Optics

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.

5/16/2023

Optics

OPTICS	6A01.10	GEOMETRIC OPTICS

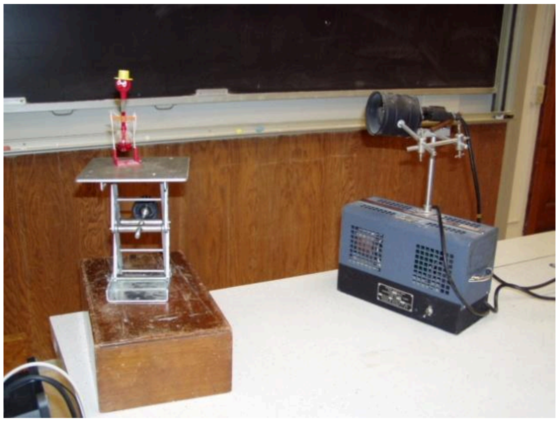
Speed of Light

Speed of Light

A pulsed IR laser, a couple of photodiodes and a retro-reflector are used with a fast scope to measure the speed of light. The scope settings are stores in a file on the scope. An IR sensitive card can be used to show the beam.

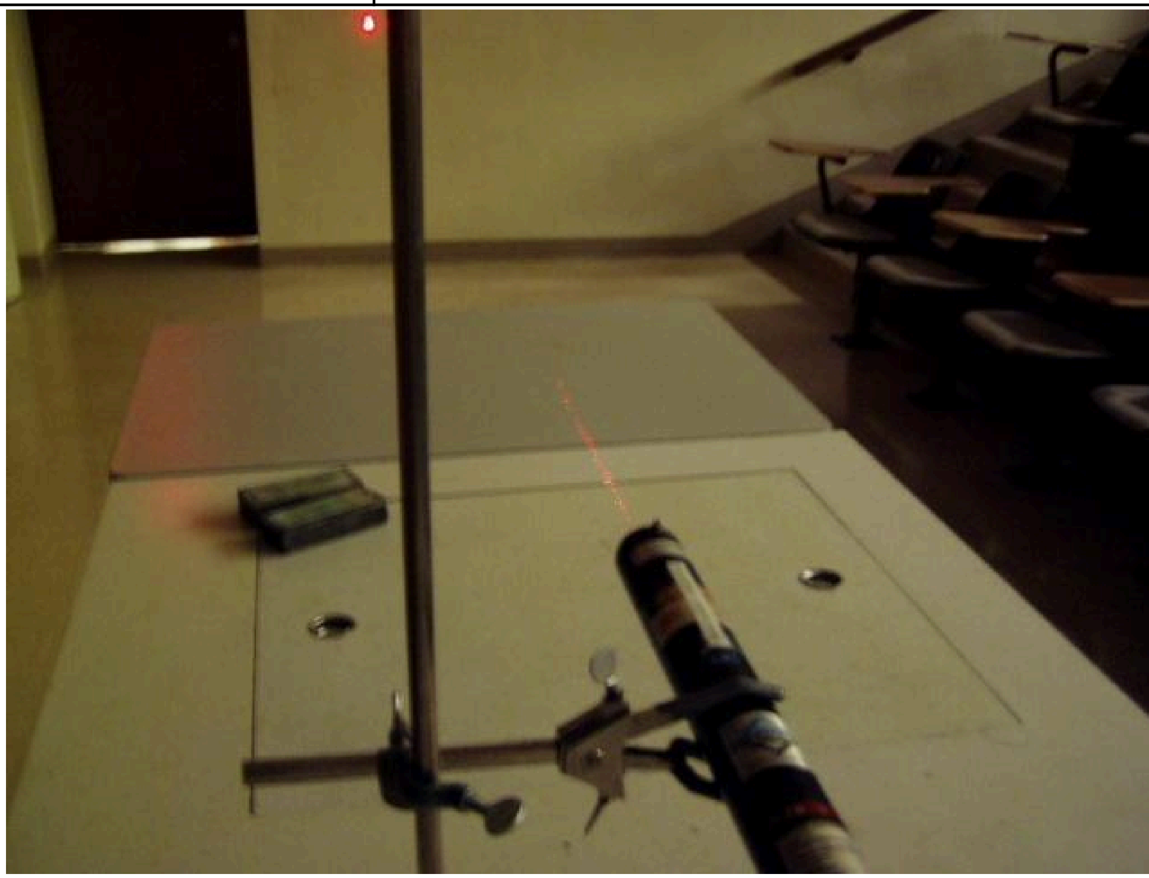
Location: Id2, Fb5

OPTICS	6A02.15	GEOMETRIC OPTICS
	Straight Line Propagation	
	# Shadows	
	Use a point source to cast sharp shadows.	



Location: Id2

OPTICS	6A02.35	GEOMETRIC OPTICS
Straight Line Propagation		
Chalk Dust		
	Use chalk dust to make a laser beam visible.	



Location: Ja6

OPTICS	6A10.18	GEOMETRIC OPTICS

Reflection from Flat Surfaces

Microwave Reflection

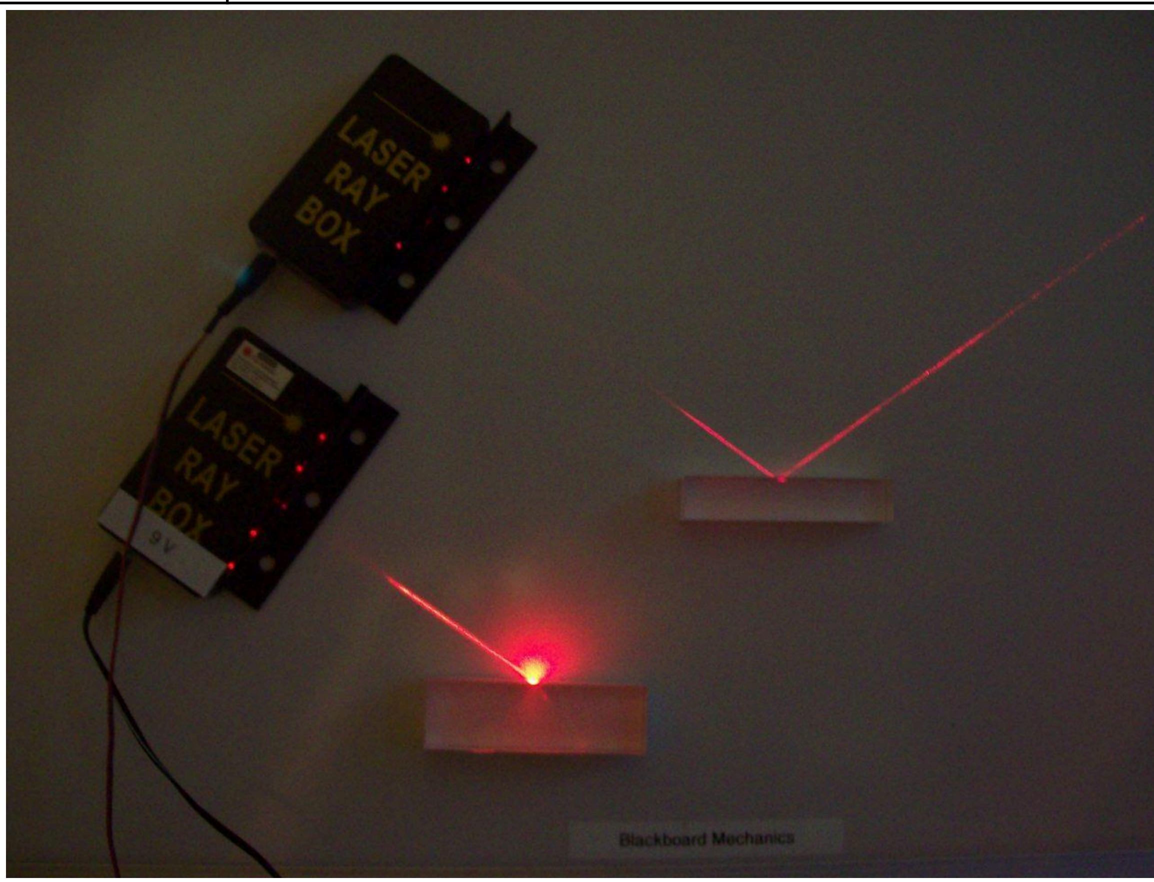
	Reflect a microwave beam off of a metal plate into receiver.

Location: Ia7

OPTICS	6A10.20	GEOMETRIC OPTICS
Reflection from Flat Surfaces		

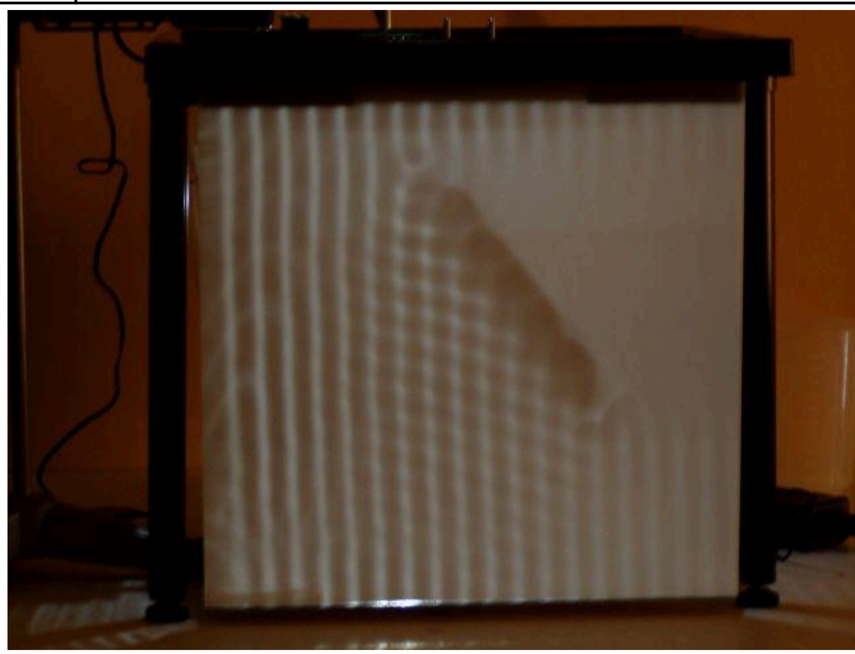
Diffuse and Specular Reflection

	Use the blackboard optics equipment to show specular reflection off of a mirror then replace the mirror with a sheet of paper.



Location: Blackboard Optics Cart

OPTICS	6A10.25	GEOMETRIC OPTICS
Reflection from Flat Surfaces		
Ripple Tank Reflection		
	A barrier in a ripple tank reflects plain waves. This can also be done with a point source to illustrate image formation in a plain mirror.	

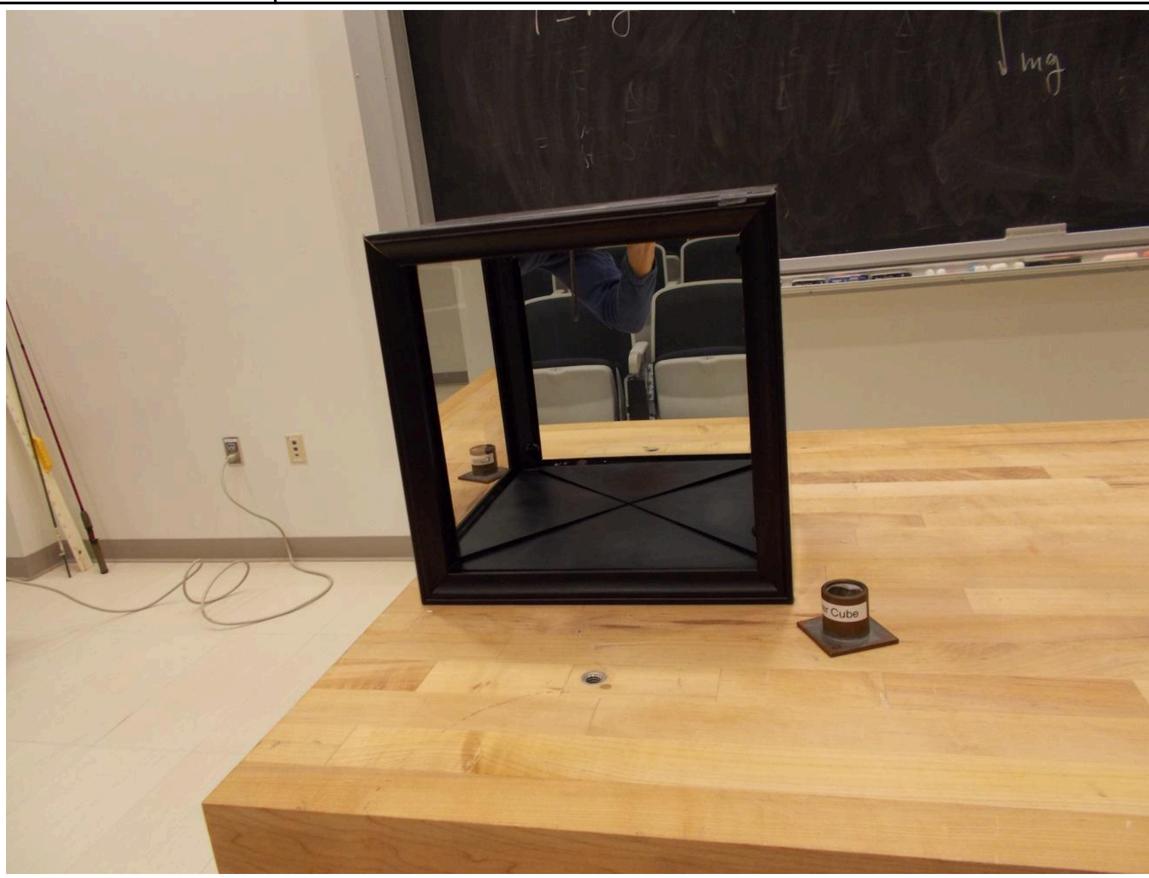


Location: Fb4

OPTICS	6A10.30	GEOMETRIC OPTICS
Reflection from Flat Surfaces		

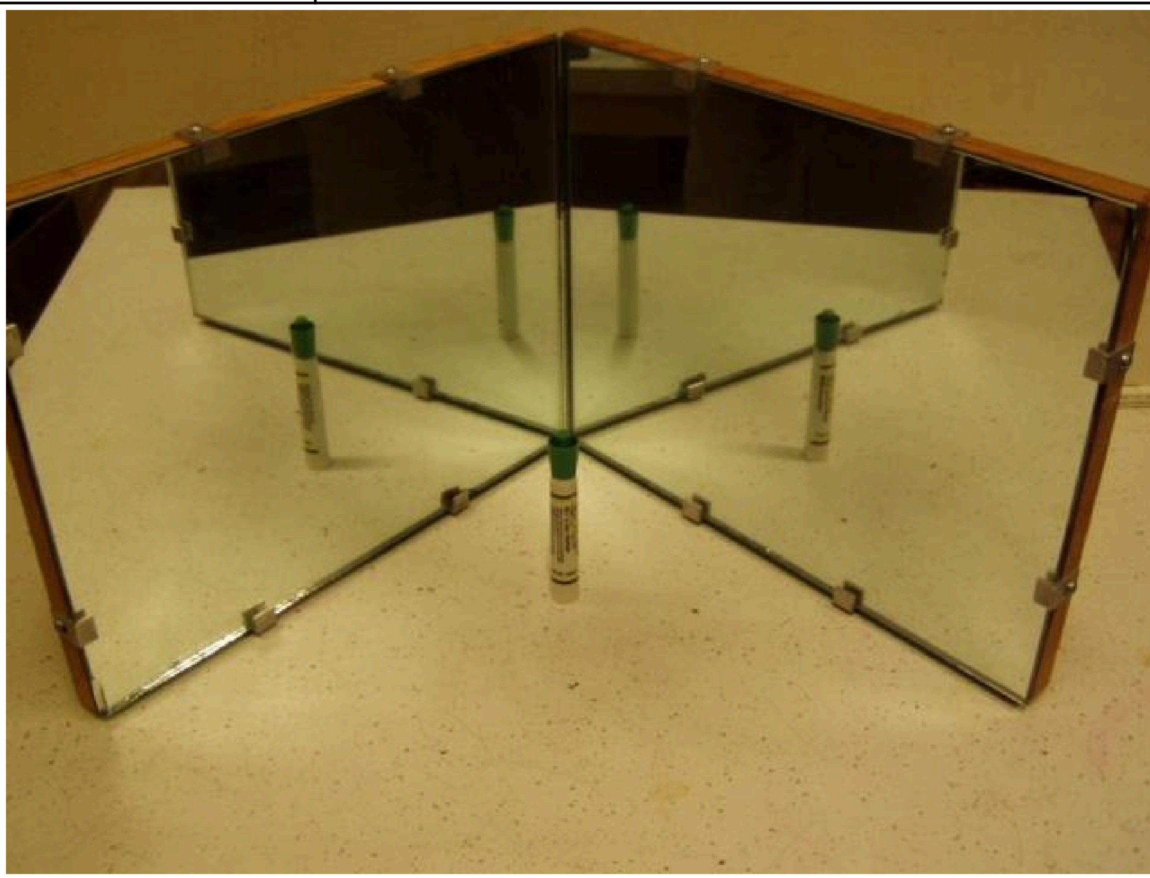
Corner Reflection

	Look at your image in a corner mirror. Also use the TV camera to look into a corner reflector.



Location: Id3, Optics Table Cabinet

OPTICS	6A10.40	GEOMETRIC OPTICS
Reflection from Flat Surfaces		
# Angled Mirrors		
	Two hinged mirrors show multiple images of an object placed between them.	



Location: Id4

OPTICS	6A10.45	GEOMETRIC OPTICS
Reflection from Flat Surfaces		
Parallel Mirrors		
	An infinite number of images are formed with a light bulb between parallel mirrors.	

Location: Id4

OPTICS	6A10.50	GEOMETRIC OPTICS
Reflection from Flat Surfaces		

Full View Mirror

	A mirror is covered with paper so that a person can just see their entire height.

Location: IdT

OPTICS	6A10.65	GEOMETRIC OPTICS
Reflection from Flat Surfaces		

Mirror Box

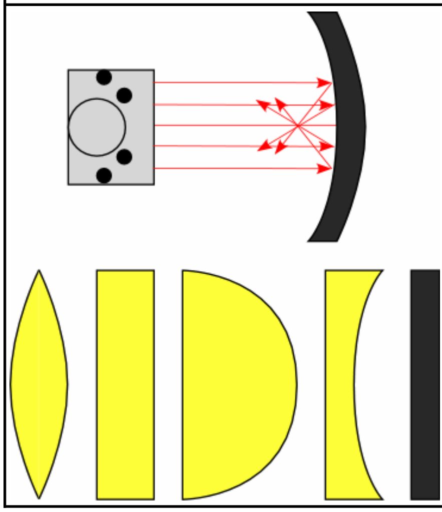
	"Pepper's Ghost", an old stage illusion. As the light on the subjects face is dimmed another light on a plastic skull brightens causing an apparent metamorphosis.

Location: Ja1

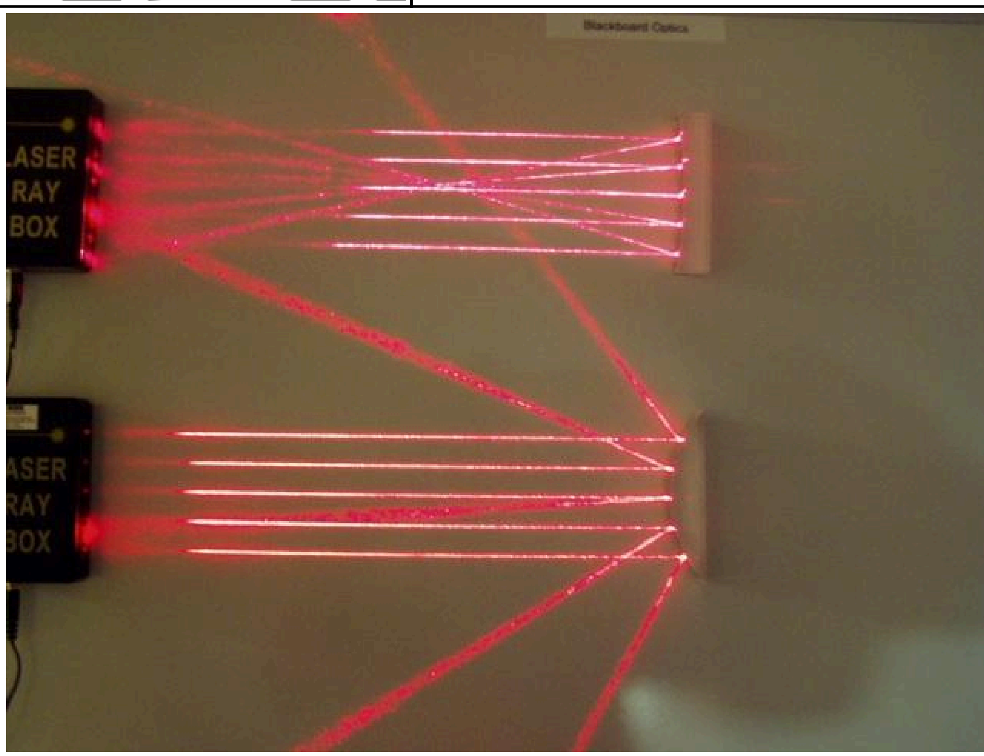
OPTICS	6A20.10	GEOMETRIC OPTICS

Reflection from Curved Surfaces

Blackboard Optics - Curved Mirrors



Shine parallel beams at convex and concave mirrors. Use the Blackboard optics for two dimensional representations.



Location: Blackboard Optics Cart

OPTICS	6A20.15	GEOMETRIC OPTICS
Reflection from Curved Surfaces		

Parallel Lasers and Curved Mirrors

	Shine parallel beams at convex and concave mirrors.

Location: Ja4, Blackboard Optics Cart

OPTICS	6A20.30	GEOMETRIC OPTICS
Reflection from Curved Surfaces		

Lamp in the Socket

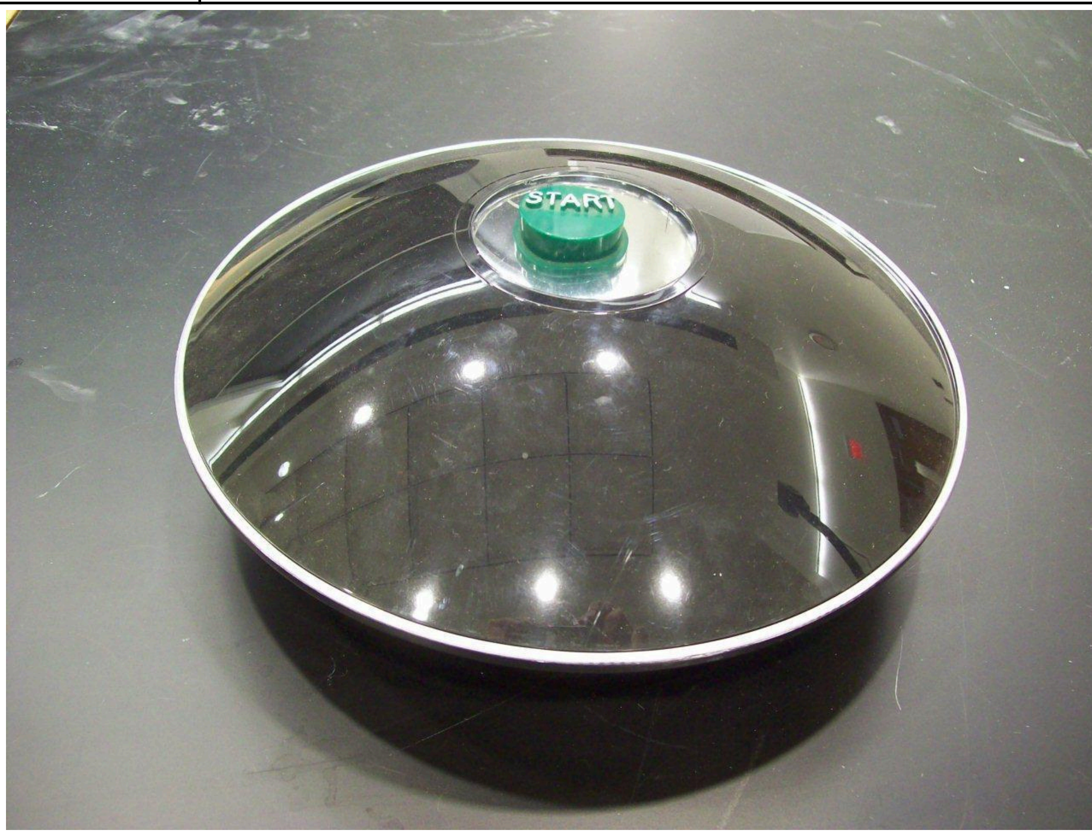
	The image of a hidden light bulb is projected at the location of an empty socket.

Location: IdT

OPTICS	6A20.35	GEOMETRIC OPTICS
Reflection from Curved Surfaces		

Optic Mirage

	Two concave mirrors face each other. Images of objects resting on the bottom mirror appear at the center hole of the top mirror.

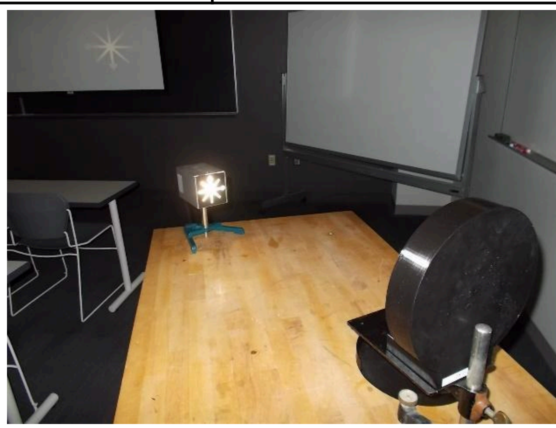


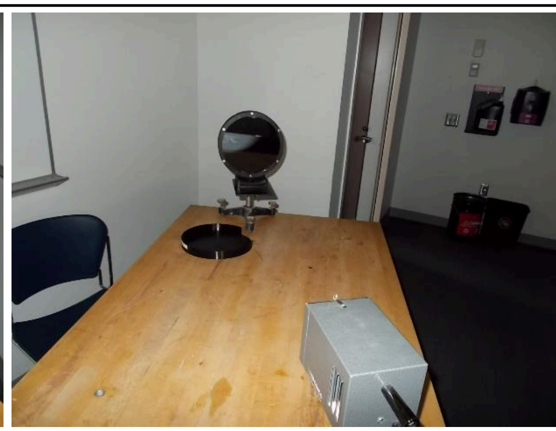
Location: Ja2

OPTICS	6A20.40	GEOMETRIC OPTICS
Reflection from Curved Surfaces		

Projected Arrow with Mirror

	A converging mirror is used to project the image of an illuminated arrow on a screen. Focal Length 0.75 m, diameter 0,203 m.





Location: Ja2

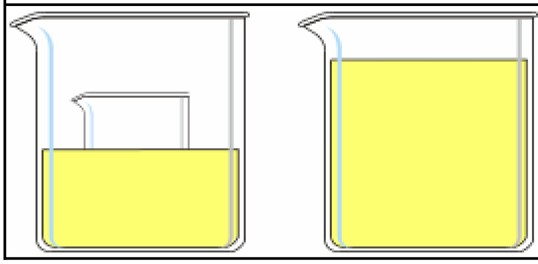
<table>
<tr><td>OPTICS</td><td>6A20.45</td><td>GEOMETRIC OPTICS</td></tr>
<tr><td colspan="3">Reflection from Curved Surfaces</td></tr>
<tr><td colspan="3"><h1>Concave and Convex Mirrors</h1></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td></td><td colspan="2">Large convex and concave mirrors are shown.</td></tr>
</table>

Location: Id5

OPTICS	6A40.30	GEOMETRIC OPTICS

Refractive Index

Disappearing Beaker



Use Johnson's baby oil or Wesson oil to make a small beaker disappear when immersed. If the beaker has graduations or words they will appear to be floating in the liquid.

Location: Ja3

OPTICS	6A40.47	GEOMETRIC OPTICS
Refractive Index		

Mirage with Laser

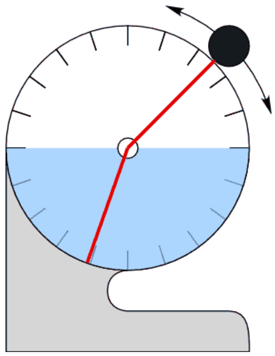
A laser beam almost grazing a hot plate will show a deflection when the plate is turned on. Level the laser and aim the beam so that it just goes over the hot plate and hits the scale at “0”, In the arrangement shown the laser spot on the scale moves up about 2 cm as the plate heats up. It takes a few minutes.

Location: Ja6, Gb2

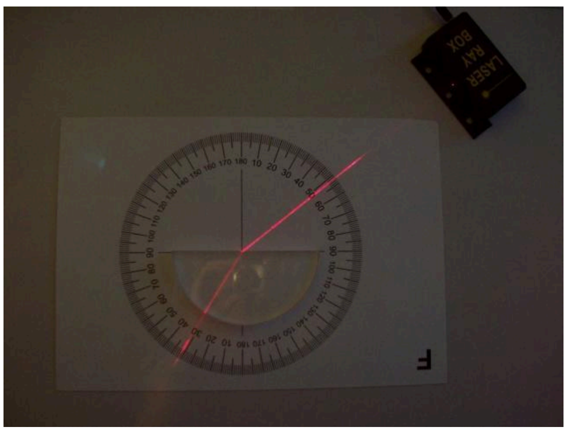
OPTICS	6A42.10	GEOMETRIC OPTICS

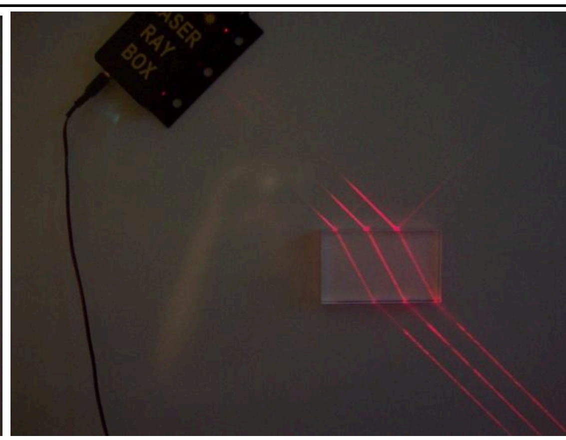
Refraction at Flat Surfaces

Blackboard Optics - Refraction



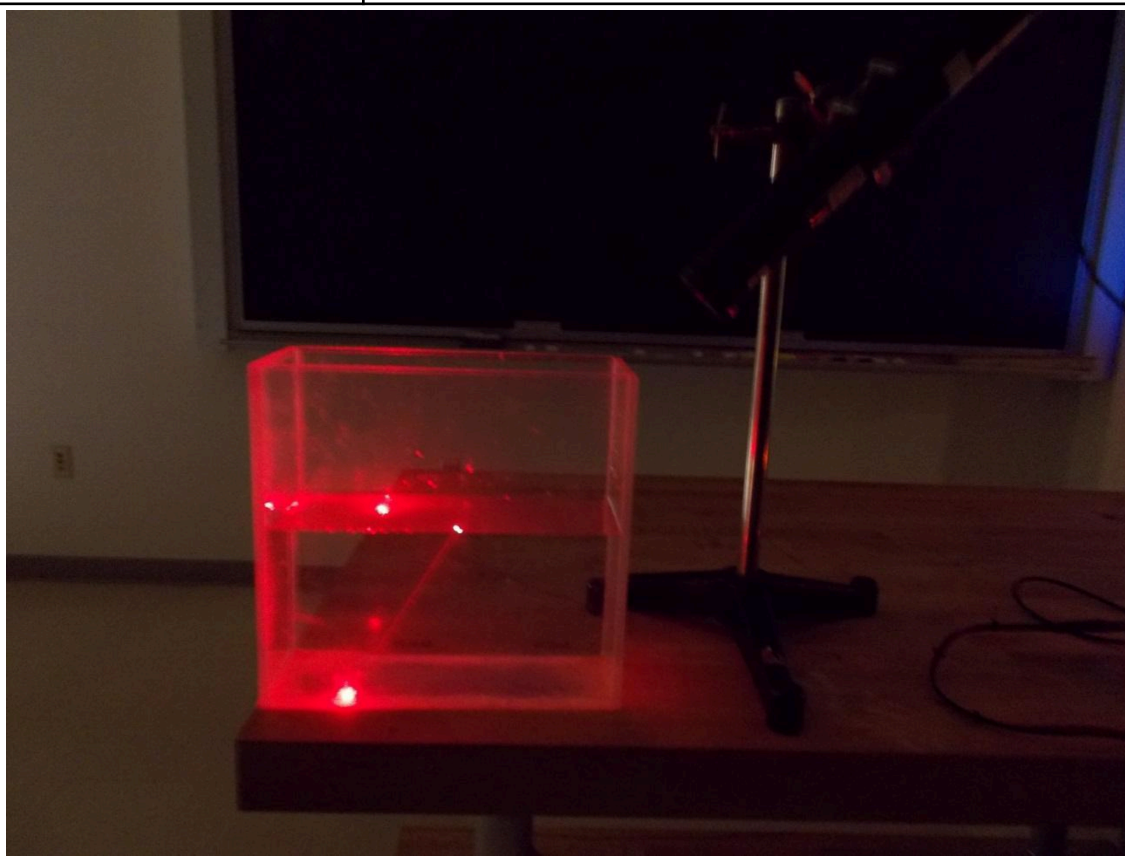
The light source can be rotated through 270 degrees to show refraction and total internal reflection for both air/plastic and plastic/air interfaces. One can also use a rectangular prism (not shown but in the supplied BBO equipment) to show refraction and internal reflection.





Location: Blackboard Optics Cart

OPTICS	6A42.20	GEOMETRIC OPTICS
Refraction at Flat Surfaces		
Refraction Tank		
	The light source can be rotated through 270 degrees to show refraction and total internal reflection for both air/plastic and plastic/air interfaces. Also can be done with an aquarium tank, water and a laser.	

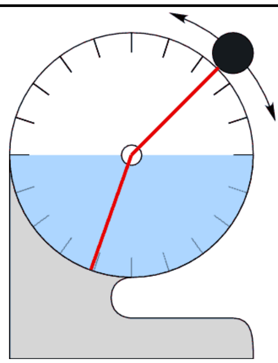


Location: Ja3, Ja6

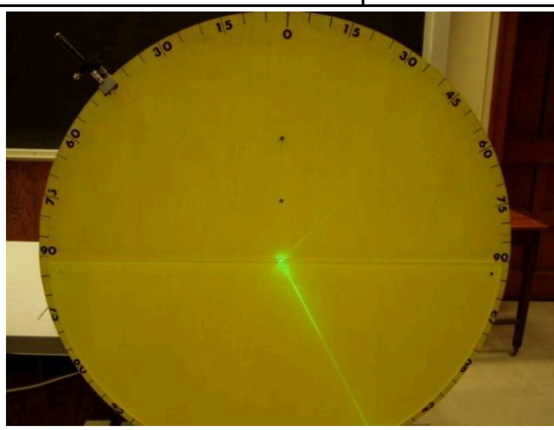
OPTICS	6A42.22	GEOMETRIC OPTICS

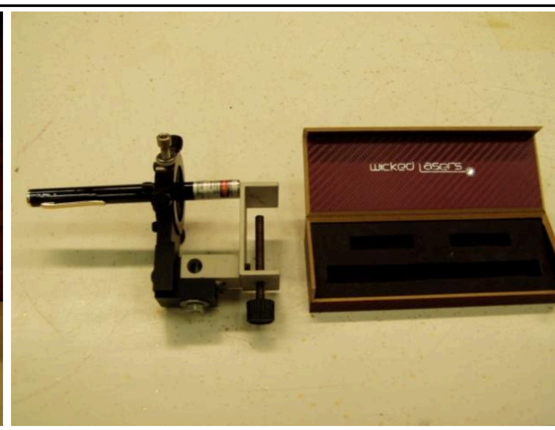
Refraction at Flat Surfaces

Big Plastic Refraction Tank



The light source can be rotated through 270 degrees to show refraction and total internal reflection for both air/plastic and plastic/air interfaces. Be careful using the bright (20 mw) green laser.



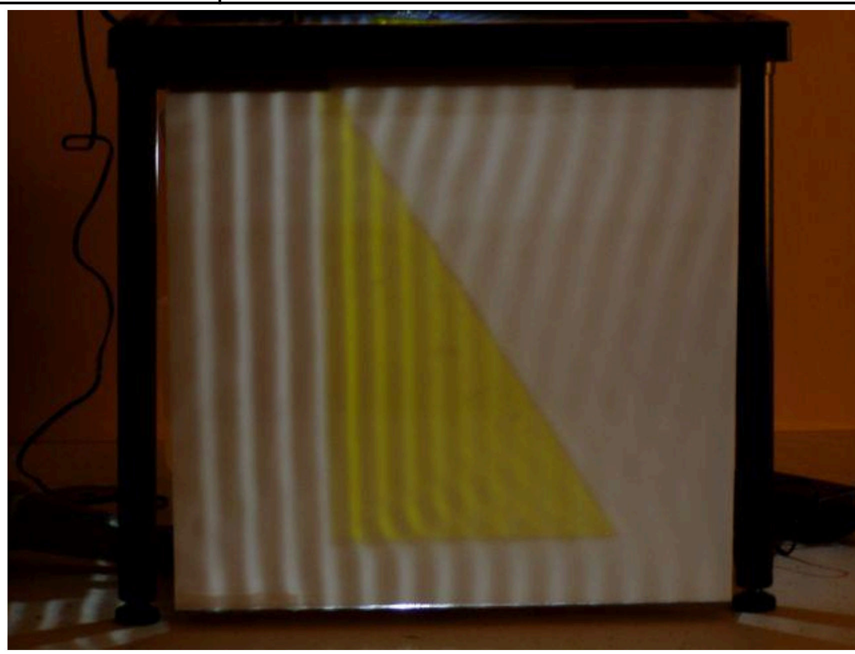


Location: PbT, Jd1

OPTICS	6A42.35	GEOMETRIC OPTICS
Refraction at Flat Surfaces		

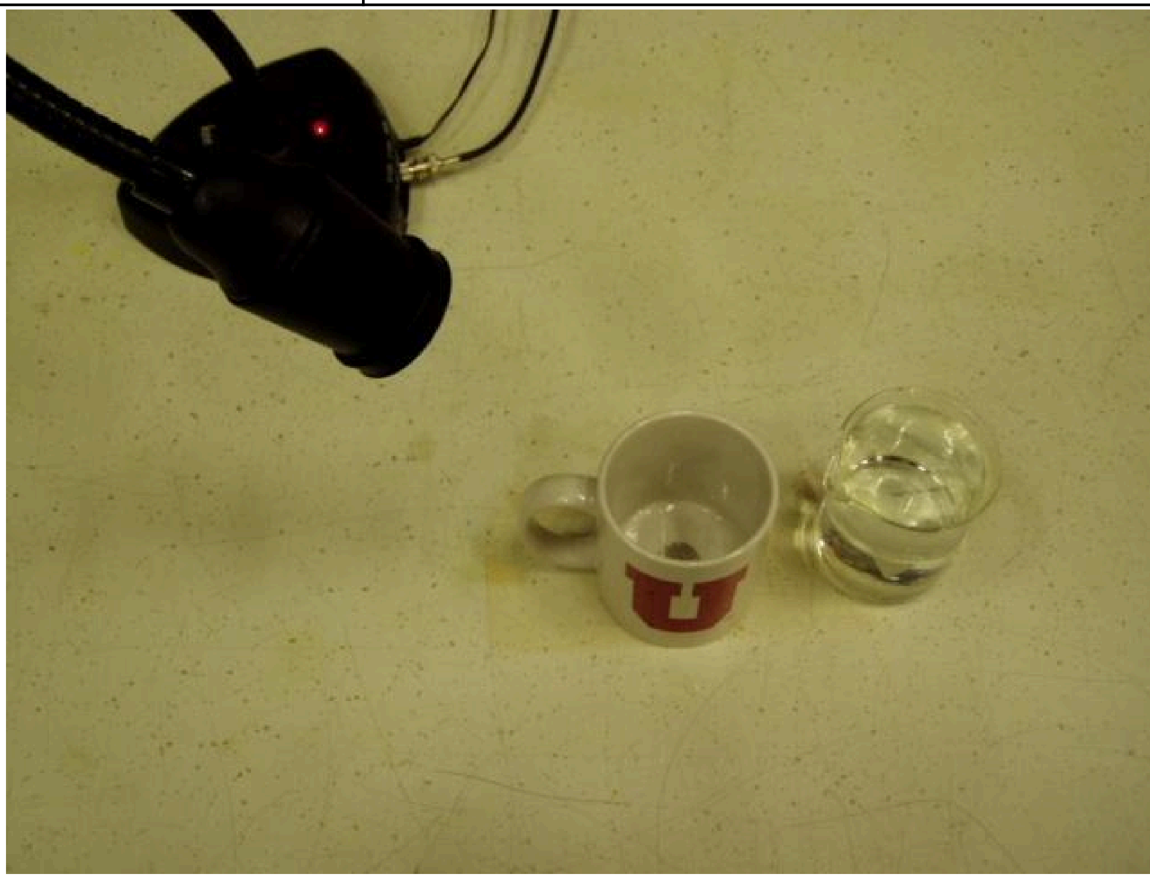
Ripple Tank Refraction

	The wave velocity over a shoal is smaller than that over deeper water and thus refraction of the ripples occurs over the plastic shoal.



Location: Fb4

OPTICS	6A42.40	GEOMETRIC OPTICS
Refraction at Flat Surfaces		
Seeing a Coin		
	Pour water in a cup until a coin at the bottom (use double stick tape to hold it in place) previously hidden by the side is visible.	



Location: Ja3

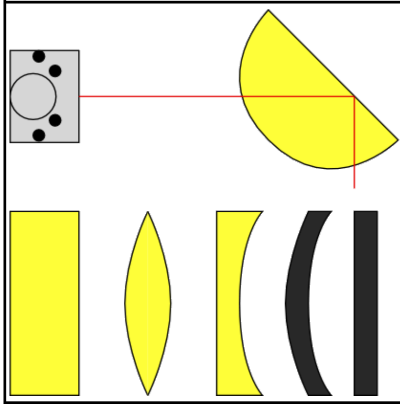
OPTICS	6A42.45	GEOMETRIC OPTICS
Refraction at Flat Surfaces		
Stick in Water		
	A stick appears bent when inserted into water.	

Location: Ja4

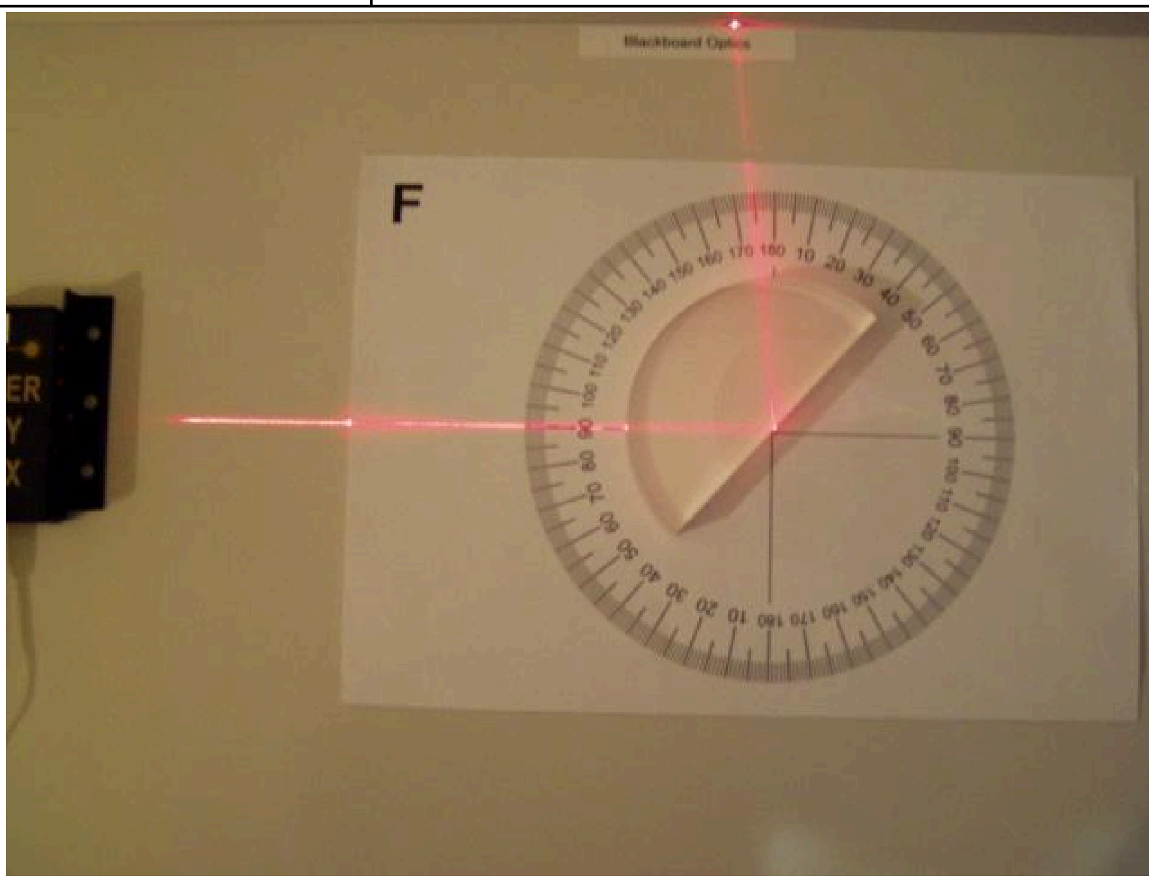
OPTICS	6A44.10	GEOMETRIC OPTICS

Total Internal Reflection

Blackboard Optics – Prism, Semicircle



Rotate the semicircular slab of Plexiglas with the light ray entering the exiting through the curved surface. Rotate the semicircular slab until the critical angle is reached and total internal reflection is obtained.

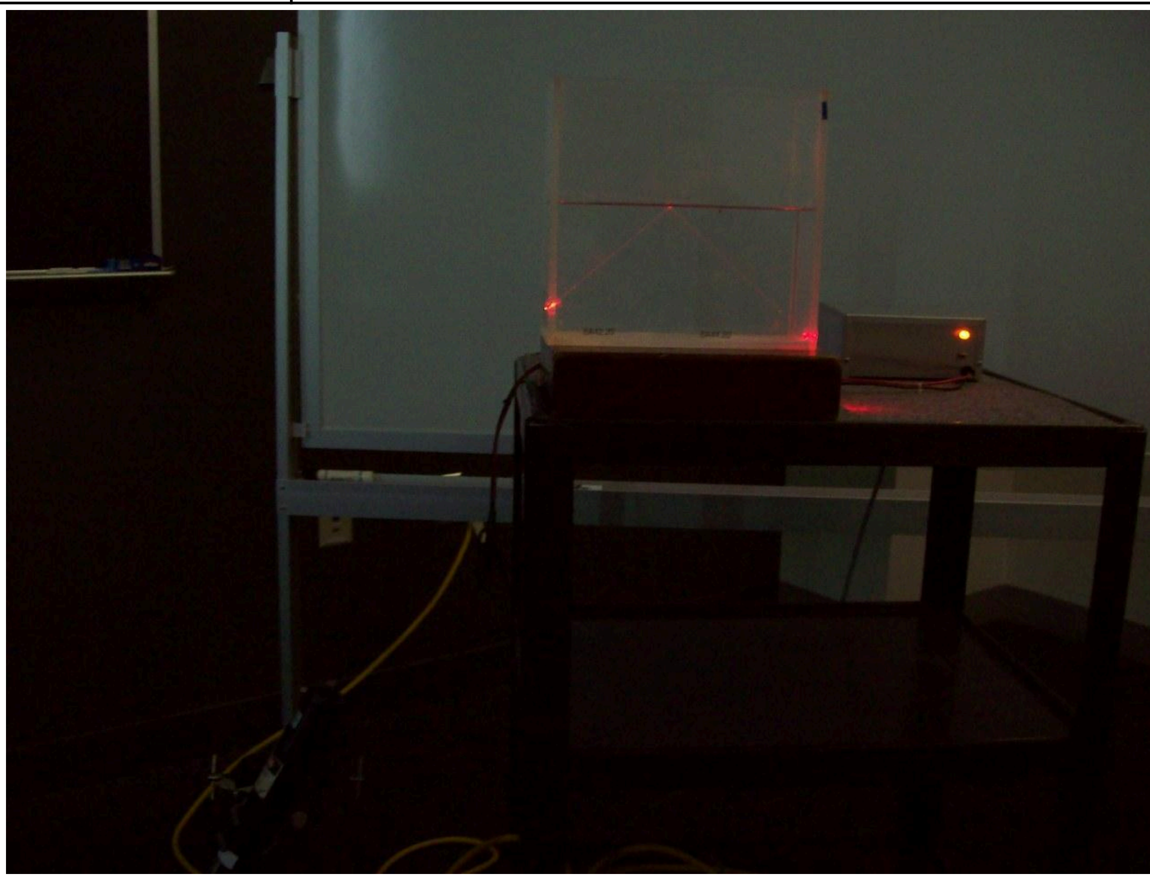


Location: Blackboard Optics Cart

OPTICS	6A44.20	GEOMETRIC OPTICS
Total Internal Reflection		

Critical Angle in a Refraction Tank

	A beam in a tank of water is rotated until there is total internal reflection at the surface.

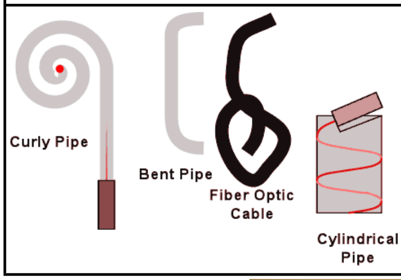


Location: Ja3, Ja6

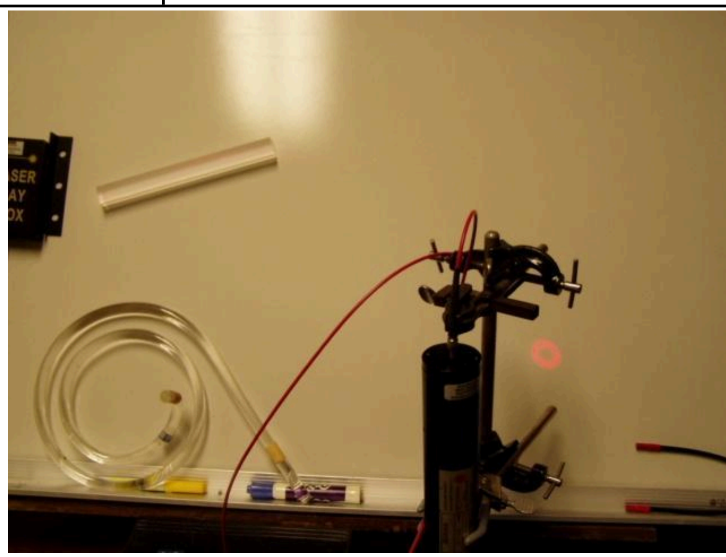
OPTICS	6A44.40	GEOMETRIC OPTICS

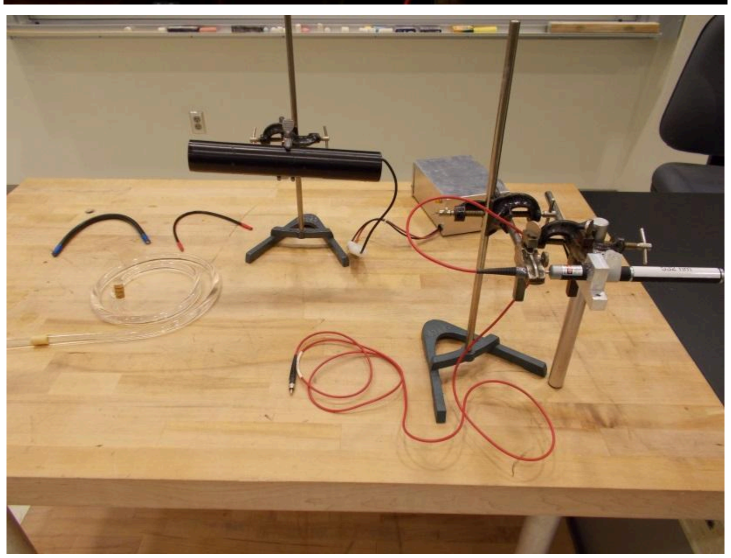
Total Internal Reflection

Laser and Fiber Optics



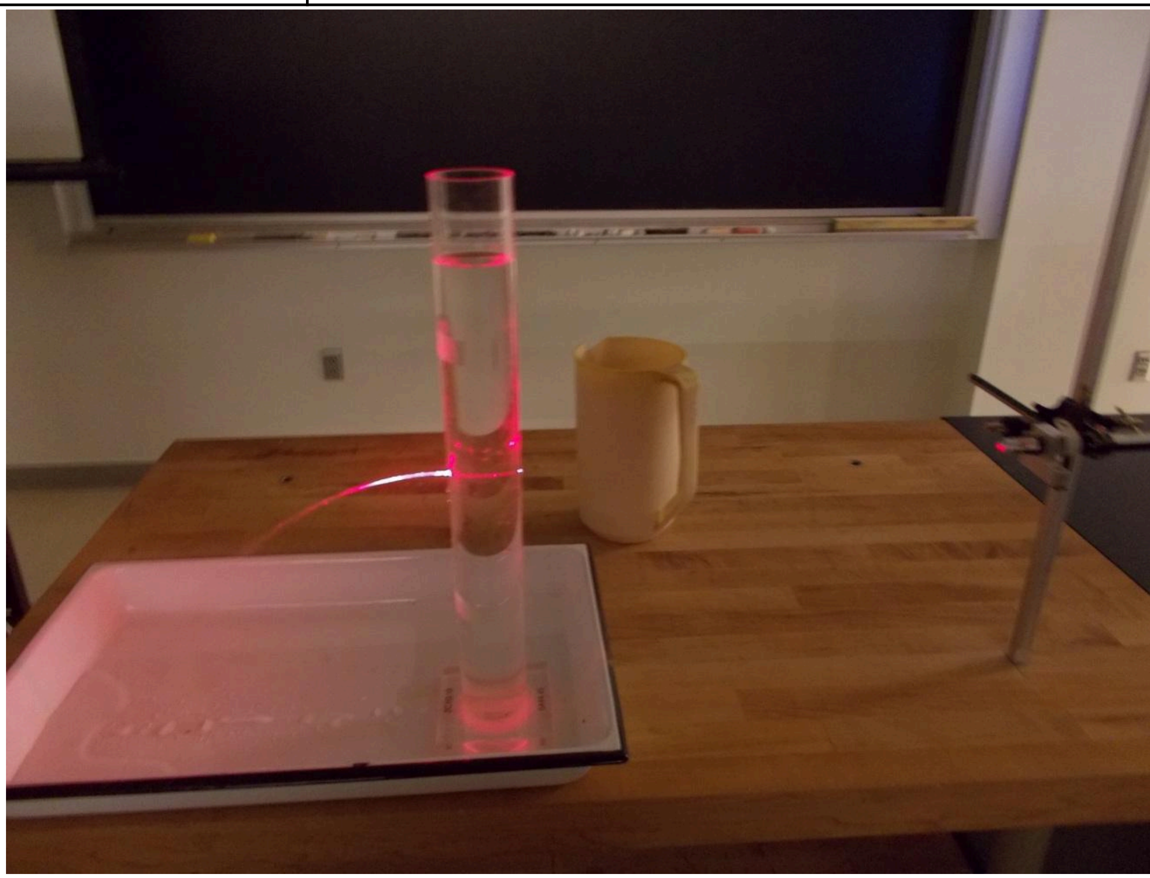
You are provided with a Plexiglas rod, Plexiglas curly Q and a section of fiber optic cable. Hold their ends in the beam near the laser. Vary the number of reflections in the rod by changing the angle.





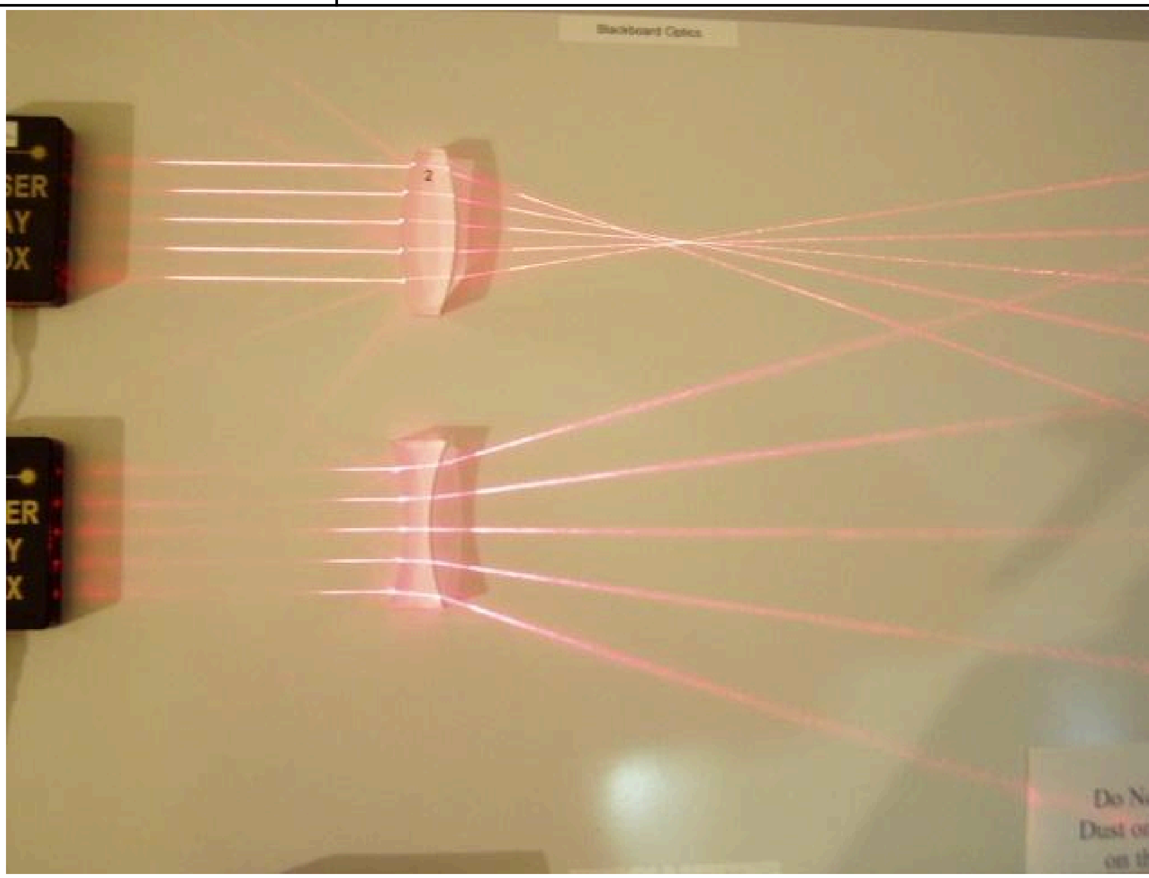
Location: Blackboard Optics Cart, Ja4, Ja6

OPTICS	6A44.45	GEOMETRIC OPTICS
Total Internal Reflection		
Laser Waterfall		
	Shine a laser down the center of a nozzle and it follows the water stream.	



Location: Dd6, Ja6

OPTICS	6A60.10	GEOMETRIC OPTICS
	Thin Lenses	
	Blackboard Optics – Thin Lenses	
	Blackboard optics are used with convex and concave thin lens elements	

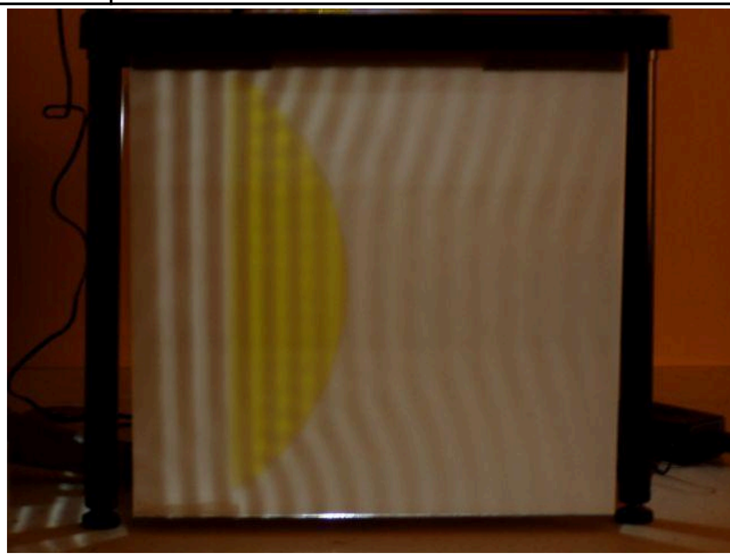


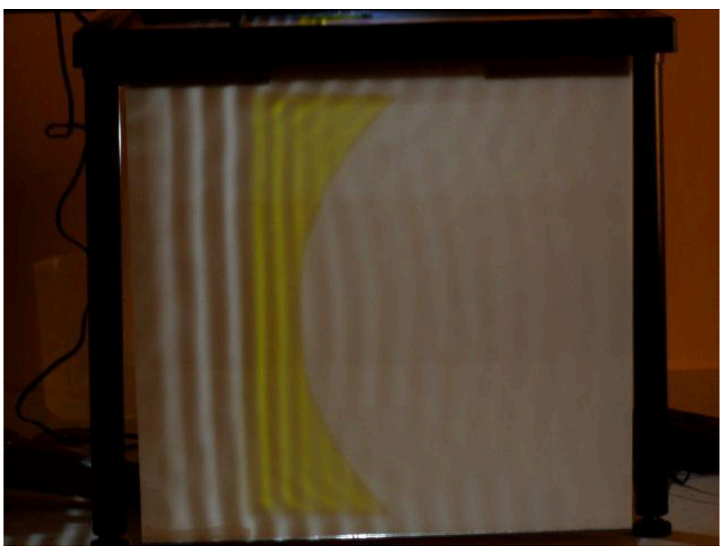
Location: Blackboard Optics Cart

OPTICS	6A60.15	GEOMETRIC OPTICS
	Thin Lenses	

Ripple Tank – Lens Model

	Refraction due to depth differences over a lens shaped area in the ripple tank.





Location: Fb4

OPTICS	6A60.20	GEOMETRIC OPTICS
Thin Lenses		

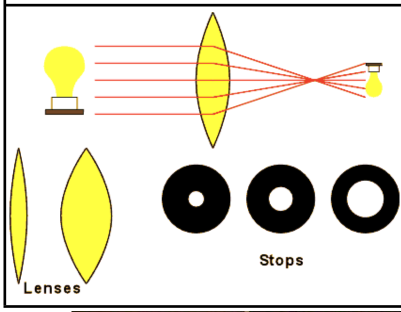
Parallel Lasers and Lenses

	Parallel lasers are passed through converging and diverging lenses. Chalk dust illuminates the beams.

Location: Id1, Blackboard Optics Cart

Thin Lenses

Projected Arrow w/Lens



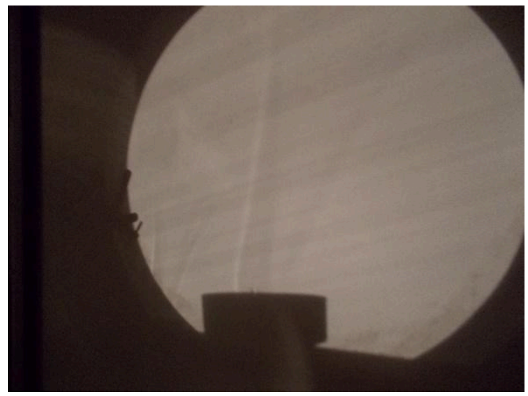
Turn on the light bulb. Move the light bulb to focus the image on the side wall. The focal lengths are marked on the lenses. Show the effect of aperture size on the sharpness on the focus by placing different sized stops in front of the lens.

Location: Id1, Jd3

OPTICS	6A60.41	GEOMETRIC OPTICS
	Thin Lenses	

Schlieren Image of a candle

	A point source, a mirror and a candle.

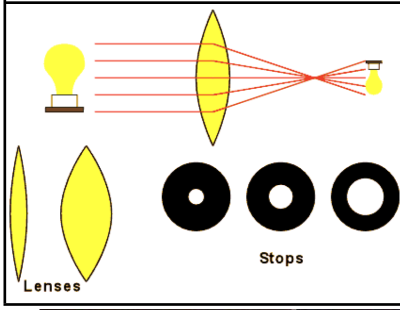


Location: Id1, Jd3

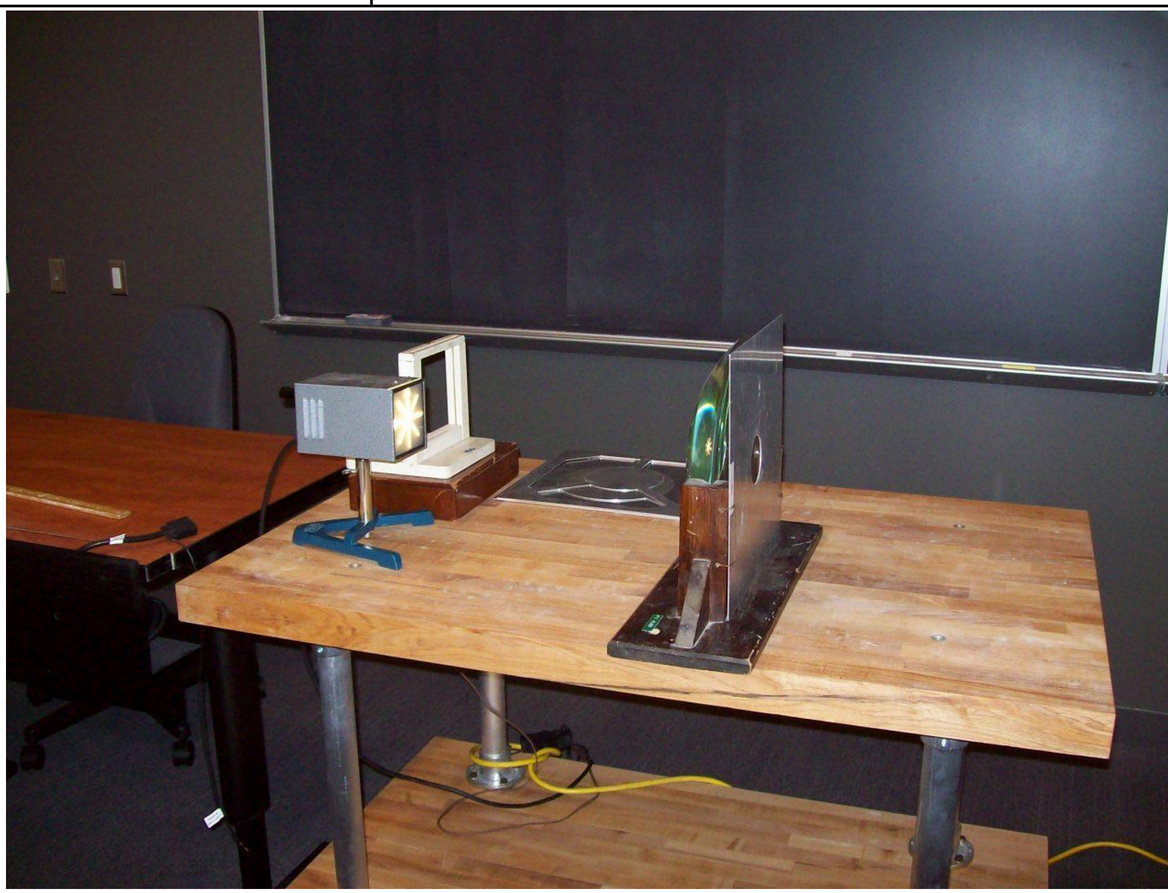
OPTICS	6A65.10	GEOMETRIC OPTICS

Thick Lenses

Improving an Image with a Stop



Turn on the light bulb. Move the light bulb to focus the image on the side wall. The focal lengths are marked on the lenses. Show the effect of aperture size on the sharpness on the focus by placing different sized stops in front of the lens. Use the thick, short focal length lens.

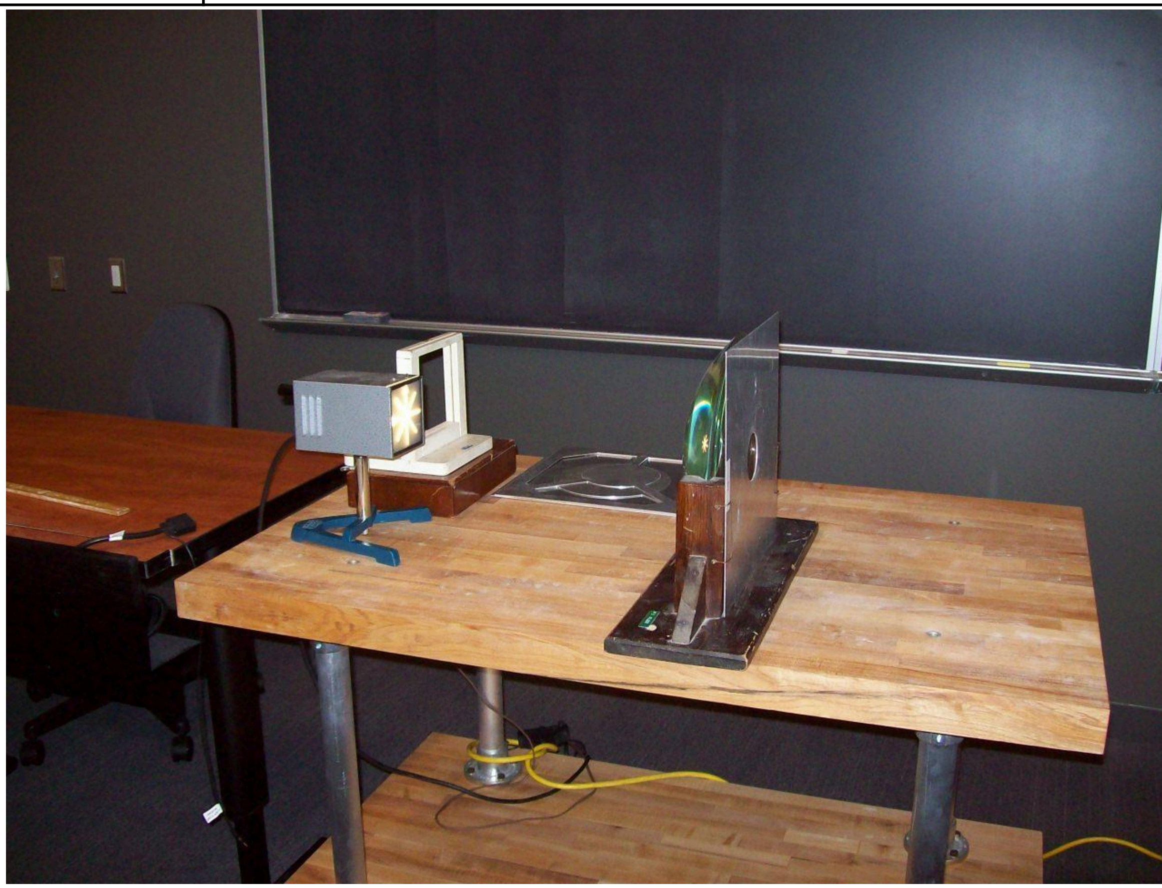


Location: Ja5, Jd3

OPTICS	6A65.24	GEOMETRIC OPTICS
	Thick Lenses	

Chromatic and Spherical Aberration

	Use diaphragms with central, annular, and other openings to show spherical and chromatic aberration.



Location: Ja6, Jd3

OPTICS	6A65.56	GEOMETRIC OPTICS
Thick Lenses		

CHOICE MATERIAL GLASS OXIDE

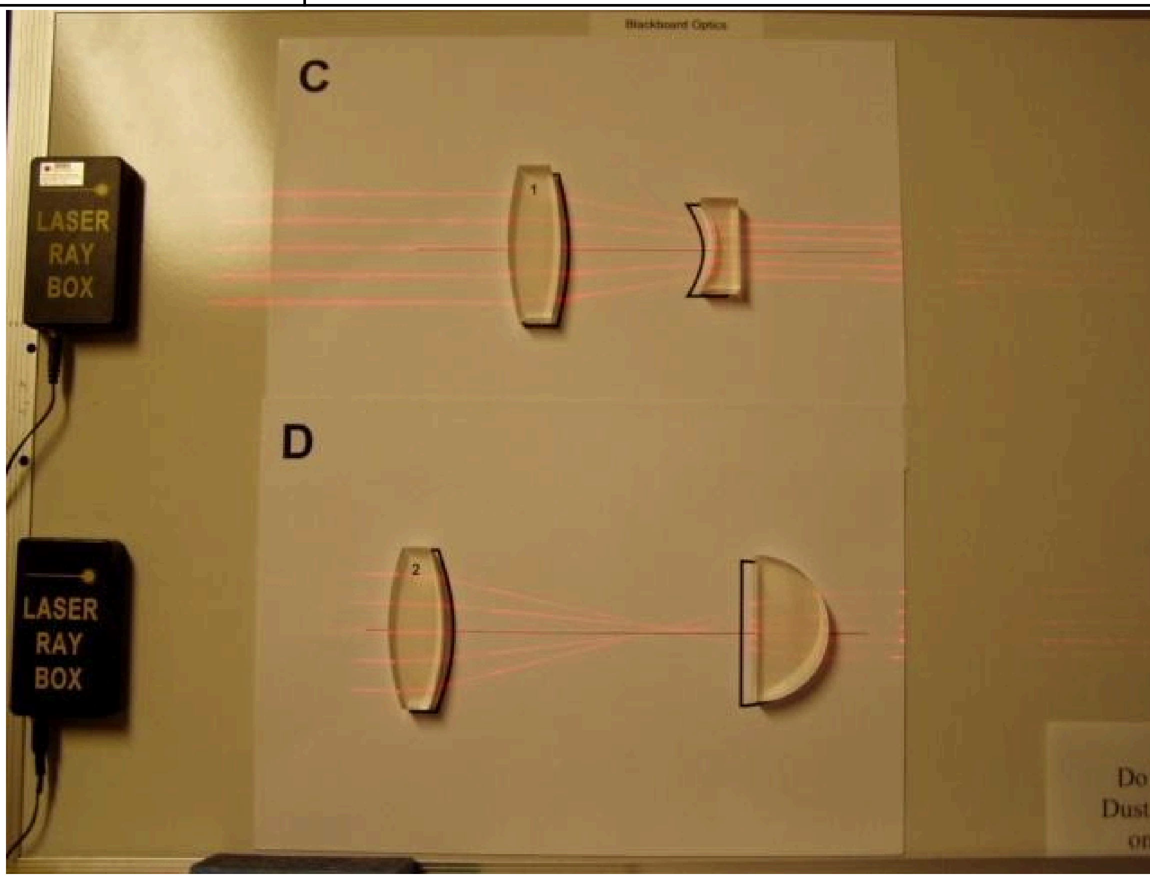
	CHOICE MATERIAL GLASS OXIDE is viewed through an acrylic rod or a plastic tube filled with water.

Location: Ja3

OPTICS	6A65.70	GEOMETRIC OPTICS
Thick Lenses		
Fresnel Lens		
	Show some Fresnel Lenses and a model of them.	

Location: Ja5, Jd3

OPTICS	6A70.20	GEOMETRIC OPTICS
	Optical Instruments	
	Telescope Models	
	Blackboard optics illustrations of a Keplerian telescope and a Gallilean telescope.	

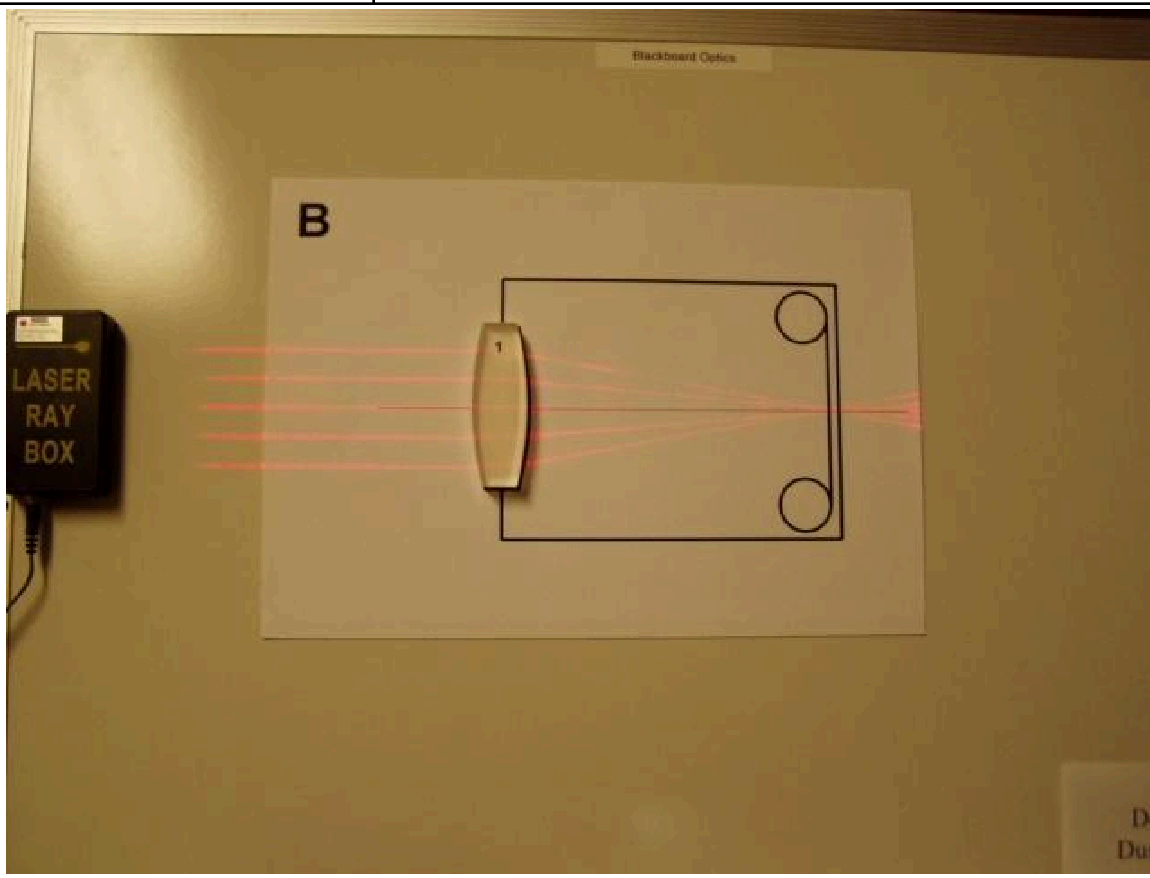


Location: Blackboard Optics Cart

OPTICS	6A70.30	GEOMETRIC OPTICS
	Optical Instruments	

Camera Model

	Blackboard optics illustration of a camera.



Location: Blackboard Optics Cart

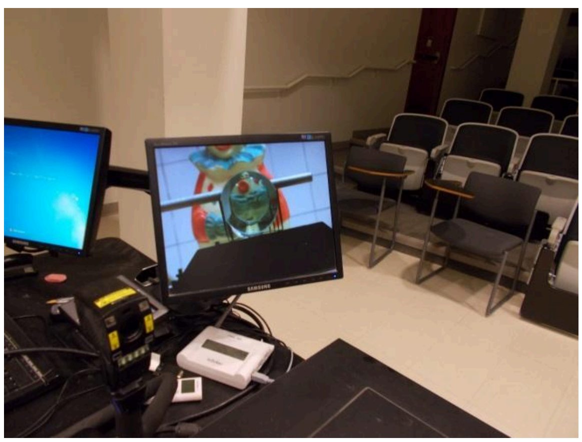
OPTICS	6A70.45	GEOMETRIC OPTICS
	Optical Instruments	

Lens Combinations

	Set up some optical systems with more than one lens. Use the TV camera and screen to show intermediate images. It is helpful to use a dimmer on the source object box to keep the TV image from being washed out.

Location: Id4, Jd3

OPTICS	6A70.46	GEOMETRIC OPTICS
Optical Instruments		
Invisibility		
	Four lenses (two 15 cm focal length and two 5 cm focal length) are arranged so that an aluminum rod seems "cloaked" when passed through certain regions.	

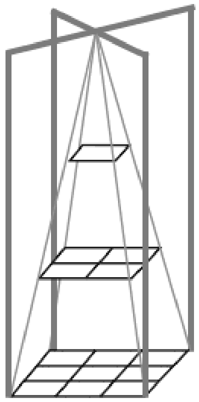


Location: Ja3, Jd2, Lb5, Bd1

OPTICS	6B10.15	PHOTOMETRY

Luminosity

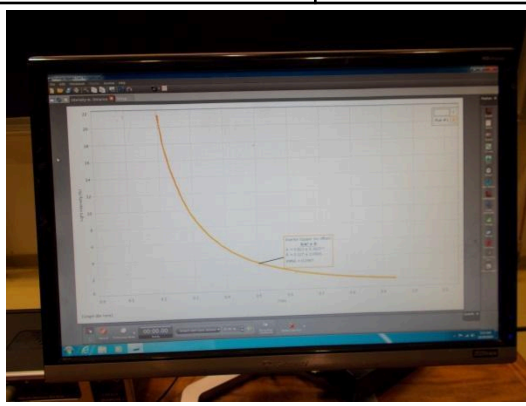
Inverse Square Model

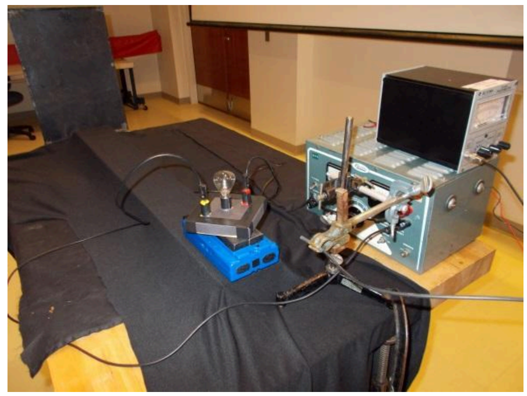


A point source casts a shadow from a square frame. A screen four times the area is placed twice as far from the source as the frame. The light going through the frame just fills the screen.

Location: JaT, Ja6, Jd3

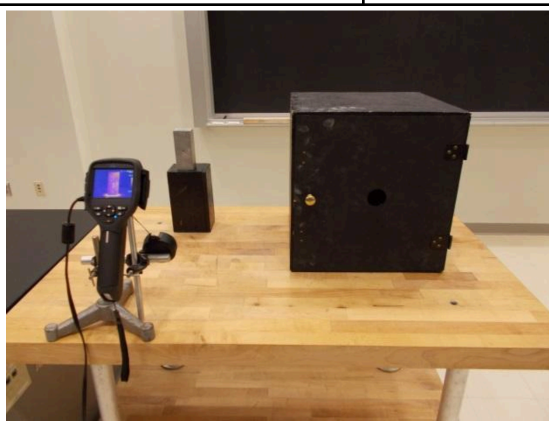
OPTICS	6B10.20	PHOTOMETRY
Luminosity		
Inverse Square Law with a Photometer		
	A photometer is used with a smart cart, a computer, and the Capstone software to plot intensity of light vs distance. The Capstone file is Inverse Square Law for Light.	

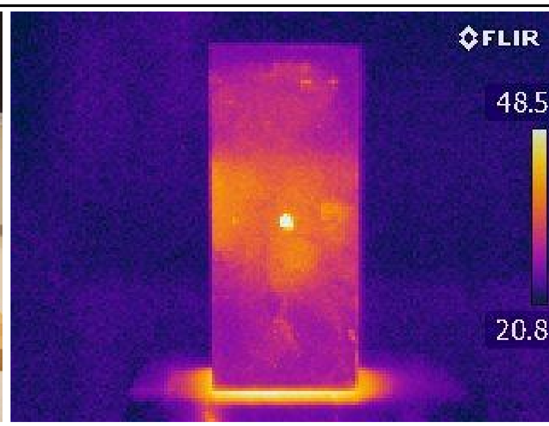




Location: Jb1, Bb2, Cc1

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).	



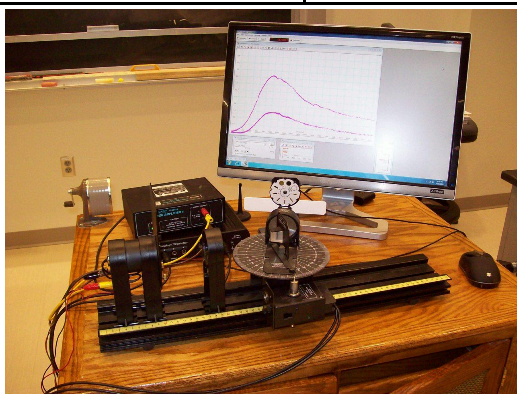


Location: Jb2, Fc5, FLIR Cabinet

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. For the TV camera version, use fixed focus and exposure. Change the variac setting to show the spectrum shift.

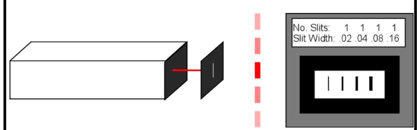



Location: Science Workshop Cabinet, Optics Table Cabinet, Kb2, Ib2

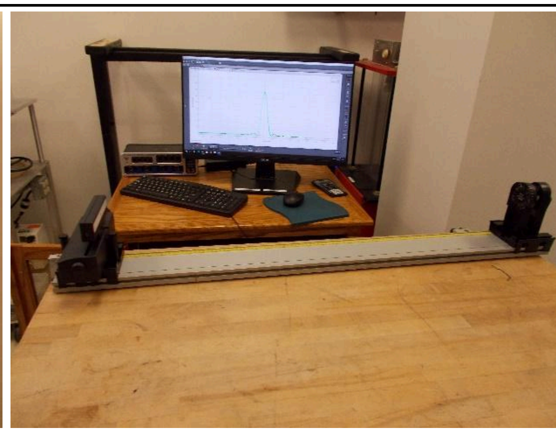
OPTICS	6C10.10, 6C10.15	DIFFRACTION

Diffraction Through One Slit

Single Slit and Laser



Turn on the laser. The pattern appears on the wall. The slit widths are printed on the wheel. To select a different slit, turn the wheel. We also have the Cornell slitfilm card, which includes a slit of gradually increasing width. There is also a variable slit one can also use to “choke” the laser beam. Also shown is the computerized version (Diffraction.cap, uses the Capstone software). Use the 40 mW green diode laser, shimmed to the proper beam height. CAUTION: the undiffracted beam is bright enough to be harmful.



Location: Ja6, Jb3

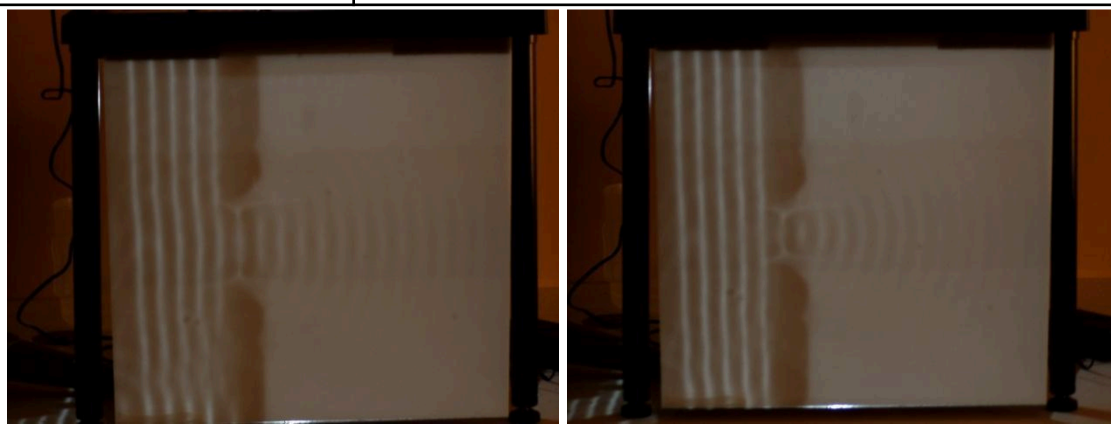
OPTICS	6C10.20	DIFFRACTION
Diffraction Through One Slit		

Two Finger Slit

	Have each student look at a vertical filament lamp through the slit formed by holding two fingers closely together.

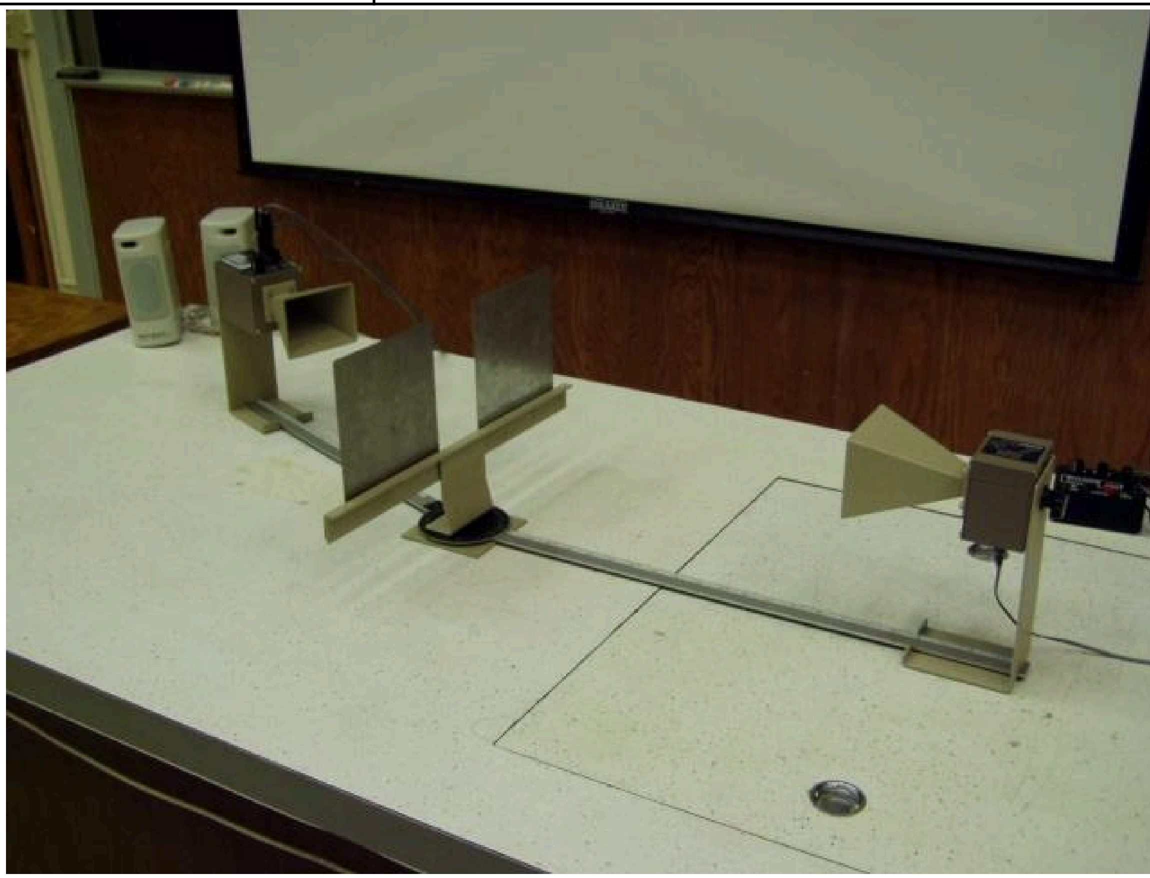
Location: Jd3

OSCILLATIONS AND WAVES	3B50.10	WAVE MOTION
Interference and Diffraction		
Ripple Tank – Single Slit		
	Set up the ripple tank with a plane wave source and a single slit.	



Location: Fb4

OPTICS	6C10.50	DIFFRACTION
Diffraction Through One Slit		
Microwave Single Slit Diffraction		
	3 cm microwave and a single slit.	



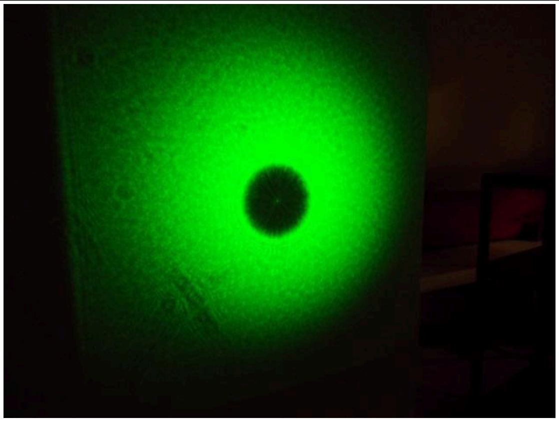
Location: Ia7

OPTICS	6C20.10	DIFFRACTION

Diffraction Around Objects

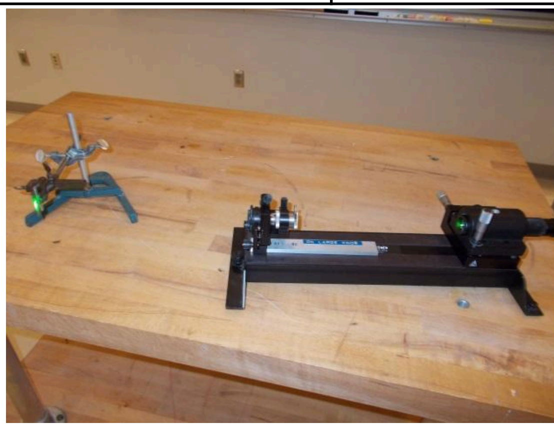
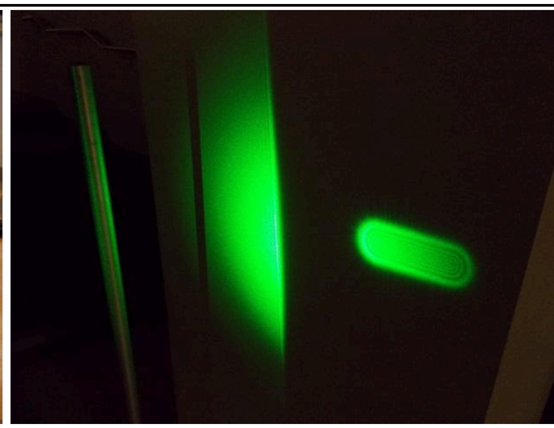
Arago (Poisson) Spot

	Shine an expanded laser beam at a ball bearing and look at the diffraction pattern.



Location: Jb3, Ja6

OPTICS	6C20.15	DIFFRACTION
Diffraction Around Objects		
Diffraction around Objects		
	Diffraction of a divergent laser beam around a razor blade or needle.	

Location: Jb3, Ja6

OPTICS	6C20.20		DIFFRACTION
Diffraction Around Objects			

Babinet's Principle

	Diffraction of a divergent laser beam around a thin line (0.08 mm) is compared to diffraction by a slit of the same size. Use the brighter laser on the slit. The wheel has both the individual line and slit that you can use by turning the wheel. Alternatively, there is a slide on the wheel that has the slit and line side by side (move the whole wheel holder from side to side to go from one to the other). Use the 40 mW green diode laser, shimmed to the proper beam height. CAUTION: the undiffracted beam is bright enough to be harmful.

Location: Jb3, Ja6

OPTICS	6C20.30	DIFFRACTION
Diffraction Around Objects		

Pinhole Diffraction

	Shine a laser beam through pinholes of various sizes. Use the 40 mW green diode laser, shimmed to the proper beam height. CAUTION: the undiffracted beam is bright enough to be harmful.

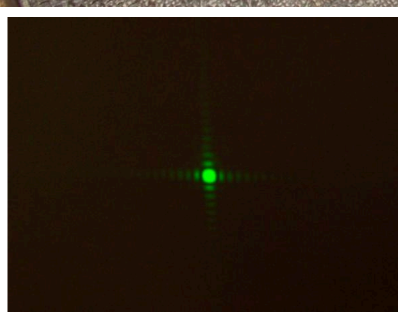
Location: Jb3, Ja6

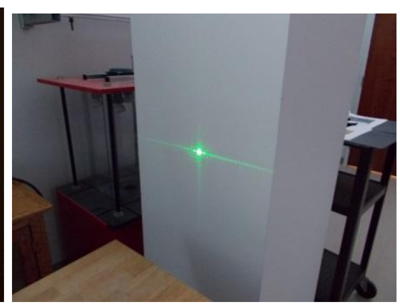
OPTICS	6C20.35	DIFFRACTION

Diffraction Around Objects

Square and Rectangular Apertures

Shine a laser beam through a square (0.16 mm x 0.16 mm) or rectangular aperture (0.16 mm x 0.08 mm) aperture. The Mounting hardware (mirror mounts) for the apertures is in the Newport Holography kit. Remove Newport mirror mount, MM2-1A, from riser (RB-MM2-2), and mount aperture slide in it. The lens (18 mm) is from the Pasco Advanced optics kit. Use steel nuts as spacers on the mounting slide so it can be moved close enough to the aperture.



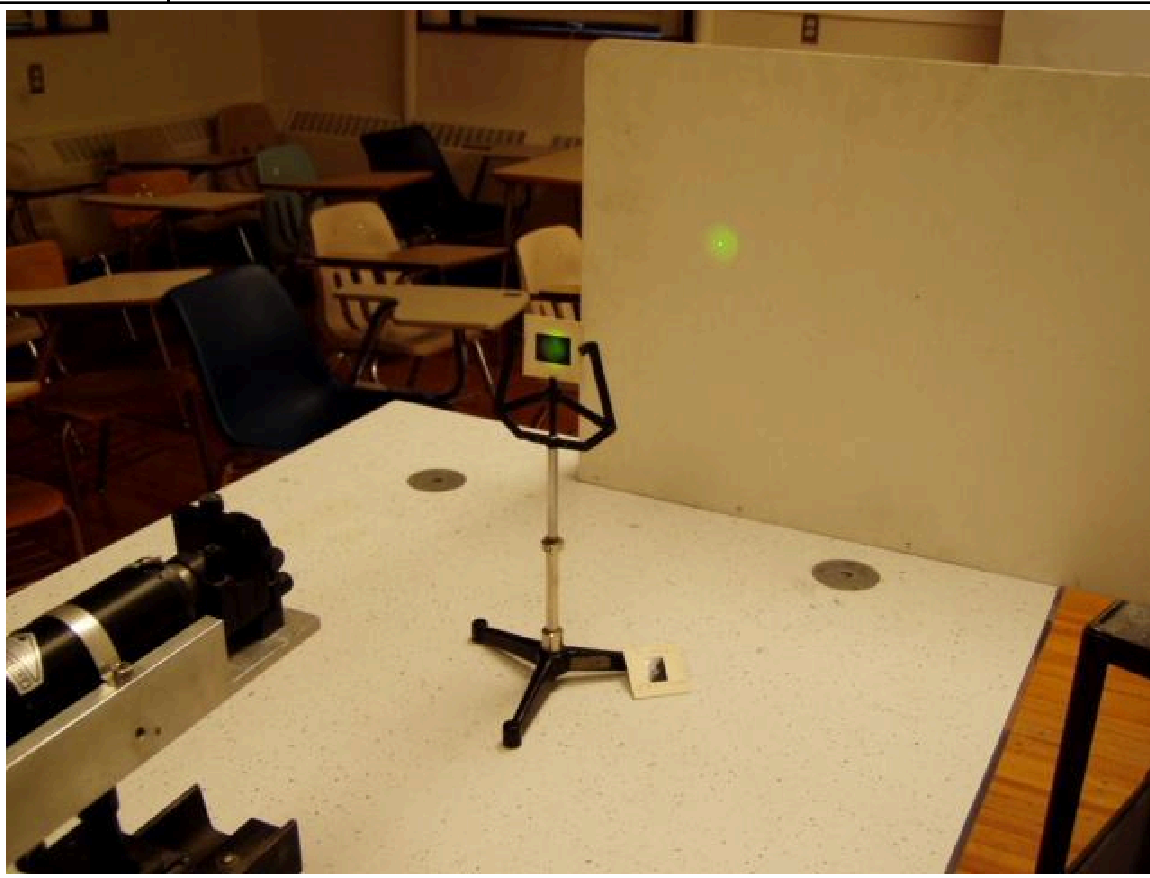


Location: Jb3, Ja6

OPTICS	6C20.40	DIFFRACTION
Diffraction Around Objects		

Zone Plate Lens

	Use a zone plate. The source is a spatially filtered diverging beam. Also place a zone plate on the overhead projector to show the center is an opaque spot (note we also have one that is not opaque in the center).

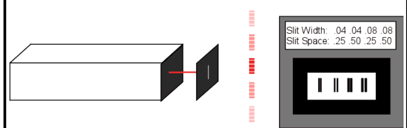


Location: Jb3, Ja6

OPTICS	6D10.10	INTERFERENCE

Interference From Two Sources

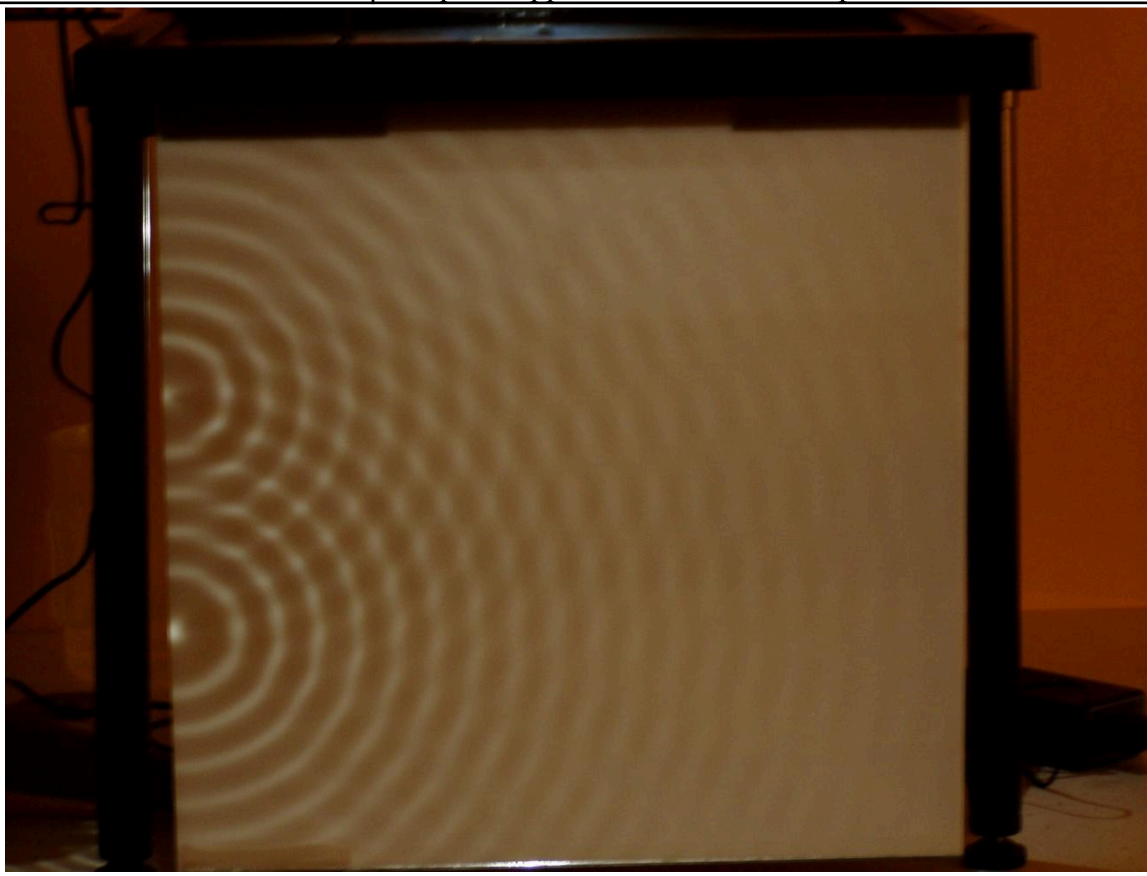
Double Slits and Laser



Turn on the laser. The pattern appears on the wall. The slit widths and spacings are printed on the wheel. To select different slits, turn the wheel. There is a continuously variable double slit that varies the slit spacing on the wheel. We also have the Cornell slitfilm card, which includes double slits of increasing width and spacing. Use the 40 mW green diode laser, shimmed to the proper beam height. CAUTION: the undiffracted beam is bright enough to be harmful.

Location: Jb4, Ja6

OSCILLATIONS AND WAVES	3B50.20	WAVE MOTION
Interference and Diffraction		
Ripple Tank – Two Point		
	Set up the ripple tank with a double point source.	

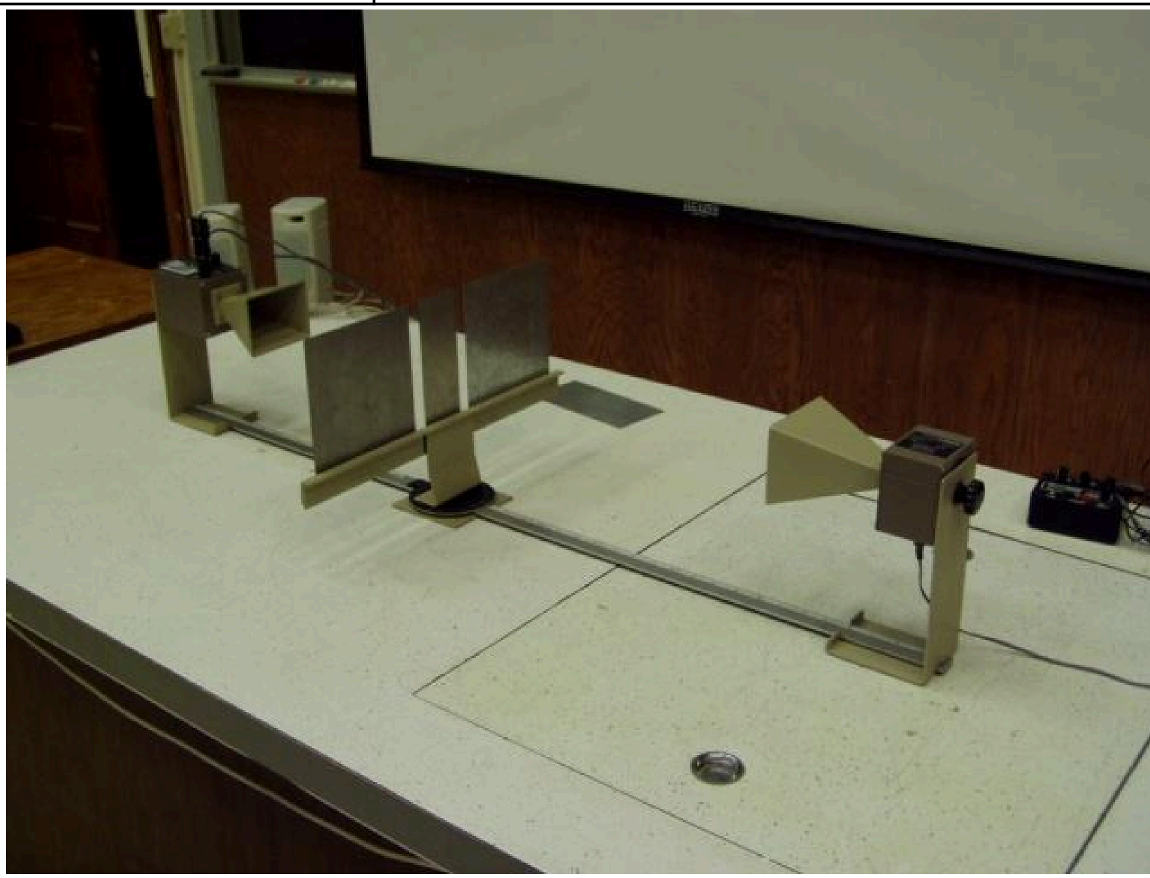


Location: Fb4

OPTICS	6D10.20	DIFFRACTION
Interference From Two Sources		

Microwave Double Slit

	3 cm microwave and a double slit.



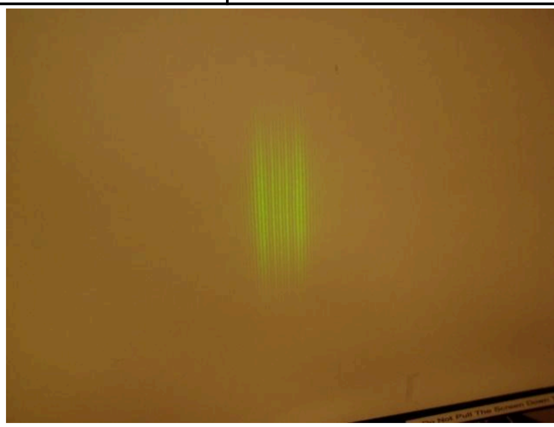
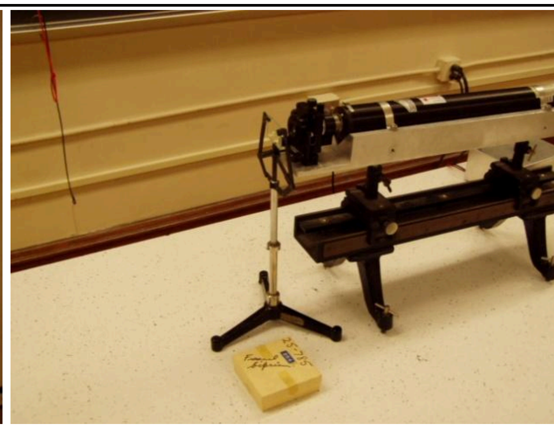
Location: Ia7

OPTICS	6D10.41	DIFFRACTION

Interference From Two Sources

Fresnel Biprism

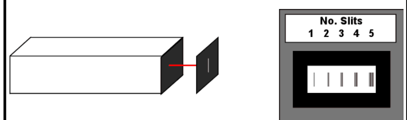
	A spatially filtered diverging beam illuminates a Fresnel biprism. A pattern similar to a double slit is produced.

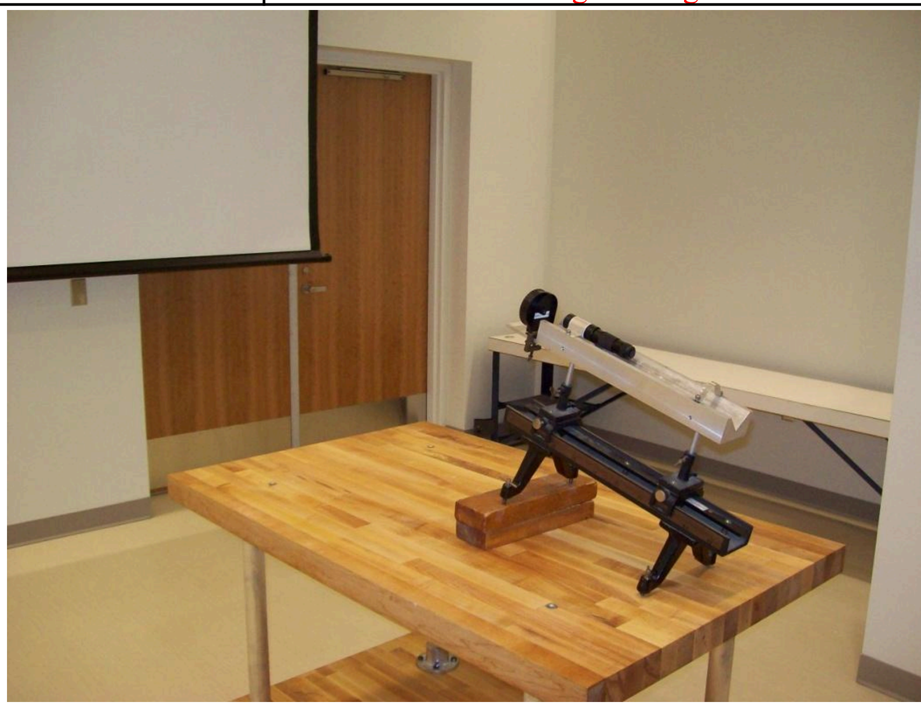
Location: Jb4, Ja6, Optics Table Cart

Gratings

Number of Slits



Turn on the laser. The pattern appears on the wall. The slit widths, numbers and spacings are printed on the wheel. To select different slits, turn the wheel. View the results of the interference pattern on the wall. The lights in the room may need to be darkened. Use the 40 mW green diode laser, shimmed to the proper beam height. CAUTION: the undiffracted beam is bright enough to be harmful.



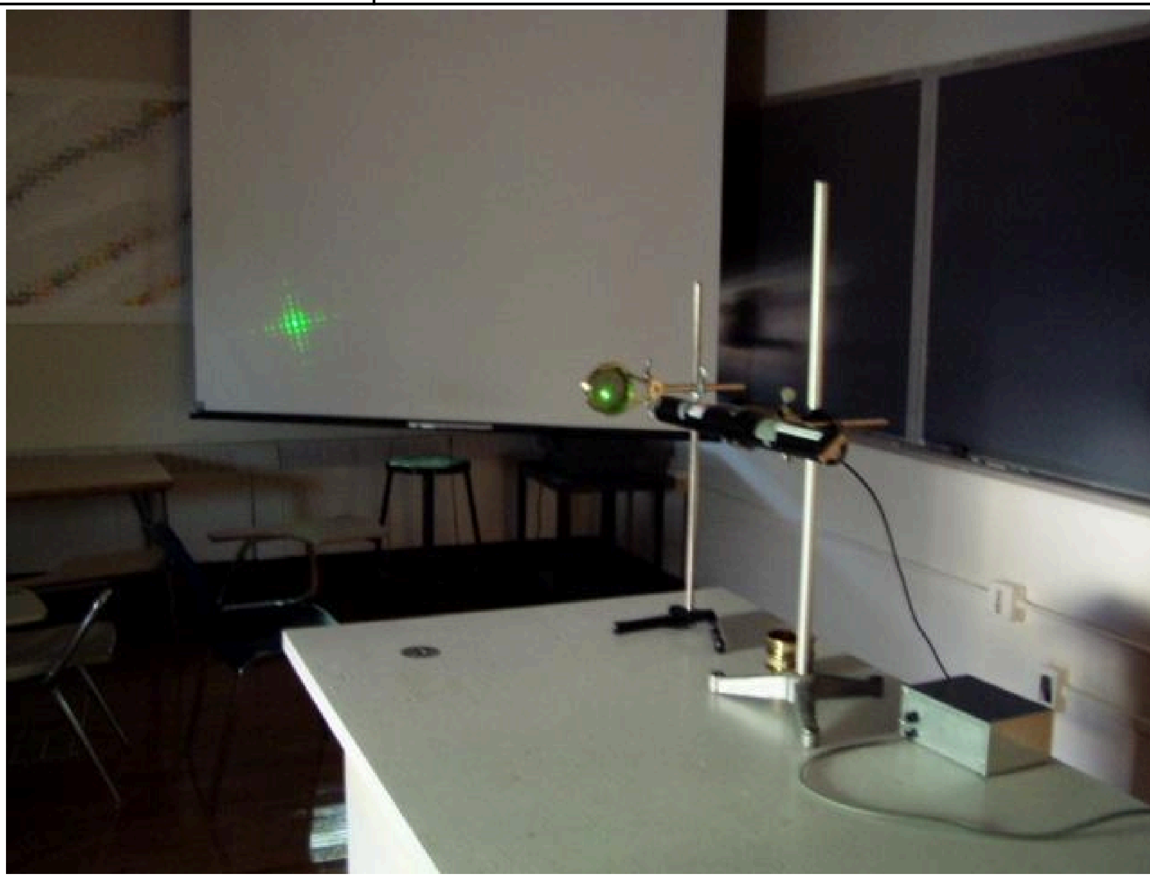
Location: Jb4, Ja6

OPTICS	6D20.55	INTERFERENCE

Gratings

Fine Mesh and Laser

	Shine a laser through a fine mesh and observe the patterns.

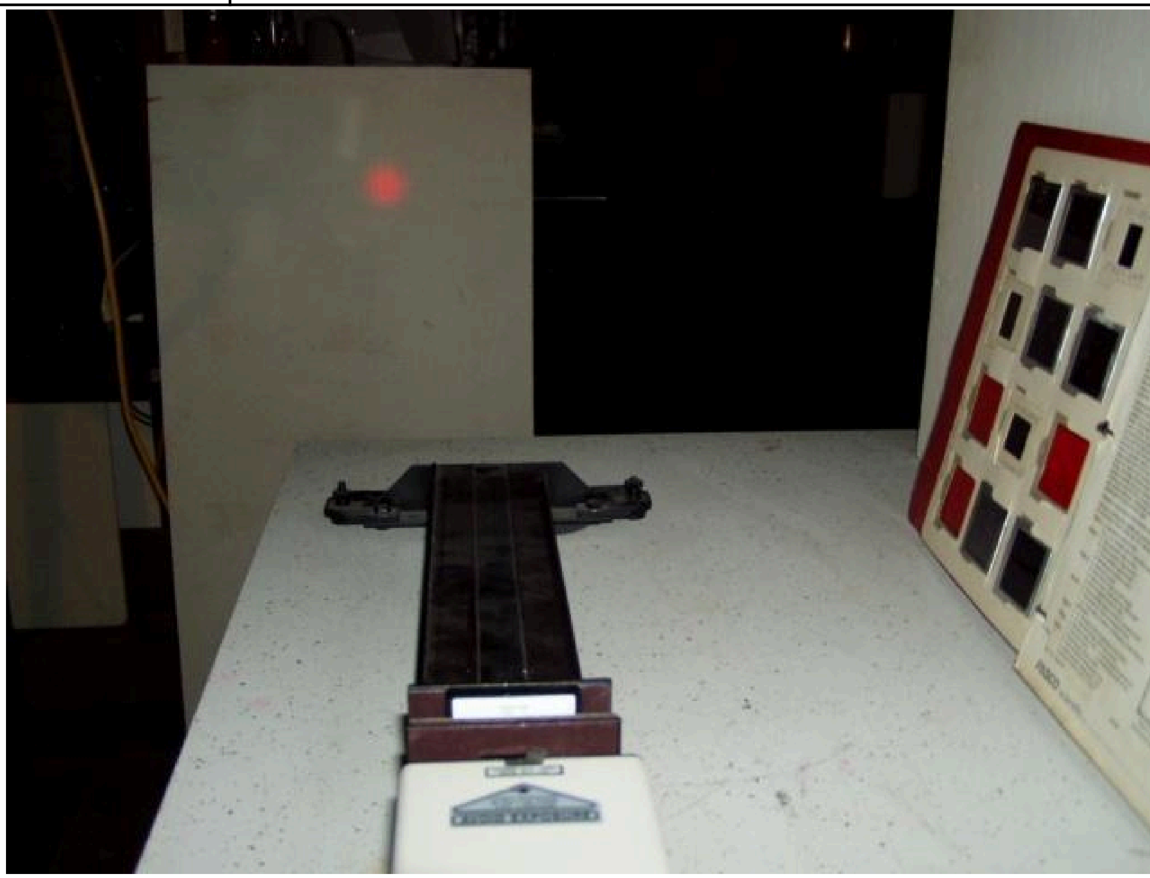


Location: Jb4, Ja6

OPTICS	6D20.57	INTERFERENCE
Gratings		

Optical Crystal Set

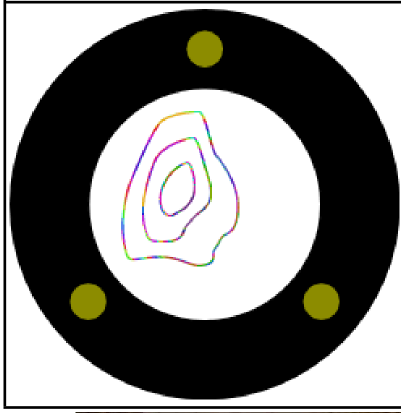
	Seven sequences of 2x2 slides used in the simple Laue approach to diffraction by crystals.



Location: Jb4, Jd2

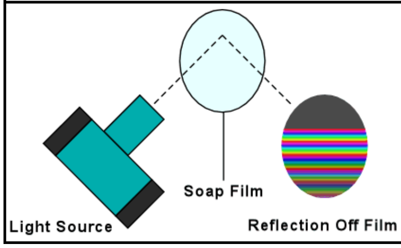
Thin Films

Newton's Rings



Turn on the light. The interference pattern is projected onto the side wall. Change the pattern by tightening a screw on the edge of the glass disk.

Location: Id1, Jb4, Jd3

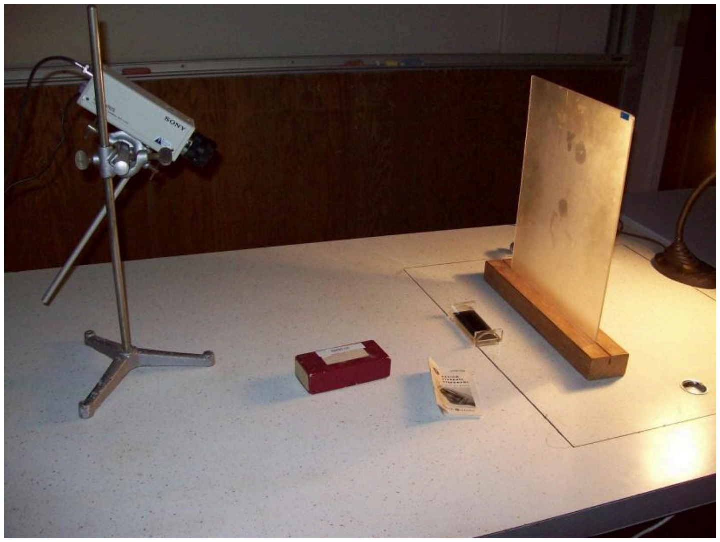
<table>
<tr><td>OPTICS</td><td>6D30.20</td><td>INTERFERENCE</td></tr>
<tr><td colspan="3">Thin Films</td></tr>
<tr><td colspan="3"><h1>Soap Film Interference</h1></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>
</td><td colspan="2">Turn on the light. Dip the wire frame into the soap solution and secure with the clip. Adjust the angle until the pattern appears on the side wall.</td></tr>
</table>

Location: Id1, Jb4, Jd3

OPTICS	6D30.30	INTERFERENCE
Thin Films		
Air Wedge		
	A sodium lamp illuminates two plates of glass (in the picture two quartz surface plates are shown). Compare with a piece of glass that is not an optical flat.	

Location: Jb3, Ka2

OPTICS	6D30.55	INTERFERENCE
Thin Films		
Step Gauge		
	Thin films of barium stearate, from 2 x10^{-6} to 16 x10^{-6} inches in microinch increments are deposited on a glass plate. The steps reflect a vivid series of interference colors when illuminated by white light.	

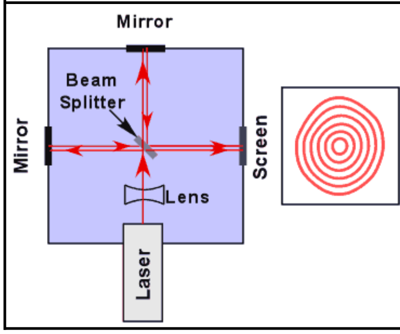


Location: Jb4

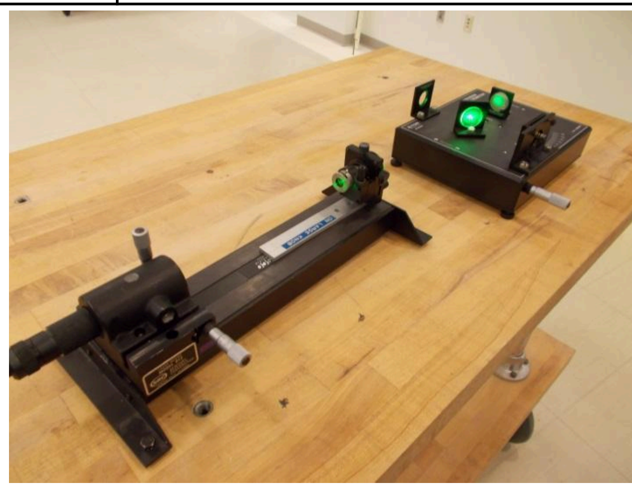
OPTICS	6D40.10	INTERFERENCE

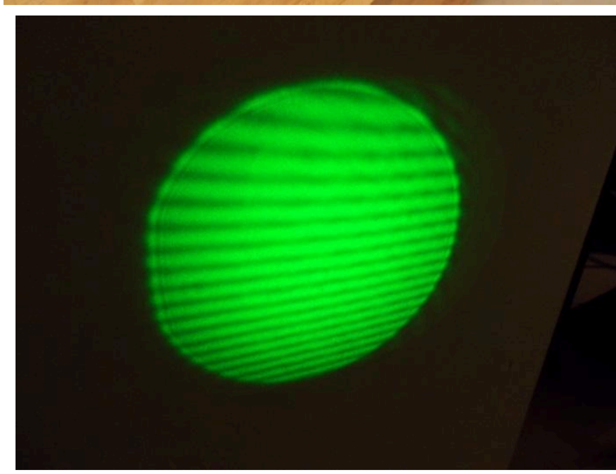
Interferometers

Michelson Interferometer



Turn on the laser. Read the initial position of the micrometer. Count the number of fringes while turning the micrometer slowly in one direction only. Read the final position. This can also be done with white light. A spatial filter is used to create a clean, diverging beam.





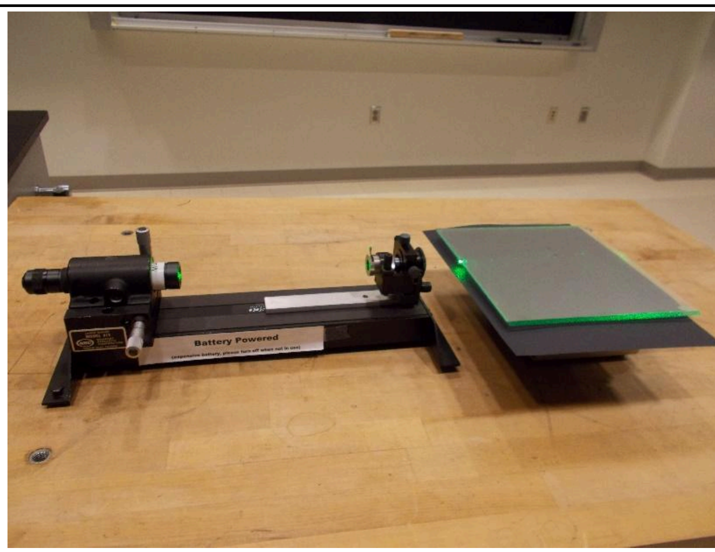
Location: Optics Table Cabinet, Jb5, Ja6

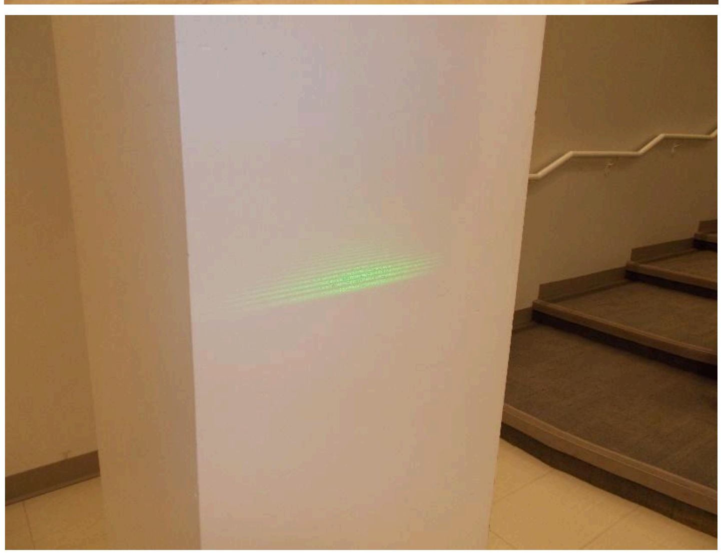
OPTICS	6D40.27	INTERFERENCE

Interferometers

Lloyd’s Mirror

The laser is aligned so that the beam grazes the surface of the glass plate. Two spots are seen on a distant screen, one from the light passing directly over the plate and the other from the light reflected from the plate. As the plate is raised into the beam, the spot of light from the reflection will lower and merge with the spot that passes directly over the plate. As it does, an interference pattern will appear.



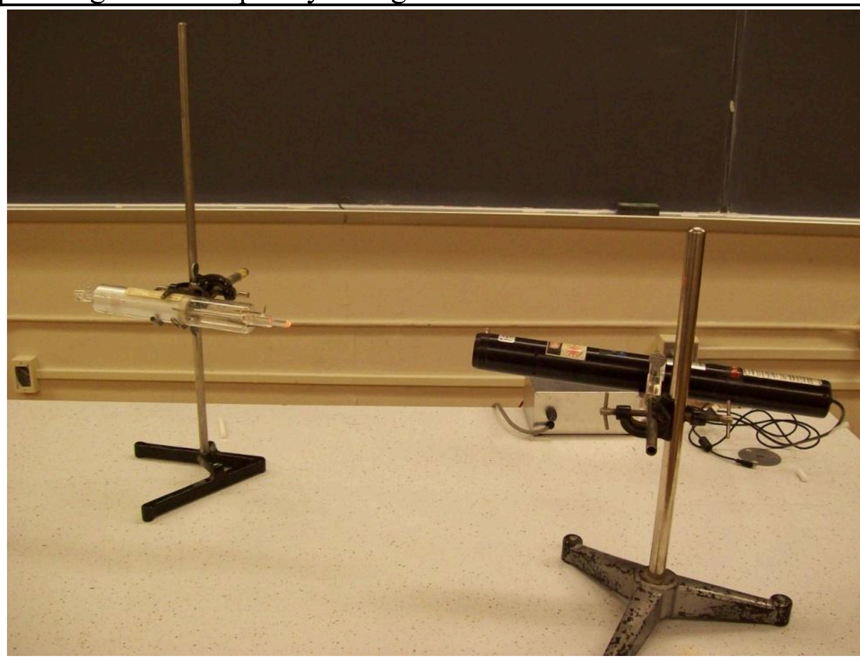


Location: Id3, Jb3,

Modern Physics	7G20.20	Lasers
Laser Polarization and Intensity Fluctuation - 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.



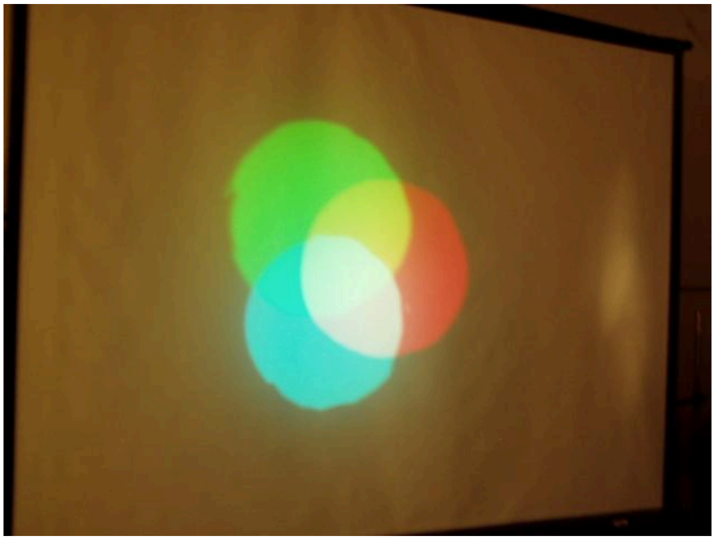
Location: Ia1, Ja6

OPTICS	6F10.10	COLOR

Synthesis and Analysis of Color

Color Box

	Three spot lights with color filters are used to project colored spots on a screen. The spots overlap to show color mixing. Colorful shadows can be cast as well.



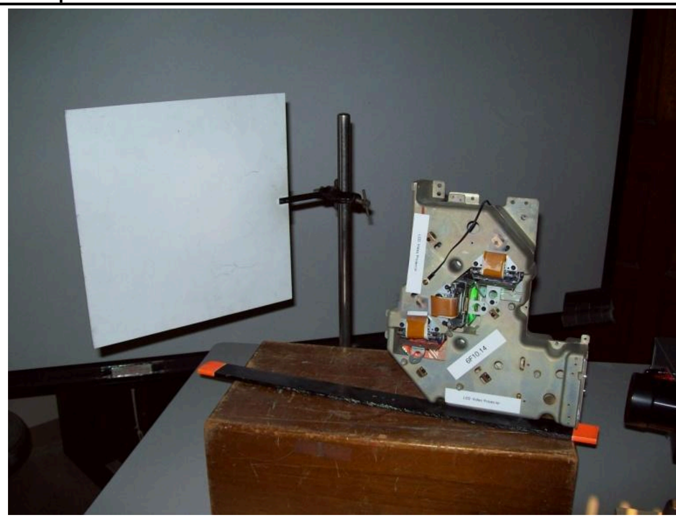
Location: Jb6

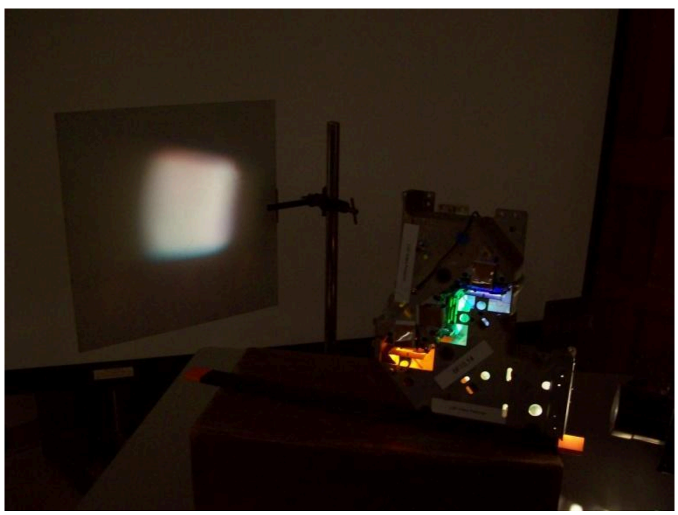
OPTICS	6F10.14	COLOR

Synthesis and Analysis of Color

Color Mixing

	Use an old LCD projector to split a white beam of light into RGB and then recombine it.



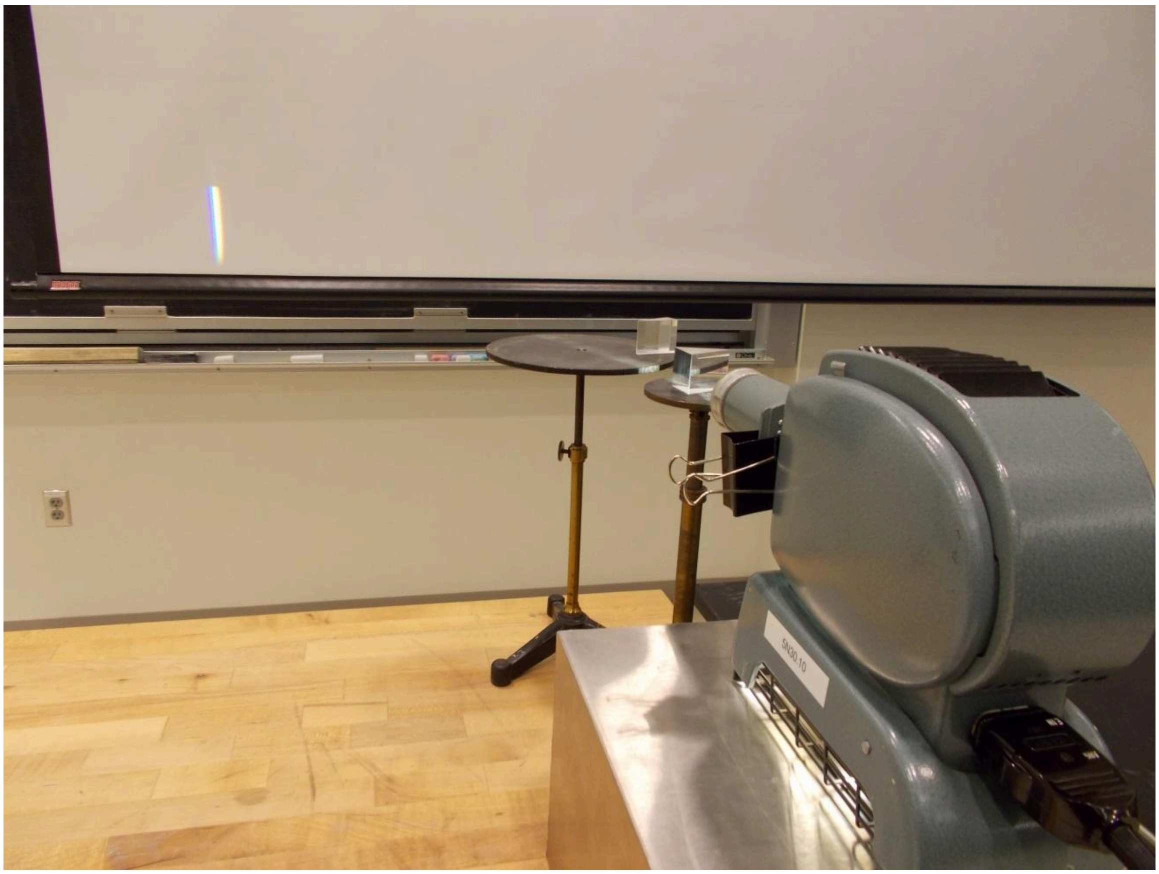


Location: Jb6

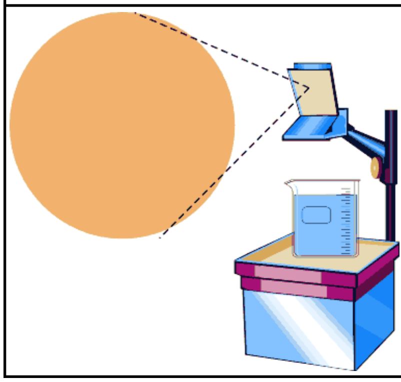
OPTICS	6F10.30	COLOR
Synthesis and Analysis of Color		

Recombining the Spectrum

	Recombine the spectrum after passing through a prism to get white light or remove a color to get the complement.



Location: Ib1, Jb3, Jc1

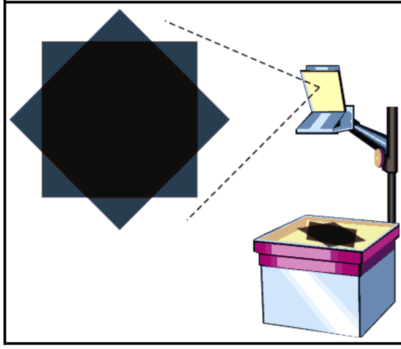
OPTICS	6F40.10	COLOR
	Scattering	
	Sunset	
	A beam of light shines through a circular slide on the overhead projector and then through one liter of water and onto the side wall. Add a few drops of Pinesol (cedarwood oil in alcohol or Lysol) to the water and stir with the stick. The "sun" will begin to turn yellow. To increase the scattering to an orange sun, add more Pinesol. It takes about 15 minutes to fully achieve the effect. Use the Polaroid film to show the scattered blue light is polarized (it becomes less so as you get double scattering).	

Location: Jc2

OPTICS	6H10.10	POLARIZATION

Dichroic Polarization

Polaroids on the Overhead



You get two sheets of Polaroid and a pair of Polaroid sunglasses. Rotate one on the Polaroids or the sunglasses.

Location: Jc3, Ja5

OPTICS	6H10.12	POLARIZATION
Dichroic Polarization		

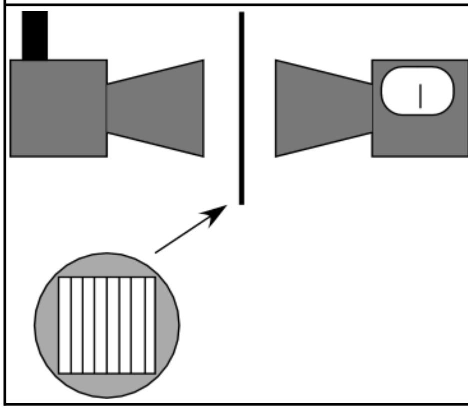
Polaroid Box

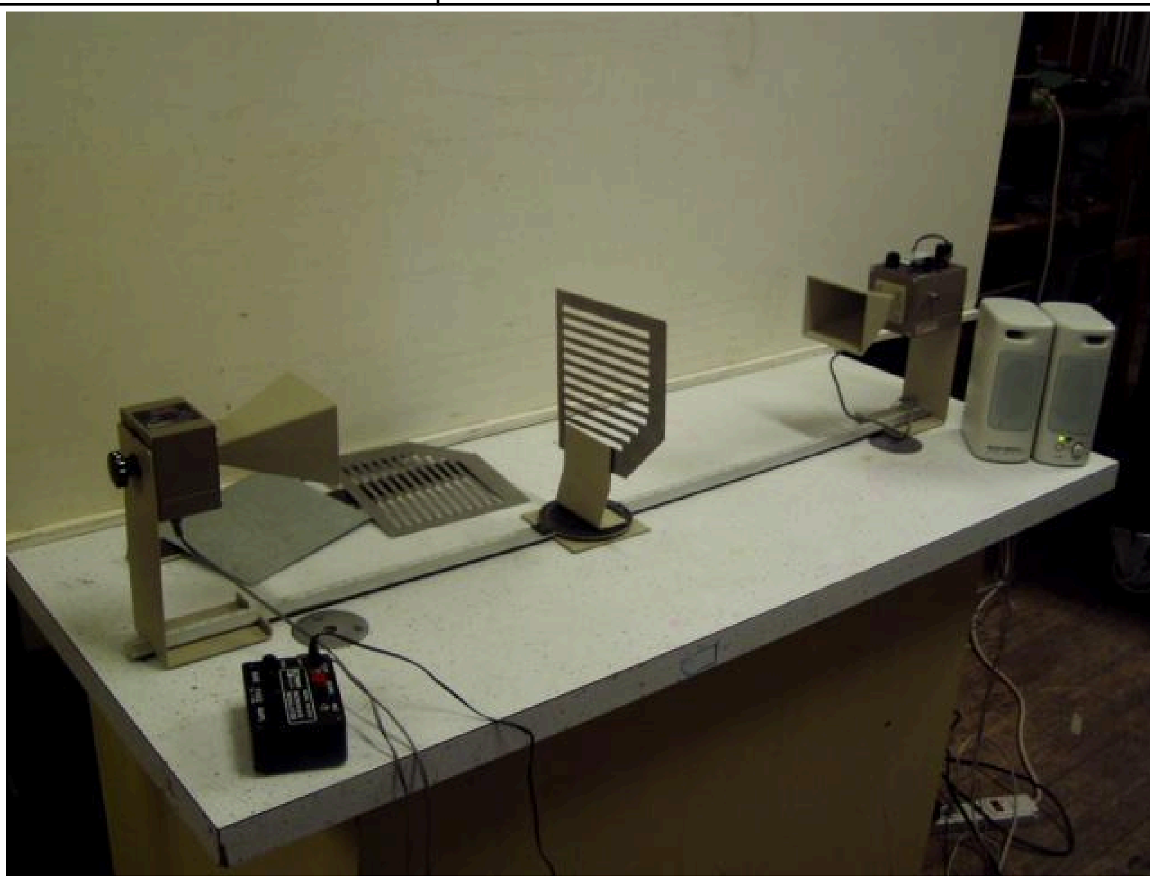
	An arrangement of cross polarizers makes it appear that there is a solid barrier inside a box.

Jc3

OPTICS	6H10.20	POLARIZATION
Dichroic Polarization		

Microwave Polarization

	Hold a grid of parallel wires in a microwave beam and rotate the grid.

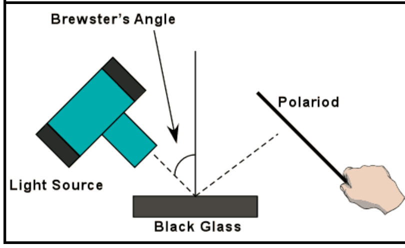


Location: Ia7

OPTICS	6H20.10	POLARIZATION

Polarization by Reflection

Brewster's Angle



Light is reflected from a sheet of black glass onto the wall. Rotate a sheet of Polaroid in the path of the reflected light. We set the light at Brewster's Angle. Vary the incident angle by rotating the light.

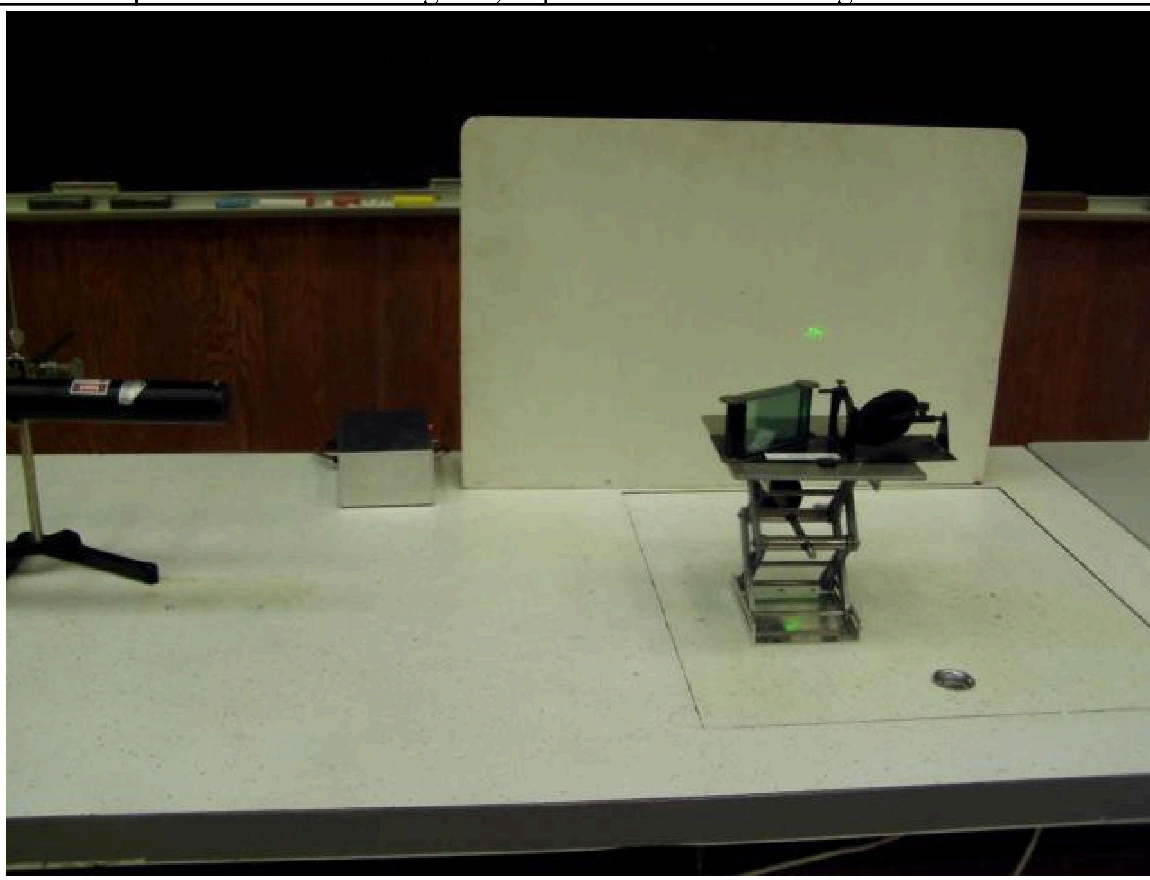
Location: Jc3, Jd3

OPTICS	6H20.40	POLARIZATION

Polarization by Reflection

Stack of Plates

A stack of glass plates at 57 degrees will transmit and reflect light that is cross polarized. In this apparatus, the black mirror serves as an analyzer for the transmitted beam and when the ray reflected off of it is in the same direction as the rays reflected off of the stack of plates, the intensity is low because the plane of polarization of the transmitted ray is normal to a line in the plane of the black glass; however, if you rotate the black mirror 90 degrees so the reflected beam is normal to the direction of the rays reflected off of the stack, then the plane of polarization of the transmitted ray is in the plane of the black glass and the ray is more intense. Use the green, unpolarized laser as the light source.

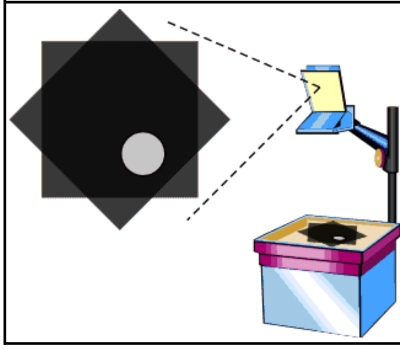


Location: Ja6, Jc3

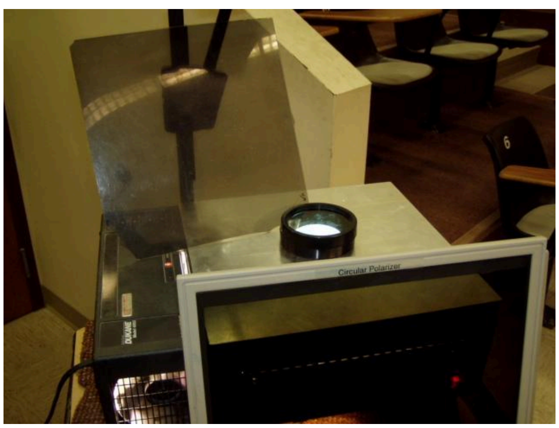
OPTICS	6H30.10	POLARIZATION

Circular Polarization

Three Polaroids



Three sheets of Polaroid are provided with an overhead projector. Also shown in the photograph is a circular polarizer. The second picture shows a version that does not use the overhead projector



Location: Jc2, Jc3

OPTICS	6H30.20	POLARIZATION

Circular Polarization

Circular Polarizer,1/4 Wave Plate, Polaroid and Mirror

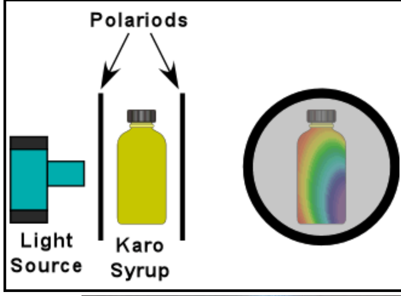
Look through a circular polarizer at your image in a mirror with the ¼ wave plate side toward the mirror. Now flip the circular polarizer so that the ¼ wave plate is on the side opposite the mirror. Also try a retroreflector and various orientations with a linear polarizer.

Location: Id5, Jc3

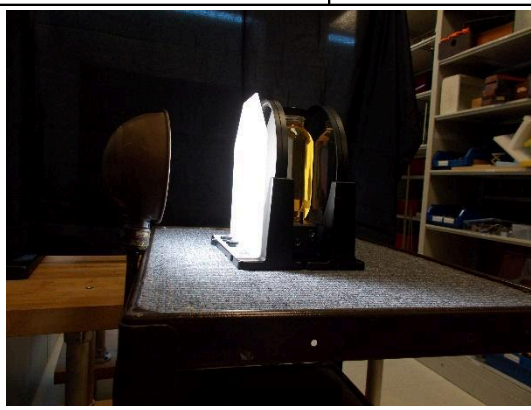
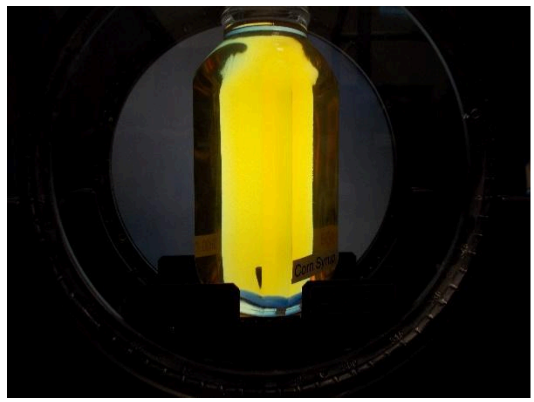
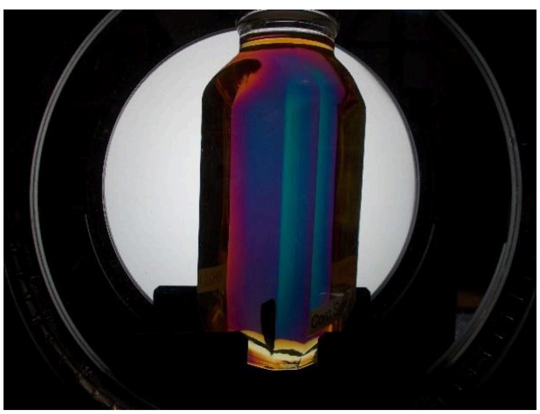
OPTICS	6H30.40	POLARIZATION

Circular Polarization

Karo Syrup



Place the Karo syrup between two circular polarizers. Place the light source behind the rear polarizer and turn the lamp on. Rotate the front polarizer and watch the syrup change colors. Use a point source with a diffuser. Show with a polarization axis finder (disk) is for fun.

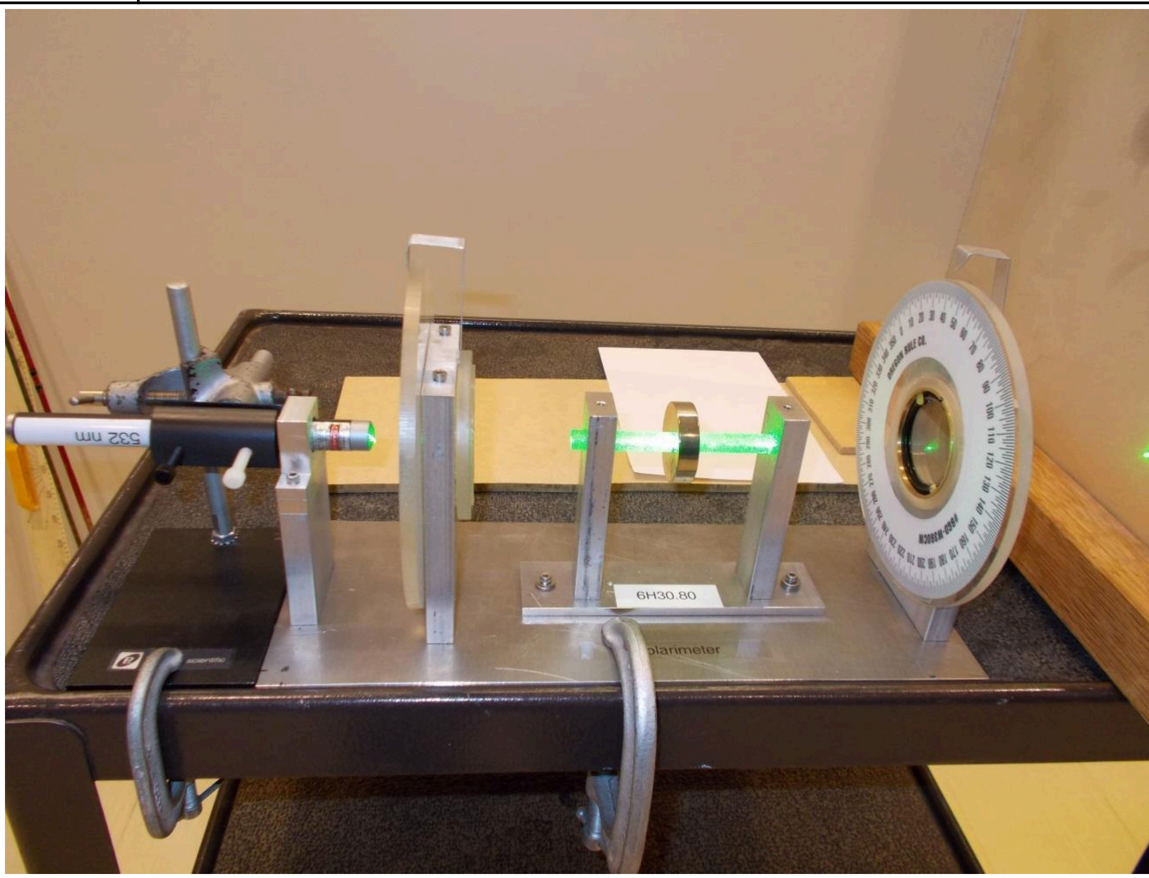

Location: Jc2, Jc4

OPTICS	6H30.80	POLARIZATION

Circular Polarization

Faraday Rotation

A TGG (Terbium Gallium Garnet) glass sample is placed in a polarimeter and illuminated with one of 3 lasers (405 nm, 532 nm and 605 nm). The polarimeter is adjusted for minimum throughput. A magnetic field is applied (0.13 T) and the Faraday rotation is observed by finding the new minimum.



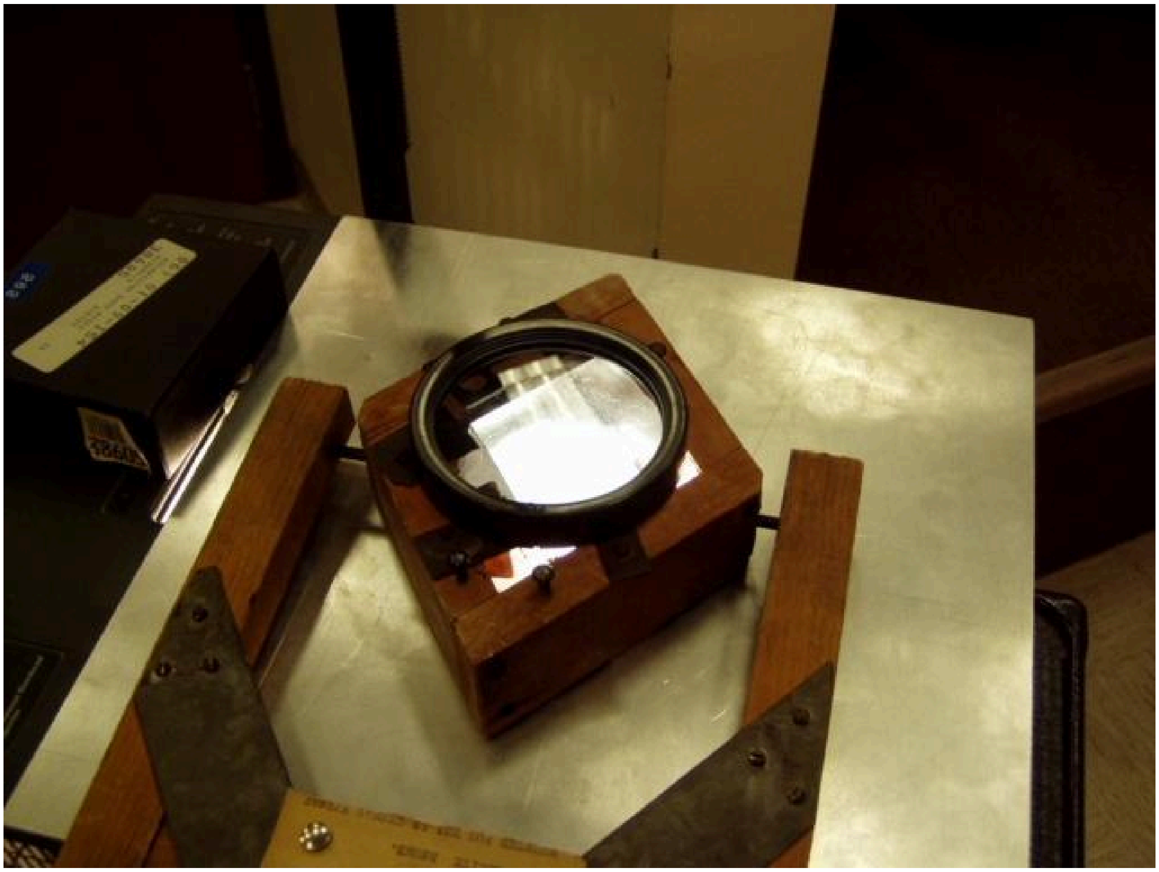
Jc2

OPTICS	6H35.15	POLARIZATION

Birefringence

Calcite and Polaroid on the OHP

	A calcite rhomb is placed on an overhead projector with a slide underneath. The double image can then be seen and manipulated with a polarizer.



Location: Jc4

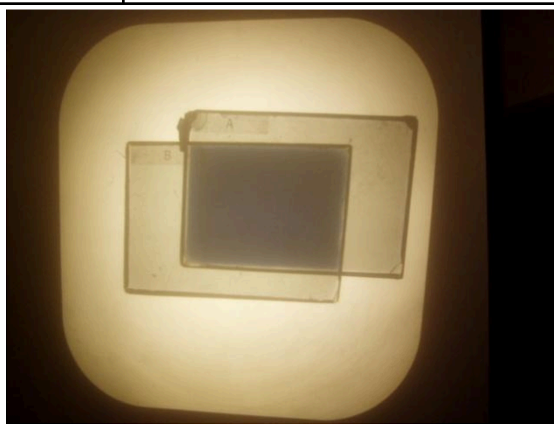
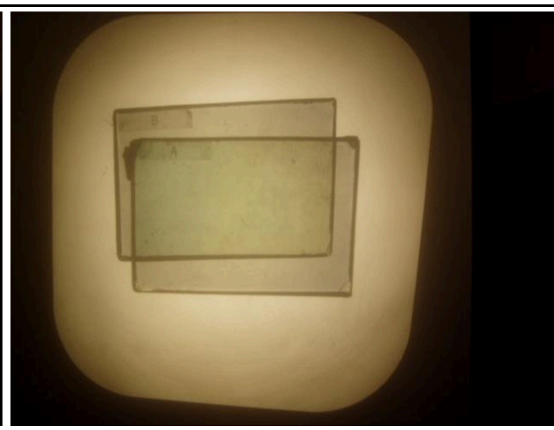
OPTICS	6H35.24	POLARIZATION
Birefringence		
Wavefront Model		
	Cast plaster model shows spherical and elliptical wavefronts in crystals.	

Location: Jc3

OPTICS	6H35.40	POLARIZATION
Birefringence		

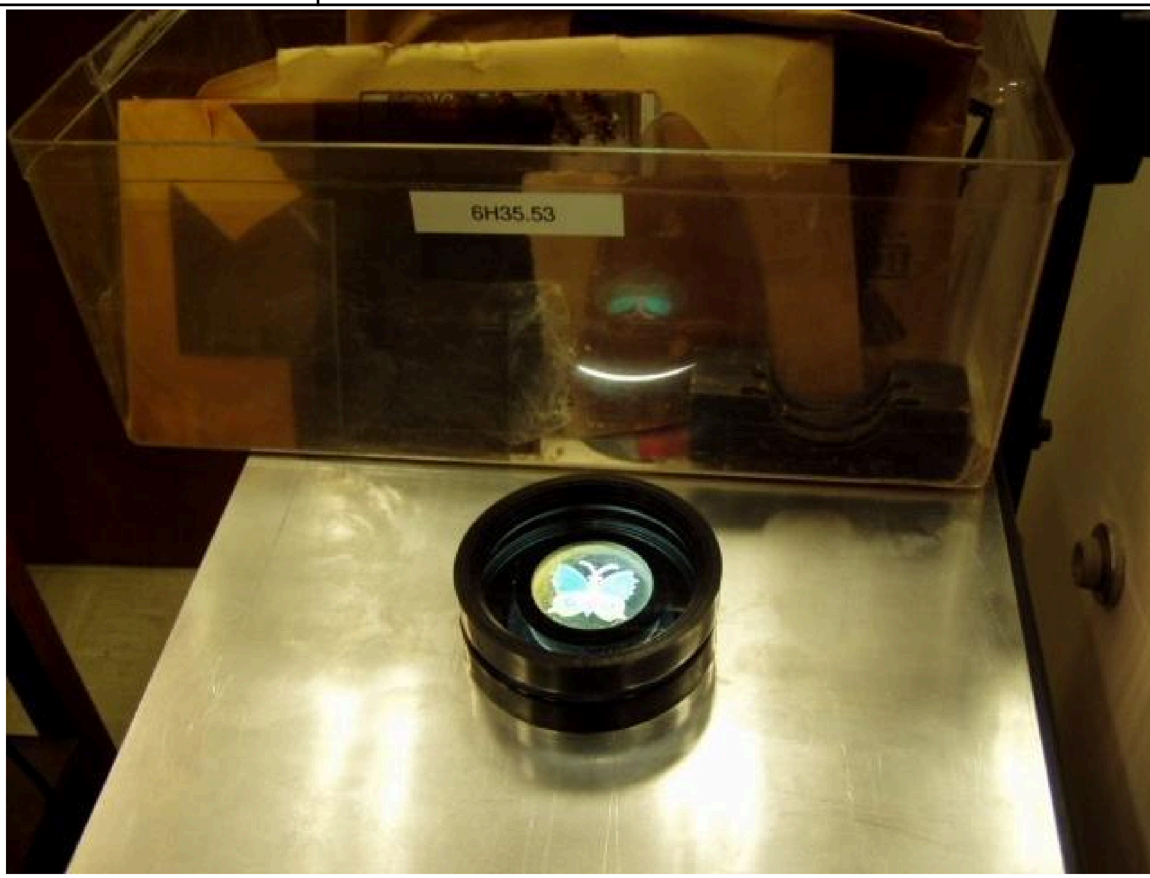
Quarter Wave Plate

	Show two plates with attached polarizers and the Magic glass trick wherein light appears to go through one way but not the reverse path (it’s a trick). One can also do this with one plate/polarizer by looking through it at a mirror and then flipping 180 degrees about a horizontal axis and looking again.

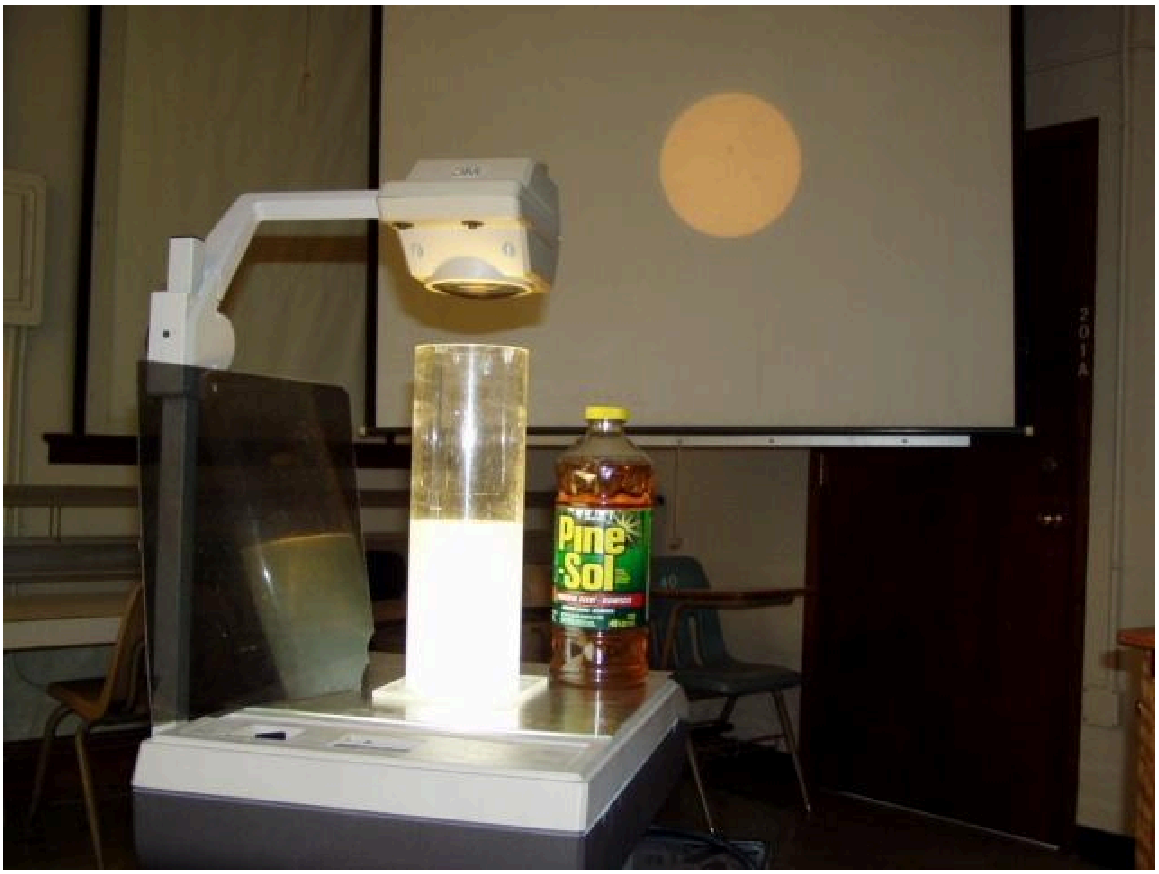
Location: Jc3

OPTICS	6H35.53	POLARIZATION
Birefringence		
# Butterfly		
	Mica, cellophane, butterfly slide, etc. are placed between crossed polarizers.	



Location: Jc3

OPTICS	6H50.10	POLARIZATION
Polarization by Scattering		
Sunset with Polarizers		
	Use a sheet of Polaroid to check the polarization of scattering from a beam of light passing through a tank with scattering particles.	

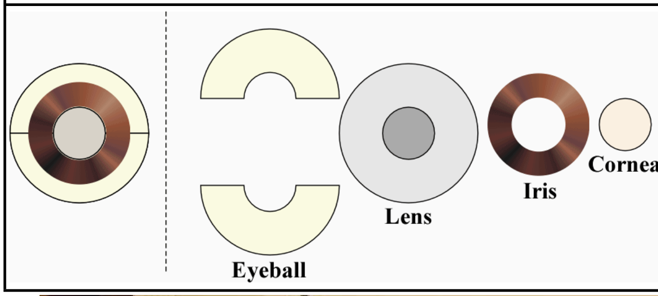


Location: Jc2

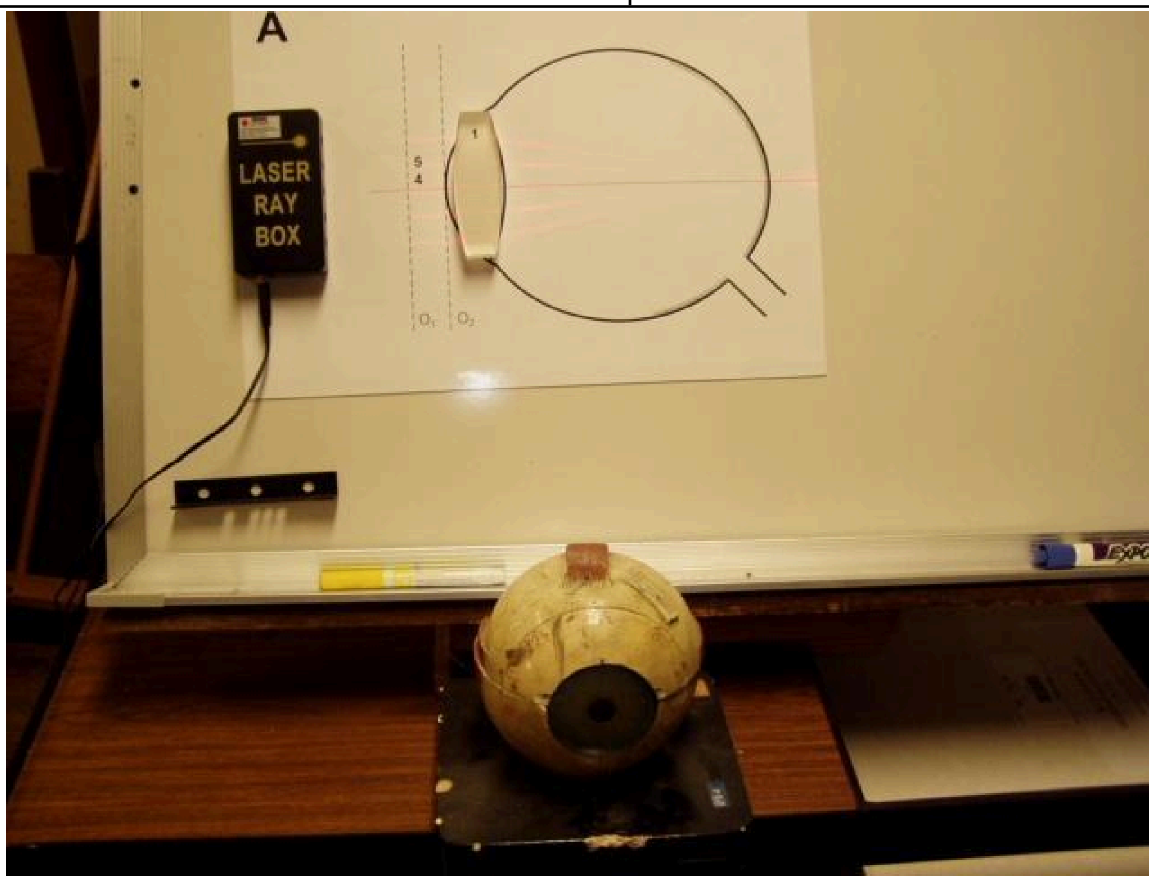
OPTICS	6J10.10	THE EYE

The Eye

Eye Model



The standard take-apart eye model. A Blackboard optics two dimensional version is also shown in the photograph.



Location: Blackboard Optics Cart, Jc5

OPTICS	6J1055	THE EYE
The Eye		

Eye Glasses

	An antique optometrist's refracting kit can be used to show how to correct vision problems. .

Location: Jc5

OPTICS	6Q10.10	MODERN OPTICS
	Holography	
	Holograms	
	Use a laser with a spatial filter to illuminate the hologram.	

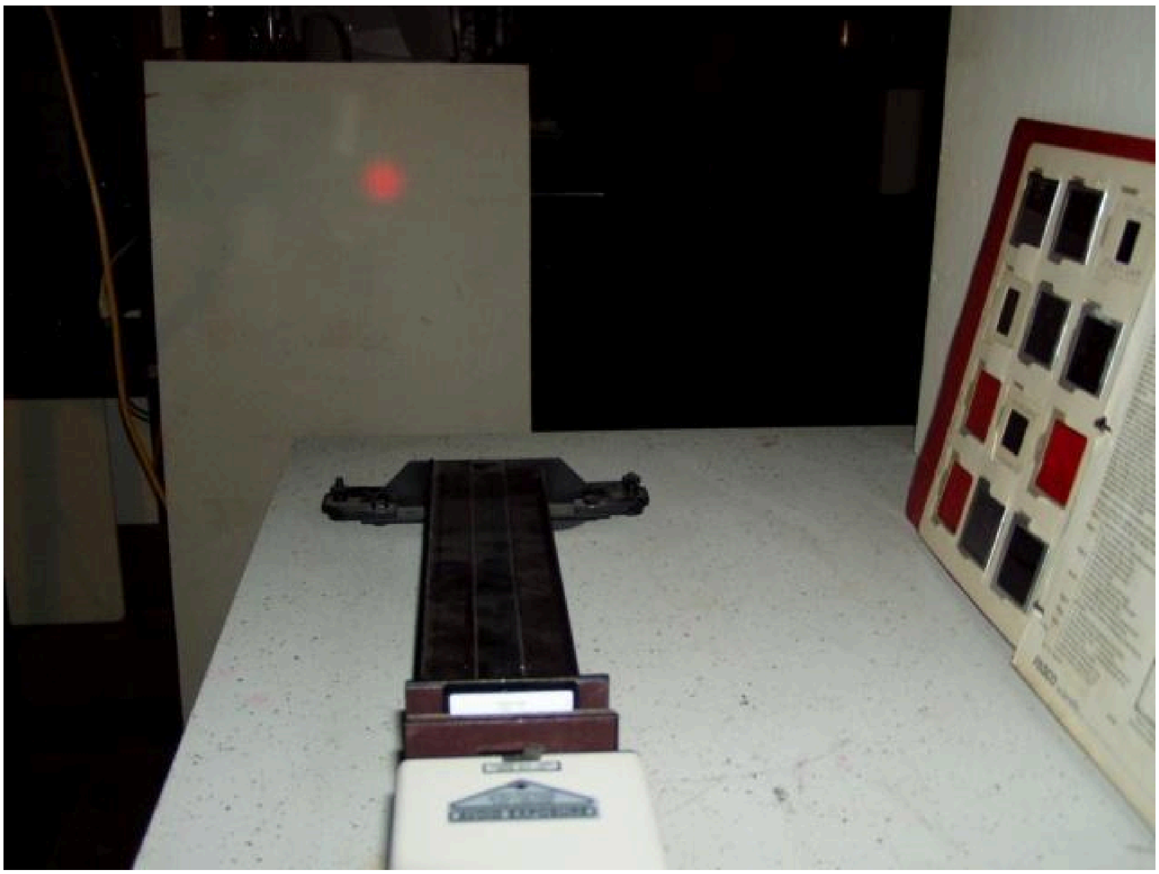
Location: Ja6, Jc6, Optics Table Cart

OPTICS	6Q20.10	MODERN OPTICS

Physical Optics

Abbe's Theory of Imaging

	A laser beam illuminates an "Optical Crystal" (a geometric array of small characters). You see the diffraction pattern consisting of the body factor convolved with the form factor. Insert a lens and you see its Fourier transform, the real image of the Optical Crystal



Location: Jb4, Jd2