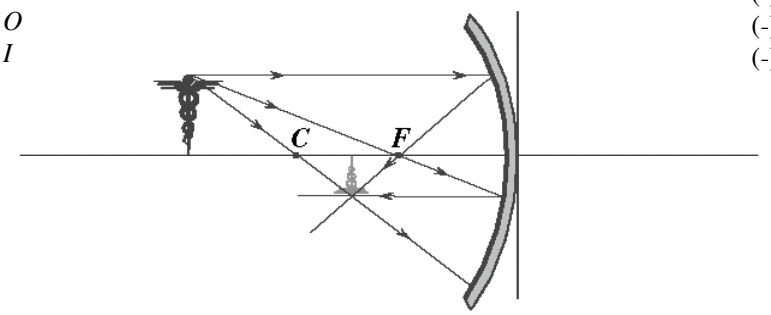
Concave Mirror

(+) F
(+) O
(+) I

(-) F
(-) O
(-) I



$(O > 2F)$ *example:* $F = 1$, $O = 3$, *then* $I = 3/2$

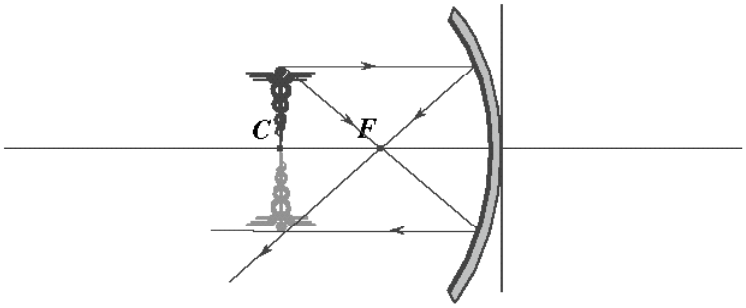
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{3} + \frac{1}{3/2}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{3/2}{3} = -\frac{1}{2}$$

M is negative so image is inverted

|M| is less than one so image is diminished



$(O = 2F)$ *example:* $F = 1$, $O = 2$, *then* $I = 2$

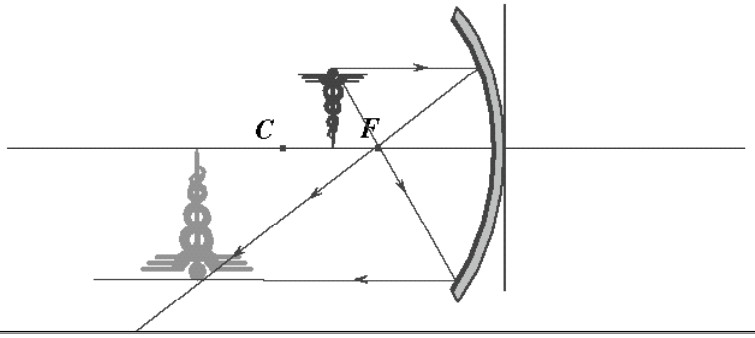
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{2} + \frac{1}{2}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{2}{2} = -1$$

M is negative so image is inverted

|M| is equal to one so image is same size



$(F < O < 2F)$ *example:* $F = 1$, $O = 3/2$, *then* $I = 3$

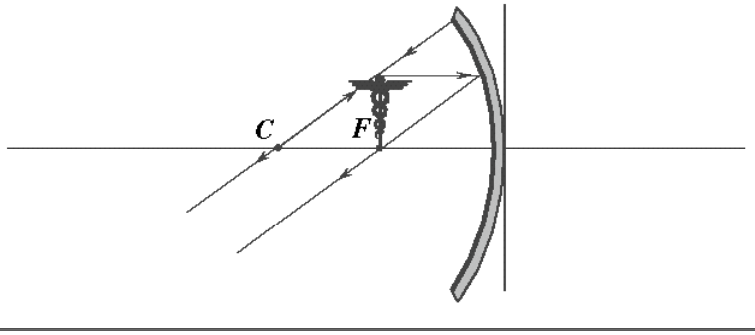
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{3/2} + \frac{1}{3}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{3}{3/2} = -2$$

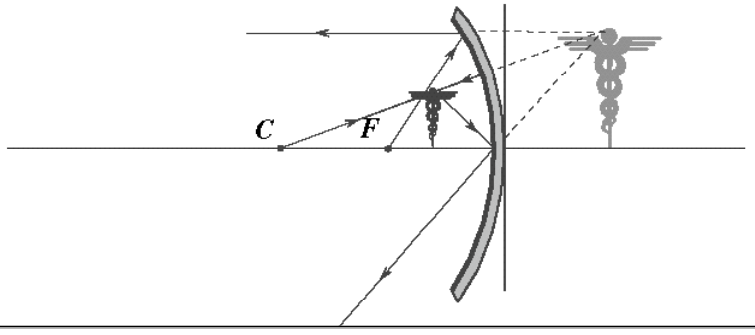
M is negative so image is inverted

|M| is greater than one so image is enlarged



$(O = F)$ *example:* $F = 1$, $O = 1$, *then* $I =$ *undefined*

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{1} + \frac{1}{\varnothing}$$



$(O < F)$ *example:* $F = 1$, $O = 1/2$, *then* $I = -1$

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{1/2} + \frac{1}{-1}$$

I is negative so image is virtual

$$M = -\frac{I}{O} \rightarrow -\frac{-1}{1/2} = 2$$

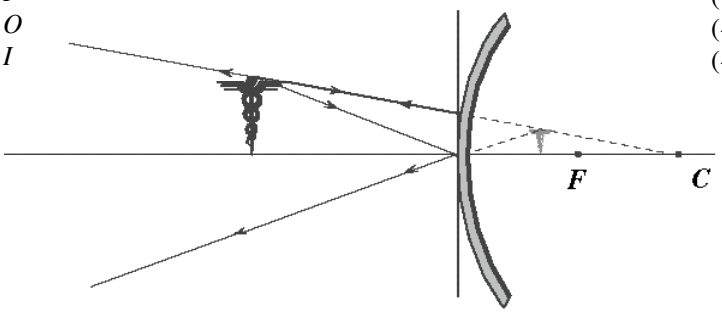
M is positive so image is erect

|M| is greater than one so image is enlarged

Convex Mirror

(+) F
(+) O
(+) I

(-) F
(-) O
(-) I



$(F < 0$ [convex]) example: $F = -1$, $O = 2$, then $I = -2/3$

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{-1} = \frac{1}{2} + \frac{1}{-2/3}$$

I is negative so image is virtual

$$M = -\frac{I}{O} \rightarrow -\frac{-2/3}{2} = 1/3$$

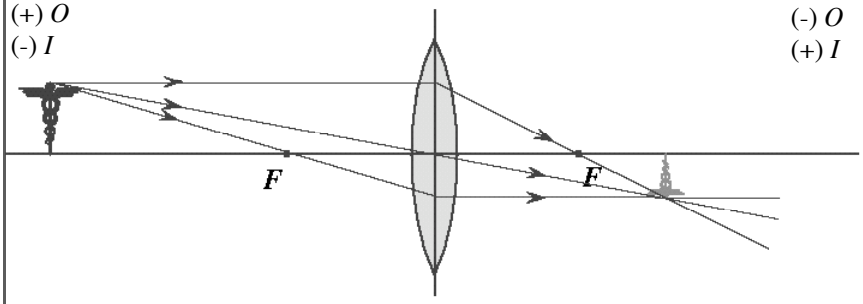
M is positive so image is erect

|M| is less than one so image is diminished

Converging Lens

(+) F
(+) O
(-) I

(-) F
(-) O
(+) I



$(O > 2F)$ *example:* $F = 1$, $O = 3$, *then* $I = 3/2$

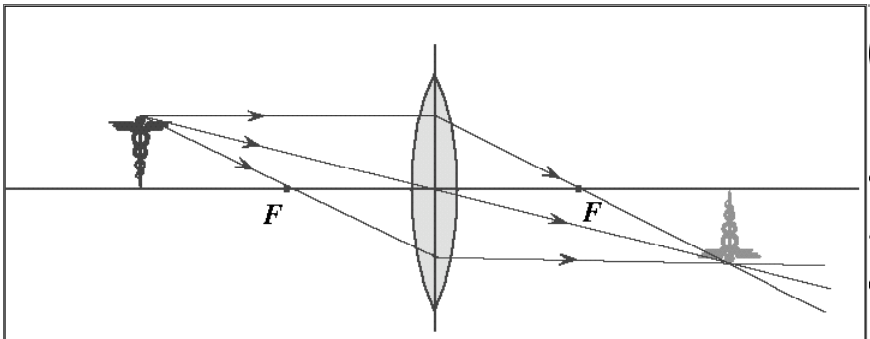
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{3} + \frac{1}{3/2}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{3/2}{3} = -\frac{1}{2}$$

M is negative so image is inverted

|M| is less than one so image is diminished



$(O = 2F)$ *example:* $F = 1$, $O = 2$, *then* $I = 2$

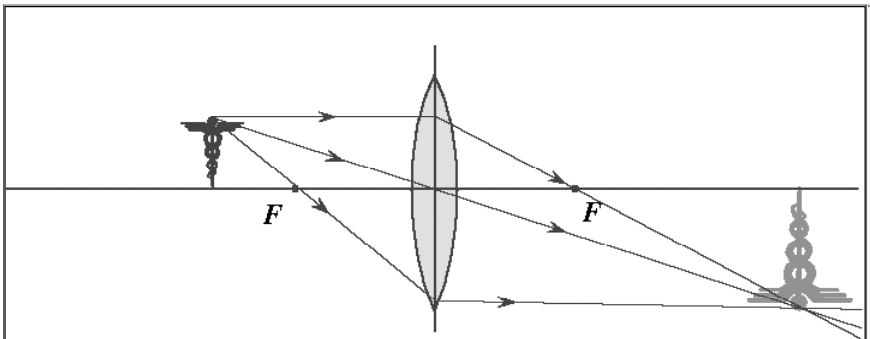
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{2} + \frac{1}{2}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{2}{2} = -1$$

M is negative so image is inverted

|M| is equal to one so image is same size



$(F < O < 2F)$ *example:* $F = 1$, $O = 3/2$, *then* $I = 3$

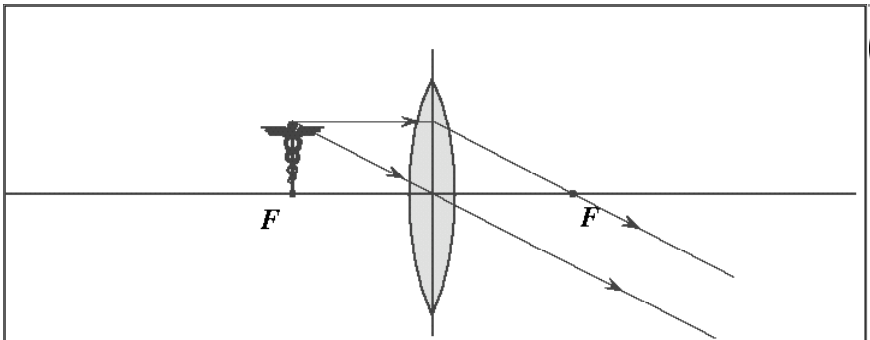
$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{3/2} + \frac{1}{3}$$

I is positive so image is real

$$M = -\frac{I}{O} \rightarrow -\frac{3}{3/2} = -2$$

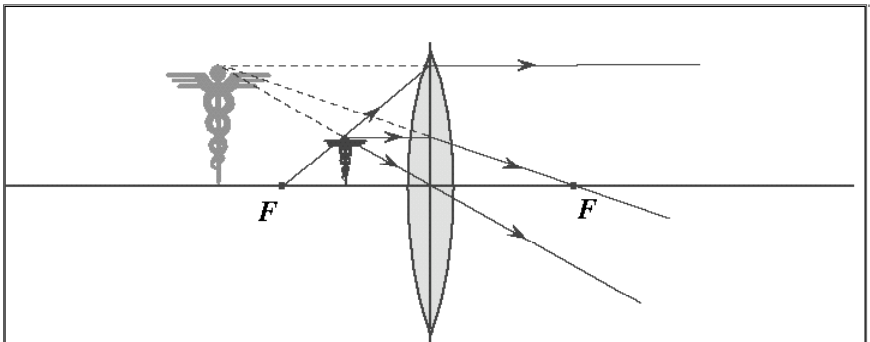
M is negative so image is inverted

|M| is greater than one so image is enlarged



$(O = F)$ *example:* $F = 1$, $O = 1$, *then* $I =$ *undefined*

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{1} + \frac{1}{\varnothing}$$



$(O < F)$ *example:* $F = 1$, $O = 1/2$, *then* $I = -1$

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{1} = \frac{1}{1/2} + \frac{1}{-1}$$

I is negative so image is virtual

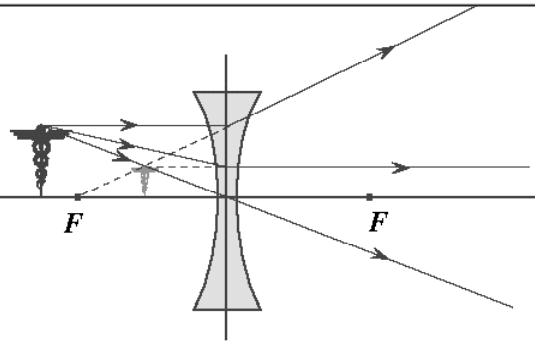
$$M = -\frac{I}{O} \rightarrow -\frac{-1}{1/2} = 2$$

M is positive so image is erect

|M| is greater than one so image is enlarged

Diverging Lens

(+) F
(+) O
(-) I



(-) F
(-) O
(+) I

($F < 0$ [diverging]) example: $F = -1$, $O = 2$, then $I = -2/3$

$$\frac{1}{F} = \frac{1}{O} + \frac{1}{I} \rightarrow \frac{1}{-1} = \frac{1}{2} + \frac{1}{-2/3}$$

I is negative so image is virtual

$$M = -\frac{I}{O} \rightarrow -\frac{-2/3}{2} = 1/3$$

M is positive so image is erect

$|M|$ is less than one so image is diminished