Laser Safety

Occupational Health and Safety
EMERGENCY PROCEDURES

Evacuation

- Alert tone (Beep, Beep) - Prepare to evacuate
- Evacuate tone (Whooping) - Evacuate the building
- Leave via nearest safe exit
- Walk - Do not run
- Do not use a lift

Emergency Contact

Ext. 333 Security

From a mobile: 9905 3333
Course Outline

- Laser Use
- Legislation
- Laser Classifications
- Effects of Lasers on the Body
- Laser Exposure limits
- What can go wrong
- Control Measures
- Other non Laser Hazards
- General Safety Practices
Lasers

- Light Amplification by Stimulated Emission of Radiation
Laser Hazard

- Intense beams of coherent radiation at optical, UV and infra-red wavelengths.

- Hazardous properties:
  - High concentration of energy
  - Hazardous a long distances
  - Not always visible

- Consequence:
  - Damage to soft tissue (especially the eye)
Laser usage

- Rapid heating of materials
  - Welding
  - Cutting
  - Laser ablation
- Confinement of particles
- Optics
- Analysis
  - Microscopes
  - Flow Cytometry
  - Spectrometry
- Communication, information transfer
- Illumination
OHS Act 2004: Key safety principles

- The importance of health and safety requires that employees, other persons at work and members of the public be given the highest level of protection against risks to their health and safety that is reasonably practicable in the circumstances.

- Persons who control or manage matters that give rise or may give rise to risks to health or safety are responsible for eliminating or reducing those risks so far as is reasonably practicable.
Reasonably Practicable

Must do what a reasonable person would do:

- to eliminate risks

or, if not reasonably practical to do so:

- reduce so far as is reasonably practicable.
Reasonably practicable in relation to ensuring health and safety:

(a) the likelihood of the hazard or risk concerned eventuating;
(b) the degree of harm that would result if the hazard or risk eventuated;
(c) what the person concerned knows, or ought reasonably to know, about the hazard or risk and any ways of eliminating or reducing the hazard or risk;
(d) the availability and suitability of ways to eliminate or reduce the hazard or risk;
(e) the cost of eliminating or reducing the hazard or risk.
OHS Act: Duties of employees

- Take reasonable care for his or her own health and safety and for the health and safety of others

- Co-operate with his or her employer

- Must not intentionally or recklessly interfere with or misuse safety equipment
Peer Group Pressure in the Laser Lab
Classification of Lasers: Class 1

- Class 1 lasers
  - Safe under most circumstances and are incapable of damaging the eyes or skin because of either engineered design or inherently low power output.

- Class 1M lasers (wavelength range 302.5 - 4000nm)
  - May be hazardous if optics are used in the beam.
Classification of Lasers: Class 2

- **Class 2 lasers** - (wavelength range 400 - 700nm)
  - Have sufficient power output to cause damage to the eyes if viewed continuously. Often used by conference presenters are common examples.
- **Class 2M lasers**
  - More hazardous if the user employs optics within the beam.
Classification of Lasers: Class 3

- **Class 3R lasers** (wavelength range $302.5 - 10^6$ nm)
  - Potential to cause damage to the eyes from intra-beam viewing. Prevention both direct viewing or viewing with optical instruments.

- **Class 3B lasers**
  - More hazardous because of either higher output or operation outside visible wavelengths, surface reflections may also be hazardous.
Classification of Lasers: Class 4

- Class 4 lasers
  - High power devices capable of producing eye damage even from diffuse reflection, may cause skin injuries and could also constitute a fire hazard.
Laser Exposure limits

- Dependent on the Laser Classification
- Check user manual for specifications
- Terms used
  - Maximum Permissible Exposure (MPE)
    - Highest safe laser power to eye or skin for a given laser
  - Nominal Ocular Hazard Area (NOHA)
    - Area in which the MPE is equalled or exceeded
  - Nominal Ocular Hazard Distance (NOHD)
    - Distance from the output aperture at which the beam irradiance or radiant exposure equals the appropriate corneal MPE
Effects of Lasers

- **Eye Hazard**
  - Different wave lengths affect different parts of the eye
  - Instantaneous, irreversible damage is possible
- **Skin Hazard**
  - Skin is less susceptible to damage than the eye
  - Ensure protection clothing is worn with class 3B and 4 when skin exposure could remain a significant hazard.
Retinal Hazard Region

- Retina susceptible to radiation at the visible and near-infrared wavelengths
Effects of Ultraviolet light

UV-C (100-280nm)
Cornea surface

UV-A (315-400nm)
Affects the lens

UV-B (280-315nm)
Absorbed by the cornea
Effects of Infra-red Region

Near IR (800 - 2500nm)
Affects the retina

Far IR
Affects cornea
and aqueous humour
When things go wrong

An unsupervised graduate student received a retinal burn to both eyes when the beam of a Class 4 laser was reflected into his eyes by a mirror. The student was not wearing laser eye protection when he attempted to repeat an alignment procedure he had observed only once.

The student did not fully understand the procedure and decided to use a procedure of his own that was inherently unsafe and was not authorized. In addition, the principal investigator had installed and operated the laser without registration and review by the Laser Safety Officer (LSO) and without required postings and documentation.
Things go wrong again

A student aligning optics in a university chemistry research lab using a "chirped pulse" Titanium-Sapphire laser operating at 815 nm, 1.2 mJ pulse energy at 1 KHz, each pulse was about 200 picoseconds. The laser beam backscattered off the REAR SIDE of mirror (about 1% of total) causing a foveal retinal lesion with hemorrhage and blind spot in central vision. A retinal eye exam was done and confirmed the laser damage. The available laser protective eyewear was not worn.
Ninety five percentage of laser accidents occurs due to the following:

- Unanticipated eye exposure during alignment
- Misaligned optics and upwardly directed beams
- Available laser eye protection not used

OH&S Risk Reduction

Can be approached in two ways:

Reducing the Hazard through the Hierarchy of controls

- Elimination
- Substitution
- Isolation
- Engineering
- Administrative
- Personal Protective Equipment

Lessening the Probability (likelihood).

- Reducing the Frequency of Exposure
- Increasing the number of levels of protection
Typical Engineering Controls

Protective housings
Remote interlocks
Typical Engineering Controls

- Optical Fibre
- Enclosed beam paths
- Screens
Typical Engineering Controls

- Power settings
- Access panels/master switches
- Emergency stops
- Filter wheels
- Emission indicators
Typical Engineering Controls

- Beam Readers
Typical Engineering Controls

- Beam Stops
- Laser Curtain
Video
Administrative Controls

- Risk assessments
  - Lasers must be risk assessed for class 3R and 3B and 4
  - Assessments need to cover initial set up/alignment, normal operation and adjustments
  - Must be reassessed with the introduction of new components
- Safe work procedures
  - Must reflect the risk assessment hazards
  - Important particularly in research applications where equipment configurations may need to be altered frequently.
  - **Ensure users are trained in procedure** (not just sitting in folder)
- Signage
  - Warning signs which comply to Australian standards in appropriate areas
Eye Test

- It is best practice that all users of Class 3B and Class 4 lasers should have a “laser eye test” before starting work with lasers.

- A medical examination by a qualified specialist should be carried out immediately after an apparent or suspected injurious ocular exposure.

- Faculty/Department Dependent
  - Faculty of Engineering compulsory
Personal Protective Equipment

- Correctly classed protective goggles to Australian Standards (if required)
- Lab coat and long pants
- Suitable footwear (closed toed and flat soled)
- Protective gloves (if required)
- Remove any potentially reflective objects from person and area.
Eye Protection

- The wavelength or wavelength range (in nm) for which the eye protector provides protection.
- A scale number (L1 to L10), depending on the level of protection offered (Absorbance)
- AS/NZS 1337.4
- AS/NZS 1337.5
- Vision
- Comfort
- Durability
Pulsed Laser Eye Protection

- ‘D’ the eye protector provides protection against a continuous wave laser.
- ‘I’ the eye protector provides protection against a pulsed laser.
- ‘R’ the eye protector provides protection against a Q-switched laser.
- ‘M’ the eye protector provides protection against a mode-coupled laser.
Other Hazards

- All potential associated hazards need to be considered in laser use.
  - Electrical shock (especially where water may be used)
  - Fire (stray or misaligned beams can heat up materials)
  - Injuries from chemicals (e.g. dyes)
  - Fumes from vaporised material

- Do not just focus on laser itself look at whole activity
## Risk Assessment

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Insignificant</th>
<th>Minor</th>
<th>Moderate</th>
<th>Major</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Extreme</td>
<td>Extreme</td>
</tr>
<tr>
<td>Likely</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Extreme</td>
</tr>
<tr>
<td>Possible</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Rare</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>
# Risk Assessment

## Identify

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Risk Factor and Risk Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Some elements of the system remain open at times, risk of beam directed towards a person.</td>
</tr>
<tr>
<td>X-rays</td>
<td></td>
</tr>
<tr>
<td>Gamma ray</td>
<td></td>
</tr>
<tr>
<td>High energy beta</td>
<td></td>
</tr>
<tr>
<td>Low energy beta</td>
<td></td>
</tr>
<tr>
<td>Alpha</td>
<td></td>
</tr>
<tr>
<td>Neutron</td>
<td></td>
</tr>
<tr>
<td>UV radiation</td>
<td></td>
</tr>
<tr>
<td>High strength magnetic fields</td>
<td></td>
</tr>
<tr>
<td>Other non-ionizing radiation</td>
<td></td>
</tr>
<tr>
<td>Splash/spill of unsealed source</td>
<td></td>
</tr>
<tr>
<td>Lasers</td>
<td></td>
</tr>
</tbody>
</table>

## Assess

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Existing Control(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select hierarchy of control and describe the existing control</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Current Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Level of Risk with existing controls</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Proposed Control(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the hierarchy of control and describe your proposed treatment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>Who is responsible?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the person and due date</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
<th>Residual Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Level of Risk after treatment</td>
<td></td>
</tr>
</tbody>
</table>

## Control

<table>
<thead>
<tr>
<th>Medium</th>
<th>Matrix</th>
</tr>
</thead>
</table>

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**MONASH University**

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# Control Band

## Summary of User Precautions

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class 1</td>
</tr>
<tr>
<td>Laser safety officer</td>
<td>Not required</td>
</tr>
<tr>
<td>Remote interlock</td>
<td>Not required</td>
</tr>
<tr>
<td>Key control</td>
<td>Not required</td>
</tr>
<tr>
<td>Beam attenuator</td>
<td>Not required</td>
</tr>
<tr>
<td>Emission indicator device</td>
<td>Not required</td>
</tr>
<tr>
<td>Warning signs</td>
<td>Not required</td>
</tr>
<tr>
<td>Beam path</td>
<td>Not required</td>
</tr>
<tr>
<td>Specular reflection</td>
<td>No requirements</td>
</tr>
<tr>
<td>Eye protection</td>
<td>No requirements</td>
</tr>
<tr>
<td>Protective clothing</td>
<td>No requirements</td>
</tr>
<tr>
<td>Training</td>
<td>No requirements</td>
</tr>
</tbody>
</table>

NOTE This table is intended to provide a convenient summary of precautions. See the text of AS 2211.1 for complete precautions.
General Safety Practices

- Identify potential hazards and controls required before you purchase a product.
- Design out as much of the hazards as possible.
- Use multiple levels of control.
- Avoid any laser set ups that operate above shoulder height.
  - Take into account people’s position of setting up.
  - The position of people while the laser is operating.
  - Examples sitting, standing, kneeling.
General Safety Practices

- Consider any reflective beams – use opaque non reflective instrumentation.
- Use screens to ensure entrapment of any potentially stray beams
- Consider incompatibilities (i.e. electricity and water)
- Consider the flow on effects of your laser usage to others in the area
- Do you work alone (or control anyone) after hours using class 3B or above lasers.
Incident Reporting

- Reporting any exposure to potentially damaging beams
- Report any near misses, the only way we can improve safety is to learn from past experience
Relevant Standards

- AS/NZS 1337.4:2004 Personal eye-protection - Filters and eye-protectors against laser radiation (laser eye-protectors)
- AS/NZS 1337.5:2004 Personal eye-protection - Eye-protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors)
How to get to the Standards

1. Monash Homepage
2. Library
3. Databases
4. S
5. Standards: on-line premium
6. Authcate
7. Search
Laser Safety – Questions to Ask Yourself

- What class is the laser?
- What controls are required?
- Is there a way to improve the safety of the process?
- How do we ensure people follow rules?
Contacts

OHS 51016

- Radiation Protection Officer
  - Margaret Rendell 51060

- OHS Consultants/Adviser
  - Bernadette Hayman (Biomed Sciences) 55739
  - Debra Bartolo (Science) 50222
  - Margaret Rendell (Engineering) 51060
  - David Hurst (Medicine & Provost) 55174
  - Priscilla Chow (Art, D & A) 32186
  - John Hayman (Pharmacy) 24215
Reference Documents

- Laser safety Information Sheet (Monash)
- Laser Safety – University of Melbourne presentation
- Course Notes Laser Safety RMIT
- Australian Standards (Laser Safety all)
- University of Queensland, Laser Safety Guidelines
- Imperial College laser safety presentation
During optics alignment involving a 30 mJ pulsed Nd:YAG laser (10 Hz) on a target using a prism, the beam exceeded the prism's critical angle and struck the scientist in the eye resulting in a permanent retinal burn. Unfortunately, no protective eyewear was worn at the time. An ophthalmologist was consulted and confirmed retinal burns.

Blurry vision resulted especially when reading.