EI-015 FIBER OPTICS AND LASER INSTRUMENTS

UNIT I

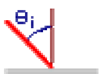
1.What is incident and reflected light?

Incident Light:Light approaching a surface is known as *incident* light. This is the incoming light before it has reached the surface.

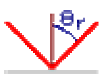
Reflected Light: After light has struck a surface and bounced off, it is known as *reflected* light. This is the light that is now departing from the surface.

2. What is angle of incidence and angle of reflection?

angle of incidence: The angle between an incident ray and the normal to a reflecting or refracting surface. The angle at which a ray of light approaches a surface, reflective or not, is called the *angle of incidence*. It is measured from an imaginary line perpendicular to the plane of the surface in question to the incoming ray of light.



3. Angle of Reflection: Once the light has reflected from a reflective surface, the angle at which the light departs from the surface is called the *angle of reflection*. This angle is also measured from a perpendicular to the reflecting surface to the departing ray of light.



When light reflects from a surface, the angle of reflection is always equal to the angle of incidence.

4. Define critical angle?

In geometric optics, at a refractive boundary, the smallest angle of incidence at which total internal reflection occurs. The angle of incidence is measured with respect to the normal at the refractive boundary.The critical angle is given by

$$\theta_c = \sin^{-1}\left(\frac{n_1}{n_2}\right) ,$$

where θ_c is the critical angle, n_1 is the refractive index of the less dense medium, and n_2 is the refractive index of the denser medium. *Note 3:* The incident ray is in the denser medium. *Note 4:* If the incident ray is precisely at the critical angle, the refracted ray is tangent to the boundary at the point of incidence.

5. What is fiber optics?

Fiber optics is a medium for carrying information from one point to another in the form of light. Unlike the copper form of transmission, fiber optics is not electrical in nature. A basic fiber optic system consists of a transmitting device, which generates the light signal; an optical fiber cable, which carries the light; and a receiver, which accepts the light signal transmitted. The fiber itself is passive and does not contain any active, generative properties.

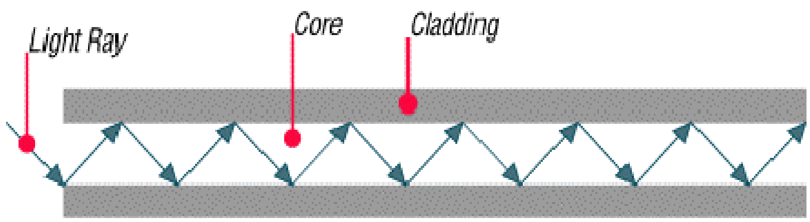
6. What is bandwidth and wavelength?

Bandwidth: Measure of the information-carrying capacity of an optical fiber

Wavelength: The distance between two successive points of an electromagnetic waveform, usually measured in nanometers (nm).

7. What is total internal reflection?

The reflection that occurs when light, in a higher refractive-index medium, strikes an interface, with a medium with a lower refractive index, at an angle of incidence (with respect to the normal) greater than the critical angle. When a light ray traveling in one material hits a different material and reflects back into the original material without any loss of light, total internal reflection occurs.



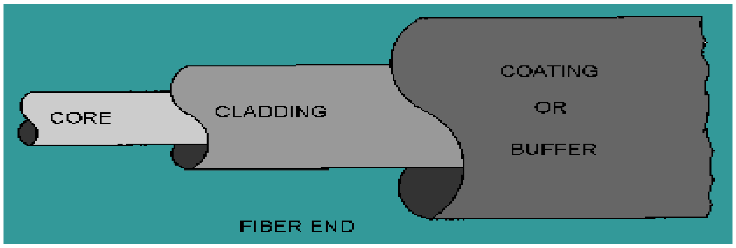
Since the core and cladding are constructed from different compositions of glass, theoretically, light entering the core is confined to the boundaries of the core because it reflects back whenever it hits the cladding. For total internal reflection to occur, the index of refraction of the core must be higher than that of the cladding.

8. Define waveguide?

A material medium that confines and guides a propagating electromagnetic wave. In the optical regime, a waveguide used as a long transmission line consists of a solid dielectric filament (optical fiber), usually circular in cross section. In integrated optical circuits an optical waveguide may consist of a thin dielectric film.

9. What are the three basic parts of a optical fiber?

The CORE, CLADDING, and COATING or BUFFER are the three basic parts of an optical fiber.

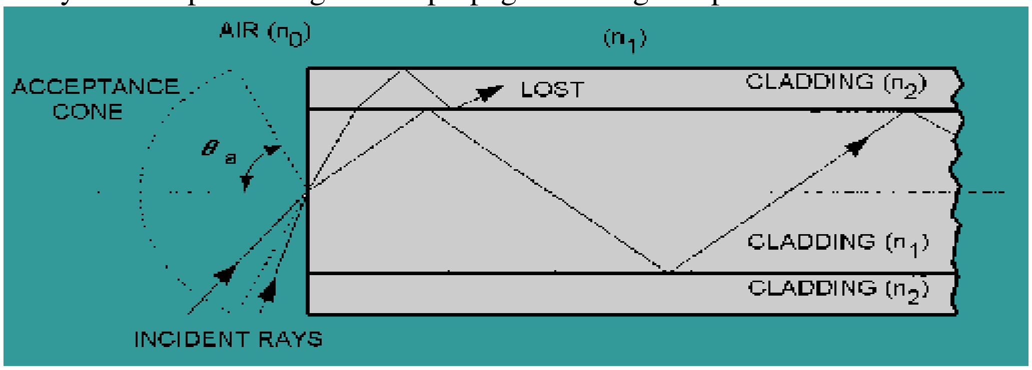


10. What are the two basic modes of fibers?

Fibers are classified by the number of modes that propagate along the optical fiber. Single mode fibers propagate only one mode because the core size approaches the operational wavelength. Multimode fibers can propagate over 100 modes depending on the core size and numerical aperture.

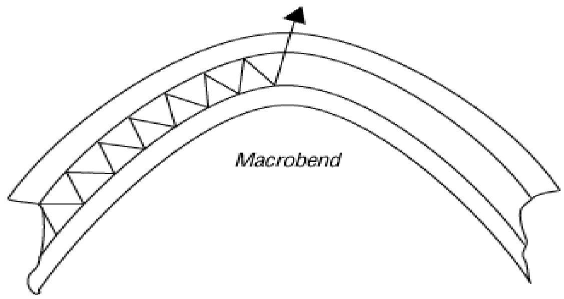
11.What is acceptance angle and acceptance cone?

The maximum angle ‘θ_a’ with which a ray of light can enter through the entrance end of the fiber and still be totally internally reflected is called acceptance angle of the fiber .The light ray incident on the fiber core must be within the acceptance cone defined by the acceptance angle to be propagated along an optical fiber.



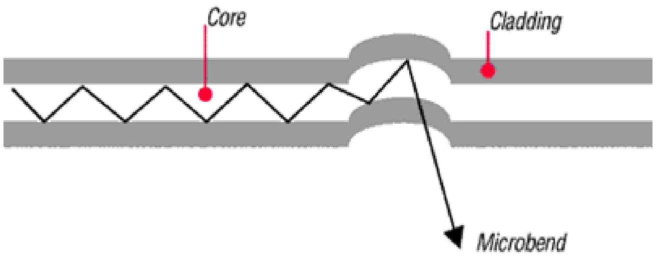
12. What is macro bending?

If a bend is imposed on an optical fiber, strain is placed on the fiber along the region that is bent. The bending strain will affect the refractive index and the critical angle of the light ray in that specific area. As a result, light traveling in the core can refract out, and loss occurs. A macrobend is a large-scale bend that is visible.



13. What is Microbending?

This is a small-scale distortion, generally indicative of pressure on the fiber. Microbending may be related to temperature, tensile stress, or crushing force. Like macrobending, microbending will cause a reduction of optical power in the glass. Microbending is very localized, and the bend may not be clearly visible upon inspection. With bare fiber, microbending may be reversible; in the cabling process, it may not.



14.What is a decibel?

Unit for measuring the relative strength of light signals. Normally expressed in dB, it is equal to one-tenth the common logarithm of the ratio of the two levels. Expressed in dBm when a power level is compared to a milliwatt.

15. What is **Zero-Dispersion Wavelength?**

Wavelength at which the chromatic dispersion of an optical fiber is zero; occurs when waveguide dispersion cancels out material dispersion.

16.Among microwaves and light waves, which have high bit rate distance product? Why?

Light waves have high bit rate distance product because light waves have high frequency (10^{14}hz) than microwave frequency (10^{11}hz) and information carrying capacity of an electromagnetic wave is directly proportional to its frequency.

17. Mention three specific communication based advantages of optical communication?

1. Due to frequency of light, more number of data can be sent per second.
2. Light waves have increased antenna gain or high s/n ratio since the signal energy received at the receiver is directly proportional to square of carrier frequency.
3. Light waves require antenna with small size due to their short wavelengths.
4. Light waves have negligible divergence due to smaller wavelengths.

18. Mention three advantages of optical fiber as waveguide over conventional metallic waveguide?

1. Optical fiber is made up of dielectric (glass) so there is no electromagnetic interference or cross talk.
2. Optical fiber cable is in small size with less weight. Hence it is flexible and it can be laid at any place without any congestion.
3. Optical fiber has low transmission loss. The transmittal signal through the fibers dose not radiate like metallic conductors.

19. What are the important elements in any communication system?

1. Transmitter to transmit the modulated carrier which carries information.
2. Transmission channel to carry to modulated carrier from one point to another point without loss and dispersion.
3. Receiver to detect or to separate the signal from carrier.

20. What is the necessity of cladding for an optical fiber?

a) To provide proper light guidance inside the core.
b) To avoid leakage of light from the fiber.
c) To give mechanical strength for the fiber.
d) To protect the core from scratches and other mechanical damages.

UNIT II

1.What are the properties that can be sensed using Fiber Optics?

The properties that can be sensed using Fiber Optics are,

- Acceleration
- Chemicals/Gases
- Color
- Displacement
- Flow
- Force
- Humidity
- Liquid Level
- Magnetic/Electric Fields
- Moisture
- Motion
- Position (linear, angular)
- Pressure (fluid, gas, etc.)
- Proximity
- Radiation
- Sound
- Speed
- State-of-Cure
- Strain
- Surface Condition
- Tactile Sensing
- Temperature
- Velocity
- Vibration
- Viscosity
- Weight

2.What is fiber optic gyroscope?

One of the more important fiber optic sensors is the fiber optic gyroscope, capable of measuring rotation rate. The principle of operation of the fiber optic gyroscope is based on the Sagnac effect.

3.What is a modulator?

Optical carrier waves can be modulated in Amplitude, Phase and Frequency in order to carry information. Modulators modulate the carrier wave by changing the material properties of attenuation ‘a’ and refractive index ‘n.’ In suitable materials a and n can be modulated at high frequencies by time dependent electrical fields (EO), magnetic fields (MO) or acoustic fields (AO). The external modulators produce much less chirp (dispersion) than eg. current-modulated SC-diode lasers.

4.What are the different types of modulators?

The different types of modulators are

a)Electro optic modulators,

b)Acousto optic modulators,

c)Magneto optic modulators.

d)Electro absorption modulators.

5. What is a acousto optic modulator?

An acousto-optic modulator (AOM) is a device which allows to control the power, frequency or spatial direction of a laser beam with an electrical drive signal. It is based on the acousto-optic effect, i.e., the modification of the refractive index by the oscillating mechanical pressure of a sound wave..

6. What are the important parameters of optical detectors?

i)Responsivity: Ratio of current output to light input. High responsivity equals high receiver sensitivity.

ii)Quantum Efficiency: Ratio of primary electron-hole pairs created by incident photons to the photons incident on the detector material.

ii)Capacitance: Dependent upon the active area of the device and the reverse voltage across the device.

iv)Response Time: Time needed for the photodiode to respond to optical inputs and produce and external current.

7. What is the principle of fiber optic sensor?

In a fiber optic sensor, one or more of the following characteristics of a propagating lightware is altered and correlated to an externally-induced physical or chemical parameter:

- Intensity
- Phase
- Frequency (color)
- Polarization state
- Time-of-flight
- Modal cross talk

8.What are the advantages of fiber optic sensor?

The advantages of fiber optic sensor are,

a)freedom from EMI,
b)Wide bandwidth,
c)Compactness,
d)geometric versatility and economy

9. What are laser diodes?

<u>Laser Diodes</u> are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. Five inherent properties make lasers attractive for use in fiber optics.

1. They are small.
2. They possess high radiance (i.e., They emit lots of light in a small area).
3. The emitting area is small, comparable to the dimensions of optical fibers.
4. They have a very long life, offering high reliability.
5. They can be modulated (turned off and on) at high speeds.

10. What is an LED?

LEDs are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. LEDs are of interest for fiber optics because of five inherent characteristics:

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11. Differentiate between the characteristics of LED and LASER?

Table 1 - Comparison of LEDs and Lasers

Characteristic	LEDs	Lasers
Output Power	Linearly proportional to drive current	Proportional to current above the threshold
Current	Drive Current: 50 to 100 mA Peak	Threshold Current: 5 to 40 mA
Coupled Power	Moderate	High
Speed	Slower	Faster
Output Pattern	Higher	Lower
Bandwidth	Moderate	High
Wavelengths Available	0.66 to 1.65 µm	0.78 to 1.65 µm
Spectral Width	Wider (40-190 nm FWHM)	Narrower (0.00001 nm to 10 nm FWHM)
Fiber Type	Multimode Only	SM, MM
Ease of Use	Easier	Harder
Lifetime	Longer	Long

12. What are the classification of fiber optic sensors?

i)Based on modulation and demodulation process:

Sensor can be called as an intensity (amplitude), a phase, a frequency, or a polarization sensor

ii)Based on their applications:

a)Physical sensors (e.g. measurement of temperature, stress, etc.);
b)chemical sensors (e.g. measurement of pH content, gas analysis, spectroscopic studies, etc.);
c)bio-medical sensors

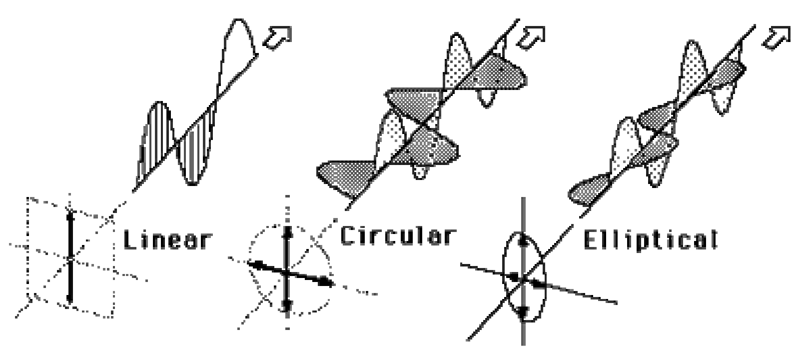
iii) Extrinsic or intrinsic sensors

13. What is extrinsic and intrinsic sensors?

In the extrinsic sensor, sensing takes place in a region outside of the fiber and the fiber essentially serves as a conduit for the to-and-fro transmission of light to the sensing region efficiently and in a desired form. The fiber merely acts as a light delivery and collection system, i.e., the propagating light leaves the fiber, is altered in some way, and is collected by the same (or another) fiber. On the other hand, in an intrinsic sensor one or more of the physical properties of the fiber undergo a change as mentioned in A) above. The fiber itself acts as the sensing medium, i.e., the propagating light never leaves the fiber and is altered in some way by an external phenomenon.

14.What is polarization?

Polarization is a phenomenon peculiar to transverse waves, i.e., waves that vibrate in a direction perpendicular to their direction of propagation. Light is a transverse electromagnetic wave (see electromagnetic radiation). Thus a light wave traveling forward can vibrate up and down (in the vertical plane), from side to side (in the horizontal plane), or in an intermediate direction. Ordinarily a ray of light consists of a mixture of waves vibrating in all the directions perpendicular to its line of propagation. If for some reason the vibration remains constant in direction, the light is said to be polarized.



15. What are Interferometric sensors?

An interferometric sensor is based on the detection of changes in the phase of light emerging out of a single mode fiber. In the case of a fiber the phase change in general is given by, $\mathbf{\Delta\Phi = \Delta\Phi_L + \Delta\Phi_n + \Delta\Phi_g}$ where the three phase terms on the RHS are due to the length, the index and the guide geometry variations, respectively. The phase change is converted into an intensity change using interferometric schemes (Mach-Zehnder, Michelson, Fabry-Perot or Sagnac forms).

16. What is a Fiber Optic Polarimeter?

The birefringence property arising from optical anisotropy is used in the study of photoelastic behaviour . The anisotropy may be due to naturally occuring crystalline properties or due to stress induced birefringence. It is the latter that is used in a photoelastic fiber optic strain gauge. In a simple setup two lead fibers are used to illuminate and collect light passing through a photoelastic specimen. A pair of linear polarizers is used in the crossed form to obtain a conventional polariscope. In such a case the intensity at each point on the specimen is given by $I = I_o \sin^2 2\theta \sin^2\alpha /2$where I_0 is the total light intensity and θ is the angle that the principal stress directions make with respect to the axes of the polarisers

17. What is Pockels effect?

Pockels effect refers to the change of refractive index of the medium by the applied electric field. Due to phase shift or phase retardation is produced in the transmitted polarized light and hence there in a change in the intensity of the transmitted light.

18.What are the laser diode performance characteristics?

The performance characteristics of laser diodes are,

a)Peak wavelength
b)Spectral width
c)Emission pattern
d)Power
e)Linearity

19. What is Kerr effect?

Kerr effect (or quadratic electro-optic effect, QEO effect): change in the refractive index proportional to the square of the electric field. All materials display the Kerr effect, with varying magnitudes, but it is generally much weaker than the Pockels effect.

20. What is the principle of micro bending sensor?

Micro bending sensor is based on the production of micro bending in the fiber by the given variable and the measurement of intensity of the transmitted light through the fiber. The micro bending produces phase shift and coupling between different modes present in the transmitted light. This will lead to reduction in intensity of the transmitted light.

UNIT III

LASER FUNDAMENTALS

1. What is meant by coherence in laser light?

A coherent light is pure sine wave and during its transmission it can maintain constant phase difference between any two points in space as well as in a given time interval at any point along the transmission path. Thus it is traveling in a continuous manner without undergoing abrupt change in phase. Thus the laser light is a coherent light.

2. Which gives the special characteristics for laser light?

Stimulated emission is responsible for the characteristics of laser light. Stimulated emission means the emission of light photon by the stimulation of an atom to undergo laser transition through a phase whose energy is equal to the emitted photon's energy or equal to the energy difference between the laser transition levels.

3. What is modelocking? Give the principle of modelocking?

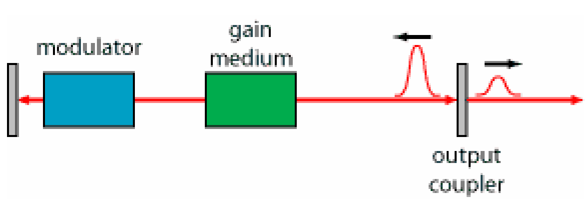
Modelocking is a technique in optics by which a laser can be made to produce pulses of light of extremely short duration, on the order of picoseconds (10^{-12}s) or femtoseconds (10^{-15}s).The basis of the technique is to induce a fixed phase relationship between the modes of the laser's resonant cavity. The laser is then said to be phase-locked or mode-locked. Interference between these modes causes the laser light to be produced as a train of pulses. Depending on the properties of the laser, these pulses may be of extremely brief duration, as short as a few femtoseconds.

4. What are the different Modelocking methods

Methods for producing modelocking in a laser may be classified as either active or passive. Active methods typically involve using an external signal to induce a modulation of the intra-cavity light. Passive methods do not use an external signal, but rely on placing some element into the laser cavity which causes self-modulation of the light

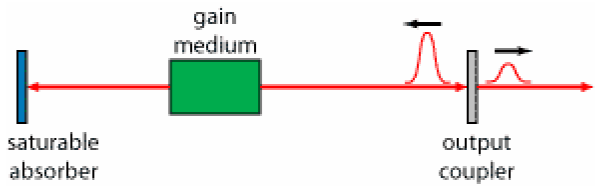
5. What is active modelocking?

The most common active modelocking technique places a standing wave acousto-optic modulator into the laser cavity. When driven with an electrical signal, this produces a sinusoidal amplitude modulation of the light in the cavity.



6.What is passive modelocking?

Passive mode-locking techniques are those that do not require a signal external to the laser (such as the driving signal of a modulator) to produce pulses. Rather, they use the light in the cavity to cause a change in some intracavity element, which will then itself produce a change in the intracavity light. The most common type of device which will do this is a saturable absorber.



7. What is Q switching?

Q-switching, sometimes known as giant pulse formation, is a technique by which a laser can be made to produce a pulsed output beam. The technique allows the production of light pulses with extremely high (gigawatt) peak power, much higher than would be produced by the same laser if it were operating in a continuous wave (constant output) mode. Compared to modelocking, another technique for pulse generation with lasers, Q-switching leads to much lower pulse repetition rates, much higher pulse energies, and much longer pulse durations. Both techniques are sometimes applied at once .

8. What is the principle of Q-switching

Q-switching is achieved by putting some type of variable attenuator inside the laser's optical resonator. When the attenuator is functioning, light which leaves the gain medium does not return, and lasing cannot begin. This attenuation inside the cavity corresponds to a decrease in the Q factor or quality factor of the optical resonator. A high Q factor corresponds to low resonator losses per roundtrip, and vice versa. The variable attenuator is commonly called a "Q-switch", when used for this purpose.

9. What is Active Q-switching?

Here, the Q-switch is an externally-controlled variable attenuator. This may be a mechanical device (e.g. a shutter, chopper wheel or spinning mirror placed inside the cavity), or (more commonly) some form of modulator such as an acousto-optic device or an electro-optic device—a Pockels cell or Kerr cell. The reduction of losses (increase of Q) is triggered by an external event, typically an electrical signal. The pulse repetition rate can therefore be externally controlled.

10. What is Passive Q-switching?

In this case, the Q-switch is a saturable absorber, e.g. an ion-doped crystal material (e.g. Cr:YAG for Q-switching of Nd:YAG lasers), a bleachable die, or a passive semiconductor device. Initially, the loss of the absorber is high, but still low enough to permit some lasing once a large amount of energy is stored in the gain medium. As the laser power increases, it saturates the absorber, i.e., rapidly reduces the resonator loss, so that the power can increase even faster.

11. What are the applications of Q switching?

Q-switched lasers are often used in applications which demand high laser intensities in nanosecond pulses, such as dentistry, metal cutting or pulsed holography. However, Q-switched lasers can also be used for measurement purposes, e.g. for distance measurements (range finding) by measuring the time it takes for the pulse to get to some target and the reflected light to get back to the sender.

12.What is dye laser?

Dye lasers use an organic dye as the gain medium. The wide gain spectrum of available dyes allows these lasers to be highly tunable, or to produce very short-duration pulses (on the order of a few femtoseconds).

13.What is solid-state lasers?

Solid state laser materials are commonly made by doping a crystalline solid host with ions that provide the required energy states. For example, the first working laser was made from ruby, or chromium-doped sapphire. Another common type is made from Neodymium-doped yttrium aluminium garnet (YAG), known as Nd:YAG. Nd:YAG lasers can produce high powers in the infrared spectrum at 1064 nm. They are used for cutting, welding and marking of metals and other materials, and also in spectroscopy and for pumping dye lasers. Nd:YAG lasers are also commonly frequency doubled to produce 532 nm when a visible (green) coherent source is required.

14.What is free electron laser?

Free electron lasers such as in figure have the ability to generate wavelengths from the microwave to the X-ray region. They operate by having an electron beam in an optical cavity pass through a wiggler magnetic field. The change in direction exerted by the magnetic field on the electrons causes them to emit photons.

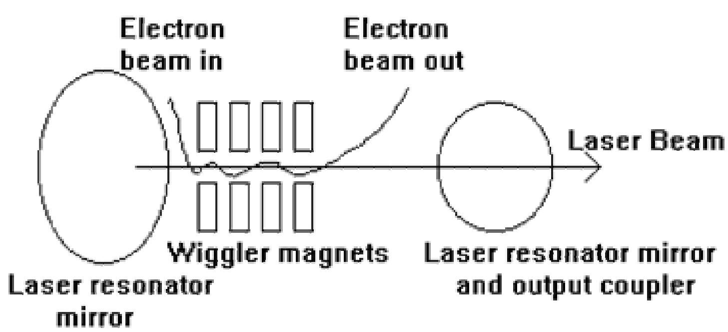


Figure Free Electron Laser Diagram

15.What is gas laser?

Gas lasers consist of a gas filled tube placed in the laser cavity. A voltage (the external pump source) is applied to the tube to excite the atoms in the gas to a population inversion. The light emitted from this type of laser is normally continuous wave (CW). One should note that if brewster angle windows are attached to the gas discharge tube, some laser radiation may be reflected out the side of the laser cavity. Large gas lasers known as gas dynamic lasers use a combustion chamber and supersonic nozzle for population inversion.

16. What is meant by quantum well laser?

Quantum well laser cavity has dimensions of 50-100À.They have low threshold current.

17. Why gain guided lasers are not in practice?
Due to their instability, higher spectral width and highly astigmatic, they are not used.

18. What are the merits of index guided lasers?
a) Highly stable
b) Optical confinement is very high.
c) Very narrow spectral width
d) High directionality

19.Why do we prefer injection laser for long haul operation?
It has narrow spectral width. It's power level is in the range of 1 to 10 mW.It has high directional coherent radiation. Threshold current is in the range of 20 to 300mA.It has better linearity with the power output with driven current. Since it has higher wavelength, the bandwidth length product of a transmission line can also be increased.

20. What is Brewster Windows?
- Windows at the ends of a gas laser, used to produce polarized electromagnetic radiation. The window is at Brewster angle to the optical axis of the laser, so only one type of polarization can pass through.

21.What is Beam Divergence ?
Beam Divergence is the angle of beam spread, measured in (milli)radians. Can be approximated for small angle by the ratio of the beam diameter to the distance from the laser aperture.

22. What is Ion Laser?
Ion laser is a laser in which the active medium is composed of ions of a Nobel gas (like Ar+ or Kr+). The gas is usually excited by high discharge voltage at the ends of a small bore tube.

23.What is Irradiance (E)
Irradiance is the radiant flux (radiant power) per unit area incident upon a given surface. Units: Watts per square centimeter. (Sometimes referred to as power density, although not exactly correct).

24. What is Laser Rod ?
- A solid-state, rod-shaped active medium in which ion excitation is caused by a source of intense light (optical pumping), such as a flash lamp. Various materials are used for the rod, the earliest of which was synthetic ruby crystal (see Solid State Laser).

25. What is Laser Pulse ?

A discontinuous burst of laser radiation, as opposed to a continuous beam. A true laser pulse achieves higher peak powers than that attainable in a CW output.

1. What are industrial lasers?

Lasers having high beam power (>1MW) and very narrow pulse width ($<10^{-9s}$) are called industrial lasers. For example mode locked or Q-switched Nd YAG laser and CO_2 laser are the industrial lasers.

2. What are the industrial applications of lasers?

a) Surface alloying and surface cladding can be done using lasers to improve the hardness, water resistance, wear resistance, corrosion resistance and fatigue strength of the surface of the engineering components.

b) Using lasers welding, cutting and drilling can be done in a precious manner with less heat-affected zone. These can be done at a faster rate.

3. What are the uses of shielding gas during material processing by lasers?

a) It is used to remove the molten material and to favor vaporization.
b) It is used to provide cooling effect.
c) It is used to protect the focusing optical arrangement against smoke and fumes.
d) It is used to increase the absorption of laser energy by the material.

4. What are the two modes of laser welding process?

a) Conduction limited welding by low power lasers
b) Deep penetration welding by high power lasers.

5. What are the advantages of laser welding, cutting and drilling?

a) Heat affected zone is very narrow.
b) The material processing can be done even at room temperature.
c) Difficult materials like titanium, quartz and ceramics can be welded, cut or drilled.
d) Higher welding speed or cutting speed can be achieved.
e) There is minimum residual stress and distortion.

6. What are the techniques uses for distance measurement using Laser?

The most common application of laser is distance measurement. Direct optical interferometry is used over short distances and beam modulation echo pulse technique is used for long distances.

7.What is the principle of velocity measurement using laser?

Measurements of the velocity of the fluid can be made by laser Doppler effect. The frequency of the scattered light is slightly Doppler shifted and it is proportional to the fluid velocity.

8.What is Doppler effect?

The Doppler effect, is the apparent change in frequency or wavelength of a wave that is perceived by an observer moving relative to the source of the waves. For waves, such as sound waves, that propagate in a wave medium, the velocity of the observer and the source are reckoned relative to the medium in which the waves are transmitted The total Doppler effect may therefore result from either motion of the source or motion of the observer. Each of these effects is analyzed separately. For waves which do not require a medium, such as light or gravity in special relativity only the relative difference in velocity between the observer and the source needs to be considered.

9.What is laser cutting?

Laser cutting is a technology which uses a laser to cut materials, and is usually used in industrial manufacturing.Laser cutting works by directing the output of a high power laser at the material to be cut. The material then either melts, burns or vaporizes away leaving an edge with a high quality surface finish. The most popular lasers for cutting materials are CO_2 and Nd:YAG, though semiconductor lasers are gaining prominence due to greater efficiency.

10. What are the advantages of laser cutting?

Advantages of laser cutting over mechanical cutting vary according to the situation, but important factors are: lack of physical contact (since there is no cutting edge which can become contaminated by the material or contaminate the material), and to some extent precision (since there is no wear on the laser). There is also a reduced chance of warping the material that is being cut as laser systems have a small heat affected zone. Disadvantages of laser cutting may include the high energy required

11.What is laser welding?

Laser beam welding is a technique in manufacturing whereby two or more pieces of material (usually metal) are joined by together through use of a laser beam.The laser beam is a coherent (single phase) light of a single wavelength (monochromatic). The laser beam has low beam divergence and high energy content and thus will create heat when it strikes a surface.

12.What is a laser rangefinder?

A laser range-finder is a device consisting of a pulsed laser and a light detector. By measuring the time taken for light to reflect off a far object, and knowing the speed of light, the range to the object can be found. A laser rangefinder is thus a simple form of LIDAR. The distance to the target can then be used to aim a weapon such as a tank's main gun.

13.What is laser heat treatment?

Heat treatments for hardening or annealing have been long practiced in metallurgy. But lasers offer some new possibilities for selective heat treatments of metal parts. For example, lasers can provide localized heat treatments such as the hardening of the surfaces of automobile camshafts. These shafts are manufactured to high precision, and if the entire camshaft is heat treated, some warping will inevitably occur. But the working surfaces of the cams can be heated quickly with a carbon dioxide laser and hardened without appreciably affecting the remainder of the shaft, preserving the precision of manufacture.

14. What are the advantages of laser material processing?

The main advantages of lasers for material processing are:

- Very high accuracy in the final processed products that can be obtained without the need for polishing.

- No wearing of mechanical tools. Mechanical tools change their dimensions during the working process, and require constant measurements and feedback to adapt their position to original plan in computerized instrumentation.

15. What is hardening?

Hardening is the process of heating specific areas of the material. When laser hardening is done the laser irradiates the work area and causes very quick heating of a thin layer of material near the surface. When the laser beam is removed form the heated area, the area gets cooled abruptly due to heat transfer by conduction. The cooling creates hardness of the material which occurs by metallurgical transformation.

16. What are the types of laser hardening techniques?

i)Shock hardening,
ii)Surface glazing,
iii)Surface alloying.

17. What is shock hardening?

In this method a shock pulse of very high peak power density of more than 10^9 W/cm^2 is made incident on the surface. This produces rapid surface vaporization. This is accompanied by an absorption wave, which is supported by laser. This wave drives a shock front into the material. As the shock crosses the material, the material gets surface hardened.

18. What is laser glazing?

In this process the surface of the material gets melted by the CO_2 laser. When he laser beam moves away from the spot, there occurs a rapid solidification, which results in surface microstructure with unique characteristics. Since the rate of quenching is quite rapid, the size of the grains near the surface is quite tiny. The surface appears to be glassy and this process is known as ‘surface glazing’.

19. What is mechanism of interaction between the laser beam and the processed material?

The mechanism of interaction between the laser beam and the processed material:

- Thermal Effects - Most of the applications of lasers in material processing were based on the absorption of the laser radiation inside the material, and the effects were thermal in nature. The absorption process transfers energy to the material. As a result, there is a rise in the temperature in that region to high temperatures.
- Photochemical Effects - Breaking the bonds between the molecules in the material. The Excimer laser (see chapter 6.1.7) emits in the Ultra-Violet (VU) part of the electromagnetic spectrum, and its photons are very energetic. It can be used to cut very delicate and accurate structures without causing thermal damage to surrounding areas.

20.What is the principle of laser gyroscope?

The principle of Operation of Optical Gyroscope is that Two laser beams are moving in opposite directions in the same ring path. Any change in the direction of the system will cause a difference in the path of these two beams. By using inteferometric measurements (see chapter 10), it is possible to detect very small changes, so the laser gyroscope is a very sensitive device.

UNIT V

1. What are the different laser interactions with tissues?
a) Photo chemical processes b) Thermal processes c) photo ablative processes and d) Electromechanical processes. Above processes are greatly utilized for diagnosis, therapy and surgery

2. Discuss the effect of photo thermal processes in tissues?
Photo thermal processes are used to increase the temperature of tissues

At 60^0C, there is protein denaturation and coagulation
At 80^0C , there is collagen denaturation.
At 300^0C, there is vaporization and ablation.
At 500^0C, there is carbonization and tissue burning.

3. What are the advantages of laser surgery?
The Advantages of Laser Surgery:

- Dry field of surgery, because laser energy seals small blood vessels.
- Less postoperative pain, because of the sealing of nerve ends.
- No contact with mechanical instruments, so sterilization is built in.
- Clear field of view, because no mechanical instrument blocks it.
- Possible wavelength specific reaction of specific colors of biological tissue.
- Possibility to perform microsurgery under a microscope. The laser beam passes through the same microscope.
- Possibility to perform surgical procedures inside the body without opening it, using optical fibers to transmit the laser beam.
- The laser can be used as a precise cutting tool.
- It can be controlled by a computer, and operate with a very small area of effect under a microscope.

4. Mention the names of some lasers and their main use with respect to medical field?
a) Argon ion laser: It is used to do photocoagulation of retinal bleeding since its wavelength (0.48 µm, 0.5145 µm) is highly absorbed by retinal tissues.
b) Carbon dioxide laser: It is used to do neuro surgery like removal of brain tumor.
c) Nd YAG laser: It is used to do kidney stone extrusion and to do angioplasty

5. What are endoscopes?
The endoscopes or fiberoscopes are the optical instruments used in hospitals for diagnosis, treatment of diseases and surgery. In each endoscope there are two optical fiber bundles, one is used to illuminate the inner structure of the object and other is used to collect the reflected light from the area from which we can view the image of the object.
Examples:
a) Laparoscopes, used to do family planning operation.
b) Cardio scopes used to view the valvular defects and septal defects

6. What is holography?

Holography is the process of three dimensional image constructions by recording and reconstruction of hologram by means of interference techniques without the aid of lenses

7. Distinguish between a hologram and photographic film?

A hologram contains phase and amplitude information of reflected light from an object. But a photographic film contains only amplitude information. So that the three dimensional information of the object can be obtained only from the hologram.

8. What are the uses of holography?

a) It is used to store data with 100 percent security

b) Holographic non-destructive testing is used to view the stress distribution in a pipefitting or wheel and the nature of deformation of the surface of the engineering components.

c) It is used to obtain three-dimensional images of the objects.

9.What are the classifications of holograms?

a)Reflection and transmission holograms,
b)Thick (volume) and thin(surface) holograms,
c)Multiplexed holograms, *where several images are simultaneously stored,*
d)Colour holograms, *producing colour images*
e)White light holograms,
f)Computer generated holograms.

10. What are the applications of holography?

a)Holographic microscopy,
b)particle size analysis,
c)pulsed laser photography,
d)holographic memories

11. What is the application of holographic interferometry?

-used to measure vibrational amplitudes and deformations in a number of objects including biological specimens,
-used for recording the wave form from the object.
-finds wide application if holographic non destructive testing. (HNDT)

12.What is HNDT?

HNDT is a laser sensing technique for observing, with great detail, the changes in the surface of a part as it deforms under stress. The stress can arise from the gentle application of heat, pressure, mechanical stress, or vibration.

13.What is brain tumor?

A brain tumor is any intracranial mass created by an abnormal and uncontrolled growth of cells either normally found in the brain itself: neurons, glial cells (astrocytes, oligodendrocytes, ependymal cells), lymphatic tissue, blood vessels), in the cranial nerves (myelin producing Schwann cells), in the brain envelopes (meninges), skull, pituitary and pineal gland, or spread from cancers primarily located in other organs (metastatic tumors).

14. Write about the light propogation through a tissue?

Normally, when a laser beam is directed toward tissue, the resulting direct reflection accounts for only about 3% of the incident light. The remaining light goes into the tissue, where absorption and scattering take place.

15. What is the principle of medical applications of LASER?

The principle of the medical application of lasers is selective photothermolysis. The selective effect of laser light on biological tissue is obtained due to the monochromatic character of the light. If a particular wavelength is absorbed by the target tissue type, and transmitted, reflected or scattered by other surrounding tissues, the therapeutic effect may be achieved.

16.What is the role of laser in medical surgery?

Almost every medical surgery in which a removal of tissue is required or a cut needs to be made, can be done with a laser. Laser surgery is a type of surgery that uses special light beams instead of instruments for surgical procedures. Certain parts of the skin, called chromophones, absorb the light. When these chromophones absorb the light, physical, mechanical, chemical, or temperature changes may occur in the tissue. There are many different types of lasers, including the carbon dioxide laser, the YAG (neodymium, or yttrium aluminum garnet) laser, and the argon laser.

17. What are the areas of medical laser surgery where laser will be used?

The areas of medical laser surgery are well established, and include:

- Eye Treatment.
- General Surgery.
- Ear, Nose and Throat.
- Dentistry.
- Dermatology.
- Gastroenterology and colo-rectal.
- Plastic surgery.
- Gynecology.
- Urology.
- Oncology.
- Orthopedics.
- Neurosurgery.

18. How are lasers used during cancer surgery?

Laser surgery is a type of surgery that uses special light beams instead of instruments, such as scalpels, to perform surgical procedures. There are several different types of lasers, each with characteristics that perform specific functions during surgery. Laser light can be delivered either continuously or intermittently and can be used with fiber optics to treat areas of the body that are often difficult to access.

19.What is oncology?

Oncology is the medical subspecialty dealing with the study and treatment of cancer.Oncology is concerned with:

i)The diagnosis of cancer

ii)Therapy (e.g. surgery, chemotherapy, radiotherapy and other modalities)

iii)Follow-up of cancer patients after successful treatment

iv)Palliative care of patients with terminal malignancies .

20.What is photodynamic laser theraphy?

Photodynamic therapy (PDT) is a well-investigated locoregional cancer treatment in which a systemically administered photosensitizer is activated locally by illuminating the diseased tissue with light of suitable wavelength. PDT offers various treatment strategies in oncology, especially palliative ones.