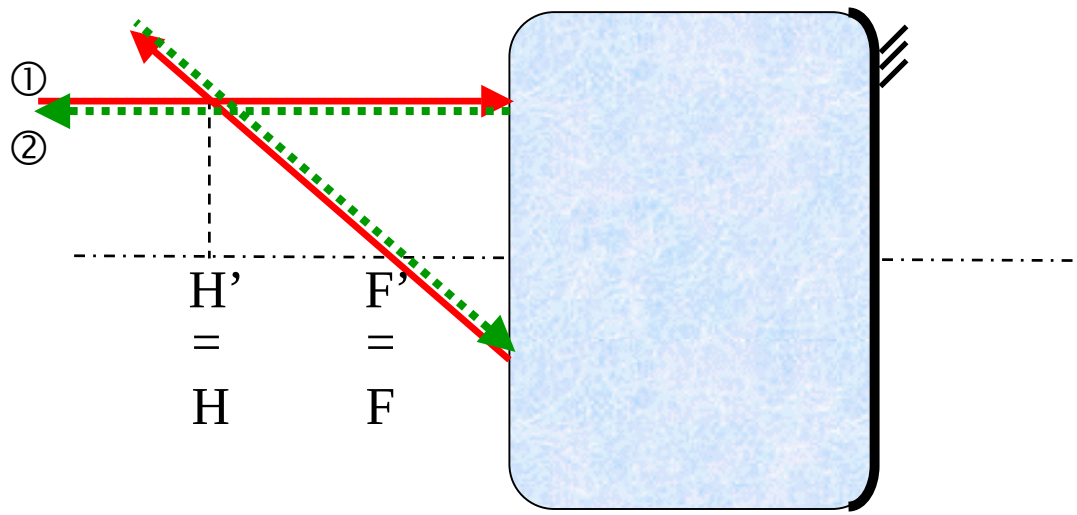
Optical instruments with mirrors

part 2: reflective telescopes and catadioptric systems

part 2b: catadioptric systems

Systems with mirrors and lenses (catadioptric)

Systems with one mirror



Ray ① entering // to the axis ➔ gives F' and H'

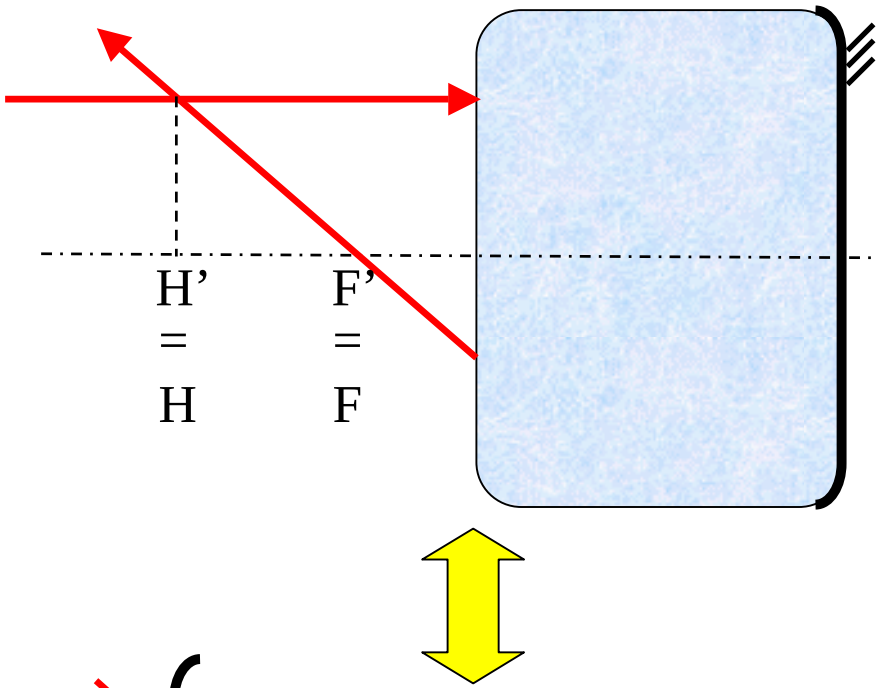
Ray ② exiting // to the axis ➔ gives F and H

Inverting direction of light

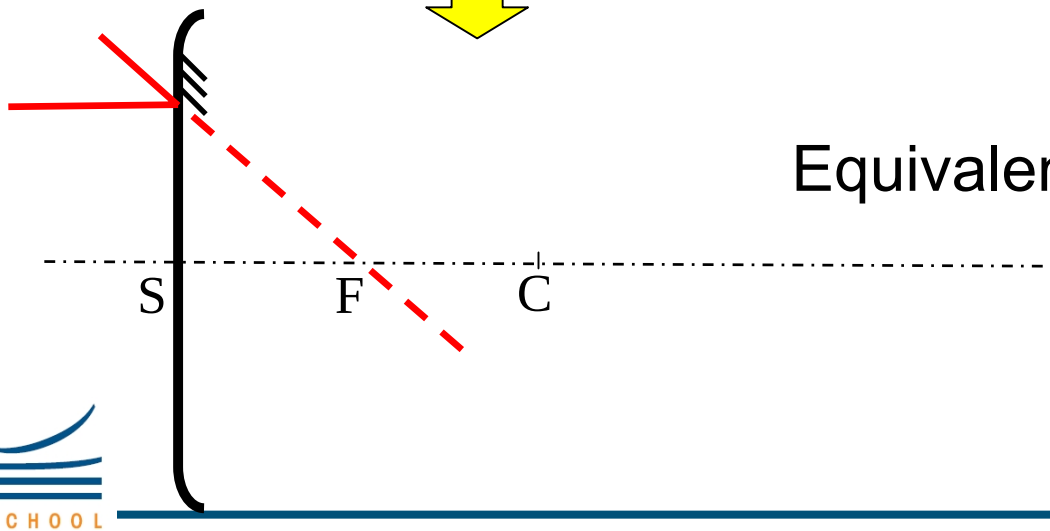
➔System equivalent to a single mirror :

- with vertex S = H = H'
- with foci F = F'

Systems with one mirror



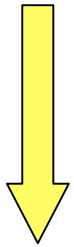
Catadioptric system



Equivalent spherical mirror

Systems with one mirror

Find the equivalent mirror ?

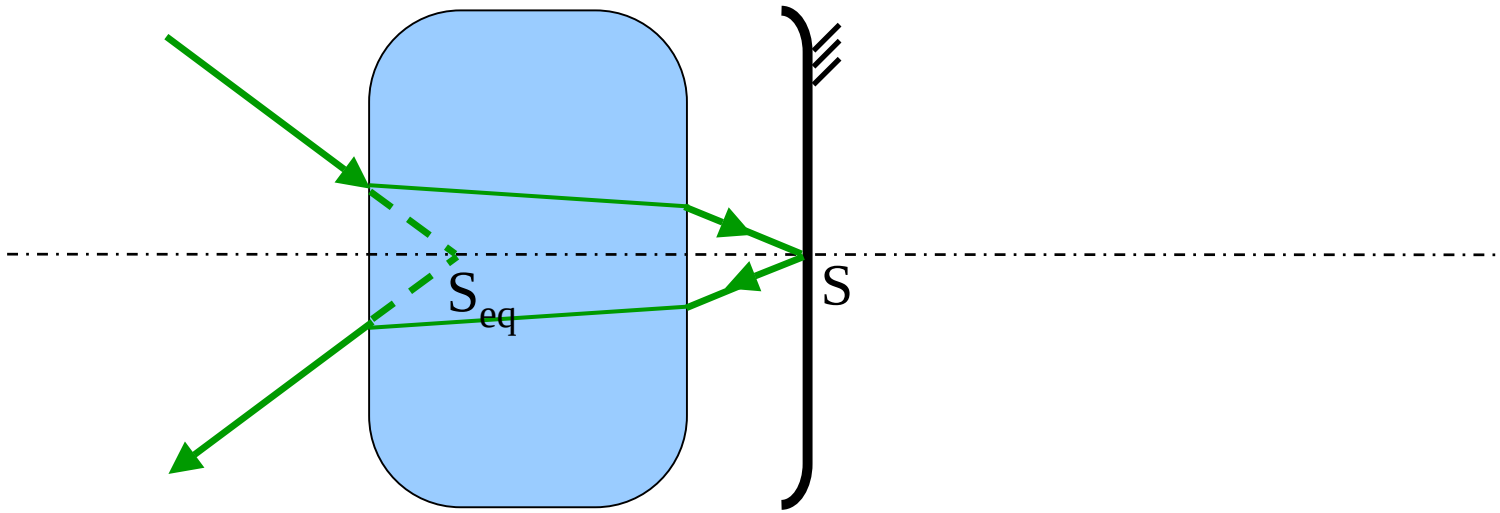


Find 2 characteristic points of this mirror :

its **vertex**

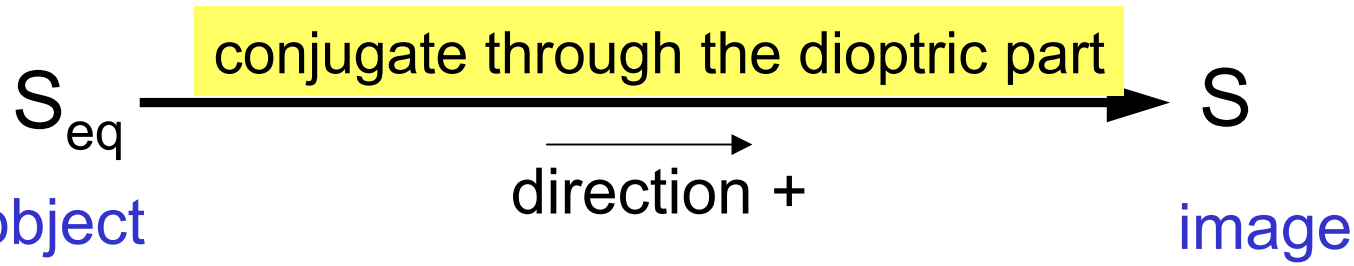
its **center of curvature**

Systems with one mirror

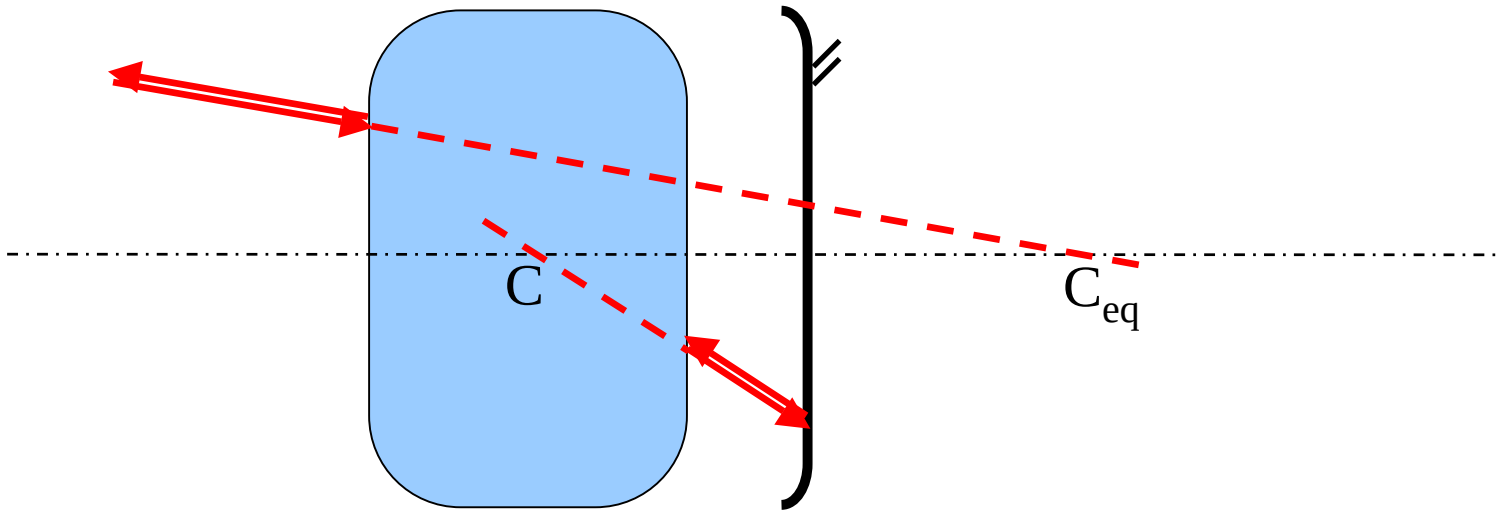


➔ How to find the vertex S_{eq} : look for a ray that passes through S

➔ This ray will necessarily go through S_{eq}

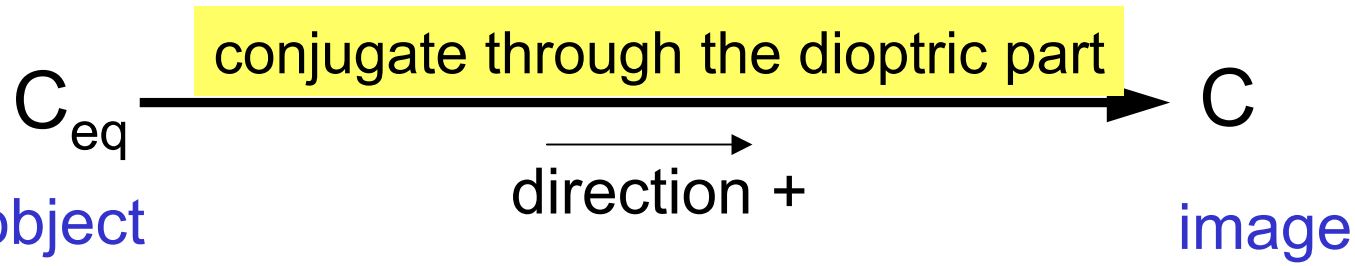


Systems with one mirror



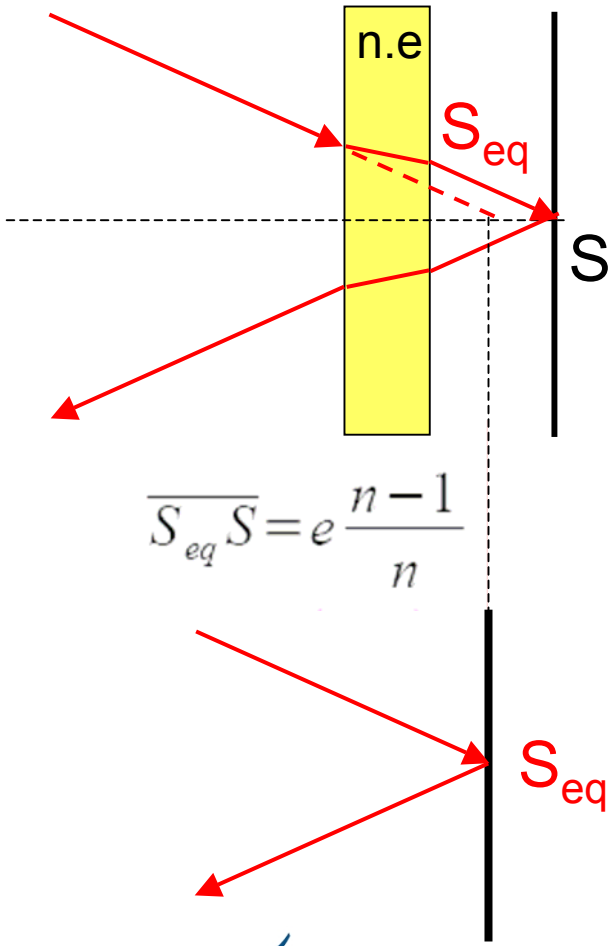
➔ How to find its center C_{eq} : look for a ray that passes through C

➔ This ray necessarily goes through C_{eq}

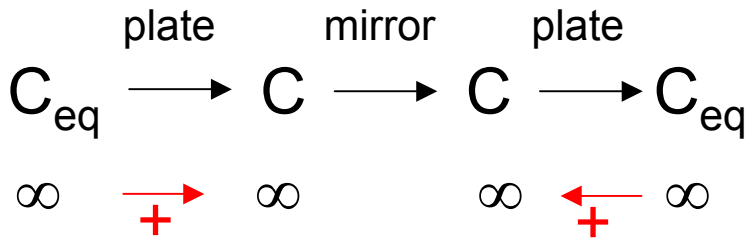


Examples of catadioptric systems

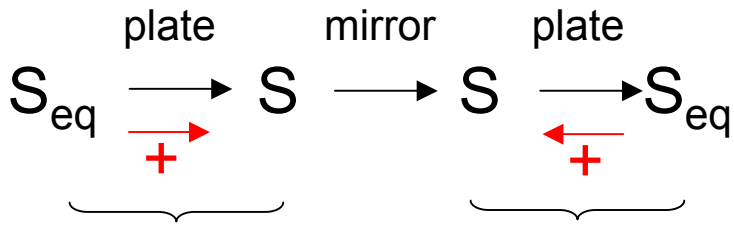
Plane parallel plate + plane mirror



Equivalent center



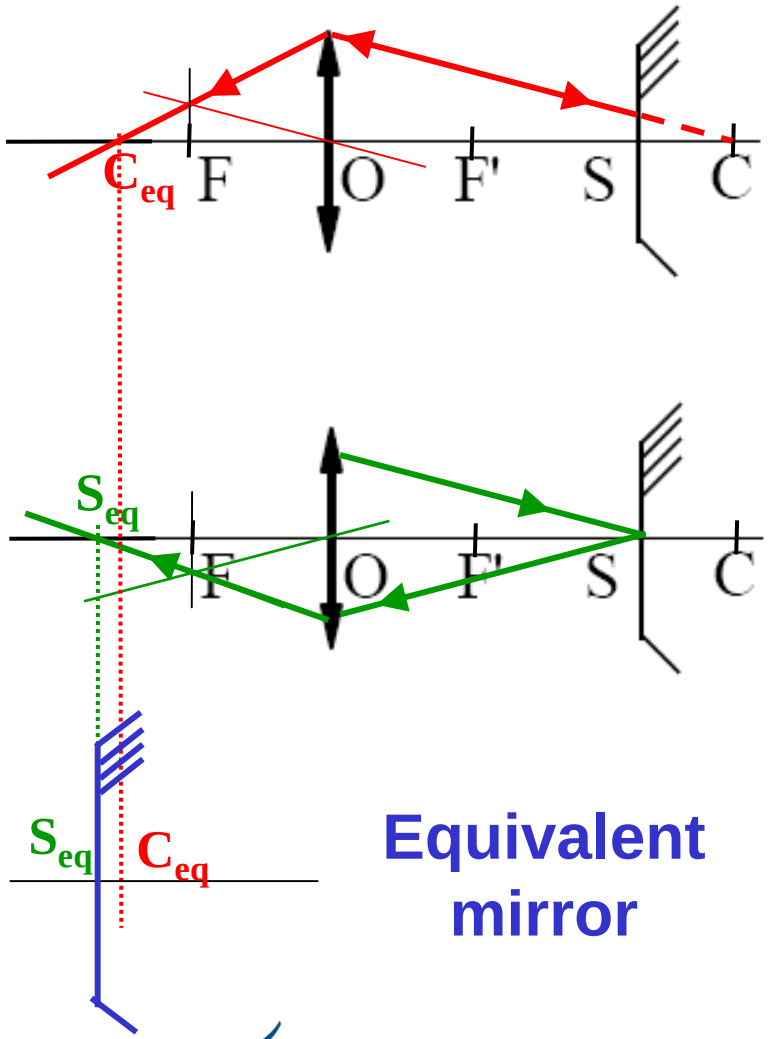
Equivalent vertex



Choose one of those to calculate S_{eq}

⇒ equivalent to a plane mirror in S_{eq}

Converging lens + convex mirror



Equivalent mirror

Equivalent center

lens mirror lens

$C_{eq} \rightarrow C \rightarrow C \rightarrow C_{eq}$

(+) (+)

Newton $\overline{FC_{eq}} = \dfrac{-f'^2}{\overline{F'C}}$

$C_{eq}=\infty$: plane mirror if F'=C

Equivalent vertex

lens mirror lens

$S_{eq} \rightarrow S \rightarrow S \rightarrow S_{eq}$

(+) (+)

Newton $\overline{FS_{eq}} = \dfrac{-f'^2}{\overline{F'S}}$

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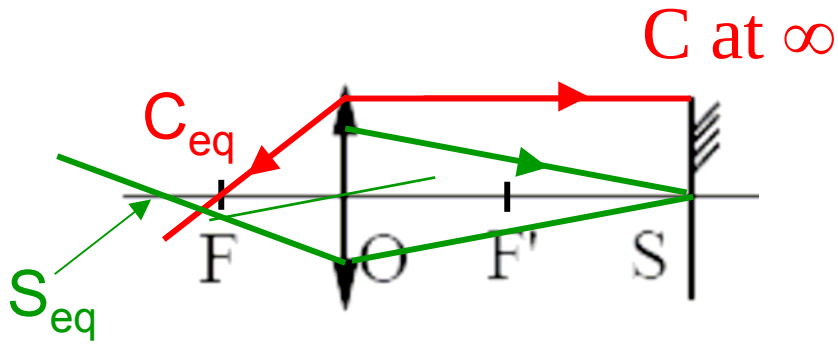
Converging lens + plane mirror

$C_{eq} = F \xrightarrow[+]{\text{lens}} C = \infty$

$S_{eq} \xrightarrow[+]{\text{lens}} S$



1. if F'S > 0 $R_{eq} > 0$ equivalent to a convex mirror
2. if F'S < 0 $R_{eq} < 0$ equivalent to a concave mirror

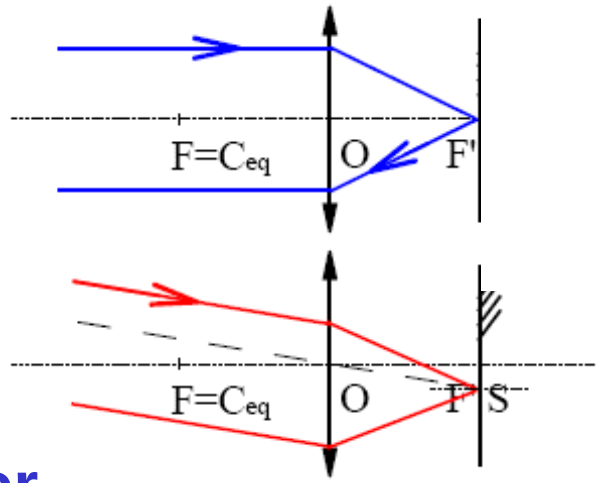
What happens if the plane mirror is in the focal plane of the lens?

Converging lens + plane mirror in the focal plane of the lens: CAT's EYE

$S_{eq} = \infty \xrightarrow[+]{\text{lens}} S=F'$

The vertex of the equiv. mirror is at ∞

But its center C_{eq} is in F



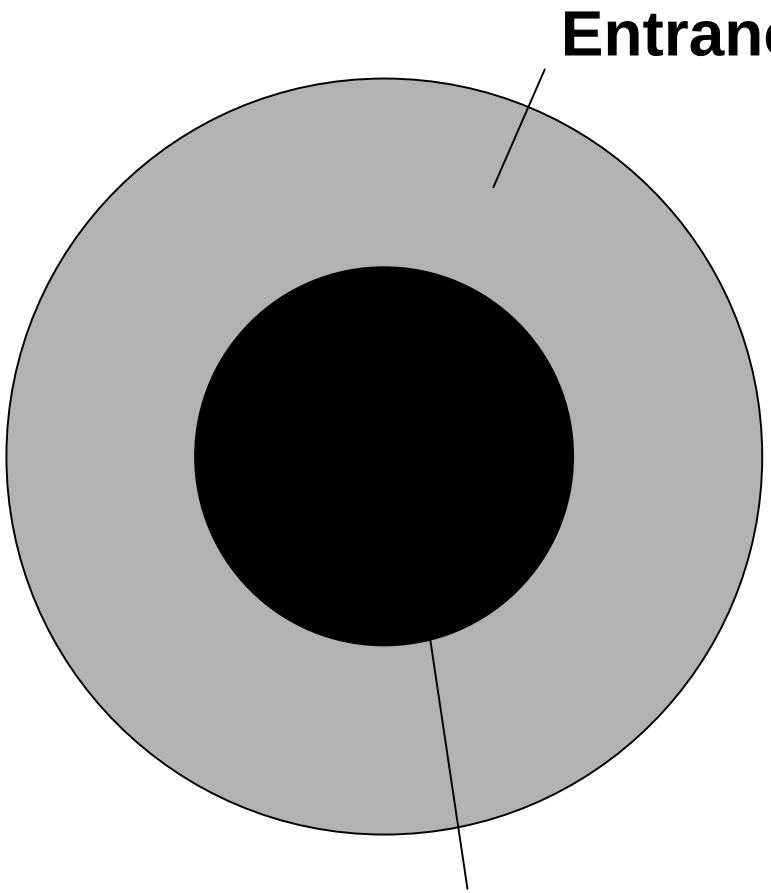
⇒ **Equivalent to a spherical mirror located at infinity!**

Properties:

- afocal system with $g_y = -1$
- reflection always in the incident direction
- image is always symmetric with respect to C_{eq}

A few extra slides about reflective telescopes

Central obturation

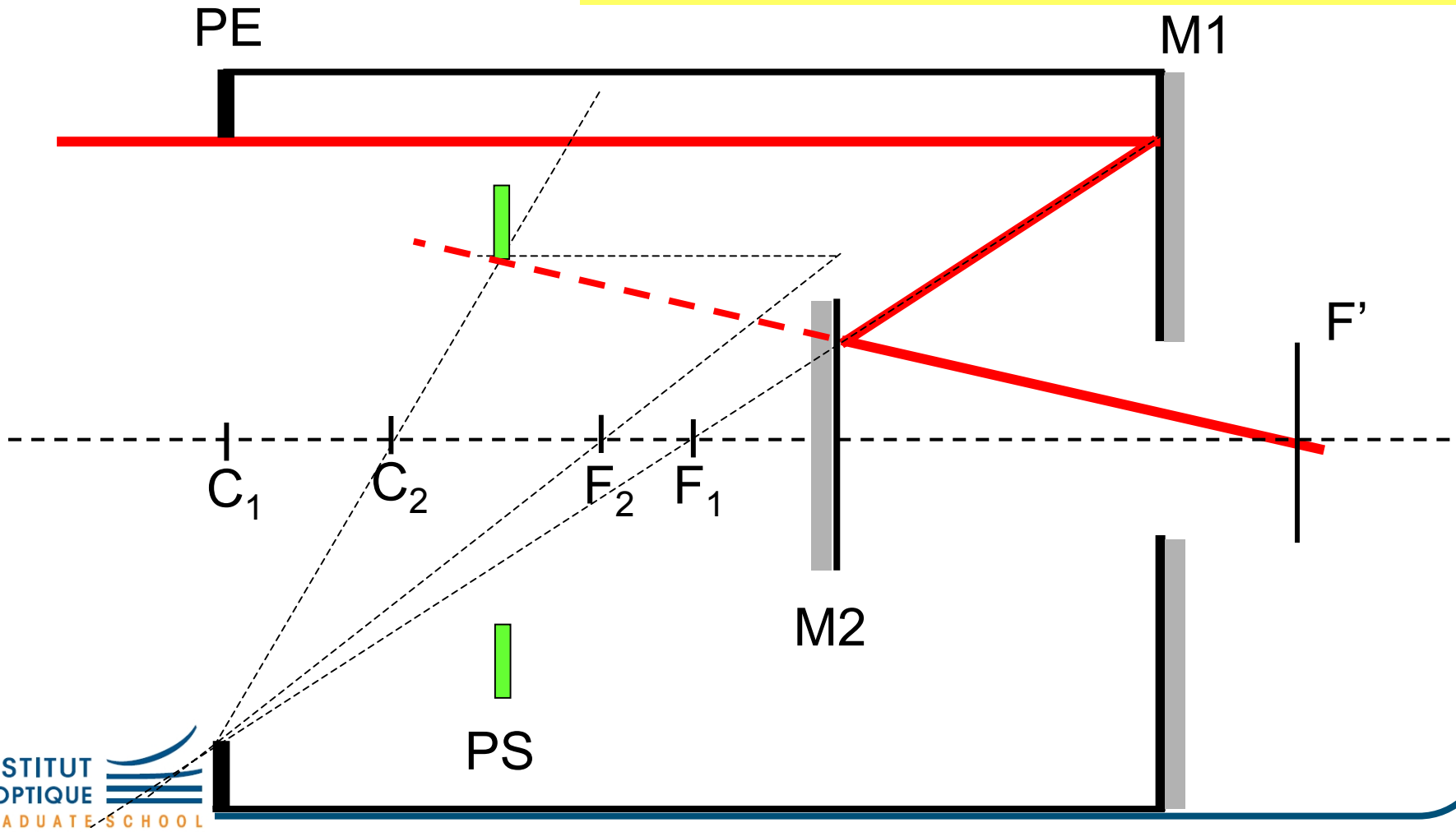


$$\text{Tobt.} = \frac{\text{Blocked surface Pe}}{\text{Surface Pe}}$$

Aperture and pupils (see problem 8)

Example : entrance pupil at the center of the primary mirror

PS = image through M1 and M2 of PE



Field of view

The out-of-axis rays passes through the edges of the pupils