LASER SAFETY

Introduction

The term LASER is an acronym for Light Amplification by Stimulated Emission of Radiation.

Laser emits electromagnetic radiation by the process of optical amplification based on stimulated emission of photons.

Characteristics of Lasers

- Monochromatic – laser consist of mostly single wavelength rather than different wavelengths.

- Coherent - wavelengths in a laser beam are in phase. The wave crests and troughs are parallel to each other.

- Collimated – very narrow, travel in the same direction.

As a result of these properties intense power is produced at a small point of concentration.

Components of a Laser

A laser consists of

- An optical cavity,
- A pumping system (energy source) and
- An appropriate lasing medium.

Types of Lasers

Lasers can be classified by the type of lasing material in the optical cavity.

- Solid state lasers make use of a crystalline lasing material. e.g., ruby or neodymium-YAG (yttrium aluminium garnet) lasers.

- Gas lasers uses pure gas or mixture of gases. e.g., carbon dioxide and helium-neon.

Types of Lasers

- Semiconductor/diode lasers employ n-type and p-type semiconducting element materials.

- Liquid/dye lasers employ organic dye in a liquid solution or suspension as lasing media.

- Excimer lasers (the name is derived from the terms excited and dimers) use gases such as chlorine and fluorine mixed with inert gases such as argon, krypton or xenon.

Laser beam exposure

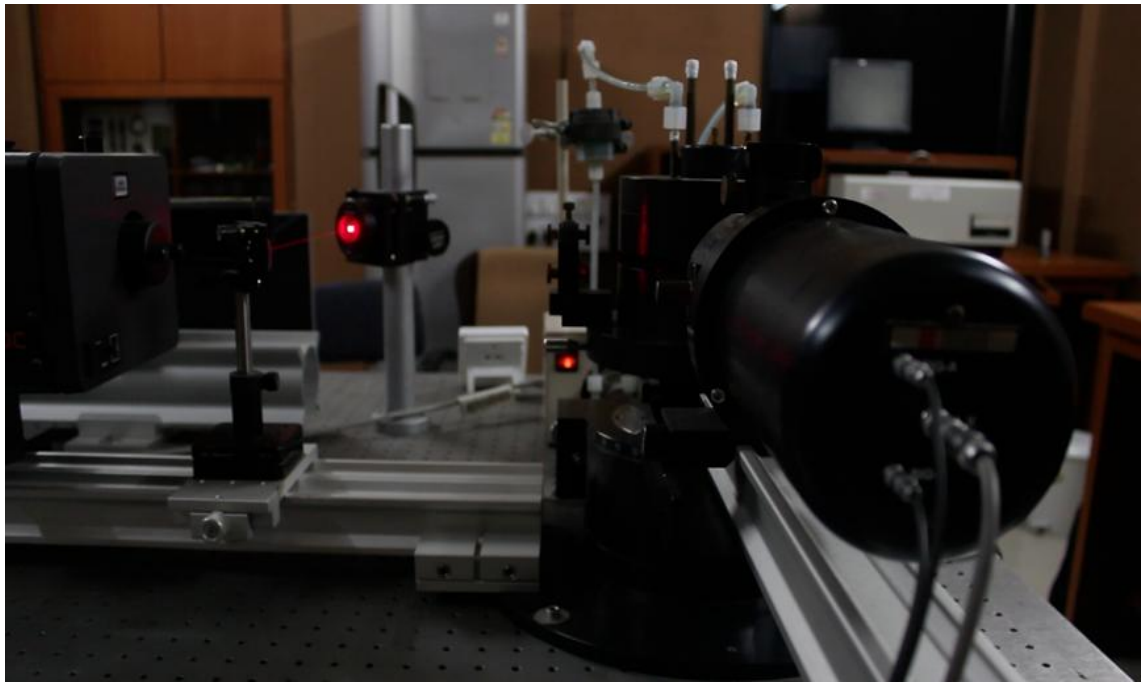
Exposure to laser beam can occur by the following means

- Direct viewing of the beam
- Specular reflection – from a shiny surface
- Diffuse reflection – from an irregular surface

Classification of Lasers

On the basis of the damaging effects on the eyes and skin lasers are classified into the following types:

- Class 1
- Class 1C
- Class 1M
- Class 2
- Class 2M
- Class 3R
- Class 3B
- Class 4



Class 1 Laser System

- Is usually not capable of producing damaging radiation levels during normal operation.
- Class 1 laser systems are exempted from control measures.
- Lasers used in laser printers and compact disc players are examples.

Class 1C Laser System

- Class 1C lasers are laser products used on the skin or internal body tissues for medical procedures.

Class 1M Laser System

- Is not capable of producing hazardous exposure conditions during normal operation, except when the beam is viewed with an optical instrument.

- Control measures are not recommended but potentially hazardous optically aided viewing to be avoided.

- Lasers used for fiber optic communication system comes under this classification.

Class 2 Laser System

- Because of the human aversion response, these lasers do not normally present a hazard, but may be a potential hazard if viewed directly for a long time.

- Laser pointers are examples of lasers coming under this classification.

Class 2 Laser System

Class 2M Laser System

- Aversion response of eyes offer protection to the eyes.
- Class 2M can be potentially hazardous when viewed with optical aids.
- Lasers used in level and orientation instruments in civil work are examples of Class 2M lasers.

Class 3R Laser System (medium power)

- Potentially hazardous under direct and specular reflection viewing condition if the eye is appropriately focused and stable, but the probability of injury is small.
- Is not a fire hazard or diffuse-reflection hazard.
- Some laser pointers are classified as Class 3R lasers.

Class 3B Laser System (medium power)

- Can be hazardous under direct and specular reflection viewing conditions.
- Is normally not a diffuse reflection or fire hazard.
- Class 3B laser systems are used in physiotherapy treatments and research work.

Class 4 Laser system (high-power)

- Is a hazard to the eye and skin from the direct beam.
- May pose a diffuse reflection hazard.
- Can cause fire.
- May produce laser generated air contaminants and hazardous plasma radiation.
- Class 4 lasers are used in displays and cutting of metals.

Biological effects of Laser Beam

Lasers can cause damage in biological tissues, both to the eye and to the skin, by the following mechanisms.

- Thermal damage - burns occur when tissues are heated to the point where denaturation of proteins occurs.

- Photochemical damage - where light triggers chemical reactions in tissue.

Biological effects of Laser Beam

Eye injury

- The ocular focus region is a range of wavelengths from 0.4-1.4 µm, which is focused by the eye's components with a power of approximately 100,000 times.
- This portion of the spectrum reaches the retina and are absorbed there resulting in injury.
- All rays outside the ocular region are absorbed by the outer components of the eyes.

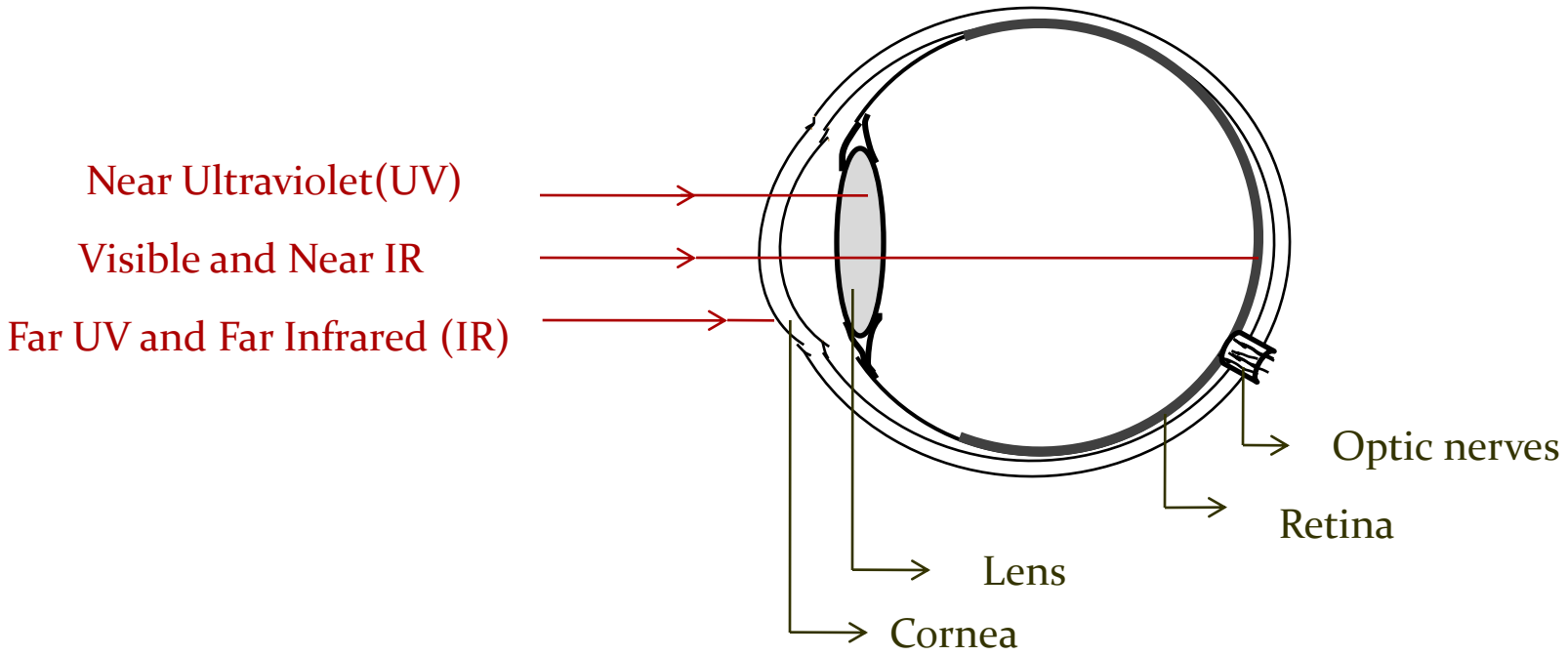
Biological effects of Laser Beam

Eye injury

- Moderate and high power lasers in the visible to near infrared range (0.4 -1.4 μm) will cause burns on the retina resulting in permanent blind spots.

- Laser radiation with wavelengths less than 0.4 μm and greater than 1.4 μm are largely absorbed by the cornea and lens, leading to the development of cataracts or burn injuries.

Absorption of electromagnetic radiation in the eye



Biological effects of Laser Beam

Skin injury

Excessive exposure to UV light from lasers can cause effects similar to sunburn, while visible and infrared rays can cause thermal damage.

- UV-A (**0.315 µm-0.400 µm**) can cause hyper pigmentation and erythema.
- UV-B range (**0.280 µm - 0.315 µm**) is most injurious to skin. Can cause radiation carcinogenesis.
- UV-C (**0.200 µm-0.280 µm**) is less harmful to human skin.

Causes of laser accidents

- Eye exposure during alignment
- Misaligned optics
- Non use of laser safety glasses
- Equipment malfunction
- Improper methods of handling high voltage
- Unauthorised operation
- Lack of protection for non-beam hazards

Control measures for Class 3B and Class 4 Lasers

- To be operated by authorised personnel only.
- Access to the area for visitors to be limited, by the provision of partitions.
- Visitors not to be allowed when the laser is in operation.
- Any potentially hazardous beam to be terminated in a beam stop of an appropriate material.

Control measures for Class 3B and Class 4 Lasers

- Warning sign to be posted at the entrance.

- Warning lights to be provided outside the laser room to warn visitors when the laser is in operation.

Control measures for Class 3B and Class 4 Lasers

- Materials that can cause specular reflection must not be kept in the laboratory.

- Laser safety glasses must be used if the permissible exposure limits for the laser are exceeded.

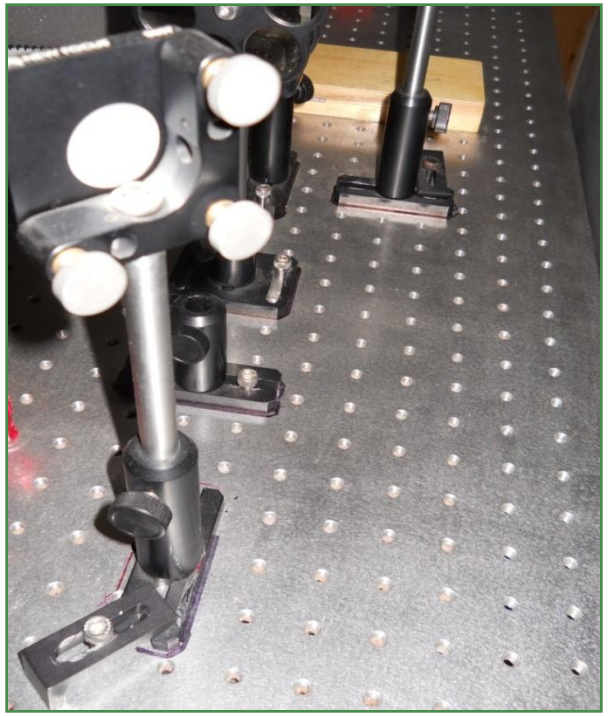
Control measures for Class 3B and Class 4 Lasers

- Wherever possible the beam path must be enclosed. Use fire resistant materials for enclosing Class 4 laser beam path.
- All windows and doors in the laser room to be made opaque.
- The laser system must be disabled (e.g., removal of the key) after use to prevent unauthorised use.

Control measures for Class 3B and Class 4 Lasers

A screen or curtain must be used to prevent exposure to the laser beam at the entrance of the laser room.

Control measures for Class 3B and Class 4 Lasers



Secure optical components to the table to prevent stray reflections from misaligned optics.

Control measures for Class 3B and Class 4 Lasers

- Users must never view the beam at the level of the horizontal plane where they are passing.
- Watches and jewelry must not be used in the laboratory.
- Alignment of beams and optical components must be performed at a reduced beam power whenever possible.
- Fire extinguishers must be at an easily accessible location in labs using Class 4 lasers. Keep flammable materials away from open beams.

Factors in determining appropriate eyewear

- Wavelength of the laser output
- Potential for multi wavelength operation
- Optical density of eyewear at laser output wavelength
- Visible light transmission requirement
- Peripheral vision requirement
- Comfort and fit

Non-beam laser hazards

Non-beam hazards are also associated with use of laser systems.

- Lasers use high voltages which can be a hazard during normal operation and maintenance.
- The laser system must be properly grounded.
- Electrical switches must be locked and tagged while servicing electrical equipment to prevent inadvertent energisation.

Non-beam laser hazards

- Capacitors can contain dangerous charge even after disconnecting from the main power. They must be safely discharged by grounding before maintenance.
- Electrical equipment must be installed a few inches above the floor to prevent contact with water in case of flooding.
- Organic dyes used must be labelled and Material Safety Data Sheet for the same to be referred before use.
- High-pressure arc lamps and filament lamps shall be enclosed to contain lamp explosion.

THANK YOU