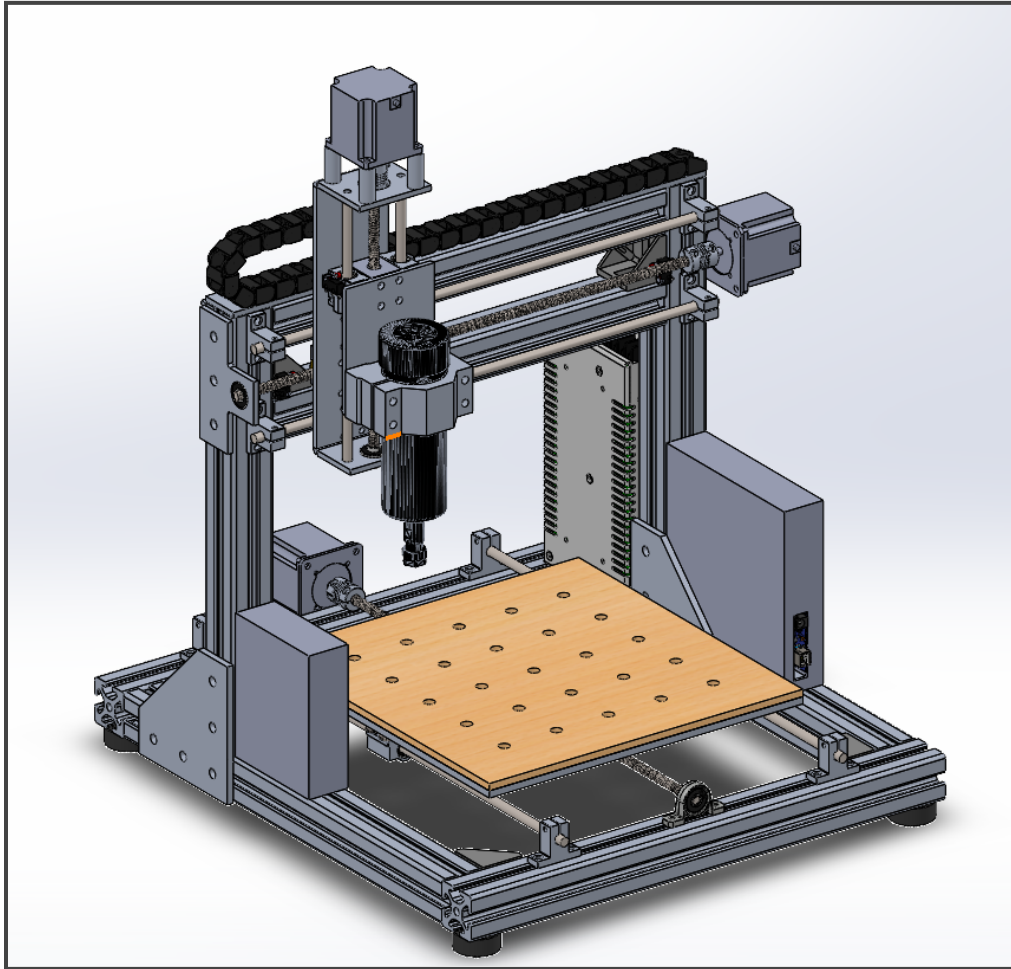




2.5 Axis Mini CNC Machine Design Report

University of the Pacific

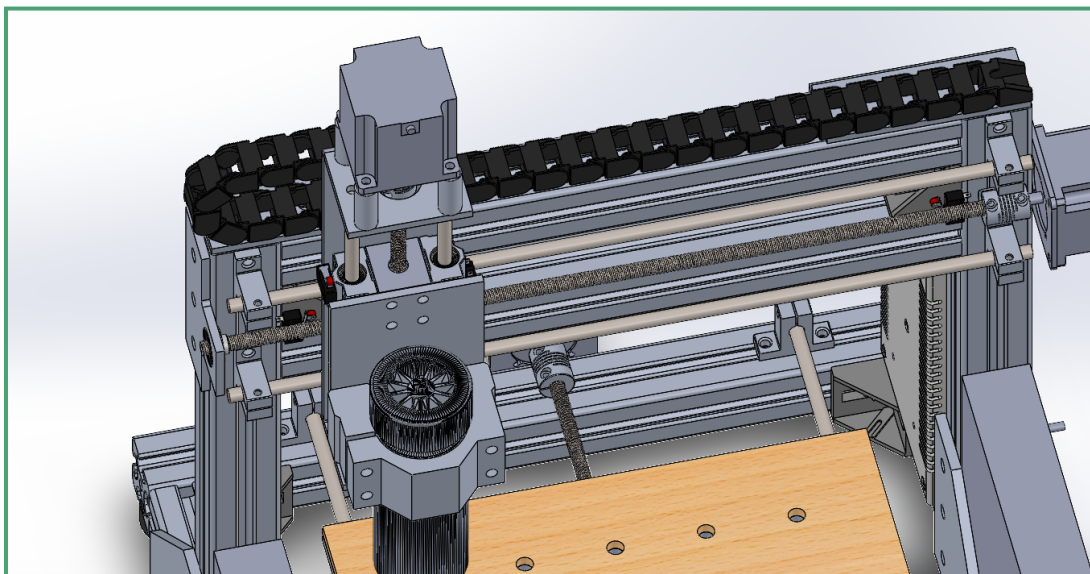
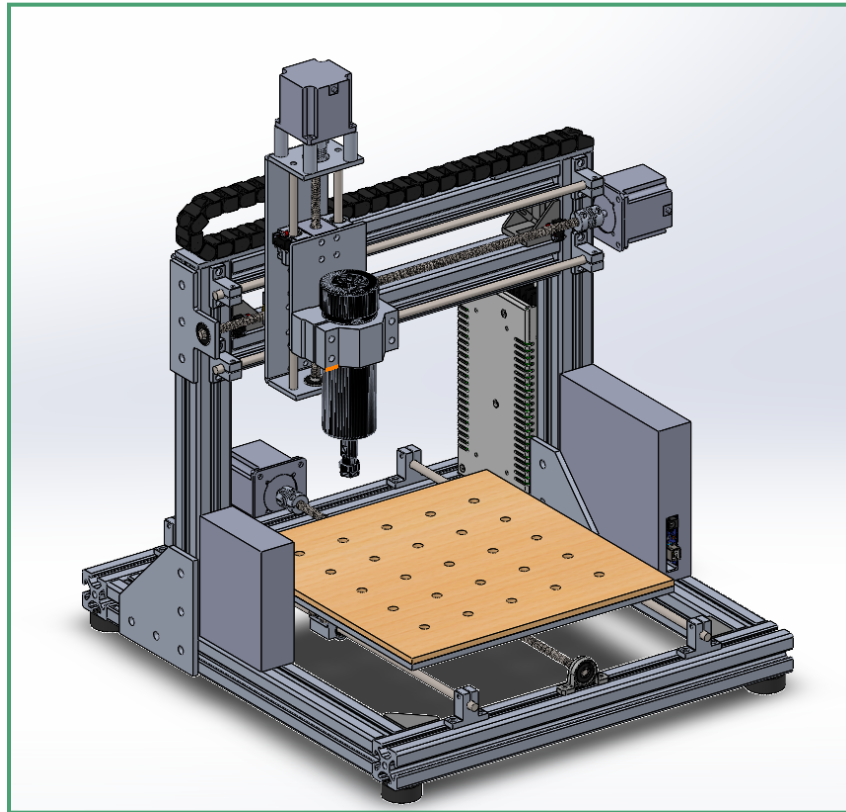
MECH 200 with Dr. Jiancheng Liu

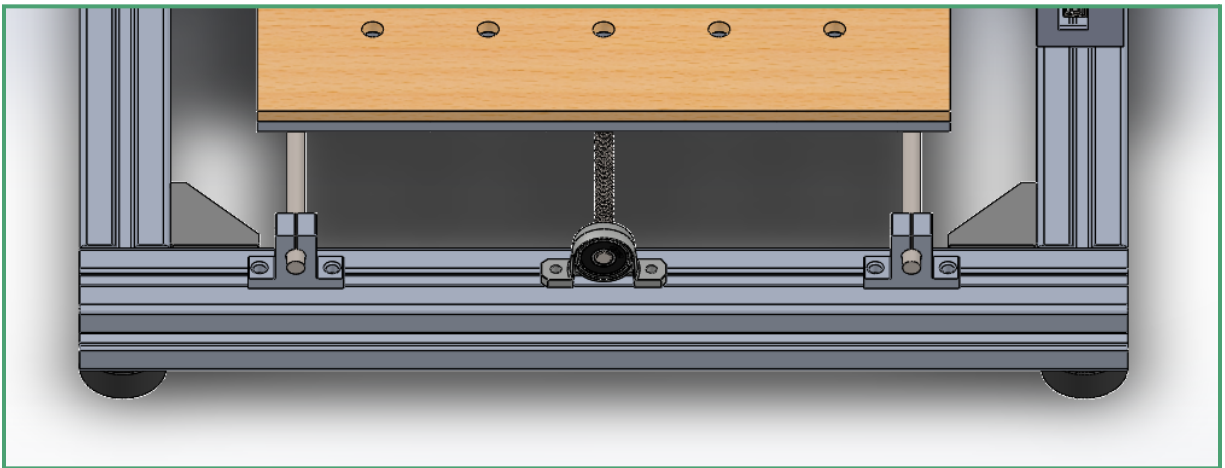
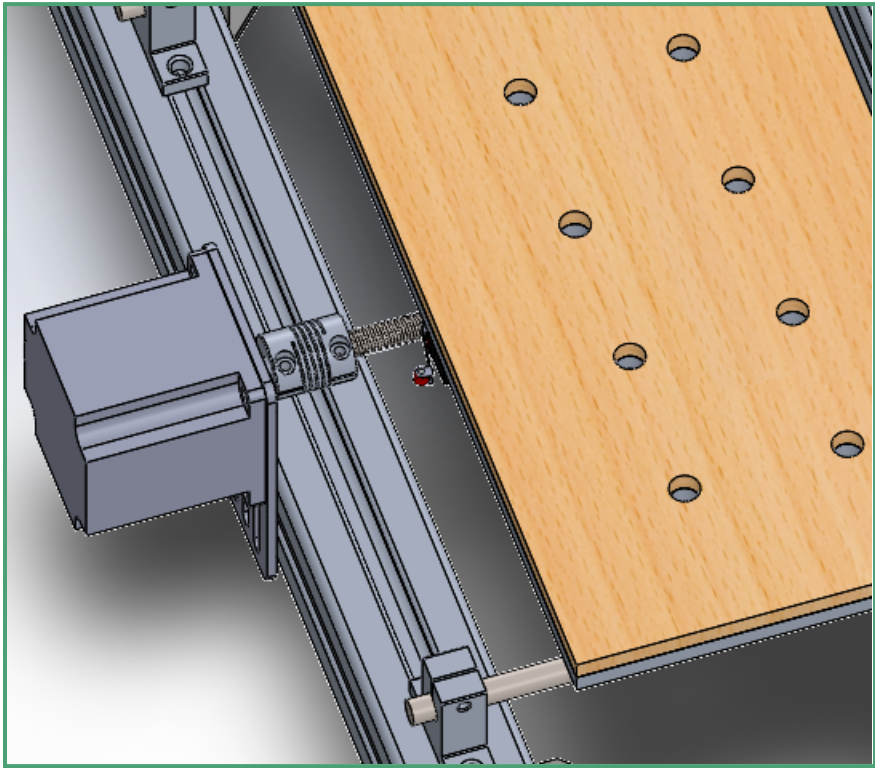
Group 3— Justin Boetius, Tina Phan, & Jan Schlegel

Design & Specifications:

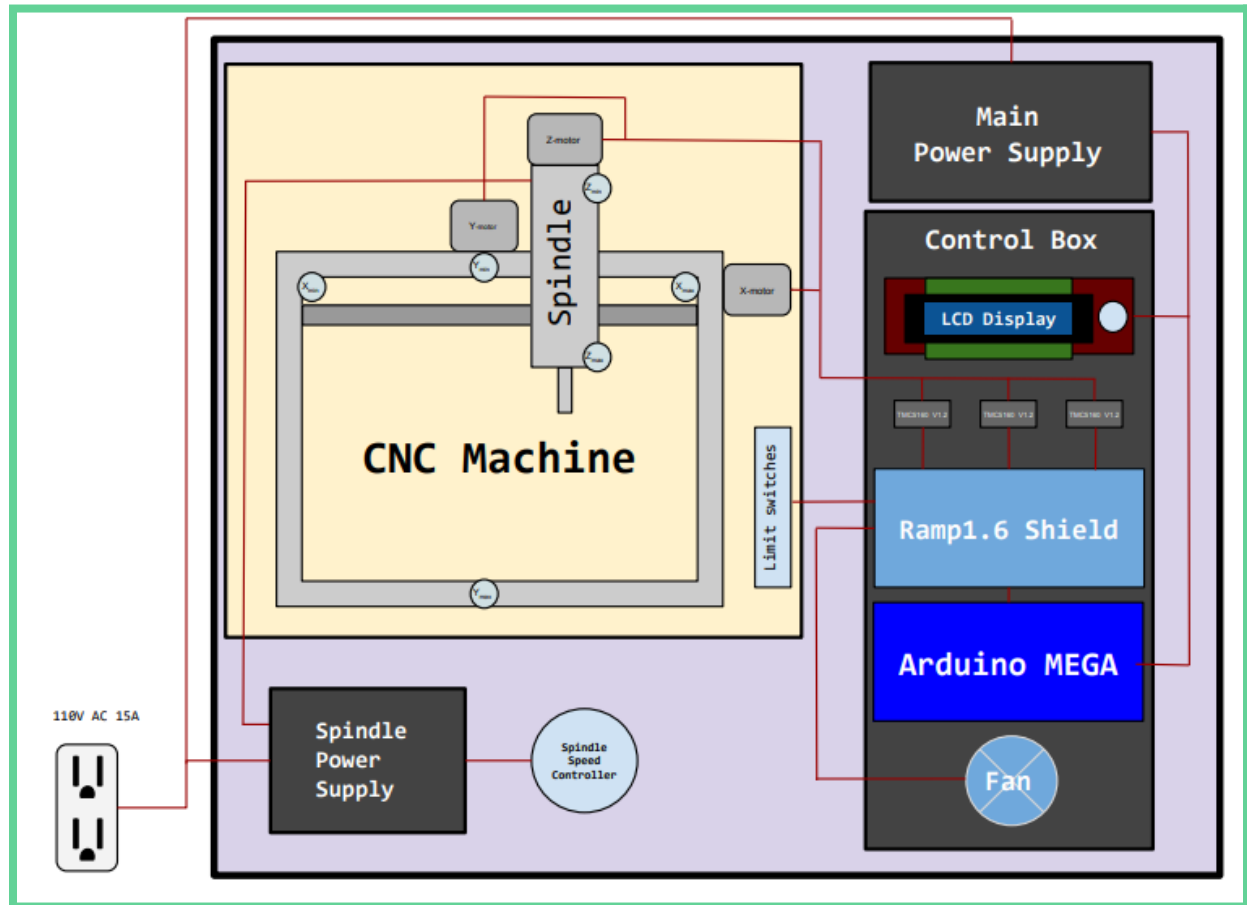
For this project, the group was asked to create a 2.5 Axis controlled CNC machine, capable of simultaneous X/Y axis control, and Z axis plunge, where the spindle would have constant set speed. Initially, the group decided upon multiple CNC options, with varying mobility and axis setups, and advantages and disadvantages of each model were discussed and considered. Ultimately, a design was selected that enabled 12" of travel in the X and Y axis, and up to 8" of plunge depth in the Z axis direction. The spindle was mounted along the lead screw of the Z axis with a custom bracket, and a cable chain allowed for effective cable management when the tool was in operation. The Z axis was mounted along the horizontal X axis, while the workpiece was allowed to move only in the Y axis. Each axis featured two additional linear guide rails to allow for additional stability, robustness, and less chance of deflection in the workpiece, spindle, and X axis travel. To accommodate cutting forces experienced when in operation, one NEMA-23 stepper motor was chosen for each of the three respective axis. The group believed that this model had better ability to accommodate larger cutting forces on the magnitude of 50-200N, which was the range researched in common wood routers. Each motor was connected to a stepper driver (TMC5160 V1.2) capable of supplying 4.4A of current to each motor. These drivers were attached to a Ramps V1.6 shield atop an Arduino Mega 2560 controller. With this controller, a successful machine operation could be ensured from an input .gcode. The group created an octagonal shape in AutoCAD and transported into openbuilds generator and control to create a .gcode file. This file was simulated in CAMotics and represented the tool path that the CNC would take to create this shape. Overall, the group believes that the parts and components chosen would generate a fully functional 2.5 axis CNC machine with high rigidity, machining accuracy, and efficient operation.

Solidworks Model

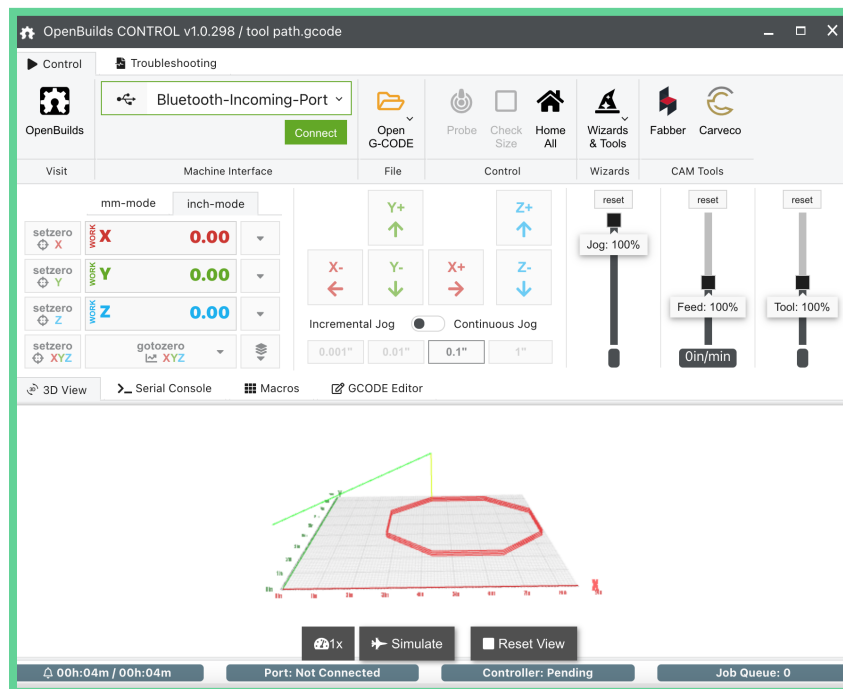
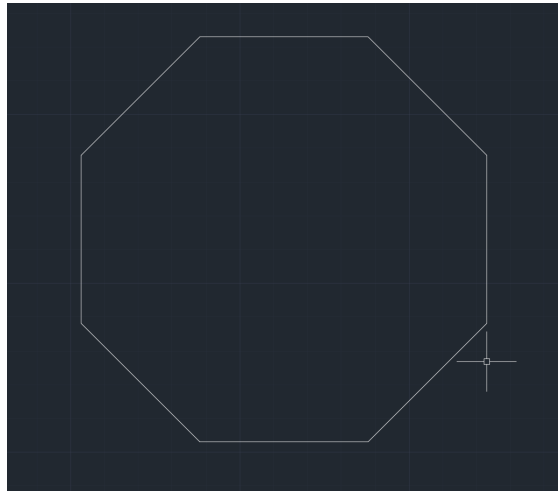




Design Schematic



Shape & G-Code Setup



Detailed Parts List:

Part Name	Quantity	Cost	Description
40 mm x 40 mm T-Slotted Profile Aluminum Extrusions 80/20	132	\$0.61/inch	40 series square T-slot profile with four open T-slots. Sold by the length.
NEMA 23 CNC Stepper Motor	3	\$20.00/each	Stepper motor with 1.26 Nm holding torque, bipolar 2.24"x2.24"x2.2" 4-wire, 1.8 deg. step angle(200 steps/rev), & rated current 2.8A & resistance 0.9ohms
NEMA 23 Stepper Motor Mount Bracket	2	\$16.99/each	Designed to allow for modular connection for NEMA 23 Stepper Motor. Has anti-rust paint tech, precise hold-cutting, high hardness.
Lead Screw & Linear Guide Set	3	\$40.89/each	Includes: - 500 mm Optical Axis & Lead Screw - Pillow Block Bearing - Linear Rail Support - CNC Stepper Coupler and Ball Bearing
Machifit T8 Lead Screw Nut Housing Bracket For T8 Screw Brass Nut Housing	3	\$5.67/each	Housing for T8 lead screw nut. Allows more stability
Machifit ER11 Chuck CNC 500W Spindle Motor with 52mm Clamps and Power Supply Speed Governor	1	\$69.99	500W Spindle Motor with 52mm Clamps and AC 110-220V Power Supply Speed Governor For CNC Machine It is an upgraded AC 110-220V one and now it can be used in AC 110-220V±10% 50/60Hz power supply.
Eiechip CNC 3D Printer Kit for Arduino Mega 2560 R3 + RAMPS 1.4 Controller + LCD 2004 + 6X Limit Switch Endstop + 5 A4988 Stepper Driver 3D Printer Interface & Driver Modules	1	\$35.99	3D printer accessory set includes - CNC Shield V3.0 - UNO R3 Board - A4988 StepSTick Stepper Motor Module - Marlin firmware
4x TMC5160 V1.2 Drivers	1	\$58.99	Used to control Nema 23

Ramps 1.6 plus	1	\$14.59	Used to control all cnc functions
Fan	1	\$3.49	12V 80mmfan used to cool electronics
12Vdc Switching Power Supply	1	\$19.80	Input Voltage: 115/230 Vac Selectable Output Voltage: 12 V Output Current: 12.5 Amps Max Power: 156 W
Sheet of Alu for bed Mcmaster	1	\$33.12	12"x12"x 1/4" aluminium sheet to support the bed
Washers Mcmaster	1	\$7.11	100x1/4" ID stainless washers to raise the bed for clearance
Aluminium plate Mcmaster	1	\$26.76	4"x24"x0.19" aluminium bar to fabricate Z-axis and all custom mounting brackets
Spacers Mcmaster	4	\$2.42/each	6.3mm ID 30mm L to offset the z-axis stepper motor
80/20 40 series bracket	4	\$7.10/each	Rigidly holds the uprights vertical
80/20 40 series corner bracket	6	\$3.90/each	Use to assemble frame
80/20 40 series rubber feet	4	\$3.15/each	Used to be able to leave the bed and dampen any vibrations
80/20 M6 screw	130	\$0.32/each	Used to mount brackets and mounts to aluminium extrusion
80/20 40series M6 T-nut	80	\$0.84/each	Used to mount brackets and mounts to aluminium extrusion
Wire guide	1	\$9.99	To guide the z axis wires to the electronics box
Total		\$776.89	

Links for Parts:

Part Name	Link
40 mm x 40 mm T-Slotted Profile Aluminum Extrusions 80/20	https://8020.net/40-4040.html
NEMA 23 CNC Stepper Motor	https://www.amazon.com/STEPPERONLINE-Stepper-Motor-179oz-Bipolar/dp/B00QG1ZF48/ref=dp_prsubs_1?pd_rd_i=B00QG1ZF48&psc=1
NEMA 23 Stepper Motor Mount Bracket	https://www.amazon.com/CALIDAKA-Printer-Stepper-Bracket-Aluminum/dp/B08RNNC78M/ref=asc_df_B08RNNC78M/?tag=hyprod-20&linkCode=df0&hvadid=475790020230&hvpos=&hvnetw=g&hvrnd=678977211336745647&hvpone=&hvptwo=&hvgmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-1185679582734&th=1
Lead Screw & Linear Guide Set	https://www.amazon.com/Industrial-Combination-Ideaker-Horizontal-Bearings/dp/B01LQ9OG80/ref=asc_df_B01LQ9OG80/?tag=hyprod-20&linkCode=df0&hvadid=475788732916&hvpos=&hvnetw=g&hvrnd=16124791186763188759&hvpone=&hvptwo=&hvgmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-953814531337&psc=1#productDetails
Machifit T8 Lead Screw Nut Housing Bracket For T8 Screw Brass Nut Housing	https://usa.banggood.com/T8-Lead-Screw-Nut-Housing-Bracket-For-T8-Screw-Brass-Nut-Housing-p-1199303.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=US&utm_content=minha&utm_campaign=minha-usg-pc&currency=USD&cur_warehouse=CN&createTmp=1&utm_source=googleshopping&utm_medium=cpc_bgcs&utm_content=frank&utm_campaign=pla-usg-rm-all-purchase-pc&ad_id=322129867575&gclid=CjwKCAjw07qDBhBxEiwA6pPbHrQe7hqbMXfUMAzl_U6-zfsWht-ffqJMEIPHjrJ5E6Z7E3y7KwPERoCOOwQAvD_BwE
Machifit ER11 Chuck CNC 500W Spindle Motor with 52mm Clamps and Power Supply Speed Governor	https://www.banggood.com/Machifit-ER11-Chuck-CNC-500W-Spindle-Motor-with-52mm-Clamps-and-Power-Supply-Speed-Governor-p-1027937.html?utm_source=googleshopping&utm_medium=cpc_organic&gmcCountry=US&utm_content=minha&utm_campaign=minha-us-pc&currency=USD&cur_warehouse=CN&createTmp=1&utm_source=googleshopping&utm_medium=cpc_bgs&utm_content=frank&utm_campaign=frank-ssc-us-1127-11sale-0222&ad_id=482681714377&gclid=CjwKCAjw07qDBhBxEiwA6pPbHuHd3TPCqdJpJrDgVARK8zLbQDqzQrIYSEe5otJJQyuoVCo6uHEvFxoC2V0QAvD_BwE
Eiechip CNC 3D Printer Kit for Arduino Mega 2560 R3 + RAMPS 1.4 Controller + LCD 2004 + 6X Limit Switch Endstop + 5 A4988 Stepper Driver 3D Printer Interface & Driver Modules	https://www.amazon.com/Eiechip-CNC-3D-Printer-Kit/dp/B07BKVPZ71/ref=asc_df_B07BKVPZ71/?tag=hyprod-20&linkCode=df0&hvadid=312158958852&hvpos=&hvnetw=g&hvrnd=16235896085983116734&hvpone=&hvptwo=&hvgmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-570584643241&psc=1
Drivers	https://www.amazon.com/BIGTREETECH-TMC2209-Stepper-TMC2208-TMC2130/dp/B07QFVGPIJ7/ref=asc_df_B07ZPV4HFP/?tag=&linkCode=df0&hvadid=416690212234&hvpos=&hvnetw=g&hvrnd=309359748020052249&hvpone=&hvptwo=&hvgmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-872852697577&ref=&adgrpid=93604210013&th=1

Ramps	https://www.amazon.com/Expansion-Control-Upgraded-Motherboard-Support/dp/B07HK8655Y/ref=asc_df_B07HK8655Y/?tag=hyprod-20&linkCode=df0&hvadid=459517264276&hvpos=&hvnetw=g&hvrnd=271543396454187894&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-943919964840&psc=1
Fans	https://www.amazon.com/Kingwin-CF-08LB-Efficient-Excellent-Ventilation/dp/B002YFShPY/ref=asc_df_B002YFShPY/?tag=hyprod-20&linkCode=df0&hvadid=459623382939&hvpos=&hvnetw=g&hvrnd=13886719510358222617&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-499632127837&psc=1
12Vdc Switching Power Supply	https://www.trcelectronics.com/View/Mean-Well/LRS-150-12.shtml?gclid=CjwKC-AjwvMqDBhB8EiwA2iSmPL91Yq7iYrxlfMp-2_0vokoI09oEyqhs-EGNLWSoKfyRCJ2j7A7clRoCyk4QAvD_BwE
Sheet of Alu for bed McMaster	https://www.mcmaster.com/9246K13/
Washers McMaster	https://www.mcmaster.com/90107A029/
Aluminium plate McMaster	https://www.mcmaster.com/89015K273/
Spacers McMaster	https://www.mcmaster.com/94669A196/
80/20 40 series bracket	https://8020.net/40-4351.html
80/20 40 series corner bracket	https://8020.net/14074.html
80/20 40 series rubber feet	https://8020.net/40-2849.html
80/20 M6 screw	https://8020.net/19-6325.html
80/20 40series M6 T-nut	https://8020.net/40-1964.html
Wire guide	https://www.amazon.com/Black-Plastic-Chain-Carrier-Router/dp/B00880AVL2/ref=asc_df_B00880AVL2/?tag=hyprod-20&linkCode=df0&hvadid=198071192844&hvpos=&hvnetw=g&hvrnd=15724571738100762795&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013953&hvtargid=pla-365229598478&psc=1