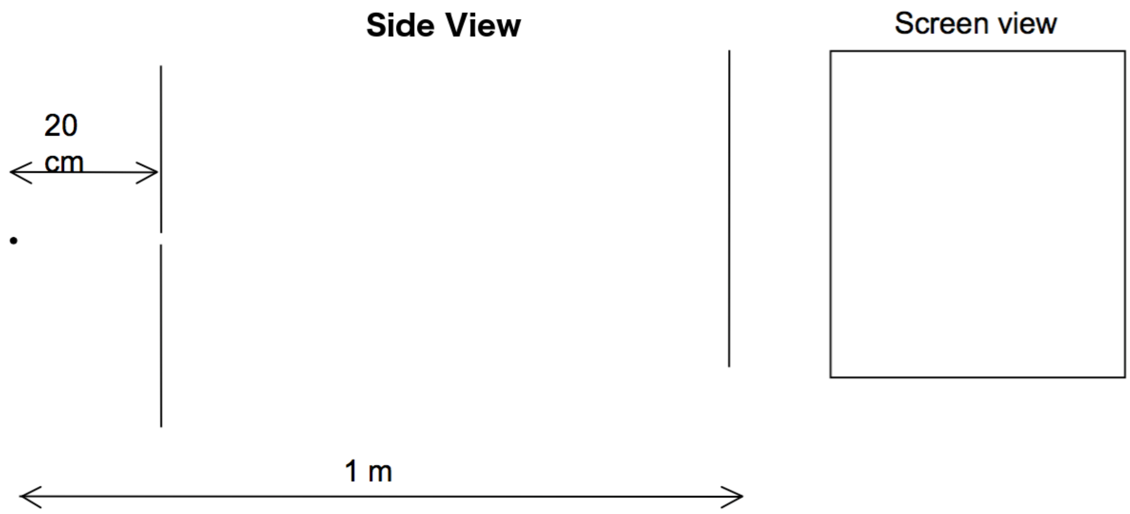
I. POINT SOURCE[1]

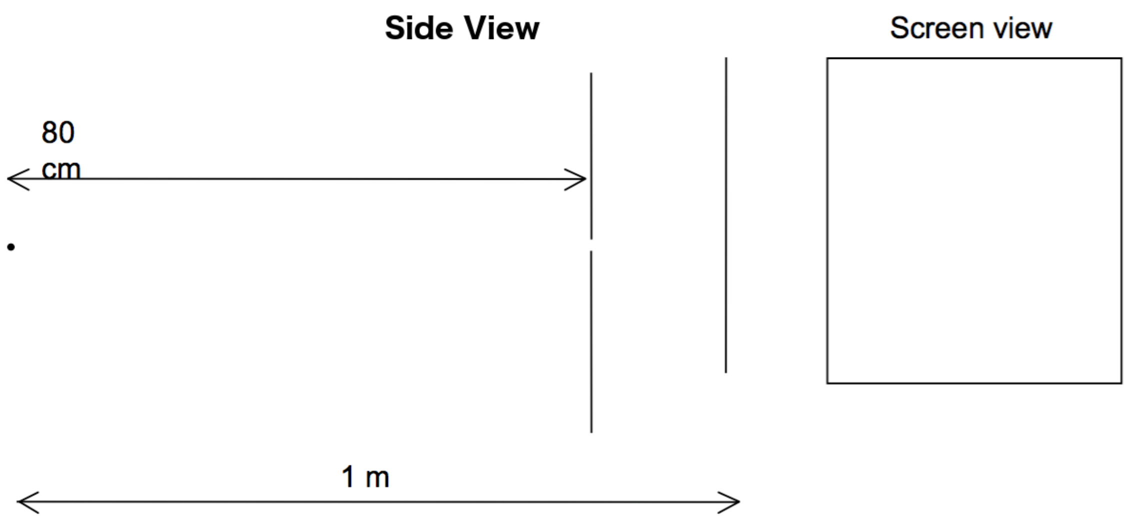
Consider the hypothetical circumstances shown below. A point source is 1.0m from a screen. A baffle (to block stry light) with a circular aperture (diameter of 0.7 cm) is 0.20m from the point source. Everything is drawn to scale. Predict what you expect to see on the screen (shape and size of the image).



Explain your diagram.

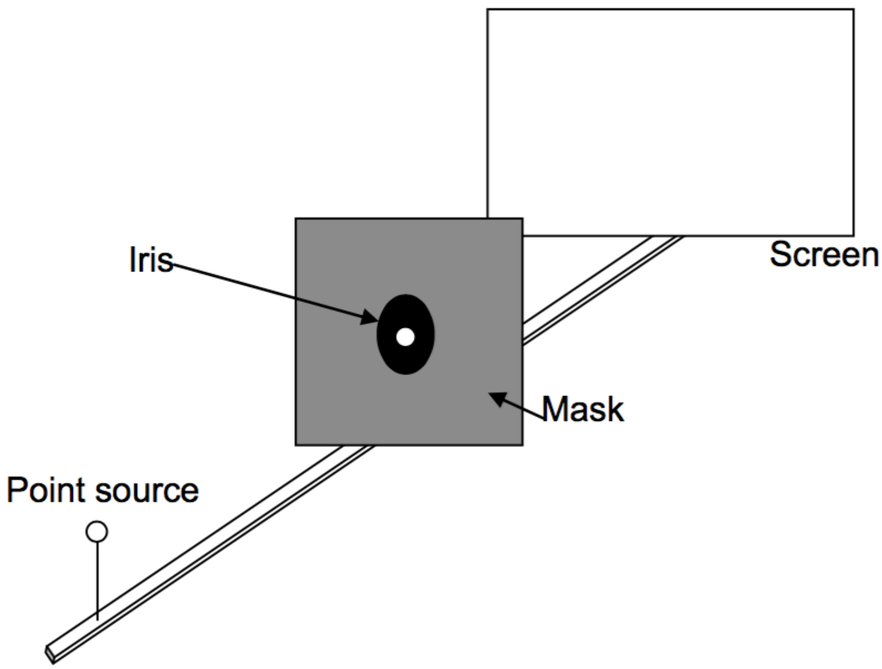
If the total distance between the source and screen is constant at 1 m and the source-baffle distance is set at 80 cm (same aperture), predict what size and shape of an image you would see on the screen.

Explain your prediction.



1 This lab is loosely based on "Tutorials in Introductory Physics", McDermott, Shaffer, and P.E.G. (U. of 11 Washington), First Edition, 2002 as modified by Mark Masters and Timothy Grove of Indiana University, Purdue University, Fort Wayne.

Set up a light point source (a white LED), an iris, the large centimeter-ruled screen, a black mask with circular aperture.



For fixed source-iris and iris-screen distances, make a prediction for how the image diameter changes size as the aperture changes size. Make quantitative predictions for three different aperture diameters, then take data to test your predictions.

Do your observations agree with your predictions? If not, then resolve the discrepancies between your predictions and your observations.

Develop a mathematical model (formula) for the image diameter, r_i, based on a point source being a distance d_o away from the baffle, the aperture having a radius r_a, and the distance d_i between the baffle and the screen. Assume the point source is on axis with the aperture hole.

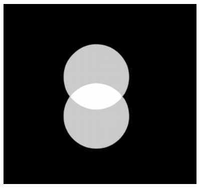
II. TWO POINT SOURCES

Predict how placing a second point source above the first point source would affect what you see on the screen with the iris set to a 0.7 mm aperture. Explain. Draw a picture if you think it will help.

Predict how moving the second point source *upward* would affect what you see on the screen Explain. Draw a picture if you think it will help.

Consider a second point source above the first. Set up the sources and distances (but don't turn it on yet!) and make quantitative prediction for the location of the second image.

Perform the experiment using both point sources. Compare with your predictions. If any of your predictions were incorrect, resolve the inconsistency.



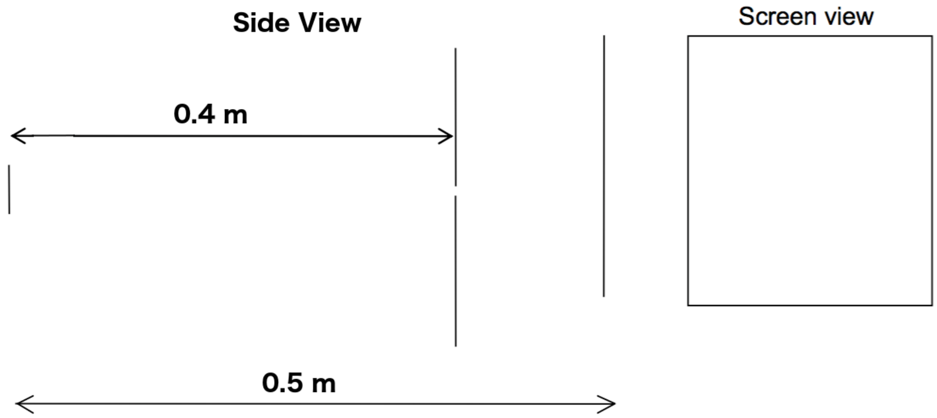
Open and close the iris until you see two overlapping source images like in the figure. You may have to adjust the image distance too. Predict what you would see if you remove the white screen and look backward through the aperture from different places on the screen.

Now look and compare what you predicted with what you saw. State what you learned.

Finally, what do your observations suggest about the path taken by light from the bulb to the screen? (Summarize your observations so far)

III. EXTENDED SOURCE

Use the bulb with the long straight filament as an extended source. Place the extended source is 0.5 m from a screen. Place the baffle with the iris set to 0.7 cm 0.40m from the extended source. Observe and record the illumination pattern on the screen. Comment on any variations in brightness you see in the image.



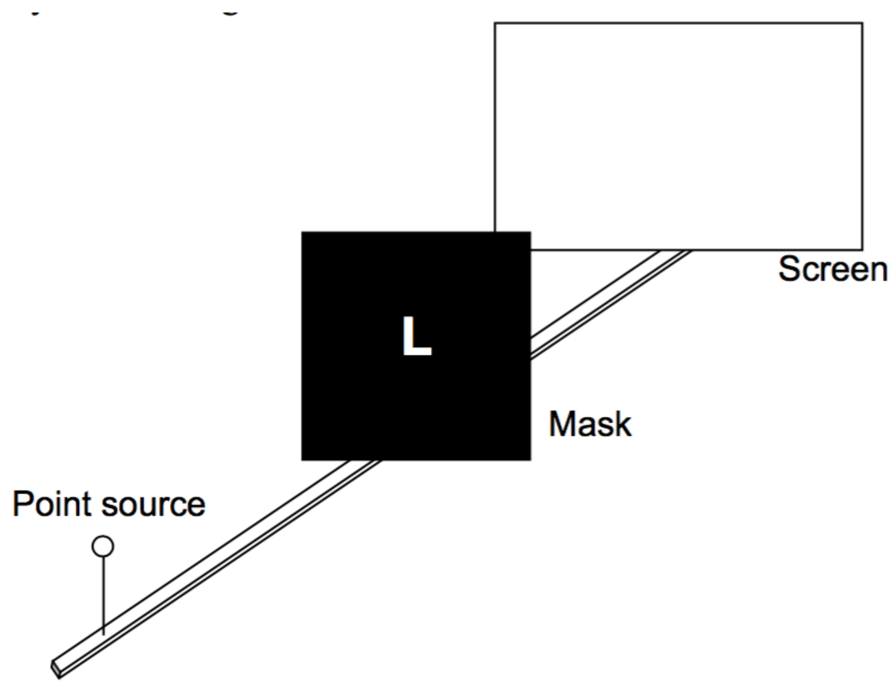
Using your previous observations and conclusions concerning point sources (sections I and II), come up with an explanation for how the above illumination pattern could have occurred.

SHOW YOUR EXPLANATION TO YOUR INSTRUCTOR!

Explore changing the distance between the extended source and the aperture, the distance from the aperture to the screen, and the aperture size. Comment on your experimental measurements. Explain any brightness variations you see. (It helps to think about looking backwards through the aperture to the source.)

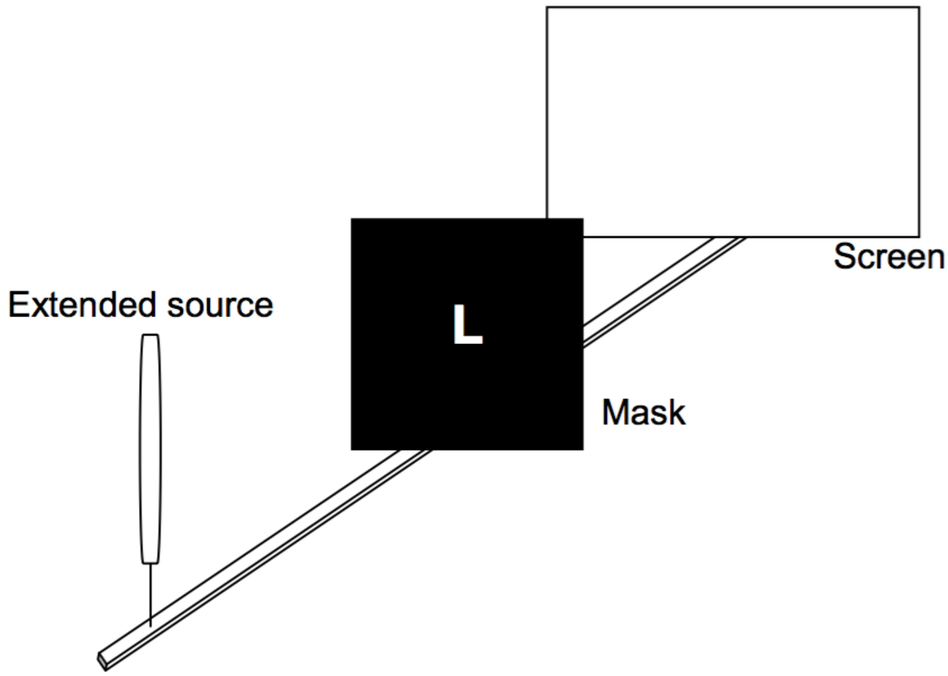
IV. NON-SYMMETRIC APERTURES

A mask containing a hole in the shape of the letter L is placed between a screen and a very small bulb as shown below. On the diagram, sketch what you would see on the screen when the bulb is turned on. Explain your reasoning.



Now test your prediction. Attach (with tape) an "L" shaped aperture to the black screen. Record a picture using the webcam. Reconcile the differences between your prediction and experimental results.

Now consider what would happen if you replace the point source with a **vertical** line source. Predict what you would see on the screen.



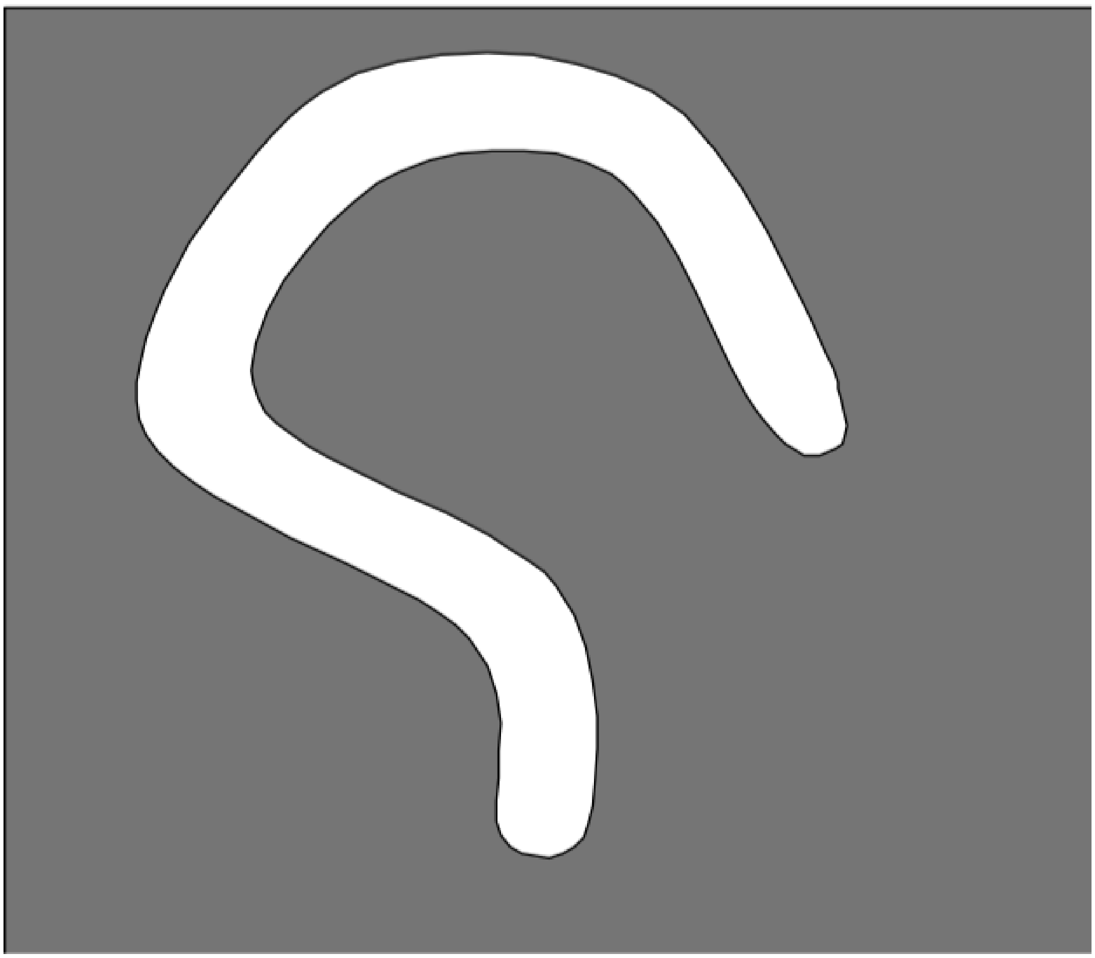
Also predict what the difference would be if you rotated the line source so it was **horizontal**.

Now test your prediction, Sketch the results below. Reconcile the differences between your prediction and experimental results.

V. FILL IN THE BLANK QUESTIONS

1) Using a circular aperture, the region of illumination from a single point source on the screen is __________________ shaped.
2) An extended source can be modeled as a collection of __________________.
3) With a circular aperture and an extended source (shaped like a line), the region of illumination is ___________________ shaped.
4) To make the region of illumination on the screen the most accurate, scaled representation of the extended source's shape, the aperture should have a ______________ size.

FINAL TASK #1

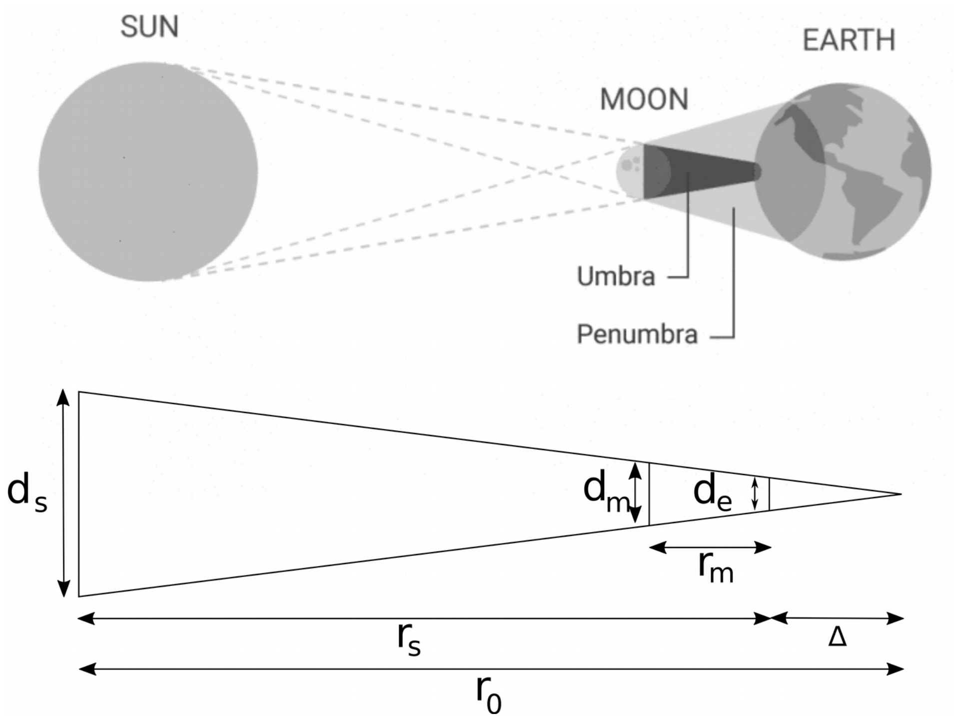


A line light source is placed 100 cm from a screen. An opaque baffle with a 2 mm aperture is placed exactly halfway between the light source and the screen. The image formed on the screen is drawn to actual size above. Determine the size and shape of the light source *as seen from behind the source looking toward the aperture*. Explain your answer completely.

FINAL TASK #2

The Sun has a diameter of 1,390,000 (6.96e5) km and on August 21, 2017 the distance from the Earth is 150,000,000 (1.50e8) km. On that date, the Moon will exactly come between the Sun and Earth in a solar eclipse that will be visible in the continental United States. The diameter of the Moon is 3,480 (3.48e3) km, and it will be 367,000 (3.67e5) km from the surface of the Earth that day.

The figure below shows the geometry of a solar eclipse. In the second figure, the vertex of the triangle is the point in space where the umbra vanishes; it is not a part of the Earth.



You may answer on the back.

1) What is meant by a "total solar eclipse" and what in the diagram corresponds to a total solar eclipse?

2) What is meant by a "partial solar eclipse" and what in the diagram corresponds to a partial solar eclipse?

3) For the Sun-Moon-Earth system, what is the shape of the area on Earth that has a total eclipse?

4) What is the **size** of the area? ***Hint****: set up similar triangles. There are three triangles similar to each other.* The second figure shows the triangles I used. d_s – diameter of the Sun, d_m – diameter of the Moon, d_e – diameter of eclipse spot, r_m – distance from surface of the Earth to the Moon, r_s – distance from the Earth to the Sun, and r_0 – the distance from the Sun to the vertex. Note that neither r_0 nor Δ has a relationship to the Earth.

5) From the Earth looking toward the Sun, draw and describe what is seen during
   a) a total eclipse,
   b) a partial solar eclipse, and
   c) no eclipse on that day (or a near miss).