

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science
6.161 Modern Optics Project Laboratory

Laboratory Exercise No. 0

SAFETY IN THE LAB

Spring 2023

Agenda for Safety Lab Day

1. Introductions

Everyone sign in and introduce themselves

2. Bags and hands

Bags along the back wall. Wash hands when you arrive

3. Lab Notebook and how lab runs

4. Orientation (where things are)

Start at fire extinguisher, move clockwise around the room (drag everyone along)

5. Chemical, Electrical, and Laser Safety

General

Wear shoes

Pants suggested (leg covering required for holography or chemical work)

Shower and change clothes in the 36 hours preceding lab

No working alone (implications for final projects)

Chemical

No food and drink (EHS rule, this one's absolute)

No eating chemicals (please)

Eyewash station location and use

Chemical disposal

Glove disposal

Electrical

Few experiments (and some final projects) require > 40V

Signs of someone being zapped

How to knock someone loose

Location of circuit breakers and how to turn off

Lasers (you will get more of this as the semester goes on)

Shiny jewelry (none of that)

Watches - remove them

Keep your head out of the laser beam

6. Violations

Persistent and egregious violations will have consequences

(e.g., getting kicked out and failing)

Small errors will evoke warnings

PRE-LAB EXERCISE

Please read this entire safety document. After you have read it, please sign the agreement on the last page of this document (*EECS Electrical Safety Agreement For Staff and Students*) and turn it in to the MOL staff. Be prepared to answer questions about high-voltage and laser safety before arriving at the MOL.

SAFETY IN THE LAB

Why put safety first? Because safety is EXTREMELY important. We strongly urge you to always follow prescribed safety instructions. If you are unsure about anything, especially when dealing with high-intensity light sources (such as lasers) or with high-voltage power supplies (such as those found powering lasers or other laboratory equipment), ask someone who knows (viz., the lab staff). You will receive training on how to deal with lasers and optics, and high voltage sources in this Lab Exercise. Some basic pointers to remember are listed in this document.

1. VIOLATION OF THE SAFETY RULES

Violation of safety rules, if severe enough, may lead to automatic dismissal from the class. Such dismissible offenses include roughhousing, as well as moderate or serious injury due to careless action. Severe safety violations may lead to an automatic failing grade as well as possible action by the Institute or even possible criminal liability. Some general rules follow:

For minor safety violations, you will receive a warning. After two warnings, you will be asked to leave the lab and come back on the next lab day (if it exists). If you are asked to leave due to an accumulation of minor safety violations (more than twice), you will receive an incomplete for the current lab, and therefore will not be able to receive a passing grade for the class.

Safety violations can be caused by a lack of sleep, drug use (antihistamines, pain killers, alcohol, etc.), or emotional strife (daydreaming, family illness, etc.). Therefore, temporary dismissal from the lab is not meant to be punishment, but rather an opportunity for you to remedy what ails you. You may discuss your temporary dismissal with the lab staff AFTER the lab day. However, no excuses or arguments will be accepted at the time of dismissal - arguing will only result in disciplinary measures. So far, we have never had to dismiss a student for safety violations... please don't be the first.

2. SAFETY TRAINING

2(a) Laser safety (through MIT EHS)

Some of the experiments we will perform in Modern Optics Lab require the use of class 3B and class 4 lasers. The laser classes are defined in Appendices 1 and 2. For example, the lasers used in the holography lab (3B by output power) and some of the lasers that you may want to build as final projects could be class 3B/4 by power or wavelength.

To meet MIT's Environmental Health and Safety (EHS) requirements **all undergraduates taking the class must complete a laser safety training class. Any graduate student who would like to participate in labs involving our higher-power lasers must also complete a EHS laser safety training class, as described below.** To sign up for one of the EHS laser safety classes, go to: <http://atlas.mit.edu/> and click on >Learning Center > Course Catalog > scroll to Radiation Safety > Laser Safety. Both in-person and Web-based classes are offered. In the meantime, some quick tips for working with lasers are given in the summary below, and more details are given in Appendices I and II. **Please read both Appendices now.**

Summary of Laser Safety Requirements

1. Never look directly into a laser source, even low-power lasers can blind!
2. Keep track of all stray light (and then block it).

3. Keep all high-intensity light beams at table-level.
4. Always keep your eyes a couple feet above table level. If you violate this exclusion zone, you will be asked to either leave the laboratory for the day, or you will be excluded from working on your project or laboratory exercise.
5. Wear safety glasses when appropriate. You MUST wear them when working with IR and UV laser light, as well as with mercury discharge lamps and strong light sources.
6. Keep your colleagues notified - tell them what you are doing so that they may protect themselves (and you). Always notify them if you turn on a laser or change the direction of the beam. Precautions also include closing the laboratory door, closing the window drapes (if appropriate), as well as turning on the laser warning light (light switch behind the chemical cabinet).
7. Always listen to the suggestions of the laboratory staff and your colleagues.
8. Keep your optics (lenses, mirrors, beam splitters) clean to reduce scattered light
9. Practice good common sense.
10. Institute policy requires that all persons working with high-voltage work in pairs. (see high voltage safety requirements below).
11. No drinking or eating is allowed in the lab. Hands must be washed before handling optics or electronics.
12. You may not work in the lab without supervision of an LA or a TA until final-project time. During final-project time you must work in pairs (only the TA, LA or lecturer may ever be in the lab alone).
13. Cell phones (except for the lab staff) are not allowed to be turned on inside the Modern Optics Lab.
14. Always inspect optical fiber carefully - bare fiber can easily puncture your skin or eye!

More, very important details for working safely with lasers are given in Appendices 1 and 2. Reading of these materials is essential, but that is not intended to be a substitute for taking the EHS course. A brief discussion about the human eye and the damage thresholds for laser light is contained in Appendix 2.

2(b) Chemical Safety

We are also requiring that everyone participating in the holography lab complete the EHS required online chemical safety classes. The required chemical safety classes can be completed online and will take about 2 hours (faster if you read quickly). We would like you to take the online versions of the two courses listed below:

1. General Chemical Hygiene
2. Managing Hazardous Waste

2(c) High-Voltage Safety

In the lab on electro-optic and acousto-optic light modulation, students will be working with high voltage amplifiers. Further, some of the final projects carried out by the students in this class also involve the use of high voltage. Therefore, all 6.161 students and graduate students intending to work in the laboratory must receive high-voltage training. Our department offers beginning-of-term safety training on high voltage use. Please sign up for one of these sessions. A list of tips for working with high voltage (from the MIT EECS department) is given in summary below.

Summary of High Voltage Safety Requirements

1. **SHIELDING:** Live parts of all electrical equipment must be completely enclosed or otherwise guarded against accidental contact.

2. **INTERLOCKING:** Where continual maintenance or adjustments must be performed, enclosing shields must be provided with interlocks which will disconnect all power to conductors and short out capacitors when the shield is removed or opened.
3. **DISCONNECTS:** Provide an accessible, labeled main power disconnect switch.
4. **GROUNDING:** Ground all exposed non-current carrying parts. (Metallic optical table tops should be grounded to the nearest water pipe.)
5. **BONDING:** All grounded parts must be bonded to each other to keep them at the same grounded electrical potential.
6. **INSULATORS:** Adjustment mechanisms must be insulated from live electrical parts or be made of nonconductive material.
7. **SPACE:** A minimum of 30 inches width should be maintained on all working sides of equipment operating at 600 volts or less; 36 inches if over 600 volts.
8. **WORKING ALONE:** Working alone at any time is contrary to Institute policy.
9. **CPR:** It is recommended that all persons working with high voltage have training in cardiopulmonary resuscitation, available through the EHS, through the American Red Cross or through the American Heart Association.

More important electrical safety details are provided in two EECS documents in Appendix 3 of this handout. The documents are titled "*ELECTRICAL SAFETY FOR STAFF AND STUDENTS IN EECS DEPARTMENT TEACHING LABORATORIES*" and "*BASIC ELECTRICAL SAFETY PRACTICES*". **After reading these two documents, the last page must be signed and returned to the Modern Optics Lab TA who then turn in your signed form to the EECS Department.**

APPENDIX 1

LASER SAFETY

The Helium-Neon laser used in the Optics Laboratory produces an intense beam of light. The power level of the weakest laser used in the Optics Laboratory is approximately 1.5 mW. This is a low-power laser. The beam will not harm the skin, even upon direct exposure. The human eye, however, is much more susceptible to injury by laser light. The lens of the eye focuses the beam to a very small spot on the retina, the light sensitive layer at the back of the eye. The resulting high intensity may lead to a local burn, which may cause degradation of vision, depending on the exact location and size of the spot.

The components of the eye are vulnerable to different wavelengths of electromagnetic radiation. Each wavelength region must be considered separately when evaluating the potential hazards. The far ultraviolet and the far infrared wavelengths are entirely absorbed by the cornea and the lens. Near ultraviolet light is partially absorbed in the cornea, lens and the retina, and can damage all three. Light with visible or near infrared wavelengths poses the greatest danger to the retina because the lens focuses these wavelengths on the retina.

Tissue damage by heating occurs when the heat energy deposited by light exceeds the capacity of the tissues to safely carry the heat away. Lasers hazards are characterized by Classes. The class of a laser depends on the laser power and on the emission wavelength. The Class of a laser is defined by the American National Standards Institute (ANSI) according to the degree of hazard presented.

CLASS I LASERS: Class I lasers are low-powered and **do not emit** hazardous radiation under normal operating



conditions because they are completely enclosed. Class I lasers are exempt from any control measures. Equipment, such as laser printers and laser disc players, are examples of this class.

CLASS II LASERS: Class II lasers emit accessible visible laser light with power levels **less than 1 mW** radiant power and are capable of creating eye damage through chronic exposure. The human eye blink reflex, which occurs within 0.25 seconds of exposure to the Class II laser beam, provides adequate protection. It is possible to overcome the blink response and stare into the Class II laser long enough to damage the eye. Class II lasers are exempt from any control measures. Equipment, such as some visible continuous wave Helium-Neon lasers and some laser pointers, are examples of Class II lasers.

CLASS IIa LASERS: Class IIa lasers are special purpose lasers that emit accessible visible laser light with power levels **less than 1 mW** radiant power and are not intended for viewing. This class of lasers causes injury when viewed directly for more than 1,000 seconds. Class IIa lasers are exempt from any control measures. Equipment, such as some bar code readers, are examples of Class IIa lasers.

CLASS IIIa LASERS: Class IIIa lasers are systems with power levels of **1 to 5 mW** that normally would not produce a hazard if viewed for only momentary periods with the unaided eye. They pose severe eye hazards when viewed through optical instruments (e.g., microscopes, binoculars, or other collecting optics). Class IIIa lasers must be labeled. A warning label shall be placed on or near the laser in a conspicuous location and caution users to avoid staring into the beam or directing the beam toward the eye of individuals. Equipment, such as some visible continuous wave Helium-Neon lasers and some solid state laser pointers, are examples of Class IIIa lasers.

CLASS IIIb LASERS: Class IIIb lasers are systems with power levels of **5 mW to 500 mW for continuous wave lasers or less than 10 J/cm² for a 0.25 s pulsed laser**. These lasers will produce an eye hazard if viewed directly. This includes intrabeam viewing or specular reflections. Higher power lasers in this class will also produce hazardous diffuse reflections. Specific control measures covered in Class IIIb lasers shall be used in areas where entry by unauthorized personnel can be controlled. Entry into the area by personnel untrained in laser safety may be permitted by the laser operator if instructed in applicable safety requirements prior to entry and provided with required protective eye wear.

CLASS IV LASERS: Class IV lasers are systems with power levels **greater than 500 mW for continuous wave lasers or greater than 10 J/cm² for a 0.25 s pulsed laser**. These lasers will produce eye, skin and fire hazards. This includes intrabeam viewing, specular reflections or diffuse reflections.

EMBEDDED LASERS: Embedded lasers are found in laser products with lower class ratings. Laser printers, CD players, and laser welders may have Class III or Class IV lasers in their protective and interlocked housings. When such a laser system is used as intended, the lower laser class applies. When such a system is opened (e.g., for service or alignment) and the embedded laser beam is accessible, the requirements for the higher class of the embedded laser must be implemented.

Laser Safety Guidelines

Follow these guidelines at all times to insure the safety of yourself and others working in the Optics Laboratory

- Be aware of the laser hazards present.
- Know the appropriate laser Class and take the necessary precautions.
- Follow operation instructions carefully.
- Never point a laser beam at a person.
- Never look directly into the laser beam.
- Never look directly into specular, mirror-like reflections of the laser beam.
- Do not wear any objects on your hands and wrists that may cause specular reflection, such as watches or jewelry.
- Do not let the laser beam or any of its reflections leave the experiment table unless the experiment requires it.
- Keep all the beams in a plane parallel to the experiment table.
- Do not bring your eye level down to the plane of the laser beam, keep the beam axis below typical standing and sitting positions.
- Close your eyes if you bend down to pick something up off the floor.
- Use beam stops and carefully plan the placement and movement of optical elements.
- Laser light scattered by rough surfaces, such as paper is harmless to the eye at low power levels. However, it is still a good idea not to stare at bright diffuse spots for a long time.
- Leave the room lights **ON** when possible. The eye's pupils open wide in a dark room and present a larger target for dangerous laser light.
- Use common sense and be alert at all times.

APPENDIX 2

From Laser Safety Program, sixth edition, MIT Radiation Protection Committee, January 2003, pp 7-13

VII. Laser Classifications

The American National Standards Institute (ANSI) has established a laser hazard classification system in publication ANSI Z136.1-1993, Safe Use of Lasers. Certified laser manufactures are required to label their products as to the Class type as of September 19, 1985 (21 CFR Part 1040). Information regarding appropriate eyewear for a specific laser may be obtained from the manufacturer at time of purchase. The following table summarizes this laser classification scheme and the hazard capabilities associated with each class of laser.

Class	Hazard Capabilities
1	Cannot produce hazardous radiation.
2	Continuous intrabeam exposure damages the eye. Momentary intrabeam exposure (<0.25 seconds) is not damaging to the eye. Visible radiation only.
2a	Continuous intrabeam exposure damages the eye. The accessible radiation shall not exceed Class 1 AEL for an exposure duration <10 ³ seconds.
3a	Eye damage may occur if the beam is viewed directly or with optical instruments.
3b	Eye and skin damage will occur for direct, momentary intrabeam exposure.
4	Can damage the skin as well as the eye during direct, momentary intrabeam exposure or exposure to diffuse reflections. Potential fire hazard.

VIII. Eye Protection and Maximum Permissible Exposures

Laser irradiation of the eye may cause damage to the cornea, the lens, or the retina, depending on the wavelength of the light and the energy absorption characteristics of the ocular media (see Fig.1). Lasers cause biological damage by depositing heat energy in a small area, or by photochemical processes. Infrared, ultraviolet, and visible laser radiation are capable of causing damage to the eye.

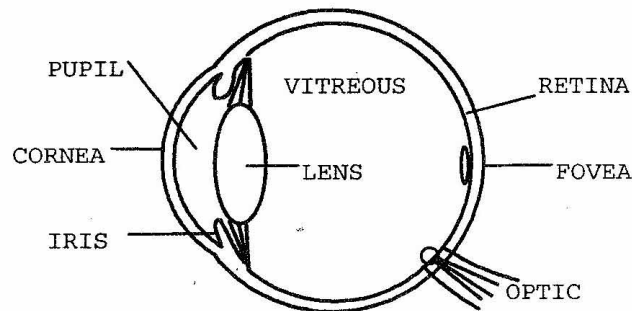


Figure 1, Schematic Diagram of the Human Eye

1. Retinal Damage

Visible and Infrared A (Spectral Regions 400-760 nm and 760-1400 nm)

Visible and infrared A wavelengths penetrate through the cornea to be focused on a small area of the retina, the fovea centralis (see Fig. 2). This process greatly amplifies the energy density and increases the potential for damage. Lesions may form on the retina as a result of local heating of the retina subsequent to absorption of the light.

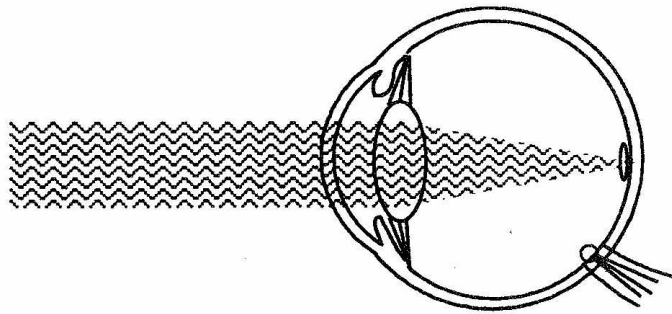


Figure 2, Ocular Absorption of Visible Light and Infrared A

2. Lens Damage

Ultraviolet A (Spectral Region 315-400 nm)

Wavelengths in this spectral region is primarily absorbed in the lens (Figure 3). Damage to this structure, either photochemical or thermal, disrupts the precise relationship between the tissue layers of the lens. This results in areas of increased light scatter - a cataract. Under normal conditions, the lens will begin to harden with age. Exposure to UV-A accelerates this process and may lead to presbyopia (the loss of the ability of the lens to accommodate or focus).

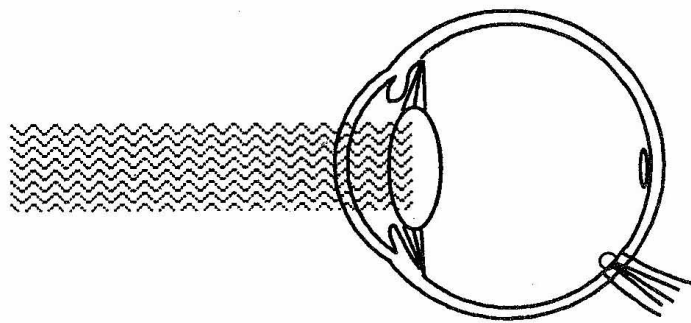


Figure 3, Ocular Absorption of Ultraviolet A

3. Corneal Damage

Infrared B and Infrared C (Spectral Region 1.4 to 100 μm)

The Cornea of the eye is opaque to infrared radiation (Figure 4). The energy in the beam is absorbed on the surface of the eye and damage results from heating of the cornea. Excessive infrared exposure causes a loss of transparency or produces a surface irregularity on the cornea.

Ultraviolet B and Ultraviolet C (Spectral Region 100-315 nm)

The cornea of the eye is also opaque to ultraviolet radiation. As with infrared radiation, the energy of the beam is absorbed on the surface of the eye and corneal damage results (Figure 4). Excessive ultraviolet exposure results in photokeratitis (Welder's Flash), photophobia, redness, tearing, conjunctival discharge, and stromal haze. There is a 6-12 hour latency period before symptoms to photochemical damage appear.

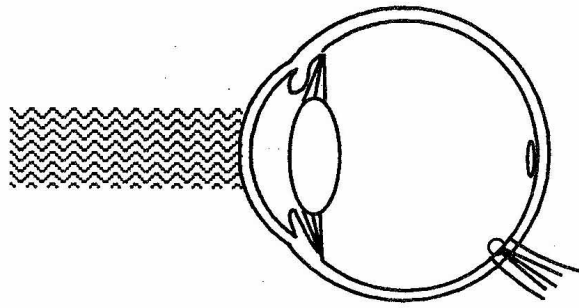


Figure 4, Ocular Absorption of Infrared B, Infrared C, Ultraviolet B and Ultraviolet C

4. Other Ocular Damage

There are two transition zones between corneal hazard and retinal hazard spectral regions. These are located at the bands separating UV-A and visible, and IR-A and IR-B regions. In these regions, there may be both corneal and retinal damage. An example of this hazard would be the Nd: YAG near-infrared region laser. This wavelength can be focused by the eye but not perceived by it. Damage can thus be done to the retina in the same manner as visible light even though the beam itself remains invisible.

5. Maximum Permissible Exposure (MPE)

On the basis of retinal damage thresholds and concentrations of light by the lens, maximum permissible exposure limits have been recommended by the American National Standards Institute (ANSI Z136.1-1993). The MPE values for visible light are based on a pupil diameter of 7 mm, which is considered to be the maximum opening of the iris of the eye. For other wavelengths, the incident laser energy is averaged over a 1 mm diameter circle. The MPE values are below known hazardous levels. However, the MPE values may be uncomfortable to view. Thus, it is good practice to maintain exposure levels as far below the MPE values as practical.

6. Protective Eyewear

ANSI Z136.1-1993 requires that protective eyewear be available and worn whenever hazardous conditions may result from laser radiation or laser related operations. The eye may be protected against laser radiation by the use of protective eyewear that attenuates the intensity of laser light while transmitting enough ambient light for safe visibility (luminous transmission). The ideal eyewear provides maximum attenuation of the laser light while transmitting the maximum amount of ambient light. No single lens material is useful for all wavelengths or for all radiation exposures. In choosing protective eyewear, careful consideration must be given to the operating parameters, MPEs, and wavelength. The Radiation Protection Program will recommend the appropriate laser safety eyewear during the laser registration process. A list of laser safety eyewear manufacturers can be found in **Appendix J**.

Persons working with lasers emitting in the visible region are often unwilling to wear protective eyewear during alignment procedures due to the inability to see the beam. Laser alignment goggles are available which provide acceptable protection during reduced power alignment procedures while allowing an outline of the beam to be seen. Appropriate eyewear information may be acquired for a particular laser from the manufacturer at the time of purchase. Insight as to proper and reasonable eye protection may also be obtained from the Radiation Protection Program. It is recommended that the RPP evaluate all protective eyewear.

It is extremely important that laser workers wear the appropriate laser safety eyewear correctly. For example, only eyewear such as goggles specifically designed to fit over prescription glasses may be worn with prescription glasses. Other protective eyewear worn over prescription glasses may not provide complete eye protection.

Summary Table

Spectral Region	Wavelength	Principal Tissue at Risk
Ultraviolet C	100 - 280 nm	Cornea
Ultraviolet B	280 - 315 nm	Cornea
Ultraviolet A	315 - 400 nm	Lens
Visible Light	400 - 760 nm	Retina
Infrared A	760 -1400 nm	Retina
Infrared B	1.4 - 3.0 μ m	Cornea
Infrared C	3.0 - 1000 μ m	Cornea

IX. Skin Exposure and Maximum Permissible Exposures

Acute exposure of the skin to large amounts of energy from the laser may cause burning of the skin. These burns are similar to thermal or radiant (sun) burns. The incident radiation is converted to heat which is not dissipated rapidly enough due to poor thermal conductivity of the tissue. The resulting local temperature rise causes denaturation of tissue protein. Injury of the skin depends on the wavelength of laser light, exposure time, and degree of skin pigmentation. Skin carcinogenesis may occur at some specific ultraviolet wavelengths (290-320 nm).

X. Electrical Hazards

There have been several electrocutions in the U.S. from laser-related electrical accidents. These accidents could have been prevented. Contact the MIT Safety Program if you have

any questions concerning electrical safety and the MIT Electrical Safety Program. The following are general guidelines to prevent electrical shock:

1. Avoid wearing rings, metallic watchbands and other metallic objects.
2. When possible, only use one hand when working on a circuit.
3. Assume that all floors are conductive when working with high voltage.
4. Check that each capacitor is discharged, shorted and grounded before allowing access to the capacitor area.
5. Inspect capacitor containers for deformities or leaks.
6. Provide such safety devices as appropriate rubber gloves and insulating mats.
7. Do not work alone.
8. Specific approval is required to work on live electrical equipment.
9. The requirements of the MIT lockout/tagout program must be implemented as required.

XI. General Safety Procedures

1. Do not work with or near a laser unless you have been authorized to do so.
2. Do not enter a room or area where a laser is be energized unless authorized to do so.
3. Before energizing a laser, verify that prescribed safety devices for the unit are being properly employed. These may include opaque shielding, non-reflecting and/or fire-resistant surfaces, goggles and/or face shields, door interlocks, and ventilation for toxic material.
4. Make sure that a pulsed laser unit cannot be energized inadvertently. Discharge capacitors and turn off power before leaving the laser unit unattended.
5. Don't stare directly into the laser beam. Use appropriate eyewear during beam alignment and laser operation. Beam alignment procedures should be performed at lowest practical power levels.
6. Control the access to the laser facility. This can be done by clearly designating those who have access to the laser room. Implement access control by locking the door and installing warning lights and signs on the outside door.
7. Never leave the laser unattended when it is in operation.
8. Remove any jewelry to avoid inadvertent reflections.

XII. Laser Safety Controls

- A. Class 1 Controls** No user safety rules are necessary.
- B. Class 2 Controls**

1. Never permit a person continuously stare into the laser source.
2. Never point the laser at an individual's eye unless a useful purpose exists and the exposure level and duration will not exceed the permissible limit.

C. Class 3b Controls

1. Do not aim the laser at an individual's eye.
2. Permit only experienced personnel to operate the laser.
3. Enclose as much of the beam path as possible. Even a transparent enclosure will prevent individuals from placing their head or reflecting objects within the beam path. Terminations should be used at the end of the useful paths of the direct beam and any secondary beams.
4. Shutters, polarizers and optical filters should be placed at the laser exit port to reduce the beam power to the minimal useful level.
5. Control spectators.
6. A warning light or buzzer should indicate laser operation. This is especially needed if the beam is not visible, i.e., for infrared lasers.
7. Do not permit laser tracking of nontarget vehicles or aircraft.
8. Operate the laser only in a restricted area - for example, in a closed room without windows. Place a warning sign on the door.
9. Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible. The laser should be mounted firmly to assure that the beam travels only along its intended path.
10. Always use proper laser eye protection if a potential eye hazard exists for the direct beam or a specular reflection (Figure 5).
11. A key switch should be installed to minimize tampering by unauthorized individuals.
12. The beam or its specular reflection should never be directly viewed with optical instruments such as binoculars or telescopes without sufficient protective filters.
13. Remove all unnecessary mirror-like surfaces from the vicinity of the laser beam path. Do not use reflective objects such as credit cards to check beam alignment.
Note that the reflectivity of an object is a function of the wavelength of the laser beam.

D. Class 4 Controls

1. All controls listed for Class 3b laser systems also apply to Class 4 lasers.
2. These lasers should only be operated within a localized enclosure, in a controlled workplace, or where the beam is directed into outer space. If a complete local enclosure is not possible, indoor laser operation should be in a light-tight room with interlocked entrances to assure that the laser cannot emit energy while a door is open.
3. Appropriate eye protection is required for all individuals working within the controlled area.
4. If the laser beam irradiance is sufficient to be a serious skin or fire hazard, a suitable shielding should be used between the laser beam and any personnel or flammable surfaces.

APPENDIX 3

Department of Electrical Engineering & Computer Science

Electrical Safety

for Staff and Students in EECS Department Teaching Laboratories (DTL)

NEVER WORK ALONE

If you will be working with energized circuits or equipment **over 50 volts peak or 50 volts DC**, make sure that at least one other person can see you and hear you. In case of emergency **DIAL 100** from any institute phone [**617-253-1212** from cell phones]; and notify the stock clerk or lab instructor on duty.

VOLTAGE RULES

All EECS Department Teaching Laboratories lab kit voltages are **below 50 volts peak or 50 volts DC**. (OSHA permits “unqualified persons” to work on such circuits with “awareness-type” training, which is what this document is.)

If you intend to work on a project using power sources **over 50 volts peak or 50 volts DC**, you must first **secure permission** from your Faculty or Staff Instructor; and take an ***Electrical Safety Familiarization class*** from either David Lewis [38-501, 617-653-5629] or Karl Berggren [36-219, 324-0272] **before** any work on the project begins.

No power tools or energized machine tools are to be used in the Teaching Laboratories without prior review by David Lewis and Karl Berggren and the Course Instructor.

PREVENT ACCIDENTS: FOLLOW THIS ADVICE

- Never hurry. Work deliberately and carefully.
- Connect to the power source **LAST**.
- If you are working with a lab kit that has internal power supplies, **turn the main power switch OFF** before you begin work on the circuits. Wait a few seconds for power supply capacitors to discharge. These steps will also help prevent damage to circuits.
- If you are working with a circuit that will be connected to an external power supply, **turn the power switch of the external supply OFF** before you begin work on the circuit.
- Check circuit power supply voltages for proper value and for type (DC, AC, frequency) before energizing the circuit.
- Do not run wires over moving or rotating equipment, or on the floor, or string them across walkways from bench-to-bench.
- Remove conductive watchbands or chains, finger rings, wristwatches, etc., and do not use metallic pencils, metal or metal edge rulers, etc. when working with exposed circuits.
- When breaking any high-voltage or high current inductive circuit open the switch with your left hand and turn your face away to avoid danger from any arc which may occur across the switch terminals.

- When using large electrolytic capacitors be sure to wait long enough (approximately five time constants) for the capacitors to discharge before working on the circuit.
- All conducting surfaces intended to be at ground potential should be connected together.

ADDITIONAL CAUTIONS

- The EECS Department Teaching Laboratories (38-500, 38-600, 38-601) are equipped with Ground Fault Current Interrupt (GFCI) circuit breakers. Check for leakage paths to ground when breakers trip repeatedly and the problem is not due to an overload.
- Any equipment used in the laboratories must be equipped with a standard three-prong AC plug or a two-pronged polarized plug.
- All exposed non-current-carrying metal parts of fixed and portable equipment that may accidentally become energized should be grounded.
- All electrical equipment or apparatus that may require frequent maintenance must be capable of being completely disconnected from the power source.
- Do not bring into the lab or use in the lab equipment that does not conform to these rules.

ACTIVITIES REQUIRING SPECIAL CONSIDERATION

The "50 Volt" safety voltage, below which a student may work with the "awareness training" provided by this document, is a necessary guideline, but not a sufficient condition to ensure safety in all situations. For example, batteries may be below 50 volts, but may be capable of tremendous short-circuit currents that can cause arcs and injuries. Experiments under and over 50 volts can produce excessive temperatures that can cause burns, electromagnetic forces that throw metal, blinding light, and extreme magnetic or electric fields that can interfere with medical implants or attract metal jewelry with tremendous force.

Course Instructors are responsible for ensuring the safety of experiments conducted in the EECS teaching laboratories, whether or not these activities are over or under 50 volts.

For experiments over 50 volts, students must attend the Electrical Safety Familiarization class. Further, before any experiment over 50 volts is energized, the physical experiment must be reviewed by the Course Instructor. Such experiments should have an obvious electrical shutdown in case of emergency. A procedure should be developed for using the experiment, and this procedure must be clearly discussed by the Instructor with students conducting the experiment. Students should demonstrate their understanding of proper procedures to the Course Instructor. Example considerations for proper procedures would include, but are not limited to:

- Ensuring the presence of a clear and accessible electrical shutdown for the experiment in case of emergency.
- Is the experiment mechanically secure? An open, line-operated chassis balanced on a stool or rolling cart is not, for example, a satisfactory mechanical setup.
- Do the students, staff, and faculty involved in an experiment understand and follow a procedure for using their experiment safely? For example, do they know not to move probes or touch the circuit while it is activated?
- Are voltages above 50 volts or conductors carrying large currents adequately insulated and mechanically mounted?
- Do the students, staff, and faculty have appropriate safety glasses, thermal protection, and any other equipment necessary to protect from unique aspects of their experiments? Safety glasses should **always** be worn for experiments over 50 volts.

These are examples and guidelines and are **not** exhaustive. No experiment should be conducted or undertaken if the safety considerations associated with the activity are not understood or cannot be determined by the participants. No experiment should be conducted or undertaken if proper procedures have not been developed and promulgated to ensure safe and effective activities in the laboratory.

If in doubt, do **not** do the experiment.

Students are expected to insist on person-to-person review with the Course Instructor for any and every experiment that exceeds 50 volts before the experiment is activated.

Course Instructors should review any questions or concerns with Karl Berggren and David Lewis prior to issuing a lab activity or experiment to students.

LASER LABORATORY SAFETY

- Students who intend to use laser systems **must** read the Radiation Protection Office (RPO) Laser Safety Program Handbook **before** working with lasers. Copies of this handbook are available from the 38-501 Stockroom.
- Students must attend the RPO Safety Training Seminar if they will be using Class III or IV lasers.

RIGHT-TO-KNOW LAW (OSHA HAZARD COMMUNICATION STANDARD)

- OSHA requires MIT to inform employees (and MIT requires students be informed the same as employees) about potential exposure to hazardous chemicals and about the Institute's Hazard Communication Program and the requirements of the Federal Right-to-Know Law. Your supervisor/instructor and department are responsible for providing you with safety information and/or training on:
 - MIT Policies and Procedures on Environmental Health & Safety
 - Material Safety Data Sheets
 - Labeling requirements for all hazardous materials
 - The location of the hazardous material inventory of your work area
 - Any operations in your work area that involve hazardous chemicals and the associated health and safety hazards
 - Safety precautions and procedures
 - Emergency procedures
 - The hazards of tasks done infrequently
- The OSHA Hazard Communication Standard and MIT's written Hazard Communication Program are on file in the MIT Safety Office and will be made available to any member of the MIT Community, upon request.

QUESTIONS ABOUT WORK/SCHOOL SAFETY

- Any questions about work or school safety should be brought to the attention of your immediate supervisor or instructor. If problems arise that cannot be solved at this level, you should contact the EECS Teaching Laboratories EHS representative:

David Lewis

Rm. 38-501

617-653-5629

dlew123 @ MIT.EDU

BASIC ELECTRICAL SAFETY PRACTICES

The Institute requires everyone who uses electrical equipment to understand these safety precautions to comply with the OSHA Electrical Safety-Related Work Practices standard and MIT's electrical safety policies. The following safe work practices can prevent electrical shock. Contact your supervisor for additional safety training if your job involves repairing, installing or working on energized parts.

A. Safe Work Practices

1. Turn off and unplug equipment (instead of relying on interlocks that can fail) before removing the protective cover to clear a jam, replace a part, adjust or troubleshoot. Ask a qualified person to do the work if it involves opening equipment and creating an exposure to energized parts operating at **50 volts peak or 50 volts DC** or more.
2. Don't use an electrical outlet or switch if the protective cover is ajar, cracked or missing. Call FIXIT (x3-4948) and report this.
3. Only use DRY hands and tools and stand on a DRY surface when using electrical equipment, plugging in an electric cord, etc.
4. Never put conductive metal objects into energized equipment.
5. Always pick up and carry portable equipment by the handle and/or base. Carrying equipment by the cord damages the cord's insulation.
6. Unplug cords from electrical outlets by pulling on the plug instead of pulling on the cord.
7. Use extension cords temporarily. The cord should be appropriately rated for the job.
8. Use extension cords with 3-prong plugs to ensure that equipment is grounded.
9. Never remove the grounding post from a 3-prong plug so you can plug it into a 2-prong wall outlet or extension cord.
10. Re-route electrical cords or extension cords so they aren't run across the floor, under rugs or through doorways, etc. Stepping on, pinching or rolling over a cord will break down the insulation and will create shock and fire hazards.
11. Don't overload extension cords, multi-outlet strips and wall outlets.
12. Heed the warning signs, barricades and/or guards that are posted when equipment or wiring is being repaired or installed or if electrical components are exposed.
13. Do not move probes or connectors while an experiment is activated. Turn off the experiment, set up the measurement, then activate the experiment.

B. *Check for Unsafe Conditions* (either before or while you're using equipment:)

1. Is the cord's insulation frayed, cracked or damaged, exposing the internal wiring?
2. Are the plug's prongs bent, broken or missing, especially the third prong?
3. Is the plug or outlet blackened by arcing?
4. Was liquid spilled on or around the equipment?
5. Are any protective parts (or covers) broken, cracked or missing?
6. Do you feel a slight shock when you use the equipment?
7. Does the equipment or the cord overheat when it is running?
8. Does the equipment spark when it is plugged in or when switches or controls are used?

C. **If you observe any of these unsafe conditions:**

1. Don't use (or stop using) the equipment.
2. Tag/label the equipment UNSAFE--DO NOT USE and describe the problem.
3. Notify your supervisor, FIXIT or the service company, as appropriate.

Electrical safety is for everyone because even contact with the standard 120-volt AC electrical circuits, which we constantly use, can be lethal under certain conditions.

EECS Electrical Safety Agreement For Staff and Students

I CERTIFY THAT I HAVE READ AND UNDERSTOOD **"ELECTRICAL SAFETY FOR STAFF AND STUDENTS IN EECS DEPARTMENT TEACHING LABORATORIES"** AND **"BASIC ELECTRICAL SAFETY PRACTICES"** AND I AGREE TO ABIDE BY THOSE RULES AT ALL TIMES WHILE I AM ENROLLED IN ANY EECS LABORATORY COURSE, OR WHILE TEACHING OR ASSISTING IN A LABORATORY COURSE.

TA's & LA's ASSIGNED TO ANY ONE OF THE LISTED SUBJECTS MUST, AS A CONDITION OF EMPLOYMENT, ATTEND ONE OF THE ELECTRICAL SAFETY TRAINING LECTURES HELD DURING THE FIRST WEEKS OF THE SEMESTER. EXACT TIMES AND PLACE WILL BE POSTED. ALL OTHER STUDENTS: FILL OUT, SIGN, AND RETURN THIS PAGE ONLY TO ONE OF THE EECS STOCKROOM WINDOWS at 38-501 or 38-601, IN ORDER TO RECEIVE YOUR LAB KIT.

[No laboratory kits or supplies or equipment will be issued to students until this form is filled out and signed and on file at the EECS stockroom in 38-501.]

SIGNED: _____

PRINT NAME: _____

MIT ID NUMBER: _____

DATE: _____

SUBJECT NUMBER: _____(specify)