



Basic Laser Safety Training

Course for all users of lasers in research, education and at work in the University of Essex

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Who should attend: anyone (employee, student, others) who use lasers as part of their research or education. (The course can be modified laser workers who work with laser products or could be at increased risk from laser eg cleaners, maintenance worker etc.)

Who delivers the training: UNIRPA, DNIRPA or the Responsible Person. The choice of trainer depends on the department's local arrangements, whether they have a good understanding of laser hazards and harm, the experiment or exposure scenario. The trainer must be familiar with the University of Essex's NIR Standard and Laser Safety Standard. Also, they should familiar with the AURPO Guidance on the safe use of lasers on education and research (August 2012. pdf) and have an understanding of laser hazards and risk.

Pre-requisites: None

Resources:

- Basic Laser Safety.ppt
- Attendee signature sheet. (Must include attendees name, their signature, the date the training was given and who gave it. Please keep a copy for your records and send a copy to HSAS as soon as the training is completed.)

Programme: 1 hour for session. 30 minutes for assessment. 5 minute per trainee for marking assessment.

Objective Check: Multi choice and true or false questions x 18, pass rate 16 or more question right. Trainer marks the assessment. Failed trainees can take the assessment again within two weeks on finishing the course. Another assessment fail is retake of course.

2. Course content

- What is the general nature of laser radiation?
- What are the laser health hazards, tissue of the body at risk and severity of harm?
- Why are there different laser classes and warning labels?
- What are the University's laser hazard controls?
- What are the laser hazard controls for non-routine activities and emergencies?
- An Introduction to the University Laser Safety Standard

3. Course aims

Laser users will be able to:

- Describe laser radiation
- List parts of the body at risk
- Identify laser injuries.
- Identify different class of lasers
- Recognise laser warning symbols
- List common laser safety controls
- Find the University Laser Safety Standard

4. General nature of laser radiation

LASER is an acronym:

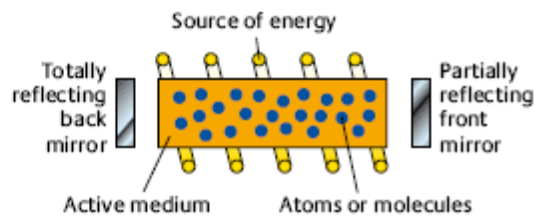
Light Amplification by Stimulated Emission of Radiation.

Scientifically, the word 'radiation' is used to describe something that radiates out from a source. However, it has negative associations and tends to remind people of nuclear explosions and harmful x-ray or gamma rays. The term used instead will be **Laser Beam**.

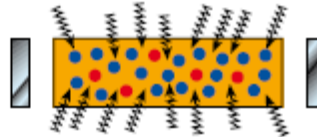
How a laser beam is generated

How Laser Radiation is Generated

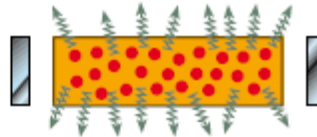
Energy from a flashlamp, an electrical discharge or another source is pumped into a material called the active medium, which is contained within the laser cavity.



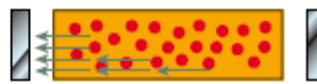
As this energy is absorbed, the individual atoms in the active medium move into an 'excited' state.



The energy is re-emitted from the active medium as optical radiation in random directions.



Mirrors at either end of the cavity reflect some of the radiation back into the active medium. This stimulates the active medium into producing further radiation which now travels in phase between the two mirrors.



The radiation is amplified by the process of stimulation. As one of the mirrors is only partially reflecting, some of the radiation will be emitted as the *laser beam*.



The laser beam is a coherent form of optical radiation, ie the emitted waves are in phase, or in step, with each other, and travel in the same direction.

LASER: Light Amplification by the Stimulated Emission of Radiation

Source: HPA Radiation at Work Laser Information Poster.

ACTION: If you are able to do so, show trainees the laser and help them identify the main parts.

Why is laser light different?

Light emitted from laser is manmade. It does not exist in nature. The light beam has these properties:

- Monochromatic – one pure wavelength or colour depending on the gas or material that is used in the laser.
- Very intense – it is high power

- Low divergence – this means the light once emitted from the sources does not spread out much.
- Coherent – all the photons are in phase, in step.

5. Laser health hazards, tissue of the body at risk and severity of harm?

Laser health hazards

Optical radiation is a known hazard to the eye and skin.

The collimated beam from a laser and the high irradiance (power) can result in large amounts of energy being transmitted to very small volumes of body tissue.

Over exposure to laser beams can damage tissue in the following ways.

1. Thermal effects – burning of the tissue. Excessive temperature elevation of the absorbing tissue.
2. Photochemical effects – absorbed laser energy may produce damaging chemical reactions in tissue, potential causes of cancer.
3. Acoustic transients – absorption of laser energy, usually from laser pulse, causes shock wave in the tissue and cause physical damage.
4. Chronic (long time) exposure – may cause damage.

Tissue of the body at risk

EYES

The eye is an amazing optical system designed to focus, detect and transmit light.

Most vulnerable part of the body to laser beam damage – you only have two!

Injuries can be caused at very low power levels than the skin.

Laser beam into the eye will be focused by the lens onto the retina. The resulting spot is a concentration of laser energy and may be as small as 10 µm.

Severity of harm to eyes.

Ultraviolet UV 180-400nm.

UVC 180 – 280nm and UVB 280 – 315nm laser beam is absorbed deeper in the cornea and can turn it milky white due to photochemical reactions. May appear 6 – 12 hours after exposure. At <315nm absorbed by cornea surface. Inflammation of corneal inflammation, known as KERATITIS (other names 'snow eye' or 'arc eye'). Very painful, like hot grit in eye, heavy tear flow and marked aversion to light. Recovery within 48 hours.

Visible 400 – 780nm and infra-red (IR) 780 – 1400nm – RETINAL HAZARD REGION

Laser beam focused on the retina and absorbed by the retinal pigment epithelium and choroid.

Eye is more sensitive to green light.

Magnitude of retinal damage = retinal irradiance x exposure time.

Damage to the fovea stops the optic nerve impair vision forever.

IR 700 – 1000nm. Flash burns to the cornea. Rapid temperature rises in absorbing tissues resulting in burn injury.

SKIN

Damage will depend on power and wavelength of the laser beam, spot size and duration of exposure.

Severity of harm to the skin

UV – reddening of the skin ERYTHEMA. ACCELERATED AGEING. INCREASED RISK OF SKIN CANCER.

Visible – changes in skin pigmentation.

IR – laser beam penetrates the skin and can cause burning, abnormal pigmentation.

Non-beam hazards

ACTION: Refer to the webpage: *A Guide to Laser and Non-beam Hazards*

6. Different laser classes and meaning of the warning labels.

Laser products are classified to take into account the amount of laser beam to which you can get access when the product is in normal use or during routine user maintenance. In the UK British Standard on Laser Safety: BS EN 60825-1:1994 is followed.

NOTE: other countries use slightly different system. For example the USA use the Federal Product Performance Standard and use roman numerals. If you are unsure of laser class speak to the DNIRPA or UNIRPA.

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

ACTION: Work through power point detailing the different classes. Refer to the webpage: *A Guide to Laser and Non-beam Hazards*.

Warning label look like this in the AURPO guidance, appendix 10 of ACTION:

<http://www.aurpo.org/images/documents/guideance/aurpogn7.pdf>

7. Laser safety controls

This is carried out by the person responsible for the laser work. It will detail hazard risk controls for laser beam and non-laser beam hazards. Different laser classes require different types of risk assessment.

ACTION: Refer to the webpage: *Laser Safety Risk Assessment*

Laser Safety Controls

The laser controls in place are designed to protect you and depend on the hazard risk level the laser class. For example, Class 3R, 3B and 4 lasers require a range of controls more complex than for laser Classes 1, 1M, 2 and 2M.

For a break down on what you need to know about laser controls go to:

ACTION: http://www.essex.ac.uk/ohsas/radiation/Laser_safety.htm

Summary of laser controls:

Departmental laser local rules – how you do things in the department at a local level for laser class. Essential for classes 3B and 4. Strongly recommended for 1M, 2M and 3R.

Laser inventory – keeping records on lasers or laser containing equipment in or out of use in the department.

Identification of Lasers – correctly labelled.

Authorised users for certain types of laser. This training and additional training based on risk and local laser risk controls.

Departmental registered on authorised laser workers.

Training – basic (this training), additional laser training based on class and specific laser equipment training. Managers responsible for laser work also have laser safety management training.

Designation of laser controlled areas – special areas where high risk lasers are used. Authorised persons only and clearly marked.

Laser scheme of work – a detailed scheme on how the work will be carried out based on risk assessment. This includes experimental setup and lab design.

8. Laser hazard controls for non-routine activities and emergencies

It is essential you know what to do in an emergency and how to protect yourself when carrying out non-routine activities.

Non-routine activities.

This covers: break down, planned maintenance, planned serving, cleaning, set up and set down of the experiment.

This needs to be risk assessed and controls, such as those mentioned before, put in place to protect you and others.

In some cases, contractors may be needed to carry out these activities. Speak to the DNIRPA or the UNIRPA for more detail.

Emergencies

You will need to know what to do in an emergency situation or when someone is hurt. A laser incident is an undesired event that results in injury or another loss. Another loss is: damaged equipment, time loss out of the experiment. Harm to you or other as described above.

ACTION: Refer to local arrangements for emergencies. These may include grab cards next to the laser, knowing who to report incidents to and how to raise the alarm for fire and first aid University emergency arrangements are detailed here <http://www.essex.ac.uk/ohsas/emergencies/default.htm> and how to report health and safety incidents here: <http://www.essex.ac.uk/ohsas/hsincident/Report.htm>

Reporting incidents

You must report laser incidents using the University Health and Safety Incident Report Form. This ensures the University Non-Ionising Radiation Protection Advisor is made aware as soon as possible. The UNIRPA is member of the Health and Safety Advisory Service (HSAS)

ACTION: Website: <http://www.essex.ac.uk/ohsas/hsincident/Report.htm>

This must be done as soon as possible.

For a high class laser an emergency information card should be with it and can be grabbed on the way to the hospital. The appropriate emergency response will be detailed in the scheme of work. Make sure you know what to do if there is an incident.

9. Introduction to the University Laser Safety Standard

The UK Law

In the UK the *Health and Safety at Work Act. 1974* means the University must ensure the health and safety of staff and students who work with laser or others who may be affected by laser work.

The *Management of Health and Safety at Work Regulations* require the person responsible for the laser work and laser to carry out a suitable and sufficient risk assessment.

The *Control of Artificial Optical Radiation at Work Regulations* require the University to manage work with lasers to protect the eyes and skin.

To ensure the University meets these laws a *Non-Ionising Radiation Standard* and *Laser Safety Standard* has been produced to help you and managers control the risks from lasers.

ACTION: Bring up the standard webpages. Highlight roles and responsibilities.

ACTION: Show trainees the Standard, the resources, sources of information.

10. Assessment

Separate the trainees, issue assessment. Allow 30 minutes and collect papers. Paper and answers available. Please contact the UNIRPA.