FOR PRESENTATION AT THE
NATIONAL SCIENCE TEACHERS ASSOCIATION
EASTERN REGIONAL CONVENTION

2 - 4 November 2006
Baltimore, Maryland

DOZENS OF ZINGERS GUARANTEED TO KNOCK YOUR SOCKS OFF!

Wyndham Baltimore-Inner Harbor
McKeldin Room

Part I — 2:00 to 3:00 Part II — 3:30 to 4:30

Compiled and Presented by

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Mitchell E. Batoff
28 October 2006

SOME EXPLANATIONS, COMMENTARY, BACKGROUND INFORMATION, AND SOURCES FOR ITEMS USED IN THE PRESENTATION

Mitchell E. Batoff
28 October 2006

1. **THE MAGIC COLORING BOOK.** Remember, the purpose of this demonstration is to help nurture **close, careful observation**. I do **not** use it as magic or as a gimmick or trick. Professor Alyea did chemical demonstrations like this—with the same objective—in his freshman chemistry course at Princeton. There are several versions of the Magic Coloring Book, available at any magic store around the country. There is surely one near your home.

2. **NOT ONE BULB WILL LIGHT.** This very useful sheet was developed in the 1960s by the renowned Elementary Science Study **(ESS)** as part of the unit **Batteries and Bulbs**. Like so many things in the past, it is as valuable today as it was four decades ago. In addition to the purpose for which it was intended, I came up with this use in connection with the concept of a **complete circuit** and understanding the construction of a **bulb**. Observe that in each of the 12 drawings, **as pictured**, there is **not a complete circuit**. Why? Note the filament in midair, an impossible situation in any bulb. There is no complete circuit. In a real bulb one "leg" of the filament extends down and attaches to the **side** of the bulb; the other leg extends farther down (inside the screw or bayonet part of the bulb) and attaches to the bottom of the bulb, usually the tip.

3. **THE AQUA VASE.** The construction of this device involves **two chambers**, an inner and an outer. The science concept entails **air pressure** controlled by your index finger which opens or closes a very small inconspicuous hole in the neck of the vase several inches below the lip. To get a sense of what is going on in the inner chamber, place a drinking straw in a container of water. Then put your index finger over the open end of the straw and lift the straw out of the tumbler or the like. What do you see in the straw? Now take your finger off the open end. What happens? How high did the water rise in the straw? There's more to the story in terms of the Aqua Vase. I am sure you can go on from here. At one time, the larger version of the Aqua Vase (rather pricey) which I used in my presentation, as well as a smaller version, which I've used in the past, were available in many magic stores; or they could order one. I am not sure if they are still made. Check it out. In any event, you can make one. It won't have the same quality look as the commercial version but it will illustrate the same concepts. See ahead in the handout. I've included six pages as well as the changing colors of the liquid in the plastic tumblers. The film clip of Harry Wong, which I showed, is from Episode 5 of the eight-part video set "The Effective Teacher." Check out Harry's web site.

4. **THE MYSTIFYING LIGHT BULB.** I've used this in classes for many years in connection with a unit on ***Batteries, Bulbs, and Circuits***. I like the idea of using it at the outset of the unit, in the same manner as in my presentation. Ask me questions to which I can answer only "yes" or "no". Hopefully, no one will explain fully or correctly what's going on. Put it away at just the right time. Tell the class that you will bring it out again at the end of the unit, and that they should do better with their questions (after working with complete circuits, switches, bulbs, and an energy source such as a D-cell). Let them "lose a little sleep" in the meantime. For your information—not theirs, at least not until much later (and even then, elecit it from them, with subtle clues; much better than telling them outright)—it is not "an ordinary living room light bulb" but rather a specially constructed one available in any magic store. Remember, as in the case of the coloring book and the Aqua Vase, I don't use these as gimmicks or tricks or magic but rather as an attention grabber, motivator, discrepant happening. "What is possibly going on here?" ...There must be a source of electrical energy. Right? Is it in my hand?... ...What is it? Where is it? It is a small AA cell ("battery") placed inconspicuously inside a "dissected" bulb, with a small flashlight bulb mounted on top of the cell. A delicate wire goes from the side of the flashlight bulb (the screw-in part) to the side or screw-in part of the lookalike living room light bulb. Another wire connects the base of the "battery" (AA cell) to the base of the living room light bulb (the tip of the screw-in part). Thus, we have a circuit. But is it a complete circuit? No. If it were, the little flashlight bulb would be lit. So, what is lacking to complete the circuit, and then incomplete the circuit, or in other words, to turn the bulb on and off? Usually a switch of some sort does this. Where is the switch in this case? Well, it is a different kind of "switch" but it does the same thing. It is a tiny piece of aluminum foil placed inconspicuously in the palm of my hand! ...Which I flick off at the opportune time. How does this act like a switch to complete the circuit? It touches the tip of the light bulb as well as an area beyond the tip (which is really part of the screw-in part) and thus completes the circuit. Some clever person thought of this intriguing device! Available in any magic store. **Tip:** Don't keep it lit very long at any one time. Also, like any demonstration, try it out beforehand. These things have a limited life and do burn out. I always have a few on hand; and need to get a new one from time to time. Diagram below.

5. **SOME "IMPOSSIBLE" AFTER-DINNER SCIENCE.** This mind-boggling demonstration is not difficult to do. It just requires a little patience and some practice. **Flat** toothpicks are my preference. The real drama occurs when you light the toothpick and it burns down to the edge. It's kind of like extending your body out over a canyon with only your foot touching the rim. Again, I don't use this as a trick but rather a thought-provoking discrepant phenomenon. What is the physics involved? What is the explanation? What's going on here? This and No. 6 (**THE BIRD**), as well as many variations are explained as follows. Three concepts are involved in explaining this bizarre phenomenon: a) Center of gravity (almost always synonymous with center of mass; b) Torque; and c) Equilibrium. The **center of gravity** of an object or a system is a point at which you can imagine all the mass is concentrated. It is sometimes called the **balancing point** or **pivot point** since we can balance an object at that point and have the several forces acting on the object be in equilibrium. This often involves torque which I will get to shortly. Note that the center of gravity of an object or system (in this case, the fork-spoon system) does not have to be on the object itself. It is often outside the object as is the case with the fork-spoon system or a boomerang, or **THE BIRD** (see No. 6). Now back to **torque**. A torque is the rotational counterpart of **force**. A force tends to change the motion of things; torque tends to twist or change the state of rotation of things. If you want to make a stationary object move, apply a force. If you want to make a stationary object move, apply torque.[1] There's more to torque, but that can wait for another time. Now, back to the fork-spoon system. Observe that when you set this up, the fork and spoon are hanging almost on their sides from the toothpick and this causes a **torque** to be exerted in a counterclockwise direction. However, this is countered by a downward force (clockwise in a sense in relation to the torque) viz., the weight of the system acting at the balancing point or center of mass. Thus, a state of equilibrium is reached resulting in balance.

   In summary, an attempt was made above to provide a more detailed and complete explanation of this interesting counterintuitive demonstration than I and others have given in the past. An abbreviated and simpler explanation is that **the center of gravity/center of mass of the fork-spoon system is at or beneath the point of support—the balance point—on the rim of the**

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[1]Acknowledgment to Paul G. Hewitt. *Conceptual Physics for Parents and Teachers*. Newburyport, MA: Focus Publishing, 1998. P. 102. Acknowledgment, also, to Tik L. Liem.

glass. After several adjustments of the system on the toothpick, and a little patience, **you discover a point at which the whole system is in stable equilibrium**. With a modicum of care you can blow or **gently** tap the fork-spoon and set it in motion! Slight motion.

6. **THE BIRD...** and numerous other demonstrations are explained as given above.

7. **"IMPOSSIBLE" BALANCING BOTTLES.** Same as above except that the center of gravity is at or above the balance point.

8. **KNITTING NEEDLES AND STYROFOAM SPHERES** demonstrated—via video—by the late Tik L. Liem. Same explanation as No. 5 and No. 6.

   - If you are a physics teacher, feel free to write to me at mbatoff@aol.com if you have any disagreement with my explanation above, or if you have anything to add. A dialogue is most welcome. I am always learning.

9. **YOUR FINGERS.** Usually muscles are on or close to the bones that they move. In the case of the fingers it is a different story. Delicate movement of the fingers, as in playing a musical instrument, threading a needle, buttoning a collar button, or similar manipulations, are only possible because the muscles are elsewhere. Where are they? On the forearm, along the radius and ulna, connected to the fingers by "strings" (tendons). Convince yourself of this. Move the fingers of your right hand as though you were playing the piano and place your left hand on your right forearm. What do you feel?

10. **A PERPLEXING QUESTION LEADING TO AN IMPRESSIVE FACT.** What is the mass of a cubic meter of water? As shown on the following page, a little arithmetic reveals a surprising answer: **ONE TON, 2,000 POUNDS, THE WEIGHT OF A SMALL CAR!** Why do you suppose I didn't ask for the answer in a metric unit (kilograms)? No wonder a bucket of water (nowhere near a ton) is heavy. No wonder roofs collapse from the accumulation of quantities of ice or packed snow.

The Inexhaustible Bottle

To get something for nothing has been humankind's perennial dream. Here is a Bottle that seems to constantly refill itself. Time after time you spill out its liquid contents, only to find it refilled a minute later. Magic? No, but it sure appears so. And kids can be challenged to "Imagineer" drawings, or even working models, of how the device might work.

Effect and Storyline

"Centuries ago, alchemists tried to change inexpensive metals such as lead or iron, into valuable gold or silver.As you know, they never succeeded. But they did invent a number of amazing devices. For example, this bottle was designed by the great alchemist Al Wayse Flowe in his Egyptian laboratory. It is now filled with water and if I tip it upside down and command "Flow"you see that it empties itself of its contents." The seemingly empty bottle is replaced on the table. "But, the great Al Wayse Flowe had magic in his mind when he invented this, because if I turn it upside down and command "Flow" once again it is full of water."

This procedure can be repeated many times, as you remark on how nice it would be to have such a bottle while on a trip through a desert, how good it would be for our environment, and how it may render all other water containers obsolete.

But, most kids will be suspicious, and when you ask the usual question: "How many of you believe the bottle to be truly inexhaustible?", few will agree. So the stage is set for creative thinking once again. Issue the customary Imagineering Blueprint forms and encourage generation of drawings to explain how the bottle may work.

The Point

1. To involve students in creative idea production.
2. To encourage application of science principles in the solution of a problem.

What You Need

Spray paint
A large plastic soda bottle (1-3 liter size)
Epoxy cement
A plastic tube that closely fits into the opening of the bottle
Utility knife or hack saw for cutting the plastic
Electric drill with a small bit (about 1/8" or less)

How You Do It

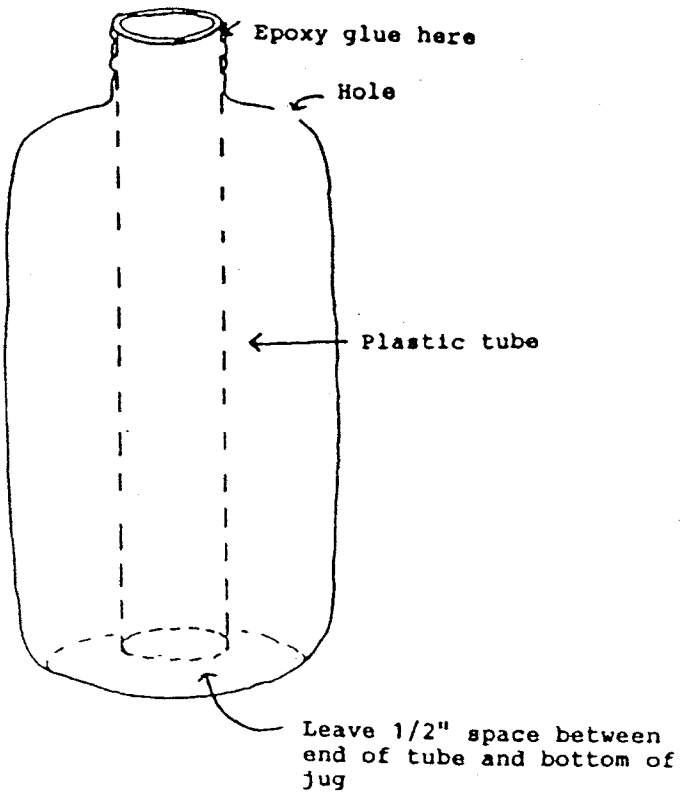
The operation of this bottle depends on construction of a secret compartment to hold water plus the controlled use of air pressure to give the illusion of a never-emptying jug. Here's how to construct yours:

1. Obtain a plastic tube that just fits into a large plastic soda bottle. Place the tube into the bottle so that it extends to about 1/4 inch above the end of the bottle. Mark the tube where it just protrudes from the bottle. Remove it and cut it at the mark.
2. Drill a 1/8 inch or smaller hole in the neck of the bottle.

From McCormack, Alan J. Magic and Showmanship for Teachers. Riverview, Florida: Idea Factory, 1990.

See ahead for new publisher.

3. Use epoxy cement to glue the tube into the bottle. Your final product should look like this:



4. Spray paint the bottle so that it becomes opaque. (Use as many coats as you need to be sure that no one can see inside the device.)
5. When the cement and paint are dry, fill the jug up to just below the drilled hole.
6. When you are ready to perform, pick up the bottle. *Place your finger or thumb over the hole* and pour "all" of the water from the bottle. This causes only the water trapped inside the inner tube to flow out.
7. Turn the "empty" bottle upright. Water from the secret compartment will refill the inner tube when you remove your finger from the hole (air moves into the bottle through the hole and equalizes the pressure inside and outside the bottle - this allows the inner tube to refill).
8. When you want more water to flow, once again secretly cover the hole and pour. The bottle will refill itself over and over again.
9. Be sure you don't do this simply as entertainment - have kids work at creative solutions to the mystery.

Sidetrips

1. In science, this could be used in lessons on liquids or air pressure.
2. For social studies, use this to highlight the Medieval period of alchemists and legends.
3. Art teachers could use the water flowing from the bottle to symbolize the needed flow of ideas for producing excellent art.
4. Reading teachers might use this demonstration in conjunction with reading about *Aladdin and the Magic Lamp.*

Some References:

McCormack, Alan. "Harry Potter Science," Instructor magazine, May/June 2005.

McCormack, Alan. Magic and Showmanship for Teachers. Showboard, Inc., Tampa, Fl, 1992.
Call 1-800-323-9189 and talk to a customer service representative.

Mail orders to P.O. Box 10656, Tampa, FL 33679.

Fax orders to 1-813-876-8046.

Subj: **MITCH--MG SLIGHTLY REVISED in the interest of accuracy**
Date: 11/17/04 5:12:45 PM Eastern Standard Time
From: Mbatoff
To: NJSTAnews@edusite.com
CC: Mbatoff

MENTAL GYMNASTICS You Can Use Tomorrow

By Mitch Batoff of New Jersey City University and President, NJSTA.... mbatoff@aol.com

More Thought Provoking Problems and Queries---

166. THE PERPLEXING AQUA VASE. While teaching my sixth grade class at Roosevelt Elementary School in Ossining, New York I did the following demonstration. In a nonchalant manner I picked up a metal vase and poured a clear and colorless liquid into a nine ounce plastic tumbler. Immediately the liquid turned **red** and as the vase was held vertically upside down it appeared to be **empty** since no more liquid flowed out. A few minutes later I picked up the "empty" vase and poured liquid into a second plastic tumbler and immediately it turned **blue.** Again, as the vase was inverted above the tumbler it appeared to be **empty** since no more liquid came out! A short time later I picked up the "empty" vase and poured liquid into a third tumbler and immediately the liquid turned **green.**
Once more, as the vase was held upside down above the tumbler, it appeared to be empty since no more liquid came out. This procedure was repeated through three more colors-- **yellow, orange, purple-** and then colorless, and each time the vase emptied all its liquid; each time as the vase was inverted no more liquid came out! **What is going on here? How do you explain these bizarre observations? There really are two perplexing things to explain, right?**

167. TWO COINS. Ask your students the following question: Which is larger, a nickel or a dime? What lesson can be

Subj: **NJSTA--NEWSLETTER--JUNE--MENTAL GYMNASTICS**
Date: 5/31/2005 1:50:12 P.M. Eastern Standard Time
From: Mbatoff
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CC: Mbatoff

Mental Gymnastics You Can Use Tomorrow

By Mitch Batoff of New Jersey City University...mbatoff@aol.com

ANSWERS AND EXPLANATIONS FROM PAST NEWSLETTERS

174. HOW LONG (May 2005). As part of a science fair project Yolanda had to cut a ten-foot plank into ten equal sections. She was approaching a deadline and had to complete this task as quickly as possible. She found that it took her one minute for each cut. **Question:** How long did it take her to finish the job? **Answer:** It should take her nine minutes. Only nine cuts are required to obtain ten sections.

175. RECYCLING (May 2005). A small town in south Jersey had a very active recycling program. They found that they were able to get one new can for every twenty-four cans that were collected. At the end of the third week in January, 1728 cans were turned in.
Question: How many new cans will they have at the end of the entire cycle?
Answer: 75 cans. Here's the explanation. 1728 cans divided by 24 gives 72 cans. And 72 cans divided by 24 yields another 3 cans. So the answer is 72 plus 3 or a total of 75 cans.
That is, 72 for the first time around and another 3 for those recycled

173. SUNRISE, SUNSET (May 2005). Here are two **clues**: Does the sun really set in the west, i.e., due west most of the year? And does a road on a map that is shown as going North-South really go North-South at every point along the way? A detailed explanation will be given in the September Newsletter.

156. THE RACETRACK PROBLEM CONTINUED (October 2004, February and March 2005). The answer is **IMPOSSIBLE,** it can't be done; and one way to explain **why** this is the correct answer is that in order to obtain an average of one mile per minute you would have to go around the track the second time in zero minutes! 2 plus 0 divided by 2 equals 1. This is the only way to get an average (mean) of 1. Thus, it is impossible to average a mile per minute (i.e., 60 mph) for both times around.

166. MORE ON THE AQUA VASE (January, February, and March 2005). Here is a variation on the construction of the "Inexhaustible Bottle" which I have not tried but might be an improvement. Drill holes all around the circumference of the rigid plastic tube about 1/4-1/2 inch from one end. Then epoxy this end to the inside bottom of the soda bottle and, of course, glue the top end of the tube into the neck as shown in the diagram in the March newsletter. This variation may make the

whole construction more rigid and permanent. But remember, whichever design you use, liquid must be able to flow into the inner compartment as you inconspicuously remove your finger from the small hole thus equalizing the air pressure in the two compartments.

Here is another suggestion to enhance the value of this device in teaching. Use the opaque spray-painted bottle during the "imagineering" experience and until your students have gone crazy trying to figure out what's going on! **Make a second bottle** that is not spray-painted and thus is **transparent**, allowing students to see exactly what is happening inside as the pressure is controlled by closing and opening the small hole. Use this bottle at a later stage when you are ready to delve into the explanation. Magicians and some teachers never reveal what's going on with this mind-boggling demonstration.

There's one more part to this story which I have not yet explained. It's the easy part. You may recall in the original description of the Perplexing Aqua Vase demonstration (January 2005)...poured a clear and colorless liquid into a nine ounce plastic tumbler. Immediately the liquid turned **red**. A few minutes later I picked up the "empty" vase and poured liquid into a second plastic tumbler and immediately it turned **blue**... liquid into a third tumbler and immediately it turned **green**... fourth tumbler and it turned **yellow**...
and a fifth tumbler the liquid remained **clear and colorless! Explanation:** I'm sure by now you have figured this out. If not, here is how it is done. Prepare the plastic tumblers in advance by placing a **very small drop** of food coloring in the bottom along the inner rim of each tumbler. Make it as inconspicuous as possible. Place the tumblers aside and by the next day the tiny spots of color will be dry. I use McCormick Assorted Food Colors and Egg Dye. There are four drop control vials in a box: green, yellow, red, and blue. After students have lost some sleep trying to figure this out elicit explanations from the class. I prefer this approach to just telling them outright.

Can you think of some thought provoking science **questions** related to the food coloring part of this demonstration? There's more to this than "just magic." Or at least there should be.

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More problems, queries, and explanations next month. Keep reading the Newsletter.

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Nina, please preserve **CAPS** and **bolding.** If space permits add some clever / cute graphics. Thanks. Mitch

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Oh, My New Shirt. By way of introduction, let's start with the topic of assumptions, which pervade all science. Assumptions need to be checked and questioned at every turn. Did you assume that the blue Sheaffer ink or the Quink, which I held up at the outset of this demonstration, was the liquid in the spray bottle and the same liquid that I sprayed on the white shirt and handkerchief? It would be interesting to see whether your students make this erroneous assumption. Beware of erroneous assumptions. The blue "ink" is not ink but a solution called "Disappearing Ink." What follows is not a trick, not magic, just a little chemistry and an ideal introduction or complement to lessons on acid-based indicators. By way of introduction, recall that litmus paper is an acid-base indicator which turns pink in an acidic solution and blue in a basic solution. There are many other acid-base indicators. Some are found in pet stores and are used to test the pH of an aquarium; others are used to test the pH of soil. The pH range from 0 to 6 is acidic, 7 is neutral, and 8-14 basic. Now back to the "Disappearing Ink." Chemist and teacher, David Katz, years ago investigated this blue solution sold in toy and novelty stores as well as magic shops. He found that it simply contains a slightly basic solution of the indicator thymolphthalein. Thymolphthalein is blue in the pH range 9.4-10.6 but in this solution it is near its kick over point (about pH 9.5) where it goes from blue to colorless. The ink fades because the carbon dioxide in the air (somewhat like acid rain) reacts to form an acidic solution. This solution neutralizes the basic solution just enough to lower the pH past the kick over point for the indicator thymolphthalein and the blue color fades to colorless.** The color change takes only a few minutes. It is hastened by the carbon dioxide fire extinguisher as used by Lee Marek with Dave Letterman. Hilarious and dramatic but you probably shouldn't do this in your class. It is not needed to cause the color change. Just wait a few minutes and the blue will be gone.

**Acknowledgment to Dave Katz and Lee Marek for this explanation. Lee Marek is one of the Weird Science Group. Note: there is an additional reaction involving NaOH and CO_2 forming sodium carbonate (NA_2CO_3) and H_2O.

Disappearing Ink

Will an "ink" stain on a white towel disappear? This activity shows how you can make ink that will disappear with the help of carbon dioxide in the atmosphere.

Activity Guidelines

This activity works well as a demonstration with any size audience.

Time

Getting Ready: 10 minutes
Doing the Activity: 5–10 minutes.

Materials

- 1–5 mL of 0.25 M sodium hydroxide (NaOH) solution
- 10 mL of ethyl alcohol or rubbing alcohol
- water
- 0.1 g of either thymolphthalein powder or phenolphthalein powder (acid–base indicators are available from a science supply house; see Shopping List)
- two 100-mL beakers or small jars
- 2 stirring rods
- spray bottle or eyedropper
- 2 pieces of white cloth
- soap solution or Windex® with ammonia D®, or household ammonia
- vinegar

Variation

- commercial disappearing ink (available from Loftus; see Shopping List)

Doing the Activity

1. Squirt a small amount of the ink on two pieces of cloth with an eyedropper or spray bottle. Set one aside. Blow on the colored portion of one cloth and note the color change. The colored spot on the one you set aside will fade with time, leaving a colorless water spot.

   If loosely woven fabric is used, the color will fade more quickly.

2. After the ink has disappeared, spray the area with soap, a dilute sodium hydroxide solution, Windex® with ammonia D®, or household ammonia, and the color will reappear.

Variation

Instead of preparing the ink, use the commercially available disappearing ink to do the activity. This solution is sold to put into toy water guns or trick ink pens.

Explanation

Thymolphthalein is an alcohol-soluble **acid-base indicator** (colorless if the pH is less than 9.4 and blue if the pH is greater than 10.6). Addition of the sodium hydroxide (NaOH) solution increases the pH of the thymolphthalein solution and produces the blue color. Phenolphthalein is colorless if the pH is less than 8.0 and red if the pH is greater than 10.0.

When the solution is exposed to air, the sodium hydroxide reacts with the carbon dioxide (CO_2) in the air to form sodium carbonate (Na_2CO_3) as shown in the following equation:

$$\underset{\text{sodium hydroxide}}{2\,NaOH(aq)} + \underset{\text{carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{sodium carbonate}}{Na_2CO_3(aq)} + \underset{\text{water}}{H_2O(l)}$$

As the carbon dioxide reacts with the sodium hydroxide, the pH is lowered, and the indicator changes from the colored form to the colorless acidic form. When the liquid evaporates, it leaves behind a white residue of sodium carbonate, which washes out easily with water.

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Safety and Disposal

Dust, pellets, and concentrated solutions of sodium hydroxide (NaOH) are very caustic. They can cause severe chemical burns and destroy cell membranes. Contact with the skin and eyes must be prevented. Should contact occur, rinse the affected area with water for 15 minutes. If the contact involves the eyes, medical attention should be sought while the rinsing is occurring.

The above precautions must be followed when preparing the dilute solutions used in this activity. Eye protection is required even when using dilute solutions.

The sodium hydroxide solution used in this activity can be diluted with water and flushed down the drain. Unused solutions can be saved for further use.

Getting Ready

Preparing the Ink:

1. Dissolve 0.1 g of thymolphthalein or phenolphthalein in 10 mL of ethyl alcohol or rubbing alcohol, and add water to bring the volume to 50 mL.

2. Prepare 0.25 M sodium hydroxide solution by dissolving 1 g of sodium hydroxide in 100 mL of water (or dissolve about 1/4 teaspoon of lye in about 1 cup of water).

3. Add 0.25 M sodium hydroxide solution dropwise until the solution is blue (or red if phenolphthalein is used). The ink is now ready for use.

The time it takes for the color to disappear depends on the amount of sodium hydroxide in the ink solution.

- If the color fades too rapidly, add a few more drops of the sodium hydroxide solution to the ink solution.
- If the color lasts too long, dilute the ink solution with water or add a few drops of a dilute acid solution (e.g., vinegar) to the ink solution.

If the ink has been stored, test it before use; if it is colorless or fades too rapidly, add more 0.25 M sodium hydroxide solution.

4. Test a sample of the cloth before spraying or pouring to assure that no permanent stain will result.

Educational Innovations

SM-925
Goldenrod Paper (pack of 100 sheets)

This goldenrod paper is colored with a dye which is an acid-base indicator. It turns bright red in bases (eg. solutions of ammonia, baking soda or washing soda) and golden-yellow in acids (eg. vinegar or lemon juice). Try the following:

1. With a Q-Tip, write a message with household ammonia. As the ammonia evaporates, the red message will disappear.

2. Write a permanent message with a base such as a solution of baking or washing soda. The message remains.

3. Write an invisible message on the goldenrod paper using a piece of candle wax. Spray the paper with a basic solution to see the message.

4. Use goldenrod paper to classify safe household products as acidic or basic.

5. Use goldenrod indicator paper to test for acids and bases.

For over 150 years litmus paper has been used to test the acidity of a solution. Now you can use goldenrod paper in the same way.

	COLOR		
	Basic Solution	**Acidic Solution**	**Neutral Solution**
Red Litmus Paper	*Turns Blue*	*Stays Red*	*Stays Red*
Blue Litmus Paper	*Stays Blue*	*Turns Red*	*Stays Blue*

Note: You can change red litmus paper into blue litmus paper by soaking the red paper in a weak solution of a base, such as, baking soda, $NaHCO_3$ and allowing it to dry.

	COLOR		
	Basic Solution	**Acidic Solution**	**Neutral Solution**
Yellow Goldenrod Paper	*Turns Red*	*Stays Yellow*	*Stays Yellow*
Red Goldenrod Paper	*Stays Red*	*Turns Yellow*	*Stays Red*

Note: You can change yellow goldenrod paper into red goldenrod paper by soaking the yellow paper in a weak solution of a base, such as, baking soda, $NaHCO_3$ and allowing it to dry.

Suggested Activity: Provide students with the above litmus paper chart (not the goldenrod chart), a few pieces of red and blue litmus paper, vinegar, baking soda, and a sheet of goldenrod paper. The challenge is to prepare a similar type chart for goldenrod paper.

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EGGS, EQUINOX, AND CARL SAGAN

Question: What do you suppose we are going to do in this class/workshop? What do you make of this cryptic title?

Grade Level: 4 or 5 and up.

Time: About 3/4 hour plus follow-up on another day.

Materials: Newspaper article published around the time of the equinox in March or September; one uncooked egg for each student; optional: Carl Sagan's book, The Demon-Haunted World, Science as a Candle in the Dark (Random House, 1995), Chapter 12 in particular, also references on pp. 443-444; in addition, articles by Carl Sagan, over many years, on the topic of this book and Chapter 12 in particular.

Suggested Procedure: Start by reading the article to the class or have a pupil read the article if he or she brought it in. The news reports will mention that this is the time of the spring equinox (in March) or autumnal equinox (in September) and that "EGGS CAN BE STOOD ON END AT THE EQUINOX." Articles on this topic appear in the news nearly every year. Furthermore, you might read or hear in the news that this phenomenon occurs only at the time of the equinox. You might even see photographs of adults doing it or a classroom in which students are shown trying to balance eggs. You can also display photographs such as you saw in this workshop/class which you took at the time of the vernal or autumnal equinox. Mine were taken at home and show eggs balanced on end on the kitchen table, dining room table, and in the living room.

What is an EQUINOX? The equinox is a certain day on the calendar. Specifically, it refers to the two times each year--in March and September, spring and autumn--when the sun is on or over the equator resulting in day and night being of equal length. The March or vernal equinox and the September or autumnal equinox are two points on the sun's apparent annual eastward path along the ecliptic, the path the sun seems to follow as the earth revolves around the sun.

Getting back to the phenomenon of eggs standing on end at the equinox, some people will even go on to say that "this can happen only for an hour or two centered on the exact time of equinox."

Pause and wait for comments and questions from the class, particularly questions. What is the question you hope one or more students will ask? HAS ANYONE TRIED TO BALANCE EGGS ON END AT OTHER TIMES OF THE YEAR? IF SO, WHAT HAPPENED? IF NOT, WHY NOT? Try to elicit these questions from the class. They are significant and go to the heart of the whole lesson.

Perhaps a pupil will suggest that "we try it" or "I'm going to try it at home tonight." Or, you might ask the class, "Would you like to try it at your desks?" Naturally, they will say, "yes." Then you might say, "Well, I just happen to have two dozen eggs in my desk drawer!"

Carefully distribute the fresh, uncooked eggs to each pupil. Have them keep the eggs in the center of their flat-top desk. "No one move during this activity." "Do it very carefully, holding the egg with the larger end resting on the desk top. Wait for the fluid contact of the egg to settle, then carefully test the balance. Be patient as you find the point where you can ever so gently let it go to remain standing on end."

N.B. I have tried this, at various times of the year, just to obtain some experiential evidence to support some understanding of physics and to apply principles of science and clear thinking. It is foolish to accept things as true (that can easily be tested) without testing them. STANDING AN EGG ON END ON A HARD AND SMOOTH SURFACE, SUCH AS A FLAT DESK OR KITCHEN TABLE, REQUIRES CARE AND PATIENCE, BUT IT CAN BE DONE ANY TIME OF THE YEAR. Equinox means balanced light, not balanced eggs! There is absolutely no astronomical reason why you should be able to balance raw eggs on the first day of spring (the vernal equinox) as opposed to any other day. Do you have any doubts? Ask an astronomer!

Von Del Chamberlain, an astronomer, has this to say:

> The underlying assumption relating to standing eggs on end is that there must exist some special gravitational balance. No such thing occurs at equinox time. Concerning gravitational effects, here are a few things to ponder. (1) Earth's orbit is elliptical, not circular. Thus, there is a slightly stronger force between Earth and Sun when we are closest to the Sun in January, and slightly less force when we are farther out in July. (2) Tidal forces on Earth are caused mostly by the Moon and Sun, and these two bodies nearly align each month at new moon and full moon, being strongest twice each year when eclipses occur, the two "eclipse seasons." Currently our eclipse seasons are in the months of March/April and September/October, but this changes constantly as the

years go by. (3) Earth is not spherical, so that some places on Earth are nearer to our planet's center of gravity than are others. (4) There are other forces that are smaller, yet significant, involving the pull of gravity from the other planets, and for that matter even from distant stars. I list these things to remind us that for anything we want to consider, there are many factors and never ever the perfect balance we might wish for, and there is no special gravitational balance at equinox time.

Getting back to our topic, even though the situation is complex, the most dominant force of gravity is the one between Earth and egg, the weight of the egg, the force pulling the egg to the counter top. All the variations listed above are negligible for the experiment of standing eggs on end.

Physicist Andrew Warner sheds some light on the matter:

Imagine the Sun, a great big sphere. The Earth is orbiting the sun at 150 million km.

The Earth is spinning on its own axis but this axis is inclined at 23.5 degrees to the plane of the Earth's orbit. This is what gives us the seasons.

When the northern hemisphere is closest to the sun, it's northern hemisphere summer and southern hemisphere winter. When the southern hemisphere is closest to the Sun, the converse is true.

When the Earth goes past that point in its orbit when the hemispheres are equal distances from the Sun, it is called equinox. At this point the axis of the Earth's rotation is perpendicular to the line joining the Sun and the Earth.

What this means in practice is that in the northern hemisphere mid-summer the Sun at noon would be directly overhead along the Tropic of Cancer. Mid-winter (northern hemisphere) the sun would be directly overhead along the Tropic of Capricorn. At the equinox--either spring or autumn (fall)--the Sun will be directly overhead along the equator.

So, if the sun exerted sufficient influence to make any difference to an egg's balance it would depend on where in the world your were; i.e., mid-northern hemisphere summer--the summer solstice--you would have to do the egg trick at noon somewhere along the Tropic of Cancer. Like Cuba or perhaps the United Arab Emirates.

The fact is, however, that the gravitational force exerted on an egg by

the Sun is, by virtue of the intervening 150,000,000 km of space between the egg and the Sun, negligible compared to that of the Earth on the egg. The upshot of that is that even if the effect were large, which it's not, the effect would not be restricted to the equinox and would apply at noon at different parts of the world at different times of the year.

Now, if we include the effects of the moon which are larger than those of the Sun as evidenced by the tides....

So, what do you think about explanations for the egg-balancing act involving gravity, that gravity is somehow "balanced" when the sun is over the earth's equator or that the sun exerts a greater gravitational attraction over the earth on these two days?

As Bob Riddle points out, balancing an egg on the equinox may be one of the all-time great examples of bad science, a hoax; it certainly offers a wonderful opportunity to question a popular misconception and test its validity and explanations.

Have your students consider the following:

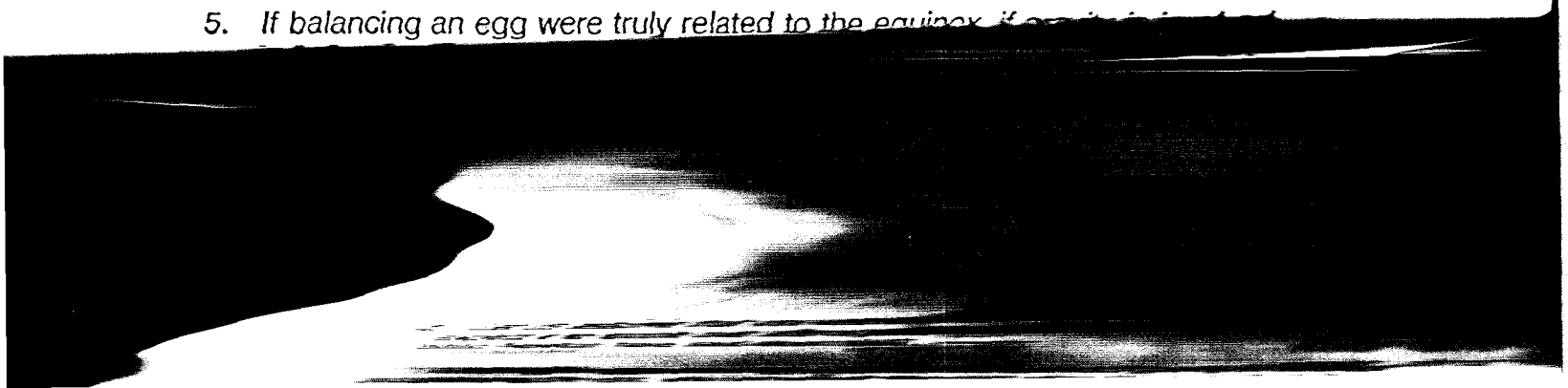
1. If balancing eggs were truly related to the equinox, if these explanations had any validity, shouldn't you always be able to balance an egg during the equinox? Can you?

2. If balancing eggs were truly related to the equinox, shouldn't the balanced eggs topple over one minute after midnight, at the end of the equinox? Does this occur? Have you tried it and observed the eggs after midnight?

3. If balancing eggs were truly related to the equinox, then it should be impossible to balance an egg at any other time of the year except the equinox. Is it impossible to do this at other times besides the equinox? How many times have you tried it? What have you found? Suppose you were never able to balance an egg during these trials throughout the year, what can you infer? What can you conclude from these experiences?

4. Let us assume that you were able to balance an egg on end. Would you expect it to topple over after a period of time? How long? What would Isaac Newton have said about this?

5. *If balancing an egg were truly related to the equinox, if*



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5. If balancing an egg were truly related to the equinox, if gravity is involved in balancing the egg, why just eggs? Shouldn't other objects balance just as well on this special day? Or is gravity selective so that only an egg is affected on this particular day? Have you tried to balance other objects on the equinox?

→ Folding Paper, Biology, and More. Although you won't be able to fold the paper more than 6 or 7 times, you can do the arithmetic up to any number. Consider 32 folds: you would have this number of pieces of paper: 2,147, 483,648. If, instead of folds, you just started with a paper napkin three-thousands (0.003) of an inch thick, after the 32nd doubling you would have a pile 6,442,451 inches high. Divide by 12 and you get 536,871 feet. Divide by 5,280 and you get nearly **102 miles**! This is an example of EXPONENTIAL GROWTH. This type of growth is characterized by doubling in a fixed period of time (e.g., as applied to finances or the energy crisis or biological processes) and a few doublings can lead quickly to <u>enormous numbers</u>. Using the famous Rule of 72, Interest rate x number of years = 72 or doubling time = 72/interest rate. Money doubles in the amount of time that interest rate is divisible into 72. Thus, at 6% compound interest, money doubles in 12 years. Doubling time = 72/% growth per unit time.

Princeton Workshop
29 June 2000
M. E. Batoff

EXPONENTIAL GROWTH AND DOUBLING TIME

There is an important relationship between the **percent growth rate** and its **d o u b l i n g t i m e,** the time it takes to double a quantity (e.g., money, population, growth of bacteria, electric power generating capacity, etc.)

To estimate the doubling time for a **steadily growing quantity,** we simply divide the number 70 by the percentage growth rate per unit time. (e.g., 7% per year or 2% per minute).

Just remember:

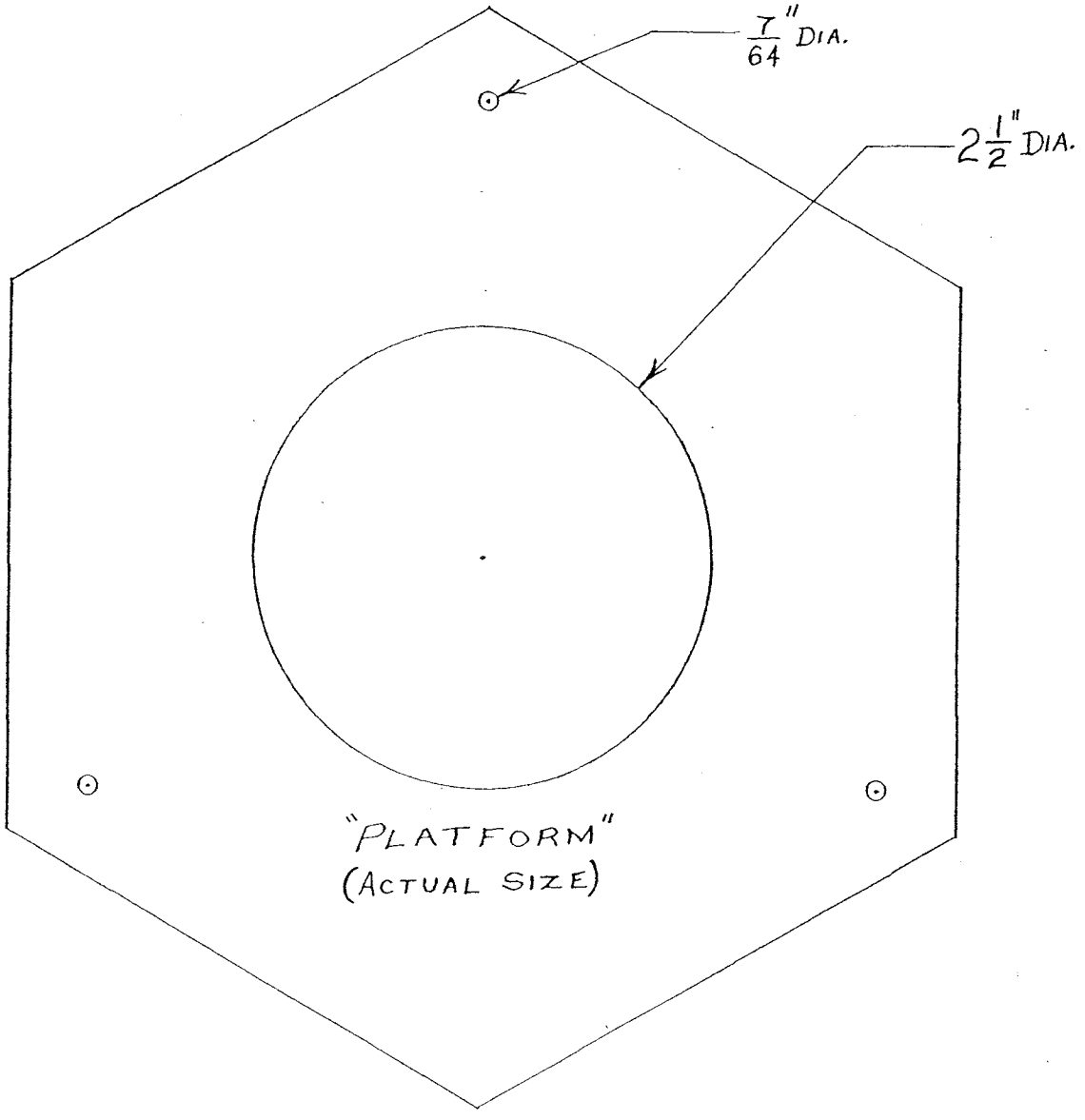
Topic: Centripetal force. Johnston's "Singapore Sling". Another discrepant event?

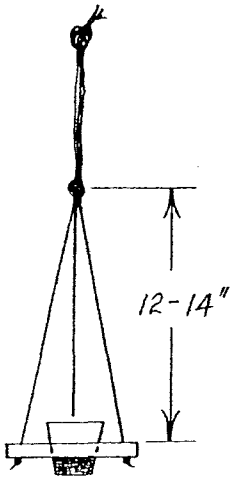
The problem: How can you have a liquid in a half-filled, open-topped tumbler on its side and upside down and never spill a drop?

Set-up: Make a platform out of ¼" or 3/8" plywood. Copy (xerox) this page and cut out the "platform". Use it as a pattern to trace the edges on the plywood. The center hole accommodates the very popular 9 oz. party tumblers that are on the market. #18 nylon mason's line is recommended for the strings. Cut three strings 24 in. long. Thread each string through the hole from the top and tie a tight half knot at the bottom. Gather the three strings together and carefully tie another half knot about 12-14 inches above the platform, making sure the platform is level before tightening. Then make a large knot(s) at the end to hold onto.

Perform: Hide the apparatus until after the problem has been presented and discussed. Put the tumbler in the hole and begin the swing. (You should always practice beforehand.) Start with a vertical circle, go to a horizontal circle above your head, and return to the vertical circle before you stop. Remind your students that 80% or more of the rides at amusement parks utilize the concept of centripetal force. The liquid didn't spill out; the riders don't fall out. If you didn't spill, celebrate by taking a sip of the liquid!

(Written up by John B. Johnston, The Faraday Center, ~~RR-1 Box 188,~~ 103 CREAMERY RD. Livingston Manor, NY 12758 ; phone no. ~~(914)~~ (845) 439 - 4706.)





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TOOLS THAT TEACH.

Colliding Steel Spheres P6-6070

Contents:

Two 1-pound, 2-inch diameter chrome steel spheres

Background:

Most students can tell you that mechanical systems convert some energy to heat. When objects collide, the kinetic energy transforms into sound, heat, and kinetic energy in the opposite direction. But it can be difficult to observe the heat produced.

Experiments

Note: Do not place fingers or important documents between the spheres!

1. Hold the spheres on either side of a sheet of plain paper. Carefully (but firmly) crash the spheres together, with the paper in between. Look at the paper. There should be a hole. To confirm that the hole was actually burned in the paper, sniff the paper and smell the smoke.
2. Try thicker papers, or multiple layers. Avoid paper with wax coatings (such as manila folders), as the wax will prevent a hole from forming.

Related Products

Energy Discovery Pack (P6-6060). Demonstrate different types of energy transformation with this collection.
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77. **H.G. WELLS 1897 CLASSIC.** The container used in this demonstration contained Wesson Canola Oil and the test tubes are Pyrex, brand name for a borosilicate glass. If possible, you should try to obtain Pyrex test tubes without markings. If not, they can still be used. As you may realize, this intriguing demonstration has to do with the bending of light and i_____n. I've given you a start. There's more to this interesting story. The following is a "must read": H.G. Wells's *The Invisible Man*, originally published in London and New York in 1897. It was republished by Dover in 1992 as an inexpensive paperback ($2.00) ISBN-0-486-27071-8. You may wonder, as you begin to read this and reach pp. 20 or 30 or so, "Where the heck is the science?" Keep going. It's there, and quite fascinating.

First published in 1897, *The Invisible Man* ranks as one of the most famous scientific fantasies ever written. Part of a series of pseudoscientific romances written by H.G. Wells (1866-1946) early in his career, the novel helped establish the British author as one of the first and best writers of science fiction.

Wells's years as a science student undoubtedly inspired a number of his early works, including this strikingly original novel. Set in turn-of-the-nineteenth century England, the story focuses on Griffin, a scientist who has discovered the means to make himself invisible. His initial, almost comedic, adventures are soon overshadowed by the bizarre streak of terror he unleashes upon the inhabitants of a small village.

Notable for its sheer invention, suspense and psychological nuance, *The Invisible Man* continues to enthrall science-fiction fans today as it did the reading public over 100 years ago.