The thin lens equation is not the whole story. The Lens Maker’s Equation considers that the lens might have a different radius of curvature (rL and rR) on the left and right sides of the lens. This equation also includes the index of refraction of the material outside of the lens and allows us to consider lenses underwater or in other optically transparent materials. In the equation below, the focal length is f, the index of refraction of the lens materials is nlens and the external material is noutside. Use this simulation of the Lens-maker’s Equation (https://www.geogebra.org/m/cvsthyez). Use the controls at the bottom of the screen to set the two indices of refraction and the lens radii as shown below. Keep the lens radii equal magnitudes but opposite in sign for this activity, e.g. rL = - rR. Noutside=1 nlens=1.56 rR=-5 rL=5 ctrThick=-0.34

Experimentally determine the relationship between the index of refraction of the lens (nlens) and the radius of curvature for some constant value of the focal length. Choose a radius of curvature other than the default value. Change the index of refraction by some small increment. Observe the change in the position of the focal point. Use the slider bar to change the radius of curvature to bring the focal point back to its original position.

Record both the index of refraction and the radius of curvature in your laboratory notebook. Repeat the process of changing both the index of refraction and the radius of curvature to obtain at least 10 data points. Plot your data on a scatter plot using your favorite spreadsheet program. What is the shape of this curve? What happens to the required index of refraction as the radii becomes arbitrarily large or arbitrarily small? What conclusions can you draw about the material requirements of manufacturing small spherical lenses for use in personal electronic devices?