LASER

The word laser is an acronym for “light amplification by stimulated emission of radiation”. It refers to the production of a beam of radiation.
An output power of less than 0.5 Watts is classed as Low Level Laser Therapy LLLT (class III in the USA) whereas lasers with an output powers greater than 500mW or 0.5 Watts are termed High Power Laser Therapy HPLT (Class IV lasers in the USA).
HPLT creates heat on the surface of the skin due to their higher power density (irradiance).
LLLT is often referred to as “Cold Lasers” since they do not cause heating or tissue damage during treatment.
Lasers with different wavelengths, varying from 632 to 904 nm, are used in the treatment of musculoskeletal disorders.

CHARACTERISTICS OF LASER:
Lasers are different from ordinary light by having following characteristics:

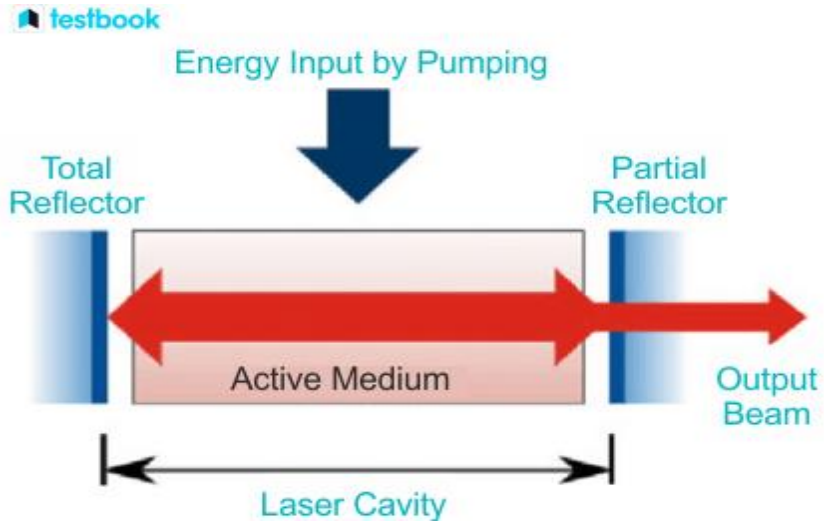
1. **Monochromaticity (of single colour):**
   Laser are of a single specific wavelength & hence of a defined frequency. In case of visible laser a single pure colour is produced. For e.g. Ruby laser gives a red light.

2. **Coherence (held together):**
   Laser radiation travel in same phase i.e. the peaks & troughs of electric & magnetic fields all occur at the same time. This is called **temporal coherence**. Furthermore they are all travelling in the same direction this is called **spatial coherence**. The distance over which the wavelength stays in phase is called coherence length. It varies from less than a mm to hundreds of meters.

3. **Collimation (in parallel beam):**
   As a result of spatial coherence laser remain in parallel beam. Because the radiations do not diverge the energy is propagated over very long distances.

PRINCIPLES OF WORKING/PRODUCTION OF LASER:

- Laser production requires four essential components i.e. an active medium (amplifying medium), mechanism for exciting the medium (pump), a fully reflective mirror & a partially reflective mirror that allows for some transmission of light & reflects rests.



- Lasers are referred by the type of active medium like HeNe or GaAs etc. The active medium is solid, liquid or gas that contains atoms, molecules or ions that are capable of storing energy which when stimulated release their energy as light. Any subsequent increase in light energy through lasing mechanism is known as **gain**.

- If an active medium is given additional energy for e.g. by heating or by passing electricity the outer electrons can be made to occupy higher energy levels. When outer electrons are in one of the higher energy levels they will tend to return to lower energy levels while returning from higher energy state to lower energy state or ground state it must give an additional energy & this is done by giving off a photon of radiation of same wavelength as the photon that was absorbed. Each step from one energy level to the next is known as **transition**.

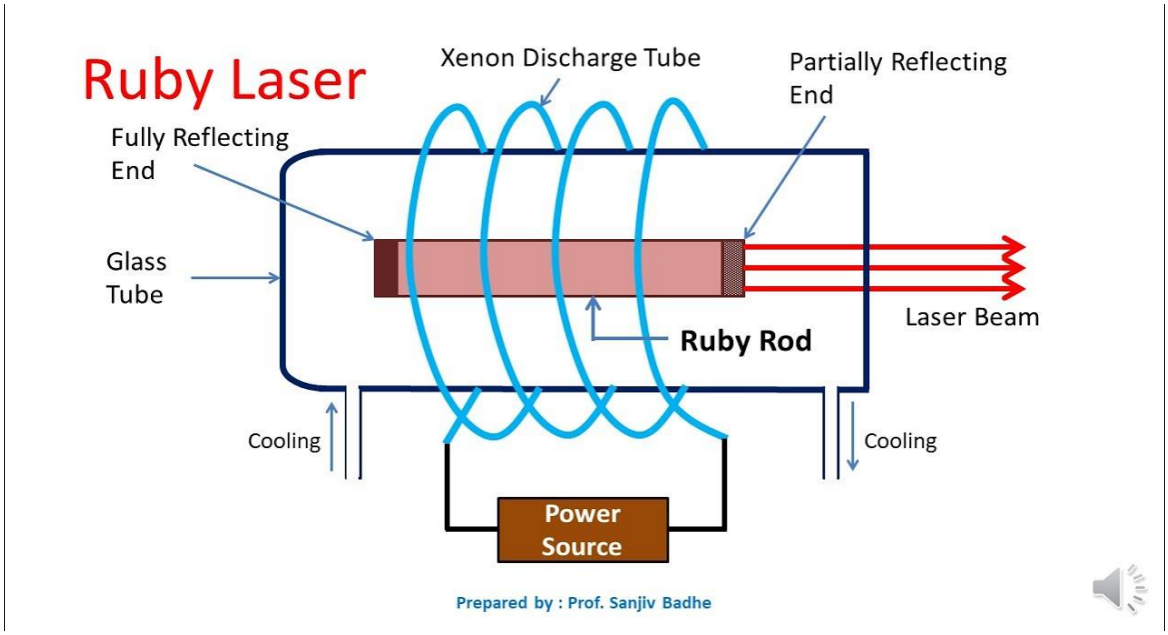
- When an electron is in higher energy state the atom is said to be excited & this state lasts for a very short period. There are some excitation levels in all the atoms from which electrons cannot easily leave spontaneously. Such electrons remain in their higher energy state for much longer times & are referred as **metastable state**.

- Photons themselves if absorbed can give energy to an atom this causes excitation & the photon is called stimulating photon. A large number of atoms which electrons in their excited state lead to amplification since one photon releases a second & these two can release two more & so on – **a kind of cascade or avalanche effect** occur. Having more atoms in the excited state or upper energy state than lower is called **population eversion**.

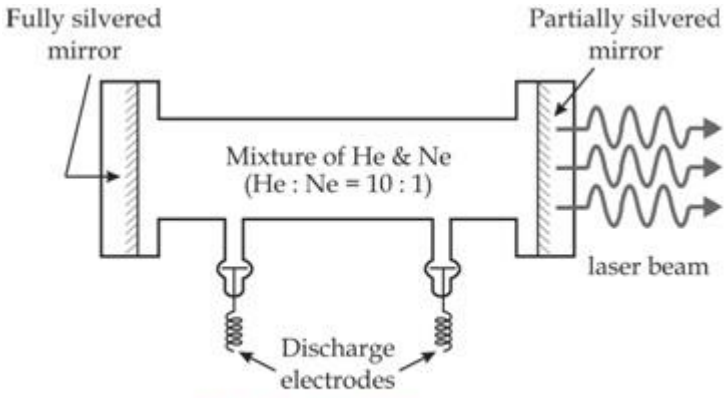
- The active medium located between two mirrors one reflects 100% of photons that strike it & other mirror is partially reflective. Photons that reflect off the mirror are reflected back into the medium for further amplification. Those photons that transmit through the partially reflective mirror forms laser output.

TYPES/ PRODUCTION OF LASER BY VARIOUS METHODS:

1. **RUBY LASER:**
   - This consists of a small synthetic ruby rod made up of aluminium oxide. A helical xenon flash tube wrapped around it gives an intense flash of light. Both ends of rod are made flat & silvered, one end being totally reflecting & the other partially transparent so that some radiation can be emitted.
   - This brief light pulse excites the ruby molecules & raises many electrons to higher levels which give photons on returning to the ground state. This photon if absorbed can give energy to an atom leads to excitation causing them to return to the ground state & so emitting an identical photons. The process rapidly accelerates as more & more photons are released i.e. stimulated emission of radiation occurs. The photons having wavelength of 694.3nm which of course red light. This emerges from the rod at the partially transparent end.



1. **HELIUM-NEON LASER:**
   - It consists of a long tube containing these natural gases at low pressure surrounded by a flashgun tube producing a wavelength of 632.8nm within the visible red light range, o/p is 1mw or less.
   - Excitation of these atoms raises the electrons to the higher energy state giving off a photon. The photons are reflected to & fro along the tube giving rise to further photon emission & emerging as a narrow beam.



He-Ne LASER

2. **DIODE LASER:**
    - These are specialized light emitting diode based on semiconductors p-n junction. They are of various kinds involving gallium aluminium arsenide (GaAlAs). Wavelength is 830nm & o/p is 30mw.
    - The electrons are excited by the application a suitable electrical potential & their occupation of holes in the crystal lattice arrangement may lead to the emission of a photon which may then stimulate identical photons. The photons are reflected to & fro & emitted as laser beam from one partially transparent end. Semiconductor laser diodes can give either a continuous or a pulsed output.

PHYSIOLOGICAL EFFECTS OF LASER:

- Visible radiations are markedly absorbed in the haemoglobin & melanin. Red light of laser beam is absorbed by cytochromes in the mitochondria of the cells. All cells have these cytochromes so all may be stimulated by the red light. This in turn possibly affects the cell membrane permeability that leads to transport of calcium ions across the cell membrane which have healing properties.
- The healing process is enhanced by phagocytic activity & the selective destruction of bacteria.
- The absorption of photon is believed to cause ATP synthesis that increases cellular metabolism.
- Pain reduction is believed to occur as a result of decreased nerve conduction velocity & decreased muscle spasm. Although the underlying mechanism is not fully understood low intensity laser can reduce the rate & velocity of sensory nerve impulses.

THERAPEUTIC EFFECTS:

There are two major areas for which laser therapy is used i.e. wound healing & pain control.

1. **Wound healing:** This can be achieved;

- By increasing the cell membrane permeability results in transport of calcium ions that is used for tissue healing.
- By using 660, 820 & 870 nm wavelengths encourage macrophages to release factors that stimulate fibroblasts proliferation.
- By increasing collagen formation, vasodilaton, DNA synthesis & an increase in RNA production.
- Laser is also used in the treatment of indolent ulcers.

2. **Pain control:**
    - Musculoskeletal pain: Laser therapy is used for the relief of pain in many conditions both acute or chronic such as tennis elbow, golfers elbow, rheumatoid arthritis, osteoarthritis, bursitis back pain etc.
    - Neurogenic pain: Neurogenic pain is also relieved by laser application e.g. trigeminal neuralgia.
    - Trigger or acupuncture point: Pain is also often treated by application of laser to the trigger or acupuncture points.

DOSAGE PARAMETERS OF LASER:

The wavelength & the area of application are fixed by the types of laser apparatus used.

- **Wavelength:** Therapeutic or low level laser produced with the wavelength between 600-1000 nm which penetrates up to 3-4 mm deep but some low power laser can penetrates up to 2cm deep especially when applied to bony prominences such as cervical spine. Visible red light is recommended for superficial conditions such as wounds, ulcers & skin condition. For e.g. HeNe laser (632 nm), Diode laser (830 nm).

- **Power density:** The measurement of laser o/p is similar to that used for therapeutic ultrasound. The power density of treatment is expressed in milli watts/square cm (mw/cm^2) & is based on the laser o/p & the surface area. This is based on the formula:

$$\text{Power density } (mw/cm^2) = \text{Watts } (cm^2) / \text{Target area } (cm^2)$$

- **Energy density:** This is the actual amount of time that the energy is being emitted & is expressed in terms of Joules per square centimetres (J/cm^2).

$$\text{Energy density } (J/cm^2) = \text{Watts } (w) \times \text{Time } (sec) / \text{Target area } (cm^2)$$

- The usual ranges are from 1-10 J/cm^2 but dose as low as 0.5 J/cm^2 & up to 32 J/cm^2 have been suggested. Acute conditions are treated with an output of less than 0.5 J/cm^2 & for chronic it is normally less than 3 j/cm^2.

- **Frequency & progression of treatment:** If there is no response to the treatment then dose should be increased. 5-6 treatment sessions are said to be sufficient to show some response to the treatment.

- **Mode of treatment:** Continuous beam is recommended for acute pain & fresh wounds & pulsed beam has been found to be more effective in chronic conditions. Pulsed mode varies from 1-10 pulse per second depending on the manufacturers.

Treatment area:

- Discrete lesions should be treated directly over the affected part.
- For larger area the part is divided into centimetre square like a grid & each area is separately treated.

- For treatment of normal skin the applicator is firmly placed over the area but for treatment of open wounds it should be held just off contact.
- Scanning technique may also be used in which laser is moved continuously over the wound surface.
- Painful areas are usually treated at the point of maximum pain for e.g. a trigger or acupuncture point.

DANGERS:
The main danger of laser therapy is a risk of eye damage if the beam is directly fall into the eyes so a protective goggle should be used to avoid this problem.

SAFETY PRECAUTIONS:
- Laser should not be applied within six months of radiation therapy.
- Laser should not be applied to the abdomen during pregnancy, over unfused epiphyseal plates or to the small children.
- If the patient experience dizziness during the treatment discontinue the treatment.
- Switch on the laser machine only when the applicator is in contact with the skin.
- Avoid reflecting the laser beam from shiny surfaces.
- Always wear protective goggle during the treatment.

CONTRAINDICATIONS:
- Application to the eyes.
- Neoplastic tissues.
- Pregnant uterus.
- Over anterior frontanelle.
- Over haemorrhagic area.
- Over infected tissues.

PRINCIPLES OF APPLICATION:
Most low or medium power laser sources are applied to the skin by a hand held applicator about the size of a marker pen. The laser diode is close to the tip which is small lens. Direct application to the skin ensures maximum transfer of energy & light pressure.

Preparation of the part:
The nature of the treatment & the need to wear goggle or spectacle are explained to the patient. Protective goggles designed for the particular wavelengths are being used to prevent any risk of accidental fall of the laser beam into the eyes.

Preparation of the part:
The surface of the skin to be treated is cleaned with an alcohol wipe in order to remove any material on the surface. The part is supported in such a way that any pressure of laser applicator does not cause movement or discomfort.

Application:

- The laser applicator is applied to the surface before switching on. It is important to maintain the laser applicator in contact with the tissues so that beam is applied at right angle in order to achieve maximum penetration.
- If contact is not desired for e.g. an infected wound or ulcer the applicator may be held just off the surface or covered with transparent non reflective film.
- In all other treatment firm contact should be maintained throughout the treatment but should not provoke pain where tenderness is present.
- If a larger area is to be treated the applicator is removed & repositioned on a new site, turning off the output during transfer.

Termination: The device is switched off before removing the applicator from the skin contact.

References:

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