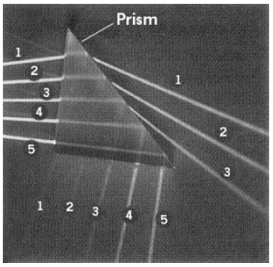
Physics 1161: Lecture 18

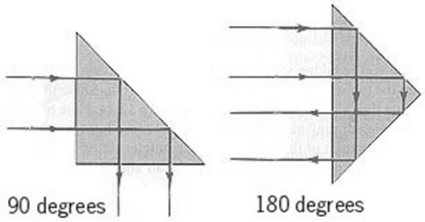
Rainbows, Fiber Optics, Sun Dogs, Sun Glasses

- **sections 26-8 & 25-5**

Internal Reflection



Internal Reflection in Prisms



Total Internal Reflection

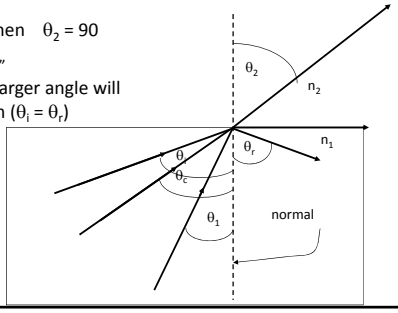
Recall Snell's Law: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

$(n_1 > n_2 \Rightarrow \theta_2 > \theta_1)$

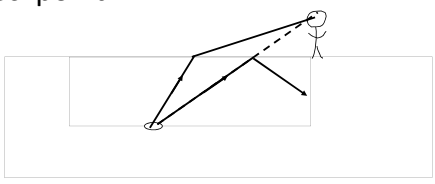
$\theta_1 = \sin^{-1}(n_2/n_1)$ then $\theta_2 = 90$

"critical angle"

Light incident at a larger angle will only have reflection ($\theta_i = \theta_r$)



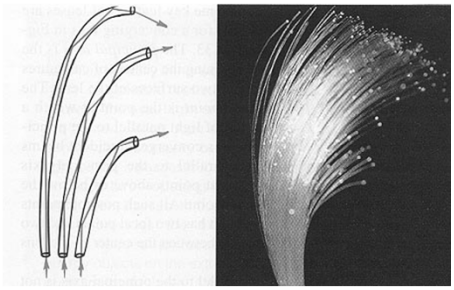
Pool Checkpoint



Can the person standing on the edge of the pool be prevented from seeing the light by total internal reflection ?

1) Yes 2) No

Fiber Optics



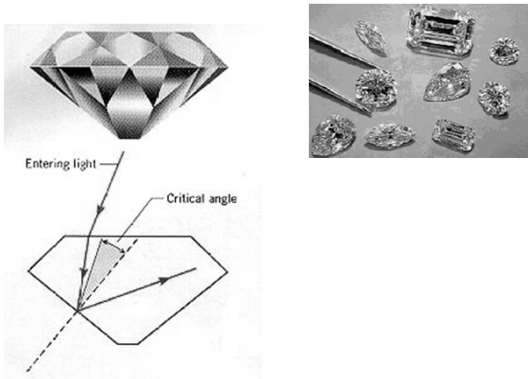
Indices of Refraction

Material	Index of Refraction	
Vacuum	1.0000	<--lowest optical density
Air	1.0003	
Ice	1.31	
Water	1.333	
Ethyl Alcohol	1.36	
Plexiglas	1.51	
Crown Glass	1.52	
Light Flint Glass	1.58	
Dense Flint Glass	1.66	
Zircon	1.923	
Diamond	2.417	
Rutile	2.907	
Gallium phosphide	3.50	<--highest optical density

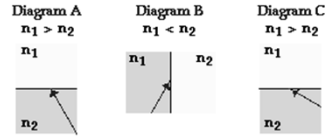
What is the critical angle of a diamond-air boundary?

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$ ← critical angle

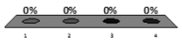
Internal Reflection in Diamond



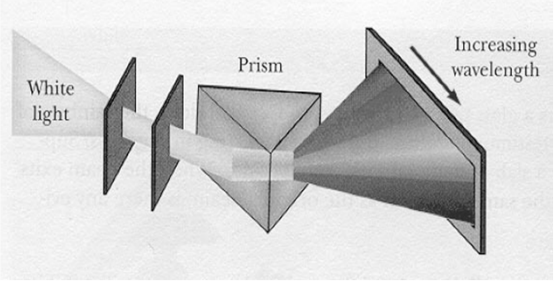
The diagrams show incident rays approaching a boundary with a second medium. The relative indices of refraction of the two media are indicated. In which diagram will total internal reflection occur, providing the angle of incidence exceeds the critical angle?



1. Diagram A
2. Diagram B
3. Diagram C
4. None of these



Dispersion
Blue Bends Best



Refractive Index Function of Wavelength

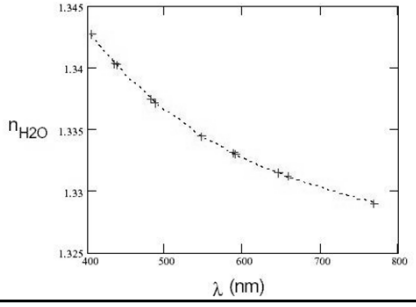
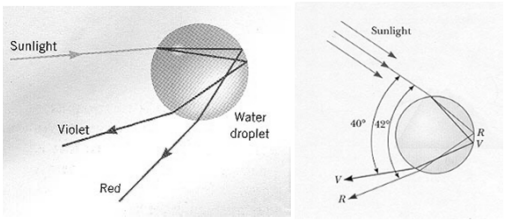


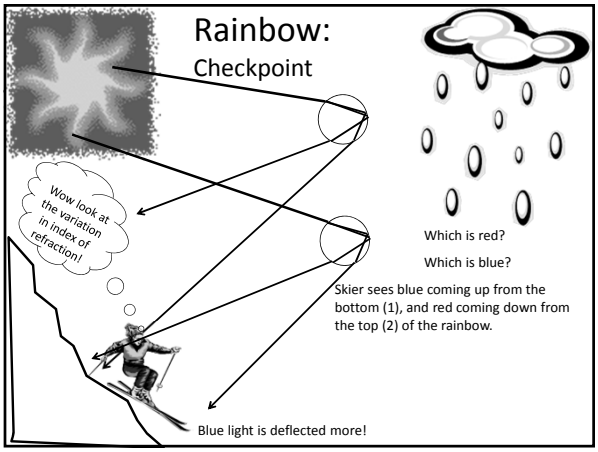
Table of Indices

Material	Blue (486.1 nm)	Yellow (589.3 nm)	Red (656.3 nm)
Crown Glass	1.524	1.517	1.515
Flint Glass	1.639	1.627	1.622
Water	1.337	1.333	1.331
Cargille Oil	1.53	1.52	1.516
Carbon Disulfide	1.652	1.628	1.618

Refraction & Reflection in a Raindrop



Rainbow: Checkpoint



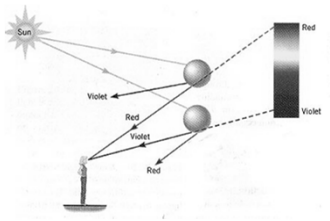
Which is red?

Which is blue?

Skier sees blue coming up from the bottom (1), and red coming down from the top (2) of the rainbow.

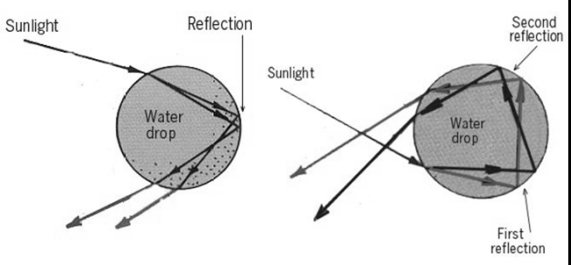
Blue light is deflected more!

Rainbow Formation

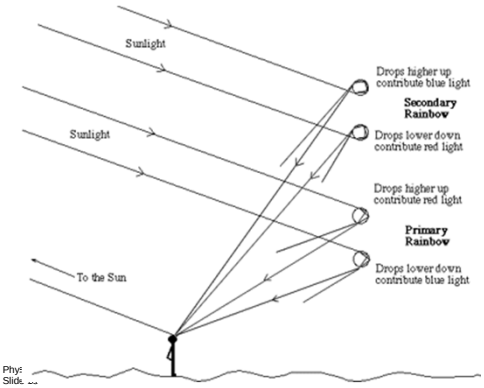


- An observer sees red light coming from droplets of water higher in the sky.
- Droplets of water lower in the sky send violet light to the eye.

Double Rainbow Diagrams



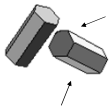
Double Rainbow Diagram



Alexander's Dark Band

- Sky is light inside primary rainbow
- Dark between primary and secondary bows
- Light beyond the secondary rainbow
- Dark region between is called Alexander's Dark Band

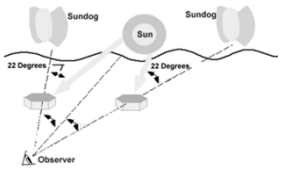
22° Halo

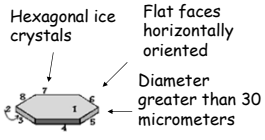


- A halo is a ring of light surrounding the sun or moon.
- Most halos appear as bright white rings but in some instances, the dispersion of light as it passes through ice crystals found in upper level cirrus clouds can cause a halo to have color.

Sundogs

- Sundogs or parhelia on right and left of sun

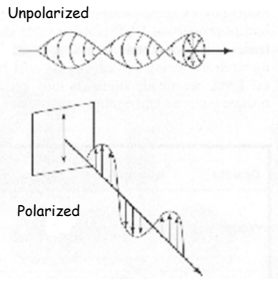




Sundog

Unpolarized & Polarized Light

Polarization of Light



Electric fields of unpolarized light vibrate in all directions perpendicular to the direction the light travels.

A **polarizing filter** can constrain light to vibrate in only one direction

Unpolarized Light Checkpoint

- Unpolarized light (like the light from the sun) passes through a polarizing sunglass (a linear polarizer).
- The intensity of the light when it emerges is
  1. Zero
  2. 1/2 what it was before
  3. 1/4 what it was before
  4. 1/3 what it was before
  5. Need more information

Polarized Light Checkpoint

- Now, horizontally polarized light passes through the same glasses (which are vertically polarized).
- The intensity of the light when it emerges is:
  1. Zero
  2. 1/2 what it was before
  3. 1/4 what it was before
  4. 1/3 what it was before
  5. Need more information

Polarizing Filters

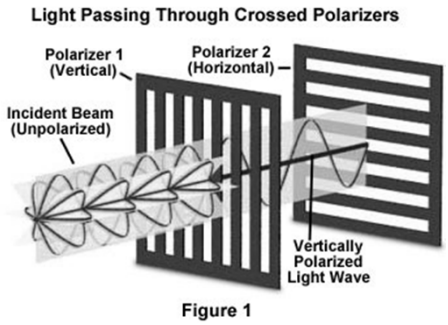
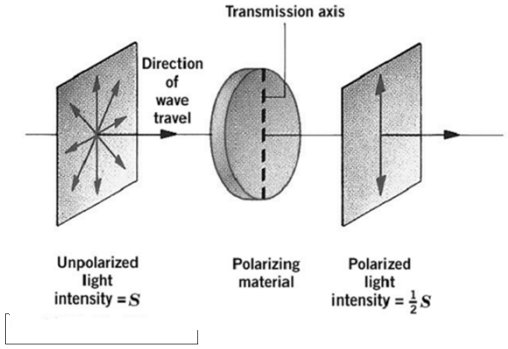


Figure 1

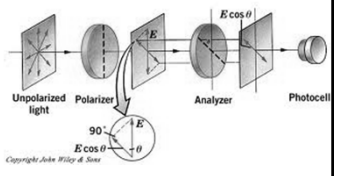
Polarization



Law of Malus

When a second polarizer is rotated, the vector component perpendicular to its transmission plane is absorved, reducing its amplitude to

$E = E_0 \cos\theta$

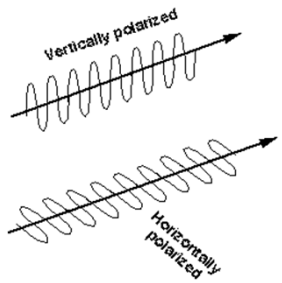


Since the transmitted intensity is proportional to the square of the amplitude, the intensity is given by the formula

$I = I_0 \cos^2\theta$

Theta is the angle between the two poloarizers.

Polarization



Reflected Horizontally Polarized

·**Polarization of Reflected Light**

Sun Glasses Checkpoint

- Polaroid sun glasses are often considered better than tinted sunglasses because:
  1. They block more light
  2. They are safer for your eyes
  3. They decrease glare
  4. They are cheaper

Brewster's Angle

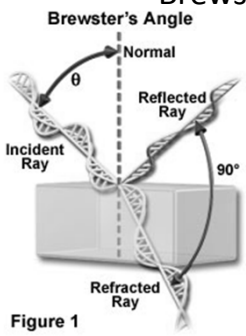
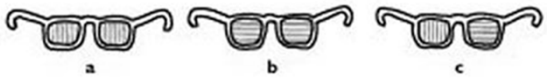


Figure 1

·**Polarization of Reflected Light**

Which pair of glasses is best suited for automobile drivers? (The polarization axes are shown by the straight lines.)



1. A
2. B
3. C