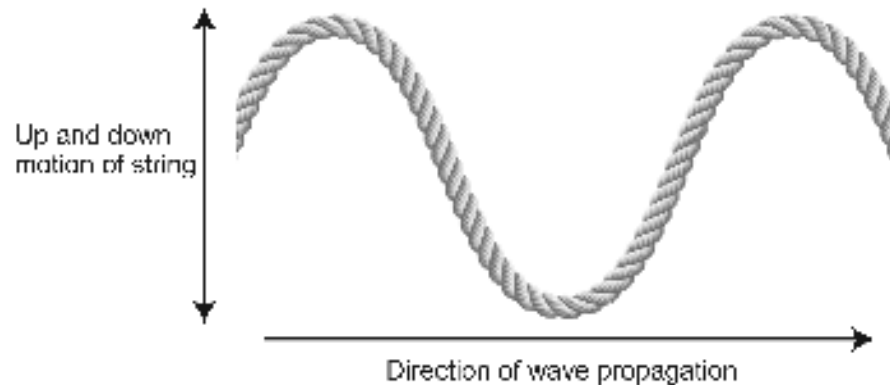


Electromagnetic radiations

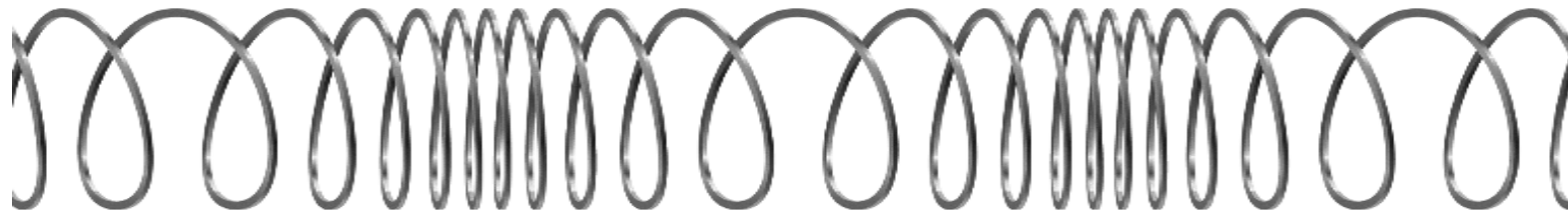
DR.AYESHA BHATTI

BSPT, PP.DPT

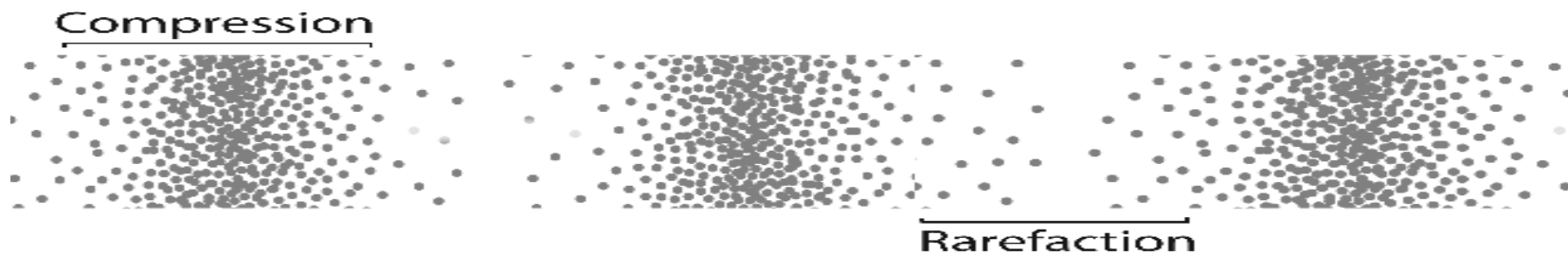
What are the two types of waves?



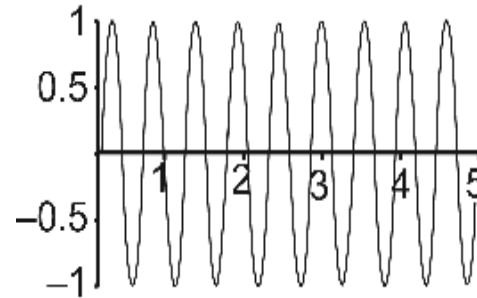
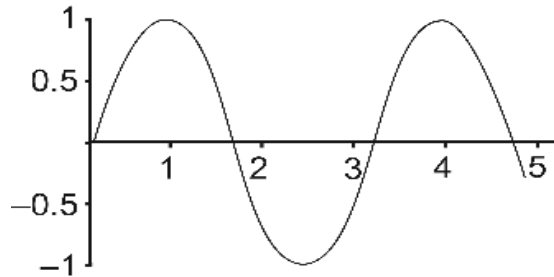
- In transverse waves, the disturbance of the medium is perpendicular to the direction of wave travel.
- Water waves and electromagnetic waves are transverse waves. *(contd.)*



- In longitudinal waves, the elements of the medium move back and forth in the same direction as the wave motion.
- Sound waves and waves in toy springs are examples of longitudinal waves.
- In longitudinal waves, the medium is compressed in some places and stretched in others.

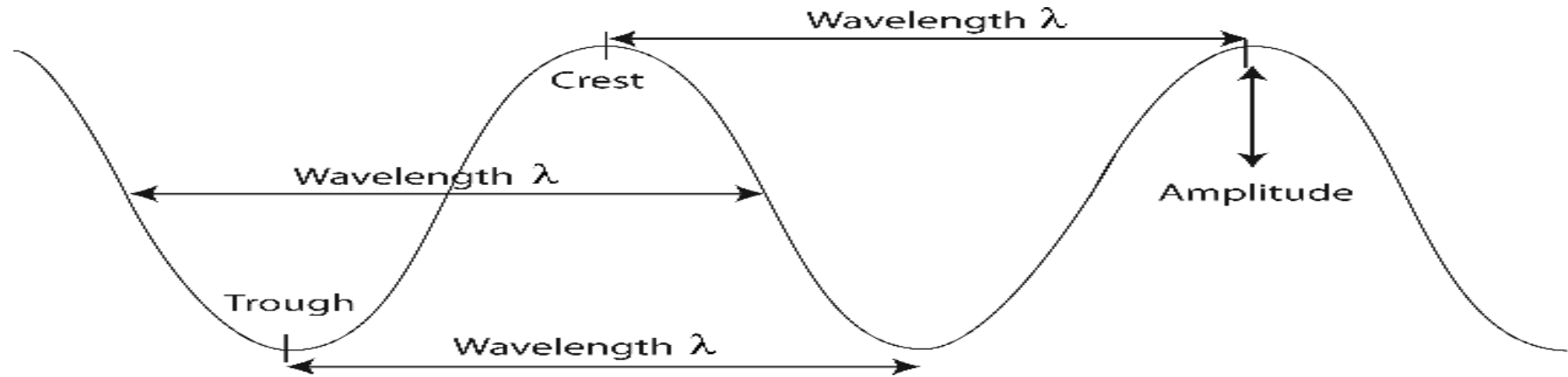


What are some wave characteristics?



- The frequency of a wave is the number of vibrations produced each second by a source.
 - The unit of frequency is the hertz.
- 1 Hz = 1 vibration per second.
- A low-frequency wave (left) has few vibrations per second.
 - A high-frequency wave (right) has many vibrations per second.

(contd.)



- The **wavelength** of a wave is the distance between a point on one wave and the same point on the next wave.
- Wavelength can be measured from crest to crest, from trough to trough, or between any two corresponding points on successive waves.
- The **amplitude** is half the vertical distance from trough to crest.
- **Wave speed** is the speed at which the disturbance in the medium travels.

Relationship between wavelength, frequency, and wave speed

- In linear media, any wave pattern can be described in terms of the independent propagation of sinusoidal components.
- The wavelength λ of a sinusoidal waveform traveling at constant speed v is given by where v is called the phase speed (magnitude of the phase velocity) of the wave and f is the wave's frequency. In a *dispersive* medium, the frequency depends upon the wavelength of the wave, and accordingly waves with different λ in general will travel with a different speed v .
- The basic formula for wave speed is:
 - wave speed = frequency \times wavelength

Relationship between wavelength, frequency, and wave speed?

Assuming a sinusoidal wave moving at a fixed wave speed, wavelength is inversely proportional to [frequency](#): waves with higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths.

- wavelength = wave speed / frequency

$$\lambda = v/f$$

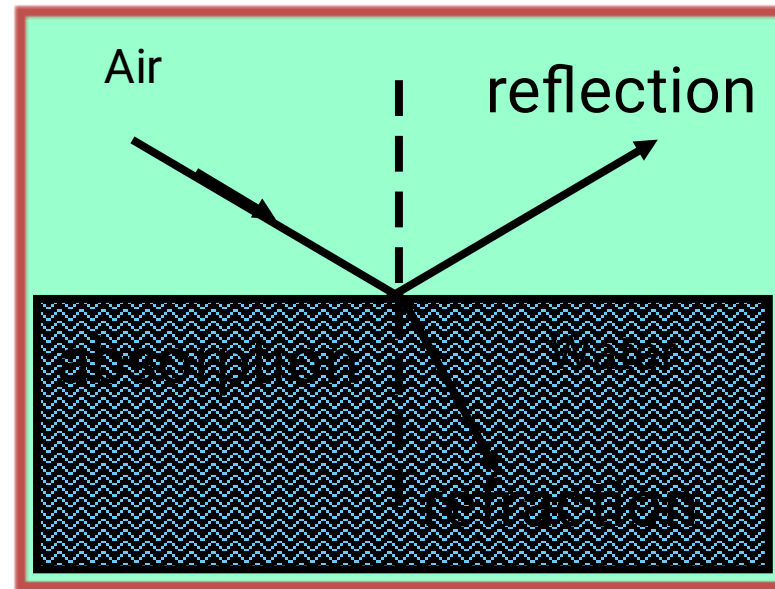
- frequency = wave speed / wavelength

$$f = v/\lambda$$

REFLECTION, REFRACTION AND ABSORPTION

In the study of how light behaves, it is useful to use “**light rays**” and the fact that light travels in straight lines.

When light strikes the boundary between two media, three things may happen:
reflection, refraction, or absorption.



REFLECTION

- The behavior of waves traveling along a rope from a more dense medium to a less dense medium (and vice versa) is discussionable.....
- The wave doesn't just *stop* when it reaches the end of the medium.
- Rather, a wave will undergo certain behaviors when it encounters the end of the medium. Specifically, there will be some reflection off the boundary and some transmission into the new medium.
- Reflection involves a change in direction of waves when they bounce off a barrier.

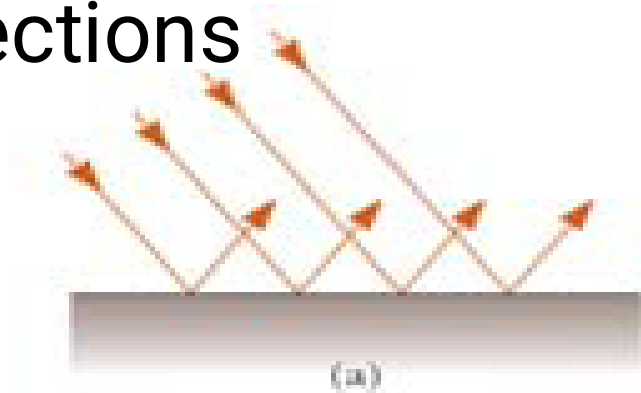
Reflection

- Two general types of reflection
 - – Specular reflection
 - – Diffuse reflection
- Reflection that occurs due to shiny flat surface. Most of geometric optics deals with specular reflection
- Reflection that occurs due to non-shiny irregular surface and most of the time ambient lighting is due to diffuse reflection.

Specular reflection

Flat surface

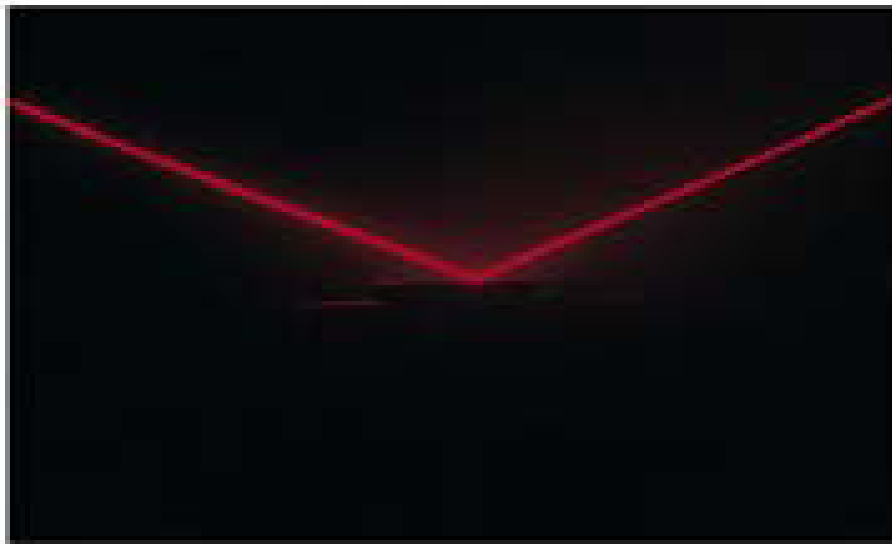
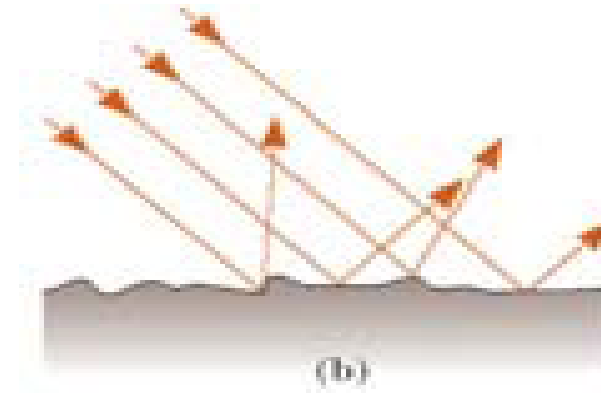
Reflected in one direction
directions



Diffuse reflection

Irregular surface

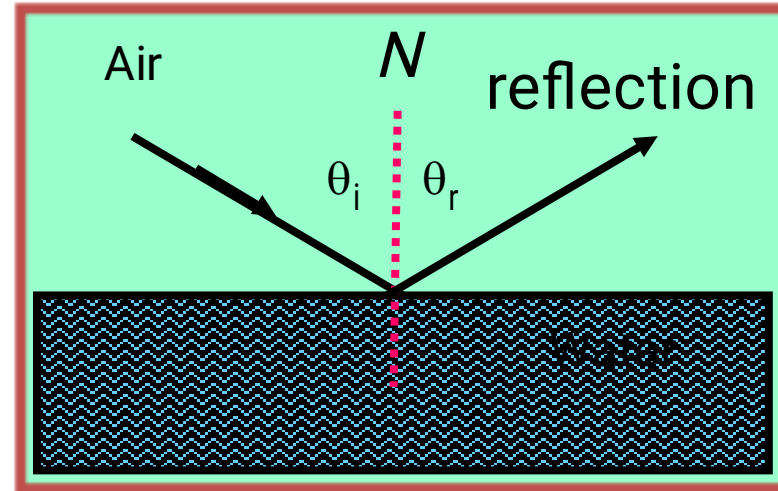
Reflected in all



The Laws of Reflection

1. The angle of incidence θ_i is equal to the angle of reflection θ_r .

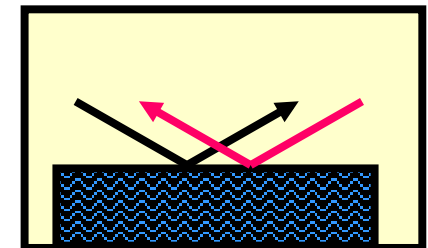
$$\theta_i = \theta_r$$



All ray angles are measured with respect to normal N .

2. The incident ray, the reflected ray, and the normal N all lie in the same plane.

3. The rays are completely reversible.

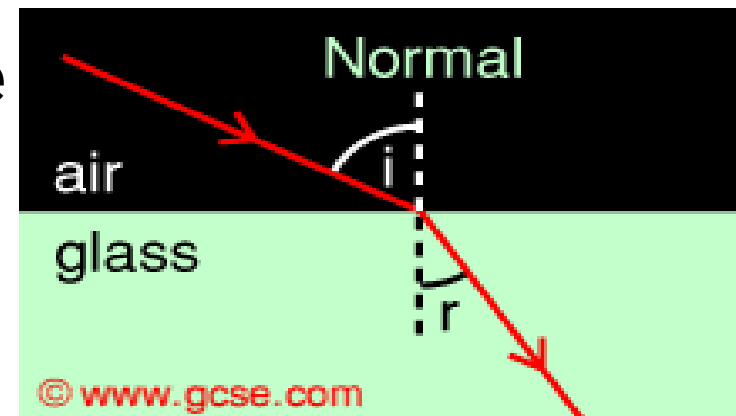


REFRACTION

- **Refraction** of waves involves a change in the direction of waves as they pass from one medium to another. Refraction, or the bending of the path of the waves, is accompanied by a change in speed and wavelength of the waves. It was mentioned that the speed of a wave is dependent upon the properties of the medium through which the waves travel.
- So if the medium (and its properties) is changed, the speed of the waves is changed.
- **Example 1:** The most significant property of water that would affect the speed of waves traveling **on its surface is the depth of the water**. Water waves travel fastest when the medium is the deepest.

REFRACTION

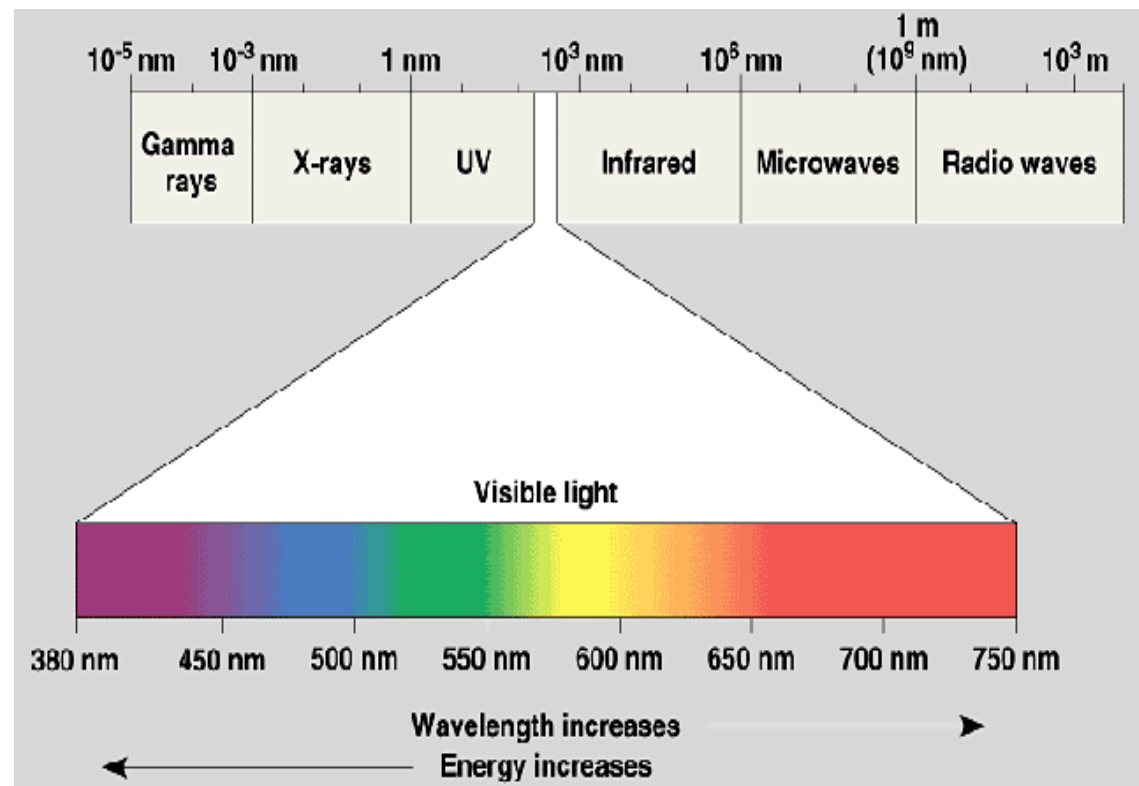
- Thus, if water waves are passing from deep water into shallow water, they will slow down. this decrease in speed will also be accompanied by a decrease in wavelength. So as water waves are transmitted from deep water into shallow water, the speed decreases, the wavelength decreases, and the direction changes as in such a manner that they seem to be traveling more perpendicular to the surface. If traveling from shallow water to deep water, **AND** the waves bend in the opposite direction.
- **Exapmle2:** Refraction happens when light changes speeds and/or is bent (traveling from air to water/ low dense to high dense medium), rays bend toward from normal and vice versa.

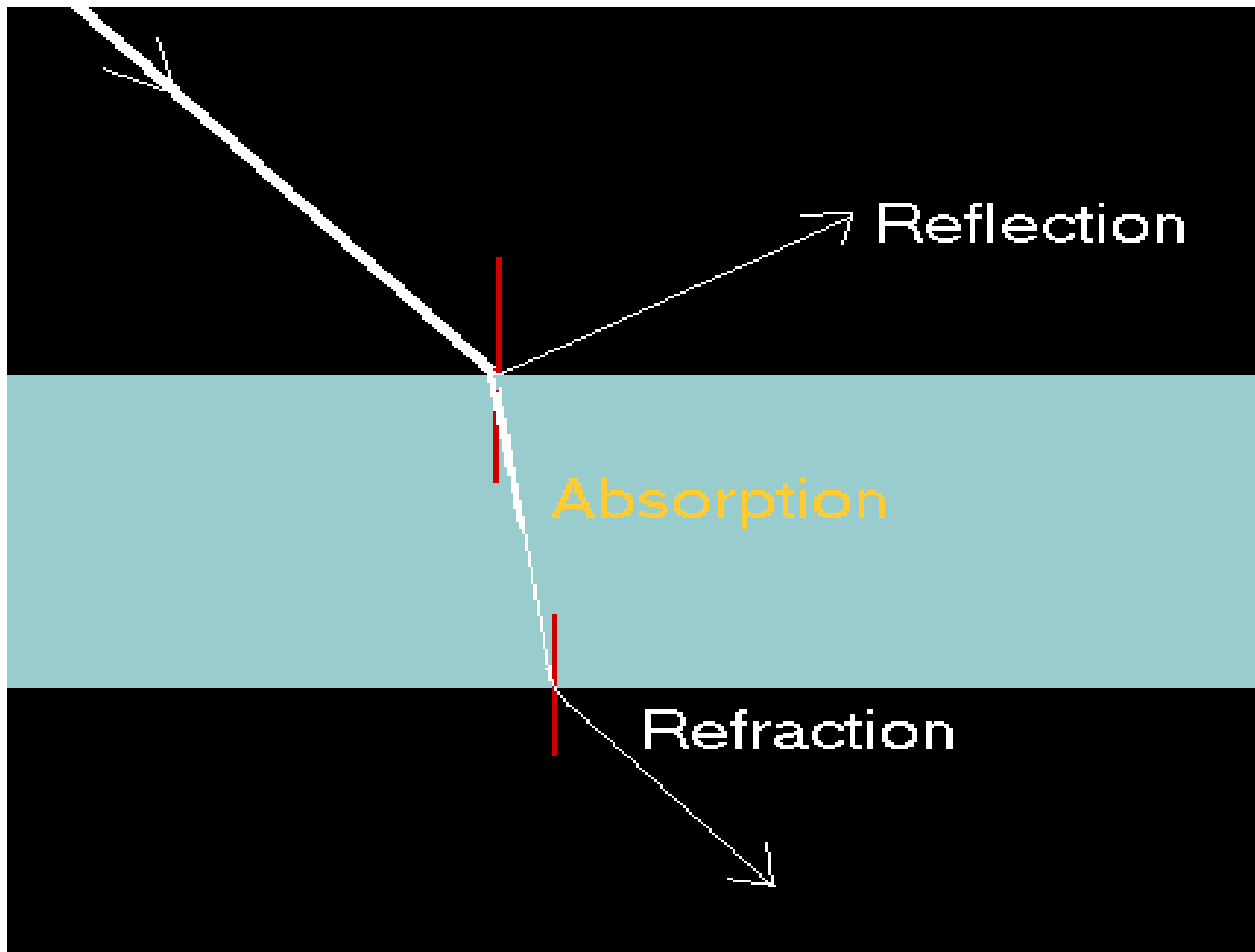


Absorption

- Absorption of light happens when atoms in an object absorb (take in and hold) the light waves.

For example: You are able to see a red apple because all of the other light waves are absorbed but red is reflected to your eyes.

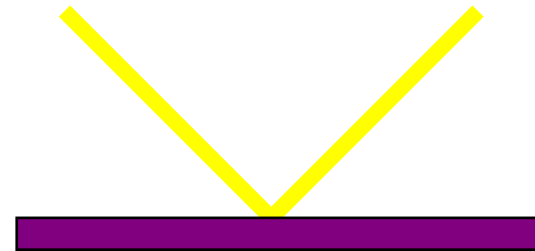




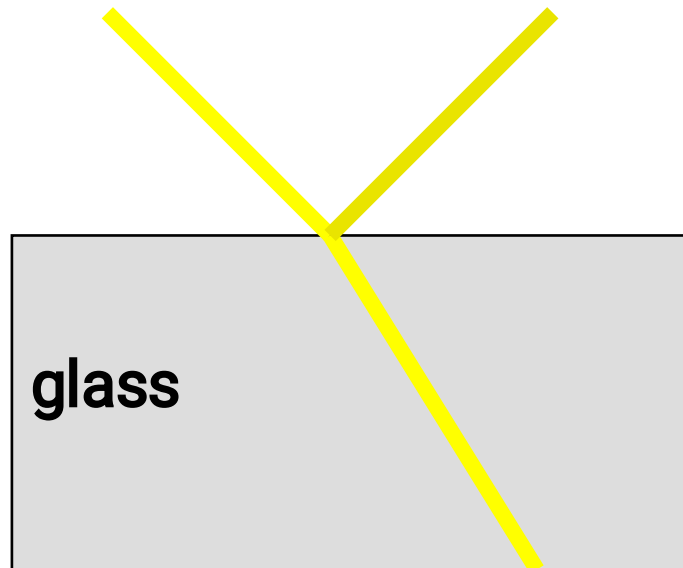
Total Internal Reflection

Reflection and refraction

- **Mirror reflects light**

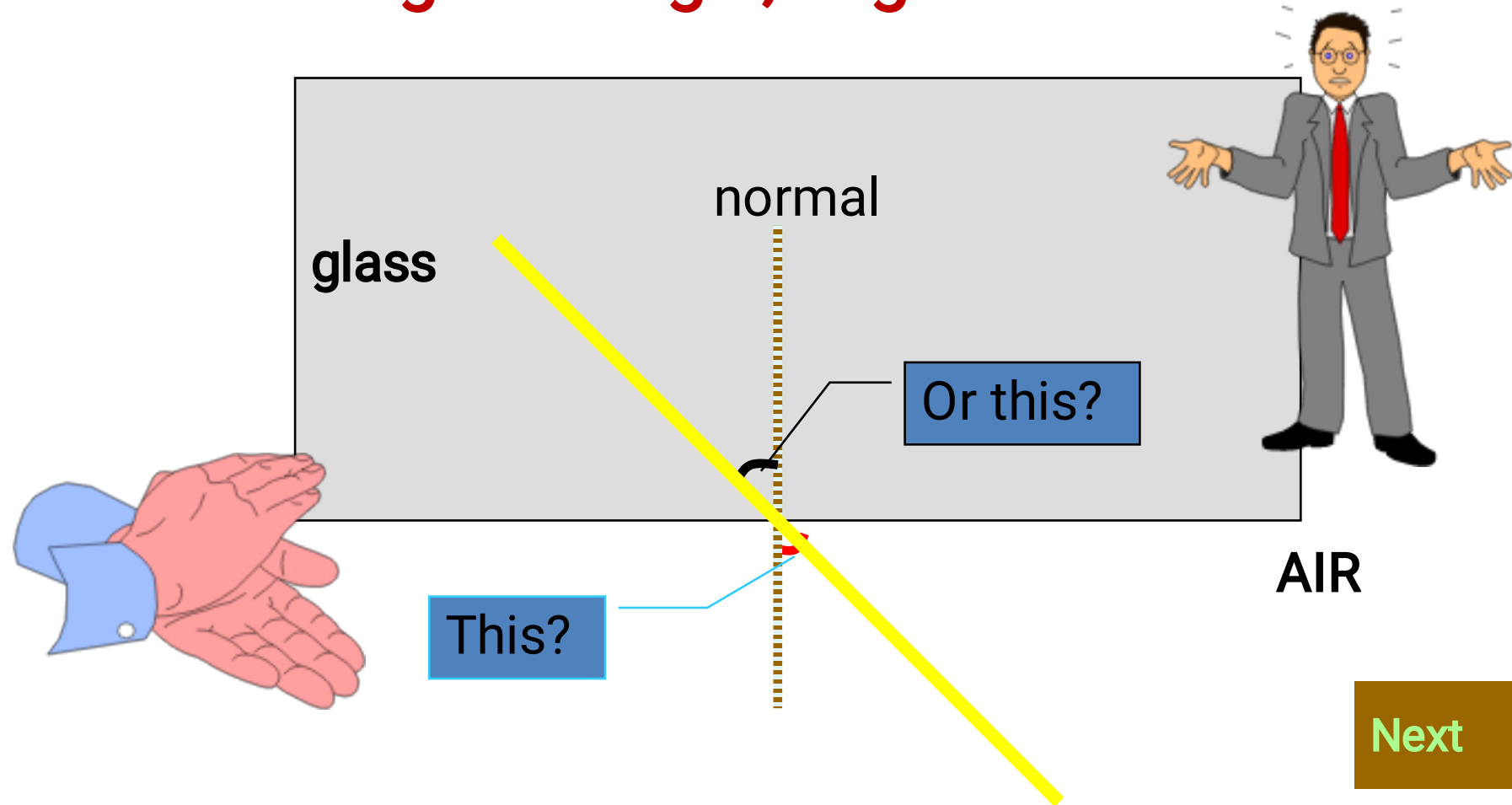


Transparent medium refracts light

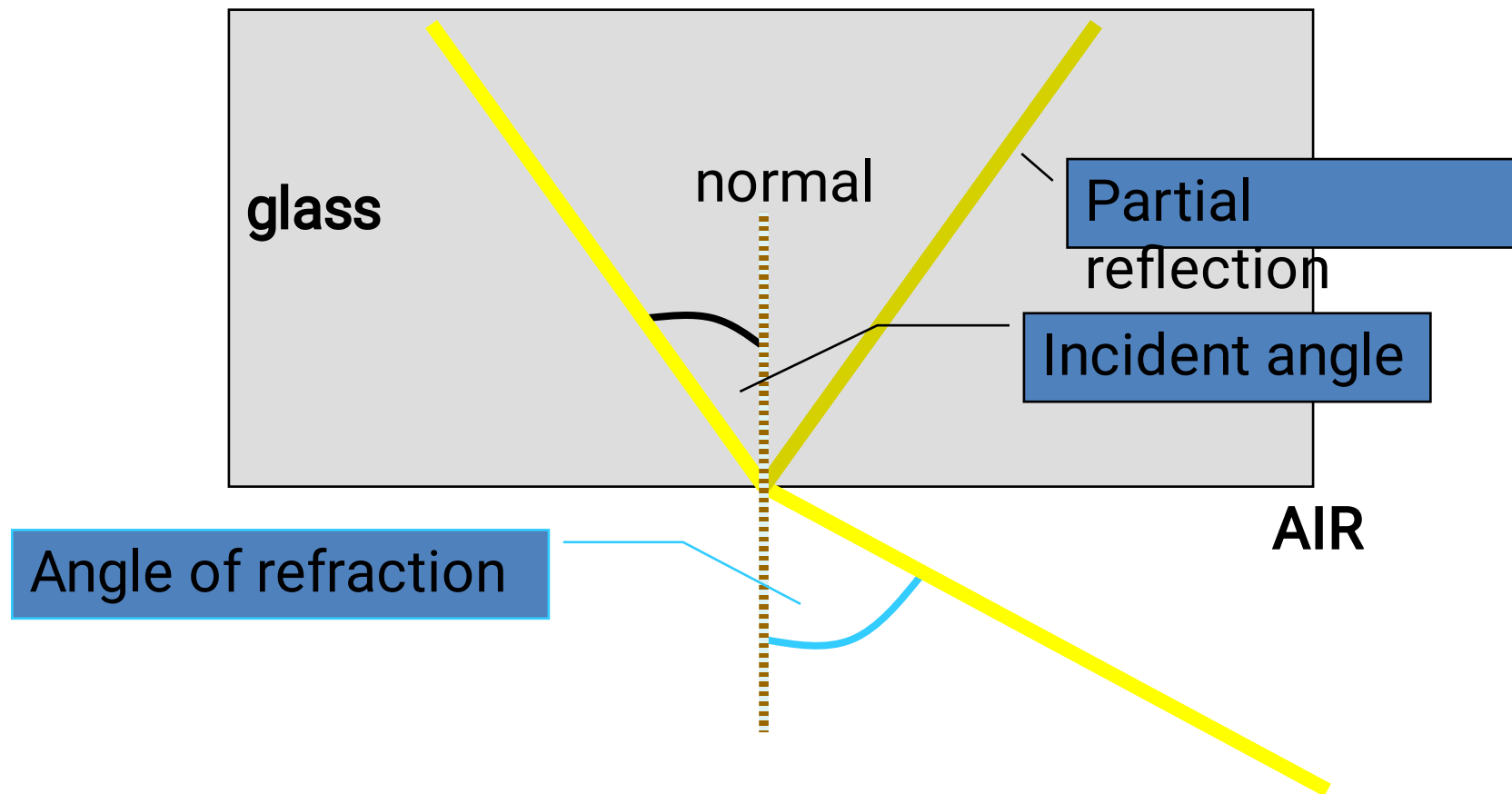


Which angle is larger?

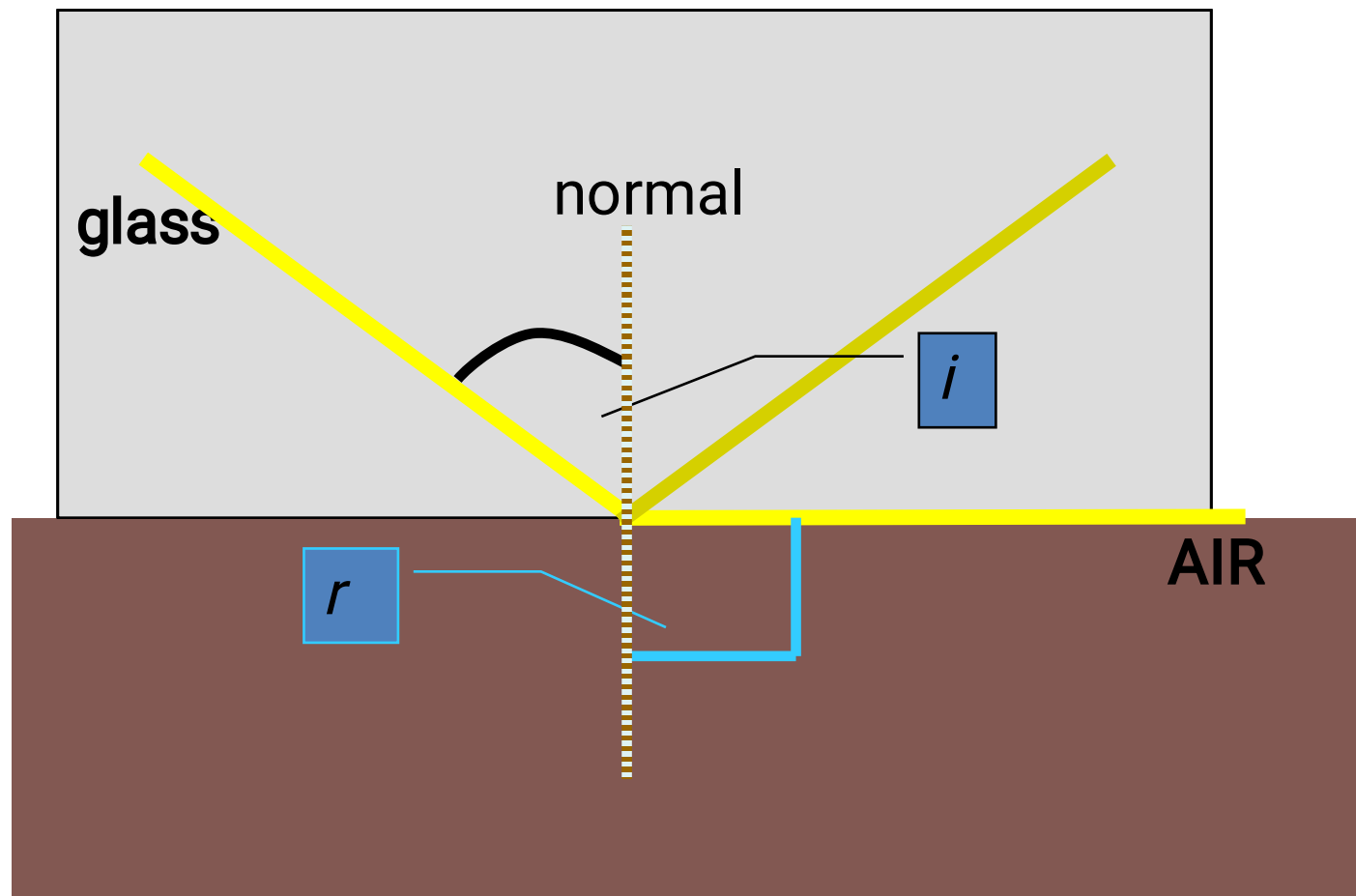
- A light ray is emerging from glass to air. Which angle is larger, in glass or in the air ?



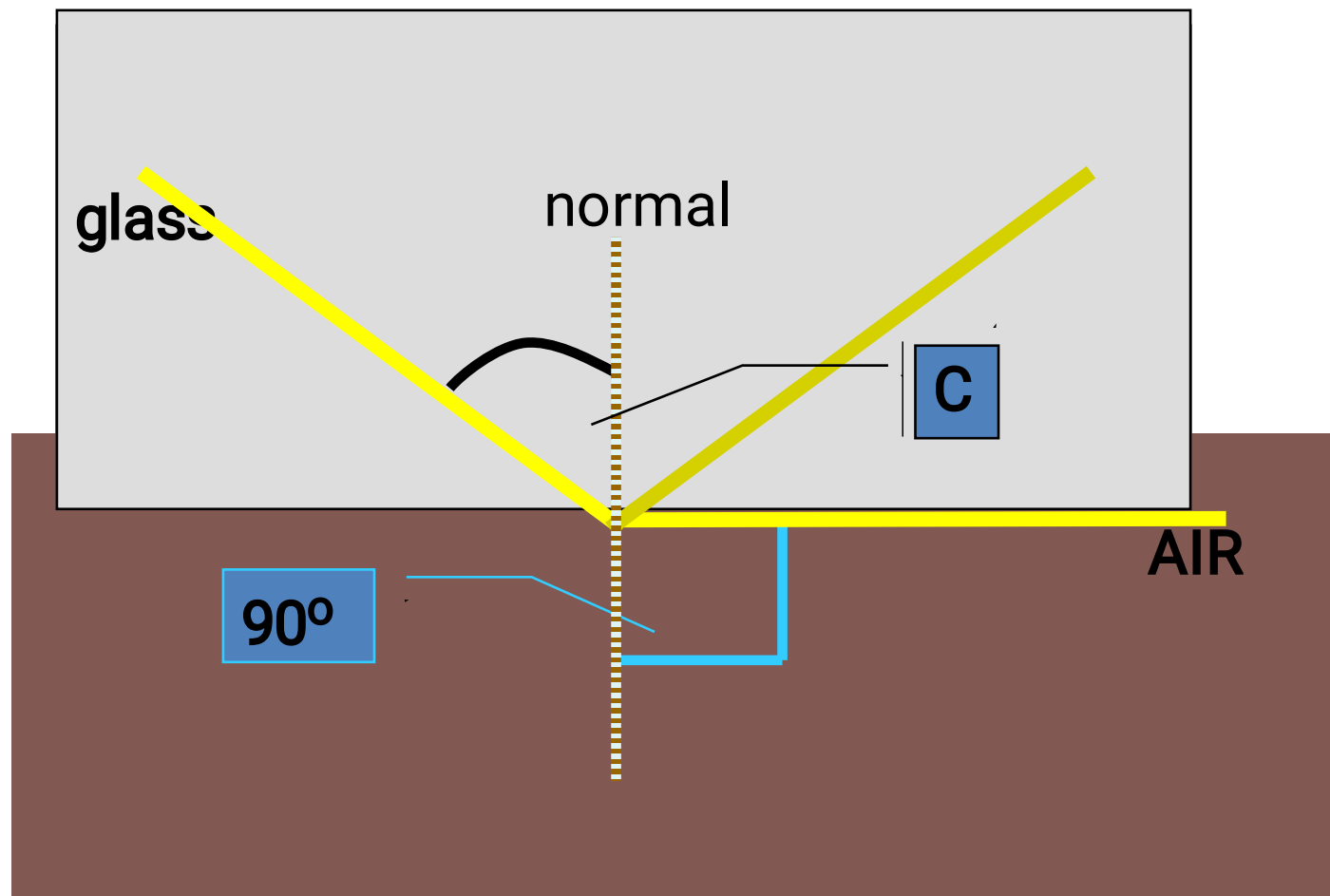
- For glass-air interface, the angle of refraction in air $>$ incident angle



- When we increase the angle of incidence (i), the angle of refraction (r) increases until



- when the angle of refraction is 90° , the incident angle is called the **critical angle (C)**.

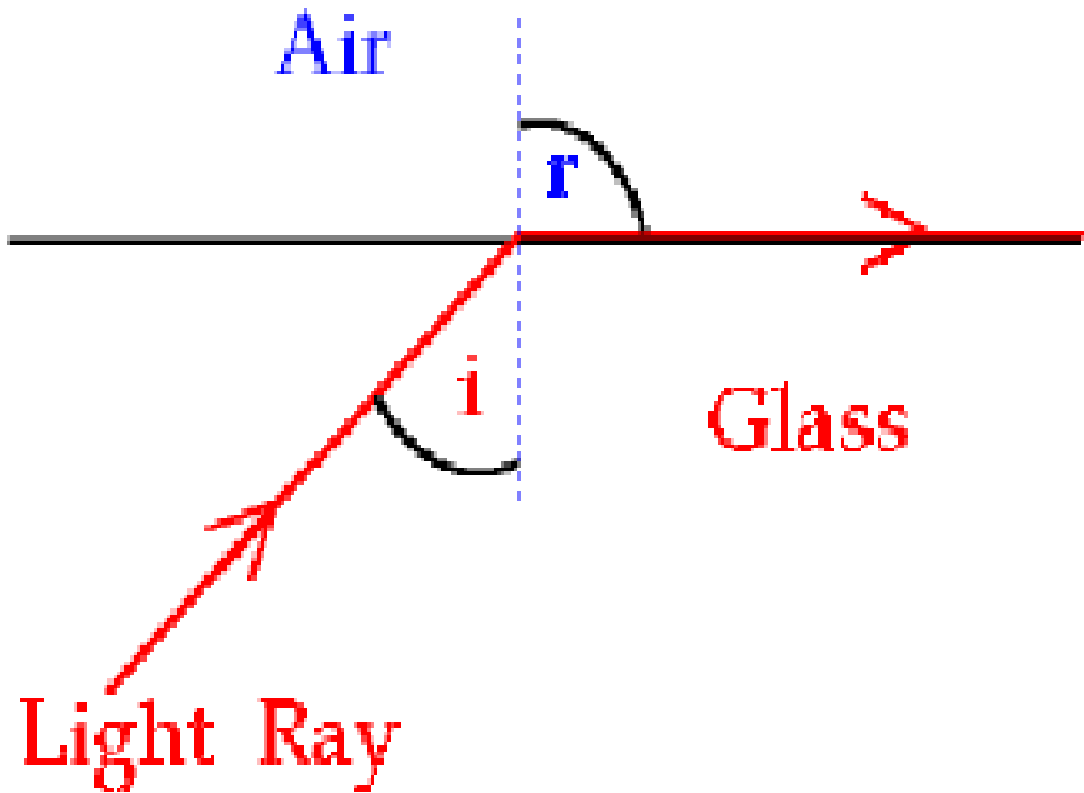


Critical Angle

- Recall light bends away from the normal when it speeds up between two materials (acrylic to air)
- angle of refraction always larger than angle of incidence
- As $\angle i$ increases, so does $\angle R$
- **Critical angle** is the angle of incidence that produces refracted angle of 90 degrees
- Critical angle is a physical property

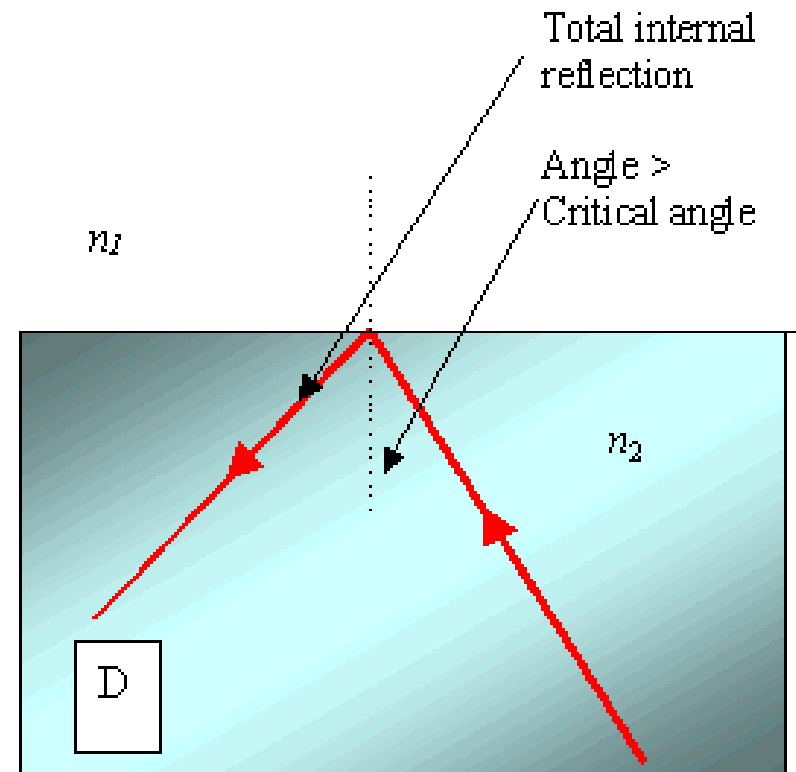
Critical Angle

Critical Angle



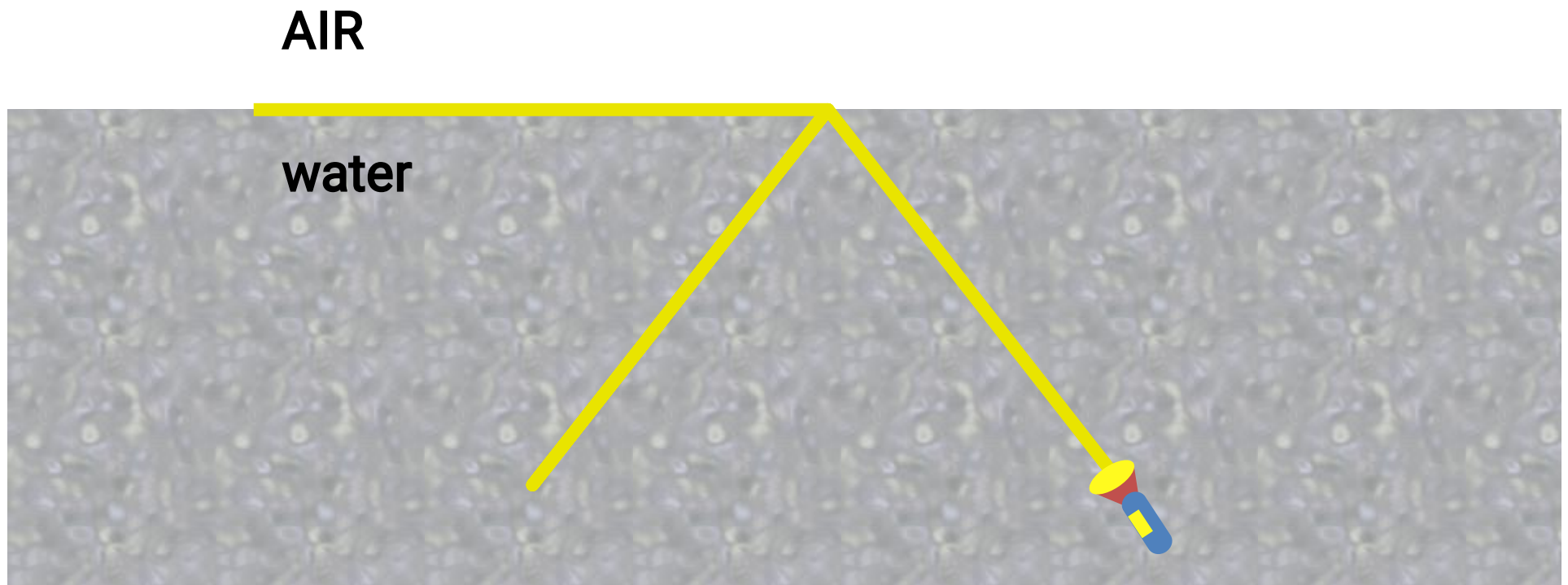
Total Internal Reflection

- Increasing $\angle i$ past critical angle, refracted ray no longer exits the medium
- Will reflect back instead
- So, refracted ray disappears; only a reflected ray is visible
- Called **Total Internal Reflection (T.I.R.)**



Total internal reflection (1)

- When the light ray (from water) is emerging at the critical angle, the refracted ray w *along* the interface.

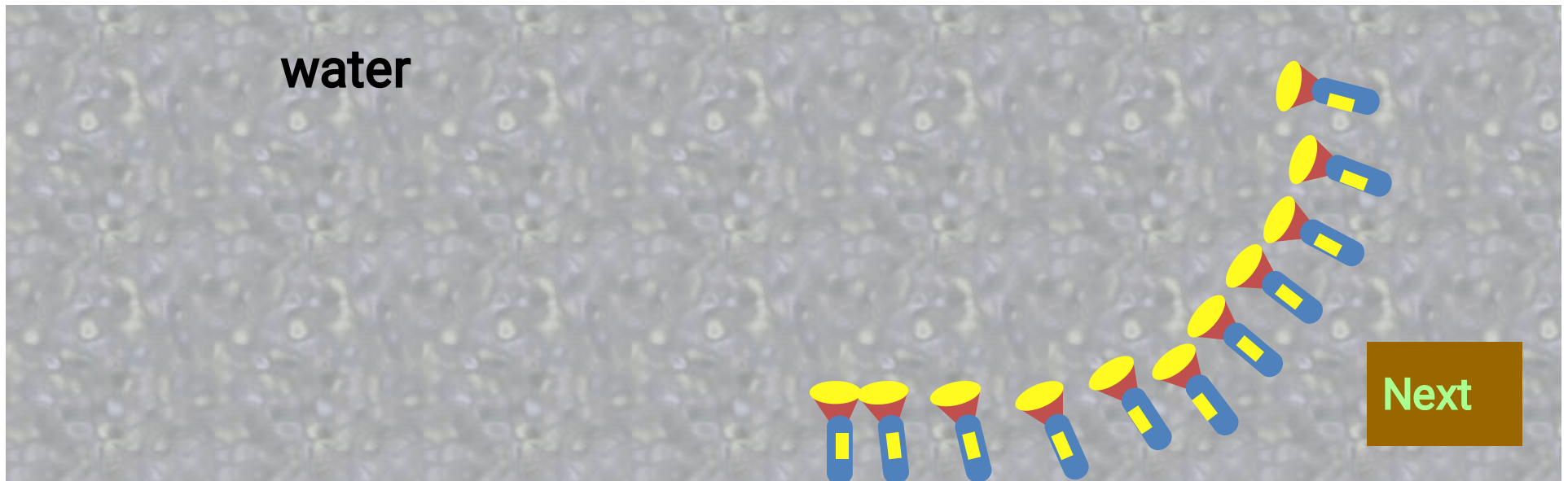


Total internal reflection (2)

- When the incident angle is larger than the critical angle, total internal reflection will occur (at the interface).

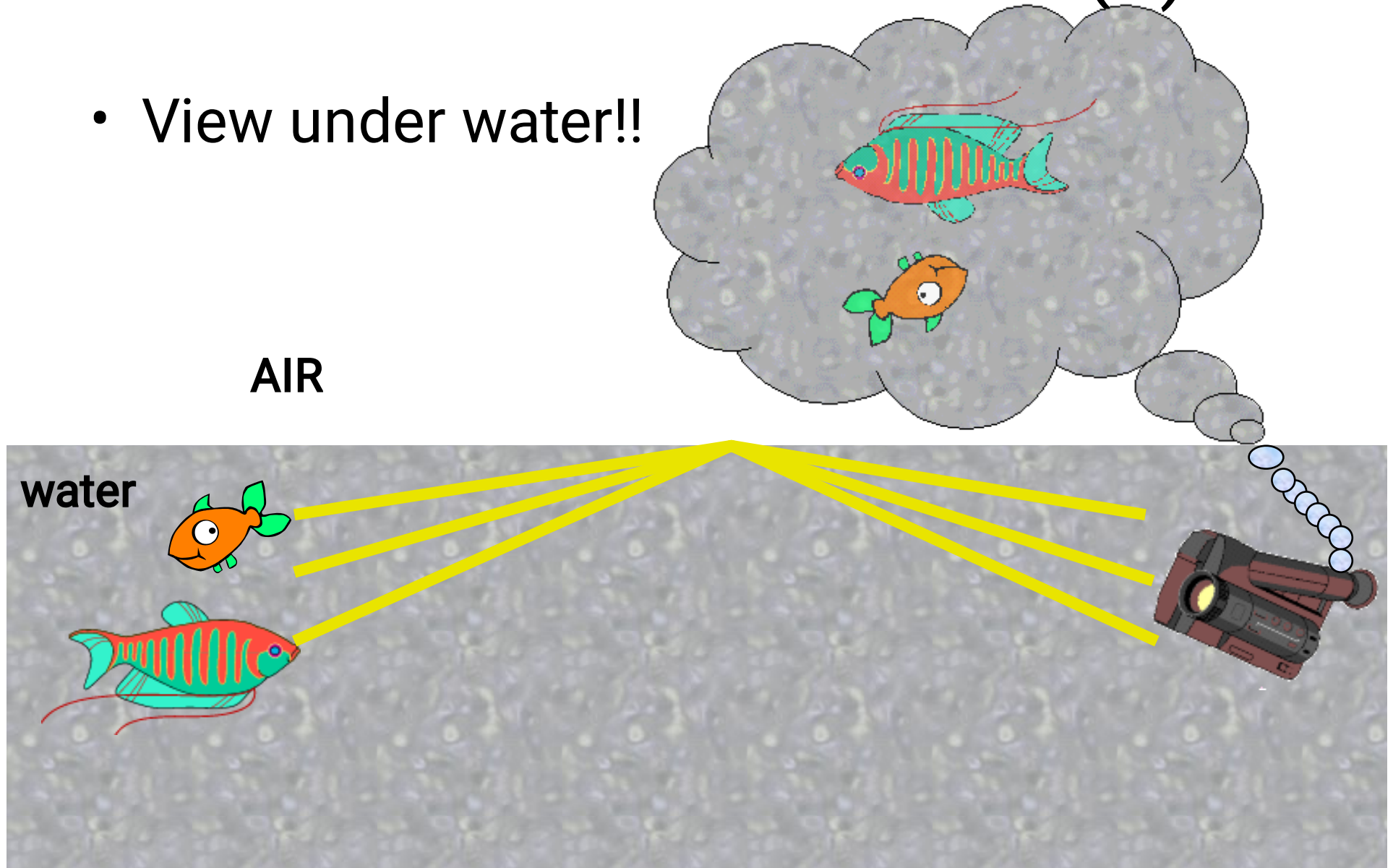
AIR

water



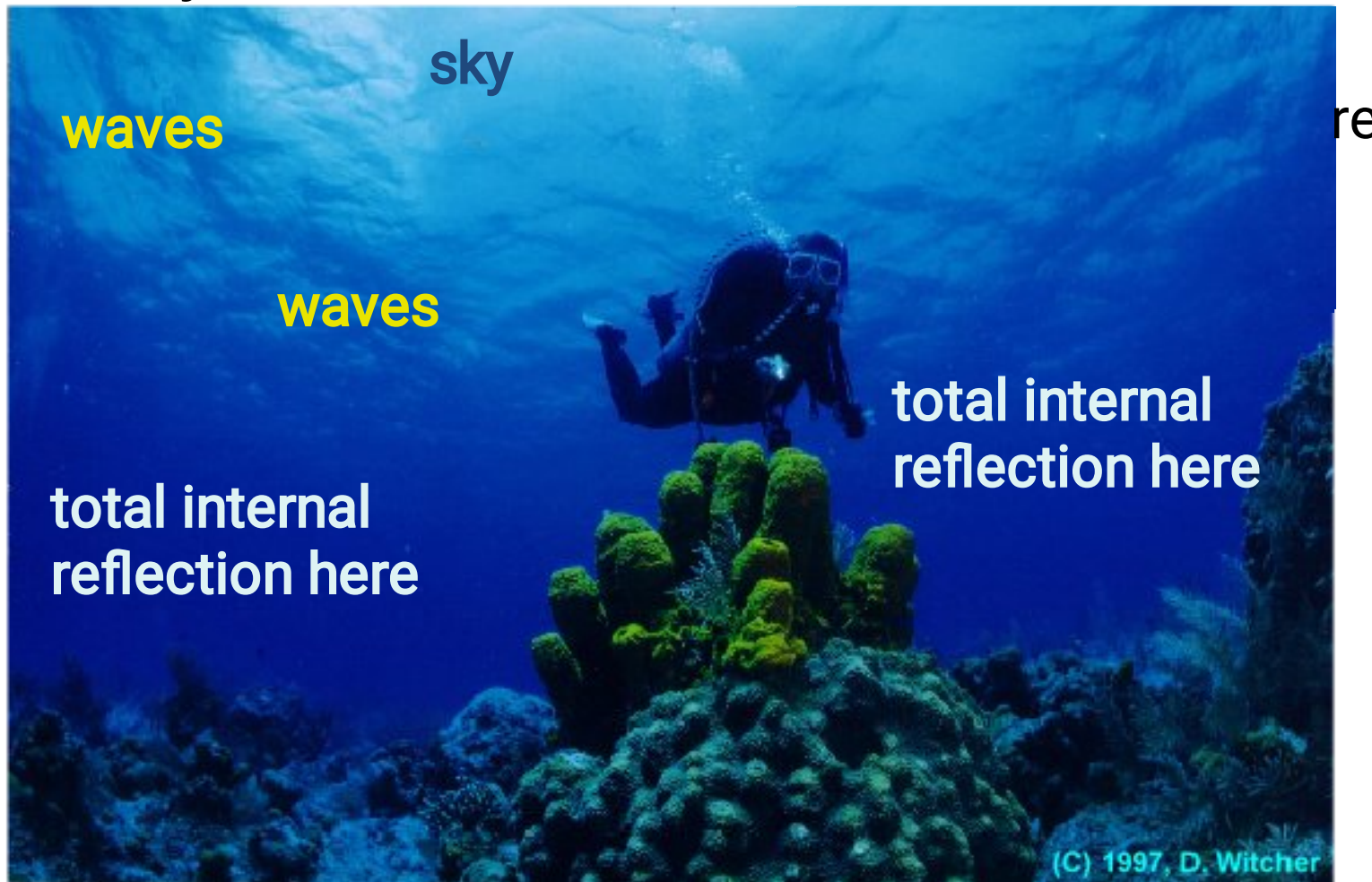
Total internal reflection (3)

- View under water!!



Total internal reflection (4)

- Fish-eye view



The Inverse Square Law

$$\frac{I_1}{(I_2)} = \frac{(d_2)^2}{(d_1)^2}$$

I_1 is the initial intensity of radiation, d_1 is the initial distance, and d_2 is the final distance, and I_2 is the final intensity.

What is the inverse Square Law Formula?

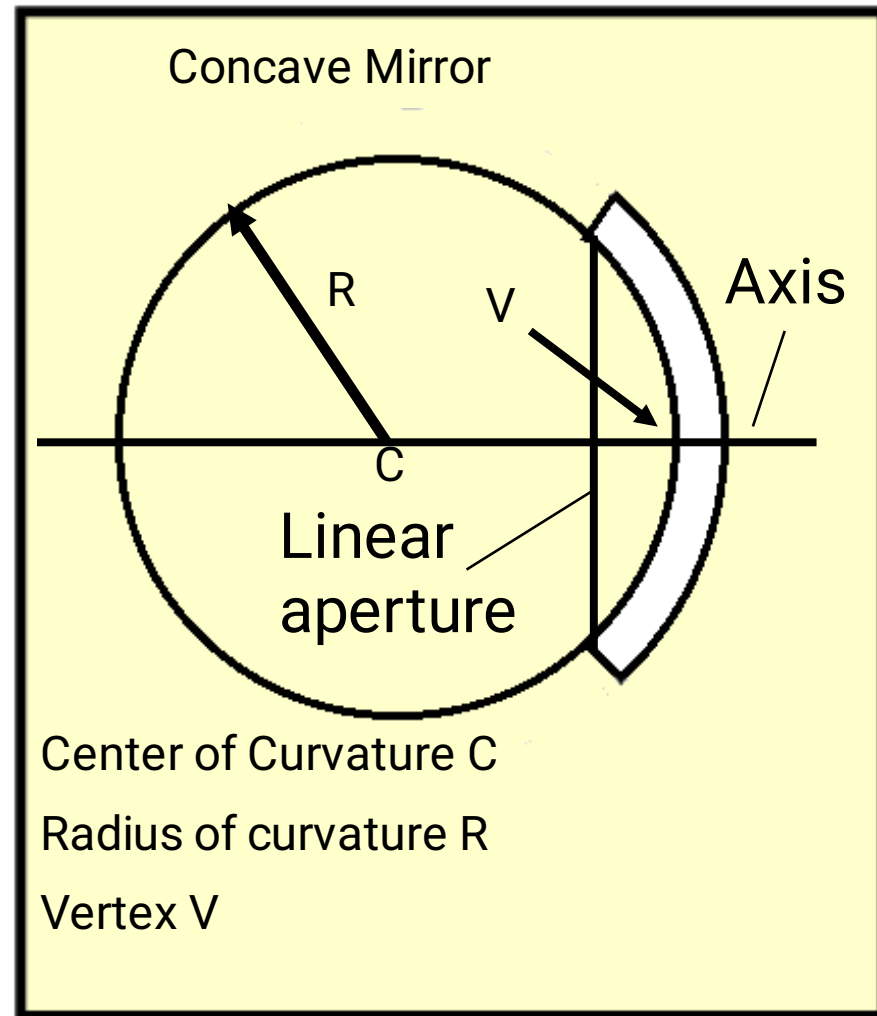
$$\frac{I_2}{I_1} = \frac{(D_1)^2}{(D_2)^2}$$

Terms for Spherical Mirrors

A spherical mirror is formed by the inside (concave) or outside (convex) surfaces of a sphere.

A concave spherical mirror is shown here with parts identified.

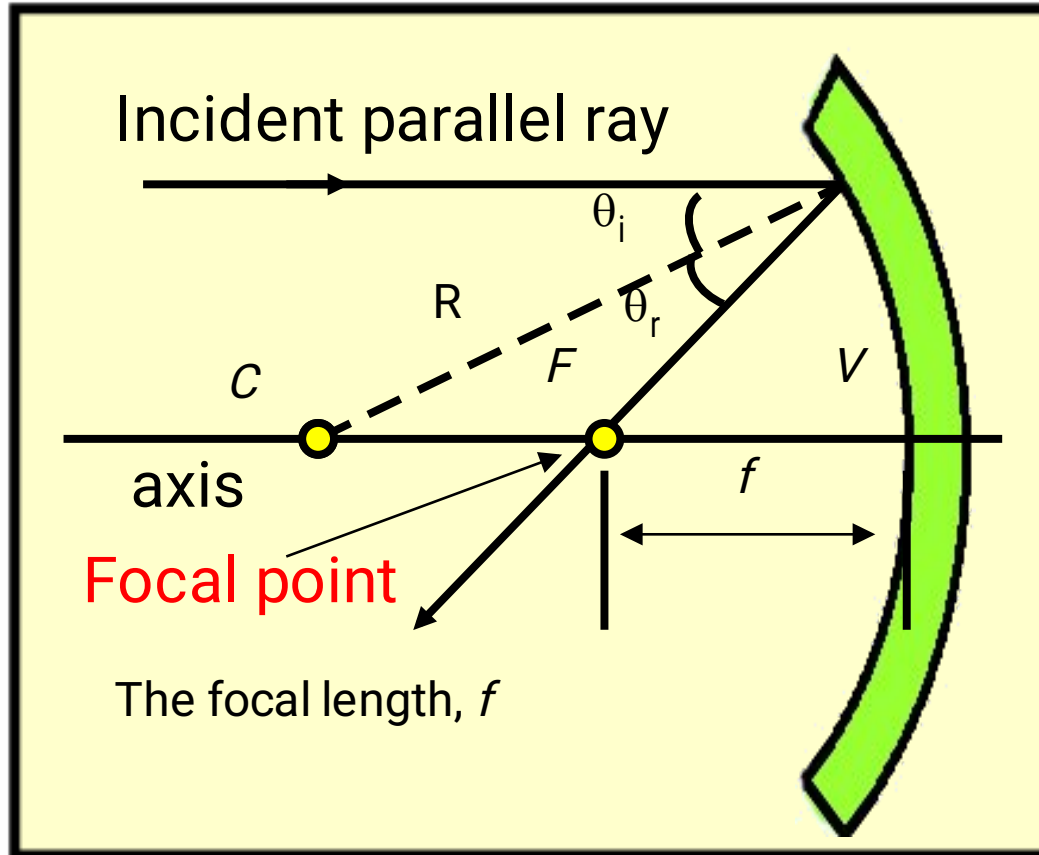
The axis and linear aperture are shown.



concave mirror

- A **concave mirror**, or **converging mirror**, has a reflecting surface that bulges inward (away from the incident light).
- Concave mirrors reflect light inward to one focal point. They are used to focus light. Unlike convex mirrors, concave mirrors show different image types depending on the distance between the object and the mirror.
- These mirrors are called "converging" because they tend to collect light that falls on them, refocusing parallel incoming [rays](#) toward a focus. This is because the light is reflected at different angles, since the normal to the surface differs with each spot on the mirror.
- Concave mirrors are used in some telescopes. They are also used to provide a magnified image of the face for applying make-up or shaving.

The Focal Length f of a Mirror



Since $\theta_i = \theta_r$, we find that F is mid-way between V and C ; we find:

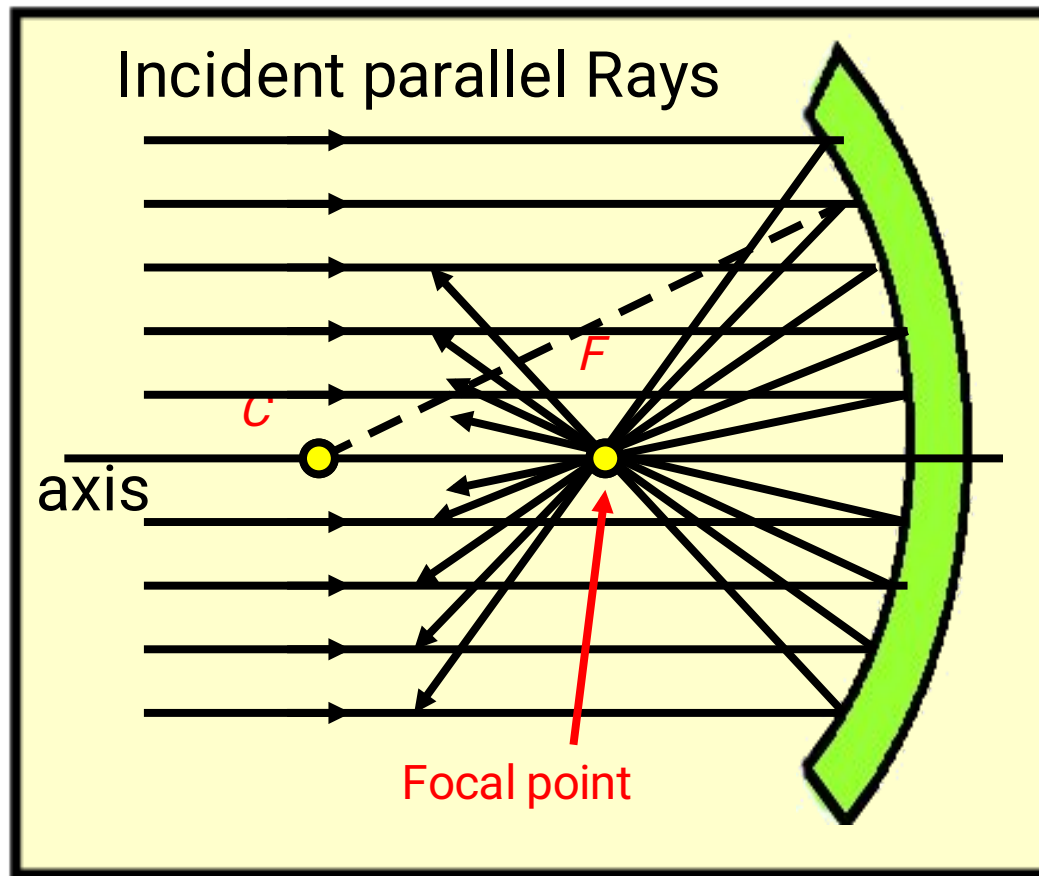
The focal length f is:

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

The focal length f is equal to half the radius R

The Focus of a Concave Mirror

The focal point F for a concave mirror is the point at which all parallel light rays converge.

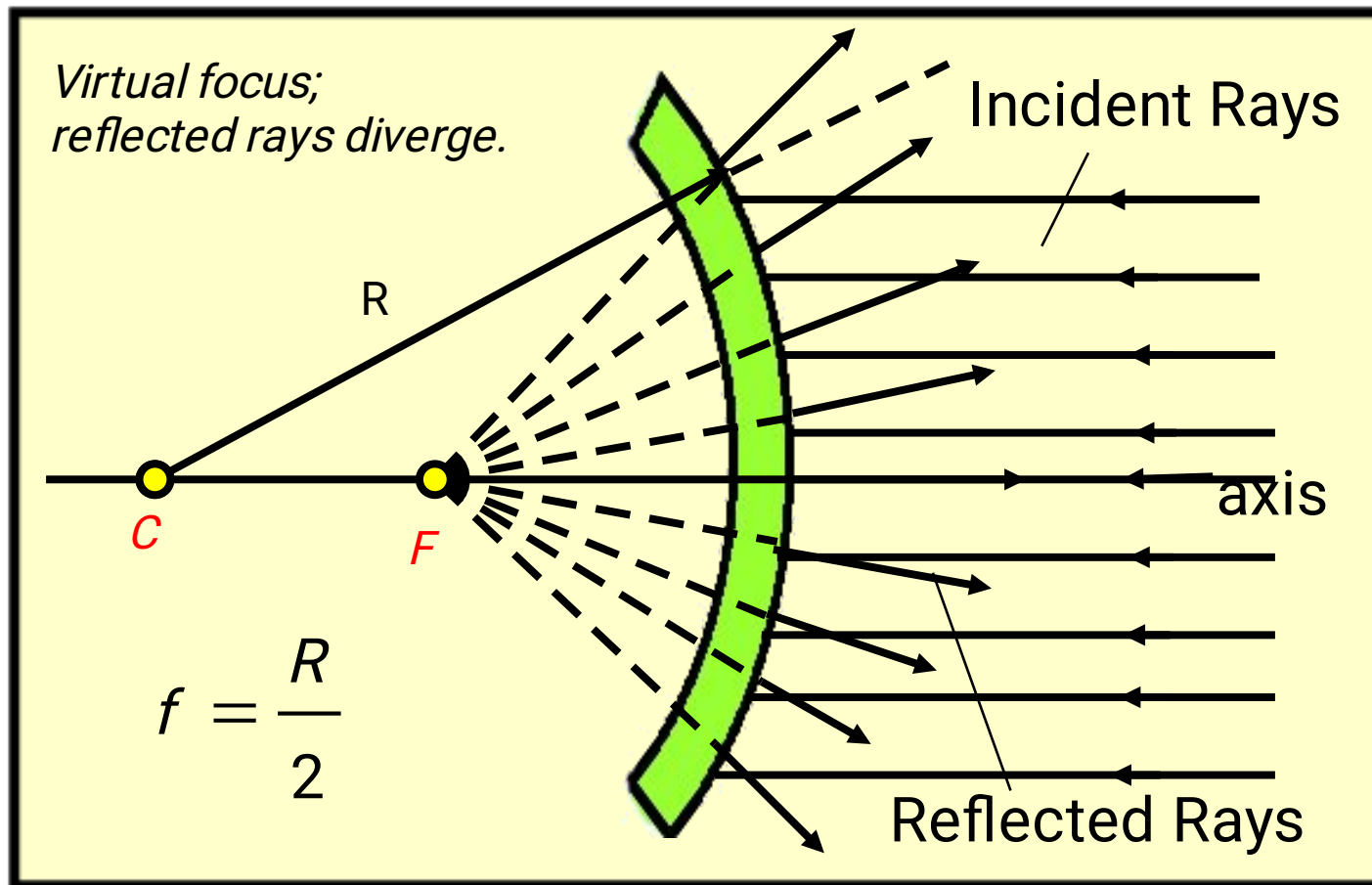


For objects located at **infinity**, the **real** image appears at the **focal point** since rays of light are almost parallel.

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

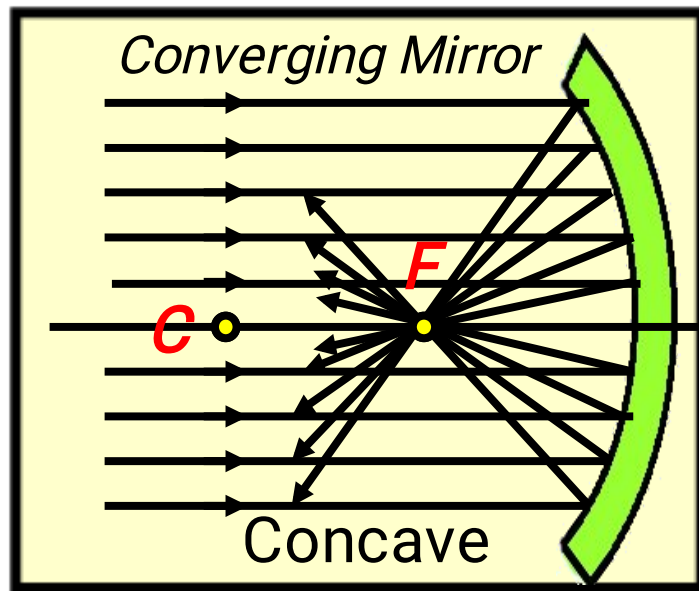
The Focus of a Convex Mirror

The focal point for a convex mirror is the point F from which all parallel light rays diverge.



Converging and Diverging Mirrors

Concave mirrors and converging parallel rays will be called converging mirrors from this point onward.



Convex mirrors and diverging parallel rays will be called diverging mirrors from this point onward.

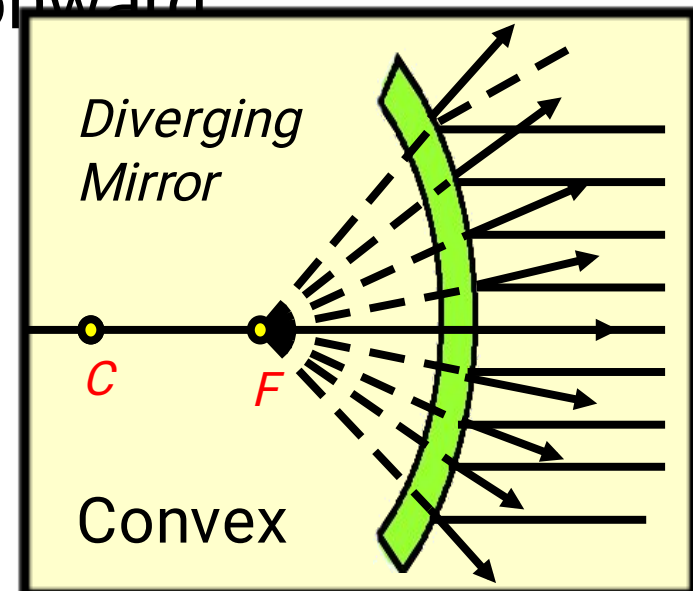
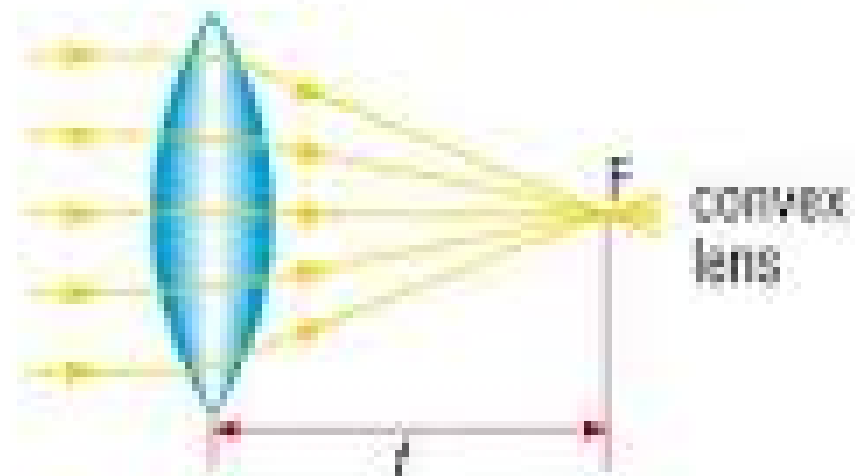
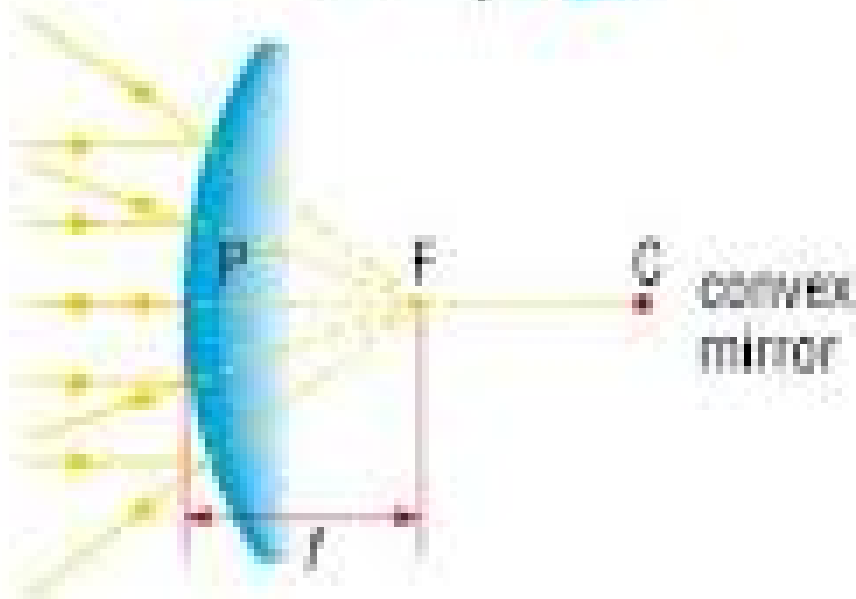
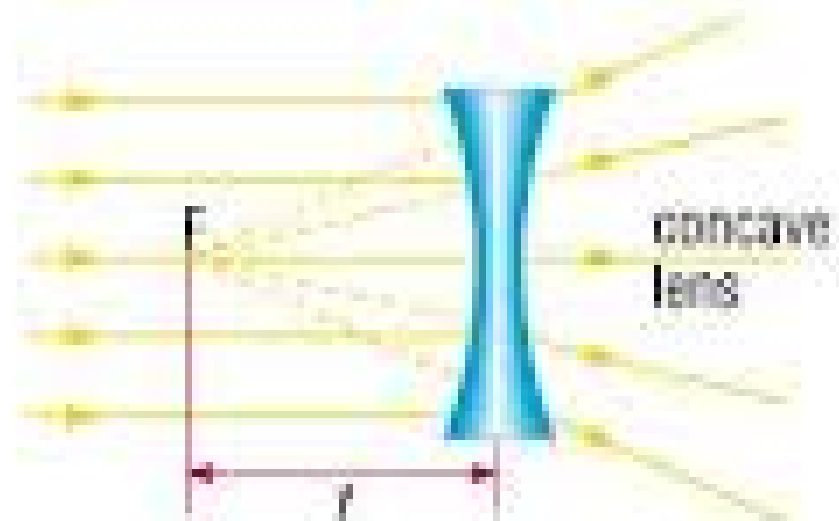
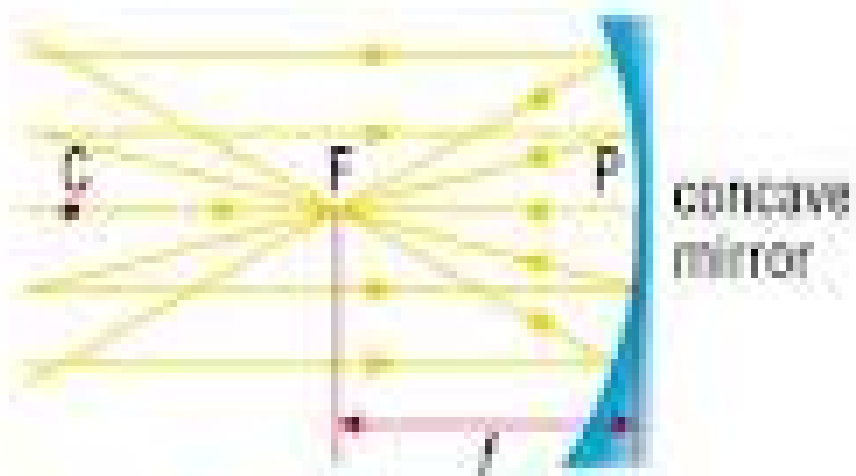


Image from convex mirror

- A **convex mirror**, **fish eye mirror** or **diverging mirror**, is a curved mirror in which the reflective surface bulges toward the light source.
- Convex mirrors reflect light outwards, therefore they are not used to focus light.
- Such mirrors always form a virtual image, since the focus (F) and the centre of curvature ($2F$) are both imaginary points "inside" the mirror, which cannot be reached.
- As a result, images formed by these mirrors cannot be projected on a screen, since the image is inside the mirror.
- A collimated (parallel) beam of light diverges (spreads out) after reflection from a convex mirror, since the normal to the surface differs with each spot on the mirror.

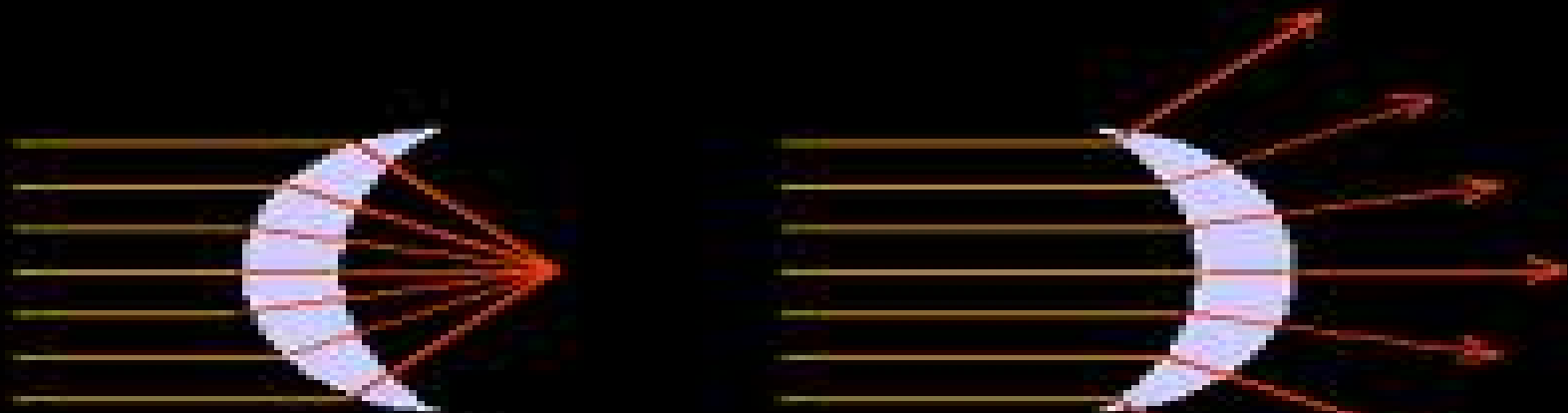
Lenses

- a transparent optical device used to converge or diverge transmitted light and to form images.
- [camera lens](#), [optical lens](#) - a lens that focuses the image in a camera
- [compound lens](#) - a lens system consisting of two or more lenses on the same axis
- [optical condenser](#), [condenser](#) - lens used to concentrate light on an object
- [contact lens](#), a thin curved glass or plastic lens designed to fit over the cornea in order to correct vision or to deliver medication
- [converging lens](#), [convex lens](#) - lens such that a beam of light passing through it is brought to a point or focus
- [concave lens](#), [diverging lens](#) - a lens such that a parallel beam of light passing through it is caused to diverge or spread out
- [field lens](#) - the lens that is farthest from the eye in an optical device with more than one lens
- [object glass](#), [object lens](#), [objective lens](#), the lens or system of lenses in a telescope or microscope that is nearest the object being viewed
- [optical device](#) - a device for producing or controlling light
- [optical instrument](#) - an instrument designed to aid vision



C = centre of curvature
 F = focus

P = pole
 f = focal length



Lenses



Mirrors

DEFINITIONS AND EXAMPLES OF PHYSICAL AGENTS

- Physical agents are various forms and means of applying of energy and materials to patients.
- Physical agents include heat, cold, water, pressure, sound, electromagnetic radiations, and electrical currents.

❖ CATEGORIES OF PHYSICAL AGENTS

Physical agents are most readily categorized as thermal, mechanical or electromagnetic agents.

THERMAL	Deep-heating agents Superficial heating agents Cooling agents	Diathermy Hot pack Ice pack
MECHANICAL	Traction Compression Water Sound	Mechanical traction Elastic bandage Whirl-pool Ultrasound
ELECTROMAGNETIC	Electromagnetic field Electromagnetic currents	Ultraviolet TENS

UV effect on cells:

Ultraviolet radiation is a form of energy. As such, when it contacts any surface, skin included, it must be either reflected or absorbed and transmitted.

If UVR strikes the skin at a 90-degree angle, 90 to 95 percent of the energy will be absorbed. Most will be absorbed within the epidermis of the skin (80–90%), whereas the rest will reach the dermis.

As the UVR is absorbed within the tissue it causes the energy level of exposed atoms to increase.

These atoms will quickly return to their normal energy state; however, the presence of excess energy causes chemical excitation within the cells of the exposed tissue.

This chemical excitation is the cause of the various effects of UVR on living cells and tissue leads to physiologic changes within these cells called photochemical event.

This photochemical event results in an alteration of cell biochemistry and cellular metabolism.

PHYSIOLOGIC RESPONSES TO DIATHERMY.....THERMAL EFFECTS

Most common types of diathermy is Short wave, microwave diathermy.

The diathermies are not capable of producing depolarization and contraction of skeletal muscle since the wavelengths are much too short in duration.

Thus, the physiologic effects of continuous shortwave and microwave diathermy are primarily thermal, resulting from high-frequency vibration of molecules.

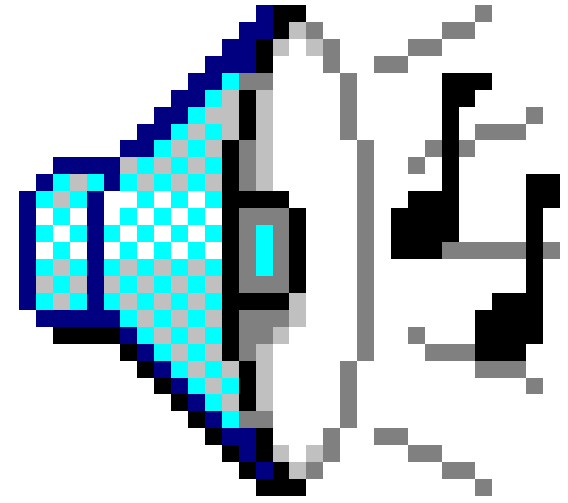
The primary benefits of diathermy are those of heat in general, , tissue temperature rise, increased blood flow, dilation of the blood vessels, increased filtration and diffusion through the different membranes, increased tissue metabolic rate, changes in some enzyme reactions, alterations in the physical properties of fibrous tissues (such as those found in tendons, joints, and scars), decreased joint stiffness, a certain degree of muscle relaxation, a heightened pain threshold, and enhanced recovery from injury.

Infra-red: continue:

The electromagnetic spectrum has a relatively large region of radiations designated as infrared.

The infrared wavelength provides the radiant energy used therapeutically. Penetration of the energy is dependent on the source but is generally considered to be a superficial form of treatment.





End