UM TCAUP
Digital Fabrication Lab (Fab-Lab)
Handbook W2009

Lab Policies

HOURS
Any announcements or changes in schedule will be posted on the door of Room 1219 and on the web-page

LAB COORDINATOR
Wes Mcgee   wesmcgee@umich.edu

ACCESS
It is highly recommended that you speak with one of the lab coordinators prior to undertaking a new project. This will allow for input on issues you may not have considered such as material limitations, dimensional constraints, and scheduling. Please bring all your files to the lab either on a portable storage device or save it to Temp Storage or your personal IFS space.

A signup sheet for available time on the various CNC machines will be kept in the Lab. Students and fabulty wishing to use the CNC machines should contact the relevant Lab Assistants(addresses are listed below) in order to discuss their job before signing up for a time slot. The submission process for 3d printing is outlined in the section below on 3d printing.

Scheduling, equipment and software problems will occur, please plan your necessary lab time in advance.

Faculty members wishing to make use of the lab for their courses should meet with the coordinators at least two weeks in advance to discuss the project, relevant work flows, and general scheduling constraints. Every effort will be made to support faculty members wishing to perform independant research in the lab. In general, during the school term, student work must take priority. Lab assistants will be available to assist faculty at times when students work is not occurring.

During summer, Faculty members are encouraged to use the Lab resources for research. Summer interns will be hired by the lab to assist in performing this research. Faculty members may also hire work study students who are trained Lab assistants directly, however, all equipment scheduling must be approved by the Lab coordinator. For large production requirements, there may be fees associated for tooling and machine consumables.

MATERIAL STORAGE
Materials to be cut can be temporarily stored on carts in the router area for a few days. Any material left unattended without contact information will be used or discarded. Label all material with your name and uniqname. After a job, all scrap material must be cut down and discarded either in the wood recycling bin on the loading dock or in the woodshop dumpster. No exceptions. REPEAT: you are responsible for your material scraps.

Lab Resources

HARDWARE

3 axis Routers:
CR Onrud 96C18 CNC router
CR Onsrud 96C12 CNC router
Mills 3D surfaces out of solid materials and cuts 2D profiles of flat stock materials.
www.cronsrud.com/cnc.html

3 axis Milling machine
DPM SX2
Mills 2D and 3D components out of most metals(aluminum, stainless steel) and plastic
http://www.southwesternindustries.com/swi/prod_bedmills1.shtml

3 axis Abrasive Water Jet Cutter
IFB4800 with dynamic head
Cuts Accurate parts out of flat stock, including metals and plastics
http://www.flowcorp.com/waterjet-products.cfm?id=125

7 axis Robotic Fabrication Workcell
KR100HAL90 on K1500-3
Large format robotic workcell with high speed spindle and abrasive water jet cutter
Also for assembly and various other cutting operations
www.kuka.com

Rapid Prototyping

ZCorp Z310 Rapid Prototyping 3D printer
ZCorp Z403 Rapid Prototyping 3D printer
Prints 3D gypsum or starch models from digital files
www.zcorp.com

Dimension 1200es ABS 3d Printer
10"x10"x12" build volume

Dimension 768 SST ABS 3D Printer
8"x8"x12" build volume
Prints 3D ABS models from digital files
www.dimensionprinting.com

MicroScribe 3D Digitizer
Allows you to digitally capture points and curves from physical artifacts.
www.immersion.com/digitizer/

(2) LaserCAMM laser cutters

(2) VLS 6.60 Laser cutter

32"x18" work area, 50W laser
Cuts sheet material(in wood and plastic) for 2d files
http://www.ulsinc.com/

SOFTWARE

MasterCAM X3
Generate CNC machining toolpaths from 3D models. Also performs part-nesting.
www.mastercam.com

Robotmaster plugin
Converts 3-5 axis toolpaths to Robotic lanquage, and allows full 3d offline simulation

KukaSIM pro/OfficeLite
Allows import of text based robotic programs, with full 3d offline simulation for scripted fabrication and verification

ZEditPro
Allows correction of STL errors for 3d printing

CNC Routers

OVERVIEW
The Lab operates two 3 axis CNC routers. Both machines have a 4' x 8' work envelope with a 10" z axis clearance. They perform both 2D profiling of flat sheet stock and 3D surface machining of solid materials including wood and foam. The machines are only operated by trained Lab Assistants. Email them at TCAUProuter@umich.edu to discuss your job.

DIMENSIONAL LIMITATIONS
The machine can move within the limits outlined in the following diagram. However, this is often restricted due to the design of the model (steepness, curvature, etc.) and the limitations of the tools (limited depth of the bits, potential collision with the tool holder, etc.). Check your file early on with a lab assistant if you are unsure of the feasibility of your job. You can email the CNC lab assistants at TCAUProuter@umich.edu.

JOB PREPARATION
Our CAM software (MasterCAM X4) can handle almost any vector and surface file type. For most purposes, 2D files can be submitted as AutoCAD DXF files. Surfaces to be milled out of 3D solids can be submitted as Rhino 3DM files. Please set the origin and orientation of the file according to the diagram below. It is also helpful to model an outline of the stock to be milled in addition to the design.

x

z

48"

96"

0,0,0

~10"

y
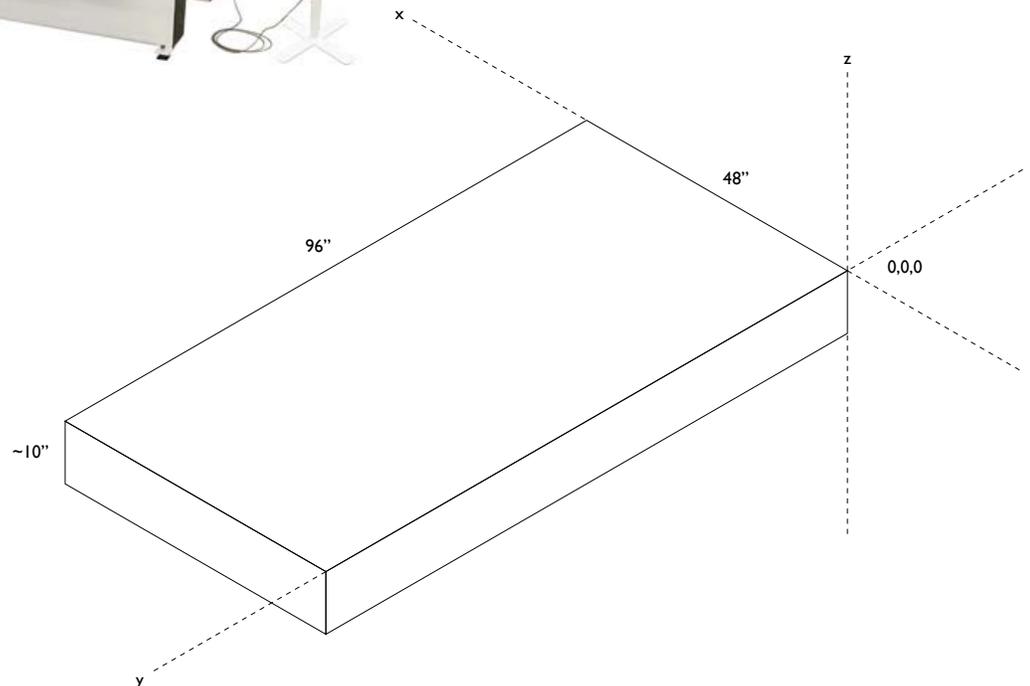
Router Materials

FOAM
Foam is the best option for milling a large surface out of a solid block. Jobs created out of foam are much quicker to mill than wood and put less wear on the bits. They can also be coated for a more durable surface. We ask that you use polyurethane foam, polystyrene foam (pink and blue), or some other foam with approval by the lab. Material samples are available in the lab.

PLASTIC
Various types of plastic can be cut with the CNC, but it is in general more difficult than wood and may require special tooling to get good results.

WOOD SHEETS
In general, plywoods and wood composites (MDF, LDF, OSB, fiberboard, etc.) are all acceptable materials for cutting out profiles. If you are planning on using a non-standard material or finish, please check with a lab coordinator before placing your order. Special bits or tools might be required (for example, to cut drywall).

WOOD SOLIDS
If something more durable than foam is necessary, you can create a solid block of material from sheet material. To save the bits from excessive wear, we ask that the solid blocks be created out of a lightweight version of MDF called LDF which is inexpensive and readily available. Other materials may be used with approval.

SOLID BLOCK PREPARATION

Before gluing your sheets together, remove as much material as possible with standard woodworking tools or through 2D profile cuts with the router. In looking at the two examples below, the time difference between milling the surface out of the first block versus second block could be measured in hours. The second block also creates considerably less material waste and dust. Large blocks of foam are also readily available.

When gluing up your block, apply thick even layers of glue. For best results use the vacuum laminating table in the router room. Allow the block to set at least overnight. If this is not followed through, the layers of the block could delaminate, ruining your job. Please also avoid using toxic glues such as construction adhesive as this material will become airborne.
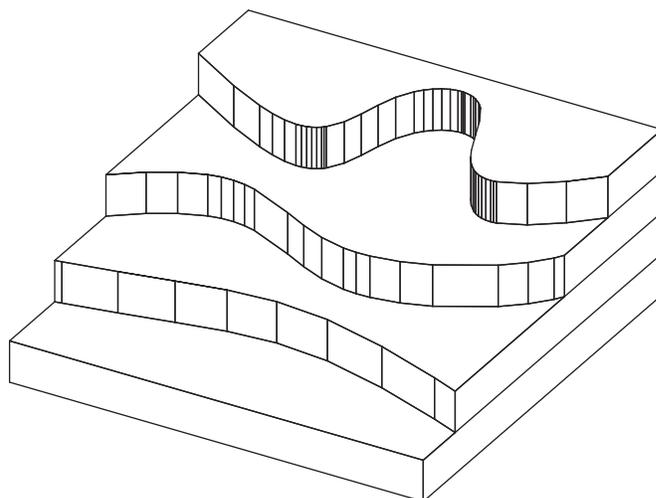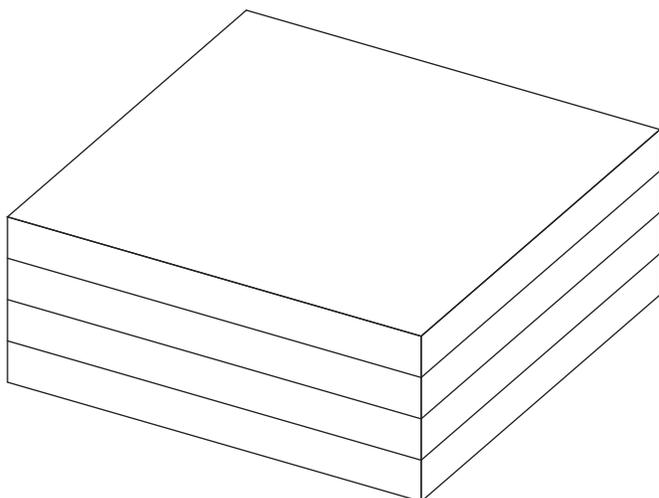
CNC Milling Machine

VERVIEW

The CNC milling machine is of a 3 axis bed mill type. The machine can be run in a man ual mode for traditional milling operations. It has a user friendly programming language that allows 2/2.5 D programs to be written at the machine. For complex 3D machining, mastercam is used for programming.

MATERIALS

The machine can machine most metals including stainless steels, though the majority of work is done in aluminum. Small plastic parts requiring a high accuracy can also be machined.

ACCESS

The machine is only operatied by trained Lab Assistants. If you have a job that requires the mill, email TCAUP-mill@umich.edu . to discuss the application. Complex 3d work will require the student learn Mastercam. Simpler jobs may only require a drawing.

Abrasive Water Jet Cutter

OVERVIEW
The 3 axis Water Jet cutting system is designed for cutting 2 dimensional profiles or shapes out of flat sheet materials, ranging from sheet metal to metal plate and plastics. For a description of the abrasive water jet process, go to http://en.wikipedia.org/wiki/Water_jet_cutter. It is important to note that in all but a few cases, water jet systems cut completely through a part, and do not have control over depth, like routers or milling machines.

DIMENSIONAL LIMITATIONS
THe IFB4800 has a working range of 4'x 8' with around an 8'' Z axis. This machine is equipped with state of the art dynamic head technology, which elimintates the kerf taper common with waterjets, and can reliably produce parts with .005'' tolerances.

MATERIALS
The machine can cut all metals and plastics, as well as rubber and wood. The material must be resistant to moisture, however, so wood is rarely used.

ACCESS
The machine is only operated by trained Lab Assistants. If you have a job that requires the waterjet, email TCAUPwaterjet@umich.edu to discuss the application.

7 axis Robotic Workcell

OVERVIEW
The 7 axis Robotic Workcell is a large format 6 axis articulated robotic arm mounted on a 10 m linear axis. The robotic system serves as a flexible, reconfigurable, motion control platform. A variety of tools can be moutned to the arm, including a high speed router spindle and an abrasive waterjet cutting nozzle. In addition to machining processes, the arm can be reconfigured to perform assembly work using a gripper.

PROGRAMMING WORKFLOW
Robotic programming requires additional steps not found in typical CNC programming operations. There are two primary methods used to program this system. One uses the standard Mastercam X4 software, using 3-5 axis toolpaths. This is augmented by a plugin called Robotmaster, which converts the toolpath to robotic motion instructions, and simulates the toolpath on a 3d kinematic model of the TCAUP workcell. This offline simulation reduces the amount of physical testing needed to verify the program..

DIMENSIONAL LIMITATIONS
The Robotic system is composed of a Kuka KR100 HA L90 arm mounted on a K-1500-3 linear axis. The Arm has a max reach of 2.8m and a max payload of 90 Kg. The linear axis has a 10m travel. This allows the system to move between workcells, allowing rapid conversion from one task to the next. Due to the complexity of the kinematics, there is no simple answer for how large a workpiece can be; in general is must fall within the maximum limits. The workcell is pre configured with a 4'x8' cutting are for multiaxis waterjet and a 4'x8' cutting area for multiaxis routing.

MATERIALS
In waterjet applications the robot can cut all metals and plastics, as well as rubber and wood. In routing applications, the robot is limited to wood and foam materials. In general, robots do not possess the necessary rigidity to perform heavy cuts compared to a gantry or bridge type router.

ACCESS
In general, use of the robot is limited to specific dedicated course taught in the fabrication lab. As the number of trained users increases, access to the machine will increase as well. The machine is only operated by trained Lab Assistants. If you have a job that requires the robot, email wesmcgee@umich.edu to discuss the application.
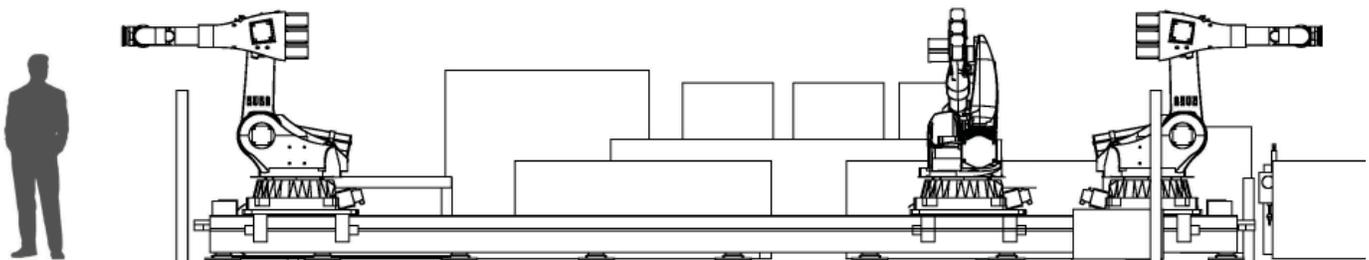
Digitizer

DIGITIZING POINTS

To activate the digitizer within Rhino, use Tools > 3-D Digitizer > Connect then select MicroscribeDigitizerSupport. You will be promted to enter an X and Y axis and specify a point in your Rhino file to match the origin of the digitized area. You can then use the digitizer as you would a mouse.

~30"

0,0,0

~20"   ~20"
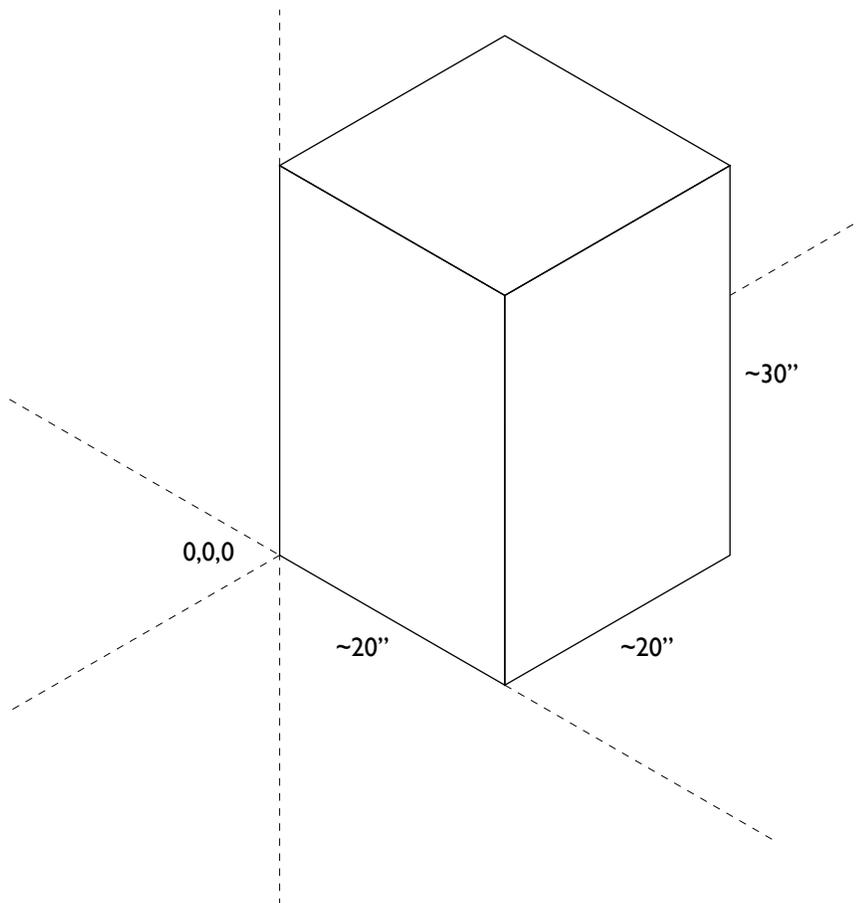
3D Printers

DECRIPTION

The printers accept only "watertight" (closed surface) STL files. These are best created in Rhino. For tips on STL file preparation, see a thorough tutorial in the Rhino Help titled "STL import/export." Set the units to Inches and check that your model does not exceed the dimensional limitations of the following diagram. STL files cannot contain any "naked edges." Please allow adequate lead times for printing as jobs are typically processed overnight. During busy periods of the semester, the turn-around time between job submission and printing can be several days to a week.

PROCEDURES

1. Email TCAUP3dprint@umich to discuss project
2. Verify STL integrity
3. Email TCAUP3dprint@umich to alert of submission
4. Hand in submission form physically at lab. The form is available from the main Fab Lab wepage.
5. Submit a properly named stl file in the location specified on the form; Z:/FABLAB TEMP.
6. If the estimated cost exceeds your indicated cost, you will be emailed; you may lose your spot in the queue if you do not reply promptly. The costs are outlined on the submission form.
6. If errors are detected you may be bumped to a later position in the queue, unless fixed promptly.
7. Jobs that are more fragile than the established guidelines and break will not be reprinted for free.
8. Complete prints will be removed from the printer and kept downstairs until picked up.
9. You must pay for your print in the Media Center before picking up the model. If the model breaks due to machine errors, you will be notified. Otherwise you must pay for the print.

## BASIC VERIFICATION FOR STL FILES

1. All surface normals must point out from the enclosing volume.
2. In Rhino use Analyze>Direction to determine vector orientation
3. Under the view settings, the color for backfaces can be changed to a contrasting color, to aid checking in a shaded view
4. Once normal vectors are aligned, create a polysurface('join')
5. Check for naked edges with Analyze>show edges.

MACHINES/MATERIALS

Zcorp Z310
The Z310 printer uses a high strength gypsum composite. The cost is $3.00 per cubic inch. Models

Zcorp Build Envelope

z

7.5"

x

y

9.625"

7.625"

0,0,0
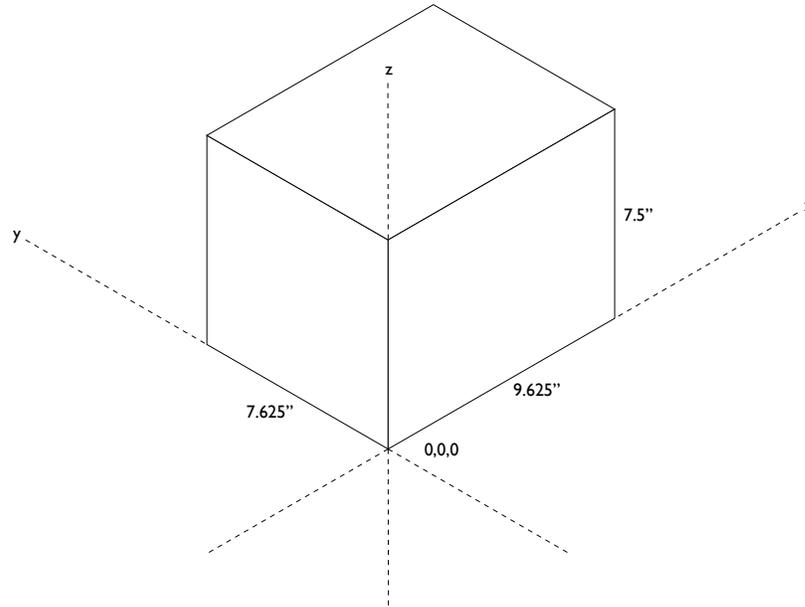
should be made hollow leaving enough wall thickness for strength. The minimum thickness will vary based on structure, but in general 1/8" is the minimum.

Zcorp Z403
The Z403 printer uses a high strength gypsum. The cost is $2.00 per cubic inch. Models should be made hollow leaving enough wall thickness for strength. The Z403 resolution is not as good as the Z310.

Dimension 768SST/1200es
The Dimension printer is an FDM printer using an ABS thermoplastic. The cost is $4.00 per cubic inch. The machine prints a soluble support structure around the part. The parts are put in a heated circulator bath for several hours to remove the support. The support is the same cost as the model, though the

Dimension Build Envelope
768/1200

12"

0,0,0

8"/10"   8"/10"
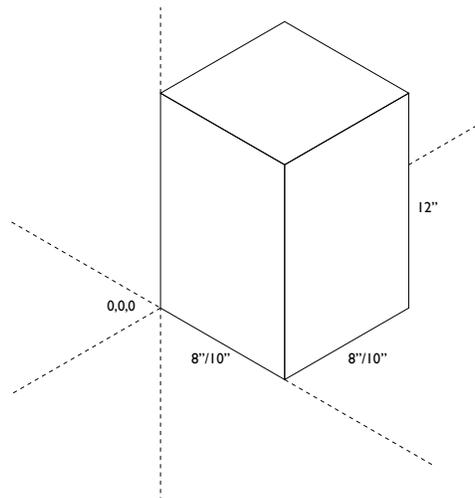
usage can vary widely depending on the geometry. Support is automatic and is required. The ABS parts are much stronger than the Zcorp, so the wall thickness can go down to .040" if needed. Te Dimension printer is considerably slower than the Zcorp. Large jobs utilizing the z height of the envelope can take up to 72 hours to complete.
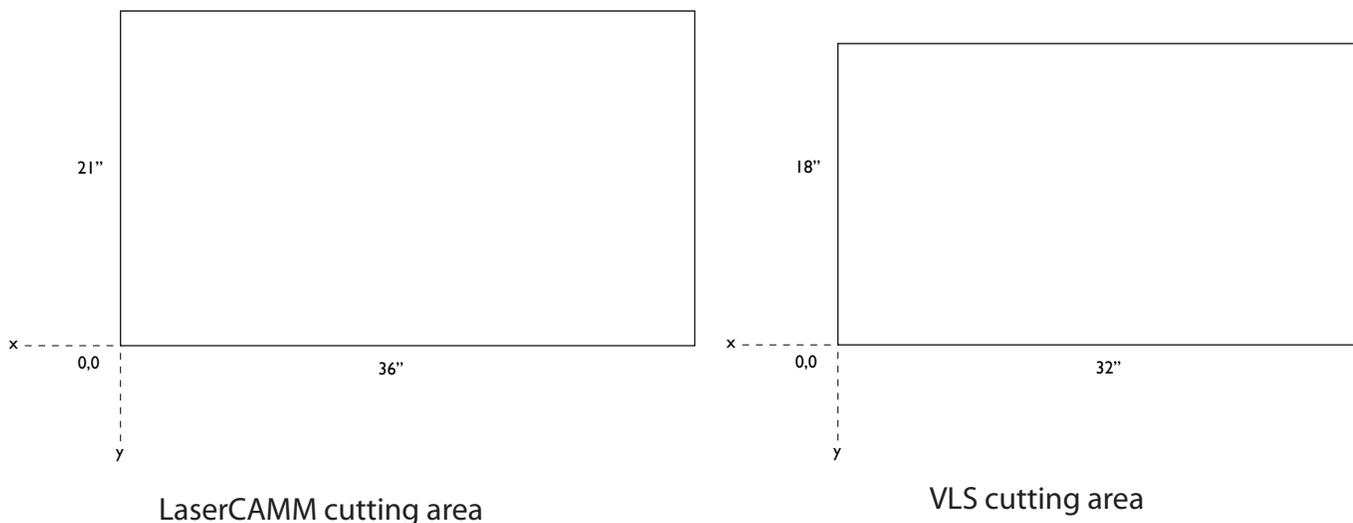
FINISHING
Models can be printed in sections and adhered together after printing. After printing the Zcorp models are brittle. To strengthen them, they may be waxed to provide additional strength or be infiltrated with a resin or CA glue if painting, priming or sanding is desired. ABS prints can be glued(if in pieces) with acrylic cement, and can then be primed or finished further.

Laser Cutters

DESCRIPTION

The College operates four laser cutter systems. Two LaserCAMM systems are located in the A+AB woodshop and are generally available for use on a sign-up basis during wordshop hours. Students should consult Mark Krecik or Gerry Weston for orientation and assistance in using the two laserCAMM machines. More information is available at:

http://www.tcaup.umich.edu/lasercamm/

21"   18"

x   x
   0,0   36"   0,0   32"

   y   y

        LaserCAMM cutting area   VLS cutting area

Additionally, two VLS 6.60 laser systems are located in the west computer lounge, on the 3rd floor. In order to use the VLS 6.60 systems you must go through an orientation with a Lab Assistant. These systems are available for use on a weekly sign up basis. The sign up sheet will be posted Friday at 2:00pm for the following week. Students may sign up for two hours per week. If no one signs up for a certain time, it is first come first serve. If it is 15 minutes past the allotted time, the slot is canceled and it is first come first serve until the next slot comes up.

Once you have been trained and authorized to use the laser, you will be able to log in to the system using your uniqname. The laser can only be activated by logging in to the PC connected to it. You must log off when finished. Not logging off can result in the suspension of laser privileges.

The VLS laser systems have a working area of 32"x18". They are 50W lasers. The power and speed settings are controlled by a printer driver. The laser can be used to cut a wide variety of materials, including most natural materials. Chipboard up to 16 ply can be cut. Fabrics should only be cut if tested by a lab assistant; generally they must be dampened to cut without burning. Acrylic plastics, both cast and extruded, can be cut. Decent quality can be obtained up to 1/4"; beyond this multiple passes are necessary and quality is reduced. Polycarbonate(Lexan), copolyester, and PVC must not be cut. If the material is not listed here, a lab assistant must be consulted before cutting.

Important:

        You must clean up after yourself.

        Do not place materials on top of the machine, it is not a worksurface!

        You absolutely must not leave the machine unattended while cutting, no matter how experienced you are.

        If the machine is found cutting unattended it will be shut down, and could result in revocation of laser priviledges for the logged in user.

        If a problem occurs, or you observe anything out of the ordinary, send an email to TCAUPlaser@umich.edu

Suppliers

MATERIAL SUPPLIERS

Aircraft Spruce
Specialty metals, woods and composites.
www.aircraftspruce.com

Alro Metals
Local Metal supply

ASAP Metal Source
Local metal supplier.
www.asapsource.com

Demand Products
Specialty foam coatings.
www.demandproducts.com/ent.html

AIN Plastics
Cheap local plastic supplier with a wide selection.
Catalog available in the lab.
800-521-1757 in Southfield, MI

McMaster-Carr
See "Ultra-Machinable High-Strength Plastic Foam"
and "Polystyrene Foam Sheets."
www.mcmaster.com

Fingerle Lumber
Ann Arbor based lumber supply yard, good source
of blue EPS foam and all wood products.
www.fingerlelumber.com
734 663 0581

Plastic-Tech
Local and expensive plastic supplier
www.plastictech-inc.com

Foam N' More & Upholstery
Inexpensive local foam supplier.
www.foamandupholstery.com
248 284 0002

Freeman Manufacturing & Supply
Machinable waxes and foams.
www.freemansupply.com

Polytek
Mail-order molding and rubber supplies.
www.polytek.com

Small Parts
Model making parts and hardware. Catalog available in the lab.
www.smallparts.com

RenShape
Tooling supplies
www.huntsman.com/renshape

TFB Plastics
Good local source of rubber and sculpture supplies. Pricelist available for tooling foam in the lab.
586 566 7900 in Shelby Township, MI.

All America Pywood
Excellent source of plywoods and wood products.
Detroit.
313 891 6880

McCausey
Specialty woods and machining materials.
www.mccauseylumber.com

Reklein Plastics
Somewhat local supplier of high density tooling
foams. Pricelist available in the lab.
586 739 8850 in Sterling Heights, MI.

TOOLING SUPPLIERS

Onsrud Bits
Supplier used in the lab.
www.onsrud.com

MSC Industrial Supply
Large selection of tooling and industrial supplies.
Catalog available in the lab.
www.mscdirect.com

McMaster Carr
See "Solid-Carbide Spiral-Flute Router Bits for
Wood and Laminates"