

The Machining Lab

1.0 Expected Learning Outcomes

- Understand how to operate common machine shop equipment safely.
- Demonstrate capability to use machine shop equipment to fabricate simple experimental apparatus.
- Demonstrate ability to understand standard mechanical design documents and to use them to guide fabrication of moderately complex items.

2.0 Grading

The grading for this portion of the class will be as follows:

- Lathe projects (heater block, cooling rod, brass cap) – 30 pts.
- Mill project (jack-in-a-cube) – 20 pts.

3.0 Introduction to the machine shop

Before you can work in a machine shop, it is necessary to be trained in proper safety procedures. It is also necessary to be trained in the operation of the particular machines you will be using. During our first class period in the shop, we will complete the safety training. The safety guidelines are included on page 2 of this document.

We will also provide training for the machines we use in our projects. The training will be given when you are ready to use a particular machine, so it is fresh in your memory as you begin.

Several resources are available to introduce the machines and give an overview of their operations. Having a general understanding of the machines can also help in understanding the rules and regulations described in this chapter.

Links to a Virtual Machining Tutorial can be found at <https://www.physics.byu.edu/faculty/petersonb/Phys240/VirtualMachiningTutorial.html> to make it possible to review the machines and operations that are available in the machine shop.

It will also be useful to read Sections 1.1.2 to 1.1.4 (Machines for Making Holes, The Lathe, and Milling Machines) and 1.4.1 (Threaded Fasteners) in the text.

4.0 Machining lab regulations and safety

One of the most important responsibilities of each student in the laboratories on campus is to learn and observe appropriate safety procedures. The machines with which you will work in the machine shop are designed to manipulate all forms of materials. They can cause serious injury if not used correctly.

4.1 The basic rules

One simple rule:

If you do not know how to use the machine,
DO NOT USE IT WITHOUT HELP!

Do not be afraid to ask questions of the TAs and machine shop staff.

1. Always protect your eyes. Safety glasses must be worn at all times in the lab. Eye protection must comply with the American National Standards Institute, ANSI Z87.1-1989 standard. You must be able to find the code Z87.1 stamped on or molded into the glasses somewhere for them to be acceptable.
 - Goggles or a face shield should be used when additional protection is needed.
2. Ear protection is not required but may be desirable for operating some machines or if you are sensitive to loud noises.
3. Ensure that other individuals are present in the lab before using any equipment.
4. Dress correctly.
 - Long pants and closed-toed shoes are required in the machine shop. Sandals, bare feet, shorts, skirts, capris, kilts, and mu'umu'us are not allowed.
 - Never wear loose clothing or long sleeves. Remove your necktie or tuck it into your shirt.
 - Keep your hair cut reasonably short or tied back to prevent it from contacting any moving parts.
 - Remove all jewelry such as rings and wristwatches.
5. Machines must be stopped before taking measurements or making adjustments.
6. Never leave a running machine unattended.
7. Never start or stop a machine for someone else.
8. Never leave a chuck wrench in the chuck of a machine - if your hand is not on the wrench, the wrench must not be in the chuck.

9. Never use rags or hands to remove chips - chips are often hot and sharp.
10. Know your job and follow instructions. If you don't understand the instructions, ask a TA or the instructor, NOT another student.
11. Remember: a shop is a place to work. Always attend strictly to business and keep your mind on what you are doing. "One moment of carelessness may mean a lifetime of sorrow."
 - Never distract others who are using a machine.
12. Report all accidents to TAs and instructor.
13. Use only tools in good repair and report all tools that are not.
14. Never try to stop a revolving chuck with your hands.
15. Use only those pieces of equipment which have been demonstrated.
16. Never test the finish of revolving work with your finger.
17. Always check to see that spindles and chucks are tight before use.
18. Stay away from moving parts and equipment.
19. Work stock should not project more than 2.5 times the diameter out of the chuck or collet without being supported.
20. Permission must be obtained from a TA or instructor before any work is done in the lab.
21. Oily and greasy rags should be placed in a special covered container.
22. If you spill any liquids they should be cleaned up immediately.
23. When required to move long or heavy stock, get assistance.
24. Always use the proper tool for the job.
25. Sharp tools are safer because they require less force to perform the operation.
26. When cutting with a knife or hand tools always cut away from your body.
27. When cutting on a bandsaw, the work must rest flat on the table.
28. Make sure that stock, tool, and tailstock are properly tightened before an operation is started.
29. Keep work area clean.
 - There is a place for everything, and you must keep everything in its place.
 - Do not place tools where they may fall or be accidentally pushed into a running machine.
 - Keep tools properly arranged.
 - Keep the area around the machine clean and free of oil.
 - Keep benches, aisles, and floors clean and clear.
 - **Always clean up your machine when you finish using it**, as well as the surrounding area.
30. User proper feed and speed for the operation being performed.
31. Keep machine guards in place.
32. Know the location of fire extinguishers.

4.2 General safety guidelines

Speeds and Feeds: Choose and set the correct speeds and feeds. It is critical to many machine operations. If you do not know how to determine these parameters, ask for help. The [Tool Speeds Chart](#) found on Learning Suite under **Content** ⇒ **Machine Shop** gives guidance on choosing the proper tool speeds for various materials and operations.

Unusual Noises: Stop what you are doing if you hear something unusual or suspect something has changed and check it out. Pay close attention to what you are doing at all times.

Broken or Damaged Tools: Immediately report broken or damaged equipment and tools to the lab supervisor or TA. It is expected that tools will occasionally break, and equipment will suffer from wear and tear. It is important that these items be brought to our attention so that the equipment and tooling can be maintained and operated safely.

Machine Operation: Operate a machine only one person at one time. It is extremely hazardous for more than one person to work the controls of a machine. If assistance is needed to support material being processed, the assistant should only provide support and allow the operator to provide all motion to the work-piece or machine.

Horseplay: Never engage in horseplay of any kind.

Correct Tools: Always use the correct tool for the job. If you are not sure what is needed, please ask for assistance.

Sharp Tools: Sharp tools are safer, provide better results, and require less effort to accomplish a task. Ask for assistance to have tools sharpened or replaced.

Safety Equipment: Know the location of any safety equipment, such as fire extinguishers or emergency showers.

Emergency Situations: Call 911 on a BYU campus desk or wall phone or 801-422-2222 on a cell phone if there is any question about the seriousness of an emergency. Your first responsibility is to get as much assistance as possible to the situation while providing emergency care to the best of your knowledge.

First Aid: Immediately report all accidents to a lab supervisor, TA or faculty member. First aid kits are available for simple cuts or abrasions. BYU is not responsible for paying for medical services in response to accidents within its lab areas unless specific liability is established. You should make medical care decisions based on the assumption that you are responsible for payment.

Material Spills: Immediately clean up if you spill liquids or materials on the floor. If the materials are hazardous in nature, immediately notify the supervisor or TA to determine what course of action should be taken.

Disposing of Chemicals: Never put anything but water (and hand soap) down the drain. BYU has a chemical management department that will assist with the disposal of chemicals.

Mixing of Chemicals: Never mix chemicals of unknown origin or if you are in doubt about the outcome. Many chemicals are incompatible and become volatile or toxic when mixed improperly. If you are in doubt, get assistance.

4.3 Lathe operation safety guidelines

Chip Removal: Never remove chips with your hand. Use a brush, wire, or pair of pliers to remove chips.

Rotating Parts: Use extreme caution to keep away from the rotating parts. Lathe operations involve rotating chucks and workpieces. Never touch the workpiece or make measurements while the part is turning. Remove long, stringy chips only when the lathe is stopped. Turn the spindle by hand before turning the power on to ensure that there is no interference between the rotating parts and the machine.

***NOTE:** If lathe chuck jaws are opened too far, they can come out of the chuck during lathe operation, causing serious injury.

Changing Speeds and Feeds: Never change gears while the lathe is running. If you cannot get the machine into gear, rotate the spindle or lead screw by hand to align the gear-set and allow the gears to engage.

Chuck Wrenches: Always remove the wrench from the chuck, even if you will be using it soon. You can only remove your hand from the chuck wrench if the wrench has been removed from the chuck. Make this a habit!

Mounting Stock in Chucks: make sure the stock does not protrude from the chuck or collet more than 2.5 times the stock diameter unless supported by a center or other rest.

Tool Alignment: Check the alignment of the tools and spindle. When stopped the tools should be aligned with the spindle. Proper tool alignment is critical for good material removal and finish. Tools should be mounted with a minimum overhang to provide maximum rigidity.

Automatic Feeds: Be sure you know in which direction and how fast the cross-feed or carriage will move before engaging the automatic feed. It is usually wise to verify motion by moving the tool away from the part and engaging the feed to check the direction and speed.

4.4 Milling machine operation safety guidelines

Variable Speed Heads: Only change speed with the spindle running on machines equipped with variable speed heads.

Removing Chips: Never remove chips with your hands. Use a brush to sweep chips from the part.

***CAUTION:** The chips produced by milling cutters are very hot and can be thrown some distance.

Measuring: Never measure parts with the spindle turning.

Climb (Up) vs. Conventional (Down) Milling: Use climb milling whenever possible. It causes less tool wear, requires less cutting force, and leaves a better surface finish. Conventional milling is best used when milling thin sections, using large cutters, or when the milling machine has excessive backlash in the feed screw.

To remove tooling from the spindle:

1. Ensure that the spindle is fully retracted.
2. Hold the tool with a towel or rag to protect your hand.
3. Press and hold the off button until the tool loosens into your hand.

To install a collet/tool in the spindle:

1. Ensure that the spindle is fully retracted.
2. Clean the inside of the spindle and the collet/tool.
3. Hold the tool with a towel or rag to protect your hand.
4. Insert the collet/tool into the spindle and rotate it until the keyway on the collet/tool lines up with the key on the spindle.
5. Press and hold the on button until the collet/tool fully engages into the spindle head.

4.5 Drill press operation safety guidelines

Clamp All Work: Secure all work in a vise or clamp it to the table. If the workpiece breaks free and begins to rotate, immediately turn the drill off and wait for the piece to stop rotating.

Chuck Key: Never leave the chuck key in the chuck.

Drilling Tip: Let up on the pressure as you approach breaking through material that you are drilling.

4.6 Cut-off band saw operation safety guidelines

Speed: Be sure the speed is set correctly for the type of material to be cut.

Clamp All Work: Verify that the piece is firmly clamped in the vise. Just because the clamp screw is tight (that is, it won't turn any further), that doesn't mean the piece is clamped.

Feed: Use the hand wheel or the power feed to feed the blade through the part *after the coolant begins to flow*. If using the power feed, choose the pressure that is appropriate for the material being cut. Typically material four inches thick requires about fifty pounds of cutting pressure. Thinner material requires proportionately less.

Thickness: Material must be thick enough so that *at least two teeth of the blade are engaged in it at all times*.

Retracting the Blade: Use caution when running the blade back after finishing the cut. If the back edge of the blade catches on your material, it could push the blade out of its guides. This destroys the blade and may propel broken saw teeth at the operator.

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