CMSC427 Fall 2020
Exercises for Tuesday, Oct. 27th
Global illumination starter

Objectives:
1. Describe differences between rendering with local, direct illumination, and with global illumination that accounts for more light transport paths. List several features that distinguish them.
2. Explain basic features of ray tracing and radiosity, and list features that characterize images rendered with this approaches.
3. Describe the basic algorithm of ray tracing, including the rays involved: primary, shadow, reflection and refraction. Describe
5. Work with Snell's law to compute the output angle and the output 3D vector.
6. Work with Fresnel equations to determine the percentage light reflected vs. refracted.

You won't be expected to derive Snell's law or the Fresnel equations, but the variations on

Elms modules:
See Week 8, lectures for Tuesday, Oct. 27^{th}.

Readings:
This document from Stanford explains reflection and refraction well for our purposes.
https://graphics.stanford.edu/courses/cs148-10-summer/docs/2006--degreve--reflection_refraction.pdf

Scratch Pixel has promises, but is incomplete as a tutorial site. Still, this link gives the complete source code for a ray tracer in reasonable form:
https://www.scratchapixel.com/lessons/3d-basic-rendering/ray-tracing-overview

Exercises:
1. Work with the ratio form of Snell's law enough to be comfortable with it. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

a. Assume we are moving from water (n=1.33) to flint glass (n=1.66), input angle of 30 degrees. What the output angle?
b. Assume you are moving from crown glass (n=1.52) to air (n=1.00029).
c. Can you get total internal reflection if n1 < n2?
d. A ray of light in air strikes a block of quartz at an angle of incidence of 30°. The angle of refraction is 20°. What is the index of refraction of the quartz? (Credit to DJ Wagner).
e. Show that for a sheet of glass with parallel faces, the output ray is parallel to the input ray.

2. Work with the 3D vector form of Snell's law to compute the output refraction vector from the input vector and the refraction indices n1 and 2.

There's multiple forms of the 3D vector form – if you google it you'll find variations. You should be able to read and relate these versions. One difference is that despite Snell's law using sines, many variations of the 3D version use cosines. Based on our work this semester with vectors, why would we prefer cosines over sines in calculations?

Interestingly, Wikipedia has a reasonable take on the different versions:

https://en.wikipedia.org/wiki/Snell%27s_law#Vector_form

Version from our slides:

$$\boldsymbol{r} = \frac{n_1}{n_2}\boldsymbol{v} + \left(\frac{n_1}{n_2}\cos\theta_1 + \cos\theta_2\right)\boldsymbol{n}$$

Alternative version:

$$\boldsymbol{r} = \frac{n_1}{n_2}\boldsymbol{v} + \left(\frac{n_1}{n_2}\cos\theta_1 + \sqrt{1 - sin^2\,\theta_2}\right)\boldsymbol{n}$$

And a third:

$$\boldsymbol{r} = \frac{n_1}{n_2}\boldsymbol{v} + \left(\frac{n_1}{n_2}\cos\theta_1 + \sqrt{1 - \left(\frac{n_1}{n_2}\right)^2 cos^2\,\theta_1}\right)\boldsymbol{n}$$

a. Why are these equivalent and which would you use to do the computation? Hint: start with the ratio law version.

b. Given the normal n=<0,0,1> and the input vector v=<-1,0,-1>, with n1 for air, and n2 for water, compute the output vector.

3. Fresnel equations

Read the section in the Stanford link above on Schlick's approximation. Then compute the percentage of reflected light for some different angles using n1 = 1 and n2 = 1.5. Get a sense for the behavior of the

Then go back to the Stanford link and check out the graphs for air and water on page 4.

This material illustrates an element of graphics programming. You can always search and find how to do refraction, or how to do reflection, or so on – you need to be prepared enough to interpret what you find, and know what to look for.