Physics 132 Demos and Demo Schedule

Physics for Scientist and Engineers, A strategic Approach 4th Edition

More information can be found here: http://www.physics.calpoly.edu/physics-132-demo-schedule

All YouTube videos are tagged with:
The Demo Guy, CP SLO, Cal Poly Physics, Physics, PHYS 132/122, [Demo Name]

Week 1

CH 15: Oscillations

Pendula

1) **Pendula:** Two pendula with different massed bobs hang from a stand at equal length. This can be used to prove that a pendulum's period is mass independent.
2) **Large Pendulum:** Pendulum with red ball is set up on a tall stand allowing you to manipulate length. **Please do not disconnect the small stopping rod**
3) **Variable "g" Pendulum**: A physical pendulum is mounted on a bearing so that you can rotate the plane of oscillation, changing gravity's contribution on its period.
4) **Pendulum Wave**: A set of pendulums with differing lengths are set into harmonic motion. Their differing periods create a predictable and repeatable pattern.
5) **Simple vs Physical Pendula:** A ball on string pendulum, and a solid rod pendulum are both set up on the same stand. Both pendula have the same mass, and are the same length, but oscillate with different periods due to their differing moments of inertia

Oscillatory Motion

1) **Periodic Motion Devices:** A Ball in a Bowl, Winding Spool, and Maxwell's Wheel all undergo oscillatory periodic motion when set in motion.
2) **Masses on Springs:** 2 or 3 springs, with differing "k" values, hang vertically from a stand. Place a mass on the spring and set it in motion. ***Do not exceed 500g on any spring***
3) **Linear Oscillator**: A red cart is attached by two springs on either side and set into periodic motion. A pair of masses can be placed on or removed from the carts at maximum displacement to show mass dependency on period.
4) **Simple Harmonic Motion and Circular Motion:** A ball is glued to a record spinning vertically, and a projector is used to cast the edge view shadow on a wall. You can then compare the behavior of the ball's shadow with that of a mass on a spring that oscillates with the same frequency.
5) **Damped Oscillator**: A hacksaw blade is allowed to vibrate back and forth to establish a baseline. Attach a card to the end and observe the damping. "Springing" a meter stick with part hanging off the edge of a table will show another example of underdamping.

Week 2

CH 16: Traveling Waves

Waves

1) **Transverse and Longitudinal Pulses**: Send a transverse/longitudinal pulse down a slinky.
2) **Transverse Wave Model**: Apparatus consists of an array of beads, which are allowed to move up and down. A sine wave cutout is pushed past the beads to simulate the motion of particles when a transverse wave passes through them.
3) **Transverse Waves with Rods**: A transverse wave can be visualized when set in motion. By sending two waves towards each other you can also demonstrate superposition. Different "add-ons" can be used to change boundary conditions or aid in creating standing waves.
4) **Longitudinal Wave Pulses**: Strings suspend a slinky horizontally. Compressional pulses are sent along the spring. By matching mass heights on either end you can show resonance.
5) **Longitudinal Wave Model**: Generates traveling longitudinal waves when you rotate the driving knob. **Make sure to rotate the knob in the indicated direction**
6) **Particles in a Longitudinal Wave:** Magnetic "particles" are rolled towards each other to show how a compression wave can propagate. Level the track before use.

Sound Production

1) **Dual Function Generator with Speakers:**
   - *Nodes and Antinodes*: Plug both speakers into the same output, hold them facing out with your arms extended, and slowly rotate your body. This will cause the nodes and anti-nodes formed by the standing waves to move around the room. The students should hear amplitude change…OR… keep the speakers stationary and have your students walk around the classroom to locate the nodes and antinodes.
   - *Beats*: Plug each speaker into a separate output, and adjust frequencies to create beats.
   - *Destructive Interference*: Plug both speakers into the same output, but switch the leads for one of the speakers. Then, face the speakers at each other and bring them together.
2) **Tuning Forks and Xylophone Keys:** Tuning forks have different frequencies. Strike them with a rubber mallet. You can also drop xylophone keys to produce their frequencies.
3) **Disassembled speaker**. Display the parts of a cone speaker.

Doppler Effect

1) **Bloogle Tubes**: Swing in a horizontal plane, and increase angular velocity until a tone is generated. Students will hear a doppler effect based on their relative locations in the room.
2) **Doppler Shift Apparatus:** Swing in a horizontal plane. A built in buzzer turns on when you swing around your head. Students will hear a doppler effect based on their relative locations in the room.

Refraction

1) **Simple Refraction:** Shine laser light through a clear plastic block. Starting with the incident beam at 0 degrees, rotate the block and see how the "exit" beam bends away from the expected straight line.
2) **Water Refraction:** A wooden dowel is placed half-way into a tank of water and observed.
3) **Disappearing Glass (Same "n"):** A glass rod and plastic rod are placed into a container full of Wesson oil. The plastic rod has the same "n" as the oil so it "disappears".

Week 3

CH 17: Superposition

Standing Waves

1) **Standing Slinky Wave:** Have a student hold one end of the slinky, and then oscillate the other end to create various standing waves.
2) **Standing Wave from Speaker:** Attach one end of the string to a fixed pole secured to the desk, connect the other end to a pole and clamp the speaker to it close to that end. Using a frequency generator various standing waves can be created.
3) **Standing Wave Model**: Apparatus consists of an array of beads, which are allowed to move up and down. A sine wave cutout is pushed past the beads to simulate the motion of particles when a transverse wave passes through them. There is also a black transverse wave drawn on the background. A second set of beads show the superposition drawn wave and cut out.

Resonance Cavities and Beats

1) **Rijke Tubes:** Cardboard tube is held over the flame from a Fisher burner. They air will begin to resonate as it's funneled through the tubes.
2) **Resonance in Open-Closed Tube:** After striking a tuning fork (512 Hz), hold it a few cm above an open-ended tube in water. Raise/lower the tube until a standing wave is created resonating with the tuning fork.
3) **Resonance in Open-Open Tube:** Just like above, but sliding the inner tube back and forth varies tube length.
4) **Large Resonance Tube:** Hook a speaker up to a function generator, and then place it at one end of the opening. Adjust the white column until you achieve resonance. A ruler is printed on the white tube should you choose to gather quantitative data.
5) **Driven Resonator:** Firmly press the device into the table after turning it on. Then slowly sweep through increasing frequencies to get each hacksaw blade to resonate.
6) **Dual Function Generator with Speakers:**
   - *Beats*: Plug each speaker into a separate output, and adjust frequencies to create beats.
7) **Beat Bars:** Tuning forks have an adjustable clamp. Strike the bars on the side opposite the clamp, and adjust the clamp until you hear beats.

Week 4

CH 33: Wave Optics

Interference

1) **Two source Interference:** Two transparencies, representing circular wave fronts, are superimposed on overhead projector or document camera. This will demonstrate constructive and destructive interference when the two transparencies are slowly moved across each other.
2) **N-Slit Interference:** Cornell slide consists of 1,2, and multiple slit configurations. A laser beam (red or green) is passed through the slide to demonstrate how interference changes with various slit configurations.
3) **Newton's Rings:** Using a mercury light source, light is reflected off the Newton's ring apparatus illustrating concentric interference patterns. **Do Not Adjust The Screws**

Diffraction

1) **Single Slit Diffraction Slides:** An adjustable Cornell Slide and laser are set on a track. Chose the slit width that you want, and turn the laser on. Works best when the laser is as close as possible to the aperture.
2) **Adjustable Single Slit Diffraction:** A laser beam is sent through an adjustable single slit to illustrate a diffraction pattern. Adjust slit width by turning the knob on top.
3) **Color Spectrum with Diffraction Gratings:** Place different bulb types behind a large diffraction grating, or pass out smaller gratings to your students so they can see how different light bulbs diffract.
4) **Spectrum Tubes:** Pass out small diffraction gratings or the diffraction glasses and demonstrate the various spectra given off by gas discharge tubes. **Glass will become hot if left on for too long, so use a paper towel to pull out. AND.. Do Not Touch Exposed Leads**
5) **Diffraction Gratings:** An assortment of diffraction gratings can be used to demonstrate light diffraction.
6) **Compact Disk Diffraction:** Show a diffraction pattern by reflecting laser light off a CD.

Weeks 5 and 6

CH 34 and 35: Ray Optics and Optical Instruments

Light Properties

1) **Linear Light:** Use "canned fog." Show how the laser light propagates in a straight line.
2) **Pinhole Projector:** A clear 500-watt light bulb is enclosed in a box with an iris diaphragm. Adjust the size of the iris to show image of the light bulb filament on the wall or ceiling.

Reflection

1) **Corner Reflectors:** Multiple mirrors are set up and create a corner (2 that fold, or 3 at right angles) Demonstrate reflection off multiple surfaces, and introduce total internal reflection.
2) **Law of Reflection:** Demonstrate the law of reflection with a mirror and laser.
3) **Collection of Mirrors:** Plane, Convex, Concave, Confocal (mirage demo), Fresnel, Spherical

Refraction

1) **Simple Refraction:** Shine laser light through a clear acrylic block. Starting with the incident beam at 0 degrees, change the incident angle to see it refract through the acrylic.
2) **Prism Dispersion:** White light from a slide projector is incident upon a glass prism (high dispersion). Make sure the slit slide is in the projector (gives a narrow beam), and rotate the prism if you do not see the rainbow immediately.
3) **Refraction Tank:** Circular tank is filled halfway with water. With the built-in light source, the angle of incidence and refraction can be directly measured. Can be used to verify Snell's Law, and show what happens during total internal reflection.
4) **Water Refraction:** A wooden dowel is placed into a tank of water and observed.
5) **Disappearing Glass (Same "n"):** A glass rod and plastic rod are placed into a container full of Wesson oil. The plastic rod has the same "n" as the oil so it "disappears".

Total Internal Reflection

1) **Total Internal Reflectors:** Each one of these objects undergoes total internal reflection.
3) **TIR in a Beaker.** Shine a laser on a glass beaker such that the incident angle is almost 90 degrees to the beaker's lip. Multiple reflections are seen in the glass shell.

Lenses

1) **Collection of Lenses:** Double convex, Plano-convex, Convex meniscus, Cylindrical, Double concave, Plano-concave, Concave meniscus.
2) **Fresnel Lenses:** Positive and negative focal lengths.
3) **The Shrinking Penny**: Penny is shown to class and dropped through slot. The lenses give the illusion that the penny is significantly smaller.
4) **Optics Kits:** Combine the lenses with a laser box to who how light interacts with lenses.
5) **Water as a Lens:** A ruler is placed at 2r inside the cylinder. The image appears farther away than the object and is magnified 2 times.
6) **Magnified Penny in Water:** A penny is placed at the center of curvature of a glass sphere filled with water. The image and object location are in the same place, but the magnification of the image is 1.33 times the object size.

Week 7

CH 14 and *18: Fluids and Elasticity and A Macroscopic Description of Matter*

Density/Pressure

1) **Density Cubes:** Cubes (27 cm^3) of wood, aluminum, brass, and lead are weighed on a balance. Their differing masses show that they have different densities. You can also use the set of masses made from the same material to help introduce density.
2) **Feeling Pressure:** Given a brick, dowel, and a knife; discuss which object would be the most uncomfortable if placed on your hand with equal amount of force.
3) **Pascal's Vases:** Plastic (or glass) container has several interconnecting chambers. Show that the liquid rises to the same level in each chamber by adding water to 1 chamber, demonstrating that pressure is dependent on depth and no other properties.
4) **Pressure and Depth:** Tall flask has horizontal tubes that serve as openings along the side. Fill the column with water while holding fingers over the openings. Adjust water fill rate to supply constant water as you relate exit velocity and range to pressure and depth.
5) **Simple Hydraulic Machine:** Large hypodermic syringe is joined to a small syringe. Compare the effort and load forces using comparative ratios.

Air Pressure

1) **Atmospheric Pressure:** Place suction cups or rubber mat with handle on top of a flat surface and have students try to remove it. Or, place two suction cups together and have students try to pull them apart.
2) **Magdeburg Plates**: Two plates are fit together with an airtight seal. Evacuate the air in between the plates using the hand pump. Make sure to close valve and detach air pump, then ask student volunteers to try and pull them apart.
3) **Atmospheric Can Crush**: Add a small amount of water to a soda can, and then boil it using a hot plate. Once steam begins to form, quickly grab the can with tongs, and invert it while putting it in a bowl of ice water. **Some cans may use a "pre crease" beforehand**
4) **Atmosphere Bar**: 1 inch x 1 inch steel bar represents the weight of one square inch of atmosphere when held upright.

Thermometers

Thermometers *(Use a heat lamp or hair dryer for changing temperature)*:
- *Constant-Volume thermometer (Gas)*
- *Alcohol Thermometer (Liquid)*
- *Galileo's thermometer (Bouyancy)*
- *Bi-metallic Dial Thermometer (Solid)*
- *Thermocouple and Galvonometer (Electricity)*
- *Liquid Crystal Heat Strips (Thermochromic Liquid)*
- *Thermister (Electricity)*
- *Black and Decker IR Thermometer (EM Radiation)*

Thermal Expansion

1) **Bi-Metallic Strip**: Heat over flame, and then cool in water. Two metals with differing specific heats are combined in one strip. When heated or cooled, the differing expansion rates will cause it to bend.
2) **Ball and Ring**: Insert ball into ring, and then heat ball. You cannot remove the ball because it has expanded larger than the opening. Place ball in water to cool it down and cause it to contract, or heat the ring, causing the ring to expand in order to remove the ball.
3) **Wire Expansion**: A wire is attached to a dial. When a flame is placed under the wire, the wire expands moving the dial. Place a flame directly on the wire for a more dramatic result.

Gas Laws

1) **Boyle's Law Apparatus**: You or students attempt to compress a syringe with a known gas. As the volume decreases, the pressure increases until you cannot compress it anymore.
2) **Steam Gun**: Heat a glass tube filled with a small amount of water and sealed by a cork. Make sure the cork is snuggle fastened before heating and keep clear!
3) **Fire Syringe**: When you quickly compress air inside the fixed volume syringe it increases the temperature enough to ignite a small piece of paper or cotton. **Do not blow into the tube, and make sure to apply lubrication to the piston to aid in compression and to create a seal**
4) **Hand Boiler and Pulse Glass:** Hold both at a 45^{o} angle. Use your hand to heat up the lower sphere for the hand boiler, or use a hair dryer for the pulse glass. As pressure builds in the lower sphere it pushes the liquid into the upper sphere.
5) **Mole box:** Box is the size a mole of gas would take up at S.T.P.
6) **3D Phase Change Model:** A model used to show how something can exist in different phases given different temperatures and pressures. Can also be used to illustrate the “Triple Point”

Week 8

CH 19: Work, Heat, and the First Law of Thermodynamics

Applying Thermodynamics

1) **Adiabatic Cloud Creation:** Large glass container with a few ml of H_2O is pressurized after a match is tossed in using the hand pump. By removing the rubber stopper (suddenly reducing the pressure) a fog forms inside the container. (DO NOT USE ALCOHOL)
2) **Work and the "PV" Diagram:** This device works best with a large temperature difference between a hot and cold reservoir. Start with the aluminum chamber in a cold bath and then close the system with the white clamp. By transferring the chamber between hot and cold water you drive the piston.

Conduction

1) **Thermal Conduction Rods:** Have students hold onto each rod and time how long it takes until they feel the heat (start with copper as it will be noticeable relatively quickly). Or, have students hold both rods in separate hands, but cross the tips of each rod so that they can both be hit by the blowtorch simultaneously. **Have a water dunk container nearby for rods after they are heated**

Convection

1) **Chimney Model**: Show students that a match goes out when surrounded by a tube, but continues to ignite when a metal vane is added. Use smoke from a separate match to show the convection of air in the chamber above a flame. For best results, put the vane off to one side.
2) **Convection Tube:** Fill with water then heat one side with flame. Put a couple of drops of dye into tube to show the convection current. You can move the flame to reverse the direction

Radiation

1) **Crook's Radiometer:** Not the photo-electric effect… When placed under a heat lamp, the black side absorbs heat making one side of the vane hotter than another. This causes a pressure difference between the two sides of the vanes, which ultimately cause the motion.
2) **Parabolic Reflector:** Use a film projector light to ignite a match placed in the focal point of the reflector.

Weeks 9 and 10

CH 20 and 21: The Micro/Macro Connection, and Heat Engines and Refrigerators

Specific Heat

1) **Specific Heat Comparison:** Equal masses of H_20 (in a metal cup) and aluminum are placed on a hot plate. Wait for water to get hot to the touch. Then place, with tongs, the aluminum block into the water. The hotter aluminum will sizzle demonstrating that it increased its temperature more rapidly.
2) **Air and Water-Filled Balloons**: Place and inflated balloon over candle flame, and it will pop. If you add a little water in a balloon, inflate it, and then hold it over the flame, the balloon does not burst due to the high heat capacity of H20.

Thermodynamic Engines

1) **Drinking Birds**: The "birds" contain a fluid under high pressure. When the bird's head gets wet, evaporation cools the interior of the head. This lowers the vapor pressure and allows the fluid to move up, this moves the bird's center of mass causing it to fall.
2) **Stirling Engine**: Place on top of the coffee mug warmer to cause the flywheel to spin. Expanding and contracting gases do work on the wheel causing it to rotate. Add an icecube to the top for a more dramatic effect.
3) **Steam Engine**: Check water level (tank should be about 1/3 full of water). Plug in heater and wait for water to boil. Open the whistle or wheel valves or both to show how the steam drives the engine.
4) **Thermoelectric Fan:** Semi-conducting thermoelectric cells convert thermal energy into electrical energy. A 50-degree temperature differential will drive the electric fan. Place one leg in a hot bath, and one in a cold bath. You may need to give the fan a little push to start it.
5) **Crook's Radiometer:** Not the photo-electric effect… When placed into sunlight, the black side absorbs heat making one side of the vane hotter than another. This causes a pressure difference between the two sides of the vanes, which ultimately cause the motion.