Geometrical Optics - FAFA60

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1 Your own digital camera

I chosed a lipbalm for this assignment which is placed 32 cm from the camera and the lipbalm is 7 cm high, which makes $L_1 = 32cm$ and $y = 7cm$. Here is the picture (slightly compressed in LaTeX, and apparently when i download the pdf it gets rotated by 90 degrees, no idea why, sorry in advance):

Figure 1: Picture used for first assignment

With Microsoft Paint the pixels could be measured to $P_{height} = 3363px - 2602px = 761px$. The pixel size of my camera which is on a OnePlus 7T Pro is $S_{camera} = 1\mu m$. To calculate the image height in pixels by the size of each pixel we are using the relation $y^{‘} = S * P = 1 * 10^{-6} * 761 = 7,61 * 10^{-4}$.

To get the magnification of the object we need to use the magnification formula: $M = -\frac{y^{‘}}{y} = -(7,61 * 10^{-4})/0.07 = -0,01$ which means that the image is upside down but the phone turns the image. To measure L_2 we need to use this formula again however this time as $M = -\frac{L_2}{L_1} \Leftrightarrow L_2 = -M * L_1 = 0,01 * 32 = 0.32cm = 32mm$ Lastly we need to get the focal length of the camera which we will compare with the technical specification of the manufacturer. To do this we need to use Gauss Lens formula. $\frac{1}{a} + \frac{1}{b} = \frac{1}{f} \Leftrightarrow \frac{1}{L_1} + \frac{1}{L_2} = \frac{1}{f} \Leftrightarrow f = 1/((1/32) + (1/0.32)) = 0,3168cm = 32mm$

According to the internet the focal length should be 27 mm. The difference here is $32.27 = 5mm$. This could occur to human errors and measurement failures with paint and measurement to the object.

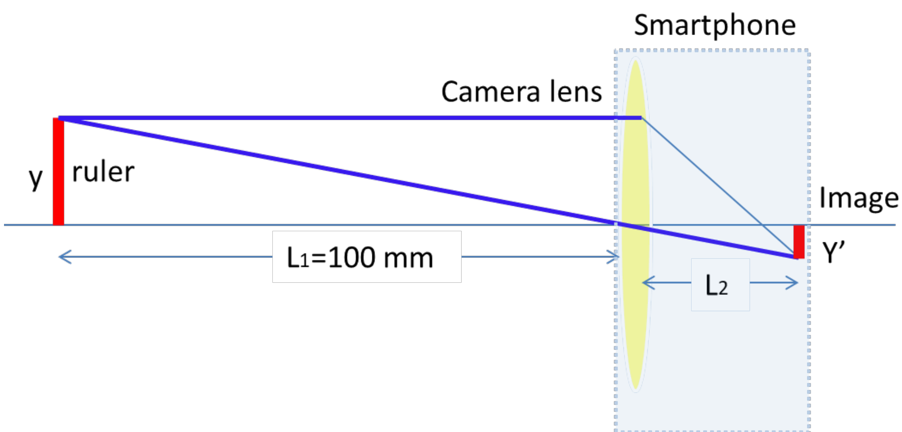


Figure 2: Model used for assignment one

2 Telescopes and microscopes - using the Geometrical Optics Tool

2.1 Galilei Telescope

To first get that $G = 3$ we need to calculate the f_{ob}. Note that during this lab the first lens which is convex is always a Optimal Convex lens. The focal length of the objective was set to $f_{ok} = 9cm$ which will give us the focal length of the ocular with the magnification formula: $G = \frac{f_{ob}}{f_{ok}} \Leftrightarrow f_{ok} = \frac{f_{ob}}{G} = \frac{9}{3} = -3cm$ (concave lenses have anegative focal length).

From the formula from the breaking strength (excuse my english) with a lens we can do the following: $abs(R_1) = abs(R_2) : R = 2 * f * (n - 1) = 3cm$.

If a_1 goes to infinity we get that $b_1 = 9cm$. After that we set that b_2 goes to infinity to get that $a_2 = -3cm$.

Why does a beam-type source represent a faraway object? Because the rays are parallel when a object is far away.

What radii, focal lengths, and lens placements did you choose? Following is a picture of the setup and the data which answers the question.

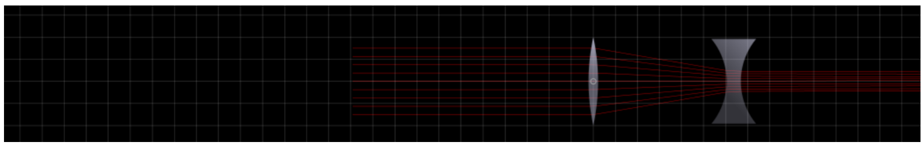
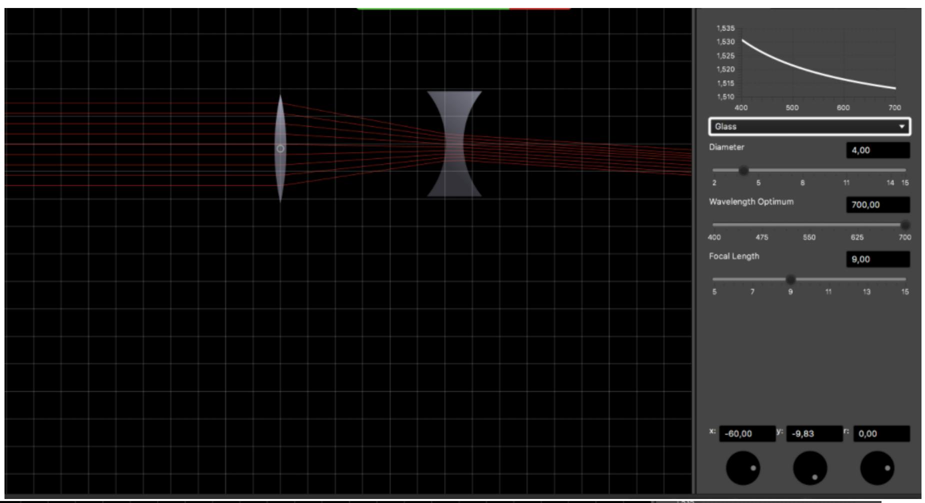
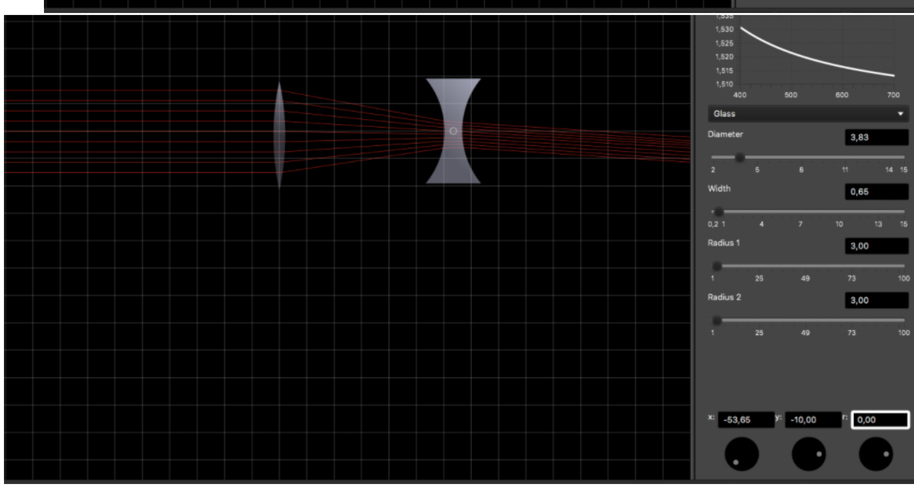


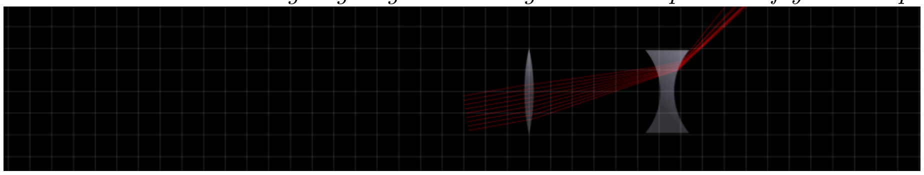
Figure 3: Setup for Galilei telescope



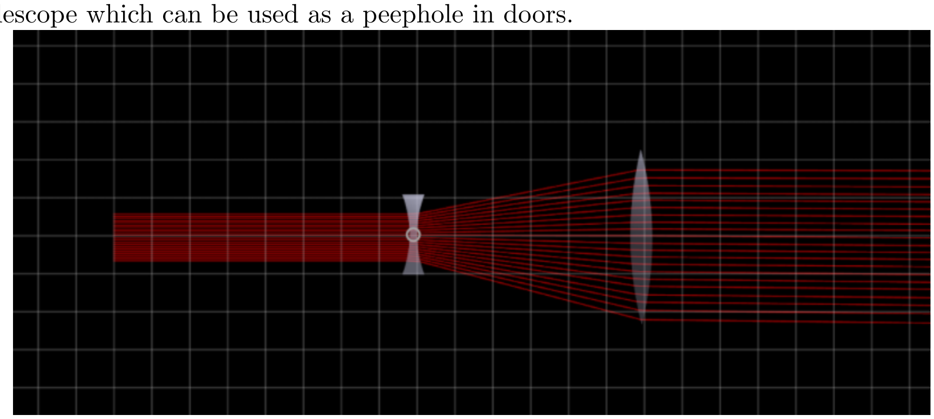


When the incoming beams are parallel, the magnification is a pure angle-

magnification. In order to see this, tilt the angle of the light source by 10 degrees and observe that the outgoing angle is 3x larger. Give a picture of your setup.



Switch the setup around to obtain a magnification of G = 1/3. When is this type of telescope used? The same distances and radiuses are used as before but the lenses have switched places. What we have in front of us is a reversed Galilei telescope which can be used as a peephole in doors.

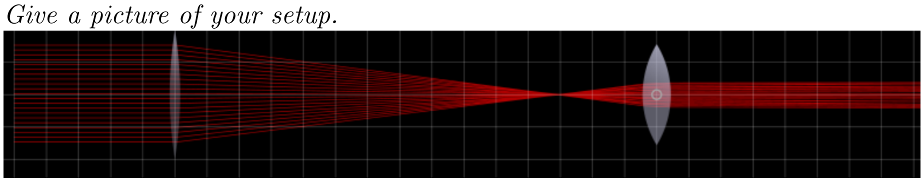


2.2 Kepler Telescope

First a object should be created with two suitable lenses that has a magnification of G = 4. Here the same kind of method is used as above. Therefore i wont explain thoroughly what happens. The focal length of the first lens is $f_{ob} = 12cm$. $G = abs(f_{ob}/f_{ok}) \Leftrightarrow f_{ok} = f_{ob}/G = 12/4 = 3cm$. $R = 2 * f * (n - 1)$. To calculate the positions of the lenses we need to use the breaking strength formula used above and Gauss lens formula. $R = 2 * f_{ob} * (n - 1) = 12cm$. $a_1 = infinity, b_1 =?$ which gives $b_1 = 1/((1/f_{ob}) - (1/a_1)) = 1/((1/12) - (1/infinity)) = 12cm$.

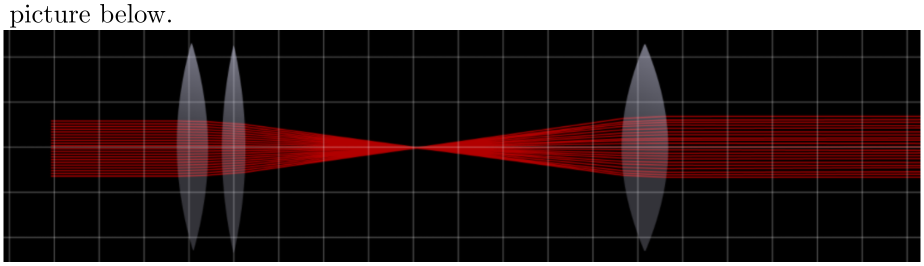
$R = 2 * f_{ok} * (n - 1) = 3cm$. $a_2 =?, b_2 = infinity$ which gives $a_2 = 1/((1/f_{ok}) - (1/b_2)) = 1/((1/3) - (1/infinity)) = 3cm$.

Give a picture of your setup.



What primarily separates the Galilei and Kepler telescope? The Galilei telescope uses one convex lens as an objective and a concave lens as ocular. The Kepler telescope uses two convex lenses where one acts as objective and the other as a ocular.

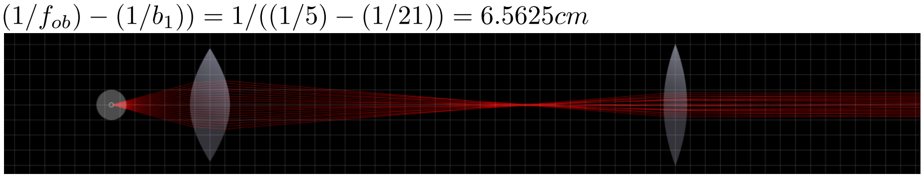
Now build a Kepler telescope with an image turning lens (M = -1). Use three lenses with 50, 75, and 100 mm focal lengths and try to construct it as compact as possible. Which lenses go where? (Hint: place the image turning lens such that it fits with the distance-relation you found in task 2.2 from part 1 of this lab, ie, the automatically corrected quiz. Hint2: When placing the image turning lens, you can use "optimal convex lenses "in order to avoid aberrations, and make the effect a bit clearer). The order is 75mm, 100mm and 50mm. See the picture below.



2.3 Microscope

Why should you use a cone (that is a point-like) light source in the microscope? The light is placed so that the studied object receives concentrated light on it to get optimum resolution.

Give a picture of your setup, where the distances of the light source and the lenses can be seen. The focal lengths of the lenses are already told, $f_{ob} = 5cm$. $f_{ok} = 10cm$. To get the correct lengths for the microscope you need to calculate the positions. b_1 = the distance between the lenses where the focal point is for the first lens $= L + f_{ob} = 16 + 5 = 21cm$. Now we have what we need to figure out where the light should be placed using Gauss lens formula: $a_1 = 1/((1/f_{ob}) - (1/b_1)) = 1/((1/5) - (1/21)) = 6.5625cm$



Are the rays coming out of the ocular reasonably parallel / collimated, as they should be? (If the setup is longer than the screen, remember that you can zoom out to see the whole setup.) Yes

What is the magnification of the microscope? Microscope magnification is calculated with the formula: $G = (L * d_0)/(f_{ob} * f_{ok}) = (16 * 25)/(5 * 10) = 8$. This means the microscope has a magnification of 8x.

How can the (angle) magnification be seen on the rays? If you draw the normal through all the objectives the angle magnification can be seen.