EXPERIMENT STUDY NOTES: THIN LENSES

1. Objective

To determine the focal lengths, radii of curvature, and refractive indices of various lenses, and to investigate image formation by lens combinations.

2. Theory

A thin lens is defined as a lens whose thickness is much smaller than the radii of curvature of its surfaces. The image formation for a thin lens follows the **Thin Lens Equation**:

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} \tag{1}$$

where o is the object distance, i is the image distance, and f is the focal length.

To calculate the magnification (m) of the image, we use the ratio of the image size to the object size:

$$m = -\frac{i}{o} \tag{2}$$

If m is negative, the image is inverted. If positive, it is in the same orientation as the object.

Furthermore, the **Lens Maker's Equation** relates the radius of curvature (R) and the focal length (f) of a lens based on its refractive index (n):

$$\frac{1}{f} = \pm(n-1)\frac{2}{R} \tag{3}$$

Note: The plus sign applies to a converging lens, and the minus sign applies to a diverging lens.

Sign Conventions (Crucial for Calculations!)

To use these generic formulas correctly, you **must** follow these sign conventions (assuming the light source is on the left):

- **Image distance (i):** Positive (+) if formed on the right side of the lens; Negative (−) if formed on the left side.
- **Object distance (o):** Positive (+) if on the left side; Negative (−) if on the right side (e.g., when the object is actually an image from a previous lens).
- **Focal length (f):** Always Positive (+) for a converging lens; Negative (−) for a diverging lens.

The Spherometer

A spherometer is used to determine very small thicknesses and the radius of curvature of a surface.

$$R = \frac{D}{2} + \frac{A^2}{6D} \quad \text{where} \quad D = |CR - MR| \tag{4}$$

Here, CR is the Calibration Reading (on a flat surface), MR is the Measurement Reading (on the lens), and A is the distance between any two outer legs of the spherometer.

3. Experimental Procedure – *Read these instructions together with the experiment video.*

Part I: Focal Length of the Converging Lens

1. Mount the converging lens on the holder.
2. Adjust the position of the lens and screen to obtain a sharp image of the illuminated cross object.
3. Measure the object (o) and image (i) distances for two different positions of the lens.
4. Use the thin lens equation to calculate the focal length (f) for each measurement, then compute the average focal length (f_{avg}). This average will be used for all subsequent calculations.

Part II: Focal Length of the Diverging Lens

1. Adjust the positions of the converging and diverging lenses along with the screen to obtain a sharp image. *(Remove each lens one at a time and ensure the image disappears to confirm the image is formed by the combination).*
2. Measure the values o_1, i_2, and d (distance between lenses).
3. Calculate i_1 using the converging lens's f_{avg} from Part I.
4. Calculate the focal length of the diverging lens (f_{div}). **Note that i_1 and o_2 coincide. The final answer for f_{div} should be negative!**

Part III: Spherometer Measurements

1. Measure A (the distance between any two outer legs of the spherometer).
2. Place the spherometer on a flat surface and adjust the removable leg until all legs touch. Record this as the calibration reading (CR).
3. Place the spherometer on the converging lens and turn the knob until all four legs touch again. Record this as the measurement reading (MR).
4. Calculate R, determine the experimental refractive index (n), and find the percentage error using the theoretical value $n_{tv} = 1.52$.

Important Notes for Your Applied Exam

How to prepare for the lab session:

- **No Long Instructions:** You will NOT be given these lengthy procedures during the 40-minute exam. You are expected to know how to set up the lenses and use the spherometer before arriving.
- **Formulas are Provided:** You do not need to memorize the formulas. A "Reference Formulas" box will be provided at the top of your exam paper.
- **Data Sheet Grading:** Your exam paper will consist of data tables and calculation boxes. You will be graded strictly on the accuracy of your readings, significant figures, units, and your calculations shown on the Extra Sheet.