Introduction

Lasers are commonly found within the university in Laser pointers, within equipment such FACS machines, confocal microscopes, scanners and other equipment. The use of lasers is covered under the Artificial Optical Radiation Directive and the Control of Artificial Optical Radiation at work regulations 2010.

Laser Types

Lasers emit a single frequency of coherent light. The light can be emitted from the following sources

- Dye
- Gas
- Chemical
- Metal vapour
- Solid state
- Semi conductors

The wavelengths of commercially available lasers range cover wavelengths in the UV, Visible and IR frequencies. The human eye will respond to light or electro-magnetic radiation of frequencies between 400 - 700 nm.

Laser Classes

Lasers are classified into 4 main classes and several sub-classes depending upon the power that is emitted in Watts / Square Metre. Lasers in high classes produce more energy or irradiance than those in lower classes. Lasers are placed in a particular class depending upon the Maximum Permissible Exposure (MPE). This is a level of exposure where it is believed that an individual would not suffer eye or skin damage. The MPE is a function of the wavelength of the laser and the length of exposure to the beam. The MPE is translated in use into an Accessible Exposure Limit which is the maximum amount of energy a person could be exposed to while the laser is in use.

Class 1 These are believed to produce insufficient energy to damage the tissue of the eye but must never be shone directly into a person's eye.

Class 1 M These produce a wide diameter beam of similar power to a Class 1 laser or a beam that is divergent. These lasers can cause damage if viewed under a magnifying lens.

Class 2 These have a maximum power output of 1mW and emit at frequencies between 400 and 700nm. The blink response may protect a person who inadvertently looks at the beam. The laser must never be shone directly into a person's eyes.

Class 2 M These produce a wide diameter beam of similar power to a Class 2 laser or a beam that is divergent. These lasers can cause damage if viewed under a magnifying lens.

Class 3 R These lasers have a maximum output of 5mW and their beam can cause eye damage.

Class 3 B These lasers have a maximum output of 500mW and their beams are capable of causing damage even if viewed for a limited period of time. The amount of damage will depend on the angle of viewing, power of the beam and the duration of exposure.

Class 4 These lasers will emit more than 500mW and their is no upper limit on the amount of power they produce. The beam can cause damage to eyes and skin and in certain circumstance can result in fires.

A video on the classification can be viewed Laser safety classification.

Information on the different laser classification systems is available from Rockwell Laser Industries.

Laser Hazards

The main physical hazards associated with lasers are eye damage and also skin damage. The damage can be caused by impact from the original beam or from reflected beams. Due to power of class 3R and 4 lasers damage can occur in a short period.

Eye Damage: This is caused by the heating effect of the beam on the tissues of the eye and direct impact of the beam on the Retina. In some cases laser strikes can cause haematoma's in the blood vessels of the eyes. It is possible for multiple laser impacts to cause partial or complete blindness. The following effects have been reported as occurring after laser strikes to the eyes: flash blindness, dazzle, dark spots, floaters, retinal bleeding, retinal burns, hazy vision.

Skin Damage: This is caused by localised heating effects where the laser beam strikes the skin.

The following table shows the wavelengths at which lasers cause eye or skin damage

Wavelength	Target eye / Damage	Target Skin
200 - 280 nm (Ultra Violet C)	Photokeratitis	Erythema Skin Cancer Accelerated aging
280 - 315 nm (Ultra Violet B)	Photokeratitis	Increased pigmentation
315 - 400 nm (Ultra Violet A)	Cataract	Pigment darkening Skin burn
400 - 7780 nm (Visible light)	Photochemical and thermal injury	Pigment darkening Photosensitive reactions Skin burn
780 - 1400 nm (Infra Red A)	Cataract and retinal burns	Skin burn
1400 - 3000 nm (Infra Red B)	Corneal burn, aqueous humour damage, cataract	Skin burn
3000 nm - 1 M (Infra Red C)	Corneal burns	Skin burn

Fires: Lasers are capable of starting fires should the beam contain sufficient energy to ignite the material on which it impacts.

Electrical: High voltages and currents have the potential to cause electric shocks should interlocks or switchgear fail.

Common causes of laser accidents

The American National Standard for the Safe use of lasers quote the following as causes of accidents.

Failure to use eye protection

Failure to use eye protection suitable for the frequency and power of the laser in use.

Laser beams impacting the skin

Unintended exposure to beams during alignment

Misaligned optics and beams directed upwards

Inadvertent reflection of beams

Equipment failure

Failure to follow proscribed methods

Operator not trained in the model and type of machine being used

Lasers being shone into people's eyes or at their skin

Working with Lasers

Risk Assessment

All work involving lasers or systems containing lasers of classes 2, 3 or 4 should be risk assessed before the work commences. The assessment should consider not only the equipment being used, but any dyes, chemical or high voltages that the work may be involved. The assessment must consider the potential for stray or reflected beams particularly for work involving open source experiments with class 3 or 4 equipment. It should also assess whether the beams will be reflected from smooth or rough surfaces as this will affect the scattering of the light.

As part of the risk assessment the use of illuminated "Do Not Enter" signs interlocked with the power switches of Class 3 and 4 lasers may be an adequate safety precaution.

Equipment location

Equipment should be located where stray or reflected beams cannot be directed into the eyes of passers-by.

Equipment Alignment

Equipment used in open source experiments must be aligned so that all the beams are directed towards the target and that stray beams are not produced. A video on the alignment of lasers is available to view.

Training

Staff must have documented training for the machine and protocol that they will use. In the case of class 3 and 4 lasers this should include information on the use of laser goggles and the damage that lasers can cause to skin and eyes.

Registration of Equipment

The acquisition of Lasers or systems containing Lasers of classes 3 or 4 should be notified to Anne Harris in the Safety, Health and Environmental office (ext 5166).

Is it genuine?

It is important to try and order lasers from reputable primary distributors. There have been instances where laser pointers purchased on amazon have been found to produce light at a greater power than indicated by the markings.

Additional Sources of Information

Information on Lasers can be obtained Public Health England.

Information on Laser goggles can be obtained from LASER 2000.

Information on Laser eye protection is available from Wickedlasers.com, laserlines

The Association of University Radiation Protection Officers has produced "Guidance on the Safe Use of Lasers in Education and Research" which can be downloaded.