Laser and Intense Pulse Light Therapy Safety
Course title: Intense Light Pulse (IPL) Therapy and Class II Laser Safety

Course provider: Jonathon Thwaites, Medical and Scientific Services Pty Ltd
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Core knowledge the course will provide:
The course is appropriate for operators of IPL machine operators such as beauty therapists. In particular the nature of intense light source hazards is outlined, how protection might best be afforded when working with IPL and Class II laser light sources, appropriate working techniques to minimize the injury risk to staff and patients and administrative arrangements and legal obligations.

Appeals policy:
An open book (course notes) multiple choice test / True/False concludes the course. A pass mark of at least 60% is required. Individuals who fail the exam may re-sit the exam after an interval of 1 week.

Format:
The course can be attended as a formal classroom training course given by Jonathon Thwaites. Alternatively, the course may be completed on line, with course notes provided on line in 6 modules. Each module includes a multiple choice and True/False test. Participants must achieve 60% or more in each module for a pass. Individuals who fail may re-sit the course after an interval of 1 week.

Duration: 4 hours

Location: As organized

Course Notes:
Will be provided prior to the course if carried out in class. Alternatively, Participants will be given a login username and password to gain access to the course notes and quizzes. They will complete the quizzes on line. The quizzes will be assessed by the online training software.
Laser and Intense Pulse Light Therapy Safety

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1.0 LIGHT AND LIGHT SOURCES

Light is electromagnetic radiation and generally refers to that part of the electromagnetic spectrum ranging over the ultraviolet through visible to infrared (i.e. light with a wavelength between 100 nm to 10,000 nm). Light can be characterised by its wavelength (λ) i.e. its colour, frequency (f) and energy (E). The spectrum of electromagnetic radiation is shown in Figure 1.1. where you can see if you look at the scales that infrared light has a longer wavelength than UV and UV has a higher energy.

![Electromagnetic radiation spectrum](image)

Figure 1.1 Electromagnetic radiation spectrum, lasers operate in the UV, Visible and IR regions.

Light can be thought of as being a wave, a picture of a wave is shown in Figure 1.2. It also comes in small packets call photons with discrete amounts of energy. The wavelength of a wave – the distance between two adjacent crests determines the colour of the light.

![Light waves](image)

Figure 1.2 Light comes as waves but in the form of little packets called photons.

The light from a laser is very ordered and has special properties particularly useful for certain medical light therapies, but also can carry a risk of acute injury.

1.1 Important properties of light

1.1.1 Divergence

Laser light does not spread out much - its divergence is small. The beam intensity does not decrease appreciably with distance from the source and can remain hazardous over large distances, up to kilometres.

IPL light is divergent but lenses, mirrors and light guides are used to direct the light at the skin surface usually to an area of the order or 1 cm x 4 cm. The light applicator is held on the skin surface to ensure
the intensity is high. Moving it away from the skin surface will dramatically reduce the intensity at the skin surface.

1.2.1 Monochromaticity

Laser light is very pure in colour – it all has the same wavelength. Sometimes there are several colours but they are very pure (with narrow bandwidths of colour).

IPL light has a broad range of colour (called broad band) when compared to a laser. The light is however filtered to match coloured material in the skin or hair to improve its efficiency at targeting specific parts of the skin and to minimise heating in the bulk of the skin.

1.2.3 Coherence

Laser light is coherent the light waves move in unison. Figure 1.3. It is the coherence that gives a laser beam reflection its speckled look.

![Coherence](image)

Figure 1.3 Coherence

1.2 Laser light sources

The word LASER is an acronym for Light Amplification by Stimulated Radiation Emission of Radiation. The light from a laser is very ordered and has special properties particularly useful for certain medical light therapies, but also can carry a risk of acute injury.

Normal light sources emit light in a very disordered fashion made up of many wavelengths (colours) without coherence and emitted in all directions. Laser light sources emit light in a very orderly fashion, and have four main distinguishing characteristics:

- **Divergence is very low** - light doesn’t spread out much.
- **Monochromatic**, single coloured - very pure colour
- **Coherence** - high degree of temporal and spatial coherence – makes its light speckled looking
- **High intensity at distance** from the laser source

1.3 IPL Light sources

Flash lamps are generally used in IPL’s and the light emitted is pulsed and of high intensity. This light is broadband and includes a range of wavelengths including the ultraviolet, visible and near infrared (between 300 nm and 1200 nm). The light is usually filtered to obtain a maximum intensity matching absorption in various materials in the skin eg. hair, melanin etc. These coloured materials in skin are called chromophores. Filtering varies from manufacturer to manufacturer but is generally centred on green and limited to 400 nm (blue) and 1100 nm (near infrared).
Colour (i.e. wavelength) selection will affect therapeutic outcome. Sufficient energy at the correct wavelengths is essential for effective interaction with the desired chromophores at a rate fast enough to produce results with minimal peri-lesional (surrounding tissue) damage.

Different filters can be used to treat different tissue in the skin.

IPL beams can be 1 cm x 3cm or more in size and usually rectangular. Power densities are sufficient that they can cause damage to the eye if directed at the eye. The light is usually collected by mirrors, lenses and light guides around the lamp so that as much as possible can be directed in a controlled fashion on the skin surface.

In general IPL devices are simpler to use and the acute risk of injury is lower. Care is still required to avoid injury. Their main characteristics are:

- **Divergence is high** – the light spreads out so it must be collected and directed at the skin surface.
- **Polychromatic** – broadband light – there is a broad range of colours in the light
- **Intensity drops off rapidly at distance** from the light source.

IPL devices achieve therapeutic effects in tissue largely through thermal damage mechanisms, they therefore have the potential to cause injury if used improperly.

Selection of wavelength or colour band offers the following general advantages:

- Filtering one wavelength through safety glasses offers maximum visibility of the target tissue.
- Lower energy density is required as the colour is optimised for absorption in the target tissue.
- Power output per pulse is lower for example 1/10 of the power for unfiltered light beams.
- Wavelength is chromophore specific and so targets specific tissue..

The difference between and ordinary light and a laser light is shown in Figure 1.4.

![Ordinary light and laser light sources](image)

**Figure 1.4** Ordinary light and laser light sources

### 1.4 How a laser works

A laser has three basic components, Figure 1.5.

- **Energy source** or pumping system or excitation source
- **Lasing medium**
- **Mirrors to trap light** - A resonant (optical) cavity

Other accessories, for example lenses, shutters and mirrors may be added to the system to obtain shorter pulses, more power or special beam shapes.
Figure 1.5 Basic components of a laser

1.4.1 Lasing medium

The lasing medium is the material whose atoms or molecules have the correct properties to sustain the lasing process. The laser medium largely determines the colour (wavelength) of the laser light and gives the laser its name.

1.4.2 Energy source or pumping system

A source of energy (pump source) is required to maintain the lasing process. This energy source may be a light source such as a xenon flash tube, arc lamp, another laser or chemical reaction. Optical pumping sources often present an eye hazard and should never be looked at.

1.4.3 The optical cavity

An optical cavity is usually formed by carefully placing a mirror at each end of the laser material so that laser light may be reflected back and forth between the mirrors through the lasing medium many times. The perpendicular alignment of the mirrors and the distance between them is critically important to the laser operation.

1.4.4 Laser operation

Initially there is no light in the space between the mirrors (cavity). The supply of energy to the system creates a condition where light with the correct properties is produced. Laser light travelling along the cavity axis is reflected back and forth through the laser medium. This light causes more light to be produced of the same colour and moving in the same direction effectively amplifying the light. The useful laser beam emerges from the cavity through one of the end mirrors that is partially reflecting. Only light travelling on axis with the cavity is amplified and so that the light emitted from the laser is all moving in the one direction and does not spread out much (i.e. it has low divergence).

1.5 Focussing light beams

Laser beams, with non-divergent light can be focused to a very small spots - roughly the wavelength of the light making the light extremely intense and usually very dangerous at the focus, shown in Figure 1.6a. Figure 1.6b shows the focusing of an ordinary source where the light is focused to an image of larger size and therefore of lower intensity.
Figure 1.6  Focussing incoherent light and laser beams

If the focussing system is the eye the intense light of a laser beam will focus on the retina causing an almost immediate burn and probably blindness.

A laser of even moderate power such as a few milliwatts (laser pointer) typically has an intensity (irradiance) which is far greater than that of the brightest conventional light sources. A 1 mW laser pointer has an irradiance of about 500 - 1000 times that of the sun when focused onto the retina and can be dangerous to look into. Figure 1.7 puts the brightness of lasers into perspective with other light source we are likely to be exposed to.

Figure 1.7  Irradiance and retinal size for sources, adapted from Sliney and Wolbarsht 1980: 135
Intense Pulse Light and Low Power Laser Therapeutic Applications Safety Course

Name: __________________________ Date: ___________________
Address: __________________________

Open book exam. Answer each item. Total marks 141. Pass mark 75%

Quiz for Section 1  Laser & Intense Pulse Light Sources

1. Which parts of the electromagnetic spectrum are included in the term light (circle the correct one/s)?
   Electric power  Radiowaves  Infrared  Visible  Ultraviolet  X-rays  Cosmic rays

2. Light can be characterised by its wavelength ($\lambda$) i.e. its colour, frequency (f) and energy (E)  T  F

3. The colour of light is determined by its wavelength  T  F

4. Infrared light has a longer wavelength than visible light.  T  F

5. UV light particles or photons have more energy than infrared photons.  T  F

6. Laser is an acronym for Light Amplification by Stimulated Emission of Radiation  T  F

7. The three main components of a laser are:
   Energy source  Lasing medium  Mirrors to trap light  T  F

8. Four distinguishing characteristics of laser radiations are:
   Low divergence, high power density, monochromatic, coherent  T  F

9. IPL light sources are usually pulsed flash lamps emitting a broad spectrum.  T  F

10. IPL light sources are usually filtered to give a more useful colour band  T  F

11. What property of laser light allows it to produce a much smaller focal spot than a regular light source (circle the correct one)?
    Coherence  Monochromatic  Small divergence  High intensity

12. Laser pointers, patient alignment beams and aiming beams are low power and safe to look into  T  F

13. Which of the following are important properties of a laser beam

   (a) Low divergence  T  F
   (b) Monochromatic  T  F
   (c) Coherent  T  F
   (d) High irradiance at distance  T  F

14. Which of the following are properties of an IPL light sources

   (a) Divergence is high  T  F
   (b) Polychromatic – usually filter broad band light  T  F
   (c) Intensity drops off rapidly at distance from the light source  T  F
2.0 LIGHT UNITS

2.1 Energy

Energy has units of Joules (J). The amount of energy delivered into tissue will determine how hot it gets. Other factors play a role such as time, area, colour and the ability of different tissues to lose heat.

Energy (J)

2.2 Laser Power – this is the energy delivery rate

Power has units of Watts (W). It is the rate of flow of light energy (J/sec) from a light source. Power is used to describe “strength” of a light source. Pulsed lasers are described in terms of radiant energy per pulse (J).

\[
\text{Power} = \frac{\text{Energy (J)}}{\text{time (s)}} \quad \text{W}
\]

2.3 Energy Dose from a light source

The total energy delivered to tissue from the light beam is the energy of each photon times the number of photons delivered to the tissue per second times the time the light beam is on. For all light sources that are not pulsed the total energy delivered to the skin is:

\[
\text{Energy} = \text{Power (Watts) x time (s)} \quad \text{J}
\]

For a pulsed light sources the energy is given by the energy per pulse times the number of pulses delivered.

\[
\text{Energy} = \text{Energy/pulse (Joules) x No. of pulses} \quad \text{J}
\]

2.4 Power Density (Irradiance)

As mentioned in 2.3 the area of skin illuminated is also important to the therapeutic outcome and the units Power density and Radiant Exposure include area.

Power density, or irradiance, is the power per unit area in a beam of light (it is what you think of as intensity). Power is the rate of energy flow. So power density is the energy per unit time, divided by the area illuminated. If a small area of skin is illuminated for a given power then it will get hotter than a large area for the same power. In other words spreading the light out reduces its intensity and its ability to heat skin quickly. Irradiance is used for light sources that are not pulsed. Radiant Exposure is used for pulsed light sources.

\[
\text{Power density} = \frac{\text{power (Watts)}}{\text{area (m}^2)} \quad \text{W.m}^{-2}
\]

Power density at the treatment site can be varied by changing the power setting on the light source console, moving the light away from the tissue surface so that the larger area of the defocused beam illuminates the tissue, or holding the light on an oblique angle thus increasing the illuminated area.

2.5 Radiant Exposure

Is used for pulsed light sources where the power per unit time is delivered in short bursts.
Radiant exposure = energy per pulse (Joules) / area (m^2) J.m^{-2}

Irradiance and Radiant exposure are shown in Figure 2.1

![Figure 2.1 Units: Irradiance and Radiant exposure](image)

Important properties of light for causing damage in tissue:

- **Total Energy delivered** in a light beam determines its thermal effect in tissue and therefore the therapeutic outcome.
- **Time** is important - if the energy is delivered quickly the tissue will get hot. If delivered too slowly and the heat will dissipate before any effect in tissue can occur.
- **Area** is important – if the light energy is spread out over a larger area of tissue it will be less intense and the tissue will not get so hot.
- **Colour** of light is also important
- **Tissue** properties – like colour and ability to dissipate heat are also important
3.0 LIGHT DELIVERY SYSTEMS

Delivery systems affect the useful light intensity at the skin surface in a number of ways and can be used to enhance the properties of a light source for particular biological effects. A great variety of delivery systems are available.

3.1 Laser delivery systems

The four main ways of delivering medical laser radiation, and examples, to target tissue are:

<table>
<thead>
<tr>
<th>Delivery system</th>
<th>Direct delivery</th>
<th>Articulated arm</th>
<th>Hollow waveguide</th>
<th>Fibre optic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>All and Far UV</td>
<td>Far infrared</td>
<td>Far infrared</td>
<td>Visible/Near infrared</td>
</tr>
<tr>
<td>Laser type</td>
<td>Eximer / Diode</td>
<td>CO₂</td>
<td>ErYAG</td>
<td>ArIon</td>
</tr>
<tr>
<td>Use</td>
<td>Corneal / Pain reshaping</td>
<td>Surgery</td>
<td>Skin resurfacing</td>
<td>Ophthalmology</td>
</tr>
</tbody>
</table>

Figure 3.1 Articulated arm delivery system

Figure 3.2 Fibre optic delivery system

Fibre optics contains a thin strand of glass fibre through which the light passes. Only visible and near infrared light will pass efficiently through glass-like materials so they are used for these light sources.

Lasers used in medicine usually require aiming beams so you know exactly where the light is being directed. Aiming beams are usually low power diode lasers aligned and coincident with the treatment beam. It is important to ensure the aiming beam and treatment beam are coincident. Users must be aware that the aiming beam diameter on the target tissue may not be the same size as the treatment beam and also that it is aligned properly, Shown in Figure 3.3.

Figure 3.3 Aiming beam alignment issues

3.2 IPL delivery systems
A range of systems exist to get the light from the flash lamp efficiently onto the skin surface. Generally as much light as possible is collected from the lamp and directed onto the skin surface as shown below in Figure 3.4. There would often be different filters placed in the light path to optimise particular treatments by choosing the correct colour for the treatment.

**Optimised system**
- No light conduction through air
- Optical guide = fibre – low scatter
- Optical gel
  - low reflection
  - low refractive index changes

**Low energy loss**

![A typical IPL light delivery system](image)

Figure 3.4 A typical IPL light delivery system
Quiz for Section 2 and 3  Light units and Light delivery systems

1. It is the energy delivered in Joules that gives rise to heating in tissue. T F
2. The Power of a laser is the energy per unit time emitted by a laser T F
3. The Power density of a laser beam is measured as Watts/m\(^2\) T F
4. The Irradiance of a laser is the same as power density T F
5. Radiant exposure is measured as Joules/m\(^2\) T F
6. Power density can be thought of as light intensity T F
7. The important properties involved in heating tissue with light are:
   (a) Total Energy delivered T F
   (b) Time T F
   (c) Area T F
   (d) Colour of light T F
   (e) Tissue properties – tissue colour and heat dissipation in tissue T F
8. The four main ways of delivering medical laser radiation to target tissue are:
   Direct delivery Articulated arm Hollow waveguide Fibre optic T F
9. Fibre optic delivery systems are used for UV light T F
10. Low power alignment lasers are used on many medical lasers so the operator can see where the beam is T F
11. Typical IPL light delivery system use flash lamps, light guides, filters and mirrors T F
4.0 USE OF LASERS AND LIGHT IN PATIENT TREATMENTS

In 1960 Theodore H. Maiman built the first laser using a ruby crystal, it produced pulses of light in a deep red colour. 1964 was a prolific year for the development of lasers with Patel introducing the CO$_2$ laser, Guesic, Marcos and Van Uitect the Neodymium-doped Yttrium Aluminium Garnet laser (Nd:YAG) and Williem Bridges the Argon ion laser. Many thousands of different types of lasers are now available and the technology is still rapidly changing. The choice of technique, laser and delivery system are still undergoing rapid change and procedures are moving in and out of vogue every few years. Medical lasers have been used for cutting, cauterising, debulking tissue, lithotripsy, fluorescence imaging and photochemical effects.

4.1 Use of lasers falls into the following broad areas:

- Tissue cutting
- Tissue destruction - coagulation
- Microsurgery
- Photochemical
- Photomechanical

Lasers can be compared with other tools available in surgery. They have the potential to be a versatile tool as shown in Figure 4.1. The reality is that much care, training and experience is required in using and choosing a laser for a particular application. Clinical training and experience is necessary in order to achieve optimal results.

4.2 Advantages of laser use:

- Can be very precise - sub millimetre accuracy possible.
- Can cauterise blood vessels as it cuts.
- Sterilises tissue during use.
- Can be tissue specific in destructive power.
- Internal surgery can easily performed without major physical invasion.

4.3 Disadvantages of laser use:

- Can affect and destroy non-target tissue
- Healing can take longer due to local tissue necrosis
- Laser type delivery system, power and focus to be chosen very carefully
- Safety aspects: ignition of materials intercepting the beam
- Risk to operators eyesight and skin
- Laser plume can contain viable viral material
- Large capital cost

4.3 Basic light interactions
The fundamental physical processes by which light can interact with matter are:

- Reflection, also known as backscatter;
- Absorption, where the energy is transferred to the tissue;
- Scatter, i.e. a change of direction; and
- Transmission, where no energy is lost during the passage through tissue.

Typically all four are involved in therapeutic treatments. Figure 4.2 illustrates these processes. Light that is scattered, reflected or transmitted will not heat tissue, although it may interact with tissue further on. Absorption leads to heating.

![Diagram of transmission, absorption, scattering and reflection](image)

Figure 4.2 Transmission, absorption, scattering and reflection

Light output power and the area of tissue illuminated and time determine the energy density and distribution of light reaching a target site. The combination of light wavelength, and reflection, scattering, absorption and transmission characteristics of different tissues, together with the thermal properties of tissue determine the three dimensional thermal response that will be induced. By manipulating these factors one can obtain the desired therapeutic effects of cutting, coagulation, vaporisation etc.

### 4.3.1 Light effects in tissue - Thermal and Non-Thermal

Light-tissue interactions include:

- **Thermal** – tissue heating
- **Non-thermal**
  - Photomechanical (high power pulsed lasers usually)
  - Photochemical
  - Biostimulation.

#### Thermal

The total energy of light delivered is important in these effects. Colour (or photon energy) will also affect reflection, scattering, transmission and absorption.

Most light sources used in Medicine produce an effect that is thermal in nature with tissue destruction being achieved by simple heating. The tissue temperature rises, causing coagulation and eventually vaporisation.

The temperature at which the stages of thermal tissue reaction occur are not exact and depend on the particular circumstances of the treatment, they are given in Table 4.1. At 60°C protein in tissue denatures and is permanently damaged.
IPL light sources generally produce lower power densities insufficient to achieve cutting or ablation. They produce light over broader colour bands. Their main therapeutic effect is to heat tissue - killing selected cells by elevating the temperature of selected tissues or materials (like hair follicles) in the skin.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>37 - 55°C</td>
<td>Warming, dehydration (no permanent damage)</td>
</tr>
<tr>
<td>55 - 60°C</td>
<td>Coagulation - welding</td>
</tr>
<tr>
<td>60 - 100°C</td>
<td>Denaturation - blanching (increased tissue reflection)</td>
</tr>
<tr>
<td>around 100°C</td>
<td>Vacuolation</td>
</tr>
<tr>
<td>100 - 300°C</td>
<td>Vaporisation of tissue water</td>
</tr>
<tr>
<td>300 - 1000°C and over</td>
<td>Carbonisation of tissues</td>
</tr>
</tbody>
</table>

Table 4.1 Stages of thermal tissue reaction

**Non-thermal**

The energy of the individual light photons determines absorption in these effects.

**Photoablative effects** involve the direct breaking of molecular bonds and subsequent release of biological material. As an example, excimer lasers that operate at several ultraviolet wavelengths can produce photoablation in tissues without appreciable thermal effect. Ultraviolet radiation is strongly absorbed by biomolecules so penetration depths are small, of the order of a few micrometres.

**Photochemical** mechanisms are chemical processes initiated by the absorption of visible, ultraviolet or infrared radiation. These reactions convert light energy into chemical energy. Everyday examples are the tanning of skin by sunlight and the taking of photographs.

**Biostimulation** is purported to occur with the use of low intensity red or infrared light sources. The light is reported to produce microcirculatory effects and to stimulate certain cellular processes.

### 4.4 Light factors and tissue effects

The way in which a light source reacts with tissue is not only dependent upon the properties of the light but also on the properties of the tissue exposed as shown in Table 4.2. The main parameters of the light that effect the scope and rate of tissue damage are (these are discussed in the subsections below 4.4.1 to 4.4.6):

<table>
<thead>
<tr>
<th>Light properties</th>
<th>Tissue properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>Vascularisation - ability to remove heat</td>
</tr>
<tr>
<td>Reflectance</td>
<td>Scattering</td>
</tr>
<tr>
<td>Beam area at target</td>
<td>Transmission</td>
</tr>
<tr>
<td>Energy delivered</td>
<td>Initial temperature of the area exposed</td>
</tr>
<tr>
<td>Time of exposure</td>
<td>Absorption</td>
</tr>
<tr>
<td>Colour of light</td>
<td></td>
</tr>
<tr>
<td>Pulse duration</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 Main parameters of light and tissue that affect the scope and rate of damage.

### 4.4.1 Colour (Wavelength)
Heating of tissue depends on the wavelength of the light, and determines reflection, scattering, absorption and transmission of the light in the tissue. Tissue contains a large percentage of water and its absorption characteristics play a major role in the absorption of light energy. Absorption in water is low at about 1,000 nm, climbs to a peak at 2,900 nm, falls to a shallow trough at 3,500 nm and then slowly climbs to a peak again at 10,000 nm. Lasers operating near these absorption peaks, eg CO₂, Ho:YAG or Er:YAG will be good for cutting tissue. IPL sources avoid these wavelengths as this light would simply heat the bulk of the skin surface causing non-specific burns to the skin.

The haemoglobin absorption curve peaks at 400 nm and 577 nm and lasers at these wavelengths are useful for the treatment of vascular lesions (eg port wine stains). The 577 nm wavelength is the most suitable because melanin also has a strong absorption peak at 400 nm. Argon laser (515 nm and 488 nm) has been used to treat vascular lesions but in fact these wavelengths are in a trough between the 400 nm and 577 nm peaks and copper vapour laser and tuneable dye lasers with wavelengths of 577 nm are the most effective. Argon lasers are used in ophthalmology where the light is readily transmitted through the lens cornea etc but absorbed readily in melanin in the retina and other structures with colour. Schematic diagrams of haemoglobin, melanin and water absorption are given in Figure 4.2.

![Haemoglobin, melanin and water absorption as a function of wavelength](image)

**Figure 4.2** Haemoglobin, melanin and water absorption as a function of wavelength

Skin penetration as a function of wavelength is shown in Figure 4.3. Greatest penetration is in the near infrared around 750 nm and is up to 5 mm depth.

![Skin penetration depth and colour (or wavelength)](image)

**Figure 4.3** Skin penetration depth and colour (or wavelength)
As tissue is heated proteins within it are denatured and often cause the tissue to change colour, it may blanch enhancing reflection temporarily reducing the rate at which a therapeutic effect is achieved. Similarly tissue charring may enhance absorption and increases the rate of tissue heating.

### 4.4.2 Area exposed

The light beam area effects tissue damage rate. Smaller areas have a greater ability to conduct heat away than larger areas and hence for the same irradiance will take longer to heat. Similarly tissues that are well vascularised can remove heat more rapidly than those that are not.

### 4.4.3 Power density

This is the rate at which energy is deposited on the tissue surface. The faster the energy is deposited the faster the tissue will heat. Thermal properties of the tissue will work to dissipate this heat. If energy is deposited slowly there may be a lot of coagulation at depth or simple dehydration of the tissue. If deposited quickly there may be almost instant ablation with little damage below the surface as the heat is lost with the ablated tissue. Tissue properties at transmitting, scattering, reflecting and absorbing light are of course colour dependent.

### 4.4.4 Time of exposure

The longer the light energy impinges on the tissue surface the more energy will be deposited. Together with power density the pulse shape and time determine the total energy delivered. If energy is delivered in pulses – the pulse properties will determine the differential tissue temperature rise - for example the blue pulse in Figure 4.4 below is generally better for hair removal than the red pulse. Vascularisation will also affect the temperature.

![Figure 4.4](image)

**Figure 4.4** Blue line shows square pulse and the red line is the normal pulse output

Figure 4.5 shows how pulsing regimes have changed in time to achieve better therapeutic outcomes for hair removal. Note other pulsing regimes will be better for other outcomes.

![Figure 4.5](image)

**Figure 4.5** 1st picture shows square pulse, 2nd picture shows 2nd generation pulse (multi pulse with cool off period between pulse and 3rd picture is first generation pulse with a single pulse
4.4.5  Pulse duration

Short pulses will generally deliver energy more quickly than tissue can conduct and convection heat away. Pulsed light will generally effect certain components of tissue rather than the total bulk of the tissue or cause very superficial heating. The effects change with colour and tissue type.

4.4.6  Total energy

Will determine with the other parameters above the temperature rise and therapeutic effect.
Quiz for Section 4  Lasers and light in patient treatments and Basic light interactions

1. Lasers are commonly used in the following broad areas in medicine:

   (a) Tissue cutting  T  F  
   (b) Tissue destruction - coagulation  T  F  
   (c) Microsurgery  T  F  
   (d) Photochemical effects  T  F  
   (e) Photomechanical effects  T  F  

2. A disadvantage of laser use is that there is a risk to operators eyesight and skin.  T  F  

3. The laser plume presents no hazard from viral material.  T  F  

4. The fundamental physical processes by which light can interact with tissue are:

   (a) Reflection  T  F  
   (b) Absorption  T  F  
   (c) Scatter  T  F  
   (d) Transmission  T  F  

5. Light-tissue interactions include thermal and non-thermal  T  F  

6. Protein in tissue is not damaged until it reaches boiling point 100°C  T  F  

7. Important light source parameters in light therapy techniques are:

   (a) Wavelength  T  F  
   (b) Beam area at target  T  F  
   (c) Energy delivered  T  F  
   (d) Time of exposure  T  F  
   (e) Colour of light  T  F  
   (f) Pulse duration  T  F  

8. Important tissue parameters in light therapy techniques are:

   (a) Reflectance  T  F  
   (b) Vascularisation - ability to remove heat  T  F  
   (c) Scattering  T  F  
   (d) Transmission  T  F  
   (e) Initial temperature of the area exposed  T  F  
   (e) Absorption  T  F  

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5.0 INTENSE PULSE LIGHT THERAPY (IPL)

Training and Instruction are required to gain an appropriate level of skill and knowledge to carry out IPL therapy safely and effectively. You must always understand the capabilities of your equipment and how to use it properly. The patient and the patient’s safety is the responsibility of the user at all times.

5.1 Treatments

IPL is used most commonly for hair management and skin pigmentation removal. These therapies are generally for cosmetic purposes.

5.1.1 Hair management

The traditional ways of achieving hair removal are:

- Waxing, shaving, depilatory creams, tweezers - regrowth within two weeks.
- Needle electrolysis - excellent results very time consuming, painful, scarring risk, skilled task.
- Medical lasers - medium to excellent results depending on laser, skilled task, individual hair type dependent, expensive.
- Pulsed light or flash lamps - safer than lasers and employ lower energy levels and achieve comparable results.

Procedures need to be:
- Efficient
- Rapid
- Durable
- Safe
- Proximity
- Affordable

5.1.2 Intense Pulse Light Principles

Broad spectrum of light from a flash lamp or xenon short arc lamp or similar is filtered to remove ultraviolet (UV) and infrared (IR) wavelengths. This Intense and Selective Light is directed at the melanin, the pigment contained in, among other things, the hair. After the treatment, virtually all the visible hairs (except white or red hairs) in the treated area then fall out in approximately twenty days.

The sessions are rapid, virtually painless and the results are 2 to 3 times more durable than a properly conducted wax treatment. Over the number of sessions, the number of hairs diminishes. The remaining hairs thin and their growth becomes slower and slower. Progressively, unsightly hairs in the treated area disappear. After this, only a maintenance session from time to time is necessary depending on the needs of the individual.

5.2 The skin

The skin, Figure 5.1, contains sensory receptors, capillary blood vessels, glands (sebaceous glands, sweat glands), hairs and their associated structures (arrector pili muscle, hair follicle), fibres (collagen, elastin). The skin has numerous roles:

- Protection (mechanical, physical and chemical)
- Regulation of body temperature (capillaries and sweat glands)
- Vitamin synthesis (vitamin D)
- Relation with the external milieu (sensory receptors)
The skin is made up from 3 distinct layers:

5.2.1 The epidermis
The keratinocytes, the cells in contact with the basal membrane, differentiate and are progressively expelled. This is the phenomenon of exfoliation or skin peeling. This process takes around 30 to 45 days. In the basal layer, the melanocytes synthesise melanin, the pigment that protects the core of cells from harmful UV radiation. This melanin, transitory or permanent, is responsible for skin colouring (tanning, dark skin or black skin). There are no blood vessels in the epidermis. The epidermis produces phanera or keratin-based appendages, such as hair or nails.

5.2.2 The dermis
This deeper layer is formed from a network of fibres (collagen, elastin) that ensure the proper structure and behaviour of the skin. It also contains blood vessels, nerve endings, various glands (sweat glands and sebaceous glands). In addition, the dermis houses hair follicles.

5.2.3 The subcutaneous
The last deep layer contains adipose cells or fat lobules. The number of adipose cells varies from one individual to another.

Skin pigmentation relates to the quantity of melanin contained in the epidermal cells. The more melanin that they contain, the darker the skin and the less specific and effective the treatment becomes. The synthesis of melanin depends on 2 factors:

- Genetic factors
- Exposure to sunlight

During exposure to sunlight, the quantity of melanin and the speed of the synthesis depends on the genetic heritage of each individual. Individuals are classified into 1 of 6 skin types - Table 5.1.

<table>
<thead>
<tr>
<th>Skin type</th>
<th>Hair</th>
<th>Eyes</th>
<th>Skin</th>
<th>Freckles</th>
<th>Sun tan</th>
<th>Degree of tan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red/Blond</td>
<td>Blue or green</td>
<td>Milky</td>
<td>+++</td>
<td>Always</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Blond/Medium</td>
<td>Light to medium</td>
<td>Clear</td>
<td>++</td>
<td>Always</td>
<td>Light tan</td>
</tr>
<tr>
<td>3</td>
<td>Chestnut</td>
<td>Medium to dark</td>
<td>Matt</td>
<td>+</td>
<td>Frequent</td>
<td>Dark tan</td>
</tr>
<tr>
<td>4</td>
<td>Brown</td>
<td>Dark</td>
<td>Matt</td>
<td>0</td>
<td>Rare</td>
<td>Dark</td>
</tr>
<tr>
<td>5</td>
<td>Brown</td>
<td>Dark</td>
<td>Very matt</td>
<td>0</td>
<td>Exceptional</td>
<td>Very dark</td>
</tr>
<tr>
<td>6</td>
<td>Black</td>
<td>Dark</td>
<td>Black</td>
<td>0</td>
<td>0</td>
<td>Black</td>
</tr>
</tbody>
</table>

Table 5.1 Skin and pigmentation skin types

5.2.4 Hair
The hair is a keratin based structure produced by the epidermis shown in Figure 5.2. The principle role of hair is thermal and mechanical protection. There are approximately 5 million hairs on the body with 1 million of these on the head.

![Diagram of hair structure](image)

**Figure 5.2** The hair

The hair is implanted obliquely in the dermis via epidermic intussusception. It comprises a shaft or hair emerging from the skin and an invisible part, the root, implanted at varying depths and terminating in the bulb. It receives nourishment via capillaries that enter the root sac. The root is contained in an envelope known as the follicle.

The number of hair follicles is determined for life at an embryonic stage. Three types of hairs succeed each other throughout the lifetime of the individual:

- Lanugo. This is foetal hair that is transformed into vellus
- Vellus. Fine colourless or lightly coloured hair with a length of less than 2 cm
- Terminal hair. Long, thick and pigmented

Vellus is transformed into terminal hair through the action of androgen hormones. This is why, during puberty, the vellus covering certain areas (axillae, pubis) becomes into terminal hair. In women, the vellus covering other areas (torso, back) remain in the vellus state since their production of androgens is low. External factors (shaving, waxing) cannot transform vellus into terminal hair. In other words, contrary to rumour, shaving does not lead either to accelerated growth or increase hair size or change hair pigmentation.

In certain cases, hair growth and its distribution over the body may be modified. This is the case in hirsutism (linked to hormonal changes in women) and hypertrichosis (abnormal hair growth in either a normal or abnormal areas). In both of these cases hair management may become highly complex and require medical treatment.

### 5.2.5 Hair growth cycle

A single hair has an ephemeral existence. It undergoes periods of growth and periods of stasis. This so-called hair growth cycle is divided into 3 phases, shown in Figure 5.3:

- **The Anagene Phase** or growth period. A new hair is generated by the follicle. It pierces the dermis and becomes active (synthesising keratin and melanin)
• **The Catagen Phase.** This is a regression phase. The synthesis activity halts. The bulb detaches itself from the papilla. It remains linked by an epithelial cord formed by the outer epithelial sheath. This phase lasts 2 to 3 weeks.

• **The Telogen Phase** or rest phase. During this phase, no hair is produced. Its duration is variable and depends upon numerous factors (anatomical location, internal and external factors).

![Figure 5.3 Phases of the hair growth cycle](image)

The length of the hair growth cycle as well as the distribution of Anagene/Catagen varies from one individual to another. In the same way hair density and growth speed is variable. Table 5.2 below shows the commonly accepted data.

<table>
<thead>
<tr>
<th>Location</th>
<th>Anagene</th>
<th>Telogen</th>
<th>Time Anagene</th>
<th>Time Telogen</th>
<th>Density hairs/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair</td>
<td>87</td>
<td>13</td>
<td>2-6 yrs</td>
<td>2-5 months</td>
<td>350</td>
</tr>
<tr>
<td>Eyebrows</td>
<td>10</td>
<td>90</td>
<td>3-9 weeks</td>
<td>2-4 months</td>
<td>145</td>
</tr>
<tr>
<td>Ears</td>
<td>15</td>
<td>85</td>
<td>3-9 weeks</td>
<td>2-4 months</td>
<td>60</td>
</tr>
<tr>
<td>Cheek</td>
<td>50-70</td>
<td>30-50</td>
<td>12-15 months</td>
<td>12-16 weeks</td>
<td>455</td>
</tr>
<tr>
<td>Chin</td>
<td>70</td>
<td>30</td>
<td>9-15 months</td>
<td>8-12 weeks</td>
<td>455</td>
</tr>
<tr>
<td>Upper lip</td>
<td>65</td>
<td>35</td>
<td>14-18 weeks</td>
<td>4-8 weeks</td>
<td>380</td>
</tr>
<tr>
<td>Axilla</td>
<td>30</td>
<td>70</td>
<td>3-5 months</td>
<td>2-4 months</td>
<td>65</td>
</tr>
<tr>
<td>Pubis</td>
<td>30</td>
<td>70</td>
<td>3-5 months</td>
<td>2-4 months</td>
<td>60</td>
</tr>
<tr>
<td>Arm</td>
<td>20</td>
<td>80</td>
<td>11-16 weeks</td>
<td>14-22 weeks</td>
<td>70</td>
</tr>
<tr>
<td>Leg</td>
<td>20</td>
<td>80</td>
<td>15-19 weeks</td>
<td>20-28 weeks</td>
<td>50</td>
</tr>
<tr>
<td>Thigh</td>
<td>20</td>
<td>80</td>
<td>15-19 weeks</td>
<td>20-28 weeks</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 5.2 Hair growth cycles in relation to anatomical location

At the base of a follicle there are generally 2 other non active follicles. Sometimes, after a depilatory wax treatment, it is possible to find 2 or 3 hairs issuing from the same orifice. In this case the various non active hairs have become active at the same time. They are said to be synchronised. In humans, contrary to animals, the follicles are rarely synchronised. The anagene phases do not all begin at the same time. This particularity explains, among other things, the need to employ multiple sessions since these hairs grow over different time periods.

5.3 **Physics of IPL hair removal**

5.3.1 **The absorption of light**

The coloured substances in tissue that absorb light are known as chromophores. The main chromophores in the skin are:
- Melanin
- Haemoglobin (Oxyhaemoglobin)
- Water

Each chromophore absorbs more or less energy depending on the wavelength involved, Figure 5.4.

![Chromophore absorption curve](image)

Figure 5.4 Chromophore absorption curve

Depending on the range of wavelengths involved, it is possible to specifically target one chromophore instead of another. The chromophore on absorbing light will heat up and transmit its heat to neighbouring tissues. The speed of transmission of the heat to nearby tissue depends upon the thermal-relaxation time. The thermal-relaxation time (TRT) corresponds to the time necessary for the target to return to half of the temperature to which it was heated. This time is smaller the smaller the target (thus a short pulse for fine hairs, a long pulse for thick hairs).

5.3.2 Action of light on the hair follicle

Looked at in the framework of hair removal, the target is the hair follicle. However, the hair follicles do not contain any specific chromophores. On the other hand, the hair itself contains melanin (except for white hairs and blonde vellus). It is this melanin that is used as the target and intermediary.

![Wavelengths specific to melanin](image)

Figure 5.5 Wavelengths specific to melanin

By selecting wavelengths that target melanin, the hair will preferentially absorb light energy, transform it into heat and transmit it to the hair follicle providing the hair is in its anagene phase. This
thermal energy transmitted to the hair follicle allows the follicle to be destroyed. The hair depending upon it will therefore never grow again. This phenomenon is known as Selective Photothermolysis. The light of most IPL machines is filtered so as to selectively target the chromophore: melanin, shown in Figure 5.5 and 5.6.

Figure 5.6  Light scattering on hair

If the hair is not in its anagene phase, it is no longer in contact with its nourishment structure. The follicle cannot therefore be reached. Nevertheless, the hair will fall in the following days. This is why after a session, virtually all the hairs fall. However, such hairs will rapidly grow again.

It is extremely important to pay attention to skin pigmentation. The more the skin is pigmented, the more melanin it contains. This cutaneous melanin stops part of the light rays, Figure 5.7, from reaching the hair and results in:

- A loss of efficiency
- The risk of secondary effects (burns)

Figure 5.7  The case of highly pigmented skin

This is why it is essential not to use this type of treatment on skin types 5 and 6 nor with individuals having dark suntans. The results obtained by treatment therefore depend upon:

- The skin colour
- The hair colour
- The phase of the hair growth cycle
- The pulse duration
- The amount of energy used

It is the proper understanding of these different parameters that allow optimum results to be obtained.

5.4  Patient selection

The majority of patients that you will encounter will want to rid themselves of unsightly body hair for purely aesthetic reasons. Any abnormal hair should first be subjected to a medical inspection to
determine whether or not it is linked to an underlying pathology. In such cases, only a qualified doctor can determine whether it is possible or not to envisage treatment.

It is very important to select your patients. The ideal profile is that of a patient having light skin and dark hairs. It is preferable to begin your treatment experience with such patients. As your experience grows you will be able to widen your range of patients.

You are reminded that too heavily pigmented skins should not undergo treatment. Consequently, it is essential to use extreme caution when treating skin types 5 and 6 if your machine allows you to treat skin types 5 and 6 at all, better eliminate them altogether from treatment. For the same reasons, patients with too dark a suntan should either be refused or asked to return in two or three weeks when it has faded.

White hairs, red hairs and very fine light vellus do not respond to treatment. It is therefore essential to carefully examine both the colour and type of hair.

The satisfaction of your patients will be directly related to this initial selection. The patient must know what to expect in order to be satisfied. If your promises are too optimistic your patients will feel deceived.

5.4.1 Contra-indications

Before beginning any cycle of pulsed light treatment, it is recommended that the patient has a medical opinion. Such an examination will determine whether the patient can follow pulsed light treatment without risks. However, there are a certain number of cases that it is essential to understand and which represent major contra-indications. This list, far from being exhaustive, nevertheless it represents those cases that you must categorically refuse. In the majority of these cases the patient can be questioned and examined without needing a medical examination.

- Suspect skin blemishes
- Antecedents of tumours
- Pregnant women
- Diabetics
- Wearers of a Pace Maker
- Haemophilia
- Treatment with anticoagulants
- Epilepsy
- Photo sensitizing treatment (particularly those based upon isotretinoin often known as RoacutaneND)
- Skin diseases (herpes, psoriasis, eczema, acne etc.).

In the case of suspect skin blemishes, your role should be preventative. Your training must permit you to identify these blemishes and you must advise your patient to consult a specialist.

In the case of photo sensitizing drugs, a careful reading of the label or leaflet generally indicates if there is a risk of photo sensitizing effects.

5.4.2 Informing the patient

You must correctly inform your patient about this method and what he or she can reasonably expect. Among other things you must inform your patient concerning:
5.3 Precautions

It is essential that your patient:

- Does not carry out hair removal in the 2 weeks preceding the treatment
- Does not use depilatory creams in the days prior to the treatment
- Does not bleach the hairs in the days prior to the treatment
- Does not sunbathe for 15 days before the treatment

In certain cases, it is difficult to judge whether the treatment can be carried out without risk (skin pigmentation, type of hair, sensitivity of the patient). It is judicious in such cases to carry out a spot test. This should be carried out on a non-visible zone (behind the ear, axilla, etc.) and the patient seen 20 days later to judge the reaction of the skin and the fall of hairs. If the hairs have not fallen 20 days after a session it is vital that the treatment is not continued. Apart from the incorrect selection of patients at the outset, there are 2% to 3% of individuals who do not respond suitably to photo-depilation. Similarly, such a period permits the observation of any possible skin reactions (marks) and hypo or hyper pigmentation.
5.5 Consent Form 1st Consultation

SAMPLE

FIRST NAME: ___________________ SURNAME: _____________________

DATE: ________________________ SEX: ____________________ D.O.B: ____/____/____

ADDRESS: ________________________________________________________________

PHONE (H)______________________ (W)____________________ (M)________________________

EMAIL ADDRESS: ____________________________________________________________

AREA(S) TO BE TREATED: ____________________________________________________

WHERE DID YOU HEAR ABOUT US? ____________________________________________

<table>
<thead>
<tr>
<th>TICK</th>
<th>TYPE</th>
<th>SKIN COLOUR</th>
<th>REACTION TO FIRST SUN EXPOSURE YEARLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I</td>
<td>White</td>
<td>Always burns, never tans, blue or green eye colour</td>
</tr>
<tr>
<td>II</td>
<td>II</td>
<td>White</td>
<td>Mainly burns, sometimes tans, light to medium eye colour</td>
</tr>
<tr>
<td>III</td>
<td>III</td>
<td>White/Asian</td>
<td>Sometimes mild burns, average tans, medium to dark eye colour</td>
</tr>
<tr>
<td>IV</td>
<td>IV</td>
<td>Moderate Brown</td>
<td>Rarely burns, tans easily, dark eye colour</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>Dark Brown</td>
<td>Very rarely burns, tans easily, dark eye colour</td>
</tr>
<tr>
<td>VI</td>
<td>VI</td>
<td>Black</td>
<td>Never burns, dark eye colour</td>
</tr>
</tbody>
</table>

Medical Background...

Do you have ANY current or chronic medical illnesses we should know about or are you taking any medication of any kind?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Are you taking any medication such as Aldactone or Androcur? (Medication used to slow hair growth). Or medication containing Tetracycline?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Have you ever had or used Vitamin A Cream, Chemical Peel, Alpha-Hydroxy-Acid, Retinoids, Glycolic Acids, micro-dermabrasion, Roacctuane, or Dermabrasion, Laser Resurfacing or Cortisones or any light sensitive medication?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Have you ever consulted an Endocrinologist?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Do you have any tattoos or permanent makeup in the area(s) to be treated?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Have you had any previous treatment with other Intense Pulse Light or Laser?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Do you use sun beds or self-tanning products?

( ) Yes ( ) No If yes, please give details: ........................................................................................................

Are you currently pregnant or trying to conceive?

( ) Yes ( ) No

Have you ever experienced or been treated for any of the following? Please circle.

- Metal Implants
- Pacemaker
- Melanoma
- Skin Cancer
- Diabetes
- Keloid Scarring
- Melasma
- Menopause
- Cancer
- Skin Blemishes
- Psoriasis
- Epilepsy
- Herpes
- Vitiligo
- Pace Maker
- Polycystic Ovaries
- Anti-Coagulant Therapy
- Hormone Therapy
- Haemophilia
- HRT
- Photo Sensitizing medication

Please give details: ........................................................................................................
Consent Form Part 2  SAMPLE

I__________________________________________________ on (date)____/____/____ hereby duly authorize specifically

trained associate technicians of_______________________________________________________________ to perform progressively
permanent hair management procedures using Square Intense Pulsed Light Technology.

I understand that this is a relatively new medical cosmetic procedure and that long term studies are ongoing.

Pulse Light Technology is FDA approved for long term hair reduction. It will only work on hair at the growing stage. The estimated number of treatments and approximate cost may change according to any variation that may occur in skin colour and hair thickness. With ongoing treatments the re-growth and melanin will lose structure which could affect the result.

I am aware that multiple sessions will be required and I have been informed of the approximate number of treatments involved for my skin type/area to be treated. I am aware that maintenance sessions may be required according to individual needs.

I have been advised of the possible following effects of Intense Pulse Light.

The treated area can include mild discomfort, slight reddening, minor swelling, and erythema and per follicular edema (goose bumps) which should disappear within a few hours.

Scarring is a rare possibility but it has occurred in less than 1% of the population.

Skin lightening (hypo-pigmentation) or darkening (hyper-pigmentation) may appear on the treated area. This should be a temporary condition and may take a few months to return to normal.

The treated area must be protected using SPF 30+ for three weeks before and after treatment. Unprotected exposure to the sun three weeks before treatment may increase the chance of increased reddening, superficial burns or changes in pigmentation in response to the treatment. Unprotected sun exposure after treatment may increase the risk of sunburn and could develop hyper or hypo-pigmentation.

If the client has used Oral Isotretinoin (Roaccutane) they must wait 6 months before proceeding with Intense Pulse Light treatments. Herpes simplex virus may become active if the treatment is on the face. It is recommended that Valtrex or Zovirax be taken as prescribed to avoid an outbreak.

Client must wear eye protection as recommended whilst under treatment.

This treatment may not produce permanent hair removal. An exact result cannot be predicted and I acknowledge that no guarantees have been made to me.

My questions regarding this procedure have been answered to my satisfaction. I accept the possible adverse effects of the treatment and agree to provide after care as suggested by this salon.

I have answered all the medical questions honestly and to the best of my knowledge.

I have read all the material provided and had all my questions answered satisfactorily. I have not been advised of any matter verbally that is not included in this consent form.

I am aged 18 years or over (otherwise parent or guardian to sign).

DO NOT SIGN THIS FORM UNTIL YOU HAVE READ AND UNDERSTAND THE ENTIRE CONTENTS OF THIS PAGE AND ALL YOUR QUESTIONS HAVE BEEN ANSWERED SATISFACTORY.

Name_________________________  Signature_________________________

Witness_________________________  Signature_________________________

Date____/____/_____  Date____/____/_____

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SECOND AND SUBSEQUENT TREATMENT(S) CONSENT FORM

NAME: (PLEASE PRINT)________________________

<table>
<thead>
<tr>
<th>TREATMENT NO:</th>
<th>PLEASE CIRCLE YES OR NO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you satisfied with your results since your last treatment?</td>
<td>YES/NO</td>
</tr>
<tr>
<td>Are you satisfied that your expectations are being fulfilled?</td>
<td>YES/NO</td>
</tr>
<tr>
<td>Do you wish to continue with your Treatments?</td>
<td>YES/NO</td>
</tr>
<tr>
<td>Have you had any sun exposure or sun-less tanning treatment since your last Treatment?</td>
<td>YES/NO</td>
</tr>
<tr>
<td>Are you satisfied with the performance &amp; professionalism of your Operator?</td>
<td>YES/NO</td>
</tr>
</tbody>
</table>

**Medical Background...Since your last IPL Treatment**

Do you have ANY current or chronic medical illnesses, or have you commenced medication of any kind since your last IPL treatment?

( ) Yes ( ) No If yes, please give details:______________________________________________________________

Are you taking any medication such as Aldactone or Androcur since your last IPL treatment? (Medication used to slow hair growth).

( ) Yes ( ) No If yes, please give details:_________________________________________________________________

Have you used Vitamin A Cream, Chemical Peel, Alpha-Hydroxy-Acid, Rocactuane, Dermabrasion, Laser Resurfacing or Cortisones or any light sensitive medication since your last IPL treatment?

( ) Yes ( ) No If yes, please give details:_________________________________________________________________

Do you have any tattoos or permanent makeup in the area (s) to be treated?

( ) Yes ( ) No If yes, please give details:_________________________________________________________________

Do you use sun beds or self-tanning products?

( ) Yes ( ) No If yes, please give details:_________________________________________________________________

Are you currently pregnant or trying to conceive?

( ) Yes ( ) No

Have you experienced or been treated for any of the following since your IPL treatment started? Please circle.

<table>
<thead>
<tr>
<th>Metal Implants</th>
<th>Pacemaker</th>
<th>Melanoma</th>
<th>Skin Cancer</th>
<th>Diabetes</th>
<th>Keloid Scarring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melasma</td>
<td>Polycystic</td>
<td>Ovaries</td>
<td>Menopause</td>
<td>Cancer</td>
<td>Anti-Coagulant Therapy</td>
</tr>
<tr>
<td>Blemishes</td>
<td>Psoriasis</td>
<td>Epilepsy</td>
<td>Hemophilia</td>
<td>HRT</td>
<td>Skin</td>
</tr>
<tr>
<td>Please give details:___________________________________________________________________________________</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*I confirm that the above is true and accurate and am aware of the risks if I have not answered truthfully.*

Client’s Signature:________________________________________Date:________________________

*Sun Exposure refers to ANY time in the sun with IPL treated area exposed to sunlight / Sun beds. Please initial and date the boxes after reading this page and before EVERY subsequent treatment. Thank you.*

1 2 3 4 5 6 7 8 9 10 11 12
## Quiz for Section 5  
**Intense Pulse Light Therapy (IPL)**

1. In IPL broad spectrum of light from a flash lamp or xenon short arc lamp is filtered to remove ultraviolet (UV) and infrared (IR) wavelengths  
   - T  F

2. Pulsed light or flash lamps are safer than lasers and employ lower energy levels and achieve comparable results and so patient injury is not possible.  
   - T  F

3. The skin has numerous roles:
   - (a) Protection (mechanical, physical and chemical)  
     - T  F
   - (b) Regulation of body temperature (capillaries and sweat glands)  
     - T  F
   - (c) Vitamin synthesis (vitamin D)  
     - T  F
   - (d) Relation with the external milieu (sensory receptors)  
     - T  F

4. Important parameters for IPL light absorption in tissue and therapeutic outcome are:
   - (a) Skin pigmentation  
     - T  F
   - (b) Melanin content in skin  
     - T  F
   - (c) Stage in hair growth cycle  
     - T  F
   - (d) Exposure to light sensitising agents  
     - T  F
   - (e) Previous use of hair removal pharmaceuticals  
     - T  F
   - (f) Difference in colour between hair and skin  
     - T  F

5. The results obtained by IPL treatment therefore depend upon:
   - (a) The skin colour  
     - T  F
   - (b) The hair colour  
     - T  F
   - (c) The phase of the hair growth cycle  
     - T  F
   - (d) The pulse duration  
     - T  F
   - (e) The amount of energy used  
     - T  F

6. The synthesis of melanin depends on 2 factors genetic and exposure to sunlight  
   - T  F

7. Increase melanin in skin makes treatments more effective  
   - T  F

8. Which of the following skin/hair types are amenable to IPL therapy:
   - (a) Dark skin and dark hair  
     - T  F
   - (b) Light skin and dark hair  
     - T  F
   - (c) Blond and red hair  
     - T  F
   - (d) Dark skin and light hair  
     - T  F

9. The coloured substances in tissue that absorb light are known as chromophores. The main chromophores in the skin are:
   - (a) Melanin  
     - T  F
   - (b) Haemoglobin  
     - T  F
   - (c) Water  
     - T  F
   - (d) Protein  
     - T  F
6.0 LASER and IPL SAFETY - BIOLOGICAL EFFECTS AND ASSOCIATED HAZARDS

Two organs are of importance in laser and IPL safety – they are the skin and the eye.

6.1 Hazards to the skin

Damage to skin is normally considered secondary to the eye for laser work despite the fact that thresholds of injury to the skin and eye are comparable, except in the retinal hazard region (400-1400 nm). An irradiance of approximately 20 kW.m$^{-2}$ will cause thermal skin burns for an exposure time of the order of a second. A surgical laser would typically have an irradiance of 10 MW.m$^{-2}$, a thousand times the threshold for a skin burn. An IPL light source would typically have an irradiance of 10 kW.m$^{-2}$, and could achieve a skin burn in a few seconds. Any colour of light at this irradiance will cause a skin burn.

The skin is comprised largely of water and is relatively transparent to most laser radiation. It is non-homogeneous and contains many scattering points that reduce the depth of penetration. The melanin pigment granules and blood are the principal radiation absorbers of the skin in the visible spectrum. Water absorption dominates for wavelength above approximately 2000 nm. The greatest penetration of skin occurs at around 750 nm and is up to 5 mm; Figure 6.2.

High-powered lasers and IPL sources may cause effects ranging from mild erythema to severe blistering and deep burns. The thresholds for skin damage vary considerably between individuals, due to the diversity of skin pigmentation. Dark skinned individuals are up to nine times more susceptible to thermal injuries from light with a wavelength up to 1000 nm (1 µm), due to the greater concentration of melanin and reflection efficiency; Figure 6.1.

Photochemical changes from ultraviolet UVB and UVC (200 nm - 315 nm) light sources can cause changes in the skin that may lead to accelerated skin aging or cancer. Skin colour will determine absorption over the visible light spectrum as shown below. Several microwatts per square centimetre of ultraviolet radiation delivered over several hours will generally cause erythema.

![Light penetration as a function of wavelength for human skin.](Figure 6.2)

![The spectral reflectance of human skin, from Sliney and Wolbarsht 1980: 165.](Figure 6.1)

6.2 The eye

The principal hazard associated with laser radiation is exposure of the eye. IPL sources also present an acute injury hazard to the eye. This is particularly important in the visible and near infrared spectral regions (400 - 1400 nm) where the light may be focussed to the retina. The danger in this spectral range results from the refraction and transmission of light by the eye media and focusing at the retina. The
increase in irradiance from the cornea to the retina is approximately the ratio of the pupil diameter (5 to 7 mm a maximum dilation) to focused retinal image diameter 10 to 20 μm or 1000 times. 20 μm is the smallest spot size the eye can produce on the retina – it is the aberration or error limited spot. For a collimated laser beam the retinal irradiance is up to 50,000 times higher than at the cornea. It is this very focusing system, so necessary for good visual performance, that renders the eye vulnerable to damage from lasers or the sun. Pupil diameter is also an important parameter in laser safety as it is related to the probability of a beam reaching the retina. There are also serious potential hazards in other spectral regions as outlined in the following sections. IPL sources produce sufficient irradiance at the retina to cause thermal damage or photo bleaching of sensory receptors. They may also cause thermal damage to the retina, cornea or lens if directed at the eye.

The main features of the eye are shown in Figure 6.3. The eye consists of two parts, an anterior chamber bounded by the cornea, iris and lens; and a posterior eye-cup which is lined by the light sensitive retina, and contains the gel like vitreous humour. Light passes through the various structures of the eye to fall upon the retina where it triggers photochemical processes evoking the neural impulses that lead to vision.

Cornea
The cornea of the eye is the living tissue exposed directly to the environmental elements and must therefore survive very harsh conditions. It has one of the highest metabolic rates in the body, with cells being replaced in about 48 hours. Damage to the superficial layers of the cornea are repaired rapidly, within 2 days, damage to deeper layers may be permanent and leave scar tissue that will interfere with focusing. It provides 70% of the refractive power of the eye. The very surface of the cornea is called the conjunctiva.

Lens
The lens provides 30% of the refractive power of the eye, however it is the dynamic refractive element of the eye. The cells of the lens are arranged in a very ordered fashion, somewhat like skins on an onion. The interface between the cells is critical to minimisation of light scatter within the lens – too much scatter will cause the lens to appear opaque. The lens has a very low metabolism and very poor repair mechanisms, any damage to the lens will generally not be repaired perfectly. The aqueous and cornea serve as the absorbing filter for the lens protecting it from IR-B and IR-C thermal radiation.

Iris and pupil
The iris is a muscular sphincter of muscle and tissue that adjusts the pupil of the eye. The pupil diameter is a function of ambient light levels, age, emotional state and medications taken. In going from daylight to
dark conditions the average pupil diameter can increase from 2 mm to between 6 and 7 mm, thus increasing the pupil area by ten times. For this reason, it is recommended that many laser applications be conducted under bright light conditions. Upon exposure of the retina to a very bright light source a dilated pupil will constrict in about 20 msec.

**Vitreous**

The vitreous body is a colourless gel filling the posterior chamber of the eye. It is connected to the retina and ciliary body. Damage to the vitreous will cause it to shrink and can lead to detachment of the retina.

**Retina**

The retina is the light absorbing structure of the eye containing the neural receptors that initiate the vision process, Figure 6.4. A blind spot in the retina surface is located at the point where the optic nerve enters into the eye. The fovea is the portion of the retina which is most sensitive to detail and which discriminates colour. This structure fills an angle of approximately two degrees in the central portion of the retina, a 2 cent piece viewed at arms length will create an image roughly the size of the fovea on the retina. The fovea is located in a small dip in the centre of the area called the macula. The macula fills an area of about 1 mm diameter.

![Figure 6.4 Principle structures of the retina, adapted from Marshall 1978.](image)

An injury to the fovea will severely reduce visual function - detail and resolution. An injury to the parafovea or peripheral retina is less incapacitating and may be undetectable from a functional point of view. The fovea is 0.2 mm in diameter, the remainder of the retina, the parafovea to the peripheral retina are increasingly less sensitive to light and do not contribute significantly to fine detail in the vision process.

### 6.3 Hazards to the eye

If the inside of the eye is examined by shining a light through the pupil, the scene viewed is called the fundus, the circular image in Figure 6.4. The fundus appears a reddish brown colour due to the layer called the pigment epithelium. The retina is relatively transparent and consists of two layers of nerve cells plus a photosensitive cell layer. Light falling on the retina must pass through the two nerve cell layers before it reaches the photoreceptor cells – the rods and cones. Cones are responsible for colour vision and visual acuity and are exclusively present in the fovea. Only visible and near-infrared light passes into the eye to fall on the retina. Only 5% of this light is absorbed in the visual pigments in the cones and rods - the major part of the light is absorbed in the melanin granules of the pigment epithelium. Damage to the eye is dependent on the wavelength of light. The transmittance, absorption and reflectance of the various structures of the eye are strongly dependent on wavelength. That part of the electromagnetic spectrum called light covers the ultraviolet, visible and infrared wavelengths and is broken down into different bands, CIE bands, for convenience, these are shown in Table 6.1.
### Table 6.1 International Commission on Illumination (CIE) bands of the electromagnetic spectrum

<table>
<thead>
<tr>
<th>Ultraviolet</th>
<th>UVC</th>
<th>100 - 280 nm</th>
<th>Far UV (to 300 nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVB</td>
<td>280 - 315 nm</td>
<td>Near UV</td>
<td></td>
</tr>
<tr>
<td>UVA</td>
<td>315 - 400 nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible</td>
<td>400 - 700 nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared</td>
<td>IRA</td>
<td>700 - 1400 nm</td>
<td>Near IR</td>
</tr>
<tr>
<td></td>
<td>IRB</td>
<td>1400 - 3000 nm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IRC</td>
<td>3000 – 106 nm</td>
<td>Far IR</td>
</tr>
</tbody>
</table>

### 6.3.1 Exposure to Short wavelengths - ultraviolet

There are three general UV bands known as A, B and C. The UVC and UVB have the highest photon energies (shortest wavelength), and are capable of disrupting molecular bonds. UVC and UVB (100 nm to 315 nm) have low penetration and cause superficial tissue damage e.g. photo keratitis (inflammation of the cornea) and conjunctivitis. The longer wavelength band, A, is more penetrating and can reach the lens, where cataract formation is possible. The crystalline lens of the eye is the principal absorber of UVA radiation (wavelength 315-400 nm) with little of this light reaching the retina. For the longer ultraviolet radiations (315 nm to 400 nm) a greater penetration is achieved which can result in cataract formation in the lens. Penetration and absorption of UV radiation in the eye is shown in Figure 6.5.

![Figure 6.5](image_url)

**Figure 6.5** Schematic of absorption of ultraviolet radiation in the ocular media. Values are the percent of ultraviolet radiation incident upon the corneal surface that are absorbed by various layers, from Matelsky, 1969.

### 6.3.2 Exposure to visible and near infrared

Visible and near infrared radiation (400 - 1400 nm) are transmitted through the cornea, aqueous humour, lens and vitreous humour, absorption taking place at the retina, pigment epithelium and choroid as shown in Figure 6.6. Corneal exposures of as low as 0.08 to 0.4 Wcm² in the near-infrared spectra are believed to have aided cataract formation.

With the visible wavelengths, the colour of the tissue becomes an important factor, e.g. green light is efficiently absorbed by orange/red substances. Depending on the duration of the exposure, the retina can sustain thermal damage (high power, short time) or photochemical damage (low power, long period). It must be remembered that for lasers the amplification in power per unit area caused by the focusing action of the eye is between as much as 50,000 times from cornea to retina. For this reason, an intra-beam laser exposure has great potential danger. For lasers the beam is almost parallel, usually of smaller diameter than the pupil adapted to normal light conditions and hence the full power can be focused to what is
known as an aberration limited spot on the retina. The resultant power per unit area (irradiance) can be enormous. Up to about 5% can be absorbed directly in the rods and cones but most is absorbed in melanin, the pigment in the pigment epithelium. As noted earlier, where the beam strikes the retina determines the outcome in terms of partial loss of vision or total loss of sight.

Figure 6.6 shows the transmittance of the ocular media as a function of wavelength. Retinal effects can be anticipated for laser wavelengths between 400 nm and 1400 nm, outside this range structures other than the retina, for example the cornea or lens, are affected.

A laser of even moderate power such as a few milliwatts has a radiance which is an order of magnitude greater than that of the brightest conventional sources due to the highly directional property of the beam e.g. a 1 mW helium-neon laser has a radiance of about 500 - 1000 times that of the sun.

6.3.3 Far infrared

The cornea and aqueous humour are almost total absorbers of infrared radiation for wavelengths between 1400 and 1900 nm. The penetration of this type of radiation e.g. from the Ho:YAG, Er:YAG and CO₂ lasers, is extremely limited and damage occurs to corneal tissues only. These lasers, at the powers typically used in surgery are easily capable of punching a hole right through the cornea and into the aqueous in a fraction of a second. A summary of the pathological effects associated with excessive exposure to light is provided in Table 6.2.
<table>
<thead>
<tr>
<th>CIE spectral region*</th>
<th>Eye</th>
<th>Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultraviolet C</td>
<td>Photokeratitis</td>
<td>Erythema (sunburn)</td>
</tr>
<tr>
<td>(200 to 280 nm)</td>
<td></td>
<td>Accelerated skin ageing</td>
</tr>
<tr>
<td>(280 to 315 nm)</td>
<td></td>
<td>Ultraviolet B Increased pigmentation</td>
</tr>
<tr>
<td>Ultraviolet A</td>
<td></td>
<td>Pigment darkening</td>
</tr>
<tr>
<td>(315 to 400 nm)</td>
<td></td>
<td>Photosensitive reactions</td>
</tr>
<tr>
<td>Visible</td>
<td></td>
<td>Photochemical and thermal</td>
</tr>
<tr>
<td>(400 to 780 nm)</td>
<td></td>
<td>retinal injury</td>
</tr>
<tr>
<td>Infra-red A</td>
<td></td>
<td>Cataract, retinal burn</td>
</tr>
<tr>
<td>(780 to 1400 nm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infra-red B</td>
<td>Aqueous flare, cataract</td>
<td>Skin burn</td>
</tr>
<tr>
<td>(1.4 to 3.0 μm)</td>
<td>corneal burn</td>
<td></td>
</tr>
<tr>
<td>Infra-red C</td>
<td>Corneal burn only</td>
<td></td>
</tr>
<tr>
<td>(3.0 μm to 1 mm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The spectral regions defined by the CIE are useful in describing biological effects and may not agree perfectly with spectral breakpoints in the MPE tables.

Table 6.2 Summary of pathological effects associated with excessive exposure.

6.4 Viewing hazards

Viewing hazards are usually classified into three groups, they are:

- Extended source viewing – lasers and IPL
- Intrabeam viewing - lasers
- Viewing with optical instruments – lasers and IPL

6.4.1 Extended source

This is the condition of viewing in which the eye sees a large source area of light. The source may be, for example, the diffuse reflection (non shiny surface reflection) from an expanded laser beam striking a wall or an IPL source.

6.4.2 Intra-beam viewing

Intra-beam viewing is viewing of a laser beam directly or reflections of small diameter from highly reflective surfaces.

Specular reflections (mirror like) occur typically on smooth surfaces such as glass. The non-divergent properties of the laser beam are retained and the power density in the beam may still be very high at large distances from the reflector.

Diffuse reflections are off non-shiny surfaces and are usually less hazardous than specular reflections although for a class 4 laser they may still blind a person easily.

Specular and Diffuse reflections are shown in Figure 6.8.
Despite the low reflectance from many surfaces such as glass or stainless steel being typically 5% to 10%, these beams may themselves be dangerous owing to the high initial power in the primary beam.

### 6.4.3 Viewing with optical instruments

May enhance the hazard as more light may be collected and delivered through the pupil to the retina.

### 6.5 Associated hazards

Some of the associated laser and IPL hazards that may be found in medicine or research are listed below:

1. Electrical  
2. Airborne contaminants  
3. Infection – viruses in plume  
4. Noise  
5. Patient's eyes  
6. Non-laser beam radiation  
7. Explosion  
8. Fire  
9. Heated instruments

These hazards have usually been minimised in any commercially produced lasers. Poorly planned laser or IPL facilities and improvised equipment generally lead to unsafe conditions.
### Quiz for Section 6  Laser & IPL Safety Biological Effects

1. Two organs are of importance in laser and IPL safety - they are the skin and the eye.  
   - T  F

2. An irradiance of approximately 20 kW.m\(^{-2}\) will cause thermal skin burns for an exposure time of the order of a second.  
   - T  F

3. An IPL light source would typically have an irradiance of 10 kW.m\(^{-2}\), and could achieve a skin burn in a few seconds.  
   - T  F

4. Ultraviolet UVB and UVC light sources can cause changes in the skin that may lead to accelerated skin aging or cancer.  
   - T  F

5. Ultraviolet light

   (a) Generally reaches the retina  
     - T  F
   (b) Can cause skin cancer  
     - T  F
   (c) Can cause thermal burns  
     - T  F
   (d) Is generally transmitted by the lens of the eye  
     - T  F
   (e) In the UVA region can cause damage to the lens  
     - T  F

6. The cornea is likely to be damaged by excessive UVC and UVB exposure.  
   - T  F

7. The fovea provides for colour and detailed vision  
   - T  F

8. In the eye the fovea is roughly 0.2 mm in diameter  
   - T  F

9. Visible and near infrared laser light can be focussed to the retina resulting in very high power densities and damage at the retina.  
   - T  F

10. IPL devices usually emit light in the visible and near infrared region.  
    - T  F

11. Up to 90% of UVA is absorbed in the lens of the eye  
    - T  F

12. Light in the retinal hazard region has wavelength from 400 to 1400nm.  
    - T  F

13. The blink reflex protects the human eye.

   (a) For invisible light  
     - T  F
   (b) For near infrared light  
     - T  F
   (c) For visible light  
     - T  F
   (d) Occurs within about 0.25 seconds  
     - T  F
7.0 LASER AND LIGHT HAZARD CONTROL AND LEGAL ASPECTS

The Australian Standard 2211.4 covers the Safe use of lasers and similar high intensity light sources. Although IPL devices are not lasers they are capable of causing injury and are generally considered to be a Class 2M products.

7.1 Laser safety definitions

The following definitions are useful in the assessment of the laser radiation hazard from a laser.

(a) **Accessible Emission Limit (AEL)** is the maximum accessible emission level permitted for a particular class of laser product. Tables of AEL in AS/NZS 2211.1 determine which class is applicable and are based on:

(b) **Maximum Permissible Exposure (MPE)** is that level of light to which, in normal circumstances, the eye or skin may be exposed without suffering adverse effects. MPEs are the damage threshold and are given in AS/NZS 2211.1 for the following exposures:

- direct to eyes (intra-beam viewing);
- to eyes from an extended source (large retinal image) or diffuse reflections; and
- directly or indirectly to skin.

7.2 Classification of lasers and light sources

There are a large number of different light sources available to users. Rather than assess the hazard associated with every laser/light source, a classification system has been developed to simplify hazard assessment. A much summarized version of the laser classification system is shown below in Table 7.2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Reason for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>safe</td>
<td>Either 'inherently safe' or because laser is totally enclosed so that the relevant ME cannot be exceeded.</td>
</tr>
<tr>
<td>Class 1M</td>
<td>safe</td>
<td>Provided optical instruments are not used. Total output &lt;3B limit. Often lasers or LEDs with divergent or wide collimated beams.</td>
</tr>
<tr>
<td>Class 2</td>
<td>low power</td>
<td>Visible cw &amp; pulsed. Protection is afforded by the natural aversion responses including the blink reflex. Simple hazard control procedures.</td>
</tr>
<tr>
<td>Class 2M</td>
<td>low power</td>
<td>Visible. Provided instruments are not used and blink or aversion responses operate. Total output &lt;3B limit. Often lasers or LEDs with divergent or wide collimated beams.</td>
</tr>
<tr>
<td>Class 3R</td>
<td>low-medium power</td>
<td>AEL exceeds the MPE for 0.25 s exposure - visible, 100 s - invisible. Output &lt; 5 AEL for Class 2 (visible) or Class 1 (invisible).</td>
</tr>
<tr>
<td>Class 3B</td>
<td>medium power</td>
<td>Hazard from direct and specular reflection viewing. Detailed control measures necessary. Power &lt; 0.5 W for visible and IR cw. Licence required in WA.</td>
</tr>
<tr>
<td>Class 4</td>
<td>high power</td>
<td>Hazard from direct, specular reflection and possibly diffuse reflections viewing. Requires extreme caution. Fire risk. Licence required in WA. For cw &gt; 0.5 W.</td>
</tr>
</tbody>
</table>

Table 7.1 Laser classification

Surgical lasers always fall into Class 4. Aiming beams should be Class 2. Laser manufacturers are responsible for classification and labelling of their lasers.

7.3 Hazard evaluation and control measures

A risk assessment of a laser installation should be performed by a competent person before use:
• The hazard involved and the associated risks
• An evaluation of the suitability of that laser type
• The capability of the laser to injure personnel.
• The environment in which the laser is used.
• The level of training of personnel operating the laser or may be exposed to its radiation.

Hierarchy of control measures:

• Elimination
• Substitution
• Isolation
• Engineering controls
• Administrative controls
• Personal protective equipment

7.4 Administration

The use of lasers in Western Australia is controlled by the Radiation Safety Act 1975. The Act is administered by the Radiological Council through the Radiation Health Section of the Health Department of Western Australia. The Act is supplemented with the Radiation Safety (General) Regulations 1983 which provide many of the specific requirements for the use of radiations and of lasers in WA. For users of lasers the items of importance are

(a) Licences for individuals. Laser licence categories include acupuncture, educational, entertainment, industrial, medical, physiotherapy, research, service and veterinary. Licenses are required by Laser Safety Officers. Medical practitioners carrying out medical laser procedures must be licensed or be under personal supervision of a licensed medical practitioner. Licenses can only be obtained after completing an approved (by the Radiological Council) laser safety course. Laser Safety Officers must also be licensed and are required to pass the written test set by the Radiation Health Section. Laser licenses are required for the use of Class 3B and Class 4 lasers in WA.

(b) Registration of lasers and premises. Class 3B and 4 lasers must be registered (under the Radiation Safety Act 1975). Hospitals generally hold a single registration that lists lasers and their locations of use.

(c) Requirements for use and premises. These are contained in Schedules XIII (Class 3B lasers) and XIV (Class 4 lasers) of the regulations (Attachment A) and refer extensively to Australian Standard publications for specific items. Compliance with AS/NZS 2211 is often sufficient to ensure compliance with the regulations.

(d) Laser Safety Officer. The Laser Safety Officer (LSO) carries responsibility for laser safety in the organisation. Their function is to ensure:

• Responsibility for the safe operation of the laser
• Security of the operating key is appropriate
• Ascertain that only authorised licensed users use the laser
• Setting up and testing procedures are appropriate
• Ensuring supplies of safety goggles
• Ensure that engineering controls are appropriate
• Rules are appropriate and up to date
Lists of personnel appropriately trained are maintained
Those present at a laser procedure are properly instructed and have read the Working Rules.

(e) **Working rules.** Specific working rules are required for each Class laser 3B or 4 and often for each different application of a laser. The rules must be approved by the LSO.

### 7.5 Training

High power laser or IPL users should receive detailed instruction in the actual use and not rely on the details of an instruction manual. Approved working rules (by the Laser Safety Officer) are required for each high power light source. A list of users who have read and understood the working rules should be maintained.

### 7.6 Engineering controls

Generally includes beam stops, barriers, provision of adequate lighting, use of non-specular reflecting surfaces, mechanical clamps, interlocks on the fibre to the laser output port, doors and equipment, keyed switch, warning lights and signs. Signs should look like the one in Figure 7.1 – see AS 2211.1

![Figure 7.1 Laser sign](image)

### 7.7 Personal protective equipment - eye protection and care

The following should be considered when specifying suitable protective eyewear:

- Sufficient OD at the nominated wavelength/s
- Properly labeled according to the Australian Standards
- Ergonomics – comfortable, don’t fog up etc
- Can see through them
- In good repair
- Labelled properly

Eye protection must be available in all hazard areas where Class 3B and Class 4 lasers or IPL devices are used. The patient and attending staff also require eye protection. Eyewear manufacturers and suppliers **must be consulted if there is any doubt whatsoever as to what is required.**

### 7.8 Accidents and incidents

All accidents and incidents involving lasers shall be immediately reported to the Safety Officer and investigated, and recommendations made and followed to prevent recurrence. If a damaging exposure is
suspected then a medical examination by a qualified specialist should be carried out immediately. Ophthalmic examinations are not required for pre employment or as a routine surveillance of laser users.

7.9 Protection of staff and patients

The main elements of effective protection are listed below:

- Engineering – warning signs and interlocks
- Clear chain of responsibility
- Careful work practices documented in a procedures manual
- Clear chain of responsibility
- Personnel training
- Personal protective equipment (goggles)

7.10 Laser safety for specific classes of lasers

Class 3B
Lasers in this class is very likely to be dangerous and can be a hazard to the eye or skin. However, viewing of the diffuse reflection is safe. Control measures include laser warning notices at entrances to the areas where these classes of lasers are being used and containment of the light to the treatment room – closed blinds etc. Each Class 3B laser should be provided with a "captive-key" control switch such that the key cannot be removed from the lock except when in the "off position".

Class 4
This is the highest class of laser radiation and is very dangerous. Viewing of the diffuse reflection may be dangerous. Class 4 laser beams are capable of setting fire to materials.

Precautions needed for each Class 3B or Class 4 laser installation should be planned in advance with the Laser Safety Officer. These classes of lasers must only be used in clearly defined areas where the hazards can be effectively controlled. These areas will be known as controlled access areas and must be clearly defined. Signs must be prominently displayed at all entrances of each Controlled Access area.

7.11 Quality assurance

A routine quality assurance program should be implemented in order to ensure the laser operates safely and according to specifications. Table 7.3 shows items that should be included in the QA program.

<table>
<thead>
<tr>
<th>Equipment part</th>
<th>Recommended frequency of test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power and footswitch cables</td>
<td>Prior to each use, daily, whichever is least frequent</td>
</tr>
<tr>
<td>Emergency switch</td>
<td>Monthly</td>
</tr>
<tr>
<td>User accessible interlocks</td>
<td>Monthly</td>
</tr>
<tr>
<td>Laser emission indicators</td>
<td>Prior to each use, daily, whichever is least frequent</td>
</tr>
<tr>
<td>Beam power/pulse energy</td>
<td>Prior to each use, daily, whichever is least frequent</td>
</tr>
<tr>
<td>Articulated arm movement and physical checks</td>
<td>Commencement of each procedure</td>
</tr>
<tr>
<td>Convergence of main and aiming beams</td>
<td>Commencement of each procedure</td>
</tr>
<tr>
<td>Fibre physical check</td>
<td>Each change of fibre</td>
</tr>
<tr>
<td>Aiming beam quality</td>
<td>Prior to each use, daily, whichever is least frequent</td>
</tr>
<tr>
<td>Fibre calibration</td>
<td>Prior to each use, daily, whichever is least frequent</td>
</tr>
<tr>
<td>Specialised accessories</td>
<td>Prior to each use</td>
</tr>
</tbody>
</table>

Table 7.2 Items to be included in a QA program.
7.12 Bibliography


Radiation Safety (General) Regulations 1983.

Quiz for Section 7  Laser Hazard Control & Legal Aspects

1. Maximum permissible exposures are threshold levels of exposure where damage will occur.  T  F

2. Maximum permissible exposures are used to determine the class of a lasers.  T  F

3. Maximum permissible exposures are only based on effects on the eye and not skin  T  F

4. Class 2 lasers
   (a) Require registration under the Radiation Safety Act  T  F
   (b) Don't require labels as they are pretty safe  T  F
   (c) Can be stared into with little consequence  T  F
   (d) Include only visible lasers  T  F

5. Class 3B lasers:
   (a) Their location and the laser must be registered under the Radiation Safety Act  T  F
   (b) Require users to be licensed or supervised  T  F
   (c) Are safe to look into  T  F
   (d) Must have a keyed power switch  T  F

6. Class 4 lasers:
   (a) Can result in hazardous diffuse reflections  T  F
   (b) Must be used in controlled areas  T  F
   (c) Need not be registered under the Radiation Safety Act  T  F
   (d) Must have a keyed power switch  T  F

7. Warning signs and labels:
   (a) Are required with all classes of lasers  T  F
   (b) Can be any colour as long as the message is clear  T  F
   (c) Must be in place at entrances to the controlled area for Class 3B & Class 4 lasers  T  F

8. Laser safety eye wear:
   (a) Is required for all lasers of Class 3B or Class 4  T  F
   (b) Should only be used for lasers at the wavelength indicated on the filter  T  F
   (c) Must be clearly labeled with wavelength, OD and laser type  T  F
   (d) Are very robust and are not easily damaged  T  F
   (e) Should allow some visible light transmission  T  F
9. Working rules:

(a) For Class 3B and Class 4 lasers should be specific to a particular laser T F
(b) Must be read by all present at the use of the laser except in display environments T F
(c) Must be approved by the LSO T F
(d) Define clearly the responsibilities of personnel involved with the use of the laser T F

10. AEL s (accessible emission limits) are:

(a) wavelength T F
(b) power or energy density T F
(c) exposure time T F
(d) divergence T F
(e) beam area T F

11. What are the main requirements for protective eyewear for laser radiations?

(a) Sufficient OD at the nominated wavelength/s T F
(b) Properly labeled according to the Australian Standards T F
(c) Ergonomics – comfortable, don’t fog up etc T F
(d) Can see through them T F
(e) In good repair T F