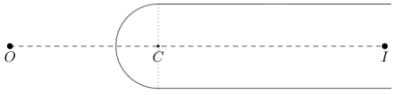
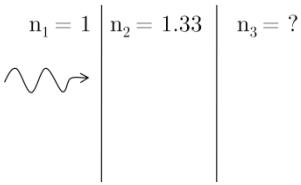


Optics Test - UChicago 2018 Invitational

Note: please give 3 significant figures unless otherwise specified.

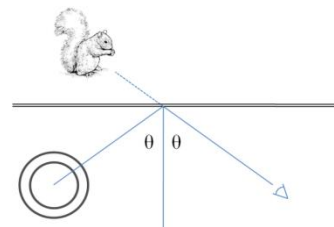
Problems

- (5 pts) A point object can be placed anywhere on the principal axis of a biconvex lens ($n = 1.52$) with both radii of curvature 5 cm. If the object is placed on the axis at a point A, and the lens forms a real image of this object at a point B, what is the minimum possible distance AB?
- (5 pts) A ray is incident upon a spherical water droplet ($n = 1.33$) at an angle of 37 degrees to the normal. The ray refracts at the surface of the droplet, travels within the droplet, reflects off the back surface of the droplet, and eventually exits the droplet. Determine the total angle through which the ray was deflected in this process.
- (6 pts) Let A, B, and C be points in the coordinate plane with A(0,7), B(0,0), C(5,0). Suppose triangle ABC is made of material with index of refraction n . A point light source is at the point (-1,1) and shines light in the +x direction.
 - (3 pts) Determine the minimum value of n for which the ray will totally internally reflect off of the surface of segment AC.
 - (3 pts) When the light reflects off of AC, it will then hit the surface BC. Determine the minimum value of n for which total internal reflection will occur here as well.
- (5 pts) A cylindrical tube has 10 evenly spaced polarizers inside of it so that the transmitted light has an intensity that is 1% of the incoming light intensity, assuming the incoming light is unpolarized. Each polarizer is offset from the next by a exact same angle X (where $0 < X < 90^\circ$). Determine the angle X .
- (5 pts) Two infinitely long plane mirrors make an angle of 30 degrees with one another. An object is placed between these mirrors, equidistant from both (i.e. placed between the mirrors along the angle bisector of the 30 degree angle). Determine the number of distinct locations at which an image is formed.
- (5 pts) A very long cylindrical glass tube ($n = 1.52$) of radius 1 cm has one end altered so that it forms a hemisphere of radius 1 cm. Let C be center of curvature of this hemisphere. An object is placed outside the tube, on the central axis of the tube, at point O, so that $OC = 3.5$ cm. An image I is formed inside the tube. Determine the distance CI.
 
- (5 pts) In the diagram on the right, there are 3 regions with different refractive indices. Find n_3 so that each interface has an equal fraction of power transmitted (transmission coefficient).
 
- (5 pts) As in question 7, suppose there's a setup with 3 regions, each with different refractive indices. But this time for (power) transmission coefficient T and reflection coefficient R , let $T=R=1/2$ (and ignore the refractive indices from question 7). The light is monochromatic, and the separation of the two interfaces is some integer multiple of half the light's wavelength.
 - (4 pts) What's the transmission coefficient of the system? (hint: consider light reflected off of the right interface)
 - (1 pt) Compare this value to T^2 .

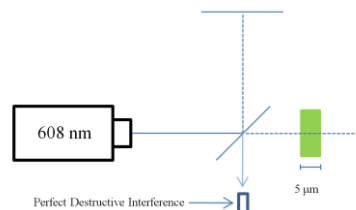
Team Name: _____

Team Number: _____

9. (7 pts) You're trying to look outside a window ($n=1.52$) at night, but there's a reflection of a lamp right where you're trying to look (at eye level). You get the idea to look through a polarizer to try to block out some of the light from the lamp.



- (3 pts) For what angle θ is this approach most efficient? (hint: think about whether there is more reflection when the light first hits the glass or when it's about to leave the glass)
 - (1 pt) What is this angle known as?
 - (1 pt) If you put on a pair of sunglasses and stand straight, will the reflection of the lamp be blocked out?
 - (2 pts) If you're using a wire-grid polarizer, should the wires be parallel or perpendicular to the floor to block out the reflection of the lamp?
10. (5 pts) Albert Michelson, who would later become the first head of UChicago's physics department and win the Nobel Prize in 1907, invented the Michelson Interferometer. It was famously used in the 1887 Michelson-Morley experiment, as well as the recent 2015 LIGO observation of gravitational waves.



This setup can be slightly altered to tell us about how an object in a beam's path alters its phase. In the figure above, the mirrors are equidistant from the beamsplitter. The laser's wavelength is 608 nm; the glass is 5 μm in thickness with a refractive index known to be between 1.42 and 1.50; and there is perfect destructive interference at detector at the bottom. What is the index of refraction of this object? Please give 4 significant figures.

Questions

- (2 pts) _____ reflection is reflection off of a surface that is smooth at the molecular level.
- (2 pts) Monochromatic light traveling in air hits a pool of water. Which of the following changes? (Pick one: frequency, color, wavelength).
- (2 pts) Would you use a converging or diverging lens to correct for a myopic eye?
- (2 pts) What's the focal length of a 2.50 dioptre lens?
- (2 pts) What's the name of the protein found in the lens of a human eye?
- (3 pts) What wavelengths are the cones in our retinas most sensitive to? (blue, green, red)
- (2 pts) An electron in a hydrogen atom drops from energy level $n=5$ to $n=3$. The spectral line generated is part of what hydrogen spectral series of transitions?
- (2 pts) The Very Large Array in New Mexico is a set of telescopes that operates between 74 MHz to 50 GHz. What range of light does this fall under?
- (2 pts) What's the wavelength of 266 MHz light?
- (2 pts) What's the diffraction limit for 550 nm green light for an imaging system with Numerical Aperture 1.2?
- (2 pts) What main advantage does a reflecting telescope (e.g. Newtonian) have over the refracting telescope (e.g. Keplerian)?
- (2 pts) What property of calcite allows it to create two images with different polarizations?
- (2 pts) What's the momentum of a photon with frequency 1420 MHz?
- (2 pts) What causes colors in soap bubbles and oil films on water?
- (2 pts) What property of the laser in a Blu-ray player allows Blu-ray discs higher storage capacity than normal DVDs?