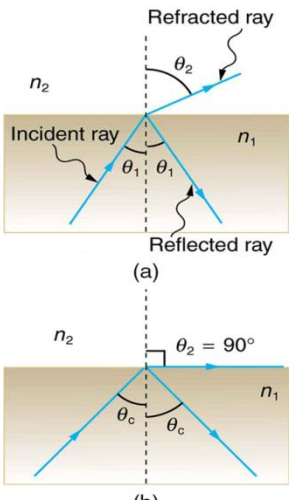
Physics 11-04 Total Internal Reflection Name: _____

Total Internal Reflection

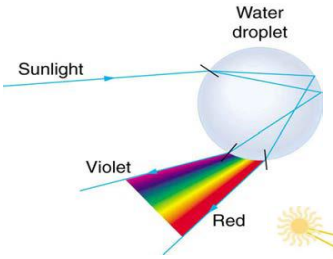


- When light hits an _____ between two types of _____ with different indices of _____
  - Some is _____
  - Some is _____
- Critical angle
  - Angle of _____ where _____ angle is _____
  - Angles of incidence _____ than this cause the _____ angle to be _____ the material. This can't happen, so _____ refraction occurs.
  - $\theta_c = \sin^{-1}\frac{n_2}{n_1}$
    - Where $n_1 > n_2$

What is the critical angle from cubic zirconia (n=2.16) to air? Will an angle of 25° produce total internal reflection?

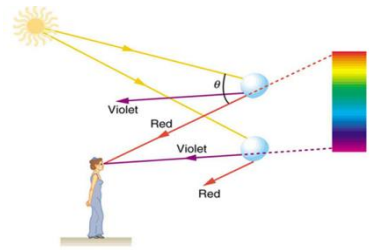
Uses of total internal reflection

- _____ _____ for
  - Endoscopes
  - Telecommunications
  - Decorations
- _____ /telescopes
  - Makes them shorter
- Reflectors
- Gemstones
  - Cut so that light only _____ at certain _____



Dispersion

- Each _____ of light has a different _____ of refraction
  - Red — _____
  - Violet — _____
  - When light is refracted, the violet bends more than red, which _____ the colors
- Rainbows
  - _____ by _____ with internal _____
  - Rainbows are always the _____ direction from the sun



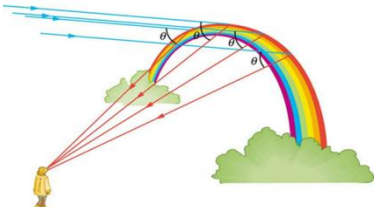


Table 25.2 Index of Refraction *n* in Selected Media at Various Wavelengths

Medium	Red (660 nm)	Orange (610 nm)	Yellow (580 nm)	Green (550 nm)	Blue (470 nm)	Violet (410 nm)
Water	1.331	1.332	1.333	1.335	1.338	1.342
Diamond	2.410	2.415	2.417	2.426	2.444	2.458
Glass, crown	1.512	1.514	1.518	1.519	1.524	1.530
Glass, flint	1.662	1.665	1.667	1.674	1.684	1.698
Polystyrene	1.488	1.490	1.492	1.493	1.499	1.506
Quartz, fused	1.455	1.456	1.458	1.459	1.462	1.468

"I have set my rainbow in the clouds, and it will be the sign of the covenant between me and the earth." Genesis 9:13

Homework

1. A high-quality diamond may be quite clear and colorless, transmitting all visible wavelengths with little absorption. Explain how it can sparkle with flashes of brilliant color when illuminated by white light.
2. The most common type of mirage is an illusion that light from faraway objects is reflected by a pool of water that is not really there. Mirages are generally observed in deserts, when there is a hot layer of air near the ground. Given that the refractive index of air is lower for air at higher temperatures, explain how mirages can be formed.
3. Verify that the critical angle for light going from water to air is 48.6°. (OpenStax 25.20) **48.6°**
4. (a) Verify that the critical angle for light going from diamond to air is 24.4°. (b) What is the critical angle for light going from zircon to air? (OpenStax 25.21) **24.4°, 31.3°**
5. An optical fiber uses flint glass clad with crown glass. What is the critical angle? (OpenStax 25.22) **66.3°**
6. At what minimum angle will you get total internal reflection of light traveling in water and reflected from ice? (OpenStax 25.23) **79.11°**
7. You can determine the index of refraction of a substance by determining its critical angle. (a) What is the index of refraction of a substance that has a critical angle of 68.4° when submerged in water? What is the substance, based on Table 25.1? (b) What would the critical angle be for this substance in air? (OpenStax 25.25) **Fluorite, 44.2°**
8. A ray of light, emitted beneath the surface of an unknown liquid with air above it, undergoes total internal reflection as shown in Figure 1. What is the index of refraction for the liquid and its likely identification? (OpenStax 25.26) **1.50, Benzene**
9. (a) What is the ratio of the speed of red light to violet light in diamond, based on Table 25.2? (b) What is this ratio in polystyrene? (c) Which is more dispersive? (OpenStax 25.28) **1.020, 1.012, diamond**
10. A beam of white light goes from air into water at an incident angle of 75.0°. At what angles are the red (660 nm) and violet (410 nm) parts of the light refracted? (OpenStax 25.29) **46.5°, 46.0°**

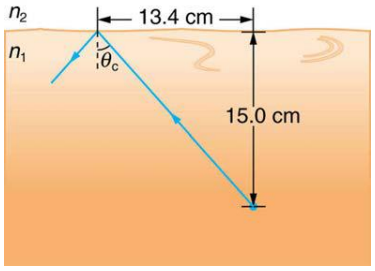


Figure 1

11. By how much do the critical angles for red (660 nm) and violet (410 nm) light differ in a diamond surrounded by air? (OpenStax 25.30) **0.51°**