

Physics Demonstrations & Labs: Motion & Forces

Laura Henriques, Kevin Dwyer, Shin Adachi, Kayla Bollinger, Marwing Cervantes, Mahmoud Elaraby, Tara Klamrowski, Terry Soliz, Rachael Yarbrough

– *CSULB faculty & students*



**NSTA/CSTA Conference
on Science Education**

Long Beach, CA Dec. 6, 2014

*HANDOUTS AVAILABLE ON THE
CONFERENCE SITE*

This workshop is presented by students enrolled in PHYS491 at CSULB as part of the PhysTEC project. Find out more about PhysTEC at physicsatthebeach.com

Introduction – Kevin & Laura

- PhysTEC at CSULB
- Opportunities for **you** to get involved
 - Monthly Demo Days (2nd Thursday of the month, 4:30 in HSCI280 at CSULB)
 - Physics Teacher Open House Events – each semester for you (and 2 of your students!)
 - Newsletter
 - PHYS491 – Content specific physics teaching course
- Full handouts will be available on conference website
- NGSS: PS2 Forces & Motion obviously, but also look for SEP & CCC
 - Ask questions, develop models, plan investigations, construct explanation, patterns, cause and effect

“Hearing” Acceleration - Shin

Topic: Kinematics

Materials: Hex nuts, string, pie tin

Set-up: Tie the hex nuts to the string at pre-calculated positions.

“Hearing Acceleration” – Teaching Tips

- The positions at which the hex nuts are tied should be multiples of 1, 4, 9, 16, 25, etc. (Ground as the origin) to get a constant time interval.

Roller Coaster Rides – Mahmoud

- Topic: Two-dimensional motion, free fall, projectile motion, normal force.
- Materials: 4 stage ramp, 4 marbles, ruler.
- Set up: A marble on each individual ramp, use ruler to hold marbles at same place at start line.
- Tell student to be mindful of falling marbles, no other safety concerns.

Newton's EGGciting 1st Law– Rachael

Relevant Physics Topic: Newton's first law

Materials: Beaker, Pie tin or cookie sheet, water, cardboard tubes, eggs, broom

Set Up: Set the pie tin on top of the beaker full of water with the cardboard tubes on top holding up the eggs.

Safety Considerations: Flying objects



Newton's EGGciting 1st Law– Teaching Tips

- With the pie tin swiftly removed the eggs want to stay in the same place
- They succumb to gravity and fall into the water
- TIPS
 - Make sure the pie tin is over the edge of the table.
 - Make sure the cardboard tubes are lined up directly over the water.
 - Plant your foot firmly on the bristles of the broom and pull back to get the spring action working.

Mrs. Dowdle's Inertia Eggs

(<http://www.youtube.com/watch?v=B20GRM64JU8>)

Dom Deluise on Johnny Carson

(<http://www.staged.com/video?v=4Vkc>)

ROCKET BALLOONS - Terry

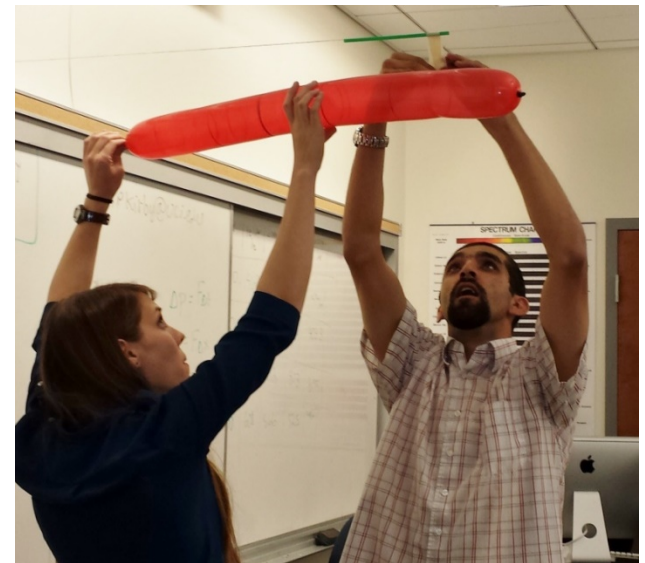
- Relevant Physics Topic: Newton's 2nd & 3rd Laws of Motion
Balanced Forces and Space Exploration
- Materials: Balloons of various sizes and shapes; scissors, masking tape, plastic drinking straws, string, meter stick, 1-quart plastic bag (optional), balloon pump (optional), student lab books and a stop watch



- Set Up: Group Project, measure off length for rocket runway with string, tie one string end taut to a secure object, like a door knob, tape plastic bag to the straw, pass the end of string through the straw, insert inflated balloon while pinching the opening so no air escapes into the plastic baggie or tape balloon directly to straw.
- Safety Considerations: This is a great project for an outdoor activity. If you have an air valve use slow short burst of air.

ROCKET BALLOONS – Teaching Tips

- Newton's 3rd Law of Motion- for every action there is an equal and opposite reaction. When releasing the air from the balloon the air escapes and the rocket moves forward along the runway.
- It's all about thrust. As the air is released from the balloon it creates a forward motion called thrust. The thrust comes from the energy of the balloon forcing the air out.
- The following link from UC Irvine includes a well developed lesson plan http://www.cfep.uci.edu/cspi/docs/lessons_secondary/Rocket-Balloon.pdf
- In a real rocket thrust is created by the force of burning rocket fuel as it blasts from the rockets engines – as the engines blast down the rocket goes up.



Medicine Ball Momentum – Tara

Relevant Physics Topic: Newton's third law and conservation of momentum

Materials: Medicine ball (10-14 lbs) ; low friction carts (or skateboards)

Set Up: Two persons, each seated on a cart, with the carts placed close together

Safety Considerations: Medicine ball is heavy— make sure the students are strong enough to catch it

Medicine Ball Momentum–Teaching Tips

Physics Involved:

Newton's 3rd Law:

- Person exerting a force (throwing or catching) on ball → There will be an equal but opposite force exerted on the person, making her move backwards

Momentum:

- Momentum of ball will cause students to move farther apart from each other
- Catching the ball— momentum will be transferred to student
- Throwing the ball— student will move with equal force in the opposite direction of the ball

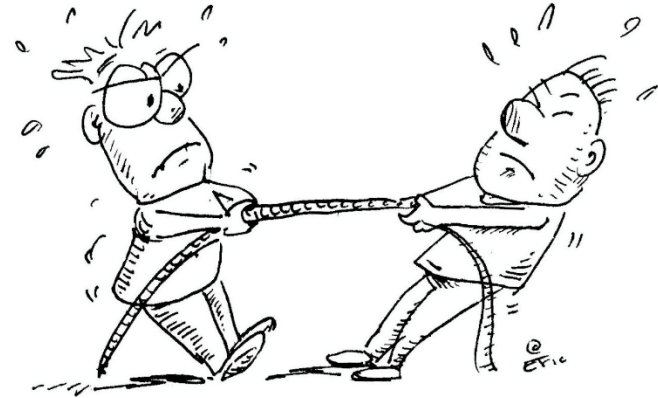
Tips:

- NO CARPET
- Low friction carts is a must
- Throw the ball straight out from chest

Tug of War - Kayla

Relevant Physics Topic:
Direction/Components of Force

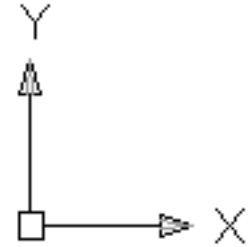
Materials: Rope, ≥ 3 Volunteers



Set Up: Have at least one person on each end of the rope. Have them pull on the rope as hard as they can—just like Tug of War. Have one person stand next to the center of the rope, and push down on the rope.

Safety Considerations: Normal Tug of War risks—if the group of people on one end of the rope suddenly let go, the other side will fall.

Tug of War – Teaching Tips



Physics Involved:

- Direction/Components of Force
- Pulling on the ends of the rope is a force in the $\pm x$ direction.
- Pushing down on the rope is a force in the $-y$ direction.
- Since these force components are perpendicular to each other, one should not affect the other.
- Summary: The ease at which you can push down on the center of the rope has nothing to do with how strongly the rope is being pulled towards either side.

Tips:

- If possible, have seemingly stronger volunteers pulling the rope, and a seemingly weaker volunteer to push down on the rope. It will be more surprising to see a smaller force “overcoming” a stronger force.

Gravity & the “Fabric of the Cosmos”–Kevin

Topic: Gravity, circular motion

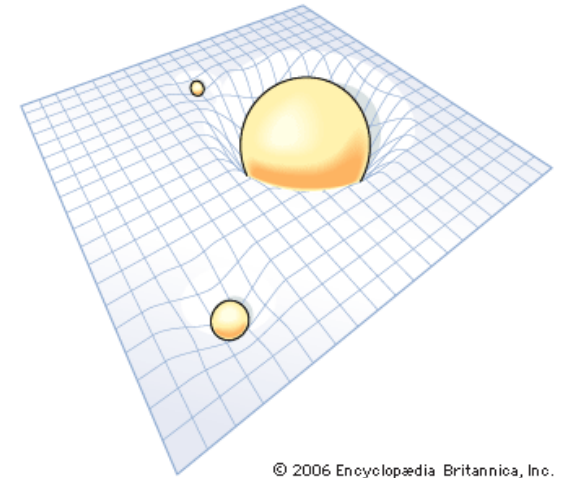
Materials: Hula Hoop, Spandex material (1 sq yd), large paper clips, Large mass (1 kg) and marbles

Set-up: Stretch the material over the hoop and secure with clips

Safety Considerations: Beware of large falling masses

Gravity & “Fabric...” – Teaching Tips

- Mass warps space
- You can show:
 - Two objects attract each other
 - Satellites orbit a central mass
 - Why planets all orbit in one direction
 - Moon orbits Earth while Earth orbits the Sun.
- Larger version can be made using tent poles or PVC
- [youtube.com/watch?v=MTY1Kje0yLg](https://www.youtube.com/watch?v=MTY1Kje0yLg) (or search “gravity visualized” - 7 million views!)



© 2006 Encyclopædia Britannica, Inc.

Whistling Balloons

Terry Soliz

Relevant Physics Topic: CENTRIPETAL FORCE

Newton's Second Law of Motion

Materials: Two clear balloons, penny, hex nut

Set Up: insert penny in one balloon, hex nut in the other, blow up balloons and tie off and spin the balloon

Safety Considerations: Hex nut can pop balloon, students might swallow small objects.



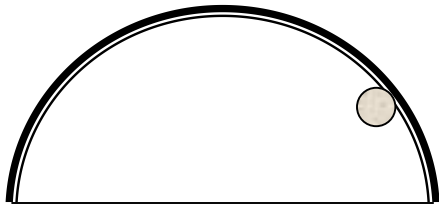
Whistling Balloons – Teaching Tips

- CENTRIPETAL FORCE – A CENTER SEEKING FORCE –
- CENTRI → CENTER SEEKING
- NEWTON'S SECOND LAW OF MOTION $F=ma$
- CENTRIPETAL FORCE EXPERIMENT WITH Astronaut Jeff Williams onboard the on International Space Station
- <https://www.youtube.com/watch?v=bs2orRFuolk>

Round & Round It Goes.....

Circular Motion & Misconceptions

- Circular motion requires a net force – we know because the direction is always changing.
- What provides the force to keep an object moving in a circle? What happens if that force is removed?



What happens to a marble that is rolling around the edge of a plate when it comes to the end?

What are the forces involved here?

Relevant Physics Topic: Circular Motion

Materials: disposable plastic plates, marbles, ruler (with center groove)

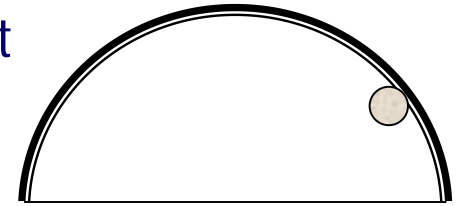
Set Up: place plastic plate on a horizontal surface

Safety Considerations: N/A

Round and Round It Goes

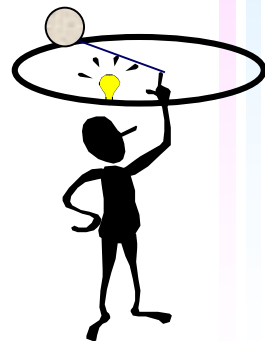
This works well on an overhead (with transparent plate) or with document camera.

Have students predict before doing the demo.



Extension: challenge students to set up multiple plates through which the marble can traverse (gives you a good sense of whether or not they really *get* what's going on.

Extension: play 'catch' with a tennis ball inside a plastic bag. Where should I release the string so that the ball travels to you. (If doing this inside use nerf ball, outside you can use a tennis ball.)



Spinning Glass– Tara Klamrowski

Relevant Physics Topic: Centripetal Force

Materials: Platform (“The SpillNot”); glass; liquid (water)

Set Up: Fill glass with water (at least halfway), and place on platform

Safety Considerations: Maintain consistent velocity as much as possible so the glass experience centripetal force.

Spinning Wine Glass– Teaching Tips

Physics Involved:

- Centripetal “center-seeking” force is experienced by the glass
- Centripetal force generated is greater than gravity
- Thus, the force holds glass and liquid in place during rotation

Tips:

- Maintain a consistent velocity (with a large enough magnitude) to avoid the glass slipping off
- Starting and stopping are the hardest parts

https://www.youtube.com/watch?v=uxiz27_La7M

Balancing Penny- Marwing

Relevant physics topic: Centripetal Force and Newton's First Law of Motion

Materials: Wire hanger and a couple of penny's

Set up: First you must bend the wire hanger until the end is pointed back, similar to a shape of a diamond. You then place the penny on the hook end of the hanger. With your index finger (opposite side of the hook) start swinging the hanger back and forth, then gradually start increasing the swing. Increasing the swing will let you spin the hanger in a full circular motion.

Safety Considerations: Try not to poke yourself while spinning. Fairly easy and simple.

Balancing Penny- Teaching Tips

- According to Newton's First Law of Motion, the object is in motion and stays in motion unless acted upon by an external force. In this case Newton's law requires the penny to continue moving in a circular motion. Thus a force is required to keep it always turning towards the center of the circle.
- Centripetal Force: a force that acts on a body moving in a circular path and is directed toward the center around which the body is moving. Which means that the force is always directed toward the center of the circle. Without this force, an object will simply continue moving in a straight line motion.
- <http://www.youtube.com/watch?v=oAqOksj4Kvg> Centripetal Force Penny-Sick Science! #157

Free Fall Madness - Mahmoud

- Free fall / Torque
- Door hinge, two 2-foot wooden slabs, 1-inch ball, small cup, 2 velcro stickers, clay, 8 inch wooden stick, ½ inch pvc.
- Safety hazards: falling ball & pinching hand/fingers

Free Fall Madness – Teaching Tips

- The only force acting on the ball during the fall is GRAVITY
- Two things are acting on the cup during the fall – GRAVITY & TORQUE

Spinning Chairs – Kayla

Relevant Physics Topic: Moment of Inertia, Conservation of Angular Momentum

Materials: Spinning Chair, Weights, 2 volunteers

Set Up: Have one person sit in the spinning chair, holding one weight in each hand--away from their body. Have the second person start to spin them in the chair. Then, have the person sitting pull the weights in towards their body.

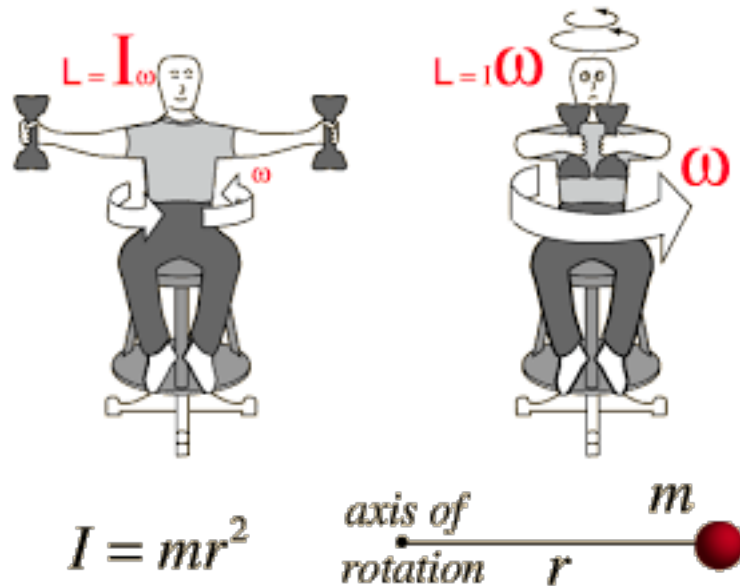
Safety Considerations: Falling off the chair. If the weights are too heavy, it will be easier to lose control when bringing the weights in—might pinch fingers.



Spinning Chairs– Teaching Tips

Physics Involved:

- Moment of inertia
 - Conservation of Angular Momentum
- Momentum
- Holding weights farther away results in larger radius (r), and hence larger moment of Inertia (I)
 - Pulling in weights reduces (r) and, consequently, Reduces (I). To conserve angular momentum, the angular velocity(w) must increase.



Tips:

- Use a chair that spins easily.
- The heavier the masses, the greater the increase in spin.

I Can't Stop Spinning – Marwing

Relevant physics topic: Angular Momentum and Moment of Inertia

Materials: Wire hanger (coat hanger), some string, two masses (two D batteries about 5oz each), two flat washers, scissors, and tape

Set up: You first would have to cut two pieces of string one will go on the top of the hanger and the other leveled up to the bottom of the hanger. You will use a flat washer that will go in the center (bottom) to even out the length between the two masses. You then set a mark on the hanger (pulling in the weights to the center from 8 inches to 4 inches) and as you pull the string the two masses should come to the center of the hanger. The speed should gradually increase (four times as fast) as the two weights get indefinitely closer.

Safety considerations: Fairly simple, just make sure you don't cut yourself with the scissors

I Can't Stop Spinning – Teaching Tips

- Angular momentum: a principle in which states that the total angular momentum of an object remains constant as long as no external torque acts on that object
- Moment of Inertia: a measure of resistance of a body to angular acceleration
- Removing any factors as possible: the string on top of the hanger reduces any chance of friction of the device, the low mass of the device itself compared with the mass of the weights also insure you can discount any effect from the mechanism itself, and the string we pull from the center, without affecting the spin rate, will change just the radius of the experiment in order for the mechanism to increase its speed (accelerate)
- <http://www.youtube.com/watch?v=Zt5HXj-hCE8> 11-Rotational Motion Experiment

PHET Simulations– Rachael

Relevant Physics Topic: All of them

Materials: Computer, access to internet beforehand

Set Up: Download simulation to run

Safety Considerations: Giving students access to the internet in class.



PhET Simulations – Teaching Tips

Projectile motion:

<https://phet.colorado.edu/en/simulation/projectile-motion>

Orbits:

<https://phet.colorado.edu/en/simulation/gravity-and-orbits>

And lots more:

<https://phet.colorado.edu/en/simulations/category/physics>

Magnetic Accelerator – Shin Adachi

Topic: Momentum and Energy

Materials: “Magnetic Accelerator” (\$27 on Arbor Scientific)

Set-Up: Perform on a level table top.



Magnetic Accelerator Explanation

- Conservation of Momentum – Although very deceptive, momentum is conserved before and after the collision. The magnetic ball is drawn toward the balls at rest, therefore colliding with a much faster velocity than expected.
- Conservation of Energy – Magnetic Potential Energy is converted to Kinetic Energy.

For more information

- www.physicsatthebeach.com for information about PhysTEC at CSULB.
- To contact lead presenters:
Kevin Dwyer: dwyer_k@auhsd.edu
Laura Henriques: Laura.Henriques@csulb.edu