BUDD
The Boston University Demo Database

This is the Boston University Demo Database (BUDD). BUDD allows you to browse our current demo database which represents the most of our demo collection. Some of our most popular demonstrations are marked with a double asterisk ** next to their names. Also, some demos must be requested at least a day in advance because they need to be tested and set up so they work properly. These demos are marked with a double caret ^^ next to their names. If a demo has a video clip it is marked with V; if there is a theoretical explanation the mark is T.
There are currently **461** demos in the demo database.
If you would like to see the old website (not the old BUDD but the one before that) click here. A list of demos used for some of our courses in the past can be found here
The Physics Lecture Demonstration Facility in located in the Metcalf Science Building at 590 Commonwealth Ave., Rm 109A. You can stop by in person and visit or call 617-353-2634. Valentin Voroshilov is in charge of the Physics Department Demostration Facility and can be reached at 617-353-2634 or at demos@physics.bu.edu
The best time for setting up the needed demonstrations is: Monday, Wednesday, Friday from 10 am to 2 pm for the Tuesday, Thursday, and Monday classes (respectively). Tuesday and Thursday from 1 pm to 5 pm for the Wednesday and Friday classes (respectively).
Along with the actual demonstrations the use of short video clips might be helpful. The CD with a set of movies is available at the Physics Lecture Demonstration Facility. The original source of the clips is the set of laser disks: Physics; Cinema Classics, by Zteck Co. In order to watch the clips you may need to install the Quick time 7 which is provided with the CD. All the movies are copyrighted and cannot used for any other needs except being use during the lecture. Each folder has the read_me file holding the short descriptions of the clips in the folder. Not copyrighted demo movies developed at the Physics Lecture Demonstration Facility could be seen here.

Fundamentals

Measurement

Basic Units

Basic Unit Set 5-0B10.10

Show a standard meter, a 1 kg mass, and a timer with a second hand to illustrate the basic units in the MKS system.

*Density Samples 435-0B10.70

Assortment of same dimensioned cubes of various materials to compare their weight and thereby their density.

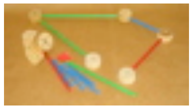
Error and Accuracy

Reaction Time 6-0B20.60

Paper covers three quarters of a clock face. Person tries to stop the second hand as soon as it is visible. This gives the reaction time of the person.

Vectors

Tinker Toys 1-0B40.25



You will be provided with a box of Tinker Toys, which can be assembled to show how vectors add or are resolved in two or three dimensions.

*Vector Manipulation 10-0B40.30

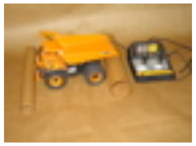
Physical arrows are used to demonstrate vector manipulation.

Mechanics

Motion in One Dimension

Velocity

** Frame of Reference, Velocity Superposition - Truck on Moving Paper 22-1C10.10



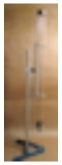
Demonstrate superposition of velocities and frame of reference by pulling on the sheet below the moving truck.

*Velocity with PASCO dynamics carts 23-1C10.20

PASCO cart on a track used to demonstrate one dimensional velocity.

Uniform Acceleration

*Penny and Feather 8-1C20.10



Penny and a feather in a plastic tube (~79 cm long) fall at different rates when the tube is filled with air. When the tube is evacuated, they fall together. Requires some practice.

*Drop ball and paper 26-1C20.16

Simultaneously drop a ball and a sheet of paper. Crumple the paper into a ball and repeat the drop.

*1-D Acceleration and Velocity with Pasco Cart 437-1C20.34

A pasco cart and propeller is used to demonstrate velocity and acceleration.

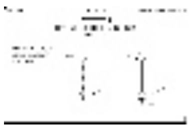
Uniform Acceleration - Ball down angle iron 438-1C20.45

A ball bearing is rolled down an inclined angle iron to demonstrate uniform acceleration.

Constant Acceleration 525-1C20.50

Logger Pro is used along with a cart on a track to display the concept of constant acceleration.

Measuring g



Catch a meter stick 28-1C30.55

-Drop a meter stick and have a student catch it. -convert distance to reaction time.

Motion in Two Dimensions

Motion of the Center of Mass

*Center of mass toss 31-1D40.10

An object has two lights on it. When tossed between people the object rotates around one light. With a weight added the object rotates around the other light.

*Center of mass of a system; V, T 32-1D40.11

A motorized cart sits on a movable short track sitting on another long pasco track.

Central Forces

** Ball on a string 33-1D50.10

A tennis ball is attached to a string to whirl around to demonstrate circular motion.

Rotational kinematics; V, T 444-1D50.11

Even though the weights travel different distance over the same time, the angular displacement, velocity and acceleration are the same.

Centripetal Acceleration 534-1D50.15

Whirligig conical pendulum - Central Forces 34-1D50.20

Whirl the smaller ball around your head. It will transfer the rotational motion of the smaller ball to the vertical motion of the larger ball.

Conical Pendulum; V, T 65-1D50.21

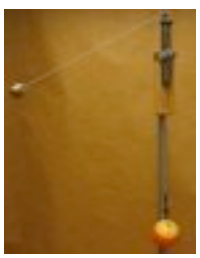


Illustration of the application of N II L to a circular motion.

** Carnival ride model; V, T 35-1D50.22

This is a miniature version of the Barrel of Fun carnival ride in which people stand against the wall of a rotating circular platform. When the platform is spinning fast enough the floor drops away, but the large frictional force prevents people from sliding down the wall. Requires some practice.

** Spinning a Pail 36-1D50.40

A container of pennies or water is spun around in a circle. Spun fast enough the pennies stay in the bottom of the container too slow and the pennies will clatter as they fall.

Rotational Dynamics: V, T 554-1D50.5

The weights have the same angular acceleration but different centripetal acceleration. One weight starts sliding off the turntable before another one.

Deformation by Central Forces

Flattening earth 39-1D52.10

Spinning this globe outline results in it being squashed.

*Water parabola 40-1D52.20

A plexiglass container with water is attached to a turntable. Turn the turntable to observe the parabola.

Centrifugal Escape

Release ball on a string 45-1D55.15

Just be careful not to hit anyone in the audience when you let go! This equipment is the same as 33-1D50.10.

Projectile Motion

Ball to throw 43-1D60.05

Several balls are available to show projectile motion.

** ^^ Ballistics cart and tunnel 13-1D60.10

A moving cart fires a ball vertically. The cart then catches it again as it comes down. This can be done with or without a tunnel for the cart to pass through while the ball is in the air (requires some practice).

Ballistics cart and tunnel on incline 381-1D60.15

A moving cart on an incline fires a ball perpendicular to the track and then catches the ball further down the track as both are accelerated by the same amount.

** Independence of X and Y 12-1D60.20

A release mechanism mounted at a height drops two masses: one with initial horizontal momentum and one without (Obviously, all in the lab reference frame). The masses strike the ground simultaneously. How do you know? Because you only hear one impact.

** ^^ Monkey and hunter 14-1D60.30

This is one of the classic physics demonstrations, one not to be missed. A shot is fired at a monkey which drops at the same time the shot is fired. Aim directly at the monkey to hit it (requires some practice).

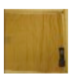
Relative Motion

Moving Reference Frames

** ^^ Car on a Moving Cart 519-1E10.10

This demo deals with relative motion. Both the velocities of the cart and tractor determine the perceived speed and direction of the toy tractor. (See also "Center of mass of a system below")

2D relative velocity; V, T 15-1E10.11



illustrates vectorial properties of velocity (also see "Crossing the river" below)

*Crossing the river 4-1E10.8

As vehicle crosses moving river of paper see how vehicle position changes in reference to the bank. Same equipment as Frame of Reference, Velocity Superposition - Truck on Moving Paper 22-1C10.10

Newton's First Law

Inertia of Rest

Inertia cylinder 49-1F20.33

This is the old whipping out the table cloth and keeping all the dishes and silverware in place trick. A cup with water is placed on a large sheet of paper. Yanking the paper out quickly enough leaves the cup sitting there and the demonstrator dry. Must have your hands up to speed before the paper becomes taunt.

Newton's Second Law

Force, Mass, and Acceleration

Acceleration Block 21-1G10.25

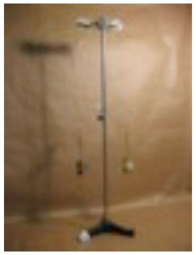
A pulley is clamped to a pasco track and a cart is hooked to a mass hanging off the pulley. The mass is varied to produce a variety of constant forces to accelerate the cart.

Second N-L 536-1G10.26

Third N L 537-1G10.27

Mechanical Advantage 535-1G10.30

Atwoods Machine 389-1G10.40



A physics classic. Two equal masses are hung from each side of the pulley. A small additional mass is added to one side which slowly accelerates the motion of the pulley.

Forces Between Carts 526-1G10.45

Two carts with attached force sensors are placed on a track. Logger Pro is used to display the forces acting between the carts.

Accelerated Reference Frames

*Suspended ball accelerometer 52-1G20.76

A fluorescent orange ping-pong ball suspended by a string in an upturned flask full of water acts as an accelerometer. The ball responds to a pressure gradient in the flask; an acceleration to the right, for example, causes a build-up of pressure on the left, pushing the ball to the right. In general, the ball moves in the same direction as the acceleration.

Newton's Third Law

Action and Reaction

PASCO carts 54-1H10.17

Metal carts can have various accessories attached. 1.2m and 2.2m tracks.

Sailboat a la Newton 390-1H10.20

A pasco cart has a propeller attached to it. The propeller is allowed to operate with and without a sail attached down wind of it. The resulting motion of the cart is observed.

Recoil

*Skateboad and medicine ball 55-1H11.10

37lbs ball and skateboard. Another similar ball is filled with Styrofoam peanuts is provided for contrast.

Statistics of Rigid Bodies

Finding Center of Gravity

** Big pig, plumb bob method 56-1J10.10

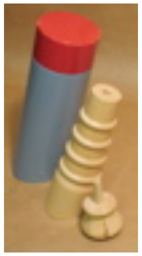
Giant pig is always a favorite with the students. Easy to understand as well as adding some fun into a lecture.

Meter stick on fingers 58-1J10.30

Meter stick alone as well as adding weight (such as a cap) to one end.

Exceeding Center of Gravity

Leaning tower of pisa 59-1J11.10



A cylinder with a removable top, and a wooden tower like object. Two different towers.

*Tipping block on incline 60-1J11.15

An adjustable inclined plane with a box or block resting on it. Put a finger on the base to prevent slipping down and increase the angle until the box tips over.

Leaning tower of Lyre 386-1J11.20

Boards are placed so that the maximum extension is achieved.

Double cone - Large 61-1J11.50

A double cone and a ramp that widens the higher up the slope becomes. Seemingly counter intuitive.

Stable, Unstable, and Neutral Equilibrium

Ball stability 62-1J20.10

A clear plastic hemisphere shows stable equilibrium (sitting inside an upturned hemisphere), unstable (sitting on top of a dome/hemisphere) and neutral (sitting on a flat surface).

** Balancing Eagle 441-1J20.22

An eagle will balance on its beak because of weights in its wings. Another eagle has its weights taken out and will not balance.

Resolution of Forces

Equilibium Turntable 542-1J30.15

Tension in a string 19-1J30.20

A mass in hung from a spring scale. The force required is noted. Then a mass hangs from one side of the scale and the other side of the scale is pulled horizontally by another mass of the same size. The force is again noted.

Rope and three students 63-1J30.25

Have two strong students pull on either ends of a rope. By pulling perpendicular to the rope in the center a small force will bring the two pullers towards each other.

Tug of war 64-1J30.57

Two students pull on the ends of a rope. Forces are discussed.

Static Torque

*Meter-stick balance 66-1J40.20

A meter stick is placed on a pivot. Various masses are hung from it to show the torque they produce and how they sum.

** Torque rod 395-1J40.21

A rod is attached to a bench is allowed to rotate. Masses are added and the force to rotate it are shown by using a spring scale at various points on the rod.

*Loaded beam 67-1J40.40

A plank of wood is placed between two scales. A mass is moved around on top of the plank to show how the weight on each scale changes.

Applications of Newton's Laws

Dynamic Torque

Torque with Weight 543-1K10.25

** Large yo-yo (walking the spool) 69-1K10.30

A strap is attached to a large spool. When the strap is pulled parallel to the ground the spool moves towards the puller. When the strap is pulled vertically the spool rolls away.

Friction

** Friction blocks on incline 71-1K20.10

Blocks with various surface roughnesses are placed on an incline. The incline is increased to see when each of them will start sliding.

*Weight dependence of friction 72-1K20.15

One weighted box is pulled with a spring scale. Then a second box is put on top of the first and pulled. The force required to move that is noted.

*Area dependence of friction 73-1K20.20

Demonstrates the independence of friction and contact area.

Static vs. sliding friction 74-1K20.30

Work and Energy

Work

Shelf and block 81-1M10.10

Pile driver with nail 82-1M10.20

The pile driver is used to pound a nail into a block of wood. If the pile driver is raised twice as high the nail goes twice as deep.

*Pile driver with soda cans 83-1M10.25

A pile driver is used to flatten an aluminum can.

Energy and Work 528-1M10.30

Determine the energy loss due to friction between a cart and a track.

Simple Machines

Pulleys 84-1M20.10

Pulley advantage 85-1M20.11

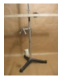
Conservation of Energy

** Spring and mass 90-1M40.03

A weight is attached to a spring and oscillating in a vertical direction.

Bouncing ball 91-1M40.04

*topped pendulum 92-1M40.15



A pendulum with a stop bar that allows for instantaneous shortening of the pendulum’s arm.

** Loop-the-loop; V, T 93-1M40.20

Watch the video on YouTube. By releasing the ball at the top of one of the inclines, it gains momentum and velocity as it travels toward the loop. The ball remains on the track even though it travels upside down due to the momentum its gained. When the initial height is not enough, the ball falls off the track.

Potential well 94-1M40.25

^^ A race: T, V 363-1M40.30

Two carts are racing on two tracks.

*Ballistic pendulum 95-1M40.40

A ball shot into a pendulum demonstrates conservation of energy and momentum.

Yo-yo 96-1M40.50

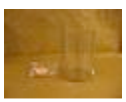
Energy Conservation 527-1M40.95

A cart on an inclined track is used to demonstrate energy conservation. Force sensors and Logger Pro are used to measure and display the forces acting on the cart.

Linear Momentum

Impulse and Thrust

Drop egg in water 98-1N10.25



Conservation of Linear Momentum

*Car on a rolling board 101-1N20.15

Pasco Motorized Cart on a Relative Motion track

*Spring apart PASCO carts 103-1N20.22

Demonstrates conservation of momentum.

Rockets

CO2 Rocket 105-1N22.20

*Balloon rocket 106-1N22.25

A balloon is inflated. The valve is released and the balloon shoots off across the room - or perhaps into your face.

CO2-catridge rocket 18-1N22.33

A carbon dioxide cartridge is mounted in a counterbalanced arm. When punctured the escaping CO2 will propel the arm in a circular motion (you have to be fast for not being hit by the arm).

Collisions in One Dimension

** Newtons cradle (collision balls) 396-1N30.10

The classical demo on the law of the conservation of momentum.

** Cart collision, equal and unequal mass 108-1N30.32

Carts on a track collide to show elastic collisions (magnetic ends of carts together) or inelastic collisions (velcro ends together). Additional mass can be added to the cart to see the impact on behavior.

Collisions 529-1N30.33

Use Logger Pro to analyze cart collisions.

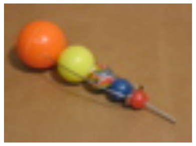
** Dead and live balls (Happy and sad balls) 141-1N30.35

Two balls with a different bounce coefficient hit the wooden block.

** Double ball drop 109-1N30.60

A softball and basketball are dropped with the softball sitting on top of the basketball. When they hit the ground, the softball rockets off the basketball and the basketball stays on the ground. The basketball bounces the least if the other ball is one third its mass (requires some practice for not being hit by the small ball).

Astroblaster (quadruple ball drop) 110-1N30.61



As the package of the Astroblaster says, it "works just like a real supernova". When the Astroblaster is dropped so the large ball hits the ground first, with the other balls stacked vertically on top, momentum is transferred along the chain of balls to the small one on top, causing it to rise to a much larger height than the height from which the Astroblaster was originally dropped. The small red ball on top is easy to lose, so please try to keep track of it! Some practice shots should also be carried out before doing this in front of an audience, too.

Collisions in Two Dimensions

Air puck collisions 112-1N40.20

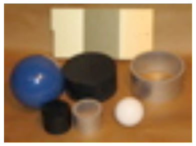
Rotational Dynamics

Moment of Inertia

** Moment of Inertia Wands 113-1Q10.10

Two rods, about a meter long, one red and one blue have the same mass. The red rod has the mass located at its center while the blue rod has the mass on the ends. The red rod is much easier to rotate than the blue one.

** Rotational Inertia - Racing ring, disk, and sphere 114-1Q10.30



A ring, a disk, and a sphere all roll down an inclined plane. Because of differing inertia the sphere will get to the bottom first followed by the disk and then the ring. This is true regardless of radius.

Rotational Inertia - All rings roll the same 115-1Q10.35

Rings of the same mass, different diameters roll down an inclined plane at the same linear speed.

Rotational Energy

Adjustable angular momentum 117-1Q20.10

Inertia wheel 118-1Q20.15

Acceleration faster than g 120-1Q20.50

Rotational Dynamics Paradox 42-1Q20.80

Demonstrates the height of balls on four spinning wire loops is the same regardless of mass of balls.

Transfer of Angular Momentum

Passing the wheel 121-1Q30.10

Conservation of Angular Momentum

*Rotating stool with weights 123-1Q40.10

Person spinning on a stool holding weights in both hands.

Pulling on a whirligig 124-1Q40.25

Gyros

** ^^ Bicycle wheel gyro 128-1Q50.24

The spinning wheel is hanging on a string.

** Toy Gyroscope 130-1Q50.77

A set of small gyroscopes.

Properties of Matter

Hooke's Law

** Stretching a spring 135-1R10.10

Demonstrates Hook's Law.

Tensile and Compressive Stress

Bending beam 137-1R20.20

Coefficient of Restitution

Bouncing balls 140-1R40.10

Surface Tension

Minimal Surface

Pop the center 146-2A15.10

A circular wire frame has a loop of thread tied to the frame by three threads. Dip the entire frame into the soap solution. Hold over the overhead and pop the center film. The center loop will form a circle.

Soap film shapes 147-2A15.20

The frames are in the shape of a cube, a tetrahedron, an octahedron, and a triangular prism. To form the minimal surface, hold each shape by its handle so it is fully immersed in the soap solution. Withdraw the shape so that one corner emerges first, and another corner emerges last.

Surface Tension of Rubber Balloon 549-2A15.25

Capillary Action

*Capillary tubes 148-2A20.10

Five capillary tubes of increasingly smaller diameter draw from the same reservoir. Can be displayed to the classroom over monitors using a tv camera.

Statics of Fluids

Static Pressure

** Pressure syringe 398-2B20.11

Boyles law is demonstrated with a syringce attached to a pressure meter. As the volume varies so does the pressue so the product remains constant.

Pressure in Liquid 545-2B20.35

** ^^ Pascals vases 400-2B20.40

Tubes of varying shapes are filled with water. Atmospheric pressure forces the water in all the tubes to the same height.

Atmospheric Pressure

*Crush the soda can 150-2B30.15

Fill pop can with steam by boiling a small amount of water in it. Quickly turn upside down in a beaker of cold water.

** ^^ Crush the can with vacuum pump 151-2B30.25

Attach a 1 gallon tin can to a vacuum pump with a rubber hose. Turn on pump and watch the can collapse.

*Magdeburg hemispheres 152-2B30.30

Make sure valve is open. Turn on the vacuum pump to evacuate the hemispheres. Shut the valve, turn off the vacuum pump, and remove hose. Have two students try to pull the hemispheres apart.

*Balloon or Shaving Cream in Vacuum 503-2B30.32

Both the balloon and the shaving cream will expand when in a bell jar and the pressure around them is reduced.

*Vacuum Cannon 439-2B30.70

Insert a ping pong ball into a PVC tube. Seal both ends with tape and pump out some air. Puncture one and and the ball with fly out with A LOT of force.

Density and Buoyancy

** Weigh submerged block 154-2B40.10

Weigh a sphere of plastic in air, and then in water.

Archimedes Tower 7-2B40.14

A bowling ball suspended from a spring scale is lowered into a water tank, which sits on a scale. As the ball is lowered into the tank, the spring scale registers decreasing force and the buoyant force exerted by the tank is matched by an equal and opposite increasing normal force at the scale under the tank.

*Finger in beaker 172-2B40.15

A beaker of water is placed on a triple beam balance. The students are asked to predict what will happen to the weight when a finger is inserted into the water.

Cartesian diver 155-2B40.30

A two liter plastic bottle with an eyedropper inside. Squeeze the sides of the bottle to send the "diver" to the bottom.

Weight In & Out of a Boat 402-2B40.77

A boat and a weight are placed in the water. Then the weight is placed in the boat. The difference in water level is observed.

Siphons, Fountains, Pumps

Siphon 404-2B60.20

A tube is filled with water and used to siphon one tank to another. Shows the simple efficiency of the siphon.

Dynamics of Fluids

Flow Rate

*Velocity of efflux or Toricellis Tank 156-2C10.10

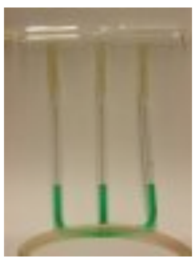
A plastic tube has three holes. Use a beaker to keep the tube full. A rod servers as a horizontal reference line.

Turbulence Ball 544-2C10.15

Syphone 547-2C10.20

Bernoulli Force

** ^^ Venturi tubes 157-2C20.10



Slowly turn on the air from the lecture bench. Do not turn on the air fully, as this will blow the water out of the tubes.

** Floating ball 158-2C20.30

Turn on the air supply from the bench. Place Styrofoam ball in the air stream. Try to blow the ball out of the stream. Change the angle of the air stream until the ball falls.

*Ball and funnel 159-2C20.35

A large glass funnel hangs upside down, its narrow end is connected to the air supply from the lecture bench. Turn on the air supply. Hold the ball in the funnel and release it.

*attracting sheets 160-2C20.45

Compressed air is blown between two plates. Since the inside pressure is less, the plates "attract".

Viscosity

Parachute 546-2C30.50

Terminal velocity of coffee filters 161-2C30.65

Drop crumpled and uncrumpled coffee filters to observe different terminal velocities.

Vortices

Vortex Cannon - Smoke 504-2C50.10

Smoke rings are send across the room by tapping a membrane on the back of a tube.

Tornado tube 163-2C50.30

This is very easy to set up. Simply fill one of the soda bottles 2/3 of the way up with water, screw on the tornado tube that joins the bottles, and screw the empty second bottle on top. Place the bottles on a flat surface, invert, whirl the top bottle around a few times and you should have a nice vortex.

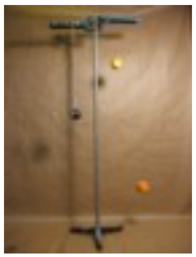
Oscillations

Pendula

** Simple pendulum 406-3A10.10

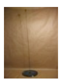
A mass at the end of a string is used to demonstrate the oscillatory motion of a pendulum.

*4:1 pendulum 164-3A10.14



Release the two pendula simultaneously. The small pendulum has a length equal to one quarter of the length of the longer pendulum.

Torsion pendulum 165-3A10.30



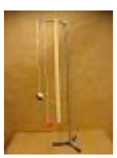
A disc is supported by a platform attached to a spring. Which rotates back and forth.

*Variable g pendulum 407-3A10.40

The magnitude of the gravitational force acting in the direction of the mass motion is changeable by modifying the angle of the pendulum in relation to gravity. This shows the effect of g on the penduluar motion.

Physical Pendula

*Bar pendulum 408-3A15.15



A bar is hung from close to one end and made to oscillate. Its motion is compared to a simple pendulum of 2/3 of its length.

*Hoop pendulum 409-3A15.25

A hoop is hung from a pivot and gently nudged to make it oscillate. It can be driven either perpendicular or parallel to the plane of the hoop.

Springs and Oscillators

** Mass on a spring 167-3A20.10

A mass is hung vertically with a spring. When perturbed from its resting position it will oscillate. The mass can easily be varied to show the effect on oscillation period.

*Springs in series and parallel 168-3A20.20

Two springs in parallel can support the same weight to show the effect of varying the spring constant. The mass can also be changed. Two springs hooked together in series can also hang a mass.

** ^^ Pasco Cart Between Springs 169-3A20.35

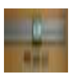
A horizontal version of mass on a spring two springs are hooked to either end of a Pasco cart. When perturbed from its rest state, the cart will oscillate. Modifying the mass of the cart will change the period.

Simple Harmonic Motion

Simple Harmonic Motion 530-3A40.25

The position, velocity, and acceleration of a pendulum are measured with time.

Horizontal Simple Harmonic Motion; V 558-3A40.26



A cart with two springs attached to it is placed on a track to demonstrate the basic properties of Simple Harmonic Motion.

Damped Oscillators

*Damped Track-Cart Oscillation 516-3A50.40

A Cart on a track is placed between two stretched springs to create an oscillator. Its motion is then damped with an eddy current damper attached to the cart and track.

*Eddy current pendulum 173-3A50.77

An aluminum pendulum swings through a magnetic field. Eddy currents in the pendulum damp its motion. Different amounts of damping can be shown by varying the magnetic field strength or the topology of slots in the pendulum.

Driven Mechanical Resonance

** ^^ Driven mass on a spring 410-3A60.40

This resonant system is set up and ready to go. There is both a coarse and a fine frequency control on the driver, with the position at resonance marked. If you start off-resonance, building up a low amplitude oscillation (with beats), and then move to resonance, be patient; it takes two or three minutes for the amplitude to build up. When tuned correctly, the dragon will almost reach the base of its support stand.

Coupled Oscillators

*Coupled pendula 177-3A70.20

Two vertical pendula are coupled with a spring between them. When one is started moving the other will eventually start moving and the first will stop. The period of oscillation can be adjust to investigate resonance.

Lissajous Figures

Lissajous sand pendulum 178-3A80.10

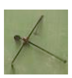
A pendulum filled with sand that spills out a small hole in the bottom is swung. It leaves Lissajous patterns below the pendulum. Lissajous patterns are complex harmonic motions.

Lissajous figures - scope 179-3A80.20

An oscilloscope that can be hooked to a VGA projector displays Lissajous patterns created by two function generators feeding the scope in XY mode. Lissajous patterns are complex harmonic motions.

Non-Linear Systems

Chaos systems 180-3A95.50



The Pendumonium consists of a magnet-mounted cross-piece into which as many as 4 of 5 included elements can be snapped. 68 different configurations are possible, ranging from 1 to 4 degrees of freedom. Using it is easy; simply construct the configuration you want by snapping in the appropriate parts, mount it vertically using the magnet, and give it a good push.

Wave Motion

Transverse Pulses and Waves

Pulse on a long spring 183-3B10.10

A long spring is attached to a very stable point and stretched most of the way across a class room. A pulse can be introduced by the instructor. Varying the tension of the spring will vary the speed of the pulse.

** Hanging slinky; V, T 189-3B10.13

A delicate slinky hangs from a frame. Longitudinal pulses and waves can clearly be seen propagating along its length with plucked or driven by hand.

Standing Waves

** Vibrating string standing wave 190-3B22.10

A string, with one end attached to a mass that sits on the ground, is driven with a mechanical vibrator. At the appropriate frequencies, a standing wave can be observed. The visibility of the wave can be enhanced by tuning the flashing frequency of a strobe light to the standing wave frequency.

Impedance and Dispersion

** Spring wave reflection 193-3B25.25

With the long spring stretched across the room send a pulse along it and see how it reflects off the end. It is only possible to do this with a fixed end.

Fixed and free rope reflection 194-3B25.26

A rope is secured at one end so that it can either move or be fixed. The other end is held and a pulse is sent down. The reflection can be observed for the fixed and free cases. **Under Construction**

Compound Waves

Wave superposition apparatus 195-3B27.20

A fixed wave made of beads is displayed. A second wave is then added to it demonstrating constructive and destructive interference.

Wave Properties of Sound

** ^^ Bell in a vacuum 196-3B30.30

A ringing doorbell placed in a bell jar is turned on so the students can hear it. The jar is the evacuated and the bell should can no longer be heard. Demonstrating how sound requires matter to move through.

Speaker and candle 197-3B30.40

A lighted candle is placed before a speaker. An amplified function generator drives the speaker. The candle flame with flicker with the air currents created by the speaker creating sound.

Doppler Effect

** Doppler buzzer 198-3B40.10

A buzzer is used to show the Doppler effect. It can be either whirled around the head or thrown in a straight line to get the shift in sound waves we know and love.

Interference and Diffraction

Ripple tank single slit 412-3B50.10

The tank is set up over the projector on a movable cart. Only one source is used; the opening is produced by placing two pieces of Plexiglas close together. They are movable, so the separation is set by hand. The frequency (and therefore wavelength) is controlled by the voltage. Tip 1 - the darker the room, the easier it is to see the pattern. Tip 2 - for best results, the overhead projector should be out of focus. Its best to have the lens closer to the tank then it would be when in focus.

Ripple tank double source 413-3B50.20

The tank is set up over the projector on a movable cart. The relative phase of the sources can be adjusted to change the pattern; the oscillation frequency is controlled by the voltage and the separation is set by hand. Tip 1 - the darker the room, the easier it is to see the pattern. Tip 2 - for best results, the overhead projector should be out of focus. Its best to have the lens closer to the tank then it would be when in focus.

*Moire pattern transparencies 200-3B50.40

An enchanting illustration of interference patterns. Two overhead slides with concentric ring patterns are overlaid replicating two point sources. The resulting dark and light bands are clearly visible.

** ^^ Two speaker interference pattern 508-3B55.10

Two speakers driven in phase produce an audible interference pattern.

*Destructive speaker interference 107-3B55.15

Two speakers are hooked to the same signal generator with the poloarities reversed. Placed about 0.5 meter apart and facing towards each other the sound is quite attenuated. Demonstrating destructive interference.

Beats

** Beat tuning forks 201-3B60.10

Two turning forks on resonators are placed next to each other. One fork has a bracket attached to it that will change its pitch slightly. When both tuning forks are struck you should hear a very clear beat in the aplitude of the tone. The speed of the beat can be adjusted by moving the bracket. This demonstrates constructive and destructive interference of sound.

*Beating Two Speakers 442-3B60.10

Two speakers are driven at two frequencies close together. Beats can be heard and you can see the results on an oscilloscope.

Coupled Resonators

*Coupled tuning forks 202-3B70.10

These tuning forks on boxes are best used in pairs of the same frequency. Point the box openings at each other, and strike one of the forks. If you stop that fork after a few seconds, you will hear the same tone coming from the other fork, set into vibration by the first one.

Acoustics

Pitch

** ^^ Range of hearing 203-3C20.10

An amplified function generator drives some speakers. The frequency is adjusted to show the maximum and minimum frequencies people can hear.

Intensity and Attenuation

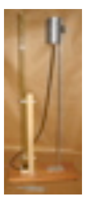
dB meter and horn 205-3C30.20

A loud source is placed at the front of the room. A dB meter is used to measure how sound attenuates with distance.

Instruments

Resonance Cavities

*Water column resonance tube 207-3D30.10



A vertical tube is filled with water the level of which can be adjusted. A tuning fork is struck and held above the open end of the tube.

Open and closed tubes - boomwackers 208-3D30.20

Tuned plastic tubes (Boomwackers) are struck and resonate at different frequencies. An end cap can be used to demonstrate the difference between the sound made by open and closed tubes.

*Hoot tubes 209-3D30.70

The end of the tube with the stainless steel mesh is held over the burner for about 15 seconds. It should glow orange. When the tube is removed from the burner and held vertically (mesh end down) it will emit a loud hoot. If the tube is then turned horizontally, the noise will stop, returning again when the tube is put back in a vertical position. If you like, you can create the illusion of pouring the sound out of the tube into a container, and then pouring the sound back into the container again.

Air Column Instruments

Organ pipes 210-3D32.10

Wooden organ pipes can be blown on to talk about resonant cavities.

Resonance in Plates, Bars, Solids

Chladni plate 212-3D40.30

A mechanical oscillator drives a plate on which sand has been shattered. The sand gathers in the nodes as there is (ideally) no motion there. This shows the resonance modes of different 2 dimensional shapes.

Thermodynamics

Thermal Properties of Matter

Thermometry

*Various thermometers 214-4A10.10

Thermometers of various types are shown to the students to familiarize them with existing technology

Solid Expansion

** Bimetallic strip 215-4A30.10

A thin metal strip where each side is made of a different metal is heated with a blowtorch. The metal bends demonstrating different materials behave differently when heated.

** Ball and ring 414-4A30.21

When heated, the ball increases its diameter and cannot get through the ring anymore.

Break the bolt or Tyndalls Apparatus 217-4A30.30

A bar is heated and screwed tightly against a bolt. As the bar cools it contracts with enough force to break the metal bolt.

Expansion of Al rod moves needle 187-4A30.63

A 10cm length of aluminum is heated with a blow torch. Its expansion pushes against a long rod that acts as a needle magnifying the expansion to make it visible.

Properties of Materials at Low

*Smashing rubber hose 220-4A40.30

A rubber hose is placed in liquid nitrogen until the bubbling subsides. Take it out and smash it with a hammer.

Heat and the First Law

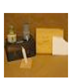
Heat Capacity and Specific Heat

Use heated lead to heat water 384-4B10.10

A 300g lead sphere is heated in water on a hot plate then transfered to 300g of water in a stryofoam container. The temperature of the water is monitored.

Convection

Two-chimney convection box 222-4B20.20



[Rheoscopic fluid](#) 223-4B20.77

The fluid can be poured into a plastic box, and a vial of ice can be floated on top of the room-temperature fluid, setting up convection currents. Similarly, a weighted vial of hot water can be placed on the bottom of the box. The flow can be seen by a large audience using the video camera and TV.

Conduction

*Metal heat condution 224-4B30.12

Parafin wax is placed on the tips of several types of metals placed in a star pattern around a center hub. The hub is heated and the wax bits fall off as different metals conduct the heat to their tips at different rates.

Liquid crystal indicator 415-4B30.13

These liquid crystals are red at 25C, violet at 30C, and the other colors of the spectrum in between. Boiling water should be placed in one of the Styrofoam containers, and room-temperature water in the other. When the bar is placed with one end in the hot container and one end in the cold, heat will be conducted along the bar. A thin red band slowly works its way along the bar as the temperature goes up, and the other colors follow behind. The liquid crystal must be brightly illuminated, because you need a lot of reflected light to see the colors. Placing a light bulb in front of it is a good idea.

Radiation

Two can radiation 226-4B40.40

Pour boiling water into both cans, filling them. Cap, and insert a thermometer into each through the cap. Monitor the temperature as the cans cool. The black can should cool significantly faster than the silver can.

Heat Transfer Applications

Water balloon heat capacity 228-4B50.25

A balloon is filled with air and then popped by putting it in a flame. Another balloon is filled with water and placed in the flame. It does not pop as the water does not let the balloon get hot enough to ignite.

Adiabatic Processes

[Fire Syringe](#)505-4B70.10

Demonstrates how an increase in pressure results in an increase in temperature by lighting a piece of special paper by pressing down on a piston.

[** CO2 Cartridge Adiabatic Cooling](#)520-4B70.25

A CO2 cartridge is used to adiabatically cool a metal sample.

Change of State

Phase Changes: Liquid-Solid

[*Ice bomb in liquid nitrogen](#)233-4C20.20

A cast iron small bomb shaped sphere is filled completly with water and the top screwed on tightly. It is placed in liquid nitrogen. When it has cooled enough, the bomb splits apart with startling force. Some form of sheilding must be used so shrapnel does not injut people.

[** Fire extinguisher](#)235-4C20.45

A CO2 fire extinguisher is discharged. Because the CO2 is released quickly it forms a solid. Show cooling with expansion. **DO NOT USE CLASSROOM FIRE EXTINGUISHER.** The demo facilities have a specially designated extinguisher.

Cooling by Evaporation

[Temperature probe dipped in water](#)237-4C31.11

Taking a thermocouple and wetting it and then letting it air dry will produce a significant reduction in the tip temperature.

Kinetic Theory

Mean Free Path

[Crookes radiometer](#)417-4D20.10

An evacuated vessel holds a spinner that has black and white faces. A bright light or heat lamp is applied and it spins.

Kinetic Motion

[Pasco molecular motion model](#)265-4D30.12

The function generator should be set to sine output, and a frequency of about 50 Hz. The amplitude is analogous to temperature: increasing the amplitude gives the ball bearings more energy, which results in them occupying more space; decreasing the amplitude does the reverse.

Diffusion and Osmosis

[Diffusion of liquids](#)251-4D50.61

A wine glass filled with water is allowed to become still. A drop or two of food coloring is dropped in. The color slowly diffuses throughout the water.

Gas Law

Constant Pressure

[Cp/Cv](#)538-4E10.10

[** ^^ Balloon in liquid nitrogen](#)252-4E10.20

Balloons are added to a bucked of liquid nitrogen. This shows that as the temperature goes down so does the pressure. The balloons and LN can then be dumped out and the balloons will re inflate.

Constant Temperature

[** Boyles&s Law Syringe](#)253-4E20.10

As different pressure is applied to the syringe the pressure in the syringe goes up. Visible with an overhead projector.

[*Balloon in a vacuum](#)266-4E20.40

A partially inflated balloon is placed in a bell jar. The air is pumped out and the balloon expands. Shows atmospheric pressure was squeezing the balloon.

Constant Volume

*Constant volume bulb 255-4E30.10

A sealed bulb is attached to a pressure gage. The bulb is placed in boiling water, ice water, and liquid nitrogen. The resulting pressure is then measured. It acts like a thermometer.

Entropy and the Second Law

Entropy

** Ball Entropy Mixer 521-4F10.20

The balls in the jar are placed in colored layers. A student or professor is then to tip the jar, with the lid on, six times in one direction followed by six in the other. The resulting mixture will not be the same.

Heat Cycles

** ^^ Sterling engine 268-4F30.10

This is a nice motor that makes it easy to see how it works. The motor can be placed on top of a beaker full of hot water, on some ice, or even on a cup of hot coffee or an ice cream cone.

*Heat engine 418-4F30.15

The heat engine has a can that is placed in hot water to slowly raise a piston. Putting the can in cold or room temperature water then brings the piston back down.

Steam engine 262-4F30.20

A small boiler is heated electrically and the steam then spins around a flywheel.

Electrostatics

Producing Static Charge

Some movies; V 556-5A10.1

The links to some videos on youtube related to the experiments described below

** Rods and fur 269-5A10.10

The clear acrylic rods will be positively charged when rubbed with the black silk. You should be able to hear the snap, crackle, and pop as the charge builds up. The black plastic rods will be negatively charged when rubbed with the red wool, the fur, or the small blue cloth. In humid conditions, the blue cloth gives the best results.

Electrophorus 270-5A10.20

Used as a source of electrostatic charge. The acrylic base is charged by rubbing. The electrophorus is placed upon it and the edge touched with a finger to inductively charge it. When removed the metal plate will have a charge.

Coulomb's Law

** Rods and pivot 271-5A20.10

The clear acrylic rods will be positively charged when rubbed with the black silk. You should be able to hear the snap, crackle, and pop as the charge builds up. The black plastic rods will be negatively charged when rubbed with the red wool, the fur, or the small blue cloth. In humid conditions, the blue cloth gives the best results.

Electrostatic Meters

** Electroscopes 272-5A22.10

Used to show the amount of static charge. By wiping charge onto them from a charged rod the needle in the middle will move indicating the amount of charge.

Conductors and Insulators

Wire versus string 273-5A30.10

Two electroscopes are connected with a wire or a string. One is charged with a statically charged rod and the response of the other electroscope is observed.

Induced Charge

*Charging by induction 420-5A40.10

An electroscope can be charged without touching it with a charged rod.

*Charge propelled soda can 275-5A40.20

An aluminum soda can is placed on the table and drawn towards a charged rod of either polarity. Do not touch the can with the rod.

** Charge propelled 2 x 4 rotation 276-5A40.30

A piece of wood is placed on a watch glass as a pivot. A rod is charged with static electricity and held near one end of the wood. The wood will be attracted to it and rotate towrads the rod.

** Metal rod attraction 277-5A40.35

A metal rod placed in a pivot is made to spin by placing a charged rod near it due to the charge separation in the metal rod.

*Deflection of water stream 278-5A40.40

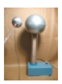
A charged rod displaces a steady flow of water.

Electrostatic Machines

** Wimshurst machine 280-5A50.10

Turning the crank causes the wheels to spin, building up opposite charges on the two balls. Nice bright sparks are easily created with this device.

** ^^ Van de Graaff generator 421-5A50.30



Plug the discharge rod into the ground plug (the middle one) of a three-prong extension cord, and plug the cord into an electrical outlet. When turning the Van de Graaff on or off, or when changing the speed, always place the discharge rod close to the generator globe. In high humidity or when the generator has not been used for a while, it may take a few minutes to get the generator operating properly; when doing so, sparks of several cm in length can be set up between the globe and the discharge rod.

Electric Fields and Potential

Electric Fields

*Van de Graaff streamers 282-5B10.15

Streamers attach to the to of the generator. When charged up the will follow the field lines.

** ^^ Styrofoam peanuts 283-5B10.25

Before doing anything else, connect the grounding rod to the ground (middle) connection of a plugged-in extension cord. Pour enough Styrofoam peanuts into the pan to cover the bottom, and then add a few more. Balance the pan on top of the generator, and turn it on to a moderate level. A setting of 30 - 50 is about right. After a few seconds, peanuts should start flying out of the pan. Because they are so light, close to the generator the electric force dominates, and the peanuts travel along field lines.

** ^^ E Field Viewer - Grass Seed 284-5B10.40

A static electric charge is applied to electrodes that move grass seed in a tank to show the E field. Projects with an Overhead. Multiple charge configurations available.

Gauss' Law

*Faraday ice pail 285-5B20.10

Put the ice pail on the insulating stand, and connect it to the van de Graaff by means of an alligator-to-alligator lead duct taped to the van de Graaff and the inside of the pail. Make sure you have good contact. Position the balls so that one hangs just below the lip outside the pail, and the other hangs at the same height inside. Both should be a couple of cm from the pail. Switch on the van de Graaff, running around 40. As the pail charges, nothing happens to the inside ball, but the outside ball is first drawn to the pail by induced charge, and then, after contact with the pail, is repelled. Set up properly, the ball will bounce back and forth, making a satisfying clanging sound each time it hits the pail.

Electroscope in a cage 286-5B20.30

A charged rod is brought near an overhead projector electroscope both by itself and when enclosed in a cage.

** ^^ Radio in a cage 287-5B20.35

A very nice demo of how a Faraday Cage works. A radio is tuned to a station but when placed inside the cage and then with the second cage placed on top the station goes completely dead.

Electrostatic Potential

Angle of Curvature Effect on Charge 288-5B30.35

A Van de Graff Generator is discharged through various shapes to show pointer shapes collect charge more readily.

** ^^ Pinwheel 289-5B30.50

A spinner made of 4 sharp points ending perpendicular to the radius spinner radius is placed on top of a Van de Graff generator. When the generator is charged the spinner will spin as charge leaks from the points.

Capacitance

Capacitors

Sample capacitors 290-5C10.10

A variety of commercially available capacitors to demonstrate the different packages and capacitor technologies.

Parallel plate variable gap capacitor 291-5C10.20

A simple capacitor compassed of two parallel places is charged with a 9V battery. The voltage on the places is measured using an electro meter. The distance between the plates can be changed to show the effect on the voltage.

Dielectric

Dielectric Properties 539-5C20.05

Capacitor with dielectrics 257-5C20.10

A parallel place capacitor can have dielectrics placed between the plates to see what impact that has on the capacitor voltage. **Not consistent results**

Dissectible Capacitor 258-5C20.30

A demonstration to show the energy of the capacitor is stored in a dielectric.

Energy Stored in a Capacitor

** ^^ Short a capacitor 259-5C30.20

A capacitor is charged to several thousand volts and then shorted out creating a significant bang. This is used to illustrate the amount of energy a capacitor can store.

*Light a bulb with a capacitor 260-5C30.30

A capacitor is charged up and disconnected from the battery. A light bulb is the attached to the capacitor. This demonstrates the a capacitor stores energy.

Resistance

Resistance Characteristics

Resistor assortment 256-5D10.10

An assortment of resistors is displayed to show the various packages and power ratings. **Under Construction**

** Resistance dependence on length/area 250-5D10.88

The three strips of conductive paper are all the same length, but have widths in the ratio 1:2:4. You can show that resistance depends on length by measuring the resistance between various points on one of the strips, and that resistance depends on area (or width, at least, in this case) by comparing the resistance measured between two points the same distance apart on each of the three strips

Resistivity and Temperature

[Wire coil in liquid nitrogen]427-5D20.10

Begin by measuring the resistance of the coil at room temperature; it should be about 20 ohms. Then set up a circuit with the 200 W bulb in series with the coil, powered by 120 V AC. Do not leave this circuit on too long, or the coil will get too hot! In this configuration, the bulb should glow dimly. Place the coil in the flask, and pour in liquid nitrogen via the funnel. As the coil cools and its resistance drops, the light bulb will glow brightly. Measure the coil resistance, which should be about 8 ohms.

Conduction in Solutions

Electrical Conductivity of Solutions 443-5D30.20

Pure water does not conduct electricity well. However, with the addition of salt, water will become ionized and conducts electricity.

Conduction in Gases

Jacob&s ladder 424-5D40.10

A spark will travel up two separated wires. Demonstrates the breakdown of air and then the following of a path of ions through the air. **Under Construction**

Electromotive Force and Current

Electrolysis

Electrolysis of water 241-5E20.10

A current is run through water which separates it into hydrogen and oxygen gas one at each electrode. The gas is collected in test tubes.

Cells and Batteries

** Lemon battery 242-5E40.25

Two electrodes - one copper and one zinc are placed in a lemon. A volt meter is attached to them and the resulting potential difference is observed. This can also be done with a potato.

*Two-potato clock 243-5E40.26

Use fruit or vegetables to drive a clock.

Piezoelectricity

*Piezoelectric sparker 248-5E60.20

The deformation of the crystal causes a spark. This can also be hooked to an electroscope and the deformation of the crystal can charge the electroscope.

DC Circuits

Ohm's Law

*Ohm&s law 425-5F10.10

Current and volt meters are attached to a variable resistor hooked to a power supply. Varying the resistance shows how Ohm was correct.

Potential drop along a wire 426-5F10.20

A piece of wire is attached to a battery. The voltage at various points along the wire is found.

Circuit Analysis

Continuity of current 294-5F20.15

At a T-junction replace each of the three wires with an ammeter and show that all the current that goes into a joint must come out.

Superposition of Current (Junction Rule) 295-5F20.20

Create a circuit with two batteries. Measure the current. Take out one battery and short across its connections and measure the current and then replace the other battery with a short with the first battery back in the system and measure the current. Show the sum of the currents is the same as the case with both batteries.

Potentiometer 296-5F20.30

Demonstrate the operation of a potentiometer (variable resistor) by hooking it to a battery and looking at the voltage and/or current.

** Series and parallel light bulbs 298-5F20.50

Light bulbs are in a series and a parallel configuration to observe the effect on power output. Interesting effects are observed when a 100W and 40W are placed in series.

RC Circuits

** ^^ Capacitor and light bulb 299-5F30.10

A 6V battery is used to charge a capacitor through a light bulb. It can then be discharged without the battery in the circuit. The current is observed with moving LEDs.

** ^^ RC time constant on scope 300-5F30.20

A capacitor and resistor in series is charged and discharged with a square wave from a function generator. Shows the time constant. Be careful when setting this up about the ground connection of the scope probes.

Magnetic Materials

Magnets

[Magnet assortment]302-5G10.10

An assortment of permanent magnets is presented to show students differing strengths and morphologies.

[Magnetite or Lodestone]517-5G10.16

Naturally occurring magnetized minerals.

[** Break a magnet]303-5G10.20

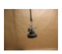
A magnet that has been pre scored for easy breaking is shown to have two poles and then broken. Then both pieces still have two poles - amazing.

Magnets Domains and Magnetization

[Compass arrays]304-5G20.30

An array of compasses is oriented to show domains and randomly. A magnet is brought near each.

[** Electromagnet]305-5G20.71



An electromagnet is hooked to a single D cell and can easily lift up a 2 kg mass. Very impressive.

Temperature and Magnetism

[Curie point]307-5G50.10

An iron wire that can swing is attracted to a permanent magnet. The magnet is heated until it reaches the curie point where the iron wire will swing away from the magnet as it loses magnetization. As magnet cools the wire is attracted again. **Under Construction**

[** Meissner effect]308-5G50.50

A magnet is levitated above a superconducting disk cooled with liquid nitrogen.

Magnetic Fields and Forces

Magnetic Fields

[*Dip needle]429-5H10.15

Use a compass to map out a horizontal north-south line. Align the dip needle with this line, and the needle will be aligned with the Earth&s field. The inclination can be read from the scale. Note that the direction of the local magnetic field may be strongly affected by the presence of metal objects; be sure to check the area ahead of time for anything that might influence the magnetic field.

** Oersteds effect 430-5H10.20

A compass needle will align itself with the magnetic field of a current carrying wire.

*Magnet and iron fillings 309-5H10.30

Iron filings show a magnetic field.

*Big magnet and steel balls 310-5H10.34

Place balls in chains of about 5 balls at various points around the magnet, especially near the poles. One long chain, with one ball missing in the center, strung across the gap is also useful.

Fields and Currents

** ^^ Field of wire and iron filings 311-5H15.10

A vertical wire carries current and is surrounded by iron filings that show the resulting magnetic field. This is best observed on the overhead.

** ^^ Solenoid and iron filings 312-5H15.40

A solenoid embedded in an acrylic sheet has current running through it. The resulting magnetic field is shown with iron filings. Best viewed on an overhead projector.

Forces on Magnets

Magnets and pivot 313-5H20.10

Magnets are placed in a pivot to show their reaction to other magnets.

*Levitation magnets 314-5H20.20

Multiple ring magnets are placed on a rod so their poles repel leading to a stack of floating magnets.

Magnetic Forces 531-5H20.25

Determine how the force between two magnets varies with distance.

Force on Moving Charges

** ^^ Electron Beam Deflection with Magnet 317-5H30.20

An electron beam shown on a phosphorous surface is moved by waving a magnet in its vicinity.

Forces on Electron Beam - Circle Formation 316-5H30.21

A beam of electrons in a cathode ray tube (CRT) is forced into a circle by Helmholtz coils. The beam is visible in the gas of the CRT.

Force on Current Wires

** ^^ Parallel wires 318-5H40.10

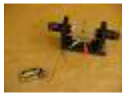
Two wires free to swing closer or farther apart have current flowing either in the same direction or opposite direction. Depending on the relative current flow the wires will experience a magnetic attraction or repulsion. A very nice demo.

** ^^ Jumping wire 319-5H40.30

A wire is looped around a strong permanent magnet. Current flows through the wire and, depending on the direction of current flow, the wire will either jump out of the magnet or be pushed down.

Torque on Coils

*Spinning coil over magnet 431-5H50.45



Demonstrates force on a current in magnetic field. Its operation is the basis of an electric motor.

Inductance

Self Inductance

Inductor assortment 432-5J10.10

An assortment of inductors to pass around for the students to see different styles.

LR Circuits

** ^^ LR time constant on scope 320-5J20.10

The charging and discharging of an inductor is observed by driving it with a square wave. The resulting voltages are observed with an oscilloscope. Current can be found by looking at the voltage across the resistor. When hooking up be aware of the oscilloscope ground connections.

RLC Circuits - DC

** ^^ RLC Ringing 440-5J30.10

An RLC circuit is hit with a square wave and the resulting ringing is shown on an oscilloscope.

Electromagnetic Induction

Induced Currents and Forces

*Motional EMF 511-5K10.13

An aluminum bar is passed through a magnetic field. Wires on either end attached to an analog volt meter show the EMF generated.

** ^^ Induction Coil and Magnet Induced Current 321-5K10.20

A magnet is moved through a coil of wire attached to a galvanometer. This generates a current that moves the meter.

** ^^ Mutual Inductance of Two Coils 445-5K10.30

One coil is attached to a galvanometer and the other to a high current DC supply. The coils are placed end to end. When the current is pulsed, with no core, the galvanometer moves a litte. When a core links the solinoids, the meter moves considerably more.

Eddy Currents

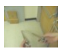
** ^^ Pendulum Eddy Current Damping 322-5K20.10

A flat plate pendulum swings though a magnetic field. The eddy currents damp the motion. Slotted pendulums have reduced eddy currents so are not damped as much.

** Osheroff Plate 510-5K20.17

A large plate of copper is cooled with liquid nitrogen. A very powerful magnet then can be moved with great resistance around the surface.

*Racing Magnet 323-5K20.25



A spherical magnet and a ball bearing are both released either inside an aluminium tube or down a highly sloped aluminum angle iron. Generating the eddy current significantly slows down the magnet.

** Magnet Falling Down in a Pipe 522-5K20.25

This demonstrates eddy currents in a pipe.

** ^^ Jumping ring 324-5K20.30

A coil produces a magnetic field the induces an oppositely directed magnetic field in an aluminum rang placed around the core and the ring flies off. An aluminum ring with a break in it is also provided showing the currents in the ring have to be completed.

Faraday’s Law 533-5K20.40

Show Faraday’s Law by dropping a magnet through a coil.

Transformers

*Dissectible transformer 325-5K30.20

A sine wave function generator is attached to one side of the transformer. The output voltage, viewed either with an oscilloscope or volt meter, will vary dependent upon the ratio of the number of turns in the two coils.

Motors and Generators

** ^^ DC motor 328-5K40.10

A simple DC motor with a single wire forming the coil of the rotator. Placed between the poles of a magnet and powered by 2 D cell batteries this motor can be spun quite quickly. Clear casing allows for easy viewing on the overhead.

** Hand crank generator 329-5K40.80

Electricity is generated by a cranking motion. The generator can be hooked to a light bulb to indicate electricity is being created. Two generators can be hooked together to show a generator is merely a motor.

*Shakelight 512-5K40.90

A flashlight is charged by shaking it. A visible linear generator generates electricity and it is stored in a capacitor.

AC Circuits

Impedance

AC circut with only R, C and L 330-5L10.17

If the following parameters are used, the capacitor or inductor can be substituted for the resistor with needing to adjust the power supply or scope settings. Set the amplitude on the frequency generator to about halfway, and the frequency to 1500 Hz. R = 300 ohms; C = 0.04 micro farads; and L = 0.04 H. With any of the three components in place, the value of R, C, or L can be adjusted to see the effect on the current; the dependence of current on frequency can also be seen by changing the frequency. In a small room, the students can view the scope directly. In a larger room, the video camera can show the scope screen on a TV monitor, or all 4 monitors in room 107.

LCR Circuits - AC

RLC Phase Difference 502-5L20.10

An RLC circuit is driven with a sine wave. The current through the inductor and the voltage across the capacitor are measured with an oscilloscope. They are 90 degrees out of phase which demonstrates how the C an L pass energy back and forth.

** ^^ RLC Resonance 501-5L20.20

A series RLC circuit is driven with a sine wave. The voltage across the capacitor and/or the current through the inductor are monitored on an oscilloscope. When the driving frequency is passed, the signal magnitude increases greatly.

Electromagnetic Radiation

Tesla Coil

*Tesla coil 331-5N20.40

A hand held Tesla coil can be operated. The point will show a mild corona. A corona can also be observed between two concentric rings.

*Plasma globe 333-5N20.56

Our plasma globe is a commercial device hat will either give a continuous display or a display that responds to loud sounds.

Electromagnetic Spectrum

*Projected spectrum with prism 334-5N30.10

The rainbow produced by a prism is discussed in the context of electromagnetic radiation.

Geometrical Optics

Reflection From Flat Surfaces

** ^^ Blackboard optics - plane mirror 336-6A10.10

Mount the mirror and the 5-ray box on the blackboard, powering the ray box with as much as 12 V DC. Shift the angle of the mirror, or the orientation of the ray box, to show that the angle of reflection equals the angle of incidence.

Reflection From Curved Surfaces

*Blackboard optics - curved mirrors 339-6A20.10

Mount the curved mirror, which is concave on one side and convex on the other, and the 5-ray box on the blackboard, powering the ray box with as much as 12 V DC. Using the concave mirror, it is easy to see that the reflected beams converge at a point. With the convex mirror, you can extend the reflected beams back behind the mirror with chalk to show that they meet at the focal point.

Parallel lasers and curved mirror 340-6A20.15

Two laser pointers are shown on a curved mirror. The reflection is observed.

Refraction at Flat Surfaces

*Blackboard optics - refraction 341-6A42.10

Mount the rectangular block and the 5-ray box on the blackboard, powering the ray box with as much as 12 V DC. It might be easier to use three rays rather than 5, so the outer two can be eliminated by changing the angle of the deflecting mirrors. The angle of incidence can be adjusted by changing the orientaion of the block. The refraction of the light at the two interfaces should be clearly seen; point out that the light emerging from the block is parallel to the light entering the block.

*Paraffin prism and microwaves 342-6A42.55

Microwaves are refracted by a paraffin prism.

Total Internal Reflection

*Blackboard optics - total internal reflection 343-6A44.10

Mount the rectangular block and the 5-ray box on the blackboard, powering the ray box with as much as 12 V DC. In this case, it might make the situation less complicated if only the central ray is used. The other four can be removed by changing the orientation of their aligning mirrors. At small angle of incidence, light will be transmitted from the block to air. At higher angles of incidence no light will be transmitted.

*Optical Light Guide 344-6A44.40

An assortment of light guides are available to shine a laser through and observe how the light stays in the guide.

Water stream light pipe 345-6A44.45

A stream of water exiting a bottle guides a light beam along its path.

Thin Lens

*Blackboard optics - thin lens 346-6A60.10

There are two lens available, one plano-convex and the other plano-concave. Mount the appropriate lens and the 5-ray box on the blackboard, powering the ray box with as much as 12 V DC.

Parallel lasers and lenses 347-6A60.20

Two laser pointers are shown through a lens.

Optical Instruments

Microscope model 348-6A70.10

Appropriate lenses are mounted on an optical rail to form a microscope. Students can then come and look through it.

Telescope models 349-6A70.20

Appropriate lenses are mounted on an optical rail to form a telescope. Students can then come up and look through it.

Diffraction

Diffraction Through One Slit

** ^^ Single slit and laser 350-6C10.10

A slit from a Cornell Grating or a slide with single slits has a laser shone upon it. The resulting diffraction pattern is observed.

** ^^ Microwave diffraction 352-6C10.50

A microwave source is placed on the opposite side of a slit from the receiver. The receiver is moved in a circle to find the diffraction pattern. The output can be heard with a speaker.

Diffraction Around Objects

*Arago&s or Poisson&s Spot 507-6C20.10

A sphere is placed in the path of an expanded laser beam creating a shadow on a projection screen. In the middle of the shadow is a small point on light due to diffraction around the sphere.

Interference

Interference From Two Sources

*Double slits and laser 353-6D10.10

A double slit from a Cornell Grating or a slide with double slits has a laser shone upon it. The resulting diffraction and interference pattern is observed.

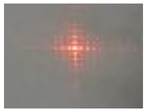
Microwave two slit interference 355-6D10.20

A microwave source is placed on the opposite side of a double slit from the receiver. The receiver is moved in a circle to find the diffraction and interference pattern. The output can be heard with a speaker.

Moiré Pattern 552-6D10.30

Gratings

** Gratings and laser 357-6D20.15



A laser pointer is shown through a diffraction grating and the resulting horizontal pattern of dots is seen on the wall. Some gratings are scored in two directions and you will get a 2 dimensional pattern of lights.

Thin Films

** ^^ Newtons Rings 506-6D30.10

Two plates of glass with a very small air space between them produces an interference pattern of colors. This can also be projected using an overhead projector though the colors do not show up well.

*Soap film interference 360-6D30.20

The thin film created by a soap bubble can be shown to the whole class with a video camera aimed at the soap bubble viewer.

Polarization

Basics

*polarizers on the overhead 361-6H10.10

Two polarizers are placed on an overhead or looked through. As their relative angles are varied the amount of light let through changes.

*Microwave polarization 362-6H10.20

A wire screen in placed between the microwave transmitter and receiver as a polarizer.

Brewsters Angle 551-6H10.30

A light is reflected off the surface of water. A polarizer is then rotated and the spot of light reflected off the water surface disappears at a certain orientation.

The Eye

The Eye

Rayleigh Criterion (Angle of Resolution) 550-6J10.40

Angle of Resolution 433-6J10.80

Two light bulbs close together are resolved by the naked eye close up but at a distance look like one.

Modern Optics

Holography

Holograms 368-6Q10.10

Along with the reflection hologram of the eagle, taken from the front cover of the National Geographic, there is a cylindrical hologram of a toy car, possibly a Volkswagen Beetle, and a transmission hologram of a magnifying glass in front of a telephone. The reflection hologram can be viewed under ordinary lighting, but the laser light is necessary for the transmission and cylindrical holograms.

Modern Physics

Quantum Effects

Photoelectric Effect

** Photoelectric effect in zinc 213-7A10.10

A zinc plate is attached to an electroscope and charged with electrons (from a black plastic rod rubbed with fur). The zinc plate is exposed to UV light and the charge on the plate is quickly discharged.

Wave Mechanics

** ^^ Vibrating circular wire 370-7A50.40

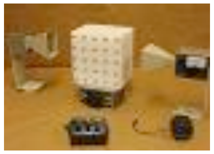
A hoop is made to oscillate by driving it with a mechanical oscillator. It can be driven either perpendicular or parallel to the plane of the hoop.

X-ray and Electron Diffraction

** ^^ Electron diffraction 371-7A60.10

When the voltage of one of the CRT tubes is increased to between 2500 and 3000 V concentric circles on the display screen appear indicating electron diffraction.

Microwave Bragg diffraction 373-7A60.50



A crystal structure of ball bearings in Styrofoam is placed between the microwave emitter and receiver. The receiver is then moved in a circle to see the amount of energy at each point around a circle.

Atomic Physics

Spectra

** Student gratings and line sources 374-7B10.10

Students view atomic spectra through student diffraction gratings. A variety of substances are available.

Nuclear Physics

** ^^ Geiger counter and samples 175-7D10.10

A Geiger counter is exposed to some samples and students can hear the clicks. Currently we have a smoke detector and some fiesta ware dishes as sources.

Range and absorption 377-7D10.60

A radioactive source is placed in front of a Geiger Counter. An assortment of barriers are placed between to show the effect on absorption. The distance can also be varied.

*Mousetraps 378-7D20.10

This is an excellent chain reaction demo. Many mousetraps are set and a ping pong ball is placed on top of each one. A clear half-sphere is placed above them. A single ball is then dropped in and all the traps trip.

*Geiger counter 379-7D30.05

Several sources can be placed in front of a Geiger Counter which emits an audible click when detecting.

*Diffusion cloud chamber 380-7D30.60

Planetary Astronomy

Telescope Models 541-8A10.10

Appropriate lenses are mounted on an optical rail to form a telescope. Students can then come up and look through it.

Orbits 548-8A10.20