1 **Laser Certification Review**
Certified Medical Laser Safety Officer
www.LaserCertification.org

2 **Written Examination**
- 100 Multiple Choice Questions
  - 1 Correct (Best) Answer
- 70% Required for Passing
  - can miss up to 30 Questions
- 3.0 Hours allotted for completion
- Closed Book. "Controlled" breaks allowed.

3 **Requirements**
- One Year Experience with Lasers for full certification – may take test before that.
- 4 Year Degree or Medical OR a licensed medical professional OR 2 yr degree or H.S. Diploma AND advanced education & training
- 2 Letters of Recommendation
- Certificate for Laser Safety Course

4 **Exam Content Areas**

The examination tests for a knowledge of medical laser and energy concepts, and safety. It is not a test of specific medical procedures, though the exam sometimes uses a clinical setting to test for the underlying concepts.

5 **Exam Content Areas**
The areas of testing for various NCLE Laser Certifications basically boil down to the areas of:

(1) Laser Concepts
(2) Tissue Effects, and
(3) Safety

- as defined by the American Society for Laser Medicine & Surgery, and ANSI in their recommendations.

6 **Energy Concepts**
- Joules = Watts x Seconds (watt-seconds)
  i.e. 10 joules = 1 watt x 10 seconds, or
  10 joules = 10 watts x 1 second
- Joule = amount (dose) of energy delivered (Laser Energy)
- Watts = rate (speed) at which it was delivered (Laser Power)

7 **Energy Concepts**
- Power Density – Watts/cm^2 – properly termed "irradiance". Concentration of power per surface unit area..
- Energy Density – Joules/cm^2 – also commonly termed "fluence" but properly termed "Radiant Exposure". This is the "dosage" of light and usually used in dermatology applications. Concentration of energy per surface unit area.
-

8 **Wavelengths**
- Visible light is roughly 400-700+nm
- Invisible light is below 400nm in the UV, and above 700+nm in the Infrared (IR)

- Shorter wavelengths penetrate less deeply in tissue than longer wavelengths.
- The wavelength is the distance between two successive peaks or troughs in a wave.

9 **Wavelengths**
- Medical Lasers are found in the Near Infrared, Visible, and Ultraviolet segments of the electromagnetic spectrum.

10 **Yag Crystals**
- Yag is an acronym for Yttrium Aluminum Garnet as a crystal rod.
- It is a "carrier" for other active elements which are the "real" laser medium which include:
- Nd: -- Neodymium, primarily at 1064nm
- Ho: -- Holmium, at 2140nm
- Er: -- Erbium, at 2940nm

11 **Q-Switched Lasers**
- Very Fast Pulsed & High Peak Powers
- Produce photo-acoustic effects
- Pulses or Pulse trains of 5-100 nanoseconds (ns)
- Tattoo Lasers, Ophthalmic Nd:Yag lasers
- Q-Switch stand for "Quality Switching" of the resonator cavity.

12 **Laser Safety**
- Aversion Response time is the "jerk" away from bright light – 0.25s in people
- Used in determining "eye safe" levels for low level lasers (not class IV surgical)
- In safety definitions, the 0.25s aversion response time differentiates between continuous wave (cw) and pulsed laser emissions. (but not true difference)

13 **Laser Safety**

Aversion Response
- Those lasers that cannot exceed the MPE within this time are considered eye-safe
- The aversion response time is not fast enough to guarantee protection from Class IV lasers, but it would reduce one's exposure

14 **Laser Safety**

Eye & Skin Injuries basically fall into two categories:
- Thermal – burns to retina, cornea, skin, etc..

- Photochemical – chronic exposure to some UV wavelengths resulting in cataracts or potential skin cancers. i.e. 351nm and below in the UV.

15 **Laser Safety**

Generally:

Photochemical reactions are at the shorter wavelengths in the U.V and are chronic exposure hazards.

Photothermal (burns) reactions are in the visible and I.R. regions and are acute thermal responses.

Retinal burns in the visible with pulses greater than 1ms are photothermal.

16 **Laser Safety**

Photochemical:

Repeated chronic exposure to U.V. light (351nm and below) might result in Cataract and/or skin Cancer.

17 **Laser Safety**

Thermal Eye Injuries
- Corneal/Scleral burns – those wavelengths that do NOT pass through fluid: roughly above 1400nm and below 400nm
- Retinal burns – those wavelengths that DO pass through fluid from roughly 400-1400nm (visible & near infrared)

18 **Laser Safety**

Retinal Injuries (burns)

- The actual damage to visual function depends on the severity of the exposure and the location on the retina.
- Laser Safety Eyewear DO NOT guarantee protection from direct impacts into the eye through the glasses.
- Retinal risks are primarily from visible and near infrared (IR-A) wavelengths.

19 **Laser Safety**

Retinal Injuries (burns)

- Most debilitating when the injury is on the Macula – the sensitive part of your eye responsible for central vision.
- Least debilitating in the periphery of the retina – this is where ophthalmologists intentionally place laser burns to treat diabetics from losing more vision for instance.

20 **Laser Safety - Glasses**

Labels on Safety Eyewear must include both the wavelength for which they afford protection, AND their Optical Density.

Optical density represents the degree of protection, the higher the number the greater the protection.

21 **Laser Safety - Glasses**

- Safety Eyewear DOES NOT guarantee protection against direct beam impacts into the eye through the glasses.

- The intent of safety eyewear is to reduce the ocular exposure below that of the MPE (Maximum Permissible Exposure) from reflections.

22 **Laser Safety - Accidents**

The LSO is required to incorporate into the Laser Safety Program an incident reporting policy whereby all accidents are reported, no matter how minimal.

23 **Laser Safety**

Maximum Permissible Exposure

- MPE – Exposure limit used in safety calculations for eye and skin burns.
- Nominal Hazard Zone (NHZ) is area where actual exposure exceeds the MPE.
- For wavelengths that transmit to the retina, the lens of the eye CONCENTRATES the beam by a factor of 100,000 and the resulting new MPE is used for those calculations.

24 **Laser Safety**

Maximum Permissible Exposure

- Determination of an accurate MPE reference requires knowledge of the laser wavelength and exposure duration.

- Medical Laser Safety Officers may rely upon manufacturers recommendations for the NHZ, rather than making measurements to compare to the MPE.

25 **Laser Safety**

Nominal Hazard Zone

- Where the exposure level meets or exceeds the MPE (would need to know wavelength, MPE value and beam energy)
- Determined solely by the LSO
- Safety Eyewear and all other precautions must be followed within the NHZ once it is determined.
- The NHZ is within the Laser Treatment Controlled Area (LTCA), and sometimes these are one and the same (entire room).

26 **Laser Safety**

Nominal Hazard Zone

The NHZ varies depending upon several factors:

- The delivery system used (lens on a laser)
- Intrabeam viewing (direct exposure)
- Diffuse Reflections
- Fiber Optic Viewing

27 **Laser Treatment Controlled Area (LTCA)**

- The room in which the laser is used.
- Incorporates the NHZ within it.
- Signs must be posted on the entryways
- Glasses must be made available at entry, but not worn until within the NHZ
- Supervised by personnel trained in laser safety
- Controlled Access only by authorized personnel who have had laser safety training. (Class IIIb & IV)
- Windows must be covered if they are within the NHZ and the wavelength goes through glass

28 **Laser Safety**

Nominal Ocular Hazard Distance (NOHD)

- When viewing a direct output of the laser beam (not reflections), the distance where an eye injury could occur.
  (note that this is not "normal usage")
- Someone standing at this distance and looking into the beam – even from IR lasers, would probably incur no harm.

29 **Laser Safety**

Eye Anatomy

- Cornea – outer "window-like" membrane
- Lens – focusing optic to create clear image
- Retina – Neural membrane on the back of the eye that responds to the light
- Macula – part of Retina responsible for the most acute central vision

30 **Laser Safety**

Eye Anatomy

- Fovea Centralis – The most sensitive part of the macula - sharpest vision and most color perception.
- Aqueous – fluid in front part of the eye
- Vitreous – fluid/gel in the back part of the eye
- Sclera – outer "white" part of the eye
- Optic Disc – "blind spot' in the eye where the optic nerve connects to the retina

31 **Laser Safety**

Laser Plume (Smoke)

- LGAC – Laser Generated Airborne Contaminants
- Local Exhaust Ventilation (smoke evacuator) is the first line of defense
- The beam irradiance (power density or watts/cm^2) is the most significant factor creating laser plume.
- End of evacuator tubing must be held closely (within about 2cm) of smoke production to be effective.

32 **Laser Safety**

Laser Plume (Smoke)

- Smoke Evacuators are either the large bore, high flow evacuators, or the small bore suction such as wall suction.
- When using wall suction an inline filter should be used between the wall outlet and fluid collection canister.
- All filters and evacuator tubing should be treated as contaminated when disposed of.

33 **Laser Safety**

Laser Plume (Smoke)

- LGAC from lasers contain similar toxins to smoke created by electrosurgical devices
- Contaminants in LGAC can include Carbon, Formaldehyde and viral DNA (at least viral DNA fragments but not necessarily intact Virions)

34 **Laser Safety**
CDRH Requirements
- Center for Devices & Radiological Health of the FDA – Regulates Laser Manufacturers
- Federal Laser Product Performance Standard is Federal Law imposing requirements on manufacturers.

35 **Laser Safety**
CDRH Requirements
- Manufacturer control measures built in to lasers are called Performance Requirements.
- Manufacturers must pre-classify their lasers as ANSI class (usually IV for medical lasers) which is why the need for measurements is minimized for the Medical LSO. The Certification of their lasers to meet the federal law is their responsibility.

36 **Laser Safety**
CDRH Requirements
- Manufacturer Performance Requirements may include:
  - Interlocks – to prevent human access to hazardous laser radiation within the protective housing
  - Standby button – to prevent inadvertent firing
  - Covered foot pedals – to prevent inadvertent firing.
  - Emission indicator lights – warning lights

37 **Laser Safety**
CDRH Requirements
- ANSI classifies lasers from I-IV
- Surgical Lasers are Class IV, and some Low Level Lasers for medical therapy are class IIIb.
- Class IV can cause skin & eye burns
- Class IIIb can cause retinal injury if impacted directly in the eye by the beam.
- The CDRH federal law requires a DANGER label on IIIb lasers that says Laser Radiation – avoid direct exposure to the beam.

38 **Laser Safety**
ANSI Laser Classes & Labeling
- The Laser Class denotes the level of risk and goes from I-IV with several subclasses, IV being the highest risk.
- ANSI standards require the word "DANGER" only on the warning labels of Class IIIB and IV lasers,
  and sometimes IIIR lasers.

39 **Laser Safety**
ANSI Laser Classes
ANSI Laser Classes proceed in the following order of increasing output power & hazard:
- 1
- 1M
- 2
- 2M
- 3R
- 3B
- 4

40 **Laser Safety**
Class IIIb lasers
- Used in medicine in areas such as sports medicine or pain management clinics for low level treatment of conditions ranging from pain relief to wound healing.

- Eye hazards are from viewing the beam directly (shoot yourself in the eye), but poses little risk from diffuse reflections, unlike Class IV lasers. Still considered a serious eye hazard.

41 **Laser Safety**

Class IIIb lasers warning label

- ANSI recommends the wording of "Danger – Laser Radiation – Avoid Direct Exposure to Beam", on the laser warning labels.

42 **Laser Safety**

Class IIIB & IV lasers

- If laser output power is 0.5 watt or *less,* and the laser is NOT Class I, II or IIIR, it is considered a Class IIIB laser.

- If laser output power is 0.5 watt or *more,* or can cause eye or skin burns, it is considered a Class IV laser. This presents a risk even from diffusely reflected radiation.

43 **Laser Safety**

ANSI Laser Safety Standards

- These are voluntary recommended practices but do not have the force of law.
- However, many agencies including OSHA, Joint Commission and many States do enforce based on these ANSI standards.
- ANSI standards represent voluntary advisory standards that are the best current practices and standards of care.

44 **Laser Safety**

OSHA Enforcement

When OSHA, utilizing ANSI standards, writes a citation for improper laser safety control measures, it comes under the General Duty Claus (GDC) – Section A-1 of the Occupational Safety Health Act, and not under ANSI per se.

45 **Laser Safety**

OSHA Enforcement

OSHA utilizes their publication 8-1.7 as a document for investigators for on-site laser facilities. This document is an instructional handbook used to evaluate safe laser practices based upon ANSI Z136.1 Safe Use of Lasers Standard.

46 **Laser Safety**

ANSI Terminology

ANSI uses the words SHALL and SHOULD within their standards. These are defined as:

- SHALL – is mandatory in order to be in compliance with ANSI standards
- SHOULD – is recommended but not required in order to be in compliance

47 **Laser Safety**

Laser Safety Program

- Administered by the LSO and required in all facilities that use lasers. They have the authority to monitor & enforce the control of laser hazards and effect the knowledgeable evaluation & control of those hazards.
- For staff working with Class IV lasers the safety program shall cover:
  - Laser Physics
  - Institutional Policies and Procedures
  - Patient Protection

48 **Laser Safety**

Laser Safety Program

- The LSO shall implement controls necessary for safety of patients & personnel in the areas of:

  - Engineering Controls (Mfg created)
  - Administrative Controls

- Procedural Controls

49 **Laser Safety**

Laser Safety Program

- Common safety control measures utilized in Health Care Facilities include closing the door, opaque screens, and blocking barriers.

- Door interlock systems, such as might be used in commercial laser facilities, are not used in Health Care Facilities. (inappropriate)

50 **Laser Safety**

Warning Signs

- Warning signs shall be posted at the entryway to each entrance into the Laser Treatment Controlled Area (LTCA) – laser room.
- Signs for Class IV lasers shall include wording:
  "Laser Radiation – avoid Eye or Skin exposure to Direct or Scattered Radiation."

51 **Laser Safety**

ANSI: Education and Training

-

The Laser Safety program shall provide safety education and training for ALL PERIOPERATIVE PERSONNEL associated with lasers or working in a laser room such as operators, technicians, staff, students and other health care personnel, working around class IIIb or IV lasers.

52 **Laser Safety**

Authorized Personnel

"Authorized" personnel shall include those individuals approved by management (the LSO) to operate, install or service laser equipment, or to work within the Laser Treatment Controlled Area (LTCA).

53 **Laser Safety**

Operator Functions

- The standby mode of the laser should always be selected when the laser is not actually being fired. This disables emission of laser energy but preserves the laser control panel settings.
- Before activating the laser and depressing the footpedal it is important to ensure the proper power/energy setting is set.

54 **Laser Safety**

Fires

Airway Fires can present a significant risk – particularly with the CO2 laser in the airway.
Inspired Oxygen concentrations should be minimized
Helium or Nitrogen should be used as the balance gas when decreasing Oxygen

55 **Laser Safety**

Fires

Nitrous Oxide (N_20) should NOT be used as a balance gas because it supports combustion as well as oxygen

60% Helium and 20% Oxygen will prevent an airway fire for at least 60 seconds.

Helium is a good balance gas. Nitrogen also works.

56 **Laser Safety**

Fires

During a Fire Emergency the Laser Assistant should engage the emergency switch on the laser or otherwise turn it off.

If the patient is intubated, the physician should immediate remove the ET tube and the

anesthesiologist should disconnect ventilation circuits. Emergency procedures should then commence.

57 **Laser Safety**

Airway Fire Safety Practices

- Specific written safety protocols
- Use of properly selected ET tubes – considering wavelength of laser and expected surgical parameters.
- Annual airway fire competency validation for staff.

58 **Laser Safety**

Safety Audits

The LSO shall periodically effect a complete Audit of the entire Laser Safety program. The frequency of the audit shall be determined by the LSO, but it is recommended to perform this annually.

59 **Laser Safety**

Policies & Procedures

The LSO shall effect written policies & procedures for the safety program. Such hazard based policies are based on risk assessment, control measures and personnel responsibilities.

60 **Laser Safety**

Test Firing

- Lasers that have separate aiming beams and surgical beams must be fired prior to each case to test their alignment
- On systems such as CO_2 lasers, a common method is to fire on a wet tongue blade with the intended delivery system using about 10 watts of power.

61 **Laser Safety**

Only non-flammable and non-toxic fluids or materials should be used in the laser field. These may include:

- Water
- Saline
- Blood
- Nonflammable/nontoxic irrigating solutions

62 **Laser Safety**

Combustible Materials

Although not directly included in ANSI Z136.3, a general precaution taken to avoid explosive accidents with combustible materials is to store them in a closed, secured cabinet.

Combustible materials are not to be used in the operative field of the laser.

63 **Laser Repair**

Repairs should be performed by an authorized laser service person. ANSI requires that they have:

- Laser Safety Training
- Laser Repair Training commensurate with the level of work they are performing.
- They can include the Mfg service, 3rd party agents, or inhouse biomedical engineers.

64 **International ElectroTechnical Commission (IEC)**

- International Standards for Electrical, Electronic and related technologies
- Application of IEC standards in the United States is voluntary both for manufacturers and users of lasers.

65 **Energy Concepts**

- Pulsed lasers (not just a timer) are a "compression" of laser energy that allows the power to be momentarily delivered at a higher rate (watts) than it otherwise could in a continuous wave (cw) mode.
- 0.25s differentiates pulsed vs CW lasers for safety definitions, but this time frame does not

necessarily indicate a true laser pulse.

66 **Laser Pulsing**

- Millisecond time frame – 10^{-3} seconds – typical pulsed laser for aesthetics such as hair removal.
- Microsecond time frame - 10^{-6} seconds – typical pulsed laser such as in lithotripsy
- Nanosecond time frames - 10^{-9} seconds – Q-Switched lasers of very high peak powers - tattoo & ophthalmic Nd:Yag lasers

(Photoacoustic (shock wave) range)

67 **Electromagnetic Spectrum**
wavelengths for typical medical lasers

- Visible Light ~ 400-700+ nanometers (nm) from purple/blue to red
- Near Infrared (invisible) 700nm+ and higher
- Ultraviolet (invisible) 350nm+ and lower

68 **Electromagnetic Spectrum**

- Shorter wavelengths contain more energy (but are not necessarily more powerful)
- Typical medical laser wavelengths are non-ionizing (unlike X-rays)
- Wavelength is the distance between successive peaks or troughs in the light "wave".

69 **Laser Safety**

The higher energies of shorter wavelengths, like UV, generally create photochemical reactions.

Lower energies of the longer wavelengths in the visible and infrared generally create thermal reactions.

70 **Photodynamic Therapy**

- PDT (photofrin is the old, outdated drug)
- Light (frequently laser but not always) is used to activate photoactive drugs which have been selectively absorbed into cells, creating singlet oxygen and cell death.
- Patients must stay out of sunlight and intense light sources for 4-6 weeks post injection to avoid severe reactions.

71 **Tissue Effects**

Primary Tissue Effects Created by:

- Power (Watts)
- Spot Size (surface area)
- Exposure Time (resulting in Joules)

72 **Tissue Effects - Thermal**

- Tissue absorbs the laser light, which in turn generates heat, which in turn can coagulate or vaporize tissues.
- Coagulation and cauterization can occur at temperatures at or above 45◦ C
- Tissue vaporization occurs at over the boiling point of water – 100 ◦ + C – rupture of intracellular fluid and possible carbonization if power density too low.

73 **Epidermal Cooling**

- A cooling device must be used to protect the epidermis when targeting structures below the epidermis.
- Melanin in the epidermis can absorb the light energy causing heat energy.

74 **Tissue Effects**

Light Absorption in Skin

- Shorter wavelengths (toward the green-blue end of visible light) don't penetrate as deeply as longer wavelengths – reds & particularly the near infrared wavelengths.
- In the visible light range (about 400-700nm) about 99% of the total light is absorbed within 4mm of the skin's surface.

75 **Tissue Effects**

Skin Cooling – Derm Procedures

- Melanin in the epidermis is the primary chromophore resulting in heating
- External cooling methods are used to prevent epidermal injury such as burns, blisters, scarring and pigmentary changes.
- Cooling strategies include cooling gels, refrigerated air blowers, contact cooling devices such as sapphire plates, and cryogen sprays.

76 **Tissue Effects – CO2 laser**

- Photothermal effects (heat)
- Does not pass through fluid
- Does not pass through glass/optics
- Highly absorbed by soft tissues (water) so precise & limited zone of thermal necrosis
- Primary safety risk is skin & eye burns – corneal burn on the eye, not retina.

77 **Tissue Effects – Ho:Yag laser**

- Photothermal effects (heat)
- Does not pass through fluid (but can work under fluid endoscopically)
- DOES pass through glass/optics
- Highly absorbed by soft tissues (water) so precise & limited zone of thermal necrosis, but not as precise as the CO2 laser.
- High energy pulses

78 **Laser Safety - Reflections**

- Specular Reflections – intense reflection off mirror-like surfaces creating significant safety hazard.

- Diffuse Reflection – diffused reflection off rough or irregular surfaces, included anodized instruments – less of a hazard

79 **Laser & Energy Concepts**

LASER ACRONYM

L IGHT
A MPLIFICATION, by the
S TIMULATED
E MISSION of
R ADIATION

80 **Laser & Energy Concepts**

Physics - Active Mediums

- Nd:Yag – Neodymium Yttrium Aluminum Garnet
- Er:Yag – Erbium Yttrium Aluminum Garnet
- Ho:Yag – Holmium Yttrium Aluminum Garnet
- Argon/Krypton – those gases
- Ruby – Chromium ion
- CO_2 – that molecule
- KTP – Neodymium, but the frequency doubling crystal is Potassium Titanyl Phosphate (KTP)
- Diode – the semiconductor

81 **Laser & Energy Concepts**

On Continuous Wave (cw) lasers, the amount of time the laser is applied is generally called the exposure duration.

On Pulsed lasers, the amount of time the pulse is applied is generally called the pulse duration.

82 **Laser Safety**

Concentrated Dye Solutions (Dye Lasers) can pose a health risk both because of the dye concentrate, and the carrier anti-freeze solution.

The most common method of contamination is through the skin. Personnel should wear rubber gloves when handling dye solutions.

83 **Laser Safety**

84 **THE END**

Ta-Da!