Modern Physics

For the complete bibliography with references as well as an explanation of the classification scheme go to:
Demonstration Bibliography

The **demonstration name** listed in the bibliography is either the name listed on the reference or, if none is given, a simple descriptive name. In cases where there are several common names for a demonstration, the committee has chosen a preferred name.

The **description** is very brief. It is not intended to be a summary of the reference. One sentence is, in general, sufficient to describe the unique characteristics, if any, of an item. Each source has a unique numbering format. These unique formats are used identify references in the Bibliography.

The formats for the **reference** column and links to the sources are listed below:

Reference	Source
M-1	Sutton
Ma-1	Freier & Anderson
M-1d	Hilton
8-2.8	Meiners
M-108	Dick & Rae
1A 12.01	University of Minnesota Handbook
AJP 52(1),85	American Journal of Physics
TPT 15(5),300	The Physics Teacher
Disc 01-01	The Video Encyclopedia of Physics Demonstrations
PIRA 200	Physics Instructional Resource Association
PIRA 500	PIRA 500
PIRA 1000	PIRA 1000

Each demonstration is listed in only one location, even if it is commonly used to illustrate several concepts.

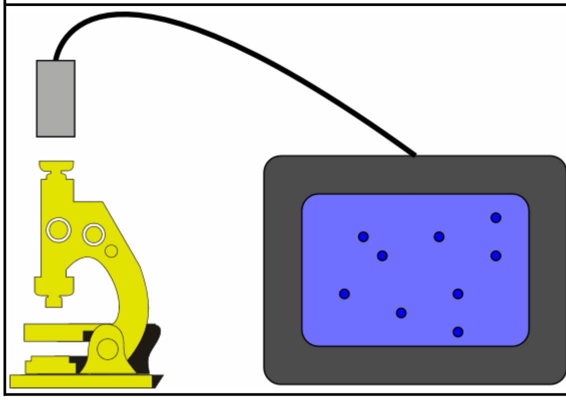
11/20/2023

Modern Physics

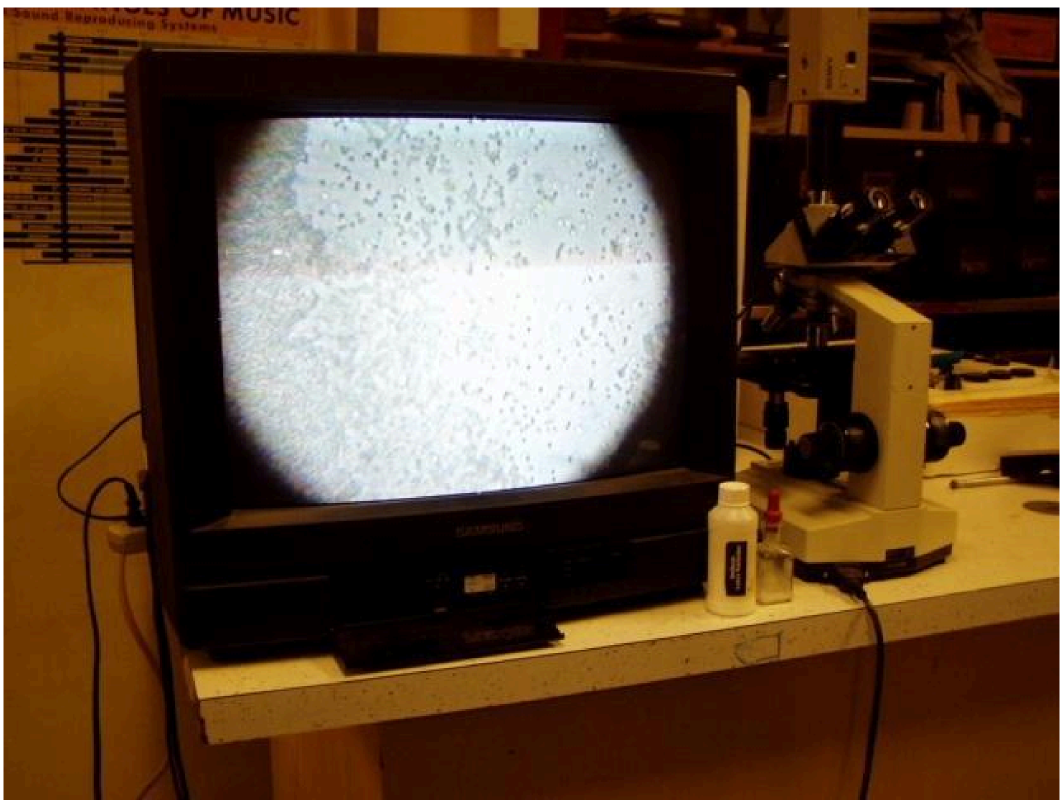
THERMODYNAMICS	4D10.10	**KINETIC THEORY**

Brownian Motion

Brownian Motion Cell



Observe the motion of particles in a smoke cell through a microscope. The balls are about 1 micron in diameter. Put a drop of the solution on a slide then place a cover slide on top of it. Use a drop of oil with the oil immersion objective. The well slide works best (less systematic movement); if you use it, place a drop in the well then dilute it with water.

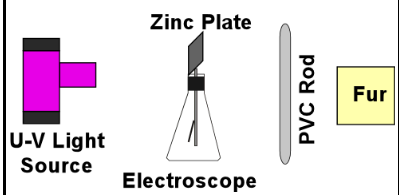


Location: Ga3

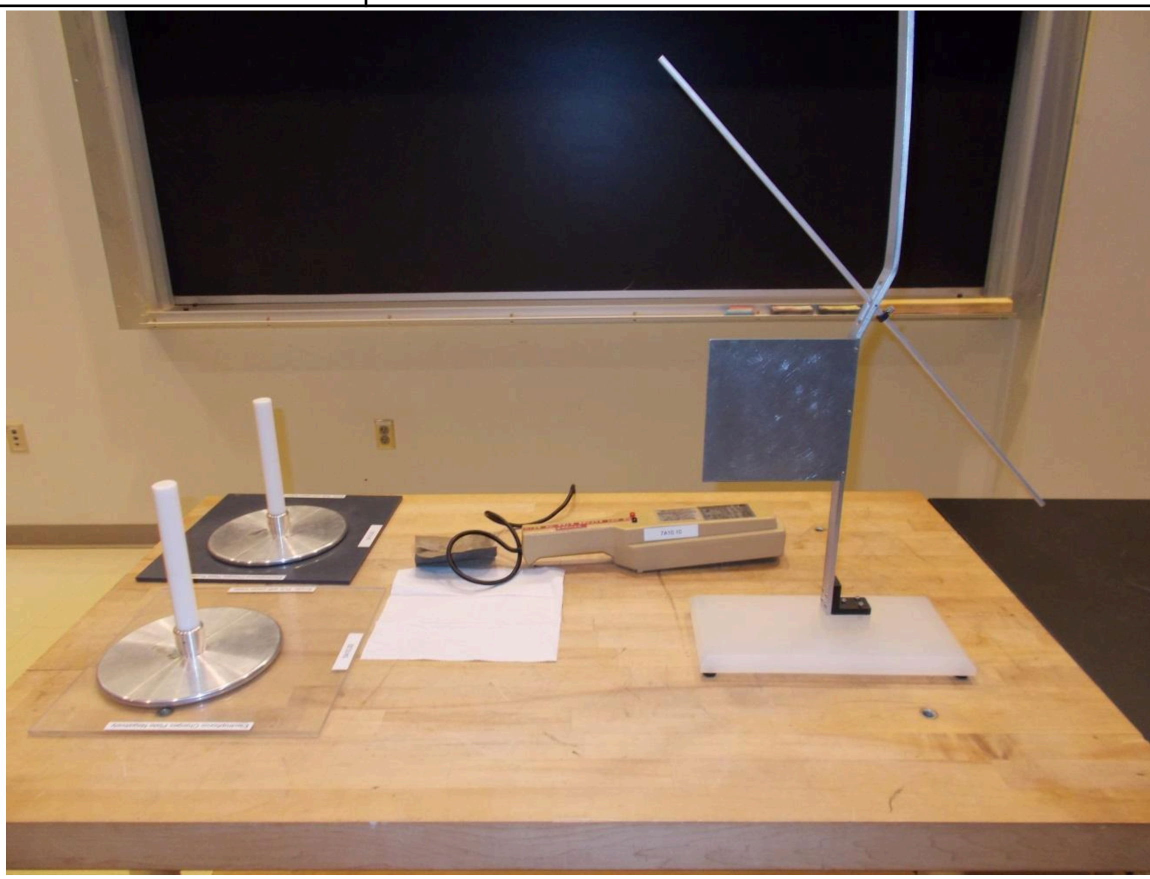
MODERN PHYSICS	7A10.10	**QUANTUM EFFECTS**

Photoelectric Effect

Discharging Zinc Plate



A polished (with fine abrasive paper) zinc plate sits atop an electroscope. Charge the electroscope with a rod. Turn on the UV light. Expose the zinc plate to the UV rays. Do not turn the UV light towards the students. Compare what happens when you charge the plate positively with what happens when you charge it negatively.

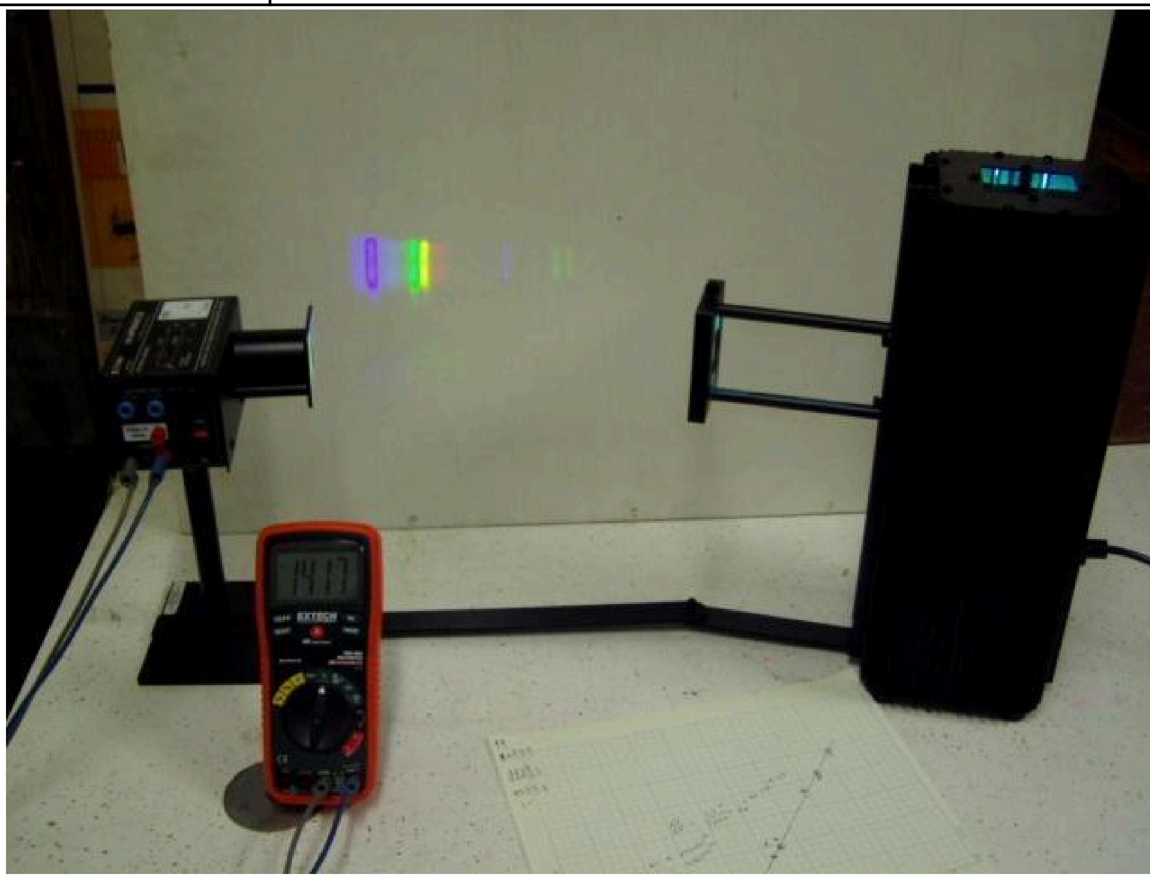


Location: Ka2, Gc1, Gd1

MODERN PHYSICS	7A10.30	QUANTUM EFFECTS
	Photoelectric Effect	

Stopping Potential

	h/e apparatus. Measure the stopping potential of the lines of the mercury spectrum with a photodiode.



Location: Ka2

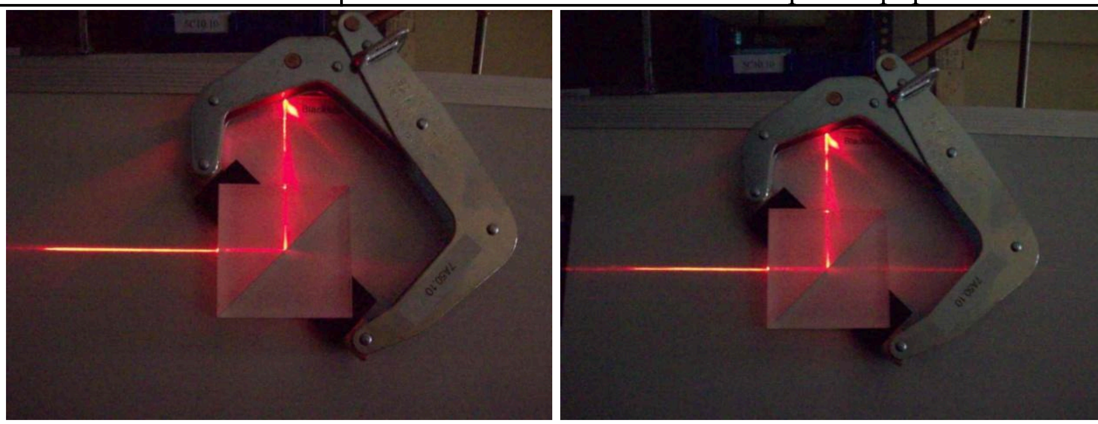
MODERN PHYSICS	7A15.10	QUANTUM EFFECTS
	Millikan Oil Drop	
	Millikan Oil Drop Experiment	
	The oil drop experiment.	

Location: Ka3

MODERN PHYSICS	7A50.10	QUANTUM EFFECTS
	Wave Mechanics	

Frustrated Total Internal Reflection

	Squeeze two right angle prisms together using a C Clamp and some notched blocks of wood while directing a beam of light at the interface. Use the blackboard optics equipment for this.

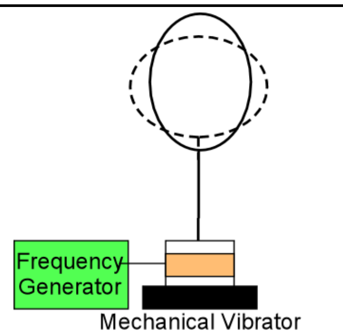


Location: Blackboard Optics Cart

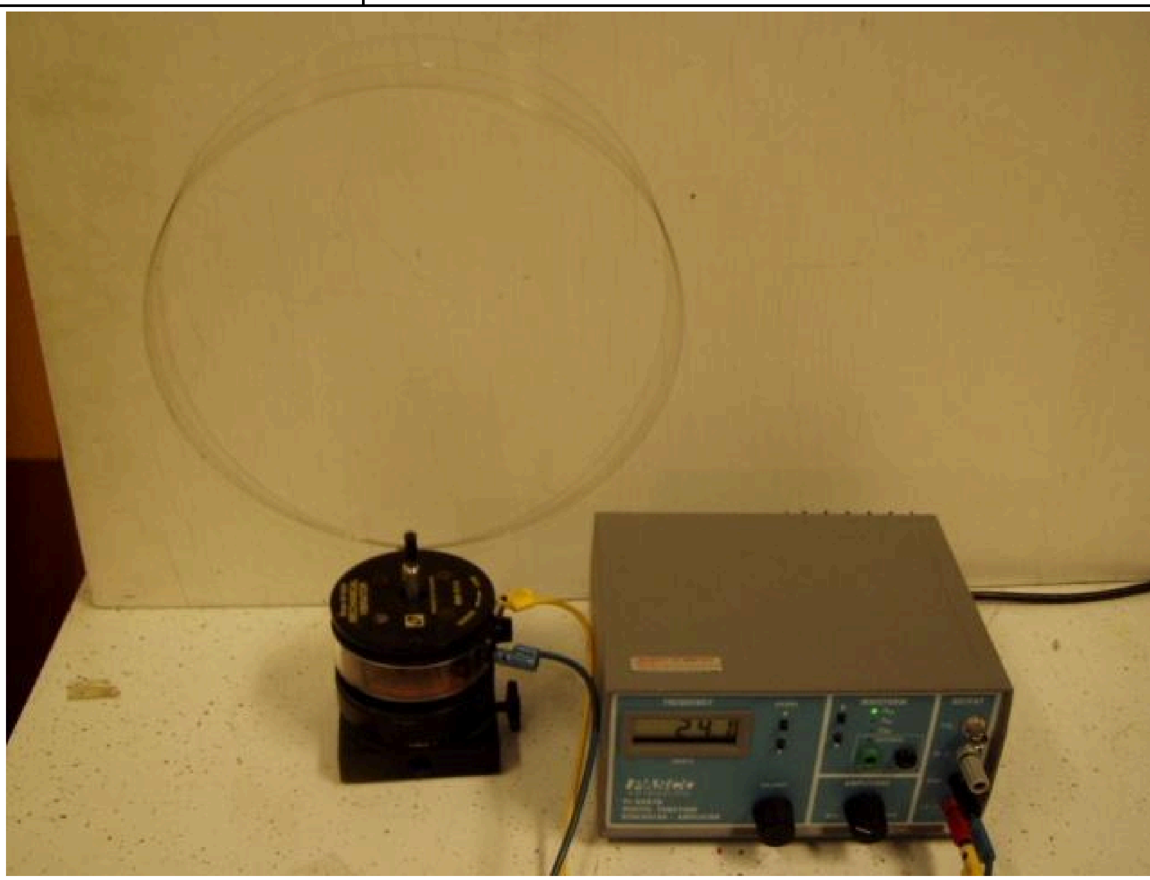
MODERN PHYSICS	7A50.40	QUANTUM EFFECTS

Wave Mechanics

Vibrating Circular Wire



The PASCO signal generator drives the PASCO mechanical vibrator. The three node resonance is at 20Hz. Turn up the amplitude after finding the resonance. Other resonances are at 60, 100, and 140 Hz. Pin the wire at 180 degrees from the mechanical vibrator to get full numbers of waves.

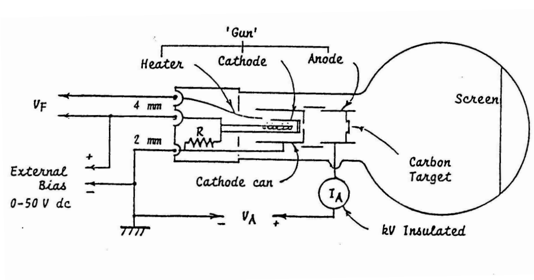


Location: Ka3, Ec2, Fb4

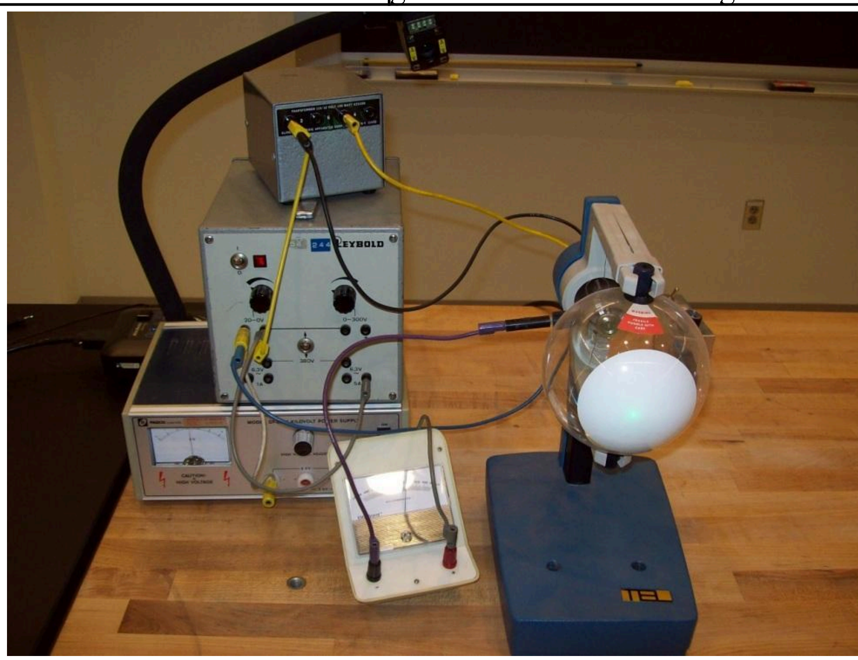
MODERN PHYSICS	7A60.10	QUANTUM EFFECTS

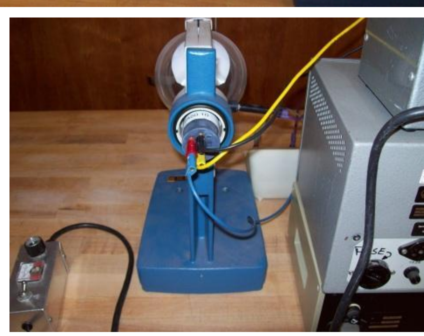
X-ray and Electron Diffraction

Electron Diffraction



Rings or spots diffraction patterns can be shown to the class using a TV camera. The beam and bias will already be adjusted. Turn up the HV until the pattern appears. Do not let the current exceed 170 microamps. Turn down the HV when you are done. The small jack at the back has a negative bias (20 V or so) on it. The filament voltage is 6.3 V and one side is connected to the common ground for the HV and negative bias supply.



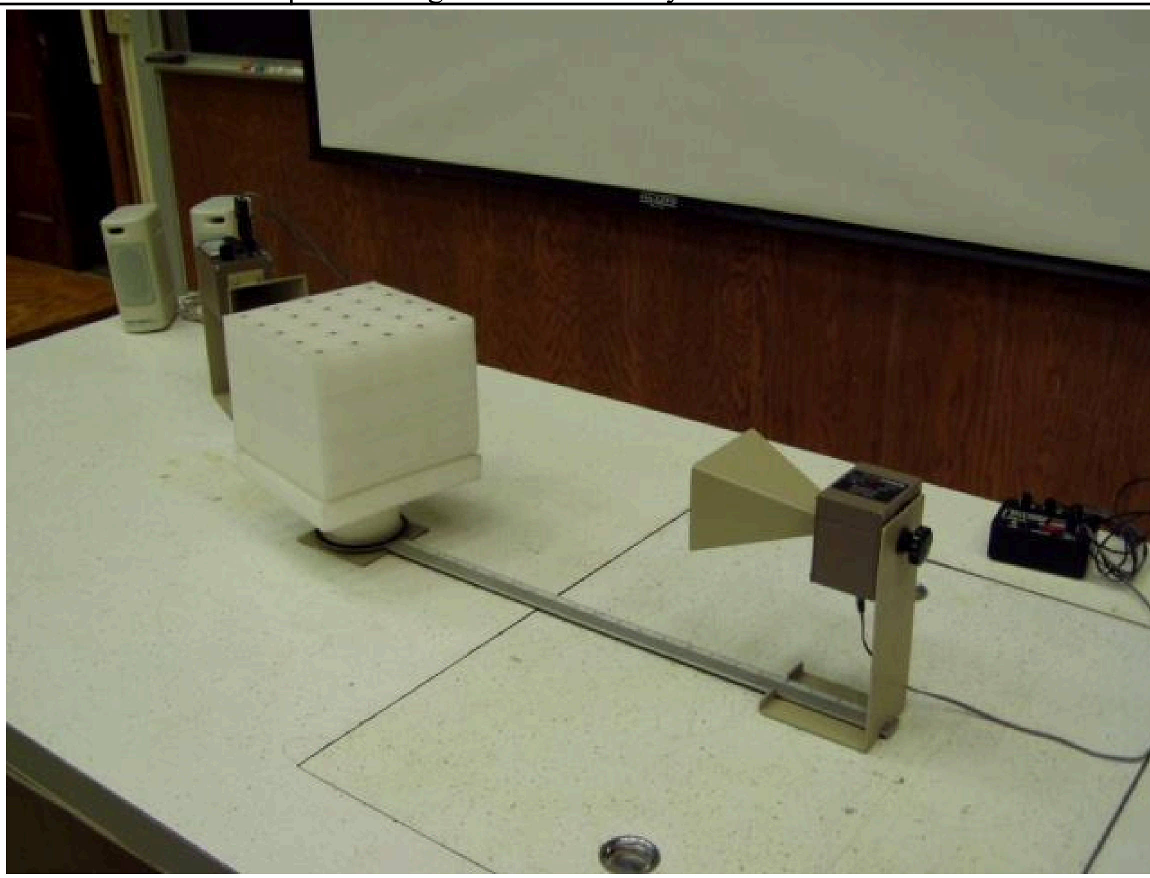


Location: Ka4

MODERN PHYSICS	7A60.50	QUANTUM EFFECTS
X-ray and Electron Diffraction		

Microwave Bragg Diffraction

	Microwave diffraction is observed from a crystal model made of steel ball bearings mounted in a Styrofoam cube.



Location: Ia7, Ka5

MODERN PHYSICS	7A60.95	QUANTUM EFFECTS
X-ray and Electron Diffraction		
Sample X-Ray Tube		
	Show a large X-ray tube.	

Location: Kd1

Condensed Matter

Quantum Levitation and Flux Pinning

	A thin film superconductor levitates over a magnet pinned in place by flux quanta.

Location: Ga5

MODERN PHYSICS	7A70.40	QUANTUM EFFECTS
Condensed Matter		

Electron Conduction Model

	The Air Cushion Table is used to show bound charge carriers in an insulator; a free charge in an insulator, conduction in a semiconductor (N type and P type. Air Cushion Table manual: 2.4.9, 2.4.10, 2.4.11, 2.4.12, 2.4.13.

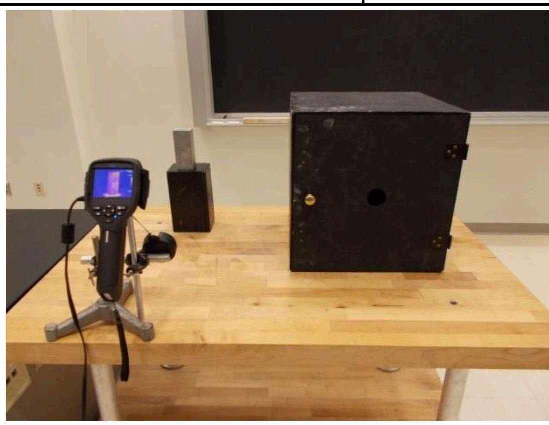
Location: Ga5

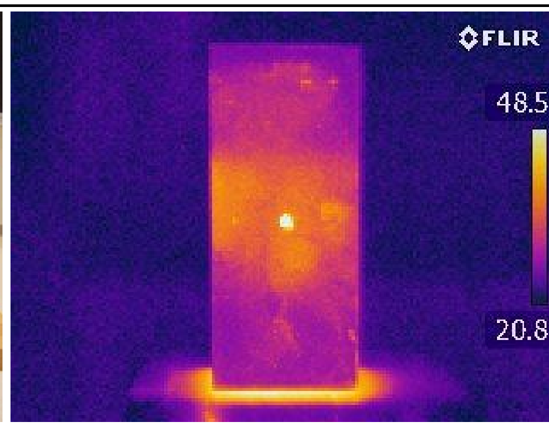
OPTICS	6B40.20	PHOTOMETRY

Blackbodies

Hole in a Box

A box that is painted black has a hole in a hinged door. The hole appears blacker than the box, When the door is opened, you see the box is actually painted white on its inside surfaces. Use an infrared camera to look at a hole in a heated aluminum block (100 C).



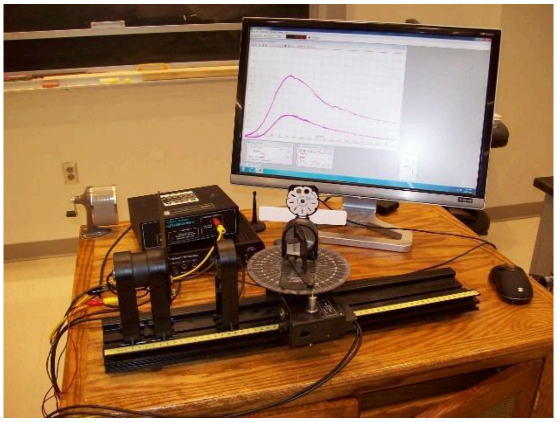


Location: Jb2, Fc5, FLIR Cabinet

OPTICS	6B40.40	PHOTOMETRY
Blackbodies		

Black Body Spectrum

	A spectrometer and bolometer connected to Science Workshop is used to record the spectrum from an incandescent bulb at various temperatures. The second version uses a bulb, grating, variac and TV camera. Use fixed focus and exposure. Change the variac setting to show the spectrum shift.

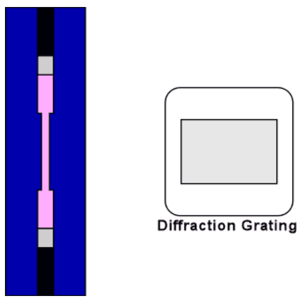


Location: Science Workshop Cabinet, Optics Table Cabinet, Kb2, Ib2

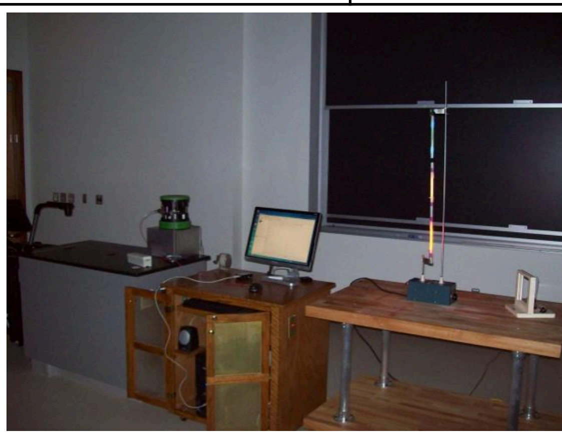
MODERN PHYSICS	7B10.10	**ATOMIC PHYSICS**

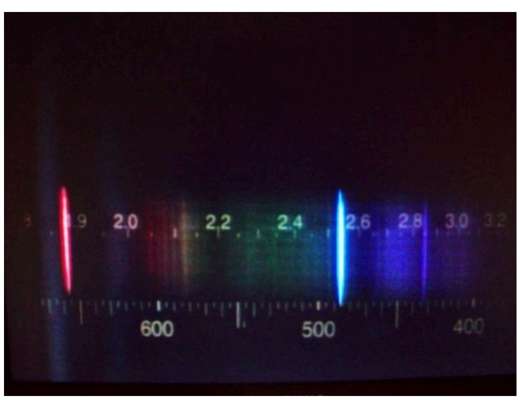
Spectra

Student Gratings and Line Sources



Pass out the 1"x1" gratings to the students. These have 13,400 lines per inch. Turn on one of the light sources. There is a single filament white light source and three discharge tubes, Hg, He, and Ne. The Didymium filter can be placed in front of the white light source to show selective absorption. Also shown is a spectrometer with a TV camera showing hydrogen Balmer lines and the Ride Tide USB spectrometer showing the line spectrum on the computer. Use the door lite curtains to darken the room.





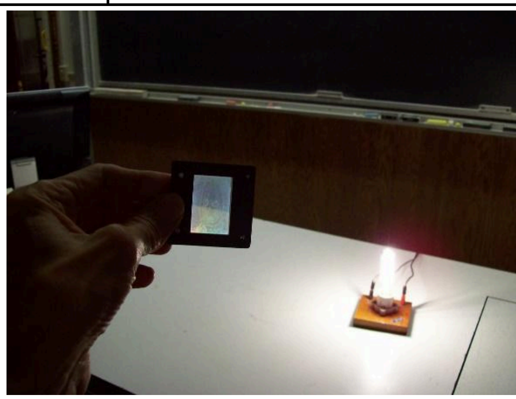
Location: Ka1, Kb2

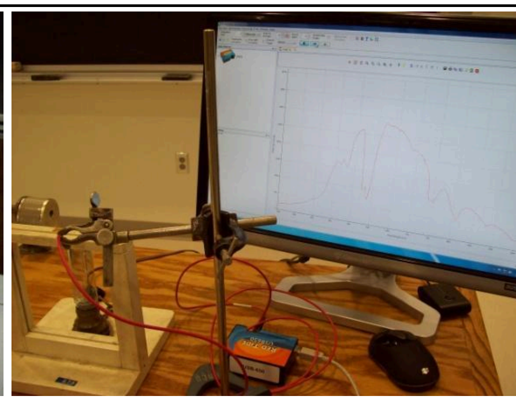
OPTICS	7B11.65	ATOMIC PHYSICS

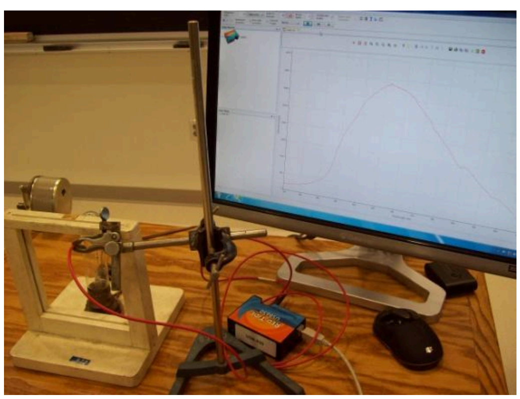
Absorption

Band Absorption Spectrum

Didymium glass is used to show band absorption. The Reveal 60 bulb is used with both a grating and the Red Tide spectrometer to show the bands. An ordinary bulb is shown for comparison. Use fixed focus and exposure for the TV camera.





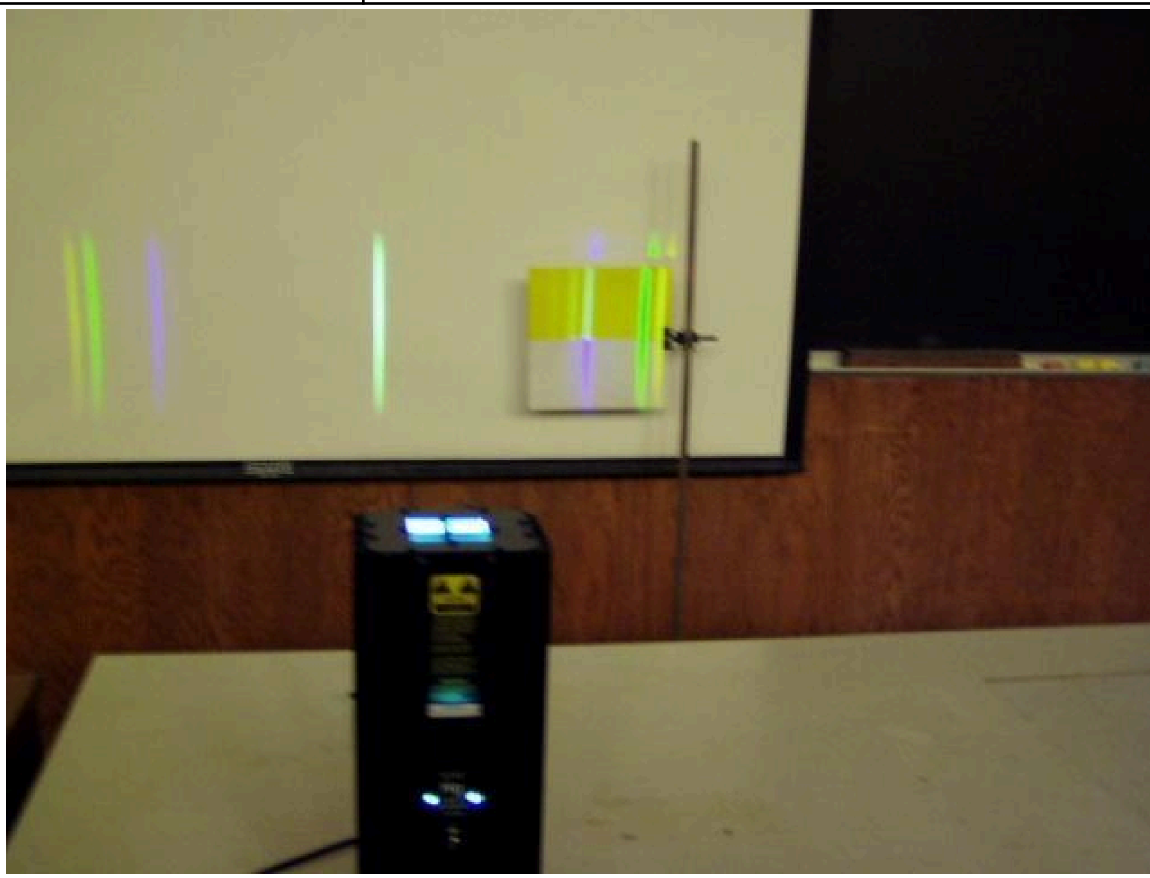


Location: Jb2, Ib1

Resonance Radiation

Projected Mercury Spectrum

	The UV lines of the projected spectrum are made visible using a fluorescent board



Location: Ka2

MODERN PHYSICS	7B13.50	ATOMIC PHYSICS
Resonance Radiation		

Fluorescence and Phosphorescence

	Fluorescent and phosphorescent materials are shown with a black light.

Location: Kb3

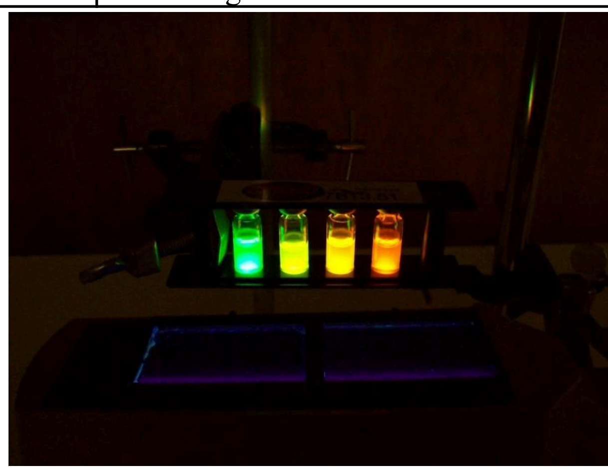
MODERN PHYSICS	7B13.51	ATOMIC PHYSICS

Resonance Radiation

Particle in a Box

Nanobeads (quantum dots) of 4 different sizes in solution fluoresce when illuminated with a UV light. The energy calculation is based on the calculation of a particle in a potential sphere (see the appendix of the instructions for more info). The quantum "sphere" or "box" is not empty but filled with a semiconductor. In order for the students to understand this they must first start with the derivation of a 1D particle in a box calculation, the sphere is basically the same physical concept with a different mathematical geometry.

Using the Red Tide spectrometer the peaks from the different fluorescing vials can be measured and compared with theory.



Location: Kb3

MODERN PHYSICS	7B30.45	ATOMIC PHYSICS

Ionization Potentials

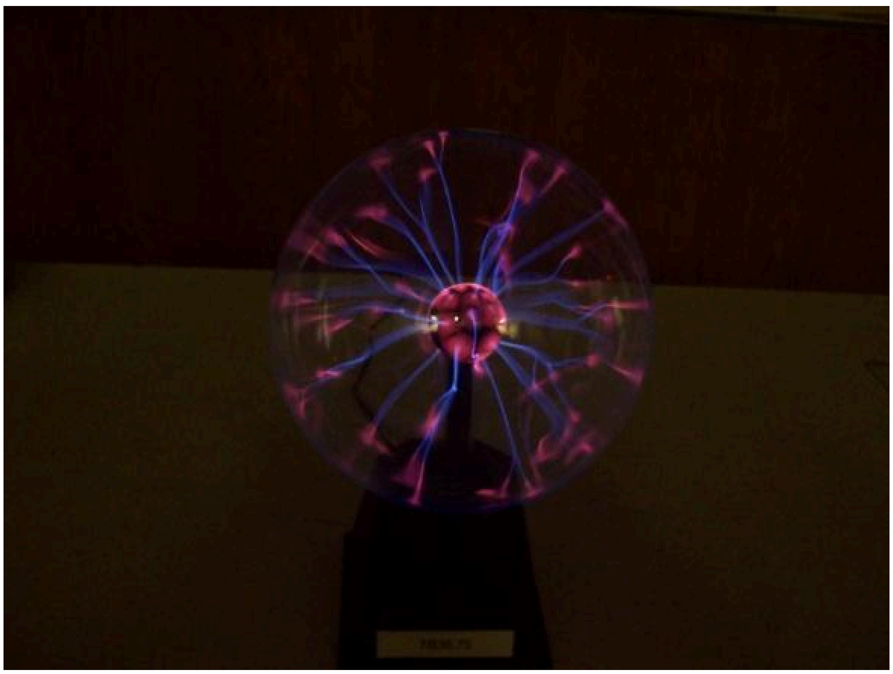
Photoionization in a Glow Lamp

In a glow lamp, when the potential across it is high enough, electrons will ionize the gas. The positive ions get attracted to the cathode and shield the electrons from the anode in the sense that there's a much reduced electric field beyond the cathode glow and Faraday dark space, so the electrons just scatter off of the neutral atoms without imparting much energy to them in that region. Between the cathode and dark space (the cathode fall), the electric field is strong enough to accelerate the electrons to excite the neon atoms causing them to glow they also provide ionizing energy to sustain the glow. If the potential is not high enough, the electrons just scatter off the neutral atoms never gaining enough energy to ionize them or excite them to emit light.

The glow does not come from the ions recombining with electrons, but a level-to-level transition in the neon atoms. The ions just serve to let the electrons accelerate to high enough energy to excite the atoms. So, when you shine the violet laser on or near the cathode when the potential across the tube is below the striking voltage, you're just initiating the formation of the ion cloud, which allows the electrons to attain enough energy in the cathode fall to excite the atoms. If a red laser is used instead, there is not enough photon energy to ionize the neon atoms and the tube remains dark. The tube can also be started by holding an electrically charged rod nearby

Location: Gc1, Ha5, Jc2

MODERN PHYSICS	7B35.75	ATOMIC PHYSICS
Electron Properties		
Plasma Globe		
	Commercial plasma tubes are discussed. Bring your hand near the globe.	

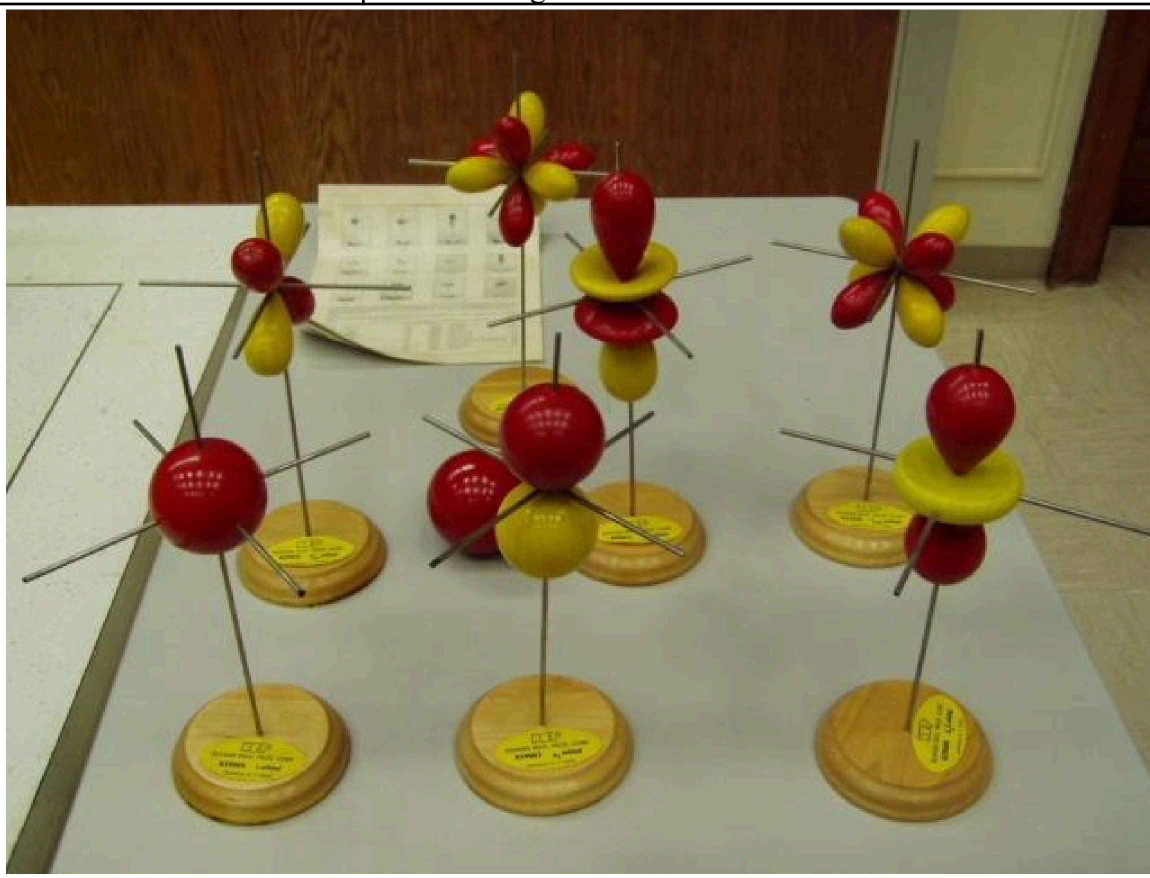


Location: Kb4

MODERN PHYSICS	7B50.10	ATOMIC PHYSICS
	Atomic Models	

Electron Orbital Models

	A set of Klinger electron orbital models.

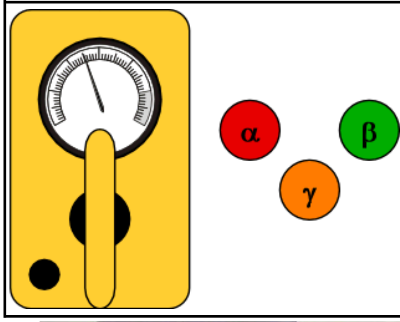


Location: Kb5

MODERN PHYSICS	7D10.10	**NUCLEAR PHYSICS**

Radioactivity

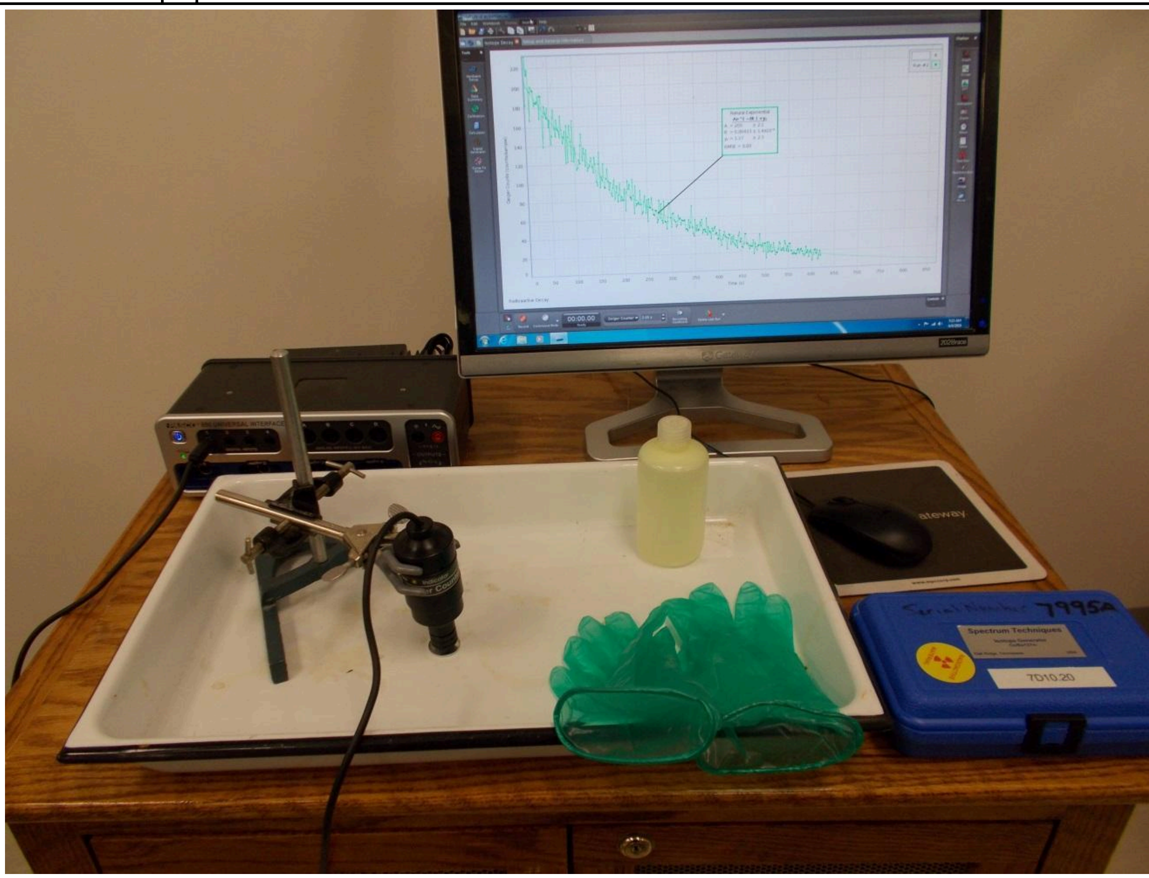
Geiger Counter and Samples



Turn on the counter and place sample under Geiger Tube. Test to see how distance from the sample affects the count. Place objects like: paper, wood, lead and other items between the source and the tube to check their shielding properties. The alpha paddle can be used to selectively detect alpha particles only.

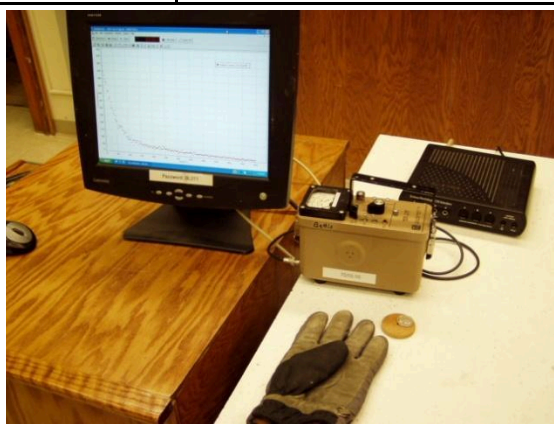
Location: Kb6

MODERN PHYSICS	7D10.20	NUCLEAR PHYSICS
Radioactivity		
Half Life with Isotope Generator		
	Follow the instructions on how to “milk” the generator. It is good practice to survey the work area before and after for contamination. The Geiger counter can be connected to the computer and using Capstone (Half Life of an Isotope.cap) one can plot the count rate as a function of time and fit an exponential curve to it..	



Location: Kb6

MODERN PHYSICS	7D10.33	NUCLEAR PHYSICS
Radioactivity		
Half Life of Silver		
	Measure the half life of silver activated by a neutron source. Use a glove to handle the “hot” silver as it is a beta emitter. Leave as the closest position to the neutron source for a few minutes to activate it.	



Location: Advanced Lab, Kb6

MODERN PHYSICS	7D10.80	NUCLEAR PHYSICS
Radioactivity		

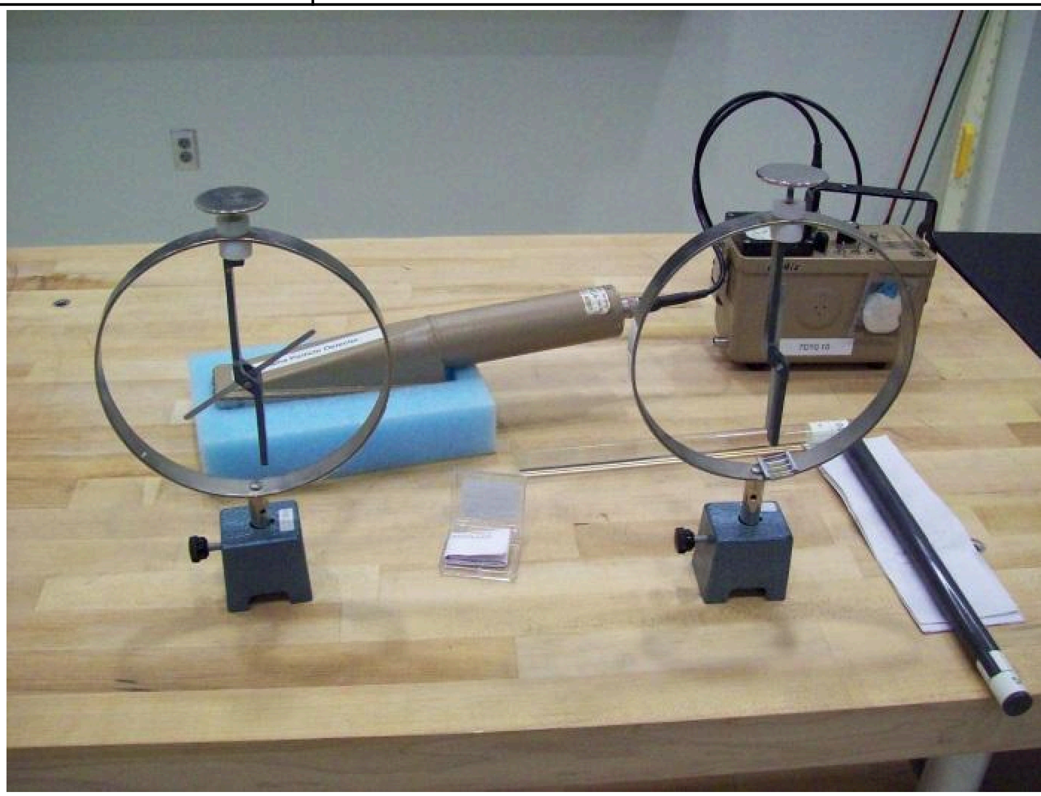
Cosmic Rays

	Scintillator detectors show the passage of a cosmic ray by coincidence counting.

Electricity and Magnetism	5D40.30	RESISTANCE
Conduction in Gases		

Discharge an Electroscope

	Charge the electroscope either positively or negatively by induction. Then place the Po-210 source (0.5 mCi when new) in the electroscope and watch the electroscope discharge in a couple of seconds. Use safety protocols when handling the source.



Location: Kb6, Gc2

MODERN PHYSICS	7D20.10	NUCLEAR PHYSICS

Nuclear Reactions

Mousetrap Chain Reaction

	A 72 mousetraps with corks set on them. Trigger with a single “neutron” (cork). This requires about 20 minutes and nerves of steel to set up. Each trap stores about a joule of energy when set.

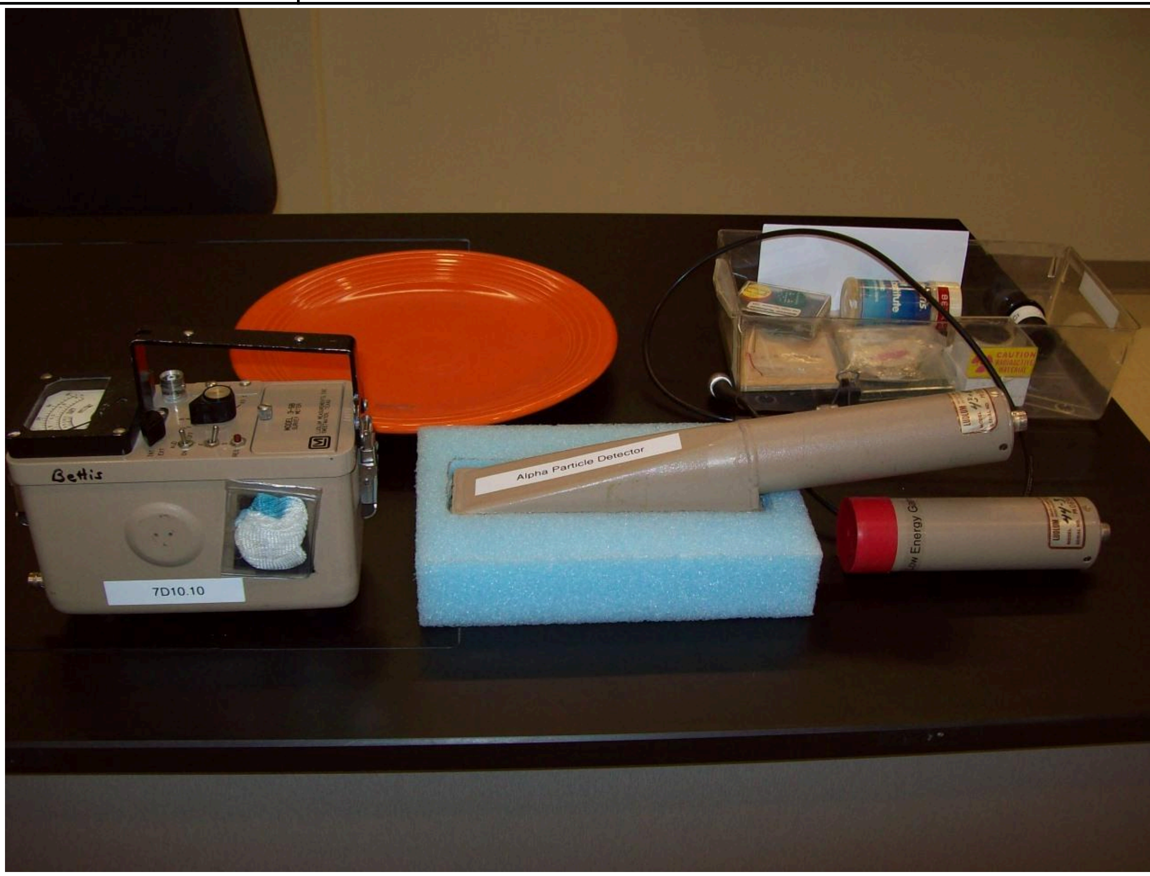
Location: KbT

MODERN PHYSICS	7D30.05	NUCLEAR PHYSICS

Particle Detectors

Ludlum Detectors

	Ludlum hand held alpha, beta and gamma detectors are used with a variety of sources.



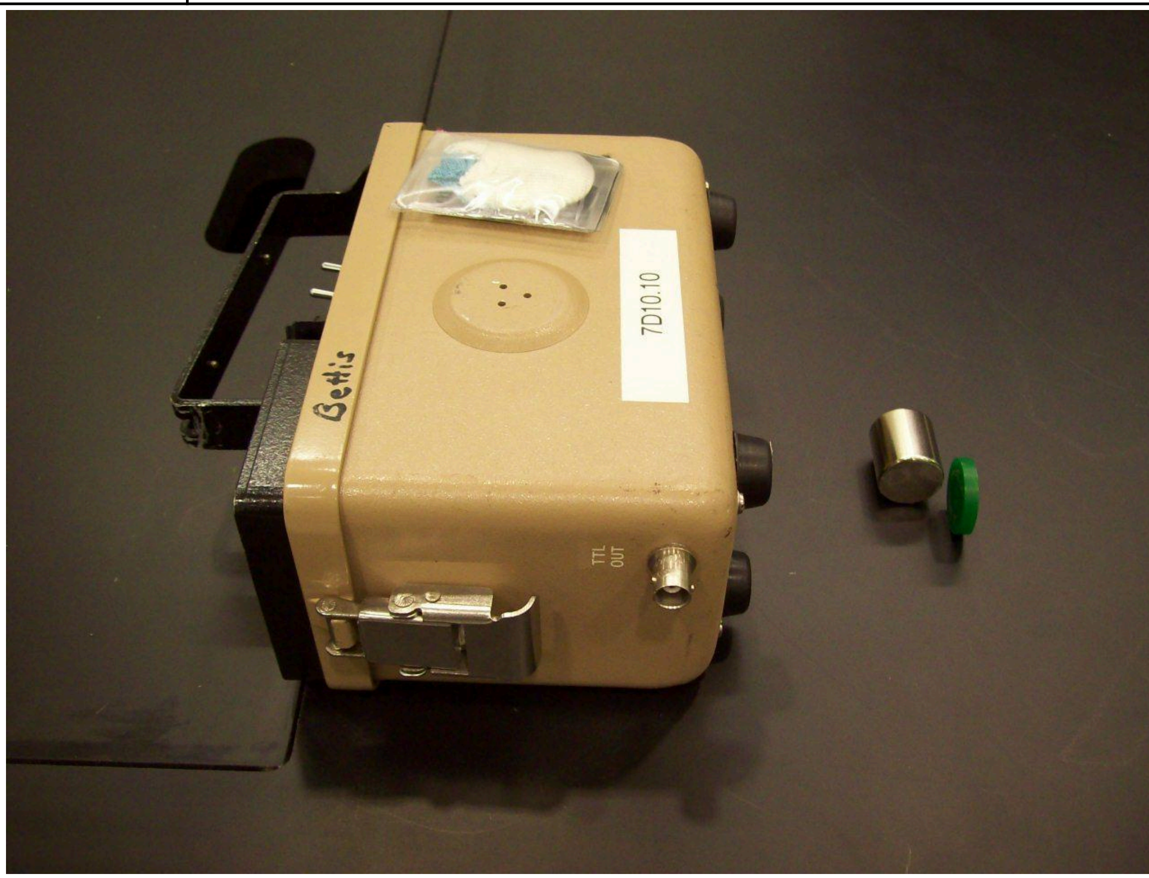
Location: Kb6

MODERN PHYSICS	7D30.30	NUCLEAR PHYSICS

Particle Detectors

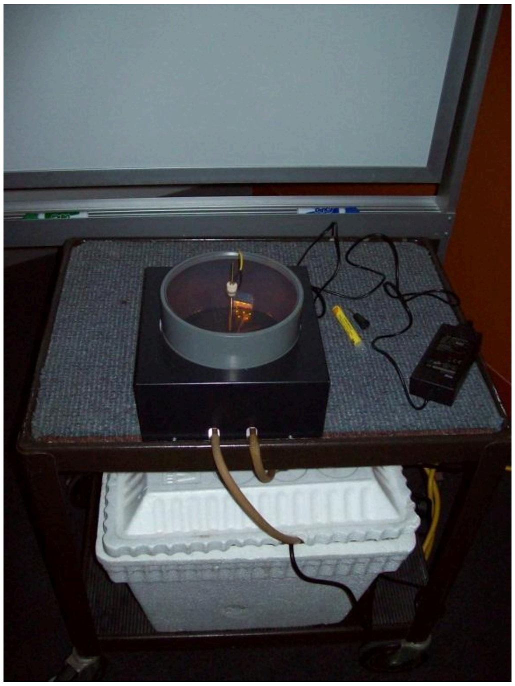
Deflection of Beta Rays

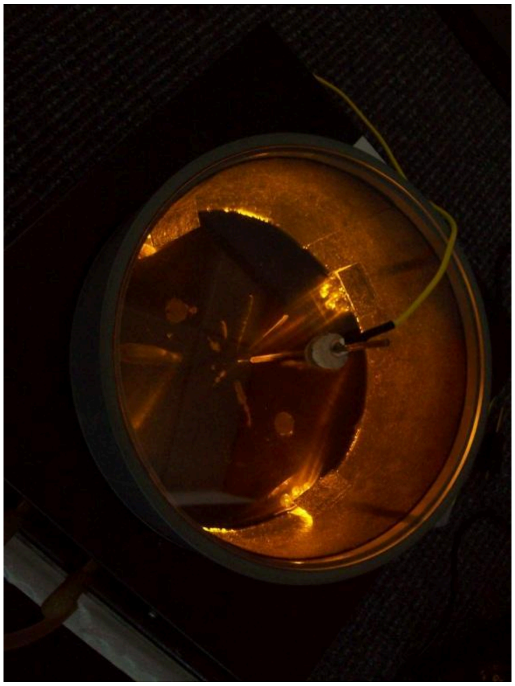
Turn on the counter and lay it on its side. Open the beta window. Place a beta source nearby, being sure the emitting side is toward the counter. Then bring a strong magnet near the source. The count rate will drop.



Location: Kb6, Hd5

MODERN PHYSICS	7D30.60	NUCLEAR PHYSICS
Particle Detectors		
Diffusion Cloud Chamber		
	This demo requires advance notice to obtain ice and let the chamber cool (about 40 minutes). Tracks are most impressive if the students are allowed to view individually. The TV works quite well too. Use either ambient cosmic rays or Pb 210 as a source.	





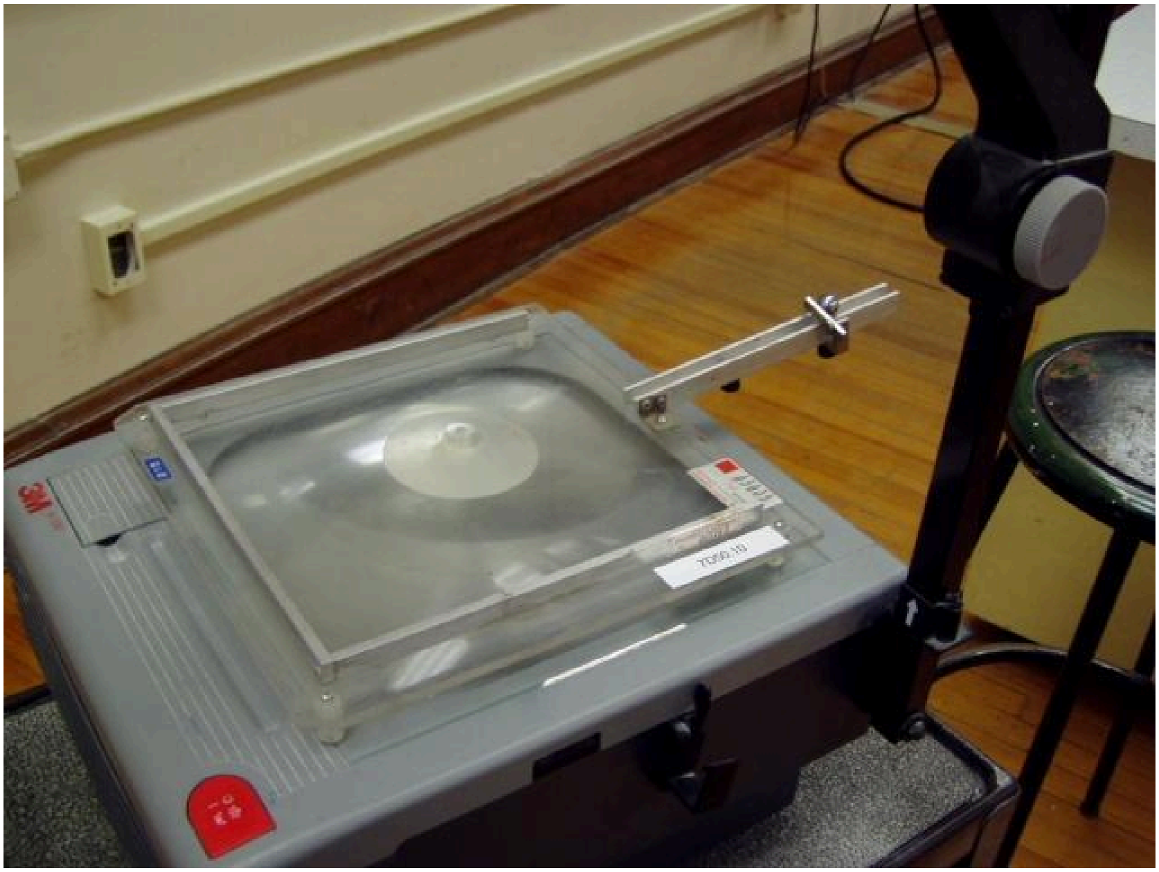
Location: Kc1

MODERN PHYSICS	7D50.10	NUCLEAR PHYSICS

Models of the Nucleus

Rutherford Scattering

	Balls roll down a ramp onto a potential surface to model Rutherford scattering.

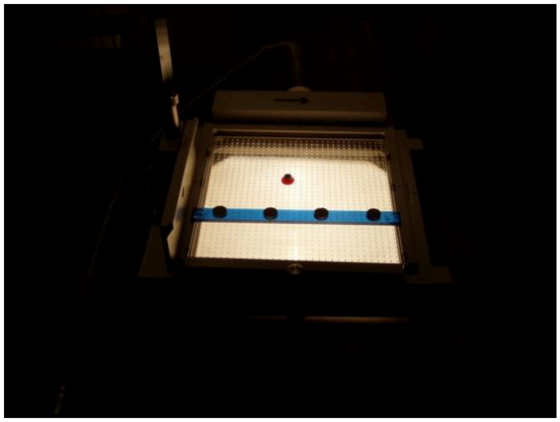


Location: Kc2

MODERN PHYSICS	7D50.14	NUCLEAR PHYSICS
Models of the Nucleus		

Rutherford Scattering on an Air Table

	The Air Cushion Table is set up with a plastic platform that holds a magnet which repels a magnetic puck that is set in motion beneath it (Air Cushion Manual, 2.5.1). One can also illustrate the scattering of alpha particles through a foil using a foil made of a 1D lattice four magnets that repel a magnetic puck that is set in motion toward it (Air Cushion Table Manual 2.5.2.



Location: Ga4

MODERN PHYSICS	7D50.25	NUCLEAR PHYSICS

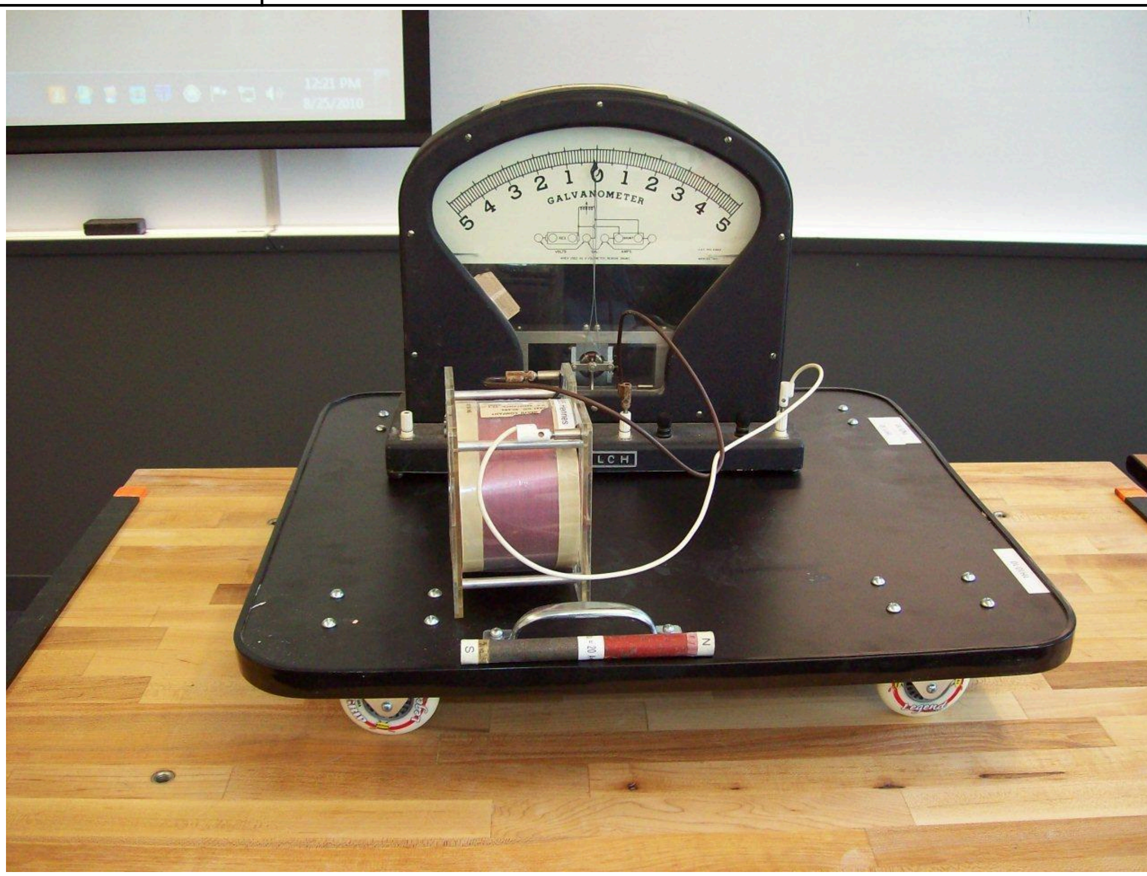
Models of the Nucleus

Rutherford Model

	The Air Cushion Table is set up with a plastic platform that holds a magnet which attracts a magnetic puck that is set in motion beneath it (Air Cushion Manual, 2.5.3). The moving puck goes into orbit beneath the attracting magnet.

Location: Ga4

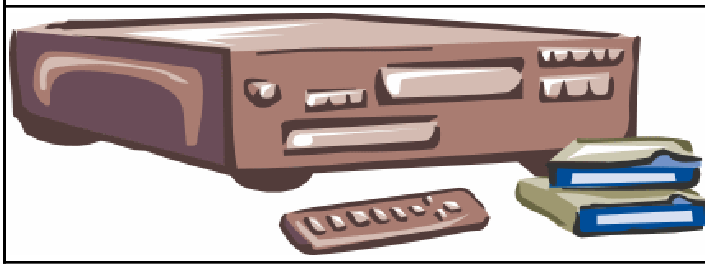
MODERN PHYSICS	7F10.35	RELATIVITY
	Special Relativity	
	Induction Coil Relativity	
	On using the simple induction coil and galvanometer as a special relativity demonstration: AJP 48(9), 780.	



Location: BdT, Hc2, Ib3

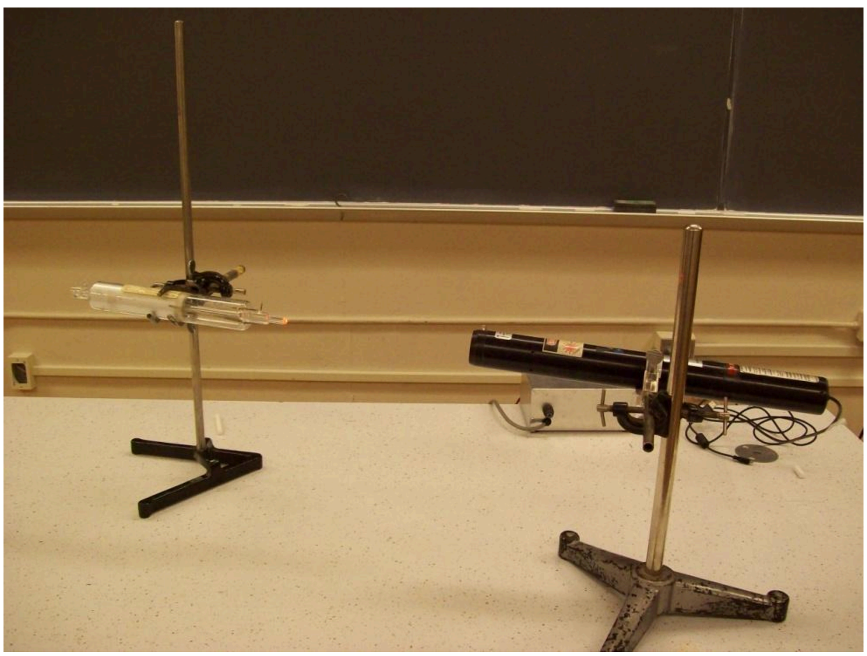
MODERN PHYSICS	7F10.60	RELATIVITY
Special Relativity		

Lorentz Transformation / Time Dilation

	The Mechanical Universe, chapter 42, and the Hewitt film "Relativistic Time Dilation"

Location: Ad5

MODERN PHYSICS	7G20.20	**Lasers**
Laser Polarization and Intensity - Modes		
Optical Resonator		
	Light from a laser is directed down the optical cavity of an old laser tube. The cavity acts as an optical resonator and as the exciting laser warms up, its frequency slews through a spectrum of frequencies. As the frequencies match resonate frequencies in the old tube (it can be thought of as a Fabry Perot interferometer), light is transmitted through it and shows up as a spot on a screen placed down beam from the exit side. Various modes can be observed as the exciting lasers frequency changes.	



Location: Ia1, Ja6