

STUDIO 2
MACHINING & MECHATRONICS

This studio is pass/fail. You must complete the assigned tasks. Failure to complete either the machining tasks or the mechatronics tasks will result in a reduction of your final grade by one letter. All tasks must be marked as completed.

Week 2 (27 August – 31 August)

Group A:

In Week 2 of the semester, *Group A* will learn how to program the National Instruments myRIO controller to use sensors and actuators. The tasks found in **Mechatronics Lab Tasks: Group A** in the **Mechatronics Section** of this document will be completed. You will have to demonstrate proper execution of the tasks to your Studio Instructor or TA. They will sign your assignment sheet, indicating the tasks have been completed.

Group B:

In Week 2 of the semester, *Group B* will learn how to use the machine tools in the ME 2110 machine shop. An instructional seminar will take place in which the TA will instruct the group on proper lab safety, tool checkout procedures, and use of the machine tools. You will then begin to machine the components needed to complete the hoist. Process plans and mechanical drawings for the components are provided in the **Machining Section** of this document. You will receive plastic (Delrin) workpieces from which you will machine your components.

Week 3 (3 – 7 September)

Week 3 of the semester gives you time to finish your parts and any remaining mechatronics exercises. You should have your parts and mechatronics exercises checked off before you come to your assigned studios on week 4.

Week 4 (10 – 14 September)

Group A:

In Week 4, *Group A* will move on to the machining section of the project. They will undergo the same machining seminar as *Group B* and receive their own workpieces.

Group B:

In Week 4, *Group B* will learn how to use the mechatronics kit. They will complete the **Mechatronics Lab Tasks: Group B** found in the **Mechatronics Section** of this document.

Week 5 (17 – 21 September)

Week 5 of the semester gives you time to finish your parts and any remaining mechatronics exercises. You should have your parts and mechatronics exercises checked off before you come to your assigned studios on week 6.

Outside of Studio

In addition to doing work during your scheduled studio time, the IDEA Laboratory in MRDC 2101 will be open for other periods of time throughout the week. These periods are known as “Open Studio.” Any ME 2110 student may use the IDEA Laboratory during Open Studio. The Open Studio schedule is posted on the ME 2110 website. Due to limited time during scheduled studio, you will need to utilize Open Studio to complete your deliverables.

Deliverables

Table 1 shows the deliverable schedule for this project.

Table 1 – Deliverables for Each Individual Student During Weeks 3 – 6.

Deliverable Schedule	Group A	Group B
Week 3 Deliverables, due at the Beginning of Studio	1) 4 of 7 completed and <i>signed</i> Mechatronics Lab Tasks: Group A	1) Motor Coupler
Week 4 Deliverables, due at the Beginning of Studio	2) All 7 completed and <i>signed</i> Mechatronics Lab Tasks: Group A	2) Motor Mount
Week 5 Deliverables, due at the Beginning of Studio	1) Motor Coupler	1) 4 of 7 completed and <i>signed</i> Mechatronics Lab Tasks: Group B
Week 6 Deliverables, due at the Beginning of Studio	2) Motor Mount	2) All 7 completed and <i>signed</i> Mechatronics Lab Tasks: Group B

Mechatronics Section

This lab will provide experience with integrating electrical, mechanical, and pneumatic systems. The lab comprises of two sections performed over three weeks. During the first week, *Group A* will complete one part of the lab, labeled “Mechatronics Lab Tasks: Group A;” during the second week, *Group B* will complete “Mechatronics Lab Tasks: Group B.” Although the programming style will not be graded, the programs created during these two labs should be helpful in developing the programs for the final project. Therefore, it is important to program using standard structure and commenting practices so that the program will be easy to follow when used as a reference later in the semester.

Before attempting to perform these programming tasks, read the **Mechatronics and Pneumatics Manual** available on the course website. The manual provides background information on the layout of the National Instruments myRIO controller and explains how to implement the electro-mechanical-pneumatic components in a design. The manual also contains instructions for installing the required LabVIEW software on your computer. At the time of each checkpoint shown in Table 1, each student is responsible for showing progress through the assignment as indicated by a signed task checklist. The tasks for *Group A* and *Group B*, and the associated checklists, are provided on the subsequent two pages. After each task is completed, the operation must be successfully demonstrated to either the section instructor or a TA. The instructor or TA will initial the checklist confirming that the team has successfully completed that task element. Remember that each individual needs a separately signed checklist. Feel free to ask the instructor, TA, or peers for help in completion of this assignment, however each student in the team must be prepared to answer questions about the program before the instructor or TA will initial the checklist.

Mechatronics Lab Tasks: Group A, Name: _____

1. Connect 2 DC motors, 2 solenoids and 2 valves to the driver board. Connect all the sensors to the sensor board. Study the LabVIEW programming template, and use the template to **verify** that every component operates correctly. In addition, look at the other VIs that are in the template, run them, and be prepared to briefly discuss what they do.
2. Follow the steps in this video: <https://youtu.be/Ak-N8o6C7C0>. As with all programs you create, be prepared to answer any questions about it.
3. Connect a potentiometer to the sensor board. Using the knob on the potentiometer, have it incrementally turn on the myRIO LEDs as you turn the knob; starting with LED0 and continuing until all 4 LEDs are lit. Use a chart to display the sensor voltage data continuously.
4. Connect a momentary switch to a Digital Input and have the DC motor run at full speed when the switch is held down and turn off when the switch is depressed. Each time the switch is pressed turn on LED1 for 1 second. The 1 second starts the moment when the switch is pressed, e.g the LED will turn off after 1 second even if the switch is still held down.
 - Hint: Connect the switch to a Digital Input, read in the value of the Digital Input when the button is pressed and the value of digital input when the button is released.
5. Connect two micro switches, the banana plugs and one pneumatic cylinder. The program starts with the cylinder retracted. The program starts by touching the banana plugs together. When switch one is pressed, the cylinder should extend and remain extended after the switch is released. When the other switch is pressed, the cylinder should retract and remain retracted. This loop continues while the banana plugs are held together. If the banana plugs are released at any time the cylinder is retracted immediately. The loop starts from the beginning when the plugs are retouched. **Set this program to run automatically on startup (without being connected to the computer).**
6. Connect two solenoids and two micro switches. When one micro switch is pressed, one solenoid is activated for 4 seconds and then released. When the other micro switch is pressed, the other solenoid is activated for 1750 ms and then released. When one actuator is active the other cannot be activated. Use LED1 and LED2 to indicate when each actuator is active.
 - Hint: It may help to use “Elapsed time” and “Time Delay” Express VIs.
7. Connect 2 solenoids and two micro switches. At the beginning, have 1 solenoid activated. Once each switch has been pressed at least once and in any order (they don’t have to be held down together), the first solenoid will be deactivated and the second one will be activated for 5 seconds. After that, the cycle starts over. Two LEDs of your choosing will show the states of the switches **at all times (even when the first solenoid is off and the second is on).**

*** Stop each program with a button you create on the front panel, unless stated otherwise.**

Checklist for *Group A*:

- | | |
|----------------------|----------------------|
| 1. _____ DATE: _____ | 5. _____ DATE: _____ |
| 2. _____ DATE: _____ | 6. _____ DATE: _____ |
| 3. _____ DATE: _____ | 7. _____ DATE: _____ |
| 4. _____ DATE: _____ | |

Mechatronics Lab Tasks: Group B, Name: _____

1. Connect 2 DC motors, 2 solenoids and 2 valves to the driver board. Connect all the sensors to the sensor board. Study the LabVIEW programming template, and use the template to **verify** that every component operates correctly. In addition, look at the other VIs that are in the template, run them, and be prepared to briefly discuss what they do.
2. Follow the steps in this video: <https://youtu.be/Ak-N8o6C7C0>. As with all programs you create, be prepared to answer any questions about it.
3. Connect both DC motors. Make them run clockwise for five seconds, stop for 2.5 seconds, run counter-clockwise for five seconds, and then stop for 2.5 seconds. Repeat this sequence four times.
– Hint: It may help to use “Elapsed time” and “Time Delay” Express VIs.
4. Connect the IR distance sensor and one DC motor. Have the motor run at 20% of its max speed for 5 seconds if the current IR sensor reading is greater than 1.2 V **and** the previous reading was below 1.2 V. Else the motor is running at full speed. Use a chart to display the IR sensor reading at all times.
– Hint: Consider using a shift register to record the previous IR sensor reading.
5. Connect the banana plugs and 2 DC motors. Run the first motor for 3 seconds after the banana plugs have been touched. Run the second motor for 4 seconds, 2 seconds after the banana plugs have been pressed. This loop continues while the banana plugs are held together. If the banana plugs are released at any time the motors stop. The loop starts from the beginning when the plugs are retouched. **Set this program to run automatically on startup (without being connected to the computer).**
6. Connect the encoder and the pneumatics. When the encoder is rotated 2 complete revolutions, the actuator should extend and remain extended until the encoder is rotated another 3 complete revolutions. Use an indicator on the front panel to display how many revolutions have been completed during each stage. The cylinder should only extend 4 times and then remain retracted regardless of how many times the encoder is rotated, but you should still show the encoder reading on the front panel.
7. Connect the 2 long-arm switches and one motor. At the beginning, the motor should run at 50% speed with all 4 LEDs turned on. After each switch has been pressed at least once and in any order (they don't have to be held down together), the motor must switch direction for 3.5 seconds. After that, the cycle starts over. Turn off LED 1 when the first switch is pressed, turn off LED 2 when the second switch is pressed. The LEDs will need to indicate the switch state **at all times (even when the motor has switched directions.)** LED 0 and LED 3 should be on the entire time.

*** Stop each program with a button you create on the front panel, unless stated otherwise.**

Checklist for *Group B*:

- | | | | |
|----------|-------------|----------|-------------|
| 1. _____ | DATE: _____ | 5. _____ | DATE: _____ |
| 2. _____ | DATE: _____ | 6. _____ | DATE: _____ |
| 3. _____ | DATE: _____ | 7. _____ | DATE: _____ |
| 4. _____ | DATE: _____ | | |

Machining Section

In the machining section of this studio, you will machine the components that will be of use in assembling your final project. Each student will machine the motor coupler and the motor mount. Mechanical drawings for these two components and associated detailed machining instructions are provided on the last few pages of this handout.

Review the machine shop safety rules in the **Machine Shop Safety** section at the end of this document before you attend the studio session. Be sure to familiarize yourself with these rules and arrive to studio dressed appropriately for working in the machine shop.

Digital Read Out (DRO) zero function instruction:


The DRO for lathe or the mill has been preset, please follow the instructions below to zero or set the axes as needed. Please, do not use other keys except the keys shown in the instructions. Otherwise you will have different settings that may yield incorrect results.




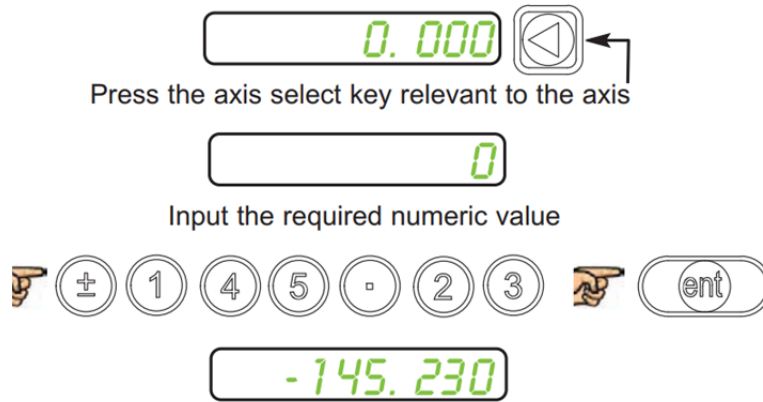
Zero mode has been selected




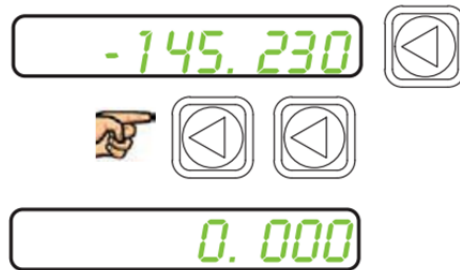
Set mode has been selected


You can toggle the button  to switch between zero mode and set mode. The currently selected mode is indicated by an LED either above or below the key as shown in the previous text.

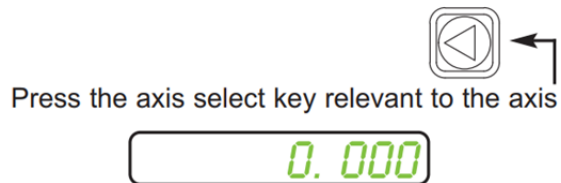
1. With **set mode** selected, this enables the select axis keys  to prompt a numeric entry into the desired axis. Once the correct value has been selected, it can be set as the axis value by pressing the enter key.



Or you can simply zero the selected axis by double pressing the axis select key, .



2. With the **Zero mode** selected, press the axis select key  to zero the selected axis.



Procedures are the same for the DROs on the mills.

Suggested Process Plan for Small DC Motor Coupler:

Please note steps 1-5 require the Lathe and Lathe Machining Kit. Steps 6-9 require the Mill and Mill Machining Kit.

1. Obtain nominal 1.5" length of round 3/4" diameter Delrin stock.
2. Square both faces. Face one end on the lathe to make it perpendicular to the axis of rotation. Use no more than a 0.02" longitudinal depth of cut for each facing pass until the face is flat. Flip the piece over and face the other end, repeat the same procedure.
3. After squaring the faces, use a caliper to measure the total length of the part. Zero the X-axis on the DRO. Calculate how much depth needs to be cut towards 1.25" final length. Repeat the facing procedure in step 2, until the cut depth on the DRO reaches to your calculation. Measure the part and do fine adjustment.
4. Make a no more than 0.02" orthogonal depth turning cut, measure the diameter of the part. Set the Y axis to the new diameter using the DRO set mode. watch the DRO and use multiple axial paths with no more than 0.08" diameter depths of cut per pass. turn down to the final length of 0.25" the stock on one end to a final diameter of 0.39".
5. Flip the part, chuck the larger center drill into the tailstock chuck. Use the center drill to start a centered hole in the end of the workpiece.
6. Replace the center drill in the tailstock chuck with the size C drill bit. Use the tailstock and drill bit to bore a 0.242" diameter hole 0.5" deep along the cylindrical axis of the part. To keep track of the drill depth, use the graduated 1/16" markings on the tailstock.
7. Switch to the Mill. Use the edge finder to zero the Y-axis on the DRO first and chuck the workpiece and zero the X-axis.
8. Switch the edge finder the No.36 drill bit. Then, use the No. 36 drill bit to drill a radial 0.1065" hole. This hole should terminate on the internal face of the size C hole, not clearing the entire piece. (Reminder: do not use a drill bit or center drill when side-milling or face-milling.)
9. Switch to the 1/4" endmill. Create the flat on the 0.39"-diameter end of the coupler. Determine the required cut depth from the drawings and the actual diameter of your workpiece.
10. Using the small tap wrench and #6-32 taps, cut internal threads in the 0.1065" hole. Start the threads with the tapered tap, cutting 5 to 8 threads (turns or revolutions). Then, finish the threads with the plug tap to ensure they are fully cut through the entire hole. This hole will house the provided #6-32 setscrew.

Suggested Process Plan for Small DC Motor Mount:

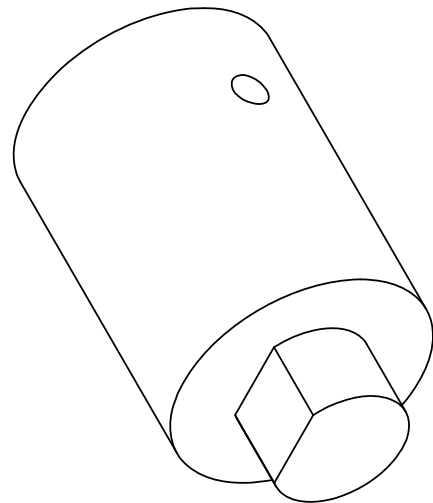
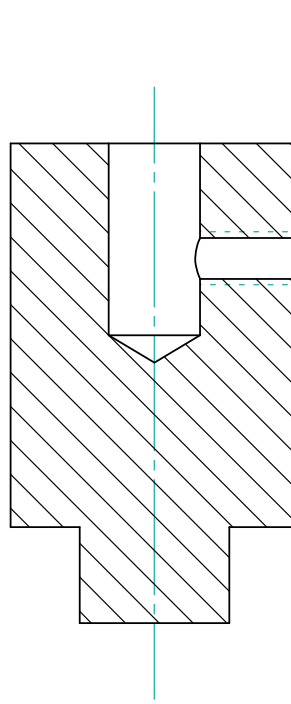
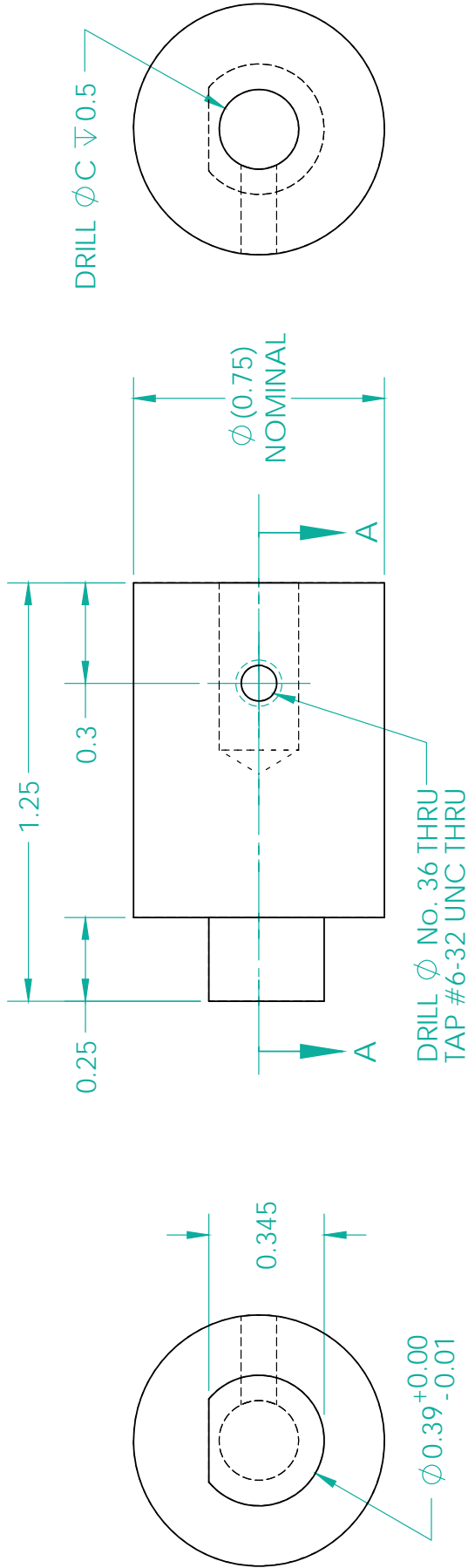
All steps require a Mill and Mill Machining Kit. Step 6 requires a drill/driver.

1. Obtain nominal 2.4" length of 1"x1/4" Delrin bar stock.
2. Using the mill and the 3/8" end mill, side mill one end of the workpiece to make its face perpendicular to the longitudinal axis of the bar. With the parallels positioned below the workpiece, secure the workpiece in the vise such that the side you are machining extends out from the vise jaws (at least 1/3 of the workpiece) so you will not run the cutting tool into the vise. Use no more than a 0.02" depth of cut when milling.
3. Side mill the other end and measure the workpiece, zero the DRO axes settings. Calculate how much needs to be removed, watch the DRO and side mill the part to the final length of 2.10".
4. Next, end mill the shoulder feature. To start, touch the top of the workpiece and zero the Z-axis. Measure the thickness and mill the final thickness of the shoulder to be 0.125".
5. Switch to the edgefinder to zero both X and Y axes. (Reminder: the edge finder has a radius of 0.1"), then use 3/16" drill bit to drill the first 0.1875" hole and then switch to 1/2" drill bit to drill the 0.50" hole, and then switch back to the 3/16" drill bit to drill the second 0.1875" hole. Use the mill to drill these holes so that they are properly spaced as indicated in the drawing. Use the parallels or place backing material under the workpiece to avoid drilling into the vise.
6. Remove the workpiece from the mill vise and check out a drill/driver. Use the motor mount drill template and a 3/16" drill bit to drill the 3, 0.1875" holes for the motor mount screws. The template can be aligned off the edge of the part and using the 0.1875" pilot hole drilled in the center. At a workbench, clamp the template on top of the workpiece with some backing or scrap material underneath so as to not drill into the table, as shown in Figure 1. Then, the holes may be drilled as located by the template.

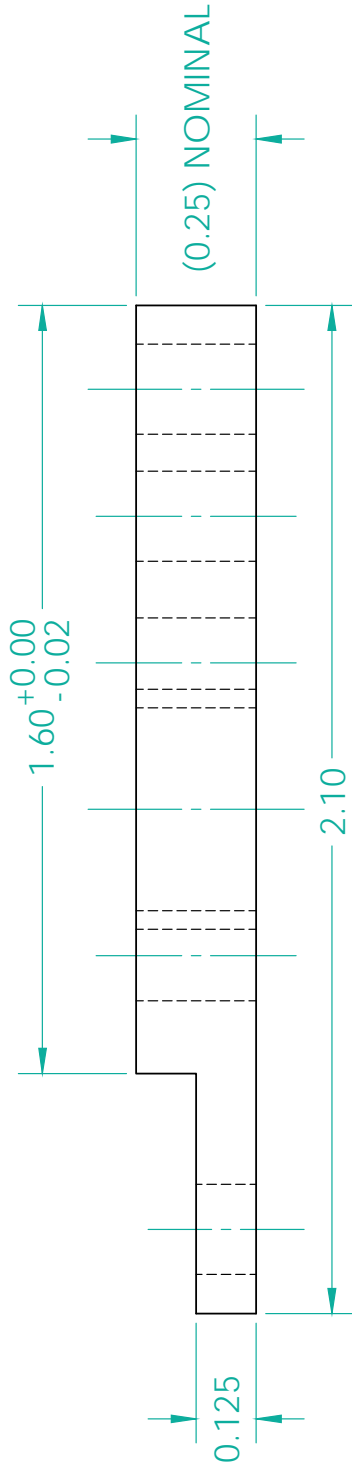
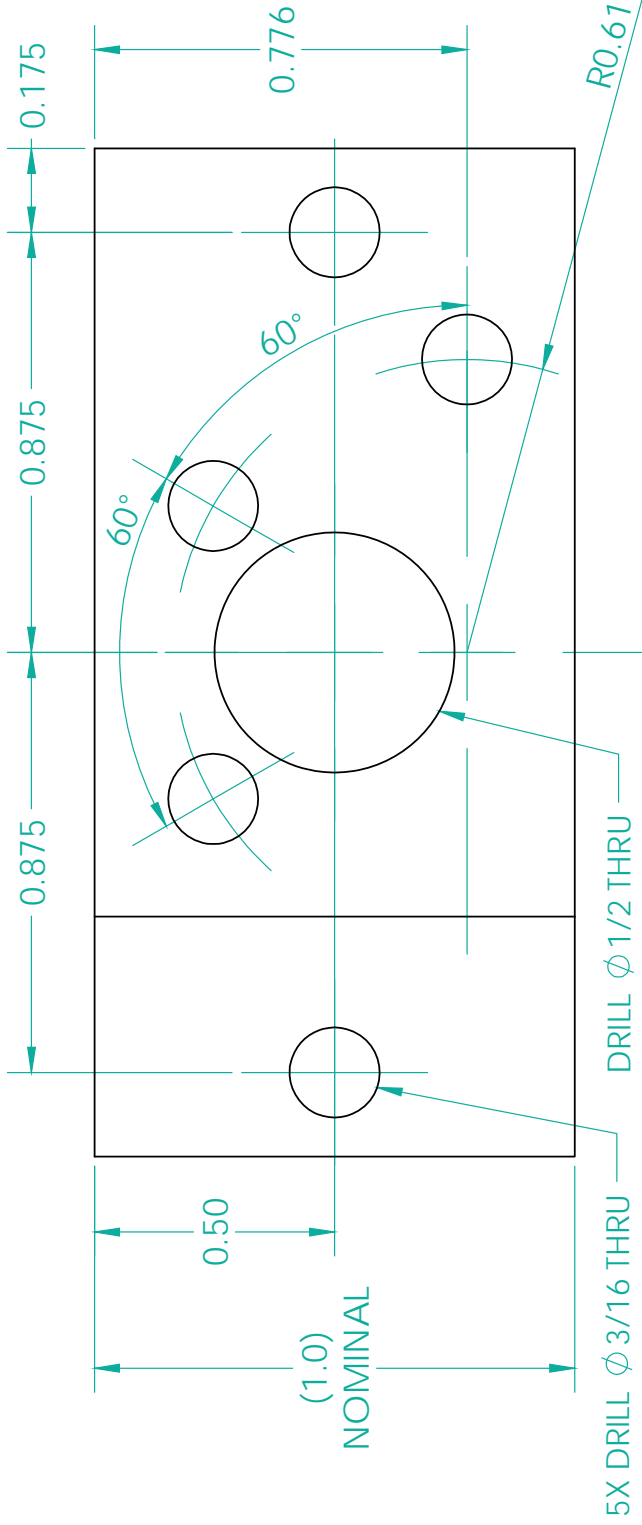


Figure 1 – Clamping Motor Mount Workpiece and Template Before Drilling

Suggested Process Plan for Small DC Motor Coupler:



DRAWN	C. Adams	2/2/2016	<p>ME 2110 Georgia Institute of Technology</p>	<p>DWG. NO. MotorCoupler</p>	<p>MATERIAL: White Delrin Plastic</p>	<p>SCALE: 2:1 SIZE A SHEET 1 OF 1</p>
<p>DIMENSIONS ARE IN INCHES TWO PLACE DECIMAL ± 0.01 THREE PLACE DECIMAL ± 0.005 UNLESS OTHERWISE INDICATED</p>						



DRAWN	C. Adams	2/2/2016
DIMENSIONS ARE IN INCHES TWO PLACE DECIMAL ± 0.01 THREE PLACE DECIMAL ± 0.005 UNLESS OTHERWISE INDICATED		

<h1>ME 2110</h1> <p>Georgia Institute of Technology</p>		
DWG. NO.	MotorMount	
MATERIAL:	White Delrin Plastic	
SCALE: 5:2	SIZE	A
		SHEET 1 OF 1

MACHINE SHOP SAFETY

ALWAYS WEAR SAFETY GLASSES

- Even when you are not working on a machine, you must wear safety glasses. A chip from a machine someone else is working on could fly into your eye.

CLOTHING, JEWELRY, AND HAIR

- Wear short sleeves or roll up sleeves.
- Wear closed toe shoes and socks.
- Remove all jewelry - watches, bracelets, rings, necklaces, dangling earrings, etc.
- Long hair or beards must be tied back.
- If your hair is caught in spinning machinery, it will be pulled out if you are lucky. If you are unlucky, you will be pulled into the machine.
- No ties, scarves, and dangling clothes.

SAFE CONDUCT IN THE MACHINE SHOP

- Be aware of what is happening around you.
 - For example, be careful not to bump into someone while they are cutting with the bandsaw (they can lose a finger!).
- Concentrate on what you are doing. If you get tired, leave.
- Do not hurry. If you catch yourself rushing, slow down.
- Do not let someone else talk you into doing something dangerous.
- Do not attempt to measure a part that's moving.
- No fooling around.

MACHINING

- Follow directions. If you do not know how to do something, ask.
- Before you start the machine:
- Study the machine. Know which parts move, which are stationary, and which are sharp.
- Double check that your workpiece is securely held.
- Remove chuck keys and wrenches.
- Do not rush speeds and feeds. You will end up damaging your part, the tools, and maybe the machine itself.
- Listen to the machine/tool. If something does not sound right, turn the machine off.
- Do not leave machines running unattended.
- Clean up machines after you use them: a dirty machine is unsafe and uncomfortable to work on.
- Do not use compressed air to blow machines clean. This endangers people's eyes and can force dirt into machine bearings.
- Report all broken or non-working machines.

VIOLATIONS OF THESE RULES WILL RESULT IN IMMEDIATE EJECTION FROM THE MACHINE SHOP.