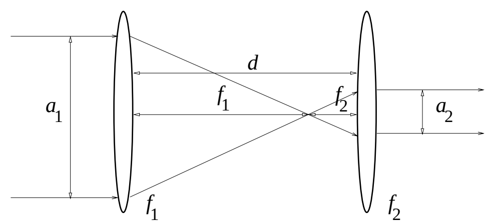
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

2.997 Optical Engineering **Fall '99**
Sept. 22, 1999

Quiz – Duration: 10 min.

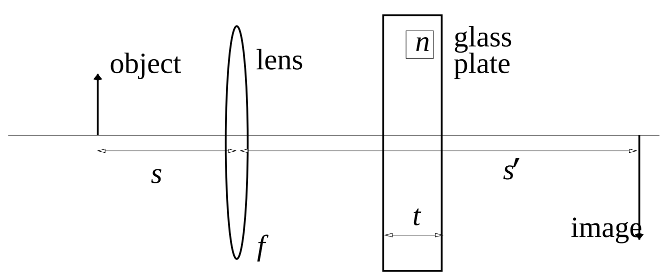
1. Two thin lenses (focal lengths f_1, f_2) are separated by distance d. The left-hand-side lens is illuminated by a ray bundle originating at $-\infty$. What is the required separation so that the bundle emerging from the right-hand-side lens is collimated (*i.e.*, comes to focus at $+\infty$)?



Answer: By definition, the input ray comes to focus f_1 behind the first lens, and a point source at distance f_2 in front of the second lens produces a collimated ray bundle at the output. Therefore, $d = f_1 + f_2$ (note that these statements are true for thin lenses; for a thick lens, one should use effective focal lengths and be more careful with the distance definitions).

2. In the previous problem, what is the ratio of beam widths a_1/a_2?
Answer: From similar triangles, $a_1/a_2 = f_1/f_2$.

3. The object shown below is distance s behind a thin lens (focal length f) followed by a thin plate (thickness t, refractive index n). Find the distance s' where the image is in focus (within the paraxial approximation).



Answer: The effective plate thickness is t/n. Therefore, the effective optical path between lens and object is $s' - t + t/n$, and the lens law applies as follows:

$$\frac{1}{s' + t\left(\frac{1}{n} - 1\right)} = \frac{1}{s} + \frac{1}{f} \Rightarrow s' = \frac{sf}{s+f} + \left(1 - \frac{1}{n}\right) t.$$