PART 1: Introduction

1.1: OVERVIEW

The purpose of this lab is to expose you to the operation of basic hand and shop tools. Completion of this lab is required for all those who need to use our department shop facilities.

Students must complete the fabrication of this simple article PLUS pass the exam on lab safety in order to obtain a card that lets them use basic tools in the MAE shop. Refer to the MAE shop policy document for details.

You may attend any of the MAE 200L lab sections that meet in the basement of the MEC building. These times are:

Monday 2PM and 4 PM  Tues, Weds, and Thurs, 1 PM  Friday 2PM and 4 PM

Be sure to wear shoes that cover your feet when you come to lab.

The week in which this activity is done varies from year to year. The announcement for the shop training will give the weeks.

1.2: SHOP SAFETY

It is MAE Department policy that anyone using tools in the fabrication of experimental equipment in labs or working in shop facilities that are part of the department must have a card showing that they have passed both the safety training course and the shop tools familiarity lab.

To satisfy the safety training, you will need to attend two evening lectures on safety and then pass an exam on this subject. These evening training sessions will be announced.

To pass the shop tools part, you will need to get a grade of 75% or better on the object that you will fabricate this week.

If you have to use the shop for your senior thesis project or any other project such as the 4th year design project (which just about everybody has to work on), you will need to have this shop card. If you do not pass the safety part or the lab part this semester, you can come back and do it next fall. We would hope that most of you will attend the safety lectures this semester since it is valuable knowledge you will need in industry. But you do not have to do the safety part now.

1.3: OBJECTIVES

Our objectives are:

a. Illustrate how to use basic hand and power tools correctly and SAFELY
b. Develop in the student an appreciation for the manual arts and the technicians who create much of the experimental prototypes and test facilities engineers use.
c. Demonstrate the kind of skill required to make something of quality.
d. Introduce several basic mechanical measuring instruments
1.4: OUTCOMES  After completing this lab the student should be able to:

a. Use the following manual tools at an elementary level
   - hack saw
   - center punch
   - combination square
   - dial calipers
   - bench vise
   - dividers
   - torque wrench
   - threading tap
   - file
   - open end wrench
b. Use the following power tools at an elementary level
   - drill press
   - hand drill
   - horizontal band saw
   - vertical band saw
   - circular saw
c. Fabricate a simple object using a mechanical drawing and set of instructions.
d. For MAE 200L students: Be able to recognize all of the basic hand and simple power tools on the display boards in MEC B014

1.5: SCHEDULE OF STUDENT ACTIVITIES

a. IN CLASS:
   - Instructor will make one of the items to demonstrate
   - Student will then go through the process and make one of the items, or sign up for another period to complete the work

   All graded objects will be returned in a box at a designated location each morning by 10AM. So you can pick yours up and see if you passed.

   Students wishing to use the department shop facilities must pass this activity with a score of 75% or better. Upon achieving this, the student’s shop admission card will be punched.
   - If you do not achieve a score of 75%, you may return and try again.

   Students may work on the project for the next two weeks during the times that the lab room is open. There will be a sign up sheet for each of the workstations placed on the door to the lab. Students may sign up for as many non-consecutive sessions as they need but only one session at a time.
   - This means that you sign up for one vacant time slot. Then after you have worked during that time period you may sign up for another vacant time slot.

1.6. LAB SAFETY

WHEN WORKING IN THE LAB WITH TOOLS, THE FOLLOWING RULES MUST BE ADHERED TO:

a. Shoes that cover your feet
b. No jewelry. Remove bracelets, watches, dangling neckwear
c. No long hair (tie it up or wear a hair net or cap)
d. No long sleeves (roll them up)
e. Safety glasses will be worn at all times. If you wear regular glasses, you will put safety glasses over them.

You will be asked to leave the lab if you do not adhere to these rules.
1.7: MAE SAFETY/SHOP TRAINING RULES FOR THIS LAB

YOU CANNOT GO INTO ROOM B014 WITHOUT SHOES THAT COVER YOUR FEET. EVEN IF YOU ARE JUST COMING IN TO LOOK AT THE DISPLAY BOARDS YOU STILL HAVE TO HAVE PROPER SHOES!!

1. This shop training activity will only be offered each fall. So even if you missed the safety training sessions, you can still do the shop training.

2. After today’s demonstration, some of you may stay here and work at a workstation. There will be a sign up sheet for this.
3. The sign up sheet for other sections later in the week and next week is on the door. You can sign up for ONLY ONE time period at a time.

4. NO ONE CAN WORK IN THIS ROOM WITH THE TOOLS UNLESS THEY ARE SIGNED UP FOR THE TIME SLOT. IF YOU COME IN AND WORK AT ANY OTHER TIME, YOU WILL BE DROPPED FROM THE PROJECT

5. Your completed object goes into the big box in the room. WRITE YOUR ID NUMBER ON THIS ITEM. We will grade the objects every night. The graded object will be set out on the table here in this room every morning. Non-mae200L students will receive an ID number at the beginning of lab

6. If you fail to make the object with sufficient quality to pass, you can sign up for another time period and try again.

1.8 GRADING Your grade is determined from the following factors

The sum of the number of standard deviations of your dimensions from the average or expected value plus 0.5 points for each of the subjective measures (wood corners, arc blending, and metal burrs) gives you a total numerical score. On the scale 90-100 = A, 80-90 = B, etc. Any score <60 means you have to do it over to qualify.
Basic Tools Familiarity Lab Manual (9/07)
PART 2: LAB PREPARATION

2.1: OVERVIEW

In order to make the assembly; you will need to use measuring instruments and tools. In this section we provide explanatory information on some of these items. If you read over this material and watch the video of the fabrication process and read through the steps with the photographs provided in the next section BEFORE YOU COME TO THE LAB you will greatly reduce the time required to complete the assembly.

Remember that time in the lab is limited so the more you know about the activities before you go to lab, the less time you need and the more likely you are able to get the item made using just one or two lab time slots.

2.2: MEASURING TOOLS

The two measuring tools we will be using are the combination square and the dial caliper. The operation of these tools is described here

2.2-1: COMBINATION SQUARE

The combination square allows you to measure off distances and draw lines perpendicular to the straight sides of things. We will use this instrument to draw lines on the workpieces to locate hole centers and places where we will cut.

The instrument consists of a cast iron body with a steel ruler that can slide.

When the knurled knob is tight, the retainer pulls down on the slot in the ruler and locks it in place. Loosening the knob allows one to slide the ruler back and forth. WARNING: If you pull the ruler all the way out, it requires some manipulating to get it back in because the slot in the ruler has to line up with the retainer.
You can set the ruler at various distances from the body like this. Then you can lay the instrument along the side of something and mark a line at the set distance from the edge.

You can also draw a line perpendicular to any edge. You can draw this line with a pencil, pen, or scribe.

A SCRIBE is a pencil that has a sharp piece of steel instead of a piece of lead. It will scratch a line in metal.

2.2-2: DIAL CALIPERS

A dial caliper is a measuring instrument that allows you to measure the size of things (like the diameter of a cylinder, etc.) with an accuracy of 1/100 of an inch or better.

The calipers have one fixed jaw and one movable jaw. The movable jaw slides along the body of the instrument on which a scale graduated in tenths of an inch is scribed. The dial rotates, one revolution corresponding to 1/10 of an inch.

A locking screw is provided so that one may set a dimension and lock the movable jaw.
A thumb wheel is attached to assist in moving the movable jaw.

Since the jaws of this instrument are made of hardened steel, one can use their edges to scratch a line parallel to and at a set distance from an edge as illustrated here.

### 2.2-3: DIVIDERS

Dividers are a compass with two sharp points.

We use it to scratch circles in metal.

### 2.3: FABRICATION TOOLS

#### 2.3-1: TOOLS AT YOUR WORK STATION

Here is a picture of the tools you have at your work station.

![Tools at Work Station](image)

FIG. 2: Basic Tools at Each Work Station

There are also some tools that are shared by two work stations. These are shown in Figure (3).
The steps in the fabrication process show you how to use these tools. The video of the process and the demonstration in lab will also help.

2.3-2: SHOP POWER TOOLS

You will also use a drill press, horizontal band saw, and vertical band saw. These tools are more easily seen in the video. Parts of them appear in the pictures below as well.

These major shop tools must be set up by the technician because it requires too much “learning” time for all students to master their operation. The types of saw blades, the saw blade speed and the drill type and speed all depend on the type of material you are working with. The lab technicians have had the training to know about these things. In general, you should not use such tools in the shop without checking with the technicians to see that they are set correctly for your particular job.
The process for making the assembly is described in detail by the steps below. The video presentation also shows these being carried out. You should follow these steps in order to make your parts.

There will be a technician in the area to assist you. Be sure to ask for clarification as needed.

And be aware that some tools will break and need to be repaired.

A quick list of the activities is as follows. The details of each step are illustrated below

A. ALUMINUM PIECE

1. Mark cutoff line for aluminum piece on the long aluminum bar
2. Mark center for hole in aluminum piece
3. Cut off aluminum piece in horizontal band saw
4. File rough edges
5. Center punch for drill
6. Drill hole for tap
7. Cut radius on vertical band saw
8. File rough edges
9. Tap threads

B. WOOD PIECE

1. Mark cutoff line for wood piece on the long wood board
2. Mark center for hole and scribe arc with dividers
3. Cut off piece with circular saw
4. Drill clearance hole on drill press
5. Drill through hole with hand drill
6. Cut radius on vertical band saw
7. File rough edges

C. ASSEMBLE

1. Put nut and washer on bolt
2. Screw bolt into aluminum piece and set spacing
3. Tighten nut
4. Put bolt through hole in wood piece and place washers and nut
5. Line up radius
6. Tighten nut to 150 in-lb with torque wrench
A. ALUMINUM PIECE

1. MARK CUTOFF LINE
Set combination square at 3 inches

Mark for cutoff location and scribe line

MAKE MARK

ROTATE SQUARE 90° and DRAW LINE

2. MARK CENTER FOR HOLE
Set combination square at 2 inches and scribe mark in center of bar
Set dial caliper at ¾ inch

Scribe line for center of drilled hole by drawing vernier caliper jaws along the workpiece

Align caliper jaw on side of workpiece and scratch this line

Scribed line from step 2

Then turn calipers over and scribe line from the other side

Line scribed in previous step above may not line up perfectly with second line. The true center is between the two lines
3. CUT OFF ALUMINUM PIECE IN HORIZONTAL BAND SAW

We are now ready to cut off our 3 inch long piece using the horizontal band saw.

The instructions for using this machine are provided on a poster beside the machine as well as in the picture sequence below.

3.a: With the vice jaws open slightly, hold saw blade up with one hand and move workpiece under the blade until the line where you want to cut off the piece lines up with the blade.

3.b: Lower the blade down almost onto the workpiece to get the final alignment.

3.c: Tighten the vice jaws to clamp the workpiece.
3.d: Lift the blade off of the workpiece while you turn on the saw. Then lower the blade slowly until it starts to cut. Then let go and the weight of the saw will do the cutting.

4. FILE ROUGH EDGES

Run the metal file along the edges to remove burrs. Remember to push the file forward to cut and then lift it up to return. DO NOT SAW.

5. CENTER PUNCH FOR DRILL

Place the center punch in the middle of the crossed lines on the workpiece and strike if moderately with the hammer. This will make a small indentation.

We need the indentation to guide the drill bit.

6. DRILL HOLE FOR TAP

Go to the large drill press with the small vise sitting on its table. Place the aluminum piece in the vise to that the drill will pass between the sides of the vise base when it comes through the aluminum piece.

Before turning on the drill motor, move the workpiece under the drill and slide the vise on the table so that the drill bit will come down at the hole center.

If you push the drill in too hard, it will catch and lift up the entire vise!! TAKE AT LEAST 5 SECONDS TO DRILL THROUGH THE METAL.
7. CUT RADIUS ON VERTICAL BAND SAW

We have made a fixture with a pin on it. The pin is 1.75 inches from the saw blade. Place the hole in the workpiece over this pin.

Hold your thumb on the workpiece over the pin. Turn on the saw and use the wooden push stick to move the workpiece through the blade. You do not have to push very hard.

8. FILE ROUGH EDGES ON RADIUS

9. TAP THREADS

Place the aluminum piece in the vise at your workstation. Place the tap in the hole and push down slightly while turning the tap wrench clockwise one turn.

This will start the teeth of the tap cutting into the aluminum.

The procedure is to rotate the tap two turns and then reverse and back the tap 1 turn counterclockwise. This procedure clears out chips. Otherwise the chips will build up on the tap and cause some of the threads to break.

Turn the tap in until it rotates easily. Then you have finished the threads all the way through.
B. WOOD PIECE

1. MARK THE CUTOFF LINE ON LONG WOOD BOARD
2. MARK CENTER FOR HOLE AND SCRIBE ARC WITH DIVIDERS

Use the combination square as you did with the aluminum piece to mark the cutoff line and locate the center for the hole. Scratch the arc for the rounded end with the dividers.

3. CUT OFF PIECE WITH CIRCULAR SAW

Clamp the wood to the table with a C-clamp, leaving enough room for the saw to fit between the location of the C-clamp and the cut line. The saw blade has a finite thickness. So watch the blade so that it follows along the inside of the cut line you that you marked.

4. DRILL CLEARANCE HOLE ON DRILL PRESS (Counterbore)

The small drill press is set up with a wood bit to drill the counterbore hole. Start by positioning the piece on the table so that the drill bit touches the center.
Then C-clamp the piece to the table

**NEVER DRILL WOOD OR THIN METAL WITHOUT CLAMPING IT DOWN. THE DRILL CAN “GRAB” THE MATERIAL AND SPIN IT AROUND!**

Turn on the drill and start the hole

When the depth is right, the drill will stop because we have set the adjustable stop (shown here) on the machine. Be sure to note this feature.

5. **DRILL THROUGH HOLE WITH HAND DRILL**

   The smaller hole is made with the power drill at your work station

6. **CUT THE RADIUS ON VERTICAL BAND SAW**

   The wood band saw is set up. You need to guide the wood yourself as you cut the arc. This can be tricky if you have never done it before. Go slow.
7. FILE ROUGH EDGES

Use the wood file to clean up the rough edges on the wood piece.

C. ASSEMBLE

1. PUT NUT AND FLAT WASHER ON THE BOLT

2. SCREW THE BOLT INTO THE ALUMINUM PIECE AND SET THE SPACING

The spacing between the underside of the bolt head and the top of the flat washer is ¾ inch. Set this on the dial calipers and use the “inside” measuring feature to set the distance

3. TIGHTEN THE NUT AGAINST THE ALUMINUM PIECE WITH THE WRENCH TO LOCK IT AT THIS DISTANCE

4. PUT THE BOLT THROUGH THE HOLE IN THE WOOD PIECE AND INSTALL THE FLAT WASHER, LOCK WASHER, AND NUT. TIGHTEN THE NUT TO 150 in-lb USING THE TORQUE WRENCH

Hold bolt head with open end wrench

Tighten nut with torque wrench
Every morning we will grade the items submitted the previous day. We will make measurements of several key dimensions. Then we will determine how far from the correct value they are. This is used to determine your grade.

The grade is posted on a sheet outside MEC B014. Here is a sample of what the sheet looks like.

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<th>torque</th>
<th>Bolt space</th>
<th>Hole space</th>
<th>Total length</th>
<th>Bolt CL offset</th>
<th>Grade = 100 - 8*SCORE</th>
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</thead>
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<td>Std dev</td>
<td>expect</td>
<td>Std dev</td>
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<td>0.75</td>
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</tr>
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<tr>
<td>4</td>
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<td>1.75</td>
<td>0.22</td>
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<tr>
<td>5</td>
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<td>0.704</td>
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</tbody>
</table>

This is the expected value for this dimension
This is the std. deviation
This is how many std. deviations it is off
This is the value the student got
This is the total score

You can do this project over as many times as you want. Just sign up for another time slot

You have to get 75% or better in order to get the safety/shop card. But if you do not want to card, you do not have to do the project over to get a score above 75.