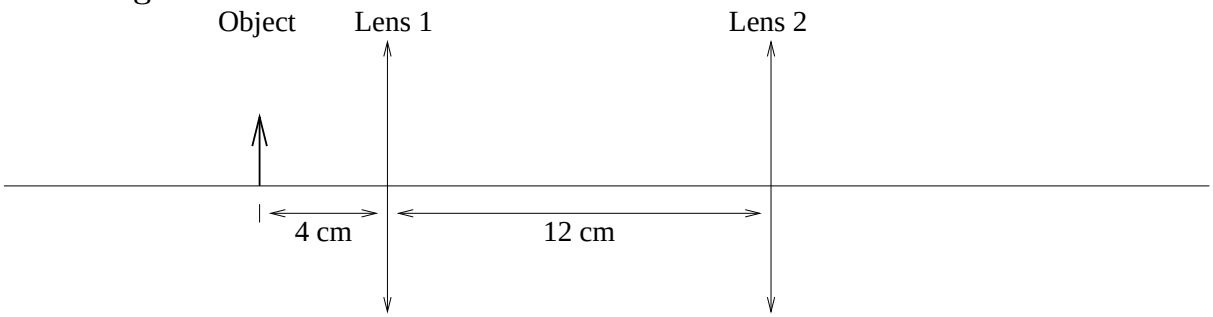
PHY6938 Proficiency Exam Spring 2002
April 5, 2002
Optics and Thermodynamics

1. A combination of two thin, convex lenses are placed as shown in the figure. An object is placed 4 cm in front of the first lens, which has a focal length of 12 cm. The second lens is 12 cm behind the first and has a focal length of 6 cm.

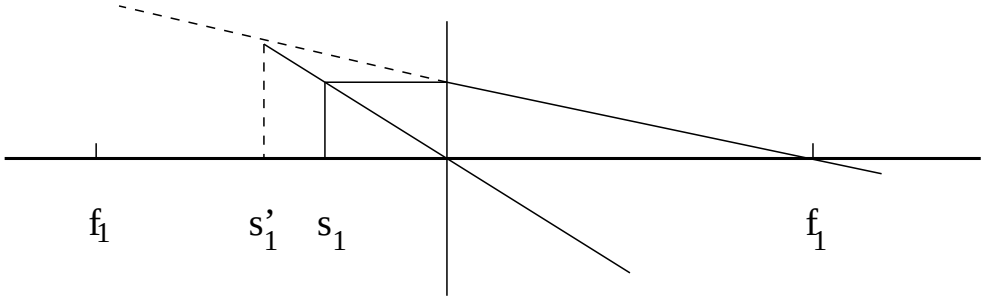


(a) Use the thin-lens formula to find the image of the first lens, and show it through a ray-diagram on the sketch.

We can find everything we need from the lens formula(e)

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}, \quad m=-\frac{s'}{s}, \tag{1}$$

The lenses are convex, this means that the focal points f_1 and f_2 are positive. Since the object is in front of the first lens then s_1 is positive too. Substitute the values of f_1 and s_1 in Eq.1 and check the result for s_1' with the figure.



$$\frac{1}{s_1'}=\frac{1}{f_1}-\frac{1}{s_1}=\frac{1}{12\text{ cm}}-\frac{1}{4\text{ cm}}=-\frac{1}{6\text{ cm}}, \tag{2}$$

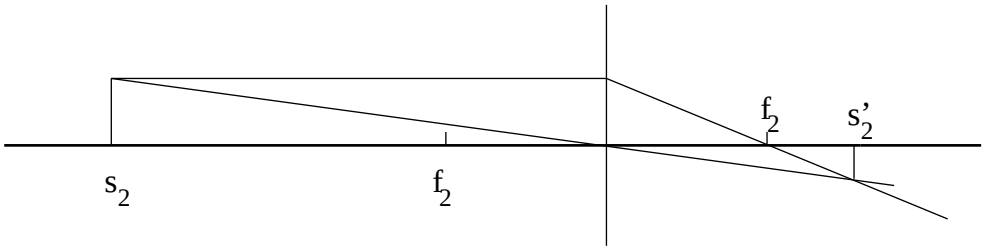
This means that $s_1'=-6$ cm.

(b) Is the image real or virtual ?

Since $s_1'=-6$ cm, this means that the image is in front of the first lens. Therefore the image is virtual.

(c) Find the image for the lens combination using the thin-lens formula, and use a ray-diagram to mark the image at the correct location on the sketch.

To find the image for this combination of lenses we use Eq.1 again. The image of the first lens, as calculated in part (a) is located at 6 cm in front of the first lens. Therefore the distance between this image and the second lens $s_2 = 18$ cm.



$$\begin{aligned} \frac{1}{s_2'} &= \frac{1}{f_2} - \frac{1}{s_2} = \frac{1}{6\text{ cm}} - \frac{1}{18\text{ cm}} = -\frac{2}{18\text{ cm}}, \\ s_2' &= 9\text{ cm} \end{aligned} \tag{3}$$

(d) Is the resulting image real or virtual ?

Since $s_2' = 9$ cm, is positive, the image is behind the second lens. Therefore, the image is real.