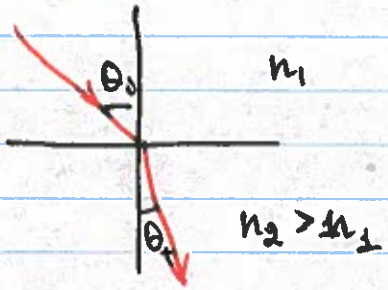
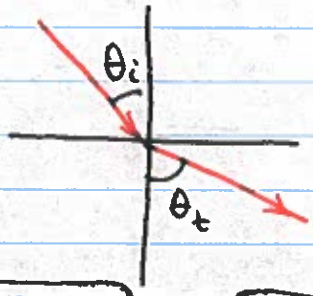
Quick recap: refraction is governed by

Snell's law: $n_1 \sin\theta_i = n_2 \sin\theta_t$



$\theta_i > \theta_t$



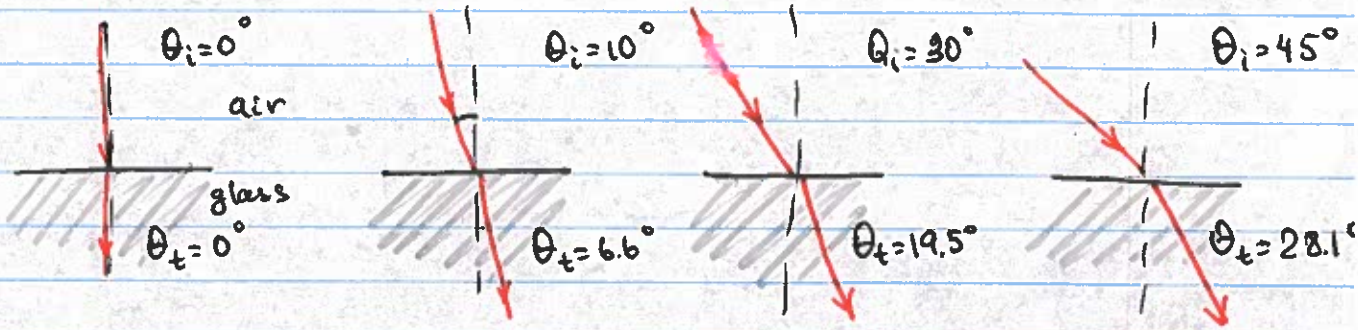
$\theta_i < \theta_t$

$$\sin\theta_t = \frac{n_1}{n_2}\sin\theta_i$$

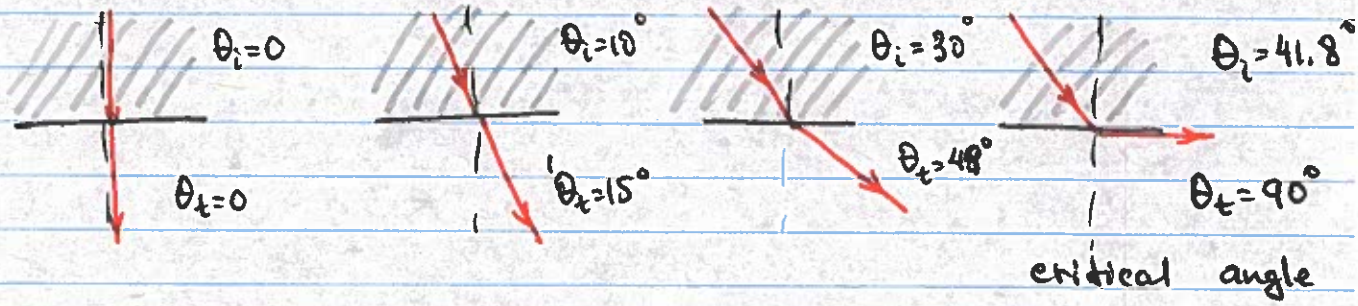
A shortcut: for angles <

$$\theta_t \approx \frac{n_1}{n_2}\sin\theta_i$$

Just for the reference: air - glass ($n_{glass} \approx 1.5$) interface



If light goes from glass to air



critical angle

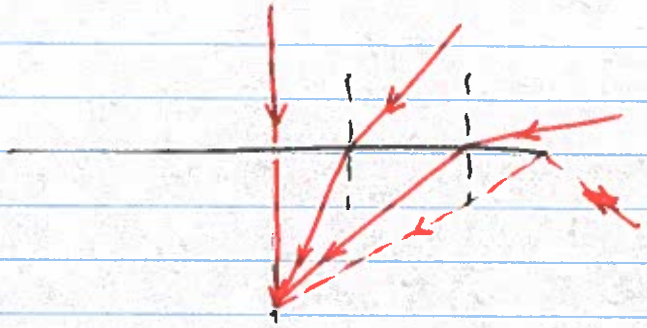
$$n_{glass} \cdot \sin\theta_i^{(cr)} = \sin 90° = 1$$

$$\sin\theta_i^{(cr)} = \frac{1}{n_{glass}}$$

if $\theta_i > \theta_i^{(cr)}$ — light cannot be transmitted

Total internal reflection (TIR)

So why we see a "window" (called Snell's window) if we are under water?



Any light from outside the water will be within a cone of critical angle for water $\theta_{cr} = \sin^{-1}\left(\frac{1}{1.33}\right) = 4^{\circ}$

For any larger angles all the light will be totally internally reflected from inside the pool

What makes diamond sparkle? – again, total internal reflection!

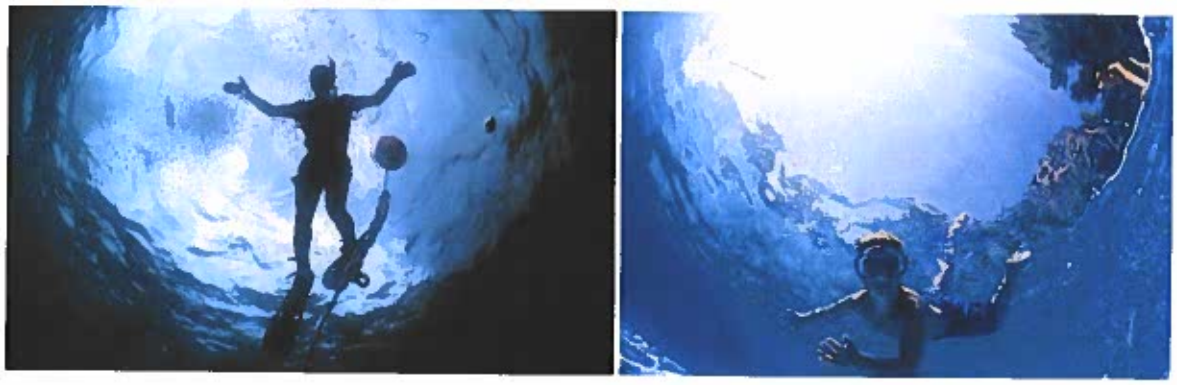
$n_{diamond} \approx 2.42$

Critical angle of TIR $\theta^{(cr)}_{diamond} = 24.4^{\circ}$

Well cut diamond reflects most of the incident light back into your eyes

TOTAL INTERNAL REFLECTION

Snell's window



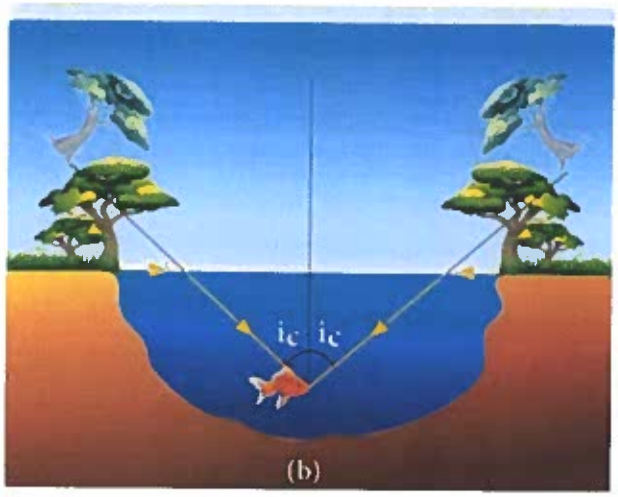


Figure 6.26 (a) Snell's window and (b) angle of view for water animals

Any light coming from outside (i.e, transmitted through the water) comes in a cone, defined by the water critical angle ($\approx 49°$)

The objects closer to the ground levels (i.e the rays arriving with $\theta_i \approx 90°$) are severely distorted / smooshed at the edges of the cone.

TOTAL INTERNAL REFLECTION

Diamond cut

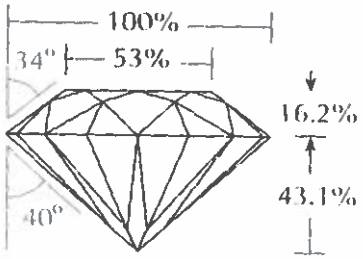
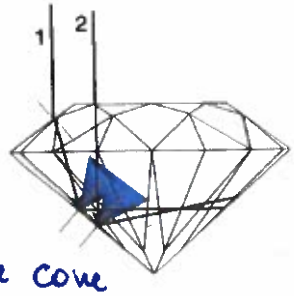
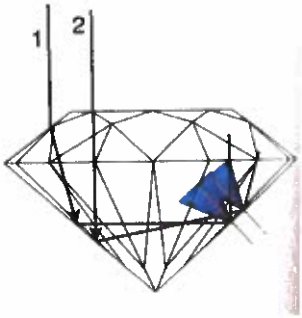


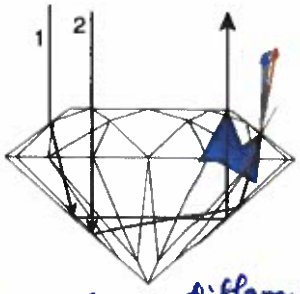
FIGURE 2.16 ▶ The precise proportions of the "brilliant cut" for diamonds.

Why diamonds are shiny? Because they reflect light back!



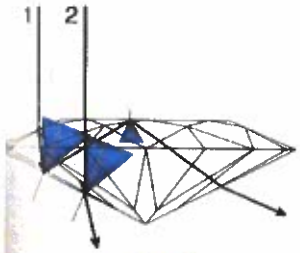
Blue cone shows diamond critical angle (24°)



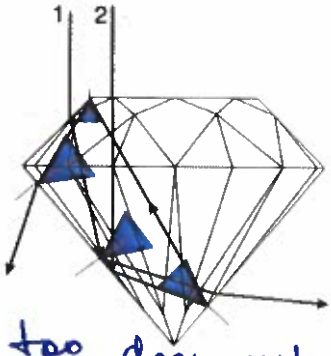


Why we see different colors? Dispersion – refractive index changes slightly with color, so red and blue emerge at slightly different angles

What can go wrong?

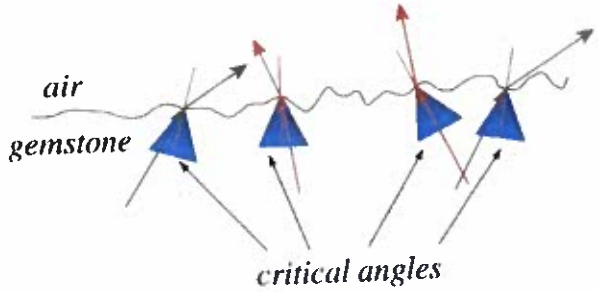


too shallow cut



too deep cut

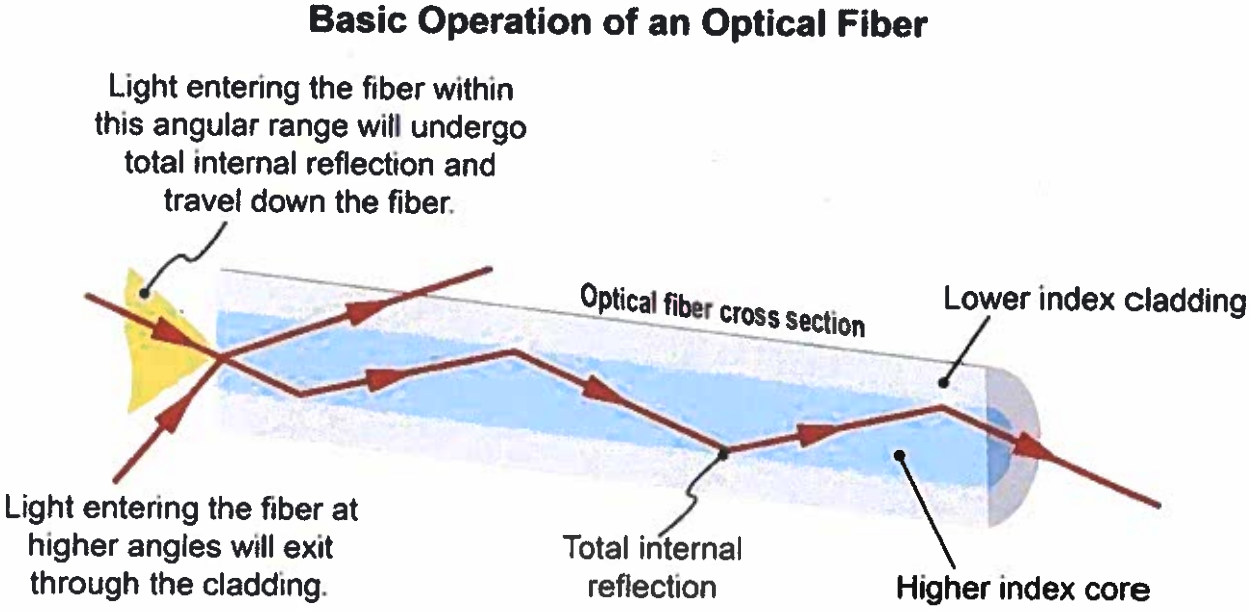
in both cases light "escapes" from the sides – less shine!



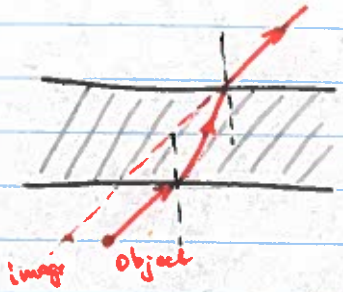
If the surface is rough, it looks dull

TOTAL INTERNAL REFLECTION

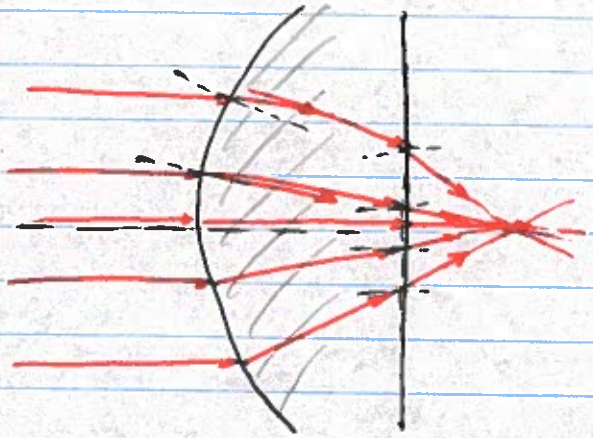
Fiber optics



Flat slab of transparent material → image is transposed, but not distorted

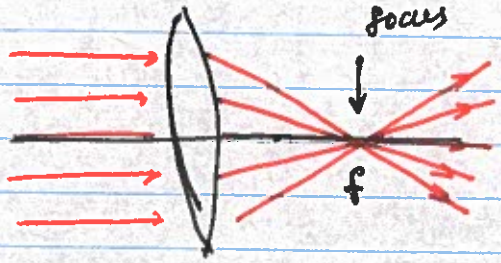


What happens when the surface is curved



We just design a focusing lens – it refracts light from its curved surface(s), leading into it convergence (or divergence) of the transmitted light

Convergent lens



Definition of focus/focal point
When parallel rays of light pass through a convergent lens, they refract and converge at a focal point

There are many possible ways to make a lens