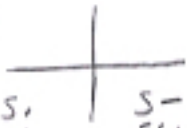
250



$$M = \frac{h'}{h} = -\frac{s'}{s}$$

Real: Virtual
upright: inverted
enlarged: unmag: Reduced

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

() $f > 0$

[] $f < 0$

$s' < 0$

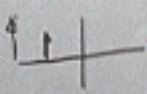
$h = 1\,cm \qquad M = +$

$h' = 2\,cm \qquad M = \frac{h'}{h} = \frac{2}{1} = +2 = \frac{s'}{s}$

$s = 20$

$\frac{s'}{s} = \frac{s'}{20} = 2 \Rightarrow s' = 40\,cm$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = \frac{1}{20} + \frac{1}{40}$

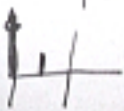


$\frac{2}{40} + \frac{1}{40} = \frac{3}{40} \Rightarrow f = \frac{40}{3}$

$f = 13\,cm$

$\frac{1}{5} + \frac{1}{5} = \frac{1}{20} - \frac{1}{40} = \frac{2}{40} - \frac{1}{40} = \frac{1}{40}$

$f = +40$



$s' > 0$

$M < 0$

~~$s = 0$~~ $s = +20$

$h' = -2$ $\quad M = -\frac{h'}{h} = -2 = -\frac{s'}{s}$

$h = 1$

$s' = 2s = \underline{40\,cm}$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = \frac{1}{20} + \frac{1}{40} = \frac{3}{40}$

$f = 13.3\,cm$

$s = -10\,cm$

$f = -5\,cm$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \Rightarrow \frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$

$\frac{1}{s'} = \frac{1}{-5} - \frac{1}{-10} = -\frac{2}{10} + \frac{1}{10} = -\frac{1}{10}$

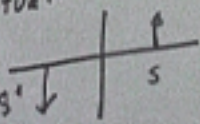
$s' = -10\,cm$

$M = -\frac{s'}{s} = -\frac{-10}{-10} = -1$

inverted ($M < 0$)

Unmag $|M| = 1$

Virtual $s' < 0$



$s = -10\,cm \qquad f > 0$

$f = +5\,cm$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \Rightarrow \frac{1}{s'} = \frac{1}{+5} - \frac{1}{-10}$

$= \frac{2}{10} + \frac{1}{10} = \frac{3}{10}$

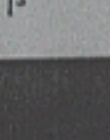
$s' = \frac{10}{3} = 3.3$

$M = \frac{h'}{h} = -\frac{s'}{s} = 3$

$= -\frac{3.3}{-10} = .33$

Real: $s' > 0$ upright $M+$

Reduced: $|M| < 1$



$s = ?$

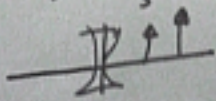
$s' = +10\,cm$ $\quad M = -\frac{s'}{s} = -\frac{+10}{-6}$

$f = -15\,cm$ $\quad = 1.67\,(+)$

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \Rightarrow \frac{1}{s} = \frac{1}{f} - \frac{1}{s'}$

$= \frac{1}{-15} - \frac{1}{10} = -\frac{2}{30} - \frac{3}{30} = -\frac{5}{30}$

$s = -\frac{30}{5} = -6\,cm$



$S_0 > 0$ S_i

$S_0 > f$

V $\frac{1}{s'} + \frac{1}{s} = \frac{1}{f} \Rightarrow \frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$

$\frac{1}{s'} = \frac{s-f}{sf} \Rightarrow s' = \frac{sf}{s-f}$

$s = s_{in} - Vt$ $Vt = S_0 - f$

$t = \frac{S_0 - f}{V}$

$s' = \frac{(S_{in} - Vt) f}{S_{in} - Vt - f}$

$V' = \frac{ds'}{dt}$