

Laser & Energy Concepts –	¹ 20%	24 Q
	² 25%	25 Q
Tissue Interactions –	¹ 15%	18 Q
	² 15%	15 Q

7 # 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

8 # of Questions by Area, CLO

SAFETY

- Administrative – 4
- ANSI Regulations – Agencies – 4
- Eye-Skin Hazards – 21
- Non-beam Hazards – 8
- Hazard Evaluation & Control – 7
- Safety Practices - 16

9 # of Questions by Area, LSO

LASER & ENERGY CONCEPTS

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

10 # of Questions by Area, CLO


LASER & ENERGY CONCEPTS

- Physics - 2
- Optical Principles - 6
- Energy Concepts - 6
- Wavelength Identification - 4
- History - 1
- Equipment Considerations - 6

11 # of Questions by Area, LSO

TISSUE INTERACTIONS

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

12  # of Questions by Area, CLO
TISSUE INTERACTIONS


- Thermal – 9
- PhotoAcoustic – 5
- PhotoChemical – 2
- PhotoDisassociation – 0
- Stimulative Effects - 0

13  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

14  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.

15  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)

16  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

17 Laser & Energy Concepts

18 Laser & Energy Concepts

HISTORY

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

19 Laser & Energy Concepts

FLUENCE

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

20 Laser & Energy Concepts

LASER ACRONYM

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

21 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)

22 Laser & Energy Concepts

- Power Density (PD) 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.

23 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.

24 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

25 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”

26 Laser & Energy Concepts

- Typical Power/Energy Display & Measurement:

General Rule

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

(Even though you can use a power meter head to measure a pulsed laser by adjusting the rep rate.)

27 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

28 **Laser & Energy Concepts**

Physics - Active Mediums

- Nd:Yag – Neodymium
- Ho:Yag – Holmium
- Argon/Krypton – those gases
- Ruby – Chromium ion
- CO₂ – that molecule
- KTP – Neodymium
- Diode – the semiconductor

29 **Laser & Energy Concepts**

Time Periods (usually related to pulsing)

- Seconds or Milliseconds, 10⁻³s, usually “long” pulse (i.e. Hair lasers typically 10-100ms)
- MicroSeconds – Fast Pulses ~ 10⁻⁶s
frequently associated with shock waves
- NanoSeconds & PicoSeconds
10⁻⁹ & 10⁻¹²s – “sparking” as in
Q-Switched or Mode Locked lasers.

30 **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

31 **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

32 **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

33 Tissue Interaction

Limiting Excessive Tissue Heating

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

34 Tissue Interactions

Laser Interactions

- Low Level Light (laser) Therapy – biostimulation, 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 ? interacts with Carbon Bond in organic materials to cause electronic release of bond)

35 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 Photomodulation is being used to describe these mechanisms

36 Tissue Interactions

High Degree of Absorption
Precise

- CO₂ (almost like a non-contact “hot knife”)
- Ho:Yag
- Er:Yag

37 Tissue Interactions

High Degree of Scattering
Diffuse Coagulation

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

38 **Tissue Interactions**

Relevance of pure color to application

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

39 **Tissue Interactions**

Pulsed Laser “shock wave” applications

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

40 **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

41 **Tissue Interactions**

Pulsed Laser “shock wave” applications

- Lithotripsy is performed with the laser fiber in contact with the 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 impact. This laser will take out anything in contact with the fiber tip.

42 **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 O₂ and N₂O concentrations
- Flammable preps not prohibited, but consider area of use
- Moistened materials in laser target area

43 **Laser Safety**

Fire Hazards

- Water available for quenching flames (irrigation solutions on backstand are

OK)

- Fire Extinguisher prominently positioned in the laser room

44 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

45 Laser Safety

Retinal Hazards

- All wavelengths which pass through fluid
- Incorporates all visible light lasers
- Between approximately 300nm – 2000nm
- Practical difference between hazards of visible vs. infrared.
- Ho:Yag on up are OK, ArFl on down OK
- Lens of eye increases power density by 100,000

46 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)

47 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

48 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

49 **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 every 6 months

50 **Laser Safety**

Window Coverings

- Must be flame retardant when used
- Applies only to wavelengths that transmit through glass
- 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

51 **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

52 **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.

53 **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

54 Laser Safety

Purge Gases

- Used on CO₂ 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)

55 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

56 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 CO₂ 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

57 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 damaged 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

58 Laser Safety

Glass Transmission

- Lasers that don't transmit through glass include CO₂, 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

59 **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

60 **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

61 **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

62 **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.

63 **Laser Safety**

Clinical Treatment Parameters

It is the responsibility of the operating physician 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)

64 **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.

65 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 CO₂ 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

66 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.

67 Laser Safety

Administrative Controls

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

68 Laser Safety

Service Information

Code of Federal Regulations (CFR's)

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

69 Tissue Interaction

Laser Pulsing

- Higher Fluences from 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.

70 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

71 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.

72 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.

73 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

74 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.

75 Laser Safety

When Eyewear might not be required

- When the LSO deems the NHZ smaller than the area that personnel occupy. Examples might include CO₂ laser laparoscopy, closed endoscopic cases – especially with Ho:Yag laser

76 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

77 Laser Safety

Skin Burns to Service Technicians

- Possible with any laser
- CO₂ greatest burn hazard
- Touching fiber outputs will burn even if the laser does not – including contact tips
- Electrical burns also possible

78 Laser Safety

Laser Safety Committee

- Not required by ANSI, but may be utilized – especially with a diversity of usage
- Does not replace the LSO as manager of the Laser Safety Program
- Frequently an appropriate committee to determine the facilities credentialing requirements for physicians

79 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.

80 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