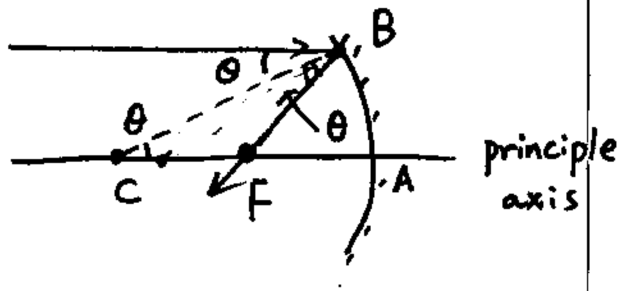
Lect 6 spherical mirrors

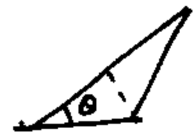
Focal point and focal length



* concave mirror: at small angle

ΔCFB: $\angle BCF = \angle CBF = \theta$

$BC = R$



$\Rightarrow FC = BF = \dfrac{R}{2\cos\theta}$

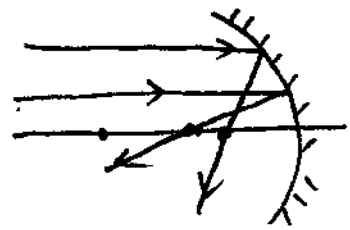
$\approx \dfrac{R}{2}$ up to θ^2

At small angles, all the ~~reflect~~ rays intersect at F with $CF = FA = r/2$.

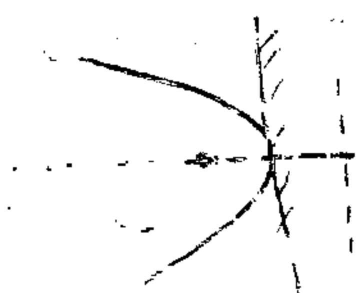
or $f = \dfrac{r}{2}$.

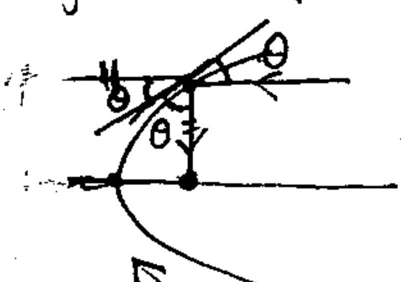
Spherical aberration: Actually CF has dependence on θ.

if θ goes larger, then CF becomes longer.

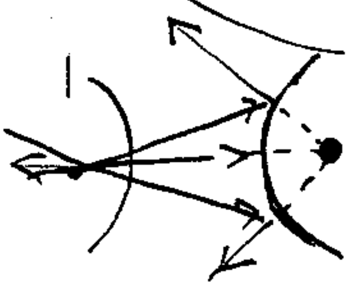


for a parabolic reflector, it has a perfect focus. (more expensive)

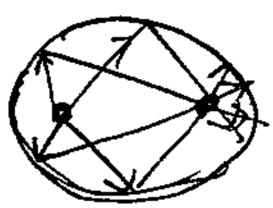




$\rho = \dfrac{p}{1-\cos\theta}$

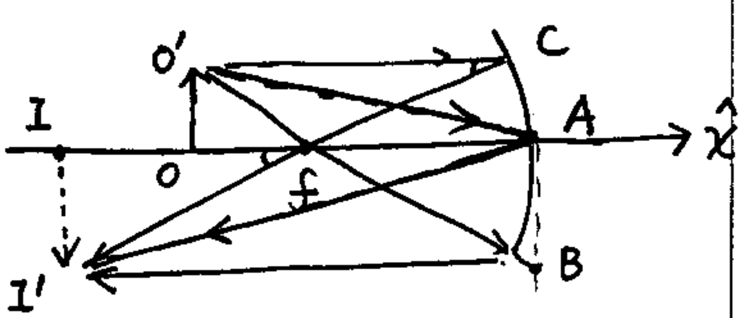


hyperbolic curves



ellipse

imagine formation:



- if object distance $d_o > f$

3 - special rays $O'A$ pependical
$O'f$
$O'C \,//\, \hat{x}$

Rt $\Delta O'AO \backsim$ Rt $\Delta I'AI$

becase $\angle O'AO = \angle IOI'$

$$\Rightarrow \quad \frac{O'O}{II'} = \frac{OA}{IA} = \frac{d_o}{d_i}$$

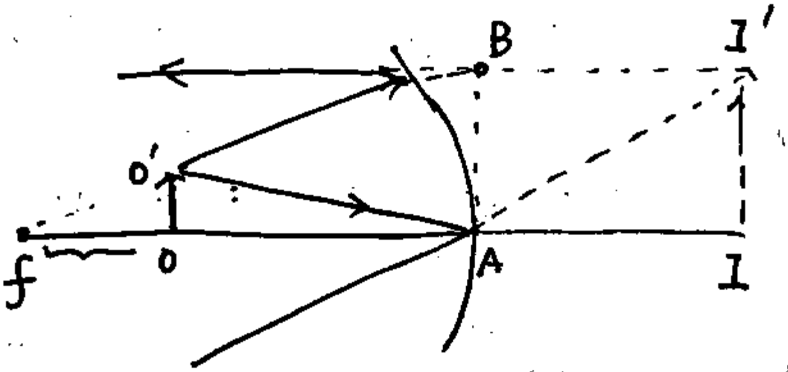
Rt $\Delta O'Of \backsim$ Rt $\Delta BAf \Rightarrow \frac{O'O}{AB} = \frac{O'O}{II'} = \frac{Of}{fA} \Rightarrow \frac{d_o}{d_i} = \frac{d_o - f}{f}$

$\Rightarrow \quad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$. we have real image, inverted

- lateral magnification $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

if object distance is smaller than f ie $d_o < f$

image distance is negative



Rt $\Delta O'AO \backsim$ Rt $\Delta I'AI$

$\Rightarrow \frac{O'O}{II'} = -\frac{d_o}{d_i}$

- Rt $\Delta O'Of \backsim$ Rt $\Delta BAf \Rightarrow \frac{O'O}{BA} = \frac{O'O}{II'} = \frac{f - d_o}{f} = \frac{Of}{fA}$

$\Rightarrow \frac{f - d_o}{f} = -\frac{d_o}{d_i} \Rightarrow \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \Rightarrow m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} > 1$

Summary : concave mirror

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \quad \text{and} \quad m = -\frac{d_i}{d_o}$$

① $+\infty > d_o > 2f \Rightarrow 2f > d_i > f$ and $|m| < 1$

real inverted, Shrinked

② $2f > d_o > f \Rightarrow +\infty > d_i > 2f$ and $|m| > 1$

real inverted, magnified

③ $f > d_o > 0 \Rightarrow \infty > |d_i| > f$ and $|m| > 1$

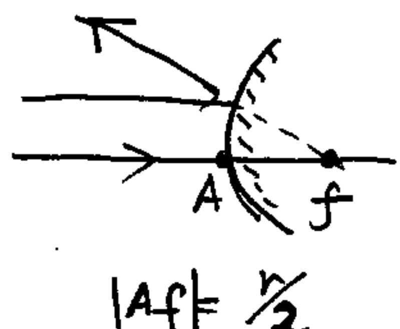
Virtual upright magnified.

if we take $f = \infty \Rightarrow \left.\begin{matrix} d_o = -d_i \\ m = -1 \end{matrix}\right\}$ — plane mirror

✯ how about convex mirrors

we only need to take $f = -\frac{r}{2}$

(on the other side of the mirror)



$|Af| = r/2$

for concave mirror, the formula

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$ is still valid, but $f<0$.

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} < 0 \Rightarrow d_i < 0$$

$$\frac{1}{|d_i|} = \frac{1}{|f|} + \frac{1}{d_o} \Rightarrow |d_i| < d_o \Rightarrow |m| = \frac{|d_i|}{d_o} < 1$$

} upright, Virtual, shrinked