

CAM 101 **FUSION 360**

Developed for CS450HO- Robotic Design and Fabrication Honors

Published by FRC7407 in November 2021

Revised February 2022

WHAT IS CAM?

- CAM = computer aided manufacturing
- When we use the term "CAM" a part we are creating tool paths that the CNC router uses to cut out our designed part
 - CNC = computer numerical control
- CAM software create g-code that the CNC read
 - G-Code is essentially a series of X,Y & Z coordinates that tell the router bit where to travel to at each point in the cutting process

FUSION 360 LICENSES

- Autodesk Fusion 360 is a CAD and CAM software
- It is very user friendly and has useful features such as automatic tabs to hold the piece down on final cutting passes
- Need to verify student status at Choate with Autodesk to get a license
 - <u>https://www.autodesk.com/education/edu-</u> <u>software/overview?sorting=featured&filters=individual</u>

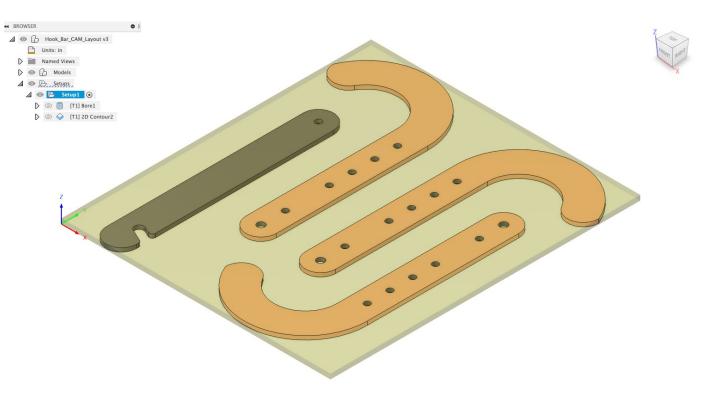
EXPORTING CAD FROM ONSHAPE

- Right click on part in Onshape and select "Export"
- Export as a .STEP file

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EXPORTING CAD FROM ONSHAPE

- If you are cutting multiple pieces in one operation, you will need to create a flat sheet assembly in Onshape of all your parts (mate all to same place) and layout in most material efficient manner
- Export entire assembly and individual parts, import all of these into Fusion 360
 - See example of a CAM layout assembly to the right



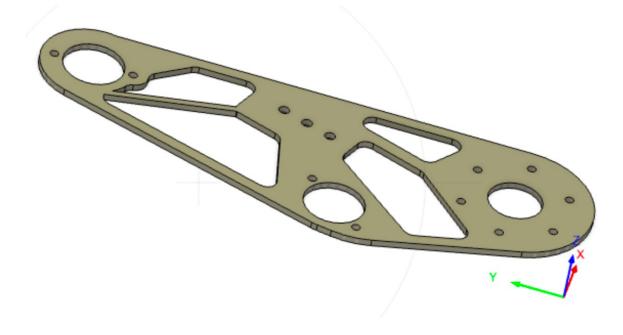
IMPORT INTO FUSION 360

- Open Fusion 360
- Select "Upload" and choose .STEP file

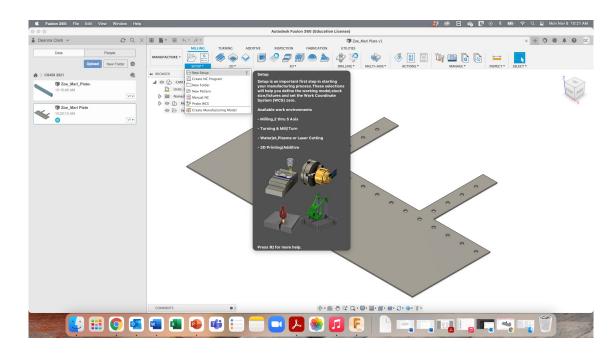
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CUTTING PLATES ON THE OMIO

This section will discuss how to cut plates of different materials on the Omio using Fusion 360 and Mach3.

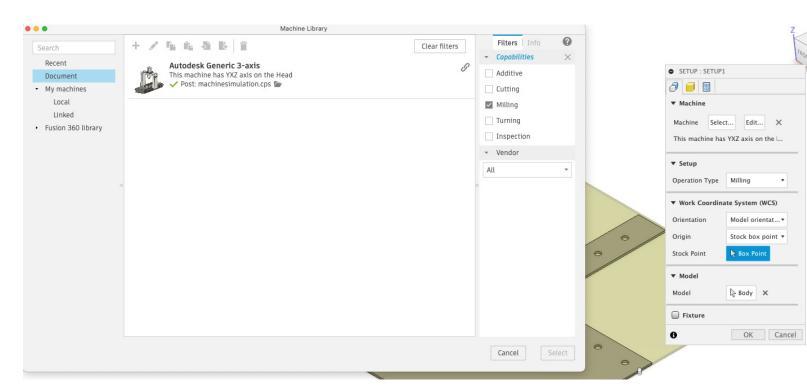


- Navigate to "Manufacture" tab
- Select "Setup" → "New Setup"

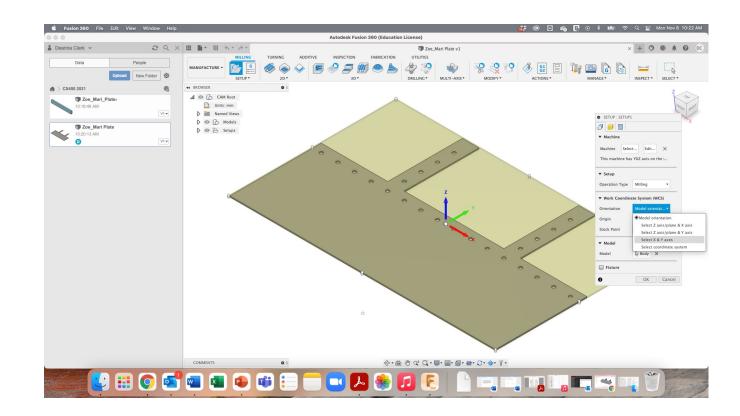


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Coe_Mari P 10:17:26 AM	vi late		ANIMATION SIMULATION MANUFACTURE DRAWING

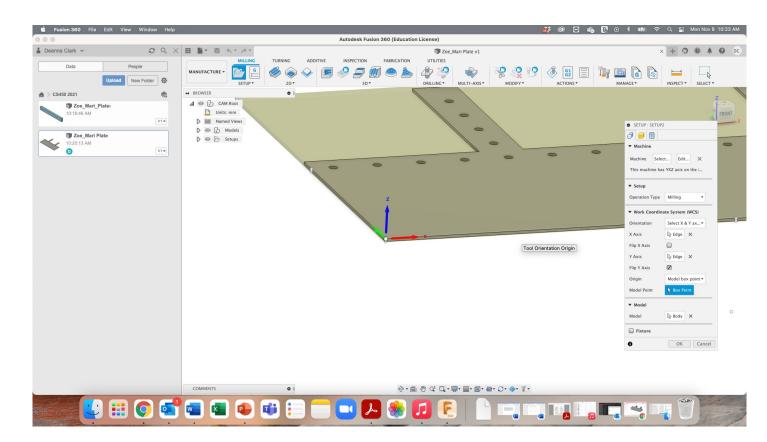
- Select "Autodesk Generic 3-axis" as machine
 - X,Y,Z on head as that is how our router works



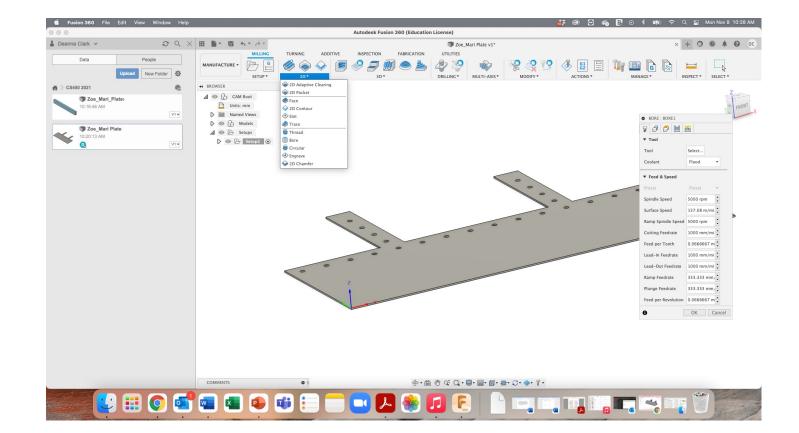
- Need to select X & Y axes on part → Select x & y axes
 - If your part doesn't have straight lines need to use stock geometry as your axes
 - May need to flip X,Y& Z axes to get right orientation



- Select "model box point" to place origin
 - Place origin in bottom left corner, topmost dot in Z direction



• Select 2D \rightarrow Bore



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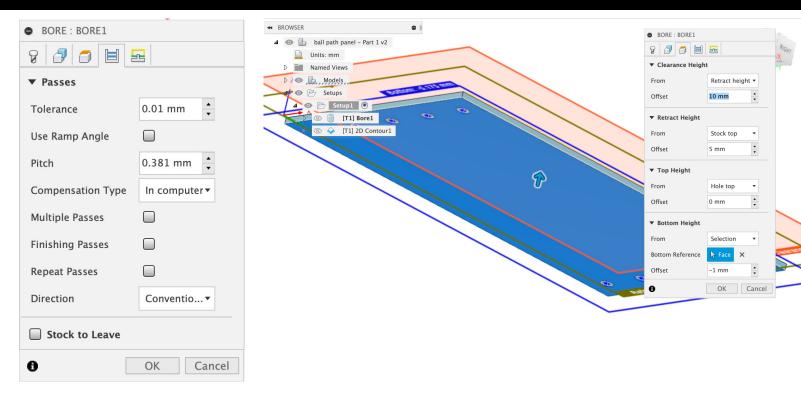
- Select cutter from Fusion 360 Tool Library
 - Select appropriate material (plastics or aluminum finishing)
 - Speeds and feeds automatically populated for you!
 - How fast the cutter spins on different operations

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Setup2		Ø1/8" (1/8" Flat Endmill)	0 in	0.125	in 0.5 i	n 1.5 ir		Flat end m	rill		diamete		0.1875 III
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Holders - Standard Taper		Ø3/8" (3/8" Flat Endmill)	0 in	0.375	in 0.87	in 2.5 ir		Flat end m	rill		length Flute ler	nath	0.625 in
Sample Holders		Ø1/2" (1/2" Flat Endmill)	0 in	0.5 in	1 in	3 in		Flat end m	rill		Coolant	•	no
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Sample Probes		Ø3/4" (3/4" Flat Endmill)	0 in	0.75 i	n 1.5 ir	4 in		Flat end m	nill		Type Unit		flat end mil inches
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		cs - Roughing	11999 rpm	589.00524 ft/			75.294 i		5.294 in/min	Flood			
		cs - Finishing	11999 rpm	589.00524 ft/	-		93.86 ir	-	3.86 in/min	Flood			
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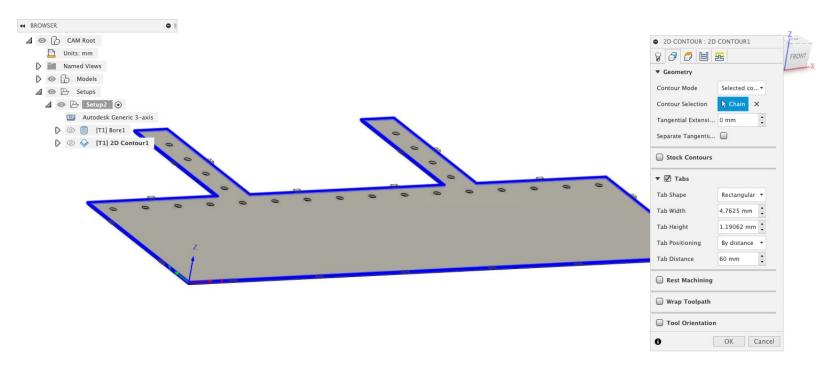
- Modify tool if needed to match your specs
 - Ensure length below holder, shoulder length and flute length match your tool
 - Change number of flutes to match your bit
 - Fewer flute bits are better for the router

elevator tube top v2 / 🞽 1 - Ø4mi	n (4mm Flat Endmill)	
General Cutter Shaft	Holder Cutting data	Post processor
Type Unit	Flat end mill Millimeters	
Clockwise spindle rotation	✓	
Number of flutes	3	
Material	Unspecified 🗸	
Geometry		
Diameter	4 mm	
Shaft diameter	4 mm f x	
Overall length	63 mm	
Length below holder	11 mm	
Shoulder length	11 mm	
Flute length	11 mm	

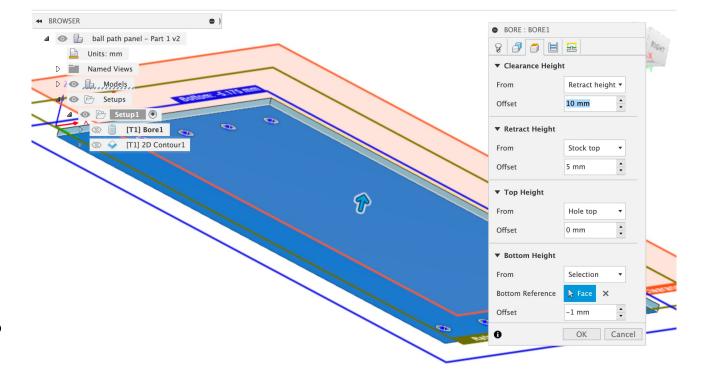
- On third tab of contour operation, change bottom face to "Selection" and select bottom face of part
- Set the tool to go -1mm beyond bottom face – this will ensure part gets cut completely if spoil board is not totally flat
- Set pitch to 0.381mm
- Set direction to "conventional"



- Select 2D contour from 2D menu
- Using same tool
- Select top edge of part, will highlight blue
- Add tabs these will prevent piece from flying off router after final cut
 - Not enough holes to retain entire part with screws
 - Space tabs out along perimeter of part

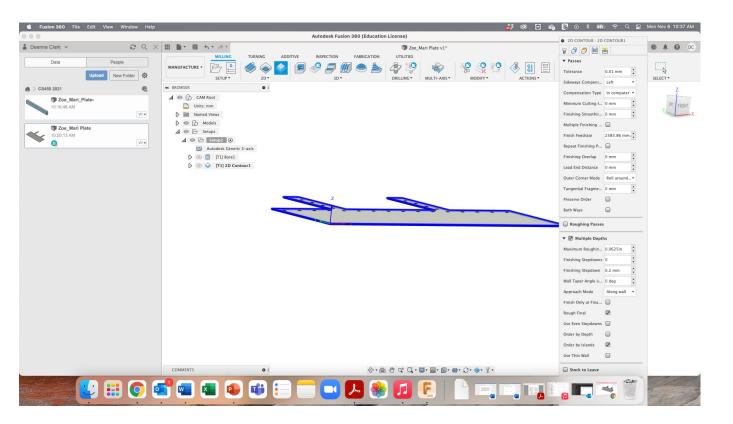


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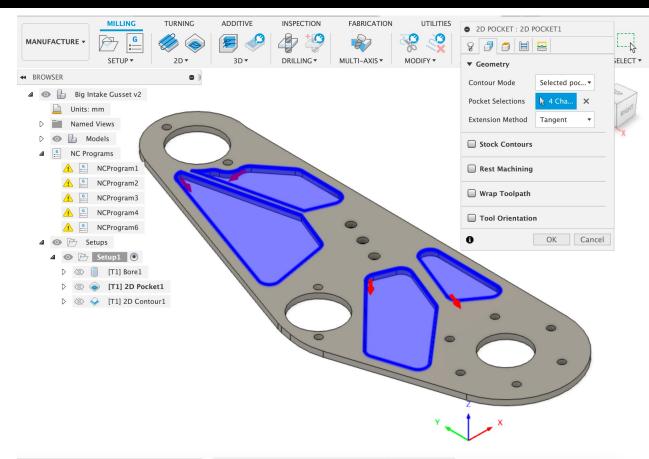
- Go to fourth tab
- Enable "Multiple Depths"
 - "Roughing stepdown" is how much material the machine takes off in the Z-direction on each pass

Material	1/8" 2 flute flat endmill stepdown	4mill 1 flue flute endmill stepdown	6mill 1 flute endmill stepdown
Polycarbonate	1mm	1mm	1mm
Aluminum	0.25mm- 0.4mm depending on complexity of the part	0.5mm	0.5mm



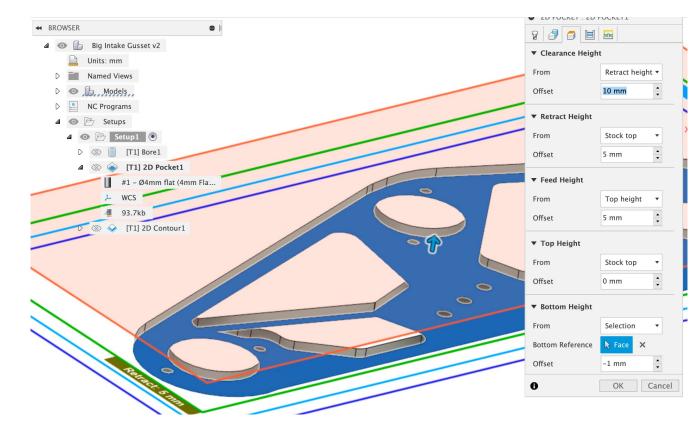
CREATE A 2D POCKET OPERATION

- Pockets can be used when cutting lightening geometry into parts, such as triangles or holes
- Pockets can go all the way through or partially through the material, depending on how you set your faces
- Use same stepdown settings under Multiple Depths as 2D contours



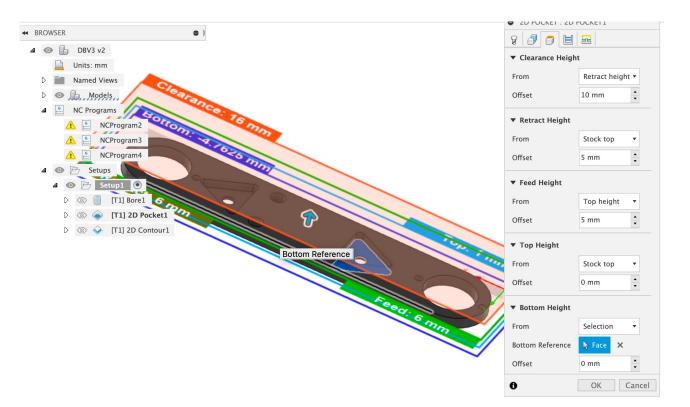
CREATE A 2D POCKET – ALL THE WAY THROUGH

- On third tab of contour operation, change bottom face to "Selection" and select bottom face of part
- Set the tool to go -1mm beyond bottom face – this will ensure part gets cut completely if spoil board is not totally flat



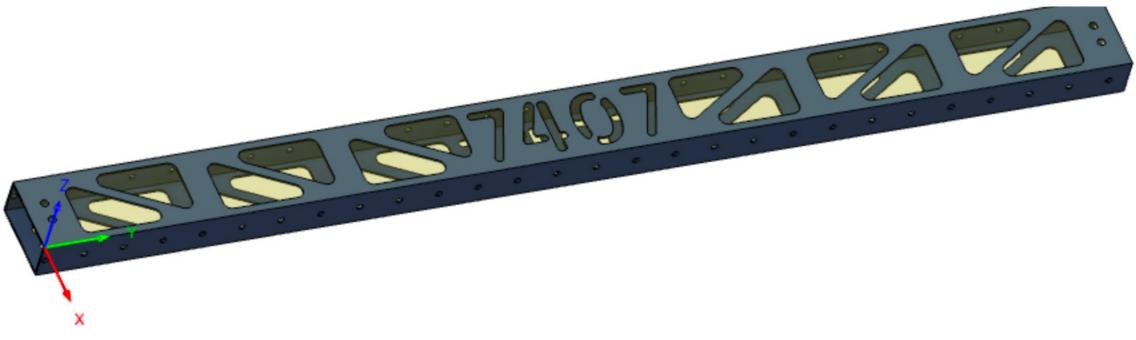
CREATE A 2D POCKET -PARTIALLY THROUGH

- On third tab of contour operation, change bottom face to "Selection" and select bottom face of part
- Set the tool to go 0mm beyond bottom face – this should leave the desired material in the pocket



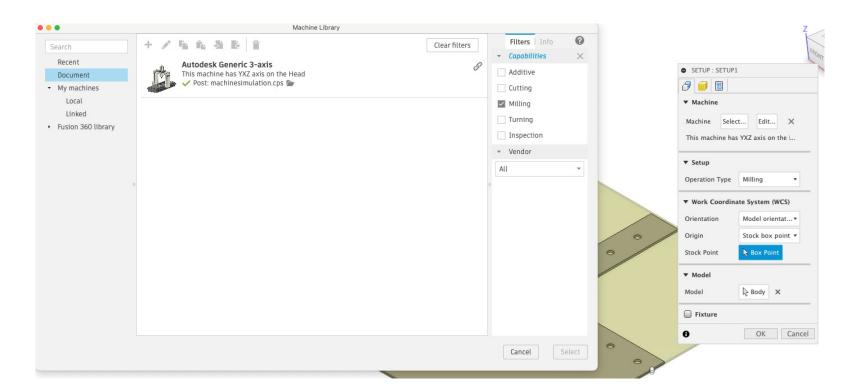
CUTTING TUBES ON THE OMIO

This section will discuss how to cut metal tubes on the Omio using Fusion 360 and Mach3. You will need a tube jig for this.

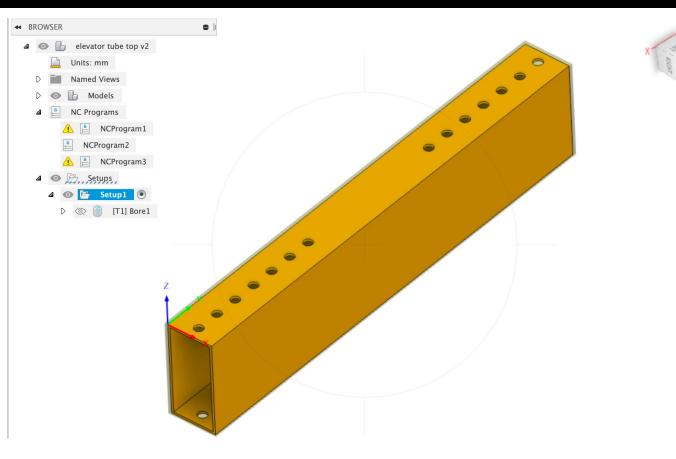


- Navigate to "Manufacture" tab
- Select "Setup" → "New Setup"
- Will need a new setup for each face you are machining on

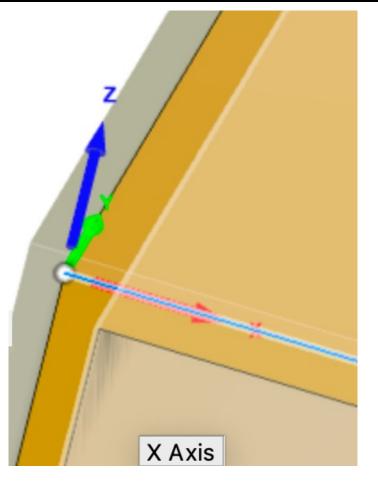
- Select "Autodesk Generic 3-axis" as machine
 - X,Y,Z on head as that is how our router works



- Need to select X & Y axes on part → Select X & Y axes
 - Ensure your X & Y match the tube jig setup you have



- Select "model box point" to place origin
 - Place origin at one corner of the tube, with Z-axis going up



~ All

- Select cutter from Fusion 360 Tool Library
 - Select appropriate material (plastics or aluminum finishing)
 - Speeds and feeds automatically populated for you!
 - How fast the cutter spins on different operations

•					Select To	01							
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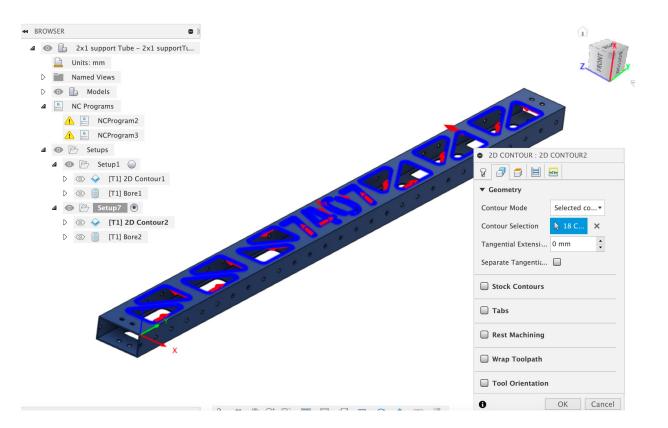
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elevator tube top v2 / 🞽 1 - Ø4mi	n (4mm Flat Endmill)	
General Cutter Shaft	Holder Cutting data	Post processor
Type Unit	Flat end mill Millimeters	
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Diameter	4 mm	
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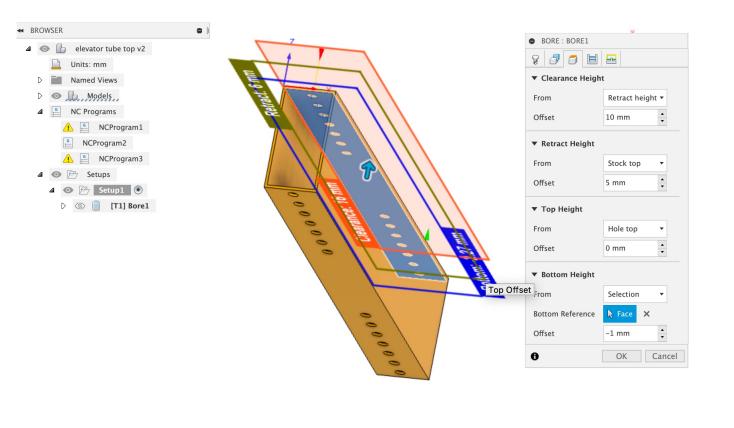
- On third tab of contour operation, change bottom face to "Selection" and select bottom face of part
- Set the tool to go -1mm beyond bottom face – this will ensure part gets cut completely through the tube
- Set pitch to 0.381mm
- Set direction to "conventional"

BORE : BORE1		7		BORE : BORE1	v
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▼ Passes				▼ Clearance Hei	ght
Tolerance	0.01 mm	Retract		From Offset	Retract height v 10 mm
Use Ramp Angle				▼ Retract Height	
Pitch	0.381 mm		5	From	Stock top 🔻
Compensation Type	In computer •			Offset	5 mm 🔹
Multiple Passes		0 0 0 0 0 0 0	- / / / /	▼ Top Height	
				From	Hole top 🔻
Finishing Passes		6		Offset	0 mm
Repeat Passes				▼ Bottom Height	
Direction	Conventio▼			op Offset From	Selection -
			0	Bottom Reference	Face X
Stock to Leave			00000	Offset	-1 mm
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-			0		

- Select 2D contour from 2D menu
- Select appropriate tool and adjust settings as needed
- Select desired contours, may need to select partial contour if making cutouts in tube

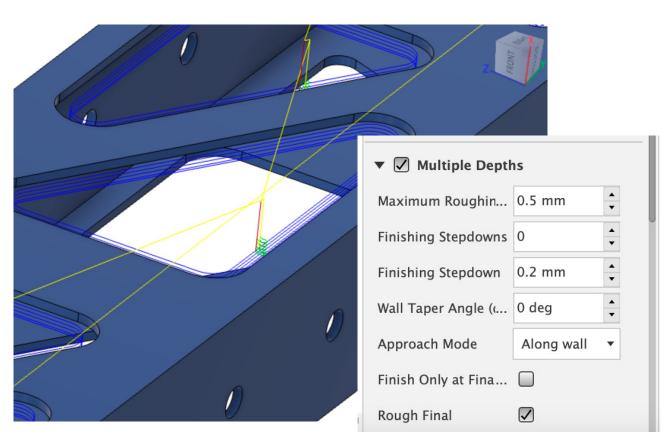


- On third tab of contour operation, change bottom face to "Selection" and select bottom face of part
- Set the tool to go -1mm beyond bottom face – this will ensure part gets cut completely through tube



- Navigate to "Passes" Tab
- Enable "Multiple Depths"
 - "Roughing stepdown" is how much material the machine takes off in the Z-direction on each pass

Material	1/8" 2 flute flat endmill stepdown	4mill 1 flue flute endmill stepdown	6mill 1 flute endmill stepdown
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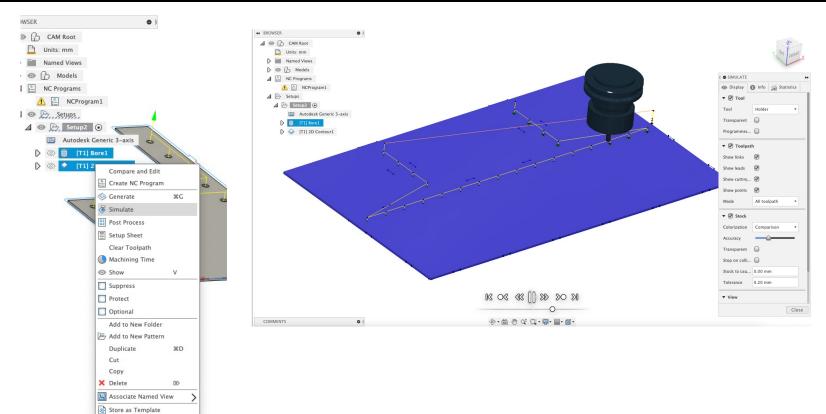


SIMULATE OPERATIONS

MMENTS

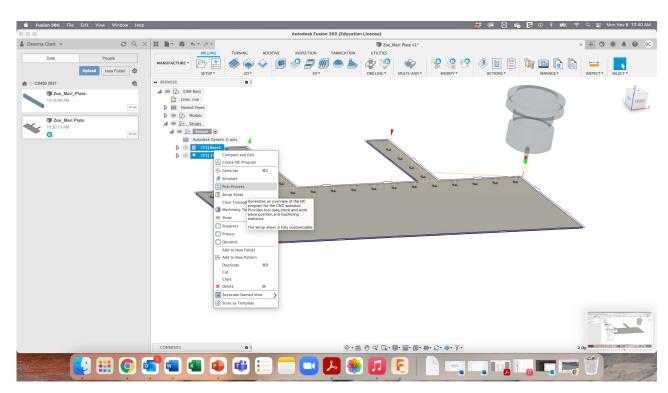
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- Select both toolpaths, right click → simulate
- Press play and make sure tool path is simulated as expected



POST PROCESS CODE

- Post processing the code enables it to be run on the CNC Router
- Can export g-code files as individual files or combine into one
 - Depends on the part and how you are retaining it → if you use screws you will need to pause before 2D contour passes to install screws
- Right click toolpaths and select post-process



POST PROCESS CODE

- Select "CENTROID" as post type for Omio
- Need to give a numerical file name – no letters
- Select post and save file to a flash drive to open on the CNC computer

• •	NC Pro	NCProgram2			
	Settings	Opera	tions		© ~ ?
Machine and post			Post properties		:
Use machine configuration					
Machine	This machine has YXZ axis on the 🔻		Write machine		
Post	CENTROID / centroid 🔹 💉		Write tool list 🔽		
Use cascading post			▼ Group 1		
Program			Preload tool	×	
Name/number	1001		Sequence number increment	t 5	
Comment			Start sequence number	10	
Output Folder	ers/dclark/Fusion 360 CAM/nc 🛛 🔭		Use sequence numbers	×	
Post to Fusion Team					
NC Extension	nc		Optional stop	~	
Unit	Document unit	-	Safe Retracts	G28	×
Open NC file in editor			Separate words with space	~	
			Radius arcs		
			▶ Built-in		
					Post OK Cancel

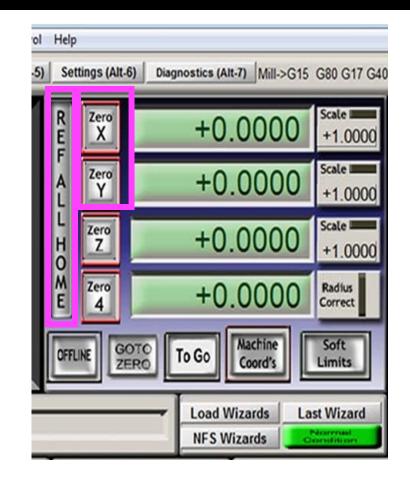
LOAD FILES INTO MACH3

- Load your g-code into Mach3 on CNC desktop computer
- An image of your tool path should appear in the software

File Config Function Cfg's View Wizards Operator PlugIn Control	Help		
Program Run (Alt-1) MDI (Alt-2) Tool Path (Alt-4) Offsets (Alt-5)	Settings (Alt-6) Diagnostics (A	Mill->G15 G80 G17 G40 G20	G90 G94 G54 G49 G99 G64 G97
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History Clear Status: ReConfiguration Estop.		Profile: Kickstarter CNC	

PREPARE CNC ROUTER FOR PLATE

- To begin prepping the machine for cutting, we need to make sure it has a proper 0,0,0 point to run the g-code from
- Begin by selecting "REF ALL HOME" in Mach 3
 - The router will go to its machine 0 points in X, Y and Z directions
 - Note machine 0 is different from the 0 position you set for the piece!
- Using remote jogger, move spindle to the desired 0,0 (X,Y) location. Once there select "ZERO X" and "ZERO Y"



PREPARE CNC ROUTER FOR PLATE

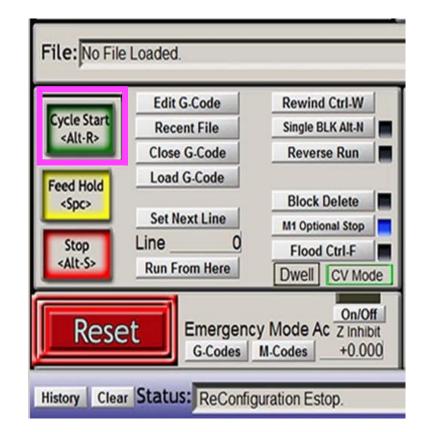
- Move router bit over where you will be cutting to prepare to zero Z
 - Connect touch pad alligator clip to side of spindle and place pad directly underneath the bit; hold in place.
 - Have a second person press "auto tool zero" in Mach3; bit will move down until circuit is completed by the metal bit touching the plate
 - Machine will automatically set Z-zero for you, ensure Z-offset for touch pad is accurate in Mach 3 or this operation will not work



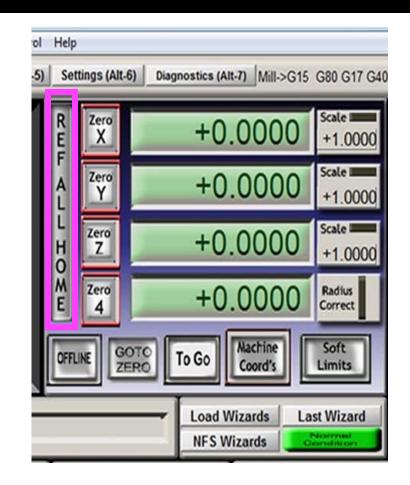


PREPARE CNC ROUTER FOR PLATE

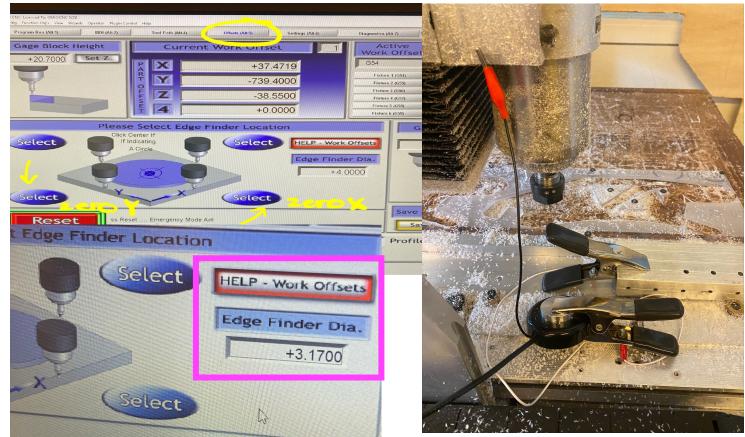
- Ensure correct tool is in router, and dust collection system running (follow toolpaths with vacuum by hand if no chip clearing is present on your machine
 - Chip loading with aluminum can compromise quality of your parts and break or wear out bits quickly
- Once you are zeroed and the machine is ready to safely run, start your program by pressing "cycle start"!



- To begin prepping the machine for cutting, we need to make sure it has a proper 0,0,0 point to run the g-code from
- FRC7407 has written special code to make zeroing tubes in Mach 3 a breeze! Please see next slides for instructions on importing the code.
- Begin by selecting "REF ALL HOME" in Mach 3
 - The router will go to its machine 0 points in X, Y and Z directions
 - Note machine 0 is different from the 0 position you set for the piece!



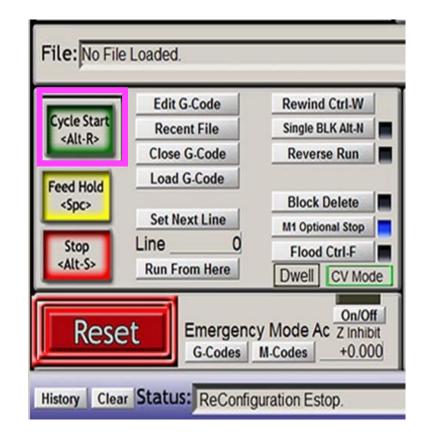
- Using alligator clips, clip one end to the touch pad and the other end onto the tube. Take the touch pad alligator clip and secure it to the side of the spindle
 - Move the bit to the side of the y-axis where you want your y-zero to be. Navigate to Offsets tab in Mach 3 and select "XYZ"
 - The bit should move towards the Y-axis until the circuit is completed when it touches the metal. This will automatically set y-zero for you.
 - Repeat the same procedure for x
 - MAKE SURE YOUR EDGE FINDER DIAMETER MATCHES YOUR BIT DIAMETER!



- Move router bit over where you will be cutting to prepare to zero Z
 - Connect touch pad alligator clip to side of spindle and place pad directly underneath the bit; hold in place.
 - Have a second person press "auto tool zero" in Mach3; bit will move down until circuit is completed by the metal bit touching the plate
 - Machine will automatically set Z-zero for you, ensure Z-offset for touch pad is accurate in Mach 3 or this operation will not work



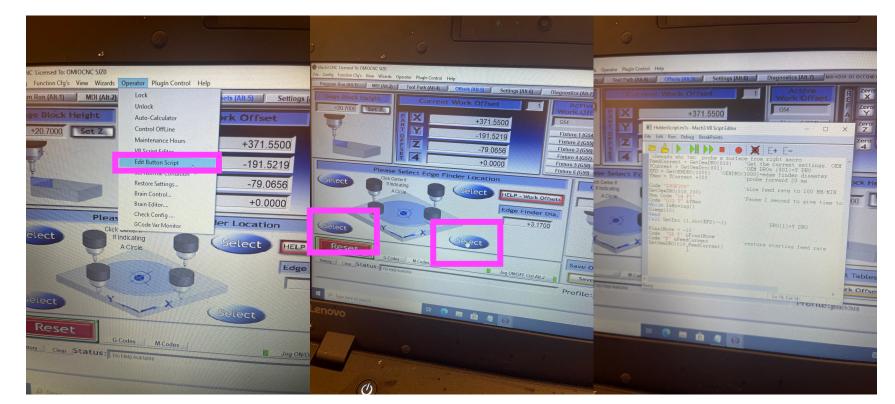
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MACH3 TUBE ZEROING CODE

Google Drive Folder with Zeroing Scripts

- To load these scripts, navigate to Operator dropdown menu and select "Edit Button Script"
- Upload appropriate script for each axis into the following:
 - X&Y zeroing buttons on offsets tab
 - Auto too zero button on program run tab



THINGS TO LOOK OUT FOR

- Make sure your tool path doesn't hit any screw heads \rightarrow bit will likely break
- Make sure your parts are secured to the router via screws in the spoil board, inside the tube jig or clamped down in a secure fashion
- If you try to cut too much material at once or use too fast or too slow speeds based on material, you may damage the bit or your part
- It takes lots of practice to make good g-code, so don't worry if you make mistake –
 > that is how we learn!
- Always wear safety glasses and watch cuts as they happen \rightarrow be ready to emergency stop if something goes wrong
- Always CNC with a buddy!

QUESTIONS OR COMMENTS?

Please feel free to email <u>robotics@choate.edu</u> with any questions you have!