① Phys 1402 2017-08-01 Lec 17

#5 Property of object vs. Environment

Mass
EMF of battery
Resistance of Resistor
Capacitance of Capacitor
Inductance of Inductor
Index of Refraction of material
Focal Length of Lens

#9: Doppler Shift

$$\frac{\Delta f}{f} = \frac{V_{rel}}{V_{wave}}$$

$$\frac{\Delta f}{600\,Hz} = \frac{34.3}{343} = 0.1$$

$$\Delta f = 0.1(600) = 60\ Hz$$

When approaching, f shifted higher

#17 $I = I_0\, 10^{\beta/10}$ → Add 30 dB

For 1000 times increase

$1000 = 10^{\beta/10} = 10^3 \rightarrow \frac{\beta}{10} = 3 \rightarrow \beta = 30\,dB$

(2)

#8 Bigger things naturally move slower.

Pendulum: freq depends on length

$$f = \frac{1}{2\pi}\sqrt{g/L}$$

$$T = \frac{1}{f} = 2\pi\sqrt{\frac{L}{g}}$$

$T_1 = 1.0\ s$ $\quad$ L factor = 2

$$T_1 = 2\pi\sqrt{\frac{L_1}{g}} \rightarrow T_2 = 2\pi\sqrt{\frac{2L_1}{g}}$$

$$= \left(2\pi\sqrt{\frac{L_1}{g}}\right)\left(\sqrt{2}\right)$$

$$= (1.0\ s)(1.414)$$

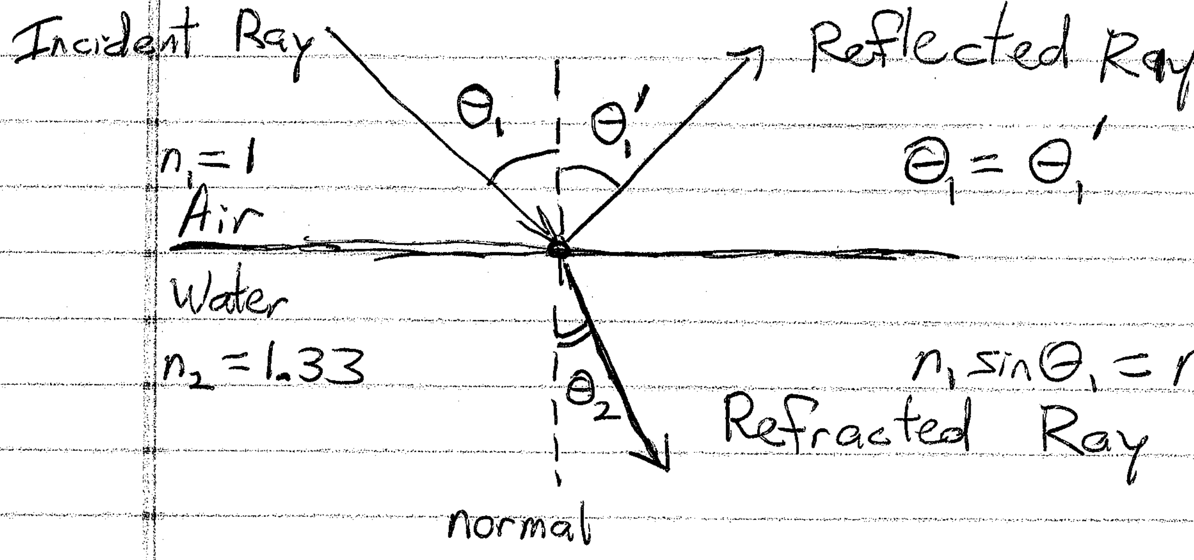
(3)

Geometric Optics - redirecting light via the shape of objects.

Two main effects:
- Reflection - Bouncing wave off surface
- Refraction - Bending wave while it enters or exits a material.

Types of Materials
- "Nothing" - Air and vacuum
- Absorbing - Flat black paint
- Reflecting, Conductive - shiny metal
- Transparent - Glass, Water

Reflection & Refraction



$$\theta_1 = \theta_1'$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Index of Refraction (n) describes each material.

Ex: $\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{(1.0)\sin(45^\circ)}{1.33} = 0.532$ $\quad \theta_2 = 32^\circ$

Grade Calculator: goo.gl/ua3sXF

With refraction, bending is deeper into
<u>slow</u> material.

Regular speed of light $c = 3 \times 10^8$ m/s

In a material: $v = \frac{c}{n}$

n = index of refraction
= slowdown factor

Usually, $n = 1 \ldots 2$

Ex: Water $n = 1.33$
Acrylic $n = 1.5$
Diamond $n = 2.4$

What if we solve and get $\sin\theta_2 = 1.1$?
What is θ_2? Not possible!
Why? $\sin\theta_2$ maxes out at 1.0.
$n_1 \sin\theta_1 = n_2$ (Set $\sin\theta_2 = 1$)
This is a threshold for Total Internal Reflection. All light follows θ_1'.

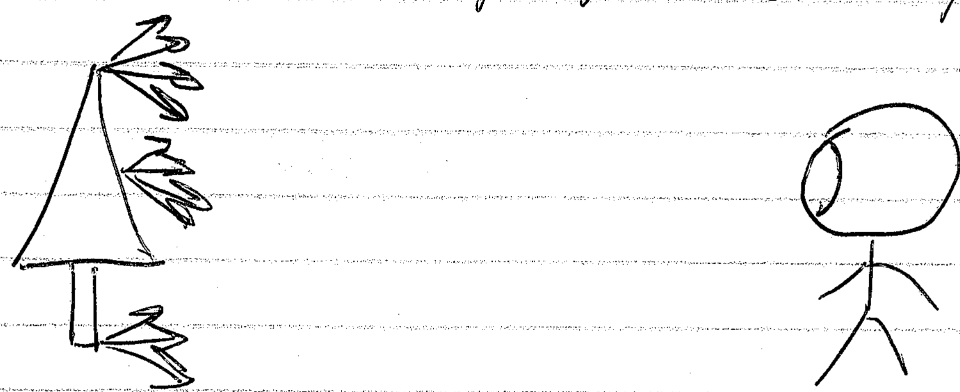
$\sin\theta_1 = \frac{n_2}{n_1}$ must be $<$ 1

Only valid if $n_1 > n_2$
Ex: Light goes from water to air.

From Rays to Images

Reflection & Refraction deal with angles of individual rays.

When we "see" an object, we see many rays.

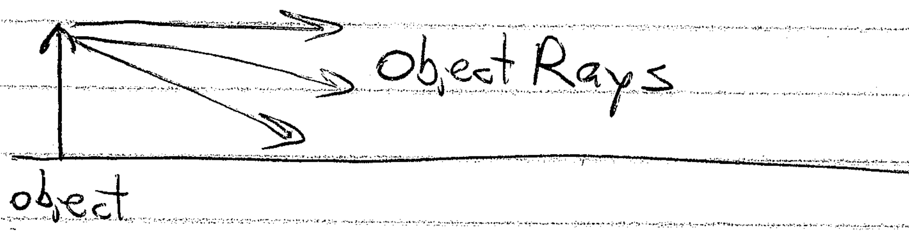


Every point emits rays in every direction.

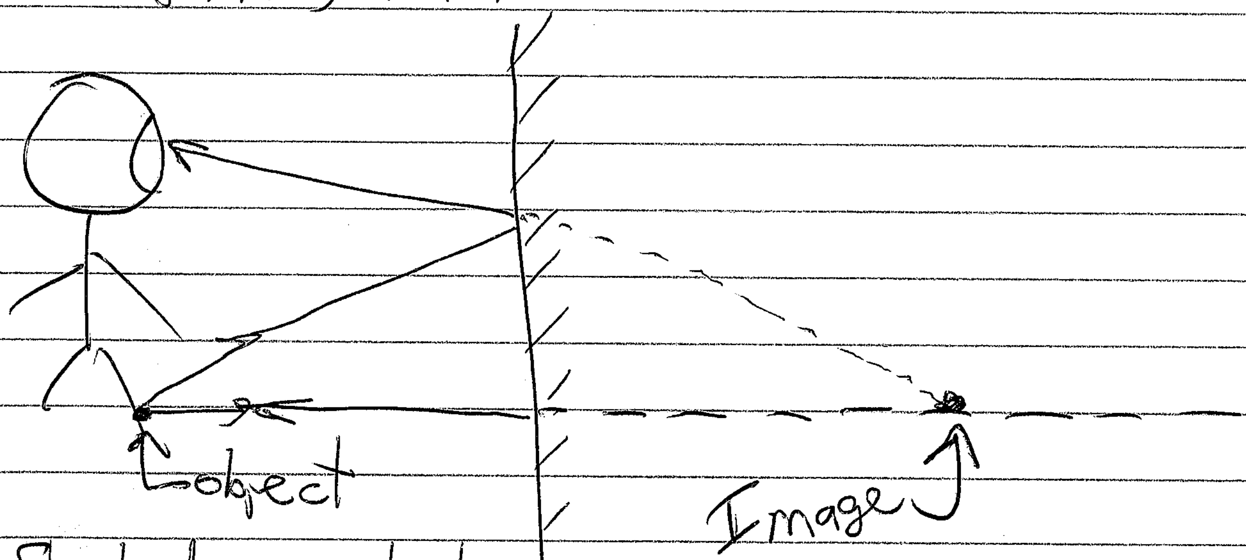
Observer sees rays that get to eye.

Tracing all rays is difficult - Let Pixar do that
Simplification: only use one point of object.

The physics object is observed as rays of light diverging from a point.



Flat (Plane) Mirror



Reflected rays look like they come from a common point.

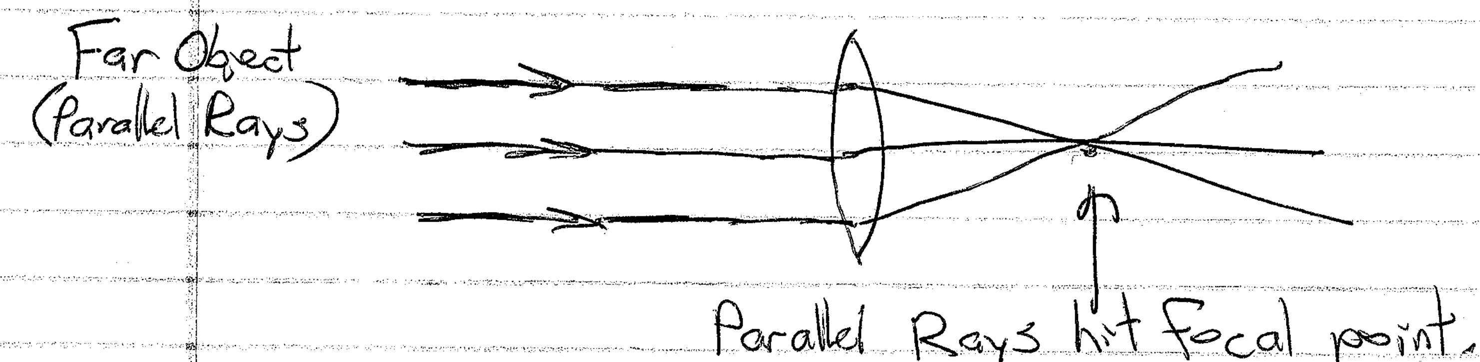
The image is where the rays look like they are coming from, after they reflect from the mirror.

For a flat mirror, the image is <u>behind the mirror</u>.

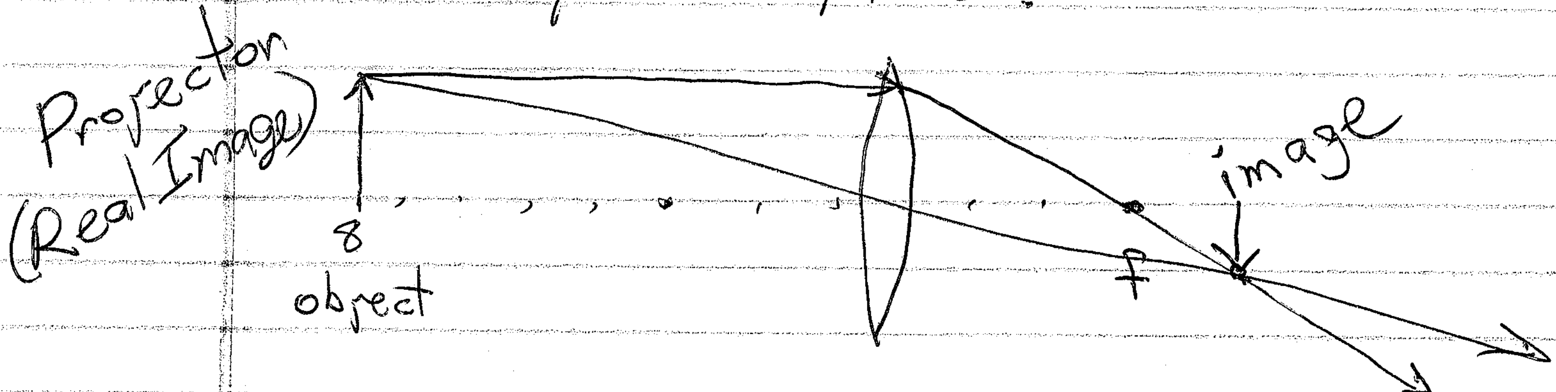
Object Distance: d_o is ⊕
Image Distance: d_i is ⊖

(This is a virtual image.) ← Image rays don't actually touch image.

A converging lens tries to bend rays inward to make them converge.



What if the rays aren't parallel?



$f = 3$ cm
$d_o = 8$ cm
$d_i = 4.8$ cm (see below)

① Parallel Ray converges to f
② Central Ray goes straight.

We see shrunken upside-down image floating in front of lens.
└ where observer is.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \;\rightarrow\; d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1}$$