

# makeLab

[User Handbook]

## [Information]

makeLab is the digital fabrication lab at the College of Architecture and Design at Lawrence Technological University.

The mission of makeLab is to use digital fabrication as an entrepreneurial opportunity and to demonstrate the theory and practice of design through technological and manual competencies.

### Faculty:

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### Lab Assistants:

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### Phone:

(248) 204-2884

### Web:

[www.make-lab.org](http://www.make-lab.org)

### Door Code:

8-4-6-1-7

Students utilizing makeLab equipment are required to provide a signed copy of the safety forms to the faculty member prior to using the CNC router.

Forms can be found at <http://make-lab.org/for-students/>

## [Lab Policies]

makeLab will make the effort to accommodate all students and faculty interested in using our facilities. Due to time constraints and limited resources, access to the lab's resources is not always guaranteed. Students and faculty are expected to take assume responsibility for the execution of their project within makeLab and to follow policies described in this handbook. Allow lead time for accessing the equipment, especially during peak times of the semester. Always plan alternative methods and communicate with the makeLab assistants in advance of any deadline.

Users are expected to dress appropriately for interaction with the equipment in the lab. No loose clothing or jewelry, always wear close toed shoes, tie back long hair, and always wear earplugs and dust masks when appropriate. Safety glasses should be worn at all times and are available in the makeLab. When handling sharp or hot material, you are advised to wear leather gloves, but not when operating equipment as they may inhibit you from properly using the equipment.

makeLab is available to trained students 24 hours a day. Access is provided to students registered in a Digital Fabrication course or to a person who has participated in orientation and training. makeLab has the right to restrict use of the lab at any given time due to a person's impairment due to lack of sleep and/or sobriety. makeLab assistants are available to ensure the facilities are used in a safe and coordinated manner and to assist with file preparation.

Never use any machine unless you have been trained fully on its operation and are knowledgeable of its safe use. If you have any questions, do not hesitate to ask a staff member or lab assistant. Equipment manuals are located in the makeLab and are available upon request.

Always return tools to proper storage positions and rooms after use, tools are not permitted to leave the makeLab. You are welcome to bring your own tools to the lab. When not in use, store all personal tools and effects in your assigned lab cubby or remove them from the lab. makeLab is not responsible for damaged tools or materials. Students and faculty are responsible for making sure that their files are properly executed and their materials and tools are properly handled.

If an injury or machine malfunction occurs, notify makeLab staff immediately. First-aid kits are available for minor injuries throughout the lab. Fire extinguishers are also found throughout the lab environment for extinguishing or controlling minor fires in emergency situations. An eye wash station is located in the CNC area for use in case of emergency.

To reduce unwanted noise, keep all doors closed when the lab is active.

## [Housekeeping]

Keeping makeLab a clean and well-maintained environment is important to the health and safety of its users. It is the responsibility of all users to clean up after themselves and to dispose of waste appropriately.

Food and drink are permitted in the lab, but you must pick up after yourself! Do not leave food or beverage containers in or around the lab equipment or work surfaces.

The low conference table is for “clean” work only: design and laptop use. Keep this table and surrounding area clear of project materials. High work tables are for fabrication. Store only work-in-progress project materials/components on the shelves under these work tables.

Space within the lab is extremely limited; do not store new material in the lab. Store new materials in approved locations in the storage room only. Materials to be cut can be staged in the lab for a short time while your project is actively in progress. Clearly label all stored materials. Materials should have the name of the person storing them clearly visible, along with contact e-mail or phone number. You are responsible for removing all of your material and scraps from the work space. All material left unattended without contact information will be used or discarded at the discretion of the lab assistants. We reserve the right to remove or relocate any project or material should it prove an obstacle to daily operations. We are not responsible for any damage that might occur while material is in the lab.

After a job, all scrap is to be either cut down and recycled in the designated storage room or placed in the wood shop dumpster (at the loading dock in the engineering wing). Do not leave scrap in lab.

Dust off tables, sweep, and vacuum the area around the table or machine and clean all tools used. The area you were working in should be cleaned entirely and all tools should be returned to appropriate positions. Using compressed air is not an appropriate method for cleaning an area as it promotes dispersion of particulate and chips into the air and potentially into the eyes, hair, clothing and skin of others in the lab environment. These rules are not just for your safety but also the safety of the building's occupants. Every day the hall should be patrolled to ensure it is clear of barriers and swept. Unswept floors can become slippery and injure passersby. It is your responsibility to keep makeLab clean and safe and you are expected to budget this time into your project planning. There are no excuses for not cleaning up. Failing to do so could result in a restriction of lab privileges.

makeLab has a variety of tools available for use by students. Users are expected to supply their own reusable materials such as : router bits, glue, sand paper, screws, gloves, ear plugs, and face masks.

## [General Shop Safety]

Never work in the lab when you are impaired or tired and always use caution.

Equipment should never be left unattended while in operation. All machines can be either stopped or paused if you have to leave the area for any period of time.

Do not distract others while they are working with equipment in the lab.

Always be conscious of sharp objects. Never place hands or other body parts in the area of any blade, drill, or other rotating or cutting tool. Remove all hand tools and accessories from the work area before beginning to operate any equipment. Only the material to be machined, its fixturing, and safety mechanisms should be in the area. Ensure that all safety mechanisms such as guards and shields are in operation and securely in place prior to operating any equipment.

Take time to review your work and make sure that all necessary precautions have been taken before making a cut. Always look over your work piece and check for nails or other foreign objects before using any tool.

Before starting any work, make sure the tool and its accessories are in proper working order. Always check alignment and rotation of all parts of the tool to ensure proper working condition. Check for proper blade guard operation before each cut. Never use a tool with a guard missing. Never alter or remove the guards. Failure to do so can increase your risk of injury.

Make sure you choose the right tool for the job. Do not force the tool. If the tool does not work with gentle pressure, an alternate tool may be required. If the tool seems not be working properly or is damaged, notify a makeLab assistant immediately.

All painting must be done in designated and well ventilated and protected areas. No damage to school property will be tolerated.

If a method of dust collection is available with the power tool, it should be used to reduce the risk of dust-related hazards.

Make all adjustments to machines and tools when power is off. Always allow the tool to reach full speed before contacting the work piece.

## [Equipment Policies and Procedures]

### Equipment Scheduling:

All 3D printing must be coordinated through a makeLab assistant.

CNC Shopbot use by all non digital fabrication students and faculty must be coordinated through a makeLab assistant. All use by non digital fabrication students and faculty cost \$10.00 for file prep and per hour of machine time.

Use of the lab's CNC ShopBot must be scheduled on makeLab's Google Calendar. Only scheduled use is permitted. E-mail faculty contact for calendar invitation.

\*\*Remember, equipment is utilized more heavily closer to deadlines. Plan accordingly. Additionally, equipment and software issues can and do occur. Give yourself time to compensate by planning early and scheduling extra time.

At a minimum, plan to spend 1.5-2.0 times the CNC run time of your project at the lab. File set up, loading, and proper material set up can be time consuming, and post-job clean-up of the CNC room is mandatory. Schedule accordingly.

## [ShopBot CNC Router]

### General Information:

The CNC router is for cutting wood, plastic, and foam. Metal cannot be cut on makeLab's router.

The lab's CNC router can handle material up to 96" x 48" in length and width. The long dimension is the X-axis and the short dimension is the Y-axis. The machine also has a 5" Z-axis cut height.

The router can perform 2.5-D profiling and 3D surface milling of sheet goods and solid stock. Although 96" x 48" x 5" is the maximum envelope for the router, geometric properties of your model design can reduce this volume. Compound curves in the model, excess boundaries needed for properly holding your material to the router bed and tool clearances impose limitations on what can be cut.

Complete Shopbot CNC information can be downloaded at <http://make-lab.org/links.html>

You are responsible for leaving the CNC router room in a clean condition. There is a dust collection system located behind the lab in a storage room. When the red light is flashing in the CNC room, the dust collector is full. You are responsible for emptying the dust into a garbage bag and replacing the dust bin.

### File Preparation:

Cut path files must be uploaded to the router controller in .SBP format. These are most commonly generated in either Part Works or RhinoCAM software. (Note-the Demo version of RhinoCAM will NOT generate cut path files.) Objects made from 2.5D profiling operations can be generated from 2D design files—3D digital modeling is not required. Surface milling operations require 3D digital modeling in order generate cut geometry. Design can be performed using many design software tools. However, if generating cut path files in RhinoCAM it is best to design your 3D model directly in Rhinoceros. This will minimize import errors in model geometry. If you are using Part Works, the number of passes needed is determined automatically, provided proper specifications are input. With RhinoCAM, the number of passes must be computed manually.

### Cutting and Transfer Speeds:

Cutting speeds are based on the bit used and the material being cut. The machine has an effective cutting speed range between 50-65 inches per minute. (See material / speed chart for recommendations). For best results never remove more than half of the cutting bit's width in a single pass i.e. 1/2" bit can remove a 1/4" of material at a time. For foam cutting the bit width is acceptable. When using a Ball bit, an 8% step over leaves a sand free surface.

Transfer speeds must remain at 65 feet per minute or less to retain tracking accuracy of the CNC gantry. DO NOT use the "high speed" transfer rate option in RhinoCAM. The Router must not go higher than 13,000 RPM for any cut. Please consult a lab assistant for any questions.

Allow space in your files to accommodate mounting your stock to the machines spoil board. Beware of cutting through screws as it may not only damage your bit, but could damage the machine or stock as well.

### Router Bit Tips:

Down Spiral Bit- Pushes material down during cut, helps with material hold down, and produces clean cut at the top of the material  
Straight Bit- Neutral, leaving particles and materials at top or bottom of stock, creating a rough cut edge.

If the bit is hot, speeds need to be adjusted.  
In the ShopBot software, Tools --> Chip Load Calculator, will help determine if cut speeds are appropriate.

Material	Cut Speed (in/min)	Bit Type	Note
Hardwoods	55	Profiling-Carbide, 2 or 3 flute, spiral. Milling varies.	Sharp Bit! Pay special attention to cut depth
Soft woods	60	Profiling-Carbide tips, 2 or 3 flute, spiral. Milling varies.	Sharp Bit!
Plastics (sim. Polycarbonate)	60	Plastic Specialty	Special plastic bits required for best result. Dependant on cut type and material.
Plastics (sim. Nylon)	60	Plastic Specialty	Special bit
High Density Foam	65	Profile-Carbide, 2 or 3 flute, spiral.	
Low/Med Density Foam	65	Profiling-Carbide, 2 or 3 flute spiral	
Laminates / Veneers	60	Carbide, 3-flute spiral or compression	Sharp Bit! Pay attention to cut pass direction and bit profile

\*\*You are required to bring your own bits for the CNC router.

### Material Considerations:

FOAM-Foam is ideal for milling large surfaces with complex geometries. It is quicker to mill and is suitable for prototyping and mold making. It can be coated and finished in a variety of ways giving it a more durable surface. Polyurethane and polystyrene foam are recommended.

PLASTIC-Plastics can be challenging to cut with the CNC. Plastic properties vary greatly by type and each requires special consideration and may require specific tooling to achieve a good result. Plastic is typically more difficult to work with than wood.

WOOD SHEET MATERIAL-Ply woods and composite wood materials (MDF, OSB, Particleboard, etc.) are suitable for profile cutting and some milling operations. Laminate and veneer sheets may require special bits and tool paths to avoid damaging the finished surface when cutting.

SOLID WOOD-Sawn lumber and built-up blocks can be used. Special care must be exercised when holding blocks to the router bed; custom hold downs may be required. When creating blocks by laminating stock together try to remove as much excess material as possible prior to laminating. Laminate blocks by gluing them evenly so that the entire surface is bonded between layers and press or clamp them together. Give blocks sufficient drying time prior to cutting (24-48 hours). Improperly bonded blocks may delaminate when cutting, potentially ruining your project and creating a dangerous situation in the CNC room. Be especially alert when cutting bonded blocks.

With any material, running a test cut is recommended.

### Procedures:

- All material being cut must be adequately held down to the router bed. Loose material is extremely dangerous! Use "tabbing" when profile cutting parts that are not fastened directly to the router bed.
- Do not operate any equipment in the lab that you have not been trained to use and are not familiar with. Never leave equipment unattended when in operation.

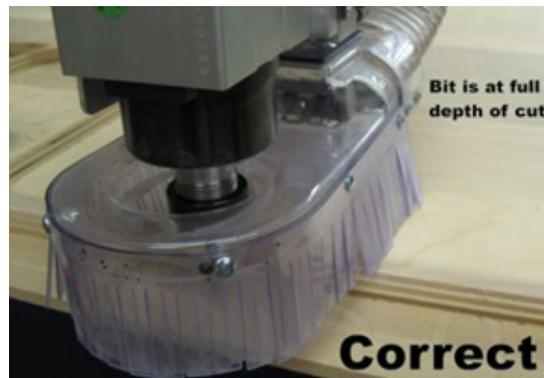
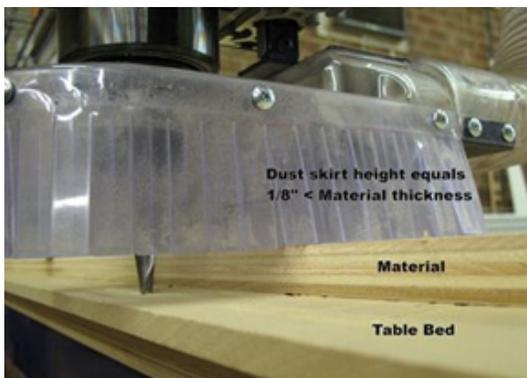
## Procedures:

- Always wear a dust mask, ear, and eye protection when operating the CNC router in the CNC room.
- To reduce unwanted noise, keep all doors closed when Lab equipment is active.
- You are responsible for your own bits. Make sure to have the correct ones for your material and cut geometry. Contact faculty or lab assistants if you have any questions.
- At a minimum, plan to spend 1.5-2.0 times the CNC run time of your project at the lab. File up- loading and proper material set up can be time consuming and post-job clean up of the CNC room is mandatory.
- To properly clean: 1) Remove all materials and project components from the CNC room. (Recycle or discard to the correct location) 2) Blow off the router table and computer console using compressed air. 2A) Blow off the gantry tracks/gears and the vent cover/switch of the router directly. 3) Sweep the floor and window sills, and dust off walls. 4) Vacuum the floor and any remaining dusty surfaces using the CNC room's portable vacuum.

Note: To minimize clean up time be sure to set the dust collector on the router head to the proper height. It is quicker and safer to perform steps 1-3 each time you pause for a material set-up, even if you are continuing to cut.

- Set the correct height for the Dust Shoe as follows. Setting the dust shoe to the correct height is most often dependent on the material thickness and length of bit. Set the height of the dust shoe equal to the material thickness, minus  $1/8''$  above the tip of the bit. This allows the bit to reach full depth of cut and only deflects the dust shoe slightly.

Positioning the dust shoe at a depth equal to the tip of the bit will cause the dust shoe to grossly deflect and may cause premature wear or even failure in the plastic shroud . In some 3D applications the dust shoe may not be applicable or practical if relief of the part is greater than 4". (See photos) If you are unsure about the placement of the dust shoe, please ask a makeLab assistant.



## [Z Corp 3D Printer]

### General Information:

MakeLab operates a Z-Corp Z510 3D color printer. The printer has a bed size of 10"x14"x8". The printer can print from many file formats. The model geometry must be "watertight". STL (for monochrome white) or VRML (for color) files are most common. Models are printed in high strength gypsum composite. The 3d printer costs \$3.00 per cubic inch, plan accordingly.

Allow adequate lead time for print jobs. Simple models may be processed overnight, complex ones may take several days. 3D printing a part requires print time, 1-hour baking time, and 2.5 hour cure time. Printed models are brittle when cured, to increase a model's strength they can be waxed, coated with resin, or coated with an Epsom salt and tap water solution.

Digital models should be hollow but with sufficient wall thickness to retain integrity (.125"). Set model units to inches. Models must fit within the build envelope of the printer. Larger models can be printed in sections and glued together after being removed from the print bed.

For tutorials on preparing files for 3D printing:

Rhino3d: <http://www.design.upenn.edu/files/preparing-3D-print-files.pdf>

Sketch-Up: <http://www.3dprint.no/BestPracticesSketchUp2008.pdf>

Additional information can be downloaded at <http://make-lab.org/links.html>

### Submission Process:

1. Contact a makeLab assistant to discuss/schedule project.
2. Provide model file and downloaded "3d Print Form" from <http://make-lab.org/links.html> to lab assistant
3. Confirm file integrity with lab assistant / redo file if not ready for printing
4. Pick-up print invoice at lab showing model volume and cost.
5. Agree to amount (print will run upon agreement confirmation)
6. Pay fees to makeLab (cash)
7. Pick up model. (Allow 24-48 hours)

## [Laser Cutter]

### General Information:

makeLab houses a 40W laser cutter with a bed size of 12" x 20".

The machine is capable of cutting material up to 1/4" thick. Materials that can be cut are cast and extruded acrylic, mat board, thin wood and wood veneer, non-PVC sign vinyl, cork, rubber, and leather. . If you would like to use a material not listed, please consult with a makeLab assistant. Using materials not listed could be hazardous to the health of the lab users and can damage the machine. Do not cut or engrave materials with reflective surfaces.

Laser safety glasses must be worn at all times when the laser is in operation.

Users must remain alert and present at the laser cutter as its operating to prevent fires.

Users must clean the laser bed of all scrap material and residue remaining after cutting.

Waste materials should be properly disposed of.

User must turn laser and affiliated fume extraction systems on and off prior to and after they are done using the machine.

Before being allowed access to the laser, users must participate in an orientation session aimed at reviewing the functions of the machine.

## [Vacuum Former]

The Vacuum former can be used to form materials over a form. The material tends to be a thin (1/32") ABS or acrylic. The sheets are heated until they are soft and droop. The sheet is then lifted and moved over the form on the perforated guide. The vacuum is attached to this perforated guide and the material is then tightened around the mold. Once the sheet is properly formed, the vacuum can be turned off and the sheet removed. For any assistance or questions with the use of this machine, please ask a makeLab assistant.

## [Table Saw]

The Table saw is used to rip, cross cut, bevel, and cut angles with precision.

- Use auxiliary work tables to properly support and control long or wide workpieces.
- Only cut wood, wood-like, or plastic materials. No metal.
- Avoid cutting small pieces of material which cannot be properly secured. Injury could result from small pieces being thrown back at operator.
- Always cut with the smooth, hard surface, on the table.
- Do not feed the material with your hands! Use push sticks and rip fences to perform cutting.
- Never clear small pieces while blade is moving.
- Keep the blade only 1/8" to 1/4" above the stock.

## [Drill Press]

The Drill press has a motor driven head that has a chuck that accepts bits or cutters. Also has an adjustable table on which the work is mounted. It is operated by pulling a rotary lever which lowers the drill bit into the material.

- Be sure the chuck is secured to the spindle.
- Tighten the bit securely to the chuck.
- Set speed for both the type of material and bit size you are using.
- Use a piece of scrap wood under your work piece to reduce splintering and protect the bit tip.
- Use a clamp or vise to securely fasten the stock to the drill press table. Never attempt to hand hold stock while drilling.
- When drilling deep holds, frequently raise the drill bit from the hold to remove cuttings and cool the bit.

## [Miter Saw]

- Never cut small work pieces that would require you to put fingers near the cutting blade.
- Be sure guard is in place and working properly before each use.
- Be sure angle mechanisms are tightened securely before making a cut.
- Never remove the saw from a cut while the blade is rotating. When making a partial cut, or if power is interrupted, release the trigger immediately. Do not remove the saw from the work piece until the blade has come to a

## [Band Saw]

The Band saw is used for cutting curves, resawing, and large depth cuts on thick material.

- Check blade tension and guard before starting. Any modifications should be made with power off.
- Never use your thumbs to push towards the blade.
- Never back out of a curve cut while machine is running.

## [Jig Saw]

- Holding the work piece by hand is unstable and may lead to loss of control.
- Support long work pieces at the same height as the saw.
- Always place the work piece securely in a vise or clamp when making cuts. Never make freehand cuts.
- Check blades carefully before each use for proper alignment and possible defects.

## [Heat Gun]

- Always hold the heat gun by the plastic enclosure.
- Contact with the tip could result in injury.
- Keep heat gun moving to avoid excessive temperatures.
- Do not leave heat gun unattended while running or cooling down.
- Contact with air stream will result in serious burns and personal injury.

## [Circular Saw]

- Know what is behind the work piece before you start a cut.
- Make sure work piece is secured.
- Use a straight edge as a guide.
- Never remove the saw from a cut while the blade is rotating.
- Be alert to the possibility of the blade binding and kickback occurring.
- Grip saw with both hands and always keep hands and cord away from blade.
- Always rest the larger portion of the saw's base plate on the supported portion of the work piece. Allow the unsupported portion to fall away.

In addition to the tools described above, makeLab also provides a variety of other hand and power tools. It is expected that caution is taken when using any tool in the lab. Safety and proper handling of equipment should be considered at all times.

## [Resources]

MakeLab: <http://make-lab.org/home.html>  
ShopBot: <http://www.shopbottools.com/>  
Router bits: <http://www.bamcarbide.com/>  
<http://www.onsrud.com>  
PartWorks: [http://www.shopbottools.com/mProducts/PartWorks\\_features.htm](http://www.shopbottools.com/mProducts/PartWorks_features.htm)  
Rhinceros: <http://www.rhino3d.com/>  
RhinoCAM: <http://www.mecsoft.com/rhinocam.shtml>  
Z-Corporation: <http://www.zcorp.com/en/home.aspx>  
Other Resources: <http://www.inventables.com>  
<http://wiki.daap.uc.edu/groups/daap/wiki/98515/>  
<http://digitaltoolbox.info>

Lowes  
12 Mile & Telegraph Rd.  
Router Bits, Materials, Supplies

J Kaltz & Co.  
730 East 9 Mile Road  
Ferndale, MI 48220-1951  
Router Bits