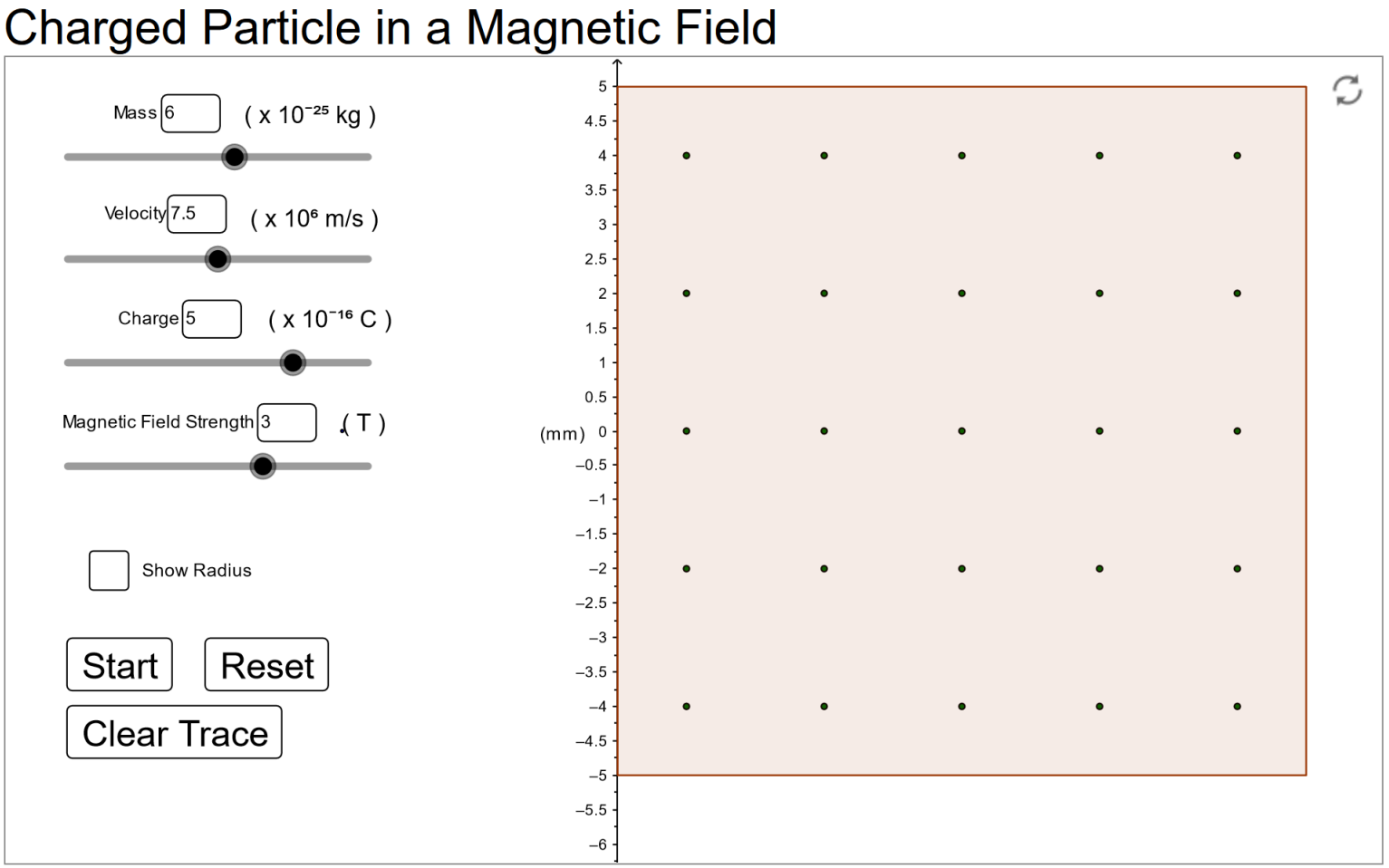
Lec 21: Light – Introduction
Lec 22: Reflection and Refraction
Lec 23: Total internal reflection
Lec 24: Plane and Curved Mirrors. Mirror Equation
Lec 25: Qualitative analysis of lenses. Thin lens Eqatuion
Lec 26: Single lens Optical systems. Magnifying glasses
Lec 27: Mirrors and Lenses - Applications

Chapter 22: Reflection and Refraction

Introduction: Reflection and Refraction
22.1 – Light Sources, Light Propagation, and Shadows
22.2 – Reflection of Light
22.3 – Refraction of Light
22.4 – Total Internal Reflection
22.5 – Reflection and Refraction – applications

A very quick LC review:



Which way will this particle deflect?
What would be the radius of the curvature of its path?

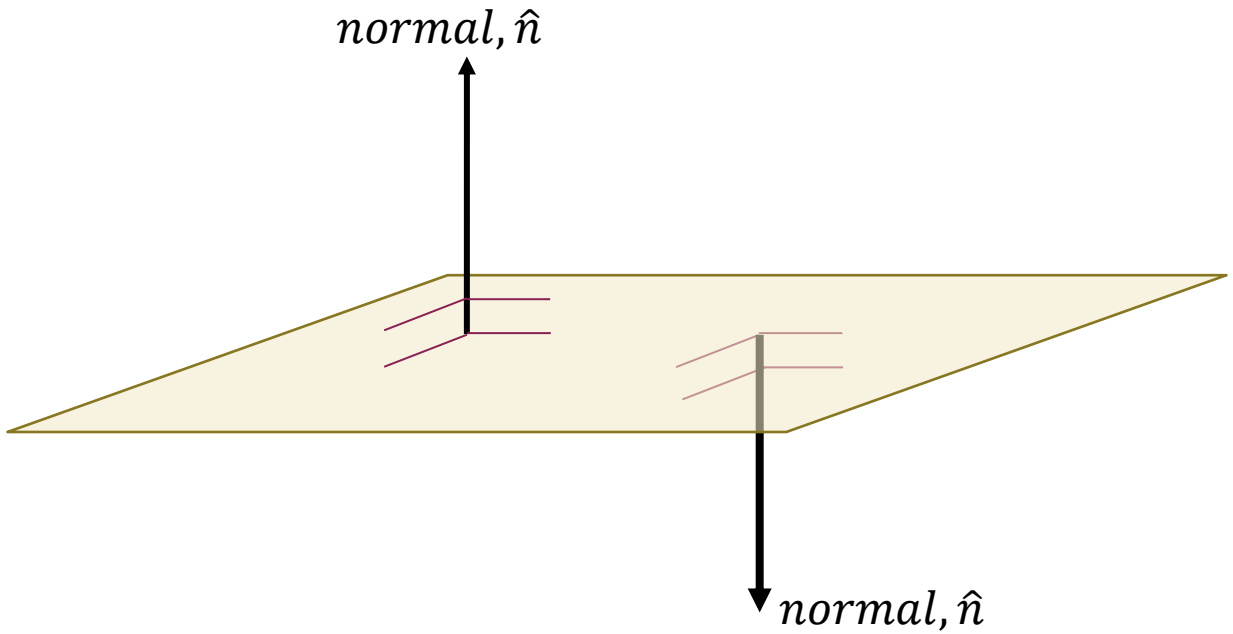
BEFORE THIS CLASS

Is light a particle or a wave?

TED-Ed video by Colm Kelleher
English transcription: Andrea McDonough

REVIEW

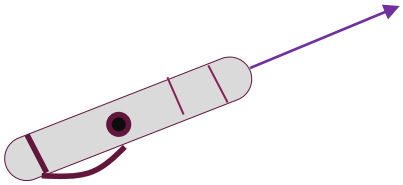
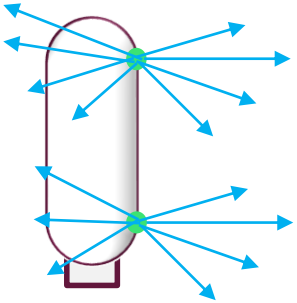
Geometry!



LIGHT SOURCES

We will represent the travel of light from one location o another with a **light ray**, drawn as a straight line and an arrow.

Diagrams that include light rays are called **ray diagrams.**

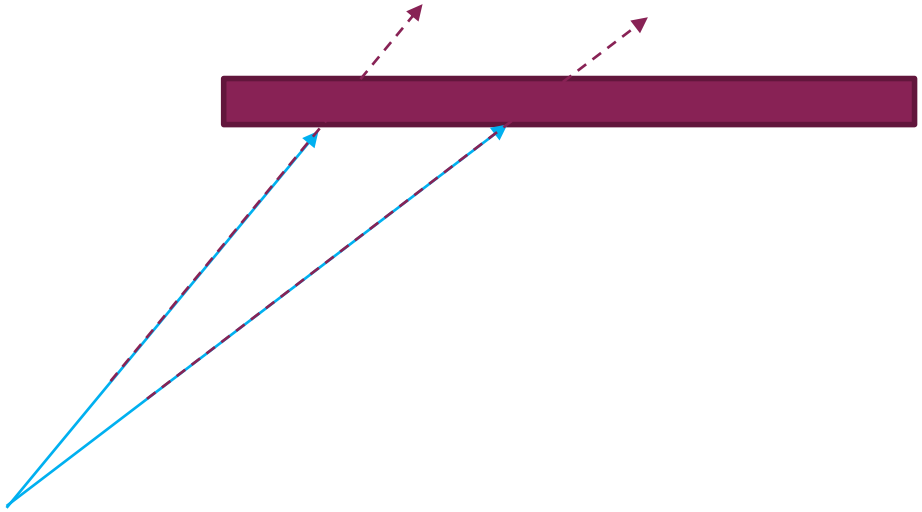
Point Light Source		Extended Light Source	
	*One ray model of the laser beam.*		*Multiple-ray model – each point on an extended light source emits light in multiple directions represented by multiple rays.*

Observation Experiment

Shine laser on the mirror (watch reflection)?

Check out this exercise!
(“Who Can See Who”)

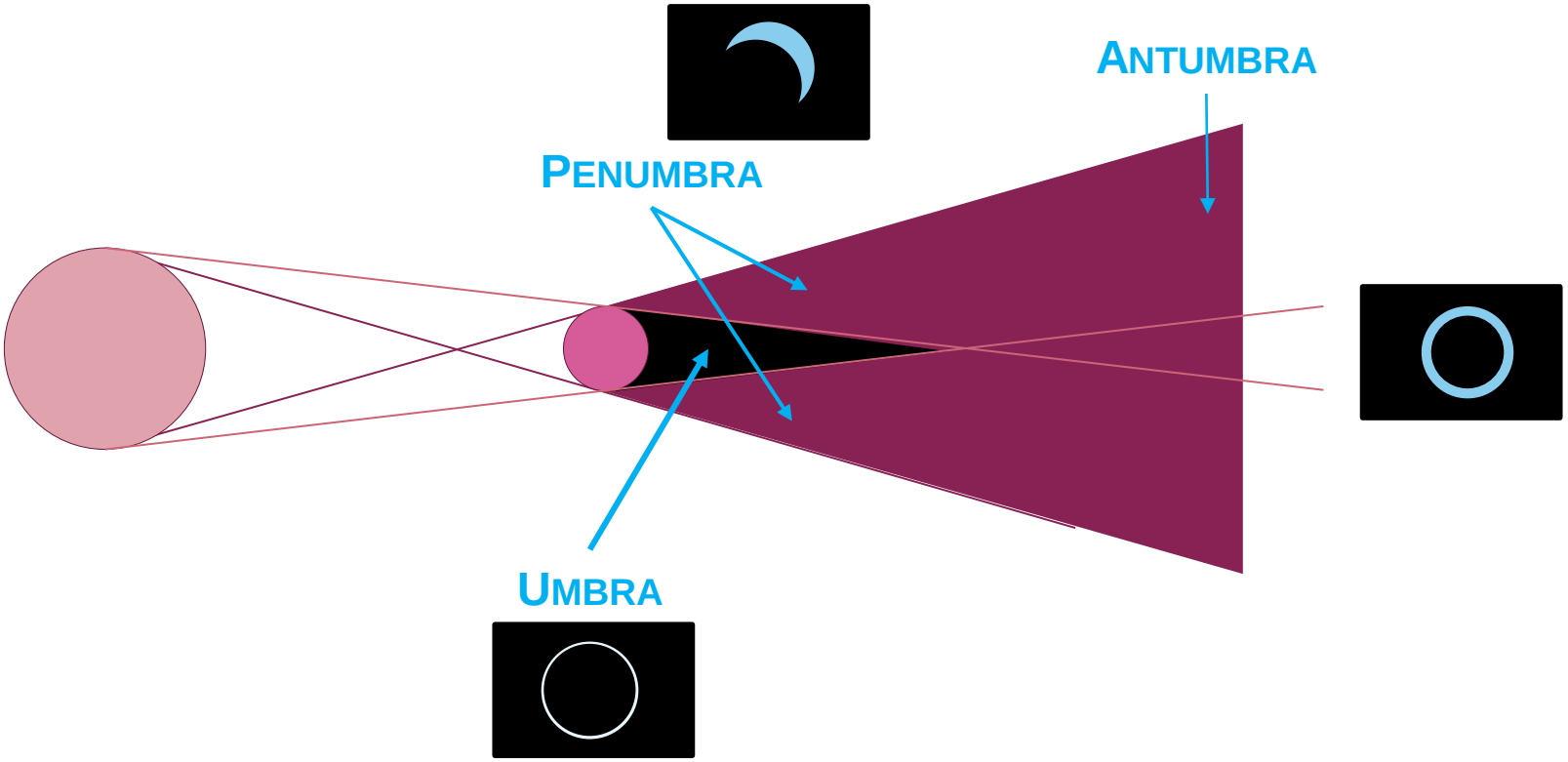
https://www.physicsclassroom.com/Physics-Interactives/Reflection-and-Mirrors/Who-Can-See-Who/Who-Can-See-Who-Interactive



SHADOW

Shadow is the dark area (volume) where the light from a light source is blocked by an opaque (non-see-through) object.

The “blocked” light can either be reflected or absorbed by the object.



WISE

WOMEN IN SCIENCE AND ENGINEERING

INTERNATIONAL WOMEN'S DAY GALA

Visionaries: Beyond the Stars

DATE: MARCH 8TH, 2023
TIME: 6:00 PM - 10:00 PM EDT
LOCATION: THE GREAT HALL, HART HOUSE
DRESS CODE: BLACK TIE

PHY132 Final Exam:

PHY132H1S	Intro Physics II	BN 210N	18-Apr	7:00 PM	10:00 PM	180	A - H
PHY132H1S	Intro Physics II	BN 210S	18-Apr	7:00 PM	10:00 PM	180	I - Q
PHY132H1S	Intro Physics II	BN 322	18-Apr	7:00 PM	10:00 PM	180	R - ZZ

When: **18 April (Tuesday) 2023, 7:00 pm – 10:00 pm**

Duration: **180** minutes

Format:

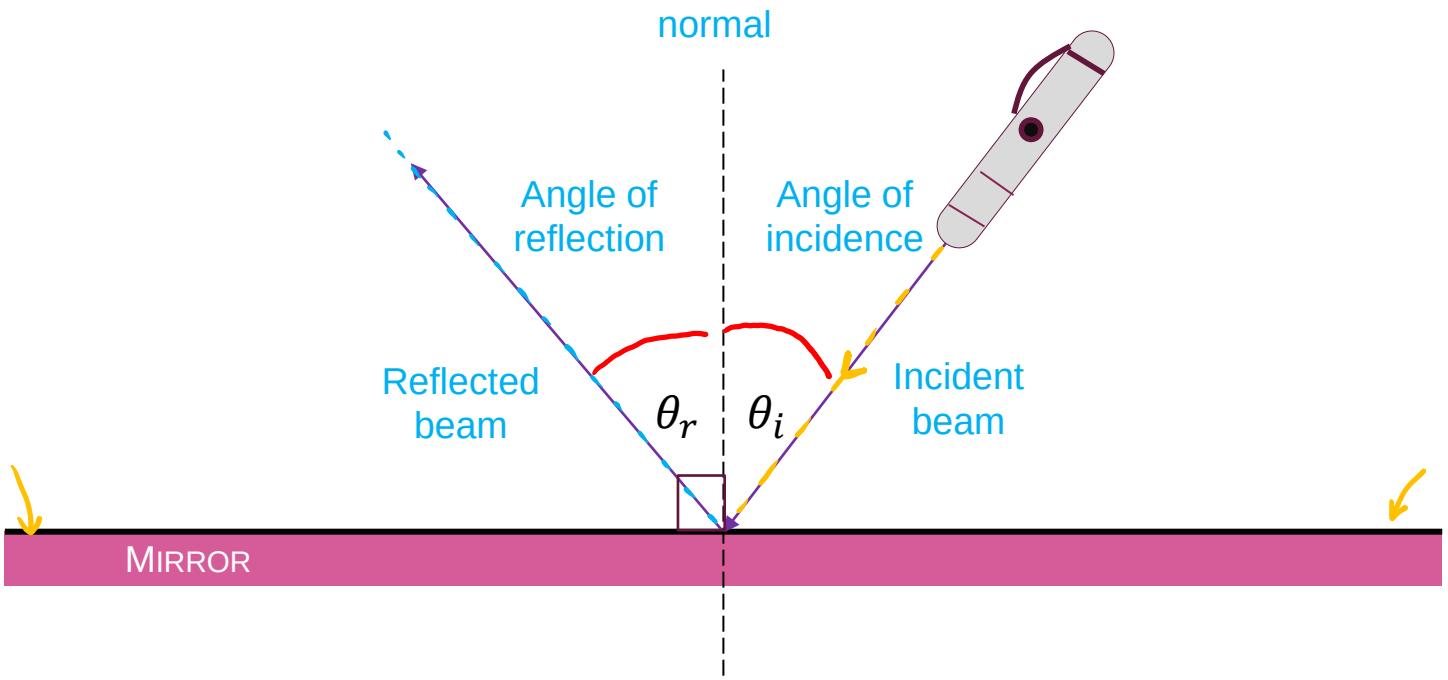
20 MC questions (2 marks each)
&
2 long – answer questions (10 points each)

Total: 60 points (2x the midterm) but 2x the time + 30 minutes

So… what if I add extra 5 – 10 True/False questions at the beginning.
They will be 1-2-minute questions, 1 mark each so the exam is out of a larger number of points?

Reflection of Light

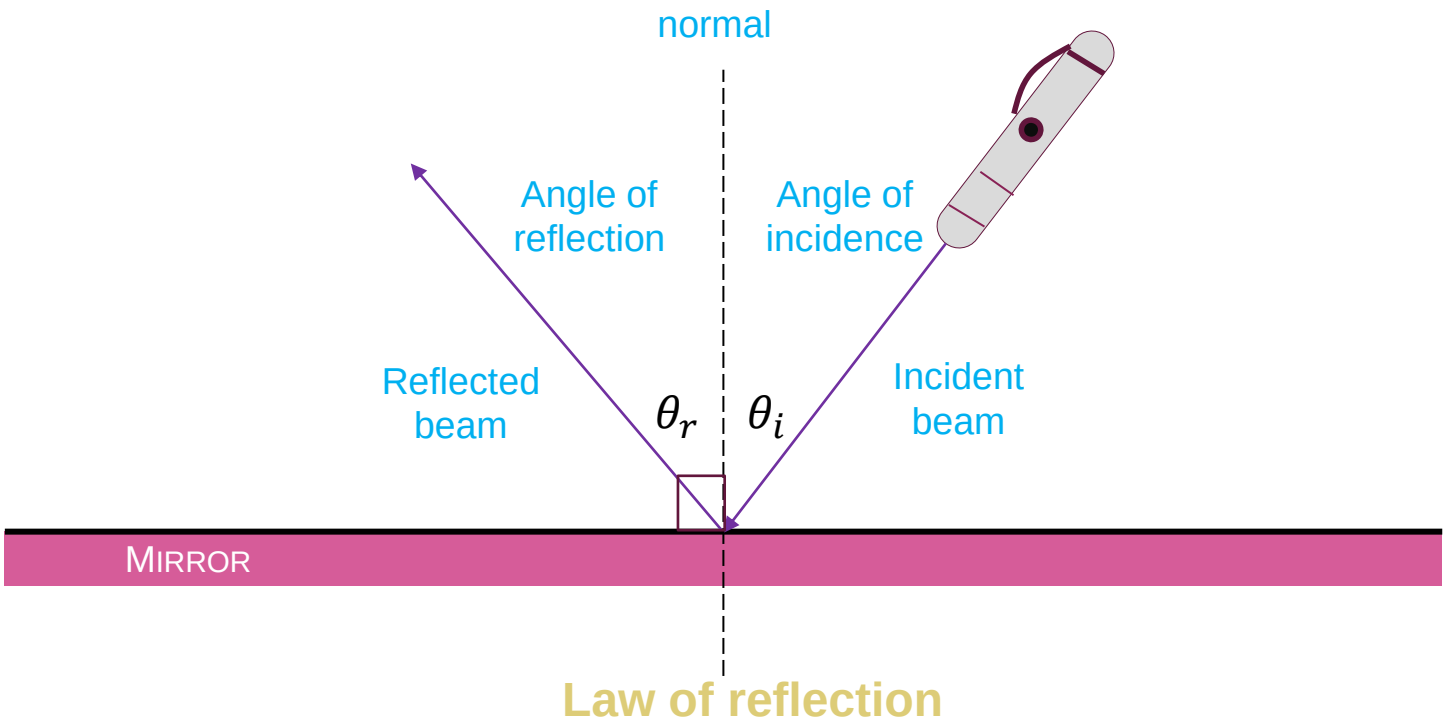
Light propagates along straight lines, which we represent as *rays*.



The angle of incidence and the angle of reflection are always the angles that light beams form with the normal line.

$$\theta_r = \theta_i$$

REFLECTION OF LIGHT

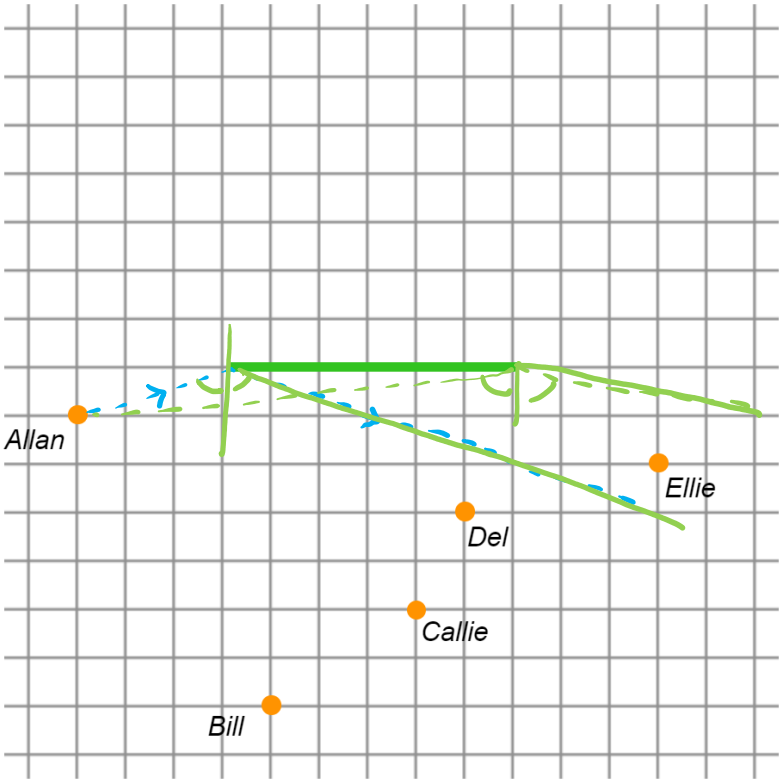


Law of reflection

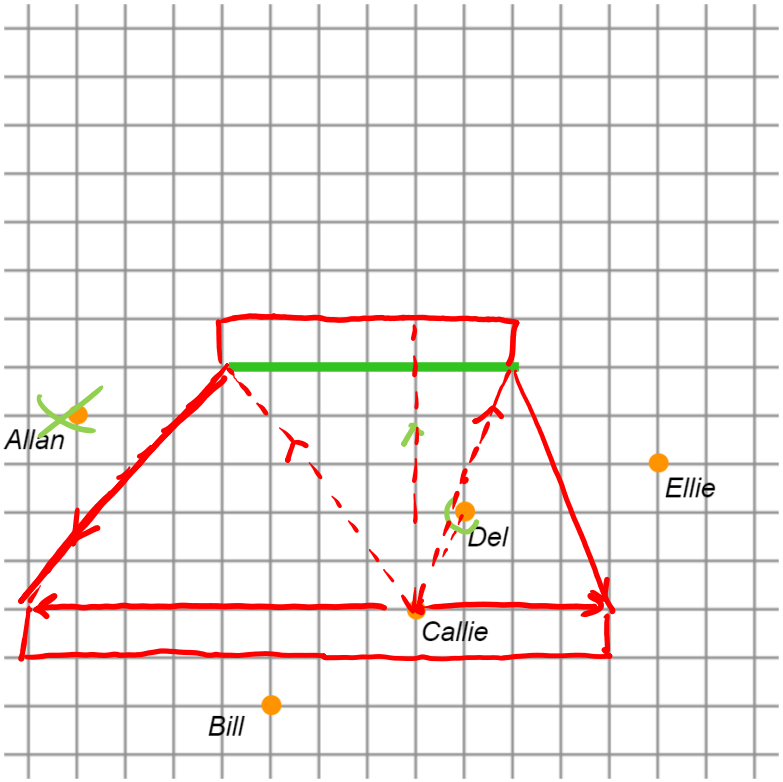
When a narrow beam of light, represented by one ray, shines on a smooth surface such as mirror, the angle between the incident ray and the normal line perpendicular to the surface equals to the angle between the reflected ray and the normal line (**the angle of reflection equals the angle of incidence**).
The incident beam, reflected beam, and the normal line are always in the same plane.

$$\theta_r = \theta_i$$

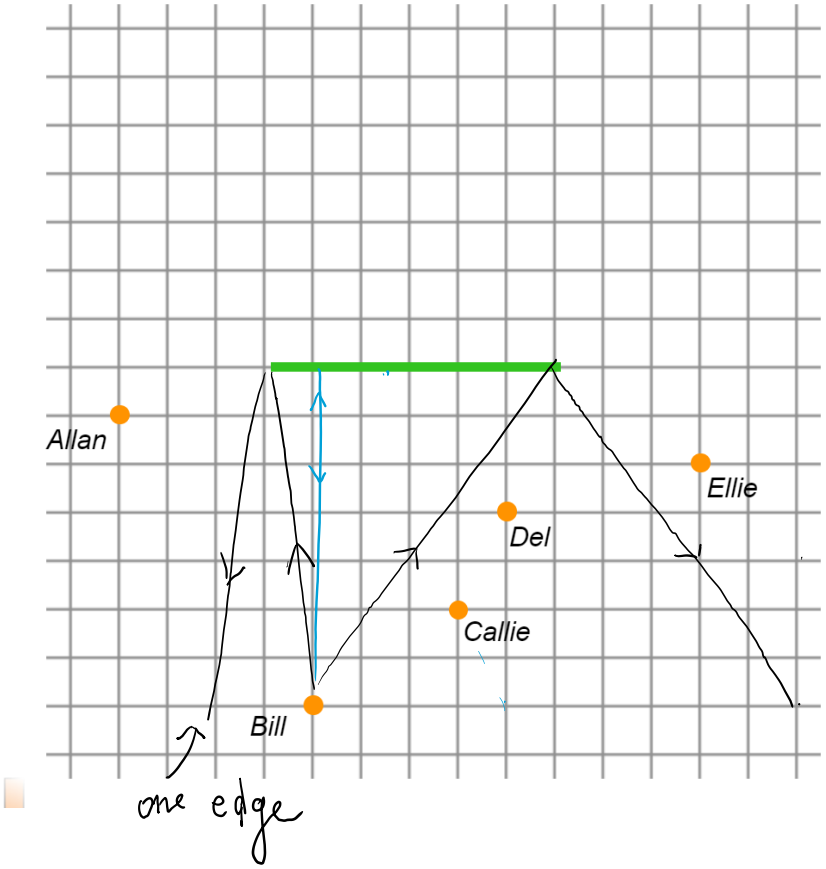
Who can Allan see?



Who can Callie see?

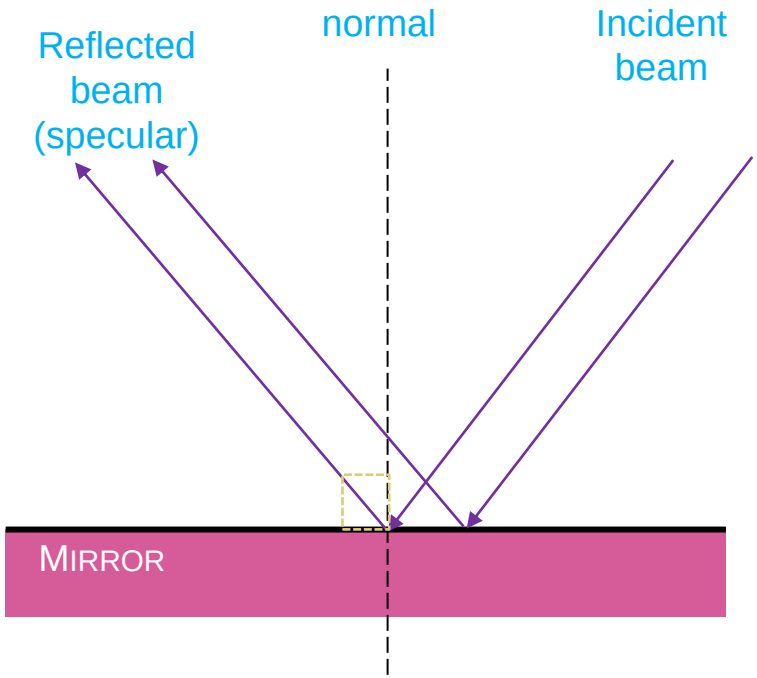


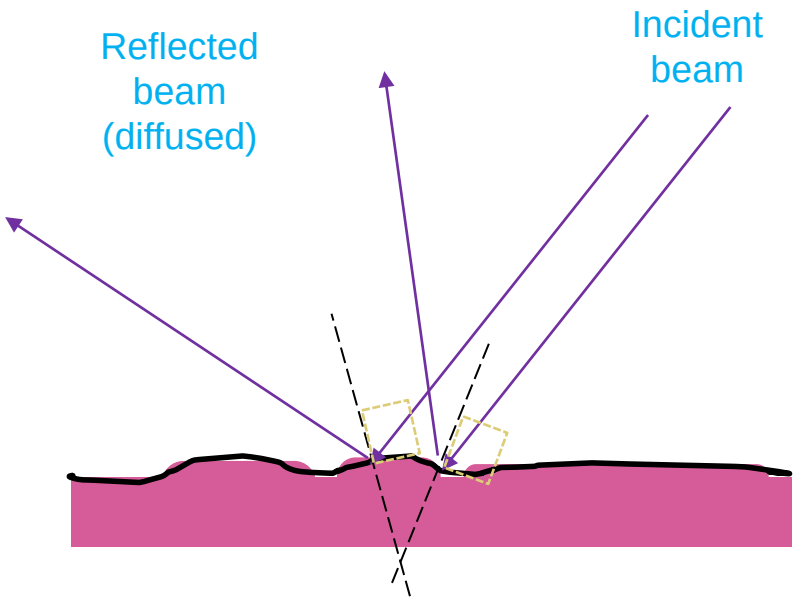
Who can Bill see?



Specular and Diffuse Light Reflection

Light propagates along straight lines, which we represent as *rays*.





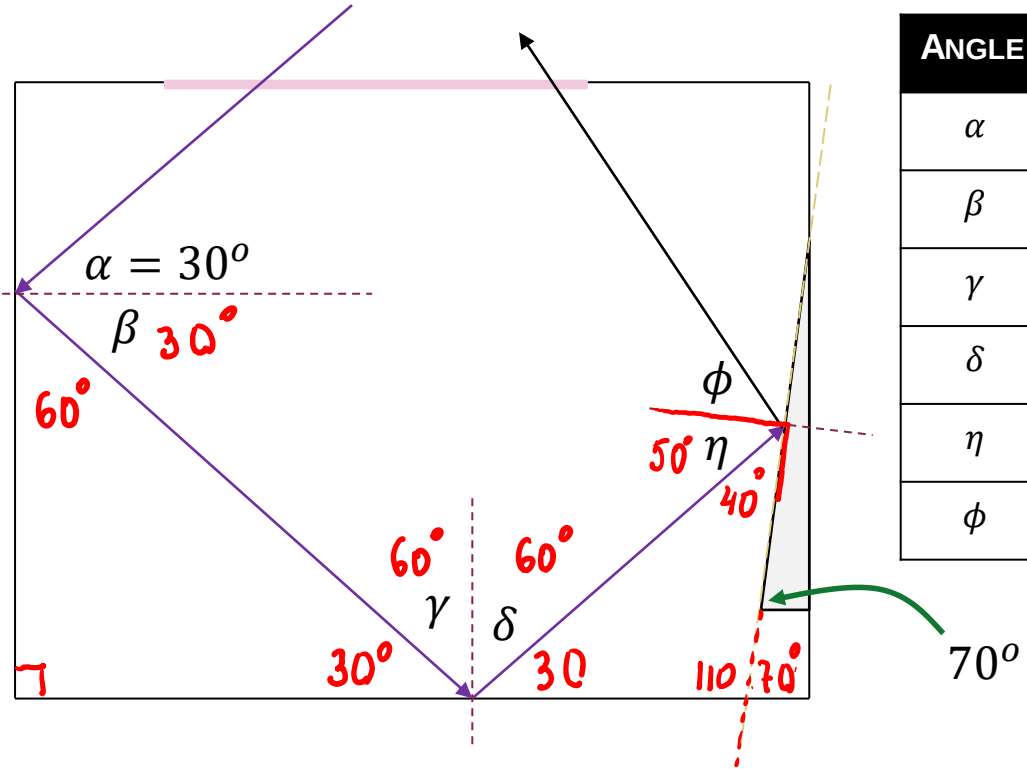
The angle of incidence and the angle of reflection are always the angles that light beams form with the normal line.

$$\theta_r = \theta_i$$

EXAMPLE 22A

A ray of light enters a very-mirrored-bathroom (probably designed in 80s) through a skylight, bounces of the wall, of a very reflective floor, and of a tilted mirror attached to the other wall.

Identify all angles of incidence/reflection.

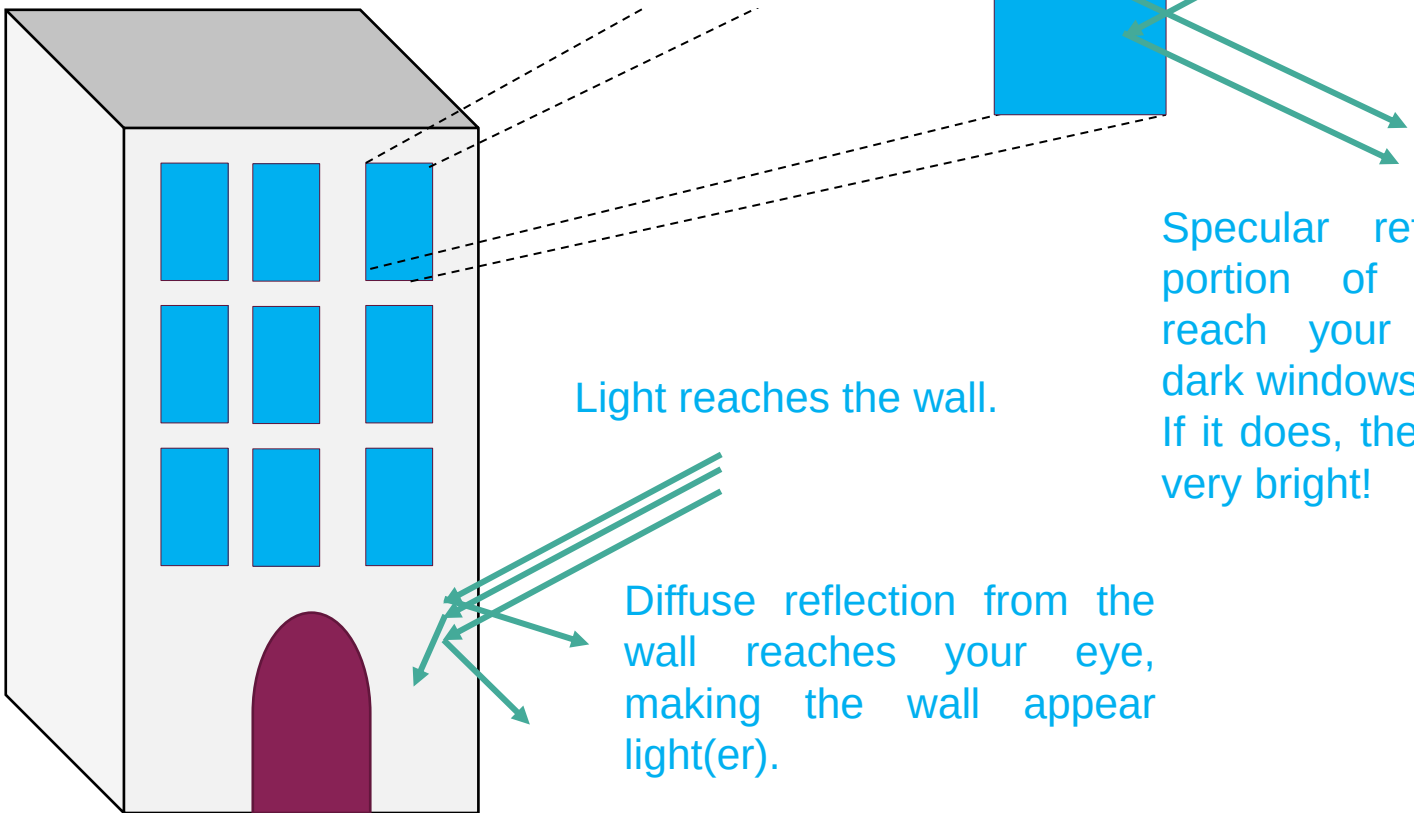


ANGLE	FORMULA	VALUE [^{o}]
α		30°
β	$\beta =$ α	30°
γ	$\gamma =$ 90 - β	60°
δ	$\delta =$ γ	60°
η	$\eta =$	50°
ϕ	$\phi =$ η	50

EXAMPLE 22B

On a sunny day a house's uncovered window looks very dark, but its outside walls do not.

How can we explain the difference?



As the window is transparent, a lot of light is actually **transferred** into the room.

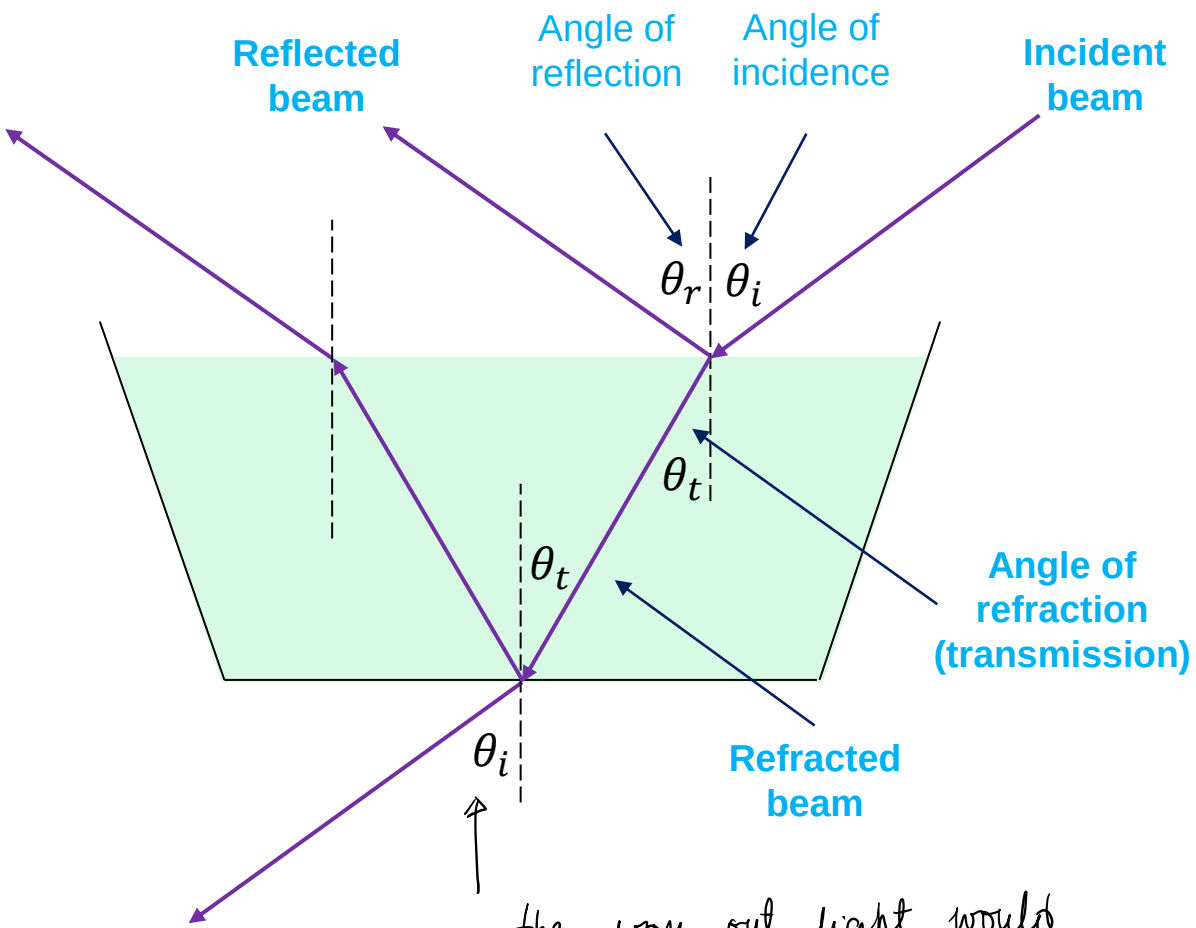
Light reaches the window.

Specular reflection of a portion of light doesn't reach your eyes (hence dark windows).
If it does, the windows look very bright!

Light reaches the wall.

Diffuse reflection from the wall reaches your eye, making the wall appear light(er).

22.3 Refraction of Light



on the way out light would make the same angle as on the entry (check Snell's law)

EXAMPLE 22C

Activity: https://ophysics.com/l7.html

Exercise 1:

1. Set the **angle of incidence** to 60 degrees.
2. Set $n1$ (**index of refraction** of the first medium) to **1**.
3. Change $n2$ (**index of refraction** of the second medium) between 1 and 3.

What observation can you make about the **angle of refraction**?.

(What is the smallest value it takes? What is the largest? At what rate does it change?)

4. Record the angle of refraction for three different values of $n2$

EXAMPLE 22C

Activity: https://ophysics.com/l7.html

Exercise 2:

1. Set the **angle of incidence** to 60 degrees.
2. Set $n1$ (**index of refraction** of the first medium) to $\mathbf{1.5}$.
3. Change $n2$ (**index of refraction** of the second medium) between 1 and 3.

What observation can you make about the **angle of refraction**?.

(What is the smallest value it takes? What is the largest? At what rate does it change? Does anything new, unobserved before happen?)

4. Record the angle of refraction for three different values of $n2$

SNELL'S LAW

From the observations similar to those we have just done, Snell formulated the mathematical model for refraction phenomena:

$$n_{1\ to\ 2} = \frac{\sin\theta_1}{\sin\theta_2}$$

$n_{1\ to\ 2}$ is the number that depends on the two materials the light is traveling through.
If we split $n_{1\ to\ 2}$ into a ratio of two numbers that depends on the material through which the incident ray travels (n_1) and the other that depends on the material through which the refracted ray travels (n_2), we get

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

Snell's Law relates the refraction angle θ_2 to the incident angle θ_1 and the indexes of refraction of the incident medium n_1 and the refracted medium n_2:

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

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

Learning Catalytics:

A beam of light is shining on the interface between a medium with refractive index $n_1 = 2$ and a medium with refractive index $n_2 = 3$. What is the angle of refraction in the second medium?

Provide your answer in degrees, with a precision of one place after the decimal. Do not include units.

$2 \sin 60^\circ = 3 \sin\theta_2$

$\frac{2}{3} \sin 60^\circ = \sin\theta_2$

$\theta_2 = \sin^{-1}\left(\frac{2}{3} \sin 60^\circ\right)$

$= 35.3^\circ$

Solution by a very brave student