How to Build a CNC Machine

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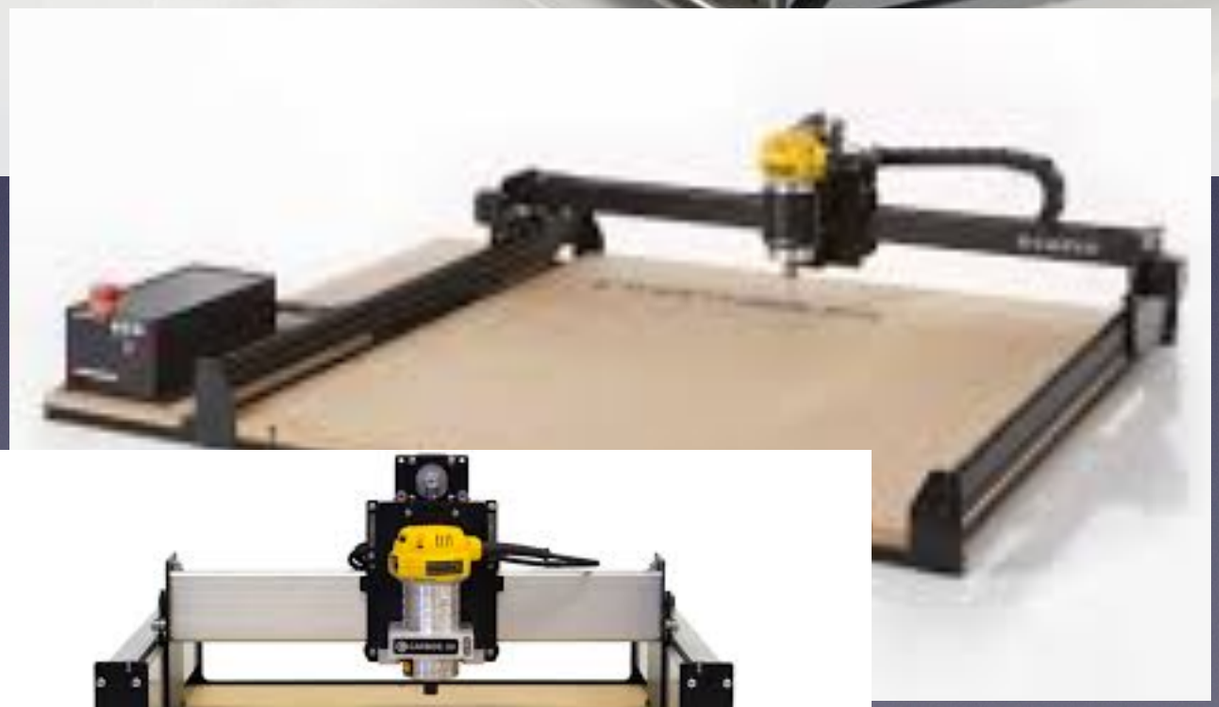
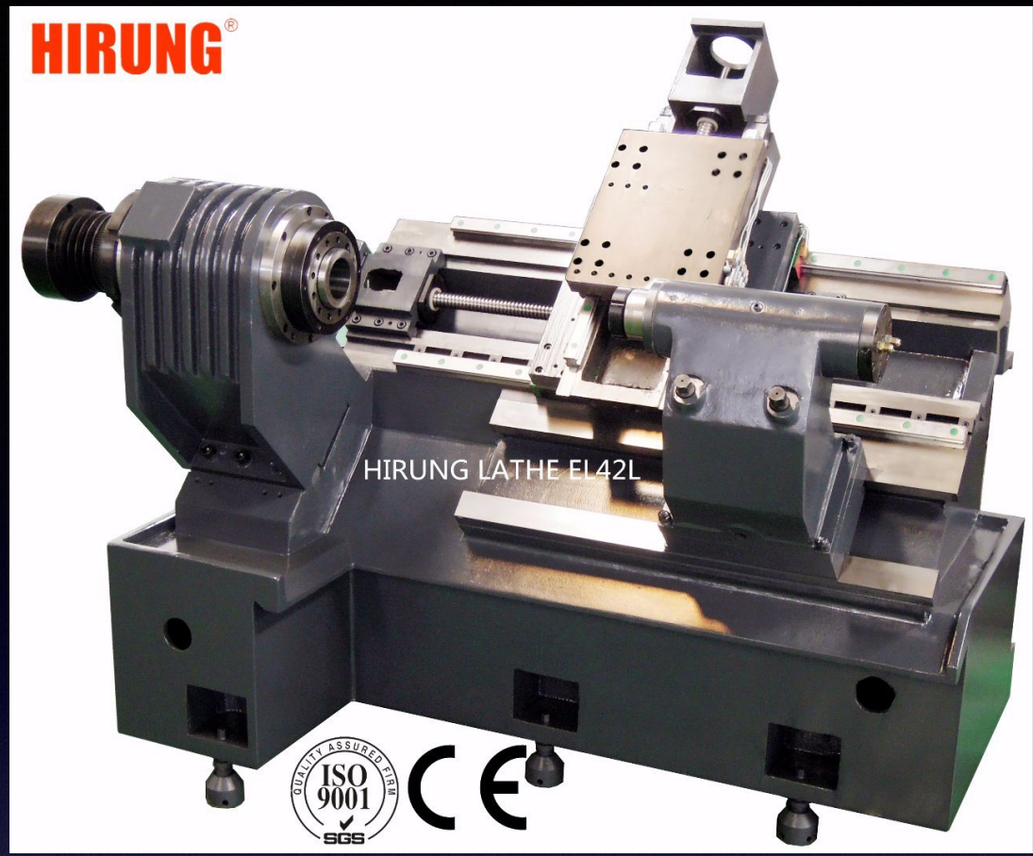
- Offhours.show

CNC
ROUTER PARTS



TORMACH®
1100M
ATC
TORMACH

MODERN


HIRUNG®
HIRUNG LATHE EL42L
ISO 9001
SGS
CE

BOXFORD
160TCL

TORRACA
15L Slant PRO CNC LATHE
DANGER

Building a CNC Machine

- Overview
- Hardware
- Electronics
- Control PC
- Control Software
- Design Software and process
- Resources
- Questions

Going to focus more on CNC Routers, but most info applies to CNC Mills and Lathes as well.

Safety

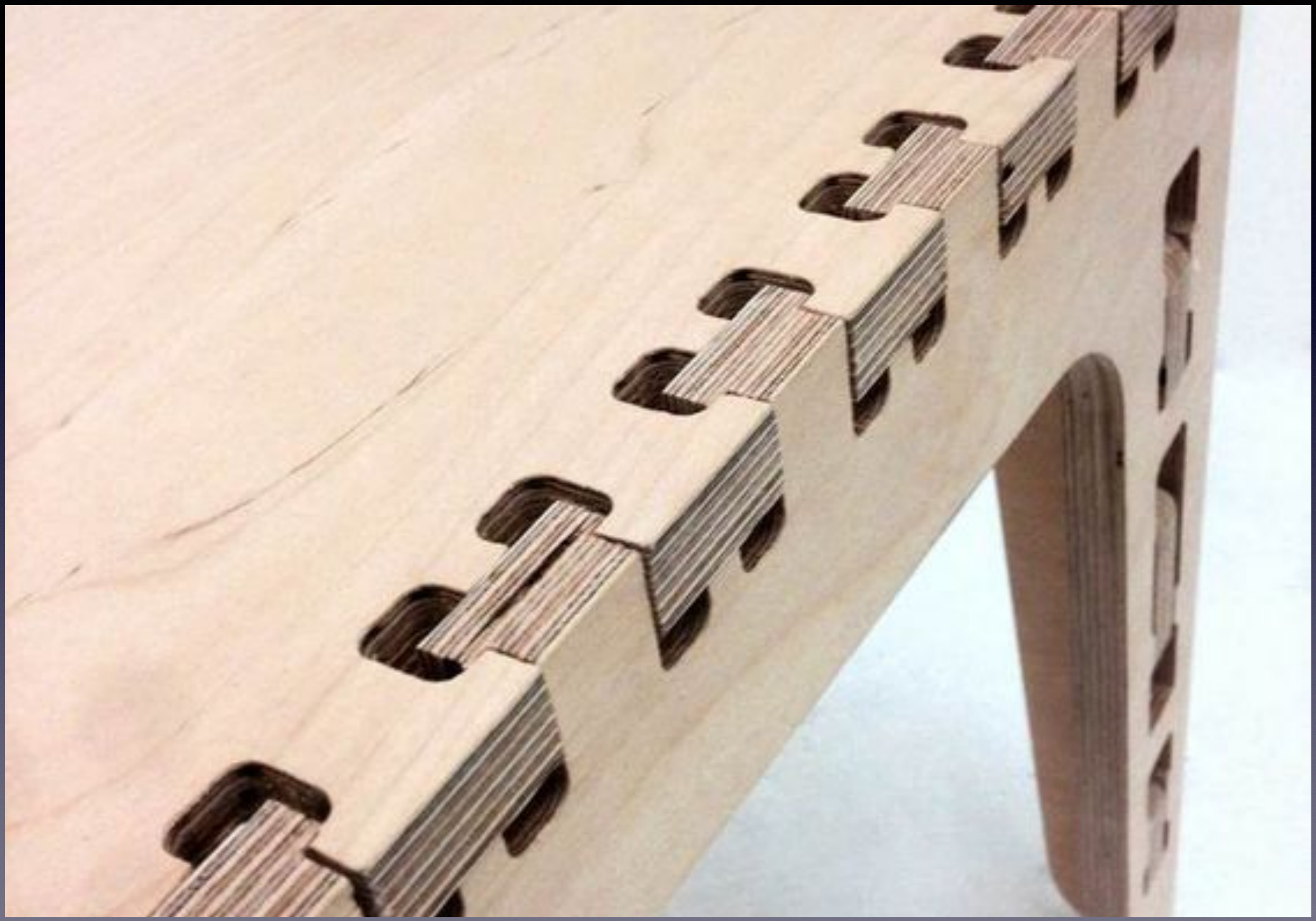
- NOT A JOKE. WE ARE TALKING ABOUT VERY DANGEROUS MACHINES.
- This is the first machine in your shop that will move on its own and try to kill you.
- You need to think about escape routes, Emergency Stop, Limit Switches, How you will call 911.
- Test cuts in the air with the spindle OFF.
- MAKE A CHECK LIST AND FOLLOW IT BEFORE YOU HIT GO.
- Wear ear and eye protection
- Don’t leave it alone. You will be tempted to...

Why use a CNC?

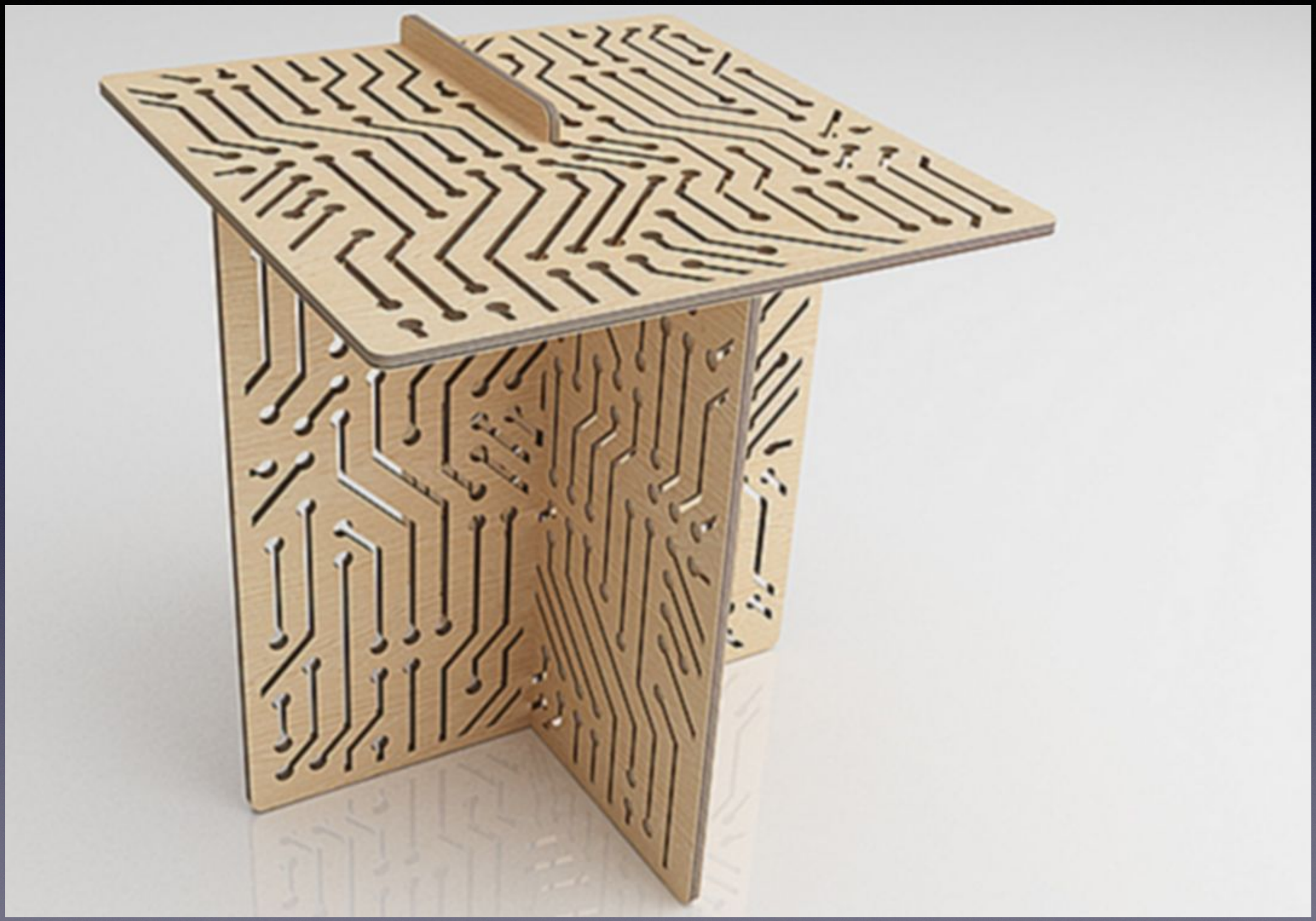
- Very similar to the transition between using a typewriter and a computer.
- Accurate
- Repeatable
- Fast
- It can work while you do other things.
- You can try something, tweak it, and cut it again. Like reprinting a single page of a document.
- Always finding new uses
- Can work with larger bits
- Can work with extremely small bits
- Convenient when you have multiple items to make

But, it has its place.
Often still use a table saw, chop saw, planer, etc.

Furniture



Furniture



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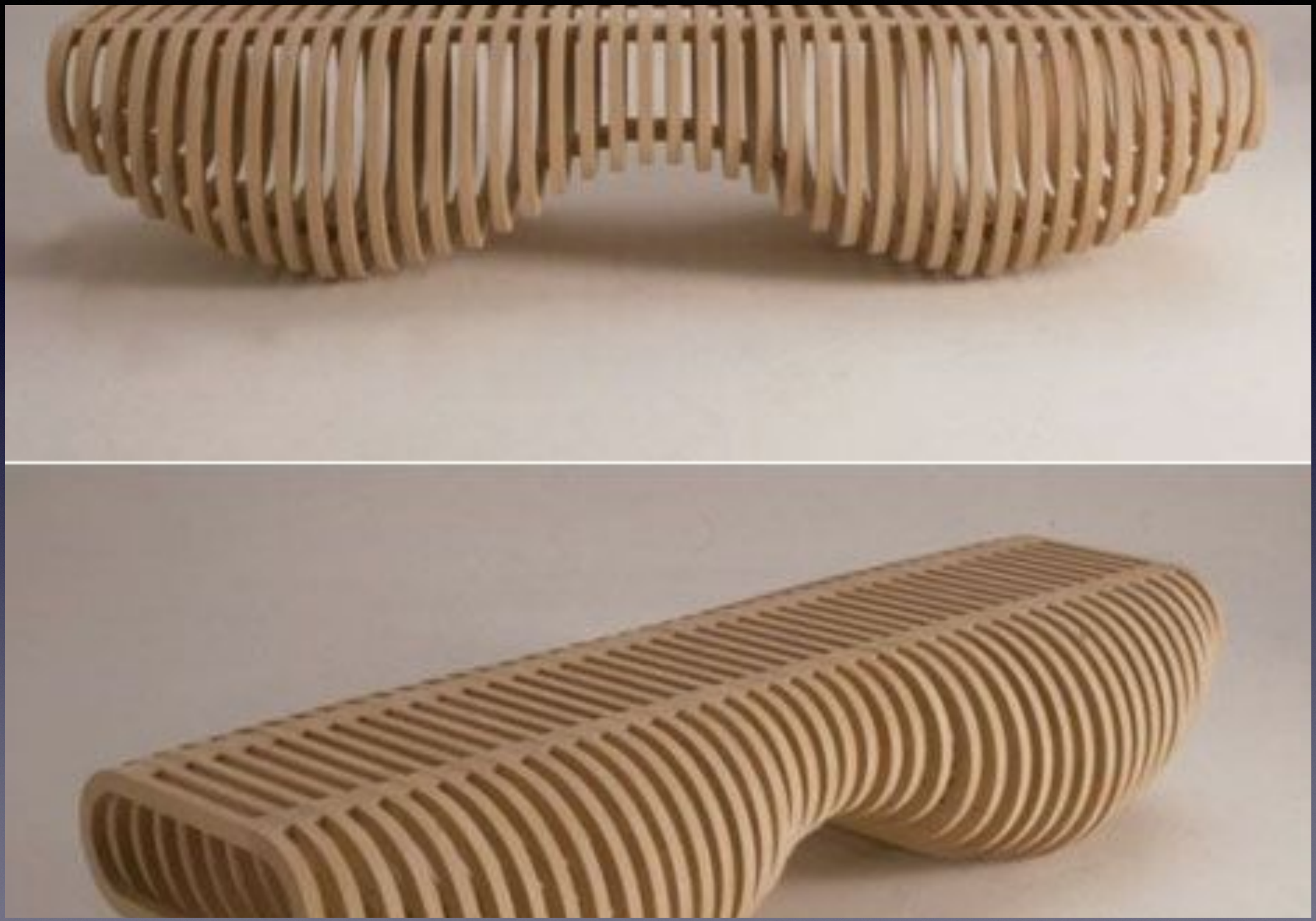

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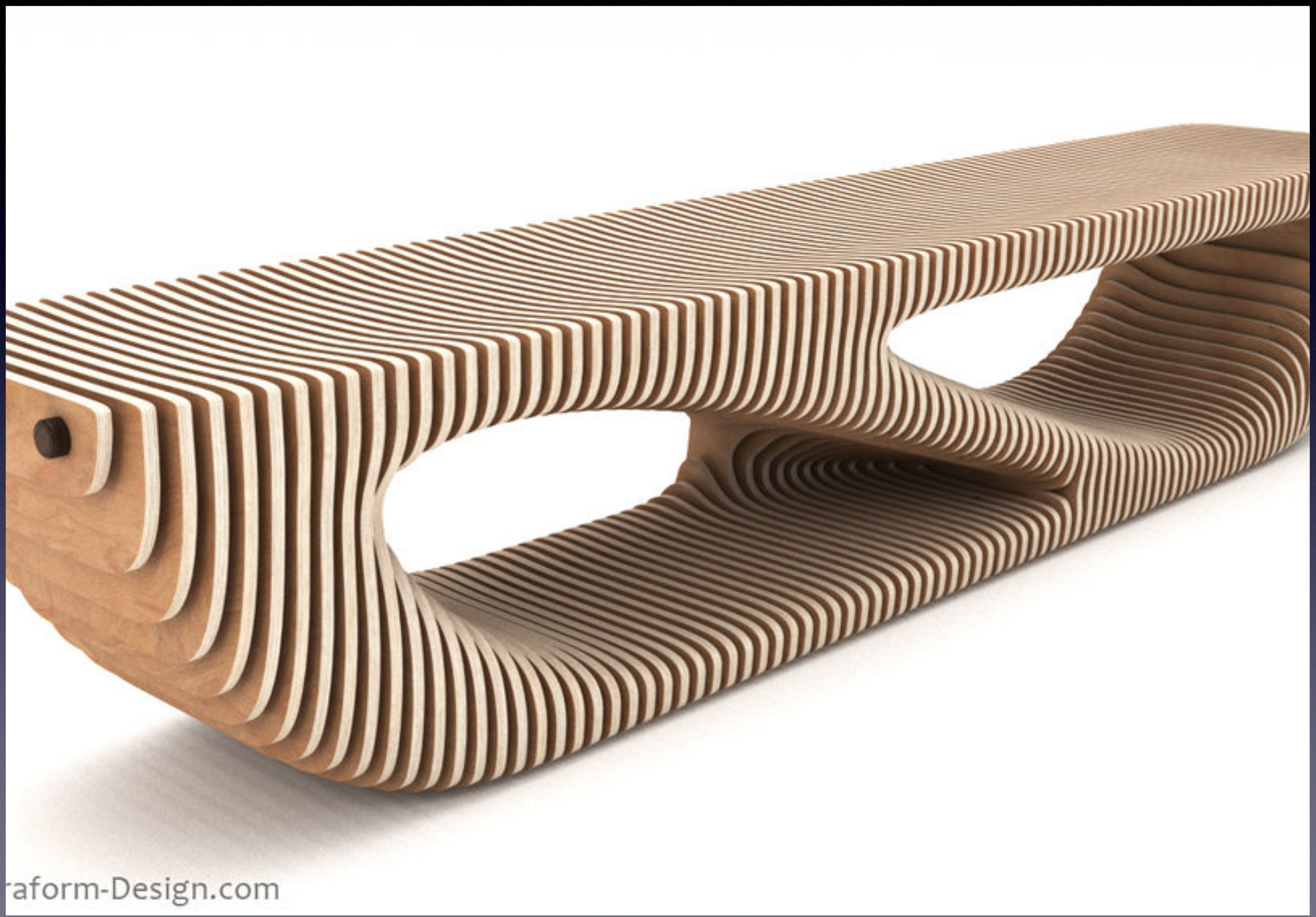

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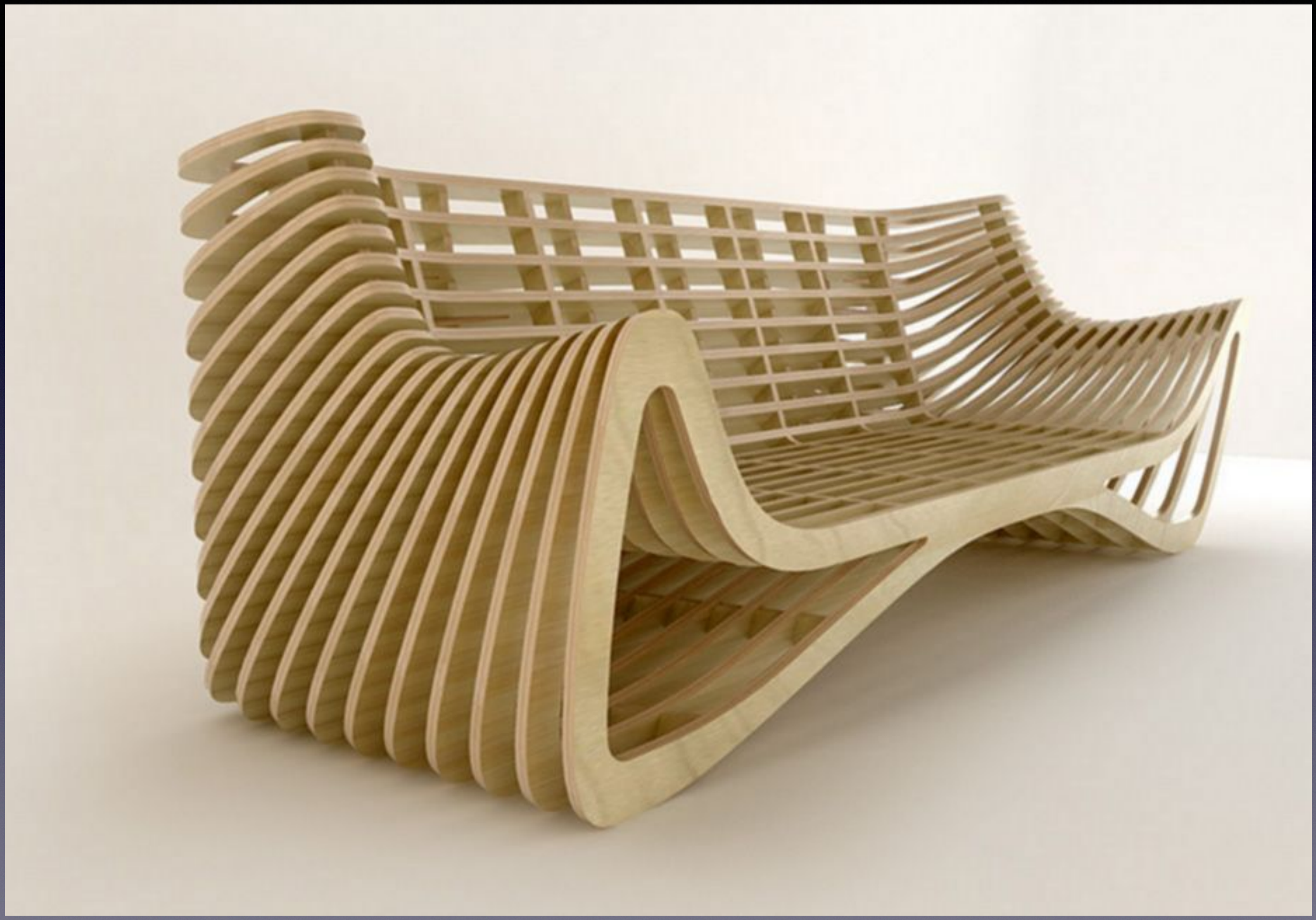


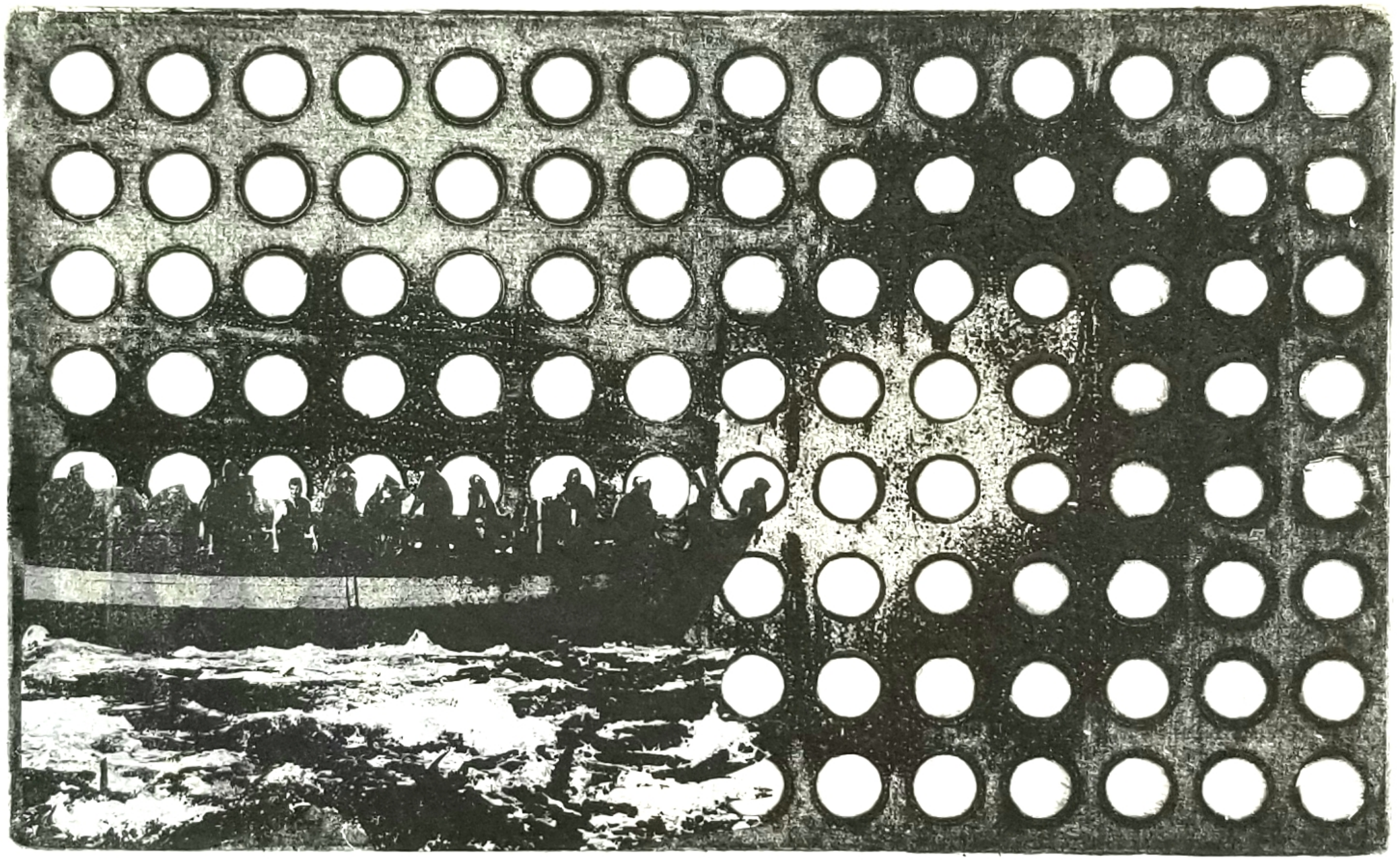
Furniture

Furniture

SketchChair

Furniture

Art



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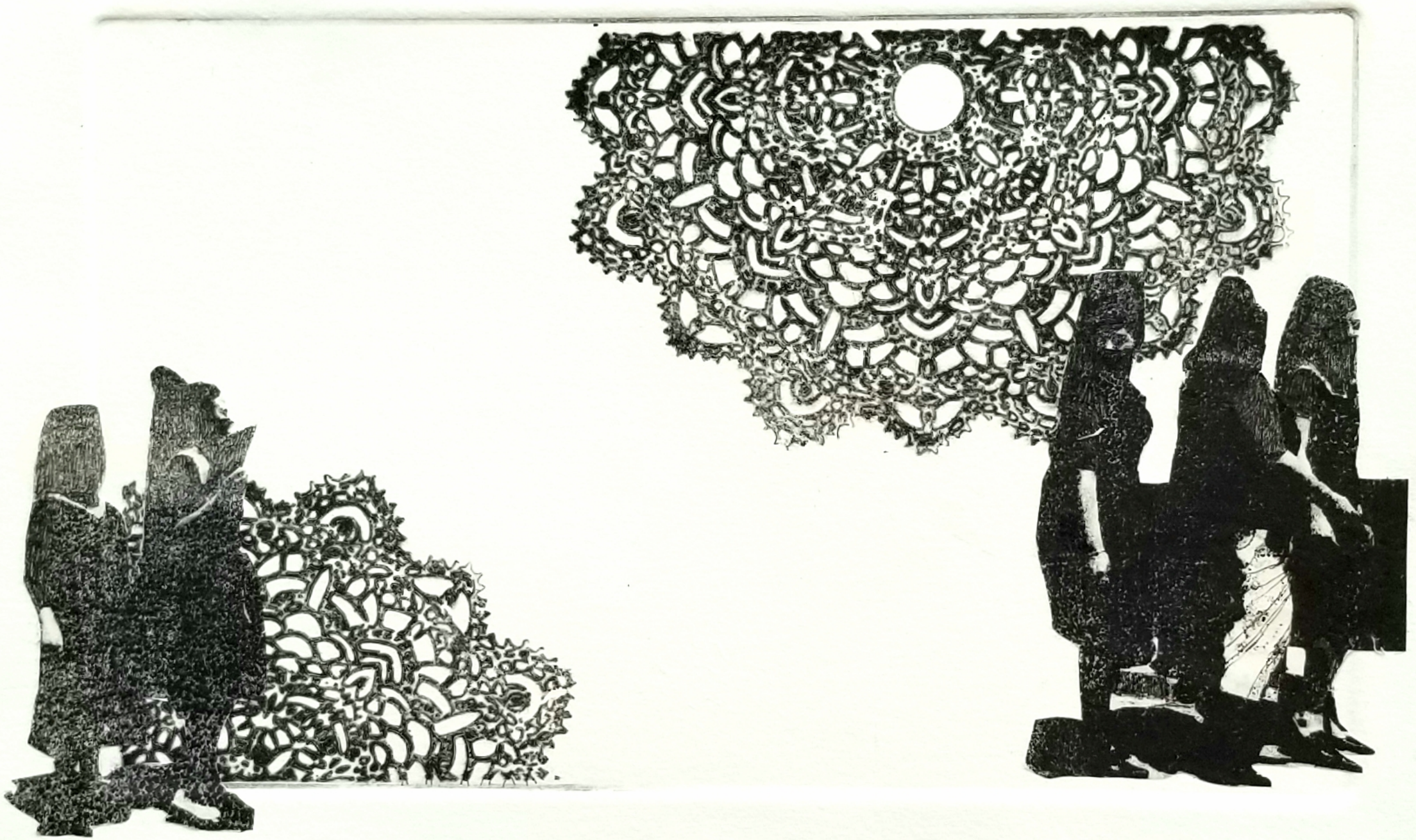

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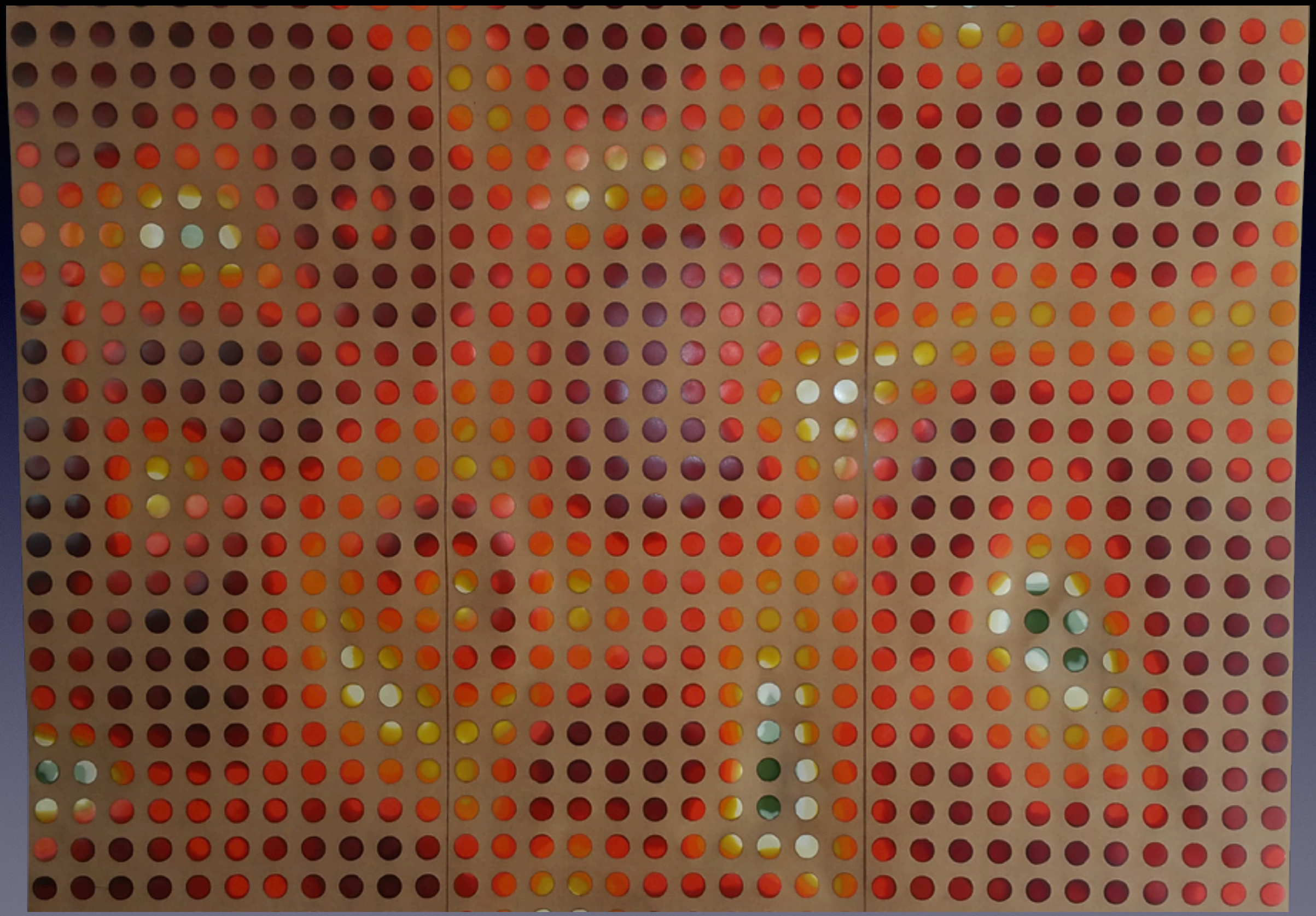
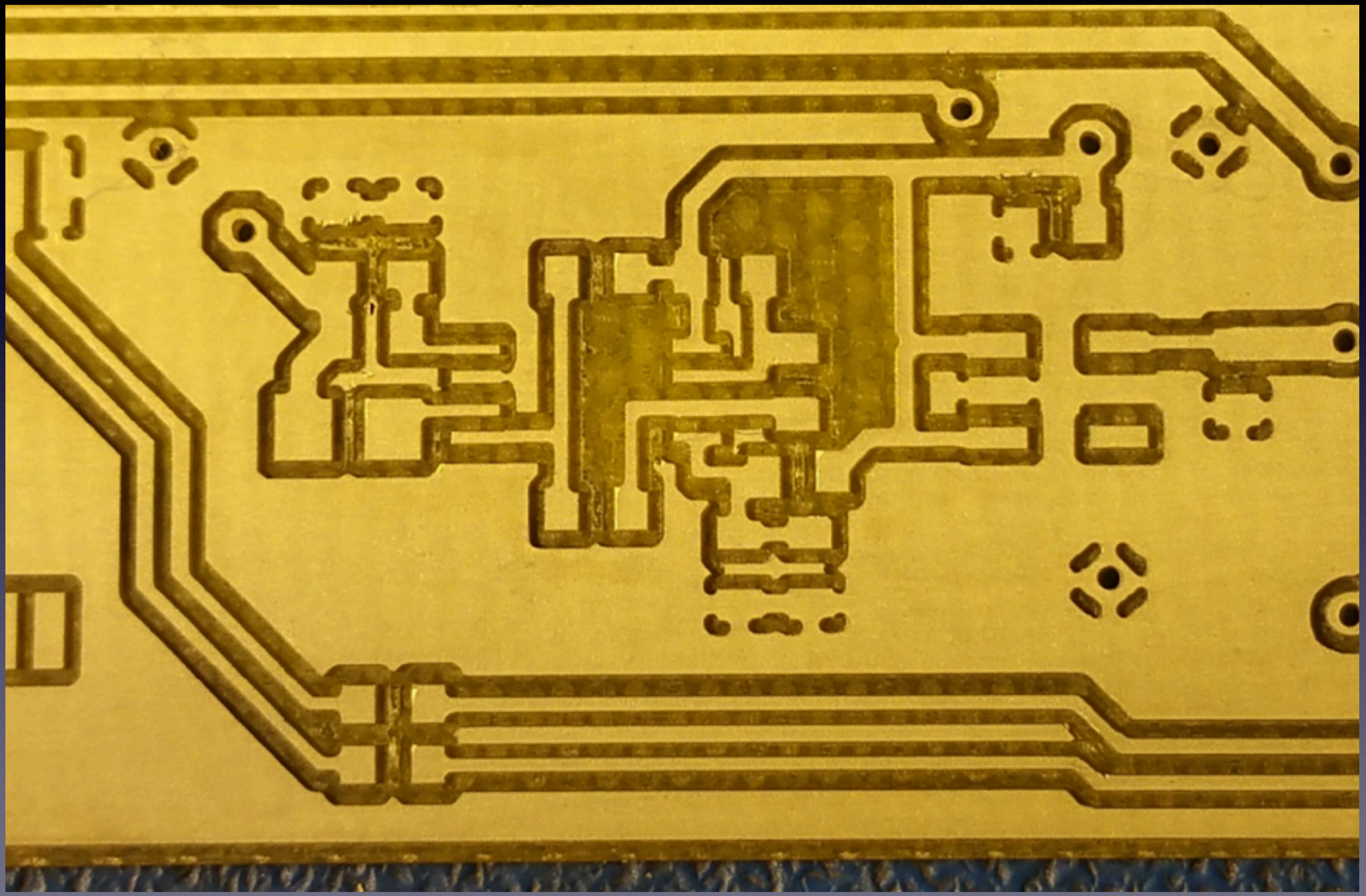


PCBs



PCBs

Components of a Design

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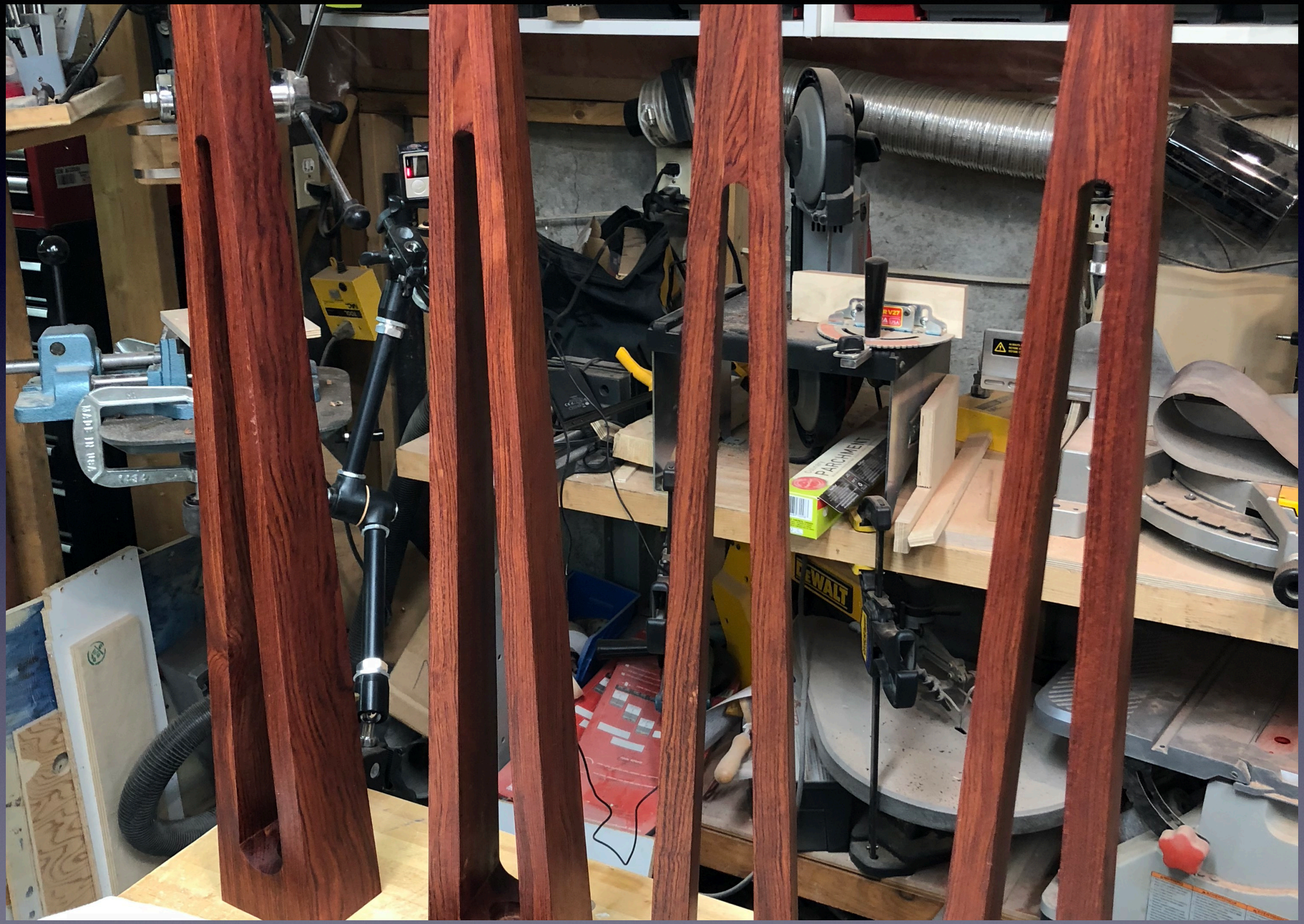


Components of a Design

Pens, Jewellery

Build vs Buy

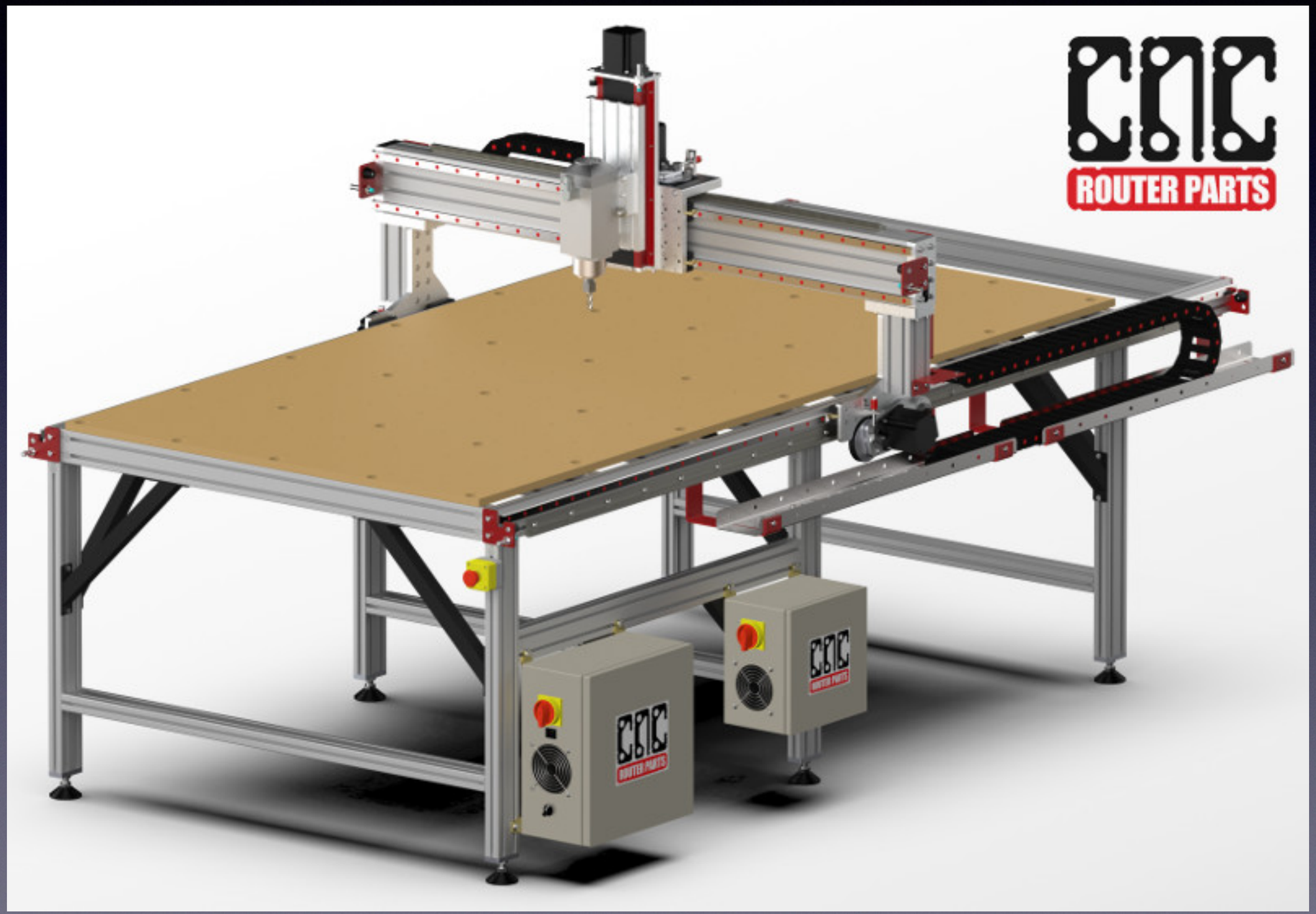
- Lots of options. More coming every week.
- Small light machines: ShapeOko (carbide3d.com), X-Carve (inventables.com)
- Heavier Machines: CNCRouterParts.com, tormach.com, many others.
- EBay, banggood.com
- Auction web sites or in Montreal/Toronto. Often big machines for $2500 - $10,000. BUT, may need 3 phase power, etc. Can be complicated to program, calibrate, etc.
- Convert an existing machine

Hardware

- The key is rigidity, even for wood
- Machine structure - 8020 extrusions, wood, Maker Slide.
- Linear bearings
- Making things move

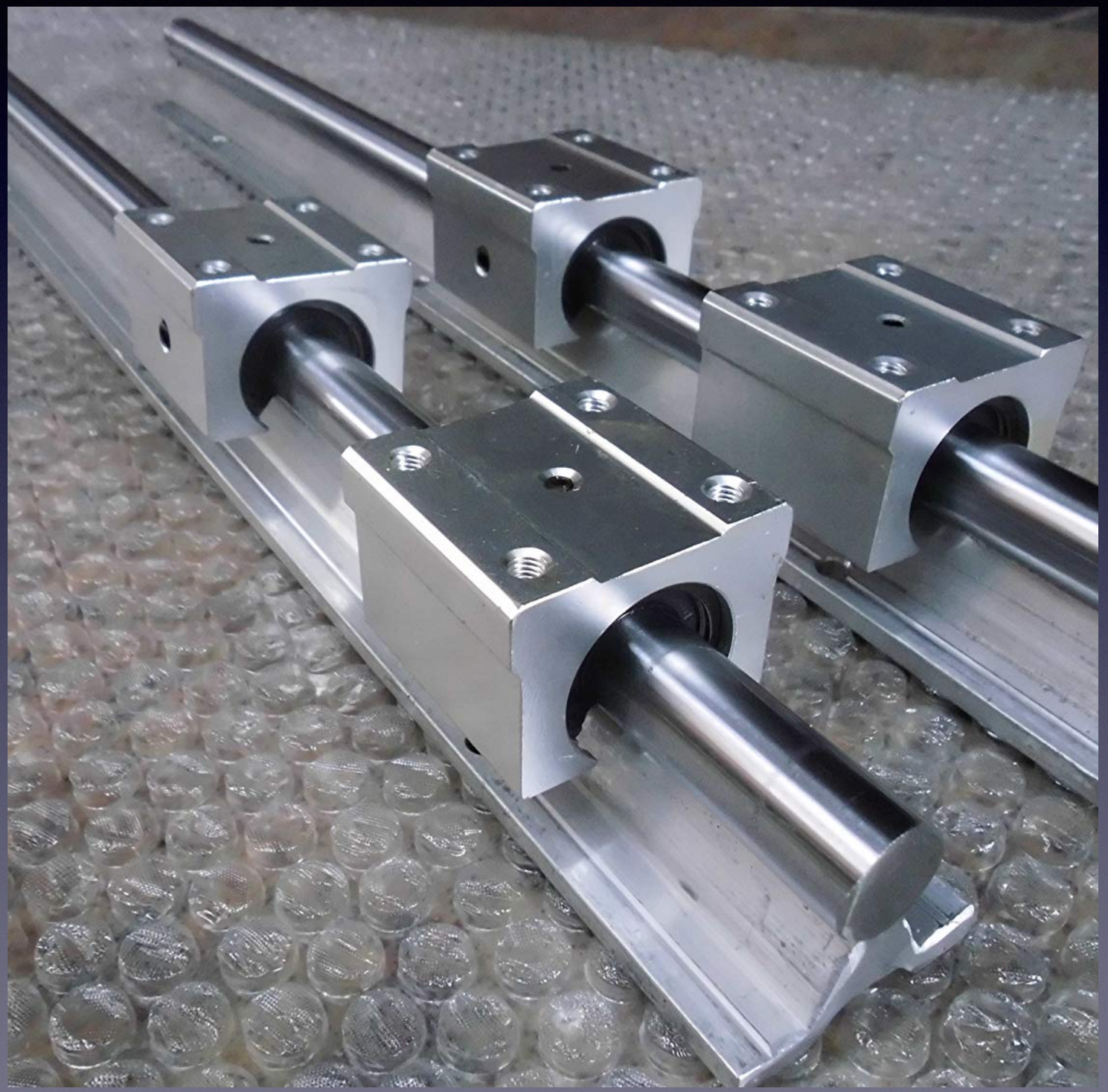
Wood Frame CNC Machine

8020 Frame



Linear Movement

- Linear Rails
- MakerSlide
- Angle Iron



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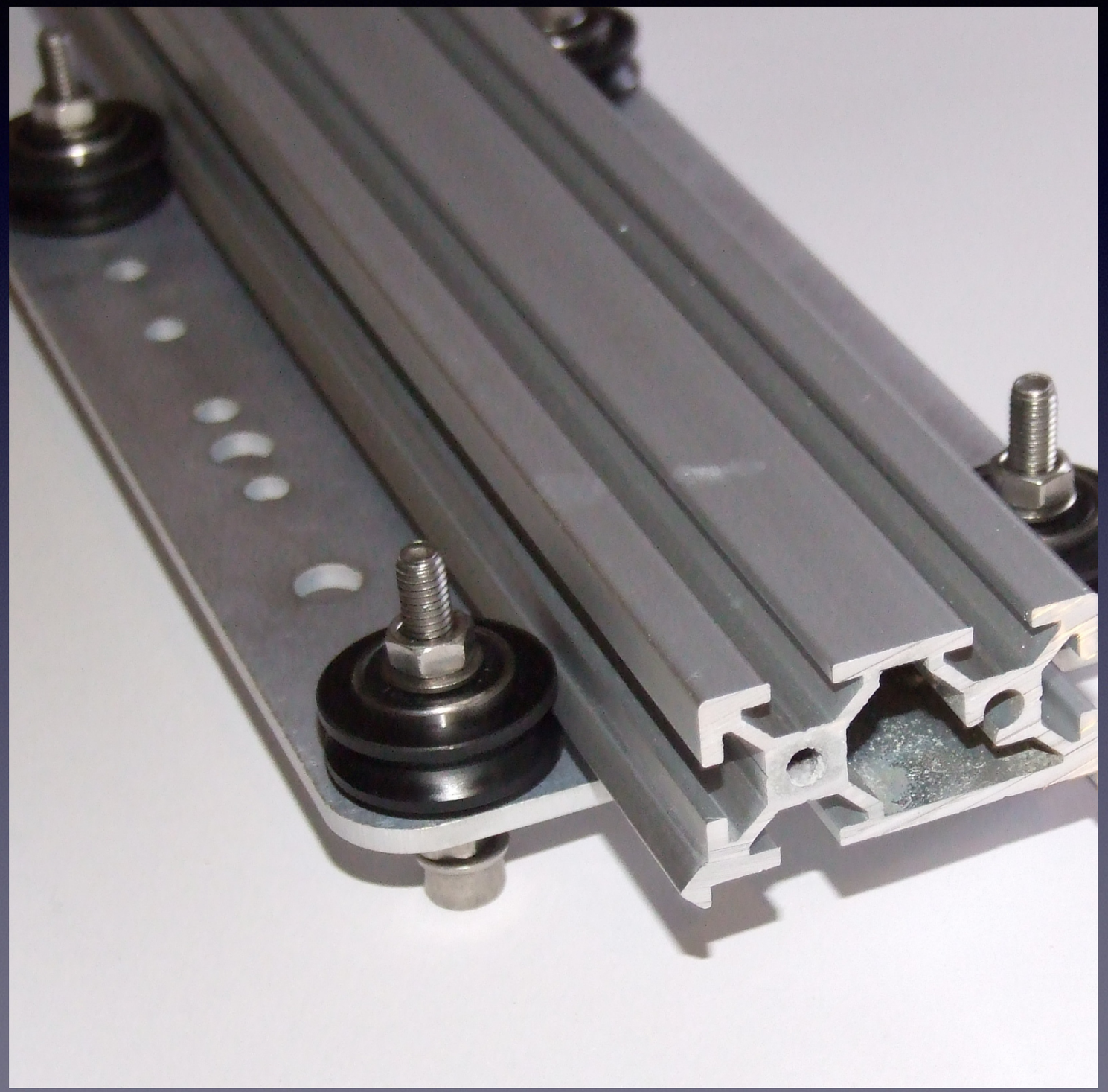

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- MakerSlide
- Angle Iron

Making things move

- Acme threaded rods
- Ball screws
- Belts, pulleys
- Rack and Pinion
- What is backlash?

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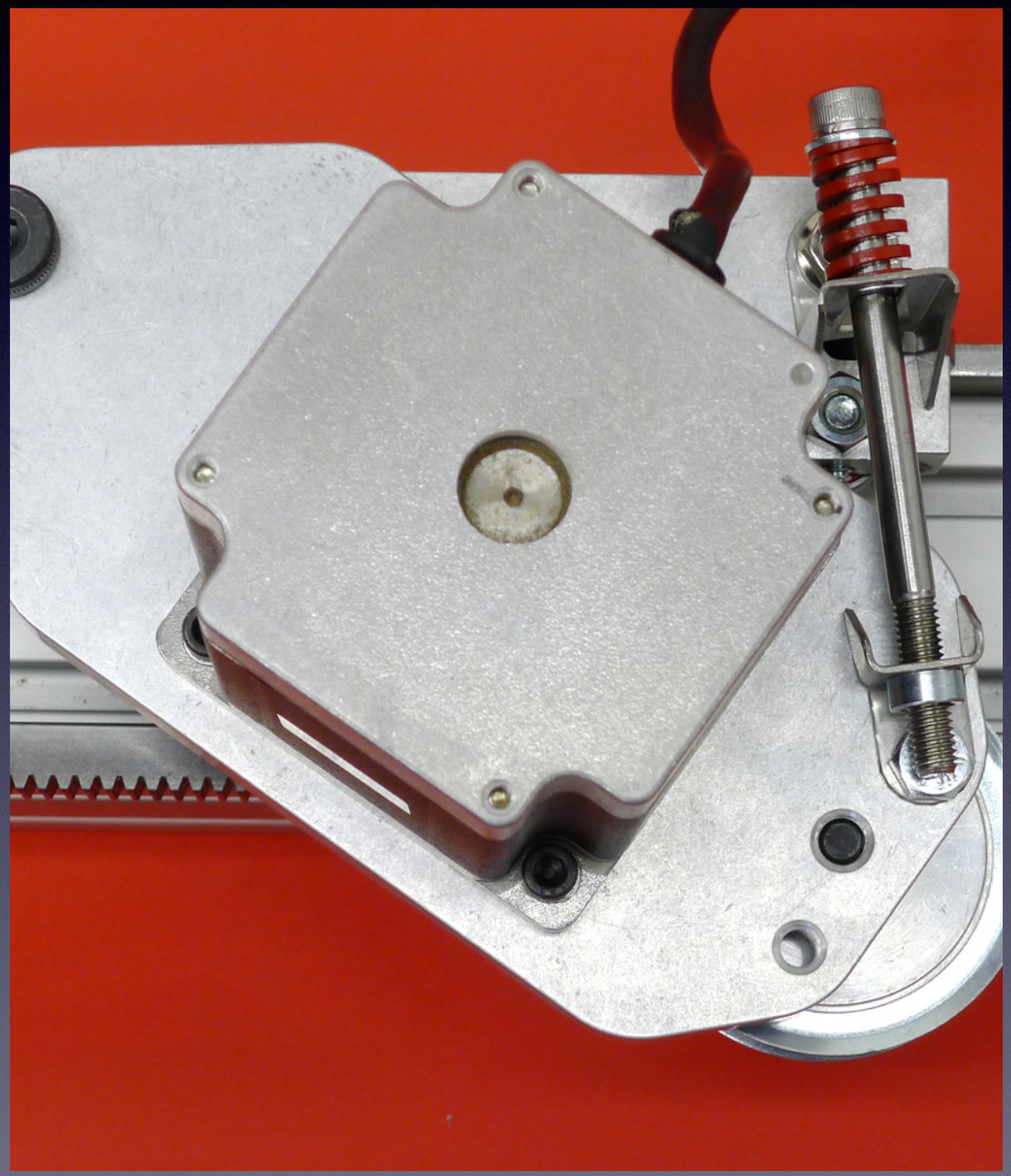


2D vs 2.5D vs 3D vs 5D

- 2D means there is no Z axis. Plasma Cutter. Water jet.
- 2.5D means there may be parts of the design at different depths, but once cutting, the machine stays at a given Z depth
- 3D means that the machine can cut while moving in X, Y and Z simultaneously. V-Carving
- 4th axis = a rotary axis.
- 5D means a rotary axis in two orientations.

V-Carving

V-Carving

Conversion kits

- G0704 or similar - tons of info on google - Hoss pages are good.
- Taig mill conversions are common - They sell kits.
- Nice because you start with a solid platform.

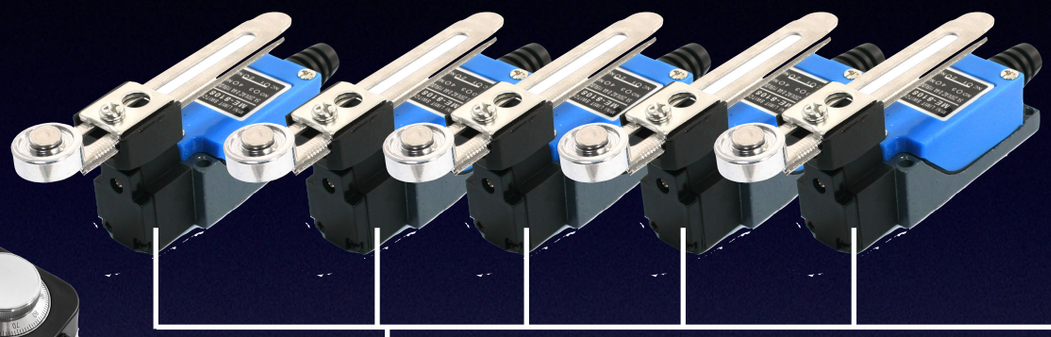
Electronics

- Motors
- Controllers
- Limit switches
- Power Supplies
- PC’s

CNC Electronics

Spindle

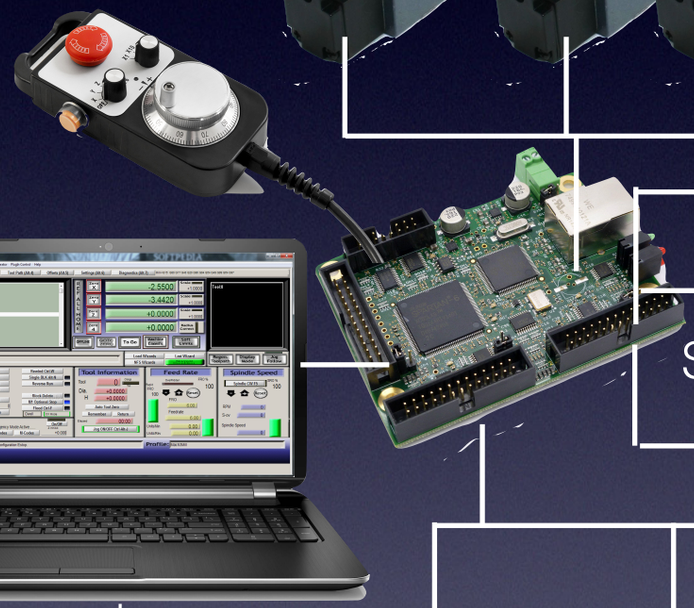
5 or 6 Limit switches X+ X-, Slave-, Y+ Y-, Z+



E-Stop Switch

Invertor

220V



Spindle Speed

Relay Output

Spindle ON/Dir

Vacuum

Smooth Stepper

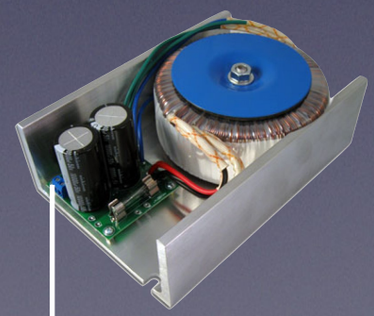
5-12V low current supply

110V

Computer Running Mach 3

3 or 4 Motor Drivers

3 or 4 Stepper Motors

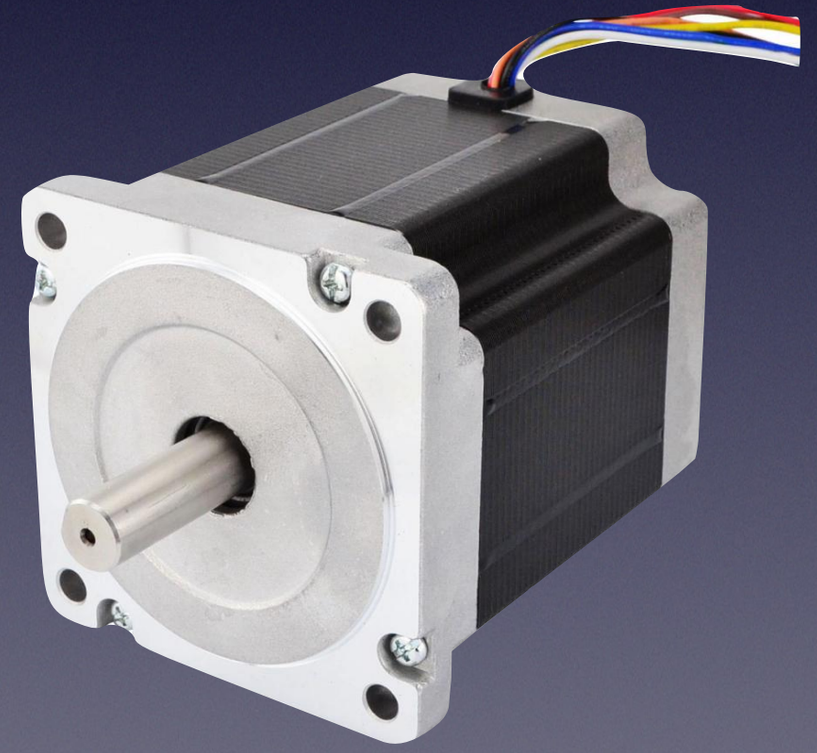


110V

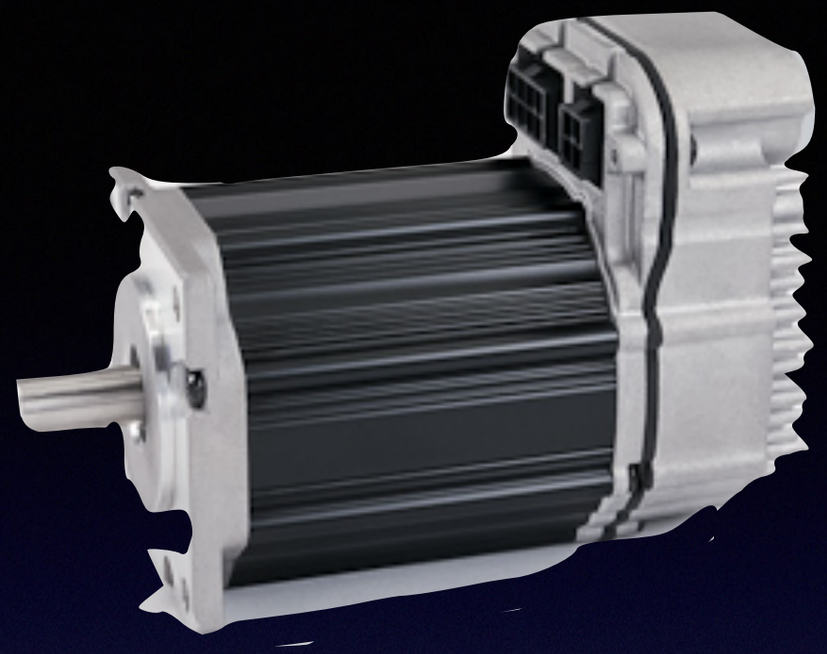
30-60V 10-20A Supply

Stepper motors

- Nema 17, Nema 23, Nema 34
- Ratings: Oz-Inch 100, 300, 500, 1000!
- Power supply - 24-48V 10-30A
- Stepper motor drivers
- Step and direction
- How to find winding pairs



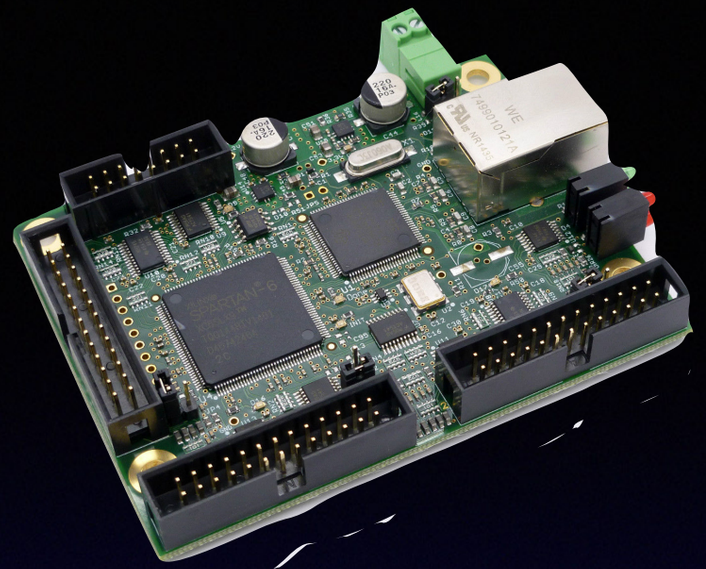
Servo motor



- Overkill for most users
- Teknic SK Series is good

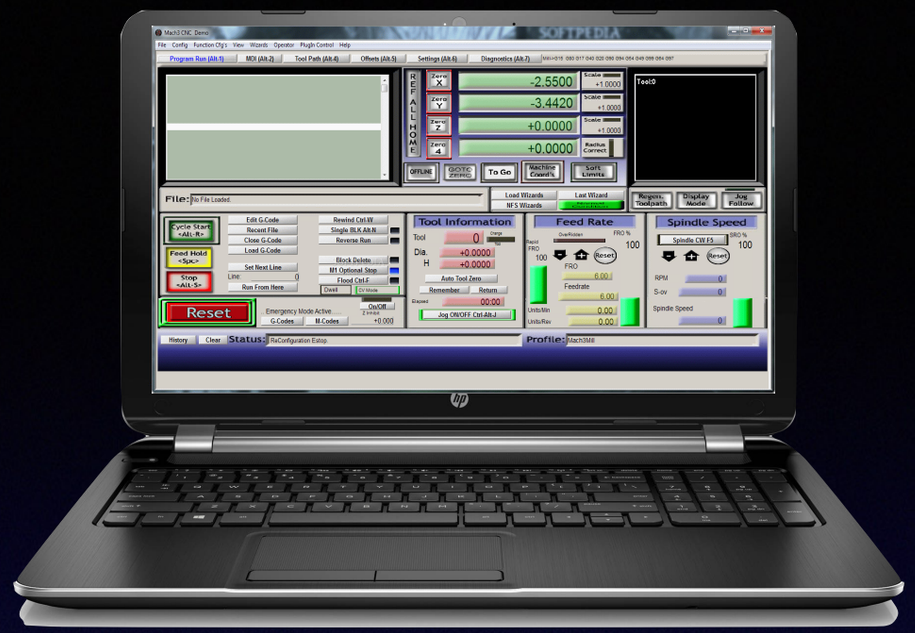
- Built-in driver
- Use with pulley and belt - reduction
- Use a beefy linear power supply

Control Hardware



- Smooth stepper - Connects to PC via USB or Ethernet
- G540 - The ole standby - but requires a 2-way parallel port
- Planet CNC or similar control computer
- Arduino-based controller. Some have built-in motor drivers, wifi, ethernet, usb, etc.

Control PC



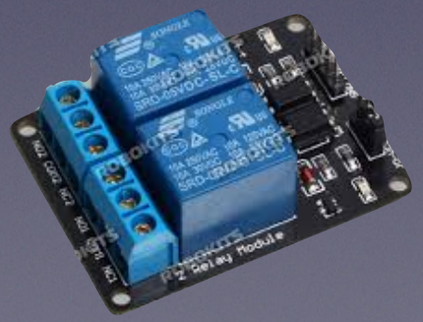
- Parallel port vs USB vs Ethernet
- Get all s/w off the pc
- Use an older version of Windows - Windows 7
- Turn off auto-everything and every background task.

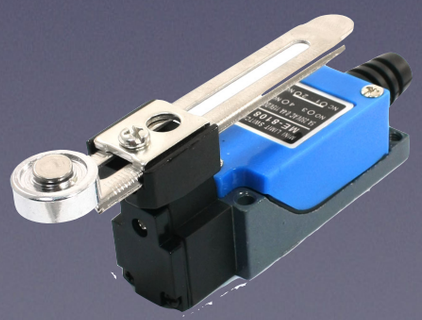
Manual control

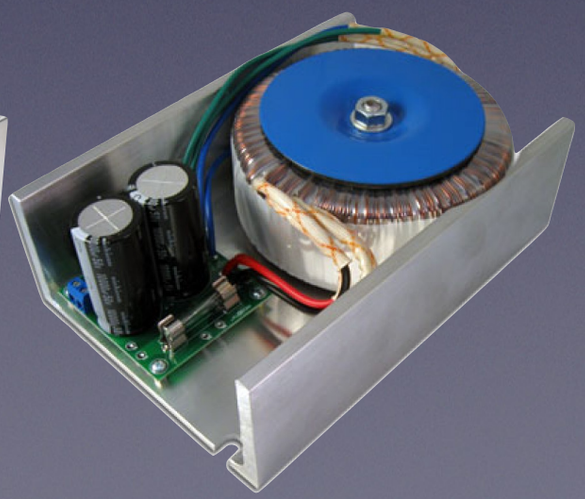
- Xbox controller - find an old USB XBox controller.
- Special controller - pendant
- Keyboard
- Custom keyboard

Wires and connectors and Miscellaneous stuff

- For steppers, want braided, fairly heavy wires. 18 guage
- Limit switches - mechanical vs hall effect.
- E-Stop is essential.
- Relay outputs - 2 is good for controlling other equipment, spindle motors, lasers, etc. Easy to control from G-Code
- Power supply - Switching vs Analog
- Use latching connectors. Don’t skimp





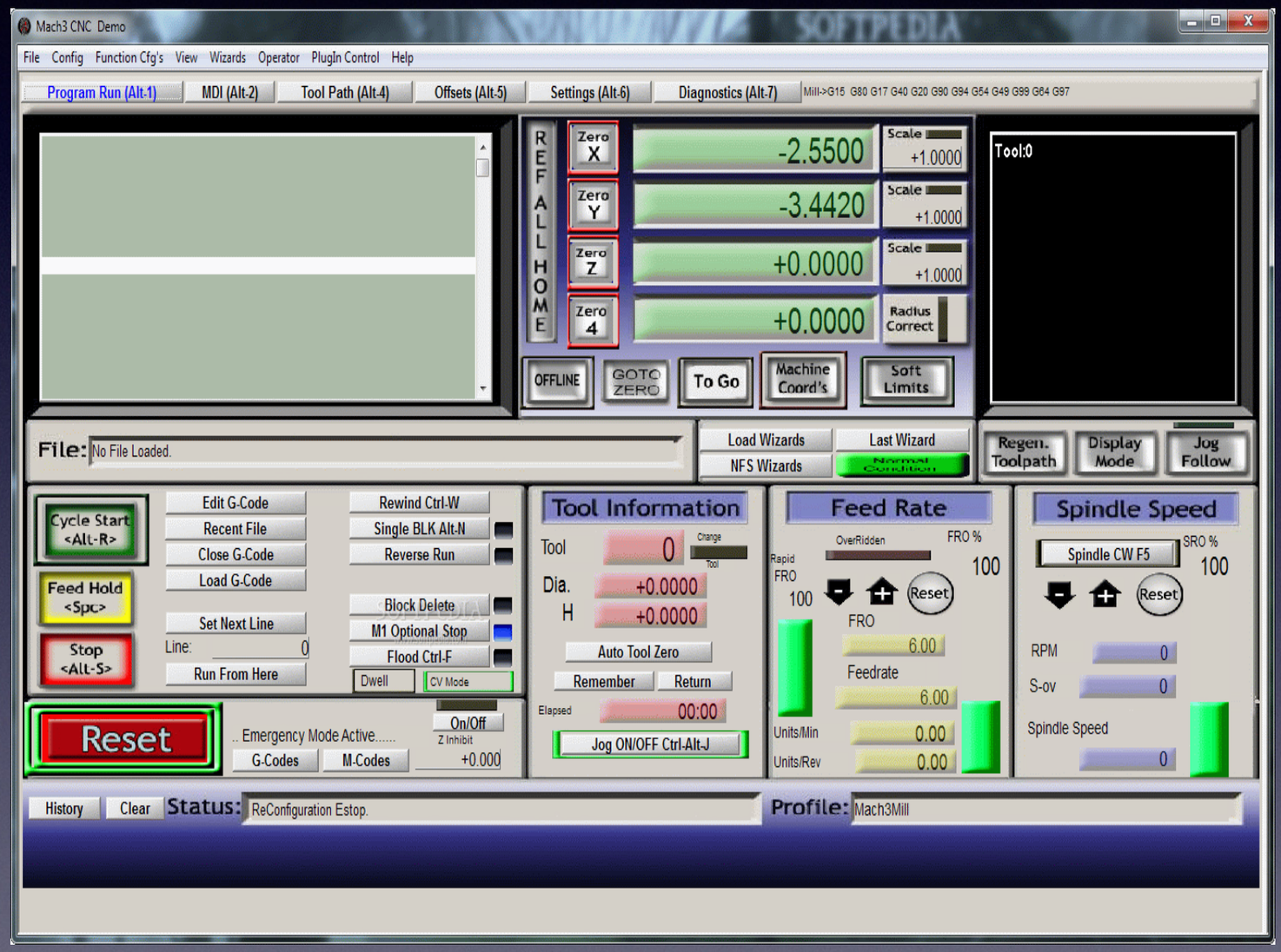


Spindle

- Simple: Use a small Dewalt Router or Bosch Colt. Mounts available.
- Air/water cooled spindle - many available on eBay. Think about collet size. Order spare collets. Don’t skimp. ER11 collets ok for 1/4” bits. ER20 good for 1/2” bit. ER32 good for a mill.
- 3 Phase Inverter Hitachi vs others - lots of instructions on setting these up. Need to set about 5-10 parameters - but set as few as possible!
- Speed control via computer - Can be done through a digital or analog connection.

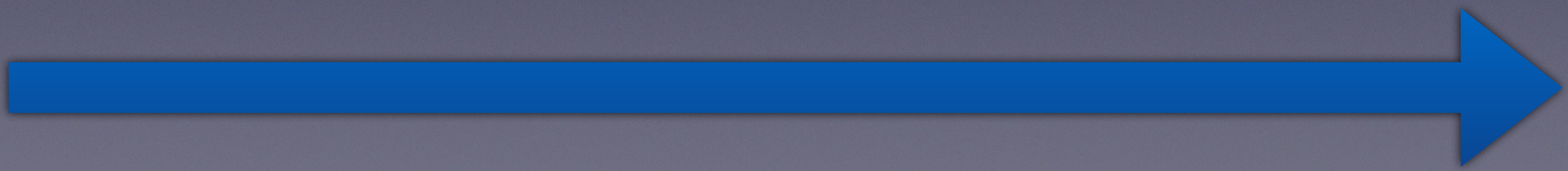
Control Software

- Mach3
- Mach4
- LinuxCNC
- PlanetCNC
- Arduino + GRBL
- Gcode



Flow of operations

CAD	CAM	GCODE	Controller PC	Hardware	Motors
Solidworks Sketchup Rhino	Meshcam RhinoCAM		Mach 3 LinuxCNC PlanetCNC	Smooth Stepper PlanetCNC	
Combined CAD + CAM Fusion360 Vectric					



Design Software

- Fusion 360
- Vectric V-Carve Pro
- Sketchup
- Rhino3D
- TinkerCAD.com
- OnShape.com
- librecad.com
- vectary.com
- OpenSCAD
- BobCAD

Good to know how to use more than one.

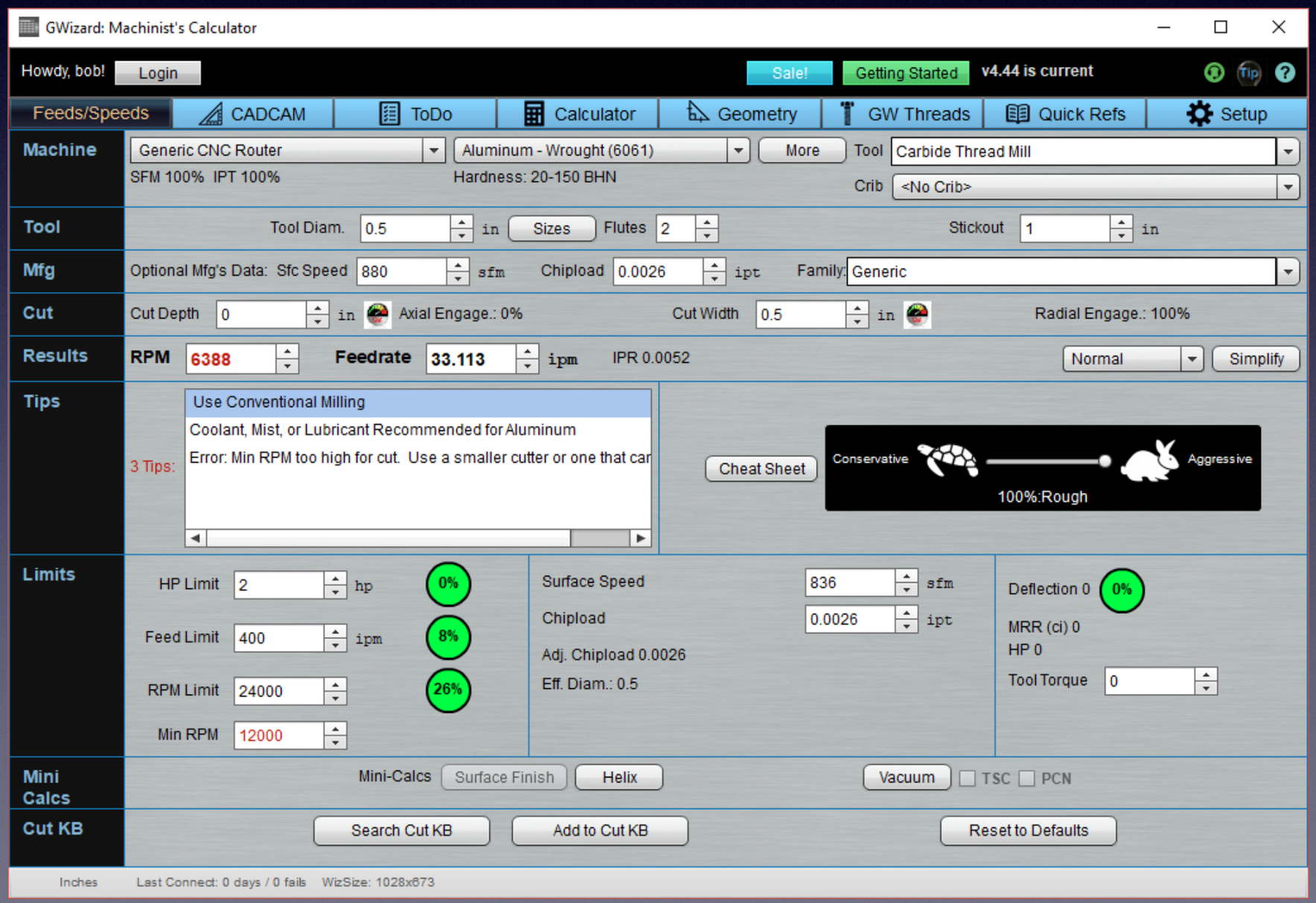
CAM

- Fusion 360
- Vectric
- BobCAD
- MakerCAM
- OpenSCAD
- RhinoCAM

CAM is often built into the CAD software these days.

Feeds and speeds software

- GWizard is pretty good.



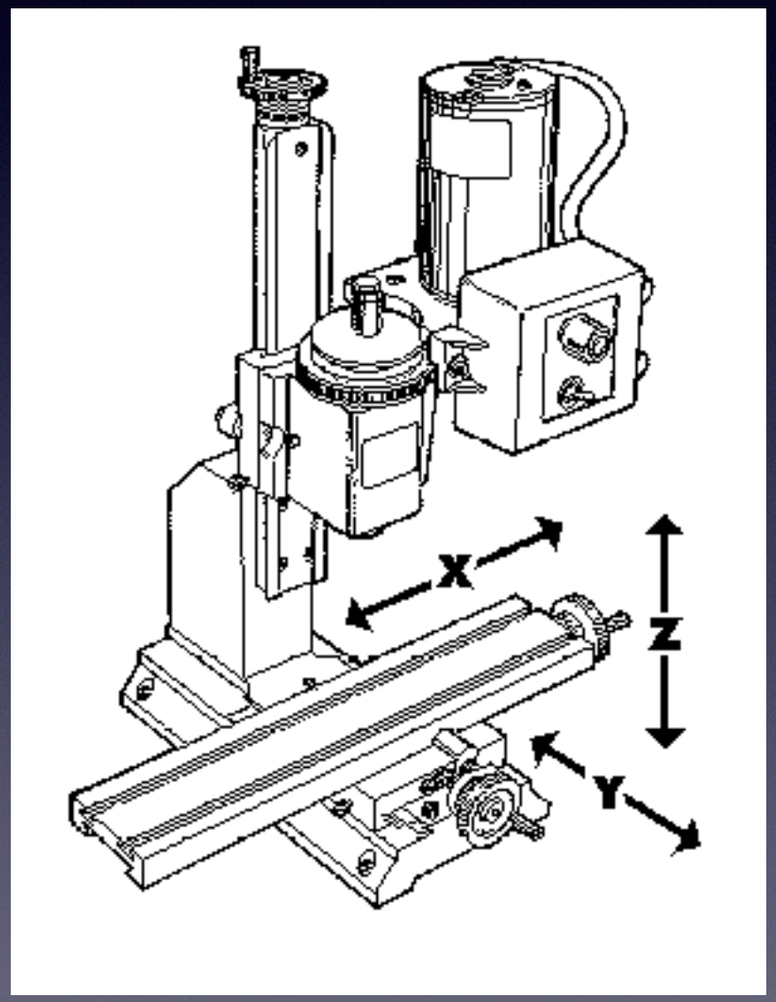
Work Holding

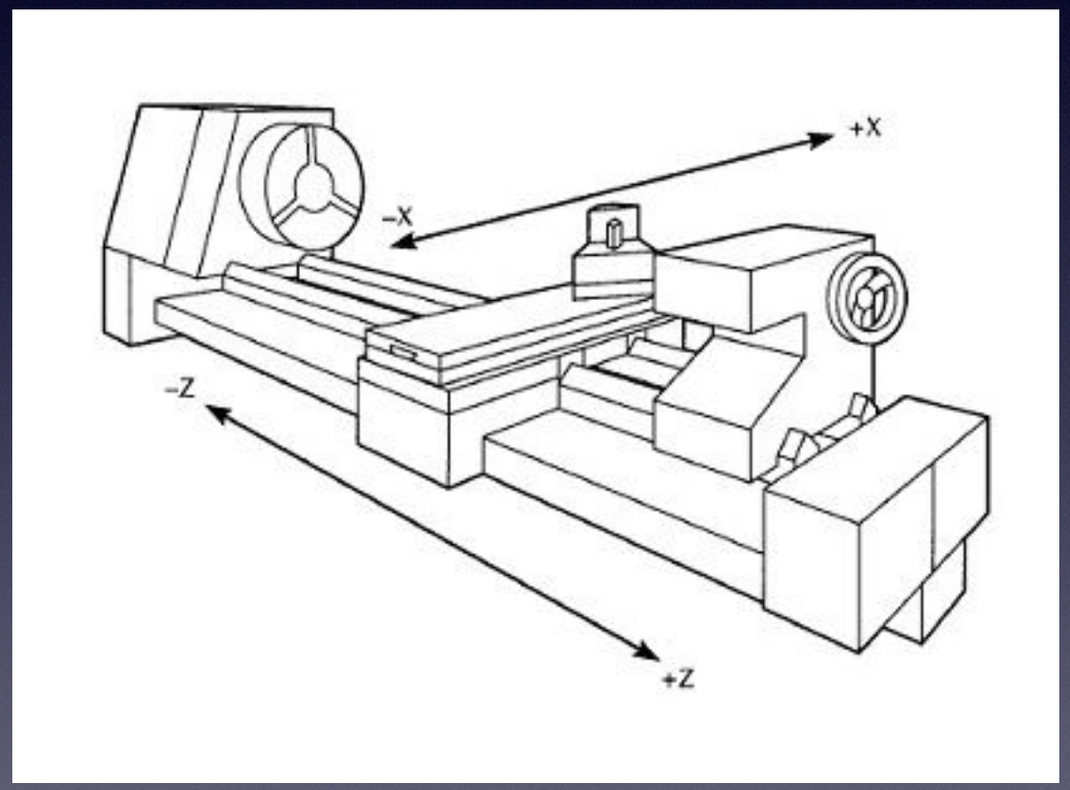
- Want low profile clamps
- Often good to make a jig
- Wood or Brass - less damage when the cutter hits it.
- Easy to screw into the spoil board
- There are plastic nails and special nailguns.
- Use tabs to keep work in place
- Vacuum Fixtures - MDF is porous!

CNC Lathes

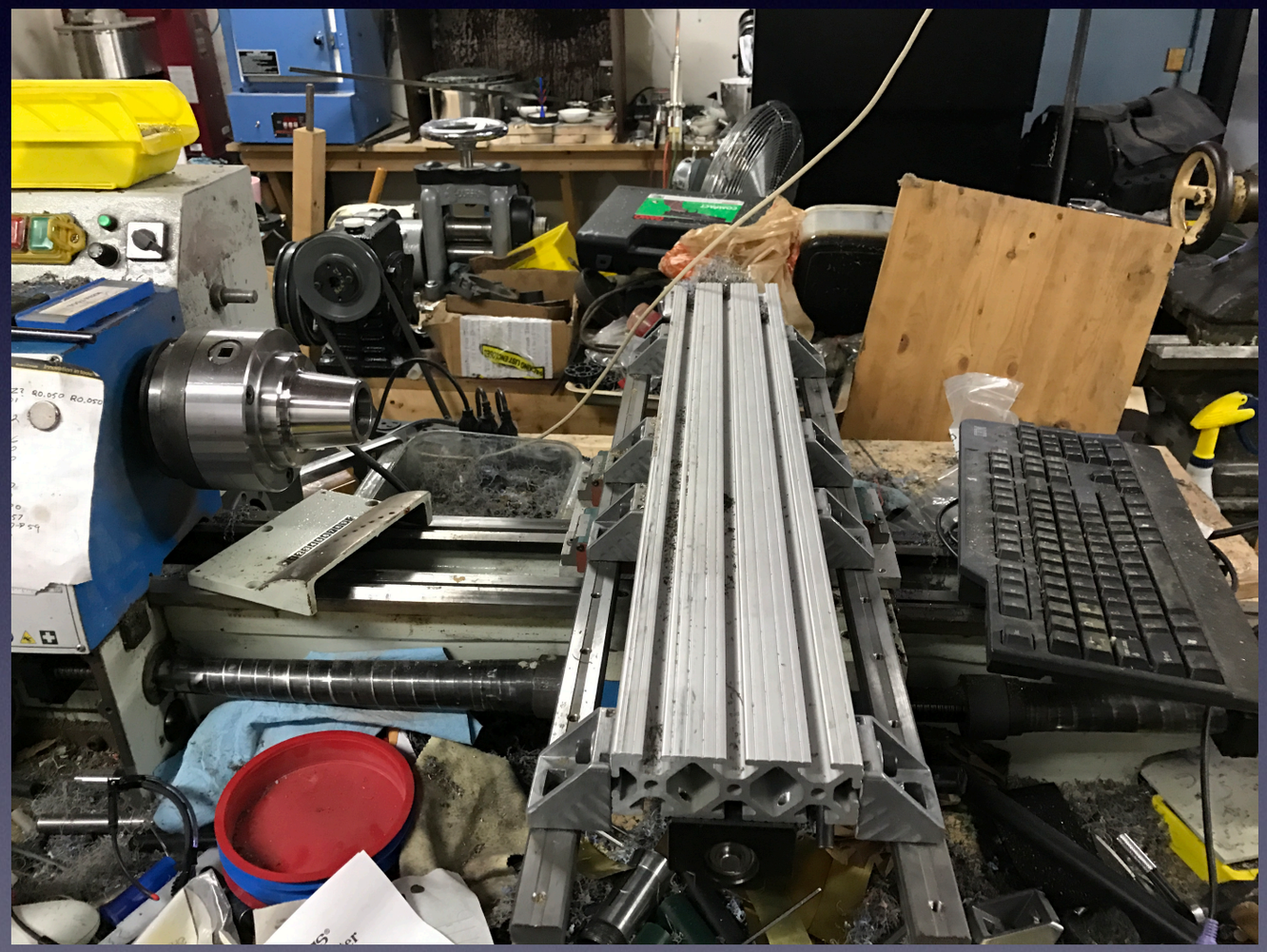
- Conversion vs new build
- Spindle indexing for threading
- Differences in CAD and CAM
- Tool holding and changing

Machine Axis



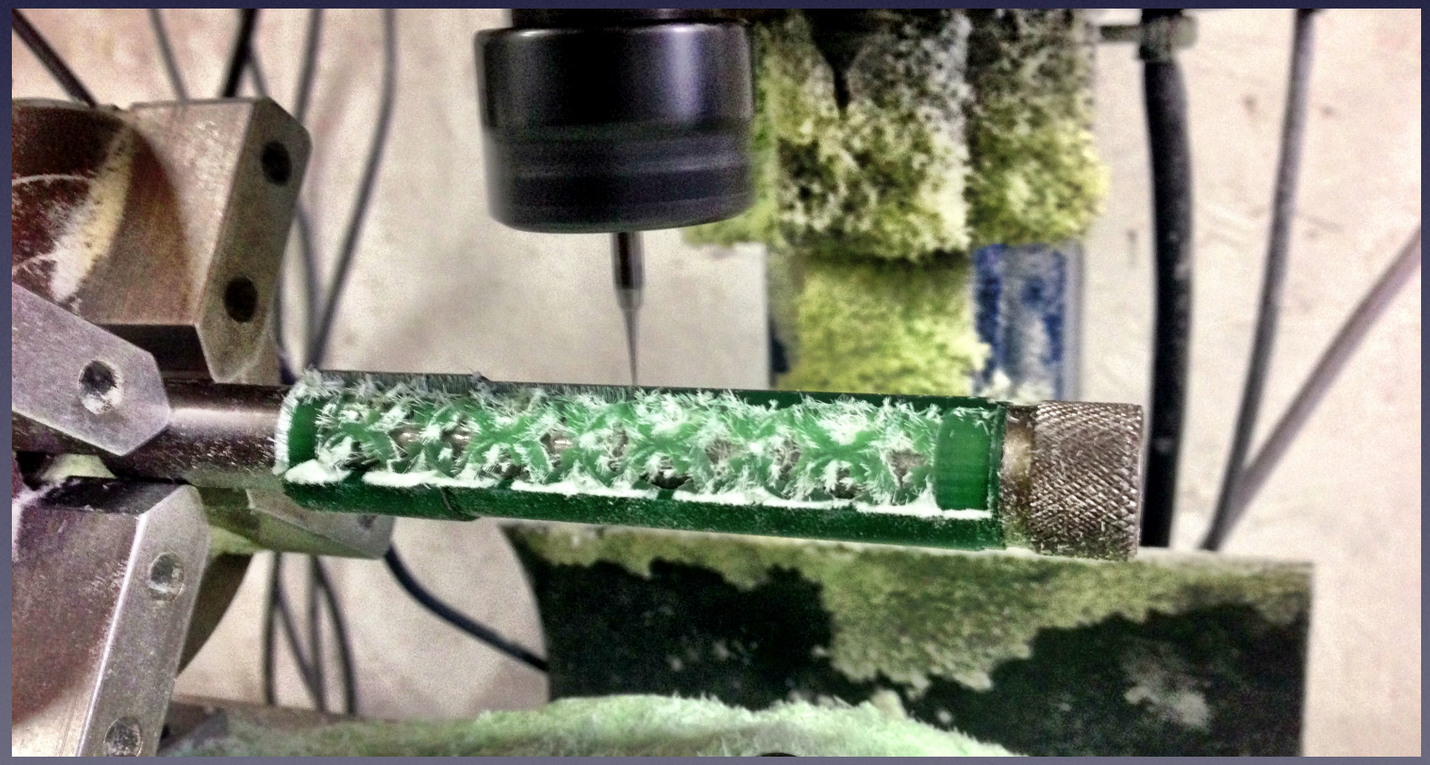


Conversion vs Custom



How to make round things

- Lathe
- 4th Axis
- Stack slices
- Think outside the box



What goes wrong?

- Parts come loose. Fly across the room or jam up the cutter - break the bit.
- Forget to follow checklist. Forget to power on the inverter or similar.
- Wrong speed of cut
- Something comes loose. Locktite!
- Stepper misses steps. Can be mechanical issue or electrical (bad connector or noise)
- Don’t stand in the path of cutters/parts that might fly

Online resources

- https://loen.design
- Vectric.com forums
- CNCCookbook.com

- YouTube
  - Frank Howarth: youtube.com/user/urbanTrash
  - This Old Tony: youtu.be/YBGqknN3gGs
  - NYCCNC
  - Lars Christensen
  - CNCNutz
  - Neo7CNC

Suppliers

- https://loen.design/suppliers-list/
- 8020 http://ipecautomation.com/
- CNCRouterParts.com
- Banggood.com
- Ebay
- http://www.automation-overstock.com

Thanks!

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