Facilities and Procedures

A. OFFICES, CLASSROOMS AND LABORATORIES

Summarize each of the program's facilities in terms of their ability to support the attainment of the student outcomes and to provide an atmosphere conducive to learning.

1. **Classrooms and associated equipment that are typically available where the program courses are taught.**

The 11,000-square-foot SHU IDEA Lab, or Makerspace, was created to improve experiential learning for SHU students. Innovative machinery makes the development and prototype of new products possible, providing space for applied learning courses across the University. While the space is open to the university, it is considered the home for Engineering as all Engineering classes are held in the lab. The IDEA Lab supports high-tech manufacturing, digital design, 3D printing, laser cutting, characterization, and assembly. Every full-time employee is provided with private office space. The IDEA Lab is located on the first floor of the West Building (W-167) on Sacred Heart University's West Campus.

A1. Engineering Classroom

There is one dedicated classroom within the lab (W-182), which can accommodate 30 students. The instructor's podium area is equipped with a desktop computer, overhead projector, and cabling for external devices (e.g. instructor laptop) to be projected on the screen. The classroom also has a ceiling camera for remote student access, online guest speaker presentations, and lecture recording/capturing. Custom-designed furniture in the classroom allows a tidy setup for equipment cables and probes. Each Engineering course has its designated drawer to store teaching material and student projects. Hardware components (e.g., resistors, capacitors, integrated circuits, sensors, microcontrollers, breadboards, and multimeters) are stored in cabinets and shelving units.

The classroom is also equipped with nine desktop computers for students to utilize Engineering software (MATLAB, ORCAD, drone simulator, Virtuoso) and six electronic workbench equipment sets (a triple-channel DC power supply, a digital multimeter, an arbitrary function generator, and a 2-channel oscilloscope) for lab sessions. Representative classroom photos are shown in Figure 1 below.

Figure 1: The Engineering classroom, which is equipped with testing equipment, circuit and sensor components, desktop computers, a projector, and course drawers.

A2. Studio Space

The spacious studio space at the entrance of the IDEA Lab (W-167) is used for project-based classes that require the space to build and test prototypes. This space can accommodate 40 students, which has also been utilized for student gatherings (club meetings, study groups, homework project builds, etc.). Seven desktop computers are located around the peripheral walls for students who do not have a laptop. Three TV screens are used for occasional instruction or speaker presentations. Power for the tables is underneath for students to plug their devices to charge. A representative photo of the studio space is shown in Figure 2 below. Studio space also has an audio-visual area and storage space for student projects. There is an extra storage space (W-164) to store classroom materials that are primarily used in studio classes or activities.

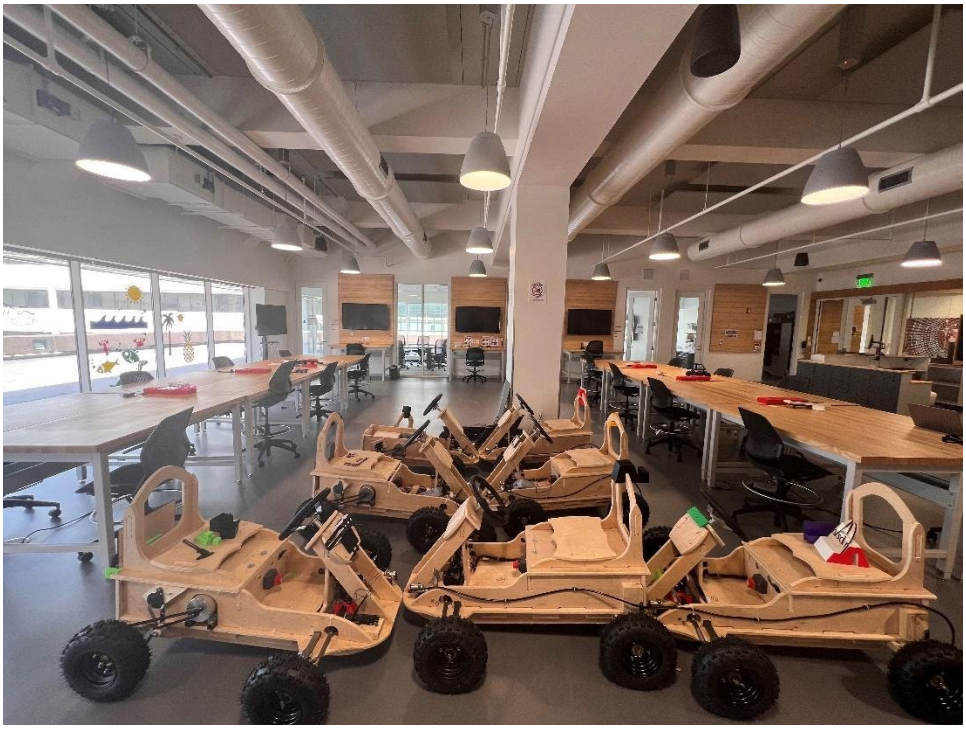


Figure 2: The Studio space at the IDEA Lab, which is used for experiential-learning instruction, student gatherings, and presentations.

A.3 Conference Rooms

The IDEA Lab has two conference rooms (W-165 and W-166) adjacent to the studio space. These two spaces can accommodate ten people for meetings. Each room has video conferencing and projection capabilities. These rooms can be used by faculty members for small meetings and by students for events.

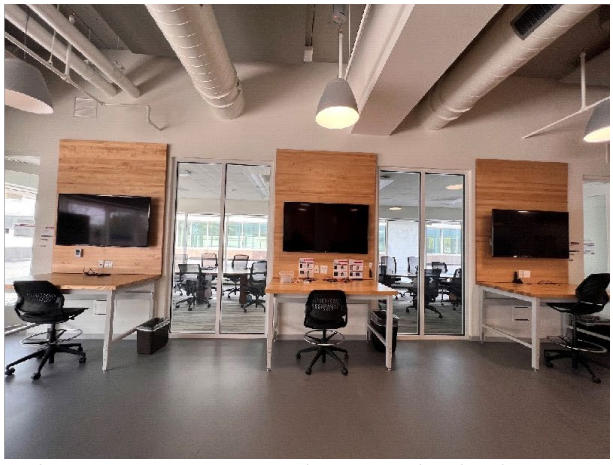


Figure 3: Conference rooms are located adjacent to the studio space that can seat up to ten people, equipped with video conferencing capabilities.

A.4 Soldering/Electronic Testing Area

This hallway provides soldering capabilities with 6 soldering stations and fume extractors, along with the components that are required for soldering (stranded solder, wick, hand tools, helping hands, etc.). There are two compact storage units with electrical tape, solder flux, different

connectors, stripboards, heat shrink, distinct types of LEDs, and cables. A separate chest of drawers contains breadboards, proto boards, batteries, soldering supplies, and parts for the tabletop carving station for PCB making. There are two stations of testing equipment that includes a digit multimeter, power supply, function generator, and digital oscilloscope.

Figure 4: Soldering/electronics workstations adjacent to the studio for electronics prototyping projects.

A.5 3D Printing Room:

The 3D printing room (W-174) is equipped with multiple 3D printers. The main system is "Mount Olympus," where 12 Prusa MK3S 3D printers (named after 12 Greek Gods) are connected to a network (using OctoPrint) that allows students to send the print job from their laptops. Two desktop computers are also available to start 3D printing jobs and utilize 3D printing preparation (i.e., slicing). There are also other types of 3D printers in this room for larger prints (Ultimaker and Gigabot). 3D printing supplies (filaments) and cleaning tools are available in the room for students. This room has a stronger filtration system to allow better ventilation. Students are advised not to spend more than 10 minutes in the room due to potential safety concerns of melting filament odors.

Figure 5: 3D printing room has 12 Prusa machines, 4 Ultimakers, and 1 Gigabot to allow for a variety of 3D printing experiences.

A.6 Machine Shop

The machine shop (W-176) contains the lab's digital manufacturing and prototyping equipment. Metal, wood, and acrylic manipulation are all possibilities in the lab. Due to the potential noise generated by heavy equipment, this room has thicker windows ind insulated walls. The lab filtration is also designed to reduce the dust in the room, in addition to in-house sawdust collection equipment. Primary capabilities include Epilog laser cutters/engravers, CNC mill and lathe, CNC ShopBot, Waterjet cutter, wood lathe, wood cutting equipment, and metal cutting/bending equipment. The machine shop also includes a variety of manual power tools and other manufacturing supplies such as tapes, caulk guns, pencils, glue, wood filler, zip ties, rags, oil, grease, pliers, hammers, cutters, clamps, wire brushes, tape measures, and spatulas. Safety gloves and masks are available (mandatory for any hand tool usage). Safety glasses (available right outside the lab) are required to enter the machine shop. The safety shower, first aid kit, and other PPE are available at the corner of the lab.

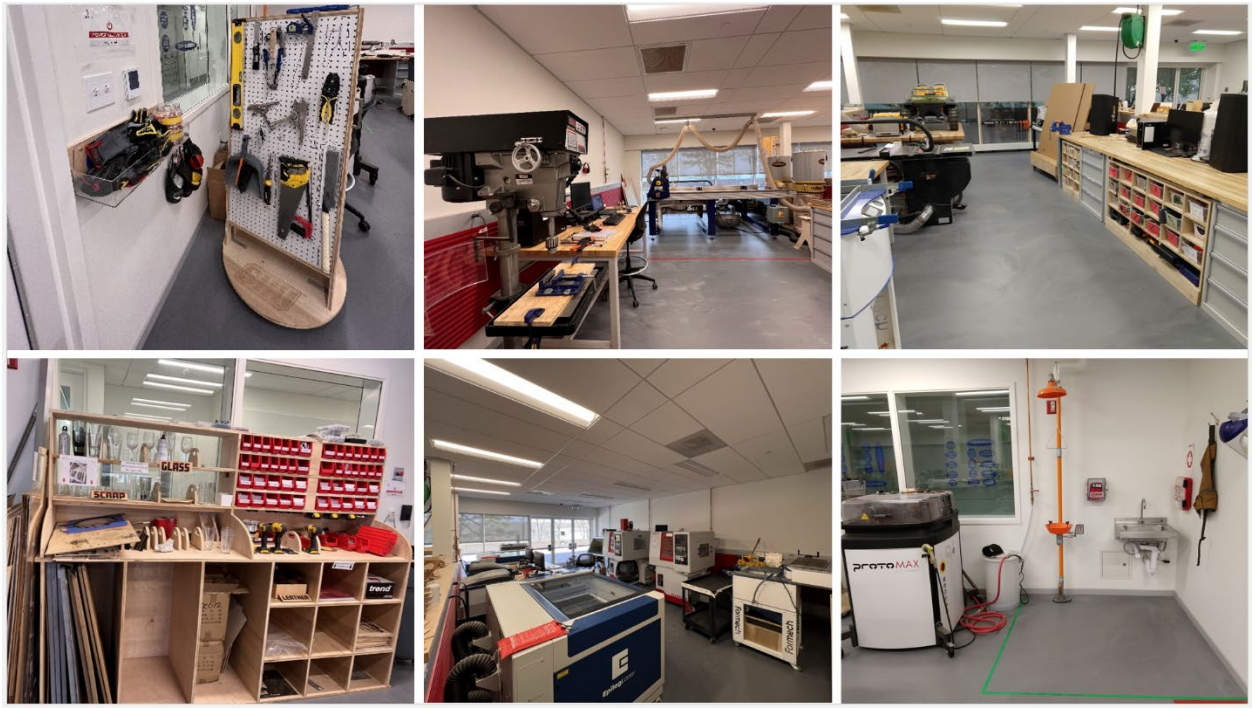


Figure 6: Representative photos of the machines shop (starting from top left to bottom right): Entrance of the lab and hand tools, wood working area, large prototyping workspace, laser cutter supplies, laser cutters, and the waterjet cutter.

A7 Wet Lab / Characterization Lab Area:

This room (W-175) is currently not utilized for its purpose, which is to characterize specimens, inspect protoboards, and work with chemicals for micro/macro fabrication projects. Chemicals such as Isopropyl Alcohol and 3D print wash liquid are stored in the chemical storage cabinet. The refrigerator is intended for specimens that need to be refrigerated, which is not currently used. The room has an emergency shower, an eye wash safety station, and a fume hood. It has different racks holding ultrasonic cleaners, beakers, jars, Erlenmeyer, funnels, balances, metalware sets, glassware, wash bottles, and gloves. The room also consists of two inspection microscopes.

Figure 7: Wet Lab/Characterization Lab.

A.8 Club/Capstone Room

This room (W-173) is designed to help students have a space for their club meetings and senior capstone design group. The SHU Innovate student club meets at this space and uses it for its planning purposes. Video conferencing capabilities also allow students to have remote meetings with alumni and potential small remote gatherings. Capstone students utilize this space also for their group discussions, project management, and planning purposes.

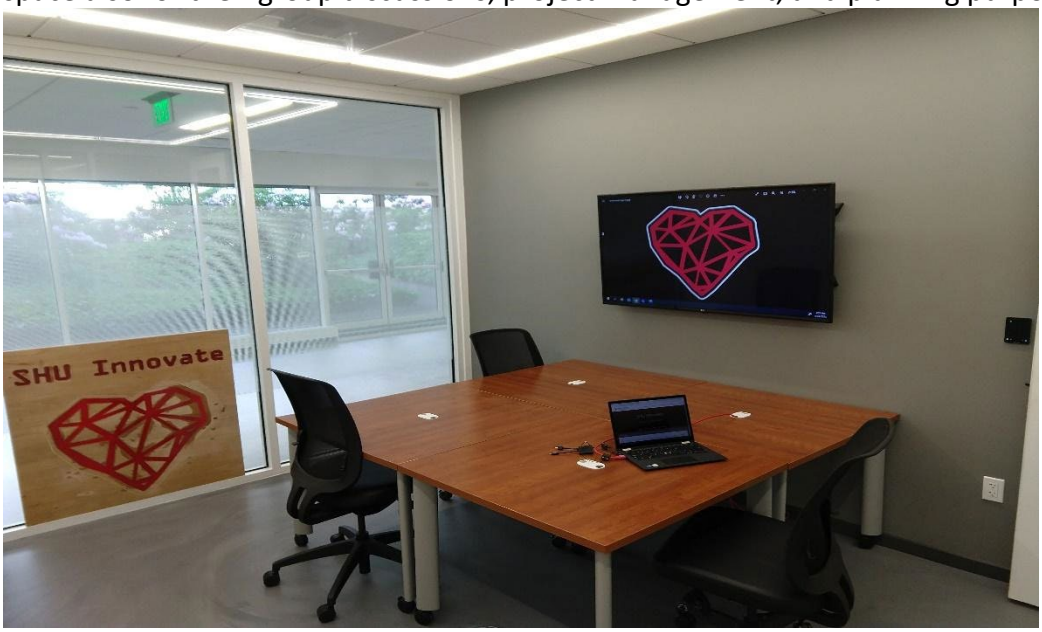


Figure 8: Club/Capstone Room

A.9 Digital Arts and Textiles Rooms

The textile room (W-172) and the digital arts room (W-171) offer various tools for merchandise design and fabrication for the SHU community. An iron, embroidery machine, sewing machine, vinyl cutter, heat presses, sublimation pigment printers, and color printer are available for student use. IDEA Lab staff are available to train students to utilize the equipment. The most

popular processes are t-shirt printing, mug sublimation, and fabric embroidery. These rooms were created as part of the Business and Technology integration. The Fashion Marketing undergraduate program utilizes this room for their classes.

Figure 9: Digital arts and textiles rooms offer students an opportunity to get creative and make their own merchandise.

A.10 Material Storage Room and Hallway Cabinets:

A separate storage room **(W-180)** allows supplies to be stored in a safe space. Also, hallway cabinets are utilized to store drone components and Engineering merchandise.

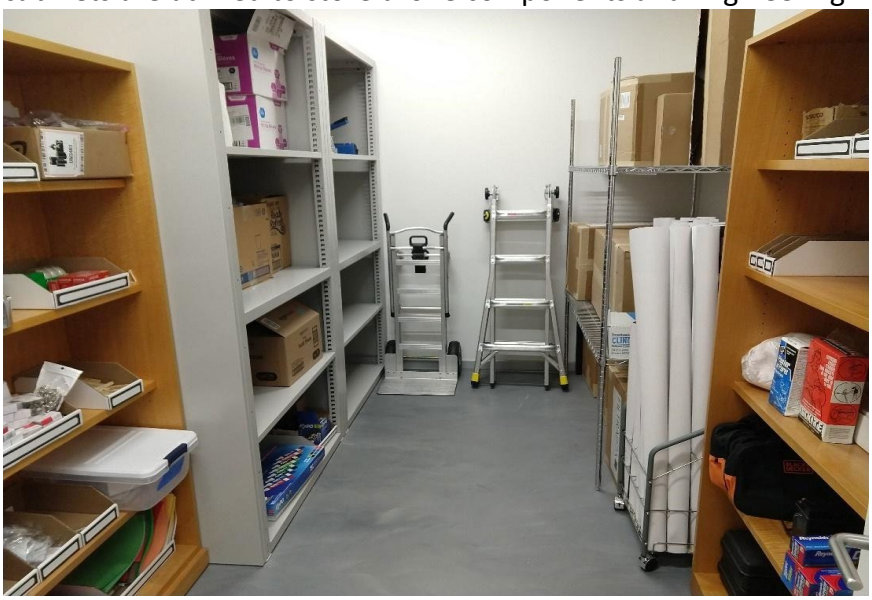


Figure 10: Material Storage Room

Table 1: The below table shows the capacity for each lab.

Room number	Room name	Seating capacity	Number of desktops
W-163	Office	1-3	1
W-164	Class Storage Area	-	-
W-165	Meeting Room 1	10	A/V monitor
W-166	Meeting Room 2	10	A/V monitor
W-167	Open Area	35	8
W-168	Storage Room for guests	1	1
W-169	Soldering/Electric Area	8	-
W-171	Vinyl/Poster Printing	2	2
W-172	Textiles	2	1
W-173	Club / Capstone Room i	3	A/V monitor
W-174	3D Printing	2	2
W-176	Machine Shop	15-20	4
W-177 A	Storage 1	-	-
W-179 B	Storage 2	-	-
W-180	Material Storage	-	-
W-181 C	Custodial Closet	-	-
W-182	Engineering Classroom	30-35	9

B. ACCREDITATION POLICIES AND PROCEDURES MANUAL

Describe how instructional and learning environments used by the program (including facilities, tools, and equipment) are safe for their intended purposes. (See APPM section I.E.5.b. (1).) Examples of information may include efforts to keep laboratories clean and free of hazards, student training, personal protective equipment used by students, safety policies and procedures, enforcement of safety policies, and routine safety inspections.

A. Training:

To ensure that the lab users operate the machinery in the IDEA Lab appropriately and safely, a variety of training is available to students, faculty members, and staff at SHU.

In addition to the in-person training sessions, training videos are available on the lab website. These videos include but are not limited to, 3D printing, Laser cutting, Water jet cutting, Shopbot, Thermoformer fundamentals, Soldering, using Carvey for PCBs, embroidering, sublimation printing, and vinyl cutting.

Additionally, each video includes supplemental materials such as a blog post or cheat sheet, as well as rules provided. These serve as a further source of information for users, giving them a more thorough overview of the instruments and any potential risks, as well as further safety requirments and standard operating procedures.

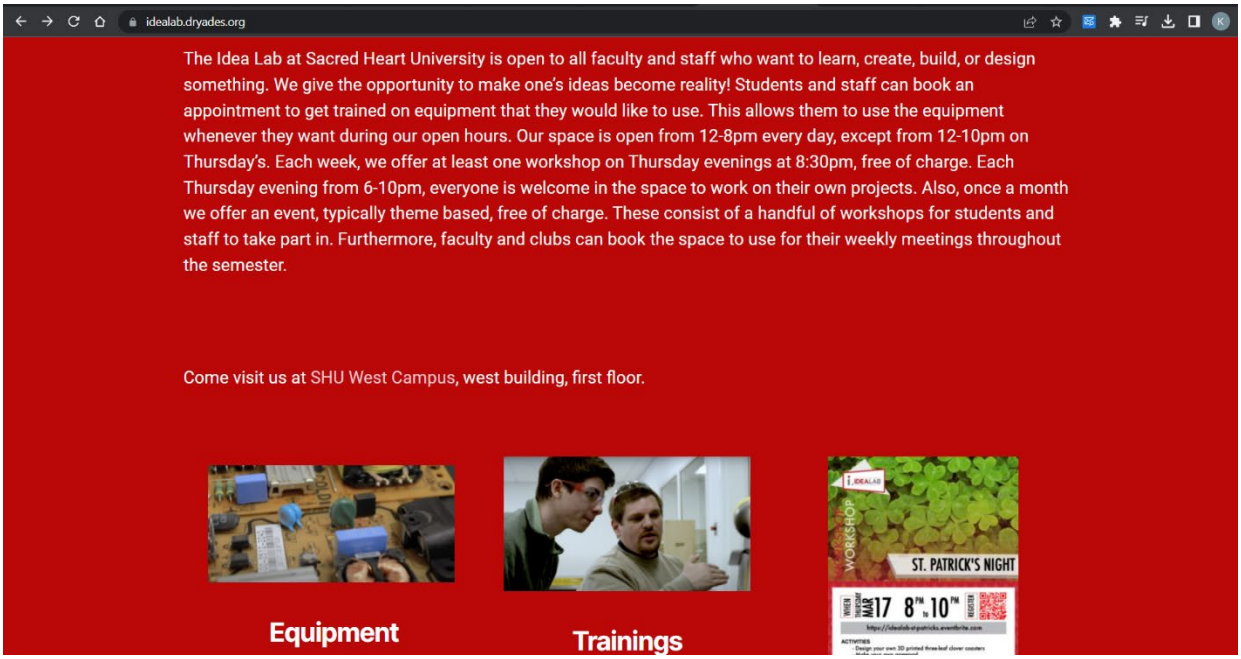


Figure 11: Screenshot of website.

Each tutorial describes the piece of equipment in detail, outlining its features, potential risks, and safety measures. Users must complete a quiz following their completion of the tutorial to demonstrate their knowledge of the essential ideas, safety awareness, and their ability to use the equipment appropriately. This procedure encourages students to become familiar with the equipment, emphasizes the value of safety, and promotes responsible behavior. The associated equipment may not be accessed until comprehension is demonstrated by passing the quiz.

The IDEA Lab promotes a culture of safety, where students feel comfortable and confident utilizing the equipment safely, enhanced with printed and audio-visual materials.

B. Emergency Equipment:

The Lab is equipped with first aid kits, fire extinguishers, and body wash / emergency eyewash stations.

B.1 First Aid Kit:

While required training and safety procedures are designed to reduce the risk of an accident, , having first aid supplies close at hand can significantly improve the ability to react quickly and efficiently to any injuries or accidents that may arise. First aid kits have been strategically positioned throughout the lab, including in the wet lab (on the left side of entrance), the machine shop, and the front entrance. The soldering area is also equipped with a first aid kit at the sink, which is located at the entrance to the soldering area.

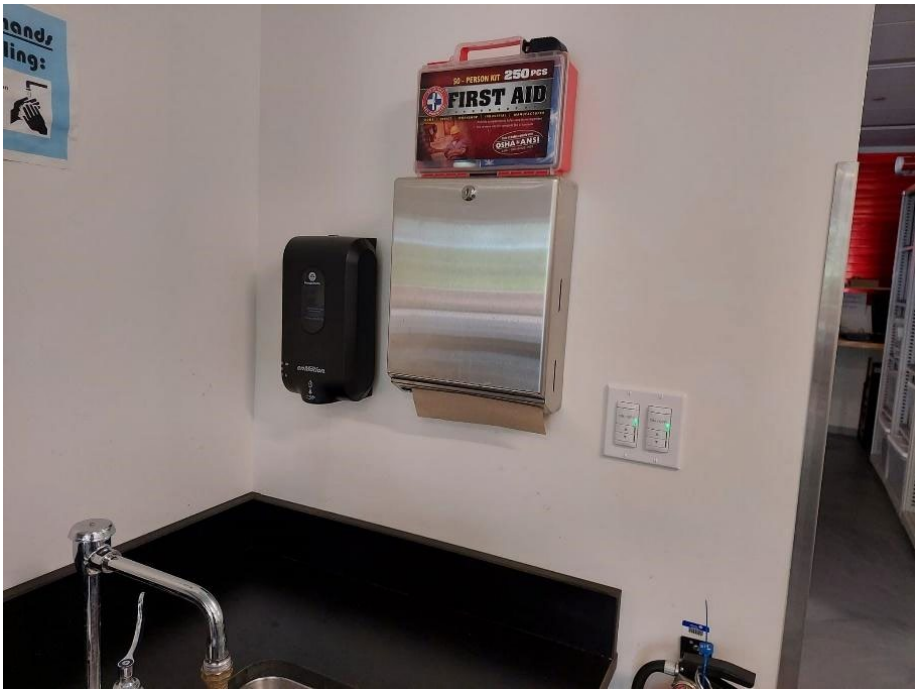


Figure 12: First aid kit near the sink in the Soldering area.

Figure 13: First aid kit in the Wet Lab to the left side of the entrance.

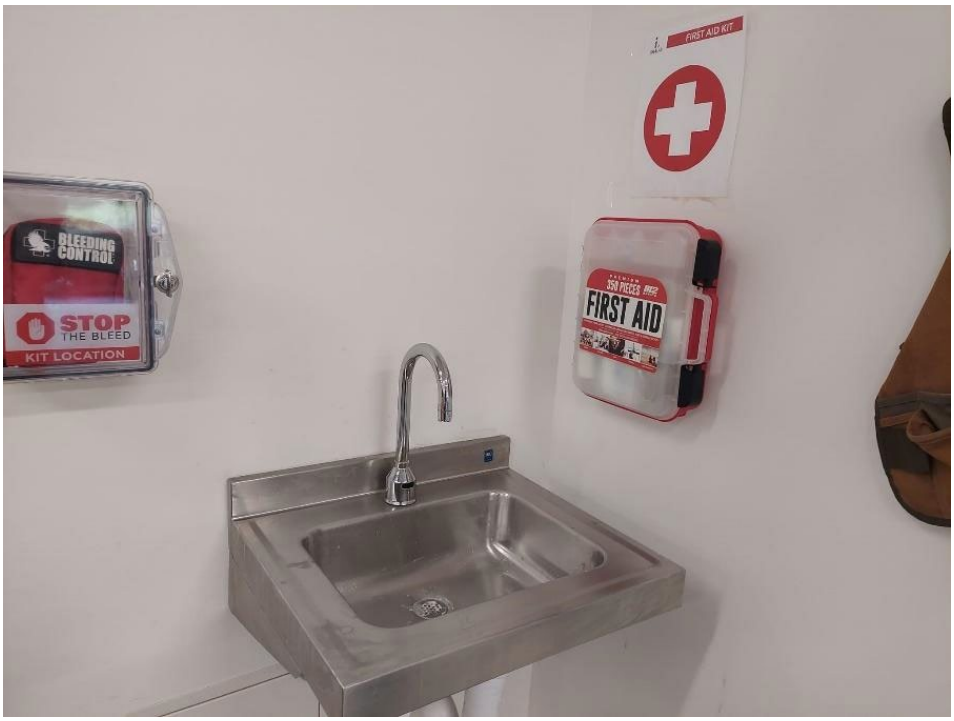
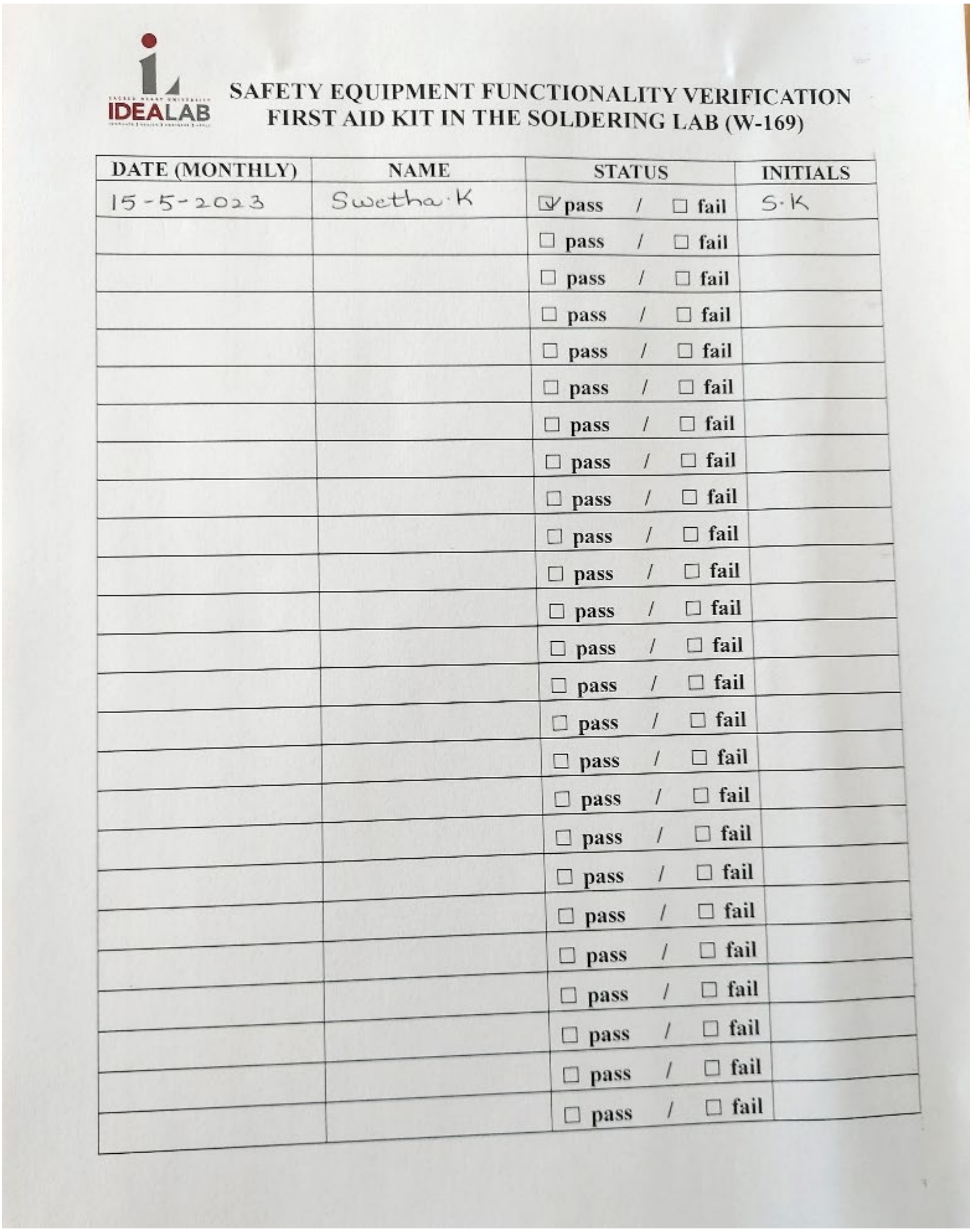


Figure 14: First aid kit near to sink in the Machine Lab.

Figure 15: First aid kit near lab entrance.



SAFETY EQUIPMENT FUNCTIONALITY VERIFICATION
FIRST AID KIT IN THE SOLDERING LAB (W-169)

DATE (MONTHLY)	NAME	STATUS	INITIALS
15-5-2023	Swetha. K	☑ pass / ☐ fail	S.K
		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
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Figure 16: First aid kit log.

The IDEA Lab staff regularly inspects the contents of each first aid box, ensuring that all items are present, in proper condition, and within their expiration dates. Additionally, these inspections are logged. All items are inspected for any signs of damage, leakage, or expiration and any compromised items are replaced immediately.

B.2 Fire Extinguisher

Fire extinguishers are strategically stationed throughout the IDEA Lab, including the wet lab, the classroom entrance, and both the front and rear entrances of the machine shop. Lab staff undergo thorough training on fire safety protocols and are equipped with the necessary knowledge to effectively utilize fire extinguishers during emergencies, ensuring their readiness to respond swiftly.

Figure 17: Fire Extinguisher at the front entrance of the Idea lab.

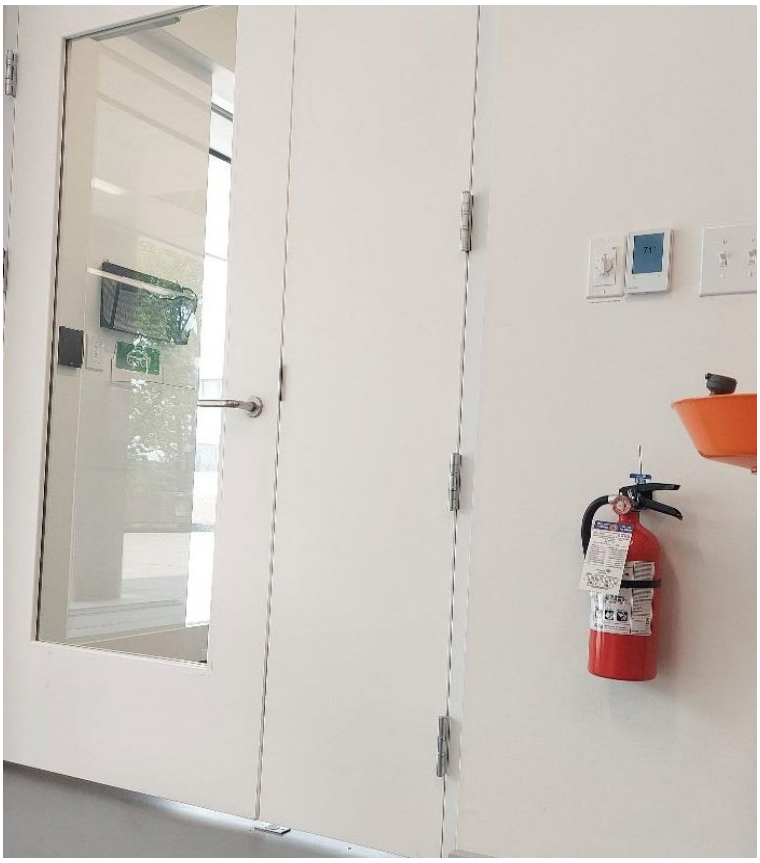


Figure 18: Fire extinguisher in the Wet Lab to the left side of the entrance.

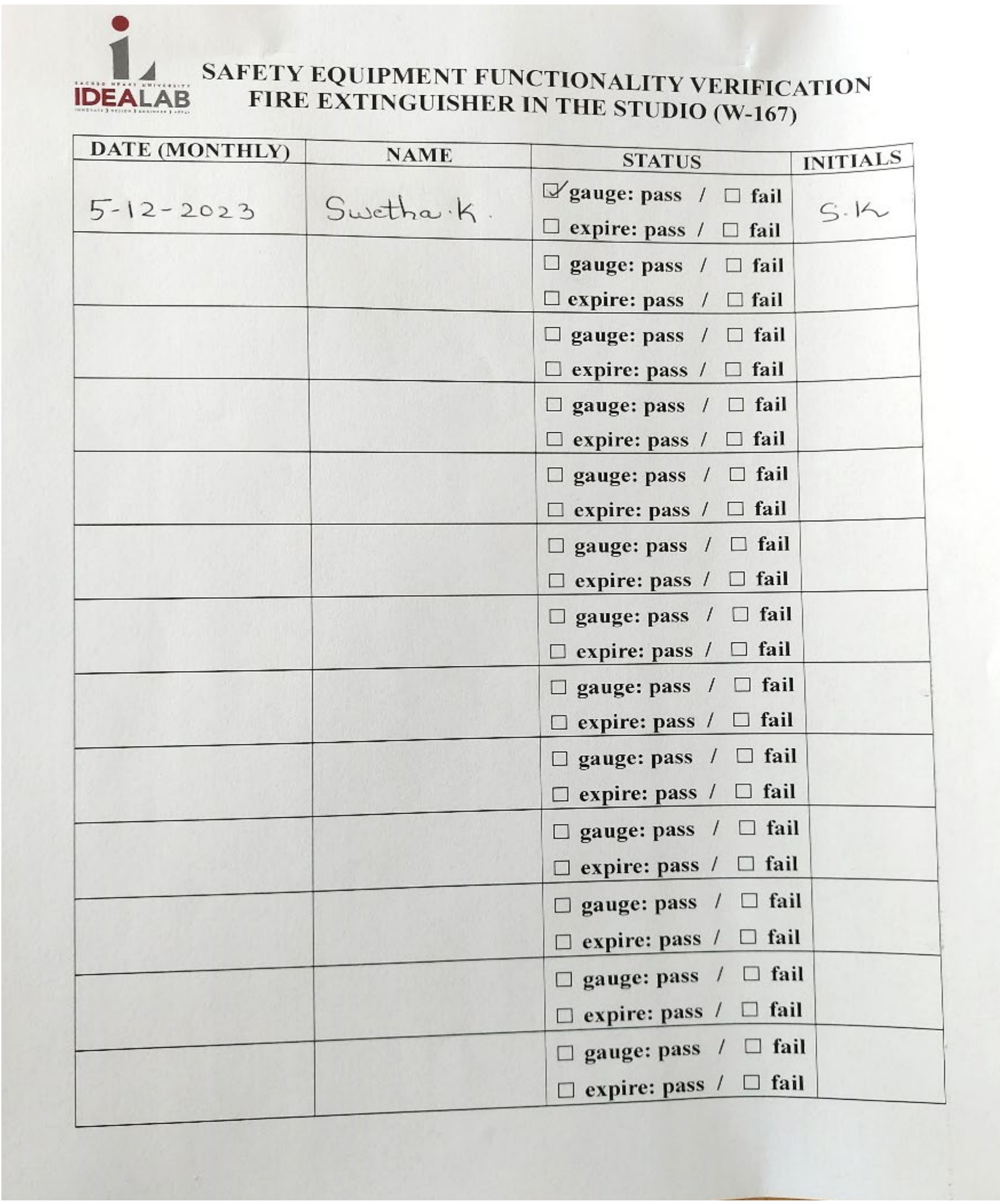
Figure 19: Fire extinguisher at the back door of the Machine Shop.

Figure 20: Classroom fire extinguisher.

Figure 21: Fire Extinguisher near the sink in the Soldering Lab.

The placement of fire extinguishers in these strategic areas and staff training on fire safety procedures all work together to make sure that all users are in a safe and secure environment. The extinguishers are mounted on brackets or placed in designated stands, keeping them off the floor and at an appropriate height for easy access.

IDEA Lab staff routinely verifies that the pressure gauge or indicator indicates that the extinguisher is always ready for use. Additionally, the expiration date of the extinguisher is regularly checked. Both of these aspects are recorded in a safety log for proper documentation.



IDEALAB

SAFETY EQUIPMENT FUNCTIONALITY VERIFICATION
FIRE EXTINGUISHER IN THE STUDIO (W-167)

DATE (MONTHLY)	NAME	STATUS	INITIALS
5-12-2023	Swetha.K.	☑ gauge: pass / ☐ fail ☐ expire: pass / ☐ fail	S.K
		☐ gauge: pass / ☐ fail ☐ expire: pass / ☐ fail	
		☐ gauge: pass / ☐ fail ☐ expire: pass / ☐ fail	
		☐ gauge: pass / ☐ fail ☐ expire: pass / ☐ fail	
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Figure 22: Fire extinguisher log.

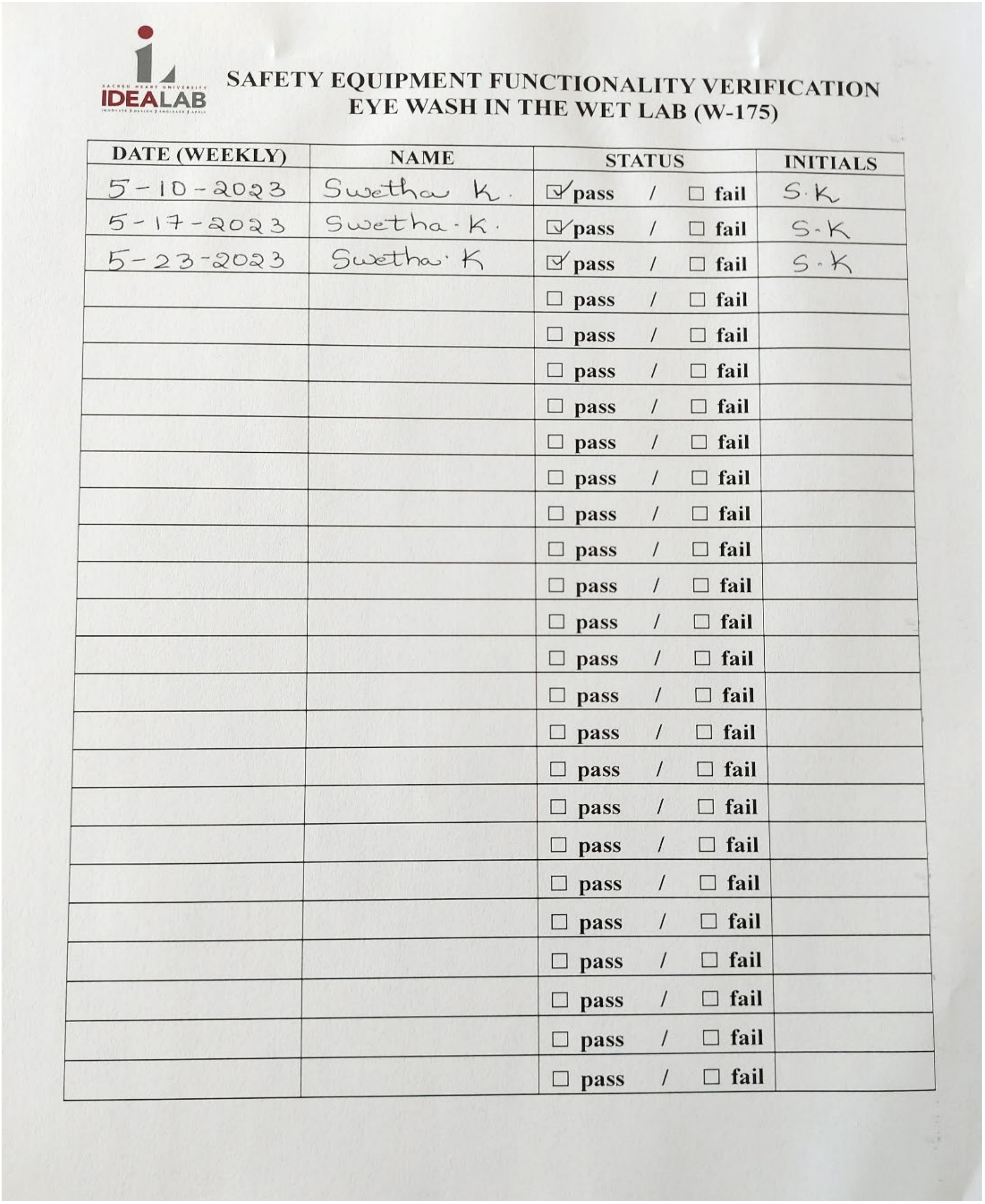
B.3 Eye and Body Wash:

Important safety equipment like the eye and body wash stations can help minimize the consequences of chemical exposure or accidental injuries that could cause eye or skin irritation. Eye and body wash stations are located in the wet lab on the left side, close to the entrance door, and another one is situated in the machine shop on the left side, close to the water jet. IDEA Lab staff members are well-versed in adhering to safety protocols and are ready to assist and guide the users in the event of an emergency.

Figure 23: Eye and Body Wash in the Machine Shop towards the left of the entrance.

Figure 24: Eye and Body Wash in the Wet Lab towards the left of the entrance.

IDEA Lab staff perform monthly inspections on the showers and weekly inspections on the eye wash stations to verify their operational status. During these inspections, the department carefully assesses whether they are functioning properly or not. All inspection outcomes are diligently recorded in a safety log to maintain a comprehensive record.



IDEALAB

SAFETY EQUIPMENT FUNCTIONALITY VERIFICATION
EYE WASH IN THE WET LAB (W-175)

DATE (WEEKLY)	NAME	STATUS	INITIALS
5-10-2023	Swetha K.	☑ pass / ☐ fail	S.K
5-17-2023	Swetha . K .	☑ pass / ☐ fail	S.K
5-23-2023	Swetha. K	☑ pass / ☐ fail	S.K
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Figure 25: Eye wash log.

IDEALAB

SAFETY EQUIPMENT FUNCTIONALITY VERIFICATION
SHOWER IN THE WET LAB (W-175)

DATE (MONTHLY)	NAME	STATUS	INITIALS
5-10-2023	Swetha K.	☑ pass / ☐ fail	S.K.
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		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
		☐ pass / ☐ fail	
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Figure 26: Shower Log.

B.4 Fume Hood

The fume hood in the wet lab is used to protect users from contact with hazardous gases and vapours. These could include, but are not limited to, paint, epoxy glue, and unhalogenated solvents. The fume hood is regularly checked, and a physical copy of the log sheet is available outside the wet lab.

Figure 27: Fume Hood in the Wet Lab.

IDEA Lab staff regularly inspect the fume hood to ensure it is always functioning properly. Lab staff are responsible for doing a weekly inspection, noting their findings in a designated logbook, and checking that the fume hood's airflow rate is adequate, its alarm is working properly, and for any indications of damage or malfunction.

Safety Measures:

- Ensure always to adjust the baffle for the intended use. The normal adjustment is to have the baffle open 1/2”. When using high heat loads, adjust the baffle accordingly using smoke or steam to observe exhaust patterns and obtain optimum performance.
- The fume hood is equipped with an airflow-indicating device to verify that the exhaust system is working properly. This airflow indicator is checked before working the fume hood.

- Do not place your head inside the plane of the fume hood face. The hood or the sash panels must be closed to the maximum position possible while still allowing comfortable working conditions.
- Also, avoid crossing traffic in front of the fume hood when the sash is open. Do not make rapid movements while operating the fume hood. The fume hood must be cleaned after use.

A. PERSONAL PROTECTIVE EQUIPMENT(PPE)

Figure 28: Personal Protective Equipment.

Various forms of Personal Protective Equipment (PPE) is available to all its users to ensure students, faculty, and staff have the essential tools to safeguard themselves when dealing with potentially dangerous chemicals or equipment. The PPE includes bleach wipes, disposable lab coats, safety vests, masks, face shields, safety glasses or goggles, gloves, earplugs, or earmuffs.

To remind employees to put on their safety glasses before entering the machine shop, the department specifically placed them in a container that is clearly labeled at the door.

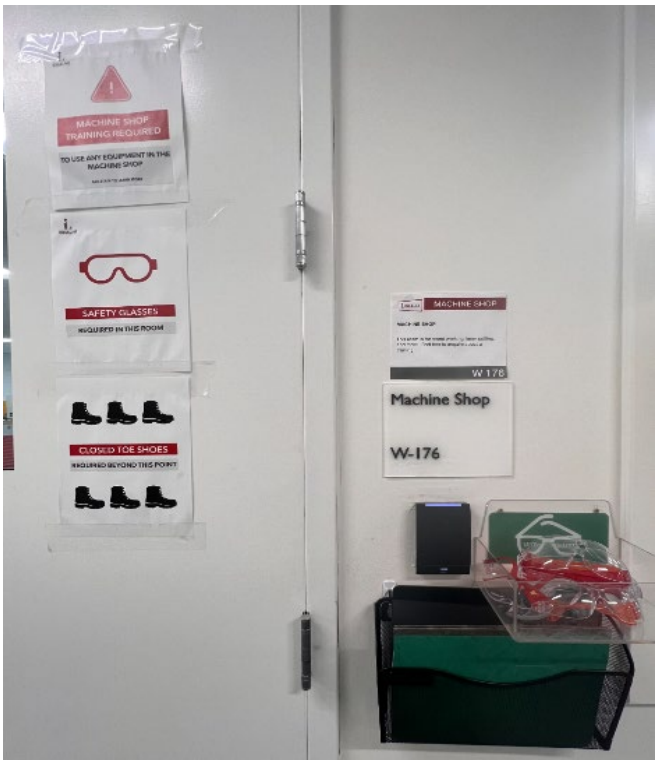


Figure 29: Safety Glasses and earmuffs outside Machine Shop.

Gloves, earplugs, earmuffs, and overshoes are kept inside the store, next to the front door on the left, in a clearly visible and reachable box upon entry.

Figure 30: Safety gloves inside the Machine Shop.

Additionally, the department has put safety gear like face shields, masks, and vests close to the water jet cutter and shop robot because those are the places where they are most frequently used.

Figure 31: First aid box, safety vests and face shield inside the Machine Shop.

These items are securely stored in a dedicated cabinet, organized for easy accessibility. Recognizing the potential hazards involved in soldering, the department prioritizes the safety of its users by emphasizing the importance of wearing safety goggles and gloves to prevent any skin contact and related health risks. To minimize potential dangers, proactive measures are taken by ensuring that gloves are readily available at every station, providing users with unrestricted access for their safety.
As detailed previously, all safety equipment throughout the IDEA Lab is regularly inspected and replaced as needed so it is always in a ready-to-use state.

B. REGULAR MAINTENANCE:

To make sure the equipment is safe to use and in good operating order, all equipment in the IDEA Lab is routinely inspected and maintained. For each tool, the manufacturer's recommended maintenance schedule is followed by the IDEA Lab Staff. For example, the Shopbot's maintenance schedule is:
https://www.shopbottools.com/ShopBotDocs/files/PRSMaintenanceSchedule.pdf

For equipment where any periodic maintenance is required after a specified amount of run time, the Staff either tracks cumulative run time manually on a usage sheet such as the one below, or the run time is tracked by the tool itself and is routinely checked by Staff in its user interface as part of the maintenance schedule.

Name	Date	Purpose (e.g., course#)	Supervisor	Time 'til maintenance	Job run time
Michael O.	6/6	KARTS for ENGR 125	MA	40 hours	23 min
				39h 37m	

Figure 32: Maintenance Log

C. SAFETY RULES AND USAGE GUIDLINES:

Safety rules and usage guidelines for each tool are prominently posted for easy reference. Staff members who are supervising student use insure adherence to these rules at all times. IDEA Lab visitors who have any issue (whether unable or unwilling) to abide by these policies will not be able to access the tools until they can demonstrate that the issue is resolved. If there is an issue for one or more members of a group, e.g., when a class has a group activity here, the non-compliant individual(s) are designate as observers for the duration of the activity and are offered the opportunity to return at a later time to try again to safely complete the activity with a Staff supervisor.

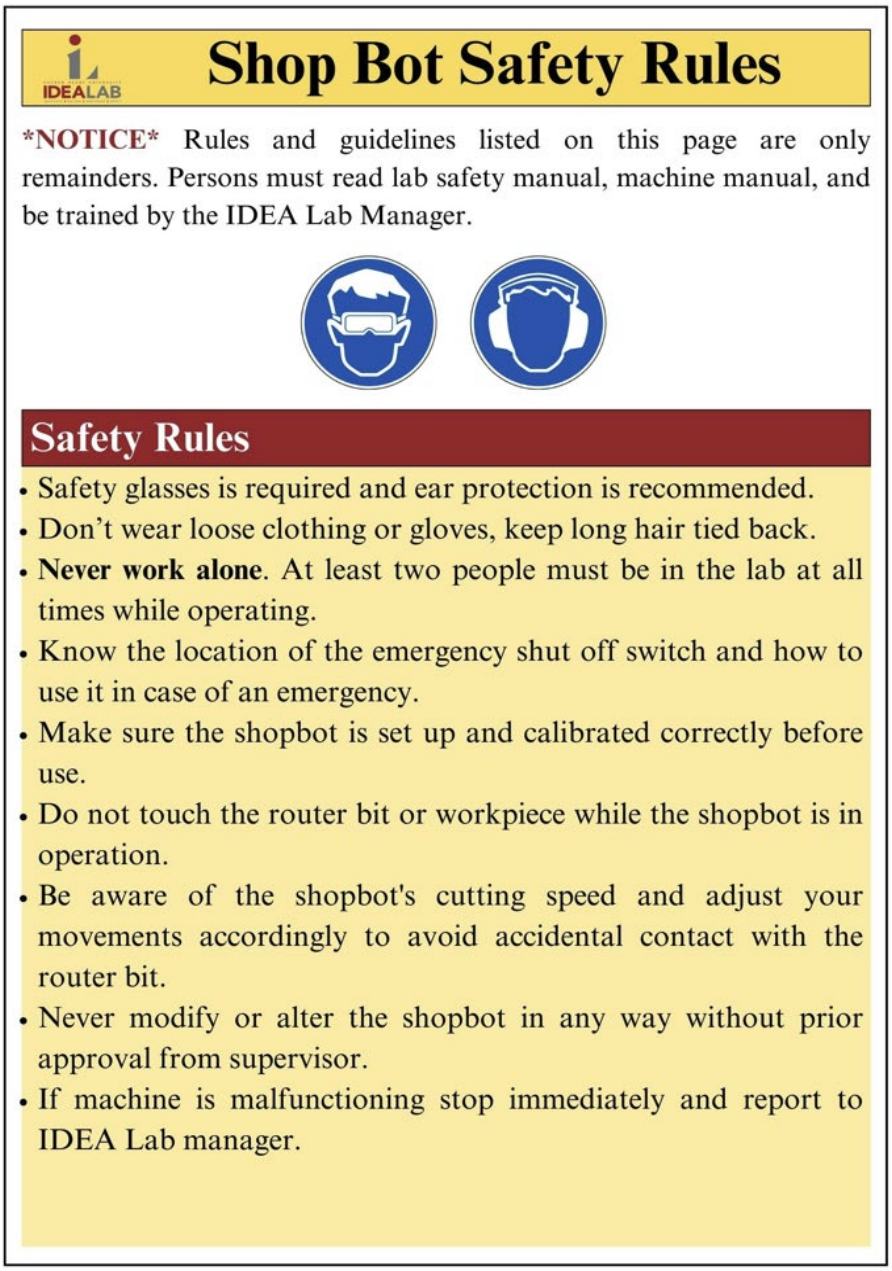
The IDEA Lab has several specialized tools for working on various projects:

E.1 ShopBot Alpha safety guidelines in the Machine Shop:

Figure 33: ShopBot in the Machine Shop.

CNC (Computer Numerical Control) machines can automatically remove material with a rapidly rotating cutting bit called an end mill, which can cut laterally as well as vertically. The cut plan is controlled by a set of instructions, which are typically generated through a workflow that begins with a drawing of the desired part in a CAD (computer Assisted Design) application. The ShopBotAlpha is a full-sized gantry tool that is used for CNC cutting, drilling, carving, and machining of wood, plastic, aluminum, and other materials up to 4' x 8' sheets which are typically ¾" or smaller in thickness. A workstation is stationed to the left of the ShopBot to set up jobs and control them from outside the Do-Not-Enter zone that is marked on the floor and must remain clear at all times when the tool is operational. Clamps are provided, and a vacuum hold-down system is integrated to secure the material while cutting. A separate vacuum is configured to automatically collect sawdust for a clear view during operation. The wrench to change the endmill bit is attached to the on/off key forcing the tool to be powered down for all tool changes. Much of the IDEA Lab's furniture, shelving, etc., has been made by students using this tool.

Safety Measures:



Shop Bot Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses is required and ear protection is recommended.
- Don't wear loose clothing or gloves, keep long hair tied back.
- **Never work alone**. At least two people must be in the lab at all times while operating.
- Know the location of the emergency shut off switch and how to use it in case of an emergency.
- Make sure the shopbot is set up and calibrated correctly before use.
- Do not touch the router bit or workpiece while the shopbot is in operation.
- Be aware of the shopbot's cutting speed and adjust your movements accordingly to avoid accidental contact with the router bit.
- Never modify or alter the shopbot in any way without prior approval from supervisor.
- If machine is malfunctioning stop immediately and report to IDEA Lab manager.

Figure 34: Shop Bot Safety Measures.

E.2 Carvey:

Figure 35: Carvey in the Machine Shop.

The Carvey by Inventables is a fully enclosed CNC suitable for smaller projects.
Although any cutting debris must be vacuumed up manually after each job, the enclosure makes this convenient and helps contain the noise. Materials approved to use in it are wood, plastic, and metals: brass, aluminum, and copper, especially the thin copper plating on FR1 PCBs, which can be milled using this to make custom circuit boards.

The Carvey's enclosure has a safety interlock, which prevents it from spinning its cutting tool when open providing an additional level of safety.

Safety Measure

Carvey Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses and mask are required, gloves and hearing protection are advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Always keep aisles, exits and access to emergency equipment (fire extinguishers, fire alarms, first aid kit) clear at all times.
- Verify the overall condition of the equipment and the material being used (e.g. condition of bits, debris buildup, defects in the tool housing or anything that would compromise the safe use of the Carvey).
- Listen for change of sounds that might indicate the machine is having issues.
- Never operate the Carvey with the front cover open.
- Keep hands clear of the sharp edges on the milling bit at all times.
- Keep hands clear of pinch points when opening and closing the front cover of Carvey.
- Never attempt to cut magnesium or any other flammable material. Sparks or fire may occur if you attempt to cut materials with Carvey that were not sold by inventables.
- Never operate if Carvey's top cover is cracked or broken. Doing so may result in injury.

Figure 36: Carvey Safety Rules.

E.3 EPILOG LASER ENGRAVER:

Laser cutters use high-powered laser light to cut through or mark various materials. Similar to the CNC, the workflow typically begins with a CAD drawing of the desired part, from which the laser can create it automatically. The extremely thin beam of the laser enables it to do exceptionally fine and detailed work.

The Epilog Laser Engraver utilizes a high-intensity beam of light that may produce a wide range of temperatures when it interacts with the material being engraved or cut It is a class 2 laser product (according to international standard IEC 60825-1), or Epilog FusionPro CO2 Laser System, because it is enclosed with safety interlocks that stop the laser if the enclosure is opened during operation. The top provides a clear view while also filtering the wavelength of light that the laser produces. In addition to the fire extinguishers positioned near each door to this room, each laser cutter has a fire blanket, which can be used to smother any flames inside the enclosure.

Figure 37: Epilog Laser Engraver in the Machine Shop.

Safety Measures:

Laser Cutter Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required.
- Don't wear loose clothing, keep long hair tied back.
- Only approved material according to the manufacturer shall be used inside the cutter.
- Make sure the laser is set up and calibrated correctly before use.
- DO NOT modify or disable any safety features of the laser system.
- DO NOT operate the laser unless all covers are in place and interlocks are working properly.
- DO NOT look directly into laser beam.
- Never leave the laser cutter unattended while it is in use.
- Know the location of the emergency shut off switch and how to use it in case of an emergency.
- Turn off laser cutter if flare-ups occur by hitting the Emergency Stop.
- Report any issues or problems with the laser cutter to IDEA Lab manager immediately.

Figure 38: Laser cutter safety rules.

E.4 Sheet Metal Roller:

Figure 39: Sheet Metal Rollers in the Machine Shop.

Metal rollers are used to form rounded sections out of flat metal stock and sheet metal. The final forms can take the shape of hoops, cylinders and cones or combinations of any of these forms. The DI-ACRO 12SR metal rollers are a small, bench-mounted manual-crank model.

Safety Measures:

Metal Roller Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required.
- Rollers are designed to form flat metal stock and sheet metal only.
- Always keep fingers and hands away from the rollers.
- Become familiar with the adjustments for the roller.
- Never attempt to roll multiple workpieces at a time.
- Make sure all material is free of debris before sending it through the rollers.
- Maintain a safe distance from the rolls and workpiece as it starts to feed into the machine.
- Due to the nature of the metal workpiece which may include sharp edges, corners, and burrs, there is a potential for cuts, lacerations, and puncture wounds.
- Any damage, or defects to the equipment, immediately report to the IDEA Lab Manager.

Figure 40: Metal roller safety rules.

E.5 The DI-ACRO Model 24FB Finger Brake:

A finger brake, also known as a box and pan brake, is a tool that is used to bend metal sheets manually. It works by clamping the metal workpiece between “fingers” that are attached to the brake and applying pressure to the workpiece with a lever. The fingers are adjustable, allowing the user to bend metal at various angles and at various locations across its width. Finger brakes are perfect for metalworking tasks, small-scale metal production operations, and repairs.

The DI-ACRO 24FB can bend metal up to 1.5mm thick and 24” wide. It can bend up to 135 degrees and has gross and fine angle stops, as well as a depth stop, that can be set for convenient repeated operations.

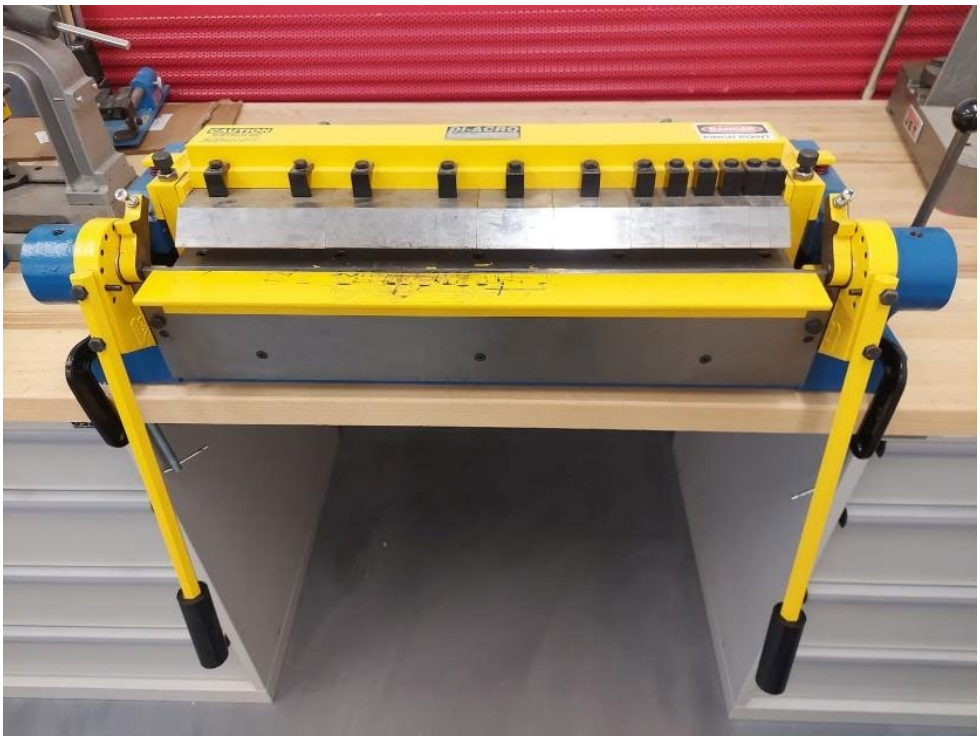


Figure 41: The Finger Brake in the Machine Shop.

Safety Measures:

Model 24 Finger Brake Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required
- Don't wear loose clothing or gloves, keep long hair tied back.
- Keep your fingers and hands clear of the bending area and any moving parts during operation.
- DO NOT attempt to manually hold or guide the material being bent.
- Ensure that the material being bent is within the recommended thickness and width capacity of the Model 24 Finger Brake.
- Use the designated handle or lever to apply force for bending. Avoid using excessive force or using tools to extend the handle length, as it may compromise control and safety.
- Be mindful of sharp edges on the material being bent and on the brake itself.
- Avoid making any unauthorized modifications or alterations to the finger brake, as it can compromise its safety and functionality.

Figure 42: Model 24 finger break safety rules.

E.6 Hand tapper:

A hand tapper helps prevent broken taps while tapping threads into straight holes. It makes cutting threads easier with a longer handle and keeps the alignment straight. The XCUT hand tapper (Figure 28) is a small tabletop version of the tool.

Safety Measures:

Hand Tapper Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required
- Don't wear loose clothing or gloves, keep long hair tied back.
- Verify tool condition and sharpness before starting tapping operation.
- Use proper hand placement to maintain control and stability
- Keep hands clear of the tapping area to prevent injury.
- Never force or overextend the tap during the tapping process.
- Be aware of the tap's direction to prevent cross-threading.
- DO NOT touch the tap or workpiece immediately after use due to high temperatures.
- Keep fingers away from the tap's cutting edge during operation.
- Use caution when removing chips or debris from the tap.
- Keep bystanders at a safe distance to prevent accidents.
- Avoid using excessive speed or force during the tapping process.
- Follow proper electrical safety precautions when using a powered hand tapper.

Figure 43: Hand tapper safety measures.

Figure 44: The XCUT hand tapper in the Machine Shop.

E.7 Hand Shear and 3-Ton Arbor Press:

Figure 45: Hand Shear in the Machine Shop.

Figure 46:3-Ton-Arbor Press in the Machine Shop.

A hand shear is employed for cutting sheet metal easily along a straight line.
The DI-ACRO 12HS shear can cut material with thickness up to 1.5mm and that is up to 12" wide. It automatically clamps the material before it starts to cut and provides a long handle for easy cuts.

An Arbot press is able to apply a large force in a very specific way. It is useful for staking, riveting, and installing/removing bearings and well as joining or disassembling a variety of press-fit parts.

The JET AP3-M 3-Ton Arbor Press is designed to perform small press jobs. The reversible ram has a magnetic tool holder on one end for securing three included punch tips and accepts dies, inserts, and other tooling for custom work.

Safety Rules for Hand Shear:

Hand Shear Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required
- Don't wear loose clothing or gloves, keep long hair tied back.
- Always keep your hands clear of the shearing area. DO NOT attempt to hold or guide the material by hand while cutting.
- Ensure that the chosen hand shear is suitable for the thickness and type of material being cut.
- Keep track of the blade position and be cautious of any exposed or protruding blades. Avoid placing hands or fingers near the blade's path during operation.
- DO NOT force the material through the blades, as it may lead to the tool jamming or causing injury.
- Avoid overreaching or leaning over the cutting area.
- Use caution when handling or disposing of metal scraps.
- Use a cutting guide or fence for straight and accurate cuts.
- Seek assistance for complex or unfamiliar metal cutting tasks.

Figure 47: Hand shear safety rules.

Safety Rules for Arbour Press:

3-Ton Arbor Press Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required
- Don't wear loose clothing or gloves, keep long hair tied back.
- Use proper clamping or fixturing techniques to hold the workpiece securely in place during pressing operations. This helps prevent movement or slippage that could lead to accidents.
- Avoid sudden or excessive force that may cause the workpiece or tooling to fail or break.
- DO NOT attempt to manually hold or guide the workpiece while pressing.
- Stay within the rated capacity of the arbor press. Overloading the press can lead to structural failure or damage to the equipment.
- Use the appropriate handle or lever to apply force to the arbor press. Avoid using excessive force or using tools to extend the handle length, as it may compromise control and safety.

Figure 48: Arbour Press safety rules.

E.8 Water Jet Machine:

Waterjets use a very high-pressure thin stream of water containing an abrasive to automatically cut through a wide variety of materials. They are often used for cutting soft materials like dense foams, components for car interiors and bodies, rubber, plastics, and cork, but can also cut hard materials such as stainless steel and glass making for a very versatile tool. Similar to a CNC or laser cutter, the workflow typically begins with a CAD drawing. The OMAX ProtoMAX is a compact self-contained unit that can cut materials up to 12x12 and upto 1" thick. Power comes from a 240-volt dryer-style plug, which is plugged in just before use and left unplugged between uses. The water supply is likewise only turned on while the machine is in use. The enclosure has an interlock that stops the cutting if the lid is opened during use, so the cutting stream is always contained. It uses a garnet abrasive, which is harder than almost all other materials for a wide set of applications. The fine kerf of the abrasive stream is second only to the laser cutter.

Figure 49: The OMAX ProtoMax water jet in the Machine Shop.

Safety Measures:

Water Jet Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses and ear protection are required.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Make sure that the workpiece is securely clamped or held in place before starting the waterjet.
- Make sure the waterjet is set up and calibrated correctly before use.
- Ensure that the waterjet's cutting stream is aimed away from any electrical cords or outlets.
- Do not touch the cutting stream or workpiece while the waterjet is in operation.
- Do not leave the waterjet unattended while it is in use.
- Avoid putting your hands or fingers near the waterjet's cutting stream, even when the waterjet is turned off.
- Know the location of the emergency shut off switch and how to use it in case of an emergency.
- Never modify or alter the waterjet in any way without prior approval from supervisor.
- If machine is malfunctioning stop immediately and report to IDEA Lab manager.

Figure 50: Safety measures for water jet.

E.9 Drill Press:

A drill press is used to cut precisely vertical holes into or through materials like metal, wood, or plastic. The advantages of a stationary drill press over a portable drill are safety, ease of operation, precision depths, and better control over adapting the cutting speed to the material.

The JET J-A5816 drill press is a floor-standing model that can drill material up to 15” thick and holes up to 6” deep. It can run at a wide range of speeds and does not require any belt changing to change speeds so the speed can be adjusted during drilling from its control panel. A ruled depth gauge makes precision depth holes easy. And the safety shield is always positioned between the operator and the bit while cutting.

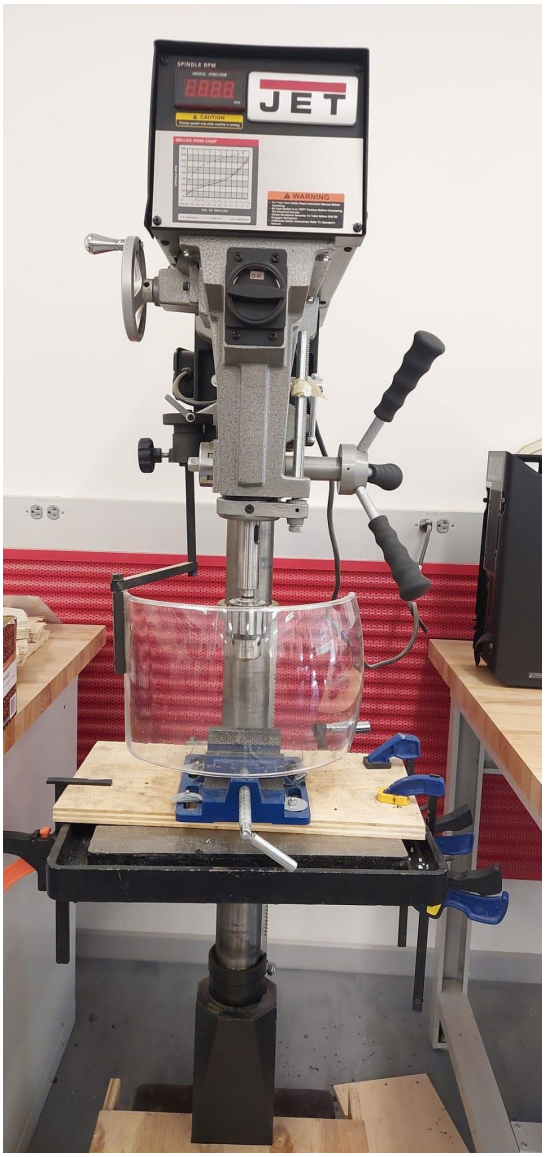


Figure 51: The JET J-A5816 drill press in the Machine Shop.

Safety Measures:

Drill Press Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required
- Don't wear loose clothing or gloves, keep long hair tied back. These items will get caught in bit or spindle.
- Never adjust the drill press or setup while it is running.
- Never leave chuck key in press. It should only be on the chuck when power is off and you are changing a bit.
- Always keep at least 4" away from the drill.
- Never force the bit. Let it cut at is own rate.
- Work must be clamped or secured to table by some means other than holding it. **Do not hold pieces to drill them.**
- Let the spindle stop of its own accord after turning the power off. Never try to stop the spindle with your hand.
- Never remove guard unless authorized by IDEA Lab manager.
- Any damage, or defects to the equipment, immediately report to the IDEA Lab Manager.

Figure 52: Safety measures for drill press.

E.10 Jet Disc and Belt Sander:

Sanders are used for fine-tuning or finishing work, usually on material with a flat profile. The Jet JSG-6DC floor-standing Disc and Belt Sander features two cast iron tilting tables for mitering applications, yet still gives full access to the belt when in the standard horizontal position, which allows fingers to stay at a safe distance while the tables support the workpiece close to the sandpaper. Shrouds on the belt and disc are piped into the manifold on the IDEA Lab's sawdust vacuum to automatically collect sawdust while in use, reducing airborne dust to a minimum.

Figure 53: The JET JSG-6DC disc and belt sander in the Machine Shop.

Safety Measures:

Disc Sander Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required. Dust mask advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Never adjust Sander or setup while Sander is running.
- Never remove guard unless authorized by IDEA Lab Manager.
- Setups requiring anything other than the standard sander equipment must be approved by supervisor.
- Sandpaper changes must be approved by IDEA Lab Manager.
- Be aware of feed direction.
- Sanding end grain or curved pieces that go in and out of end grain is dangerous. Kickback may occur. Consult supervisor before performing this operation.
- Sanding burns hurt! Keep fingers a safe distance from sandpaper.
- Sanders will throw pieces if operated improperly. Be aware of what you are doing.
- Always sand on downward turning side of sanding disc.
- Don't sand material that is too small to be held or supported properly.

Figure 54: Safety measures for disc sander.

E.11 Bench Grinder:

A bench grinder is useful for deburring metal cut with the abrasive saw, as well as fine tuning or smoothing materials.

The JET JBG-8B bench grinder has tables to keep fingers away while grinding and see-through shields to keep between the operator and where the workpiece is being ground.

Figure 55: The JET JBG-8B bench grinder in the Machine Shop.

Safety Measures:

Bench Grinder Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required. Dust mask advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Grinders are not recommended for material other than metal.
- Never grind aluminum or magnesium. Chance of fire.
- Keep fingers 2-3" away from wheel.
- Never adjust Grinder or setup while Grinder is running.
- Never remove guard.
- Setups requiring anything other than the standard Grinder equipment must be approved by supervisor.
- Never grind on side of wheel.
- Wheel changes must be approved by IDEA Lab Manager.
- Grinders will throw pieces if operated improperly. Be aware of what you are doing.
- Don't grind material that is too small to be held or supported properly.

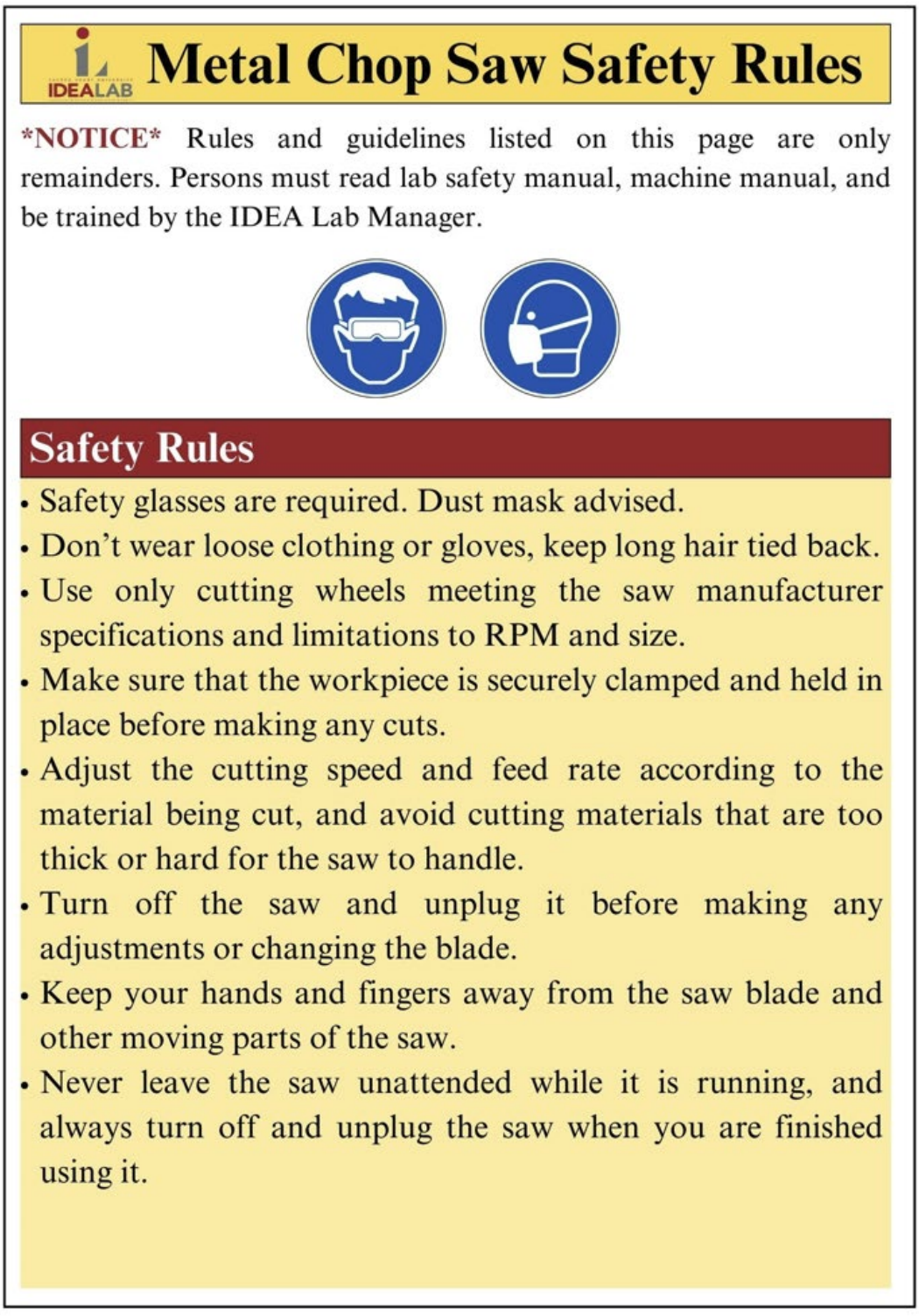
Figure 56: Safety measures for bench grinder.

E.12 Chop Saw (for metal)

An Abrasive chop saw is useful for cutting through metal stock at mitered angles.
The DeWalt D28715 chop saw has a 14" abrasive blade and a convenient quick-clamp and fence to safely hold material while cutting. It can cut round metal up to 5”" in diameter and rectangular metal up to 4 ½" x 6 ½".

Figure 57: The DeWalt D28715 chop saw in the Machine Shop.

Safety Measures:



Metal Chop Saw Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are required. Dust mask advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Use only cutting wheels meeting the saw manufacturer specifications and limitations to RPM and size.
- Make sure that the workpiece is securely clamped and held in place before making any cuts.
- Adjust the cutting speed and feed rate according to the material being cut, and avoid cutting materials that are too thick or hard for the saw to handle.
- Turn off the saw and unplug it before making any adjustments or changing the blade.
- Keep your hands and fingers away from the saw blade and other moving parts of the saw.
- Never leave the saw unattended while it is running, and always turn off and unplug the saw when you are finished using it.

Figure 58: Metal chop saw safety rules.

E.13 Benchtop Oscillating Spindle Sander:

An oscillating spindle sander is useful for sanding round profiles. It's typically used to fine tune or put a nice finish on work done with other tools.

The JET JBOS-5 sander is mounted on a pedestal, effectively making it floor standing. The table keeps hands at a safe distance, while also being able to tilt up to 45 degrees for various projects. The table insert and spindles can be changed for various diameters to match the workpiece. It is piped into the dust collection manifold to minimize airborne dust.

Figure 59: The JET JBOS-5 oscillating spindle sander in the Machine Shop.

Safety Measure:

Benchtop Oscillating Spindle Sander Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses and mask are required, gloves and hiring protection are advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Always keep fingers at least 3" from the sanding drum.
- Do not overreach. Keep proper footing and balance at all times.
- Be aware of the direction of feed. Feed the workpiece into the sanding sleeve against the direction of rotation of the sanding sleeve.
- Inspect the tool for damage prior to use.
- Verify all guards are in place and adjusted properly.
- Never clear chips from the table with your hand while the sanding drum is moving.
- Do not use the sander to sand metal, plastic, rubber or any material other than wood.
- Avoid awkward hand positions where a sudden slip could cause a hand to move into the sanding drum.
- Never stop the rotation of the sanding drum with your hands or fingers.
- Never leave a running tool unattended. Turn the power switch to OFF. Do not leave the tool until it has come to a complete stop.

Figure 60: Benchtop Oscillating Spindle Sander safety rules.

E.14 Milter Saw (for wood):

A miter saw can make straight cut through wood and some soft metals such as aluminum, at various, possible compound, angles.

The JET JMS-10SCMS sliding compound miter saw can cut wood up to 3 5/8" thick and 12” wide. It has a blade guard that automatically slides into place to protect the operator at all times except when the blade is cutting. And it has material clamps on both sides so hands are never near the blade while cutting. There are also convenient adjustable slide-out stops on both sides making repeated operations easy and precise. The slide is locked when not needed for a simple pull down to cut, or unlocked when wide materials are cut. Sawdust is collected for minimal airborne dust.

Figure 61: The JET JMS-10SCMS milter saw in the Machine Shop.

Safety Measure:

Milter Saw Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses and mask are required, gloves and hearing protection are advised.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Keep saw fences and blade guards in place and functioning properly.
- Assure saw blades are clean, sharp, and correctly set so that they will cut freely without forcing the blade against the work piece.
- Keep your fingers and hands at least four inches from a rotating saw blade.
- Do not attempt to cut pieces of stock that are too small to easily hold with your hands.
- Don't raise the blade until it's come to a complete stop.
- Do not reach in back of the saw blade behind the fence with either hand to hold down or support the workpiece, or remove wood scraps, or for any other reason.
- Breaking action of the saw causes the saw head to jerk downward. Be ready for this reaction when making an incomplete cut or releasing the switch before the head is completely in the down position.

Figure 62: Milter saw safety rules.

E.15 Vacuum Forming:

Figure 63: The Formech 508DT vacuum former in the Machine Shop.

Vacuum forming machines are able to make relatively large parts much quicker than most other tools. A heater heats a sheet of thermoplastic until it's plyable, then a vacuum is applied to pull it tightly over a "buck" or positive mold of the shape of the desired cavity. Most packaging for retail products is made this way but it can also be used with thicker plastic to make large sturdy structures.

The Formech 508DT can create shapes with a surface area up to 19" x 17" and ¼" thick. It's long handles, contained heating elements and safety interlock all help keep hands at a safe distance while operating. or easy separation of buck and workpiece.

Safety Measure:

Vacuum Forming Safety Rules

NOTICE Rules and guidelines listed on this page are only remainders. Persons must read lab safety manual, machine manual, and be trained by the IDEA Lab Manager.

Safety Rules

- Safety glasses are advised.
- Always handle heated plastic material with suitable gloves.
- Don't wear loose clothing or gloves, keep long hair tied back.
- Always handle heated plastic material with suitable gloves.
- Make sure plastic sheets fits over the grey rubber seals.
- Remove protective film of side facing the heating elements.
- Make sure your mold is clean and dust-free then place it in the middle of the drape table.
- Adjust clamps so the top plate clamps tightly over plastic.
- The heating cover on the vacuum former slides forward over the plastic and back into its housing. Only move this using the designated insulated handle (some parts of this cover are hot). Ensure the cover is always pushed back into its housing when not in use or unattended.
- The heating element will take around some time to heat up.
- The plastic is ready to be formed when its starts to slightly dip in the middle – overheating can course the sheet to pinch or puncture.
- Leave the vacuum pump on whilst the plastic cools.

Figure 64: Vacuum Forming safety rules.

F. Cleaning:

For safety and a pleasant environment, the IDEA Lab is designed to be a well-lit work area and is cleaned after each project by the participants and/or the Staff, as well as thoroughly every day that it is open by the University's custodial staff. All hazardous waste disposal is outsourced.

APPENDIX C – EQUIPMENT

Please list the major pieces of equipment used by the program in support of instruction.

The Engineering Program at SHU has significant equipment and instrumentation to support engineering teaching. This equipment and instrumentation are in the IDEA Lab.

Soldering/Electric Lab

The Soldering/Electric Lab (W-169) is where students can work on their projects using many electronic devices and tools. They can access the Carvey CNC, soldering, and electronic equipment to help them with their project work.

The Carvey (illustrated in Figure C-1) is a fully closed Computer Numerical Control (CNC) machine that can carve various materials. The Carvey can be used to create custom PCB boards. Making custom PCB boards can make an electronic project more condensed and more durable, saves time, makes the task easier to duplicate, reduces the amount of soldering needed, and familiarizes students with how electronics are distributed in a professional environment. It has a cutting area of 11.6" x 8" (approximately 30cm x 20cm) in the X and Y axes, respectively. It has a Z axis that varies in length but has an overall clearance from the waste board to the cutting head of 90mm and a maximum travel of 80mm.

Figure 65: Carvey in the Soldering/Electric W-169.

There are seven soldering workstations (illustrated in Figures C-2 and C-3) comprised of soldering irons, stands, helping hands, solder, fume extractors, safety glasses, wires, shaved brass for tip cleaning, wire strippers and flush cutter hand tools.

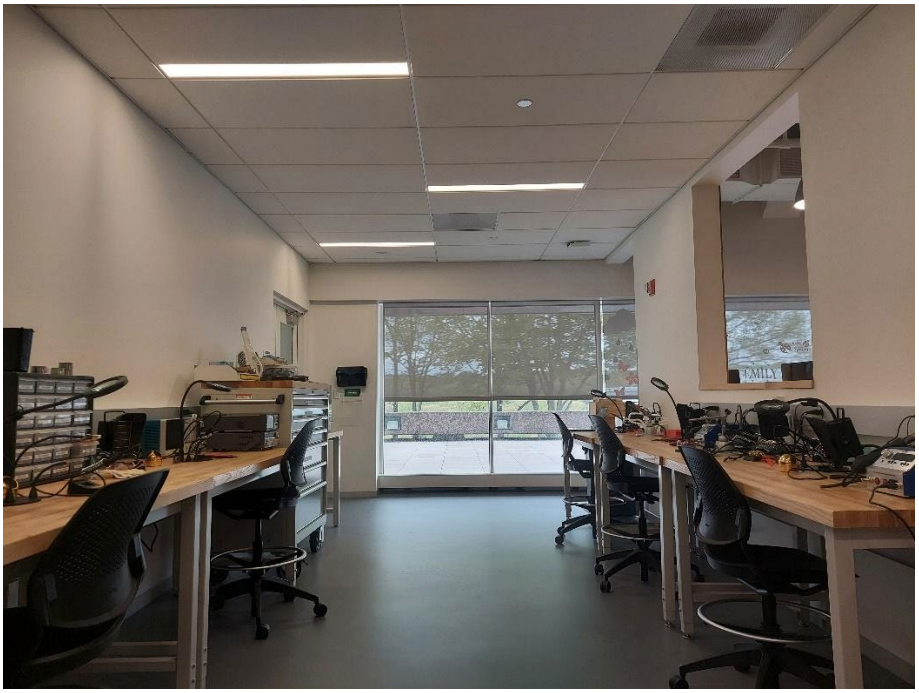


Figure 66: Soldering Stations in the Soldering/Electric W-169.

Figure 67: Soldering Station in the Soldering/Electric W-169.

There are two electronic stations, and each includes (illustrated in Figure 68):

- Tektronix AFG31000 series arbitrary function generator:
    - It allows users to generate high-quality waveforms and signals with great accuracy and precision.
    - The touch screen lets users easily navigate menus, adjust settings, and view waveform previews.
    - AFG31000 series offers various output capabilities, including analog, digital, and RF outputs.
    - It offers users a variety of connectivity options, including USB, LAN, and GPIB.
- Tektronix TBS2072 Digital Storage Oscilloscope which features:
    - A large 9-inch WVGA display provides users with clear, detailed waveform information and easy-to-read menus.
    - It offers a range of automatic measurement capabilities, including peak-to-peak voltage, RMS voltage, frequency, and period.
    - It can capture waveforms up to 2 GS/s, allowing users to capture and analyze fast signals accurately.
    - It offers advanced triggering capabilities, including edge, pulse width, runt, rise/fall time, and video trigger.
- Keithley DMM6500 6½ Digit Multimeter.
- 2231A-30-3 Triple E-channel DC Power Supply.

Figure 68: Electronic Station in the Soldering/Electric W-169.

In addition to the soldering and electronic stations, this area also includes two storage cabinets; one of the storage cabinets (illustrated in Figure 70) is stocked with a range of supplies and components.

Supplies and Components include:

- First drawer has different breadboards:
    - Mini breadboard The 3.5cm x 4.5cm mini breadboard has 170 tie points.
    - Half-size breadboard, 8.2cm x 6.2cm, has 400 tie points.
    - Full-size breadboard, 16.5cm x 5.5cm, has 830 tie points.
- Second drawer includes various custom PCBs.
- Third drawer includes various batteries and battery packs
- Fourth drawer has the material needed to make an Arduino-compatible microcontroller board.
- Fifth drawer has various Arduinos and microcontrollers (illustrated in Figure 71)
- Sixth draw has various soldering supplies (illustrated in Figure 72)

Figure 69: Storage Cabinet in the Soldering/Electric W-169.

Figure 70: The first drawer of the Storage Cabinet in the Soldering/Electric W-169

Figure 71: The fifth drawer of the Storage Cabinet in the Soldering/Electric W-169.

Figure 72: The sixth drawer of the Storage Cabinet in the Soldering/Electric W-169

Figure 73: The 2nd Storage Cabinet in the Soldering/Electric W-169 has various Carvey materials.

The workspace has two 24-bin organizers (illustrated in Figure C-9), designed to provide abundant storage space for various components and tools. The organizers can hold multiple components such as crimp connectors, photoresistors, capacitors, press-fit connectors, resistors of various values, and LEDs in assorted colors and different sizes, including mini, medium, and big. The bins also store other essential tools such as jumper wires, breadboards, protoboards, stripboards, and soldering equipment like solder tips, solder flux, and desoldering wick. In addition, the organizers provide space for alligator cables and heat shrink, allowing users to keep their workspace tidy and well-organized. These 24-bin organizers are a valuable addition to the workspace, providing a convenient and accessible storage solution for all components and tools for students' electronic projects.

Figure 74: The 24-bin organizer in the Soldering/Electric W-169

Table 2: List of Equipment Soldering/Electric W-169.

Equipment	**Quantity**	**Description**
Carvey by Inventables	1	Small enclosed CNC
Tektronix TBS 2000 Series	2	Digital oscilloscope
Tektronix AFG 31000 series	2	Function generator
Keithley DMM6500	2	Multimeter
Keithley 2231A-30-3	2	Triple-channel DC power supply
Weller WSA350	7	Benchtop smoke absorber
Weller WESD51	7	Soldering station

Engineering Classroom

The Engineering Classroom (W-182) (illustrated in Figure C-11) has seven electronic stations, nine desktop computers, several bin organizers, one storage cabinet with seven drawers, six ample storage cabinets with four drawers, and one projector used to support courses that include instruction in electronics.

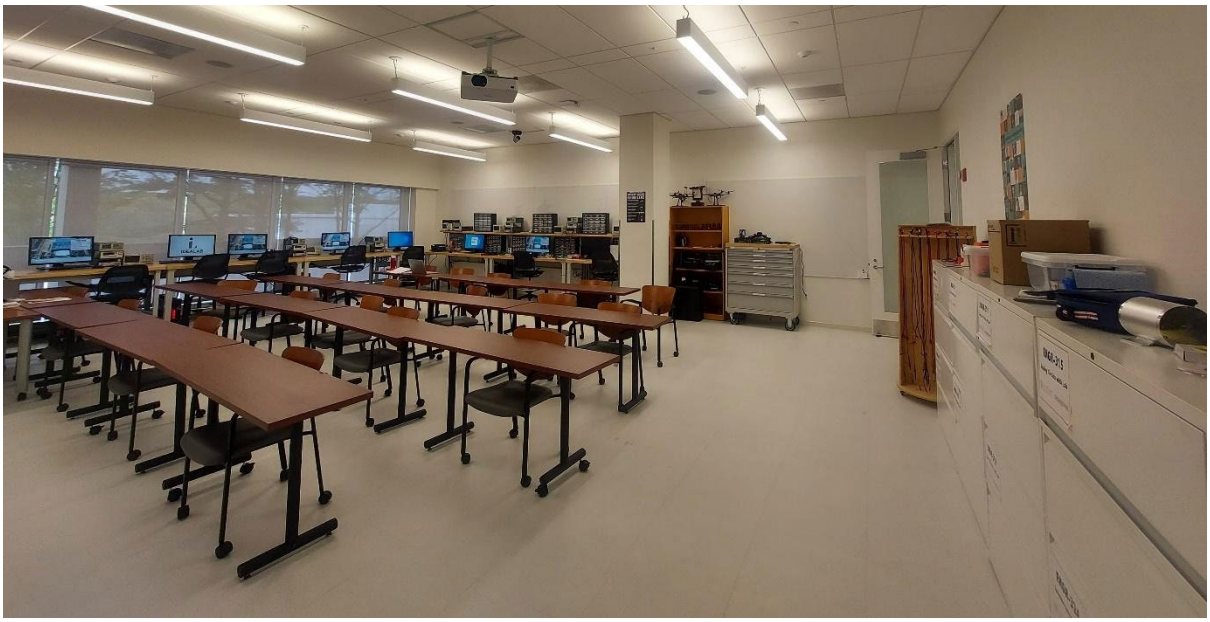


Figure 75: Engineering Classroom W-182

The electronic station helps students by providing the necessary tools for designing, testing, troubleshooting, and verifying electronic circuits; students can visualize and measure electrical signals, generate precise waveforms and signals, and measure voltage, current, and resistance.

Similar to the two in the soldering area, each electronic station (illustrated in Figure 76) includes the following:

- Tektronix TBS 1052B-EDU Digital Oscilloscope, 50MHz 1GS/s.
- Tektronix AFG1022 Arbitrary Function Generator, 25MHz 125 MS/s.
- Keithley 2110 5 ½ Digit Multimeter.
- Keithley 2231A-30-3 Triple Channel DC Power supply.

Figure 76: Electronic station in Engineering Classroom W182

The desktop computers (illustrated in Figure 77) each include an Intel processor, Core i7, 32 GB of DDR4 memory, SSD storage, and Nvidia GTX 1660 Ti graphics.

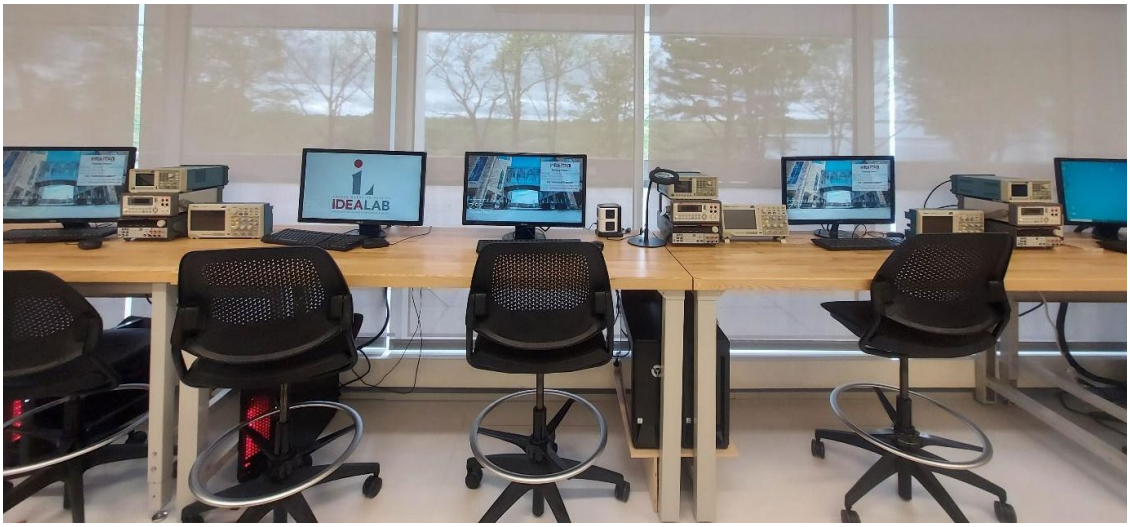


Figure 77: Desktop Computer Sets in Engineering Classroom W182

The storage cabinet (illustrated in Figure 78) includes the following:

- Pens, sticky notes
- Batteries and battery holders
- Arduinos
- Motors
- Breadboards and multimeters (illustrated in Figure C-15)
- Sensors, displays
- Wires

Figure 78: Storage Cabinet in Engineering Classroom W182

Figure 79: Multimeters in one of the drawers in the storage cabinet in Engineering Classroom W182

There are nine bin organizers to store various resistors, capacitors, transistors, LEDs, semiconductors, etc., on a workbench within easy reach of the students. This makes grabbing the necessary components while working on a project quick and convenient.

Figure 80: Bin organizer in Engineering Classroom W-182. The top 4 rows contain various semiconductors, and the bottom three have various potentiometers.

Figure 81: Bin organizer in Engineering Classroom W-182. The resistors are arranged from lowest to highest value.

Figure 82: Bin organizer in Engineering Classroom W-182. The resistors are arranged from lowest to highest value.

Figure 83: Bin organizer in Engineering Classroom W-182. The capacitors are arranged from lowest to highest value.

Figure 84: Bin organizer in Engineering Classroom W-182. The capacitors are arranged from lowest to highest value.

Table 3: List of Equipment Engineering Classroom W-182.

Equipment	**Quantity**	**Description**
Tektronix AFG1022	6	Dual-channel function generator
Keithley 2110	6	Multimeter

Keithley 2231A-30-3	6	Triple-channel DC power supply
Tektronix MSO 2002B	1	Mixed signal oscilloscope
Tektronix TBS 1052B-EDU	5	Digital oscilloscope
Tektronix RSA503A	1	Spectrum analyzer
Keithley 6430	1	Source meter
Gwinstek LCR-8110G	1	LCR meter

3D Printing Lab

The 3D Printing lab (W-174) has 3D printers (illustrated in Figure C-21) with various capabilities, including high-resolution printing, large build volumes, and multi-material printing, all available for student projects. There are also two computer workstations and a storage area (illustrated in Figure C-22). The workstations have installed PrusaSlicer, Simplify 3D, Ultimaker Cura, and OctoPi slicer software.

The Gigabot 3+ 3D printer has a larger build volume of up to 590mm x 760mm x 600mm, which allows for the production of larger objects. The Ultimaker S5 has two extruders that enable printing of complex objects with two different materials in a single print. It can print various materials, including PLA, ABS, PETG, Nylon, TPU, and PVA. It has a build volume of up to 330mm x 240mm x 300mm. The Prusa i3MK3 can produce high-quality prints with up to 50 microns resolution.

Table 4: List of 3D printers in Printing W-174 lab.

Equipment	**Quantity**	**Filament**
Re3D Gigabot 3+ XL	1	PLA: 2.85mm
Ultimaker S5	4	PLA: 2.85mm
Prusa i3 MK3 by Josef Prusa	12	PLA: 1.75mm

Figure 85: 3D printers in Printing W-174 lab.

Figure C-21. 3D printers in Printing W-174 lab.

Figure 86: 2 computer systems and storage in W-174 lab.

Figure 87: 12 Prusa i3 3D printers in Printing W-174 lab

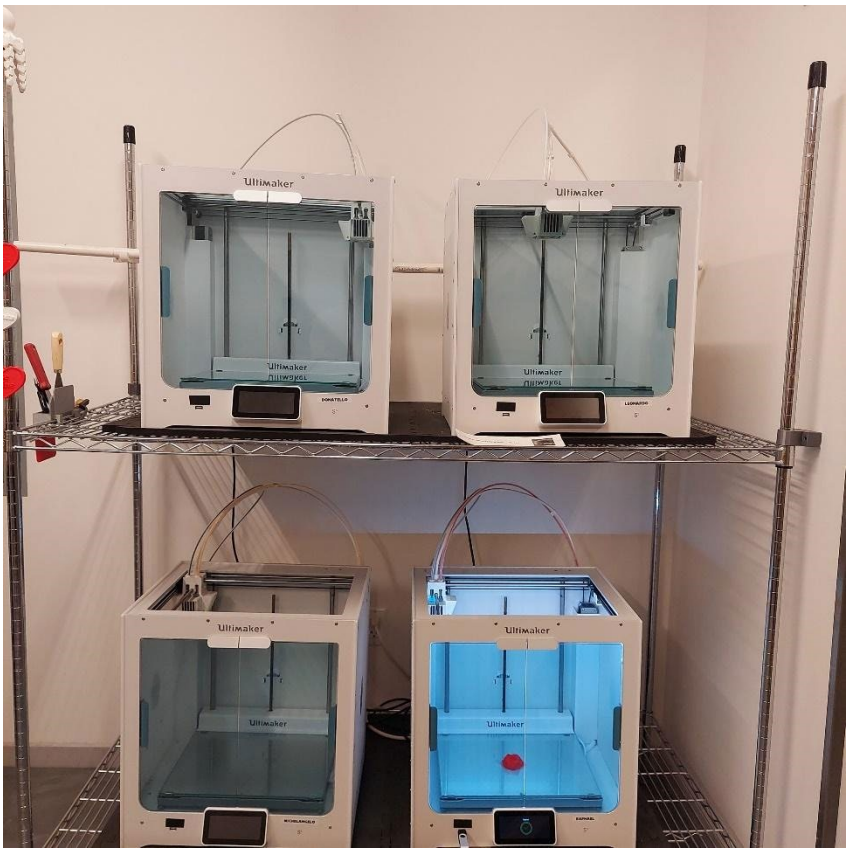


Figure 88: 4 Ultimaker S5 3D printers in Printing W-174 lab

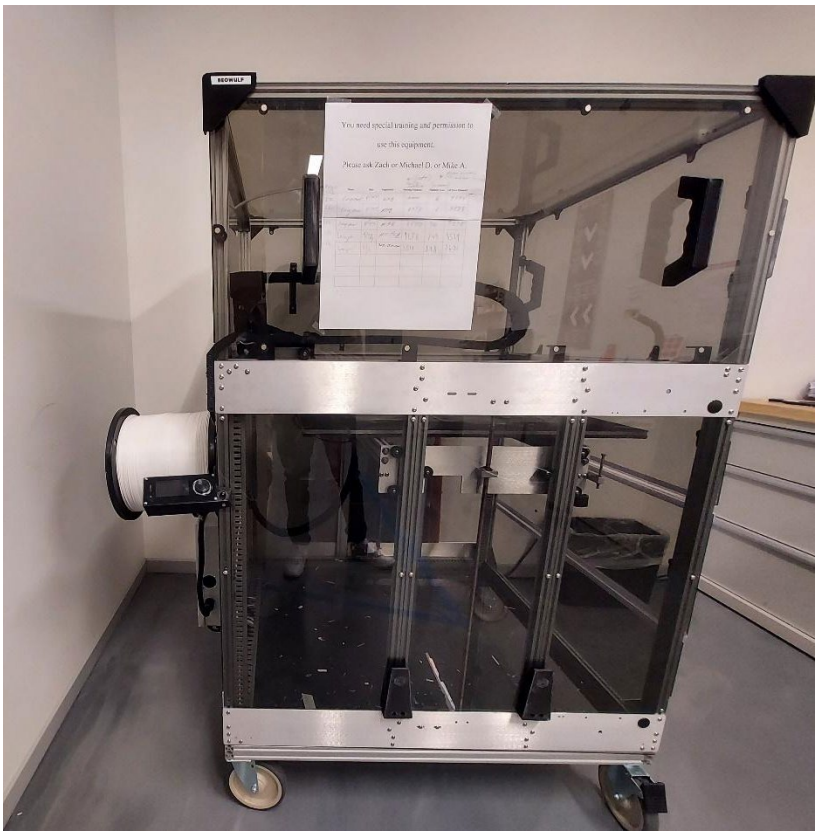


Figure 89: Gigabot 3+ XL 3D printer in Printing W-174 lab

Machine Shop Lab

The Machine Shop Lab (W-176) has large equipment for cutting and shaping and handheld tools for various uses. For the Roadkill (senior capstone design) project, several Machine Lab tools were used in manufacturing, like the chop saw, bench grinder, paint bay, etc.

Figure 90: Shopbot in Machine W-176 lab

Figure 91: Water jet in Machine W-176 lab

Figure 92:Laser Machine in Machine W-176 lab

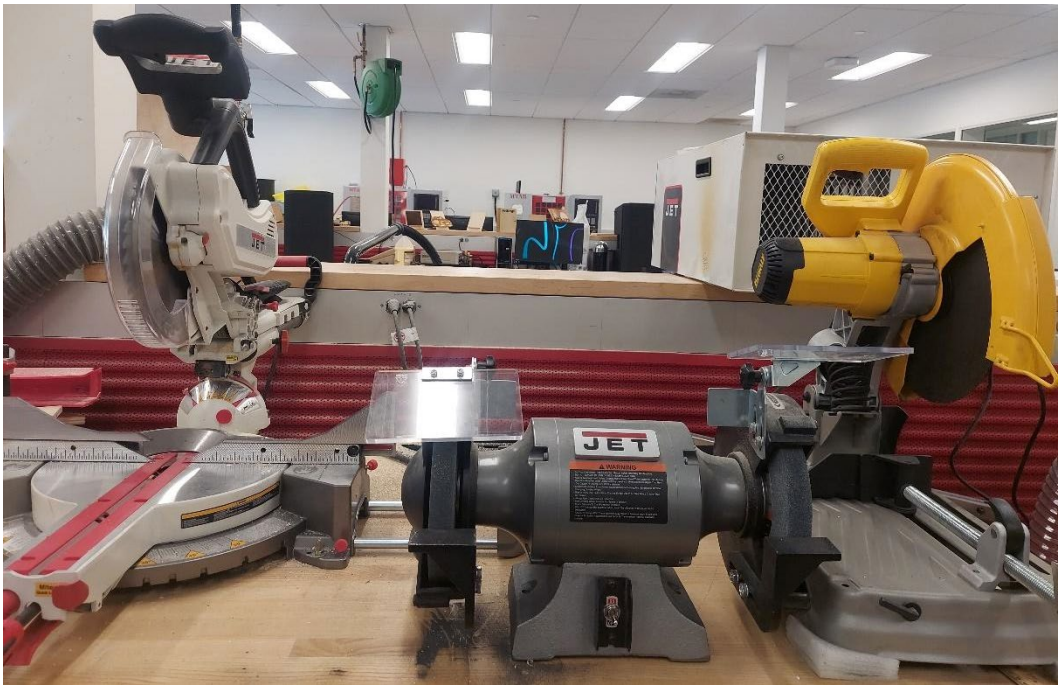


Figure 93: Wood Saw (left), Bench Grinder (middle), and Metal Saw (right) in Machine W-176 lab.

Figure 94: Vacuum Forming Machine in Machine W-176 lab.

Figure 95: Spindle Sander in Machine W-176 lab

Figure 96: Belt & Chamfering Machine in Machine W-176 lab

Figure 97: Sawstop safety table saw in Machine W-176 lab

Figure 98: MTAB FLEXMILL in Machine W-176 lab

Figure 99: MTAB FLEXTURN in Machine W-176 lab

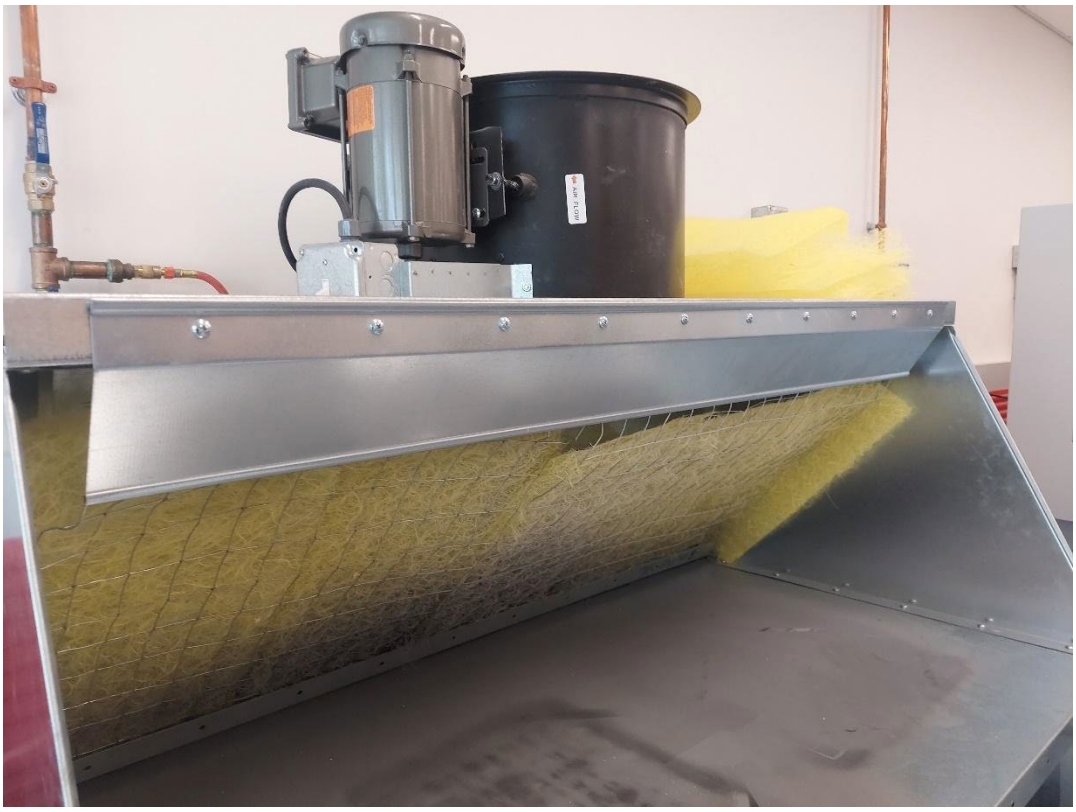


Figure 100: Paint Bay in Machine W-176 lab

Figure 101: Slip Roller in Machine W-176 lab.

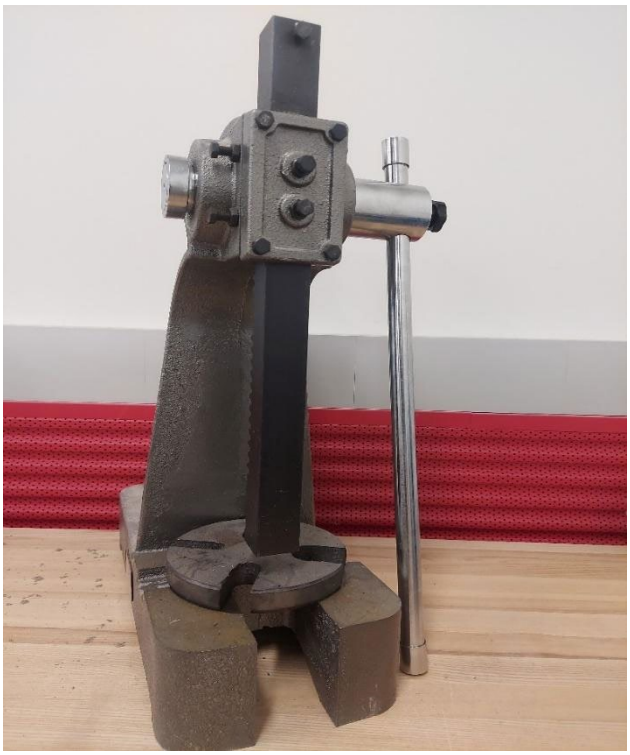


Figure 102: Arbor Press in Machine W-176 lab

Figure 103: Hand Tapper in Machine W-176 lab

Figure 104: Drill Press in Machine W-176 lab

Figure 105: Finger Brake in Machine W-176 lab

Figure 106: Thickness planer in Machine W-176 lab

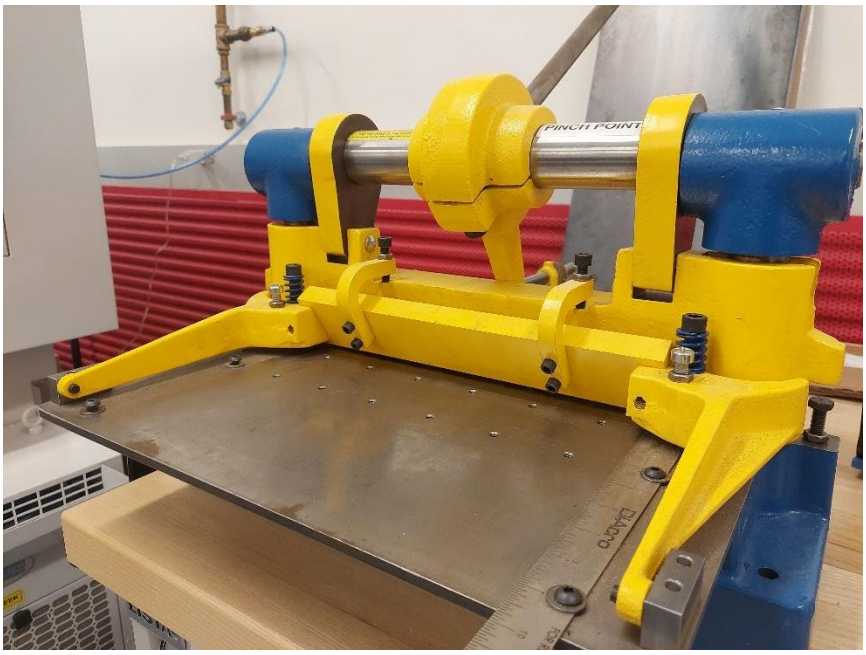


Figure 107: Hand Shear in Machine W-176 lab

Figure 108: Right Angle Drill, Oscillating Multi-Tool, Compact Router, Angle Grinder, and Flashlight in Machine W-176 Lab

Figure 109: Random Orbit Palm Sander, Circular Saw in Machine W-176 Lab

Figure 110: Heat Gun, Jig Saw, Cut-Out Tool in Machine W-176 Lab

Figure 111: Reciprocating Saw in Machine W-176 Lab

Figure 112: Drill Driver and Impact Driver (two of each) in Machine W-176 Lab

Figure 113: Hand Tool Station in Machine W-176 Lab

Table 5: List of equipment in Machine W-176 lab

Equipment	Quantity	Description
ShopBot ARM98AC-T7.2	1	Shop Bot
Jet Floor Drill Press J-A5816	1	Drill Press
Jet Spinder Sander JBOS-5	1	Sander
Jet Belt Sander JSG-6DC	1	Belt Sander
Jet Bench Grinder JBG-8B	1	Grinder
Jet Milter Saw JMS-10SCMS	1	Milter Saw

Equipment	Quantity	Description
Jet Chop Saw D28715	1	Chop Saw
Proto Max, Built By OMAX	1	Water Jet
Formech 508DT	1	Vacuum Forming Machine
Sawstop PCS31230	1	Saw Stop
Dewalt DW735	1	3Knife, 2 Speed Thickness Planer
EpilogLaser FusionPro	2	Laser Engraving and Cutting
MTAB FLEXMILL CNC 2000	1	???????????
MTB FLEXTRUN CNC 2000	1	???????????
DI-Acro 12HS	1	Hand Shear
DI-Acro 24FB	1	Finger Brake
DI-Acro 12SR	1	Slip Roller
VEVOR PN-1/2S	1	Pipe Notcher
JET AP3-M	1	Arbor Press
XCUT Hand Tapper	1	Hand Tapper
DeWALT 20v DCD740	1	Right Angle Drill
DeWALT 20v XR DCS356	1	Oscillating Multi-Tool
DeWALT 20v XR DCW600	1	Compact Router
DeWALT 20v DCG413F	1	Grinder
DeWALT 20v DCL050	1	Work Light
DeWALT DCW210	1	Random Orbit Palm Sander
DeWALT DCS391	1	Circular Saw
DeWALT D26950	1	Heat Gun
DeWALT DCS331	1	Speed Jig Saw
DeWALT DW660	1	Cut-Out Tool
DeWALT DWE305	1	Reciprocating Saw
DeWALT DCD771	2	Drill Driver
DeWALT DCF885	2	Impact Driver