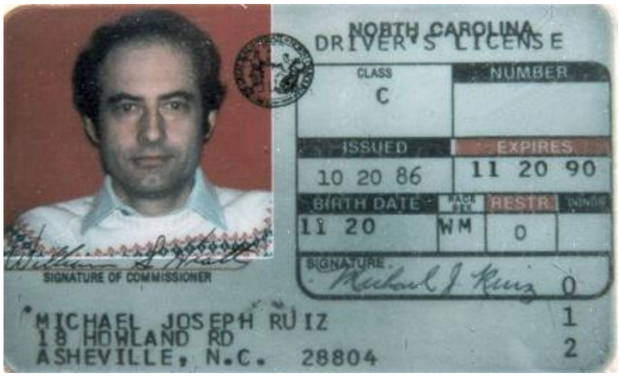
HW-E1. Special Camera Setup. Your instructor asks you to take a photo of the 30 mm x 30 mm ID picture that is on his 85 mm x 50 mm license from 1990 so that it is magnified 3x. You find a lens in the lab with focal length 60 mm. You set it up on an optical lab bench. You attach the license on one side of the lens and a large piece of covered film paper on the other side. You then turn off the lights, carefully remove the cover on the film, and activate a flash so that the film captures the magnified image.



What is the distance from the lens that you should place the license? What distance on the other side of the lens should you place the film? (a) Answer this question mathematically by doing the appropriate lens calculation using the appropriate lens formulas. (b) Give an engineering drawing of the 30-mm tall object as a vertical line with an arrow (^) on top as usual, the corresponding image, and lens all to scale. Neatly include two key rays to show that the rays accurately determine the proper location of the image. Indicate what represents 10 mm in your scaled drawing. If you use graph paper where each box is 1 cm by 1 cm, you could for example, make each box actually represent 1 cm = 10 cm and have a drawing that is exactly the correct sizes. But this scale is not required. You may use any scale, like a map, as long as you indicate the scale and your diagram is elegant.

[Grading: 4 points for the math, 3 points for the graph if correct in a roughly qualitative sense, 3 additional points if the graph is accurate and pleasing to the eye – a requirement of all engineering design drawings. Be sure to do all work on scrap paper first, including the drawing, before you prepare your report. And remember that your report includes communication through neatness, easy to follow math steps, and a nice graphical drawing. Then, I and others will want to hire you!]

HW-E2. Engineering Design of a Magic Illusion.

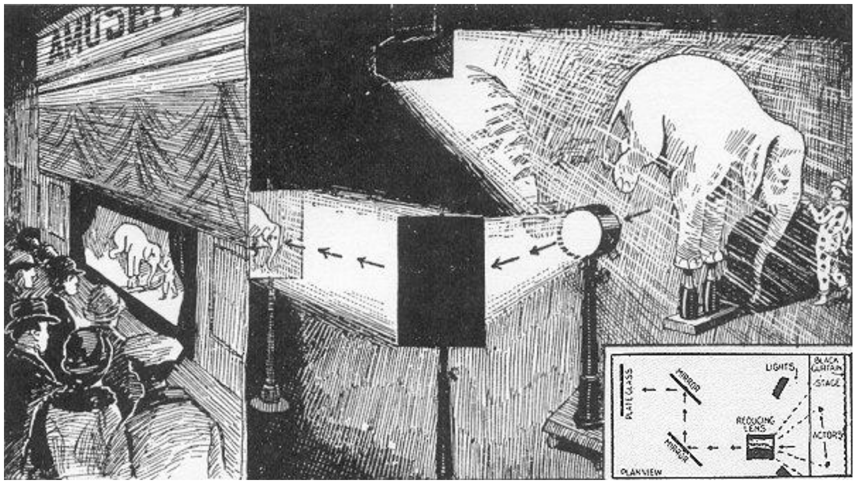
For our next problem we look to the magician Joseph Dunninger (1892-1975). In his ***Dunninger's Complete Encyclopedia of Magic***, published by Hamlyn Group Ltd, London, 1970 we find a fascinating trick where people and objects are made miniature. Dunninger explains in his book as follows. But remember that in 1922, there were no television sets. Audiences were not used to seeing little images of people and animals moving around on a screen.

"During the summer months of 1922 there was exhibited at Coney Island, New York, a most remarkable performance in the apparent reduction in size of human beings. When we say reduction of human beings we refer to the apparent reduction in the size of humans, without their undergoing any physical discomfort whatever. For that was actually what took place on a stage before the very eyes of the audience.

"In a spacious lobby of the Tanagra Theatre, a 'barker' called the attention of pleasure-seeking people to an exhibition, or rather performance, to be given on a stage 12 inches high and 24 inches wide, with as many normal-sized human beings on it as it could comfortably accommodate." Joseph Dunninger.

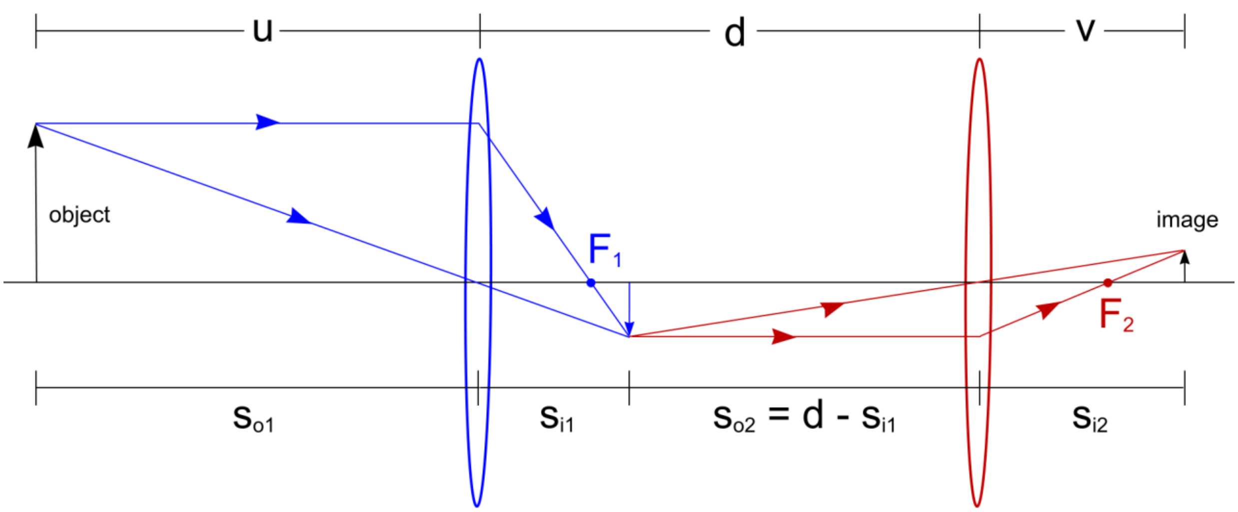
Suppose they took your date back there and you saw your date on the miniature stage?

Trick Stage



From Dunninger's Complete Encyclopedia of Magic

In the inset in the above figure there is a diagram of the mechanism for the trick. It is too small to easily read. You are going design a different setup, the system shown below. The aim in the figure below is not to draw to scale, but rather to illustrate the basic idea of your design invention.



Design Specs: You are to find the focal lengths f_1 and f_2 of the two 2 thin lenses shown above, where u = 6 ft, d = 10 ft, v = 4 ft, and the magnification is + 1 /36. In this way, a child 36 inches tall (object) will have a corresponding image size of 1 inch projected on the glass viewing screen!

[Grading: 2 points for a neat figure not to scale, 2 points for the general math setup, 2 points all or nothing for each focal length expressed in the simplest elegant form as radicals and fractions. Then if correct, 1 additional point each for the answers in decimals to 3 significant figures. Correct results are very important in engineering!] Examples of elegant forms for radicals and fractions are given below.

$$1+\frac{1}{2}+\frac{1}{3}=\frac{11}{6}=1.83 \qquad \frac{\sqrt{8+12}-6}{2}=\frac{\sqrt{20}-6}{2}=\frac{2\sqrt{5}-6}{2}=\sqrt{5}-3=-0.764$$

$$\sqrt{\frac{3+5}{16}}=\sqrt{\frac{8}{16}}=\sqrt{\frac{1}{2}}=0.707$$ or in this case, perfectly acceptable are also $\frac{1}{\sqrt{2}}$ or $\frac{\sqrt{2}}{2}$