Overview:

As part of the CE118 course, you will use a MornTech MT-L1290 CNC laser cutting machine. This is a precision machine that allows you to cut geometry from a two-dimensional .ai and .cdr files into MDF, acrylic, and foamcore. It is an ideal tool for cutting intricate shapes with sharp internal corners. It is also excellent for creating quick prototypes and for building things that can be assembled from 2D (and essentially flat) components.

The laser cutter is a very powerful tool, and therefore can be very dangerous. Use it with care and caution. This current model has a 48”x36” bed with a 60W CO2 laser. It fires a laser into the material to burn away a cut or etch a surface. It is very precise (+/- .001”) with ~.030” cut width. The best way to think of it is as a printer, except instead of outputting ink of various colors, it outputs cuts at various speeds and powers.

To use it, you start with an .ai drawing. Using CorelDRW/LaserWorkInterface software, you convert this drawing into a series of cuts. You then “print” it directly onto your chosen material.

This SOP (Standard Operating Procedure) goes over the safety procedure, set-up procedure, and operating procedure. Please use only materials listed in this SOP on the laser cutter.
SAFETY:
The laser cutter is a very powerful tool, and therefore can be very dangerous. Use it with care and caution. Some basic rules are:

1. DO NOT under any circumstances attempt to bypass the laser interlock controls. Attempting to do so will result in an immediate and permanent ban from BE138. The laser is very high power and can result in permanent physical damage. It must only operate in a sealed cabinet.
2. There is a black rectangle on the floor around the laser cutter, called the “watchbox.” There MUST be at least one person in the watchbox whenever the laser is on.
3. DO NOT use the laser cutter alone. Always have at least 2 people when cutting.
4. DO NOT OPERATE the laser cutter while SLEEPLY or INTOXICATED. This applies to both partners in the team. It is essential to your safety and that of others that you are awake, coherent and alert while operating the system. Operating while sleepy or intoxicated will result in an immediate ban from the fabrication lab. Treat operating the laser cutter as if you were driving a vehicle.
5. DO NOT use the laser cutter without the blower on. The blower reduces the risk of fire.
6. IF anything odd happens during your cut or you collide the head with something, immediately notify the authors of this SOP of the details and PUT A NOTE on the laser cutter, over the power switch. Do not attempt to fix it yourself.
7. DO NOT use any materials other than those documented in this SOP. Do not cut these materials using settings outside of the given ranges.

FIRE SAFETY
In all cases, fires in the laser cutter have been caused by unattended operation (even when the users were in the same room, but not paying attention to the laser cutter). DO NOT LEAVE THE LASER CUTTER UNATTENDED. PERIOD.

While it is not unusual for there to be a flame for the first few seconds or on a small part, it is a concern if there is a persistent or growing flame. FOAMCORE is especially flammable, any material can catch on fire under certain circumstances. Be careful with parts with lots of intricate detail that are very close to each other or jobs that take a long time to complete.

In order for fire to persist, three things are required: (1) heat source, (2) fuel, and (3) airflow. In the laser cutter, the heat source will be the laser, the fuel will be the material, and the airflow will be caused by the blower. Removing these any of these three things will put out the fire. Small fires are very easy to put out (think candle), but they will grow into big ones if you do not act promptly.

If there is a fire, DO NOT PANIC. You have time to stop and think clearly, but you will need to take actions to put out the small fires BEFORE they grow into big ones.

Fire Procedures:
• If you have a persistent flame that is more than 2 inches tall, or lasts for more than 5 seconds, STOP THE LASER CUTTER by pressing PAUSE. Immediately use the UP arrow key to move the head to the
Using the MornTech Laser Cutter v1.0

Do not turn the laser cutter off, as this will prevent you from moving the laser cutter head out of the way. Most flames extinguish themselves quickly.

- If step (1) fails to extinguish the flame, and if the flame is small and unthreatening (it is smoldering, smoking or the size of a few candle flames), then blow on the material like a candle to extinguish the flame.
- If step (2) fails to extinguish the flame, or if the flame has grown larger than 2 inches tall, use the fire blanket in the red pouch. Remove the blanket, and open it fully. Put on leather gloves, and drape the blanket over the flame.
- If step (3) fails, or if you feel a fire extinguisher is necessary, pull the fire alarm. Then, someone trained to use the fire extinguisher may attempt to use it to put out the fire. Call 911 immediately.

Once you have taken care of the flame, determine what cause it:

- Are you using the correct material? Does it have a coating?
- Are you running your cutting speed too slow or is the autofocus off?
- Are your cuts too close together?
- Could the laser possibly have been bumped or out of focus?

Rectify the problem (remove the material, change your cut, or get the TAs).

EYE SAFETY

The greatest danger in using any laser is to your retina. The amount of power concentrated on a very small area will create a permanent blind spot in your vision. The laser cutter is equipped with safety interlocks to disable the beam when the lid is opened.

DO NOT, under any circumstances, attempt to override any of the safety interlocks on the laser. These include the interlocks on the door, the flow sensor on the chiller, or the software locks in place. Doing so is expressly prohibited, and will permanently ban you from Laser Cutter use.

OPERATIONAL SAFETY

Make sure you re-read the above sections several times to make sure you completely understand them. Do not operate the laser cutter alone, and do not leave it unattended (this includes being nearby but not paying attention to it). If you cannot see the beam, then the laser cutter is effectively unattended.

Re-read the list at the top of this section. Make sure you understand it and why these are there.

Have a plan. Before you start cutting, have a plan for what you will do if things go wrong. Ask yourself hypothetical questions about what you would do “if” for various scenarios, and make sure you can execute your plan. For example, if you plan in case of fire is to use the fire extinguisher, make sure you know where it is, read the instructions on it so you know how to use it, etc.
At the time that things are going wrong, you won’t be able to make clear headed decisions. Having thought through them before gives you the ability to execute your plan without having to make decisions in the moment.

Lastly, do not panic. The laser cutter machine is designed to be extremely safe to the users. You might damage the machine, but are very unlikely to hurt yourself unless you really are being very careless. In general, you have time to evaluate the situation, and then calmly execute your plan. If your plan did not help, re-evaluate and come up with a new plan. Keep your interventions simple, and get help as soon as you can (often post event).

**Basic Usage steps:**
These steps are meant as a quick reference. More details can be found in other sections of this document.

2. Document setup:
   a. Login to the computer with your ADCRM account.
   b. Open CorelDRW (Corel Draw).
   c. From Corel Draw, open your file to cut.
   d. Draw test cut boxes and a bounding box in different colors. (In this walkthrough, we will use GREEN for the bounding box, BLUE for test cuts, and BLACK for the final cut. Any selection of colors will work though).
3. Laser cutter setup:
   a. Make sure the bed is free of debris
   b. Turn on laser cutter systems (all 4), wait for laser head to calibrate
   c. Place cutting material in the bed.
   d. Move cutting head to center of expected cutting area
   e. Use the autofocus to focus the laser head
   f. Position the head at the corner of your material and press the “origin” button.
4. Cutting:
   a. In corel draw, bring up the laserworks dialog.
   b. Do the bounding box cut.
      i. Adjust your bounding box layer settings. Refer to the “Cutting Settings” section for appropriate settings.
      ii. Set every layer to OUTPUT = OFF except for the layer you want to cut.
      iii. Click “download” and type a unique, descriptive name.
      iv. On the laser cutter, press “start/pause.”
      v. While the laser is cutting, watch the cutter and be ready to engage in fire safety protocols.
   c. Follow steps i-v for your test cuts.
d. Follow steps i-v for your main cut.
e. Wait 10 seconds for blower to remove smoke before opening the lid.

5. Cleanup:
   a. Move the laser head away from your material.
   b. Remove your material from the cutting bed. Make sure to clean up tiny pieces that were left behind.
   c. Throw waste material in the “dumpster box,” NOT one of the lined trash cans.
   d. Delete your files from the laser cutter.
   e. Turn off all 4 laser cutter systems.
   f. Log off of ADCRM account.
   g. Sign out on lasercutter sign-in sheet.

List of approved materials:
The SOP contains a list of approved materials on the front page. These materials have been used very frequently in laser cutting, and are known to be reasonably safe. Only use these materials in the laser cutter.

The SOP also contains a list of prohibited materials. While you should not use any materials but the approved ones, use of the expressly prohibited materials merits an immediate ban from the cutter for the remainder of the quarter. Do not even bring prohibited materials into BE-138, as they may be mistaken for acceptable materials.

The LaserWorks software interface:
There are two software interfaces to the MornTech Laser Cutter. There is a standalone program called LaserWorks, and an extension to CorelDraw. In this lab, we exclusively use the latter.

CorelDraw can read most vector graphics formats, including PDF, SVG, AI, and DXF. AI typically works best, though some AI objects will cause CorelDraw to misinterpret the document (use of strange fonts or very small geometry are common culprits). DXF always works, though it will import each line as a separate object, which can be inconvenient.

A cutting job typically involves frequent switching between CorelDraw’s main graphics interface (the window you see when you first open the program) and the LaserWorks interface. The main graphics interface is where you edit your shapes and layers. The LaserWorks interface is where you set the Laser Cutter settings.
To open the LaserWorks icon in the toolbar (it’s a green/gray circle with an arrow in it):

They can disappear under some circumstances. If they are not visible:

a. From the menu bar, click Tools -> Macros -> Run Macro
b. In the drop-down menu, select “global macros RLaser 15V6”
c. In the menu that appears, select “UserInit”
d. Click run.
e. The buttons should appear as a floating window. Drag them to the toolbar, as shown in the screenshot above.
   i. If this fails, try right-clicking the toolbar and checking the “LaserWorks” option.

The CorelDraw main graphics interface:
CorelDraw is a feature-packed vector graphics editor. It can be a bit overwhelming, but you only need a few tools to use the laser cutter. The important tools are:

1) Path selection tool
   a. Use this to select and manipulate whole shapes. Click and drag to move a shape. Click once on a shape to select it. Black squares (called “handles”) will appear at the corners, which allow you to stretch and resize the shape. Click again and the handles will become rotation handles. Guess what they do.

2) Draw rectangle tool
   a. Draws a rectangle. Use to draw bounding boxes and test cuts.

3) Page size
   a. It is wise to set this to 48w x 36h (as shown). This is the size of the laser cutter bed, and can help you make sure you haven’t accidentally scaled your shapes (an easy mistake in SolidWorks).

4) Object size
   a. If you DID accidentally scale your shapes, these fields will let you rectify the problem quickly.

5) 

In Corel Draw, make sure your page size is your material size or smaller. You can change the dimensions in upper left corner of the screen (see image below). If you change the dimensions, drag your virtual parts to the upper-left corner or your template.
1. Change the color of your parts to reflect your material choice (see GENERAL SETTINGS TABLE FOR OPTIONS). **Do not use the above image’s color scheme.**
   a. To actively change the color of your parts to the appropriate material color (red, orange, etc):
      i. Select all your parts by clicking on them or pressing Ctrl-A
      ii. In the “Object Properties” panel, click the pen tab. This displays a menu with line properties. Change the color to the Geneeral Settings specified color.

2. Draw a bounding box around your parts:
   a. Select the rectangle tool. (If there are any popup menus, click OK)
b. In the “Object Properties” panel, click the pen tab and change the color to GREEN-the standard color for the bounding box.

c. Drag a rectangle around your parts. Try to get it as close as possible to the edges of your parts. If necessary, use the black square handles to resize it.

3. Draw test cut rectangles:
   a. Again, select the rectangle tool.
   b. Select the color blue – the standard color for test cut shapes.
   c. Draw small rectangles for test cuts. They should be inside your bounding box, but not inside any of your parts. Put one at each of two opposite corners of your bounding box.

Here is a layout with a good bounding box and test cuts:

![Layout with bounding box and test cuts]

**Using the LaserWorks interface:**

1. Once your document is set up, click the LaserWorks button (the one you made when you ran the LaserWork macro).
2. This will bring up the LaserWorks interface (note that in this image, the settings are NOT ones you should use – you’ll change them shortly):

![LaserWorks interface](image)

   a. If the text in this window is gibberish, it means the language setting reverted to its default (Chinese). To turn it back, select what would otherwise be the “config” tab, (it’s on the far right).

   ![Config tab](image)

   b. Then find the “language” drop-down menu and select English.

3. Check the Machine menu to ensure your “Axis Mirror” and “Laser Head” settings match those in the image below. (Axis Y Mirror checked, Laser head in top left corner).

![Machine menu settings](image)
4. Next, you will assign behaviors to each layer (each color is a layer).
   a. Double-click a color to bring up the “layer parameters” window.
   b. There are four settings you’ll want to change for each layer. See the General Settings Table for more details about what settings are good for each material.
      i. If “Is Output” is set to “No”, the laser cutter will ignore that layer.
      ii. “Speed” controls how fast the laser cutter head moves.
      iii. “Processing Mode” should be set to “Cut”.
      iv. “Min Power” and “Max Power” should be set to the same thing (either 0 or 98).
   c. All other settings (besides those above) should be set as shown in the image.
   d. Click “OK” to exit the window.
5. Set all your colors to match this table (Note material specific cut settings are at the bottom).

<table>
<thead>
<tr>
<th>Color</th>
<th>Speed</th>
<th>Power</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>300</td>
<td>0</td>
<td>Bounding box. Ensures your cut is in the right place on your material.</td>
</tr>
<tr>
<td>Blue</td>
<td>Same as Material</td>
<td>98</td>
<td>Test Cut. Ensures you have the right cut speed for your material.</td>
</tr>
<tr>
<td>Purple</td>
<td>600</td>
<td>15-48</td>
<td>Etching. Advanced Technique</td>
</tr>
</tbody>
</table>

**Material-specific settings:** (note that you may need to tweak these)

<table>
<thead>
<tr>
<th>Color</th>
<th>Speed</th>
<th>Power</th>
<th>Material Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>6.5</td>
<td>98</td>
<td>MDF (.200)</td>
</tr>
<tr>
<td>Red</td>
<td>80</td>
<td>98</td>
<td>Foamcore (3/16)</td>
</tr>
<tr>
<td>Orange</td>
<td>6.5</td>
<td>98</td>
<td>Acrylic (.250)</td>
</tr>
</tbody>
</table>

**Operating the Laser Cutter:**

1. Before you begin, open the lid and make sure the laser cutter workspace is ready: The cutting bed should be free of debris and material. The fire extinguisher should be within easy reach.
2. Put on a blue lab coat and safety goggles (all teammates should do this, as well as anyone coming near the laser cutter).
3. Turn on the Laser Cutter using the surge protector (and white button). Plug in the blower if necessary.
4. **DO NOT PROCEED UNTIL YOU'VE ENSURED THE BLOWER IS ON.**
5. From here on, someone should be in the watchbox until the machine is turned off.
6. **Place the material on the laser cutter bed. DO NOT PLACE IT UNTIL AFTER THE HEAD HAS CALIBRATED ITSELF ON THE CORNER.**
   a. Do Not Bump the laser cutter head with the material when doing so.
   b. Move the material to the upper left corner of the bed.
7. **Set the origin**
   a. Use the arrow keys to move the head to the upper left corner of where you want to cut on the material.
   b. Move the material if necessary to make minute adjustments.
   c. Press “Origin” on the control panel. This tells the laser cutter that its current head location should coincide with the top-left corner of your document.
   d. **NOTE:** Pressing origin sets that spot to the duration for all subsequential cuts. It does not return the head to the origin.
8. Close the lid
   a. Gently pull down on the center handle or ribbon.
   b. Pull it to the left to get it to sit well. It will not cut if not fully closed.

9. For the next three steps, one teammate should be at the computer, and one should be at the laser cutter control panel, watching the cutter head and ready to press the start/pause button. The blower is loud, so make sure that you can communicate over the noise.

10. **Trace the bounding box.** This allows you to preview the area in which the laser will cut and make sure everything is set up well without damaging your material.
    a. Turn the output of your Green bounding box to “yes” and all your other colors’ outputs to “No.”
    b. Press the **Download** button to download your print to the laser cutter.
    c. **DON'T PRESS START ON THE SCREEN** as it immediately starts the cutter.
       i. **IF the computer operator accidentally presses Start:**
          1. The teammate in the watch box should press start/pause immediately.
          2. The teammate should then press escape and gently reprimand their partner.
          3. Finally the teammate in the box should reset the origin if they have moved the head in this process.
    d. A pop up box will emerge. Give the project a name eight letters or less and press ok.
    e. A pop up box will tell you if you are successful.
    f. Close the LaserWork Interface after sending a file on the computer.
    g. Teammate in the watchbox will see file count increment by one.
    h. Teammate in the watchbox will double check to ensure nothing is in the head’s path.
    i. Teammate in the watchbox should press start. The Laser cutter will outline the cutting area.
    j. If your box is not fully on the material, adjust the material or origin and hit start to repeat the bounding box. You can repeat the bounding box as much as you want.

11. **Cut Test Cuts.** This ensures you are cutting at the correct speed for the material. It also ensures you don’t start large fires with this material.
    a. Change your settings so Blue test cut output is on and everything else is off. **Ensure the blue speed matches your material color speed.**
    b. Download the file as you did in step 9.
    c. Teammate in watchbox presses start, and their finger does not leave start/pause button
d. **HIT PAUSE IF YOU SEE ANY SIGNS OF FIRE OR COLLISION.** See fire safety for what to do.

e. Check if your cuts can pop out. They should visibly popped down or they pop out when you open the door and press on them.

f. If the cuts have not fully popped out:
   
i. Move your test cuts on your sketch by duplicating the rectangles and then deleting the old ones. Don’t retrace half-cut lines — this is not an effective test.
   
ii. Three things you can do:
      1. Adjust your speed to be slower
      
         2. Move your material to a more appropriate place (Top right half tends to work best)

      iii. Try your test cuts again. Repeat until they fall through.

12. **CUT YOUR PIECE.** Everyone’s favorite moment!

   a. **Turn the output of your material color to Yes and everything else to no.**
   
b. **Make sure your material speed matches your blue test speed.**
   
c. Download the file as you did in step 9.
   
d. Make sure everything looks good.
   
e. Teammate in watch box hits start and hand does not leave start/pause button for a minute.
   
f. If you see flame for more than 2 seconds, press pause and then esc. Something is wrong with your material or your cut speed.

   i. You can adjust your cut-speed during a job. While the machine is paused (as it should be after a flame), press “speed” and then use the arrow keys to bump it up slightly.
   
g. Teammate in watch box will not leave watch box FOR ANY REASON and will keep checking on the material until it is done.
   
h. Once done, wait ten seconds before opening the door. This allows the smoke/smell to clear out, and lets the material cool.
   
i. Test to make sure all material has cut by pressing down on the material. If pieces break out, it has cut. If they don’t, rerun the cut on the pieces that don’t cut out. To do this, in coreldraw document, change the color of the pieces that have not cut to some other color. Rerun the macro and repeat the steps above to cut only the pieces still colored the material color.

**Shutting Down the Laser Cutter:**

1. Remove all your parts from the laser cutter. Make sure no small parts are left on the bed.
   While you can throw away small (less than 4”) pieces inside the lab. Place large scrap pieces in the dumpster (not in the lab trashcans)

2. Check bed to ensure nothing is left on it. If any debris fell into the pan, clean it with a dust broom.

3. The teammate in the watchbox can click “File” and then select “Delete All Files”. Press Enter to delete all the files, thus making life easier for the next users.
4. Turn off laser cutter. Blower will take 10 seconds to turn off. Teammate in the watchbox may now leave the watchbox.
5. Log out of your account (NOT “switch user”).
6. Take your cut parts OUTSIDE of BE-138 to assemble and test. Do NOT litter small parts around on the tables and floor. DO NOT LEAVE ANYTHING ON PETERSON’S TABLES.