Mirrors

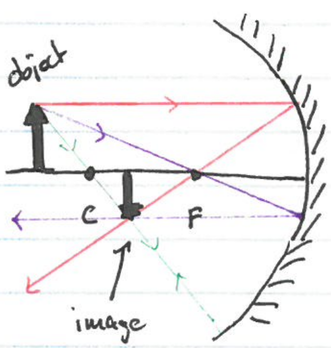
mirror equation: $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

magnification: $m = \frac{y'}{y} = -\frac{s'}{s}$

sign convention:	+	−
object distance s	same side as incident light	(we won't consider this for mirrors)
image distance s'	on side of reflected light ("reflective side")	behind the mirror ("backside of mirror")
radius of curvature r, f focal length	center of circle is on reflective side → concave	center of mirror is on the "backside" → convex
magnification m	upright image	inverted image

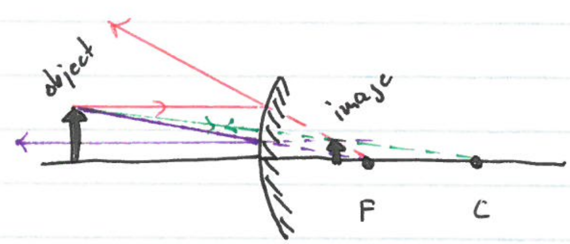
rays for ray diagram:	direction from object to mirror	direction from mirror out
parallel ray	parallel to principle axis	through focal point
focal ray	through focal point	parallel to principle axis
central ray	through center	through center

incident light from the left



concave mirror

incident light from the left



dashed lines: no actual light!

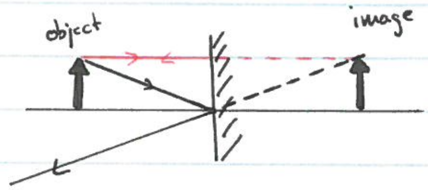
convex mirror

Note: the focal point and the center are on the other side of the mirror

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

Mirrors

flat mirror ($f = \infty$)



s : positive

f : ∞, so $\frac{1}{f} = 0$

$\frac{1}{s} + \frac{1}{s'} = 0 \Rightarrow s' = -s$

↳ s' : negative

(ie image is behind the mirror

$m = -\frac{s'}{s} = +1$ ← same size as object.

↑ upright

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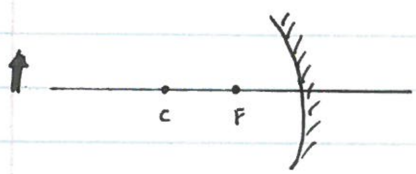
concave mirror (f positive)

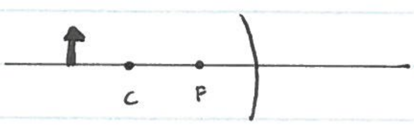


object at infinity : $s = \infty$

$\frac{1}{s'} = \frac{1}{f} \Rightarrow$ image is at focal point

s' positive → real image on the reflecting side of the mirror

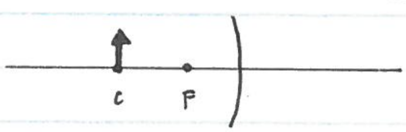
~~w~~ image is a point



$s > 2f$; s positive $\Rightarrow f < s' < 2f$

$\Rightarrow s'$ positive (real image)

$-1 < m < -\frac{1}{2}$ (inverted ; smaller)

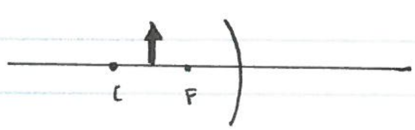


$s = 2f$; s positive $\frac{1}{2f} + \frac{1}{s'} = \frac{1}{f}$

$\Rightarrow s' = 2f$ (positive, ie real image)

$m = -\frac{s'}{s} = -1$ ← same size (magnification of 1)

↑ inverted

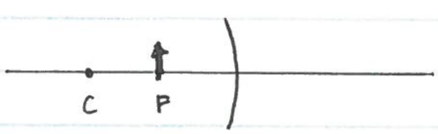


$f < s < 2f$

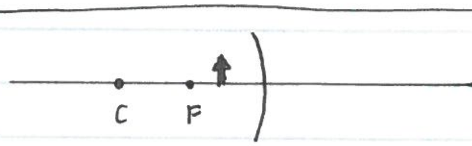
$\Rightarrow s'$ positive ; $s' > 2f$ ↗ real image

$\Rightarrow m < -1$ or $|m| > 1$; m negative

↓ magnified ↓ inverted



$s = f \Rightarrow \frac{1}{f} + \frac{1}{s'} = \frac{1}{f} \Rightarrow s' = \infty$ no image!



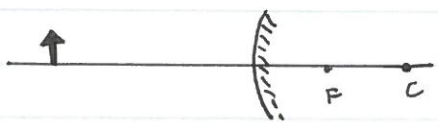
$s < f$ $\frac{1}{s'} = \frac{1}{f} - \frac{1}{s} < 0 \Rightarrow s'$ negative ↗ virtual image!

$m = -\frac{s'}{s} \Rightarrow m$ positive → upright

$|m| > 1$ → magnified

convex mirror

(f negative)



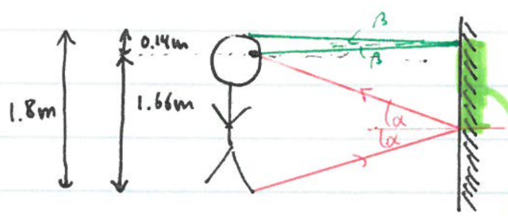
s is positive
f is negative

$\Rightarrow$ s' is negative $\Rightarrow$ virtual image

$m = -\frac{s'}{s}$ so m is positive $\rightarrow$ upright
and $|m| < 1 \Rightarrow$ smaller

Examples:

Minimum height of flat mirror such that you can see your full image.
you are 1.80m tall ; your eyes are 14cm below the top of your head.



a light ray from the top of your head into your eyes

a light ray from your feet (into your eyes, so you can see it)

minimal height of mirror

$\frac{1.66m}{2} + \frac{0.14m}{2} = \frac{1.80m}{2}$ (half your height)

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where are first four images in each mirror

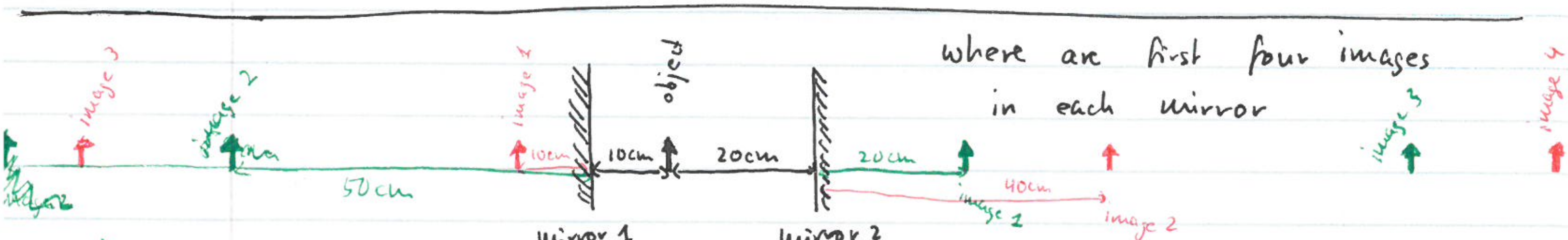

image 4 is off the left

red image

~~red image~~ : 10cm left of mirror ①

10cm+30cm = 40cm right of mirror ②

40cm + 30cm = 70cm left of ①

70cm + 30cm = 100cm right of ②

green image

20cm right of ②

20cm + 30cm = 50cm left of ①

50cm + 30cm = 80cm right of ②

80cm + 30cm = 110cm left of ①