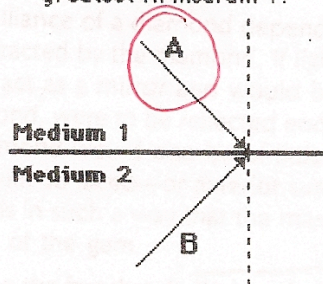


Refraction and Total Internal Reflection

- For each combination of media, which light ray (A or B) will undergo total internal reflection if the incident angle is gradually increased?

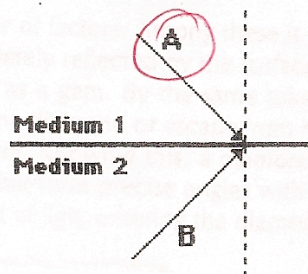
Practice A

The index of refraction is greatest in medium 1.



Practice B

Medium 1 is more optically dense. — *n is higher!*



- TIR only takes place when two conditions are met. What are they?
— incident medium has a higher index of refraction; θ_i is greater than critical angle.
- Suppose that the angle of incidence of a laser beam in water and heading towards air is adjusted to 50-degrees. Use Snell's law to calculate the angle of refraction? Explain your result (or lack of result).
↳ no refraction, θ_i is greater than the critical angle!
- Calculate the critical angle for an ethanol-air boundary. Refer to the table of indices of refraction if necessary. $n_i = 1.36$ $\theta_i = ?$ $n_r = 1.0003$ $\theta_r = 90.0^\circ$
 $n_i \sin \theta_i = n_r \sin \theta_r$ $\theta_i = 47.4^\circ$
- Calculate the critical angle for an flint glass-air boundary. $n_{\text{glass}} = 1.58$ (n_i) $n_r = 1.0003$ $\theta_r = 90.0^\circ$
 $n_i \sin \theta_i = n_r \sin \theta_r$ $\theta_i = 39.3^\circ$
- Calculate the critical angle for a diamond-crown glass boundary. Refer to the table of indices of refraction if necessary. $n_i = 2.42$ $\theta_i = ?$ $n_r = 1.52$ $\theta_r = 90.0^\circ$
 $n_i \sin \theta_i = n_r \sin \theta_r$ $\theta_i = 38.9^\circ$

And also complete:

Textbook page 363-365 # 3, 5, 7, 9, 11, 15, 20, 22, 25, 27

Critical Thinking: The Shape of a Diamond

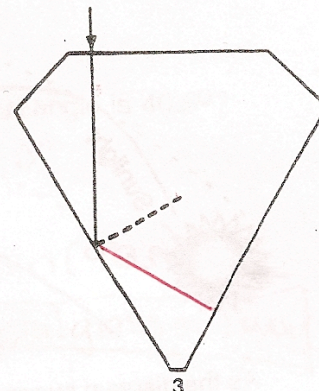
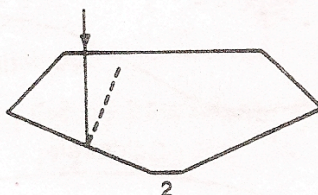
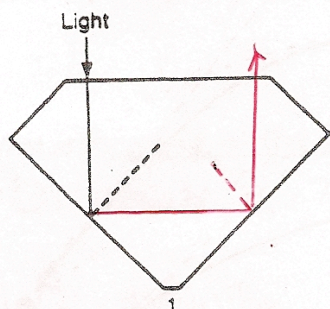
Calculating the Critical Angle (2 sided)

CHAPTER 17 Critical Thinking

THE SHAPE OF A DIAMOND

The brilliance of a diamond depends on a number of factors. Among these is the way light is reflected and refracted by the diamond. If light were completely reflected by the surface of a diamond, it would simply act as a mirror and would be of no value as a gem. By the same token if light, once entering a diamond, were to be reflected endlessly within the diamond or escape from its bottom or lower sides, the diamond would also be of little value as a gem. Knowing this, a diamond cutter must produce a stone with 58 facets—or exterior surface planes—that form precise angles with one another. The cutter does this in such a way that the maximum amount of light entering the diamond leaves the facets near the top of the gem.

Based on the fact that the index of refraction of a diamond is 2.42, examine the following three simplified drawings of cut diamonds and answer the questions that follow. The only tool you will need is a protractor.



----- Normal

1. What datum must you first calculate?

critical angle!

2. How can you accomplish this calculation?

Snell's Law $n_i \sin \theta_i = n_r \sin \theta_r$

3. What is the numerical value of this datum?

$(2.42) \sin \theta_i = (1.0003) \sin (90.0^\circ)$ $\theta_i = 24.5^\circ$

4. Which of the diamonds is most correctly cut? Explain your answer.

5. To support your answer, complete each illustration by drawing its ray diagram.

Name: Key

Calculating the Critical Angle

1. What is the critical angle if light travels from flint glass to air?

$$\theta_i = ? \quad n_i = 1.65 \quad n_r = 1.0003 \quad \theta_r = 90.0^\circ$$

$$n_i \sin \theta_i = n_r \sin \theta_r \quad (1.65) \sin \theta_i = (1.0003) \sin(90.0)$$

$$\boxed{\theta_i = 37.3^\circ}$$

2. What is the critical angle if light travels from ruby into ethyl alcohol?

$$\theta_i = ? \quad n_i = 1.54 \quad n_r = 1.36 \quad \theta_r = 90.0^\circ$$

$$n_i \sin \theta_i = n_r \sin \theta_r \quad (1.54) \sin \theta_i = (1.36) \sin(90.0)$$

$$\boxed{\theta_i = 62.0^\circ}$$

3. What is the name of the medium that light travels in if the critical angle is 40.5° ?

$$\theta_i = 40.5^\circ \quad n_i = ? \quad n_r = 1.0003 \quad \theta_r = 90.0^\circ$$

$$n_i \sin \theta_i = n_r \sin \theta_r \quad n_i \sin(40.5) = (1.0003) \sin(90.0)$$

$$\boxed{n_i = 1.54 \rightarrow \text{crystal glass or ruby}}$$

4. What is the critical angle for light when it goes from zircon to diamond?

- no critical angle from zircon to diamond (diamond is more refractive)
 - from diamond to zircon:

$$n_i = 2.42 \quad \theta_i = ? \quad n_r = 1.92 \quad \theta_r = 90.0^\circ$$

$$n_i \sin \theta_i = n_r \sin \theta_r \quad (2.42) \sin \theta_i = (1.92) \sin(90.0)$$

$$\boxed{\theta_i = 52.5^\circ}$$

BONUS: If it takes light 5.22×10^{-8} seconds to travel through 10.3 meters of a substance, what would the critical angle be if it left this substance and entered water?

$$n_i = \frac{3.00 \times 10^8 \text{ m/s}}{v} \quad v = \frac{d}{t} = \frac{10.3 \text{ m}}{5.22 \times 10^{-8} \text{ s}} = 1.97 \times 10^8 \text{ m/s}$$

$$n_i = \frac{3.00 \times 10^8 \text{ m/s}}{1.97 \times 10^8 \text{ m/s}} = 1.52 \quad \theta_i = ? \quad n_r = 1.33 \quad \theta_r = 90.0^\circ$$

$$n_i \sin \theta_i = n_r \sin \theta_r \quad (1.52) \sin \theta_i = (1.33) \sin(90.0)$$

$$\boxed{\theta_i = 61.0^\circ}$$

CRITICAL ANGLE

1. What is the critical angle if light travels from water to air?

$$n_i = 1.33 \quad \theta_i = ? \quad n_R = 1.0003 \quad \theta_R = 90.0^\circ$$
$$n_i \sin \theta_i = n_R \sin \theta_R \quad (1.33) \sin \theta_i = (1.0003) \sin (90.0)$$

$$\boxed{\theta_i = 48.8^\circ}$$

2. What is the critical angle if light travels from ethanol into air?

$$n_i = 1.36 \quad \theta_i = ? \quad n_R = 1.0003 \quad \theta_R = 90.0^\circ$$
$$n_i \sin \theta_i = n_R \sin \theta_R \quad (1.36) \sin \theta_i = (1.0003) \sin (90.0)$$

$$\boxed{\theta_i = 47.4^\circ}$$

3. What is the name of the medium that light travels in if the critical angle is ~~40.5~~ ^{48.15} degrees?

$$n_i = ? \quad \theta_i = 48.75^\circ \quad n_R = 1.0003 \quad \theta_R = 90.0^\circ$$
$$n_i \sin \theta_i = n_R \sin \theta_R \quad n_i \sin (48.75) = (1.0003) \sin (90.0)$$
$$\boxed{n_i = 1.33; \text{water}}$$

4. What has a greater critical angle, crown glass or flint glass?

$$n_{\text{crown}} = 1.52 \quad n_{\text{flint}} = 1.65 \quad \theta_i = ? \quad n_R = 1.0003 \quad \theta_R = 90.0^\circ$$

<u>crown</u>	<u>flint</u>
$n_i \sin \theta_i = n_R \sin \theta_R$	$n_i \sin \theta_i = n_R \sin \theta_R$
$(1.52) \sin \theta_i = (1.0003) \sin (90.0)$	$(1.65) \sin \theta_i = (1.0003) \sin (90.0)$
$\theta_i = 41.2^\circ$	$\theta_i = 37.3^\circ$

Crown glass has a greater critical angle