

**National Council on Laser Certification
Certified Laser Repair Technician (CLRT)
EXAM REVIEW**

1 ☐ **Laser Certification Review**

NCLC
Certified Laser Repair Technician

Note that this contains all the relevant topics on the exam, but a MUCH BETTER way to review for the CLRT exam is the ONLINE PRACTICE EXAM available at <https://lasercertification.org/Practice-Exams.php>

2 ☐ **Written Examination**

- 155 Multiple Choice Questions
 - 1 Correct (Best) Answer
- 70% Required for Passing
 - can miss up to 46 Questions
- 4 Hours allotted for completion
- Closed Book. "Controlled" breaks allowed.

3 ☐ **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 3 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.

4 ☐ **Exam Content Areas**

The examination is NOT a test of specific service procedures on specific lasers as defined in their service manuals.

The examination tests for a knowledge of laser and optical concepts including some specific alignments that are common among all lasers, and representative laser repair scenarios.

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 ☐ **Exam Content Areas**

For the CLRT Credential:

Safety – 16% 25 Q

Laser & Energy Concepts – 33% 51 Q

Laser Repair/Technical – 47% 73 Q

Tissue Interactions – 4% 6 Q

7 ☐ **# of Questions by Area**

SAFETY

- Administrative – 2
- ANSI Regulations – Agencies – 6
- Eye-Skin Hazards – 7
- Non-beam Hazards – 2
- Hazard Evaluation & Control – 1
- Safety Practices - 7

8 ☐ **# of Questions by Area**

LASER & ENERGY CONCEPTS

- Physics - 8
- Optical Principles - 14
- Energy Concepts - 5
- Wavelength Identification - 8
- History - 1
- Equipment Considerations - 15

9 ☐ **# of Questions by Area**

LASER REPAIR / TECHNICAL

- Alignments - 10
- Case Studies - 19
- Optics Cleaning - 2
- Optical Principles for Service - 14
- Power Measurement - 7
- Tubes & Resonators - 7

10 ☐ **# of Questions by Area**

LASER REPAIR / TECHNICAL

- Power Supplies - 7
- Component I.D. - 5
- Safety Practices for Service - 2
- Flashlamps - 3

11 ☐ **# of Questions by Area**

TISSUE INTERACTIONS

- Thermal – 4
- PhotoAcoustic – 1
- PhotoChemical – 1
- PhotoDisassociation - 0

12 ☐ **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.

13 ☐ **Laser Safety**

ANSI LASER CLASSIFICATIONS

- Classes 1-4
- All Surgical Lasers are Class 4
- Class 4 – all precautions required all the time in the NHZ
- Anything over 0.5w avg power or anything that burns eye or skin is Class 4

14 ☐ **Repair / Technical**

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- Review the required sequence of alignments in any laser.
- Proximal changes affect all “downstream” optics.

15 ☐ **Laser & Energy Concepts**

- Characteristics of Fibers
 - Transmitting vs Contact Tip Fibers
 - Bare Fibers versus Handpieces & other Delivery Optics (i.e. slip lamps)
 - Fiber divergence
 - Principles of total internal reflection created by changes in refractive index
 - Typical fiber sizes
 - Wavelengths amenable to fiber transmission

16 ☐ **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.

17 ☐ **Repair / Technical**

- Ion Laser Power Supply Characteristics
 - Rectified AC Line Voltage ~ 240v
 - Passbank Current or Voltage Regulation
 - Typical 30-50 amp draw
 - Tube voltage at full operational power or current is best gauge of tube condition. – actually looking at the combination of V&I condition is better.
 - Over voltage = Tube Overpressure (burn off)
 - Low Voltage = Tube Underpressure
(fill from reservoir – “ballast tank” – caution not to overfill)

18 ☐ **Repair / Technical**

Ion Laser Tube Components

- Ceramic or Glass bore (tube)
- Surrounding Magnet to "squeeze" the ionized plasma into the middle of the bore
- Anode / Cathode
- "Getter" which pulls out impurities such as hydrogen which may be in the tube
- Brewster windows at each end to seal the tube

19 ☐ **Laser & Energy Concepts**

HISTORY

- Einstein – theory of stimulated emission based on photovoltaic cells
- Schawlow / Townes – theoretical paper on optical masers
- Maiman – First Laser – Ruby
- Dr Goldman – father of lasers in medicine
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20 ☐ **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"

21 ☐ **Laser & Energy Concepts**

LASER ACRONYM

L IGH T

A MPLIFICATION, by the

S TIMULATED

E MISSION of

R ADIATION

22 ☐ **Repair / Technical**

- CW Dye Laser Characteristics
(I.E. Photodynamic Rx for Cancer)

- Uses incoming beam from an Argon or KTP laser as it's power supply.
- Produces CW Red light at about 630 nm
- Spherical Integrators required to measure energy from many types of diffusers.
- Monochrometer required to measure wavelength stability.

23 ☐ **Repair / Technical**

Dye Solutions in Dye Lasers

- Dye replacement part of normal maintenance and it needs regular maintenance, including running of the laser
- Degraded dye solution shows up as lower energies from the laser, misfires, and wavelength instability of the output.
- Dye consists of the dye concentrate and typically uses an antifreeze (ethylene glycol) carrier, and

is considered a hazardous solution.

▪

24 ☐ **Repair Technical**

Watts & Joules Conversion

- Watts x Seconds – Joules
- 1.5 J at 10hz will show as 15w avg pwr (15J in one second)
- When measuring avg pwr at 10hz, just divide by 10 to get the J/pulse

25 ☐ **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.)

26 ☐ **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

27 ☐ **Repair / Technical**

Q-Sw Ophthalmic Yag – Alignment

- The capsule which is the target is right against the new lens so pitting this lens must be avoided.
- Deferring to mfg specs, alignment of the red dot & spark is centered on X-Y axis, but the spark is placed just “behind” the red dot in the Z axis (depth) so that the red dot focuses on the capsule and the spark occurs just behind it to create the shock wave to rip the membrane, but sparing the lens.

28 ☐ **Repair / Technical**

Use of Attenuators:

- Aiming beam brightness
- Some sealed tube CO2 Lasers because unstable at very low currents.

29 ☐ **Repair / Technical**

Diode Laser Troubleshooting

- Calibrated annually (like all medical lasers)
- It either works or not – no optical assemblies except for delivery optics, and no optical

adjustments.

- Total power output is frequently the sum of multiple diodes.
- Diodes are also used as the pump source on some solid state lasers.

30 ☐ **Repair / Technical**

Brewster Windows

- Purpose – enhance transmission (reduce reflections)
- Angle – 57.3 degrees in quartz – where the surface does not reflect the light of one linear polarization
- Importance of keeping clean – power loss in ion laser.
- Can be used anywhere, but typically in ion lasers, and stack polarizers
- Use of protective covers that are sometimes pressurized with gas flow to reduce dust.

31 ☐ **Laser & Energy Concepts**

Time Periods (usually related to pulsing)

- Seconds or Milliseconds, $10^{-3}s$, usually “long” pulse (i.e. Hair lasers typically 10-100ms)
- MicroSeconds – Fast Pulses $\sim 10^{-6}s$ frequently associated with shock waves
- NanoSeconds & PicoSeconds 10^{-9} & $10^{-12}s$ – “sparking” as in Q-Switched or Mode Locked lasers.
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32 ☐ **Laser & Energy Concepts**

PULSING

- “Gated” (timed) vs. true Laser Pulse
 - Electrical Control or Mechanical Chopper
- Electrically “Spiking” the driving current
- Acoustic Optical & Electro Optical
- Optical Crystals & Cells
 - Pockel’s Cells for Q-Switching, nanosecond
 - Dye Cell for Mode Locking, picosecond train

33 ☐ **Repair / Technical**

CO2 Laser Gases

- Laser Gas Mixture – Mostly N2, some CO2, some He. N2 gives it the characteristic purple/pink color.
- Sealed tube lasers – added catalysts/inhibitors.
- Purge Gases – compressed air, or bottled N2. Needs to be filtered. Only keeps smoke off the lens.
- Problems with tank swapping
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34 ☐ **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.

35 ☐ **Repair / Technical**

LAMPS (Flash Lamps)

- Pressurized – explosion hazard – eye protection & caution required.
- Cleaning precautions – no rigorous rubbing – clean gently like an optic.
- Failure may be gradual – symptoms of repeated start attempts & “cracking” noise (bad D.I. water can mimic this)

36 ☐ **Repair / Technical**

LAMPS (Flash Lamps)

- Typical life of 150-200 hours
- Typical 100K to 250K shots
- Anode / Cathode – Note the polarity
- Flow-Tube used to direct the water tightly around the lamp for cooling – must be kept clean.

37 ☐ **Repair / Technical**

Laser Output Calibrations

- Required annually
- +/- 20% Variance – High, Mid, Low
- CFRs require that manufacturers must provide detailed procedure upon request
- Your own external meter must itself be sent in for calibration to a national standard annually

38 ☐ **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

39 ☐ **Repair / Technical**

Laser Internal Power Detection

- CO2 & Er:Yag use shutter to totally dump beam into calorimeter – so during use meter reading is only memory
- Nd:Yag, KTP, Argon and others use a beam splitter to create a small optical “shunt” into the meter, so the meter reflect the actual value during use

40 ☐ **Laser Safety**

Hazardous Reflections

- Service personnel are exposed to open housings which create greater risks of accidental exposure
- 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.

41 ☐ **Laser & Energy Concepts**

Radiant Exposure (Energy Density)

- Measured in Joules / cm²
- Used when a "Dosage" parameter of the laser is required – also applies to IPL's.
- Generally used for Aesthetic/Derm procedures like hair removal – vascular lesions, etc.

42 ☐ **Repair / Technical**

Practical Optical Principles

- Remove, Clean or Adjust
-- ONLY ONE OPTIC AT A TIME.
- In an Optical train – adjusting any optic will affect all the optics downstream of that one.
- Don't unnecessarily remove Optics for cleaning if they may be adequately cleaned in place.

43 ☐ **Repair / Technical**

Pulse Energies vs. Pulse Rate

- Pulse Energy in Joules x Rate (ppr) creates an "average" power in watts.
- Higher average powers don't necessarily mean a more "powerful" impact
- Higher energies require longer recovery time and hence lower maximum rates. – i.e. -shows up as problem if Q-sw NdYag is foot activated too rapidly.

44 ☐ **Laser Safety**

Direct Beam Hazards

- Eye burns or damage
- Skin burns
- Fires or burning of materials
- Accidental surgical perforations or incisions

45 ☐ **Laser Safety**

Indirect Laser Hazards

- Laser Plume
- Electrical – this is probably the most significant hazard to Repair Technicians, including direct laser beam hazards.
- Dyes & Solvents
- Laser Gases

46 ☐ **Laser & Energy Concepts**

47 ☐ **Repair / Technical**

Anti Reflective Coatings (AR Coatings)

- Used to increase efficiency of optical "coupling" into optic & reduce losses.
- Coating faces the incoming laser beam.
- Coating is 1/4 the wavelength of the laser
- Works by destructive interference pattern

- Identify by "V" or seeing the backside edge at a critical angle
- Inserting them wrong reduces the power output at best, and can destroy proximal optics at worst

48 ☐ **Repair / Technical**

Near / Far Alignments

- "Near" beam is closest to HeNe (aiming) and is reflective.
- "Far" beam is the beam combiner which passes the surgical laser & reflects the HeNe (aiming).
- Alternate between Near / Far adjustments
- Bring the HeNe back on top of the Burn spot each time.
- Note the mode structure when burning
- Checked on CO2 by burning tongue blade and observing coincidence – use the delivery system that will actually be used during the case (focal lengths).
(above is applicable to most lasers. Note the Coherent Ultrapulse is a different sequence – not on exam)

49 ☐ **Laser Safety**

Airway Fires

Though not directly related to laser service work, the consequences are so catastrophic that all laser personnel should be aware.

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

50 ☐ **Repair / Technical**

Beam Paths & Alignments – IR Lasers

- Thermal paper of any source
- Zap-It paper for visualization
- Fluorescent Plates & UV illumination
- Infrared viewing scopes
- Anything to burn with CO2 lasers
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51 ☐ **Repair / Technical**

Articulated Arm Alignments

- To center the beam on the rotational axis of each arm mirror
- Place tape mark on aim beam, then rotate 180 degrees & observe
- Adjust aim beam ½ way to mark, & continue back & forth until corrected.
- Centering is a byproduct at the end of correct alignments and you never try to center the aim beam by adjusting it directly to the center

52 ☐ **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.

- HoYag on up OK, ArFl on down OK
- Lens of eye increases power density by 100,000

53 ☐ **Repair / Technical**

Power / Energy Measurement

- Meter, plus various heads
- Generally heads for power in watts, and energy in joules.
- Can use a watt meter for some pulsed lasers if use prr of 10 hz.
(1J x 10pps = 10W, or 10 J in 1 second)
- Importance of using large spot to avoid burning surface of meter.

54 ☐ **Repair / Technical**

Front / Rear power mirrors

- Front mirror is the Partially Reflective, "Output Coupler" (OC), beginning of optical train.
- Rear mirror is High Reflectivity (HR), and is optically isolated from optical train so may be adjusted independently.
- "Walked" as a pair to peak power output

55 ☐ **Repair / Technical**

Flowing Gas CO2 Lasers Vacuum System

- Insufficient vacuum allows more molecules in tube & higher power output, but becomes unstable at low powers.
- Higher vacuum "thins out" the molecules and lowers max power output but increases the stability of low power outputs.

56 ☐ **Repair / Technical**

Flowing Gas CO2 Lasers Vacuum System

- Excessive vacuum can cause arcing of the anode/cathode and potential damage to laser electronics.
- Vacuum leaks can cause intermittent firing – especially at lower powers.
- Mfg's procedures should be followed for doing a vacuum check on the system, and the high voltage circuit disabled.
- Vacuum pump oil changes or vane "resetting" can sometimes correct intermittent problems.
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57 ☐ **Repair / Technical**

Ho:Yag Optics

- High energy pulses are hard on fibers and internal optics.
- "Blast Shield" used to protect laser optics from fiber fragments when exploded.

58 ☐ **Laser Safety**

Laser Plume (smoke from tissue)

- 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.

59 ☐ **Repair / Technical**

Dionizer Cartridge / Crystals

- Required when coolant flows over anode/cathode of flashlamps to prevent conduction.
- Discoloration of crystals or conductivity of fluid can indicate need for change.
- When deteriorating, laser can suffer power losses or show intermittent firing.

60 ☐ **Laser & Energy Concepts**

PHYSICS

- Stimulated vs Spontaneous Emission
 - Theory by Einstein as it related to photovoltaic
- Transition levels of electrons including metastable states
- Planck's constant defines differences in energy bands and resulting wavelengths

61 ☐ **Tissue Interactions**

Pulsed Laser "shock wave" applications

- Q-switched NdYag, Ophthalmology for posterior capsulotomy (secondary cataracts)
- Ho:Yag laser, Urology, lithotripsy
- Q-switched Ruby, NdYag, KTP, Alexandrite for tattoos
- PicoSecond lasers for tattoos

62 ☐ **Tissue Interactions**

Laser Interactions

- Low Level Light (laser) Therapy – PhotoBioModulation
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

63 ☐ **Tissue Interactions**

Free Beam Lasers (fibers or focused)

- Heat is generated when the light is absorbed in the tissue
- Wavelengths of lasers have various "chromophores" that absorb that specific wavelength

64 ☐ **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.

65 ☐ **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)

66 ☐ **Repair / Technical**

Typical CO2 Laser Power Supplies

- Flowing Gas & DC Excited Sealed Tube
 - DC, HV, Low Current, ~ 15-20KV, 15ma
- RF Excited
 - RF power in watts and frequency determined by mfg.
 - Power supply is “supposed” to be tuned to that specific waveguide resonator cavity.
 - Transmitted transversely across the cavity

67 ☐ **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
- Visible light lasers – have aversion response
- CO2, ErYag & ArFl lasers (have lenses that focus at some short distance. Corneal hazard.
- Ho:Yag – because of divergent fiber. Corneal

68 ☐ **Repair / Technical**

Output from Multi-Line Lasers

- Max power output is sum of all wavelengths when they may be emitted simultaneously.
- Ar, Kr, CuBr lasers
- Single line emission will have lower power outputs than maximum multiline.

69 ☐ **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

70 ☐ **Repair / Technical**

Basic Lens/Mirror Classifications

- Plano
- Concave
- Convex
- Plus combinations for both sides of lenses.

71 ☐ **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.

72 ☐ **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.

73 ☐ **Laser & Energy Concepts**

Laser Beam Properties

- Collimation –
All other things being equal, the larger the diameter of the beam, the lower the divergence. Beam expanders are used to do this for transmitting laser beams over long distances.

74 ☐ **Repair / Technical**

Frequency Doubling

- Usually done on Nd:Yag lasers to change (halve) wavelength to 532nm green.
- KTP (Potassium Titanyl Phosphate) frequency doubling crystal usually used, although BeO (Beryllium Oxide) may also be used.
- Usually configured as a high frequency “quasi-continuous” pulsed system of over 20Khz. (I.E. Laserscope KTP laser)

75 ☐ **Laser & Energy Concepts**

Electromagnetic “Radiation”

- One of the four forces of the Universe (also strong & weak forces, & gravity)
- Spans the range from short cosmic and gamma rays to long radio waves
- Visible light is in a very narrow range from around 400-700nm
- Measured as Angstroms, nanometers or micrometers (5320A, 532nm, .532um)

76 ☐ **Laser Safety**

Practical Safety Practices for Laser Service

- “Awareness” of hazard & possible exposure to stray & direct beams. Involves “observing & clearing” the area prior to working.
- Avoiding placing your face in direct line with the output coupler
- Exercising precaution with power supplies – the greatest hazard to service people.

77 ☐ **Laser Safety**

Laser Protective Eyewear

- Should always be worn within the NHZ
- Does NOT guarantee protection from direct impacts from the laser beam
- 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.

78 ☐ **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 other means.

79 ☐ **Repair / Technical**

Optics – Chromatic Aberration

- The same lens will focus different wavelengths to different focal lengths
- Focused on a surface (tissue) this can cause the aiming & surgical beams to be significantly different spot diameters.
- In the real world, this can also cause loss of coaxialness between the aiming beam and surgical laser

80 ☐ **Repair / Technical**

Cooling Systems – CO2 lasers

- Distilled water, or sometimes antifreeze solutions just to avoid problems in transportation in cold climates.
- Algae growth is biggest problem – change water & add inhibitors
- Vapor locks in water pumps sometimes stop flow – purge lines.

81 ☐ **Repair / Technical**

Cooling Systems – lasers with 3 phase pumps
(i.e. older external water cooled lasers)

- Polarity of the phases controls the direction of rotation of the motor
- Impellor on pump is designed to spin one direction – ensure that the phasing is correct for this – can do a “quick” test to see.
- Running the pump with incorrect phasing rotates the impellor the wrong way and can shear it from the shaft so that water flow stops.

82 ☐ **Repair / Technical**

Cooling Ion Laser Tubes

- Some lasers have flow sensors & others may not (or may be broken).
- All have overheat sensors that will shut down the unit
- Forgetting to turn on the external water source is the primary reason for overheats
- Panicking & turning the flow back on just after such a shut down can crack the tube and cause extensive damage. – Let it sit untouched for a while before attempting a restart.

83 ☐ **Laser Safety**

PREGNANCY

- The “Radiation” referenced on Laser warning signs is not ionizing radiation and poses no threat to women in any stage of pregnancy

84 ☐ **Repair / Technical**

Power Supplies – Pulse Forming Networks
(PFN)

- Used by lasers that typically fire a flashlamp in a pulsed manner
- I.E., Pulsed Dye, Ho:Yag, KTP

85 ☐ **Laser & Energy Concepts**

Measurement of Beam Divergence

- Radian used as unit of measurement.
- Angular measure – ratio of the arc length on the circumference of a circle by that angle, divided by its radius.
- At 1 milliradian, the spot would increase by 1 foot for every 1000 feet in distance.
- Typical laser divergence is 0.5 – 10 milliradians.

86 ☐ **Repair / Technical**

Frequency of use and maintenance

- Some lasers should be run periodically (once per week?) or they will develop maintenance problems.
- Argon & Krypton ion lasers will because of potential overgassing in the tubes.
- Dye lasers will because of coatings of the dye & solvent on the tubes & internal optics.

87 ☐ **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.
- Certification for Laser Medical Director available, but not required.

88 ☐ **Repair / Technical**

Accessory Shutters & Filters

- Slip on filters over eyepieces
- Electromechanical Filters that rotate in place
 - Check for proper operation during service
 - Potential problems when firing too fast & not allowing sensor to reset. (ie ophthalmic)

89 ☐ **Repair / Technical**

Launch of Ophthalmic Argon into Fiber

- 3 Axis alignment (X, Y, Z)
- Depth of focus is important because you do want to cover the face of the fiber as much as possible with the beam, rather than sharply focusing it on a small point on the fiber and burning it.

90 ☐ **Repair / Technical**

Ophthalmic Argon Spot Size Control

- Beam delivered through a slit lamp
- Focusing lenses in the laser tower on the slip lamp that focus the beam
- Spot sizes from ~ 50u to 0.5mm
- Ophthalmologist frequently uses a handheld contact lens to additional deflect the beam in the

eye

91 ☐ **Repair / Technical**

Selective Transmission/Reflection of Colors

- Dichroic Filter allows selective transmission of wavelengths.
- Dichroic filters placed "inside" the resonator cavity will allow lasing of only that wavelength.
- Principle employed in tunable Dye laser as the Birefringent Tuner to select certain wavelengths.

92 ☐ **Laser & Energy Concepts**

Active Mediums

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

93 ☐ **Laser Safety**

Glass Transmission

300-2800nm

- 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

94 ☐ **Repair / Technical**

Optics Cleaning – desirable hierarchy

Going from most gentle to roughest – levels of desperation

- Drop & Drag – sheet of lens paper
- Twist & wipe – folded paper in hemostat
- Roll & wipe – cotton tip applicator
- Rub & Scrub – cotton tip applicator
-

In practice, don't remove optics for cleaning unless they really need it and you can't adequately do it in place.

95 ☐ **Repair / Technical**

Fiber Calibrations

- In most bare fiber surgical applications this is unimportant from a practical point of view.
- Some lasers have external pod to point and shoot and no close contact is required with fibers
- Sapphire Contact Tips are NOT placed on the fiber during calibration, or they will burn up.

96 ☐ **Repair / Technical**

Fiber Calibrations

- Some lasers have sleeves into which the fiber is inserted before firing into meter
 - Glass windows on some of these & some fibers can be burned if allowed to touch the window when firing

- In sterile procedures the sleeves must also be sterilized before doing the calibration & the fiber handled with sterile gloves

97 ☐ **Repair / Technical**

Calibrations

- Meter, plus various heads for various lasers
- Avoid burning face of detector with small spots
- Can be calibrated through the delivery lens, but do NOT focus it on detector – fill about 75% of the face of the detector

98 ☐ **Tissue Interaction**

Laser Pulsing

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

99 ☐ **Tissue Interaction**

Laser Pulsing

- At even higher fluences of pulses the result is a “non-linear” thermal event and shock waves are produced.
- Fiber contact with object for lithotripsy
- Non-contact “sparks” created by Q-sw Nd:Yag for ophthalmology

100 ☐ **Laser Safety**

Service Training – ANSI recommendations

- Must have laser safety training
- Must have laser repair training commensurate with the level of work
- No requirements for any educational background or certification
- No requirements for authorization or approval by manufacturer
-

101 ☐ **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

102 ☐ **Laser Safety**

ANSI Recommendations

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