles started to pop! The marshmallows then lost a lot of the air inside them, which caused them to shrink in the vacuum, and less air inside them meant that they could not push back as much. This is why, when we let the air back in, the marshmallows were smashed!

Non Burning Money

https://www.youtube.com/embed/H2Iwo4Q_6D8

As with all fire demonstrations, keep a fire extinguisher nearby as a precaution. This demonstration is a favorite among both presenters and students, and is often requested and performed at all grade levels.

Materials

- Nonburning Solution
    - Ethanol or Isopropyl Alcohol
    - Water
    - Table Salt
- Dollar Bill & Cloth
- 2 Small Tubs
- 2 Large Tubs
- Lighter
- Tongs

Safety Precautions

Please read the Fire Safety section of the Demonstration Safety page before performing this demonstration.

This demonstration requires: Safety glasses, small blast shield, fireproof gloves

Demonstration

Preparation

Prepare the nonburning solution: In a 1 quart bottle, combine the alcohol and the water in equal amounts, making a 50/50 solution. To make the flame more visible, you may want to mix in 2-3 tablespoons of salt, which will make it a bright orange-yellow flame rather than a faint blue flame.

Presentation

Set out the tubs (small tubs if using a dollar bill, large tubs if using the cloth) and fill one halfway with water. Fill the other tub with the nonburning solution, enough to cover the bottom of the tub with a thin layer. Close the bottle with the nonburning solution and move it off the table, setting it at least five feet away from the demonstration area. Put the dollar bill or cloth into the solution, and have it soak thoroughly.Explain to the audience that you will be making a fire. Have the students list the three things needed for a fire (oxygen, a fuel source, an ignition source).Explain that you will be using an alcohol, and that alcohols are flammable. Ask the students for ideas on what will happen when you ignite the dollar bill/cloth that is soaked in alcohol. During this time, put on the safety gear and use the tongs to pick up the dollar bill/cloth and hold it over the tub of water.Have students do a countdown, and ignite the dollar bill/cloth. It will burn for several seconds, but then the flame will go out, leaving it intact! dunk it briefly in the water afterwards to cool it down before handling it, and ask the students for ideas on why it didn't burn. Is there something else in the solution?

Why This Works

Alcohols are extremely flammable, and burn very hot and very quickly. This is because alcohols are Volatile, which means they easily turn into a vapor and mix into the air. This means that we have to be careful about having alcohol near a fire or anything really hot, because if not carefully watched it might ignite! With the Dollar bill/cloth, we had it soaked in a solution that was half alcohol and half water. The water did not stop the alcohol from burning, and it was able to ignite and start burning quickly. However, water has a high Heat Capacity, meaning it can absorb a lot of heat before turning into steam. This means the water was able to absorb all the heat from the alcohol, and kept the dollar bill/cloth safe from the fire!

Demos

Polymer Milk Jug

This demon involved slightly melting the side of a milk jug with a blow torch and then blowing air into it for form a bubble. It can be used to explain what polymers are and some of their properties.

Predator and Prey

This demonstration works well as a introductory lesson on evolutionary adaptation. There are several ways to adapt this demonstration, so feel free to experiment with different kinds of environments!

Materials

- Poster Board (White)
- Optional: Green Tablecloth
- Red, Blue & White Poker Chips
- Rubber Mitt
- Foggy Goggles
- Green Filter Goggles

Safety Precautions

Please read the General Safety Precautions section of the Demonstration Safety page before performing this demonstration.

Demonstration

1. Set the poster board on one side of a table. Spread out the poker chips across the poker board. Set the mitt and goggles next to the poster board.
   - If you brought the green tablecloth, set it on the table with the poster board on top. Spread out half of the poker chips on the poster board, and the other half on the green tablecloth, making two areas to play the game in.

2. When students come up, ask them if they would like to play a game. The goal is to collect as many poker chips as they can in 30 seconds. If they want to play, explain the following rules:
   - You can only pick up one poker chip at a time. After you pick up a poker chip, you have to place it down in front of yourself before getting another one.
   - When you put a poker chip in your pile, you have to turn and look away from the table before getting another one.
   - You have to choose one of the "traits" to wear: the foggy goggles, the green filter goggles, or the rubber mitt. You have to wear them for the whole game.
   - You can only use one hand to pick up poker chips. If you are using the rubber mitt, you have to use the hand wearing it.

- If you brought the green tablecloth, then they can choose which area to play on: the white board or the green cloth.

3. Get a timer on your phone or watch ready, and when the students are ready have them go! Stop after 30 seconds, and have them count out how many they got.
4. Have them compare how each performed. The student using the rubber mitt got the fewest, and both pairs of goggles seem to perform equally well. Ask them about what was easy to see and what wasn't. Were some poker chips hard to find?

Why This Works

Evolution is the process by which the traits of a species can adapt over the course of several generations. Animals can develop different traits due to minor mutations between generations. These traits can determine an animals likelihood of surviving and passing on its genes, and can be positive, neutral, or negative. Negative Traits are traits that hinder and animal, making it harder to eat or survive. In our game, the rubber mitt is a negative trait since it makes it hard to pick up the poker chips. This would be like finding a lion that had no teeth; it would be extremely hard for it to hunt prey, and harder still to chew food. Neutral Traits are traits that, although they do not hinder greatly, they can be adapted to. The foggy goggles are a neutral trait, since they make it harder to see but not so hard that you cannot see. On the poster board the foggy goggles trait can still get the red and blue chips easily, but the white chips have adapted to hide from it. Camouflage is when an organism has adapted how it looks so it can better blend in with its surroundings, allowing it to hide from predators or sneak up on prey. The white chips on the white background have camouflage against the foggy goggle trait, but the green goggle trait can see them. Positive Traits are traits that allow an animal to hunt better, hide better and survive longer, making the animal more likely to pass on the trait. The green goggles are a positive trait on the poster board, since they can see through the camouflage of the white poker chips and have no hindrances in that environment.

On the green tablecloth, however, we see that the green goggles become a neutral trait. This is because of a change in environment, and with it a change in what poker chips have camouflage. The blue and red chips become hard to see on the green background while wearing the green goggles, meaning that they have camouflage! This is because of a common evolutionary trait; colorblindness. The most common form of colorblindness is red-green, meaning that shades of red instead look green or brown. This means that a red bird, such as a cardinal, doesn't appear red to most of the animals that hunt it, but rather appears green or brown! The color blue can also appear to look blue-green, which makes it hard for a colorblind animal to spot bluebirds. If you put a foggy plastic filter over the green goggles, then they become a negative trait on the green tablecloth!

Additional Information

There are all kinds of ways to adapt this demonstration and show different types of traits! Ideas include:

- Making red-filter and blue-filter goggles to compare them to the green.

- Having different colors for the background, or even having students reach into a bowl of water!
- Having different objects to pick up, of varying color and size.
- Having different gloves, mitts or claws for students to use and compare effectiveness for the environment.

Robot Sandwich Maker

Have one person pretend to be a robot. Introduce the robot and then form a line of audience members to give instructions to the robot. Ask the line of audience members to instruct the robot to make a sandwich. The actor playing the robot should take all the instructions as literally as possible.

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Seismometer

This a new demo that is still under development. It involves a raspberry shake hooked up to a computer with the rsudp software installed. The demo involves explaining what a seismometer is and what it is used for and then asking the audience to stomp their feet to create a mini earthquake. You can even set up a competition between two haves of the audience for more fun!

Demos

Shaker Table

This geology demo highlights the importance of foundation for earthquake resistance, by letting kids create small towers on a movable platform and then simulating an earthquake by shaking the table.

Demos

Skittle Chromatography

Chromatography is a common chemistry method that can be used to analyze the properties of a solution. The dyes used in skittles can work as a simple hands on chromatography demo.

Solar System Model

This is a partially to scale model of the solar system to demonstrate the relative sizes of the planets. (The distances cannot be proportional to the sizes of the planets because they are too far apart)

Stroboscope

We have a stroboscope and constant speed rotator. Connect a disk to the rotator and tune the frequency to the speed stroboscope to the speed of the rotating disk.

Demos

Tesla Coil

Use the tesla coil! Please be careful with the high voltage use the grounding wand and where the electric gloves.

Theremin

The theremin is very cool on its own, but even cooler if you explain how it works!

Tornado in a Box

This demo uses some dry ice and a fan to create a miniature tornado in a cardboard box.

Demos

Vacuum Spheres (aka Magna Spheres)

In the box with the vacuum pump there are a few small spherical vacuum chambers. When these are properly sealed and pumped out they are very difficult to separate. Have some audience member try to pull one apart while the vacuum pump is pumping on it.

Demos

Van de Graaff Generator

The Van de Graaff Generator generates very large amounts of static charge, very high voltage and high current (see this video), but is safe to touch and charge your own body. Try creating large arcs or making you hair stand up.

Demos

Water Balloon Catch

Throw some water balloons and catch them with a sheet to demonstrate acceleration and force.

Demos

Whoosh Bottle

A fiery demo about chemistry and pressure. In the whoosh bottle demo you add 15ml to a large water container and then spin the bottle around to spread the methanol around the inside of the bottle. Once the liquid is evenly spread, the gas will evaporate and fill the bottle. Now, set the bottle upright on a solid surface, light a large match and drop it into the top of the bottle. This will result in a large pillar of flame and a loud "Whoosh". You can then explain that the construction of gas through the small opening at the top causes the jet of hot gasses to leave the bottle extremely fast.

Leadership Roles

Responsibilities of all E-Board Members

- Lead shows!
- Volunteer for demo trainings.
- Advertise MSU Science Theatre!

Leadership Roles and Responsibilities

- **President**
  - Host general body and leadership meetings
  - Communicate with the university
  - Register as an RSO
  - Work with VP and Event Coordinator to email schools and schedule shows
  - Hold elections
  - Ensure E-board members fulfill their roles
  - Assist other E-board members
- **Vice President**
  - Work with President and Event Coordinator to email schools and schedule shows
  - Assume the responsibilities of the president in the case of a temporary or permanent absence by the president
  - Ensure E-board members fulfill their roles
  - Assist other E-board members
- **Secretary**
  - Ensure access to digital resources:
    - Email:
      - pa.sciencetheatre@msu.edu
      - list.msu.edu
    - Google Drive
    - Websites:
      - www.sciencetheatre.org
      - pa.msu.edu/science-theatre
      - sciencetheatre.kaedon.net
      - msusciencetheatre.pythonanywhere.com
  - Ensure key and key-card access to the planetarium
  - Maintain the Wiki
  - Maintain the Google Drive
  - Maintain the Constitution

    - Take notes during meetings
    - Assist other E-Board members
- **Event Coordinator**
    - Work with President and VP to email schools and schedule shows
    - Work with Demo Maintenance to host demo trainings
    - Maintain the List of Shows
    - Maintain the List of Volunteers
    - Organize leaders for shows
    - Ensure shows go smoothly
- **Treasurer**
    - Submit an annual budget to the university
    - Handle reimbursements
    - Handle donations
- **Demo Maintenance**
    - Maintain the List of Demos
    - Keep inventory of demo supplies
    - Order new demo supplies
    - Maintain old demos
    - Create new demos
    - Work with Event Coordinator to host demo trainings
    - Maintain safety boxes
    - Ensure safety procedures are followed
- **UP Trip Organizer**
    - Plan the UP Trip
    - Contact Schools for the UP Trip
    - Run the UP Trip
- **Public Relations**
    - Maintain social media accounts:
        - Discord
        - Instagram
        - Youtube
    - Make posters
    - Maintain public websites:
        - www.sciencetheatre.org
        - pa.msu.edu/science-theatre
        - sciencetheatre.kaedon.net
        - msusciencetheatre.pythonanywhere.com

Safety Precautions

General Demonstration Safety Precautions

- Always practice a demonstration before presenting it at an event. Never present a demonstration that you haven't seen before until after you have practiced it.
- All Science Theatre presenters must wear jeans or khakis, closed toe shoes, and a Science Theatre shirt or similar.
- Follow all safety precautions required for a demonstration, and use appropriate safety gear for the demonstration.

Fire Demonstration Safety Precautions

Some of our demonstrations use fire. Please take the following precautions if you are performing a demonstration involving fire:

- Tie back long hair and do not wear loose clothing.
- All presenters must wear safety glasses or goggles while the demonstration is being performed. Presenters not involved in the demonstration should stay at least six feet away from the demonstration.
- If a blast shield is used, the audience must be at least six feet away. If a blast shield is not used, the audience must be at least 15 feet away. A small blast shield is required for fire demonstrations that sit on a table.
- Fire demonstrations are never to be aimed towards the audience or demonstrators.
- Keep fire away from flammable items such as hair, clothing, and combustible powders and liquids (CPLs).
- Keep containers of CPLs closed until just before they are needed so that fumes or powders do not ignite.
    - CPLs should be measured out with ignition sources turned off and at least six feet away.
    - After they are measured out, close the container and remove it from the demonstration area before turning on the ignition source.
    - If possible, pre-measure the amount needed for the demonstration so the bulk container does not need to be brought.
    - Any spilled CPL should be taken care of immediately using a proper spill agent. Ignition sources should be turned off/extinguished if they are on/lit, and should not be turned on/lit until after the spill is taken care of.

- When using any device that produces fire or heat, with the exception of candle lighters and matches, wear heat-resistant gloves.
- When handling any object that is currently being or has recently been heated, wear heat-resistant gloves.

- Always have a fire extinguisher within easy access. Make sure you know how to operate it.
- Most fire demonstrations give off smoke. Be aware of smoke detectors, and read the safety precautions for Flying Particles.

Cryogen Demonstration Safety Precautions

- A Cryogen is a solid, liquid or gas that has been cooled far below the freezing point of water. Cryogens can cause frostbite within seconds, making them a safety hazard.
- The cryogenic materials used in our demonstrations are dry ice, Liquid Nitrogen, and objects that have been cooled by the dry ice or liquid nitrogen.
- The audience should be at least ten feet away from a Liquid Nitrogen presentation.
- **Required Safety Gear:** A small blast shield, safety googles, cryogen-safe gloves.
- **Recommended Safety Gear:** A lab coat.
- **Required Dress:** Closed toe shoes, jeans, t-shirt.

Cryogen Storage and Containment

Liquid Nitrogen

- Liquid Nitrogen must be kept in a cryogen approved container. Do not overfill the container, and keep a loose-fitting lid on the container at all times when not in use. Store and use Liquid Nitrogen in a well ventilated area.
- When carrying Liquid Nitrogen, wear safety goggles and the cryogen gloves. When transporting it, keep the container upright at all times, and buckle it into a seat to prevent it from tipping or spilling.
- During a performance, safety goggles are required at all times, and the blast shield should be in front of the container at all times. Wear the cryogen gloves whenever you are using the Liquid Nitrogen during the performance.
- If spilled, Liquid Nitrogen will vaporize quickly. However, due to the Leidenfrost effect it will roll along smooth surfaces easily, making it possible for a spill to travel rather far. To prevent a spill from traveling, keep a blast shield in front of the Liquid Nitrogen container throughout the duration of a presentation.
  - If Liquid Nitrogen is spilled and is rolling slowly across the floor, create a barrier around the spill to contain it as it vaporizes.
  - If Liquid Nitrogen is spilled and is rolling in the direction of the audience, ask the members of the audience that are not wearing closed toe shoes to lift their feet off the floor. If they are all wearing closed toe shoes, then alert them that their feet are safe, but to not touch it with their hands.

- If you spill Liquid Nitrogen on your skin, keep the exposed area angled to let it roll off of your skin. You will have a few seconds to react due to the Leidenfrost effect, so a quick response will help you avoid injury.
- If frostbite does occur, run the affected area under warm water for 3-5 minutes to rewarm the skin. Treat the affected area with an antibacterial ointment and bandage it.
- If it is spilled on your clothing, pull the clothing away from your skin and allow it to vaporize. If the spill soaked a large area of your clothing, you should remove that article of clothing promptly to avoid frostbite.

Dry Ice

- Keep dry ice in a thick-walled insulated container with a loose fitting lid. Store and use dry ice in a well ventilated area.
- Spilled dry ice should be kept away from people and sensitive materials. Use a cryogen glove or similar to collect any large pieces.
- If dry ice comes in contact with bare skin, it can cause near-instant frostbite. Always use cryogen gloves when handling dry ice.

Solid Cryogens

- Solid cryogens consists of the objects that are cooled by the Liquid Nitrogen or dry ice, such as the racquetballs, bananas and pennies we use in some of our demonstrations.
- Solid cryogens should only be handled while wearing cryogen gloves or with cryogen-safe utensils, such as the tongs we have with the demonstration.
- Solid cryogens can cause near-instant frostbite if they come in contact with skin. Avoid touching any solid cryogens with your bare hands.
- If a solid cryogen is spilled, alert the audience that they should not touch the object. Pick up the object while wearing cryogen gloves.

Dry Chemical Demonstration Safety

A dry chemical is a chemical substance that is not suspended in a liquid, most commonly water. Dry chemicals are most commonly found in powder form. If you are dealing with chemicals in a liquid form, please see Liquid Chemical Safety.

- When handling dry chemicals, safety goggles and rubber gloves must be worn at all times.
    - It is highly recommended that a lab coat is also worn while handling dry chemicals.
- Be aware of the properties of the chemicals used in a demonstration, as well as any safety hazards they might pose.
- Do not use any chemicals that you have not been trained on the use of, or are unfamiliar with.
- See Fire Demonstration Safety for additional guidance if the chemical is used to create a flame.
- See Flying Particles Safety for additional guidance if the chemical creates flying particles, including smoke/fumes.
- Dry chemicals should be kept in sealed containers at all times
    - The containers should not be opened until they are needed, and should be closed immediately after use
- If a dry chemical is spilled:
    - Scoop up as much as possible of the spilled chemical and place it in a plastic bag or other non-reactive, sealable container.

    - Wet a paper towel and wipe down the area.
    - Place the paper towel along along with the rest of the spilled chemical in the plastic bag or other container.

Liquid Chemical Demonstration Safety

A wet chemical is a chemical substance in the liquid phase, also known as wet chemistry. If you are dealing with chemicals in a powder form, please see Dry Chemical Safety.

- **Required Safety Gear:** A small blast shield, safety googles, rubber gloves
- **Recommended Safety Gear:** A lab coat
- **Required Dress:** Closed toe shoes, jeans, t-shirt.
- Properly label all chemicals and date when they were opened
    - Make sure to dispose of the chemicals before the expiration date and dispose of accordingly to the label's directions

- When dealing with volatile substances, make sure to do so underneath a fume hood or an area with appropriate ventilation
- If a flammable liquid is used in a demonstration, make sure to cap all reagent bottles after dispensing the appropriate quantities and be aware of heat sources and flammable vapors. Never repeat a demonstration using flammable liquids until all containers and surfaces are cool to the touch.
- Any volunteers must also wear approved safety gear

Flying Particle Demonstration Safety

Some of our demonstrations release particles or debris during the performance. Please take the following precautions if you are performing a demonstration which releases particles:

- Use a blast shield, if possible. It will help protect the audience from any debris.
- Have a designated "Blast Radius" for the demonstration. If you have a blast shield, the minimum radius is six feet. If you do not, the minimum radius is fifteen feet.
- All presenters and volunteers must wear safety glasses or safety goggles when the demonstration is being performed. Presenters not involved in the demonstration should stay outside of the blast radius.
- It is recommended to wear a lab coat and long pants (jeans or khakies). These articles of clothing will prevent flying particles from coming in direct contact with the skin.
- If the demonstration fires particles in only one direction, it should be aimed away from the audience and other demonstrations.
- If the debris released from the demonstration is considered hazardous (sharp edges, extremely cold or hot, etc.), Wear appropriate gloves to collect the pieces. If needed, sweep the presentation area after the show is completed.
- Unless otherwise noted in a demonstration write-up, dispose of any debris in a trash can or receptacle.

If a demonstration gives off smoke, dust or any similar micro-particles, then please use the following safety precautions:

- Only perform a demonstration which gives off micro-particles in a well ventilated area.
- Notify the contact for the event prior to the event that the demonstration gives off smoke. They may need to move your presentation to a new room, or ask for a different demonstration to replace it.
- Be aware of any smoke alarms in the room, if any, and avoid using the demonstration near one.
- Do not let anyone from the audience to come close to a demonstration that is still giving off debris.
- If possible, collect any settled micro-particles with a wet paper towel or cloth. Unless otherwise noted in a demonstration write-up, dispose of any debris in a trash can or receptacle.