

Session 17: Ray Optics – Reflection & Refraction @ curved surfaces

- Reflection at curved surfaces
- Mirror Formulae
- Ray diagrams for concave & convex mirror
- Visualizations

Example 99. A ray of light PQ is incident at angle of 60° on the face AB of a prism of angle 30° , as shown in Fig. 9.122(a). The ray emerging out of the prism makes an angle of 30° with the incident ray. Show that the emergent ray is perpendicular to the face BC through which it emerges. Also calculate the refractive index of the prism material.

[CBSE D 02C]

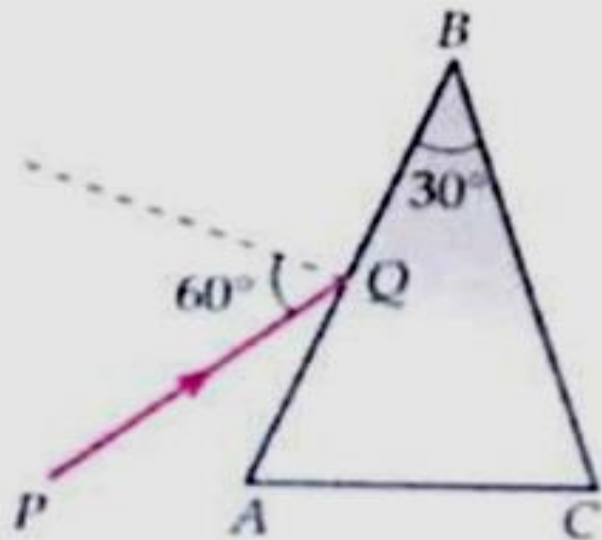
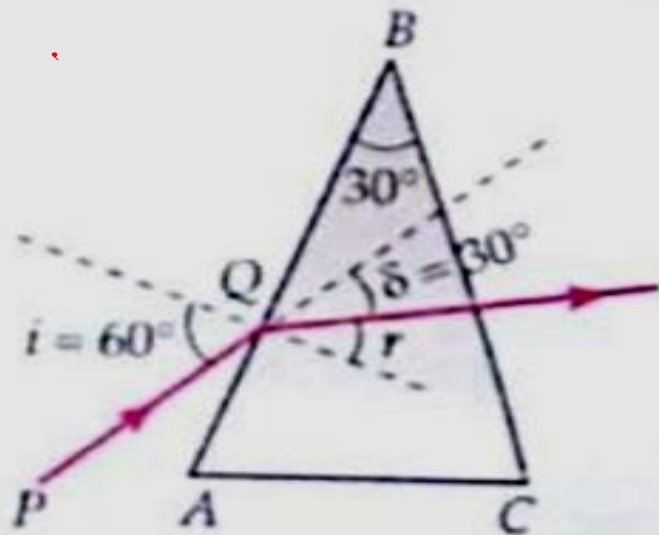
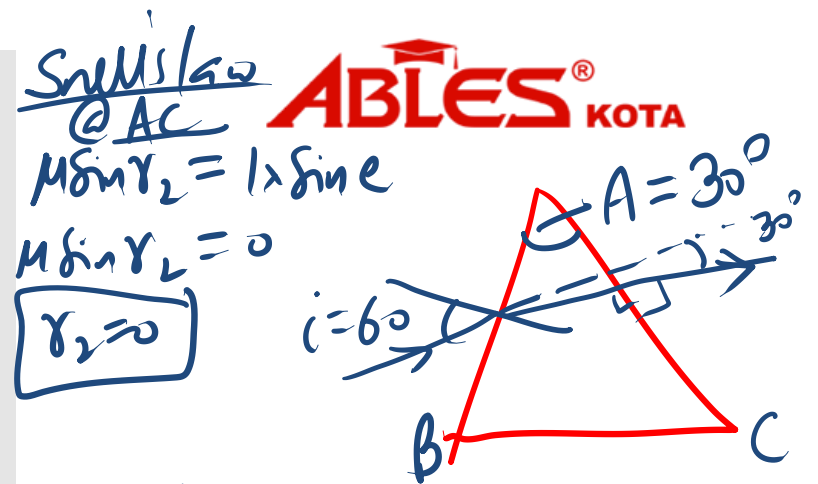


Fig. 9.122

(a)



(b)



$$\delta = i + e - A$$

$$30^\circ = 60^\circ + e - 30^\circ$$

$$\Rightarrow e = 30^\circ + 30^\circ - 60^\circ$$

$$e = 0^\circ$$

$$\gamma_2 = 0$$

$$\gamma_1 + \gamma_2 = A$$

$$\Rightarrow \gamma_1 = A = 30^\circ$$

@AB

$$1 \times \sin 60^\circ = \mu \sin \gamma_1 = \mu \sin 30^\circ$$

$$\mu = \sqrt{3}$$

$$(f = R/2)$$

$$\beta = \alpha + i \quad \text{--- (1)}$$

$$\gamma = \beta + i \quad \text{--- (2)}$$

$$\beta - \gamma = \alpha - \beta$$

$$2\beta = \alpha + \gamma \quad \text{--- (3)}$$

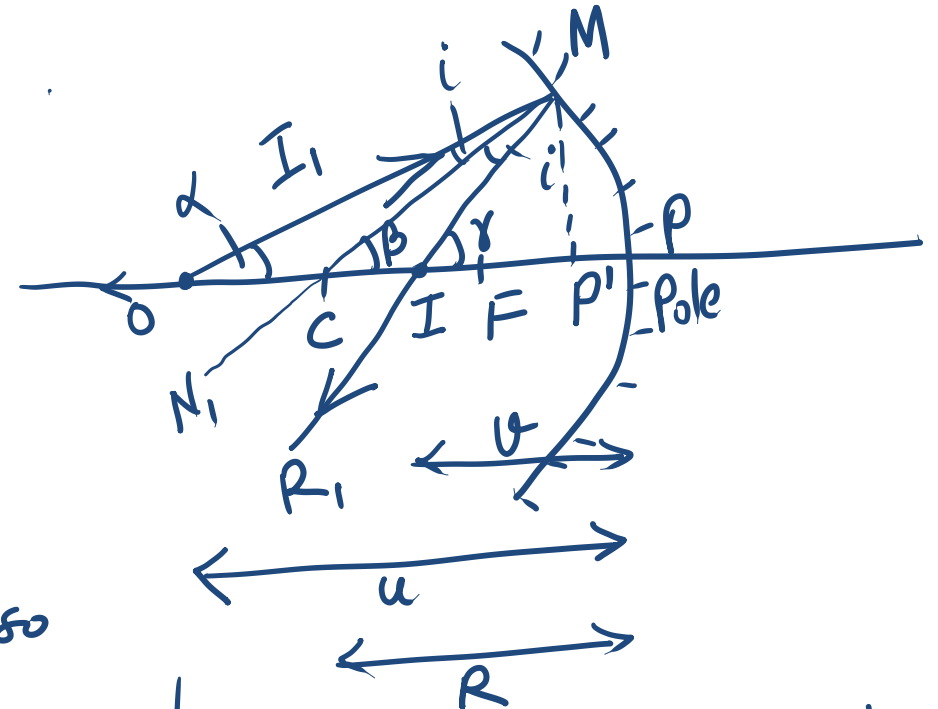
Paraxial rays $\Rightarrow (i < 10^\circ)$.

$\Rightarrow \alpha, \beta \text{ \& } \gamma$ are also small.

$$\tan \alpha \sim \alpha = \frac{MP'}{OP'} = \frac{MP'}{u}$$

$$\tan \beta \sim \beta = \frac{MP'}{CP'} = \frac{MP'}{R}$$

$$\tan r \sim r = \frac{m\rho'}{I\rho'} = \frac{m\rho'}{v}$$



$$2 \times \frac{MP'}{R} = \frac{MP'}{u} + \frac{MP'}{v}$$

$$\Rightarrow \boxed{\frac{1}{u} + \frac{1}{v} = \frac{2}{R}}$$

Mirror Formulae

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad \text{--- (1)}$$

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

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

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

$$m^2 = \frac{v^2}{u^2}$$

$$-\frac{1}{v^2} \frac{dv}{dt} - \frac{1}{u^2} \frac{du}{dt} = 0$$

$$\frac{dv}{dt} = -\frac{v^2}{u^2} \frac{du}{dt}$$

$$\boxed{\left(\frac{dv}{dt}\right)_M = -m^2 \left(\frac{du}{dt}\right)_M} \checkmark$$

$$(v_I - v_M) = -m^2 (v_O - v_M)$$

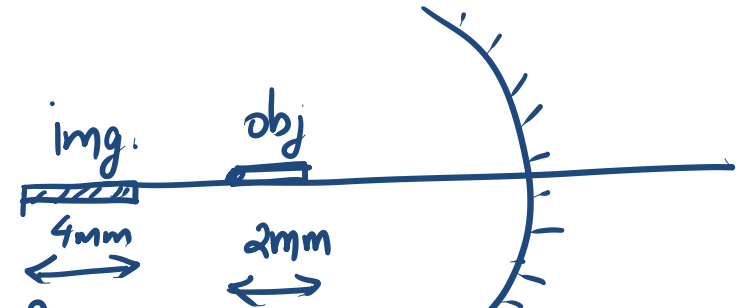
$$\boxed{dv = -m^2 du}$$

$$m_L = \frac{|dv|}{|du|} = \frac{|L_{img}|}{|L_{obj}|}$$

vel. of
img.

vel. of
obj.

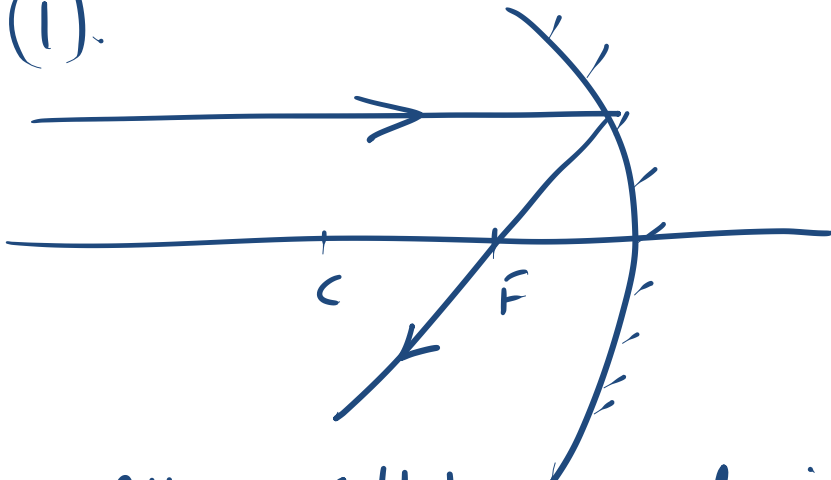
vel. of Mirror



→ +m²
(if lengths are small)

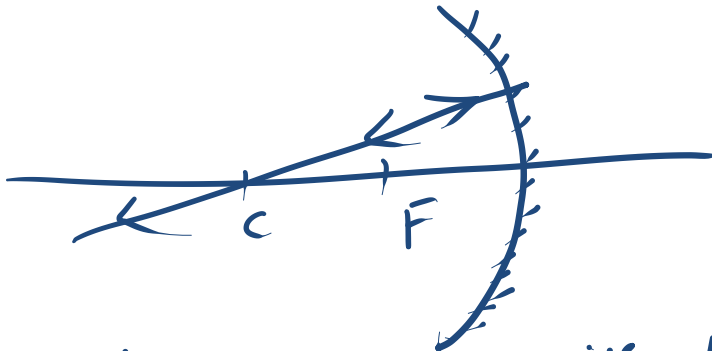
Ray diagrams (Rules + 4 rules)

(1).



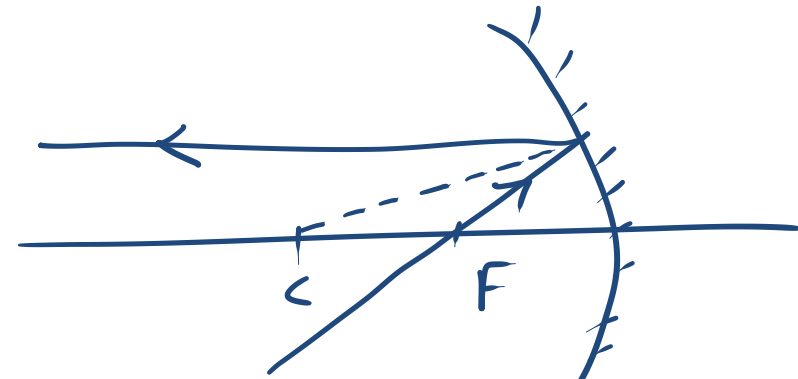
All rays || to principal axis shall pass thru focus, F .

(3).



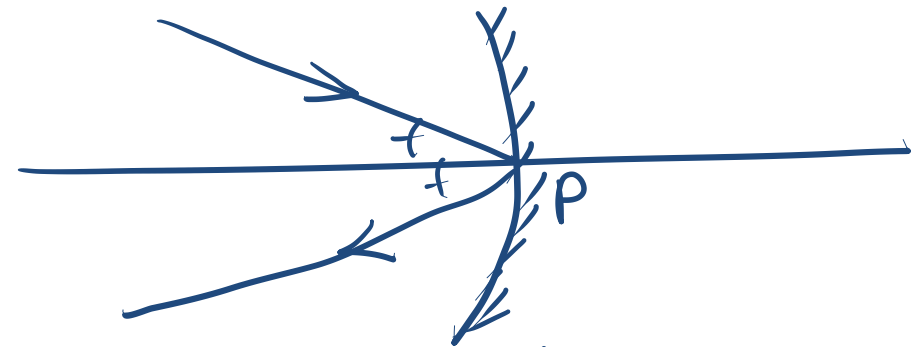
Any ray thru C will retrace its path.

(2).



Any ray thru focus will become || to principal axis.

(4).



Any ray striking @ pole will pass symmetrically.

Ray diagrams for Concave Mirror:-

(i) obj @ $-\infty$
 ↳ along principal axis.

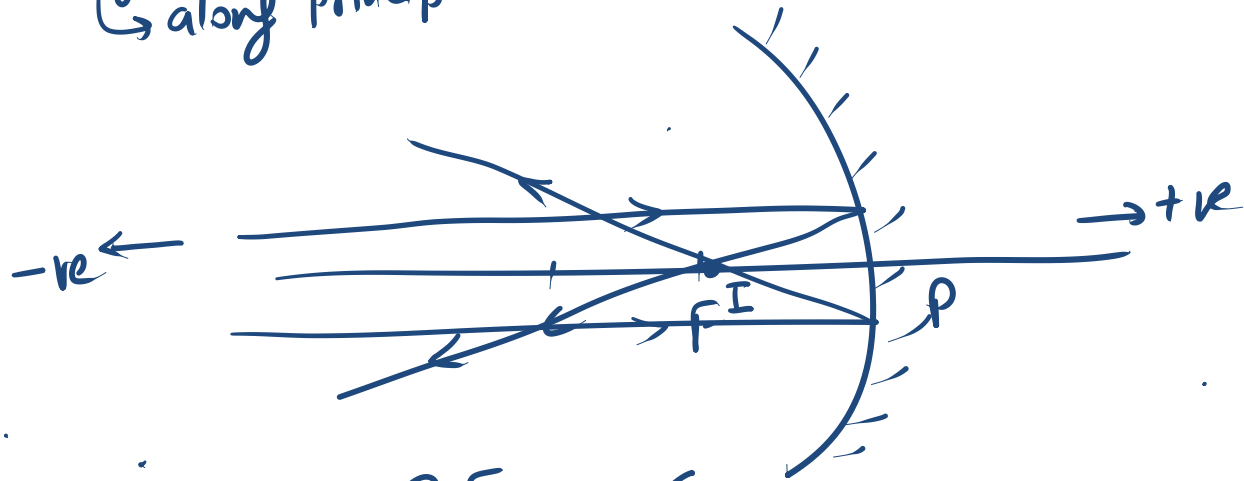
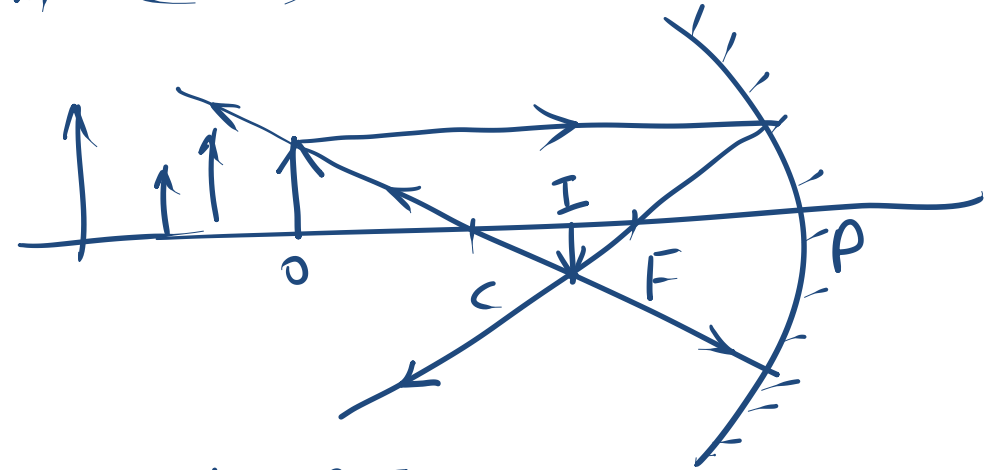


Image → @ Focus ✓
 ↳ diminished ✓
 ↳ real ✓
 ↳ inverted

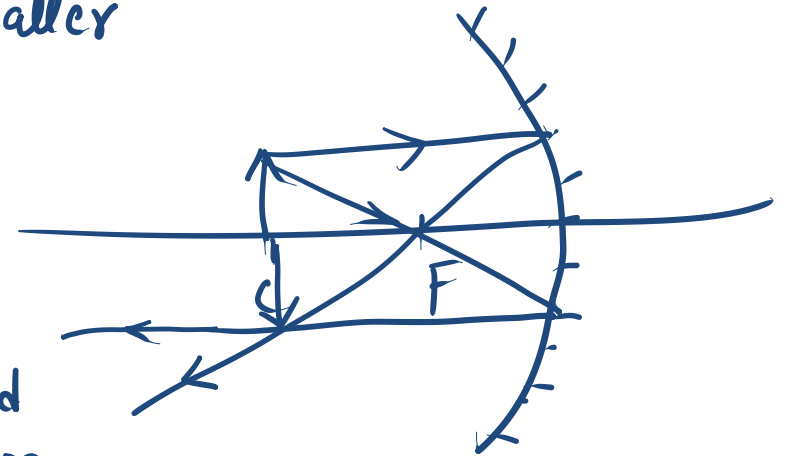
(ii) obj b/w ($-\infty$ & C).



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

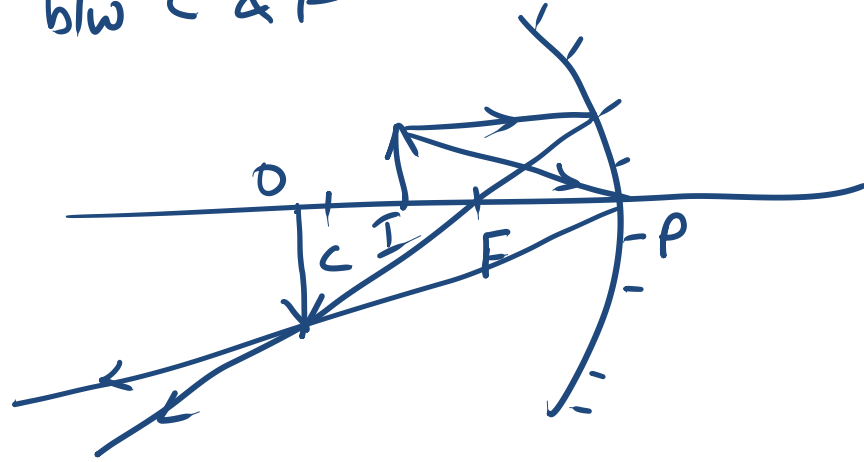
(iii) obj @ C

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



Ray diagrams - Concave Mirror - cont.

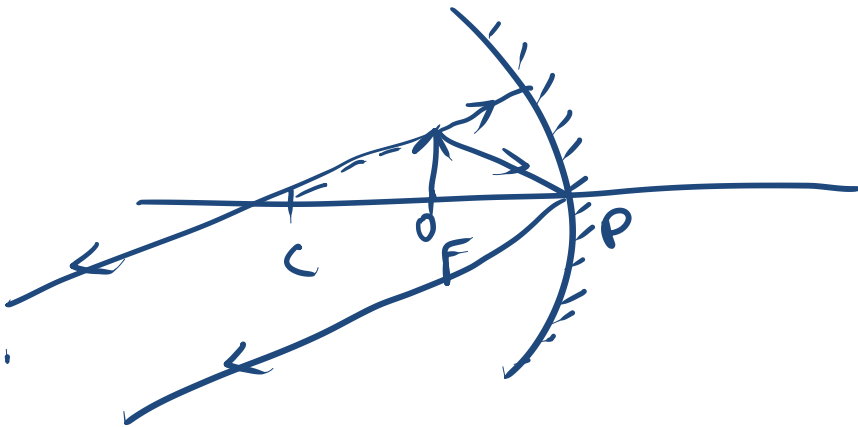
(iv) obj b/w C & F



img \rightarrow b/w (F & C).
 \rightarrow real
 \rightarrow inv
 \rightarrow enlarged.

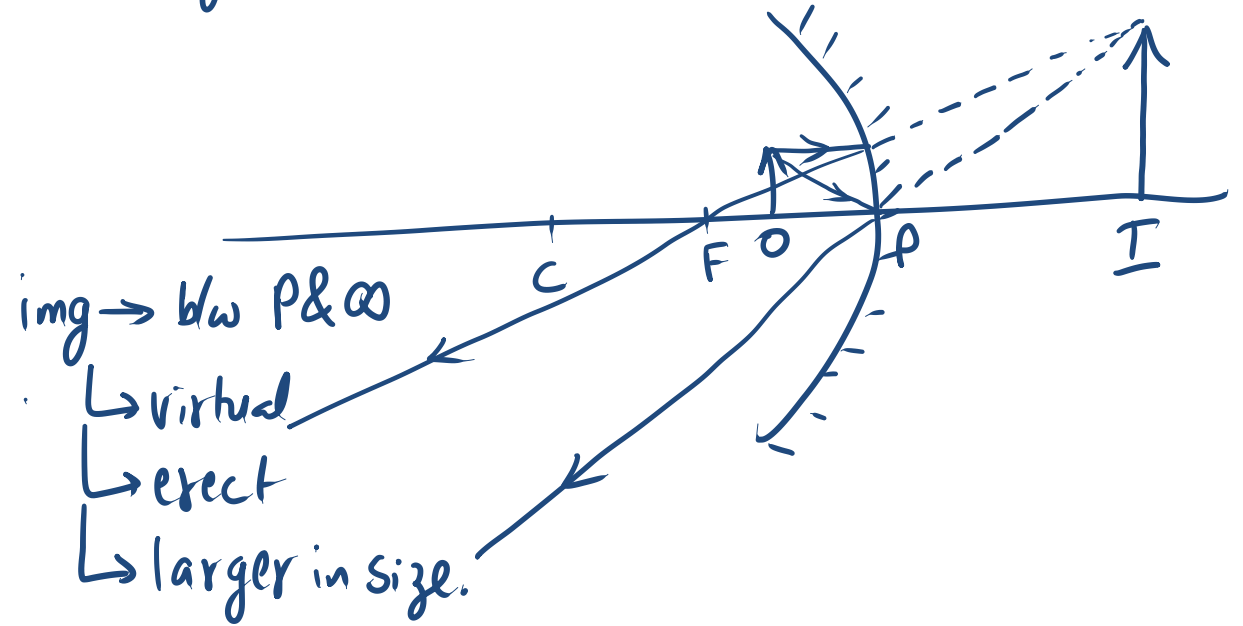
(v) obj @ F

img \rightarrow @ ∞
 \rightarrow real
 \rightarrow inv
 \rightarrow v. large.



(vi) obj b/w F & P

ABLES[®] KOTA



(vii) obj @ P \Rightarrow img @ pole

Geometrical Optics

1) Spherical Mirrors & Lenses

f is more prevalent in lenses

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

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

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

$$m = -v/u = \frac{f}{f-u} = \left(\frac{f-v}{f} \right)$$

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

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

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

$$m = v/u = \frac{f}{f+u} = \left(\frac{f-v}{f} \right)$$

Spherical Surface

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