Laser Safety : A growing concern…..

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Laser

noun, Physics

a device that produces a nearly parallel, nearly monochromatic, and coherent beam of light by exciting atoms to a higher energy level and causing them to radiate their energy in phase

Light **A**mplification by **S**timulated **E**mission of **R**adiation

*A **laser** is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.*

Characteristics of Laser

- **Monochromatic -** all light produced by the laser is of one wavelength or color. Exceptions included multiline gas lasers and new white-light lasers. ex. Nd:YAG (532,1064nm)
- **Directional -** collimated (divergence~1mRad) photons (stimulated) traveling in the same direction
- **Coherent -** all peaks of sinusoidal waves (photon) are in phase with each other

Lasers pose more hazard than ordinary light because they focus energy onto a small area

Operating parameters

Power – is the time rate at which energy emitted, transferred, or received (Watts or joules/second)

Spot Size - describes the diameter of the minimum spot achievable

Exposure Time - generally given is seconds but also occasionally in milliseconds

Power Density - The amount of power concentrated onto a spot (W/cm^2)

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Uses of lasers

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Scientific

- Spectroscopy
- Detectors
- Laser Scanner
- Photochemistry
- Microscopy

Military

- Energy Weapon
- Missile Guider
- Targeting
- Disorientation
- Firearms
- Holographic weapon sight

Medicine

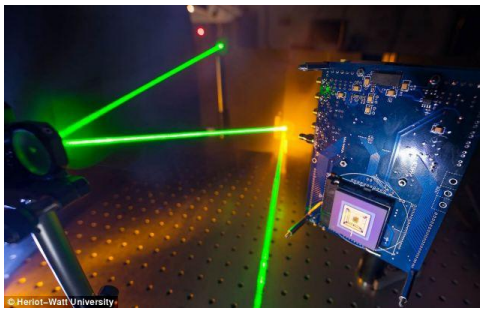
- Surgeries
  - Cosmetic
  - Eye
  - Soft tissue
  - General
  - Oral
- Photobiomodulation [laser therapy]

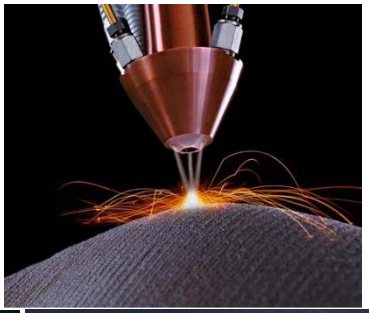
Industrial

- Cutting
- Welding
- Brazing
- Leveling
- Communication
- Surveying
- Bar code readers
- 3D Scanners
- Data storage & retrieval

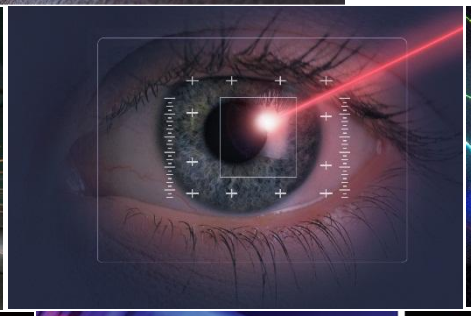
Entertainment

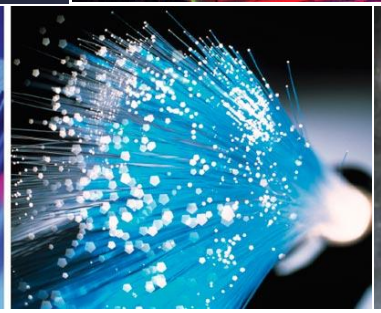
Uses of Laser










How intense is intense!!!!!

Lasers that produce a continuous beam or a series of short pulses can be compared on the basis of their average power.

Power	Uses
1 – 5 mW	Laser Pointers
5 – 10 mW	DVD & CD-ROM Drives
1 W	Green Laser in current Holographic Versatille Disc prototype development
1 – 20 W	Output of majority of commercially available solid – state lasers
100 – 3000 W	Industrial Laser Cutting
1.3 PW [1.3×10^{15} W]	World's most powerful laser [1998]
2000TW - 2 PW	Laser for fast ignition experiments [Japan] - 2015

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Hazards

Eye

Skin

Fire

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Hazards

- Low power lasers with few milliwatts are hazardous to human eyesights if beam hits eye directly or after reflection from shinny surface
- The wavelengths at which lens and cornea can focus, the laser can be focused by the eye into an extremely small spot on the retina, which can burn and do permanent damage in seconds or even in less time!!!

Lasers are labeled with "**Safety Class Number**" [lower the number safer they are….

Theodore Harold "Ted" [first working laser] ; considered having laser power of one "Gillette" as it could burn "Gillette Razor Blade"

Safety Class Number

Classified based on wavelength and maximum output power

IEC 60825-1

- **Class 1** *is* ***inherently safe****, usually because the light is contained in an enclosure, for example in CD players.*
- **Class 1M** *is* ***inherently safe****, except when passed through magnifying optics such as microscopes and telescopes.*
- **Class 2** *is safe during* ***normal use****; the blink reflex of the eye will prevent damage. Usually up to 1 mW power, for example laser pointers.*
- **Class 3R** *(formerly IIIa) lasers are usually up to 5 mW and involve a* ***small risk*** *of eye damage within the time of the blink reflex.* ***Staring*** *into such a beam for several seconds is likely to cause damage to a spot on the retina.*
- **Class 3B** *can cause* ***immediate eye damage*** *upon exposure.*
- **Class 4** *lasers can* ***burn skin****, and in some cases, even scattered light can cause eye and/or skin damage. Many industrial and scientific lasers are in this class.*

Maximum permissible exposure [MPE]

is the highest power or energy density (in W/cm^2 or J/cm^2) of a light source that is considered safe, i.e. that has a negligible probability for creating damage.

*is usually about **10%** of the dose that has a **50%** chance of creating damage under worst-case conditions.*

*is measured at the **cornea** of the human eye or at the **skin**, for a given wavelength and exposure time.*

is power or energy per unit surface

IEC 60825 – 1 & ANSI 136.1 provides methods of calculating MPEs

MPE

Laser Type	Wavelength (µm)	MPE Level (W/cm2)			
		0.25 sec	10 sec	600 sec [10 Mins]	30000 sec [8 hrs]
CO2	10.6	--	100.0×10^{-3}	--	100.0×10^{-3}
Krypton	0.647	2.5×10^{-3}	--	364.0×10^{-6}	28.5×10^{-6}
	0.568	31.0×10^{-6}		2.5×10^{-3}	18.3×10^{-6}
Argon	0.514	2.5×10^{-3}	--	16.7×10^{-6}	1.0×10^{-6}

Legislation - International

- ***ANSI Z136.3*** *– Safe Use of Lasers in Health Care*
- ***ANSI Z136.4*** *– Recommended Practice for Laser Safety Measurements for Hazard Evaluation*
- ***ANSI Z136.5*** *– Safe Use of Lasers in Educational Institutions*
- ***ANSI Z136.6*** *– Safe Use of Lasers Outdoors*
- ***ANSI Z136.7*** *– Testing and Labeling of Laser Protective Equipment*
- ***ANSI Z136.8*** *– Safe Use of Lasers in Research, Development, or Testing*
- ***ANSI Z136.9*** *– Safe Use of Lasers in Manufacturing Environment*

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Safety measures

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General

- Awareness v/s ignorance
- Proper equipment & importance of horizontal travel!!!
- No shinny surfaces…
- Eye protection
- Opacity is Must for Class 4
- Align at lower powers and then raise the power….

Eye & Skin

- Protective glasses
- Selection
- Usage
- Maintenance
- Plastic vs glass
- Protective clothing

Fire

- **Training and awareness**
- **Hot tip away from combustible items**

[for eg. Skin preparation solutions are vaporized completely]

- **Remove / eliminate surfaces which can reflect laser beam**
- **During surgeries laser beam should be in stand-by position at all times**
- **While using maintain precise control of laser beam**

- Electrical hazards
- Proper earthing / grounding of laser equipment
- Labeling of equipment

Laser Safety Program

Administrative

- Training
- Labeling
- Formation of Laser Safety Committee
- Buddy system
- Periodic eye examinations

Engineering

- LEV
- Fail safe methods [automatic shutters]
- Lock & key for prevention of unauthorized activation
- Elimination of reflective surfaces
- Window covers, if required
- Interlocks, safety latches

Personal Protective Equipment

- Eye protection
- Clothing and gloves

Selection of eye protection

- Laser glasses are marked to protect at specific **wavelengths**. Check the wavelength ranges on the glasses to see if they match the wavelength(s) your laser operates at.
- Along with the wavelengths, **Optical Densities** (OD) are marked on the glasses for each wavelength range. Higher optical densities mean higher protection.
- Optical densities above **5** are generally good enough for blocking powerful lasers.
- Optical densities between **2 and 3** are generally used for laser alignment, where the laser is powered down and turned on so the beam can be aligned.

Optical Densities for protective eyewear for various laser types

Laser Type	Wavelength (µm)	MPE Level (W/cm2)			
		0.25 sec	10 sec	600 sec [10 Mins]	30000 sec [8 hrs]
Argon 1.0 Watts	0.514	3.0	3.4	5.2	6.4
Krypton 1.0 Watts	0.530	3.0	3.4	5.2	6.4
	0.568	3.0	3.4	4.9	6.1

Source : OSHA

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