Section 1: Introduction

Slide 1.1: Welcome
Hello, and welcome to Georgia Tech’s online Laser Safety Refresher course. Click Next when you’re ready to begin.

Slide 1.2: Course Overview
This training is designed as a refresher to remind you of the basic program organization and best practices for safely working with lasers. Specifically in focus are topics for which improvement is most often identified during laser safety inspections. This refresher must be completed every two years. If you have not previously completed Georgia Tech’s initial online Laser Safety Training course, please exit this training and proceed to the initial course available via training.osp.gatech.edu.

It is strongly encouraged that you also re-familiarize yourself with the Georgia Tech Laser Safety Policy Manual and related documents, as updates are periodically implemented. All program information is available at the Environmental Health & Safety website (https://ehs.gatech.edu/radiation/laser).

At the end of this refresher, you will need to complete a brief assessment. You must score 80% or higher to successfully complete the assessment and receive credit for completing this refresher training. When your next refresher training is due, you will be notified via email.

Click Next when you are ready to start Section 2, Laser Safety Program Overview.

Section 2: Laser Safety Program Overview

Slide 2.1 Laser Policies, Standards, Regulations, and Program Applicability
The Georgia Tech Laser Safety Program is based on the ANSI Z136 series of laser safety standards and the laser regulations of the State of Georgia with the primary goal of preventing exposure above the maximum permissible exposures (MPE) for the eyes and skin detailed in ANSI Z136.1. The laser classes addressed by the program are Class 3B, Class 4, and Class 1, 2, or 3R systems containing embedded (totally enclosed) Class 3B or 4 lasers.

Click Next to hear more about the various program roles and responsibilities.

Slide 2.2 Laser Program Roles
The program is administered through the Environmental Health & Safety Office of Radiological Safety by the Laser Safety Officer (LSO) and is overseen by the Georgia Tech Laser Safety Committee. Any questions you have concerning the laser safety program or laser safety in general can be directed to the LSO. The LSO’s contact information appears in the Resources tab above.

The responsibility for the safe use of lasers falls with the end users, which are termed Laser Supervisors and Laser Users. Laser Supervisors (a subset of Laser Users) must be full-time faculty or staff. Each laser covered by the program must have a designated Laser Supervisor who provides oversight for the use of their lasers by any other faculty, staff, or student Laser User. No students of any level may be a Laser Supervisor.

When you’re finished reviewing the structure and the definition of its roles, click Next to continue.
Slide 2.3 Laser Safety Training Requirements
In addition to required initial and refresher laser safety training courses, users of all laser systems covered by the laser safety program must receive operational, hands-on training by the Laser Supervisor or the Laser Supervisor’s designee.

For laser labs where non-Laser Users have access, these non-Laser Users must complete the online Laser Awareness Training provided by Georgia Tech. Access to all laser safety and awareness training is accessible via https://www.ehs.gatech.edu/radiation/laser/training.

When you’re finished reviewing, click Next to continue.

Slide 2.4 Laser User and Supervisor Registration Requirements
If you are a Laser User, please remember to submit Form LU-1, Laser User Registration referencing the Laser Supervisor for which you are currently working. If you are a Laser User that is now taking on the responsibility of a Laser Supervisor, please complete, sign, and submit Form LS-1, Laser Supervisor Registration. Both forms are available at https://www.ehs.gatech.edu/radiation/laser/documents.

Section 3: Laser Hazards
Slide 3.1 Laser Hazards, MPE, and NHZ
Training and other control measures are used in combination to mitigate the potential hazards of laser use by limiting exposures to at or below the Maximum Permissible Exposure, or MPE. The Nominal Hazard Zone, or NHZ, defines how far away you have to be such that a direct exposure or exposure to a diffuse reflection will not expose you above the MPE.

Laser exposure hazards can be pretty neatly summed up for Class 3B and 4 lasers with some overlap at the higher power 3B and lower power 4 lasers. Class 3B lasers pose a hazard to the eyes via direct or specularly reflected beams. Class 4 lasers pose a hazard to the eyes and skin via direct, specularly reflected, or diffusely reflected beams. Class 4 lasers also pose a fire hazard, and can create hazardous laser generated air contaminants.

Slide 3.2 Non-Beam Hazards
The laser beam isn’t the only potential hazard in a laser lab. There are numerous potential non-beam hazards that need to receive proper attention. The most immediately dangerous of the non-beam hazards is the high voltage associated with laser operation. It is imperative that access to high voltage components be appropriately restricted to reduce the risk of electric shock or electrocution. The optical bench on which the lasers reside must be electrically grounded.

Besides electrical hazards, there can also be hazards due to: non-laser radiation, fire, explosion, noise, fiber optic fragments, nanoparticles, chemical agents, laser generated air contaminants (LGAC) and many others.

Should you have questions regarding the control of any potential non-beam hazards, please contact the LSO or any of the other appropriate Environmental Health and Safety (EHS) contacts listed here. Click Next when you are ready to start Module 4, Control Measures.

- EHS Contacts
  - Lab and Chemical Safety Manager
Section 4: Control Measures

Slide 4.1 Control Measure Overview
You will recall that control measures are implemented to reduce the risk of exposures above the MPE for the eyes and skin, as well as non-beam hazards. Control measures fall into one of three major categories:

- Engineering Controls
- Administrative or Procedural Controls, and
- PPE, or Personal Protective Equipment

While all three are important, proper Engineering Controls can reduce or eliminate many laser hazards at their source and should be considered first, followed by Administrative Controls and PPE, respectively. In the next several slides we will look at the most important control measures that were found during laser inspections to be most often neglected, improperly implemented, or in need of improvement for Class 3B and Class 4 lasers. These include

1. the use of laser barriers
2. written laser safety standard operating procedures (SOP)
3. laser eyewear.

As always, refer to the Laser Safety Policy Manual for a more comprehensive discussion of control measures. Click Next to learn more.

Slide 4.2 Laser Barriers
Laser barriers are used to prevent laser radiation from escaping a laser controlled area, exposing a person upon entry into or while in a laser controlled area, and from otherwise leaving the table and striking walls or other work areas in the lab. Specifically, there should be no line of sight to the beam emission or beam path for a person entering the laser lab. Laser eyewear must be placed so that a person can put the eyewear on before moving into a location where there is line of sight to an active beam path. Whether the barrier is a rigid material or a curtain, it must be opaque to the wavelength in use or filter the wavelength such that the transmitted radiation does not exceed the MPE. Especially for higher power Class 3B and all Class 4 lasers, it is also required that the material is flame resistant/retardant.

The most common issues with barriers are that:

1. Barriers aren’t used at all or aren’t used in the correct/enough locations
2. Barriers used aren’t laser rated, meaning that the material has not been tested for its damage threshold in W/cm² with laser radiation similar to that in use in the lab, and in the case of non-metallic barriers, verified to be flame resistant/retardant. Readily flammable materials like cardboard or black felt are often inappropriately used as primary barriers for beams considered to be a flammability hazard.

   o Solution: Higher power Class 3B lasers and all Class 4 lasers must be considered capable of igniting materials that are not laser rated. Purchase metal barriers and/or curtain material that has been laser rated by the vendor. In the case of non-metal barriers, like laser curtains, ensure the vendor has tested the material for flammability according to NFPA standards or similar.

   o Alternate solution: Test barrier material for damage threshold in-house, but only under the guidance of the LSO, for your specific setup. Do not conduct flammability testing in-house. Materials must have been tested by the vendor for flammability. The LSO will provide a testing procedure and documentation requirements for the damage threshold test. The general rule of thumb for metal barriers is to use matte black anodized aluminum (preferably bead blasted prior to anodizing) to present a surface that will readily diffusely scatter incident visible laser radiation.

   o Note: Use of non-laser rated materials for any Class 3B or 4 laser setup must be approved specifically by the LSO.

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**Slide 4.3 Standard Operating Procedures**

A written standard operating procedure, or SOP, is required for the alignment, operation, maintenance, and service of all Class 3B and Class 4 lasers on campus, and for the alignment, maintenance and service of embedded lasers. A written SOP is also strongly recommended for the operation of embedded lasers. The SOP is intended to guide the laser safety aspects of the operational training, and includes a signature page to be completed by each Laser User after they have received operational training for a given laser setup.

Commonly, laser SOPs either haven’t been written, are out of date, or haven’t been reviewed and signed off on by all the Laser Users. They also frequently don’t include detailed instructions for the laser safety aspects of the operation.

Solution: An SOP must include

- Information identifying the laser or lasers in a given setup, the intended use, and the beam output specs like wavelength, power, pulsing characteristics, etc. If these parameters are routinely varied in a given setup, note the range of values for that parameter.

- Additionally, the SOP must include the potential hazards expected for the laser, including both beam and non-beam hazards, and what control measures need to be in place to prevent them. Common control measures included would be barriers, warning lights, laser eyewear, etc.

- It is okay to be general about steps that don’t involve laser safety here. However, any step in the process that involves or affects safety must be listed in detail.
Slide 4.4 Laser Eye Protection

While laser eye protection (LEP) is the last line of defense for preventing a laser exposure to the eyes above the MPE, it is a very commonly used control measure. Use of appropriate laser eyewear is required for all Class 3B and Class 4 lasers. Eyewear is also required during the maintenance, repair, or alignment of any embedded laser system. The management and proper use of the eyewear are very important, and must be paid close attention, particularly when a given laser lab utilizes multiple different wavelengths with multiple optical density needs. You will recall that proper laser eyewear will be marked with the optical density (OD), the wavelength(s) to which that OD applies, and often the % Visible Light Transmission (VLT %). The right OD for the wavelength, with the highest possible VLT%, is the recipe for great LEP. The common issues observed with eyewear are:

1. All eyewear is stored inside the laser controlled area. Remember that it is important that there is no line of sight to the beam when a person enters a laser controlled area. A corollary is that the laser eyewear must be available to a person before they are able to move to a location where they have line of sight to the beam.
   a. Solution – For labs that have a laser-curtained alcove to prevent line of sight on entry to the lab, the solution is to store the eyewear storage in that alcove. For setups that use barriers mounted on the optical bench to prevent the line of sight, the solution is to store the eyewear just inside the entryway or at any location in the lab for which line of sight to the beam is not possible while the person walks to that storage location.

2. Old, damaged eyewear is used
   a. Solution – Discard old, soft-sided goggles on which the elastic strap is no longer elastic. These goggles very often have wavelength/OD markings that are no longer readable. This must be discarded as well. Any eyewear on which the lens is cracked or is severely scratched must also be discarded and replaced. The LSO can and will provide information on suitable replacements.

3. Regular safety glasses with color lenses are used instead of proper laser eye protection
   a. Solution - While eyewear specified for a given wavelength are often a particular color, color alone cannot be relied upon for assurance that the filter provides the proper OD for a given wavelength. Regular safety glasses, goggles, etc. with color lenses SHALL NOT be purchased for use as laser eye protection. If you aren’t spending at least $100 per pair (there are some lower cost exceptions), you aren’t purchasing laser rated eyewear. Be sure that your eyewear was marked by the vendor with the optical density and wavelength on the lens or frame. If you aren’t sure, ask the LSO.

4. Eyewear is not available for all wavelengths in use or with the proper optical density
   a. Solution – look at the laser warning sign provided by the LSO that is posted on your lab door. This sign indicates the combinations of wavelength and optical density (OD) that are needed for this lab for normal operation. Alignment eyewear is not typically included on these signs and must be specified in the SOP. Compare all of the laser eyewear available in your lab and make sure there is at least one pair that includes each
listed combination. If more than one person is in the laser controlled area during laser operation, be sure to have appropriate quantities of the appropriate eyewear.

5. Eyewear is not worn
   a. Solution – If you are operating a Class 3B or 4 laser, or an embedded system that has been opened, wear the eyewear indicated on the laser warning sign and in the SOP

6. Eyewear fully protective of a direct or specular beam are attempted to be used for alignment, where the beam power may be lowered and/or a diffuse spot is viewed. This leads to people simply not wearing eyewear during alignment because they can’t see the alignment spot. This is problematic, because alignment is typically a high risk activity with respect to potential eye exposure
   a. Solution – contact the LSO for assistance with determining what eyewear specifications are appropriate for your beam alignment activities.

7. Alignment eyewear is used for protection during normal operation
   • Solution – Alignment eyewear is spec’d only to protect the user from a diffuse reflection of the beam at whatever beam power is used for alignment. Do not use this alignment eyewear for normal operation. It will not fully protect the user from specular reflections or direct beam exposure at beam powers used during normal operations. It is strongly advised that you consult with the Laser Safety Officer prior to eyewear purchase so that optimal eyewear is acquired.

Slide 4.4.2 Additional LEP Tips

• Be aware that early signs of eyewear damage due to beam exposure include smoke, flame, incandescence, and luminescence

• Do not use LEP for more than momentary, direct exposure to a high-powered beam. The beam can damage or penetrate the filter in short order.

• Contact the LSO if you have a need for alignment eyewear. With these tips in mind, along with the engineering and administrative controls provided earlier in this course, you can keep your vision safe in a laser lab.

Section 5: Embedded Laser Systems

Slide 5.1 Embedded Laser Systems

An Embedded Laser System typically uses a high-power Class 4 or medium-power Class 3B laser, but are designed according to federal regulations so that they may be operated as a safe, Class 1 device or low hazard Class 2 or 3a device. There has been a dramatic increase in the availability of and need for embedded laser systems for material cutting, engraving, lithography, and even 3D printing. Devices manufactured according to federal regulations have reduced safety requirements compared to Class 4 or 3B devices per the Georgia Tech Laser Safety Program.

Click the tabs on the left to learn more about commonly encountered issues with embedded laser systems and their solutions.

One issue encountered is that numerous vendors sell low-cost versions of these devices via auction websites, their own website, and similar. The vast majority of these low-cost versions skirt the federal certification and reporting regulations. The result are products that, while costing significantly less, are
more hazardous Class 4 and 3B devices for operation and, therefore, must adhere to the full requirements of the Georgia Tech Laser Safety Program.

Solution – Consult with the Georgia Tech Laser Safety Officer prior to purchasing any laser product, especially cheaper models that are advertised as Class 1 or Class 2 systems, so that you know in advance what your initial and ongoing safety obligations will be.

A second common issue found is that a fire extinguisher is not present in the vicinity of laser cutting/engraving systems. Due to the potential for ignition of substrate materials by the laser, a fire extinguisher must be readily available in the vicinity of the machine.

Solution – Contact the Georgia Tech Fire Safety Office to obtain a fire extinguisher. The online fire extinguisher request form can be found at the Resources link above.

A third issue encountered is that proper ventilation is not provided.

Solution – Have ventilation that meets the manufacturer specifications for the embedded laser installed. This most often applies only to cutting/engraving/3D printing systems. This typically involves connection to existing fume hood ductwork or other dedicated ventilation to the exterior of the building that does not recirculate into the building. In some cases it is not feasible to connect to the fume hood ventilation duct system in a given location. It is required that these be ventilated through a localized system filtered for fume/smoke/particulates/other specific laser generated air contaminates. Consult with the LSO PRIOR to implementation of localized filtration systems of this nature. One size does not fit all when it comes to matching a filtration system with an embedded laser system. DO NOT INSTALL YOUR OWN VENTILATION DUCTWORK. Contact Facilities Management Design and Construction for assistance.

Section 6: Additional Reminders

Slide 6.1 Reminders for Laser Warning Signs

The laser warning signs posted at the entry to a laser controlled area communicate vital information about the laser operations that take place. Signs are provided by the LSO based on information about the laser use provided by the Laser Supervisor. Here is a recap of the information on these signs.

Note: Highlight each bullet and the corresponding spot on the warning sign graphically when the narration mentions each.

- Warning or Danger – Warning means possible injury or death due to exposure; Danger means definite injury or death due to exposure. Danger signs are typically reserved for kW and higher output Class 4 lasers. There are still some older format DANGER signs for both Class 3B and 4 lasers that are gradually being replaced with the proper WARNING signs.
- The highest class of laser radiation present
- The presence of visible and/or invisible wavelengths
- LEP requirements including the emitted wavelengths and the fully protective OD the LEP must possess
- Basic contact information for the LSO
- Other information as needed
Slide 6.2 Outdoor Laser Use
If your laser use involves the laser being projected outside of a building or physically operating the laser outdoors, this may require an application for approval by the Federal Aviation Administration (FAA). Laser light shows or demonstrations using Class 3B and 4 lasers, in any location, must be reported to the Food and Drug Administration (FDA).

To ensure these compliance requirements are met, please contact the LSO as soon as possible in the planning process. The LSO will conduct a laser hazard assessment, help with the reporting paperwork, and help implement the proper control measures to protect both the operators and the public.

Slide 6.3 Laser Disposal & Sales

Laser Surplus/Disposal
When a laser is no longer useable or needed, remember that they may contain materials and substances that can be hazardous if improperly handled, such chemical laser dyes. Refer to the Laser Safety Policy Manual for guidance on laser surplus and disposal.

Laser Sales
If a laser is built, modified in-house, or incorporated into a product with the intention of selling to an entity outside of Georgia Tech, or simply sending to a sponsor, the Laser Supervisor may be considered a manufacturer according to FDA regulations. If this is the case, the laser must be certified according to FDA laser product regulations. **Contact the LSO for guidance.**

Slide 6.4 Initial and Routine Laser Lab Inspections
When a Laser Supervisor notifies the LSO of a laser being added to their lab, the LSO or a designee will conduct an initial laser hazard assessment and inspection of the lab to identify any control measures that need to addressed. A routine inspection will then be carried out every other year. Typical inspection items include, but are not limited to

- Verification of Laser Users actively working for the Laser Supervisor
- Checking that all laser users have completed laser safety training
- Laser inventory verification and notation of current status of each lasers (e.g., in use, out of service, disposed)
- Tagging of out of service/in storage lasers
- Review of written SOPs for Class 3B and Class 4 lasers
- Examining laser eye protection
- Review of laser barriers in use
- Presence and accuracy of emergency contact information
- Presence and condition of proper laser warning signs and warning lights

Slide 6.5 Renovation/Construction of Labs that Contain or will Contain Class 3B, Class 4, or Embedded Lasers
If you have a lab that will be renovated or constructed for the use of lasers, a lab design guide has been created for and provided to Georgia Tech Design and Construction to help plan. Consult with the LSO for more information and involve the LSO early in the design process.
Section 7: Emergencies and Incidents

Slide 7.1 Laser Accident - Causes
Laser accidents can and do happen. The accidents can be attributed to both beam and non-beam hazards, and can often be traced back to a single mistake or oversight.

Let’s review what is considered to be an emergency situation with respect to laser exposure and how to respond. This information is incorporated into the SOP template mentioned earlier in this presentation.

Slide 7.2 Incidents Requiring Emergency Attention
Eye or skin exposure above the MPE presents the risk of injury. Suspected or known exposures of the eye, whether or not there has been a noticeable change in vision, bleeding from the eye, or burns to the eye or face require a trip to a hospital emergency room. If the injury is non-life threatening, this trip does not have to be in an ambulance. Instead, a Georgia Tech employee can transport the injured person to an emergency room in a Georgia Tech owned vehicle.

Do not go to an urgent care center for suspected or known eye injury as they will not have the means to perform a thorough eye exam.

Slide 7.3 Non-Emergency Injuries
Individuals experiencing exposures of the skin resulting in redness or burns are also encouraged to see a doctor, with hospital emergency room visits reserved for severe burns.

Contact or have someone else contact the Office of Radiological Safety at 404-894-3605 to report the injury.

Slide 7.4 Reporting an Incident
There are specific methods for reporting incidents/injuries.

As soon as safely possible following an emergency—and immediately following a non-emergency incident, like a minor burn—report the incident/injury to the Laser Supervisor. The Laser Supervisor shall then notify the LSO.

For injuries involving individuals employed by Georgia Tech, the LS shall ALSO file/make all reports and notifications detailed in the “Injury and Illness Reporting Guidelines” available at https://www.ehs.gatech.edu/general/occupational-injury.

The LSO will report any laser related injuries to the State of Georgia within 15 days.

To facilitate these reporting requirements, and ensure impacted individuals have access to prompt assistance, all labs are required to post a current emergency contact list at the entrance to any laser controlled area. The EHS Pink Card provides a convenient template for this posting. Take a moment to complete a Pink Card for your lab, if you haven’t already done so. Click Next when you are ready to start Module 8, EHSA.
Section 8: EHSA

Slide 8.1 Laser Safety Information Available in EHSA
When a Laser User or Laser Supervisor has completed laser safety training and submitted their corresponding registration form, access to laser information in the web-based EHSA database administered by Environmental Health & Safety is enabled. This information includes laser safety training completions, laser inventory, laser safety inspections, and the ability to upload your laser SOPs. Refer to the EHSA User Handbook (https://www.ehs.gatech.edu/ehsa-handbook) for instructions on accessing and using these items. The links “User Operations”, “Inspection Response”, and “PI Only Operations” are the most applicable sections of this handbook. Links for

You’ve now completed the final content module of this tutorial. When you are ready to conclude this course and complete the final assessment, click Next.

Section 9: Exam and Next Steps

Slide 9.1 Exam
You must now complete the assessment and score 80% or higher to receive credit for this refresher training. When you’re ready to take the assessment, close this window and select “Final Test.”

Slide 9.2 Congratulations
Congratulations! You have successfully completed the bi-annual Laser Safety Refresher training. If you have any questions, please contact the LSO by phone at 404-894-8847 or by email at laser@ehs.gatech.edu.