UNIT - III

ADVANCES IN METROLOGY

Light is considered as an electro magnetic wave of sinusoidal form. The high point of wave is called the crest and the low point is called trough. The distance between two crests or two troughs is called the wavelength. The time taken by light in covering one wavelength is called time period.

The amplitude of a wave is the distance from the still position to the top of a crest or to the bottom of a trough. The frequency of a wave is the Number of waves passing a point in a certain time (i.e) the velocity of transmission.

Light is produced by any two methods

* Incandescence is the emission of light from hot matter (Temp $\geq$ 800K)
* Luminescence is the emission of light when excited electrons fall to lower energy level.

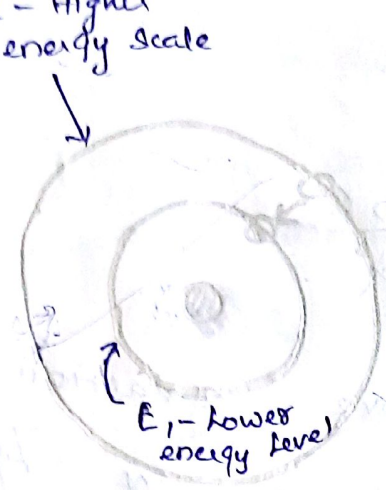
Monochromatic Light

Monochromatic Light is a narrow band of spectrum of visible light having the same wave length or colour.

LASER :

In Coherent beam, all the waves have the same frequency and phase. Lasers have greater coherent length of a light beam refers to the distance over which the beam stays in phase with itself.

* An electromagnetic radiation is emitted whenever a charged particle such as an electron drops from a higher energy state, E_2 to a lower energy state E_1.



The difference in energy level across which an excited electron drops determines the wavelength of emitted light. The wavelength or frequency of light determines its colour.

According to Quantam Mechanics, light is made up of Particles called photons. which exhibit both particle like and wave like properties.

$$E = h\nu$$

ν is the frequency of light and h,

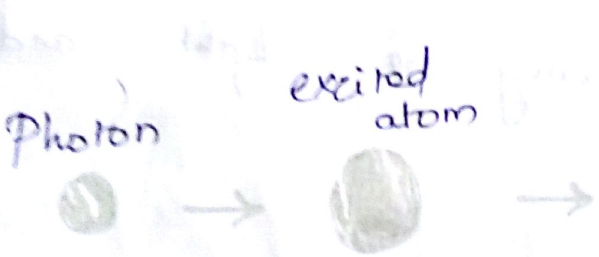
$$\lambda \nu = c$$

λ is the wavelength of light and c is the speed of light in Vaccum.

$$E = \frac{hc}{\lambda}$$

From the above operation we see that longer the wavelength of light lower the energy of photon. So the Ultraviolet light is more energetic than infrared light.

When an electron is an excited energy state, it must eventually decay to a lower level giving off a photon or radiation. This event is called spontaneous emission.



A photon strikes an exicted atom

The atom emits a New photon Just like the first one.

There is a probability that the passing photon will cause the electron to decay in such a manner that a photon is emitted at exactly the same wavelengths, in exactly the same direction and with exactly the same phase as the parent photon. This process is called as 'stimulated emission'.

The Normal thermal population in any material will have most of the electrons in the steady state ground level. But it is preferred to have most of the electrons in the excited state. So that we can get more photons through stimulated emission. Thus a population inversion.

The condition of having enough excited or higher energy states distributed in a material, that a chain-reaction of stimulated emission can occur is called population inversion.

Comparision between laser light and light from an incandecent lamp.

LASER LIGHT	ORDINARY LIGHT
Has single wavelength (i.e) spectrally pure or Monochromatic.	Has a mixture of various wavelength i.e Polychromatic.
Coherent radiation i.e all photons are in Phase	Incoherent radiation.
High directionality	No Directionality.
Prevails over long distance	Does not prevail long.

Types of Laser.

There are Vaious kinds of lasers like solid state, [illegible], gas, liquid and semiconductor lasers. The different lasers and their applications are given below.

* Types of laser :

Solid state :

Ruby laser

YAG laser

Liquid laser :

Dye laser

He-Ne laser

Gas laser :

Argon ion laser

CO_2 gas laser

Semi conductor laser :

GaAlAs laser

InGaAsP laser

InGaAlP laser

There are the types of laser are available.

Advantages of Laser :

* Lasers are More intensive than any other Monochromatic source.

Metrology lasers are Low Power Instruments.

Lasers have wide dynamic range, Low optical cross talk and high contrast.

Lasers are highly Precise, accurate and can Prevail over long distance.

Lasers are allow fabrication of fine structure with high Quality avoidy mechanical stress.

Lasers facilitate rapid non-contact gaging of soft, delicate or hot moving parts.

Applications :-

Manufacturing :-

for high Quality cutting, drilling, welding and surface treatment etc.,.

Metrology :-

for Contact measurement of Parts, for Long distance range finding and Navigation, for scanning bar codes etc.,.

Medical :-

for surgery, kidney stone, treatment, eye treatment, in dentistry, for diagonosis like laser Microscopy.

Data storage :-

for optical data storage eg: compact disk, CD, DVD, etc) for holography.

Communication :-

for optial fibre communication, for free space communication, (eg Inter satellite communications).

SCANNING LASER GAUGE :-

A scanning laser gauge or non-contact dimensional Measurements.

The main component in a scanning laser gauge are

Transmitting Unit

Photo cell (receiver)

Microprocessor a Control Unit.

Signal from the light entering the photocell is process by a microprocessor to provide display of the dimension.

The scanning laser gauge is used to measure the roundness and diameter of hot steel bars. It provides an accuracy of 0.025 mm for 5-25 mm diameter objects and offers a :

Laser Telemetric System :-

Laser telemetric system is used for high speed, Non contact dimensional and positional Measurement and Control. The system Measures Outside diameters, multiple dimensions or part positions of either opaque or transparent Object.

The laser telemetric system consist of three component : Transmitter, reciever and Processor eletronics.

Photo Diode Array Imaging :-

This system consist of a laser source, Imaging optics, photodiode array, Signal Processor and display Unit. Here, the shadow of a stationary part is Projected on a solid state diode array image sensor.

INTERFERENCE :-

The phenomenon in which two waves of greater or lower amplitude is called Interference.

Principle of Superposition :-

When two or more waves of the same type are incident at the same point, then the total displacement at that point is equal to the vector sum of the displacement of the individual waves.

On the other hand, if they are out of phase, the resultant wave amplitude is the difference of the individual amplitudes which results in decreased brightness.

If the amplitude of both the waves are same, than they nullify each other. and other will recent its darkness.

The conditions necessary for the interference of light waves at a place are

The source should continuously emit waves of the same wavelength or frequency

The amplitudes of the two interfering waves should be equal or nearly for obtaining interference fringes.

The surfaces must be reflective

The source should be narrow.

INTERFEROMETRY :-

Metre was defined as the distance between two finely engraved lines on the Platinum Iridium bar.

In order to reduce the dependence on the physical standard, the process which was prone to errors, the wave length of pure monochromatic light is used as the Natural standard of length.

Interferometer :-

It is an Instrument used to generate and compare the difference between two light waves which are reflected off two different surface. It utilizes the effect of interference.

Applications of Interferometers :-

Measurements of Lengths and small changes in lengths.

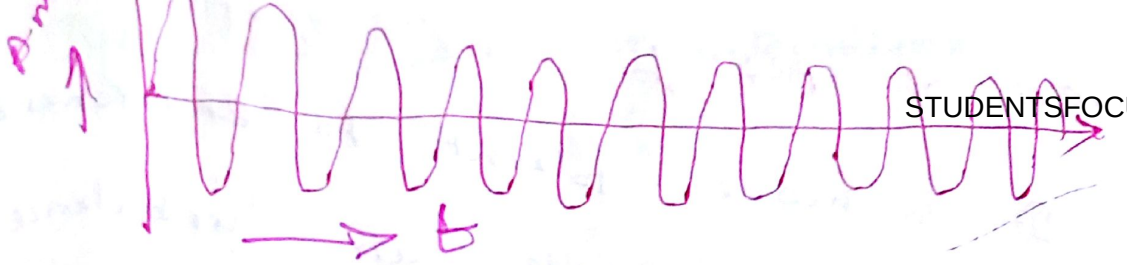
Optical testing.

Studies of surface structures

Wavelength measurement.

Ac laser Interferometry :-

A D.C Interferometer system mixes out of phase light beams of the same frequency where as the a.c system mixes beams of two slightly different frequencies, Permitting the distance information to be carried on a.c Wave form.



The envelope frequency is given by the difference of the two frequency component $(F_1 - F_2)$ of the source radiation.

So, an A.C Laser interferometer measures mirror displacement by measuring the phase change due to the doppler effect. It gives a much improved signal to noise ratio over amplitude modulation.

Description of A.C Laser Interferometer.

1. Two frequency laser source.
2. Optical Elements.
   (i) Beam splitters.
   (ii) Beam Benders.
   (iii) Retro reflectors.
3. Laser head & measurements reciver.
4. Measurement display.

Advantages of ACFI :

It is more tolerant to environmental factors like dust, smoke, air turbulence, etc that attenuate laser beam intensity.

It has high repeatability and resolution of displacement measurement.

It has high accuracy of measurement.

It facilitates to maintain long Range optical path (60 m).

It is easy to Install.

Alignment is good.

Laser Interferometry :

Conventional light source emit waves of differing frequencies and at different time from different point in the source. Hence they are not suitable for obtaing interference fringes. Laser device produce intense beam of light which are monochromatic coherent and highly collimated.

Types of Laser Interferometer :-

Homodyne or Single - frequency (or) DC Laser

Heterodyne (or) Dual - frequency or AC Laser Interferometer.

Single frequency DC Interferometer :-

For two beams of light to interfere, the beams must have same Polarization state. A Polaroides transmit only a single Polarization state.

The orientation of the transmitted Polarization state is based on the angle of the Polarizer.

Change the Polarization state of light. eg :- from horizontal to Vertical.

A Polarization beam splitter seperates the source into beams with opposite polarization stated referred to as the reference and measurement legs.

The homodyne or simple frequency DC interferometer is an improved version of the Michelson Interferometer.

Co ordinate Measuring Machine :-

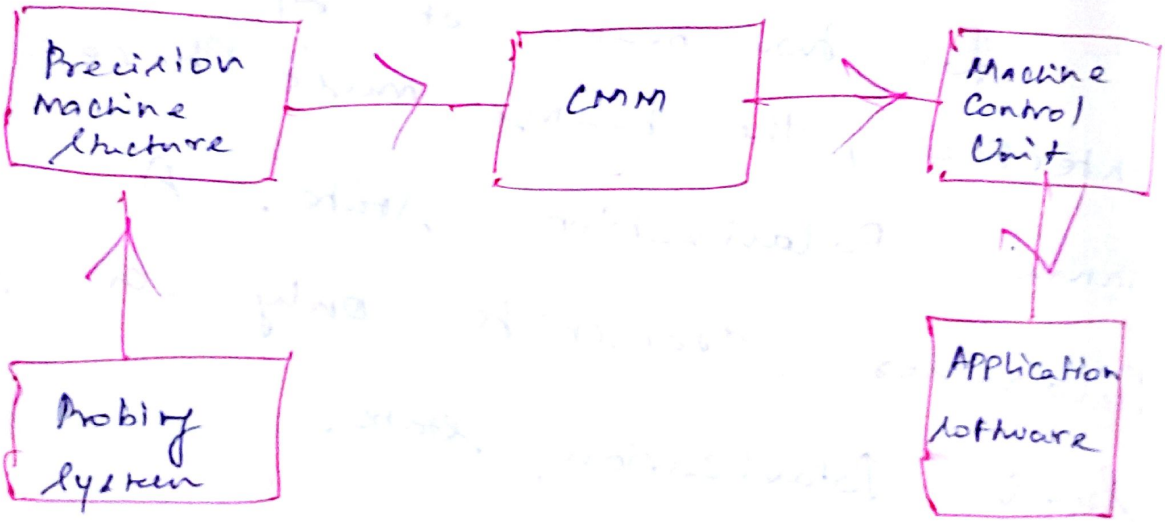


Diagram of Coordinat measuring system.

A Coordinate measuring system machine consits mainly of four elements. They are,

* The Main structure including the area of motion,
* The Probing system,
* The Machine controller and Computer hardware.
* Suitable Application software

Types of CMM :-

Cmm are classified as follows :-

1. According to Control system
   (i) Manual Cmm or Fixed Probing Cmm
   (ii) Computer Numerical Control (CNC) (or) Direct Computer Control (DCC)
2. According to design or Main structure or Orientation of Probe arm
   (i) Bridge type
   (ii) Cantilever type.
   (iii) Column type
   (iv) Gantry type.
   (v) Horizontal type

Accordy to Mounting Speed.

(i) Bench top.

(ii) Free standing.

(iii) Portable and Hand Held.

Advantage of CMM :-

* Reduced inspection cycle time.
* Flexiability.
* Reduce operator error
* Improved accuray and Precisions.
* Improved Productivity.

PROBES :-

CMM Measure work place dimensions by moving a sensing device, called a Probe.

The Probes convert Physical measurements into electrical signals using various measuring systems with the Probe structure.

Common Probes Fall into two general Categories.

* Tactile (or) Contact Probes.
* Non-Contact Probes.

Contact Probes :

It means touching, gather data by physically touching the workpiece in the acquisition of the measured point takes place by probe with Stylus. Contact probes are classified.

* Hard (or) Fixed Probes.
* Touch Trigger Probes.
* Measuring type (or) displacement Probe.

Non - Contact Probes :-

Non Contact probe also called Proximity Probes are used when fast, accurate measurements are required with no physical contact with the part.

These probes enable the measurement of flexible parts that, soft material and coronary might be distorted with a contact probe.

Applications of CMM :-

To check dimensional Accuracy of parts in various steps of production and of parts supplied by vendor.

To inspect test equipment, gauges and tools.

To determine shape and position, Minimum metal condition, Linkage of results, etc., which conventional machine can not perform.

Machine Vision :-

Machine Vision is the ability of a computer to 'see'. Machine Vision is also called as 'Artifical Vision'. (or) Computer Vision. It is defind as a Technique which allow a sensor to view a sence and drive a numerical or logical decision without further human intervention.