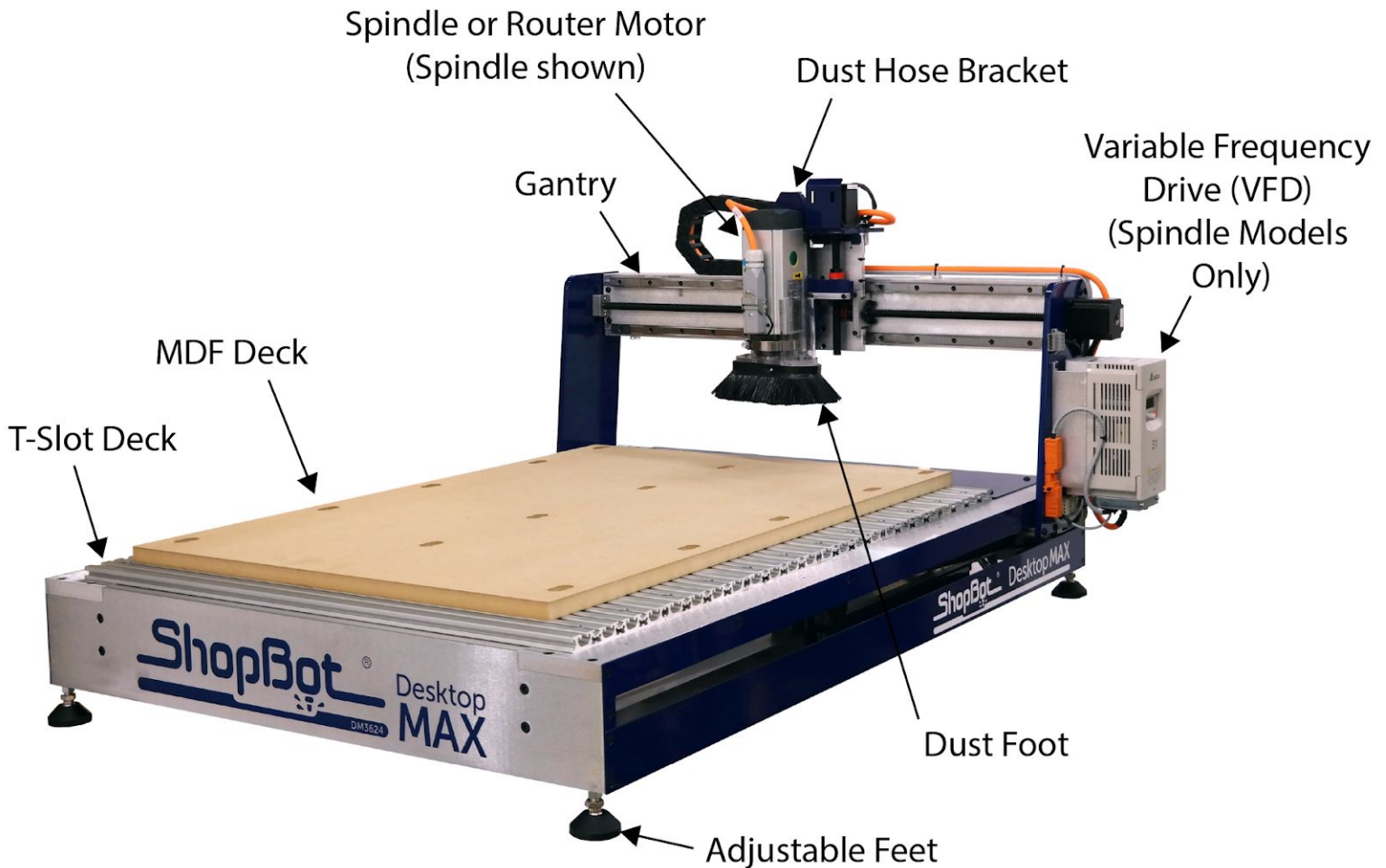


CNC Routing Orientation Packet



VCarve Pro

What is CNC Routing?

CNC Routing is a subtractive manufacturing technique that starts with a block or sheet of material which is cut down into a desired shape (as you would with a traditional mill, lathe, or chisel). A [CNC Router](#) consists of a **Bed or Deck**, where a material to be machined can be mounted, a **spindel**, which accepts a range of cutting **bits** and rotates them at high speeds, and a **gantry system** that allows the spindle to move in the X, Y, and Z **axis**, allowing it to carve out material in 3 dimensions. The CNC stands for *Computer Numerical Control* meaning that the movement of the spindle is not manually operated, but instead controlled by a program.

What Applications are there for CNC Routing?

Signage, Furniture, Cabinetry, Wood-working, metal component fabrication, plastic component fabrication, etc.

CNC Routers can cut a range of materials, from Plastic, to Wood, to Metals. They are much faster than additive manufacturing methods such as 3D Printing, and have the advantage of preserving the mechanical strength of the base material, but are limited in detail and geometry by the bit and angle of cut (for example, they cannot perform significant relief cuts or voids). Your design detail is also limited by the diameter of your bit (you cannot create inner pockets with perfectly square corners, for example).

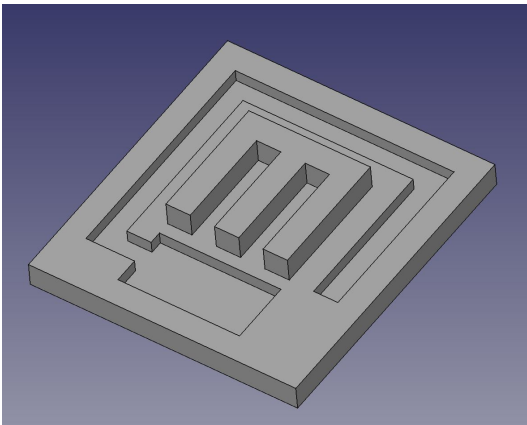
How are CNC Machinable Designs Created?

CNC Machinable designs can be 2D Vector files or 3D Models. They are composed of a collection of coordinate data that define the shape and perimeters of the object. They can be derived from 2D photos of physical objects or generated entirely in the digital world using a 2D or 3D modeling program.

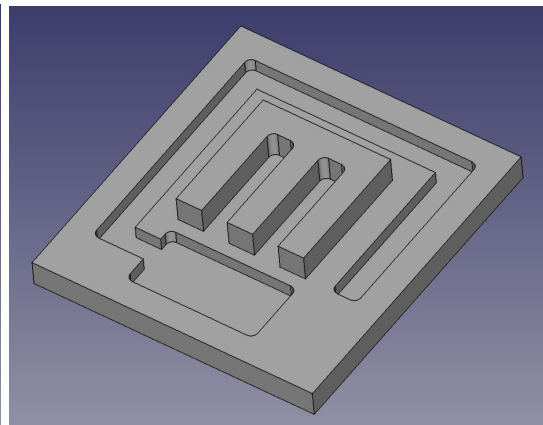
Once an design exists digitally, it still needs to be converted into a format that a CNC printer can interpret. That's where a **CAM (Computer Aided Manufacturing) Program** comes in. A **CAM Program** is a program that builds out a vector-based **toolpath** - essentially a route for the router **toolhead** to follow in order to remove the base material in the correct location. The **toolpath** is specific to the CNC Router and bit being used, while the original design is not. Most **toolpaths** are stored in a file format called **GCode**, which lists all the X,Y,Z coordinates the tool must go to. GCode is used by all sorts of machines, not just CNC routers.

CNC Toolpathing is more complicated than 3D Printing or Laser Cutting, because it requires specific tool dimensions and type to be specified for certain cuts to be achieved, and given the limitations listed in the CNC routing applications section, your design must be compatible with 3-Axis CNC Machining.

Ex: Rounded Corners Limitation (CNC Router Introduction PPT)



Model



Outcome

CNC Routing Tools used in this Program:

1. 2D Modeling and CAM Program: **VCarvePro**
2. 3D Modeling and CAM Software: **Fusion 360**
3. 2D Modeling Program: **Adobe Illustrator**
4. CNC Router: **Shopbot Desktop Max**

Resources & Training Process:

1. **VCarvePro:** VCarve Pro is a simple 2D Modeling software, in addition to a **CAM program**. It can accept 2D vector files from other sources (in a number of formats - DXF, AI, etc.).
 - a. **VCarve Website Tutorials:** <http://support.vectric.com/tutorials/V9/>
 - i. Under the drop-down “Category” Menu, search for “Getting Started” to find videos about importing a 2D design and setting up a toolpath.
 - ii. Under the drop-down “Category” Menu, search for “Vector Drawing” to find videos about Creating a 2D design within VCarve.
2. **Fusion 360:** Fusion 360 is a 3D Modeling software, in addition to a CAM program. It is more complicated than VCarvePro, but more powerful if you are creating complex 3D geometries.
3. **Adobe Illustrator:** Is a professional 2D design software. You can create vector files, but you cannot prepare a file for CNC routing in this software, it must be imported to VCarve to prepare for Cutting.
 - a. See the [Laser Cutter Orientation Packet](#) for more details about how to use the software.
4. **Shopbot Desktop Max:** The Shopbot Desktop Max is a compact version of a CNC router, which can cut out materials 3.5” high, 2 feet by 3 feet wide. It has its own dedicated software that selects, simulates, and runs toolpaths.
 - a. General Shopbot User Guide can be found with the Shopbot or at Shopbottools.com
 - b. Shopbot Video tutorials: **ShopBot Tools** Channel on Youtube
 - c. [A Feeds and Speed Guide](#) found at Shopbottools.com and with the shopbot.
 - d. In the Shopbot software you can:
 - i. Home and Zero the X, Y, Z axis
 - ii. Simulate a toolpath run to make sure the job will execute as expected.
 - iii. Run and Pause jobs.

Key Terms to Know:

- Spindle
- Collet
- Bit
- Upcut/Downcut
 - Flute
- Feed Rate
 - RPM
 - VFD

Toolpath Building Check-List:

- My design does not contain any geometries that are too detailed or complex for the bits I have to achieve
- My design will fit on the router bed
- The orientation of my design matches how I want it oriented on the router deck
- My design allows for mounting or clamping to the Router Deck
- I have identified my material and material thickness
- I have identified a bit for each cut I want to do
- I have applied the appropriate cuts to my vector lines (Pocket, Profile, Engrave,etc)
- My toolpath RPMs and pass depths are appropriate for the given material and bit
- I have grouped toolpaths from inner, superficial cuts, to outer through cuts
- I have added tabs if they are necessary to hold my design during cutting
- I know when and where I am going to add mounting screws and clamps, and have seperated my toolpaths accordingly.
- I have run a preview of my toolpath to check what the output will look like
- If I am working on a makerspace laptop, I have exported by Vcarve file, and saved it to a thumb drive
 - I have opened up my VCarve file on the Dedicated Shopbot computer.
- I have exported my toolpaths as *.SPB files, giving them clear names, so I know what they are and what order to run them in.

Shopbot Setup Check-list:

- Mount material to Shopbot deck (don't put screws near design location)
- Plug in the dedicated shopbot laptop into PWR and USB to the Shopbot.
- Turn on the Shopbot main power button (Big red button)
- Open up the shopbot program.
- Open up the control panel, confirming that the spindle output is off, and moved the head of the router within reach.
- Raise the spindle high enough to allow clearance for bit removal.
- CLOSE the control panel
- Change the bit to the first bit used in your file
- Open control panel back up, move spindle above desired X, Y home location.
- Zero X & Y coordinates
- Close control panel
- Plug in Z-leveling plate to VFD and clip onto spindle bit.
- Touch plate to bit, if a green input light turns on in the shopbot program, then the circuit is complete.
- Place plate directly under bit and run z-leveling program (keep hands away from spindle)
- After Zeroing Z-axis, remove plate and put away.
- Set desired Spindle RPM on VFD (Input F # = RPM / 60, Ex: 14000 RPM = F283)
- Run Shopbot simulation of SPB G-Code, confirm that placement and home are correct.
- Close Enclosure Doors, Alert lab users to CNC use, Run Job
- Pay Close attention to job, press emergency shut-off if anything goes wrong.

SHOPBOT Desktop Max

Rules and Safety

Additional Safety Equipment

- Eye AND Ear protection should be worn at all times (Shopbot Enclosure functions as Eye and Ear Protection)
- A dust mask may be worn if necessary

Hazards

- Small parts that become loose during cutting may be THROWN
- Poorly secured stock can FLING out

Dos

- Do keep eyes, hands, hair and clothing away from running router
- Do close the enclosure doors before running a job.
- Do stay within reach of pause and/or stop switch during job
- Do properly and safely secure stock
- Do shut down power to router spindle before changing tools
- Do use a sharp and appropriate cutting tool
- Do create jobs such that all pieces remain attached to stock material
- Do use a safe spindle speed (this often means more RPM!)
- Do leave the machine and nearby area cleaner than you found it
- Do cut plastics, formaldehyde free mdf, wood, and aluminum

Don'ts

- Don't wear long sleeves, ties, hoodie strings, jewelry, or gloves
- Don't leave a running job unattended
- Don't let excessive chips build up between jobs
- Don't clear chips while spindle is running
- Don't use hands to hold down parts that come loose during cutting
- Don't cut fiberglass, mdf, carbon fiber, or other composites

If you suspect a tool is not operating properly, contact cascadefablab@pcc.edu immediately!

ACCEPTABLE SHOPBOT MATERIALS

MIT MAKERWORKS

Woods	<i>Hard Woods</i> e.g. alder, ash, aspen, balsa, beech, birch, hickory, mahogany, maple, oak, teak, walnut
	<i>Soft Woods</i> e.g. cedar, Douglas fir, juniper, larch, pine, redwood, spruce, yew
	<i>MDF</i> Must be formaldehyde free
	<i>Plywood</i>
Plastics	<i>Hard Plastics</i> ABS, styrene, nylon, polypropylene, PVC, polycarbonate, polyurethane, acrylic, PET, polyester
	<i>Soft Plastics</i> HDPE, PEEK, PTFE, foam board, APET, acetal/delrin
Foams	Styrofoam, polyurethane, high-density, closed cell, memory, evlon
Aluminum	Must email Shopbot Team

**Be sure to select the appropriate material & tool combination!
If you don't see a tool for your material, it means it can't be used!**

CNC Router Training Worksheet:

Fill in this sheet and turn in when complete. This will fulfill your training.

1. **Are there any terms in the documentation that you are unfamiliar with? Please list at least 3 and ask the instructor to define them. Record their responses here.**

2. Answer the following questions:

- What is a toolpath? _____
- What materials can be cut with a CNC router? _____
- What is the recommended Spindle Speed for Plywood? _____
- What is the maximum recommended pass depth for a given bit? _____
- What types of cuts can a CNC router not achieve? _____
- What is the difference between a profile and a pocket cut? _____

Complete these tasks:

- Build a machinable 2D Model using Illustrator or Vcarve Pro
- Build out a CAM toolpath using VCarve Pro
(Required tools: Profile Cut , Pocket Cut, Tabs)
 - Open on Shopbot Computer and Export as Shopbot G-Code
- Mount Material and Zero X, Y, Z axis
- Preview Job
- Run Job