Chapter 23: Mirrors and Lenses

23.1 – Plane mirrors
23.2 – Qualitative analysis of curved mirrors
23.3 – The mirror equation
23.4 – Qualitative analysis of lenses.
23.5 – Thin lenses equation and quantitative analysis of lenses
23.6 – Skills for analyzing processes involving mirrors and lenses
23.7 – Single lens optical systems
23.8 – Angular magnification and magnifying glasses
23.9 – Telescopes and microscopes.

REVIEW

The lens equation
The mirror equation

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$$

f – focal length
s – position of the object
s' - position of the image

$f > 0$ $\quad$ $f < 0$

h (h_o)
h' (h_i)

$$m = \frac{h'}{h} = -\frac{s'}{s}$$

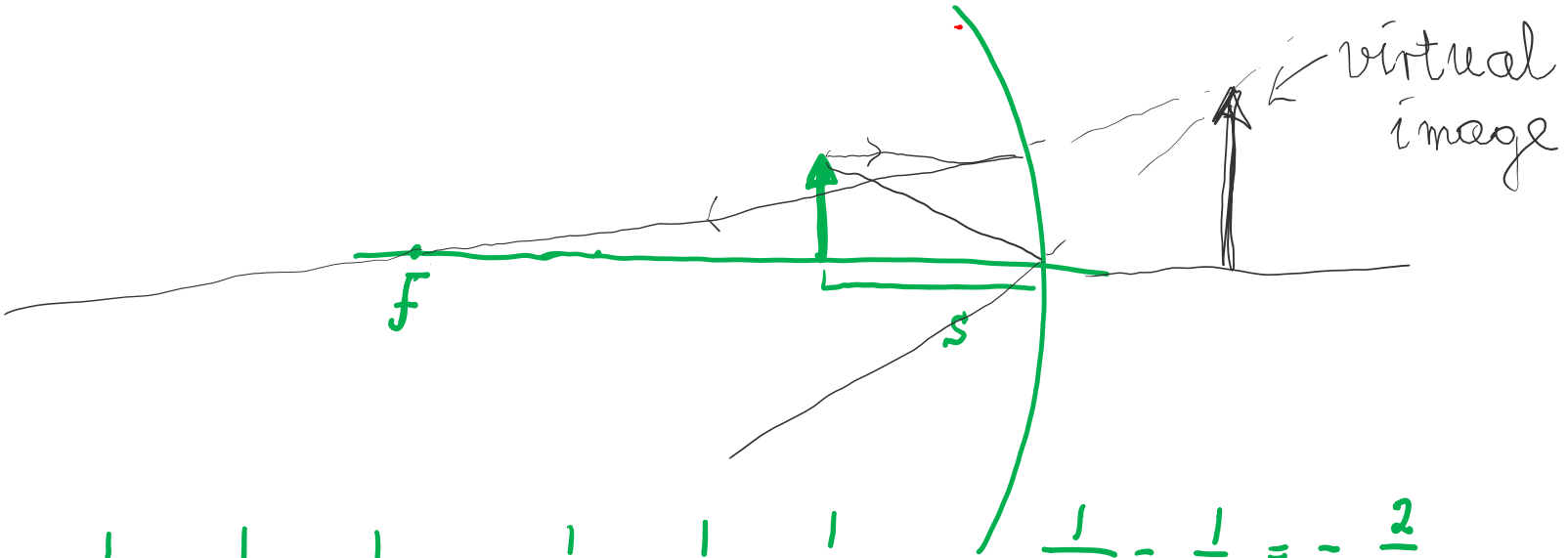
→ A lens creates a real, inverted image. What can we say about this lens?

A lens creates a virtual, upright image. What can we say about this lens?

What if we know that the object is $s > |f|$ from the lens?

EXAMPLE 23G

An 5.0 cm object is located 30.0 cm away from a concave mirror with the focal length of 90.0 cm.
Determine the minimum diameter of the mirror that would include the entire image.



$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} \rightarrow \frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{1}{90} - \frac{1}{30} = -\frac{2}{90}$$

$s' = -45$ cm

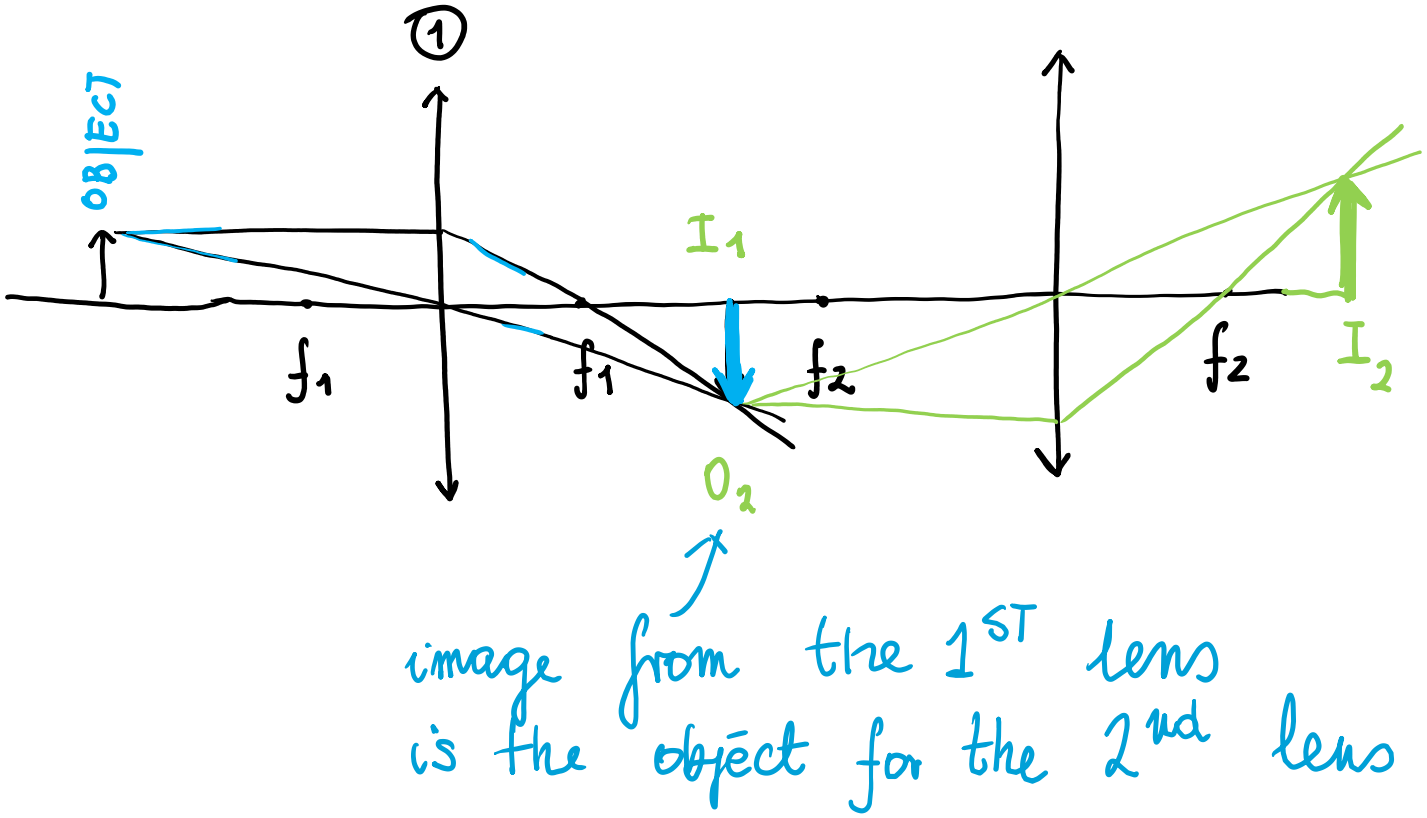
$$\left|\frac{h'}{h}\right| = \left|\frac{s'}{s}\right| = 1.5 \qquad h' = 1.5 \times 5.0 = 7.5 \text{ cm}$$

diameter here is not related to the radius of curvature but the size of the mir.

EXAMPLE 23H

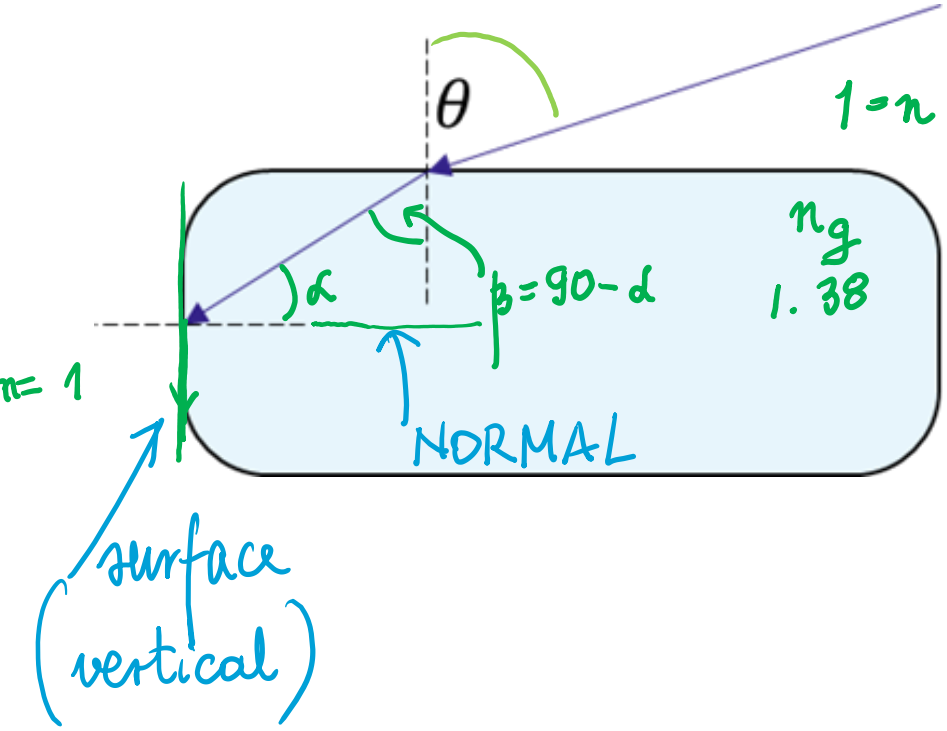
Consider a set up of two convex lenses of focal lengths f_1 and f_2 and separated by distance $d > f_1 + f_2$.

An object is located distance $s_1 > f_1$ from the first lens.
What is the final image created by the system of two lenses.



EXAMPLE – REVIEW (A)

A paper weight shown in the figure below is made of glass with an index of refraction $n = 1.38$. What is the value of the incident angle θ that just satisfies the conditions of the total internal reflection on the vertical surface?



1. $n_g \sin\alpha = n_{Air} \cdot \sin 90$

$$\sin\alpha = \frac{n_{air}}{n_g}$$

$$\sin\alpha = \frac{1}{1.38}$$

$$\alpha = 46.4^\circ$$

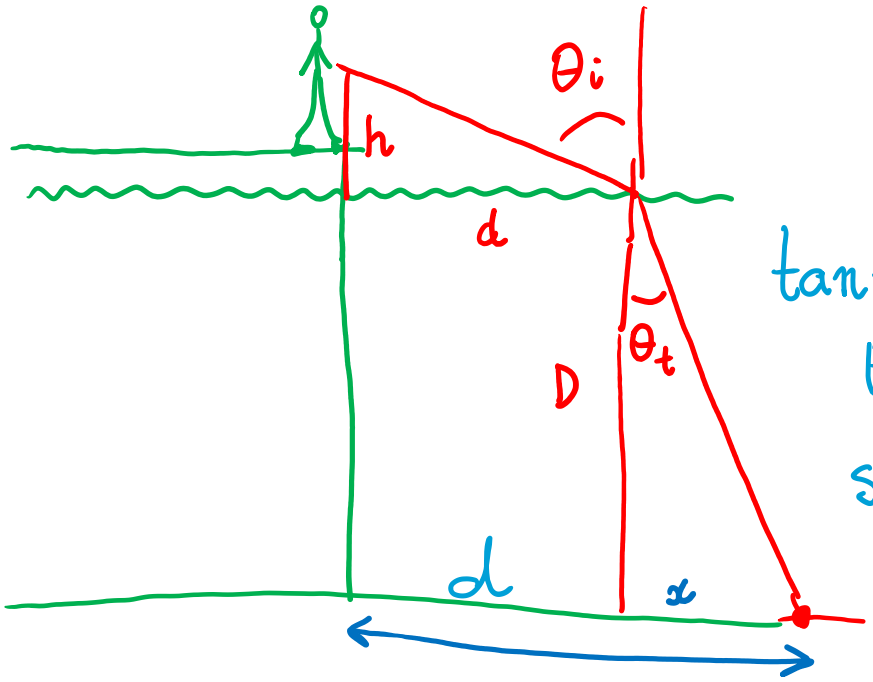
2. $n_g \sin\beta = n_{air} \cdot \sin\theta$

$$\sin\theta = \frac{n_g \sin(43.6)}{n_{air}}$$

$$\theta = 72^\circ$$

EXAMPLE – REVIEW (B)

One night, while on vacation in the Caribbean, you walk to the end of a dock and, to embrace your inner physics instructor, you shine your laser pointer onto the water. When you shine the beam of light on the water a horizontal distance 2.4 m away from the dock, you see a glint of light from a shiny object on a sandy bottom – perhaps a piece of eight. If the pointer is 1.8 m above the surface of the water and the water is 5.5 m deep, what is the horizontal distance from the end of the dock to the shiny object?



$h = 1.8m$

$d = 2.4m$

$D = 5.5m$

$n_{water} = 1.3$

$\tan\theta_i = \frac{d}{h} = \frac{2.4}{1.8}$

$\theta_i = 53.1^\circ$

$\sin\theta_i n_{air} = n_w \cdot \sin\theta_t$

$\theta_t = 37.9^\circ$

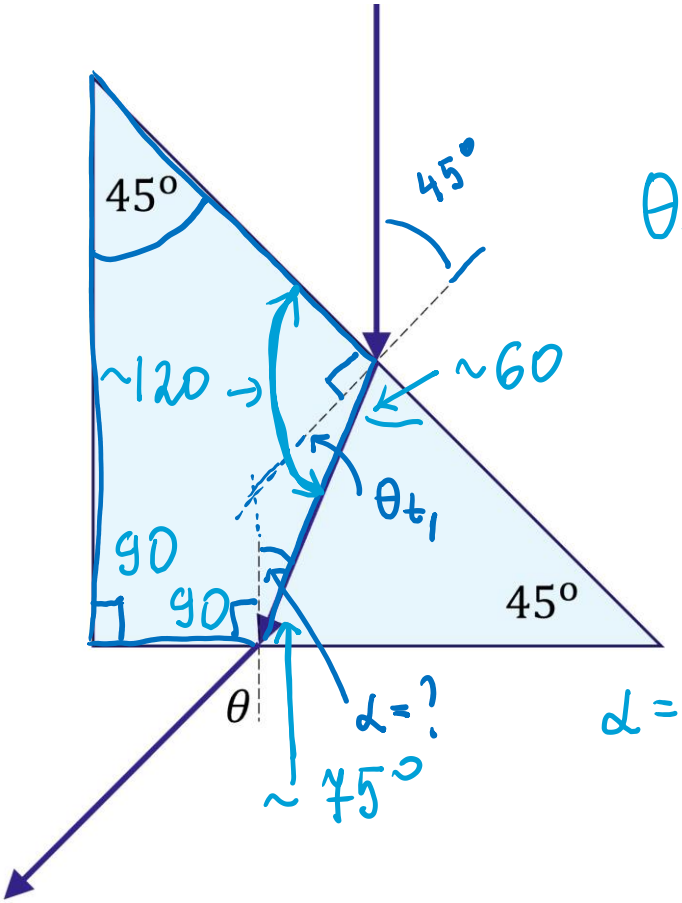
$\frac{x}{D} = \tan\theta_t, \quad x = 4.29m$

EXAMPLE – REVIEW (C)

Determine the value of angle θ.

(derivation)

$n_2 = 1.4$



θ_{t_1}: $n_1 \sin 45 = n_2 \sin \theta_{t_1}$

$\theta_{t_1} = 30.3°$

$\alpha = 360 - 120 - 90 - 90 - 45$

$\alpha = 15°$

↑ checks out!

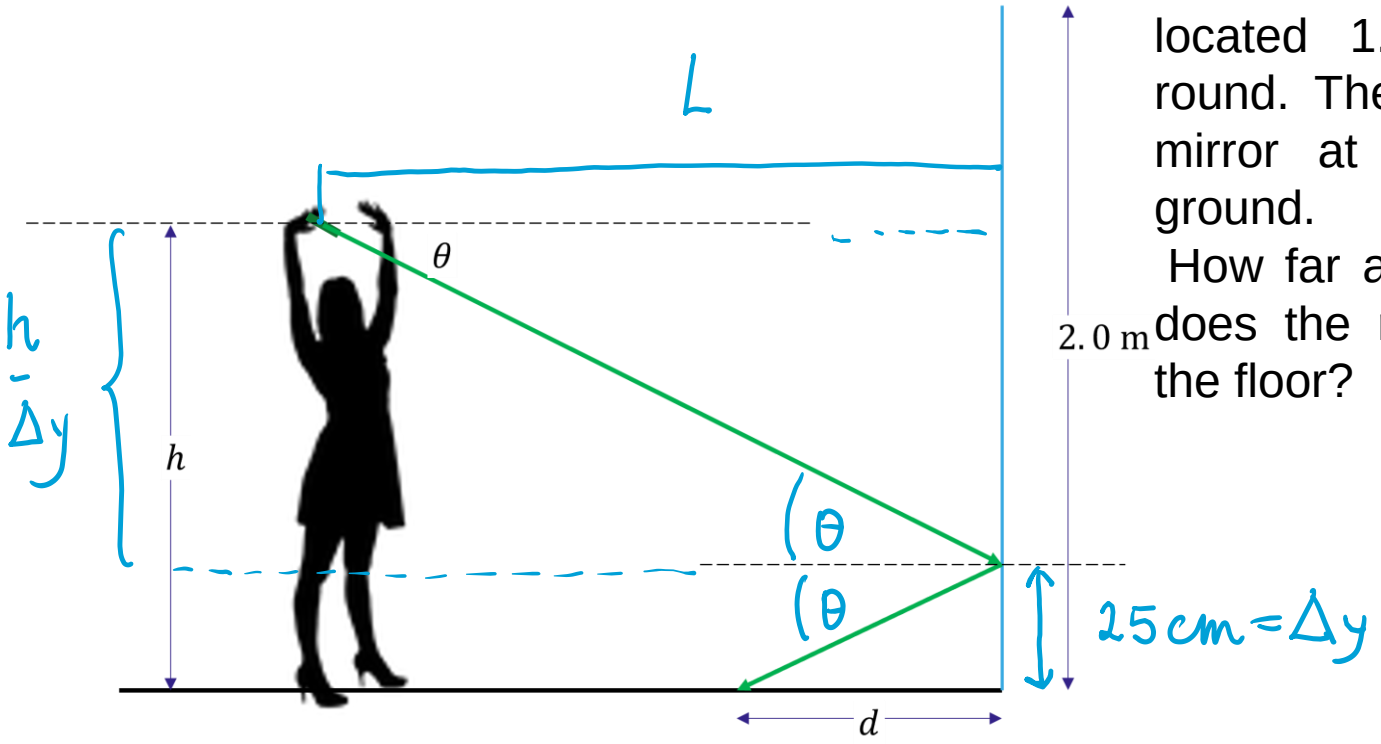
$\sin \alpha \cdot n_w = n \sin \theta$

$\theta = 21.2°$

EXAMPLE – REVIEW (D)

Ania shines a laser on her mirror, starting from a point located 1.70 cm above the round. The laser light hits the mirror at 25 cm above the ground.

How far away from the mirror does the reflection appear on the floor?



$$\frac{\Delta y}{d} = \tan\theta$$

$$\frac{h-\Delta y}{L} = \tan\theta \rightarrow \text{depends on } L!$$