Laser Certification Review

Certified Medical Laser Safety Officer

www.LaserCertification.org

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.

Certification Status

- Full Certification requires successful completion of the proctored examination, plus the experience and background requirements.
- Course participants may submit the additional materials at a later time, and have up to 5 years to complete the experience requirement.
- Those passing the exam but still awaiting completion of other requirements are designated a "Certification Candidate" and will receive the appropriate Certificate.

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.

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.

Exam Content Areas

For the LSO Credentials:

Safety –	65%	78 Q
Laser & Energy Concepts –	20%	24 Q
Tissue Interactions –	15%	18 Q

of Questions by Area, LSO

SAFETY

- Administrative – 12
- ANSI Regulations – Agencies – 16
- Eye-Skin Hazards – 16
- Non-beam Hazards – 10
- Hazard Evaluation & Control – 12
- Safety Practices - 12

of Questions by Area, LSO

LASER & ENERGY CONCEPTS

- Physics - 3
- Optical Principles - 6
- Energy Concepts - 5
- Wavelength Identification - 5
- History - 1
- Equipment Considerations - 4

of Questions by Area, LSO

TISSUE INTERACTIONS

- Thermal – 9
- PhotoAcoustic – 5
- PhotoChemical – 2
- PhotoDisassociation – 1
- Stimulative Effects - 1

Review Format

Each slide in this review will relate to the "Content Area" classification of a specific question on the exam, but will not be specific about the question asked.

Each slide will note the category of the content area covered, and it is possible that more than one question is asked within that slides content area.

Sequence of topics reviewed is random to reinforce memorization

Laser & Energy Concepts

Laser Beam Properties

- Collimated – minimally divergent, like any point source of light.
- Coherent – phased wave patterns, up to a certain distance from output. More important for sensing & diagnostics.
- Monochromatic – narrow bandwidth lines of "color", even if multi-line.

Laser & Energy Concepts

Laser Beam Properties

- Collimation –
  Probably the most important aspect for medical use because this is a "point source" of light with rays traveling parallel. Optics will focus this down to diffraction limited spot sizes. (very small spots)

HINT: When you're looking at a slide like this with ONLY one bullet point, you're pretty much assured that you're looking at an answer on the test. You just have to match it with the right question.

Laser & Energy Concepts

Index of Refraction (Optics)

- Ratio of speed of light in a vacuum to its speed in a given material (optics)
- Why a stick appears to bend when placed in water.
- Basis of all optics
- Basis for keeping laser light inside a fiber

Laser & Energy Concepts

Wavelength Identification
5 on LSO

CO2 – 10600nm	Er:Yag – 2940nm	Ho:Yag – 2100nm
Nd:Yag (harmonic) 1380nm	Nd:Yag – 1064nm	Diodes - ~ 530-1500nm
Alexandrite – 755nm	Ruby – 694nm	Krypton – 647, 568, 531
Helium Neon (HeNe) 632	Gold Vapor – 632nm	Copper Bromide 577,510
KTP (KDP) – 532nm	CW Dye (PDT) 632	Pulsed Dye, 578-600nm (Vascular)
Argon – 488, 515nm	ArFl Excimer 193nm	Pulsed Dye, 504nm (Lithotripsy)
	XeCl Excimer 308nm	

Laser & Energy Concepts

HISTORY

- Einstein – theory of stimulated emission based on photovoltaic cells
- Schawlow / Townes – theoretical paper on optical masers – Rcvd Nobel Prize
- Ted Maiman – First Laser – Ruby
- Dr Goldman – father of lasers in medicine

Laser & Energy Concepts

FLUX

- Concept of delivering more energy in shorter time periods to reduce thermal spread.
- 1W at .2s (.2J) is lower flux than 2W at .1s (.2J still).
- Look at the concept and balance of power and time

Laser & Energy Concepts

LASER ACRONYM

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

Laser & Energy Concepts

Optical Principles

- All other things equal, smaller focal length lens results in smaller spot & smaller depth of field.
- Increasing the beam diameter (& lens) at the same focal length will result in a smaller spot.
- Shorter wavelengths may be focused to smaller spot sizes (diffraction limited spot size) than longer wavelengths, if taken to their maximum.
- Higher pulse energies and shorter wavelengths are “harder” on optics. (i.e. ArFl excimer)

Laser & Energy Concepts

- Power Density (PD or Irradiance) effects on Tissue
- Power Density Parameters
  - Spot Size (Rapid Change)
  - Power (Slower Change)
- Techniques of changing Power Density with different delivery devices (i.e. focusing or collimated handpieces, bare fibers, waveguides)
- Too High PD is "clean" but loses control
- Too Low PD is controllable, but causes charring, burning and scarring.

Laser & Energy Concepts

Handpieces

- Focusing Handpieces – mostly for incisions/ablations. Shorter the focal length the smaller the spot & shorter the depth of field.
- Collimating Handpieces – mostly for aesthetic use – larger spot sizes and keeps it the same regardless of slight movements – consider hazards at distance.

Laser & Energy Concepts

- Characteristics of Fibers
  - Transmitting vs Contact Tip Fibers
  - Bare Fibers versus Handpieces & other Delivery Optics (i.e. slip lamps)
  - Fiber divergence 10-20 degrees. Smallest spot is right at the tip itself & get larger with distance
  - Principles of total internal reflection created by changes in refractive index
  - Typical fiber sizes (200u – 1000u, 600u typical)
  - Wavelengths amenable to fiber transmission

Laser & Energy Concepts

Surgical Laser Fibers

- Transmitting fibers that diverge 10-20 degrees, can touch tissue or be used off tissue
- "Contact" fibers that have sharp or ball tips that simply get hot and cut tissue
- Sapphire contact tips added to the end of the fiber catheter that converts the light energy into heat and works almost exclusively as a "hot knife"

Laser & Energy Concepts

- Typical Power/Energy Display & Measurement:

General Rule

- CW Lasers – Watts or Milliwatts
- Pulsed Lasers – Joules or MilliJoules

Laser & Energy Concepts

- Typical Power/Energy Display & Measurement:
- Watts: CO2, CW Nd:Yag, CW Dye, Argon, Many Surgical Diodes
- Milliwatts: Ophthalmic Diode Laser
- Joules: Ho:Yag, Alexandrite, Ruby, Pulsed Dye for vascular, Q-Switched Tattoo Nd:Yag
- Millijoules: Q-Switched Ophthalmic Nd:Yag, Pulsed Dye for lithotripsy

Laser & Energy Concepts

Physics - Active Mediums

- Nd:Yag – Neodymium
- Ho:Yag – Holmium
- Argon/Krypton – those gases
- Ruby – Chromium ion
- CO_2 – that molecule
- KTP – Neodymium
- Diode – the semiconductor

Laser & Energy Concepts

Time Periods (usually related to pulsing)

- Seconds or Milliseconds, 10^{-3}s, usually "long" pulse (i.e. Aesthetic & Hair removal lasers typically 10-100ms)
- MicroSeconds – Fast Pulses ~ 10^{-6}s frequently associated with shock waves such as Ho:Yag lithotripsy
- NanoSeconds & PicoSeconds 10^{-9} & 10^{-12}s – "sparking" as in Q-Switched or Mode Locked lasers for tattoos or posterior capsulotomy.

Laser & Energy Concepts

Continuous Wave (CW) Laser Emission

- Steady state of power (watts) delivery
- Has a maximum power attainable based upon the volume of the active medium
- Is generally less thermally "precise" on tissues than pulsing

Laser & Energy Concepts

Pulsed Laser Emission

- A compression of laser energy which emits power (watts) at a higher rate than is otherwise attainable in CW mode
- This is different than a simple "timer" on a CW beam, sometimes called a "Gated Pulse"
- Is more thermally "precise" on tissues than CW mode

Tissue Interaction

Photodynamic Therapy

- Light activated Photosensitizer
- Photochemistry, not Photothermal
- Applications have been primarily cancer treatment, but skin rejuvenation is beginning to see widespread use.
- CW red dye (630nm) laser used for Cancer Rx
- Blue Light used in skin rejuvenation

Tissue Interaction

Limiting Excessive Tissue Heating

- Use of higher flux pulses to reduce time component for thermal spread
- Laser plume is major mechanism of heat removal (when vaporizing)
- Low power densities burn tissue both because of inadequate laser plume, and incandescence of the char

Tissue Interactions

Laser Interactions

- Low Level Light (laser) Therapy – photobiomodulation, chronic pain treatment, hair growth, skin rejuvenation
- Thermal – non lethal heat – tissue welding, skin rejuvenation
- Thermal – destructive heat – cutting, ablating, photocoagulation, aesthetics, selective photothermolysis
- Acoustical shock waves – lithotripsy, photodisruption
- Photochemistry – PDT
- Photodisassociation – vision correction, Ar FL (energy of λ interacts with Carbon Bond in organic materials to cause electronic release of bond)

Tissue Interactions

Low Level Light Therapy (LLLT)

Use of low levels of light to photostimulate organelles within cells to mediate healing or pain relief. The term biostimulation was previously used, and recently the term Photobiomodulation is being used to describe these mechanisms

Tissue Interactions

High Degree of Absorption

Precise

- CO_2 (almost like a non-contact "hot knife")
- Ho:Yag
- Er:Yag

Tissue Interactions

High Degree of Scattering

Diffuse Coagulation

- CW Nd:Yag
- Argon or KTP (though much less than Nd:Yag)

Tissue Interactions

Relevance of pure color to application

(in decreasing order of relevance)

- Photodynamic Therapy (PDT) – photochemistry
- Ophthalmology
- Dermatology/Aesthetic
- General Surgical free beam
- General Surgical hot tips or contact tips

Tissue Interactions

Pulsed Laser "shock wave" applications

- Q-switched Nd:Yag, Ophthalmology for posterior capsulotomy (secondary cataracts - photodisruption)
- Ho:Yag laser, Urology, lithotripsy
- Pulsed Dye laser (green), Urology, lithotripsy
- Q-switched Ruby, Nd:Yag for tattoos

Tissue Interactions

Pulsed Laser "shock wave" applications

- The ones that dissect or fragment (capsulotomy & lithotripsy) are performed under fluid because the fluid best transmits the hydraulic shock wave that is created

Tissue Interactions

Pulsed Laser "shock wave" applications

- Lithotripsy is performed with the laser fiber in contact with the kidney stone
- Pulsed Dye (504nm green) is a lower energy event than the Ho:Yag lithotripsy so that impact with soft tissues (i.e. ureter) presents no risk.
- Ho:Yag laser is a higher energy event & must be done under direct vision so that soft tissues are not impacted. This laser will take out anything in contact with the fiber tip.

Laser Safety

Fire Hazards

- Greatest with CO2 laser, but all possible
- Fiber lasers a problem when the tip of the fiber is resting in drape or material
- Consider O_2 and N_2O concentrations
- Flammable preps not prohibited, but consider area of use
- Moistened materials in laser target area

Laser Safety

Fire Hazards

- Water available for quenching flames (irrigation solutions on backstand are OK)
- Fire Extinguisher available

Laser Safety

Suggested Hierarchy of Laser Eye Hazards:

- Pulsed Dye Yellow – because of high peak powers and absorption of yellow by Retina
- Infrared lasers – no aversion response. (open cases most, endoscopic least) - Retinal
- Visible light lasers – have aversion response (open cases most, endoscopic least) - Retinal
- CO2, ErYag & ArFl lasers (have lenses that focus at some short distance.) - Corneal.
- Ho:Yag – because of divergent fiber. - Corneal

Laser Safety

Retinal Hazards

- All wavelengths which pass through fluid
- Incorporates all visible light lasers
- Between approximately 400nm – 1400nm
- Practical difference between hazards of visible vs. infrared.
- Lens of eye increases power density by 100,000

Laser Safety

Laser Plume (smoke from tissue)
(Laser Generated Airborne Contaminants – LGAC)

- Obnoxious at best, and infectious at worst
- Smoke evacuation required by ANSI whenever plume is created.
- Treat tubing and filters as contaminated
- "Viral sized" face masks are considered ineffective and don't replace smoke evacuation, but no prohibition from using them with a smoke evacuator. (Local Exhaust Ventilation)

Laser Safety

Local Exhaust Ventilation
(Smoke Evacuator)

- Large Bore tubing – treat it and filters as contaminated
- Small suction tubing – ensure that inline filter is inserted between suction bottle and wall

Laser Safety

Applicability of ANSI Z136.3 Standards
Applies to ALL Health Care Settings Including

- Hospitals & Surgery Centers
- Small medical clinics & offices
- Mobile laser vans & services
- Medical Spas & Cosmetic Centers
- Anywhere a laser is used on a person

Laser Safety

Laser Service & Maintenance

- The LSO is responsible for ensuring that service is provided at appropriate intervals, by qualified individuals and documentation is retained.
- Service technicians should have both Laser Safety Training, and Laser Repair Training
- Power/Energy calibrations yearly

Laser Safety

Window Coverings

- Must be flame retardant when used
- Applies only to wavelengths that transmit through glass (300-2800nm)
- Required only when they are located within the NHZ, inside the LTCA
- Any material opaque to the wavelength is sufficient
- Consideration of barriers at doorways in special circumstances

Laser Safety

Medical vs. Industrial/Scientific LSO's

- Both are required by ANSI to be appointed by their facilities
- Industrial/Scientific based upon ANSI 136.1
- Medical based upon ANSI 136.3
- Need for measurements for Medical LSO's is minimized because of pre-classification

Laser Safety

Medical Laser Safety Officer

- Administers the Laser Safety Program
- May or may not run actual equipment
- Appointed by the facility administration
- No particular background nor education required
- Utilizes many different resources in order to manage the Laser Safety Program
- Required by ANSI in all health care facilities that utilize lasers – Hospitals, Medical or Dental Offices, MediSpas, etc.

Laser Safety

Laser Treatment Controlled Area (LTCA)

- The entire laser room, or a designated area in a very large room
- Signs required on all entryways
- Safety glasses provided, but are not required to be worn until within the NHZ
- Occupied only by authorized personnel trained in Laser Safety

Laser Safety

Purge Gases

- Used on CO_2 lasers to keep smoke cleared from the handpiece lens (adjust just high enough to keep smoke out of the handpiece, but not high enough to blow blood from the field or distort tissue)
- Used in some laser fibers (catheter type) for cooling purposes
- Both require a small inline filter to remove potential contaminants (mostly from tanks)

Laser Safety

Laser "Radiation"

- Non-ionizing type of radiation (not like X-Ray (lasers emit light – a radiant body)
- Used on warning signs and labels
- Wavelength of the "radiation" must be listed on the warning signs
- No hazard during pregnancy

Laser Safety

Nominal Hazard Zone

- Area where eye or skin burn really occurs (Where the MPE is exceeded)
- Can be designated the entire room, but is not required to be
- In laser use like CO_2 laparoscopy or Ho:Yag cystoscopy with very small NHZ's, the LSO might even designate the body cavity as the NHZ so that glasses need not be worn by personnel in the room.

Laser Safety

Endoscope Damage Hazards

- Flexible scopes may be destroyed if laser fiber is fired while still within the channel or less than ~1cm from the scope
- Channels in flexible scopes may also be damage simply by forcing the sharp fibers through a steep bend, even if not fired
- Optics in rigid scopes may be destroyed if the laser is fired with the fiber tip close to the optic
- Ho:Yag lasers will actually "bite" the optics & metal off rigid scopes if you come too close

Laser Safety

Glass Transmission
300-2800nm

- Lasers that don't transmit through glass include CO_2, Er:Yag, ArFL
- Glass in optics of scopes & instruments afford protection to the viewer
- Window glass affords protection to outside viewers so that no coverings are required

Laser Safety

Hazard Evaluation to Implement Controls

- Ability of the laser energy to injure people
- The delivery system used, which is important in defining the NHZ
- The environment where the laser is used
- Performed by the LSO utilizing their "informed judgment"
- Personnel exposed within the NHZ

Laser Safety

Indirect Laser Hazards
(Non-Beam Hazards)

- Laser Plume
- Electrical – this is probably the most significant hazard to Repair Technicians, including direct laser beam hazards, but for other personnel is not much different than other surgical equipment
- Dyes & Solvents
- Laser Gases

Laser Safety

ANSI

- American National Standards Institute
- "Recommended" practices but not law
- Used for enforcement by OSHA, JCAHO and various states
- 136.1 Parent technical document, and
- 136.3 Safe Use of Lasers in Health Care Facilities

Laser Safety

Laser Protective Eyewear

- Should always be worn within the NHZ
- Does NOT guarantee protection from direct impacts from the laser beam for retinal hazards (It is MOST IMPORTANT to not allow the beam to be directed toward one's face)
- Must be labeled according to the Wavelengths & Optical Density (O.D. or degree of protection).
- O.D. is a logarithm. I.E 10^4 = OD 4, so a change from 4-7 is a 1000 fold increase in attenuation. Higher numbers offer more protection.

Laser Safety

Clinical Treatment Parameters

It is the responsibility of the operating physician or clinical user to choose laser operating parameters and delivery devices.

Neither the LSO nor laser operators are responsible for establishing clinical laser treatment protocols or choosing laser settings. (aesthetic operators may work under a physician established treatment protocol)

Laser Safety

Airway Fires

When using the laser directly in the airway, standard PVC (polyvinyl chloride) tubes should NOT be used – and laser resistant tubes used instead.

Primarily a hazard with CO2 lasers in Microlaryngoscopy, but possible with fiber lasers in flexible bronchoscopy as well.

Laser Safety

Airway Fires

Laser use in flexible bronchoscopy is usually out past the carina & away from the E.T. tube so presents less risk than the CO_2 in the trachea. Circumstances that create higher temperatures, such as lasing through metal mesh stents, can ignite the laser fiber, bronchoscope, then E.T. tube if adequate fiber cooling is not provided

Laser Safety

CO2 Laser Case Wet Packings

When working in an open surgical field, wet packings may be used to protect adjacent structures, or prevent reflections from instruments. Anything nonflammable works including blood, saline, ringer's solution, distilled water, etc.

Laser Safety

Administrative Controls

- Standard Operating Procedures
- Documentation of Laser Training
- Documentation of Laser Service
- Annual Safety Audits
- Establishment of Credentialing standards

Laser Safety

Service Information
Code of Federal Regulations (CFR's)

- Service Manuals MUST be made available by the Mfg upon request at a reasonable cost of reproduction.
- Specific alignment and calibration information MUST be included.
- Enforced by the FDA (CDRH)

Tissue Interaction

Laser Pulsing

- Higher Flux laser pulses result in less thermal spread (better thermal precision) from the intended target when used in thermal applications such as skin resurfacing, hair removal, removal of surface vascular marks, fine incisions, etc.

Laser Safety

Contact Tip Practical Considerations

- Tip MUST touch tissues or they will burn up
- Tips remain hot for several seconds after use – DO NOT touch immediately after firing.
- Clean tips with peroxide in small cup and brush, but do NOT place in solution immediately after firing – they will crack

Laser Safety

Hazardous Reflections

- Surgical instruments can be "anodized" to create a micro-rough surface and reduce reflections
- Instruments can be "ebonized" to make them black, but this is primarily to reduce reflections from light sources which impairs the physicians vision.

Laser Safety

Maximum Permissible Exposure (MPE)

- Maximum exposure limit for eye & skin before a burn results
- This is what actually determines the boundaries of the NHZ
- Measured & Calculated by industrial/scientific safety officers, *but* medical LSO's may rely on informed judgment and information supplied by manufacturers, or equivalent assessment to determine the NHZ.

Laser Safety

Aversion Response

- The body's reaction to "jerk" away from bright light sources (aversion to bright light)
- Considered to be 0.25s
- 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

Laser Safety

Laser Operator Functions

- Ensure policies/procedures followed
- Signs on doors & windows covered when applicable.
- Glasses available, and worn in NHZ
- Aiming beam checked for alignment with surgical beam on every case.
- Must be personnel that are authorized by the facility & trained both in Laser Safety & Operation of the Laser.

Laser Safety

When Eyewear might not be required

- When the LSO deems the NHZ smaller than the area that personnel occupy. Examples might include CO_2 laser laparoscopy, closed endoscopic cases – especially with Ho:Yag laser

Laser Safety

When Eyewear might not be required

- ANSI 136.3 recognizes that indirect viewing on video (i.e. closed circuit TV) is an acceptable alternative to wearing of safety eyewear by personnel, especially when multiple wavelengths are involved and glasses "swapping" might be awkward

Laser Safety

Skin Burns to Service Technicians

- Possible with any laser
- CO_2 greatest burn hazard
- Touching fiber outputs will burn even if the laser does not – including contact tips
- Electrical burns also possible

Laser Safety

Laser Safety Committee

- Required by ANSI in large Health Care Facilities (i.e. hospitals)
- Does not replace the LSO as manager of the Laser Safety Program
- Frequently an appropriate committee to determine the facilities credentialing requirements for physicians

Laser Safety

Physician Credentialing for Laser

- Physicians are licensed by their state medical boards for medical practice in that state regardless of the tools used.
- Each health care facility sets its own standards for physician laser credentialing, according to ANSI recommendations.

Laser Safety

ANSI LASER CLASSIFICATIONS

- Classes I-IV
- All Surgical Lasers are Class IV
- Class IV – all precautions required all the time in the NHZ
- Anything over 0.5w average power or anything that burns eye or skin is Class IV

END !!

Certified Medical Laser Safety Officer

Good luck on the exam.

www.LaserCertification.org