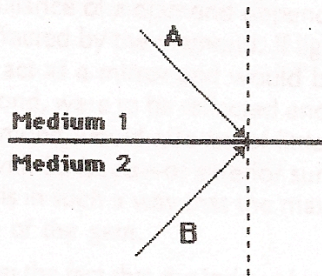


## Refraction and Total Internal Reflection

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

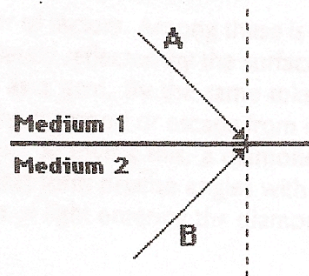
### Practice A

The index of refraction is greatest in medium 1.



### Practice B

Medium 1 is more optically dense.



- TIR only takes place when two conditions are met. What are they?
- 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).
- Calculate the critical angle for an ethanol-air boundary. Refer to the table of indices of refraction if necessary.
- Calculate the critical angle for an flint glass-air boundary.  $n_{\text{glass}}=1.58$
- Calculate the critical angle for a diamond-crown glass boundary. Refer to the table of indices of refraction if necessary.

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)

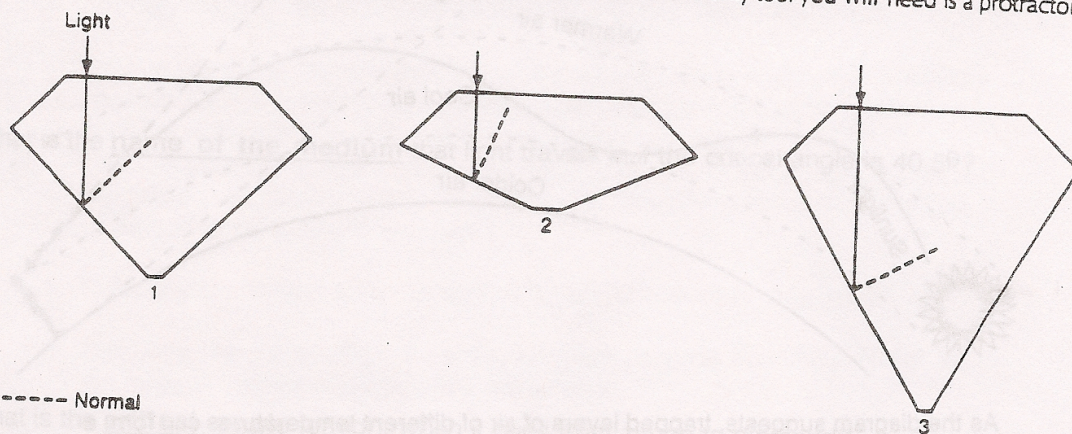


# CHAPTER 17 Critical Thinking

## 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.

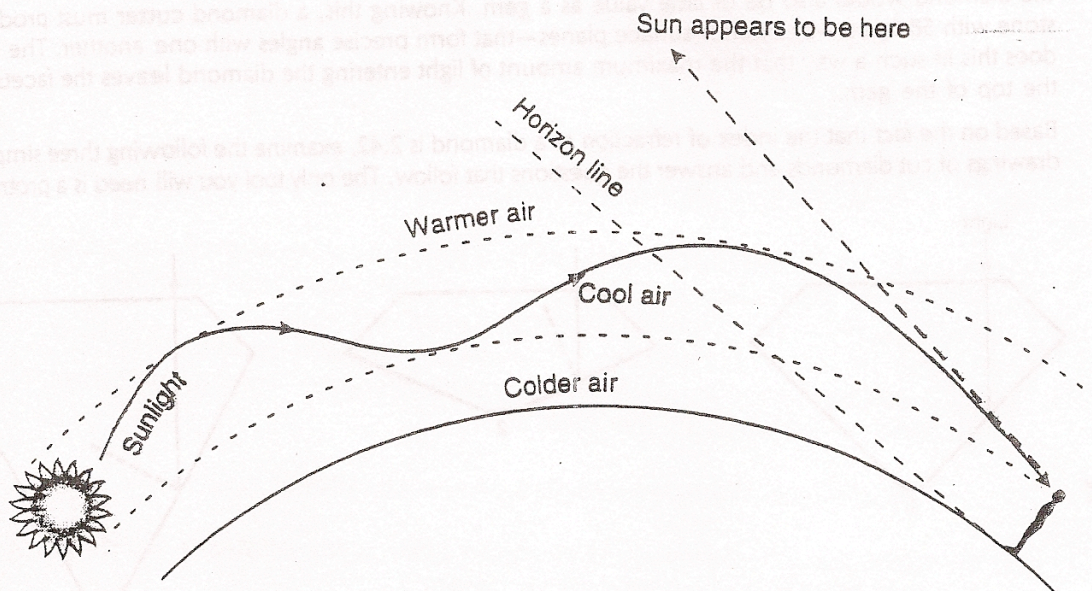


1. What datum must you first calculate?
2. How can you accomplish this calculation?
3. What is the numerical value of this datum?
4. Which of the diamonds is most correctly cut? Explain your answer.
5. To support your answer, complete each illustration by drawing its ray diagram.



## Seeing Is Not Necessarily Believing, or the Unpredictability of Sunrise

It was January 1597 and the Arctic explorer Willem Barents and his crew were locked in a high Arctic ice jam on a region north of Siberia called Novaya Zemlya Land. The Arctic gloom and cold must have been oppressive to say the least. Near the end of January at about noon Barents and his crew were startled to see the sun suddenly appear. This was very unusual because it was several weeks before Barents's astronomical almanac predicted the rising of the sun should occur. Scientists of the time refused to believe Barents. Eventually, however, an explanation for what has been called the Novaya Zemlya mirage was developed.



As the diagram suggests, trapped layers of air of different temperatures can form a natural "light pipe" that can cause light from the sun to travel along the curvature of the earth and to appear in your line of sight even though it is, in reality, below the horizon. Russ Sampson, an amateur astronomer from Edmonton, observed this effect from his high-rise apartment in January 1991. He writes: "For the first two weeks the Sun rose as expected. But on January 6, 1991, I was shocked to see the Sun's upper limb poke above the horizon more than 5 minutes and 2 degrees further north than it had on the previous morning! Equally bizarre, this sliver of the solar disk remained visible for only about 15 seconds before it sank below the horizon! Then, about 45 seconds later, a rectangular strip of the sun appeared. Over the next three minutes it crawled southward along the horizon until it reached the expected position of sunrise. A distorted Sun then rose about as predicted in the ephemeris."

The Novaya Zemlya mirage teaches us an interesting lesson. While we might think that predicting the exact time of sunrise should be a relatively simple calculation for an astronomer it turns out to be highly dependent upon atmospheric and meteorological conditions. In this sense the time of sunrise remains unpredictable!



## Calculating the Critical Angle

Name: \_\_\_\_\_

1. What is the critical angle if light travels from flint glass to air?
2. What is the critical angle if light travels from ruby into ethyl alcohol?
3. What is the name of the medium that light travels in if the critical angle is  $40.5^\circ$ ?
4. What is the critical angle for light when it goes from zircon to diamond?

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



## Seeing is Not Necessarily Understanding or the Unpredictability of the Unpredictable

### CRITICAL ANGLE

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

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

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

48.15°

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