OPTI-502 **Optical Design and Instrumentation I** John E. Greivenkamp
Homework Set 1 Fall, 2019

Assigned: 8/26/19
Due: 9/4/19 10:00 in the Academics Office
Distance Due Date: 9/11/19

Homework Instructions:

- Start each problem on a separate page (it is much easier to grade this way). Homework must be stapled. There is no stapler available in the classroom.

- Use only one side of the paper. Use standard 8 ½ x 11 paper.

- Collaboration on homework is allowed and even encouraged. But there is a right way and a wrong way to do this. Be sure to work individually on the problems first, then get together to discuss the problems and concepts. The same strategy goes for using the provided solutions.

- Use a straight edge for drawing lines. Be neat.

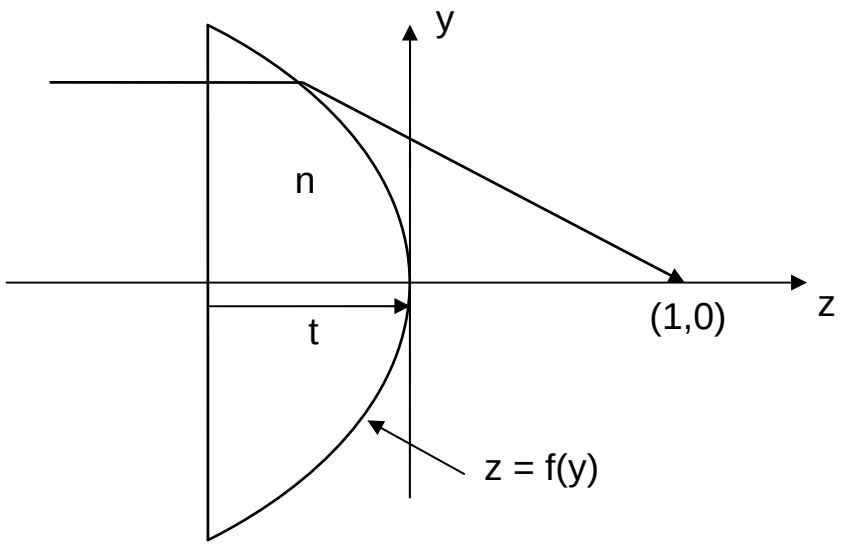
- Provide a narrative of what you are doing. Practice providing an organized solution. Not only will this help you in your future employment, it will aid in obtaining partial credit on the exams.

1-1) Use Fermat's principle to determine the shape (equation) of a concave mirror in air that produces a perfect image of a distant (at infinity) point source a distance f to the left of the mirror vertex. The focal length f of a concave mirror is given as a positive value.

Remember that for an imaging situation, the optical path lengths (OPLs) for all rays connecting the object and image points are equal. Since rays from infinity are parallel, a reference plane at an arbitrary z can be used to define the OPL.

1-2) Determine the equation of rotation about the z-axis for a plano-convex lens in air with thickness t and index n that will bring all incident rays parallel to its axis to a common focus at the point (1,0). The equation of rotation z = f(y) gives the z-coordinate or sag of the surface along an arc on the surface. This arc is rotated about the optical axis to produce the rotationally symmetric lens surface. Derive the exact analytic form of this curve. Note that because of the reference definitions, the values for z will be negative.

a) by Fermat's principle.
b) by Snell's law.



One of these methods is relatively easy; the other is very difficult and involves differential equations. Do not become overly frustrated by this problem, the level of math here greatly exceeds anything else we will do this semester.

1-3) Use Fermat's principle to derive the law of reflection. Use proper sign conventions and reference definitions.

1-4) A ray is refracted by a series of parallel layers as shown. Find the final angle θ when the incident angle is 40°.