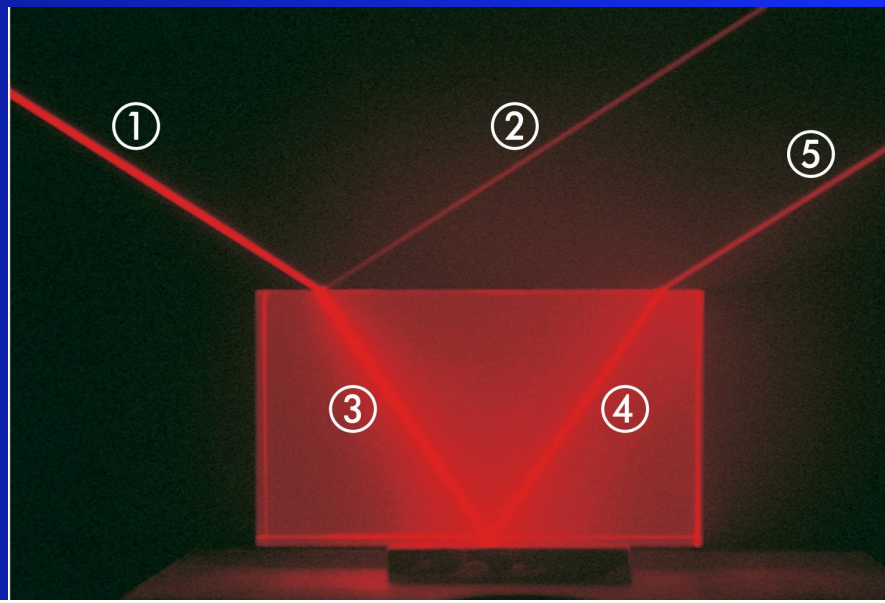
Physics 1C: Reflection & Refraction of Light

Wednesday, 29 April 2015



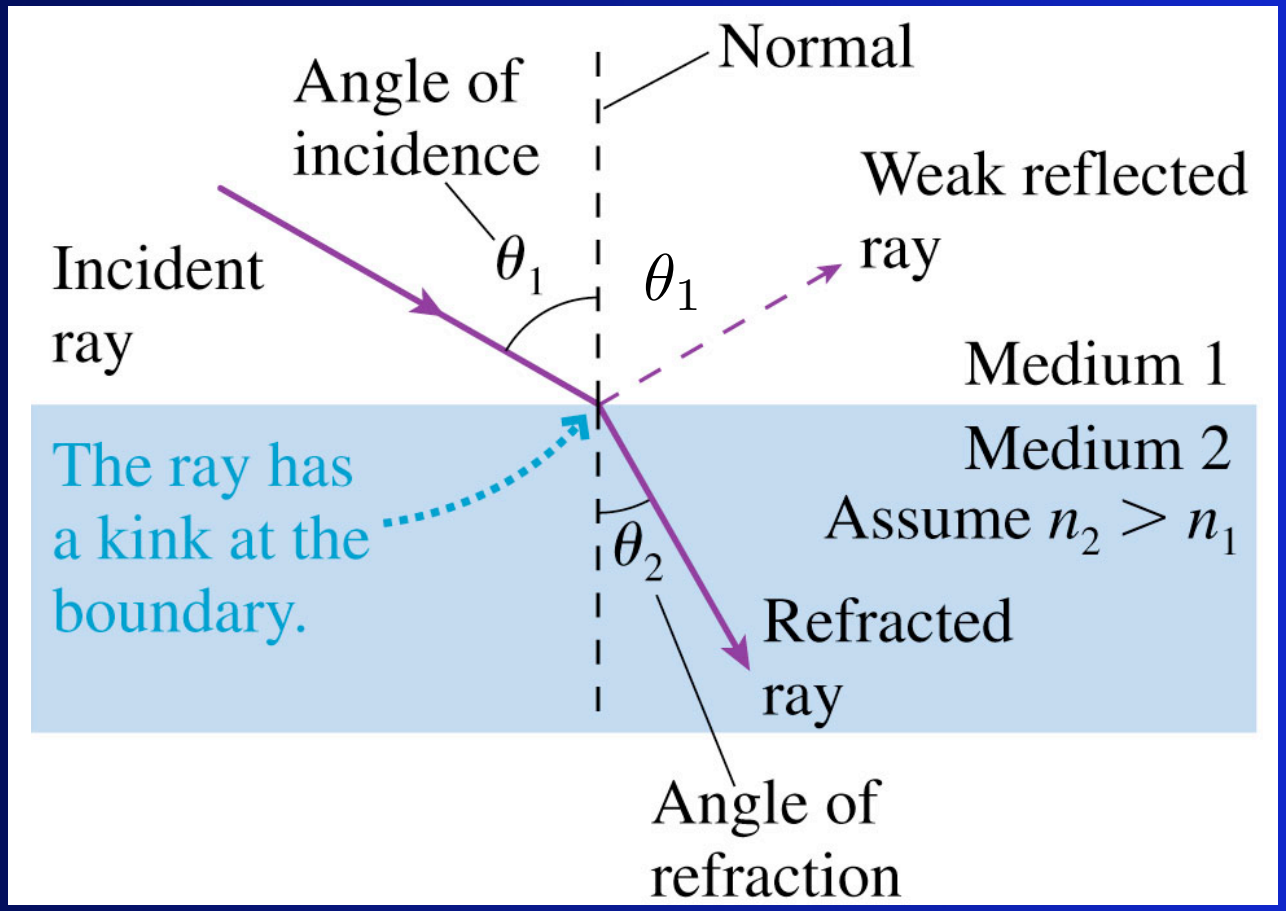
Reminders

- Quiz #2 results and answer key now available on TED site. average quiz score: 7.18±1.40. many missed last question.
- current participation scores are also posted—please check them (WebAssign's scoring system isn't the easiest to use)
- HW & reading quiz on reflection & refraction (chapter 25) due Friday
- 1st extra credit due Friday, if you're interested
- note: I'm having office hours this afternoon at 2-4pm (429 SERF building)

refraction: Snell's Law

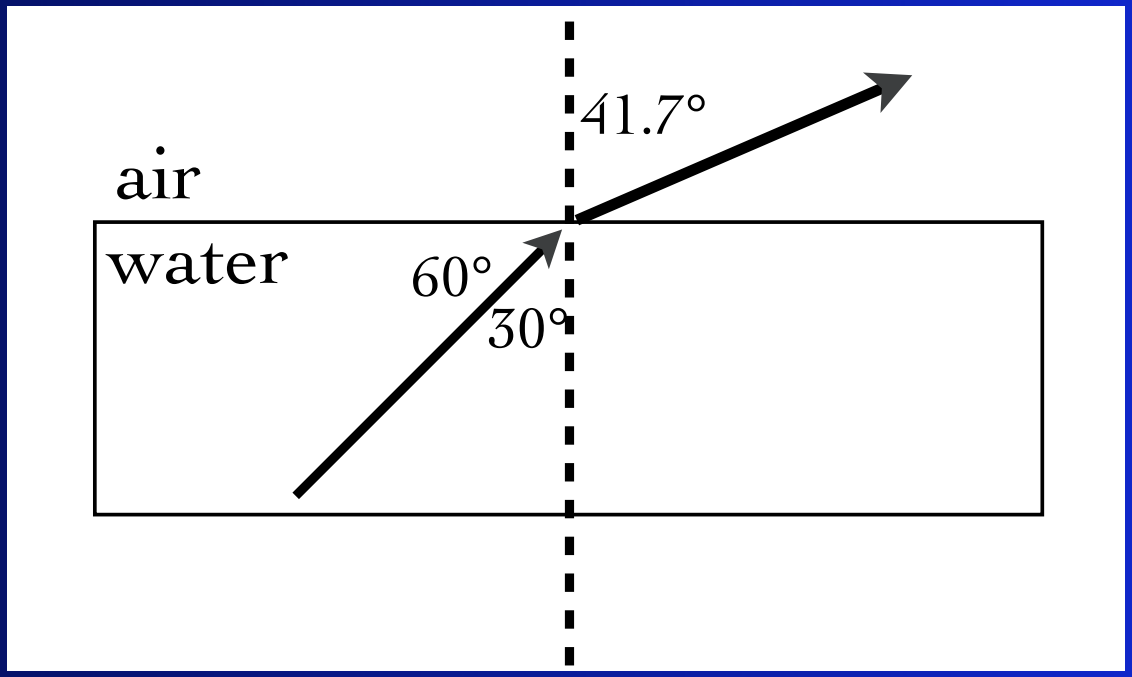
Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

where all angles are measured with respect to normal



example: refracted ray

Someone underwater shines a light toward the air.
Let's determine the refracted ray…



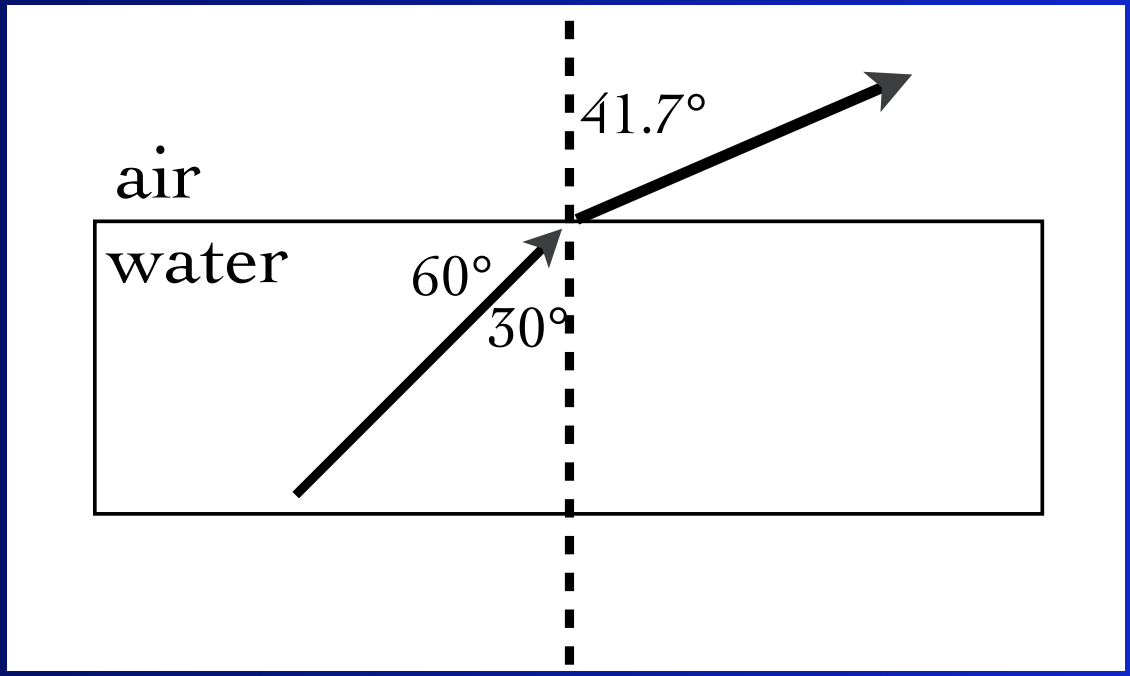
$n_1 \sin\theta_1 = n_2 \sin\theta_2$, so $(1.33)\sin 30° = (1.00)\sin\theta_2$

then $\sin\theta_2 = 0.665$, so $\boldsymbol{\theta_2 = 41.7°}$

example: refracted ray

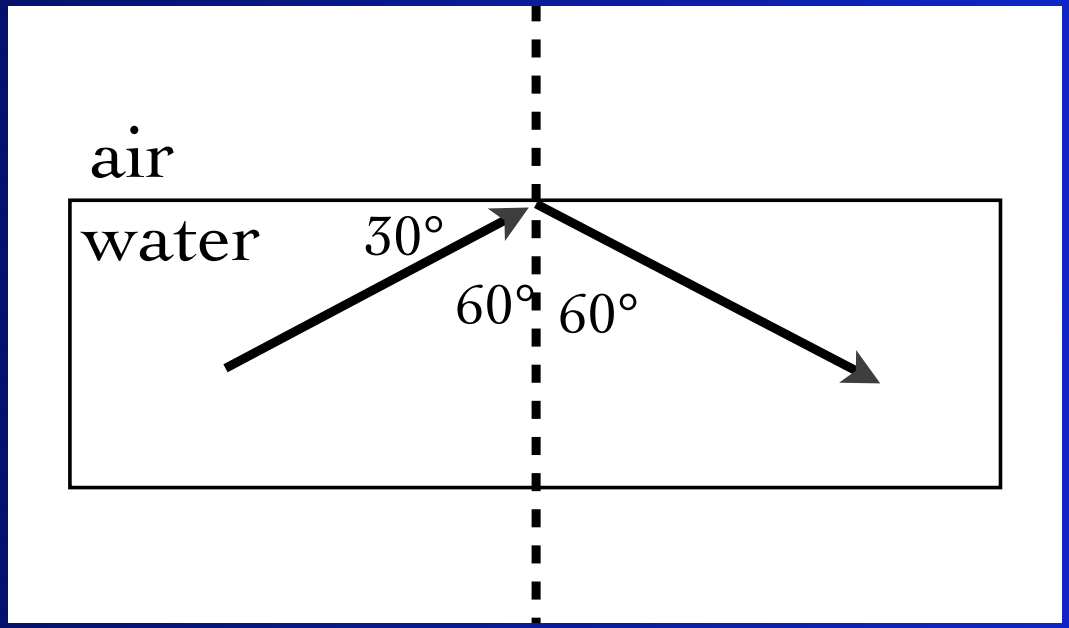
remember…

- high n → low n: angle goes away from the normal
- low n → high n: angle goes toward the normal



another example of refracted ray

Someone underwater shines a light toward the air, but at a larger angle. Let's determine the refracted ray…



$(1.33)\sin 60° = (1.00)\sin\theta_2$

then $\sin\theta_2 = 1.15$, so $\theta_2 = ???$ this is ***total internal reflection!***

total internal reflection

If the incident angle is larger than the critical angle θ_c, we have total internal reflection.

If the incident angle is smaller than the critical angle, refraction will occur.

$$\sin \theta_c = n_2/n_1$$

For the previous example (water→air), $\sin \theta_c$=1.00/1.33, so θ_c=48.8°. For glass(n=1.52)→air, θ_c=41.1°. Note that total internal reflection isn't possible when $n_2 > n_1$!

REFRACTION REVIEW

index of refraction: $n = c/v_{\text{medium}}$

When n increases, v decreases, and vice versa.

Since $v=\lambda f$, that means when n increases, λ decreases too:
$\lambda_1 n_1 = \lambda_2 n_2$

But why doesn't the frequency change? The main reason: the EM wave's energy $E=hf$ and energy must be conserved across the boundary, which implies that f is constant.

REFRACTION REVIEW

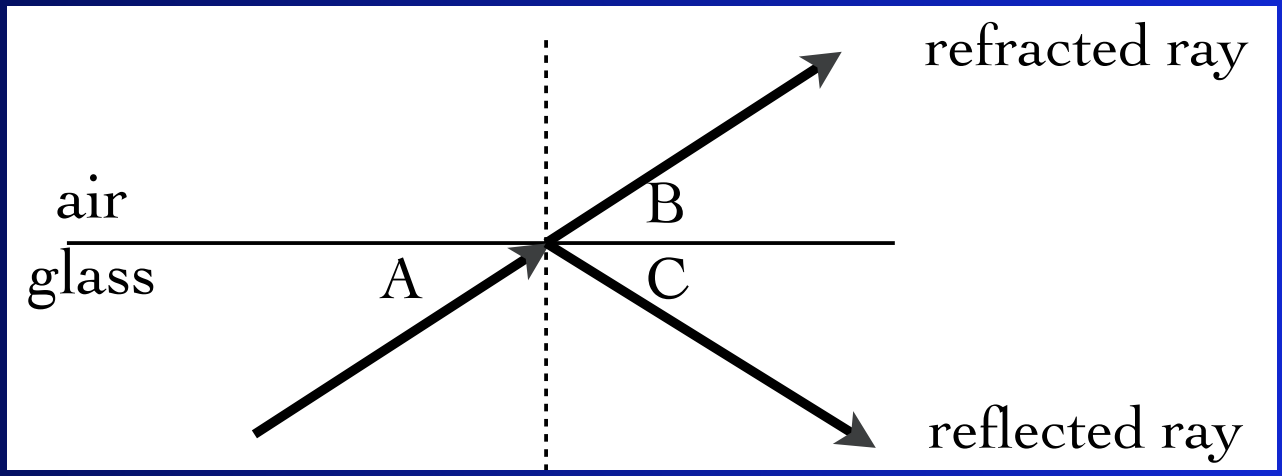
index of refraction: $n = c/v_{\text{medium}}$

law of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

This implies that if light's going from fast to slow ray refracted *toward* the normal, and vice versa

total internal reflection: $\sin\theta_c = n_2/n_1$

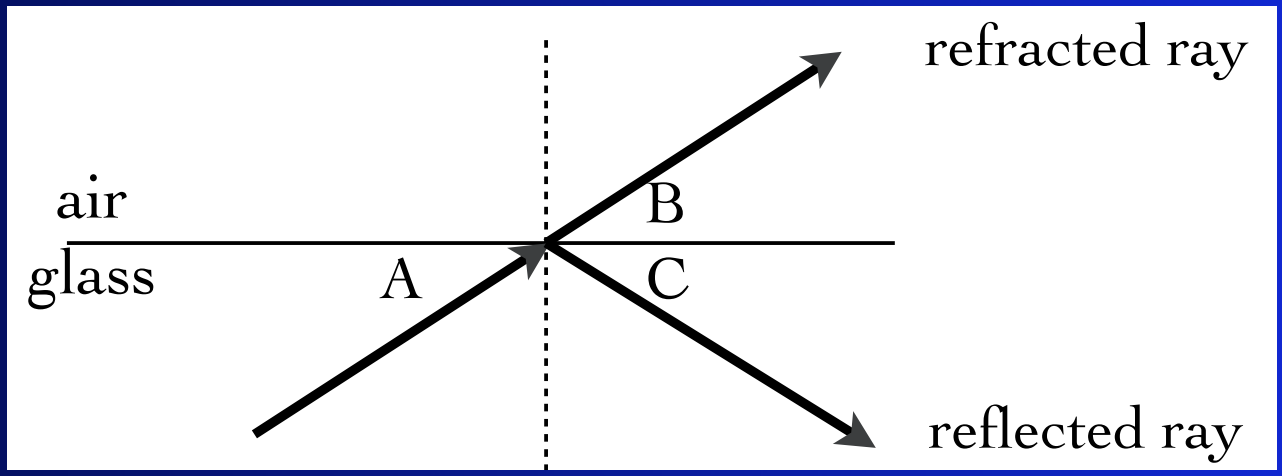
example: reflection & refraction



Assume that total internal reflection does not occur. Which angle is largest? (Note that the drawing isn't necessarily to scale.)

A. angle A
B. angle B
C. angle C
D. both angles A and C
E. all three angles are the same

example: reflection & refraction

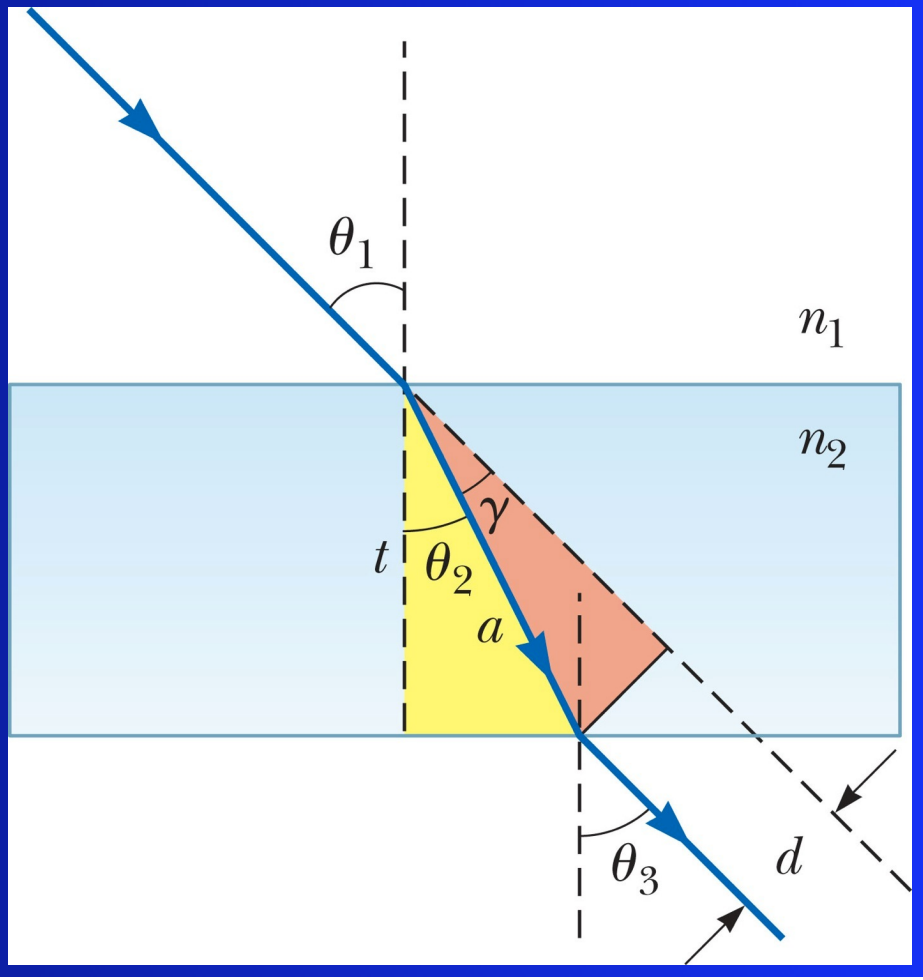


Assume that total internal reflection does not occur. Which angle is largest? (Note that the drawing isn't necessarily to scale.)

D. **both angles A and C**

example: light passing through a slab

A light beam passes from medium 1 to medium 2, with the latter medium being a thick slab of material whose index of refraction is n_2. Show that the beam emerging into medium 1 from the other side is parallel to the incident beam…

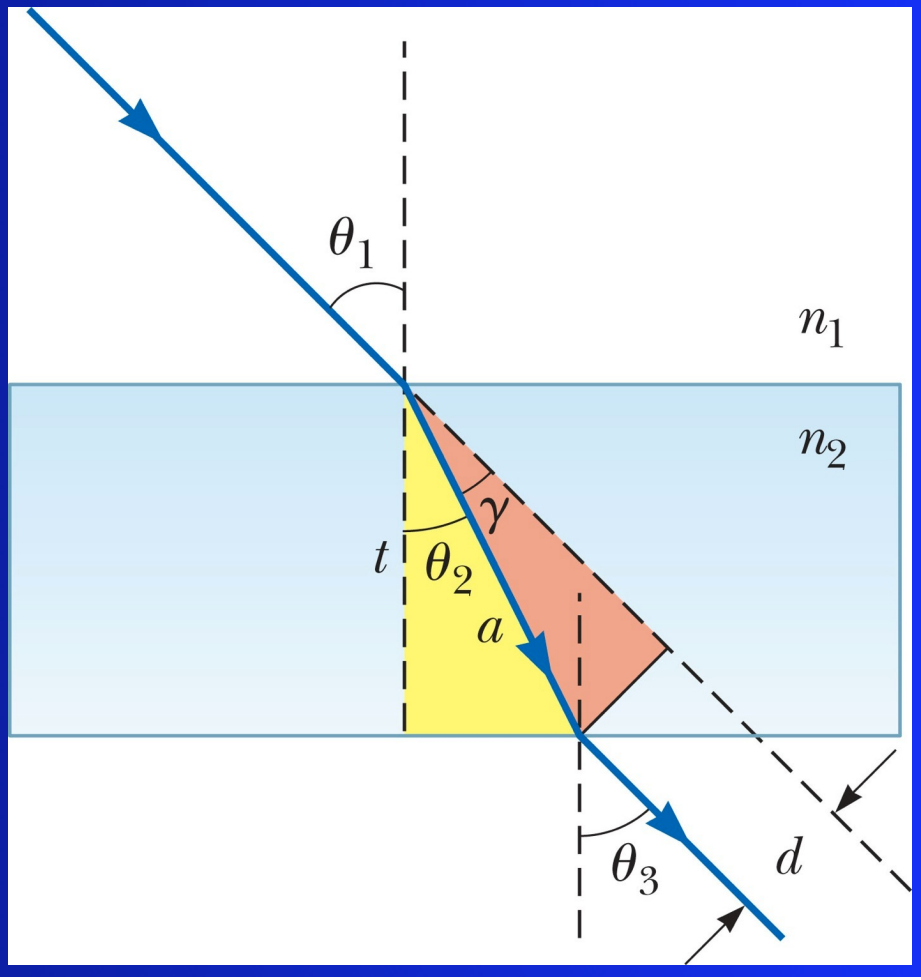


example: light passing through a slab

A light beam passes from medium 1 to medium 2, with the latter medium being a thick slab of material whose index of refraction is n_2. Show that the beam emerging into medium 1 from the other side is parallel to the incident beam…

In other words, let's first show that $\theta_1=\theta_3$.

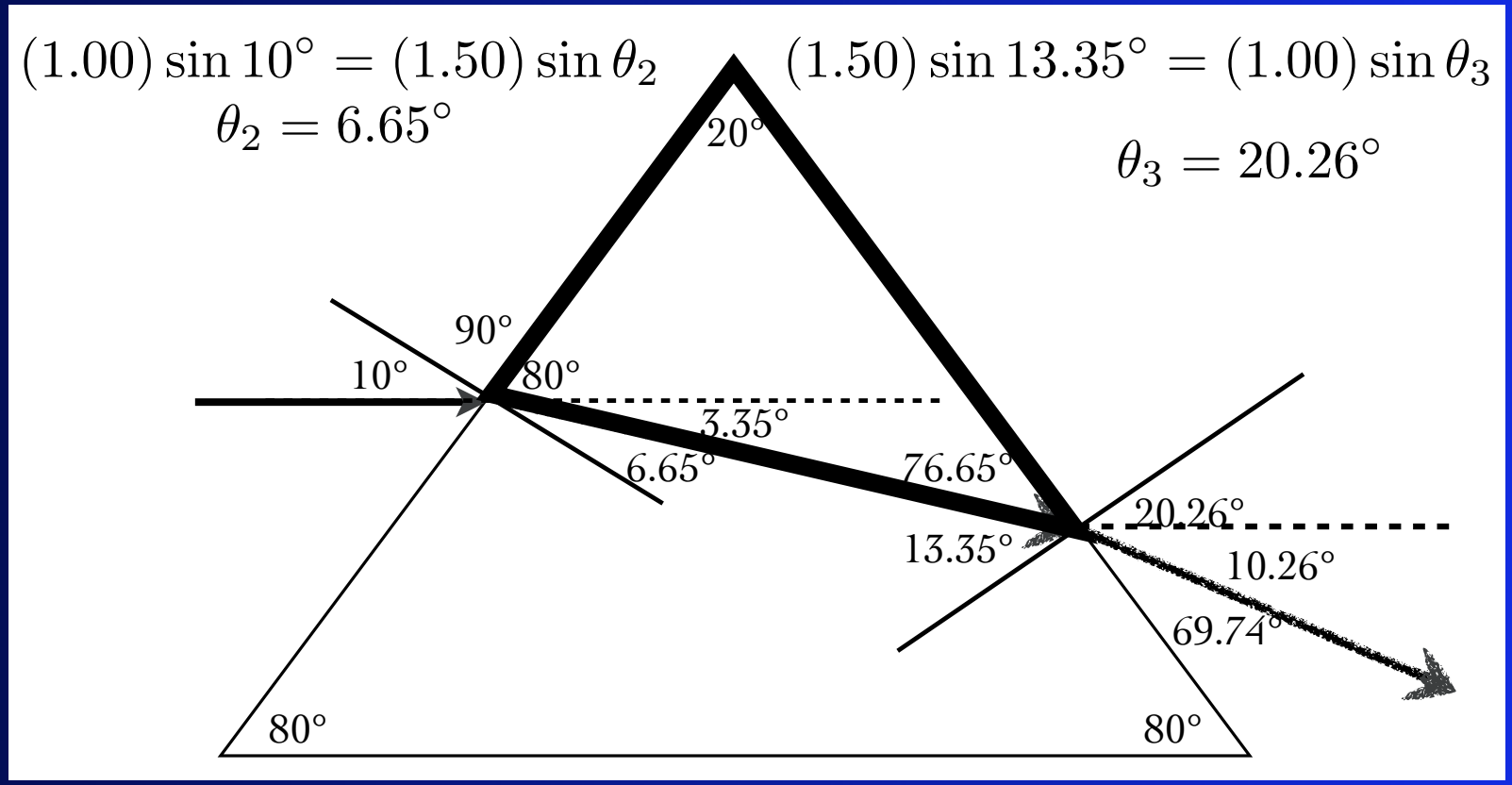
Then, let's use trig & geometry to calculate d in terms of t, θ_1 & θ_2.



example: refraction through a prism

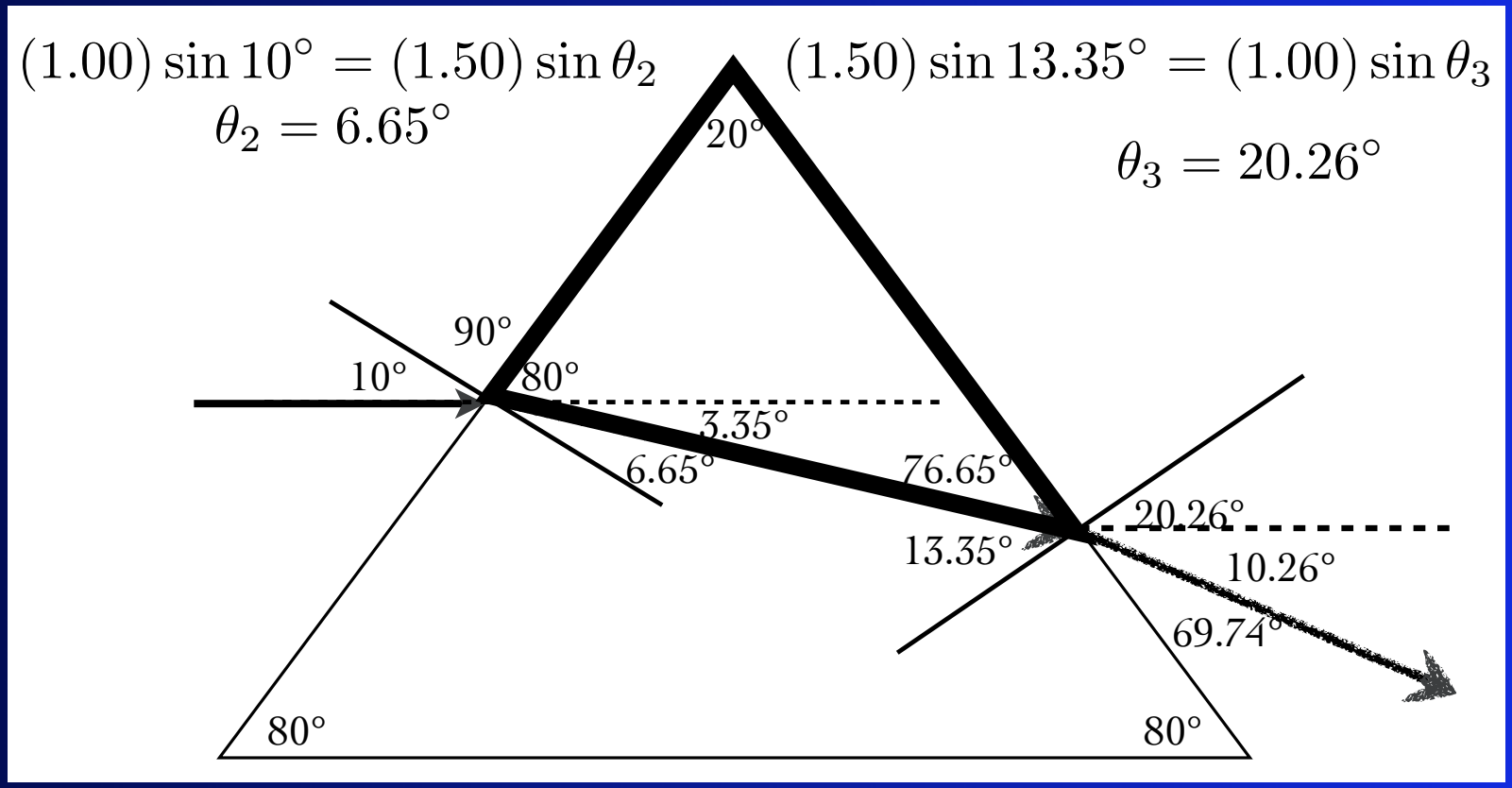
A ray of light travels from air into the glass (n=1.50) prism shown below. The triangle is isosceles with the top angle=20°. Determine the refracted ray…

(figure is not drawn to scale)



Note that 10.26°–10.0° is the *angle of deviation* for this ray and prism.

example: refraction through a prism

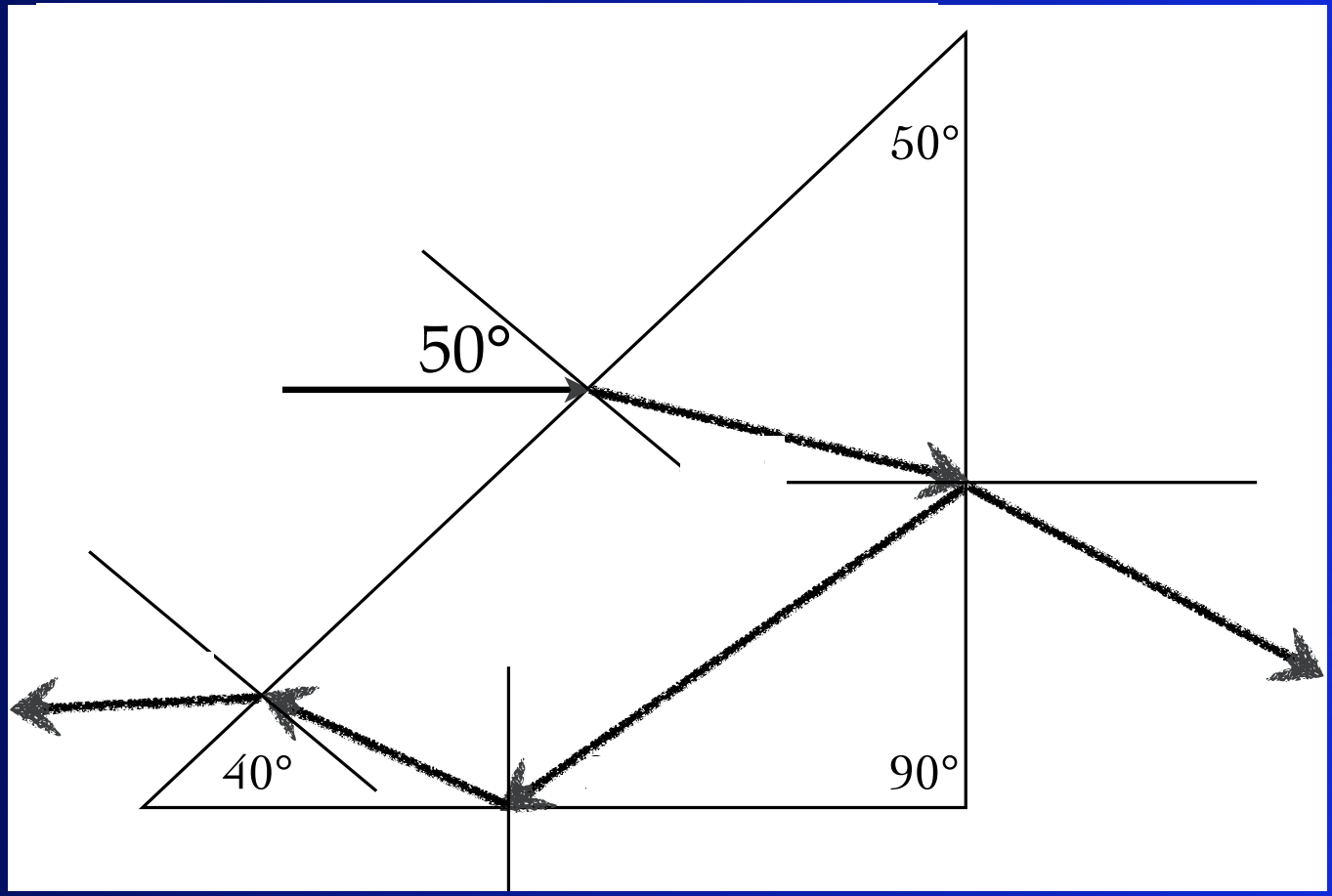


Analyze the law of refraction at one surface at a time, and remember to use the correct angles (with respect to normal) and indices of refraction.

It's useful to remember that right angles are 90° (or π/2) and angles of a triangle add up to 180° (or π).

example: refraction through a prism

A horizontal ray travels from air to a medium with n=1.60. Its incident angle is 50°. At what angle does the ray exit the right side of the triangle? and the bottom? what about the left side?



example: refraction through a prism

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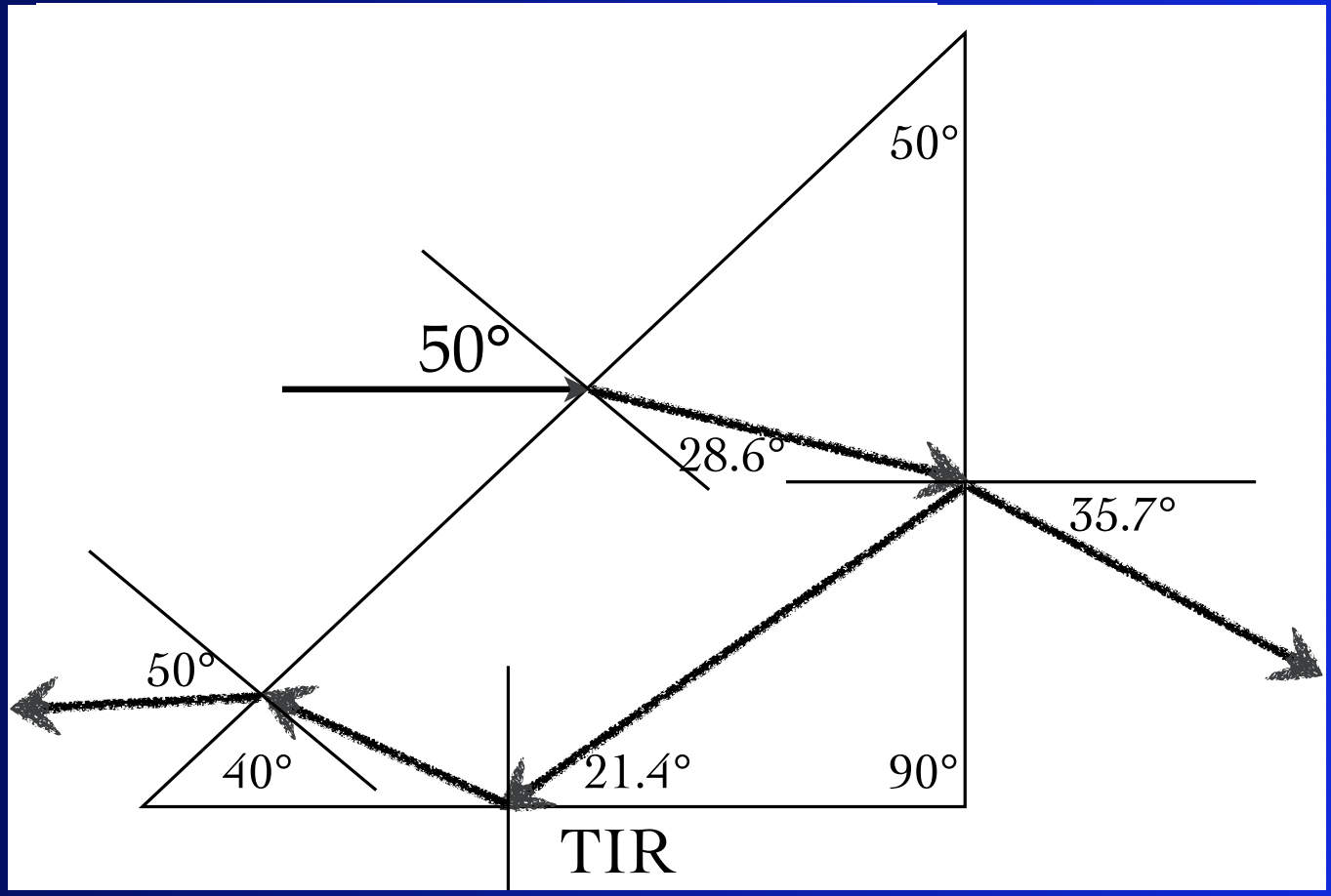
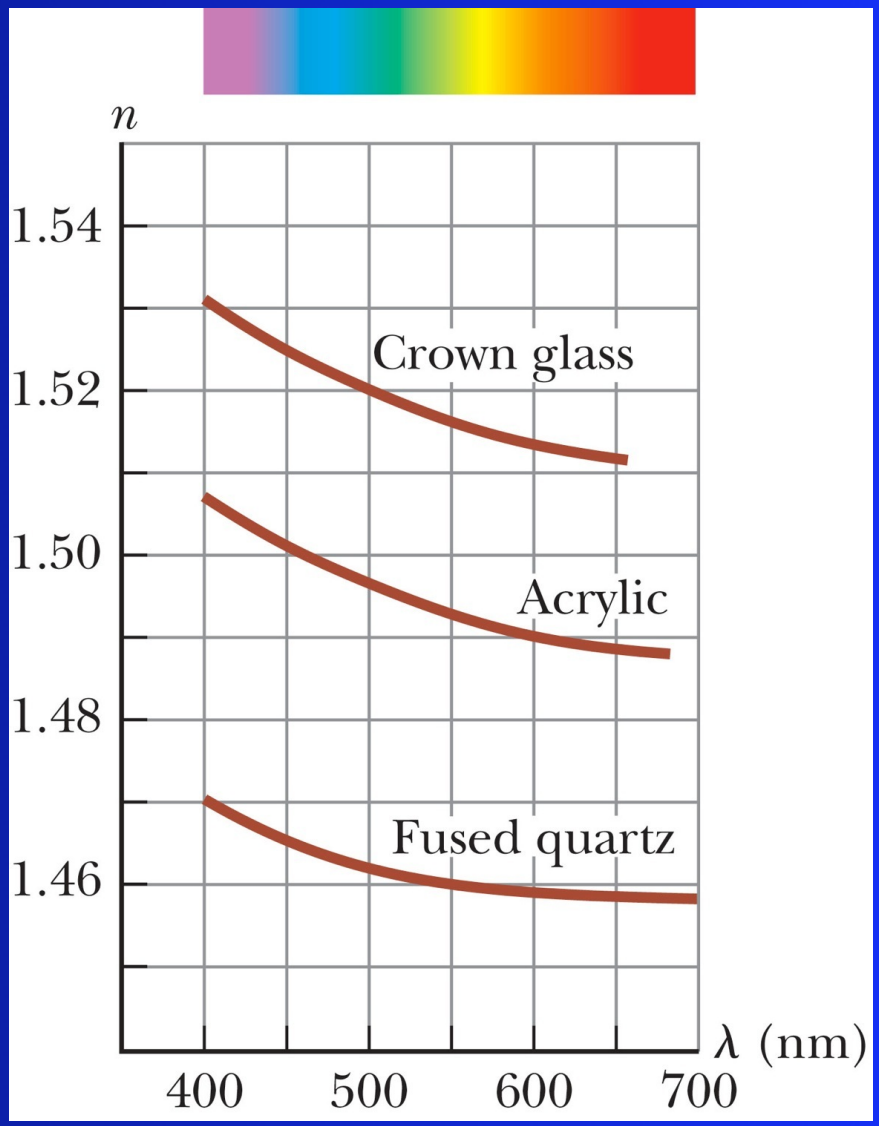


dispersion

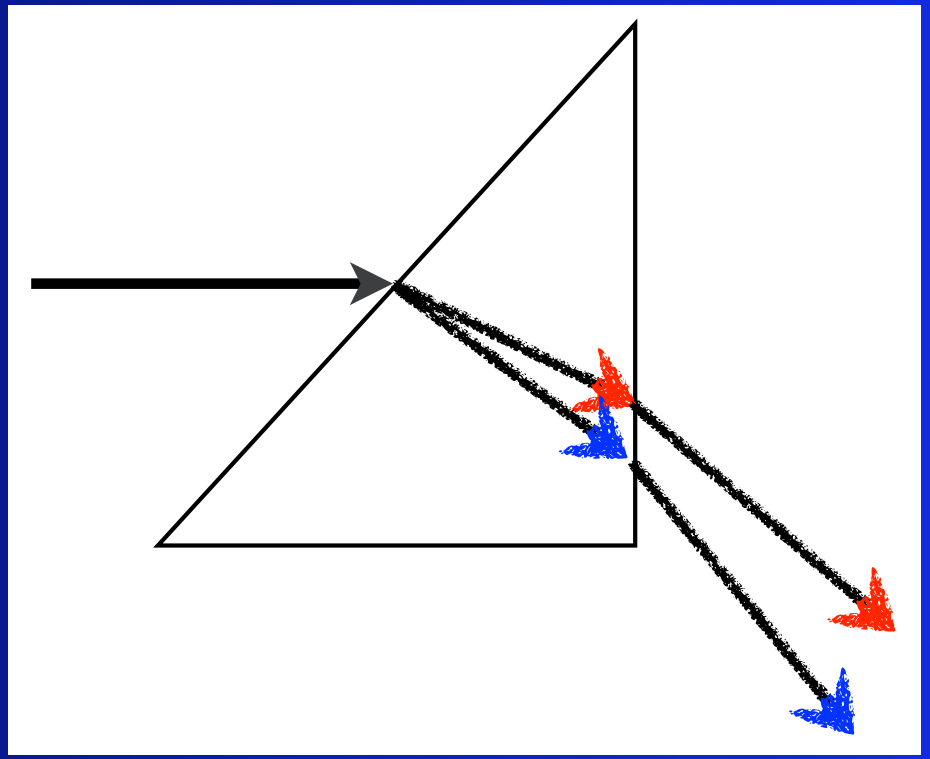
- index of refraction is not solely dependent on the medium (that is, you could have a range of n values)
- index of refraction is also different for different frequencies of light



example: dispersion

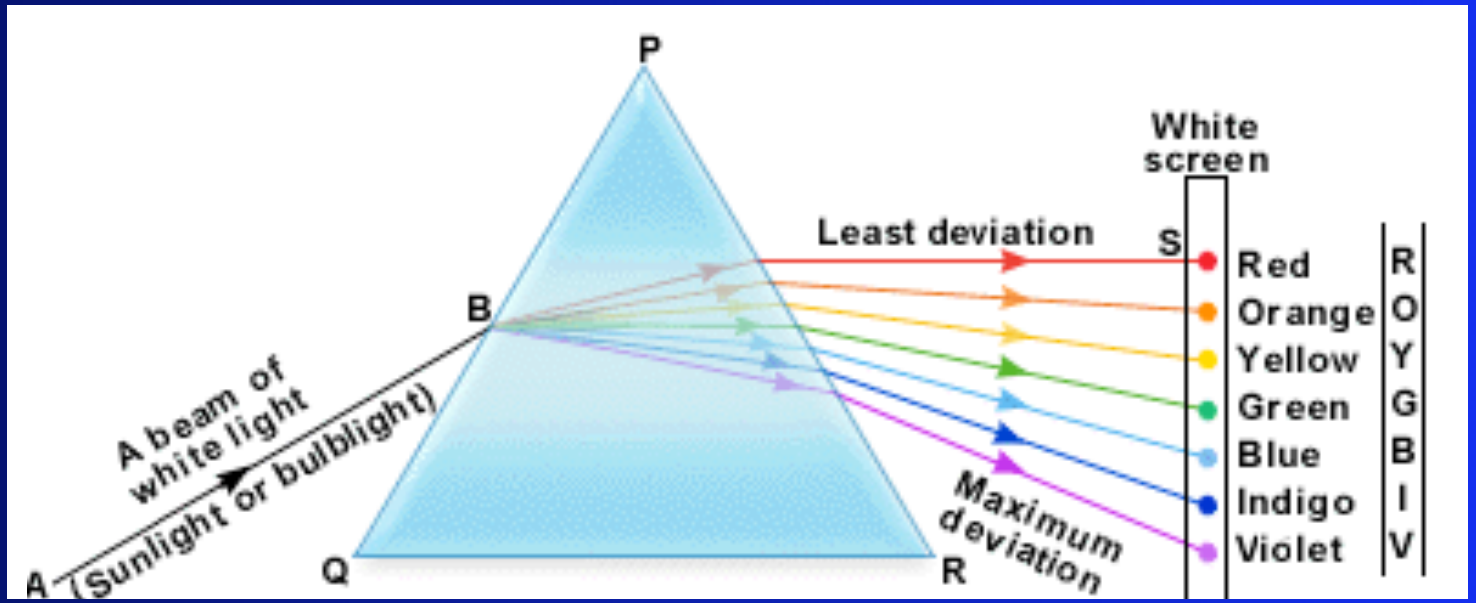
Both red (n=1.60) and blue (n=1.62) light is incident upon the prism shown. If the red light exits the prism at an angle of 35.7° (with respect to the normal), at what angle does the blue light exit the prism? [No calculations necessary.]

A. 34.5°
B. 35.7°
C. 36.9°

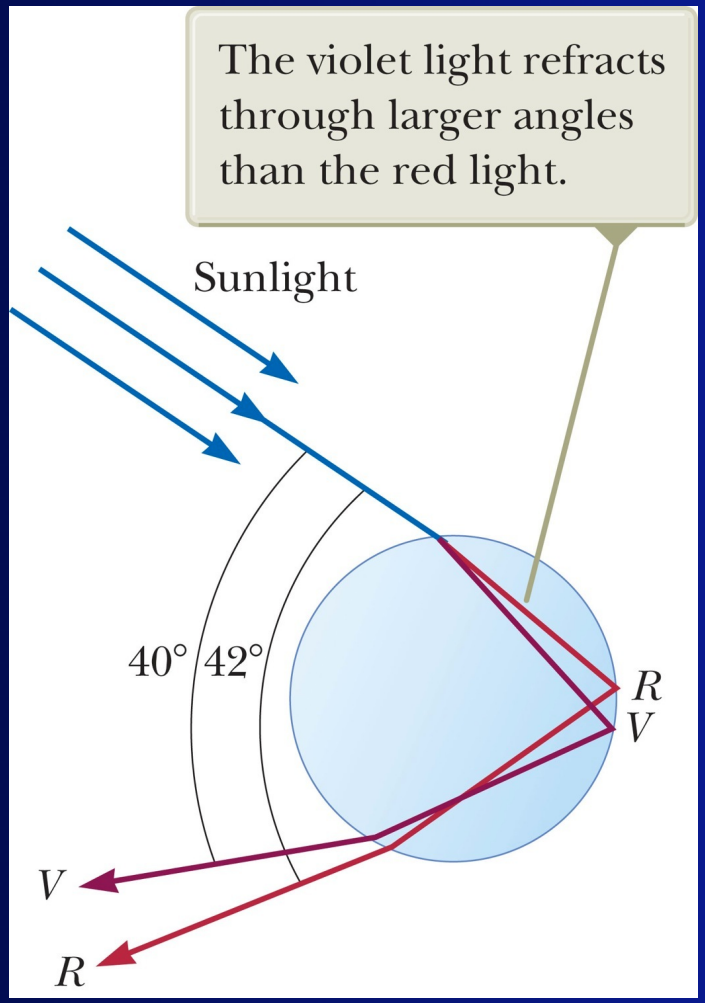


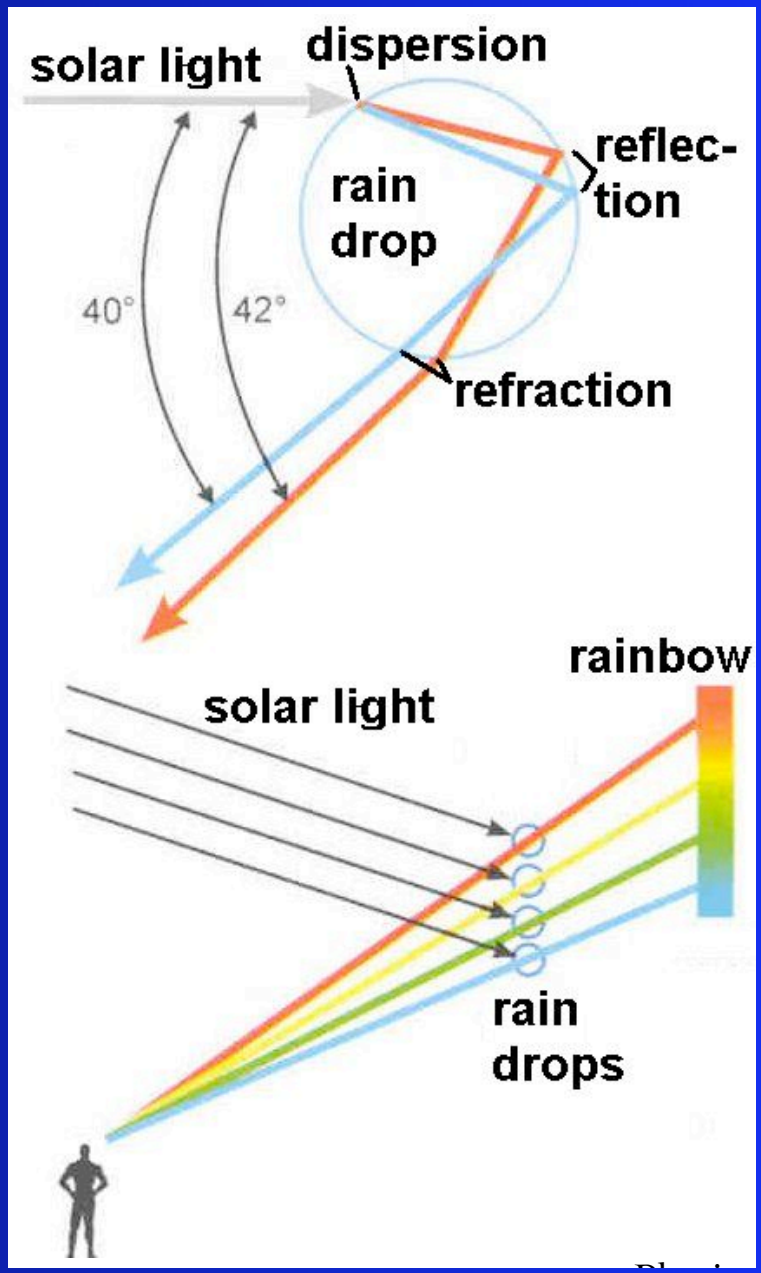
dispersion

- Since all colors have different "angles of deviation" through a prism, white light will spread out into a *spectrum*
- violet deviates the most and red deviates the least
- it's good to remember Roy G. Biv, or make your own mnemonic



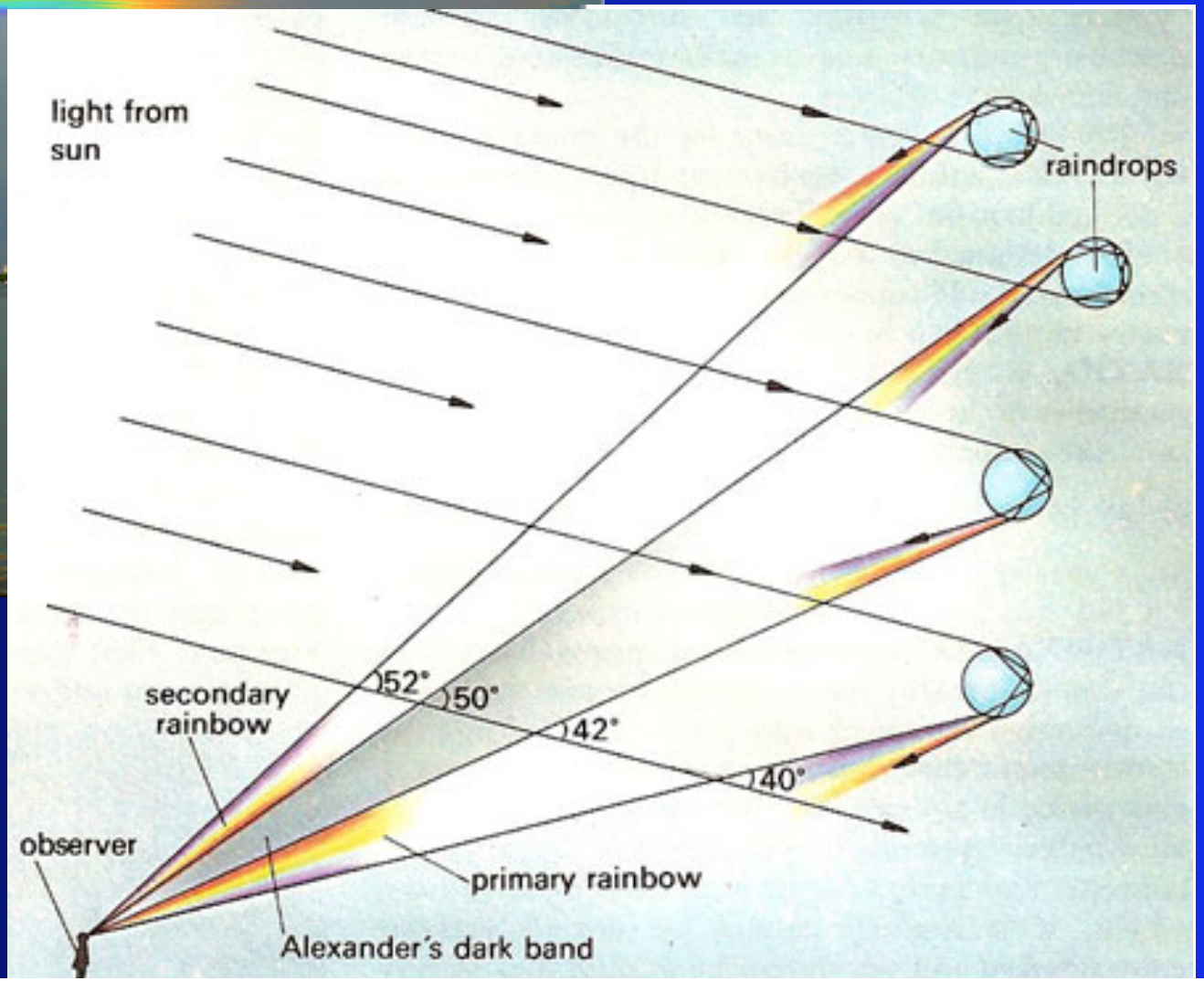
rainbows


The violet light refracts through larger angles than the red light.
Sunlight
40°
42°
R
V
V
R

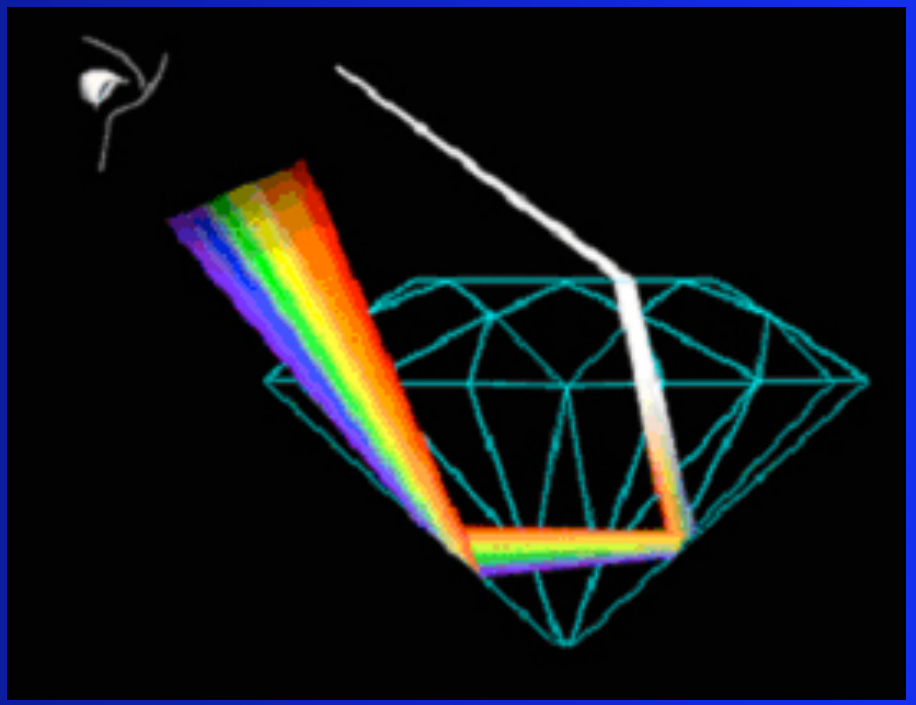

solar light
dispersion
reflec-
tion
rain
drop
40°
42°
refraction
rainbow
solar light
rain
drops

rainbows


asad gilani © 2009


light from sun
raindrops
secondary rainbow
52°
50°
42°
40°
observer
primary rainbow
Alexander's dark band

diamonds



next up: image formation

- we can see images formed by different types of mirrors and lenses
- the light rays diverge, creating an image that may appear different (such as different size) than the actual object
- images are located by extending diverging rays back to a point at which they intersect

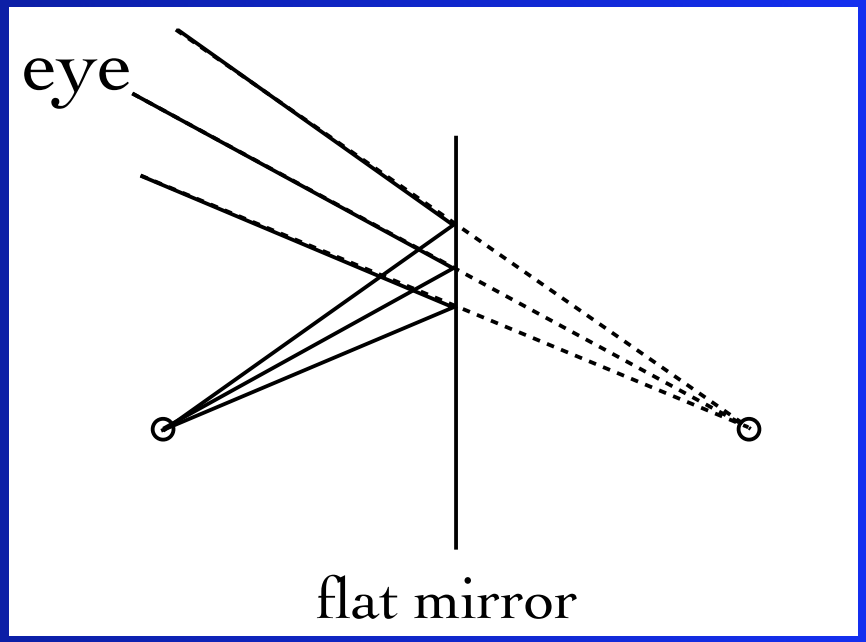
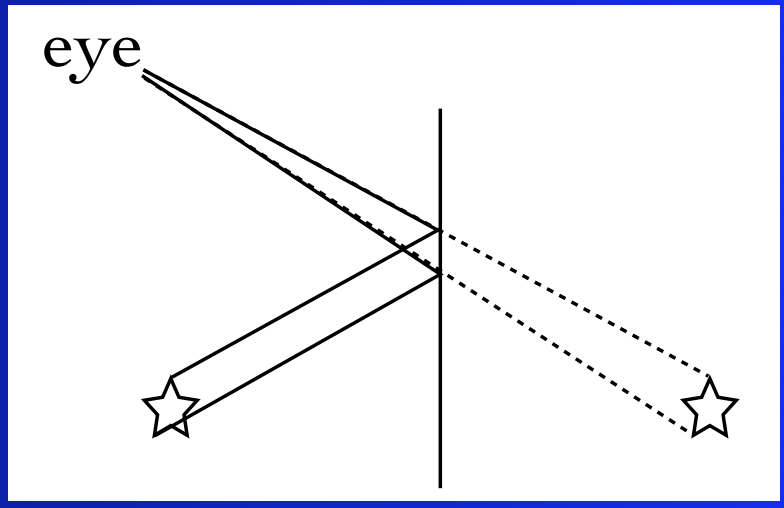


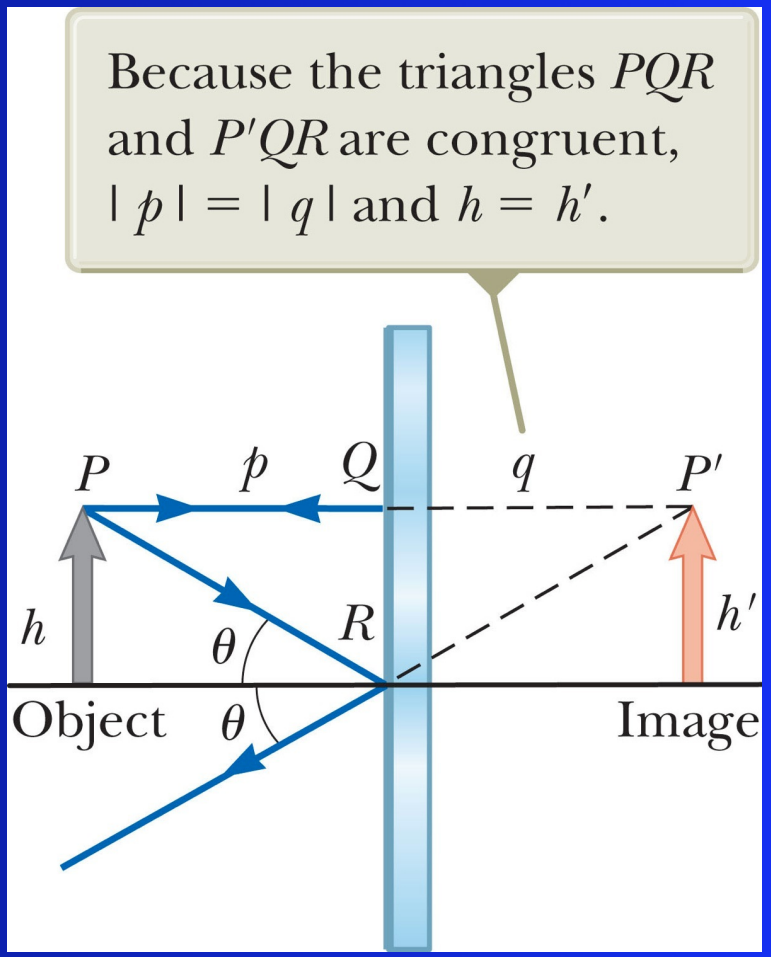
image formation by flat mirrors

- images are located by extending diverging rays back to a point at which they intersect
- distinction between a *real image* and a *virtual image*? what happens when mirror is flat or curved?



ray diagrams

- think about the trajectory of the rays and where the rays *appear* to travel
- distinction between a *real image* and a *virtual image*? (nothing is on the other side of the mirror!)



For Friday:

1. make sure you understand the laws of reflection and refraction, including total internal reflection and prisms
2. review chapter 25 and start reading chapter 26: images formed by mirrors & lenses
3. turn in the HW problems and reading quiz