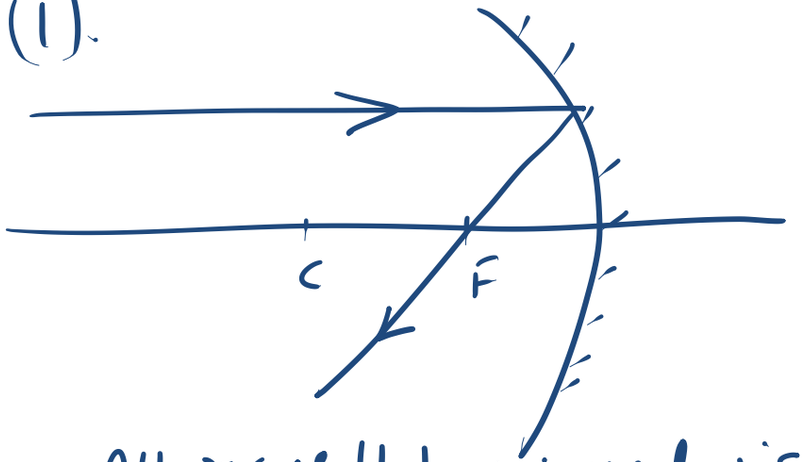
Session 19: Ray Optics – Reflection & Refraction @ curved surfaces

- Examples of concave mirror
- Ray diagram for convex mirror
- Examples of convex mirror
- Recap of comparison between different mirrors
- Newton’s formula
- Power of a mirror

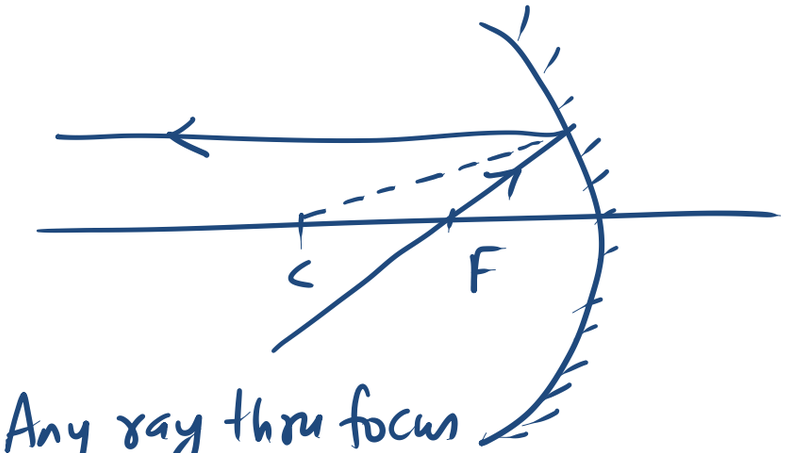
Ray diagrams (Rules) (4 rules)

(1).



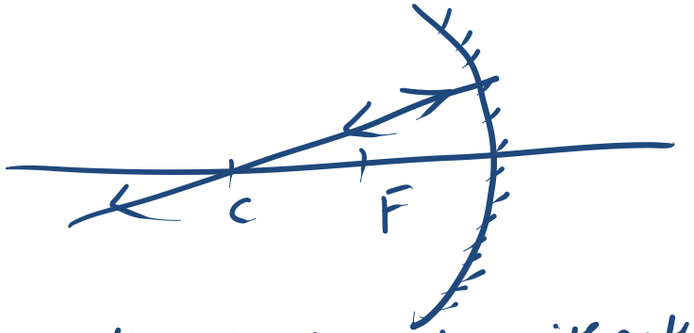
All rays ll to principal axis shall pass thru focus F.

(2).



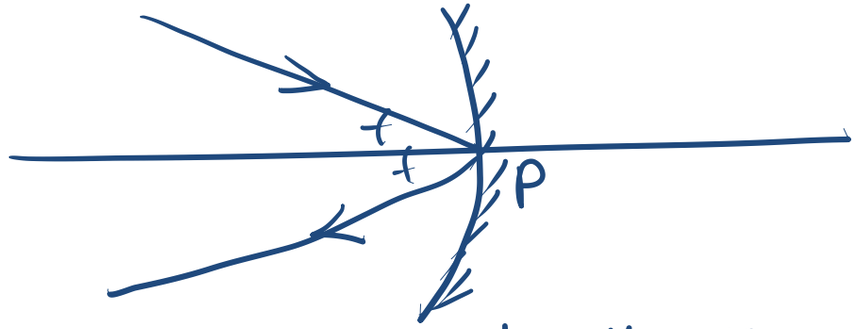
Any ray thru focus will become ll to principal axis.

(3).



Any ray thru C will retrace its path.

(4).



Any ray striking @ pole will pass symmetrically.

Ray diagrams for Concave Mirror :-

(i) obj @ -∞
↳ along Principal axis.

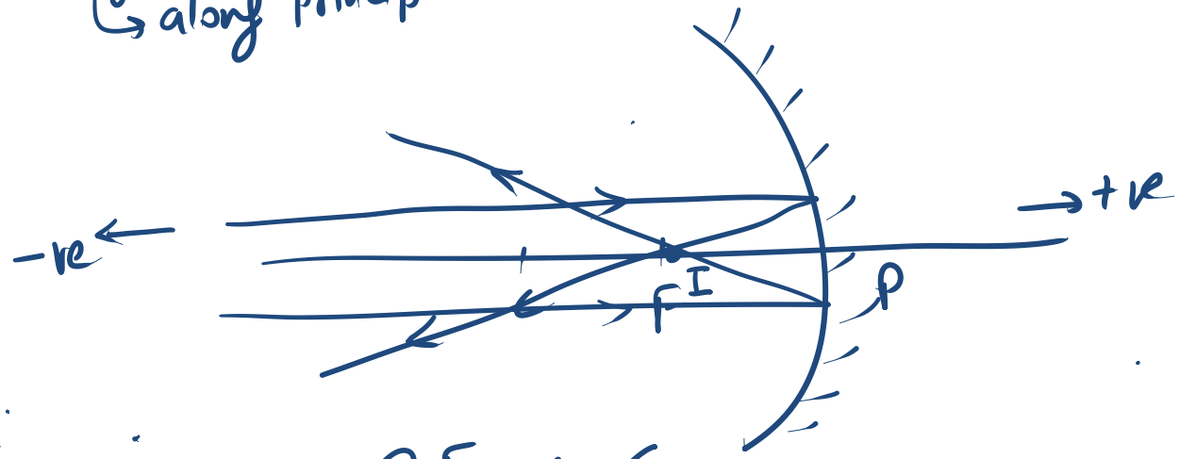
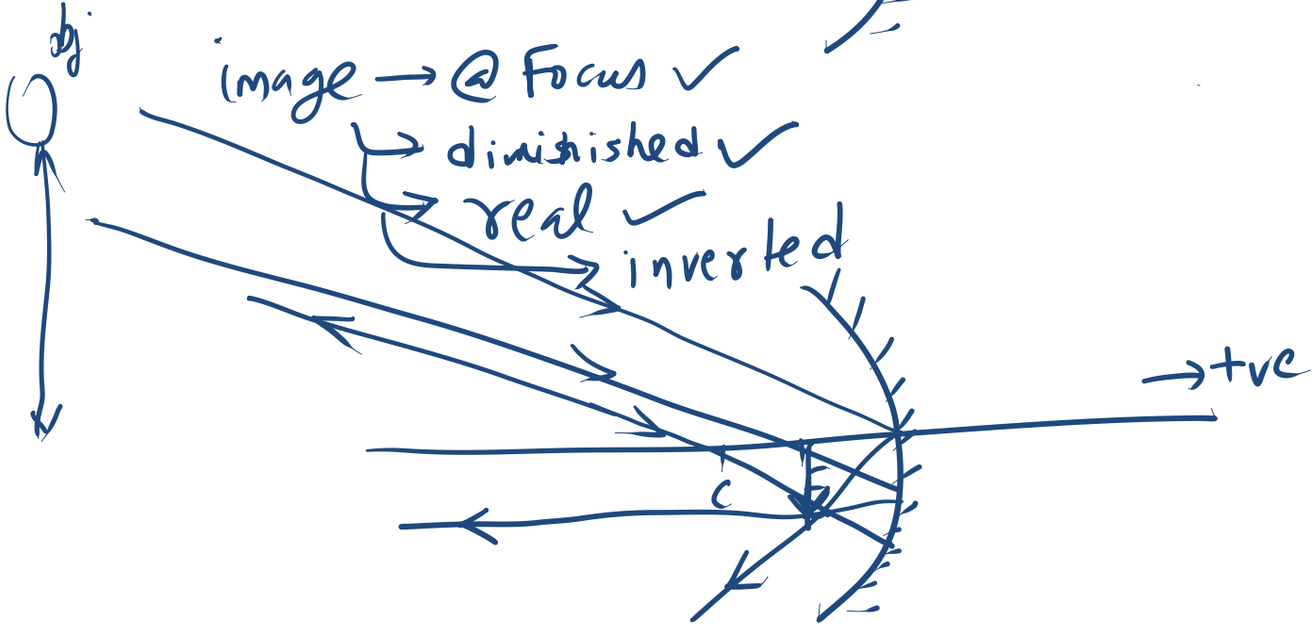
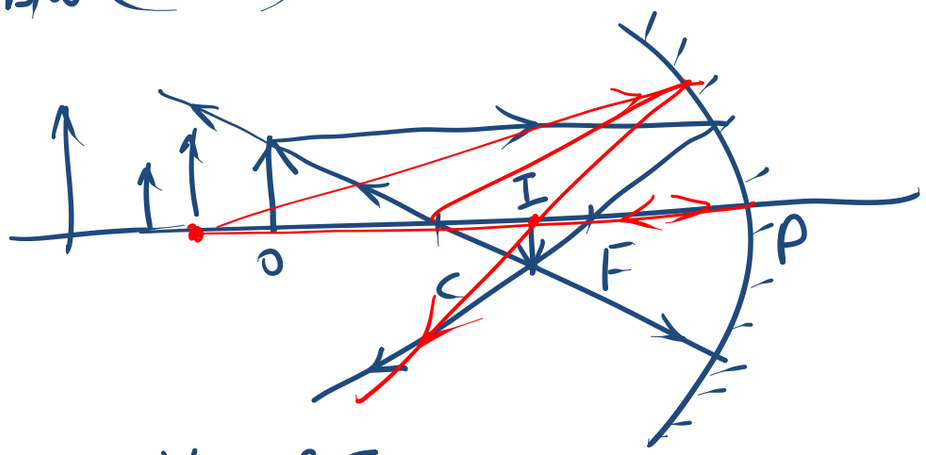


image → @ Focus ✓
↳ diminished ✓
↳ real ✓
↳ inverted

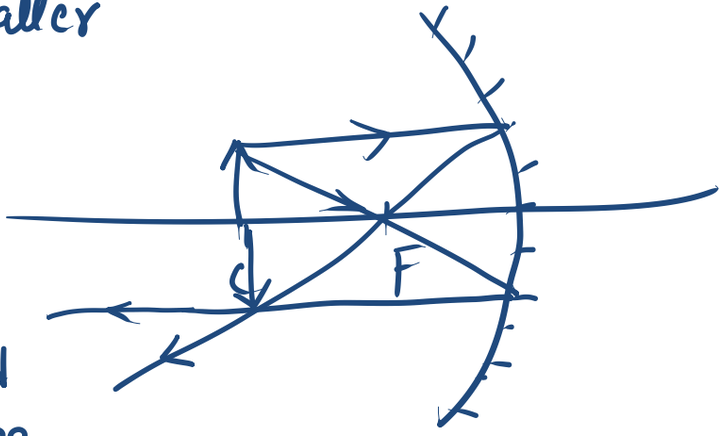


(ii) obj b/w (-∞ & C).



img → b/w C & F
↳ real
↳ inverted
↳ smaller

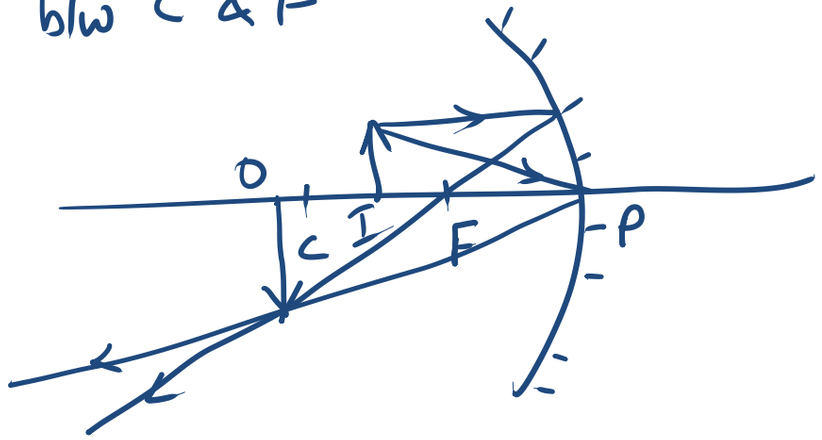
(iii) obj @ C



img → @ C
↳ real
↳ inverted
↳ same size.

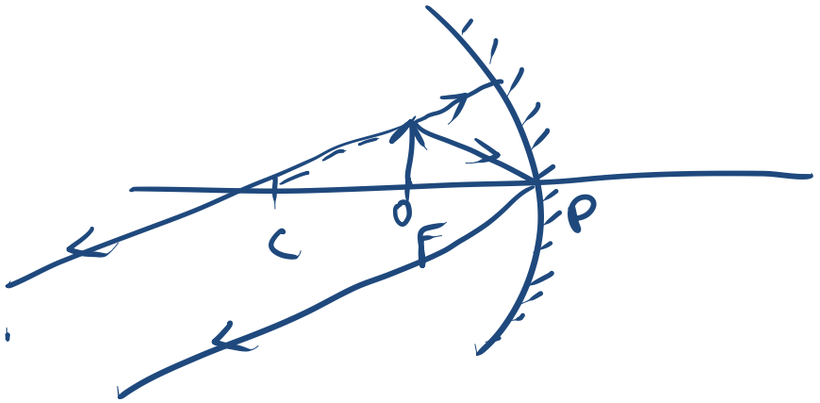
Ray diagrams – Concave Mirror – Cont.

(iv) obj b/w C & F



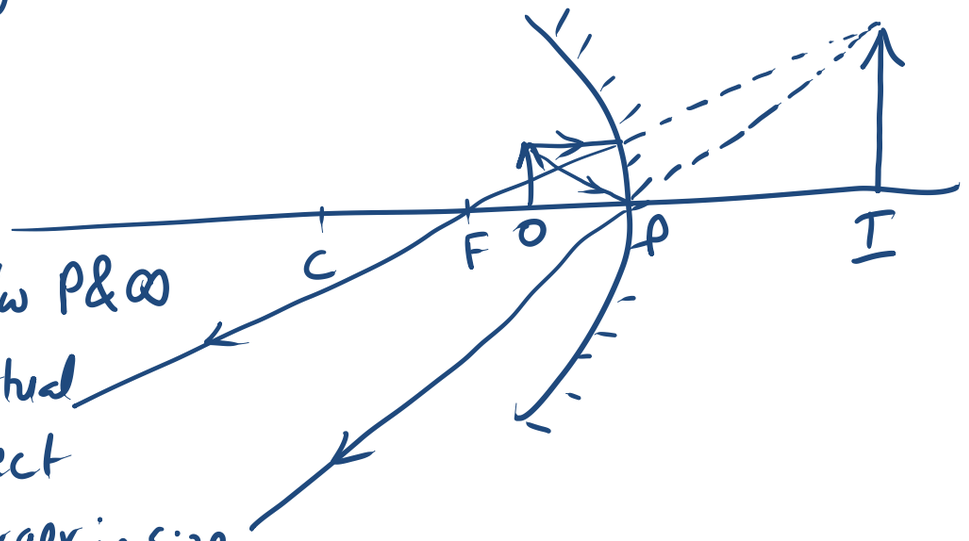
img → b/w (F & C).
- ↳ real
- ↳ inv
- ↳ enlarged.

(v) obj @ F



img → @ ∞
- ↳ real
- ↳ inv
- ↳ v. large.

(vi) obj b/w F & P

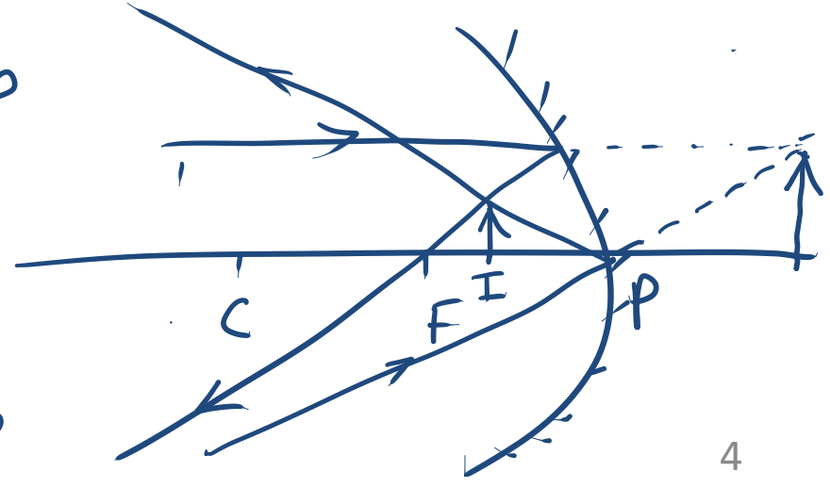


img → b/w P & ∞
- ↳ virtual
- ↳ erect
- ↳ larger in size.

(vii) obj @ P ⇒ img @ pole

(viii) obj beyond P
- ↳ virtual

img → smaller
- ↳ real
- ↳ erect
- ↳ b/w F & P

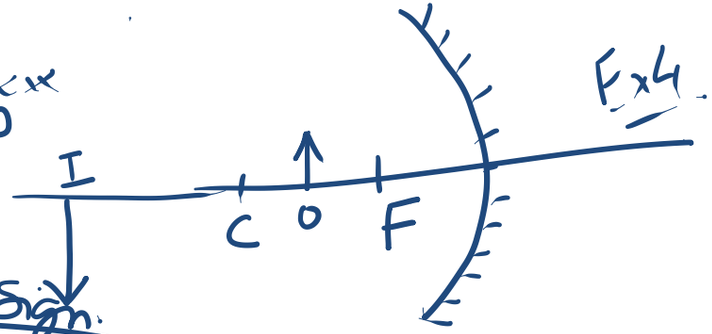


Examples on Concave Mirror

Ex.1 $m = +0.5$

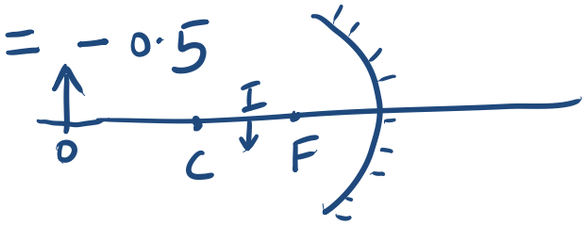
Draw ray digram.
Region of obj & img. ⟶ (−||−)

Ex.2 $m = -2$



Ex.3

$m = -0.5$



Ex.4

$|m| \leq 1$ $\quad$ $|m| \geq 1$

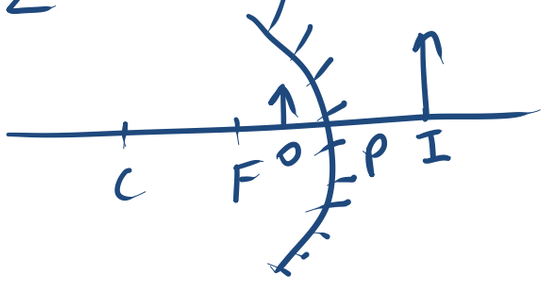
+ve $\quad$ −ve

possible for concave mirror or not?

Am. → All are possible

Mnemonic for magnification sign.

Ex.5 $m = +2$



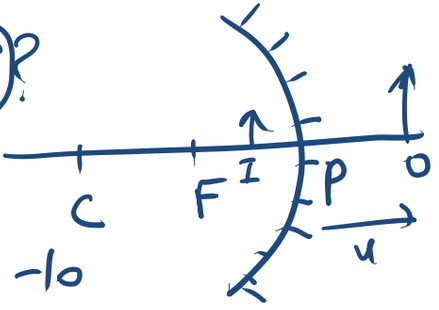
Ex.6. Virtual obj @ 10 cm
img @ f/2. Find focal length, f?
(Concave mirror)

$u = +10$, $v = -f/2$ (−f)

$v = \frac{uf}{u-f}$

$-f/2 = \frac{-10f}{10+f}$ $\Rightarrow -5 - f/2 = -10$

$-f/2 = -5$ $\Rightarrow$ $f = 10$ m



Ex 7. $h_{img} \to 3\,cm$, $h_{obj} \to 2\,cm$

h_{img} → erect

m ? ↑↑ +ve

$m = +3/2$ ↑↓ −ve

$= +1.5$.

Ex 8. $h_{img} \to 2\,cm$, $h_{obj} \to 3\,cm$

h_{img} → erect. (Concave mirror)

m ? $m = +0.66$ (Virtual obj).

$m = -3 = -v/u \Rightarrow v = 3u$.

$v = 3u = \frac{uf}{u-f} \Rightarrow 3u - 3f = f$

$u = \frac{4f}{3} = \frac{4}{3}(-20) = -\frac{80}{3}\,cm$

$v = +3u = +3\times\left(-\frac{80}{3}\right) = -80\,cm$

Ex 9. img → 3 times of obj. size

$f = -20\,cm$ (Concave)

find v, u, m ?

$m = +3$. $m = -3$.

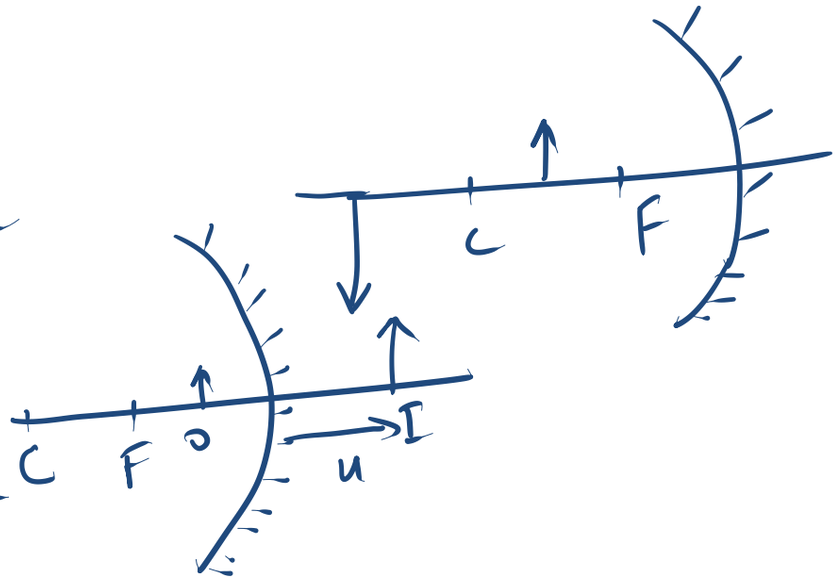
$m = +3$

$3 = -\frac{v}{u}$

$v = -3u$

$v = \frac{uf}{u-f}$

$-3u = \frac{uf}{u-f}$



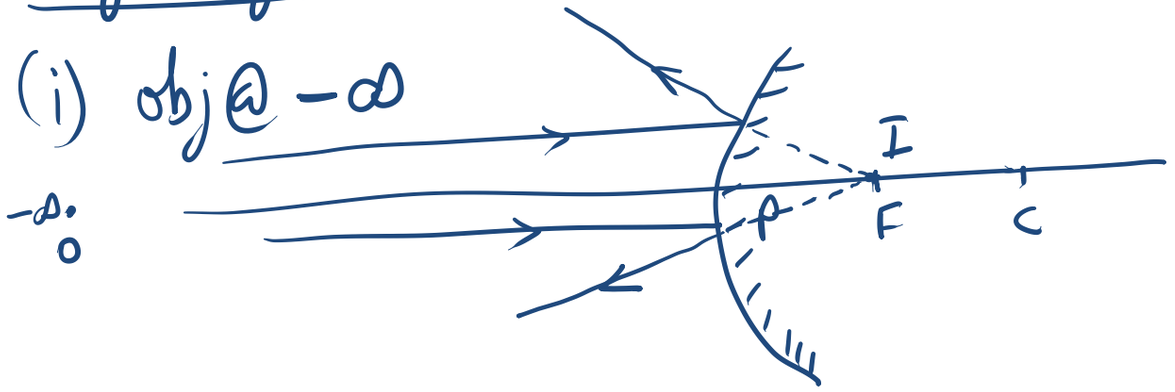
$-3u + 3f = f$

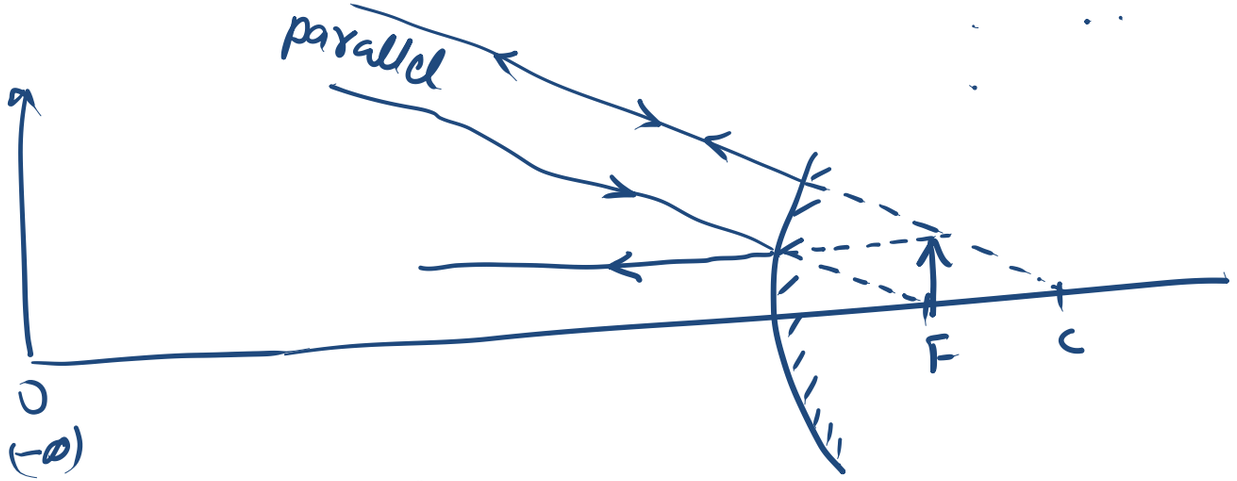
$u = \frac{-2f}{-3} = \frac{2f}{3} = \frac{2\times(-20)}{3} = -\frac{40}{3}$

$v = -3\times\left(-\frac{40}{3}\right) = +40$

Ray diagram - Convex Mirror →

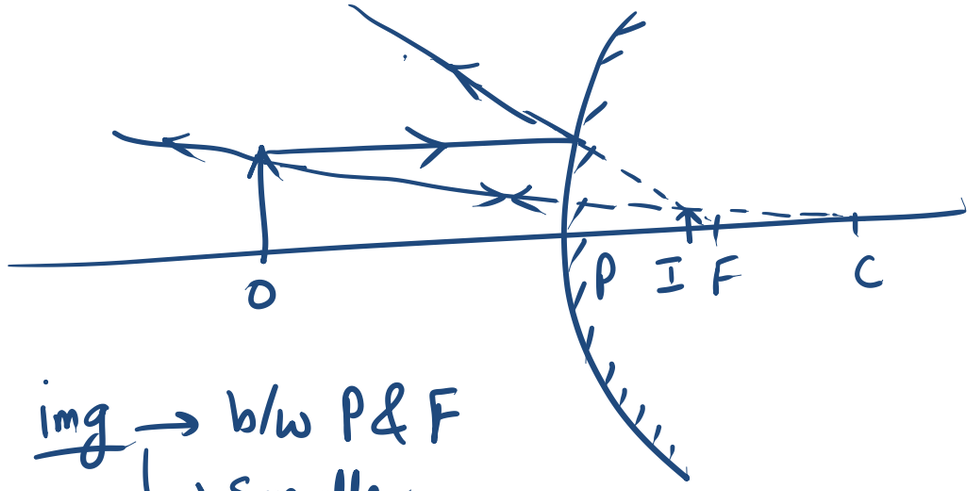
(i) obj @ −∞





img → @ focus
- highly diminished
- erect
- virtual.

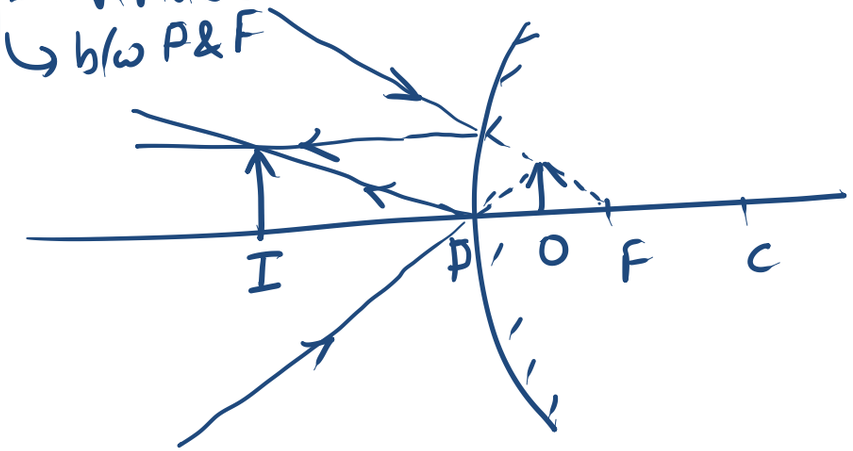
(ii) obj b/w −∞ & P



img → b/w P & F
- smaller
- virtual
- erect.

m = +ve
- < 1

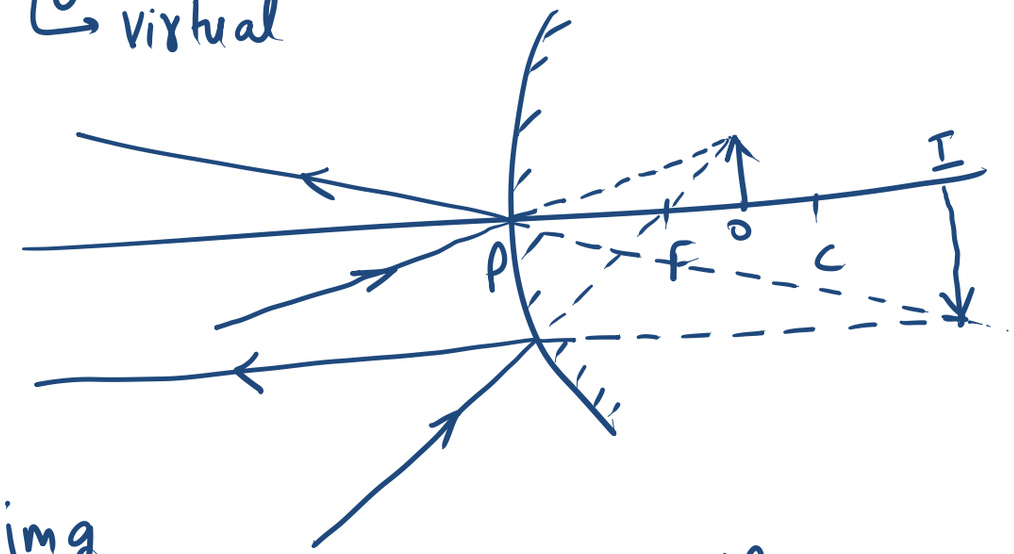
(iii). obj → virtual
↳ b/w P & F



Img → Real
↳ larger
↳ erect
↳ b/w (∞ & P)

m = +ve
↳ >1

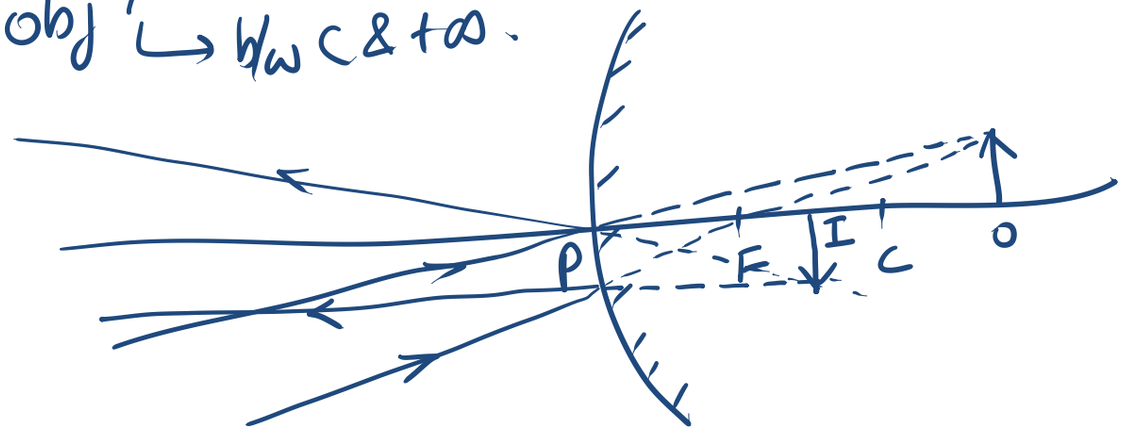
(iv) obj b/w F & C
↳ virtual



img
↳ virtual
↳ inv
↳ larger
↳ beyond (C & +∞)

m = -ve
↳ >1

(V). obj → virtual
b/w C & $+\infty$.



img → b/w F & C
→ Virtual
→ inv.
→ smaller

$m = -ve$
→ < 1

(Summary of Ray diagrams).

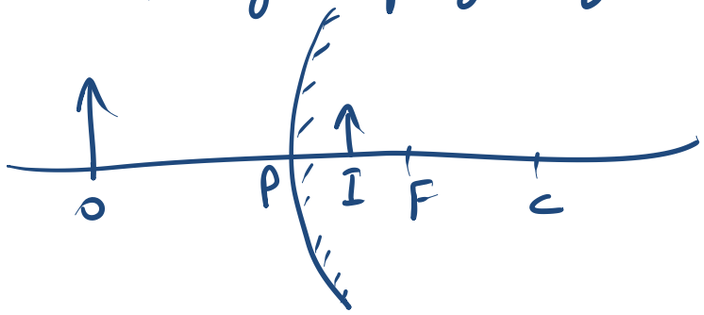
→ Focus of the mirror acts as a pt. of switching infinities for both obj. & image.

→ Concave mirror → R obj → V img (larger).
→ R obj → R img.

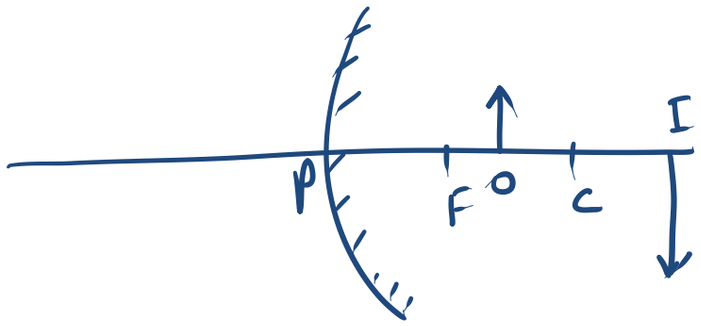
→ Convex mirror → V obj → V img.
→ R obj → V img
→ (smaller)

Convex Mirror

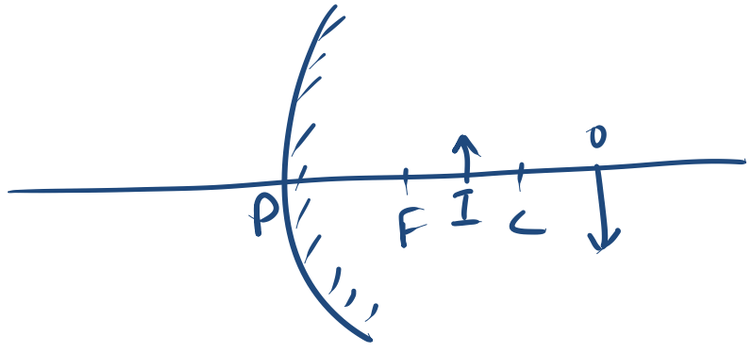
Ex.1 $m = 0.5$
Find regions of obj & img.?



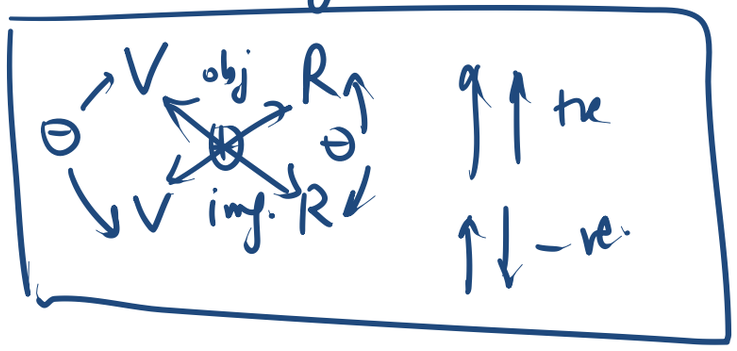
Ex.2 $m = -2$



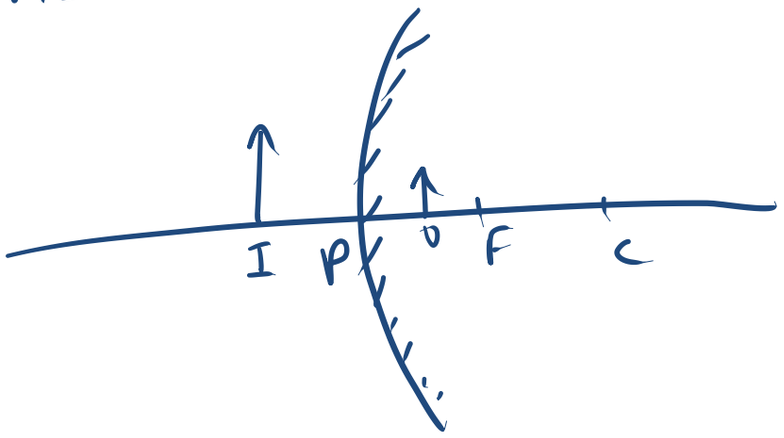
Ex.3 $m = -0.5$



m → Sign.



Ex.4 $m = +2$



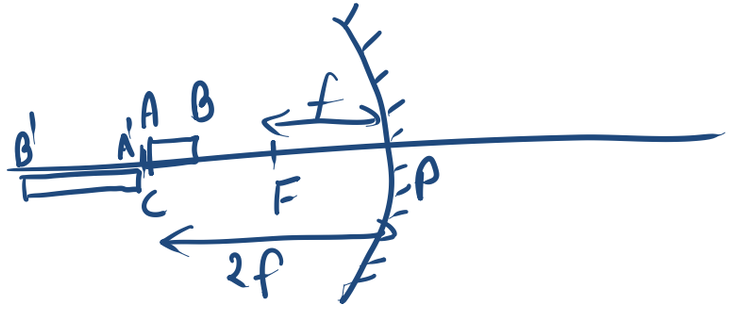
Ex 4. Rod of length $f/3$

Concave mirror → focal length f.

Image of rod touches the obj @ one end.

↳ real & elongated.

Find magnification, m?



pt B $\begin{cases} u = -(2f - f/3) \\ v = ? \\ f = -f \end{cases}$

$$v = \frac{uf}{u-f}$$

$$= \frac{-(-2f + f/3)\, f}{-2f + f/3 + f} = \frac{+\frac{5f}{3} \times f}{-2f/3}$$

$$= -5f/2$$

$AB = f/3$

$A'B' = 5f/2 - 2f = f/2$

Longitudinal magnification

$$m_L = \frac{\text{length of img}}{\text{length of obj}} = \frac{f/2}{f/3} = 1.5$$ (+ve).

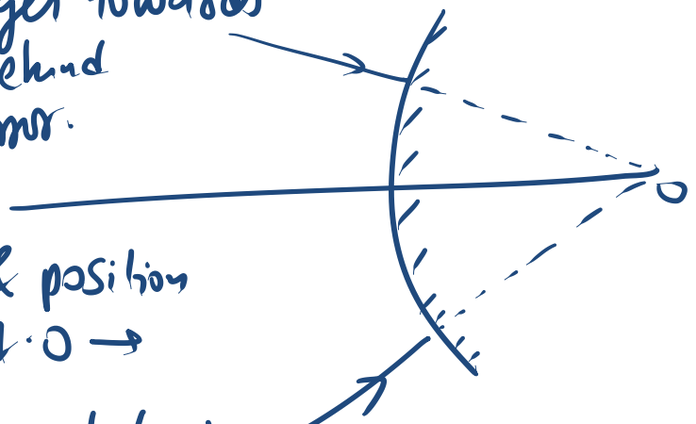
Ex. 5 Beam of light converges towards pt. O behind convex mirror.

$f = 20$ cm

Find nature & position of img. if pt. O →

a). 10 cm behind mirror.

b). 30 cm →



Power of Mirror

$$P_M = \frac{-1}{f_M(m)} = \frac{-100}{f_M(cm)}$$ → (With sign)

→ (D).

P_M → Concave mirror → +ve

→ Convex " → −ve.

→ Useful when we talk about combination of lenses & mirror.

→ helps to define equivalent focal length.

$$P_L = \frac{1}{f_L(m)} = \frac{100}{f_L(cm)}$$

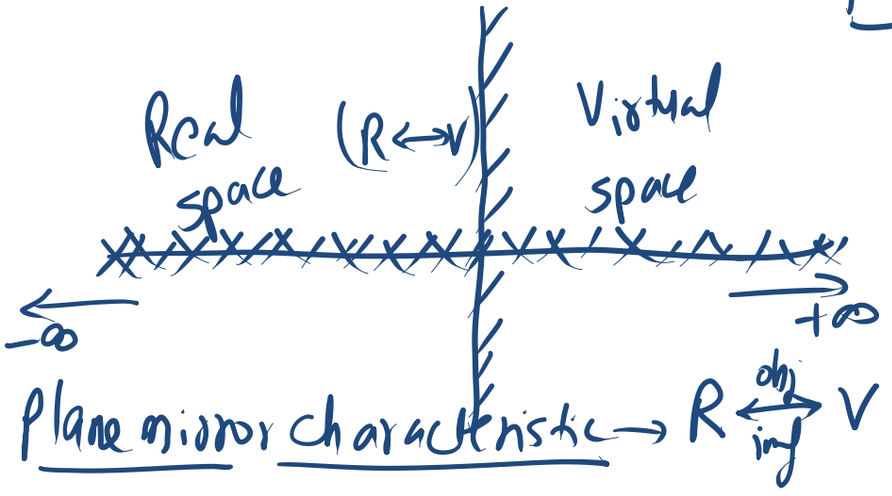
Comparison of Mirrors

ABLES KOTA

Plane Mirror

real obj → virtual img

virtual obj → real img.

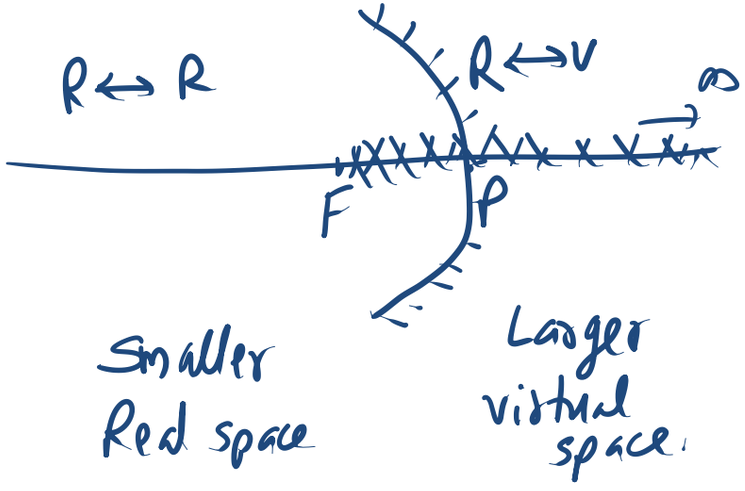


Concave Mirror

real obj → virtual img

virtual obj → real img.

real obj → real img.

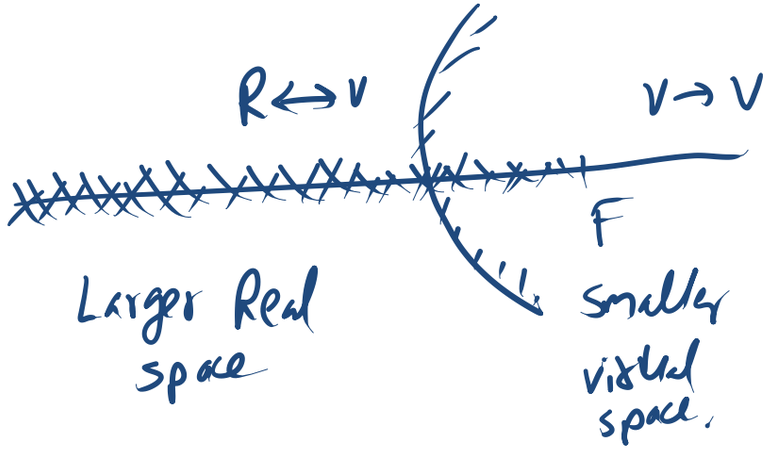


Convex Mirror

real obj → virtual img

virtual obj → real img

virtual obj → virtual img



Geometrical optics

1). Spherical Mirrors & lenses

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

f is more prevalent in lenses.

$$v = \frac{uf}{u-f}$$

$$u = \frac{vf}{v-f}$$

$$m = -v/u = \frac{f}{f-u} = \frac{f-v}{f}$$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$v = \frac{fu}{f+u}$$

$$u = \frac{fv}{f-v}$$

$$m = v/u = \frac{f}{f+u} = \frac{f-v}{f}$$

Spherical surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$