

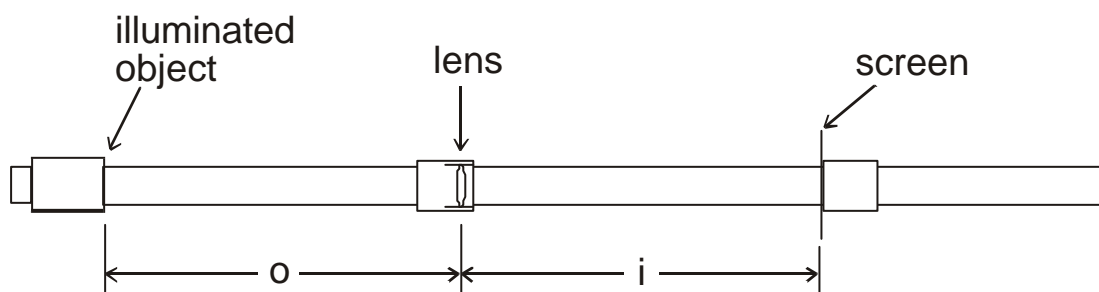
Lenses

1. **Preparation:**
- Make sure you understand the terms: *focal length*, *real image*, *virtual image*.
 - The equation relating object distance (d_o), image distance (d_i), and focal length (f) is $1/f = 1/d_o + 1/d_i$. What will be the shape of a graph of $1/d_o$ against $1/d_i$? How could such a graph be used to find the focal length, f ?
 - Learn the equation which relates the focal length (f) to the refractive index (n) and radii of curvature of the lens surfaces (r). This equation is often called the “lens-maker’s equation”.
 - See the section concerning measuring the radius of curvature of a lens surface in part 2.

2. Experiment to verify the “lens-maker’s equation” using a convex lens.

By measuring image distances (d_i) for as many different object distances (d_o) as possible, find the focal length of a convex lens.

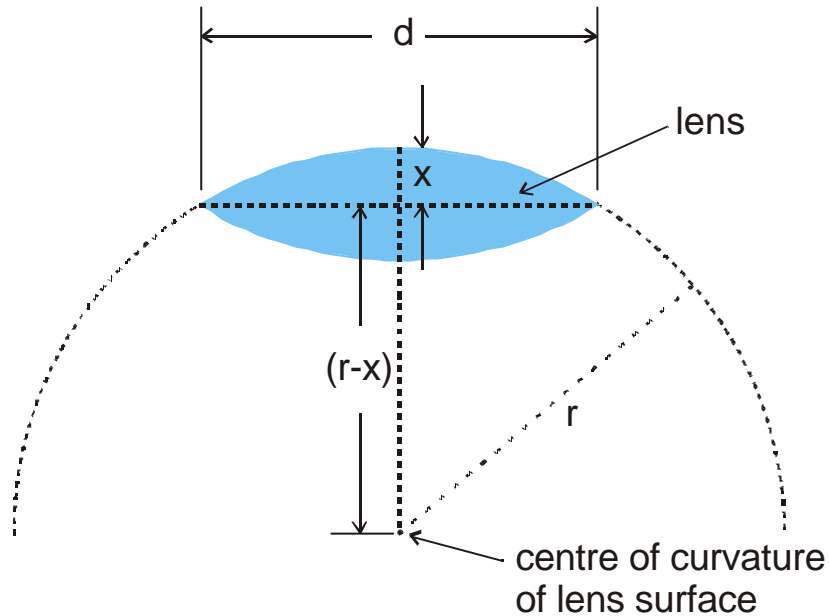
When obtaining real images (on screens) there is often quite a wide range of positions for the screen which all give fairly clear images. When trying to measure d_i you will have to think of the best way to minimise the errors due to this fact.



The value of f should be taken from a graph of $1/d_o$ against $1/d_i$.

To verify the “lens-maker’s equation”, you will also need to measure the radius of curvature of the lens surfaces, r (the lenses used are symmetrical).

The diagram below might help you to see how to measure r .



In this diagram, d is the diameter of the lens and x is half the thickness of the lens.

See if your values of f and r verify the “lens-maker’s equation” assuming that the refractive index of the material of which the lens is made is 1.47.

3. Experiment to measure the focal length of a concave lens

Your report on this experiment should start with a brief explanation of *why* it is a little more difficult to measure the focal length of a *concave* lens than to measure the focal length of a *convex* lens.

The method proposed here involves first obtaining a real image of an object using a *convex* lens (diagram 1) and then observing the change in the image distance when the *concave* lens is put in place (diagram 2).

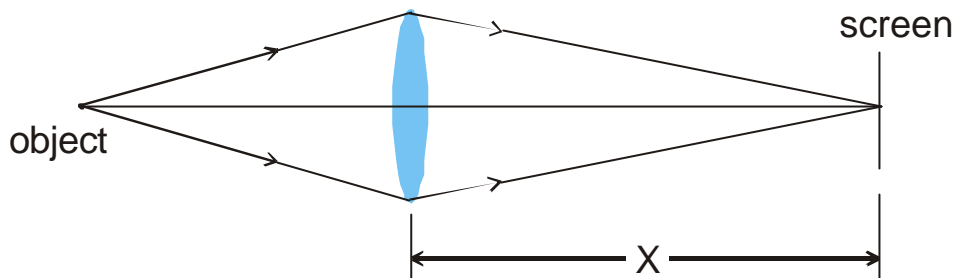


diagram 1

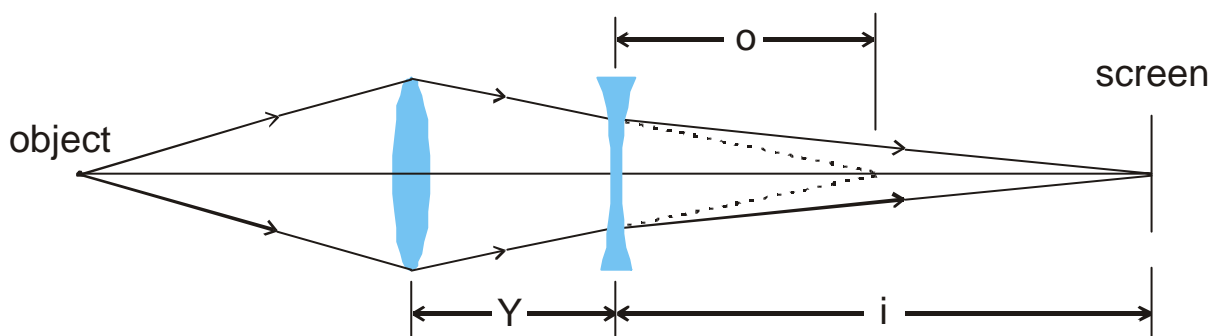


diagram 2

With the object and convex lens in the *same positions*, place the concave lens as shown and move the screen and/or the concave lens to obtain a clear image. We say that, at the point where the screen *was* there is now a *virtual object* of which the concave lens can form a real image.

When the image is clear measure $d_o (= X - Y)$ and d_i

Use the equation $1/f = 1/d_o + 1/d_i$ to calculate the focal length of the concave lens.

Remember that, in this case, d_o will be a negative quantity (why?).

Repeat the experiment with different values of X and find an average value for the focal length.

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