OPTICS MAGIC-

Explorations from the PHOTON Projects

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NSTA 2009, New Orleans

OPTICS MAGIC-

A WORD FROM OUR SPONSOR…

- New England Board of Higher Education's projects PHOTON, PHOTON2 and PHOTON PBL were funded by the Advanced Technology Education Program of the National Science Foundation (NSF/ATE)

- These activities are based on the PHOTON Explorations, favorite demonstrations of the teacher-participants of the PHOTON professional development projects in optics/photonics.

www.photonprojects.org

What can you do with light?....

FLAT PANEL DISPLAYS

Fiber Optic Communications

MEDICAL IMAGING

Materials processing

Laser surgery

REMOTE SENSING

MACHINE VISION

Microscopy

Bar Code Scanners

Satellite imaging

Smart structures

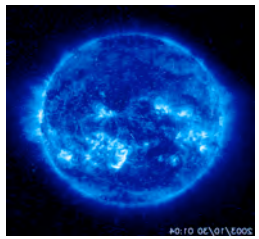
CD and DVD players

Lighting

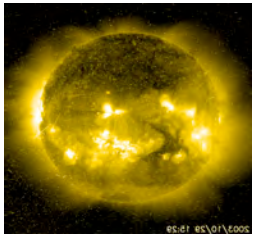
These activities use visible light..

Red
Orange
Yellow
Green
Blue
Violet

..but ultraviolet and infrared are important to science and technology too.



194 nm



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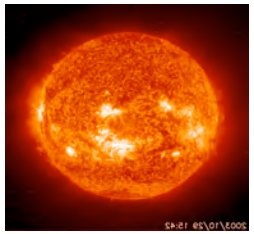

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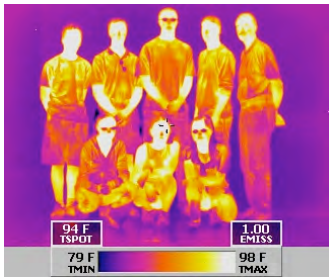


Wavelengths of visible light waves are less than one micrometer (0.000001 m)

This is one micrometer!

This is a hair. (about 80 micrometers in diameter)

This is the wavelength of blue light (0.5 micrometer)

Today's LIGHT experiments:

1. What Color is a…?- *Color vision*
2. The Hidden Colors of Light - *Spectroscopy*
3. Amazing Jello Optics -*Reflection and refraction*
4. The Magic Box - *Polarization*
5. Magic Art - *More polarization*

#1: The Colors of "Things"

THE CHALLENGE

- What color is a tomato?
- Why?
- Can you change the color of a tomato? (no paint allowed!)

THE MATERIALS

- Color LEDs (or flashlight with color filters)
- Pieces of colored candy or paper, fruit, etc

HINT

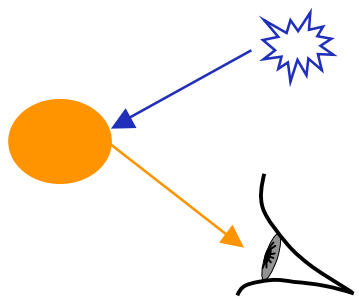
Darken room if possible. Object can be placed inside a deep carton if room lights can't be turned off

#1: The Colors of "Things"

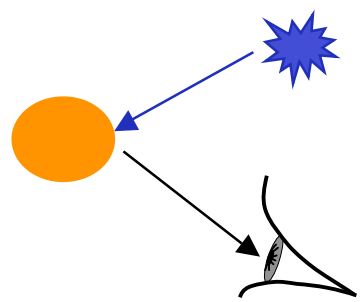
THE EXPLANATION

The color you see depends on:

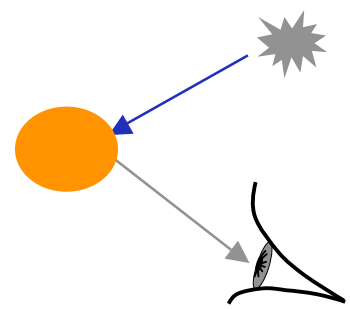
- The wavelengths reflected by the object
- The wavelengths present in the illumination
- The color sensitivity of your eyes



White Light
Looks orange



Blue Light
Looks black



Very Dim White Light
No color vision!

#1: The Colors of "Things"

APPLICATION: Color science is important to display technology, paint matching, and retail illumination.

Southern Cal Edison Lighting Showroom

#2 The Colors of Light

THE CHALLENGE

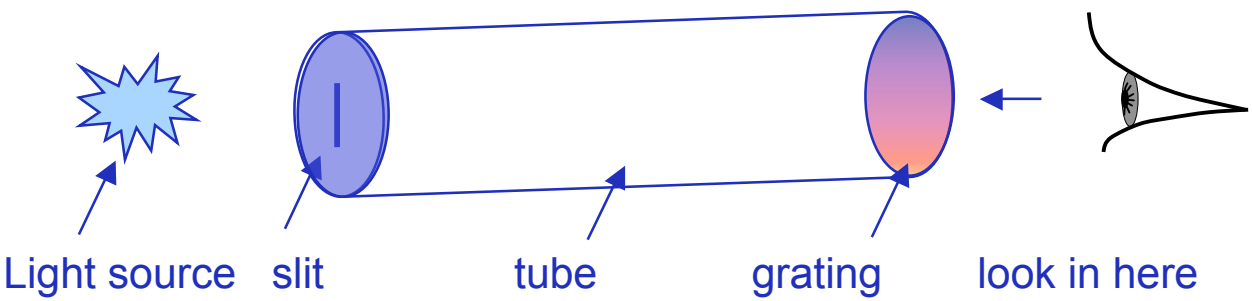
- What colors are given off by a source of light?
- Can you tell what colors are in a source of light just by looking at it?

Yellow?

#2 The Colors of Light

THE MATERIALS: Building the "spectroscope"

1. To separate the light into its basic colors, you could use a prism (difficult!) or a diffraction grating
2. Recycling: use a CD with the label stripped off. (This is a type of diffraction grating.)
3. To block out other nearby light sources, use a short cardboard tube.
4. To separate the colors so they don't overlap, use a slit.



#2 The Colors of Light

SAFETY HINT:

•Don't look at the sun or into a laser!

THE EXPLANATION

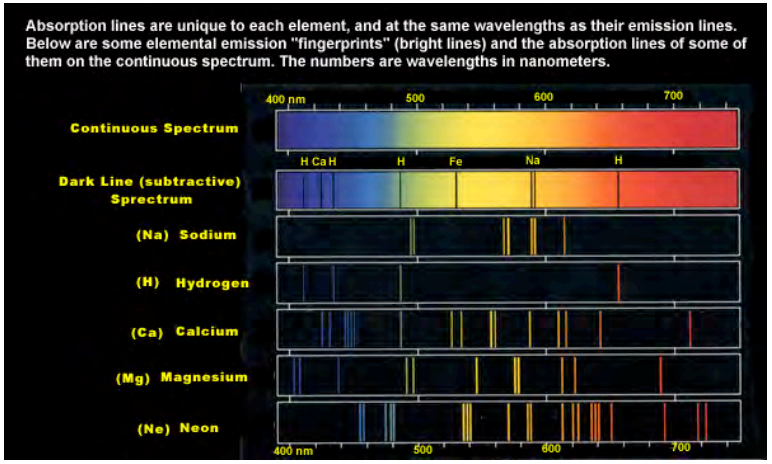
Different types of light use fundamentally different processes to create light. The colors seen depend on the type of source and the source materials (for example, the type of gas in a gas tube.)

- Heat (incandescent bulb)
- Glowing gases (neon lights, sodium street lamps)
- Fluorescent bulbs- the color is determined by the phosphor coating on the inside of the bulb
- Light emitting diodes (LEDs)
- Lasers

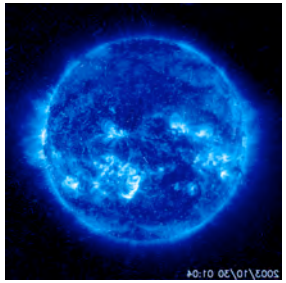
#2 The Colors of Light

APPLICATION

Substances can be identified by the colors they give off when they are heated, or by the colors they absorb.



http://honolulu.hawaii.edu/distance/sci122/



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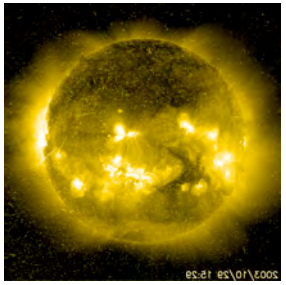

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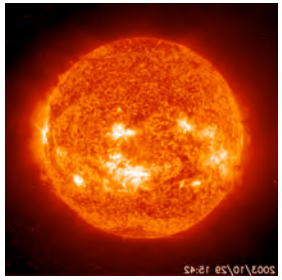


304 nm

UV images of the sun from the SOHO web site
http://sohowww.nascom.nasa.gov/

#3: Jello Optics

THE CHALLENGE

- Can you figure out how a lens works?
- Can you make a lens out of Jello® ?

THE MATERIALS

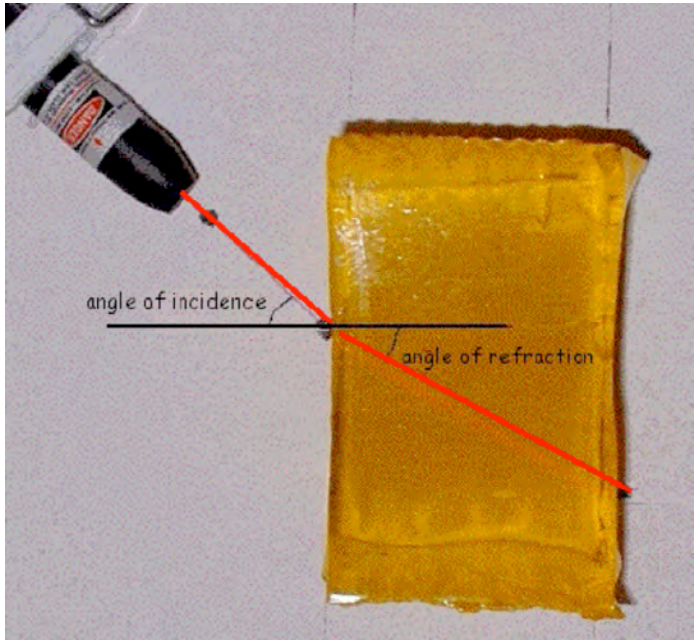
- Jello Jigglers® (recipe is on the box)
- Laser pointers (a focusable flashlight if pointers are not available)
- Toothpicks or plastic strips for cutting
- Round cookie cutter

HINT

Make the Jello 2-3 cm thick. Sugar-free is less sticky. Be sure to make cut edges as smooth as possible.

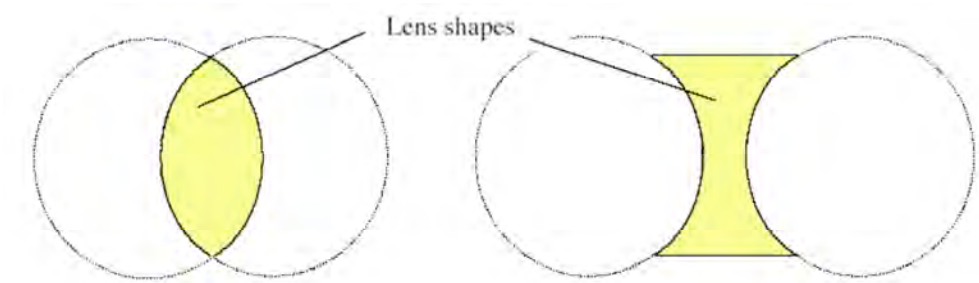
#3: Jello Optics

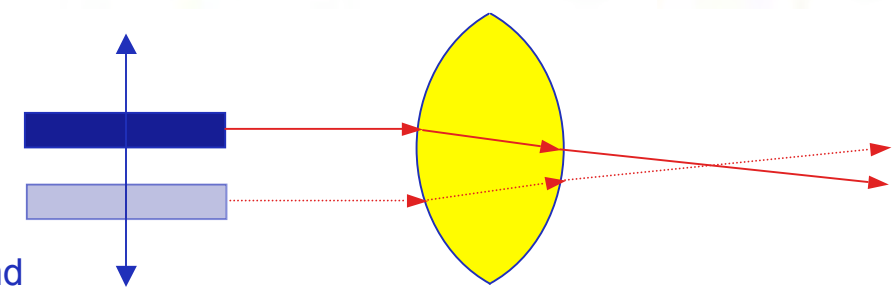
Straight Edges: Shine the laser onto the edge of a rectangular block of Jello. What does the beam do? Try different angles.



#3: Jello Optics

Lens shapes: Use a cookie cutter to make lens shapes like those below. Try to keep the edges straight and even. What happens when the laser beam is moved up and down along the shape as shown?



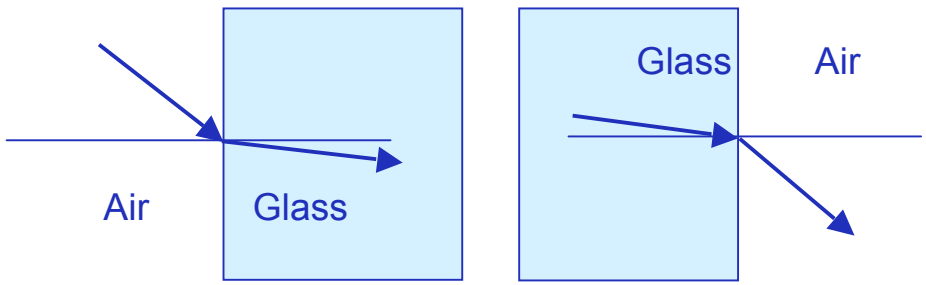


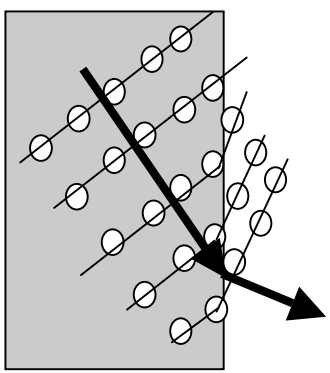
Move the laser up and down without rotating it.

#3: Jello Optics

THE EXPLANATION

When light goes from one medium to another its speed changes. This leads to the bending of the light ray.





This can be illustrated by the “bending” of rows of marchers as they go from one surface to another where their speed changes.

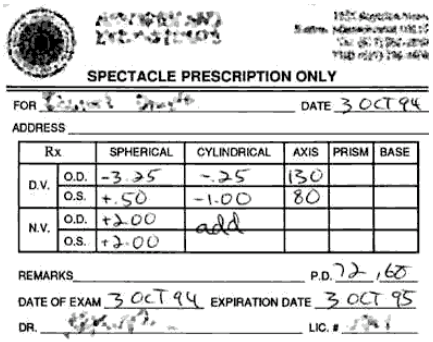
#3: Jello Optics

APPLICATION

There are countless applications of using refraction to direct light in optics! If you wear glasses you have:

- Diverging lenses if you are nearsighted
- Converging lenses if you are farsighted
- Cylindrical lenses if you have astigmatism

Or maybe a combination of all three types!



SPECTACLE PRESCRIPTION ONLY

FOR [illegible] DATE 3 OCT 94

ADDRESS

Rx		SPHERICAL	CYLINDRICAL	AXIS	PRISM	BASE
D.V.	O.D.	-3.25	-.25	130		
	O.S.	+.50	-1.00	80		
N.V.	O.D.	+2.00	add			
	O.S.	+2.00				

REMARKS P.D. 72 / 60

DATE OF EXAM 3 OCT 94 EXPIRATION DATE 3 OCT 95

DR. [illegible] LIC. # [illegible]

#4: The Magic Box

THE CHALLENGE

- Can you make a wall that your hand can pass right though?
- Where does the wall come from?
- How can things pass through it as if it weren't there?

THE MATERIALS

- Empty box
- Four pieces of polarizing filter

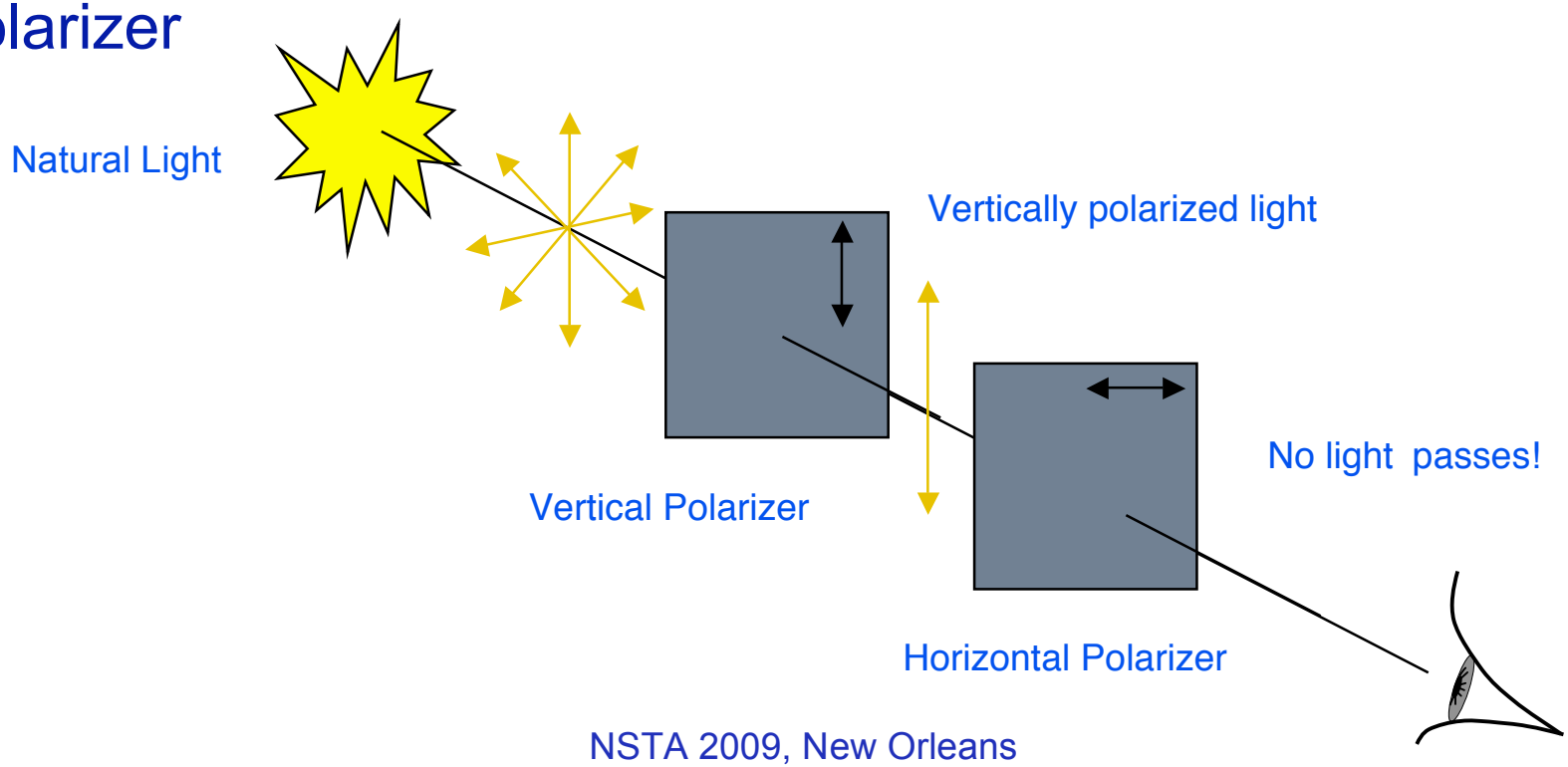
HINT

A knife or chopstick adds drama to the effect!

#4 The Magic Box

THE EXPLANATION

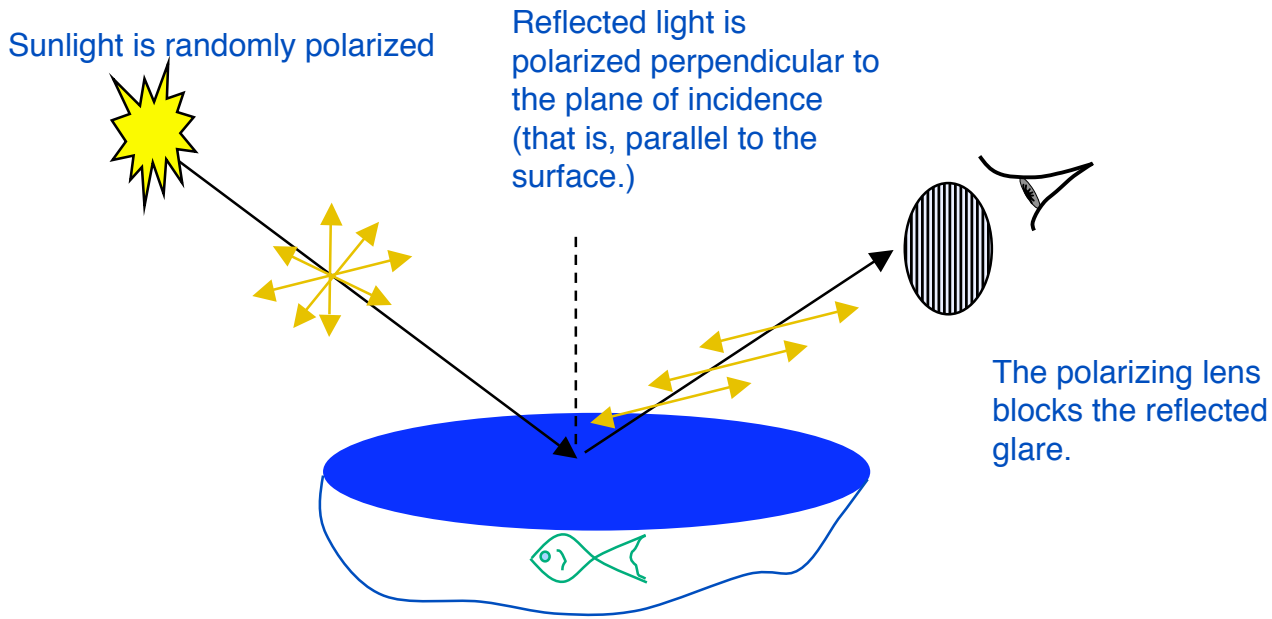
With “natural” light, light waves can vibrate in any direction. Polarizer restrict the direction of vibration along a line. Light waves vibrating vertically cannot pass through a horizontal polarizer



#4 The Magic Box

APPLICATION

Polarized sunglasses work because the glare from water or snow is polarized.



#5: Polarized Light Art

THE CHALLENGE

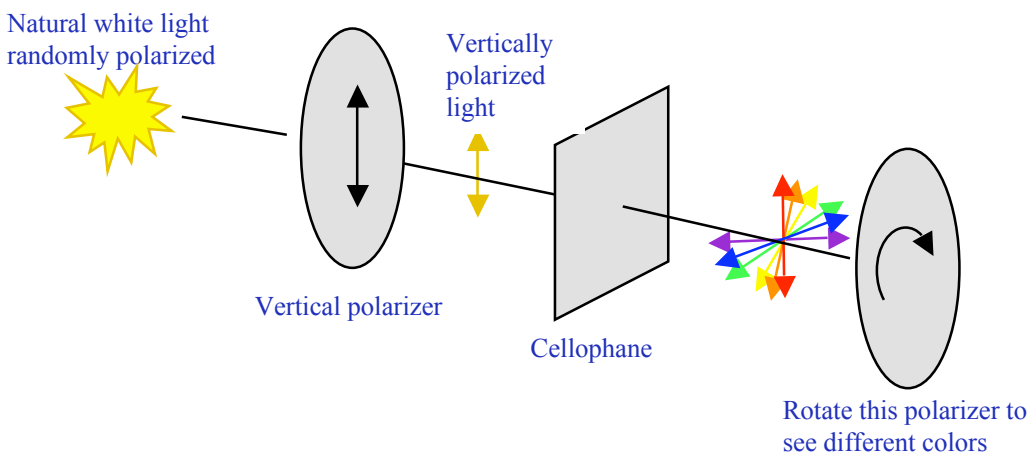
- Cellophane tape is colorless, but between two polarizers it shows brilliant colors. Where do the colors come from?
- Why do the colors change when the polarizers are rotated?

THE MATERIALS

- Two pieces of polarizing filter
- Cellophane tape or other pieces of plastic or cellophane (experiment to see what works)
- Piece of transparency film to protect the polarizing filter

#5 Polarized Light Art

THE EXPLANATION "Birefringent" materials like cellophane rotate the vibration direction of the light wave. The amount of rotation depends on the wavelength of the light (color) and thickness of the material.



#5 Polarized Light Art

APPLICATION

This technique can be used to make beautiful works of art that change as you look at them through a rotating polarizer.

from www.austine.com

Complete Instructions

The PHOTON Explorations can be downloaded from

www.photonprojects.org (Click on Teaching Resources)

Where to Buy

The PHOTON Explorations use relatively simple materials that are inexpensive and easy to find. For other items we use:

Polarizing film by the roll

www.polarization.com

Diffraction gratings

www.rainbowsymphonystore.com

Color LEDs

The best are PHOTON MicroLights, but they are expensive. You can also use a flashlight and colored plastic.

Laser pointers

You can also use inexpensive laser levels.

Resources for teaching optics

Web sites with information and activities

www.photonprojects.org
www.opticsforkids.org
www.hands-on-optics.org

Free posters and career materials

Available at www.spie.org and www.osa.org

List of optics tutorials and Java/Flash applets

http://www.lasertechonline.org/optics_links.html

College and career information

www.qcc.cuny.edu/physics/lfot/LFOT_FAQs.asp
www.opticseducation.org/