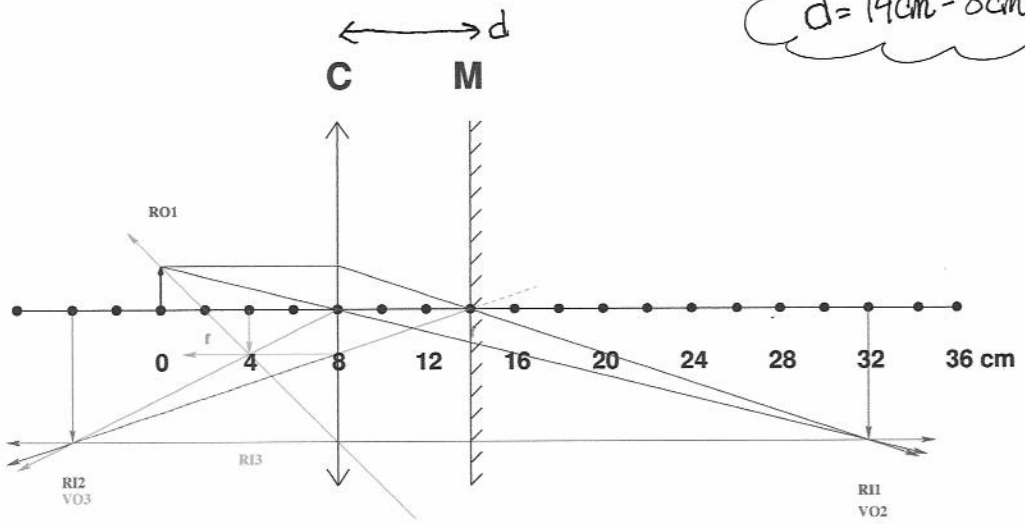
d = 14cm − 8cm = 6cm



4) Marks are made along an optical axis every 2 cm, as shown. A converging lens ($|f_1| = 6$ cm) is placed at $x = 8$ cm, a planar mirror is placed at $x = 14$ cm, and an object (2 cm tall), is placed upright at the origin. **For full credit** answer the following questions analytically (that is, compute the answer). It might not be a bad idea to confirm your answers with some rigorous ray-tracing on the diagram above (it will almost certainly be worth some partial credit).

- 4a) (10 points) At what point along the optical axis is the first image produced by the converging lens located? Is it real or virtual? ... Oriented upward or down? How tall is it?

$p = +8\text{cm}$
$f = +6\text{cm}$
$h_o = 2\text{cm}$

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\quad q = \frac{fp}{p-f}$

$M = \frac{h_i}{h_o} = -\frac{q}{p}$ $\quad M = \frac{f}{f-p}$

$q = 24\text{cm}$ (RI) $\quad (x = 8\text{cm} + 24\text{cm} = 32\text{cm})$

$M = -3$ $\quad (h_i = -6\text{cm})$

The lens produces a real image, oriented downward at $x = 32$cm. It (the image) has a height of 6 cm.

- 4b) (10 points) At what point along the optical axis is the image produced by the planar mirror located? Is it real or virtual? ... Oriented up or down? How tall is it?

You can eyeball p_2, or use $p_2 = d - q_1 = 6cm - 24cm = -18cm$

$p_2 = -18\,cm$ $\quad \frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\quad q_1 = -p$

$f = \infty$ $\quad M = \frac{h_i}{h_o} = \frac{-q}{p}$ $\quad M = 1$

$h_o = -6cm$

$q = 18\,cm$ (RI) $\quad (x = 14cm - 18cm = -4cm)$

$M = 1$ $\quad (h_i = -6cm)$

The mirror produces a real image oriented downward, at $x = -4\,cm$.
The image has a height of 6 cm.

- 4c) (10 points) At what point along the optical axis is the final image located? Is it real or virtual? ... Oriented up or down? How tall is it?

again... eyeball p_3 or use $p_3 = d - q_2 = 6cm - 18cm = -12cm$

$p_3 = -12cm$ $\quad \frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\quad q = \frac{fp}{p-f}$

$f = +6\,cm$ $\quad M = \frac{h_i}{h_o} = \frac{-q}{p}$ $\quad M = \frac{f}{f-p}$

$h_o = -6cm$

$q = 4\,cm$ (RI) $\quad (x = 8cm - 4cm = 4cm)$

$M = \frac{1}{3}$ $\quad (h_i = -2cm)$

The lens produces a 2cm tall real image
oriented downward at $x = 4\,cm$