Physics 121 Demos and Demo Schedule

College Physics: A Strategic Approach 3rd Edition

More information can be found here: http://www.physics.calpoly.edu/physics-121-demo-schedule

All YouTube videos are tagged with:
The Demo Guy, CP SLO, Cal Poly Physics, Physics, PHYS 141/121, [Demo Name]

Weeks 1 & 2

CH 1+2: Representing Motion & Motion in One Dimension

Motion

1) **Constant Velocity Cars:** When turned on, these cars will travel at constant velocity. Please make sure to allow the wheels to spin freely to avoid damaging the internal gearing.
2) **1-D Motion Using Carts and Track:** A low friction cart can be placed on the horizontal track to model constant velocity motion (within reason) or rolled down the ramp when angled to model uniform acceleration. To level the ramp, screw or unscrew the feel appropriately. Use a sturdy solid surface such as textbooks or a jack to support the ramp when angled.
3) **Graph Matching with Motion Detectors:** This Vernier probeware uses Logger Pro to project real time graphs of an object's motion. You can use it to create free standing graphs, or attempt to match pre generated graphs found in the "Physics with Vernier" folder in Logger Pro. Make sure the LED on the labquest mini is GREEN after opening Logger Pro.
4) **Constant Velocity Bubble:** Using a ratio between distance and time, students will determine the velocity of a rising bubble. "O-rings" can be used to help set start and stop locations.
5) **Galileo's Drop:** Simultaneously drop two different masses into a padded box. Show the freefall time is equal by placing the same masses into carts on an inclined plane and rolling them into the padded box.
6) **Advanced Galileo Drop:** Stand on a desk with a text book and uncrumpled piece of paper held horizontally. Ask students to predict which will hit the ground noticeably first. Repeat experiment with book on top of paper, then paper on top of book, then paper on top of book with half of the paper hanging out exposed to air. Finally (The tricky one) drop the same piece of paper edge down. If done well it will fall at the same rate as the book.
7) **Ball transfers to cup (Faster than g acceleration):** A ball is placed at the end of a hinged board, board will accelerate faster than ball and ball will fall straight down into cup.
8) **Freefall is Uniform Acceleration:** Use a Vernier motion detector to generate graphs for a fan cart or cart on a ramp undergoing uniform acceleration, then throw or drop a ball above the detector to prove that freefall is just a special example of uniform acceleration. **CAUTION** Do not let any object collide with the motion detector.
9) **Free Fall Ball:** When released, the ball's timer will start until it collides with the ground.

Foundation Skills

1) **Magnetic Vectors:** Meter sticks have been cut into various sized vectors, which have a magnetic strip, which can easily attach to your whiteboards to represent various vector quantities.
2) **Cartesian Coordinate System:** Use the wireframe to show x,y,and z axes
3) **Imperial vs Metric SI Units:** Compare common SI units in both systems
   - ***LENGTH:*** Meter stick vs Yardstick
   - ***MASS vs WEIGHT:*** 1 lb weight vs 1 kg mass (Bars and Masses)
   - ***VOLUME:*** 1L and 1Qt containers, along with a 1 cubic liter example. Also demonstrate the imperial unit 1 Qt, as well as another example of 1L so that students can compare.

Week 3

CH 3: Vectors and Motion in Two Dimensions

Projectile Motion

1) **Ballistics Cart:** This cart is set on the linear track with the Ballistics Cart adaptor (A small piece of metal that will trigger a photogate). Turn the photogate on, and slide the cart down the track. When the photogate passes over the adaptor it will shoot the ball vertically, which will follow a parabolic arc and return into the launcher.

make sure to level the track, and adjust the launcher appropriately

2) **Projectile launcher:** This device has a thumb screw which can be used to change the launch angle for a projectile, as well as housing 3 different load location to change the launch speed
3) **Trajectory Cart:** Cart launches a ball vertically (after string is pulled) upward as it moves horizontally. Have the cart travel under a "bridge" as the ball flies over it for added excitement.
4) **Foam Rocket:** Use this air powered foam rocket to shoot a projectile into the crowd.
5) **Free Fall and Trajectory Launcher:** Two identical spheres are attached to the launcher. When triggered, one ball falls straight down while another is launched horizontally. Both hit the ground at the same time. Tell students to listen for the balls hitting the ground. It is easier than trying to see them hit the ground.
6) **Monkey Hunter Apparatus:** A ball is shot at an electromagnetically held target. When the projectile leaves its track, it causes the target (monkey) to drop and the collide, demonstrating that all objects fall at "g", even a projectile. **Warning** Please include the resistor brick in series with the power source so as to eliminate the possibility of an electrical short.

Circular Motion

1) **Airplane on a String:** A battery powered airplane provides enough thrust to maintain uniform circular motion which can be used to introduce the topic while discussing various defining attributes.
2) **Arrows on a Wheel:** Using the attached magnet, the bike wheel can stick to your blackboard. Magnetic arrows can then be added in various directions to illustrate circular motion vector quantities.
3) **Ball on String:** Show that there must be a centripetal (NOT centrifugal) force or tension to allow for circular motion. Can also be swung vertically and tension on top can be compared with tension on bottom of circular pathway.

Weeks 4 & 5

CH 4 & 5: Forces and Newton's Laws of Motion & Applying Newton's Laws

Newton's Laws

1) **String Tension:** Masses and spring scales are suspended by the same string draped over pulleys. A 3rd mass and spring scale can be added perpendicularly to the taught string.
2) **String Tension from a Fixed Location:** A spring balance is attached to a ring stand, and then a string is draped over the hook on the balance. Relate the string tension on both sides of the pulley to the spring scale reading.
3) **Cart on an Inclined Plane:** A cart is set up on an inclined plane, and attached to two strings on pulleys with masses at the end. This demonstration can be used to show how the normal force due to the inclined plane can be replaced with an upward force by the string, reducing the normal force to 0.
4) **Hover Puck:** A hover puck is gently slid across a desk to illustrate constant velocity motion, or pulled by a string to demonstrate how a force causes acceleration.
5) **Action-Reaction Ramp:** A ball is rolled down an inclined plane on wheels. When the ramp is held in place, the system behaves normally. When the ramp is allowed to roll, the ramp is pushed backwards demonstrating Newton's 3rd Law.
6) **Fan Cart and Sail:** This demo has multiple stages to it. First, show students that with the fan turned on, the cart will accelerate. Then, ask students that they think will happen when the sail is held in front of the cart and when it is attached to the cart. A further conundrum can be added by putting a small folder in between the attached said and fan, causing the cart to again accelerate.

Friction

1) **Critical Angle for Static Friction:** Place a block on an inclined plane. The angle can be varied to demonstrate the difference between kinetic and static frictions, as well as to verify a calculated critical angle, or derive a coefficient of friction.
2) **Static and Kinetic Friction 2.0:** A block is set up on the desk, connected to a rubber band a force sensor. Gently pull the block while collected data on logger pro. You should generate a classic friction graph showing a linear relationship until the max static friction is achieved and the block begins to move.
3) **Old School Static vs Kinetic Friction:** Show how much force it takes to get the box to move, and how much force it takes to move the box at a constant velocity. Works best on a rough tabletop with at least 1kg of mass in the box.
4) **Terminal Velocity of a Coffee Filter:** Compare the free fall for an open coffee filter and a crumpled one.
5) **Friction and Lubrication:** Use eggshell foam to model a microscopic view of a rough surface. Both pieces of foam are dragged across each other to show how microscopic inconsistencies catch on each other, and that is what causes friction. Soda cans can then be added between the foam as a model of lubricants.

Inertia

1) **Inertia Surface Snap X2:** A plastic ball is placed on a small plastic sheet. Use the metal bar to quickly snap the sheet out from under the ball. This can also be shown with a plastic card and a coin. Flick the card from under the coin, and letting it drop. Both of these are similar to yanking a table cloth out from under some dishes
2) **Inertia Hoop:** Place metal hoop vertically on top of the jar's mouth. On top of the hoop, position the marker upright directly centered above the opening. Rapidly PULL the hoop away by

grabbing it along its inner wall, extending outwards (think of a karate chop hitting the inside of the hoop NOT the outside).

3) **Inertia Ball:** Strings are attached above and below ball. A rod is attached to lower string. A rapid pull on the rod breaks the lower string. A slow pull breaks the upper string.
4) **Foam Rock and Real Rock (Inertia):** Gently swing the rubber mallet into the side of each rock. The foam one will undergo a greater acceleration.
5) **Inertia Launch:** Use the projectile launcher to launch balls of differing mass to investigate inertia.

Week 6

CH 9: Momentum

Collisions

1) **“Happy” and “Sad” Balls:** Two rubber balls with different coefficients of restitution are used to model both elastic (“Happy” Ball) and inelastic (“Sad” Ball) collisions when dropped.
2) **Collisions with Carts:** Two Pasco carts are set on a linear track. Their magnets have been arranged so that both elastic and inelastic collisions can be demonstrated.
3) **Pendulum Collider:** Happy and sad balls are swung into a board at about a 45° angle. The happy ball will knock over the board but the sad ball will not
4) **Newton’s Cradle:** This consists of 5 hard balls suspended next to each other. When one (or some) are pulled outwards and released, they will transfer momentum to the other balls as they shoot out the opposite side.
5) **Ballistic Pendulum:** Load the steel ball into the spring loaded launcher using the black sponger. Make sure you hear a “click” to engage the stopping mechanism (multiple depths). When released, the ball will shoot into a containment vessel held at the end of a rotating rod. Depending on the mass or exit velocity you can compare height and angle with initial launch conditions to show momentum conservation.
6) **Rebounding Balls:** A basketball and tennis ball are dropped simultaneously, with the tennis ball resting on top of the basketball. After hitting the ground, the tennis ball will rebound higher than the initial drop height.
7) **Rebounding Balls II:** Same as above, but with 5 bouncy balls coupled together on a rod.

Warning these can shoot of quite quickly and rapidly. Aim away from students and wear glasses.

8) **Rebounding Masses:** A small mass and large mass on springs are dropped simultaneously on top of each other. The small mass rebounds higher than the initial drop height
   Warning Drop from no higher than ¼ total height.

Impulse

1) **Egg in Sheet:** **Please provide your own eggs** Have students hold sheet vertically but NOT TAUGHT, allowing bottom section to form a little pouch for egg to slide into after contacting sheet. Make sure students hold onto top and bottom tightly. Throw fresh egg as hard as possible at the sheet and they will not break.
2) **Rubber Poppers:** A rubber popper is turned inside out. Place on table and it shoots upward.
3) **Fist into Foam:** Slam your fist into a foam cushion on top of table.

Weeks 7 & 8

CH 10: Energy and Work

1) **Loop-the-Loop:** Use energy conservation to verify the minimum release height (h ~ 2.7 R for hollow sphere).
2) **Galileo's Pendulum:** The pendulum's supporting cord strikes a peg at the bottom of the swing. The ball wraps around the peg and returns to the starting height.
3) **Ball Oscillates on Ramps:** Two ramps with differing angles are connected so a ball can roll back and forth, it is shown that the ball reaches the same height on either side (within reason due to friction)
4) **Ballistic Pendulum:** Steel ball is shot into pendulum. Compare PE to KE.
5) **Modified Brachistochrone Tracks:** 4 balls follow 4 different paths. Final velocities are shown to be the same by launching the balls into a box on the floor, or allow balls to race across the floor.

HEADS UP* The plastic guard rails have become a bit worn, and do not have a uniform distance between them. This causes the rotational kinetic energy to change in each ball, which accounts for most of the experimental difference.

6) **Yo-yo's**: Discuss kinetic and potential energies.
7) **Pile Driver:** Use GPE to either smash aluminum cans or drive nails into wood by doing work.
8) **Springs:** 3 different springs are shown.

Weeks 9 & 10

CH 6, 7, & 8: Circular Motion, Orbits, and Gravity & The Rotation of a Rigid Body & Equilibrium and Elasticity

Circular Motion

1) **Airplane on a String:** A battery powered airplane provides enough thrust to maintain uniform circular motion which can be used to introduce the topic while discussing various defining attributes.
2) **Arrows on a Wheel:** Using the attached magnet on the bike wheel and stick it to your blackboard. Magnetic arrows can then be added in various directions to illustrate circular motion vector quantities.

Centripetal Force

1) **Colored Water in a Bottle:** Swing the bottle in a vertical circle and show how the water's inertia causes it to appear to be pushed towards the end of bottle.
2) **Measuring the Centripetal Force:** Swing the ball around in a horizontal circle and read the spring scale. Can show how varying circular motion quantities can affect centripetal force.
3) **Loop-the-Loop:** Release the ball from the top of the high ramp and use its motion to investigate circular motion and energy conservation.
4) **Equilibrium and Circular Motion:** Spin the ball horizontally such that it balances the hanging mass. When you increase or decrease the ball's tangential velocity it will accelerate the mass out of equilibrium until you find the right radius to velocity ratio.
4) **Centrifugal Force Puzzle:** Try to get both balls to go towards opposite ends simultaneously by rotating the object.
5) **Centripetal Force Apparatus:** Stretch spring by rotating, calculate approximate force using period and then compare with spring scale.
6) **Ball on String:** Show that there must be a centripetal (NOT centrifugal) force or tension to allow for circular motion. Can also be swung vertically and tension on top can be compared with tension on bottom of circular pathway.
7) **Water in Bucket:** Water is added to bucket and swung vertically. Can discuss minimum velocity necessary to keep water in bucket, or derive velocity when normal force = 0N.

Torque

1) **Torque Wrench:** Use wrench on bolt that is screwed into metal piece clamped on the table. The gauge displays your torque.
2) **Walking the Spool:** The spool will either "wind-up" or "unwind" depending on what angle you apply torque by pulling on the string. A critical angle can be found where the spool will just slide and not unwind.
3) **Torque Feeler:** T shaped bar has an adjustable location to attach masses. Have students twist the bar from vertical to horizontal to feel the torque necessary for rotation.

Moment of Inertia

1) **Inertia Wands:** Two identical wands have the same mass, but in one wand the mass is located at its center, and on the other the mass is located on the ends. Holding the wands at their centers, have students attempt to rotate the wands to feel how mass distribution affects an object's moment of inertia

2) **Moment of Inertia Races:** Using an inclined plane compare how an object's moment of inertia influences its motion down the ramp. Discs, balls, and cans are provided to offer plenty of different objects.

Rotational Energy

1) **Rolling Spool:** A large spool is rolled down a meter stick along its small axel, and allowed to roll onto a table. Even though angular velocity is constant, since tangential velocity is larger on the large axel the spool will speed up when it contacts the table.
2) **Ball transfers to cup (Faster than g acceleration):** Use the wooden dowel to hold the hinged plank open, with the dowel resting at the thumb tacks. Place the ball at the depression at the top of the angled plank. Then, quickly remove the dowel by pulling it outwards from the bottom. The plank rotates faster than the ball falls, so the ball will fall straight down landing in the cup.

Angular Momentum

1) **Angular Momentum with a Rotating Stool:** A rotating stool or platform is used to have student volunteers show what happens in various situations:
   - ***CHANGING MASS DISTRIBUTION:*** Students hold weights in outstretched arms and are given a slight push, once spinning, ask students to bring their arms into their chest.
   - ***ELLIMINATING EXTERNAL TORQUE:*** Student is given a baseball bat and asked to swing it while feet are not touching the ground, and compare with when feet are touching ground
   - ***BIKE WHEEL EXEERTS INTERNAL TORQUE:*** Student is asked to hold a bike wheel from its pegs while sitting on the stool. Spin the wheel and by moving the axis of rotation a torque is exerted on the student.
2) **Gyroscopic Precession:** Rotate a bike wheel and then suspend it by the string.

Rotational Equilibrium

1) **Seesaw:** Balance a meter stick on a fulcrum at its center. You can use the adjustable hangers to change where masses are hung so that the meter stick balances.
2) **Torque on a Lever Arm:** Just like above, but the fulcrum is at the end of the meter stick. A spring scale is attached.