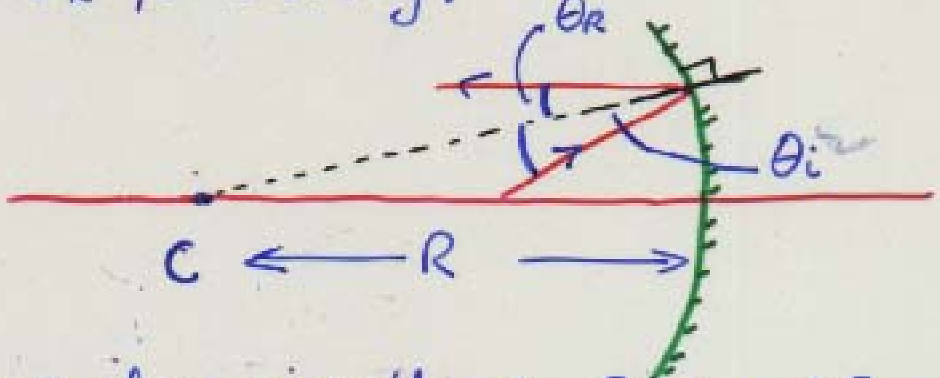
Spherical Mirrors

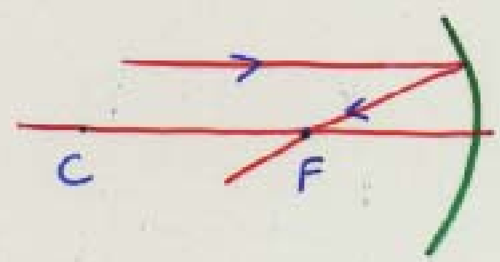
- Can focus rays of light close to $\perp$ to surface. Geometry from law of reflection $\theta_i = \theta_R$ for each ray:



(Normal to surface passes through Center of Curvature)

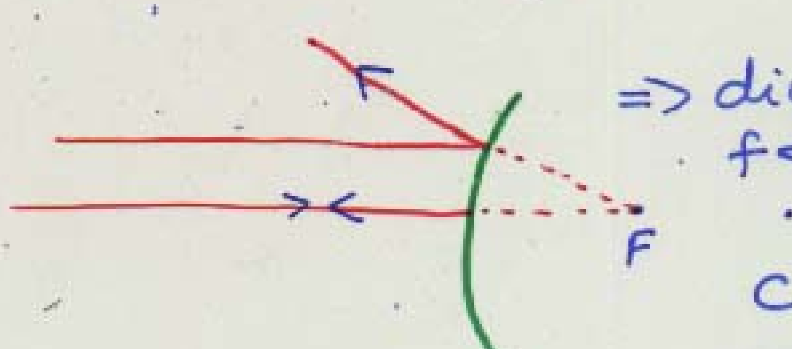
From geometry, find $\boxed{\text{focal length } f = \frac{-R}{2}}$

Concave mirror:
($R < 0$)



$\Rightarrow$ converging
$f > 0$

Convex mirror:
($R > 0$)

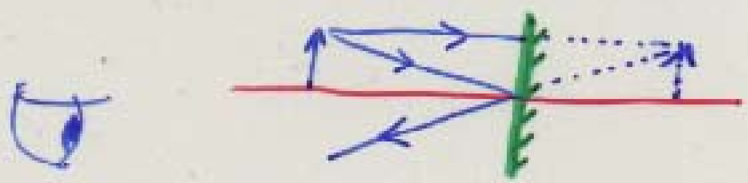


$\Rightarrow$ diverging
$f < 0$.

Mirrors

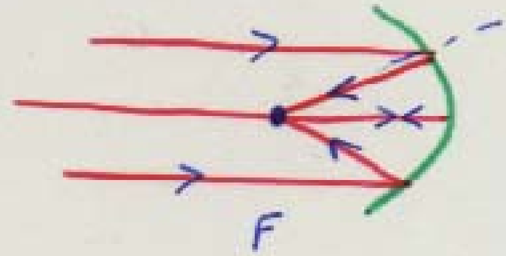
Plane mirror $\Rightarrow$ undistorted virtual image
(flipped left-right)

= special case of curved mirror with $f \Rightarrow \infty$
(i.e. ∥ rays remain ∥)



Paraboloidal Mirrors either:

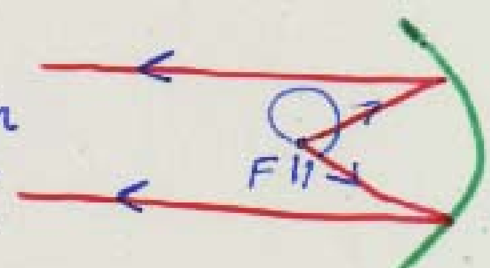
bring ∥ rays to a sharp focus F



e.g. satellite dish

or:

produce ∥ beam from source at "F":



e.g. search light

.. also ellipsoidal, hyperbolic mirrors
Hecht fig. 24.33)

Finite Imagery - Ray Diagrams

We can construct images by geometry as with lenses, e.g.

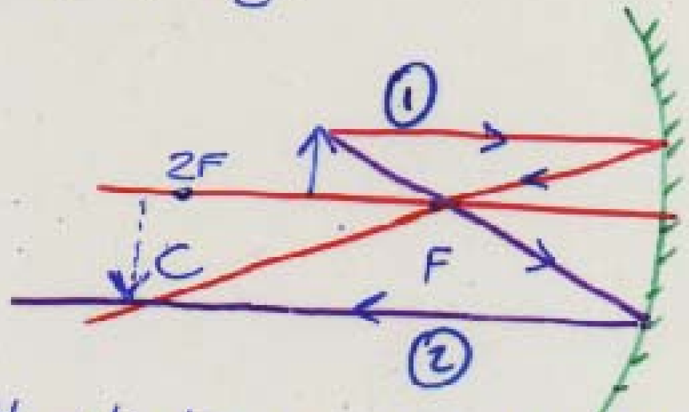
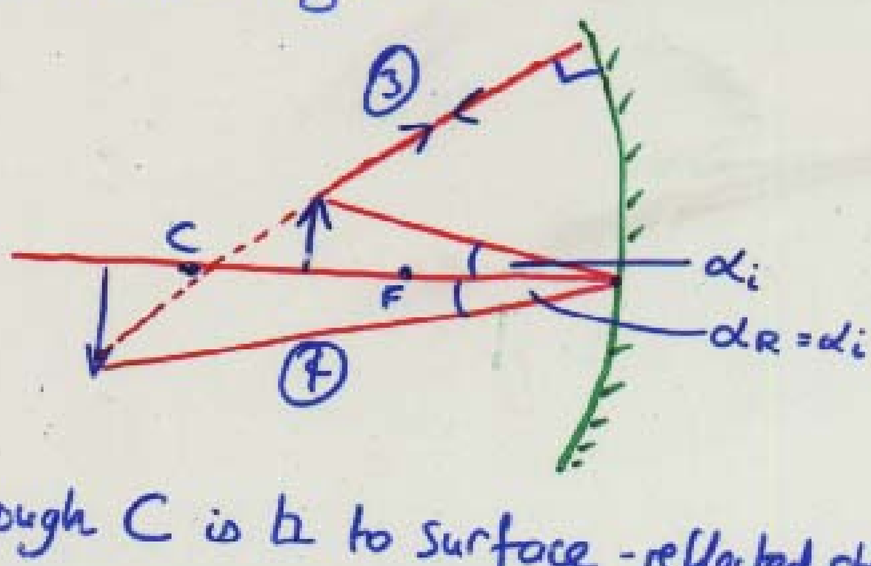


image is real, inverted magnified

① ray // optical axis reflected through F

② ray through F reflected //

Two more rays -

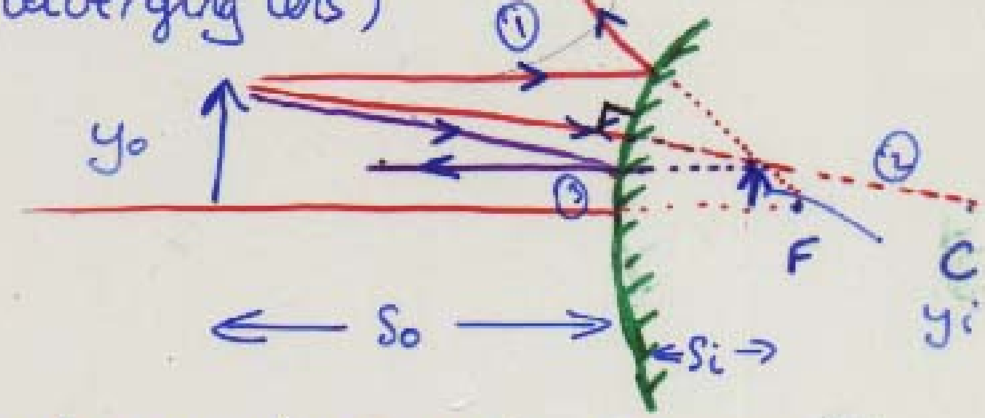


③ ray through C is ⊥ to surface - reflected straight back

④ ray striking mirror at $\theta = \alpha_i$; reflected at $\theta = \alpha_R$.

Convex mirror $\Rightarrow$ virtual, erect, minified image

(c.f. diverging lens)



① ray // opt. axis diverges from F

② ray towards C reflected straight back

③ ray towards F reflected // to opt. axis

Spherical Mirror Equation

$$\boxed{\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}}$$

- As for lenses, except $s_i > 0 \Rightarrow$ real image on left
  $s_i < 0 \Rightarrow$ virtual " " right.

Also, as for lenses from similar Δs

$$\frac{y_i}{y_o} \quad \boxed{M_T = \frac{-s_i}{s_o}}$$

Transparency 88 Figure 26.39 Page 931

Images Formed by a Concave Spherical Mirror

1. $S_o > 2f$

$-1 < M_T < 0$

"Camera"

2. $S_o = S_i = 2f$

$M_T = -1$

"Inverter"

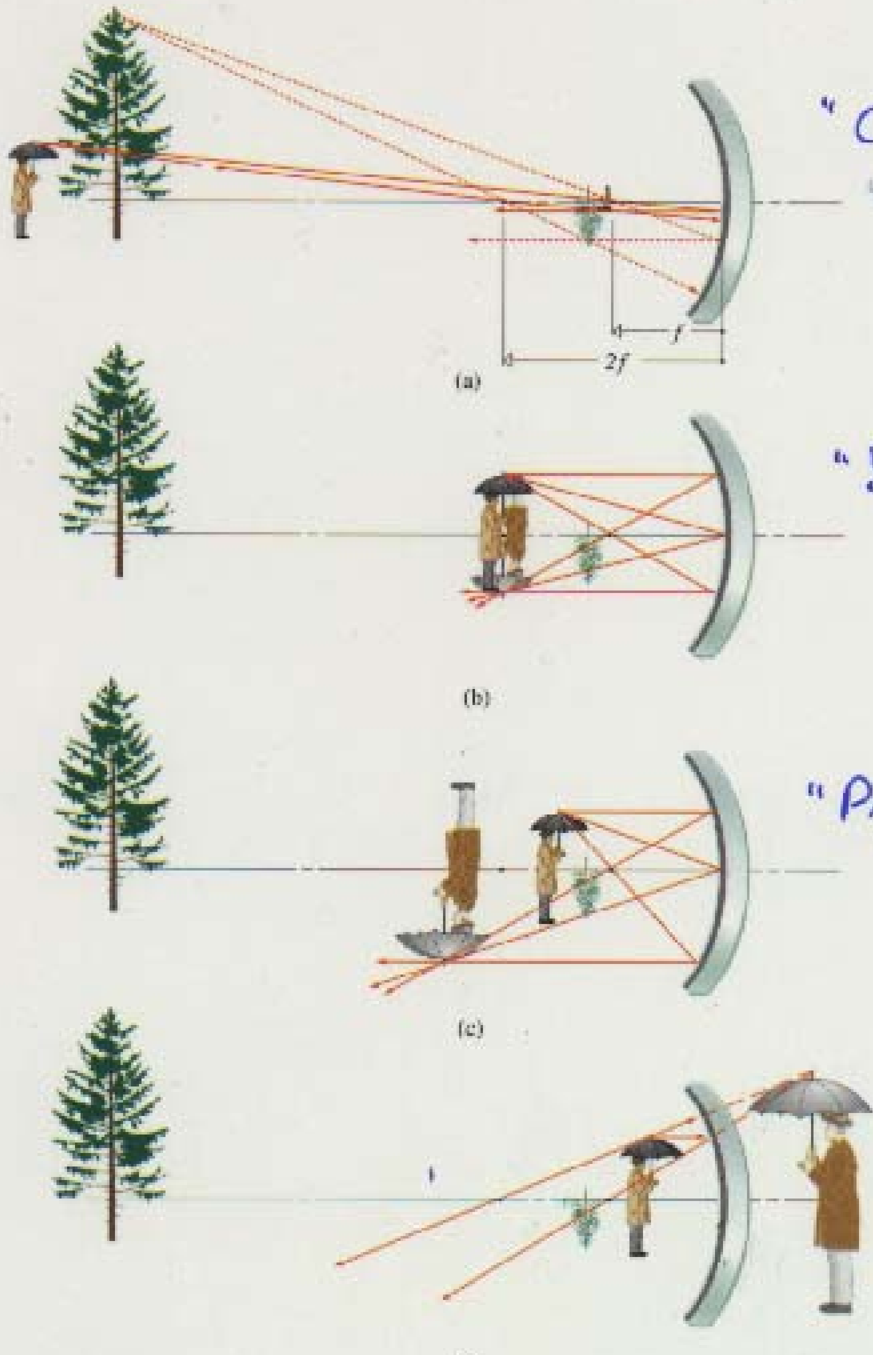
3. $f < S_o < 2f$

"Projector"

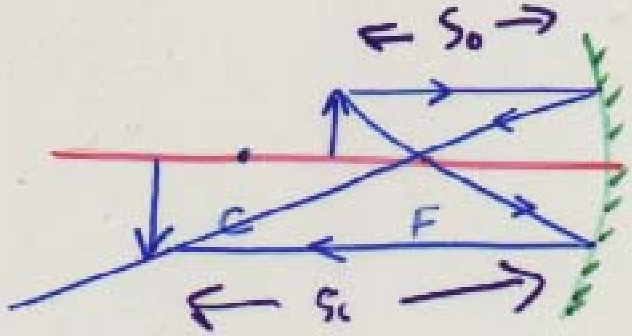
4. $S_o < f$

$M_T > +1$

"Magnifier"



Example: Use an $f = +60\,\text{cm}$ mirror to project TV image onto a wall with 3x magnification



We have real, inverted image with $M_T = \frac{-s_i}{s_o} = -3$

i.e. $s_i = 3 s_o$

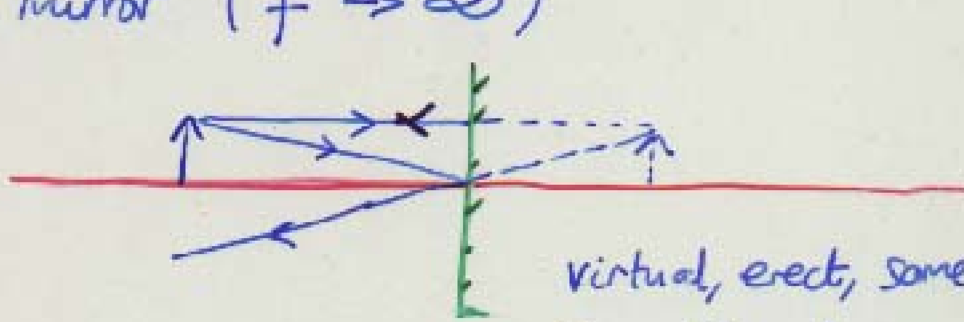
Using $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \Rightarrow \frac{1}{3s_o} + \frac{1}{s_o} = \frac{1}{f}$

i.e. $\frac{3}{4}\,\frac{4}{3s_o} = \frac{1}{f} \Rightarrow \underline{s_o = +4/3 f} = 80\,\text{cm}$,

and image distance $s_i = 3s_o = 240\,\text{cm}$.
$= 4f$

- Geometry same as lens except for left-right reflection.

c.f. plane mirror $(f \to -\infty)$



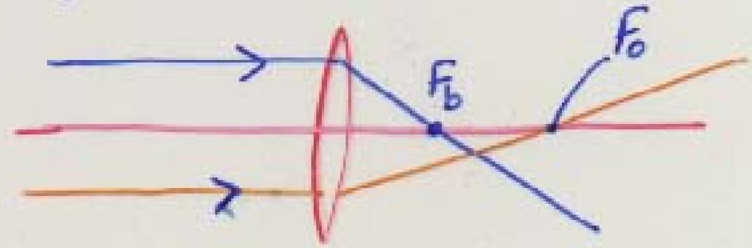
virtual, erect, same size $M_T = 1$.

Advantages of Mirrors, Applications

1. Easier to make - not transparent
2. Can be supported at back, not just edges
3. Achromatic : $\theta_R = \theta_i$ for all colors

c.f: lens $\frac{1}{f} = \left(\frac{n_g}{n_a} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$n_g = n_g(\lambda)$



- f also changes with n_a (e.g. underwater)

Applications:

Concave: headlamps, vanity / dentist's mirror

Convex: passenger-side mirror, wide-angle security mirror.