OPTICS LAB – Converging lenses and image formation

BACKGROUND:

Glass was first discovered by the Phoenicians while cooking on sand around 3500BC. Almost 3000 years elapsed between this discovery and the first recorded use of a lens – and they didn't make it out of glass, but rather out of naturally occurring quartz crystal!

This oldest lens artifact is dated to 640 BC, a quartz lens found at excavations in the city of Nineveh (the city which the biblical character of Jonah was avoiding when he was swallowed by a whale). The earliest written records of lenses date to Ancient Greece, with Aristophanes' play *The Clouds* (424 BC) mentioning a burning-glass (a biconvex lens, or magnifying glass, used to focus the sun's rays to produce fire). This one seemed to be made of glass. After that, yet another 2000 years elapsed before anybody managed to put two lenses together to make a telescope or any other multi-lens system! The individual usually credited for the telescope is almost certainly not the first to have made one, but the one who made the invention widely known. His name was Hans Lippershey, a man from Holland who lived from 1570-1619.

NOTE: Don't believe the labeled focal length (cheap lenses). Part one will get us a better value.

PROCEDURE:

Part I:

1. Set up each lens in turn on the optical bench with a screen.
2. Take the setup outside so you can use some distant object as a light source.
3. Measure d_i (distance from the focused image on the screen to the lens) for each lens. Record those numbers to the nearest tenth of a centimeter (millimeter).

Part II:

1. Use the values of d_i in the first part and plug them into $1/f = 1/d_i + 1/d_o$ to find f for each lens (rather than trusting the label on the lens). Consider what assumptions can you make about d_o?
2. Once you have f, place the light source (back in the lab) at distances of 2.0f, 1.5f, 1,0f and 0.5f from the lens, and record (if possible) the location for the screen where a focused image shows up, and the **height of the image on the screen** to the nearest tenth of a centimeter. **The light source and lens should be fixed in this part, and the screen is moved until a focused image is formed. Record the orientation of the image, and if none shows up, <u>please see if there is a virtual image that can be found and measured in some other way rather than projection onto the screen</u>.**

Part III - Analysis:

For each case in part II, we'd like to see if the lens maker equation was accurate. With this goal in mind, we will calculate each side of the equation separately.

1. Take the numbers in cm from each trial and calculate $1/d_o + 1/d_i$. Place those values along with d_o and d_i, and h_i in a table. In an adjacent column, calculate 1/f that will come from your outdoor measurements of the sun.
2. Calculate the percent error between the two sides of the equation by using the following equation:

$$\%error = \left| \frac{1/f - (1/d_i + 1/d_o)}{1/f} \right| x100\%$$. Place these % errors in the table.

3. Also calculate the % error between **theoretical and experimental magnification and place the values** in the table ($m=-d_i/d_o$) with correct signs.

QUESIONS:

1. Based on what you found to be true during your experiment, can you form a real image with a converging lens if (a) $d_o>f$, (b) $d_o=f$, (c) $d_o<f$?
2. In which case(s) (a-c) did you get a virtual image?
3. In which case(s) (a-c) was no image formed?
4. For the 3 cases above, describe images formed? (Use terms like real or virtual, upright or inverted, enlarged or diminished in size.)