Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

Electrical Safety for Staff and Students in EECS Instructional Laboratories

6.117 Introduction to Electrical Engineering Lab Skills (IAP 2020)

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.

SOLDERING RULES

Potential Hazards

- **Ingestion and Inhalation of Lead Solder or Flux/Rosin Solder**: Surface contamination of lead solder can result in ingestion of lead, a known neurotoxin. Over-exposure of lead fume inhalation can give rise to chronic health effects. Reduced ventilation when using a Flux/Rosin Solder can result in respiratory irritation and/or eye irritation.
- **Burns and Fire**: Heated parts from the iron will be extremely hot and can easily burn through skin contact or could cause a fire if placed on flammable materials.
- **Electrical**: Frayed electrical cords could be a fire and/or shock hazard.

General Safety Precautions

A. Soldering Iron Safety
    1. Never touch the element or tip, of the soldering iron. Temperatures at the element and tip of the soldering iron can exceed 400 °C, hot enough to burn flesh instantly.
    2. Ensure that tweezers, pliers or clamps are available to hold wires that are to be heated to avoid potentially receiving burns from objects that are heated.
    3. Always return the soldering iron to its stand when not in use. Never lay it directly on your workbench.
    4. **Turn OFF or unplug the soldering iron when it is not in use.** Unattended soldering equipment poses a fire hazard, and leaving the tip hot for long periods of time will oxidize the tip and render it useless.

B. Fire Prevention
    1. Conduct work on a nonflammable surface that is not easily ignited. The EECS Laboratories are equipped with heat-resistant ceramic tiles for this purpose.
    2. Wear non-flammable clothing that covers your arms and legs. Flux and molten solder can splatter during soldering and can cause burns and irritation to exposed skin.

C. Housekeeping
    1. Be sure to label all cleaning solvents clearly (ex. Isopropanol rather than IPA).
    2. Always wash your hands with soap and water after soldering.
    3. **DO NOT eat or bring food into any spaces where soldering occurs.** Beverages must be lidded and kept in a separate area where soldering occurs.

Personal Protective Equipment (PPE)

- **Protective Clothing**: To prevent burns from splashes or hot solder, long sleeve shirts and pants should be worn. Closed-toed shoes are required in all EECS Instructional Laboratories.
- **Eye protection**: Safety glasses, goggles, or face shields must be worn when soldering and clipping wires.

First Aid

If you touch the element or tip of a soldering iron, immediately cool the affected area **under cold water for 15 minutes.** Seek medical attention if the burns cover an area bigger than 3 inches across.

VOLTAGE RULES

All EECS Instructional 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[1] or Karl Berggren[2] **before** any work on the project begins.

No power tools or energized machine tools are to be used in the Instruction 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 RC 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 Instructional 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-prong 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.

[1] Office: 38-501; Phone: (617) 653-5629
[2] Office: 36-219; Phone: (617) 324-0272

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
Room 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 Safety Form

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I CERTIFY THAT I HAVE READ AND UNDERSTOOD *"ELECTRICAL SAFETY FOR STAFF AND STUDENTS IN EECS INSTRUCTIONAL 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.]

X _____ X _____

Student's signature Date

X _____

Student's name (printed)