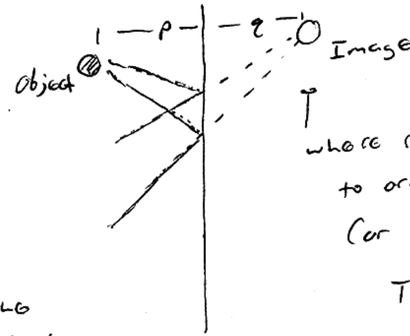
PHYS 2020

Mirrors

Flat mirrors



where rays appear to originate from (or intersect)

This is a virtual image (light appears to come from here)

p is the object distance

q is the image distance

Images formed by flat mirrors

1. as far behind as the object is in front

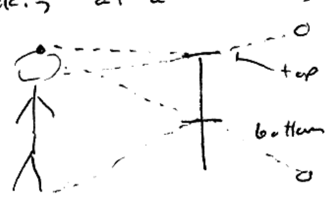
2. upright, unmagnified, virtual →

a real image is where lines intersect - not formed by a plane mirror.

magnification M is

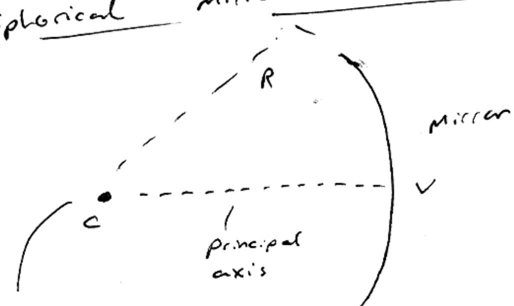
$$M \equiv \frac{\text{image height}}{\text{object height}} = \frac{h'}{h}$$

Looking at a full image example!

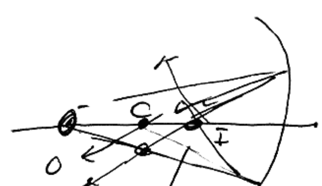


(as if he is looking out a window)

Spherical mirrors (concave surface)



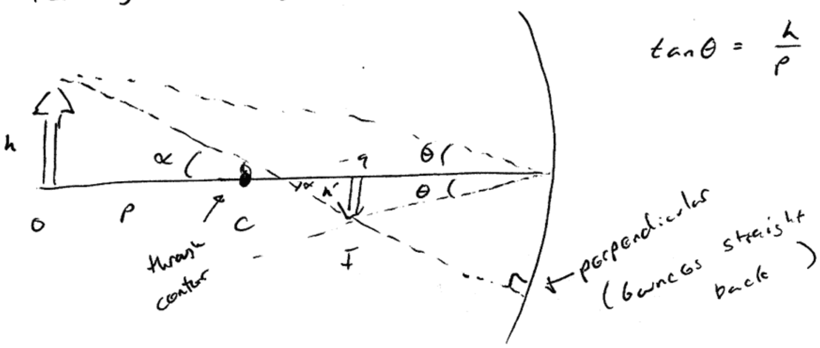
for small angles



real image!

discuss photographic plate

Forming an image!



$\tan\theta = \frac{h}{p}$

negative as image inverted

$\tan\theta = -\frac{h'}{q}$

$h = p\tan\theta$

$h' = -q\tan\theta$

$\frac{h'}{h} = \frac{-q\tan\theta}{p\tan\theta}$

$$M = -\frac{q}{p}$$

negative as image is inverted

with the little triangle

$\tan\alpha = \frac{h}{p-R} \longrightarrow h = (p-R)\tan\alpha$

$\tan\alpha = -\frac{h'}{R-q} \qquad h' = -\tan\alpha\,(R-q) = \tan\alpha\,(q-R)$

$\frac{h'}{h} = \frac{\tan\alpha\,(q-R)}{\tan\alpha\,(p-R)} = \frac{q-R}{p-R} = -\frac{q}{p}$

so $\frac{q}{p} = \frac{R-q}{p-R}$

$\frac{q}{p} = \frac{R}{p-R} - \frac{q}{p-R}$

$\frac{1}{p} = \frac{R}{q(p-R)} - \frac{1}{p-R}$

$\frac{p-R}{p} = \frac{R}{q} - 1$

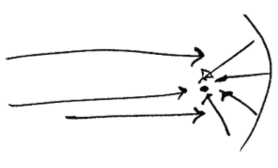
$1 - \frac{R}{p} = \frac{R}{q} - 1$

$2 = \frac{R}{p} + \frac{R}{q}$

$$\frac{2}{R} = \frac{1}{p} + \frac{1}{q}$$

mirror equation

Let $p \to \infty$ (image very far)



$\frac{2}{R} = \frac{1}{q}$

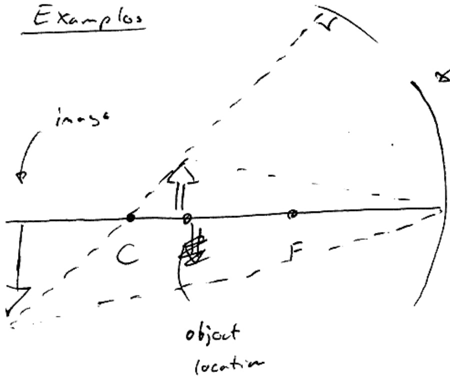
$q = \frac{R}{2}$

call this the focal length f

then $$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

discuss headlights

Examples



$R = 0.5\ m$

so $f = 0.25\ m$

$p = 0.35\ m$

$h = 0.05\ m$

$$\frac{1}{0.35} + \frac{1}{q} = \frac{1}{0.25}$$

$$2.857 + \frac{1}{q} = 4$$

$$\frac{1}{q} = 1.14285 \qquad q = 0.875\ m$$

$$M = -\frac{q}{p} = -2.5$$

← big, upside down image

Apparently when $p > C$, the real image is smaller, if $C > p > F$ the real image is far away and larger

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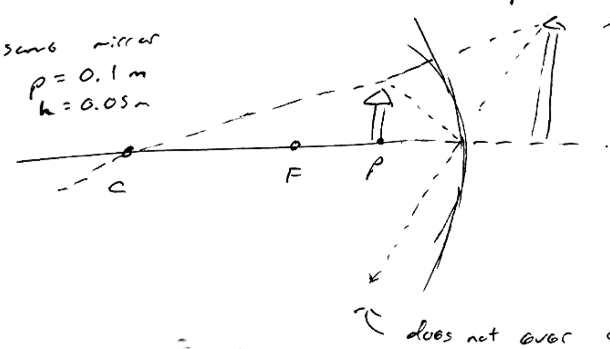
what if the object has $p < F$ — virtual image! Should have larger magnificat.

(same mirror

$p = 0.1\ m$

$h = 0.05\ m$



$$\frac{1}{0.1} + \frac{1}{q} = 4$$

$$10 + \frac{1}{q} = 4$$

$$\frac{1}{q} = -6$$

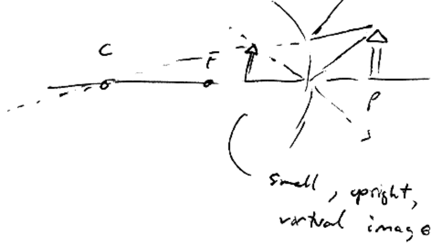
$$q = -0.167$$

← negative means on the other side!

$$M = -\frac{q}{p} = \frac{0.167}{0.1} = 1.67$$

← positive, as expected

Now make p negative ($-0.5 = p$)



Virtual Image

$$-\frac{1}{0.5} + \frac{1}{q} = 4$$

$$\frac{1}{q} = 6 \qquad q = 0.167$$

$$M = -\frac{q}{p} = \frac{0.167}{0.5} = 0.334$$