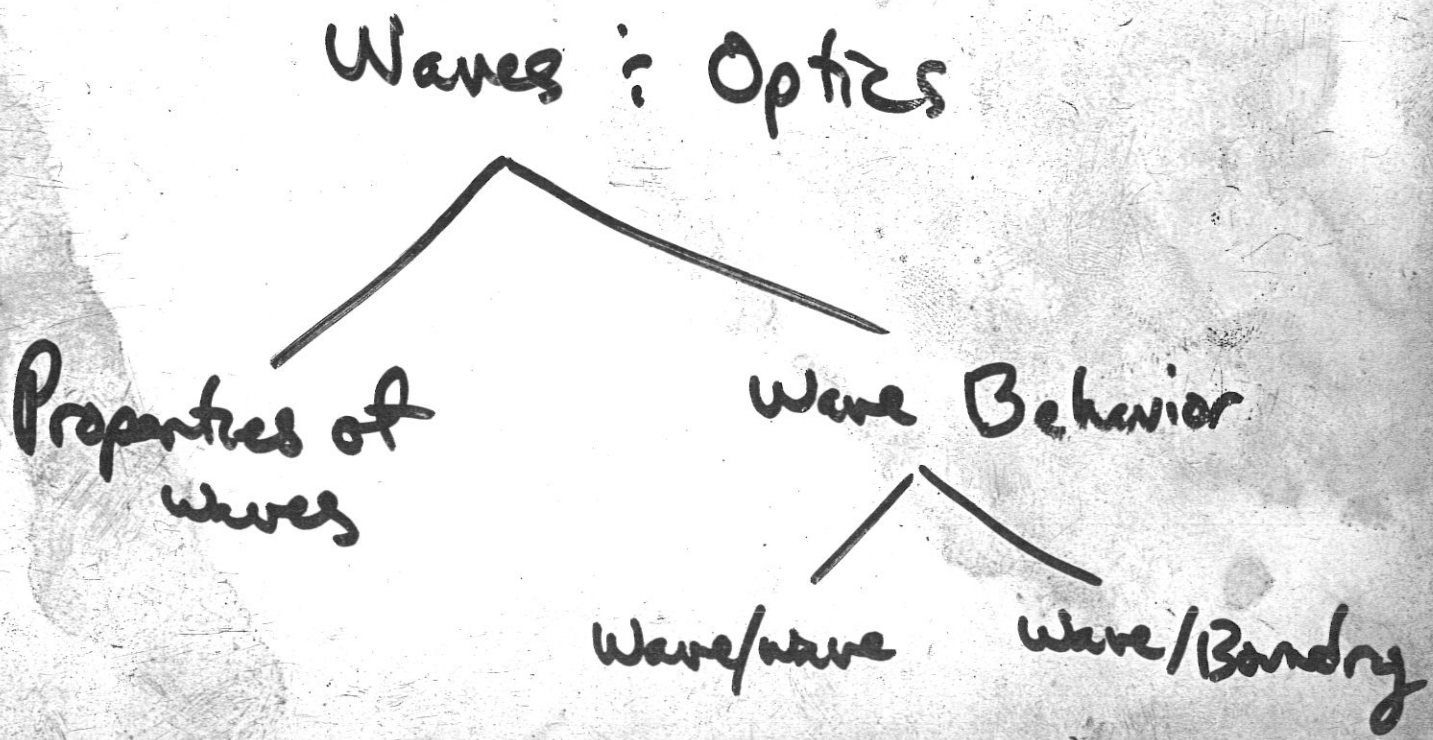
Physics
Waves

A wave is a method of transferring energy from one place to another.

Wave - a disturbance that propagates through a medium or space.

Wave pulse - a non repeated disturbance such as a single crest.

Continuous wave - periodic succession (oscillation) of positive and negative pulses.



Physics

Waves

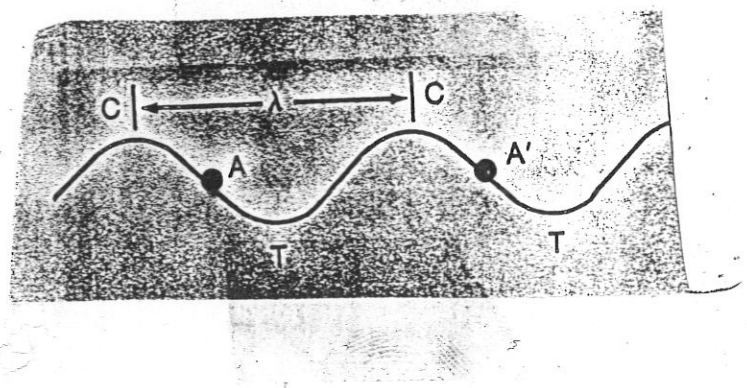
<u>Period, T</u>: the shortest time interval during which the motion of the wave repeats itself.

Unit: seconds/one cycle

<u>Frequency, f</u>: the number of cycles per second

Unit: cycles/one second
Hz (Hertz)

$f = 1/T$



The distance between two points where the wave repeats itself is called the <u>wavelength</u>, λ (lambda)

"High" points on the wave are called crests.
"Low" points on the wave are called troughs.

Assuming the velocity of a wave is constant, and using the equation v = d/t, the <u>velocity of a wave</u> can be calculated using...

$$V = \frac{\lambda}{T} = \lambda f \qquad \boxed{v = \lambda f}$$

Physics

Waves

There are three types of waves

1. Mechanical waves – water, sound, and spring waves. Newtonian mechanics describe mechanical waves. These waves require a medium.

2. Electromagnetic waves – radio, X-rays, light waves. No medium is needed for these waves. These waves travel at the speed of light; 3.0×10^8 m/s.

3. Matter waves – quantum mechanics describe matter waves.

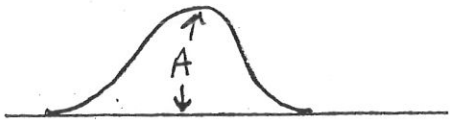
There are two seperate types of mechanical waves

1. Transverse waves: the particles of the medium vibrate perpendicularly to the direction of the motion of wave.

2. longitudinal waves: the particles of the medium move parallel to the direction of the wave.

(surface waves a mixture of both)

Wave pulse - a single disturbance (wave crest with an amplitude)

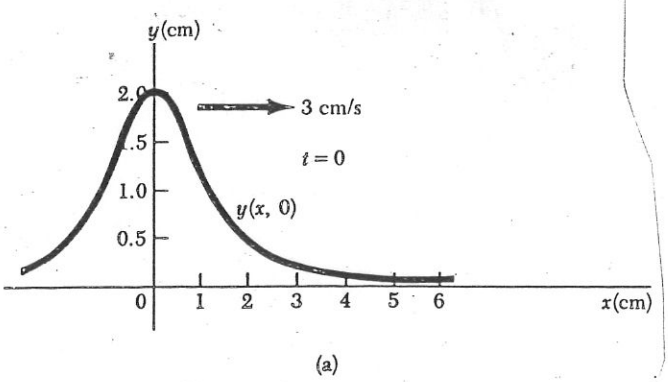


Example 4

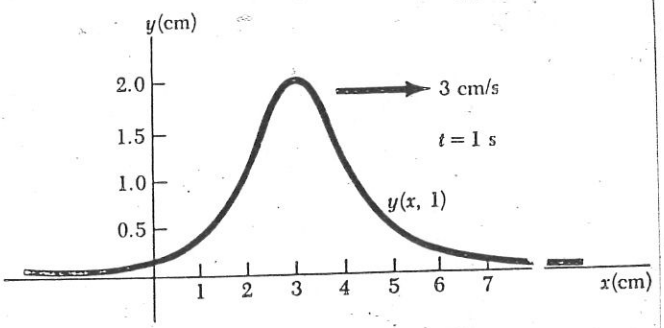
A traveling wave pulse moving to the right on the x axis is represented by the wave equation below. What does the wave pulse look like at t = 0 and t = 1 seconds?

What is the velocity of the wave crest?

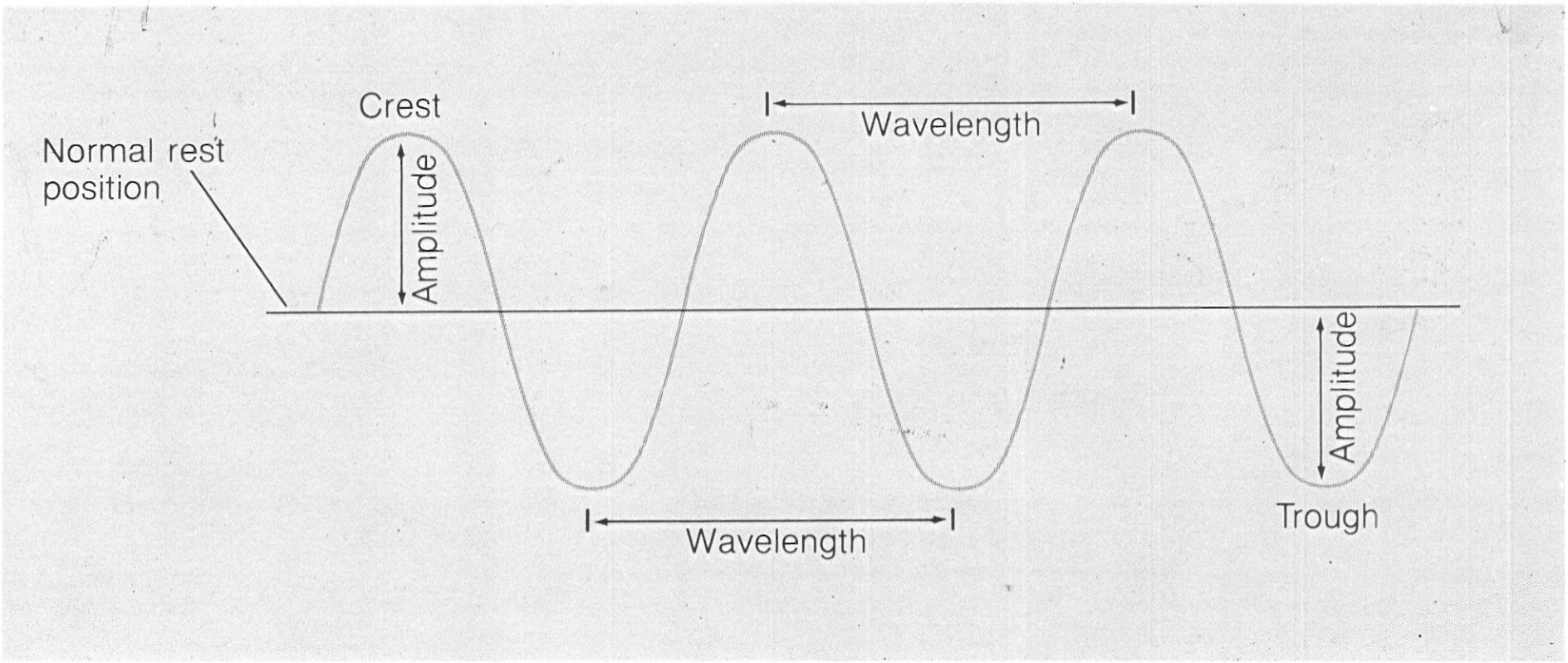
$$y = \frac{2}{(x-3t)^2+1}$$



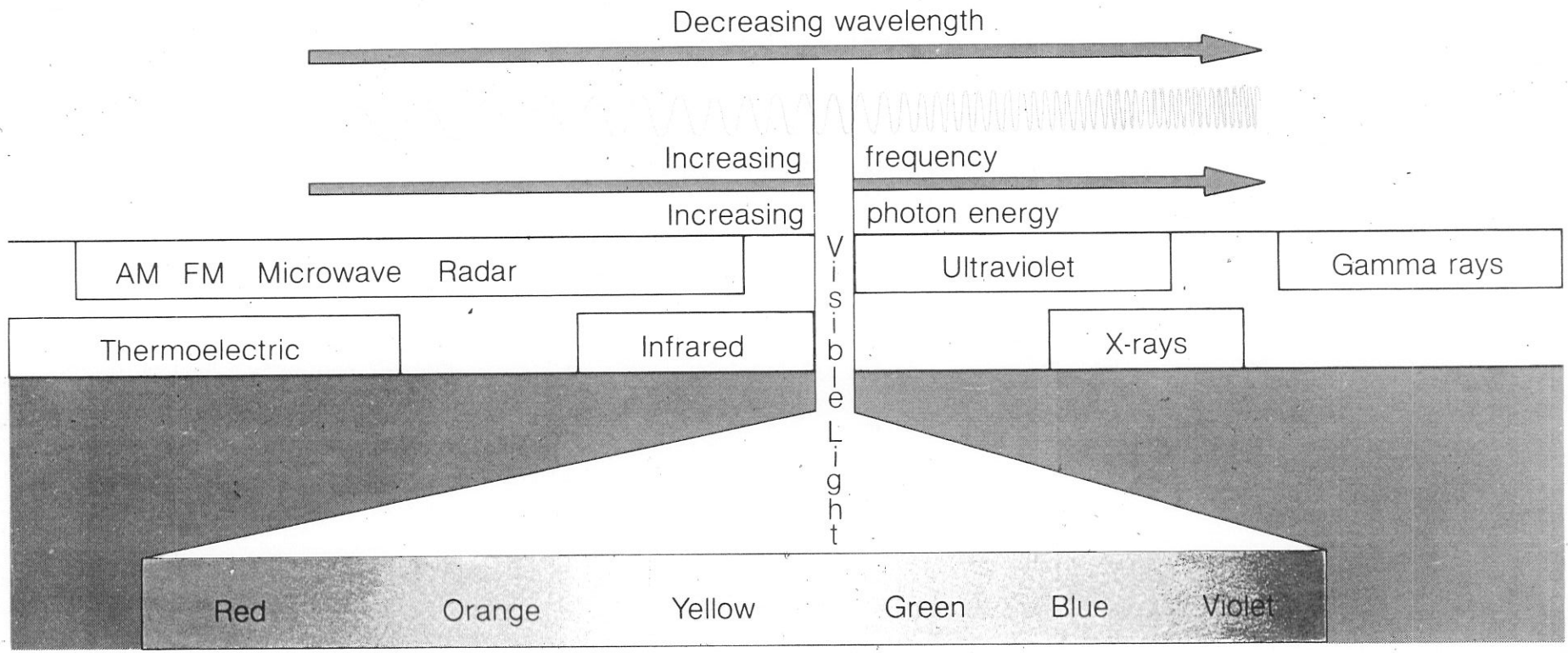
(a)

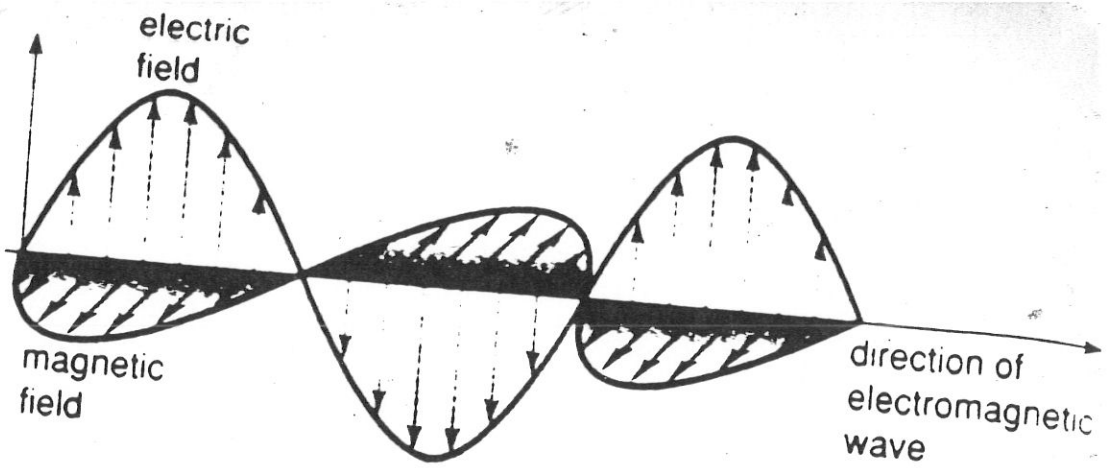


63 Wave Characteristics

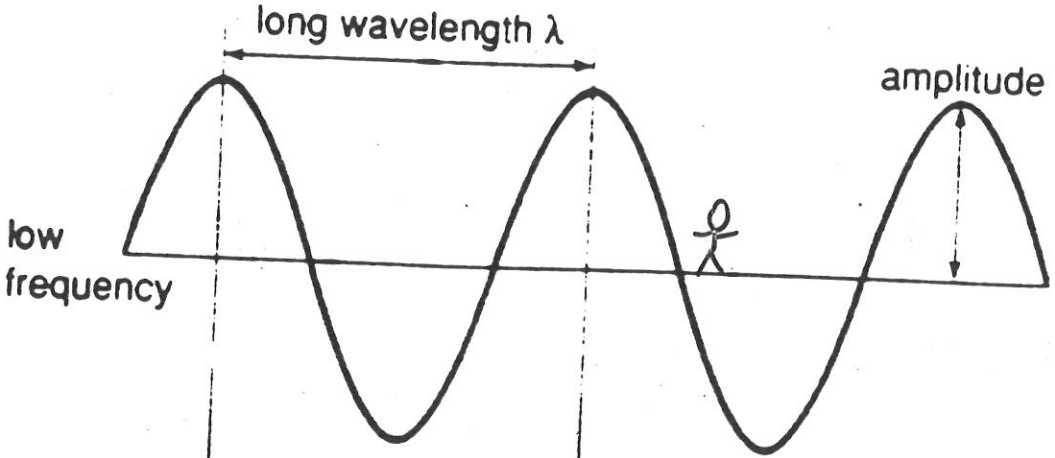


66 Electromagnetic Spectrum

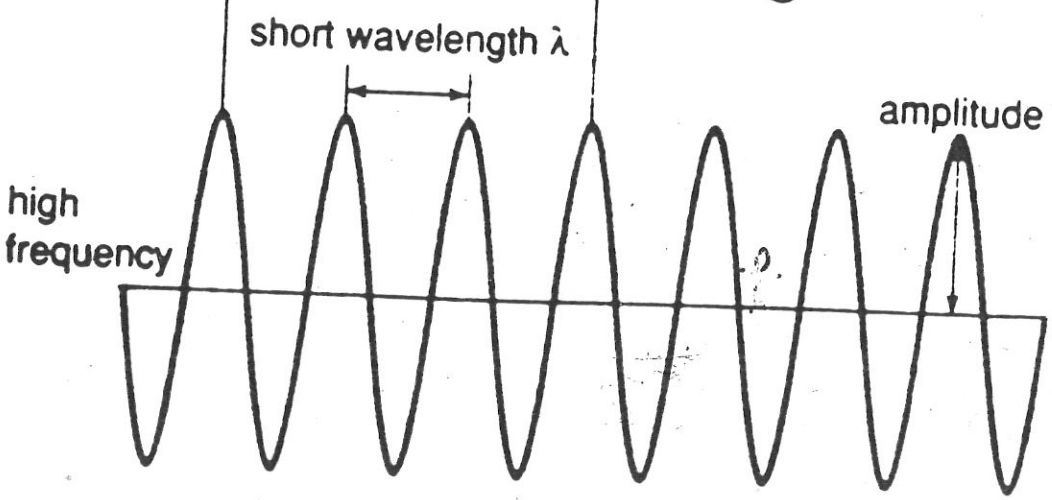



electric field
magnetic field
direction of electromagnetic wave

A

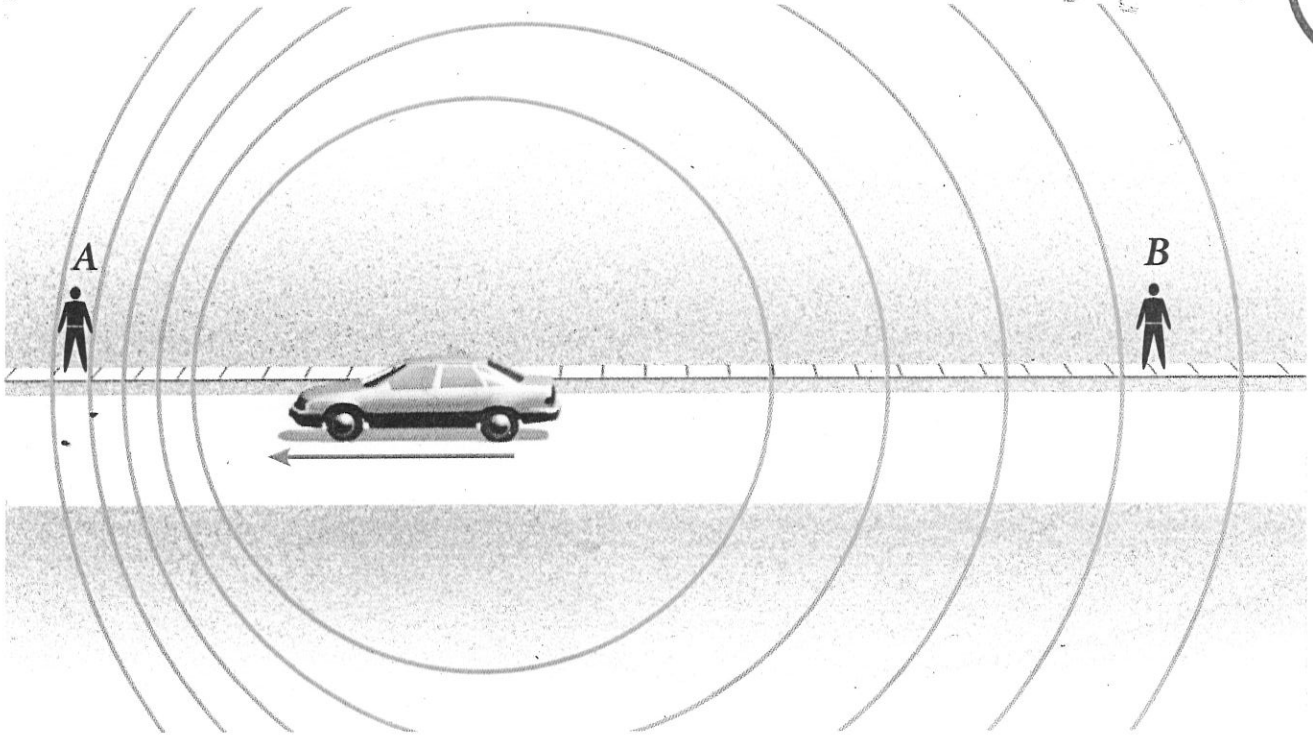

long wavelength λ
amplitude
low frequency

B

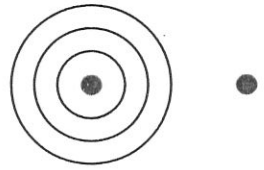
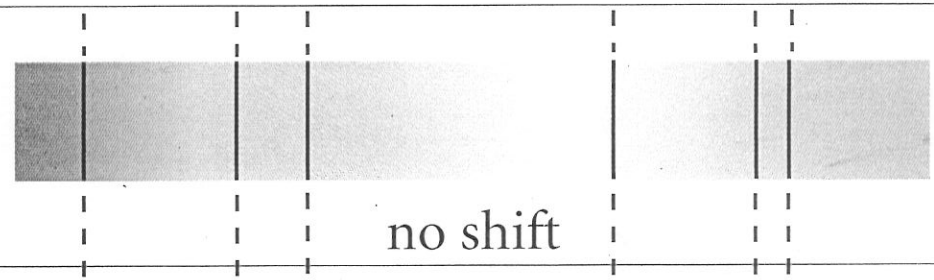
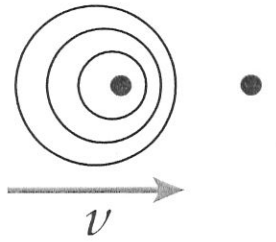
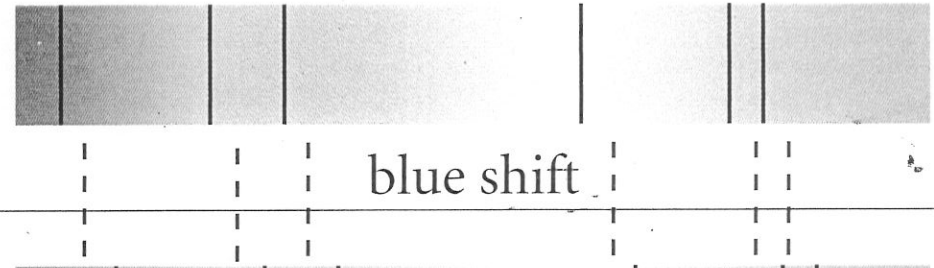
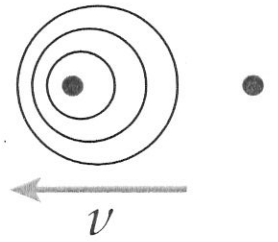
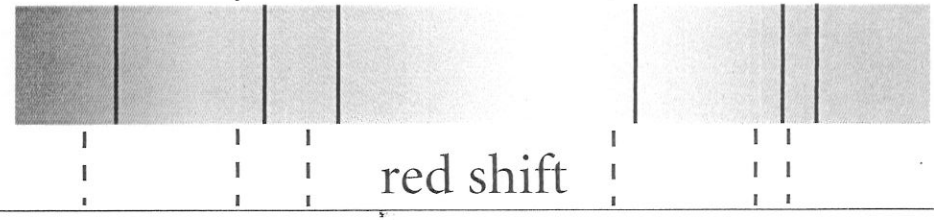

short wavelength λ
amplitude
high frequency

The Doppler Effect

$$f' = f\left(\frac{v}{v \pm v_s}\right)$$



The Doppler Effect for Light

Stationary source		
Approaching source		
Receding source		

Physics

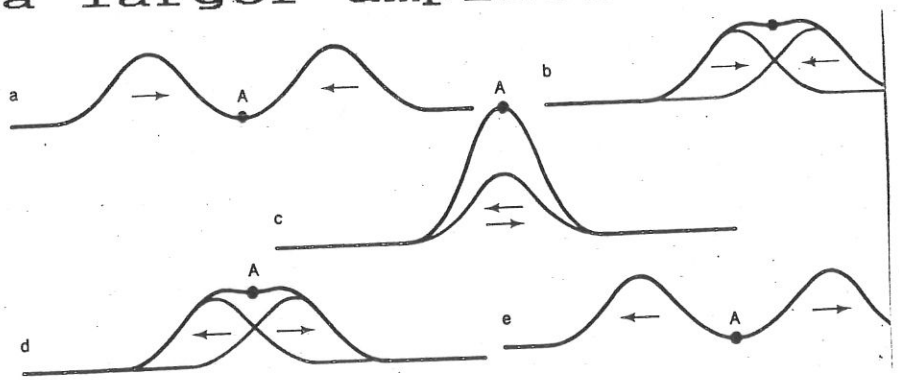
Wave Interference

When two waves meet each other, while both are traveling through a medium, interference can occur.

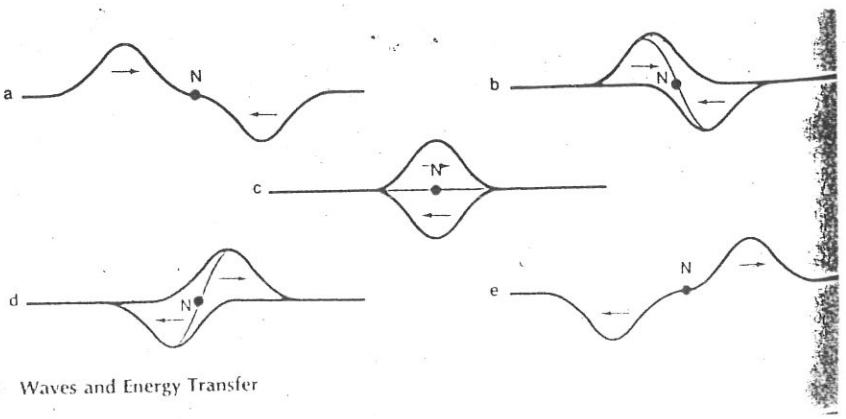
The resulting "wave" can be described using the <u>principle of superposition</u>.

The displacement of a medium caused by two or more waves is the algebraic sum of the displacements caused by the individual waves.

<u>Constructive interference:</u>
Wave displacements in the same direction, resulting wave has a larger amplitude.



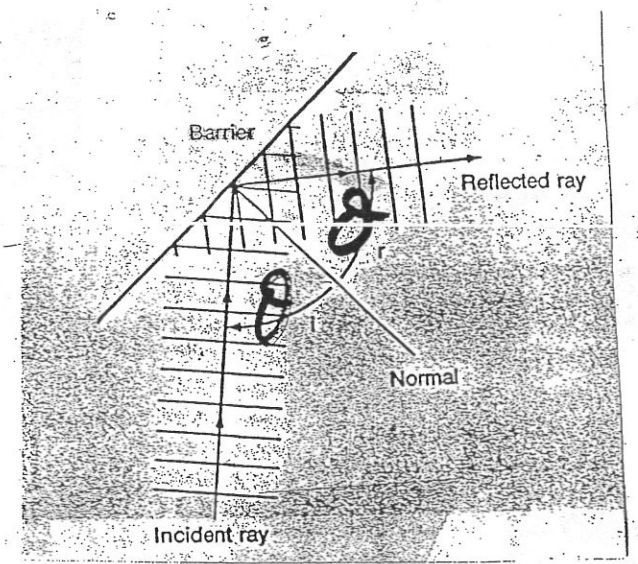
<u>Destructive interference:</u>
Wave displacements (A) in opposite directions, resulting in a node (zero A)



Physics

Reflection

Reflection: A wave pulse that strikes a barrier is reflected. A line drawn at a right angle to the surface is called the <u>normal</u>.



The angle between the incident wave and the normal is called the <u>angle of incidence</u>.

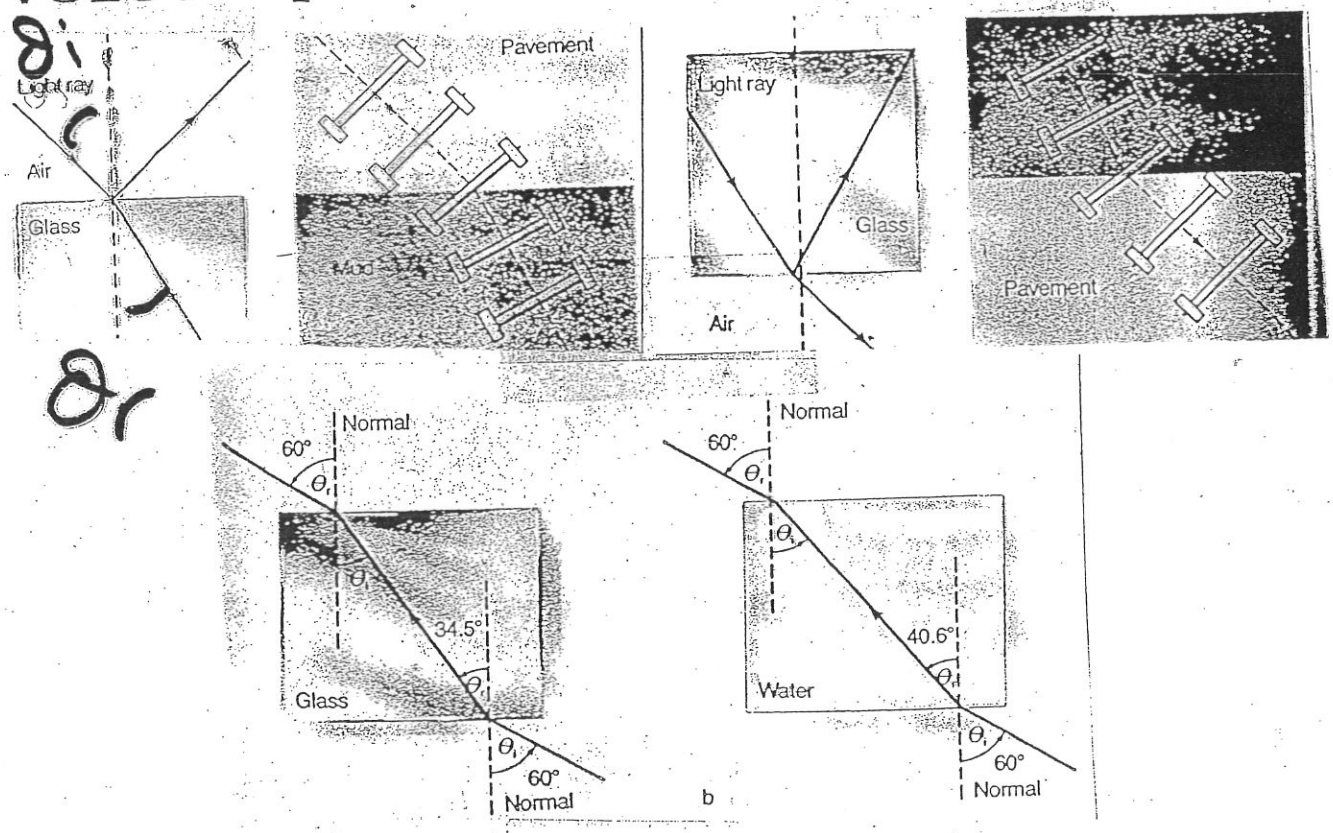
The angle between the reflected wave and the normal is called the <u>angle of reflection</u>.

<u>The law of reflection...</u>
the angle of incidence equals the angle of reflection

Physics

Refraction

When waves move from one medium to another they are <u>refracted</u> (bent). The bending is caused by the different velocity the medium allows.



<u>Snell's Law</u>... a certain substance has an index of refraction. The angle of incidence and the angle of refraction are related by the expression...

$(n_i)\sin(\theta_i) = (n_r)\sin(\theta_r)$

$n_i \sin\theta_i = n_r \sin\theta_r$

n - index of refraction

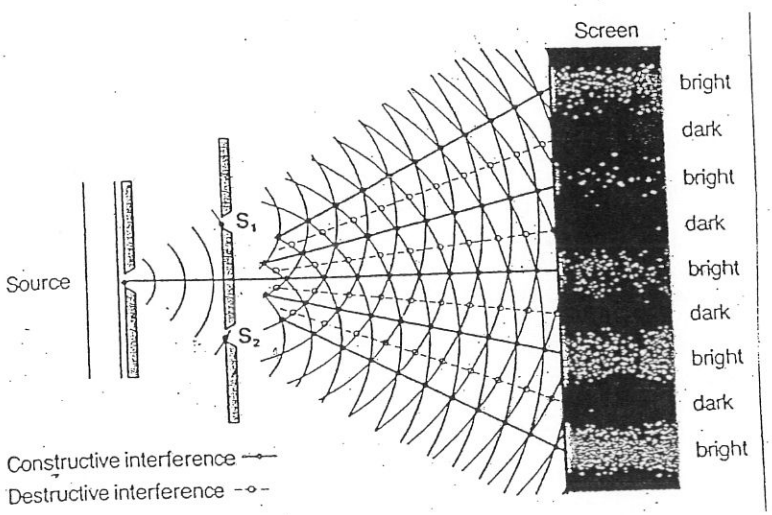
Physics

Diffraction...

When waves encounter a barrier with a small opening, waves bend around the edges of the opening to form small circular waves that spread out.

This phenomenon is called diffraction.

If two openings are used, a diffraction pattern is created that shows constructive and destructive interference.



Equations

Physics
Optics
Mirrors & Lenses

1. Plane Mirror- flat, smooth mirror that reflects light in all directions.

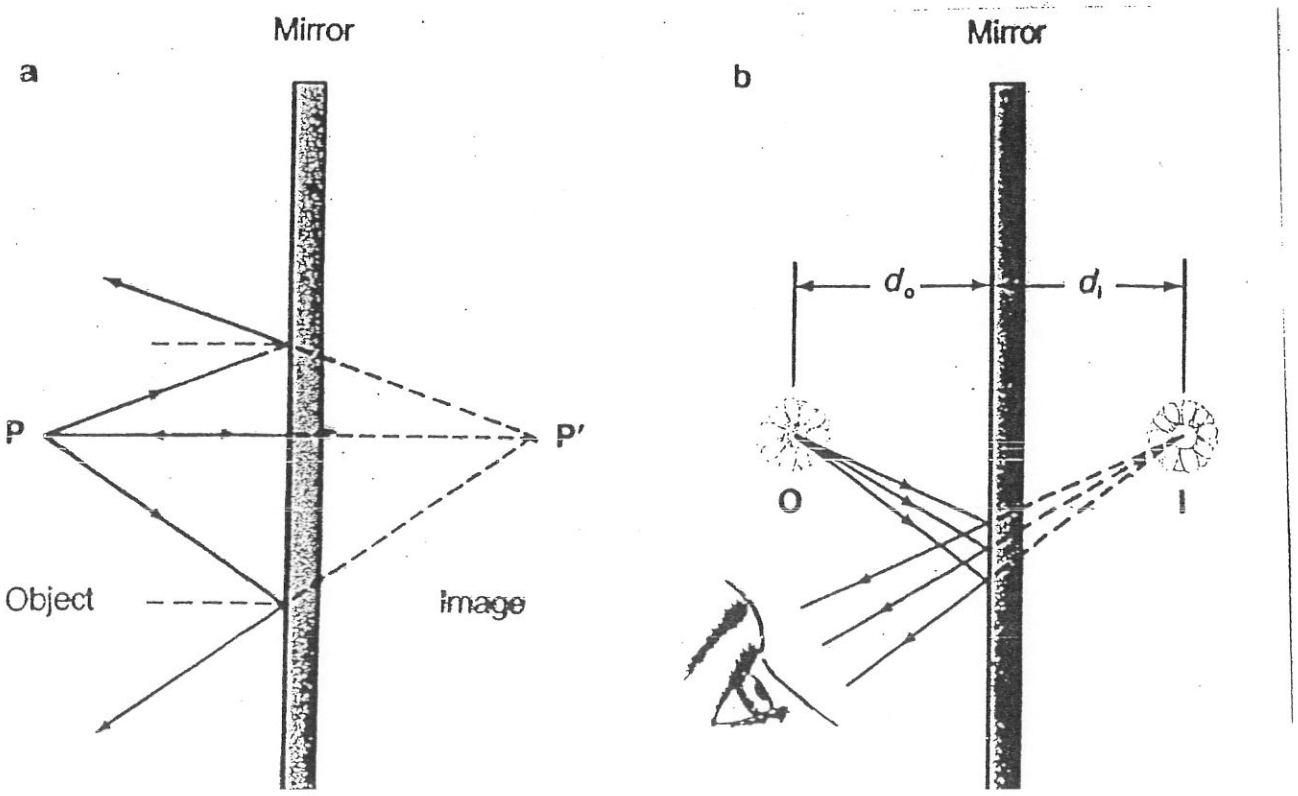
Object - a source of diverging light rays. An object is either luminous, or artificially illuminated (lights).

A plane mirror produces a virtual image.

Image - the point where rays of object intersect.

Real image - rays of light actually converge at a spot (image is formed there!)

Virtual image - rays of light do not actually meet, but appear to originate from a spot (image appears to be there!)



Concave and convex mirrors / Lens

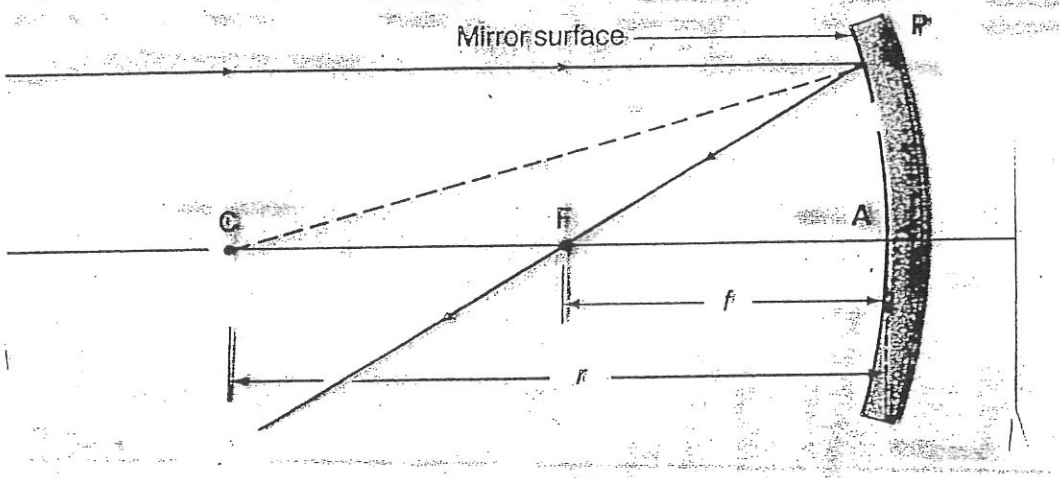
Terms

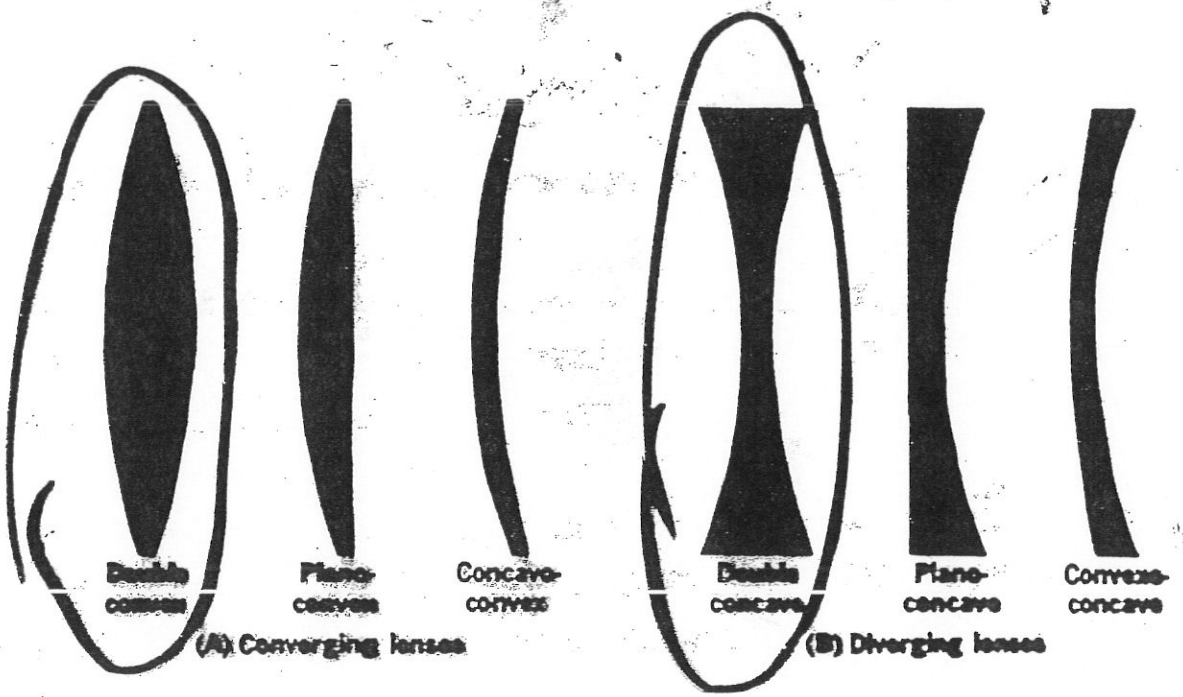
Center of curvature - geometric center of mirror or lens.

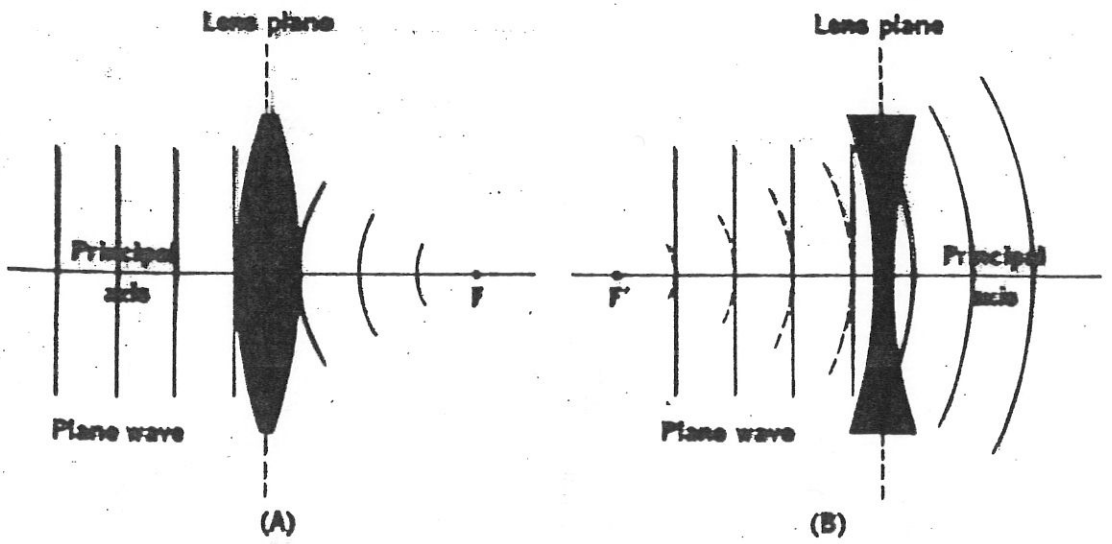
Radius of curvature- distance from center of curvature to mirror/lens.

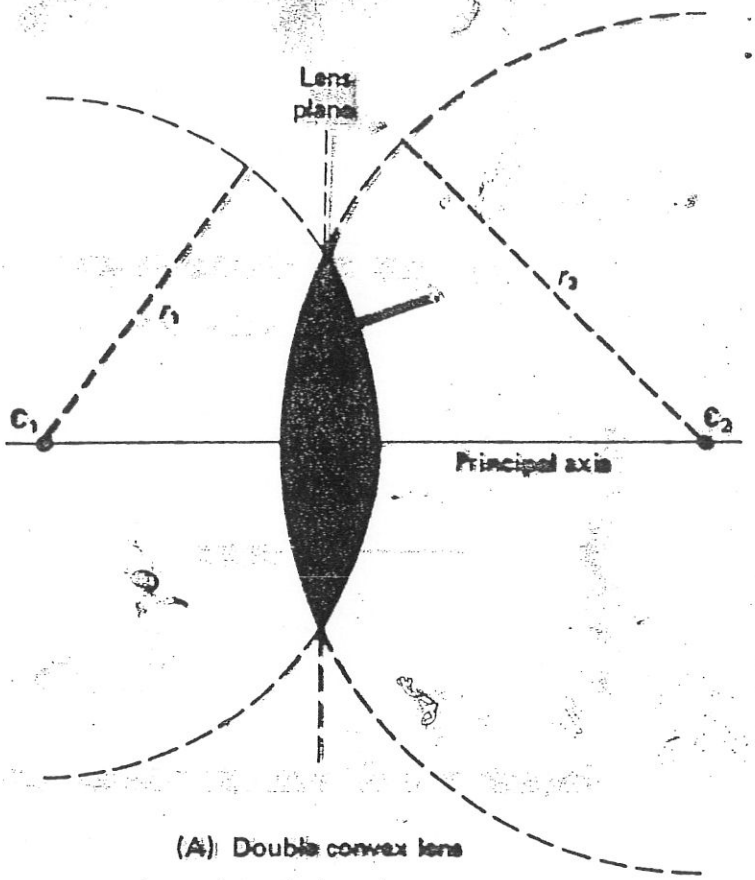
Principle axis - line drawn from center of mirror/lens through the center of curvature.

Focal length - C/2 **(Center of curvature divided by two) Where rays from distant object form.**

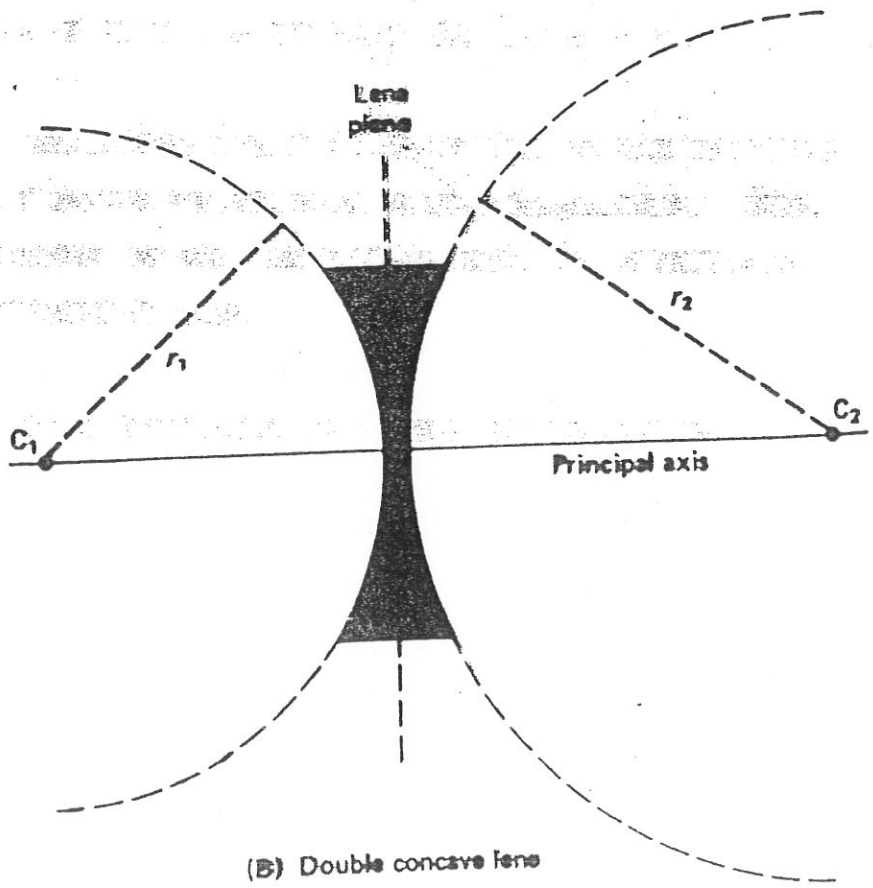



Double convex
Plano-convex
Concave-convex
(A) Converging lenses
Double concave
Plano-concave
Convex-concave
(B) Diverging lenses


Lens plane
Principal axis
F
Plane wave
(A)
Lens plane
F'
Principal axis
Plane wave
(B)

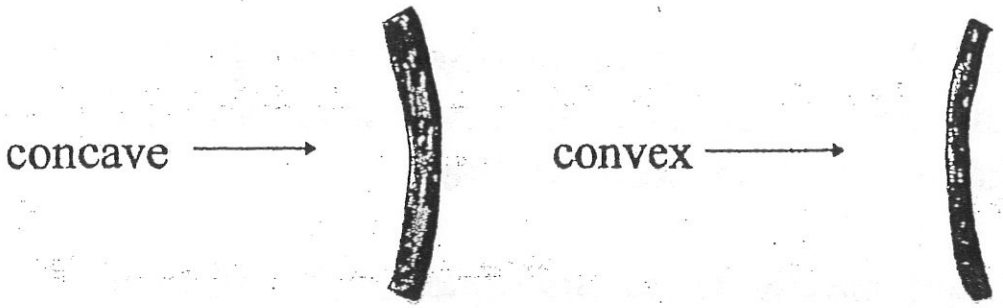


(A) Double convex lens



(B) Double concave lens

Physics
Optics
Ray diagrams for 1. concave/convex mirrors
2. convex lens



Two steps to draw ray diagram, and locate image.

STEP 1 Draw ray 1 leaving the top of the object moving parallel to the principle axis. This ray strikes the boundary, and then reflects or refracts through the focal point.

STEP 2 Draw ray 2 leaving the top of the object moving through the focal point on its way to the boundary. This ray strikes the mirror or lens and then reflects or refracts parallel to the principle axis.

Where ray 1 & ray 2 intersect, is where the image is located.

Physics
Concave Lenses

Rule for drawing ray diagrams for concave lenses...

1. Draw ray 2 from the top of the object, through the center of the lens. This ray continues in a straight line through the lens and the opposite side.

2. Draw ray 1 parallel to the principle axis , striking the lens. The ray refracts in a way that it appears to come from the focal point on the same side as the object.