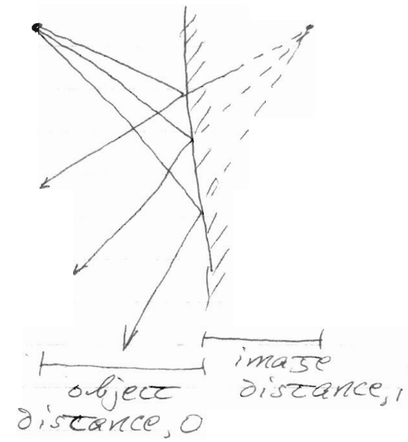
(1)

Images with Flat Mirrors

image: point where rays diverge

-or-

where rays appear to diverge.



- real vs. virtual
  - if rays actually pass thru image

flat mirrors always virtual image.

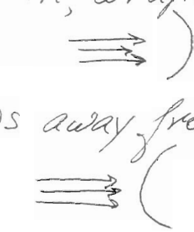
- object height = image height
- apparent reversal of image

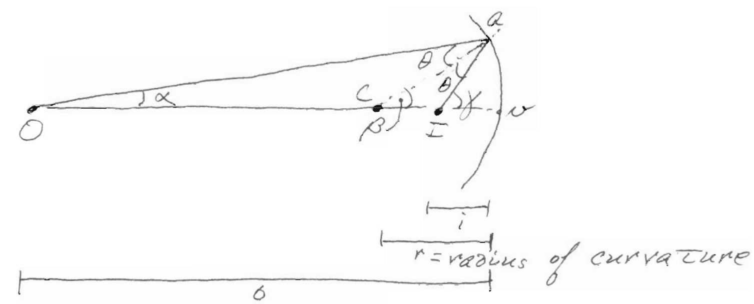
(2)

Spherical Waves: Spherical Mirror

concave: caved in, wraps around incoming light

convex: bends away from source of light





Since we have triangles (Σ angles = 180°)

$$\beta = \alpha + \theta$$
$$\gamma = \alpha + 2\theta$$

$$\alpha + \gamma = 2\beta$$

From geometry, for nearly paraxial rays (α, γ small)

$\alpha \cong aw/o$

$\beta = aw/r$

$\gamma \cong aw/i$

$$\boxed{\frac{1}{o} + \frac{1}{i} = \frac{2}{r}}$$

③

Focal Length of a Mirror

When ∥ light falls on a mirror

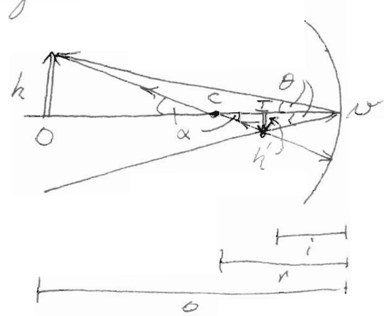
$\rightarrow o \rightarrow \infty$

$$\frac{1}{i} = \frac{2}{r} \Rightarrow i = \boxed{\frac{r}{2} = f}$$

so $$\boxed{\frac{1}{i} + \frac{1}{o} = \frac{1}{f}}$$

- a ray that is ∥ to axis will pass thru focal point upon reflection
- a ray that passes thru focal point will reflect to ∥ to axis

Magnification

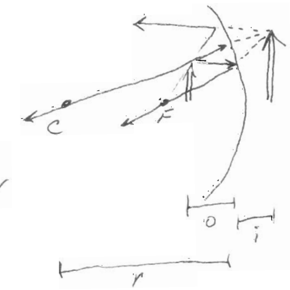


$$M = \frac{h'}{h} = -\frac{i}{o}$$

④

Virtual Images

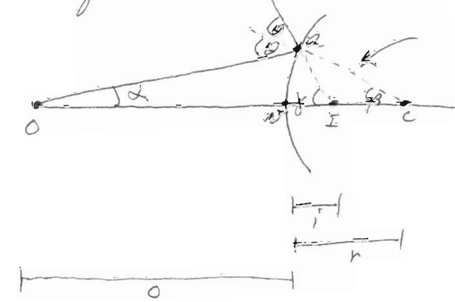
When o < f, get a larger, upright virtual image.



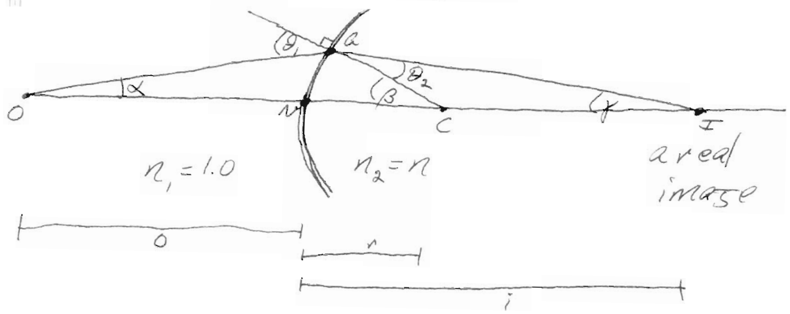
$M = -\frac{i}{o} > 0$

sign conventions

- o and i are positive for real objects, negative for virtual objects & images
- r positive if center of curvature C lies on left side, negative if lies on right side.



Spherical Refracting Surface



Snell's Law gives

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$(\sin\theta_1 = n \sin\theta_2)$$

if θ small → $\theta \approx \sin\theta \Rightarrow \theta_2 = \frac{n_1}{n_2}\theta_1$

Considering triangles

$$\theta_1 = \alpha + \beta$$
$$\beta = \theta_2 + \gamma = \frac{n_1}{n_2}\theta_1 + \gamma$$

combining

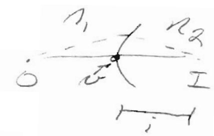
$$n_1\alpha + n_2\gamma = (n_2 - n_1)\beta$$

These angles are: $\alpha = aN/o$; $\beta = aN/r$; $\gamma = aN/i$

refraction at a single spherical surface $\quad \frac{n_1}{o} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$

Example

For previous geometry, where is image?



radius of curvature (r) = 10cm

$n_1 = 1.0 \qquad n_2 = 2.0$

The object is 20cm to left of N.

We have $\frac{n_1}{o} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$

we already know these

$$\frac{1.0}{+0.2m} + \frac{2.0}{i} = \frac{2.0 - 1.0}{+0.1m}$$

note choice of sign

note sign for r → on the "real" side of interface

$$\frac{2.0}{i} = \frac{10}{m} - \frac{5}{m} = \frac{5}{m}$$

$\boxed{i = +0.4m}$ (image is real as expected)