Ray Optics problem n°3

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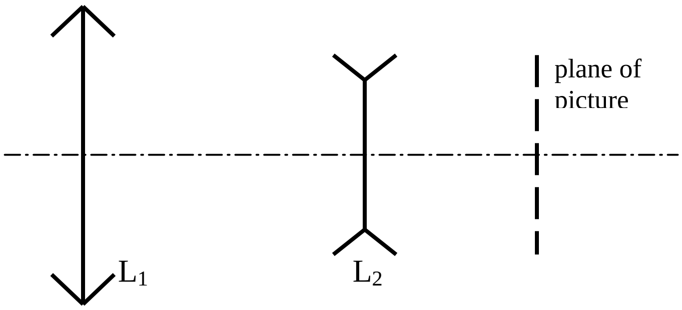
Zoom lens for a photographic camera

A tourist wants to take a picture of the Eiffel tower from the Palais de Chaillot. The height of the Eiffel Tower is 300m and the tourist is standing 1km away from the tower.

1. What will be the height of the Eiffel Tower on the picture if he uses a single lens with focal length f' = 50mm?

Instead of using a single lens, the tourist chooses a zoom lens consisting of two lenses with focal lengths in the range 50 to 150 mm. The 2 lenses will be considered as thin lenses that we can move along the optical axis. The converging lens L_1, has a focal length f'_1 = 50mm. The diverging lens L_2, has a focal length f'_2 = -25mm.



2. What must be the focal length of the whole system if we want the image of the Eiffel Tower to be 30 mm high ? Deduce from this the transverse magnification, g_{y2}, for the imaging through the lens L_2.
3. Determine the positions of the lenses to get this focal length for the zoom lens system.
4. Check the previous result using Gullstrand's formula.
5. Represent the zoom lens system to scale and construct a bundle of rays coming from a point at infinity on the axis. Locate the cardinal points H' and F'.
6. We wish to vary the focal length of the system, f', between 75 and 150 mm, while the image plane remains fixed (for an object still at infinity). The distances between the lenses and the second focal point of the whole system will be noted : $x_1 = L_1F'$ and $x_2 = L_2F'$. Express x_1 and x_2 as a function of f_1', f_2', and g_{y2}.
7. Deduce the positions of the lenses leading to a focal length of 75 mm, then of 150 mm. Represent those configurations on a drawing.