

NJIT

Laser Safety Manual

Second Edition - July 2003

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Section 1

Introduction

A. Program Intent

The New Jersey Institute of Technology Laser Safety Program is intended to provide staff, researchers, students and visitors with a safe laser use environment. The manual was written to provide NJIT laser safety policy and guidance on maintaining and documenting the program. The manual also serves as a reference source for laser users.

B. Program Authority

The Laser Safety Program was developed in accordance with a charge from the Vice President of Administration and Treasurers office. The Vice President directed that the Department of Health and Environmental Safety provide a Laser Safety Program based on the ANSI Z136.1 Standard for the Safe Use of Lasers.

C. Regulatory Requirements

Regulation of laser hazards falls under Federal OSHA and NJ PEOSHA under ANSI Z136.1 Standard for the Safe Use of Lasers as the accepted "...safe and healthy work practice..." to use in inspecting laser facilities.

D. ANSI Z136.1 Standard for the Safe Use of Lasers

In accordance with the charge from the VICE PRESIDENT OF ADMINISTRATION, the NJIT Laser Safety Program is based on the ANSI Z136.1 Standard for the Safe Use of Lasers. Copies of the standard are available from the Office of Health Environmental Safety

E. NJIT Laser Safety Program Overview

The NJIT laser safety program covers primarily Class 3a, 3b and 4 lasers and laser systems on the campus (see Section 2). The program is divided into seven basic areas.

- i. Program Administration
- ii. Program Documentation
- iii. Laser Use Registration (LUR)
- iv. Laser Safety Training
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Section 2

Laser Safety Program

A. Responsibilities and Program Administration

Environment Health and Safety Policy Committee

The Environment Health and Safety Policy Committee (VICE PRESIDENT OF ADMINISTRATION) is responsible for assuring that NJIT activities are conducted in a safe manner. The VICE PRESIDENT OF EDUCATION establishes academic committees to oversee specific areas such as ionizing radiation and lasers. The VICE PRESIDENT OF ADMINISTRATION has established the Laser Safety Committee (LSC) and has charged them with establishment of a NJIT Laser Safety Program.

Laser Safety Committee

The NJIT Laser Safety Committee (LSC) sets NJIT laser safety policy and is responsible for laser safety policy development and enforcement. They are directly accountable to the Provost for Research and their main function is to resolve safety concerns associated with laser use or with this manual. The LSC is responsible for oversight of the program and coordinating with the LSO to assure compliance with all applicable laws and regulations.

Laser Safety Officer

The Laser Safety Officer (LSO) reports to the Radiation Safety Officer (RSO) and is responsible for Laser Safety Program development, program implementation, and program compliance. The LSO is the technical advisor to the LSC regarding laser safety and regulatory affairs. The LSO is required to inform the committee of any safety concerns associated with the use of lasers. The LSO must investigate and approve all LURs. The LSO is required to classify all constructed or modified laser systems, prepare and approve all LURs, investigate laser incidents, and maintain all records associated with the Laser Safety Program.

Department Chairperson

Department chairpersons are responsible for assuring their PIs (principal investigators) who use lasers operate those lasers safely and implement the Laser Safety Program.

Principal Investigator

PIs are directly responsible for implementing the Laser Safety Program. This includes the implementation of specified hazard controls, oversight and management of non-laser hazards, and informing the LSO of any changes that affect the laser users. It is also the responsibility of the PI to assure that all laser users operating under his or her LUR have met the training requirements set forth by the LSC.

Laser User

Laser users are responsible for their own safety in the laser facility. All users must meet the laser safety-training requirement within 30 days of joining the LUR (using the laser). All laser users are responsible for following the LUR specific hazard controls and notification requirements.

B. Scope of the Program

The NJIT Laser Safety Program primarily addresses Class 3a, 3b and 4 lasers. These lasers classes are operated under Laser Use Registrations (LURs) that describe the laser; it's use, hazard class, and the required laser safety measures. A LUR file is maintained by the Office of Health & Environmental Safety.

C. Acquisition, Modification, Sale or Transfer of Lasers

The campus LSO must be informed of the acquisition, modification, sale, or transfer of any Class 3a, 3b or 4 laser. The campus purchasing department supplies the LSO with copies of laser purchase order documents, However, it is the responsibility of the PI to inform the LSO whenever acquisition, modification, sale, or transfer of a laser or laser system occurs.

D. The Laser Use Registration (LUR)

The LUR is initiated by the PI completing a LUR form (see Appendix C). The completed form is sent to the LSO who contacts the PI to discuss the laser system and application. After the LSO has evaluated the LUR, the LUR is provided to the LSC (or the Chair of the LSC) for review. After review, a copy of the LUR is sent to the PI. In general, LUR's are reviewed by ORS each year. Modification of a LUR is usually done at the request of the PI. Under special circumstances, the LSC may modify a LUR. Termination of a LUR is usually done at the request of the PI. Under special circumstances, the LSC may choose to terminate a LUR. The LUR may be suspended by order of the LSC if they feel that the health or safety of staff is in immediate danger. Documentation of all changes to a LUR are maintained by the LSO or his designee.

E. Laser Safety Training

All laser users must read the Laser Safety Manual, the Laser Safety Training Supplement, and their specific LUR and certify in writing that they have done so. The training certification document can be found in the Laser Safety Training Supplement. Completed training certificates are sent to the LSO for review. The LSO is responsible for maintaining a file of the training certificates. Formal laser safety training presentations are available from the ORS upon request. The LSC may direct a PI to obtain a formal laser safety training presentation for his/her users. The LSO maintains documentation on all formal training presentations. The PI shall also provide and document that all laser users operating under his/her LUR have received specific hands-on instruction in use of the laser system, safety precautions associated with the laser, any standard operating procedures (SOPs) relating to the laser, and proper use of laser protective eyewear.

F. Laser Safety Inspections

Periodically, all laser facilities are inspected by the LSO or his/her designee to assure that the lasers are being operated in a safe manner. Copies of the inspection reports are provided to the PI for his/her review. The LSO maintains records of all inspections performed. The PI is responsible to correct unsafe conditions in a timely manner. The LSO or his/her designee will re-inspect the laser facility within 30 days to verify the correction of unsafe conditions. The LSO informs the LSC of any uncorrected unsafe conditions. If a PI is unable to correct unsafe conditions in a timely manner, he/she may be asked to attend a LSC meeting to brief the LSC on the situation.

G. Eye Examinations

The LSC establishes criteria for eye examinations (found in Appendix D). Laser eye exams are required for all Class 3b and 4 laser users within 60 days of first joining the LUR. Additionally, laser eye exams will be performed after any suspected eye injury.

H. Personal Protective Equipment

The PI shall provide his/her laser users with the appropriate laser protective eyewear (refer to Appendix B for eyewear selection). Laser protective eyewear must be used for beam alignments if the viewed beam exceeds the ANSI Z136.1 MPE (maximum permissible exposure) value. Intra-beam viewing of lasers are not allowed on the NJIT campus. Exemptions from these policies may be only granted by the LSC. Some ultraviolet (UV) laser uses may require the use of skin protection. Any need for skin protection will be identified by the LSO and communicated to the PI.

I. Beam Management

Laser beams must be restricted to the immediate location of use. Beams should be enclosed whenever practical. Beam blocks must be used to terminate beams. The use of shutters, collimators, curtains, and other beam control devices are strongly encouraged. It is the responsibility of the PI to verify through survey that appropriate beam management is being practiced.

J. Posting and Labeling

All access points to the laser facility must be marked with the ANSI standard laser hazard signs. Laser enclosures must be labeled to alert users to laser hazards as per the ANSI standard. Labels, laser hazard signs, and advice on their use are available from ORS. Refer to Appendix F for the LSC approved ANSI laser warning sign.

K. Access Control

Whenever the laser is in operation, access to laser facilities is restricted to laser users or persons being escorted by laser users. Access control must be maintained by positive means such as locked or interlocked doors. Laser warning signs alone are not considered sufficient to control access.

L. Laser Incidents

The LSO and PI must be informed immediately of any suspected laser incidents. See Appendix G for emergency procedures and emergency contacts. Following the incident, the PI is responsible for filing an Employees Report of Injury form with the campus Office of Human Resources. The LSO is responsible for investigating laser incidents, providing a report to the PI and the LSC, and maintaining records on incidents.

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Section 3

Laser Hazard Classification

A. Determining Hazard Class Through Radiometric Parameters

The hazard class of the laser is extremely important in determining the appropriate hazard controls to make the laser system safe. The campus LSO assures that all NJIT lasers are properly designated as to their appropriate hazard class. All commercially manufactured lasers come marked with the hazard class as required under the FDA Center for Devices and Radiological Health (CDRH) regulations. Lasers made or modified at NJIT will need to be evaluated by the LSO and appropriately classed. It is the responsibility of the PI to assist the LSO by supplying the appropriate radiometric parameters of the laser system. The LSO uses the ANSI Z136.1 standard to determine the appropriate hazard class.

B. Class 1 (Eye Safe Lasers)

Class 1 lasers are lasers that cannot cause injury from viewing the accessible laser radiation for the maximum possible duration inherent in the design. Very few lasers are Class 1, however, many laser systems can be made into Class 1 systems by totally enclosing the laser beam and interlocking the enclosure. Class 1 lasers do not require a LUR.

C. Class 2a and 2 (Safe Through the Aversion Response)

Class 2a lasers are defined as visible lasers that are not intended to be viewed and do not exceed the Class 1 AEL (accessible emission limit) for an exposure duration less than or equal to 1000 seconds. Class 2a lasers are often used in grocery scanner systems. Class 2 lasers are defined as visible lasers that will not cause injury to the eye when viewed for 0.25 seconds or less. The human aversion response (blinking or turning away from the beam) is triggered by the bright glare of the visible beam entering the eye, and is estimated to occur in about 0.25 second. Eye injury can occur if collecting optics are used in viewing the beam or if an individual overrides the aversion response and continues to stare into the beam path. As with all lasers, DO NOT LOOK INTO THE BEAM. Class 2 lasers may not exceed a output power of 1 mW. Class 2a and 2 lasers do not require a LUR.

D. Class 3a and 3b (Intrabeam/Specular Reflection Hazard)

Class 3 lasers are defined as lasers which may cause injury through intrabeam viewing or through viewing a specular reflection for less than 0.25 second. Viewing a diffuse reflection from a Class 3 laser should not cause injury to the eye. Class 3a lasers are defined as; an invisible laser with an output power which does not exceed 5 times the Class 1 AEL or a visible laser with an output power that does not exceed 5 mW. Class 3b lasers exceed the output power of Class 3a lasers but cannot exceed the upper power limit of 500 mW. All Class 3a and 3b lasers require LURs.

E. Class 4 (Diffuse Reflection and Fire Hazard)

Class 4 lasers possess the same hazards as Class 3 lasers but, because of their increased beam power (greater than 500 mW), they may also cause injury to the eye when viewing a diffuse reflection. They may present a hazard to the skin and, because of their power density, they may also present a fire hazard. All Class 4 lasers require LURs.

F. Hazard Class and the Laser Use Registration

The need for a LUR is determined by the laser's hazard class. Only Class 3a, 3b and 4 lasers and laser systems are required to have an LUR. The required hazard controls are a function of the hazard class and laser use.

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Appendix A

Bylaws of the Laser Safety Committee

1. Authority and Responsibility

The Laser Safety Committee (the Committee) is appointed by the Provost for Research). The Committee reports to the Provost for Research.

The Committee is delegated the authority and responsibility for setting campus policy in laser safety, within the scope of the campus Laser Safety Program; for reviewing lasers uses, and, authorizing such uses; for reviewing the operations and procedures of the Office of Health & Environmental Safety with respect to laser safety and offering comments to the Laser Safety Officer (LSO) and the campus RSO regarding RSO laser safety operations and procedures. The Committee has the responsibility to act in the best interests of safety. The Committee has the authority to terminate a laser use, if warranted. Committee decisions to revoke or suspend the use of lasers may be appealed to the Provost for Research. The Provost for Research will meet with the petitioner, RSO staff, and members of, or the full, Laser Safety Committee, as necessary, to make a determination as to revocation or suspension. Decisions to modify actions of the Laser Safety Committee will be transmitted to the Committee in writing and included in their files.

2. Composition

The Committee consists of not more than 10 nor less than 5 members exclusive of ex-officio members. Membership of the Committee shall meet appropriate federal and state guidelines (if any) for composition of the Committee.

Experience: Members are appointed on the basis of knowledge of the principles and practices of the control of hazards resulting from or associated with the use of lasers. The membership is to reflect the diversity of scientific disciplines using lasers on campus.

Ex-officio members: The campus Laser Safety Officer (LSO), and the campus Radiation Safety Officer serve as ex-officio members. Others ex-officio members may be appointed by the Committee.

3. Length of Service

Members will normally serve for a three-year term but may be re-appointed for additional terms.

4. Appointment Process

Appointment of the Committee: the Provost for Research shall receive nominations from the current Chair and may solicit nominations from other Committees and other academic administrative officers as appropriate.

Chair of the Committee: The Chair is selected from among continuing members of the Committee, and will normally have at least two years prior service as a member. Re-appointment of the Chair beyond a one-year term will be at the recommendation of the Provost of Research.

5. Functions

(a) General

The Committee is responsible for setting campus policy in laser safety, within the scope of the campus laser safety program; for reviewing uses of lasers, authorizing laser uses; and review and approval procedures of the RSO with respect to laser safety.

(b) Use of Lasers. The Committee authorizes the use of lasers. Authorization is to be supported by documentary evidence of:

1. adequate experience and training of the Authorized User;
2. proper and sufficient equipment and facilities;
3. adequate plans and procedures for the use of lasers; and
4. establishment of procedures to reduce the potential for laser related incidents and accidents.

(c) Review of Authorized Uses

The Committee is to verify that each authorized laser use is reviewed by the RSO at least annually.

The Committee will review safety issues regarding laser uses referred by the LSO or RSO, and will determine whether to modify, restrict, or terminate the use of a laser.

(d) Review of Office of Radiation Safety's Laser Safety Activities

The ORS staff is responsible for the day-to-day implementation of the campus laser safety program; for assuring that lasers are used in conformity with policies set by the Committee. ORS brings to the attention of the Committee matters affecting campus laser safety, changes needed in campus laser safety policy, and changes in standards or regulations related to laser use or safety. ORS provides such reports, summaries and statistics as the Committee may require. The Committee reviews the operations and procedures of the ORS with respect to laser safety and offers comments to the LSO and the ORS Director regarding laser safety operations and procedures.

(e) Meetings

1. The Committee meets once each calendar quarter for the purpose of reviewing campus laser safety issues and operations and procedures of ORS with respect to laser safety, and to consider other materials needing its attention.
2. At the discretion of the Committee Chair, or the LSO, special meetings may be called to review and approve laser uses, review and act on laser incidents, review and make changes in campus laser safety policy, and/or consider matters referred by the LSO, the Director of the Office of Radiation Safety, or members of the Committee.
3. A quorum, consisting of a simple majority of the membership, shall be present at all meetings and will include the LSO and the Director of ORS, or designated alternates.
4. Minutes of the meetings are kept by the LSO, the Director of ORS, or a designated alternate. Copies of the minutes are sent to members of the Committee. ORS maintains a file of the Committee meeting minutes and associated Committee files.

6. Review of Laser Uses

Laser uses are reviewed by the LSO. ORS is to review each laser use at least annually. Problems are referred to the Chair of the Committee. The Chair of the Committee can refer problems to the entire Committee for review and comment.

Appendix B

Selection of Laser Safety Eyewear

(FROM ANSI)

AMERICAN NATIONAL STANDARD Z136.1-1993

Table 4

Simplified Method for Selecting Laser Eye Protection for Intrabeam Viewing (Wavelengths Between 0.4 and 1.4 μm).[†]

Q-Switched Lasers (10^{-9} - 10^{-2} s)		Non-Q-Switched Lasers (0.4×10^{-3} - 10^{-2} s)		Continuous-Wave Lasers Momentary (0.25 - 10 s)		Continuous-Wave Lasers Long-Term Staring (less than 1 hr)		Attenuation	
Maximum Output Energy (J)	Max Beam Radiant Exposure ($\text{J} \cdot \text{cm}^{-2}$)	Max Laser Output Energy (J)	Max Beam Radiant Exposure ($\text{J} \cdot \text{cm}^{-2}$)	Maximum Power Output (W)	Maximum Beam Irradiance ($\text{W} \cdot \text{cm}^{-2}$)	Maximum Power Output (W)	Maximum Beam Irradiance ($\text{W} \cdot \text{cm}^{-2}$)	Attenuation Factor	OD
10	20	100	200	10^5 [*]	2×10^3 [*]	100 [*]	200 [*]	10^8	8
1	2	10	20	10^4 [*]	2×10^4 [*]	10 [*]	20 [*]	10^7	7
10^{-1}	2×10^{-1}	1	2	10^3 [*]	2×10^3 [*]	1	2	10^6	6
10^{-2}	2×10^{-2}	10^{-1}	2×10^{-1}	100 [*]	200 [*]	10^{-1}	2×10^{-1}	10^5	5
10^{-3}	2×10^{-3}	10^{-2}	2×10^{-2}	10	20	10^{-2}	2×10^{-2}	10^4	4
10^{-4}	2×10^{-4}	10^{-3}	2×10^{-3}	1	2	10^{-3}	2×10^{-3}	10^3	3
10^{-5}	2×10^{-5}	10^{-4}	2×10^{-4}	10^{-1}	2×10^{-1}	10^{-4}	2×10^{-4}	10^2	2
10^{-6}	2×10^{-6}	10^{-5}	2×10^{-5}	10^{-2}	2×10^{-2}	10^{-5}	2×10^{-5}	10	1

[†] Use of this table may result in optical densities (OD) greater than necessary. See 4.6.2 for other wavelengths.

^{*} Not recommended as a control procedure at these levels. These levels of output power could damage or destroy the attenuating material used in the eye protection. The skin also needs protection at these levels.

Appendix C
NJIT LASER USE REGISTRATION (LUR) FORM

Date: _____ page: _____ of _____
Name of Principal Investigator _____ phone #: _____
Name of Laboratory Contacts _____ phone #: _____
Names of Laser Users _____
Department of Principal Investigator: _____
Laser Research Funding source (circle one) DOE other
Building and Room Location of Laser: _____
Make/Model of Laser: _____
Laser Serial Number: _____ Type of Lasing Medium: _____

LASER INFORMATION

Laser Classification Marked on Laser (circle one) 3a 3b 4 none
CW Pulsed

Wavelength(s): _____(nm) Wavelength(s): _____(nm)
Max. Op. Power: _____(W) Pulse durations: _____(sec)
Avg. Op. Power: _____(W) Pulse frequency: _____(Hz)
Max. Op. Energy: _____
Avg. Op. Energy: _____

Beam Diameter at aperture: _____(mm)
Beam Divergence: _____(mrad)

Laser Use (describe briefly): _____

Please check all items that apply:

Use of Cryogens ___	Use of Pumping Laser ___
Use of Compressed Gases ___	Beam focusing Optics ___
High Voltage Power Supplies ___	Fabricated Laser ___
High Voltage > 30 kVp ___	Modified Laser ___
Dye Laser ___	Freq. Doubling Crystals ___
Exposed Beam Paths ___	Tunable Laser ___
High Noise Levels ___	Invisible Beam ___
Laser Cutting/Welding ___	

Appendix D

Laser Eye Examination Policy and Procedure

Statement of Policy

Laser eye examinations are performed to identify those laser users which may have a predisposition for vision related injury and to meet the medical monitoring requirements of the ANSI Z136.1 Standard for the Safe Use of Lasers.

Requirement for Examinations

Those laser users who have a reasonable potential of eye exposure to Class 3b or Class 4 laser beams are required to have eye examinations within 60 days of joining the Laser Use Registration (LUR). Eye examinations will also be performed on NJIT staff whenever a laser eye injury is suspected.

Responsibilities

The Laser Safety Committee (LSC) is responsible for developing and periodically reviewing the laser eye examination policy.

The Laser Safety Officer (LSO) is responsible for implementing the laser eye examination policy. The LSO is responsible for identifying those laser users who are required to have examinations and providing a list of those users to the Principal Investigator (PI).

The Office of Radiation Safety is responsible for maintaining a database of laser users and when they receive the examinations.

The PI is responsible for assuring that laser users identified by the LSO make appointments with their own doctor. If the laser user does not wish to use their vision care insurance to cover the cost of an examination, the PI is responsible for covering the cost.

Eye Examination Criteria

Eye examinations include the following:

- Medical history of the eye and photosensitivity
- Visual acuity (far and near) for both eyes
- Macular function (Amsler grid)
- Color vision assessment
- Dilated retinal examination of both eyes
- Retinal photographs of both eyes (while dilated)

Examinations will be performed by professionally qualified personnel. Patients whose results fall outside of acceptable criteria will be referred for a comprehensive examination.

Procedure

The LSO works with the PI to identify the laser users who need eye examinations and provides the PI with a written list of those users.

The PI informs the identified laser users and works with them to assure they schedule their eye examinations.

The private practitioner performs the examination and completes the approved forms which are then returned to NJIT.

The LSO maintains a database of users identified and when they had their examinations.

Records

Medical records and forms returned from private practitioners are maintained by NJIT. Results of examinations are the property of the person examined.

The Office of Health & Environmental Safety maintains a database of laser users and the dates on which they received examinations.

EYE EXAM FORM

Page 1

OCULAR EXAM FOR LASER USERS

Patient Note: If you have had a laser exam in the past year, it may satisfy the NJIT medical surveillance requirements. Have your eyecare practitioner complete this form, which summarizes the results of your eye examination. The Section II procedures are required to be completed by your examining doctor. The Section III procedures are not required, but are recommended.

Section I: To be filled out by laser user

Name: _____ Birth date: _____

Address: _____

Laser type and class: _____

Section II: To be filled out by the examining doctor – (Required Procedure)

Examination Date: _____ Todays Date: _____ Last eye exam: _____

HISTORY

Chief Complaint: _____

Personal Ocular History: _____

Family Ocular History: _____

Personal systemic health history: _____

Medications/Allergies: _____

Visual Acuity: With/Without eyeglasses/CLs (circle one)

Distance: OD 20/ OS 20/

Near: OD OS

Page 2

Current eyeglasses OD _____
OS _____
Refraction OD _____ 20/
OS _____ 20/
Add _____

Amsler Grid (describe and/or enclose)

OD normal/abnormal _____
OS normal/abnormal _____

Color Vision

Method D-15/100Hue/other _____
Result OD _____
OS _____

Binocular vision summary _____

Anterior segment anomalies _____

Fundoscopy (with pupil dilation)

Optic nerve OD _____
OS _____
Maculae OD _____
OS _____
Periphery OD _____
OS _____

Retinal photography (35mm - enclose) _____

Section III - Optional procedures

Contrast sensitivity testing

Method _____

Result OD _____

OS _____

Macular photostress (in seconds to recover 1 line above max VA)

OD _____

OS _____

Section IV Please list cause if applicable:

Vision decrease _____

Amsler grid anomaly _____

Color vision defect _____

Any other anomalies noted _____

Examining doctor's signature **OD/MD**

Appendix E

Laser Pointer Safety Guidelines

Applicability:

All Class 2 or 3a laser pointers used for classroom instruction or presentations shall be operated under the guidelines established in this document. All Class 3a lasers other than pointers require filing a Laser Use Registration with the Laser Safety Committee. Class 3b and 4 laser devices are not addressed in these guidelines, and shall not be used in instruction or presentations without prior notification of the Laser Safety Officer.

Rationale:

By definition, a Class 3a laser can cause eye injury. However, the intended use of laser pointers carries a very low probability of injury. For this reason, the Laser Safety Committee has approved the use of Class 3a pointers for their intended use as instruction and presentation aids.

Labeling of Pointers:

The manufacturer is required by the FDA Center for Devices and Radiological Health (CDRH) to provide correct labeling for their laser pointers. This includes the laser hazard symbol, laser classification, maximum power output and laser wavelength. This information should be clearly visible on the laser pointer. Operating and safety Instructions should also be provided by the manufacturer.

If the laser is fabricated in-house or does not have the required labeling, contact the Laser Safety Officer (LSO) at ext. 3059 before using the pointer. The LSO will properly classify and provide labels for the pointer.

Equipment Purchase Considerations:

The pointer-operating switch should be a momentary contact type (designed to shut off the pointer when released). The switch should not have a locking device to keep the beam on when direct pressure is removed from the switch. Pulsed laser pointers shall not exceed the Class 3a hazard class.

For the diffuse viewing of any laser (including pointers) the relative image brightness to the human eye is a function of both output power and laser wavelength. The human eye sees yellow light (at about 560 nm) as brighter than other color. Even if the laser output power remains the same, as the wavelength grow shorter (towards the blue) or longer (towards the red) the image appears less bright to the human eye. For this reason, a Class 2 pointer (<1 mW) at 635 nm will often appear brighter than a Class 3a pointer (1 to 5 mW) at 670 nm. Longer wavelength pointers have to be made more powerful (and more dangerous) in order for their diffuse reflections to appear bright to the human eye. For this reason, it may be better to purchase a 635-650 nm laser pointer rather than a laser pointer at 670-690 nm.

Authorized Users:

NJIT employees handling 3a laser pointers on campus are required to follow these guidelines.

Access to 3a laser pointers should be limited to responsible persons who have been informed of these guidelines by the owner or user. The laser pointer should be kept in a secure place when not in use.

Persons visiting NJIT who wish to operate laser pointers are expected to abide by these guidelines. Generally, the person acting as host should inform the visitor of these guidelines.

The owner of the laser pointer is responsible for its use at the University.

Operating Safety Guidelines

No person should ever intentionally stare into the laser beam.

The laser beam should never be intentionally directed toward oneself or directed toward another person. The beam should be directed towards the screen and directed away from the audience.

The beam should be turned off when not in immediate use.

Mirror like surfaces (such as glass, metal and other highly reflective materials) should be avoided when directing the laser beam.

Use of Class 3a laser pointers should be limited to the intended purpose. Indiscriminate use may present an eye hazard.

Class 3a laser pointer use is prohibited when optically aided viewing of the beam is probable. Optical aids include telescopes, binoculars, viewing optics, and similar devices.

Exceptions:

Exceptions to the above guidelines should be coordinated with the Laser Safety Officer.

Legal Implications of Laser Pointer Misuse:

The Penal Code has several sections, which indicate the willful misuse of a laser pointer can be considered either a misdemeanor or a felony. In particular, directing any laser beam at another person may constitute assault (suggesting the use of a laser gun site) and directing any laser beam at an aircraft may constitute malicious mischief. Persons convicted of these crimes may be subject to fines and/or jail sentences.

Emergencies: Although the potential for injury from a laser pointer is very slight, notify your immediate supervisor and get medical attention if an eye injury from laser use is suspected. Also notify the Laser Safety Officer as soon as possible. Contact NJIT Campus Police for emergency medical assistance.

Appendix F
Laser Warning Sign
(from ANSI)

Appendix G
Emergency Procedure for Laser Accidents
Emergency Contact Listing

In the event of a laser accident do the following:

- 1) Shut down the laser system.
- 2) Provide for the safety of personnel (first aid, evacuation, etc.) as needed.

NOTE: If a laser eye injury is suspected, have the injured person keep their head upright and still to restrict any bleeding in the eye. Laser eye injuries should be evaluated by a physician as soon as possible.

- 3) Obtain medical assistance for anyone who may be injured.

Police 3111

Health & Environmental Safety 3059

University Health Service (Emergency) .

Ambulance (Urgent Medical Care) .

- 4) If there is a fire, leave the area, pull the fire alarm, and contact the fire department by calling 3111. Do not fight the fire unless it is very small and you have been trained in fire fighting techniques.

- 5) Inform the Office of Health & Environmental Safety as soon as possible.

(During normal working hours, call these numbers)

Police 3111

Laser Safety Officer .3059

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After normal working hours, call .3111 to contact the NJIT Police Department.

- 6) Inform the Principal Investigator as soon as possible. If there is an injury, the PI must submit a report of injury to Risk Management.

- 7) After an accident, do not resume use of the laser system until the Laser Safety Committee has reviewed the incident.
-

Appendix H
Table of Typical Laser Classes
(from ANSI)

Table A1
 Typical Laser Classification — Continuous-Wave (CW) Lasers

Wavelength (μm)	Laser Type	Wavelength (μm)	Class 1* (W)	Class 2 (W)	Class 3b** (W)	Class 4 (W)
Ultraviolet 0.180 to 0.280	Neodymium:YAG (Quadrupled)	0.266 only	$\leq 9.6 \times 10^{-3}$ for 8 hours	—	> Class 1 but ≤ 0.5	> 0.5
	Argon	0.275				
Ultraviolet 0.315 to 0.400	Helium-Cadmium	0.325 only	$\leq 3.2 \times 10^{-6}$	—	> Class 1 but ≤ 0.5	> 0.5
	Argon	0.351, 0.363 only				
	Krypton	0.3507, 0.3564 only				
Visible 0.400 to 0.700	Helium-Cadmium	0.4416 only	$\leq 0.4 \times 10^{-6}$	> Class 1 but $\leq 1 \times 10^{-3}$	> Class 1 but ≤ 0.5	> 0.5
	Argon (Visible)	0.457, 0.476, 0.488, 0.514, etc				
	Krypton	0.530				
	Neodymium:YAG (Doubled)	0.532				
	Helium-Neon	0.543				
	Dye	0.400 - 0.550				
	Helium-Selenium	0.460 - 0.550				
	Helium-Neon	0.632				
	Dye	0.550 - 0.700				
	InGaAlP	0.670				
	Ti:Sapphire	0.670				
Krypton	0.6471, 0.6764					
Near Infrared 0.700 to 1.400	GaAlAs	0.780	$\leq 0.18 \times 10^{-3}$	—	> Class 1 but ≤ 0.5	> 0.5
	GaAlAs	0.850	$\leq 0.25 \times 10^{-3}$			
	GaAs	0.905	$\leq 0.32 \times 10^{-3}$			
	Neodymium:YAG	1.064	$\leq 0.64 \times 10^{-3}$			
	Helium-Neon	1.080, 1.152 only	$\leq 0.64 \times 10^{-3}$			
	InGaAsP	1.310	$\leq 4.40 \times 10^{-3}$			
Far Infrared 1.400 to 10^3	InGaAsP	1.550	$\leq 9.6 \times 10^{-3}$	—	> Class 1 but ≤ 0.5	> 0.5
	Holmium	2.100				
	Erbium	2.940				
	Hydrogen Fluoride	2.600 - 3.000				
	Helium-Neon	3.390 only				
	Carbon Monoxide	5.000 - 5.500				
	Carbon Dioxide	10.6				
	Water Vapor	118				
	Hydrogen Cyanide	337				

* Assumes no mechanical or electrical design incorporated into laser system to prevent exposures from lasting to $T_{max} = 8$ hours (one workday); otherwise the Class 1 AEL could be larger than tabulated.

** See 3.3.3 for definition of Class 3a.

APPENDIX

Table A2
Typical Laser Classification — Single-Pulse Lasers

Wavelength (μm)	Laser Type	Wavelength (μm)	Pulse Duration (s)	Class 1 (J)	Class 3b (J)	Class 4 (J)
Ultraviolet						
0.130 to 0.400	Excimer (ArF)	0.193	20×10^{-9}	$\leq 1.9 \times 10^{-4} *$	> Class 1 but ≤ 0.125	> 0.125
	Excimer (KrF)	0.248	20×10^{-9}	$\leq 1.9 \times 10^{-6} *$	> Class 1 but ≤ 0.125	> 0.125
	Neodymium:YAG Quadrupled (Q-sw)	0.266	20×10^{-9}	$\leq 1.9 \times 10^{-6} *$	> Class 1 but ≤ 0.125	> 0.125
	Excimer (XeCl)	0.308	20×10^{-9}	$\leq 4.3 \times 10^{-6} *$	> Class 1 but ≤ 0.125	> 0.125
	Nitrogen	0.337	20×10^{-9}	$\leq 3.6 \times 10^{-6} *$	> Class 1 but ≤ 0.125	> 0.125
	Excimer (XeF)	0.351	20×10^{-9}	$\leq 4.3 \times 10^{-6} *$	> Class 1 but ≤ 0.125	> 0.125
Visible						
0.400 to 0.700	Rhodamine 6G (Dye Laser)	0.450-0.650	1×10^{-6}	$\leq 0.2 \times 10^{-6}$	> Class 1 but ≤ 0.03	> 0.03
	Copper Vapor	0.510, 0.578	25×10^{-9}	$\leq 2 \times 10^{-3}$	> Class 1 but ≤ 0.03	> 0.03
	Neodymium:YAG Doubled (Q-sw)	0.532	20×10^{-9}	$\leq 2 \times 10^{-3}$	> Class 1 but ≤ 0.03	> 0.03
	Ruby (Q-sw)	0.6943	20×10^{-9}	$\leq 2 \times 10^{-3}$	> Class 1 but ≤ 0.03	> 0.03
	Ruby (Long Pulse)	0.6943	1×10^{-3}	$\leq 4 \times 10^{-6}$	> Class 1 but ≤ 0.03	> 0.03
Near Infrared						
0.700 to 1.4	Ti:Sapphire	0.700-1.000	6×10^{-6}	$\leq 1.9 \times 10^{-7}$	> Class 1 but $\leq 0.03 C_A$	> 0.03 C_A
	Alexandrite	0.720-0.800	1×10^{-4}	$\leq 0.75 \times 10^{-6}$	> Class 1 but $\leq 0.03 C_A$	> 0.03 C_A
	Neodymium:YAG (Q-sw)	1.064	20×10^{-9}	$\leq 2 \times 10^{-6}$	> Class 1 but ≤ 0.15	> 0.15
Far Infrared						
1.4 to 10^3	Erbium:Glass (Q-sw)	1.540	10×10^{-9}	$\leq 7.9 \times 10^{-3}$	> Class 1 but ≤ 0.125	> 0.125
	Co:Magnesium- Fluoride	1.8-2.5	80×10^{-6}	$\leq 7.9 \times 10^{-6}$	> Class 1 but ≤ 0.125	> 0.125
	Holmium	2.100	250×10^{-6}	$\leq 7.9 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Hydrogen Fluoride	2.600-3.000	0.4×10^{-6}	$\leq 1.1 \times 10^{-6}$	> Class 1 but ≤ 0.125	> 0.125
	Erbium	2.940	250×10^{-6}	$\leq 5.6 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125
	Carbon Dioxide (Q-sw)	10.6	100×10^{-9}	$\leq 7.9 \times 10^{-3}$	> Class 1 but ≤ 0.125	> 0.125
	Carbon Dioxide	10.6	1×10^{-3}	$\leq 7.9 \times 10^{-4}$	> Class 1 but ≤ 0.125	> 0.125

* Assuming that both eye and skin may be exposed, i.e., 1.0 mm beam (area of limiting aperture = $7.9 \times 10^{-3} \text{ cm}^2$).

Appendix I

Laser Applications Outside the Laboratory

Introduction

The use of a laser outside of a controlled area can present special hazards to the campus community and to the general public. This appendix addresses the control of any laser (Class 3a, 3b, or 4) used outside the normal research laboratory environment. These applications may include; lasers used for telecommunications, laser research being performed outdoors, and lasers used for entertainment or public viewing.

Applicability

Any laser (Class 3a, 3b, or 4) used for entertainment, displays, demonstrations, or any related use intended for public viewing (indoors or outdoors) shall be operated in accordance with federal, state, local, and campus regulations/requirements.

Any laser system (Class 3a, 3b, or 4) used outdoors for telecommunication applications or for research projects shall be registered with the Office of Radiation Safety as per the requirements of the Laser Use Registration (LUR) Program.

The operators of laser systems used for entertainment are required by law to file a "Report on Laser Light Show Display" (or a variance document), with the Food and Drug Administration's Center for Devices and Radiological Health (FDA/CDRH). If the venue is outdoors and the beam(s) may terminate in navigable airspace, then the operators are also required to file a report with the Federal Aviation Administration (FAA) office.

All Class 3a, 3b, or 4 laser systems being used on NJIT property must be used in accordance with the campus Laser Safety Program. Any variation from the Laser Safety Program must be approved by the campus Laser Safety Committee.

Procedures

Performances, campus departments, or campus-affiliated group (student or otherwise) shall notify the LSO of any laser light show (indoor or outdoor) to be performed on NJIT property. The LSO will request from the light show operators a copy of the CDRH required "Report on Laser Light Show Display" (or variance document) prior to the show. Upon receipt, the LSO shall review the description of the show and the operator's safety procedures. The LSO may require additional safety measures to assure the safety of the operators, performers, or audience.

The Principle Investigator (PI) shall inform the LSO of any lasers used outdoors for research projects. Such laser uses will need to be covered under a LUR. The department Safety Coordinator will be responsible for informing the LSO of any indoor or outdoor telecommunication applications being pursued by that department. In both cases, the application and operation of the laser system(s) shall be evaluated by the LSO to ensure that appropriate safety measures are in place prior to operation.

Laser Safety Requirements - Laser Light Shows

NOTE: A LUR is not normally required for laser light shows.

- The CDRH and ANSI requirements specified by the LSO must be met.
- Any audience exposure to laser radiation must not exceed the ANSI Class 1 limit.
- Operators, performers, and employees must be able to perform their duties without having to directly view laser radiation exceeding the ANSI Class 1 limit, and without being exposed to laser radiation exceeding the ANSI Class 2 limit.
- All laser scanners (including mirror balls) must incorporate proper scanning safeguards.
- If the laser is not under continuous operator control, any Class 3a, 3b, or 4 level of laser radiation cannot be closer than 6 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- If the laser is under continuous operator control, any Class 3a, 3b, or 4 level of laser radiation cannot be closer than 3 m vertically or 2.5 m horizontally from any standing surface or standing position where the audience may be located.
- An operator with an accessible control to terminate the beam must be available if conditions become unsafe.
- FAA notification is required (for Class 3a, 3b, and 4 lasers) if the display is being used in navigable airspace.
- Additional safety requirements may be needed as specified by the LSO.
- The CDRH "Report on Laser Light Show Display" forms are available from the LSO.

Laser Safety Requirements - Other Outdoor Uses of Laser

NOTE: A LUR is required for the use of a Class 3a, 3b, or 4 laser.

- Meet the specified LUR safety requirements.
- The LSO will establish a Nominal Hazard Zone (any area where the maximum permissible exposure (MPE) is exceeded).
- The NHZ must be posted and/or restricted as directed by the LSO.
- The PI must ensure that only trained personnel enter the NHZ, and that appropriate PPE (personal protective equipment) is issued and used.
- The PI must ensure users are properly trained and meet the campus laser safety training requirements.
- The PI must ensure only authorized personnel are allowed to operate the laser.
- The PI must ensure the use of any required administrative/engineering controls.
- Laser beams shall not be directed toward structures, automobiles, aircraft, or other vehicles within the NHZ unless adequate training and protective equipment is provided and used by all personnel within these structures/vehicles.

- The laser beam path shall not be maintained at eye level without LSO approval.
- FAA notification is required (for Class 3a, 3b or 4 lasers) if the laser is being used in navigable airspace.
- Additional safety requirements may be needed as specified by the LSO.

Policy Exceptions

Any exceptions to this policy must be approved by the campus Laser Safety Committee. Contact the campus LSO at 3059 if you need exemption from this policy.

Emergencies

The potential for injuries from a laser light show/display is minimal if the operators observe the CDRH requirements. In the event that an individual suspects an eye injury, the operators of the laser system shall be notified immediately so that the laser beam(s) can be terminated. The event staff shall also be notified and medical attention shall be provided to the injured individual if needed. The LSO shall be informed as soon as possible should any laser injury be suspected.

Regulatory References

- Food and Drug Administration's Center for Devices and Radiological Health (FDA/CDRH)
 - Federal Aviation Administration (FAA)
 - American National Standards Institute (ANSI) Z136.1 (1993) - Safe Use of Lasers
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Appendix J

Electrical Safety Guidelines for Laser Users

Electrical Hazards and Laser Users

Laser systems and power supplies normally require thousands of volts and tens of amperes to operate. The electrical needs associated with laser use present inherent electrical safety hazards.

These hazards are normally mitigated by the engineering controls (enclosures, interlocks, grounding, etc.) built into the laser systems. However, if these engineering controls are defeated during tuning or maintenance, live contacts can be directly accessed. Contact with these may cause any number of adverse bio-effects, up to and including death by electrocution.

There are at least 15-recorded instances of electrocution directly attributed to laser systems. It is essential that laser users be aware of and protect themselves from the electrical hazards found in laser facilities.

Electrical Terminology

- a. Alternating Current (AC) - A current that reverses polarity with a given frequency expressed in cycles/second or Hertz (Hz). US wall current is 60 Hz AC.
- b. Amperage (I) - the current (number of electrons) flowing in a circuit (measured in Amperes or Amps).
- c. Conductor - a material that has a normally low resistance.
- d. Direct Current (DC) - A current with a fixed polarity normally associated with batteries or rectified AC current.
- e. Electrical Ground - AC circuits usually contain a third conductor that provides a pathway to ground should a short circuit occur. NOTE: the electrical ground is intended to protect equipment and prevent fires, it is not intended to protect persons from shock hazards.
- f. Insulator (dielectric)- a material which has a normally high resistance.
- g. Ohms Law - Amperage is equal to voltage divided by the resistance and expressed in the formula $I = V / R$.
- h. Resistance (R) - the ability of a material to allow the flow of electrons (measured in Ohms or W).
- i. Short Circuit - When current is allowed to take an unintended path back to its source. If that path runs through a person, serious injury or death can result.
- j. Voltage (V) - the potential (energy of the electrons) flowing in a circuit (measured in Volts).
- k. Wattage (W) - the unit of power, devices are often rated as to the power in Watts required for their operation ($W = V \times I$).

Materials That Are Good Conductors

Materials that are good conductors include: precious metals, copper, aluminum, other elemental metals and alloys, and ionic liquids (especially water containing dissolved salts). Both tap water and human bodily fluids are considered ionic liquids.

Materials That Are Good Insulators

Materials that are good insulators include: rubber and most plastics, dry wood, ceramics, fiberglass, organic materials, and non-ionic liquids (like distilled water).

Sources of Electrical Hazards in Laser Facilities

- a. Common AC wall current at 120 volts.
- b. Specialty AC wall current of 240 or 480 volts.
- c. High voltage (> 600 volts) AC supplies.
- d. DC power supplies (including batteries and capacitors).
- e. Static electricity (NOTE: spark temperatures exceed 1000 deg. F and can ignite solvents used for cleaning or for laser dyes).

Examples of Electrical Hazards in Laser Facilities

- a. Electrical supply boxes. These boxes may be left open and/or unlatched. Combustible materials must have a 3-foot separation distance from the boxes as required by OSHA.
- b. Wall sockets, power plugs, power cables and couplings. Wall sockets may not be properly wired. Power plugs may have exposed conductors if they are damaged. Power cables and couplings are not only a tripping hazard but may have exposed conductors if they are damaged by foot and cart traffic.
- c. Lasers, power supplies, and other lab equipment. Laser housings contain high voltage/amperage, which can be directly accessed if the covers are removed. Power supplies often contain large capacitors that can retain a lethal charge even after the laser is turned off or unplugged.
- d. Ungrounded laser systems and optical tables. Failure to maintain proper grounding of lasers and optical tables can allow short circuit conditions to endanger persons who contact the laser or optical table.
- e. Home or shop made electrical components. Often built without a knowledge of electrical safety codes, home built equipment can be improperly grounded, not have sufficient safety enclosures, etc. Research equipment must be constructed with components that have been tested by a recognized testing organization (e. g. Underwriter's Laboratory). For assistance in evaluating equipment, contact the Office of Health and Environmental Safety (EH&S).
- f. Jewelry. Care should be taken not to wear metal jewelry (gold, silver) around laser systems or power supplies. In addition to their highly conductive electrical properties, metal jewelry can also present a specular beam reflection hazard.
- g. Special situations that could create short circuits to ground. Should there be a cooling water leak that contacts a hot conductor, the current will flow through the liquid to ground. Persons in contact with the spilled water could become part of the circuit.

Types of Electrical Hazards

- a. **Shock** - If the human body becomes part of the circuit, current will flow through various organs (depending on the pathway). If current flows through the human heart, it may cause fibrillation (abnormal muscle contractions) that can result in death.
- b. **Arc** - The flash ionization of air resulting from direct flow of high current from one conductor to another. The resulting vaporization of materials (like conductors) creates a plasma with an extremely high temperature (as high as 50,000 deg. C) which can ignite combustible materials at several meters and cause severe burns to tissue.
- c. **Blast** - The pressure transient resulting from plasma arc vaporization of materials (mainly metal conductors). This blast has been known to cause severe injury through the transfer of kinetic energy to objects and persons.
- d. **Fire** - Combustion of materials from electrical sources can cause injuries and destroy property.

Electrical Exposure Bio-effects

- a. **Cardiac fibrillation** - disruption of the heart rhythm, either immediate or delayed (the major cause of death from electrical shock).
- b. **Internal (organ) burns** - often resulting in amputations or death.
- c. **External (skin) burns** - usually caused by metals melted/vaporized by an arc.
- d. **"Blow out" injuries** - from vaporized body fluids caused by current flow in tissues.
- e. **Neurological damage** - either immediate or delayed (can be very severe).
- f. **Physical shock** - usually related to trauma (complicates other injuries).
- g. **Psychological trauma** - common with severe injury.
- h. **Blast related physical trauma injuries** - broken bones, internal bleeding, etc.
- i. **Electrical shock associated injuries** - falls, etc.
- j. **Death** - by electrocution (about 500 deaths per year in the U.S. from all electrical sources).
- k. **Other deaths related to electricity** - fatal fires, contact with moving parts, etc. (accounts for about 1000 deaths per year).

Relative Bio-effects Resulting from Exposure to Increasing AC Voltage

50 V (or less)	Little shock hazard unless the skin surfaces are wet.
75 V	Dry skin provides almost no protection from shock.
120 V	Standard US wall plug voltage (causes most deaths).
240 V	Highest common wall voltage normally used in US.
480 V	Voltage from step-down transformer (not as common).
> 600 V	Skin resistance breaks down, allowing current into tissues (definition of high voltage).
2300 V	Arcing to skin occurs, preventing direct contact to source.
> 2400 V	Burning of tissues is the major bio-effect.

Relative Bio-effects Resulting from Exposure to Increasing Current

0.5 mA	No sensation usually felt with contact.
1.0 mA	Slight tingling felt with contact (perception threshold).
1.5 mA	Shock clearly felt (no pain or loss of muscle control).
7.5 mA	Painful shock (no loss of muscle control).
10 mA	Let-go threshold (loss of muscle control).
20 mA	Severe shock, hard to breath, severe muscle contractions.
30 mA	Respiratory paralysis (frequently fatal if no CPR).
75 mA	Fibrillation threshold for 0.5% of exposed persons.
250 mA	Fibrillation threshold for 99.5% of exposed persons.
4 A	Heart paralysis threshold (no fibrillation, may restart spontaneously).
> 5 A	Burning of tissue (could be fatal if vital organs are damaged).
15 A - 20	A Normal amperage in US 120 V wall circuit.
30 A - 50	A Normal amperage required for ion laser operation.

Components of a Good Electrical Safety Program

a. Qualification of Workers - Work on electrical equipment can only be performed by "qualified" personnel (OSHA requirement). These personnel must be properly trained in electrical safety practices and procedures and must be approved by their department to work on electrical equipment. It is essential that you do not work on electrical equipment if you are unfamiliar with electrical devices or if you are untrained in electrical safety.

b. Lock-Out/Tag-Out (LOTO) Procedures - As required by state and federal law, the campus has established LOTO procedures to allow for the safe installation, service, maintenance, adjustment, or other handling of laser systems and other powered equipment.

These LOTO procedures apply whenever the unexpected energizing of the equipment or release of stored energy (such as from charged capacitors) could cause injury. Equipment which has the potential to be energized must be properly locked and/or tagged out in accordance with the campus procedure if:

- A person may contact energized components while performing the work.
- A person is required to remove or bypass any guard, interlock, or other safety device (including equipment covers) to perform the work.
- A person is required to place any part of his or her body into an area on the equipment (or piece of machinery) where work is performed during the equipment's operation.

To obtain a copy of the campus LOTO procedures, please contact the campus Office of Health and Environmental Safety at 3059.

c. "Energized Work" Procedures - If the equipment can only be serviced or adjusted while energized, special "energized work" procedures, testing equipment, special tools, and personal protective equipment may be required. In these cases, special controls may be necessary to insure safety. These controls may include; the use of ground fault circuit interrupter (GFCI), insulated tools, and/or trained stand-by personnel. In accordance with the campus LOTO procedures, all "energized work" procedures must be approved by the campus Office of Health and Environmental Safety prior to beginning the work.

(Note: LOTO procedures should always be followed unless it is physically impossible to conduct the work without the equipment being energized. Only in such instances are "energized work" procedures allowed.)

d. Other Issues - All electrical hazards should be properly marked and/or labeled. Proper switching and grounding techniques must be learned and practiced. The OSHA required work clearances around energized panels must be maintained.

Obtaining Electrical Safety Assistance

a. Department Safety Coordinators - Contact your department Safety Coordinator for specific information on your department's electrical safety policies and resources.

b. Office of Health and Environmental Safety (H&ES) - The campus Office of H&ES (3059) is available to provide electrical safety training and electrical inspection services upon request.

Appendix K

Laser Laboratory Visitor Policy

Definitions:

- A laboratory visitor is any person who is present in the laboratory as an invited guest of any NJIT employee or student researcher.
- Visitors who are to be in the laboratory for a period of more than one day but less than one month are considered short-term researchers.
- Persons who will be in the laboratory for a period of more than one month are considered to be campus laser users.
- The Office of Health & Environmental Safety works with the Principal Investigators and laser users to ensure that the visitor policy is properly enforced.

Visitor Policy and Requirements:

It is the policy of the NJIT Laser Safety Committee to require the same level of laser laboratory safety for all visitors and short-term researchers as is required for laser users. All visitors and short-term researchers are to be escorted by a person whose name appears on the Laser Use Registration (LUR) as a laser user. If it is necessary for a short-term researcher to work alone in the laser laboratory, the individual must be added to the LUR as a laser user.

It is the responsibility of the Principal Investigator to assure that his/her laser users are informed of, understand, and follow this visitor policy.

It is the responsibility of the visitor's laser user escort to provide the visitor with an appropriate safety orientation covering the hazards in the laser laboratory. The escort shall also provide appropriate safety equipment and require the safety equipment be used by the visitor.

Short-term researchers must meet the same laser safety-training requirement as campus laser users (but do not need to be added to the LUR). Laser users must be immediately added to the LUR as specified in the Laser Safety Manual.

As a reminder, no unregistered use of any laser is allowed under any circumstances. The LUR indicates the registered use(s) of the laser system. All LUR and NJIT Laser Safety Policy requirements must be followed at all times. No intra-beam viewing of any laser is allowed under any circumstances by any person.

It is the responsibility of the Principal Investigator to assure that persons who are not invited into the laser laboratory or who fail to follow direction regarding safety policy or the use of safety equipment are immediately escorted from the laser facility.

Coordination with ORS:

Normally, it is not necessary to inform ORS of the presence of visitors. It is necessary to inform ORS of the presence of short-term researchers, although it is not necessary to add them to the LUR. ORS must be immediately informed of new laser users as specified in the Laser Safety Manual.

Visitor Recommendations:

Although it is primarily the responsibility of the escort to provide a safe environment for laboratory visitors, consideration should be given to the following:

- Unless it is absolutely necessary to have the laser energized during the visit, it is recommended that all lasers and laser power supplies be turned off and the activation keys removed during the visit.
- Research environments can prove very hazardous to children. It is recommended that all persons under the age of 18 not be allowed into any laboratory.
- It is recommended that any laser demonstration be conducted so that the laser beam is directed away from any visitor, regardless of the laser eye protection being used.

Patients and Visitors Exposed to Medical Lasers:

- Except as required for medical treatment or the instruction of medical staff, every effort should be made to limit the presence of visitors in the laser treatment room.
- Except as required for medical treatment of the eye, appropriate beam management shall be practiced to prevent eye exposure from any medical laser.
- Persons not receiving laser eye treatment who are present in the laser treatment room shall be provided, instructed in the use, and required to use appropriate laser eye protection.

Laser Safety Training Supplement

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Section 1: NJIT Laser Safety Program

A. Laser Safety Policy Manual

B. Laser Safety Training Requirements

Section 1 - NJIT Laser Safety Program

This supplement is intended to give the reader a basic understanding of lasers and laser safety. The NJIT Laser Safety Program requires laser users to read and use the information in this supplement.

A. Laser Safety Manual

Your Principal Investigator (PI) has a copy of the NJIT Laser Safety Manual available for your reference. You should review the manual prior to starting work covered by the Laser Use Registration (LUR).

B. Laser Safety Training Requirements

All laser users are required to read the Laser Safety Training Supplement and the Laser Use Registration (LUR) for the laser(s) they use. They are required to certify (by signature) that they have read the documents. The training certificate can be found in Appendix A. Each laser user must return a signed copy of the training certificate to the Office of Radiation Safety

Laser Safety Training Supplement

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 - B. [Monochromatic Radiation Sources](#)
 - C. [Irradiance \(Power Density\) and Continuous Wave Lasers](#)
 - D. [Radiant Exposure \(Energy Density\) and Pulsed Lasers](#)
-

Section 2 - The Unique Nature of Laser Radiation

A. Coherent vs. Non-Coherent Radiation Sources

The laser is unique in that it creates a radiation beam that is coherent (in-phase). In a coherent light source, the amplitude of the radiated waves is added (constructive interference) and results in a radiation beam of great intensity. Non-coherent radiation sources (like a light bulb) produce radiation that is out of phase. This results in the reduction of the amplitude by cancellation of overlapping wave forms (destructive interference). The intensity of coherent radiation sources normally exceeds the intensity of non-coherent sources by orders of magnitude.

B. Monochromatic Radiation Sources

Many sources produce a broad range of radiation wavelengths. Lasers will normally produce only one or two wavelengths. The single wavelength is called monochromatic radiation and, depending on the type of laser, the radiation produced can fall anywhere in the electromagnetic spectrum between 10 nm (extreme ultraviolet) and 1 mm (far infrared). Monochromatic radiation does not scatter much (as does polychromatic radiation) when interacting with lenses or mirrors (chromatic aberration). This reduction in scattering can result in very intense specular or diffuse reflections.

C. Irradiance (Power Density) and Continuous Wave (CW) Lasers

An important factor in determining the hazard of continuous wave lasers is the irradiance (power density) of the laser beam. Irradiance is normally expressed in W/cm² and is a function of the beam power divided by the beam area. Beam area is dependent on: the beam size at the aperture, the divergence (spreading) of the beam and the distance from the aperture. Focusing or defocusing the laser will dramatically affect the irradiance. Obviously, the greater the irradiance, the greater the potential hazard.

D. Radiant Exposure (Energy Density) and Pulsed Lasers

Not all lasers are operated in a continuous wave mode. Many operate in a pulsed mode with a pulse duration and a pulse repetition frequency. These lasers cannot be characterized by their irradiance and we instead refer to their radiant exposure (energy density), which is expressed in J/cm². Radiant exposure is a function of power density, pulse duration and pulse frequency. Again, the greater the radiant exposure, the greater the hazard. The averaged power (pulses/sec x J/pulse = J/sec or Watts) of a pulsed laser will usually be less than a CW laser, however the peak power in the pulse may be very large if the pulse duration is very short.

Laser Safety Training Supplement

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Section 3 - Understanding the Laser

A. Basic Operation of the Laser

The basic operating concept of the laser is very simple. Electrons in the atoms of the lasing medium are moved from a ground state into a higher energy state by absorbing energy from an energetic excitation source. For the laser to work, more electrons must be in an excited state than in a ground state (population inversion). When these electrons descend to their ground state, photons of a specific (monochromatic) wavelength are emitted in a process called "spontaneous emission." These photons are allowed to oscillate inside a mirrored resonator. This increases the laser radiation intensity through stimulating the emission of additional photons with the same wavelength and phase. Finally, the photons are allowed to escape via an output coupler (semi-mirrored mirror) as an intense laser beam (see Diagram #1).

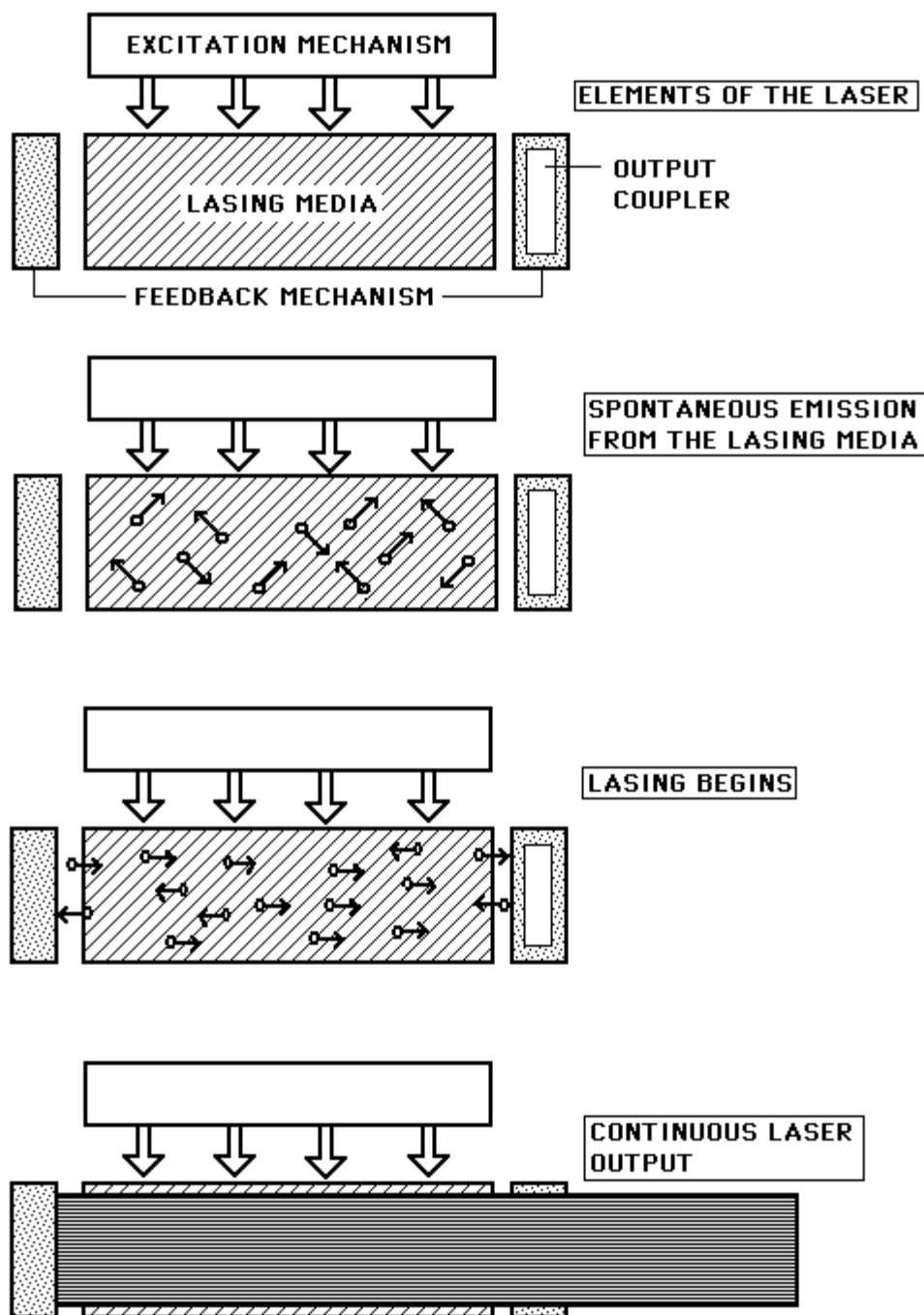
B. Types of Lasing Media

Lasing media can be solids, liquids, or gases. The type of medium dictates the wavelength of the laser beam. Some media can be manipulated to allow for tuning of the wavelength. Solid-state media (polished crystal rods), gases or vapors (sealed in a glass tube), liquid dyes, and semiconductors (laser diodes) are all common lasing media. Halogen gases mixed with noble gases can combine in an excited state to create pseudo molecules called "excited dimmers" or excimers. Excimer lasers emit laser radiation in the ultraviolet region of the spectrum. It is also possible to use an accelerated beam of free electrons as a lasing media. Free electron lasers (FEL) use a "wiggler" magnet to propagate photons from the electron beam. See Appendix C for a listing of laser types (media) typically found at NJIT.

C. Types of Excitation Sources

Flash lamps, plasma discharge tubes, high voltage current and radio frequency devices are all energy sources used to excite the lasing media. Some laser beams are used to "pump" (excite) other lasers (liquid dyes, Ti-Sapphire, etc.). It is important to remember that the excitation device itself can present a serious non-beam hazard (radiation, electrical, etc.).

DIAGRAM #1



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-

Section 4 - Laser Radiation Bio-effects

A. Tissues at Risk and Mechanisms of Injury

The tissues that are normally considered to be at risk are the eyes and the skin. There are three primary mechanisms of tissue injury associated with laser radiation exposure. These are; thermal effects, photochemical effects, and acoustical transient effects (eye only).

- Thermal effects can occur at any wavelength and are a function of the irradiance or radiant exposure and the blood flow cooling potential of the tissue.
- In air, photochemical effects occur between the 200 to 400 nm ultraviolet and the 400 to 470 nm "blue light" wavelengths. Photochemical effects are related to the duration and repetition of the exposure as well as related to the irradiance or radiant exposure.
- Acoustical transient effects are related to pulse duration and may occur in short duration pulses (up to 1 ms), depending on the specific wavelength of the laser. The acoustical transient effect is poorly understood, but it can cause retinal damage that cannot be accounted for by thermal injury alone.

B. Eye Injury Potential

The potential location of injury in the eye (see Appendix E - Eye Component Diagram) is directly related to the wavelength of the laser radiation. For laser radiation entering the eye:

- Wavelengths shorter than 300 nm or longer than 1400 nm are absorbed in the cornea.
- Wavelengths between 300 and 400 nm are absorbed in the aqueous humor, iris, lens, and vitreous humor.
- Wavelengths between 400 nm and 1400 nm are focused onto the retina.

NOTE: Laser retinal injury can be severe because of the focal magnification (optical gain) of the eye, which are approximately 105. This means that an irradiance of 1 mW/cm² entering the eye will be effectively increased to 100 W/cm² when it reaches the retina.

Thermal burns (lesions) in the eye are caused when the choroids layer blood flow cannot regulate the heat loading of the retina. Secondary bleeding into the vitreous humor may occur as a result of burns that damage blood vessels. This bleeding can obscure vision well beyond the area of the lesion.

Although the retina can repair minor damage, major injury to the macular region of the retina may result in temporary or permanent loss of visual acuity or blindness. Photochemical injury to the cornea by ultraviolet exposure may result in photokerato conjunctivitis (often called welders flash or snow blindness). This painful condition may last for several days and is very debilitating. Long term UV exposure can cause cataract formation in the lens (see Appendix F – Bio-effects Chart).

The duration of exposure also plays a role in eye injury. For example, if the laser is a visible wavelength (400 to 700 nm), the beam power is less than 1.0 mW and the exposure time is less than 0.25 second (the human aversion response time), no injury to the retina would be expected to result from an intrabeam exposure. Class 1, 2a and 2 lasers fall into this category and do not normally present a retinal hazard. Unfortunately, intrabeam or specular reflection viewing of Class 3a, 3b, or 4 lasers and diffuse reflections from Class 4 lasers may cause an injury before the aversion response can protect the eye.

For pulsed lasers, the pulse duration also effects the potential for eye injury. Pulses less than 1 ms in duration focused on the retina can cause an acoustical transient, resulting in substantial damage and bleeding in addition to the expected thermal injury. Many pulsed lasers now have pulse duration less than 1 pico second.

The ANSI Z136.1 standard defines the Maximum Permissible Exposure (MPE) that the eye can receive without expecting an eye injury (under specific exposure conditions). If the MPE is exceeded, the probability that an eye injury can result increases dramatically.

The first rule of laser safety is: NEVER UNDER ANY CIRCUMSTANCES LOOK INTO ANY LASER BEAM! If you can prevent the laser beam and beam reflections from entering the eye, you can prevent a painful and possibly blinding injury.

C. Skin Injury Potential

Skin injuries from lasers primarily fall into two categories: thermal injury (burns) from acute exposure to high power laser beams and photo chemically induced injury from chronic exposure to scattered ultraviolet laser radiation.

- Thermal injuries can result from direct contact with the beam or specular reflections. These injuries (although painful) are usually not serious and are normally easy to prevent through proper beam management and hazard awareness.
- Photochemical injury may occur over time from ultraviolet exposure to the direct beam, specular reflections, or even diffuse reflections. The effect can be minor or severe sunburn, and prolonged exposure may promote the formation of skin cancer. Proper protective eyewear and clothing may be necessary to control UV skin and eye exposure.

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3. Key Operation, Power On Indication and Power Level Meters
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1. Invisible Beam Hazards
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Section 5-Laser Beam Hazards and Control Methods

General Considerations

The primary hazard associated with the laser is eye injury caused by intrabeam viewing or the viewing of specular or diffuse reflections. Hazard controls are primarily intended to prevent the laser beam from entering the eye or contacting the skin. These control methods are divided into three areas: administrative controls (signs, labels, procedures, etc.), engineering controls (barriers, beam blocks, interlocks, etc.), and personal protective equipment (laser protective eyewear, skin covering, etc.).

Experience has shown that reliance on any one of these control methods is not as effective as using a combination of the methods. For this reason, the NJIT Laser Safety Program requires the use of a broad range of controls.

A. Administrative Controls

Administrative controls are useful in promoting laser safety in the laboratory. Each specific LUR provides information on the administrative controls to be used for the laser.

1. Standard Operating Procedures (SOPs)

The Laser Safety Program requires the development, documentation, and use of SOPs for alignments, maintenance and normal operations. These SOPs are the logical place to document in-house administrative controls. The SOPs should then be used to train laser users in the facility.

It must be stressed that administrative controls will not positively impact the laser safety environment unless they are kept up-to-date and are reinforced by the PI through example and action.

2. Posting and Labeling of Laser Systems

The posting and labeling of laser hazards on campus is intended to comply with the ANSI Z136.1 laser safety standard and the FDA/CDRH laser performance standard.

All access doors to rooms which contain Class 3a, 3b, or 4 lasers are to be posted with a sign marked with the word "**DANGER**", the international laser symbol, a description of the laser class, the wavelength, and the laser power (as specified in the ANSI Z136.1 laser safety standard). A room containing more than one laser may include information for several lasers on the same sign. Signs are available free of charge from ORS. For some Class 3b or 4 laser systems, the LSC may require that an interlocked lighted sign (that blinks on and off when the laser is operating) be located outside of the laser facility to further warn staff of the presence of laser radiation.

All Class 3a, 3b, and 4 lasers are required to be marked with the appropriate labels indicating the laser class, laser hazard, and identifying the laser aperture (as specified in the FDA/CDRH laser performance standards). The appropriate labels are available from ORS.

B. Engineering Controls

1. Controlling Access to Laser Facilities

All Class 3b and 4 laser facilities are required to have appropriate access controls to prevent unauthorized personnel from entering the facility while the laser is in operation. Key or combination locks are appropriate for this purpose. Doorways to laser facilities are to be kept closed at all times, and locked when the laser user is not in direct attendance. The LSC may require that the doorways to the laser facility be properly interlocked to the laser shutter if it becomes apparent that locked doors alone can not meet access control requirements. If a door interlock is required, it must not be disabled except with the approval of the LSC.

2. Protective Housings, Interlocks and Shutters

All Class 3a, 3b, and 4 lasers are required to have a non-combustible protective housing sufficient to contain the beam and excitation device. It is strongly recommended that the housing be interlocked so that the laser cannot normally be operated with the cover removed. If a housing interlock is required, it must not be disabled except with the approval of the LSC.

Most Class 3b and 4 lasers are equipped with a shutter mechanism that prevents the beam from leaving the housing when activated. If the laser has a shutter, it is not to be disabled except with the approval of the LSC.

3. Key Operation, Power On Indication, and Power Meters

Many laser systems are equipped with key switches that prevent operation when the key is removed. If a key switch is required, it must not be disabled except with the approval of the LSC. In order to prevent unauthorized personnel from operating the laser, the key should be removed from the laser control and stored in a secure location whenever the laser is not being used.

All class 3b and 4 lasers need to have a lighted "power on" indicator clearly visible to persons in the laser facility. The "power on" indicator should be interlocked to prevent the laser from being operated if the indicator is not functioning.

It is highly recommended that each laser system have a power meter available to measure the operating power of the laser.

4. Optical Tables, Beam Alignment and Remote Viewing Systems

Most research laser use entails the use of optical tables and optical devices to manipulate beams. To assure a safe laser-operating environment, the optical components and the optical table environment must be evaluated for hazards. The primary intent of this evaluation is to prevent the laser beam from leaving the table top. Optical components must be aligned and properly secured to assure beam control. Be aware of secondary reflections from optical devices by performing physical surveys and assure all stray beams are properly contained.

Beam height should be planned to avoid eye level (both standing and sitting) in the laser facility. In situations where the beam needs to be directed to another area, it is important to consider enclosing the beam, using fiber optics, or directing the beam well above eye level as a precaution against accidental exposure. Beams being directed between optical tables must employ a properly marked physical barrier to prevent personnel contact with the beam.

Beam alignment is the most hazardous aspect of laser use and most laser eye injuries occur during alignments. For this reason, beam alignment standard operating procedures (SOP) must be carefully thought out, documented, and users properly trained on the procedures. Beam alignment should be performed at the lowest visible beam power.

Alignments are normally performed by carefully fixing a diffuse reflecting card in the beam path, turning the beam power up slowly till the beam can just be imaged and carefully aligning the optical components. If the beam is invisible, UV or IR cards or viewers may be required to image the beam. NOTE: IR and UV viewers do not protect the eye and must be used with appropriate laser eye protection.

NOTE: Intrabeam (on-axis) viewing of laser beams is not normally allowed on the NJIT campus. In certain circumstances, intrabeam viewing may be allowed with the direct written permission of the campus Laser Safety Committee (LSC).

If the beam power cannot be reduced, it is recommended that a low powered alignment laser (Class 2/3a HeNe or diode) be used to align the optics. If alignments are being done with power levels above the MPE, the user is required to use appropriate laser protective eyewear during the procedure. This eyewear will normally be of minimal optical density (OD) at the wavelength of interest. This will enable viewing of a diffuse reflection of the beam while providing some protection from a momentary specular reflection (intrabeam viewing is not allowed). Alignments must be done so that the user is never looking directly into the beam.

When possible, it is advisable to have two users work together when performing alignments to remind each other of safety considerations. One of the safest methods to use for viewing the beam is the use of a remote camera system. Remote viewing, although expensive, virtually eliminates eye hazards associated with alignment procedures.

5. Enclosures, Beam Barriers, Beam Stops and Collimators

Whenever possible, enclose as much of the beam as possible without interfering with the application. Enclosures do not have to be sophisticated, but must contain the beam safely and be marked to indicate the presence of the beam inside the enclosure. By totally enclosing the beam, you may eliminate the need for other safety precautions. For example, you might effectively change a Class 4 laser system into a Class 1 system with proper enclosures and interlocks. Be careful not to use combustible enclosure materials with Class 4 laser systems.

Another effective and versatile tool for reducing the hazard from stray laser radiation is the use of beam barriers or beam curtains to surround all or part of the laser system or optical bench. Labyrinth designs can be used to limit the hazard while maintaining ready access to laser systems. Be sure the barrier materials will reduce the beam power below the MPE and do not use combustible barrier materials with Class 4 laser systems.

For exposed beam paths, appropriate beam stops must be used behind optical devices used to change the direction of the beam. The use of these stops will prevent the beam from leaving the table should the beam become misaligned. Again, do not use combustible beam stops with Class 4 laser systems.

Beam collimators or tubes can be useful in restricting the path of the beam should misalignment occur. Many optical devices have a metal ring surrounding the device that will act as a beam collimator. All optical supports, collimators, etc. should be surfaced, treated, or painted so as to reduce the potential for specular reflections.

6. Beam Condensation, Enlargement and Focusing

Manipulation of the beam diameter will change the hazard from intrabeam exposure. For example, beam enlargement will reduce the irradiance or radiant exposure level, but will increase the probability of scattering due to the enlarged cross section of the beam as it passes through optics.

A focused beam will present a greatly increased hazard at the focal point, but will expand quickly past the focal point, substantially reducing the irradiance or radiant exposure level (as compared to the initial beam).

7. Beam Filtration, Nonlinear Optics and Pumping Lasers

Beam power and other characteristics may be manipulated through the use of filtration devices. Do not rely on filters to reduce or eliminate beam hazards unless they are expressly designed for that purpose. Be aware that prolonged exposure to laser radiation may bleach filter devices, changing their absorption and their ability to reduce hazards.

Nonlinear optics used to manipulate the frequency of the incident laser radiation is now extremely common. The use of these optics may present multiple laser wavelengths on the optical bench top. All laser wavelengths must be considered when assessing hazards. The issue of multiple wavelengths also applies to the use of lasers to pump other lasers and amplifiers. Whenever possible, it is advisable to enclose unused beams (of differing wavelengths) to limit the number of laser hazards.

8. Preventing and Controlling Reflections

Any item placed in the beam path may result in a specular or diffuse reflection of the laser beam. For this reason, it is important to restrict the items on the optical bench to those intended to manipulate the beam path. Good housekeeping should not be overlooked as a source of laser hazard control. Tools, unused optical devices, and other items should not be left on the optical table.

For invisible beams, the nature of reflection and absorption at the particular wavelength should be considered in order to adequately control reflections on various surfaces.

C. Personal Protective Equipment

1. Laser Protective Eyewear

The exclusive use of laser protective eyewear has, in the past, often been stressed as the best method of eye safety in the laser laboratory. At NJIT, laser protective eyewear is only one of many required laser safety control measures. In general, it is better to control laser hazards through the use of engineering controls (enclosures, beam blocks, etc.) and administrative controls (posting, procedures, etc.) rather than to rely solely on laser protective eyewear.

Laser protective eyewear is essential during the beam alignment process. Most laser accidents occur during beam alignments and these can be prevented by wearing the appropriate laser protective eyewear. The laser protective eyewear selected must allow proper viewing of the beam at or just below the MPE. Laser users commonly suffer eye injury when they remove their eyewear because they can not properly view the beam. NOTE: The intensity of a visible beam at the MPE is, by definition, sufficient to trigger the human aversion response. This means a diffuse reflection off a card is more than bright enough to view in a lighted room. The visible light transmission (VLT) of the laser protective eyewear must be sufficient (35% or more) to eliminate the need to remove the eyewear while working in the lighted laser facility. ORS recommends that the lights be kept on in the laser facility. Working in a darkened room will increase the potential hazard of eye injury by increasing the pupil size while increasing the need to remove the laser protective eyewear to be able to see.

All laser protective eyewear must be marked with the absorption wavelength and the optical density (OD) at that wavelength. It is recommended that laser protective eyewear be color coded to the laser of concern with colored tape. This can prevent mishaps when several lasers of different wavelengths are being used.

Selection of appropriate laser protective eyewear is very important. Several different laser protective eyewear styles are available depending on the needs of the user (see Appendix H). The laser protective eyewear selected must have the appropriate OD at the wavelength(s) of concern and must be comfortable enough to wear as required. Contact the Laser Safety Officer if you need additional information on laser protective eyewear.

2. Skin Protection

UV laser systems or UV excitation sources can present severe hazards to exposed skin surfaces. If the UV source cannot be enclosed to prevent scattered radiation exposure, it may be necessary to wear appropriate coverings to protect the skin. These coverings may include gloves, UV face shield, lab coat, etc.

D. Combined Control Methods

1. Invisible Beam Hazards

The use of invisible beams (UV or IR) presents unique hazards. Be sure that beam paths are clearly identified. For example, tape strips can be used for defining beam paths on optical tables. Have the appropriate viewing aids (such as fluorescent cards or IR viewers) available for use during alignment procedures. Burn paper is available free of charge from ORS for use as an alignment reference.

NOTE: Particular caution should be exercised when viewing wavelengths that are at the borderline of the visible and near infrared. An example is the Ti-Sapphire laser at 800 nm. This beam (at full power) can be imaged in a dark room as a dull red spot on a card (usually without laser protective eyewear). This is very hazardous because the human eye is "seeing" the 800 nm wavelength at very poor relative efficiency (0.0001%) compared to yellow light (100% at 575 nm). The user can be fooled into thinking the power is low (what the user's eye is telling them) when the actual irradiance of the beam is very high. Many eye injuries have occurred during alignments with Ti-Sapphires. Wavelengths longer than 700 nm should be treated as infrared beams and laser protective eyewear should always be worn during alignments.

2. Repair and Maintenance Hazards

During repair or maintenance, access to laser radiation is more probable because of the removal of the laser housing. Only qualified persons should perform laser system maintenance or repair. The appropriate laser protective eyewear must be used during all alignments and whenever exposure to laser radiation is anticipated.

Vendor and service personnel working at NJIT should follow the established NJIT safety practices. It is the responsibility of the PI to inform these persons regarding the appropriate procedures. If the vendor has their own safety procedures, these should also be followed. In the event of conflict between the NJIT Laser Safety Program and the vendor's procedures, the LSO should be consulted before work begins.

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 - F. [Collateral Radiation Hazards](#)
 - G. [Fire and Explosion Hazards](#)
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-

Section 6 - Ancillary Hazards and Control Methods

A. Toxic Dye Hazards

The fluorescent dyes (used with dye lasers) can present substantial hazards due to their toxicity. Some of these dyes are suspected of being carcinogenic or mutagenic. The solvents used for mixing the dyes may be flammable, toxic, or present other health hazards. Material Safety Data Sheets (MSDS) on dyes or solvents are available from your department or by contacting the LSO.

Because the dyes normally come in a dry power form, they are readily dispersible and should be handled and mixed with great care. A lab coat, disposable gloves, safety glasses or goggles, and a properly functioning chemical fume hood must be used when handling or mixing the dyes. Good housekeeping should be maintained before, during, and after the mixing. Use double containment adequate to contain the entire volume of the dye solution when they are being mixed, stored, and used. Clean up any spills immediately using the appropriate protective equipment. Contact the LSO if you need additional information.

B. Hazards from Laser Generated Air Contaminants (LGAC)

The interaction of the laser beam with target materials may produce toxic dusts, vapors or gases called LGAC. This is particularly true during material processing (welding, cutting, vapor deposition, etc.). Toxic products resulting from laser processing must be properly controlled through the use of adequate ventilation and filtration. The LSO should be consulted whenever LGAC may result from the laser use.

C. Cryogen Hazards

Some lasers and laser systems may require the use of cryogenic liquids (liquid nitrogen, oxygen, hydrogen, etc.). These liquids present skin and eye hazards from their extremely low temperatures and should not be handled without insulated gloves, goggles and a face shield. The dewars used for transport and storage of cryogenics may present implosion hazards if they are made of glass. Glass dewars should be carefully wrapped with strong tape to contain glass fragments should they implode.

If the cryogenic liquid is allowed to warm to room temperature, the resulting gas will expand to more than 600 times the volume in the liquid state. Once it expands to become a gas, the gas may present an additional hazard (toxic, asphyxiant, etc.). The specific hazards of the cryogen can be found in the MSDS. Your department safety contact should be consulted whenever cryogenic liquids are being used.

D. Compressed Gas Hazards

The use of compressed gases is common in the laser laboratory. Some lasers use both pure gases or gas mixtures as the lasing media. The high pressure of the gas translates into substantial potential energy stored in the cylinder. If this pressure is released in an uncontrolled manner (such as broken nozzle) the cylinder can become an unguided missile. Compressed gas cylinders must be properly restrained to prevent damage to the nozzle or regulator.

The gases themselves may present a variety of hazards if they leak from the cylinder. Depending on the gas, it may be toxic, corrosive, flammable, etc. Again, refer to the MSDS for detailed information on the gas in question. If the hazards are sufficient, it may be necessary to provide a gas cabinet under negative pressure to control the hazard in the case of a leak. Inform your department safety contact if compressed gases are to be used in the laser facility.

E. High Voltage Power Hazards

The high voltage power supplies associated with laser systems have been responsible for serious injuries and electrocutions. For this reason, it is important to know the hazards associated with your laser and the laser's power supply. Capacitor systems are of particular concern because they can remain hazardous long after the main power is disconnected. Capacitor systems should be safely discharged several times with the main power off to reduce the hazard before beginning work.

Only qualified persons should perform high voltage laser or power supply maintenance or repair. As a precaution, a second person (knowledgeable in high voltage safety and CPR) should always be in attendance when high voltage work is being performed.

F. Collateral Radiation Hazards

Laser excitation systems and power supplies may produce hazardous collateral radiation of various types. These hazards are normally controlled by the equipment housings, and are usually a problem only if the protective housings are removed.

The laser excitation device may produce very intense UV/Visible/IR radiation that can be hazardous. Collateral ultraviolet radiation may injure both the eye and the skin if the exposure duration is long enough. Blue light presents a special hazard because of its ease of absorption in the retina. This "Blue Light Hazard" is thought to create photochemical injury in the retina. Exposure to any very intense visible light source can seriously degrade color vision and night vision capabilities (see Appendix F for additional information). Exposure to these intense light sources should be carefully controlled or eliminated by leaving the housings in place.

Laser power supplies capable of creating energies greater than 15 kVp may be a source of x-rays if they contain high voltage vacuum tubes. Electric discharge excitation sources in lasers may also be a source of x-rays. Generally, these x-rays are low energy and are shielded by the equipment housings.

G. Fire and Explosion Hazards

As mentioned before, Class 4 lasers can present fire hazards. Lasers being operated in a CW mode with a beam power that exceeds 0.5 Watt can ignite or cause off gassing in combustible materials left in the beam path. Beam stops, barriers, and curtains used with Class 4 lasers must be made of non-combustible materials. All Class 4 laser labs should have an ABC Type extinguisher readily available as a fire precaution. Laser users should receive fire prevention training.

Explosion hazards in the laser lab include: the storage and use of flammable solvents and gases (both compressed and cryogenic) and the implosion potential from dewars and excitation flash lamps. Proper storage and control of these sources should reduce the potential hazard.

H. Noise Hazards

Some laser systems create significant levels of noise in the laser laboratory. If the noise level seems unpleasant or painful, contact your department safety contact to have a noise survey done.

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Appendix A
TRAINING CERTIFICATION DOCUMENT

Name of Laser User (print): _____

Name of Principal Investigator: _____

LUR Number: _____ Phone No. _____

Laboratory Location: _____

I have read and understand the NJIT Laser Safety Training Supplement and Laser Use Registration and have received instruction from the Principal Investigator (or their designee) in the use of the laser system, associated optics, and laser safety systems. I am aware that I am responsible for following the established safety standards and laboratory SOP's and that I am responsible for my own safety in the laboratory.

Signed: _____

Date: _____

Send the completed form to: Laser Safety Officer

Appendix B

NJIT LASER SAFETY GUIDELINES

Operation Guidelines

- 1) Intrabeam viewing of laser beams is not allowed on campus.
- 2) Never look directly into any laser beam for any reason.
- 3) Enclose the laser beam path whenever possible.
- 4) Use appropriate laser protective eyewear for all laser beam alignments.
- 5) Restrict unauthorized access to laser facilities.
- 6) Do not operate lasers at sitting or standing eye level.
- 7) Shield all laser light pumping sources.
- 8) Remove all reflective or combustible materials from the beam path.
- 9) Use diffuse (non-reflective) beam stops, barriers and enclosures.
- 10) Use low beam power (or an alignment laser) for alignments.
- 11) Remove all keys from interlocks when the laser is not in operation.
- 12) Alert persons in the area when the beam is operating.
- 13) Be aware of and protect users from all non-beam hazards.
- 14) Never override any laser system safety interlock.

Administration Guidelines

- 1) Mark all laser facility entrances with an ANSI laser hazard sign.
 - 2) Complete, sign, and return a laser safety-training certificate to ORS.
 - 3) Report all accidents or suspected eye injuries to ORS.
 - 4) Eye exams may be required for Class 3b and 4 laser users.
 - 5) Inform ORS of any transfer or sale of lasers.
 - 6) Laser facilities are inspected periodically by ORS.
 - 7) Inform ORS of any new, modified or relocated lasers.
 - 8) Call ORS at 3059 any time you need laser safety assistance.
-

Appendix C

LASER TYPES AND WAVELENGTHS

<u>LASER MEDIA</u>	<u>WAVELENGTH (nm)</u>
(ULTRAVIOLET)	(100 nm - 400 nm)
Fluorine (diatomic gas excimer)	157
Argon Fluoride (excimer)	193
Krypton Chloride (excimer)	222
Krypton Fluoride (excimer)	248
Xenon Chloride (excimer)	308
Helium Cadmium	325/354
Nitrogen	337.1
Krypton	351/356
Xenon Fluoride (excimer)	351
Argon	351/364
(VISIBLE)	(400 nm - 700 nm)
Helium Cadmium (blue)	442
Argon (blue)	458
Helium Selenium (tunable)	460 - 1260
Krypton (blue)	476
Argon (blue)	477
Argon (blue)	488
Rhodamine 6G (tunable dye)	500 - 650
Copper Vapor (green)	511
Argon (green)	515
Krypton (green)	531
Manganese Vapor (green)	534/1290
Helium Neon (green)	544
Erbium: YLF (green)	551
Krypton (yellow)	568
Copper Vapor (yellow)	578
Helium Neon (yellow)	594
Helium Neon (orange)	612
Gold Vapor (red)	628/612
Helium Neon (red)	633
Krypton (red)	647
Gallium Aluminum Arsenide (red diode)	670
Titanium Sapphire (tunable)	670 - 1130
Krypton (red)	676
Ruby (red)	694
(NEAR INFRARED)	(700 nm - 1400 nm)
Alexandrite (tunable)	700 - 815
Lead Vapor	723
Krypton	753
Chromium: LiSAF (tunable)	780 - 1010
Gallium Aluminum Arsenide (diode)	840
Calcium Vapor	852/866
Gallium Arsenide (diode)	905
Neodymium: YAG	1064/1320
Barium Vapor	1130/1500
Helium Neon	1152/3390
(FAR INFRARED)	(1400 nm - 1 mm)
Erbium: Glass	1540
Holmium: YLF	2060
Thulium: YAG	2010
Holmium: YAG	2100
Erbium: YAG	2490
Erbium: YSGG	2790
Hydrogen Fluoride	4000 - 6000
Carbon Monoxide	5000 - 5500
Carbon Dioxide	9.6/10.6 (um)
Water Vapor	118 (um)
Hydrogen Cyanide	337 (um)

Appendix D
LASER INSPECTION FORM
OFFICE OF RADIATION SAFETY

Surveyors Name: _____ Date of Inspection: _____
Location of Laser System(s): _____
Name of PI: _____ Phone #: _____
Name of Lab Contact: _____ Phone #: _____
Applicable LURs: _____

Laser Posting, Labeling and Security Measures

Entrances properly posted: Y N Comments: _____
Room security adequate: Y N Comments: _____
Door interlock system: Y N Comments: _____
Interlock functioning: Y N Comments: _____
Laser status indicator outside room: Y N Comments: _____
Laser class label in place: Y N Comments: _____
Laser aperture label in place: Y N Comments: _____

Laser Unit Safety Controls

Protective housing in place: Y N Comments: _____
Interlock on housing: Y N Comments: _____
Interlock on housing functioning: Y N Comments: _____
Beam shutter present: Y N Comments: _____
Key operation: Y N Comments: _____
Laser activation indicator on console: Y N Comments: _____
Beam power meter: Y N Comments: _____
Emergency shutoff available: Y N Comments: _____

Engineering Safety Controls

Laser secured to table: Y N Comments: _____
Laser optics secured to prevent stray beams: Y N Comments: _____
Laser not at eye level: Y N Comments: _____
Beam is enclosed: Y N Comments: _____
Beam barriers in place: Y N Comments: _____
Beam stops in place: Y N Comments: _____
Remote viewing of beam: Y N Comments: _____
Beam condensed or enlarged: Y N Comments: _____
Beam focused: Y N Comments: _____
Beam intensity reduced through filtration: Y N Comments: _____
Fiber optics used: Y N Comments: _____
Windows in room covered: Y N Comments: _____
Reflective materials kept out of beam path: Y N Comments: _____
Laser user checking for stray beams: Y N Comments: _____
Physical evidence of stray beams: Y N Comments: _____
Class 4 diffuse reflection hazard: Y N Comments: _____

ADMINISTRATIVE SAFETY CONTROLS:

LUR up-to-date: Y N Comments: _____
LUR posted: Y N Comments: _____
SOP up-to-date: Y N Comments: _____
SOP posted: Y N Comments: _____
Emergency contact list posted: Y N Comments: _____
Laser safety guidelines posted: Y N Comments: _____
Laser safety policy manual available: Y N Comments: _____
Laser safety training supplement available: Y N Comments: _____
All users have met laser safety training requirement: Y N Comments: _____

OTHER LASER SAFETY MEASURES:

Laser eye exam requirement met: Y N Comments: _____
Proper laser eye protection available: Y N NA Comments: _____
Proper skin protection available: Y N NA Comments: _____

NON BEAM HAZARDS

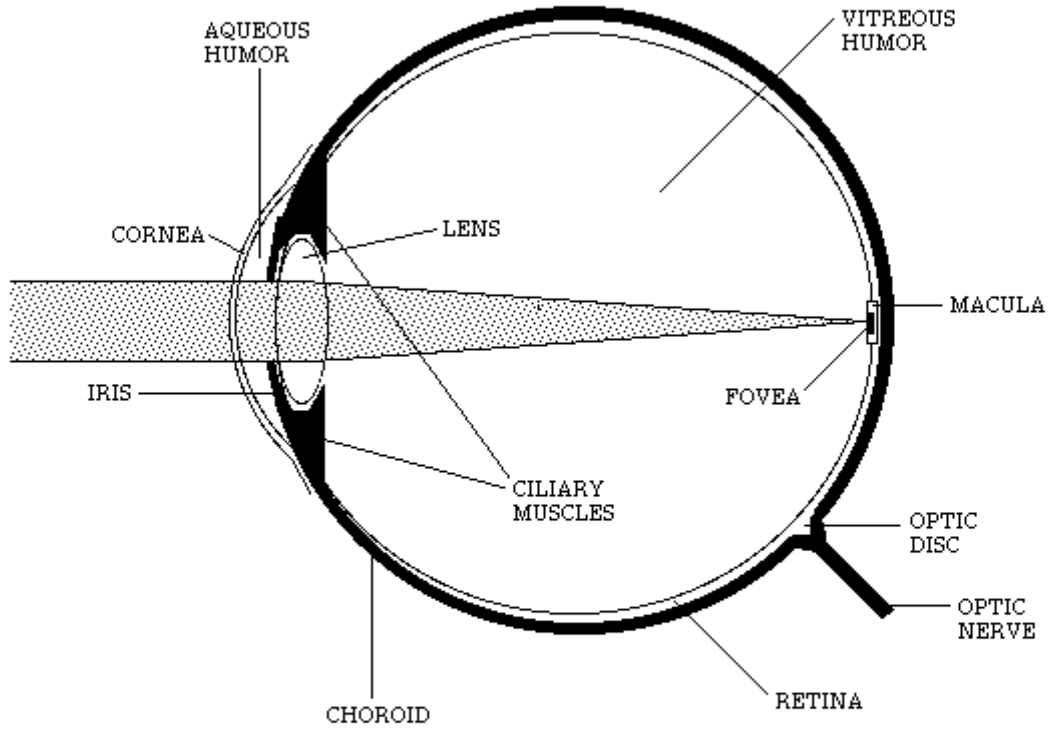
Toxic laser media in use: Y N Comments: _____
Hazardous laser media stored properly: Y N Comments: _____
Fume hood for dye mixing: Y N NA Comments: _____
Cryogens in use: Y N Comments: _____
Compressed gas in use: Y N Comments: _____
Gas cylinders restrained: Y N Comments: _____
All V belts, pulleys, and fans adequately guarded: Y N Comments: _____
High voltage power hazard: Y N Comments: _____
Electrical panels are unobstructed: Y N Comments: _____
Optical tables properly grounded: Y N Comments: _____
Collateral radiation hazard: Y N Comments: _____
Explosion hazard: Y N Comments: _____
Fire hazard: Y N Comments: _____
LGAC production: Y N Comments: _____

ADDITIONAL COMMENTS:

LASER CONFIGURATION DIAGRAM ATTACHED

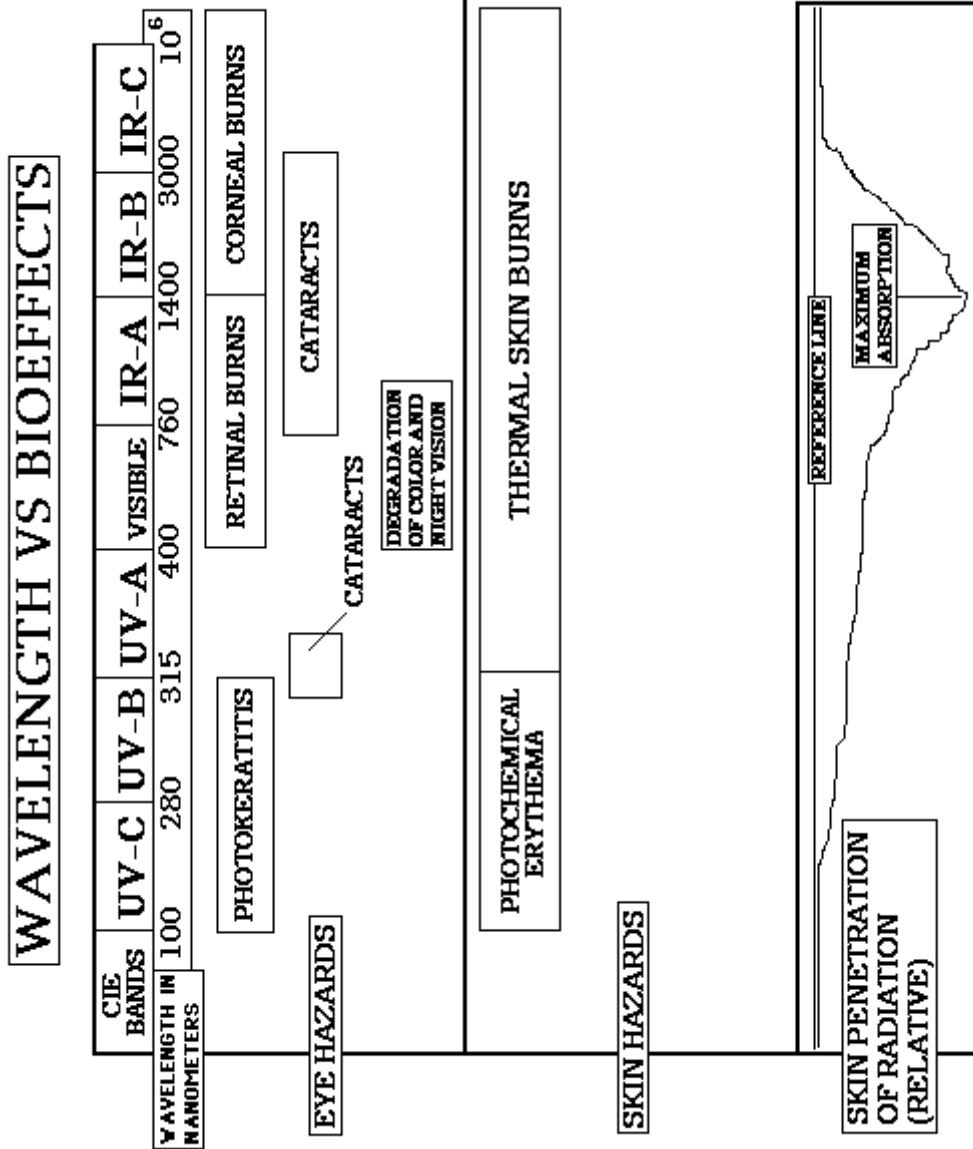
Appendix E

EYE COMPONENT DIAGRAM



NOTE: The diagram shows a laser beam entering the eye and being focused on the fovea. If the beam power is sufficient, this situation could cause blindness

Appendix F Bio-effects Chart



Appendix G

Glossary of Laser Terms

Accessible exposure limit (AEL) - The maximum allowed power within a given laser classification.

American National Standards Institute (ANSI) - The technical body which releases the Z136.1 Standard for the Safe Use of Lasers. The secretariat for the Z136.X standard series is the Laser Institute of America (LIA).

Average power - The average power of a pulsed laser is the product of the energy per pulse (J/pulse) and the pulse repetition frequency (Hz or pulses/sec). The average power is expressed in Watts (J/sec).

Coherent radiation - Radiation whose waves are in-phase. Laser radiation is coherent and therefore very intense.

Continuous wave (CW) - A term describing a laser that produces a continuous laser beam while it is operating (verses a pulsed laser beam).

Diffuse reflection - When an incident radiation beam is scattered in many directions, reducing its intensity. A diffusely reflecting surface will have irregularities larger than the wavelength of the incident radiation beam. See specular reflection.

Intrabeam exposure - Exposure involving direct on-axis viewing of the laser beam. Looking into the laser beam would constitute intrabeam exposure. NOTE: Intrabeam viewing of lasers is not permitted on campus.

Infrared (IR) radiation - Invisible radiation with a wavelength between 780 nm and 1 mm. The near infrared (IR-A) is the 780 to 1400 nm band, the mid infrared (IR-B) is the 1400 to 3000 nm band, and the far infrared (IR-C) is the 3000 nm to 1 mm band.

Irradiance - The power being delivered over the area of the laser beam. Also called power density, irradiance applies to CW lasers and is expressed in W/cm².

Laser - Light Amplification by Stimulated Emission of Radiation. A monochromatic, coherent beam of radiation not normally believed to exist in nature.

Laser user - Any person who uses a laser for any purpose on the NJIT campus.

Laser Safety Manual - A document defining the NJIT Laser Safety Program. Copies are available from the Office of Radiation Safety.

Laser Use Registration (LUR) - The mechanism used by the Office of Radiation Safety to track lasers on campus. The LUR details the safety requirements for each Class 3a, 3b, and 4 laser.

Laser Safety Committee (LSC) - The campus academic committee that makes laser safety policy and oversees the Laser Safety Program.

Laser Safety Officer (LSO) - A member of the ORS staff, the LSO is responsible for implementation of the Laser Safety Program.

Maximum permissible exposure (MPE) - The maximum level of radiation which human tissue may be exposed to without harmful effect. MPE values may be found in the ANSI Z136.1 Standard.

Material Safety Data Sheet (MSDS) - A document, required by law, which is supplied by the manufacturer of a chemical. The MSDS details the hazards and protective practices required for protection from those hazards, as well as other information.

Nominal hazard zone (NHZ) - The area surrounding an operating laser where access to direct, scattered or reflected radiation exceeds the MPE.

Optical density (OD) - Also called transmission density, the optical density is the base ten logarithm of the reciprocal of the transmittance (an OD of 2 = 1% transmittance).

Office of Health & Environmental Safety - The department responsible for the implementation of the Laser Safety Program.

Peak power - The highest instantaneous power level in a pulse. The peak power is a function of the pulse duration. The shorter the pulse, the greater the peak power.

Principal investigator (PI) - The person directly responsible for the laser and its use. The PI has direct responsibility for all aspects of safety associated with his/her research and/or teaching.

Radiant exposure - The energy being delivered over the area of the laser beam. Also called energy density, radiant exposure applies to pulsed lasers and is expressed in J/cm².

Specular reflection - Results when an incident radiation beam is reflected off a surface whose irregularities are smaller than the radiation wavelength. Specular reflections generally retain most of the power present in the incident beam. Exposure to specular reflections of laser beams is similar to intrabeam exposure. See diffuse reflection and intrabeam exposure.

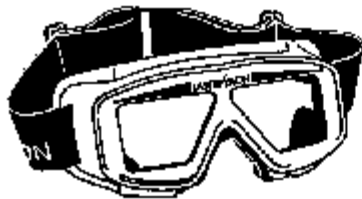
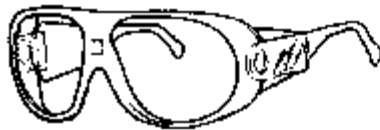
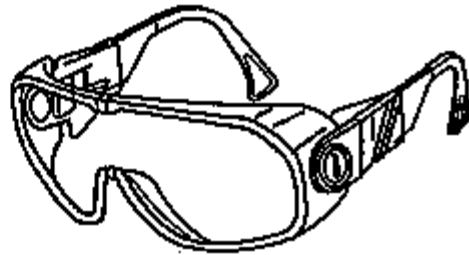
Standard operating procedure (SOP) - A procedure that explains a standard procedure or practice. For lasers, SOPs usually deal with alignment procedures.

Ultraviolet (UV) radiation - Invisible radiation with a wavelength between 10 nm and 400 nm. The near ultraviolet (UV-A) is the 315 to 400 nm band, the mid ultraviolet (UV-B) is the 280 to 315 nm band, the far ultraviolet (UV-C) is the 100 nm to 280 nm band, and the extreme ultraviolet is the 10 to 100 nm band. Note: Wavelengths below 200 nm are absorbed in the atmosphere and are known as the vacuum ultraviolet.

Visible Light - Radiation that can be detected by the human eye. These wavelengths are between 400 and 780 nm. The colors (with approximate wavelengths) are: Violet (400 - 440 nm), Blue (440 - 495 nm), Green (495 - 545 nm), Yellow (545 - 575 nm), Orange (575 - 605 nm), and Red (605 - 780 nm).

Appendix H
Types of Laser Protective Eyewear

Here are some examples:



Appendix I

Laser Protective Eyewear for Alignments

The Office of Radiation Safety receives many requests on selecting laser protective eyewear for alignment purposes. The information below should be helpful. If you have additional questions on laser protective eyewear or any other laser safety issue, please contact ORS at 3059

Even if you are wearing laser protective eyewear, **never look directly into any laser beam**. Intrabeam viewing of lasers is not allowed except with the direct permission of the Laser Safety Committee. Contact the Laser Safety Officer if you feel that aligning your laser requires intrabeam viewing.

- The LUR document for each laser indicates if laser protective eyewear is required for alignment or use of the laser. If laser protective eyewear is required, the LUR specifies the OD (optical density) at the laser wavelength(s) being used. The OD specified is the minimum OD sufficient to protect the user against a momentary intrabeam or specular reflection exposure.
 - For visible lasers, the minimum OD required to protect the user against intrabeam viewing should allow the viewing of a diffuse spot on a light colored surface. If the laser protective eyewear has an OD much larger than the specified minimum OD, it may be impossible to properly view a diffuse beam spot (or even see properly in the laser facility).
 - In some instances (visible lasers from 400 - 450 nm and 650 - 700 nm), it may be preferable to reduce the OD below the specified intrabeam minimum OD to better view a diffuse spot. Reducing the OD by 1 or 2 should substantially improve viewing while still offering adequate eye protection (the intrabeam OD has a X10 safety margin calculated into the value which includes the human aversion (blink) response). Reducing the specified OD by a number greater than 2 may reduce the protection factor enough to allow eye injury should a specular reflection be viewed accidentally.
 - For invisible lasers, the minimum OD for intrabeam viewing should not be reduced, as OD reduction will not aid in viewing the beam. Instead, the laser protective eyewear should be chosen to allow the wavelength produced by the viewing aid to be transmitted while absorbing the invisible beam. For example: a Nd:YAG beam at 1064 nm is being aligned with the use of an IR sensing card which absorbs some of the 1064 nm radiation and emits radiation at 550 nm. The calculated intrabeam OD for the Nd:YAG is 6.0. A good choice for laser protective eyewear would be a goggle with a UVEX type 06 filter (an OD of 8+ at 1064 nm and an OD of less than 1 at 400 to 700 nm). This goggle has a visible light transmission of 70% and should allow the diffuse spot to be easily viewed while giving excellent protection from the invisible Nd:YAG beam. NOTE: this eyewear would obviously not be a good choice if the Nd:YAG beam was frequency doubled to 532 nm.
 - All laser protective eyewear should have a visible light transmission (VLT) sufficient to allow safe operation in the laser facility. ORS recommends a VLT of at least 35%. Laser protective eyewear with a low VLT will generally not be worn by users and so cannot provide any protection.
-

Appendix J Laser Accident Case Studies

LASER SYSTEM STANDARD OPERATING PROCEDURE (SOP) GUIDELINES

1. BASIC GUIDANCE

- a. The written SOP must discuss beam alignment and normal operation for each laser system. It is advisable to include non-beam hazard management and servicing in the SOP.
- b. To insure the SOP is read and used, the document should not be lengthy.
- c. The primary intent of the SOP is to institutionalize good safety practices.
- d. The Laser Use Registration, Laser Safety Manual, and Laser Safety Training Supplement have information that may be useful in developing the SOP.
- e. The Office of Health & Environmental Safety will be happy to review and comment on the draft SOP. If you need help contact the Laser Safety Officer at 3059.

2. BEAM ALIGNMENTS (ADDRESS THESE SAFETY AREAS IN THE SOP)

- a. SECURITY - Secure the lab and (to avoid distractions) mark the door with the following sign: "NOTICE - Laser Alignment in Progress - DO NOT ENTER - EYE PROTECTION REQUIRED."
- b. PREPARATION - Locate all equipment and materials needed to perform the alignment prior to beginning the procedure.
- c. BEAM CHARACTERISTICS - Is the beam visible or invisible? Is special equipment needed to view the beam? If the beam is pulsed, can you fire a single pulse at a time to limit the exposure hazard?
- d. BEAM VIEWING - Intrabeam viewing is prohibited on the campus and a remote viewing camera should be used if intrabeam viewing is required to align the beam. Only diffuse reflections should be viewed directly. Use a low power alignment laser (Class 2 or 3a) or if none is available; always use the lowest beam power that will allow viewing of an image with protective eyewear.
- e. PERSONAL PROTECTIVE EQUIPMENT - Use laser protective eyewear with a low enough OD to allow viewing of the diffuse reflection (contact ORS if you need information on alignment eyewear). Use skin covers (lab coat, gloves, and UV face shield) to protect users from UV laser beam scatter.
- f. PERSONNEL - Whenever possible, the "buddy" system should be used during alignments. If another person is not available to be in the room, let someone else know where you are and check in with them on a regular basis.

g. EXPOSURE PRECAUTIONS - Keep the optical table clear of objects that may cause unwanted specular reflections. Always close the laser shutter while adjusting optics or when entering the beam path. After making adjustments, assure the optics are secured prior to opening the shutter.

h. REPLACE BEAM CONTROLS - Insure all beam blocks, enclosures, and beam barriers are replaced when the alignment is complete.

i. CHECK DOOR SIGNS - Verify that the "NOTICE - Laser Alignment in Progress - DO NOT ENTER - EYE PROTECTION REQUIRED" sign is removed from the room entrance and that the regular ANSI laser warning sign is in place and correct.

3. NORMAL OPERATION OF THE LASER (ADDRESS THESE SAFETY AREAS IN THE SOP)

a. SECURITY - Do not rely upon a closed door as adequate security. Always use key locks or activate the door interlocks (if required by the LUR) on the laser facility.

b. OPERATIONAL PREPARATIONS - Indicate the location of the Laser Safety Guidelines posting. Indicate the equipment needed to perform the (laboratory specific) experiment.

c. PERSONAL PROTECTIVE EQUIPMENT - Have the appropriate (laboratory specific) safety equipment on hand. Specify what is needed and it's use.

d. START-UP PROCEDURE - Insert key, turn on water, turn on power supply, close shutter, activate laser, etc. as specific to the laboratory.

e. EXPERIMENTAL PROCEDURE - Specific to the laboratory.

f. EMERGENCY PROCEDURE - Location of "PANIC" shut-down switch. Location of emergency procedure posting. Location of fire extinguisher, safety shower, etc.

g. SHUT-DOWN PROCEDURE - Specific to the laboratory.

h. STORAGE - Remove and store laser activation key, deactivate interlocks (if applicable) and secure door to laser facility.

4. NON-BEAM HAZARDS TO ADDRESS

a. TOXICITY OF LASING MEDIA - Toxic laser dyes should be handled with lab coat, safety glasses, and gloves. Dyes should be mixed in a properly functioning fume hood and transported in sealed, leak proof containers. Dye pumps should sit in a secondary containment tray. Concentrated halogen gases (greater than 5%) should be used and stored in a properly functioning gas cabinet.

b. ELECTRICAL HAZARDS - Only properly trained and PI approved personnel should work on high voltage systems. The "buddy" system should always be used when working on electrical systems and laboratory staff should be trained in CPR as a safety precaution.

c. COMPRESSED GASES - Staff should be trained in the safe management of cylinders and the hazards associated with the specific compressed gases being used.

d. FIRE PROTECTION - Attention should be given to protection against fires and explosions. Flammable solvents are often used for laser dyes and to clean optical components. Fire extinguishers should be well marked and staff should know how to use extinguishers and the fire alarm system.

e. HOUSEKEEPING - Poor housekeeping (on and off the bench) can create physical hazards. Staff may trip over cables that have not been secured and injuries may result from sharp tools that are not properly stored.

5. SAFETY ASSOCIATED WITH SERVICING OF THE LASER

a. Only PI approved and properly trained personnel should service laser systems. Vendor service staff are required to follow the vendor's laser safety policy. If NJIT staff are assisting the service staff, the NJIT staff must follow campus laser safety policy (eye protection, etc.).

b. If NJIT staff are to perform the service, a written service procedure with safe practice information must be available for reference (often the manufacturer will supply this information). All enclosures, interlocks, and safety devices (shutters, etc.) must be replaced and verified operational prior to returning the laser to service.

c. Safety interlocks shall not be permanently disabled without the consent of the Laser Safety Committee.

Laser Safety Signs & Labels



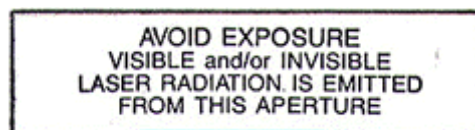
Sticker to mark high voltage hazard power supplies and laser enclosures.



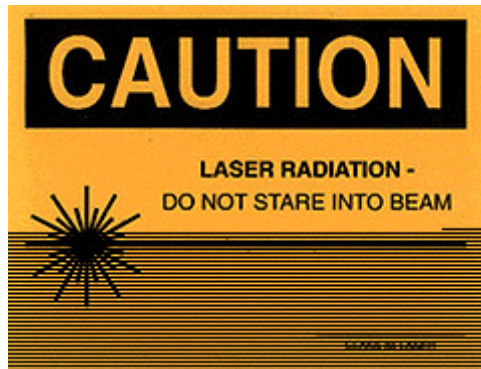
Sticker to mark laser enclosures.



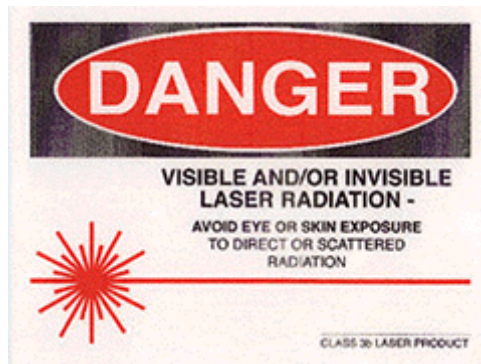
ANSI sign to mark doors to laser labs with Class 4 lasers.



Sticker to mark apertures where laser light is emitted.



ANSI sign to mark doors to laser labs with Class 3a lasers.



ANSI sign to mark doors to laser labs with Class 3b lasers.



Door sign to indicate laser alignment/maintenance.

Laser Use Registration (LUR) Program

The LUR Program

All Class 3a, 3b, and 4 lasers on the NJIT campus are required to be operated under a campus Laser Use Registration or LUR. Use of a Class 3a, 3b, or 4 laser or laser system without an approved LUR is a violation of campus safety policy.

NOTE: Laser pointers, Class 1, and Class 2 lasers are exempt from this requirement.

NOTE: This requirement applies to all laser uses on campus, not just those being used in research.

Obtaining an LUR

To obtain an LUR, please contact the campus Laser Safety Officer (LSO) by phone at 3059. The LSO will prepare an LUR document and inform the LUR holder of the safety requirements under the specific LUR. The LUR is then signed by the LSO and the Chair of the Laser Safety Committee (LSC).

LUR Specifics

The LUR holder (usually the Principal Investigator) is responsible for compliance with all safety precautions spelled out in both the specific LUR and the campus Laser Safety Program. Generally, an LUR is assigned for each laser in a facility. LUR facilities are surveyed on a periodic basis by staff from the Office of Health & Environmental Safety under the direction of the LSO. Survey reports are sent to the LUR holder to inform him/her of any items that need correction. The LSO is available to provide laser safety assistance to the LUR holder upon request.

The LUR holder is responsible for informing the LSO of any changes in laser users operating under the LUR. He/she is also responsible for assuring the laser users submit laser safety training certificates to ORS and that they receive laser eye exams (if required under the LUR).

The LUR holder is also responsible for informing the LSO of any changes in laser use, laser location, or laser transfer (inside or off campus).

For additional information on the LUR Program and on LUR holder responsibilities, see the campus Laser Safety Manual.

Emergency Procedure for Laser Accidents

(Emergency Contact Listing)

In the event of a laser accident do the following:

- 1) Shut down the laser system.
- 2) Provide for the safety of personnel (first aid, evacuation, etc.) as needed.

NOTE: If a laser eye injury is suspected, have the injured person keep their head upright and still to restrict any bleeding in the eye. Laser eye injuries should be evaluated by a physician as soon as possible.

- 3) Obtain medical assistance for anyone who may be injured.

NJIT Police Dept. 3111

NJIT Dept of H&ES 3059

University Health Service (Emergency)

Ambulance (Urgent Medical Care)

- 4) If there is a fire, leave the area, pull the fire alarm, and contact the POLICE department by calling 3111. Do not fight the fire unless it is very small and you have been trained in fire fighting techniques.

- 5) Inform the Office of Health & Environmental Safety as soon as possible.
(During normal working hours, call these numbers)

H&ES 3059

Laser Safety Officer

Radiation Safety Officer

After normal working hours, call the NJIT Police Department ext. 3111

- 6) Inform the Principal Investigator as soon as possible. If there is an injury, the PI must submit a report of injury to Risk Management.
- 7) After an accident, do not resume use of the laser system until the Laser Safety Committee has reviewed the incident.

Safety with Laser Dyes

Overview

Due to their usefulness, many laser laboratories at NJIT use various laser dyes. Most of these dyes come in a solid power form that must be dissolved in solvents prior to use in the laser system. Improper use of dyes or solvents may present a range of hazards for the laser researcher.

Dye Hazards

Although little is known about them, many organic laser dyes are believed to be toxic and/or mutagenic. Because they are solid powders, they can easily become airborne and possibly inhaled and/or ingested. When mixed with certain solvents (DMSO), they can be absorbed through unprotected skin. Direct contact with dyes and with dye/solvent solutions should always be avoided. Contact the LSO at 3059 if you want additional information on laser dye toxicity.

Solvent Hazards

A wide variety of solvents are used to dissolve laser dyes. Some of these (alcohols) are highly flammable and must be kept away from ignition sources. Fires and explosions resulting from improper grounding or overheated bearings in dye pumps are not uncommon in laser laboratories. Dye pumps should be inspected, maintained, and tested on a regular basis to avoid these problems. Additionally, dye lasers should never be left running unattended. Some of the solvents used with laser dyes may also be skin irritants, narcotics, or toxics. You should refer to the Material Safety Data Sheet (MSDS) which is supplied by the solvent manufacturer for additional information on health effects.

Dye/Solvent Handling

Powered laser dyes should never be handled where the airborne dust could be breathed. Dyes must be mixed only in a properly functioning fume hood. The proper protective equipment (PPE = safety glasses, chemical gloves, and lab coat) should always be used by the person handling the dye. The gloves being used should be resistant to the solvent being handled. Mixing of dyes and solvents should be done carefully, so as to avoid spilling. Any spills or leaks should be cleaned up immediately using appropriate PPE. Avoid breathing fumes from the solvent being used. Clearly identify and mark containers used for mixed dye/solvent solutions. Practice good hygiene and wash your hands well after handling dyes.

Storage/Use of Mixed Dye/Solvent

Limit the amount of mixed dye/solvent being stored in the laboratory. Once mixed, the dye/solvent should be stored in sealed Nalgene or other unbreakable plastic containers (beware of solvent incompatibility) until ready to use. Be sure to check transfer lines and pump connections for continuity prior to each use with the dye/solvent. All pumps and dye reservoirs must be placed in trays with sufficient capacity to contain all of the dye/solvent should it leak. This "double containment" method should prevent dye stains on floors and other surfaces.

Dye Waste Disposal

Dyes and dye/solvent solutions are considered hazardous wastes and must be disposed of properly. Contact the NJIT Office of Health and Environmental Safety (H&ES) at 3059 for guidance on proper disposal of hazardous wastes.