"Advanced Optics"

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Chapter One

Wave Motion

1.1 Nature of Light

There was many definitions for light, and theoryes, her some of them:-

- Issac Newton :- Light is a stream of very small particles emitted from a source of light and traveling in a straight lines.

- Christian Huygens:- Light is a wave motion spreading from a light source in all directions and propogating through an elastic pervasive medium called the (ether)

- James Maxwell :- He put the Electromagnetic waves Theory. His four equations yielded a prediction for the speed of an electromagnetic wave in the ether that turned out to be the measured speed of light, suggesting its electromagnetic character.

* From then on, Light was viewed as a particular region of the electromagnetic spectrum.

- Max planck :- He put the Foundation of (Quantum Theory) which states that:-

Atoms emitte light in discreate energy chunks rather than in continuous manner

$E = h\nu$

- Albert Einstein :- Light is astream of photons whose energy is related to Frequency by planks eq. ($E = h\nu$)

- Niels Bohr :- The electromagnetic energy is quantized.

- De Broylie :- Light could be treated as a matter possessing both energy and momentum. He said that subatomic particles are endowed with wave properties.

* The modern concept of light contain of both Newton and Huygen's.

(Light behaved like waves in its propagation and in the phenomena of interference and diffraction, it could, however also behave as a particle in its interaction with matter as in the photoelectric effect)

Electromagnetic Spectrum

Optics is the study of light, or the study of the electromagnetic spectrum.

Electromagnetic radiation is created by oscillating electric charges. The Frequency of oscillation determine the kind of radiation that emitted. Tabe (1) illustrates these radiations and there frequencies.

Type of Radiation		Frequency	wavelength
Ray region	Gamma-ray	10^{19} Hz to above	0.3 A° → shorter
	X-ray	10^{18} Hz to 10^{19} Hz	300 A° → 0.3 A°
Optical region	Ultraviolet	5.7×10^{14} Hz to 10^{8} Hz	0.4 μm → 0.03 μm
	Visible	4.3×10^{14} Hz to 5.7×10^{14} Hz	0.7 μm → 0.4 μm
	Infrared	10^{12} Hz to 4.3×10^{14} Hz	300 μm → 0.7 μm
Wave region	Microwave	10^{9} Hz to 10^{12} Hz	3×10^{2} nm → 0.3 nm
	Radio wave	10^{9} Hz to less	3×10^{2} nm → longer

μm = micrometer = 10^{-6} m
nm = nanometer = 10^{-9} m
A° = Angstrom = 10^{-10} m

- The visible, Ultraviolet and Infrared region's together form the electromagnetic wave range which is studied in optics

2-1 One Dimensional Wave

The most easiest wave to visualize are the mechanical waves, such as waves on strings. The simple wave moving along a string has a great many properties in common with of light wave. The displacement of the string is perpendicular to the direction of motion of disturbance i.e. the wave propagates along the string while each element of the string itself merly moves back and forth.

The waves of this sort are said to be transverse. Light is just such a transverse wave, with the electric and magnetic fields varying in direction perpendicular to the propagation direction.

Although the energy-carring disturbance advances through the medium, the individual participating atoms remains in the vicinity of their equilibrium positions (the disturbance advances, not the material medium),

waves does not transport the medium through which it travels, and it is precisely this property that allows waves to propagate at very great speeds.

The general form of a traveling wave can be determined in the following:-

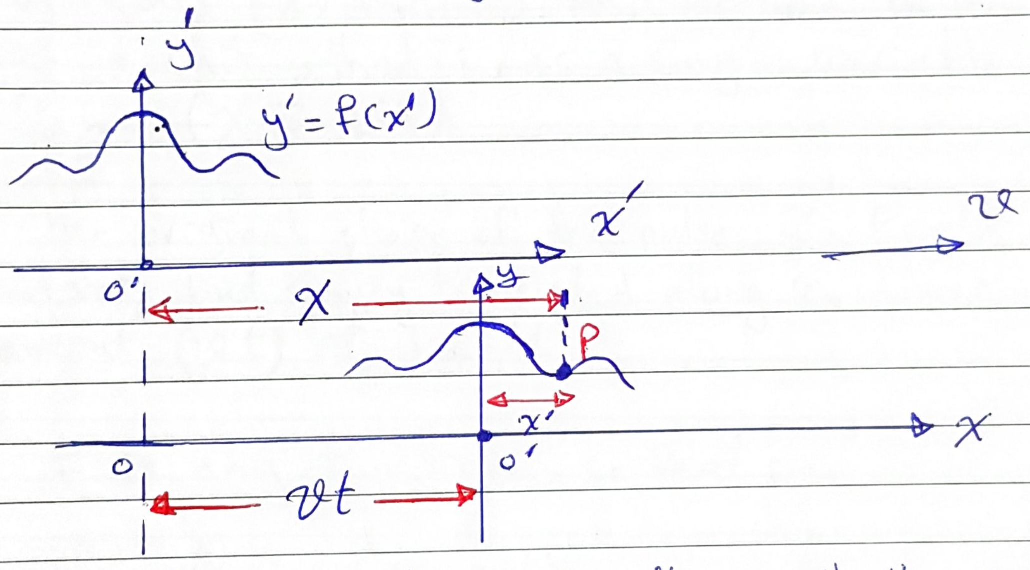
Considering a one - dimensional wave pulse of arbitrary shape, moving in the positive x-direction with constant speed (v).

This one dimensional wave pulse might be the vertical displacement of the string or the magnitude of an electric or magnetic field associated with an electromagnetic wave (or the quantum-mechanical probability amplitude of ~~the~~ a matter wave),

The one dimensional wave pulse described by:-

$$y' = f(x') \qquad \text{------ (1)}$$

fixed to a coordinate system $o'(x', y')$ as in the following figure [fig (1)].



Then the o' system, together with the pulse, moves to the right along the x-axis at uniform speed (υ) relative to fixed system $o(x, y)$. The pulse is assumed to maintain in shape. A point (P) on the pulse can be described by either of two coordinates like (x) or (x'), where:-

$$x' = (x - \upsilon t) \qquad \text{------ (2)}$$

The y-coordinate is identical in either system.

Based on the stationary coordinate system point of view the moving pulse has the form:-

$$y = y' = f(x') = f(x - vt) \qquad (3)$$

If the pulse moves to the left, the sign of (v) must be reversed, so that we have:-

$$y = f(x \mp vt) \qquad (4)$$

(general form of traveling wave)

Therefore we may conclude that, regardless of the shape of the disturbance (pulse), the variables (x) and (t) must appear in the function as a unit, that is, as a single variable in the form $(x \mp vt)$

The original shape of the pulse $y' = f(x')$ does not vary but simply translated along x- direction by amount (vt) at time (t).

f is any function, so that:-

$$y = A \sin(x - vt)$$

$$y = A(x + vt)^2$$

$$y = e^{(x - vt)}$$

all represents (Traveling waves) (5)

only the first one represents the periodic wave.

we assumed $x = x'$ at $t = 0$