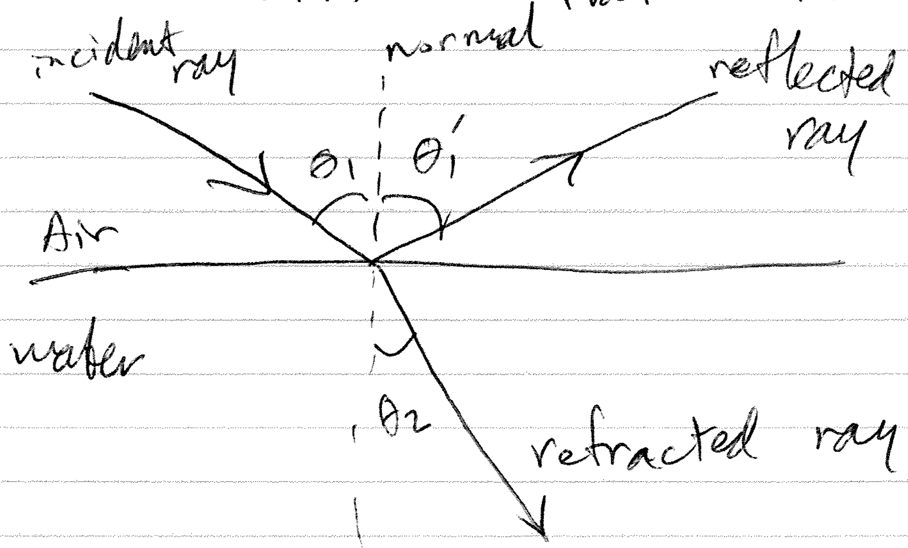
Lecture 20

Reflection & refraction

- We can often approximate light as traveling in a straight line

- study of traveling light waves under this approximation is called geometrical optics

Suppose an incident ray of light encounters a flat water surface



- part of light beam is <u>reflected</u>, going upward & to the right as if it bounced off the surface

- other part travels through the surface & into the water. It is <u>refracted</u> b/c water is transparent.

- Travel of light through a surface that separates two media is called refraction

- refraction changes the direction of travel for the light.

Key terms:

Angle of incidence $= \theta_1$

Angle of reflection $= \theta_1'$

Angle of refraction $= \theta_2$

- they are all measured relative to the normal vector (perpendicular to the surface at the point of reflection + refraction)

- plane containing incident ray + the normal is the plane of incidence.

1) **Law of reflection:**

reflected ray lies in the plane of incidence &

$$\theta_1 = \theta_1'$$

Angle of incidence = angle of reflection

2) **Law of refraction:**

refracted ray lies in the plane of incidence &

$$n_2 \sin\theta_2 = n_1 \sin\theta_1$$

- n_2: index of refraction for medium 2
- θ_2: ∠ of refraction
- n_1: index of refraction for medium 1
- θ_1: angle of incidence

law of refraction
Also called **Snell's law**

index of refraction = $\frac{c}{v}$

where c is speed of light in vacuum &
v is speed of light in that medium

Since $\frac{c}{v} \geq 1 \Rightarrow n \geq 1$

vacuum $n = 1$

Air $n = 1.00029$

water (20°C) $n = 1.33$

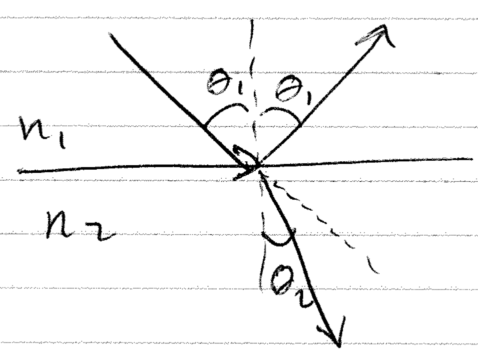
can rewrite law of refraction as

$$\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$$

some rules of thumb:

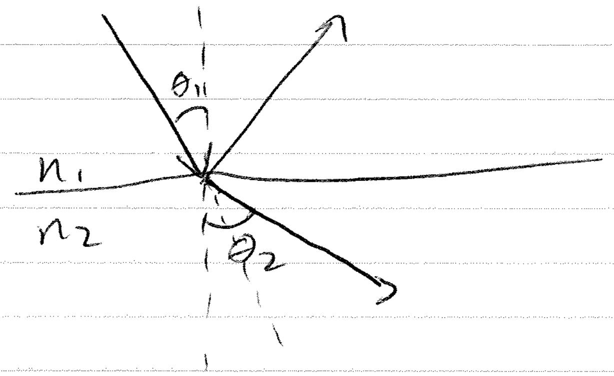
1. If $n_1 = n_2$, then $\theta_2 = \theta_1$
   & refraction does not bend
   light beam

2. If $n_2 > n_1$, then $\theta_1 > \theta_2$



ray is bent towards normal

3. If $n_2 < n_1$, then $\theta_2 > \theta_1$

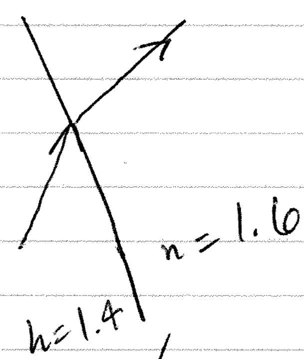


ray is bent away from normal.

refraction cannot bend a beam so much that refracted ray is on same side of normal as incident ray

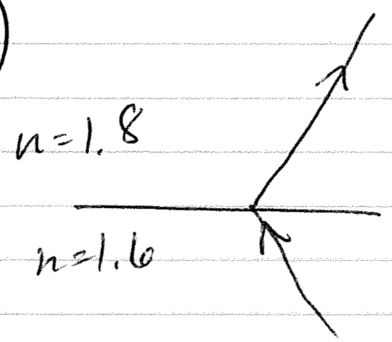
Question: Which of the following are physically possible?

a)



✓

b)



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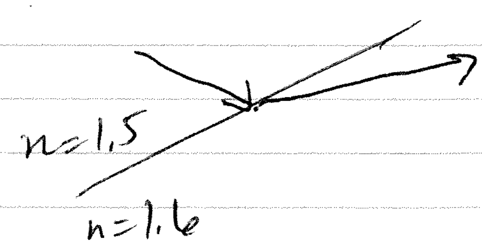
c)



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Chromatic Dispersion

- Index of refraction encountered by light in any medium besides vacuum depends on wavelength of light.
  - When light beam consists of different wavelengths will bend differently.
  - underpins prisms + rainbows
  - index of refraction is typically greater for shorter wavelength
    ⇒ blue bends more than red