

# LASER SAFETY

## SMH Off-Site Locations

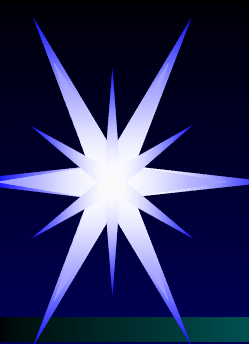
**L** ight

**A** mplification

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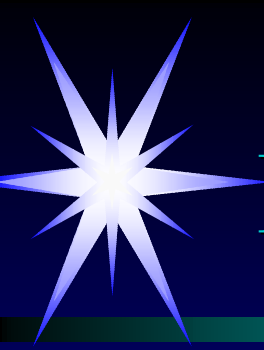
**R** adiation



# Purpose of this training

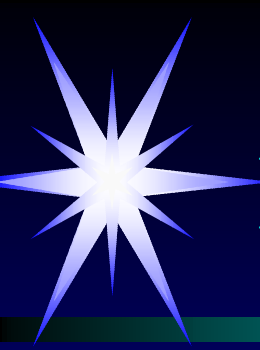
**This training session is to provide you with safety information for the use of lasers.**

**You must also receive site specific training from your Departmental Laser Safety Officer or other qualified medical care practitioner.**



# Purpose of this training

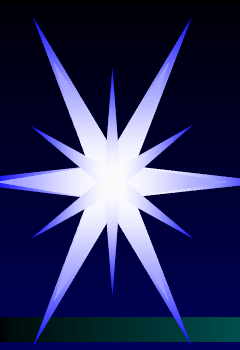
**Only laser trained personnel may use lasers. If you have a question about the use of your laser, contact your supervisor, Departmental Laser Safety Officer, or EH&S.**



# HISTORICAL

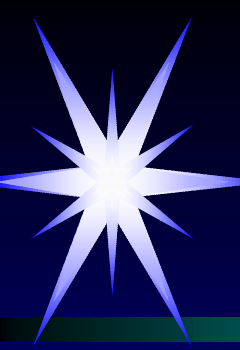
**Lasers have been in use for a number of years. Because of their abundant use, many people do not anticipate the hazards lasers might present to themselves or others!**

**Because of this, standards have been implemented!**



# LASER SAFETY STANDARDS

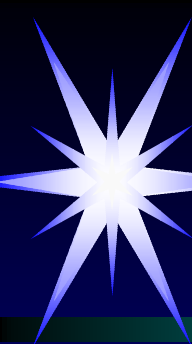
**The Occupational Safety and Health Administration, OSHA, requires personnel to observe the ANSI recommendations for the safe use of lasers.**



# LASER SAFETY STANDARDS

**The American National Standard Institute (ANSI) publishes a series of “industry” standard for the use of lasers. For medical care, we utilize ANSI 136.3-1996, the “..Safe Use of Lasers in Health Care Facilities”.**

**Not following the ANSI recommendations can result in OSHA citations and fines!**



# LASER SAFETY STANDARDS

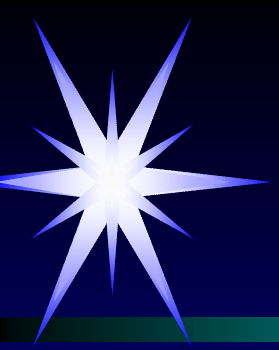
**The health care industry is heavily regulated. JCAHO and the FDA have laser requirements that must also be observed.**

## **➤ JCAHO**

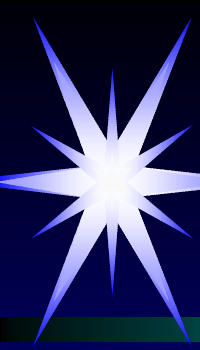
- Documentation of Quality Management & Nursing Care**

## **➤ FDA**

- Regulates marketing of laser equipment for specific procedures**



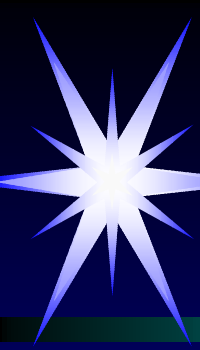
# **LASER SYSTEMS: PRINCIPLE of OPERATION**



# LASER SYSTEMS

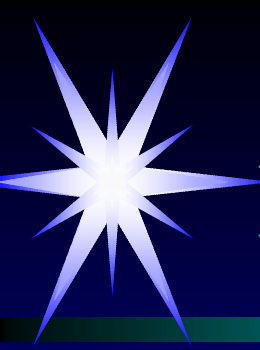
**Lets look at the components of a laser system**

- Excitation source**
- Laser head**
- Ancillary components**
- Control panel**
- Mirrors**
- Delivery system**



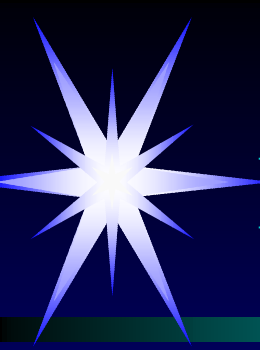
# LASER SYSTEMS

**Modern lasers operate because a material becomes “excited” when energy is applied to the system. The active medium may consist of a gas, molecules in a liquid, ions in a crystal, etc.....**



# LASER SYSTEMS

**When light energy of a unique frequency strikes an atom in the active medium, the material becomes excited. When the material releases the energy, it releases a photon of light and the atom returns to the “ground” state.**



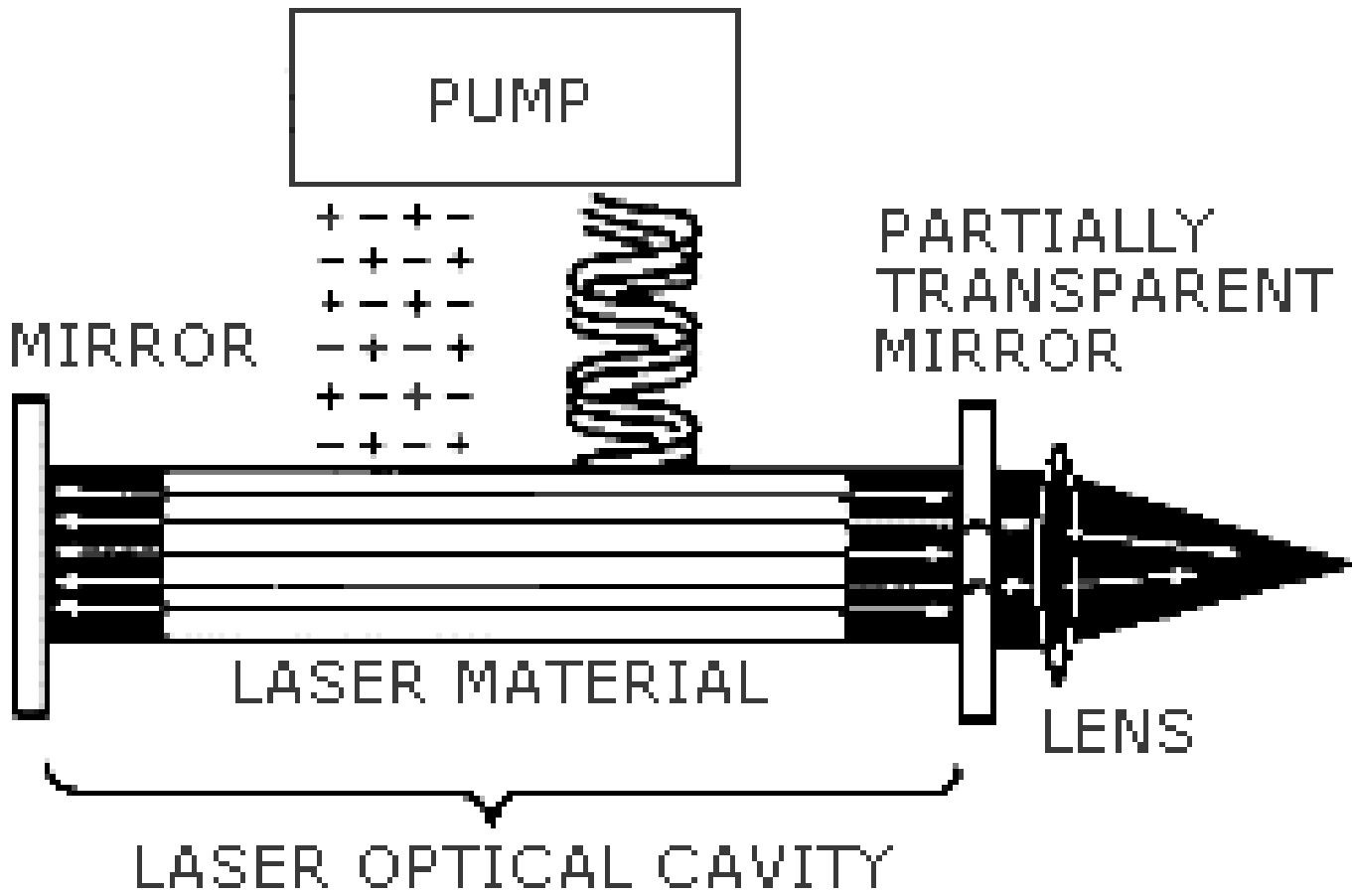
# LASER SYSTEMS

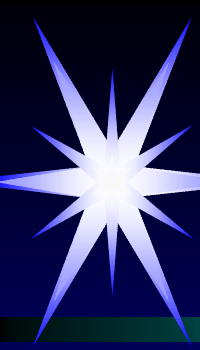
**Lasers work by pumping electrons in a suitable material (lasing medium), that is capable of storing the energy. This occurs in a resonating chamber (optical cavity).**

**The component include a source of the energy, a lasing medium, a resonating cavity, and mirrors....**



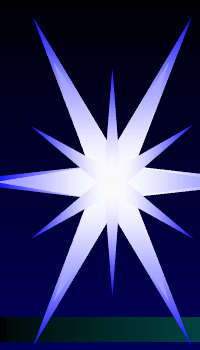
# LASER SYSTEMS





# LASER SYSTEMS

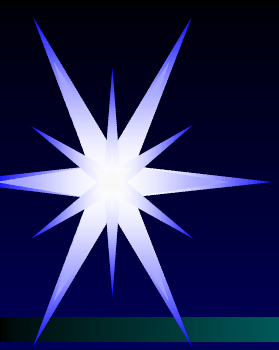
**The radiation reaches one end of the cavity and is reflected off a mirror back into the medium, striking more electrons in the atoms in the medium. Additional radiation is generated....**



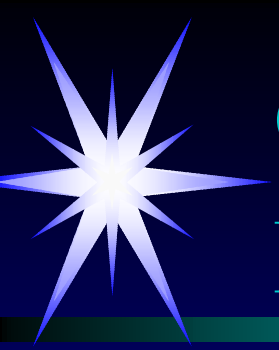
# LASER SYSTEMS

**The radiation surges back and forth gaining strength until the photons emerge from one end of the head through a partially reflective mirror....**

**The laser light then leaves and can be used in its application.**

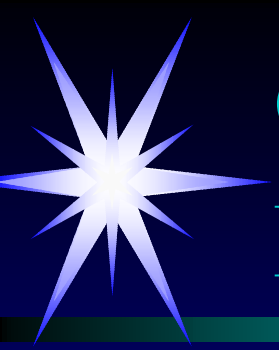


# CHARACTERISTICS OF LASER LIGHT



# CHARACTERISTICS OF LASER LIGHT

- Light photons leaving the resonating chamber is different than ordinary light. These photons are
  - Coherent
  - Collimated, and
  - Monochromatic.



# CHARACTERISTICS OF LASER LIGHT

- **MONOCHROMATIC:** emitted photons have the same wavelength (same color)
- **COLLIMINATED:** All the light waves are parallel. This minimizes beam divergence as it travels from its source.
- **COHERENT:** The laser waves travel in the same direction and are in phase (spacially and temporally) with each other.



# CHARACTERISTICS OF LASER LIGHT

- Light photons travel at the speed of light.
- Light photons act as a wave of electromagnetic energy and observes the formula:  $C = (\lambda)(f)$ 
  - Speed of light [C]  $3 \times 10^8$  m/sec
  - Frequency ( $f$ ) in hertz
  - Wavelength ( $\lambda$ ) in meters

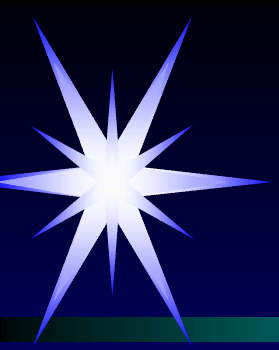
**Please note: Lasers can now generate radiation that is substantially slower than the speed of light!**



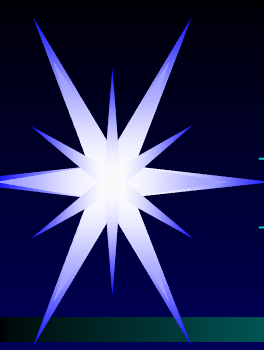
# CHARACTERISTICS OF LASER LIGHT

The output of the laser will help to determine its interaction with a target. The greater the power, the more energy that will be delivered to the target and the greater the possibility of injury.

$$\rightarrow \text{Power(Watts)} = \text{Energy(joules)}/\text{Time(sec)}$$

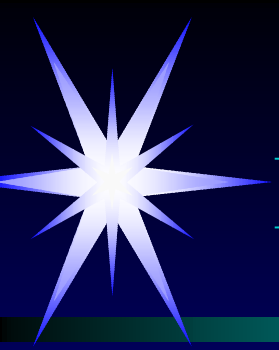


# LASER CLASSIFICATIONS AND TYPES



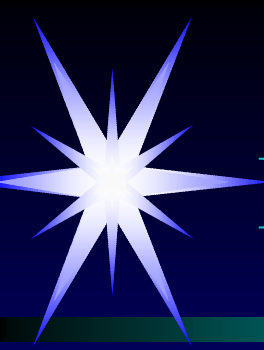
# LASER CLASSIFICATIONS

**Lasers are rated based on their power rating and their ability to result in injury to personnel. The ranking goes from Class 1, the safest, to Class 4, where serious eye and skin injuries may occur.**



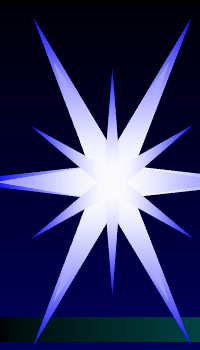
# LASER CLASSIFICATIONS

- **Class 1** - Very low energy lasers. Safe to eye/skin
- **Class 2** - low output in the 400-700 nm range, no skin injury, eye injury unlikely because of the blink aversion
- **Class 3 A&B** – medium power lasers, no skin injury, eye damage from intrabeam viewing possible
- **Class 4** - high power lasers, serious eye/skin damage possible



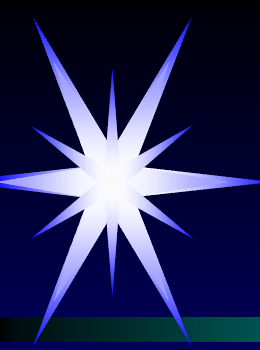
# LASER CLASSIFICATIONS

CLASS	ENERGY LEVEL	HAZARD
1	Very low power	<b>None</b>
2	Low power in 400-700 nm range	Skin – none Eye – none because of blink aversion
3a, 3b	Medium power	Skin – none Eye – from intrabeam viewing
4	High Power	Eye – YES! Skin – YES!



# LASER OPERATIONS

**The following slides highlight some important operational issues for lasers. They include the pulse frequency and the wavelength.**



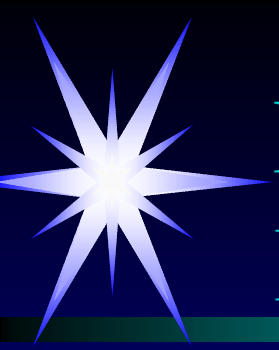
# CONTINUOUS WAVE LASERS

- **The output does not fluctuate when beam is on. The output is continuous.**
- **A laser beam will be produced as long as sufficient energy is added to the system.**



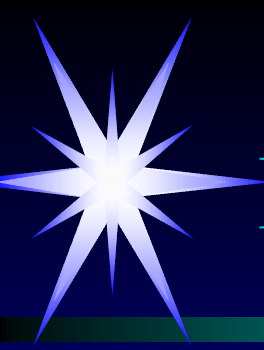
# **PULSED/CW LASERS (MODULATED OR CHOPPED)**

- The beam is pulsed by mechanical shutter that periodically opens and closes**
- The power supply turns on/off, causing a beam to be created when it is on.**
- A rotating mirror can be used. It causes the appearance of a pulsed beam**



# **NORMAL REPETITIVE PULSED**

- **A power supply develops the pulse characteristics**
- **A capacitor or a set of capacitors can be used to “fire” the flask lamp**



# PULSED Q-SWITCHED

## ➤ Single pulsed Q-switch

- The input energy is stored using mirrors
- The beam has a very short time duration but has a very large peak power

## ➤ Multiple Pulsed Q-switch

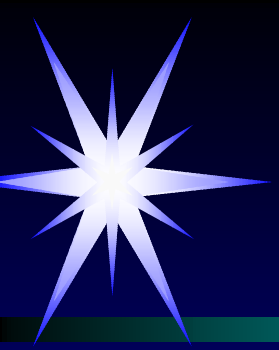
- Frequencies as high as 25,000 hertz
- Continuous excitation source used (arc lamp)
- Often, large amount of power output



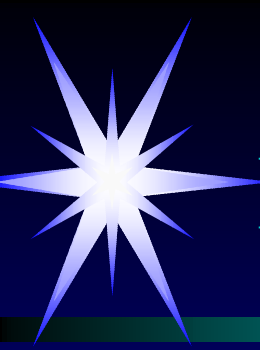
# COMMON LASER WAVELENGTHS

	WAVELENGTH
Argon (blue)	0.488 $\mu\text{m}$
Argon Fluoride (Excimer)	0.193 $\mu\text{m}$
Carbon Dioxide (IR)	10.6 $\mu\text{m}$
Doubled Nd:YAG (green)	0.532 $\mu\text{m}$
Erbium	1.540 $\mu\text{m}$
Gallium Arsenide (diode)	0.840 $\mu\text{m}$
Homium-YAG	2.100 $\mu\text{m}$
Nd:YAG (near IR)	1.064 $\mu\text{m}$
Rhodamine 6G (tunable-dye)	0.570 $\mu\text{m}$
Ruby	0.694 $\mu\text{m}$

The lasing medium will determine the wavelength of the laser.



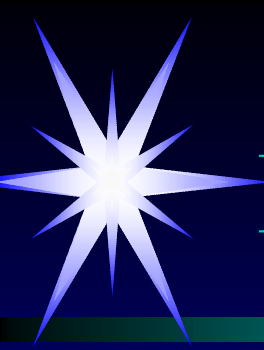
# LASER HAZARDS



# LASER HAZARDS

**The output from lasers can result in severe eye or skin damage. The injury is based on the wavelength and the output and can be from direct or reflected exposures.**

**For example:**

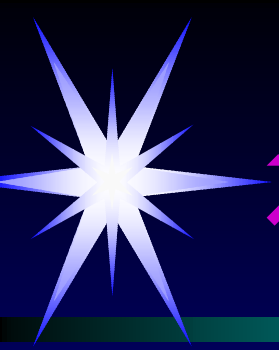


# LASER HAZARDS

## ➤ Eye/Skin damage

### ➤ Exposures to UV wavelengths can cause

- Severe acute inflammation of eye, conjunctiva, cornea, lens
- Skin erythema and carcinogenesis



# ➤ LASER HAZARDS

## ➤ Eye/Skin Damage

➤ Exposures to visible light wavelengths can cause

➤ Retina (burns), vision degradations, skin burns

➤ Exposures to IR wavelengths can cause

➤ Cornea and retinal burns, cataracts

➤ Skin burns, dry skin



# LASER HAZARDS (BIOEFFECTS)

## ➤ THERMAL EFFECTS

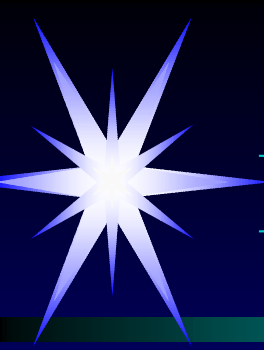
- Elevated temperature after absorption of energy, for nearly all wavelengths & exposure durations

## ➤ PHOTOCHEMICAL EFFECTS

- Absorbed energy results in chemical reactions, wavelengths  $< 0.550 \text{ } \mu\text{m}$ , durations  $> 10 \text{ seconds}$

## ➤ SHOCKWAVE (Acoustic) EFFECTS

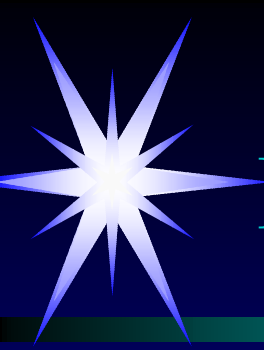
- Explosive effect on retina, pulse duration  $< 10 \text{ microseconds}$



# LASER HAZARDS

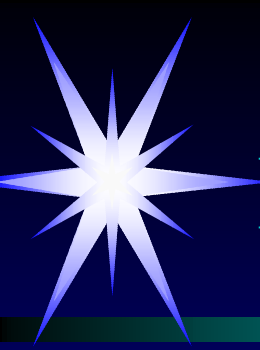
**The hazards of lasers are not limited to bioeffects from the radiation/light output.**

**For example:**



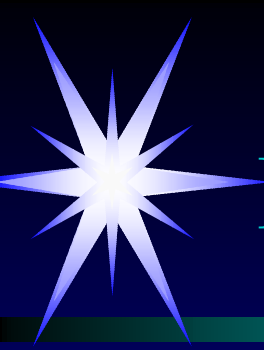
# LASER HAZARDS

- **Particulates can be released that can be inhaled when a target is hit**
- **Some lasers utilizing cryogenic materials that can present a burn hazard**
- **Some lasers use dyes (that are carcinogenic) that are dissolved in methanol (flammable)**



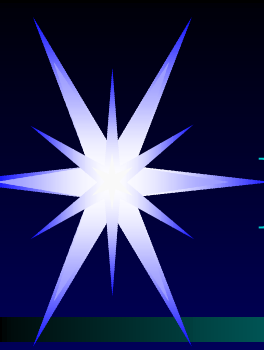
# LASER HAZARDS

- **Some lasers have chemicals in the lasing medium that can be released and cause a chemical exposure.**
- **Noise capable of causing hearing loss from some very high energy lasers.**
- **Some lasers can generate X-rays (when >15 kV power supplies are used)**



# LASER HAZARDS

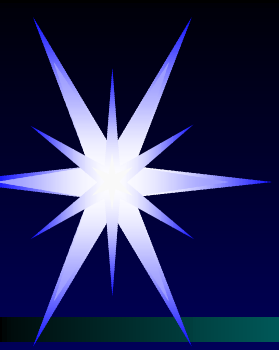
- **High energy sources can result in electrocution if there are problems with the laser's electronic component**
- **To prevent electrical problems**
  - **Install equipment to NEC & NFPA Code**
  - **Discharge store energy (capacitors) before working on a laser system**
  - **Take faulty equipment out of service for repair**



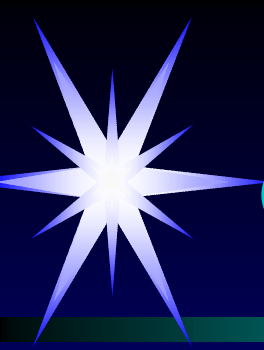
# LASER HAZARDS

## ➤ Shock Hazards

- Have positive protection for circuits if greater than 0.5 mA at 42.5 V (or 0.021VA)
- Ground frames, enclosures
- Have proper support for gas laser tubes & flash lamps (shock, fire hazards)
- Do not defeat safety interlocks



# CONTROL MEASURES



# CONTROL MEASURES

**Control measures can include the following:**

- Engineering Controls**
- Eye protection**



# CONTROL MEASURES

## ➤ ENGINEERING CONTROLS

➤ Warning signs at entries

➤ A single pedal control for the surgeon to operate

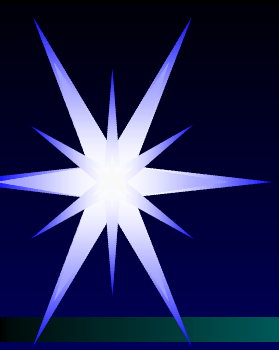
➤ A nurse at the laser console (for many applications)



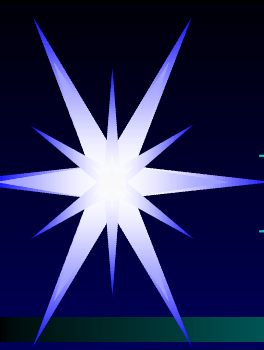
# CONTROL MEASURES

## ➤ EYE PROTECTION

- Goggles, safety glasses (for many applications)
- Reduce exposures to below the Maximum Permissible Exposure (MPE)
- Factors for eyewear includes
  - Wavelength of use
  - Multi-wavelength potentials
  - Exposure time
  - Maximum Permissible Exposure (MPE)

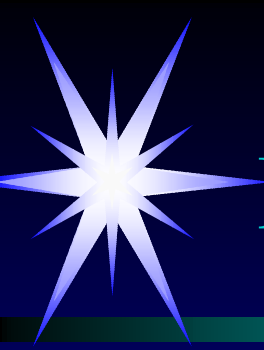


# MEDICAL SURVEILLANCE



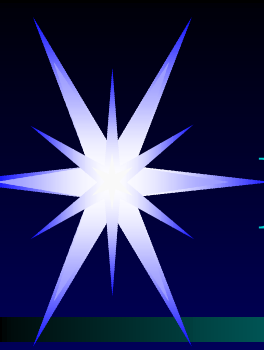
# MEDICAL SURVEILLANCE

- **In the event of an exposure, medical examinations are available**
- **Exposure Incidents**
  - **Take the appropriate first aid measure**
  - **Notify Supervisor, Laser Safety Officer**
  - **Call University Health Service at 585-275-1164 for an immediate appointment**
  - **Complete SMH 115 form (either electronically at [www.safety.rochester.edu](http://www.safety.rochester.edu) or by phone at 585-275-7250**



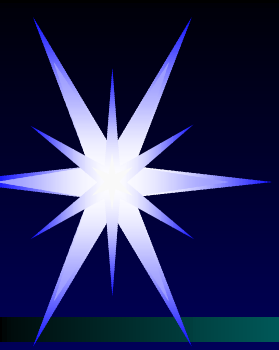
# MEDICAL SURVEILLANCE

- **If a skin exposure occurs**
  - **Call University Health Service for an appointment (585-275-1164)**
    - **They are located at the Medical Center, G-5000**

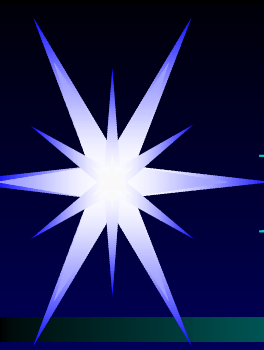


# MEDICAL SURVEILLANCE

- **If an eye exposure occurs**
  - **Notify the PI/Supervisor**
  - **If the exposure occurs during the day**
    - **Call Ophthalmology, 585-275-3446, for an emergency appointment**
  - **If the exposure occurs during the evening or weekends**
    - **Go to Strong Emergency Department**



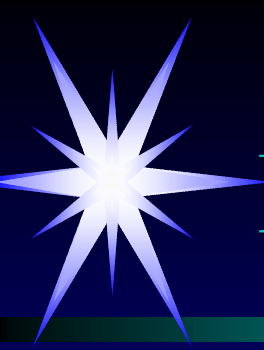
# MEDICAL APPLICATIONS OF LASERS



# MEDICAL APPLICATIONS

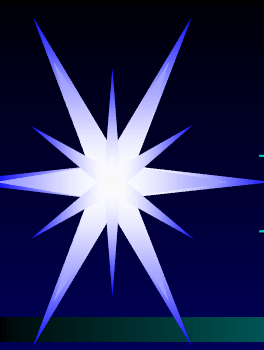
## Typical lasers used in medicine

- **CO<sub>2</sub>**
- **Neodymium:Yag**
- **Argon**
- **Ruby**
- **Diode**



# MEDICAL APPLICATIONS

- **Endoscopic use**
- **Other internal use**
- **External use**
- **Ophthalmic use**



# MEDICAL APPLICATIONS

## ➤ FOLLOW ESTABLISHED SOP

- Pre-surgical considerations
- Surgical considerations
- Post-surgical considerations



# PRE-SURGERY PREP

- **Credentialed personnel**
  - **Physician credentialed through Strong Health Credentials and Privilege Review Committee**
  - **Nurses/technicians must have completed Laser Safety Training Course (personnel must participate in a minimum of 4 procedures over a two year period to maintain their credentialing)**
- **Fire Hazards in room?**
  - **Oxygen, drapes?**
- **Reflective surfaces?**
  - **Shiny walls, surgical instruments?**



# **SURGERY PRACTICES**

## **➤ Employee safety**

- Laser sign on door (extra goggles/glasses hanging on sign)**
- Laser goggles/glasses worn by all personnel**
  - Not required for some ophthalmic procedures**
- N95 respirators used for lasing procedures**

## **➤ Patient safety**

- Eyes covered with moistened gauze (except for some ophthalmic procedures)**



# **SURGERY PRACTICES**

## **➤ Laser foot pedal**

- Pedal is to be activated only by physician performing surgery – no other foot operated device can be used by the surgeon!**

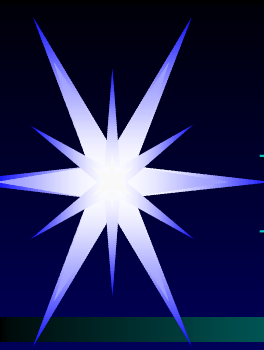
## **➤ Laser used correctly**

- Laser in “Standby” when not in direct use**
- Physician must communicate “laser on” and “laser off” with nurse/technician**
- Laser nurse or technician at control panel for emergency shut down**



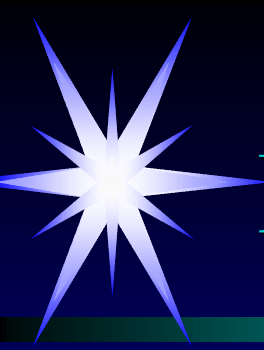
# SURGERY PRACTICES

- **Smoke evacuator used when lasing produces particulates**
  - **Check filter unit before use for capacity**
- **Check alignment of laser prior to use**
- **Set energy setting**
- **Verify “kill” switch works**
- **Oxygen and laser use**
  - **If lasing in patients airway, OR locations must be used if continuous oxygen is needed**
  - **Use a laser safe tube**



# POST-SURGERY

- **Complete medical record for laser use**
- **Smoke evacuator**
  - **Filters need replacing?**
- **Laser sign, goggles/glasses, equipment**
  - **Decontaminate equipment (if needed)**
  - **Take down signs, extra goggles/glasses**
  - **Store equipment**



# MEDICAL APPLICATIONS

**The following slides list several of the departments, some of the procedures lasers are used for, and the special precautions that may be needed.**



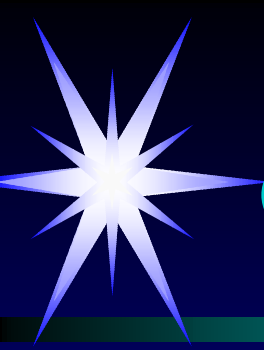
# Photocoagulators and Photodisruptors

- **Low divergence of beam results in higher beam irradiance**
- **Hazards possible to all in room**
- **Operator usually protected by optical filters**
- **Use care when aiming beam**



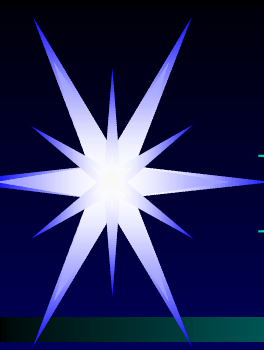
# ENDOSCOPIC APPLICATIONS

- **Thermal injury is possible**
  - **Through bladder wall & injury to adjacent organs (small bowel)**
  - **Thermally denatured bladder tumors undergo white discoloration (thermal necrosis)**
- **Excessive carbonization can occur**
  - **Avoid excessive contact between fiber tip and bladder wall**
- **Pressure considerations can cause a problem**
  - **Venting and monitoring of pressure is mandatory**



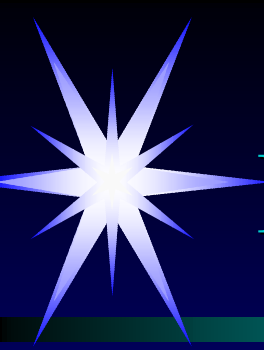
# Cardiovascular

- **Excimer, Nd:YAG, Argon, Ho:YAG, CO<sub>2</sub>**
- **Angioplasty**
  - **Coronary**
  - **Peripheral**
- **Ablation of myocardium (for ventral tachcardia)**
- **Lysis of adhesions – transplant procedures**
- **Takedown of mammary vein – cardiac bypass**



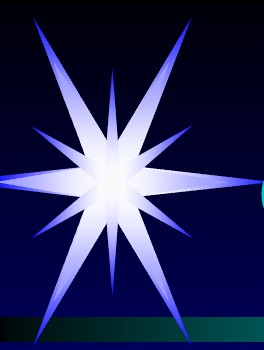
# Dermatology/Plastic Surgery (1)

- **Excision/Ablation using CO<sub>2</sub>**
  - **Warts**
  - **Moles**
  - **Basal cells**
  - **Keratosis**
  - **Dermabrasion**
  - **Actinic cheilitis**
  - **Rhinophyma**



# Dermatology/Plastic Surgery (2)

- **Photothermolysis (CV, PLDL, Ruby, Alexandrite)**
  - **Hemangiomas**
  - **Port-wine stains**
  - **Telangiectasias**
  - **Venectasias**
  - **Tattoo removal**
  - **Pigment lesions**

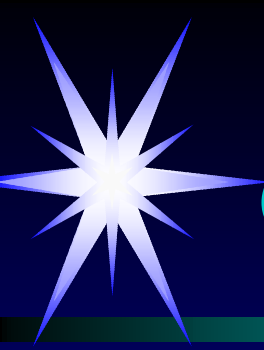


# Gastroenterology

➤ **Laser Used: Nd:YAG**

➤ **Procedures**

- **Esophageal tumors**
- **Colo/rectal tumors**
- **Villous adenomas**
- **Bleeding sites**
- **ERCP/Lithotripsy**



# General Surgery

➤ **Lasers Used: Nd:YAG, CO<sub>2</sub>, KTP**

➤ **Procedures**

➤ **Mastectomy**

➤ **Laparoscopic procedures**

➤ **Cholecystectomy**

➤ **Inguinal Herniorrhaphy**

➤ **Appendectomy**

➤ **Bowel Resection**

➤ **Hemorrhoidectomy**

➤ **Debridement**



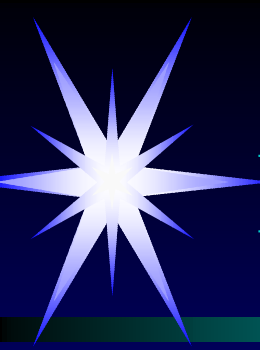
# Gynecology (1)

- **Lasers used: CO<sub>2</sub>, KTP, Nd:YAG**
- **Intra-Abdominal procedures**
  - **Lysis of adhesions**
  - **Ablation of endometrial implants**
  - **Tuboplasty**
  - **Laparoscopic assisted hysterectomy**
  - **Ectopic pregnancy**



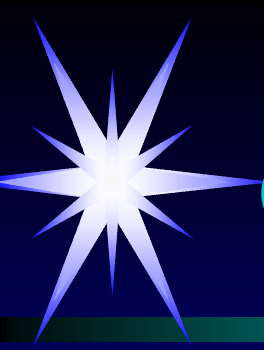
# Gynecology (2)

- **Lasers used: CO<sub>2</sub>, KTP, Nd:YAG**
- **Lower Genital**
  - **Cervical neoplasia**
  - **Vulvar neoplasia**
  - **Genetal warts**
- **Endometrial Ablations**



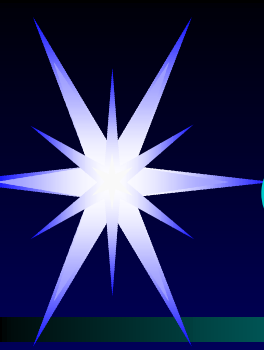
# Neurosurgery

- **Lasers used: CO<sub>2</sub>, KTP, Argon**
- **Procedures**
  - **Brain tumors**
  - **Spinal cord tumors**
  - **Discectomy**



# Ophthalmology (1)

- **Lasers used: Argon, Nd:Yag, Krypton**
- **Procedures**
  - **Diabetic Retinopathy**
  - **Glaucoma**
  - **Retinal detachment**
  - **Vitrectomy**
  - **Posterior Capsulotomy**



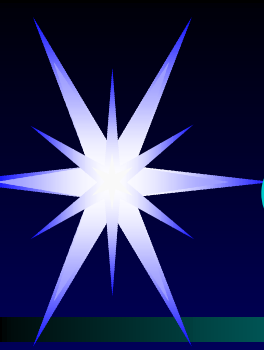
# Ophthalmology (2)

- **Retinal effects resulting in permanent scotomas (blind spots)**
- **Depending upon wavelength, various portions of the eye may be effected**
- **Chronic low-level exposure at  $<520$  nm may produce photochemical changes (blue light hazard)**



# Orthopedics

- **Lasers used: Ho:Yag**
- **Procedures**
  - **Arthroscopic**
  - **Excision ingrown toenails**
  - **Fungal nails**



# OTO/Pulmonary

- **Lasers used: CO<sub>2</sub>, KTP, Argon**
- **Procedures**
  - **Tracheobronchial lesions**
  - **Tracheal webs**
  - **Vocal cord lesions**



# ENT (OFFICE USE)

- **Sharplan CO<sub>2</sub> Laser for**
  - **Laser assisted Uvulopalatoplasty (LAUP)**
- **Patients requiring continuous oxygen will not be done in an office setting**
- **Cautery may be needed for LAUP. Have cautery on standby**



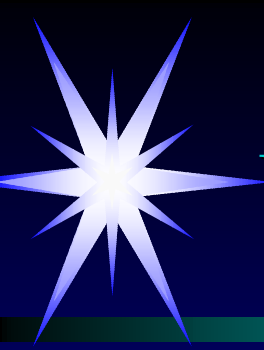
# Urology (1)

- **Lasers used: CO<sub>2</sub>, Argon, Nd:YAG**
- **Procedures**
  - **Bladder tumors**
  - **Genital warts**
  - **Lithotripsy**
  - **Prostatotomy**



# Urology (2)

- **CO<sub>2</sub>, Argon, Nd:YAG**
- **Beam direction and impact within endoscope, but**
  - **Eye protection needed because of**
    - **Faulty contact**
    - **Break in fiber**
    - **Accidental disconnect (fiber & endoscope)**



# Urethra/Bladder Use

- **Air in urethra and/or bladder**
  - Distention of both possible
  - Venting & monitoring of pressure is mandatory to prevent air embolism
  - Use suction devices (smoke evacuators)
- **Irrigation solutions**
  - Water, saline, amino acid solutions
  - Fluid cools fiber tip
- **External use**
  - Sheathed fiber (flow of CO<sub>2</sub> for cooling)

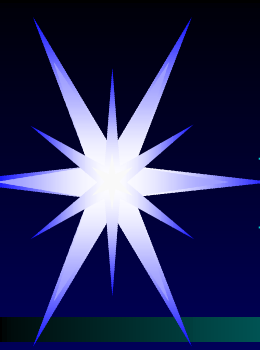


# SUMMARY

**So, how do you protect yourself when using a laser?**

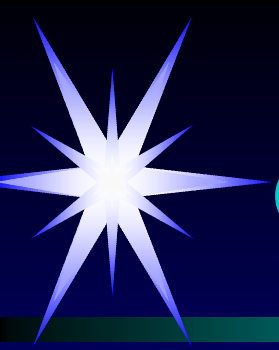
**➤ Follow established SOP**

- Set up laser with beam stops**
- Wear the required PPE**
- Check alignment at minimum setting**
- Do not operate laser at eye level**



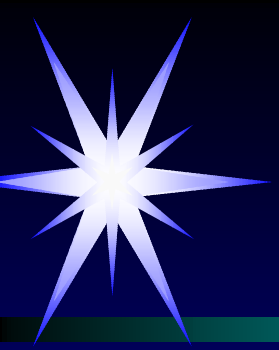
# LASER INCIDENTS

- **Be prepared to react to emergency situations**
  - **Exposures**
  - **Fires**
  - **Establish shut down procedures**

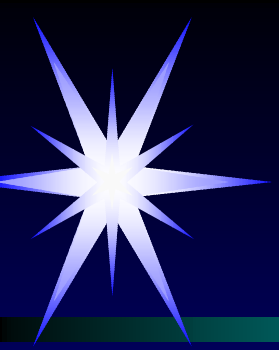


# QUESTIONS?

- **If you have a question about your laser, contact:**
  - Your supervisor
  - Your Departmental Laser Safety Officer
  - EH&S



**You need to document your attendance for this training session. Please complete the quiz and give it to your Departmental Laser Safety Officer (DLSO).**



**You must also show competency in site specific information. Your DLSO will ask you questions about the laser you use.**

**Satisfactory completion of both the computer based training and the site-specific training will be noted on your attendance sheet.**

**Thanks for your participation!**