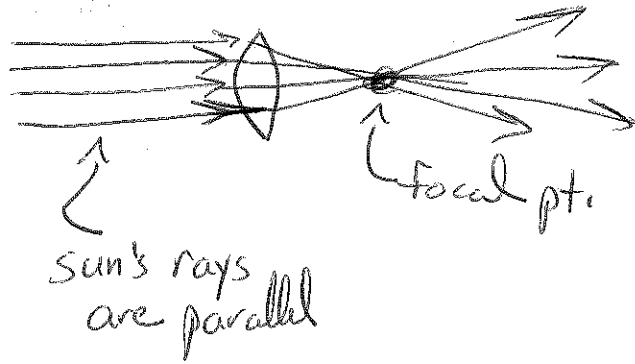
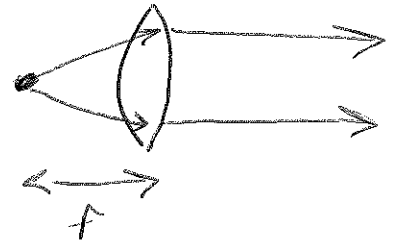


Concave & Convex Lenses

① CONVERGING



② Rays coming from the focal pt. will be refracted by the lens so they emerge parallel to one another. \Rightarrow they do NOT intersect to form an image

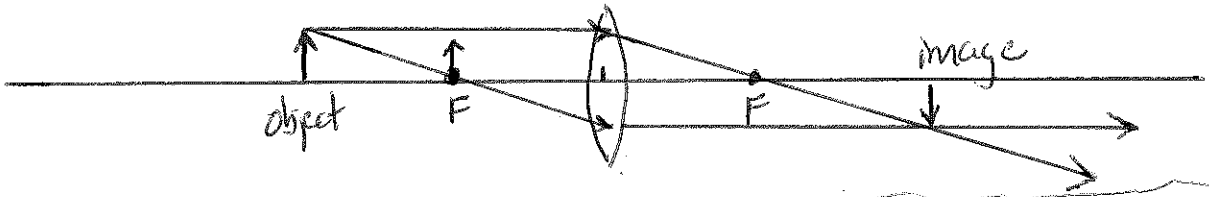


- ③
- a) ~~when $s_o > f$~~ ^{inverted when} ~~when $s_o > f$~~ $s_o > f$
 - b) upright when $s_o < f$
 - c) real when $s_o > f$
 - d) virtual when $s_o < f$

- ④
- a) NEVER
 - b) always
 - c) NEVER
 - d) always

5

a)



$s_i \approx 43 \text{ cm}$
by ray tracing

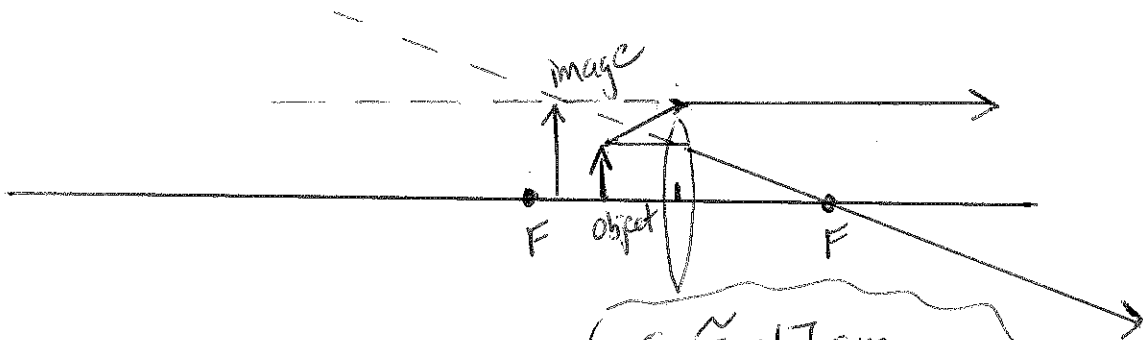
$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{40} + \frac{1}{s_i} = \frac{1}{20}$$

$$\frac{1}{s_i} = \frac{1}{20} - \frac{1}{40} = \frac{2}{40} - \frac{1}{40} = \frac{1}{40} \Rightarrow$$

$$s_i = 40 \text{ cm}$$

b)



$s_i \approx -17 \text{ cm}$
by ray tracing

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{10} + \frac{1}{s_i} = \frac{1}{20}$$

$$\frac{1}{s_i} = \frac{1}{20} - \frac{1}{10} = \frac{1}{20} - \frac{2}{20} = -\frac{1}{20} \Rightarrow$$

$$s_i = -20 \text{ cm}$$

6

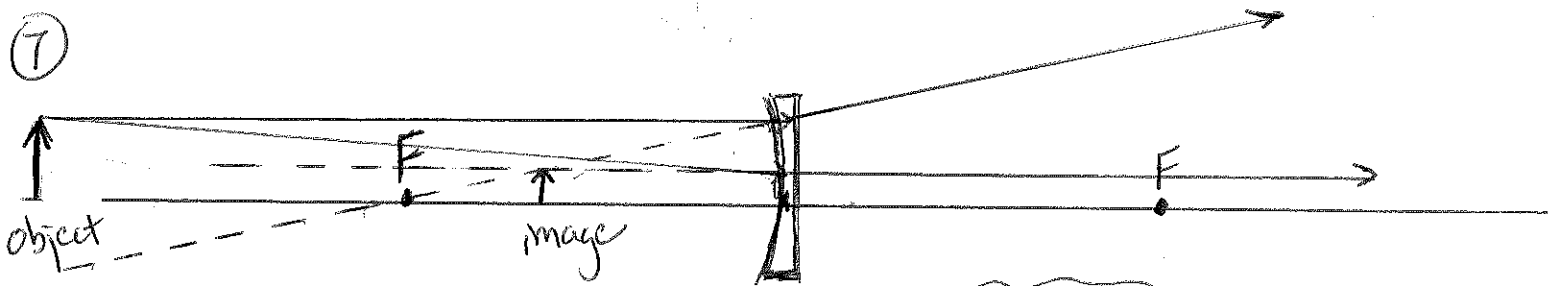
a) $m = \frac{-s_i}{s_o} = \frac{-40 \text{ cm}}{40 \text{ cm}} = -1$

$s_i > 0 \Rightarrow$ real
 $m < 0 \Rightarrow$ inverted
 $m = -1$

b) $m = \frac{-s_i}{s_o} = \frac{-(-20 \text{ cm})}{10 \text{ cm}} = +2$

$s_i < 0 \Rightarrow$ virtual
 $m > 0 \Rightarrow$ upright
 $m = +2$

7

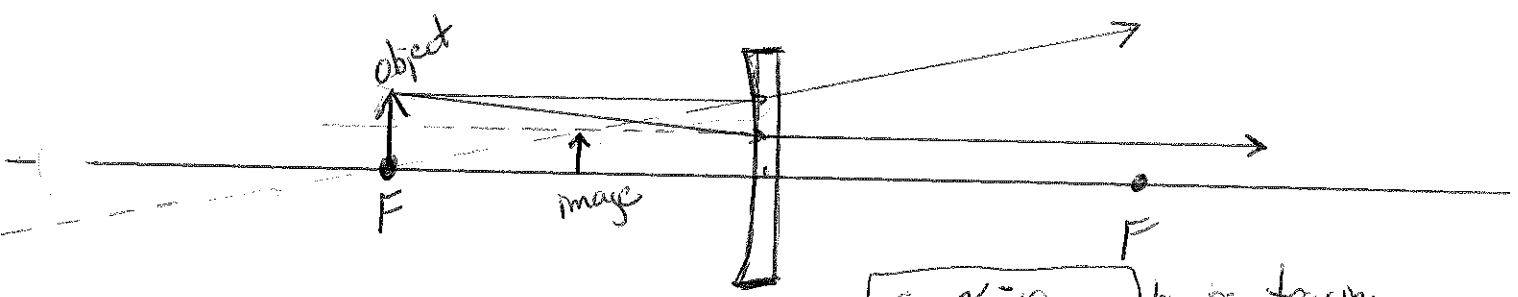


$s_i \approx -12.8 \text{ cm}$
by ray tracing

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \quad f = -20 \text{ cm}$$

a) $\frac{1}{40} + \frac{1}{s_i} = \frac{1}{-20}$ because it is a diverging lens

$$\frac{1}{s_i} = \frac{1}{-20} - \frac{1}{40} = \frac{-2}{40} - \frac{1}{40} = \frac{-3}{40} \Rightarrow s_i = -13.3 \text{ cm}$$



$s_i \approx -10 \text{ cm}$ by ray tracing

b) $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \Rightarrow \frac{1}{20} + \frac{1}{s_i} = \frac{1}{-20} \Rightarrow \frac{1}{s_i} = \frac{1}{-20} - \frac{1}{20} = \frac{-2}{20} \Rightarrow s_i = -10 \text{ cm}$

8

a) virtual because $s_i < 0$
upright because $m > 0$
 $m = +0.3325$

$$M = \frac{-s_i}{s_o} = -\frac{(-13.3 \text{ cm})}{40 \text{ cm}} = +0.3325$$

b) virtual because $s_i < 0$
upright because $m > 0$
 $m = +\frac{1}{2}$

$$M = \frac{-s_i}{s_o} = -\frac{(-10 \text{ cm})}{20 \text{ cm}} = +\frac{1}{2}$$

⑨ $f = +15 \text{ cm}$
 $s_o = ?$
 $m = +2$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{15}$$

$$\frac{1}{s_o} + \frac{1}{-2s_o} = \frac{1}{15}$$

$$\frac{-2}{-2s_o} + \frac{1}{-2s_o} = \frac{1}{15}$$

$$m = \frac{-s_i}{s_o}$$

$$+2 = \frac{-s_i}{s_o}$$

$$+2s_o = -s_i$$

$$\boxed{-2s_o = s_i}$$

$$\frac{-1}{-2s_o} = \frac{1}{15} \Rightarrow \frac{2s_o}{1} = 15$$

$$\boxed{s_o = 7.5 \text{ cm}}$$

⑩ $s_o = 80 \text{ cm}$
 $s_i = -40 \text{ cm}$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{80} + \frac{1}{-40} = \frac{1}{f}$$

$$\frac{1}{80} + \frac{-2}{80} = \frac{1}{f}$$

$$\frac{-1}{80} = \frac{1}{f} \Rightarrow \boxed{f = -80 \text{ cm}}$$

⑪ $s_o = 10f$
 $s_i = ?$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{10f} + \frac{1}{s_i} = \frac{1}{f}$$

$$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{10f} = \frac{10}{10f} - \frac{1}{10f} = \frac{9}{10f}$$

$$\Rightarrow \boxed{s_i = \frac{10}{9} f}$$