# RhinoCAM Guide

UNLV School of Architecture Fall 2023

### Introduction

RhinoCAM is a Rhino plugin that allows toolpaths to be created then exported to GCode for the CNC router. This is a step-by-step guide that shows how to create toolpaths using RhinoCAM.

This guide covers initial file setup and the most common machining operations used in RhinoCAM: **profiling**, **pocketing**, **horizontal roughing**, **parallel finishing**, **drilling**, **and engraving**. Please note that this guide is intended to help introduce users to RhinoCAM and does not cover all the machining operations available in RhinoCAM. Also, users should be aware that not all machining operations reviewed by this guide may be applicable to every project. Users must determine what machining operations are appropriate for their project.

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# Common Machining Operations





*Description:* Operation used to cut 2D linework and paths **Tools:** 1,3, and 4

Typical Uses:

1. Cut pieces out of sheet stock

2. Perform perimeter cut after surfacing operations

### Pocketing

*Description:* Operation used to surface 2D regions **Tools:** 1 and 3

Typical Uses: 1. Cut flat bottomed recessed areas into stock

### Horizontal Roughing

*Description:* Roughing, or rough cutting, 3D surfaces **Tools:** 1 and 3

Typical Uses:

1. Prepare for parallel finishing operation 2. Create "stepped" surfaces

### Parallel Finishing

*Description:* Detail finishing of 3D surfaces **Tools:** 2 and 5

Typical Uses: 1. Creating smooth 3D surfaces

### Drilling

*Description:* Drilling holes **Tools:** 6

Typical Uses: 1. Create holes to locate material hold down screws



### Engraving

*Description:* Engrave text or linework **Tools:** 7







# **II.** Feeds, Speeds, and Max Cut Depths

	Tool 1: 1/4" \$	Square End M	ill	
		Mat	erial	_
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	150	150	120	120
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		2		

	Tool 2: 1/4	" Ball End Mill		
		Mat	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	145-190	145-190	120-170	120-170
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		1-1	/2"	

	Tool 3: 1/2" \$	Square End M	ill	
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	230	230	140	140
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		2	-	

	Tool 4: 1/2"	Compression	ı	
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	270	270	190	190
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		2-1	/2"	

	Tool 5: 1/2	' Ball End Mill		
		Mate	erial	_
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	190-240	190-240	190-220	190-220
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		2-1	/2"	

# Feeds, Speeds, and Max Cut Depths (Cont'd)

	Tool 6:	1/8" Drill		
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	50	30	30	30
All other Feed Rates (IPM)		5	0	
Speed (RPM)		6,0	00	
Max Cut Depth		2		

	Tool 7: 1	/4" Vee Mill		
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	80	50	30	30
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,0	000	
Max Cut Depth		3/3	8"	

# III. Stepdowns & Stepovers

Max Stepover Di	stance: Horizo	ontal Roughin	g & Pocketing	
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Stepover (% of bit diameter)	75	50	35	25

Max Ste	oover Distanc	e: Parallel Fini	ishing	
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Stepover (% of bit diameter)	75% - 50%	50% - 35%	35% - 25%	25% - 20%

	Max Stepdow	n Distance		
		Mate	erial	
	Foam	MDF	Plywood*	Hardwood*
Stepover (% of bit diameter)	75	50	25	25

\* Tool 4 (1/2 Compression) stepdown percentages can be increased by 25%.

# Part 1 File Setup

### 1. Launch Rhino 7 & Set Model Units to Inches

Type **"units"** into the command bar to display the document properties dialog box.

### 2. Launch RhinoCAM 2022

If the RhinoCAM window is not visible, type "RhinoCAM 2022" into the command bar to activate the plugin.

Ensure "MILL" is activated at the top left of the RhinoCAM 2022 window.





### 3. Open Tools Machining Objects

Select the icon with the image of a tool directly to the right of the "mill" icon at the top left of the RhinoCAM 2022 window to launch the tools machining objects window.



Dimension Transform Tools Analyze Render Panels RhinoCAM 202

Load Tool library

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RhinoCAM 2022 - Machining Objects

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### 4. Load Tool Library

Download the ".vkb" file from: digitalfabricationlab.sites.unlv.edu/rhinocam.

To load the library, click on the second icon from the left under the tools tab in the machining objects window.

Locate the ".vkb" file and click open in the lower right corner.

### 5. Tools Successfully Loaded

If the tool library is successfully loaded, the tool library will be listed in the machining objects window.



### 6. Move Parts to Origin 0,0,0

Parts can be moved to the origin by using the **move** command and typing 0,0,0.

**<u>Tip</u>**: For best results, purge all unnecessary geometry from the file or begin with a fresh file.

### 7. Set Box Stock

Set the stock size that will be milled. Select the "**Stock**" icon and select "**Box Stock**" to launch the dialog window.

**Important:** Obtain the stock before programming and measure the stock thickness with calipers. If two or more pieces of stock are laminated (glued) together, the glue must be allowed to cure for **24 hours** prior to milling.









### 8. Input Stock Dimensions

The lower left corner of the stock should always be located at the origin. Thus, in the dialog box, the **"Corner Coordinates"** should read 0,0,0. Enter the length, width, and height in the **"Dimensions"** portion of the dialog box.

("L" corresponds to the dimension of stock along the X-axis; "W" corresponds to the dimension of stock along the Y-axis.)

### 9. Locating Geometry Within the Box Stock

The piece of stock must be larger than the part to be milled. This allows for a **1**" perimeter border to be left around the stock for attachment to the spoil board.

<u>Important</u>: It is difficult to get stock perfectly aligned to the origin and stock edges may not be true. If an absolute size is desired for the final part, it is always advisable to perform all milling operations, then cut the final piece out of the stock at the end of the job.

### **10. Postscript**

Download the "**.spm**" file from: digitalfabricationlab.sites.unlv.edu/rhinocam.

Select "Post".





### **11. Loading Postscript**

Select "..." in the dialog box.

Redirect to the folder where the "**TechnoOsai IJ Arcs**" postscript is located. Select "**OK**".

The **"TechnoOsai IJ Arcs"** postscript should populate under current post processor. Select **"OK"**.

Select Post-Processor Post-Processor Type Use Legacy Post Use Legacy Post Current Version: 2021.3 Select Post Processor: Current Post Processor: Current Version: 2021.3 Edit Folder to load post-processor files from: IMac\Home\Desktop	Select Post-Processor Post-Processor Use Legacy Post Use Programmable Pos Current Version: 2021.3 Select Post Processor Current Post Processor: TechnoOsai IJ Arcs Folder to load post-processor files from: E	t
Post-Processor Type Use Legacy Post Current Version: 2021.3 Select Post Processor Current Post Processor: TechnoOsai IJ Arcs Folder to load post-processor files from: \\Mac\Home\Desktop	Post-Processor Type Use Legacy Post Use Programmable Pos Current Version: 2021.3 Select Post Processor Current Post Processor: TechnoOsai IJ Arcs Folder to load post-processor files from:	t
Use Legacy Post Use Programmable Post Current Version: 20213 Select Post Processor Current Post Processor: TechnoOsai IJ Arcs Folder to load post-processor files from: \\\Mac\Home\Desktop	Use Legacy Post     Use Programmable Pos     Current Version: 2021.3 Select Post Processor Current Post Processor: TechnoOsai IJ Arcs Folder to load post-processor files from:	t
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Folder to load post-processor files from: \\Mac\Home\Desktop	Folder to load post-processor files from:	Edit
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# Part 2 Drilling

### 1. Locate the Drill Machining Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a **"Machining Operations"** drop down menu. **"Drill"** can be found under the **"Holes"** drop down menu.

### 2. Selecting Geometry

When the drill icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step is to select the geometry to perform the operation. Click **"Select Drill Points/Circles"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the **"Tool"** tab at the top to continue to the next step.





### 3. Select Tool For Drilling Operation

The tool library will appear in the list on the left.

Select the **1/8**" **Drill (Tool 6)** for this operation. Click the **"Feeds & Speeds**" tab on the top to continue to the next step.

### Hole Features Tool Feeds & Speeds Clearance Plane Cut Parameters Sorting 📆 Tools Tool 1: 1/4" Square End Mill Tool 2: 1/4 Ball End Mill Taper 0 Tip Ar 120 Tool 3: 1/2" Square End Mill Tool 4: 1/2" Compression Tool Properties Tool N Tool 6: 1/8" Drill Tool # 6 # of F 2 Cutco 6 Adjust 6 Z-Offs 0 Mater CARBIDE Coola None <sup>om</sup> E Feeds & Speeds Spindl 6000 Feed F 0 Edit/Create/Select Tool Preview Tool Generate Cancel Save Help

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50** in/min for all other feed rates.

	Tool 6:	1/8" Drill		
		Mat	terial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	50	30	30	30
All other Feed Rates (IPM)		5	50	
Speed (RPM)		6,0	000	
Max Cut Depth		:	2"	

**Tip:** Clicking **"Load from Tool"** will auto populate the 'speed' and all feed rates except 'Cut (CF)'.

### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".





### 6. Set Cut Parameters

When drilling basic holes, select "Standard Drill".

Input the depth of the hole you want to drill under "Drill Depth".

**<u>Tip</u>**: If the intent is to cut completely through the stock, it is advisable to add **0.03**" to the total cut depth to account for variations in the stock. In other words, if the stock was 1" thick, input the total cut depth as **1.03**".

Set the location of drill points. Always locate drill points at the **top** of the part.

The dwell setting provides a delay during the drilling operation. Set dwell to "off".

The approach distance is the distance above the part where the specified feed rate is applied. Set the approach distance to **0.5**".

### 7. Set Sorting

Sorting establishes the order that multiple holes are drilled. To optimize job time, it is recommended to set the sorting to **"Minimum Distance Sort"**.



ole Features Tool Feeds & Sp	eeds Clearance Plane	Cut Parameters	Sorting	
🔿 No Sort	Minimum Distance Sort	Directiona	I Sort	
Minimum Distance Sort Start Point Upper Left Upp	er Right		Start	
🔵 Lower Left 🛛 🔾 Low	er Right		Point	
Directional Sort				
Primary Sort Direction (P)				
Start Angle (A) 0	* *	Q		
Secondary Sort Direction (S	)			
O Low to High	gh to Low	0	End	
Traversal Pattern			Point	
⊖ Zig ⊖ Zi	gZag			

### 8. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1"** is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.



# Part 3 Horizontal Roughing

### 1. Locate the Horizontal Roughing Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a **"Machining Operations"** drop down menu. **"Horizontal Roughing"** can be found under the **"3 Axis"** drop down menu.

**Important**: To establish drive regions, use polylines located in a plane at the top of the stock. One way to create these polylines is to activate the top view, use the command "**Make2D**", then relocate and align the linework with the top of the stock. It is always necessary to ensure curves are joined together.







### 2. Selecting Geometry

When the horizontal roughing icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step is to select the geometry to perform the operation. Click **"Select Curve/Edge Regions"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the **"Tool"** tab at the top to continue to the next step.

### 3. Select Tool For Horizontal Roughing Operation

The tool library will appear in the list on the left.

Select the **1/2**" **Square End Mill (Tool 3)** for this operation. Always use the 1/2" Square End Mill if possible because it affords removing large quantities of material quicker than the 1/4" Square End Mill. Click the **"Feeds & Speeds"** tab on the top to continue to the next step.

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50** in/min for all other feed rates.

	Tool 3: 1/2" S	Square End N	lill	
		Ма	terial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	230	230	140	140
All other Feed Rates (IPM)		Ę	50	
Speed (RPM)		12	,000	
Max Cut Depth			2"	

Tip: Clicking "Load from Tool" will auto populate the 'speed' and all feed rates except 'Cut (CF)'.







### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".



The "Intol" and "Outol" should be set to 0.01.

The **"Stock"** setting under global parameters is the amount of material left beyond the finished part, or in other words, the amount of material left between the material being removed and final geometry. Set the stock to **0.0625"** (1/16").

Select "Offset" under the cavity/pocket regions cut patterns.

For cut direction, select "Conventional (Up Cut)".

Select "Inside" under start point.

Input the **"Stepover Distance**" as a percentage of the tool diameter. The tables for each tool and material combination are located in a previous section of this guide.

### 7. Set Cut Levels

Stepdown controls the depth of material removed with each pass. The tables for each tool and material combination are located in a previous section of this guide.

Select "Depth First" under cut level ordering.

Max Stepover Di	stance: Horiz	ontal Roughin	g & Pocketing	I
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Stepover (% of bit diameter)	75	50	35	25
	Max Stepdow	n Distance		

		Mate	erial	
	Foam	MDF	Plywood*	Hardwood*
Stepover (% of bit diameter)	75	50	25	25

\* Tool 4 (1/2 Compression) stepdown percentages can be increased by 25%.



Cut Parameters Cut Levels Engage/Retract Advanced Out Parameters Out of Data Stock Out of Stock	rameters tol
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Outed       0.01       Intol       Geometry         © Use Facing cut patterns for core regions       Exercise cut patterns for core regions       Exercise cut patterns         © Offset       Offset       Offset       Sprail       Redail       High Spee         Od Direction       Offset       Offset       Offset       Sprail       Redail       High Spee         Od Direction       Offset       Oduside       Sprail       Integration       Integration         Step Sprail       Outside       Outside       Sprail       Integration       Integration         Step Sprail       Outside       Outside       Integration       Integration       Integration         Step Over Distance       Outside       Integration       Integration       Integration       Integration         Step Over Distance       Outside       Integration       Integration       Integration       Integration         Step Over Distance       Outside       Integration       Integration       Integration       Integration	Į
Stock 00025 Geometry Calibration Starting Start	
Cecometry Cecometry Cecometry Constrained	
Use Facing out patterns for core regions  Avky/Pocket regions out patterns for core regions  Avky/Pocket regions out patterns Office Officet Spiral Linear Spiral Redael High Spee  Od Dicter Officet Spiral Linear Spiral Redael High Spee  Od Dicter Officet Spiral Outside Step Dictance Od Dicter Outside Step Dictance S	1
Cardy/Pocket regions cut patterns         Othset       Othset Spiral       Linear       Spiral       Radal       High Spee         Cut Direction       Convertional (Up Cut)       Spiral       Cut Direction       Cut Direction         State Point       Outside       Spiral       Outside       Cut Direction       Cut Direction         State Point       Outside       Spiral       Outside       Cut Direction       Cut Direction         State Point       Outside       Spiral       Outside       Cut Direction       Cut Direction         State Point       Outside       Spiral       Outside       Cut Direction       Cut Direction	
Othet Other Spiral Linear Spiral Redal High Spee Other Spiral Other S	
Offset Offset Spiral Linear Spiral Radal High Spee	
Cut Direction Convertional (Up Cut) State Data Steppover Distance	1
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Constanting Const	
Convertional (Up Cut) Usa Dari Ontais O trais Steppover Distance O % Tool Da.	
Moze Childs Outside Stepover Distance 0 % Tool Dia.	
State Deci Christes Outside Stepover Dutance O % Tool Dia.	
Conside Stepover Distance 0 % Tool Dia.	
Stepover Distance	
M Tool Dia.	
0 % Tool Dia. 50 +	
Distance 0.125	
→ ← Stepover Distance	
Corner Cleanup Loops	
None Inside Outside     Always Keen Tool Down	
Always Keep Tool Down	



### 8. Engage/Retract

Engage and retract are parameters used to program a tool reaching a certain depth over a sloped path, rather than directly plunging to the specified depth in a single spot.

Ensure "**Path**" is selected with default angle and height values. Set the "**Angle (A)**" to **10** and "**Height (H)**" to **0.05**.

Set "Linear Extension (D)" to 0.

### 9. Advanced Cut Parameters

Ensure "Perform Arc Fitting" is selected.

### 10. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1**" is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.

**<u>Tip</u>**: The order of machining operations under setup 1 matters and is organized sequentially. Ensure the machining operation to occur first is located at the top of the list.

ound domainy	1	Tool	Feeds & Speeds	Clearance Plane
Cut Parameters	Cut Lev	/els	Engage/Retract	Advanced Cut Parameter
Engage/Retract in	n Material			
Ramp		$\frown$		
Path	Angle (A	10	. <b>-</b>	
🔵 Linear	Height (H)	0.05	÷ /	A IT
Di	istance (D)	0.05	•	
Helix	Radius(R)	0.0625	•	
O Vertical Ap	proach(D)	0.025		//
- remays origage		.,		
				1
Engage/Retract i	n Air	_	_ //	
Engage/Retract i	n Air nsion (D)	0	÷ 🥖	
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Engage/Retract i	n Air hsion (D) roach (V)	0.0125		v t
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Cut Parameters	Tool Cut Levels	Feeds & Spee Engage/Retract	ds Clearance Plan Advanced Cut Paramete
Cut Corner Roundir Perform Cut R Rounding Radius	ng Options ounding (r) 0.1	<u>*</u>	
Cut Arc Fitting Perform Arc F Fitting Tolerance	itting (1) 0.01	×	T <sub>t</sub>
Smooth Cut Transit	ions Cut Connections		Ð

### CNC Example (309 KB) - Rhino 7 Educational - [Perspective\*]



# Part 4 Parallel Finishing

### 1. Locate the Parallel Finishing Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a **"Machining Operations"** drop down menu. **"Parallel Finishing"** can be found under the **"3 Axis"** drop down menu.

**Important:** To establish drive regions, use polylines located in a plane at the top of the stock. One way to create these polylines is to activate the top view, use the command "**Make2D**", then relocate and align the linework with the top of the stock. It is always necessary to ensure curves are joined together.



ino 7 Educational - [Perspective\*] urface SubD Solid Mesh Dimension Transform Tools Analyze Render Panels

Plane World ): \_World om Left Right Front Back Perspective TwoPointPerspective ): \_Front



### 2. Selecting Geometry

When the parallel finishing icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step is to select the geometry to perform the operation. Click **"Select Curve/Edge Regions"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the **"Tool"** tab at the top to continue to the next step.

### 3. Select Tool For Parallel Finishing Operation

The tool library will appear in the list on the left.

Select the 1/4" Ball End Mill (Tool 2) or 1/2" Ball End Mill (Tool 5) for this operation. Click the "Feeds & Speeds" tab on the top to continue to the next step.

**<u>Tip</u>**: The 1/2" Ball End Mill removes large quantities of material quicker than the 1/4" Ball End Mill, thus saves cutting time.

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50 in/min** for all other feed rates.

	Tool 2: 1/4'	' Ball End Mill	l	
		Mat	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	145-190	145-190	120-170	120-170
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Denth		1_1	/2"	

	Tool 5: 1/2'	' Ball End Mill		
		Mat	erial	
	Foam	MDF	Plywood	Hardwood
Cut Feed Rate (IPM)	190-240	190-240	190-220	190-220
All other Feed Rates (IPM)		5	0	
Speed (RPM)		12,	000	
Max Cut Depth		2-1	/2"	



Cut Parameters Z Containment

Control Geometry

Entry/Exit Advanced Cut Parameters

Feeds & Speeds

Sorting

Clearance



Tip: Clicking

"Load from

auto populate

Tool" will

the 'speed'

and all feed

rates except 'Cut (CF)'.

### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".



The "Intol" and "Outol" should be set to 0.001.

The "Stock" setting should be set to 0.

For cut direction, select "Mixed".

The angle of the parallel finishing lines can be change by entering a new value under " **Angle of Cuts**".

Input the "**Stepover Distance**" as a percentage of the tool diameter. The tables for each tool and material combination are located in a previous section of this guide.

Max Step	over Distanc	: Parallel Fin	ishing	
		Mate	erial	
	Foam	MDF	Plywood	Hardwood
Stepover (% of bit diameter)	75% - 50%	50% - 35%	35% - 25%	25% - 20%

### 7. Z Containment

Z Containment is an advance feature used to restrict the level of a cut. Z Containment is typically not applicable.



ut Parameters Global Parameters	Z Containmen	JI t	re	uus a oper	~U\$		ncarani otoro	~ riane
Global Parameters			Entry/Exi	Adva	inced Cu	t Param	cicio	Sorti
				-				
Intol	0.001			100	Sto	ck	Outt	ol
Outtol	0.001	+		Intol ,	-	-	_	
Stock	0	-		X	Geon	netry		
Cut Control								
Cut Direction				~				
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### 8. Entry

Entry and exit parameters are used to allow a tool to reach a certain depth (or retract from a certain depth) over a sloped path rather than directly plunging (or withdrawing) in a single spot.

We recommend these values be set to "**0**" as they have little impact on the type of machining typically done.

### 9. Exit

Entry and exit parameters are used to allow a tool to reach a certain depth (or retract from a certain depth) over a sloped path rather than directly plunging (or withdrawing) in a single spot.

We recommend these values be set to "**0**" as they have little impact on the type of machining typically done.

### **10. Advanced Cut Parameters**

Ensure "Perform Arc Fitting" is checked.

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Generate Cancel

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Help

### 11. Set Sorting

Sorting establishes the order that parallel finishing operations are completed. To optimize job time, it is recommended to set the sorting to **"Minimum Distance Sort"**.

### 12. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1"** is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.

**<u>Tip</u>**: The order of machining operations under setup 1 matters and is organized sequentially. Ensure the machining operation to occur first is located at the top of the list.

Control Geometry	Tool	Feeds & Speeds	Clearanc	e Plane
Cut Parameters Z Containm	ient Entry/	Exit Advanced	Cut Parameters	Sortin
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⊖ Zig ⊖ Z	ligZag			
	Generate	Cancel	Save	Help

CNC Ex	ample (309 KB) - Rhino 7 Educational - [Perspective*]	
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# Part 5 Pocketing

### 1. Locate the Pocketing Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a **"Machining Operations"** drop down menu. **"Pocketing"** can be found under the **"2 Axis"** drop down menu.







### 2. Selecting Geometry

When the pocketing icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step is to select the geometry to perform the operation. Click **"Select Curve/Edge Regions"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the **"Tool"** tab at the top to continue to the next step.

### 3. Select Tool For Pocketing Operation

The tool library will appear in the list on the left.

Select the **1/4**" **Square End Mill (Tool 1)** or **1/2**" **Square End Mill (Tool 3)** for this operation. Click the "Feeds & Speeds" tab on the top to continue to the next step.

**Tip:** The 1/2" Ball End Mill removes large quantities of material quicker than the 1/4" Ball End Mill, thus saves cutting time.

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50 in/min** for all other feed rates.

Tool 1: 1/4" Square End Mill							
		Material					
	Foam MDF Plywood Hardwo						
Cut Feed Rate (IPM)	150	150	120	120			
All other Feed Rates (IPM)		5	0				
Speed (RPM)	12,000						
Max Cut Depth		2	2"				

Tool 3: 1/2" Square End Mill							
		Material					
	Foam MDF Plywood Hardwood						
Cut Feed Rate (IPM)	230	230	140	140			
All other Feed Rates (IPM)		5	0				
Speed (RPM)	12,000						
Max Cut Depth		2					









### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".

### 6. Set Cut Parameters

The "Tolerance" should be set to 0.001.

The "Stock" setting should be set to 0.

Select "Offset" under cut pattern.

For cut direction, select "Conventional (Up Cut)".

Select "Inside" under start point.

Input the **"Stepover Distance"** as a percentage of the tool diameter. The tables for each tool and material combination are located in a previous section of this guide.

Max Stepover Distance: Horizontal Roughing & Pocketing							
	Material						
	Foam	MDF	Plywood	Hardwood			
Stepover (% of bit diameter)	75	50	35	25			

### 7. Set Cut Levels

Always locate cut geometry at the "top" of the part.

**"Total Cut Depth"** specifies the total overall desired depth of a pocket. This is divided into two parts: **"Rough Depth"** and **"Finish Depth"**. Input **"Finish Depth"** as **1/16"** (0.0625"); **"Rough Depth"** will auto populate.

**"Rough Depth/Cut"** and **"Finish Depth/Cut"** specify the depth of each cut level. The maximum stepdown tables for each tool and material combination are located in a previous section of this guide. (If using a compression bit, the minimum rough depth per cut must be **0.25"**.)

Select	"Depth	First"	under	cut	level	ordering.
--------	--------	--------	-------	-----	-------	-----------

Max Stepdown Distance							
		Mat	erial				
	Foam	MDF	Plywood*	Hard			
Stepover (% of bit diameter)	75	50	25	2			
** · · · · · · ·							

\* Tool 4 (1/2 Compression) stepdown percentages can be increased by 25%.



Control Geometry	Tool	Feeds & Speeds	Clearance	Plane
tut Parameters Cut Le	vels Pocketing E	ntry/Exit Advanc	ed Cut Parameters	Sorting
Global Parameters Tolerance: 0.00 Stock: 0 Compensation: AU		Region	Toolpath Tolerance Stock	
Cut Pattern Offset Cut Direction Climb (Down of Conventional	Spiral Clinear	○ Spiral ○ Ra	dial 🔷 High Spee	ed
Mixed Start Point Inside Stepover Distance 9 % Tool Dia.	Outside	+ +		ţ
Distance     Corner Cleanup Lo     None     I	0.125	→ + Ste	pover Distance iss ip Tool Down	



vood\*

Max

<u>Stepdown</u> <u>Calculation</u>: 50% of 1/4"

bit diameter =

1/8" or 0.125"

### 8. Pocketing Entry/Exit

Engage and retract are parameters used to program a tool reaching a certain depth over a sloped path, rather than directly plunging to the specified depth in a single spot.

Set "Approach Motion Length (L)" to 0.

Ensure "Path" is selected with default angle and height values. Set the "Angle (A)" to 10 and "Height (H)" to 0.05.

Ensure all "Retract Motion Values" are set to 0.

Check "Apply entry/exit at all cut levels".

### 9. Advanced Cut Parameters

Ensure "Perform Arc Fitting" is selected.

### **10. Set Sorting**

Sorting establishes the order that pocketing operations are completed. To optimize job time, it is recommended to set the sorting to **"Minimum Distance Sort"**.

	trol Geometry	Tool	Feeds 8	Sneeds	Clearar	ce Plane
ut Par	ameters Cut Level	s Pocketing	g Entry/Exit	Advanced	Cut Parameter	s Sortir
						ny monoria
	Approach Motion		•	1	~ .	
	Length		• /			
	Engage Motion	$\mathbf{a}$				4
	O Path Angl	e (A 10	÷	/ .	AA C	
	Linear Heigh	t (H) 0.05	• /		/ /	
	Distance	(D) 0.05	* *			
			*			/
	Heix Radiu	IS(R) 0.0025	v	$\sim$		
					E	xit Motions
	Retract Motion		1.0	Rapid →		
	O Linear Lengt	h (L)	-			
	Angl	e (A) 0	÷		Departure	
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	Departure Motion		R	etract-∕≯		
	Vertical Dis	(D):	*	~		
						$\sim$

Cut Parameters						
	Cut Levels	Pocketing	g Entry/Exit	Advanced C	Cut Parameters	Sorting
Cut Corner Ro Perform C Rounding Ra	ounding Optior Cut Rounding adius (r)	0.1	×		$\overline{\}$	
Cut Arc Fitting Perform Fitting Toler	Arc Fitting rance (t)	0.01	<b>A</b>		Tt	
Smooth Cut T	ransitions ooth Cut Conn	ections				
Round Externa	al Corners by Corners Roun	Tool Radius ding				
		Connector	0	und	Cauto	Hele



### 11. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1"** is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.

**Tip:** The order of machining operations under setup 1 matters and is organized sequentially. Ensure the machining operation to occur first is located at the top of the list.



# Part 6 Engraving

### 1. Locate the Engraving Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a "Machining Operations" drop down menu. "Engraving" can be found under the "2 Axis" drop down menu.

**Important**: To establish drive regions, use polylines located in a plane at the top of the stock. One way to create these polylines is to activate the top view, use the command "**Make2D**", then relocate and align the linework with the top of the stock. It is always necessary to ensure curves are joined together.

<u>*Tip:*</u> Text can be created using the "**Text**" command in Rhino. The recommended font to use is "**SLF-RHN Architect**".





### 2. Selecting Geometry

When the engraving icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step will be to select the geometry to perform the operation. Click **"Select Curve/Edge Regions"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the **"Tool"** tab at the top to continue to the next step.

### 3. Select Tool For Engraving Operation

The tool library will appear in the list on the left.

Select the 1/4" Vee Mill (tool 7).

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50** in/min for all other feed rates.

Tool 7: 1/4" Vee Mill							
		Material					
	Foam	MDF	Plywood	Hardwood			
Cut Feed Rate (IPM)	80	50	30	30			
All other Feed Rates (IPM)		Ę	50				
Speed (RPM)		12	,000				
Max Cut Denth		3	/8"				

Tip: Clicking "Load from Tool" will auto populate the 'speed' and all feed rates except 'Cut (CF)'.







### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".



The "Tolerance" should be set to 0.001.

Always locate cut geometry at the "top" of the part.

**"Total Cut Depth"** specifies the total overall desired depth of an engraving. This is divided into two parts: **"Rough Depth"** and **"Finish Depth"**. Input **"Finish Depth"** as **1/16"** (0.0625"); **"Rough Depth"** will auto populate.

"Rough Depth/Cut" and "Finish Depth/Cut" specify the depth of each cut level. The maximum stepdown tables for each tool and material combination are located in a previous section of this guide.

	Max Stepdow	n Distance		
		Mate	erial	
	Foam	MDF	Plywood*	Hardwood*
Stepover (% of bit diameter)	75	50	25	25



### 7. Entry/Exit

Select "None" for both entry motions and exit motions.







### 8. Advanced Cut Parameters

Ensure "Perform Arc Fitting" is selected.

Select "None" for Bridges/Tabs.

### 9. Set Sorting

Sorting establishes the order that engraving operations are completed. To optimize job time, it is recommended to set the sorting to "**Minimum Distance Sort**".

### 10. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1**" is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.

<u>**Tip:**</u> The order of machining operations under setup 1 matters and is organized sequentially. Ensure the machining operation to occur first is located at the top of the list.

Control Geometry	Tool	Feeds & Speeds	Cle	arance Plan
Cut Parameters E	intry/Exit	Advanced Cut Pa	rameters	Sortin
Cut Arc Fitting				-
Perform Arc Fitting			A A	t
Eimine Televenee	0.01	*		
Fitting Tolerance		•	Ĭ	
Bridges/Tabs				
None Triangula	ir 🔵 Rectar	igular		
Bridge Height (H)	0.1	*		
Bridge Length (L)	0.2	*	-	
Reduce feed on des	cending moti	on	<u> </u>	
	2	*		$\cup$
O Number of Bridges	1	*		
O Dist. between Bridge	is <sup>1</sup>	*		



### CNC Example.3dm (932 KB) - Rhino 7 Educational - [Perspective\*]

File Edit View Curve Surface SubD Solid Mesh Dimension Transform Tools File successfully saved as \\Mac\Home\Library\CloudStorage\GoogleDrive-kyle.kithas@unlv.ed Command: \_Save





### 1. Locate the Profiling Operation Icon

Under the program tab in the RhinoCAM dialog box, there is a "Machining Operations" drop down menu. "Profiling" can be found under the "2 Axis" drop down menu.

<u>Important</u>: To establish drive regions, use polylines located in a plane at the top of the stock. One way to create these polylines is to activate the top view, use the command "**Make2D**", then relocate and align the linework with the top of the stock. It is always necessary to ensure curves are joined together.





### 2. Selecting Geometry

When the profiling icon is selected, a dialog box will appear with a series of tabs located at the top. It is imperative to input information and check settings in every tab.

The first step will be to select the geometry to perform the operation. Click **"Select Curve/Edge Regions"**; the dialog box will disappear. Select the appropriate geometry, then press enter.

After the dialog box reappears, it will display what has been selected in the previous step in the list on the left. Once satisfied with the selection, click the "**Tool**" tab at the top to continue to the next step.

### 3. Select Tool For Profiling Operation

The tool library will appear in the list on the left.

Select the **1/2**" compression bit (tool 4) if cutting completely through the material.

If any of the following are true, the 1/4" or 1/2" square end mills (tools 1 and 3) should be used for profiling:

- 1. The material is less than 0.25" thick
- 2. The depth of profile cut is less than 0.25"
- 3. Width of profile cut needs to be 0.25"

### 4. Set Feeds & Speeds

Feeds & speeds correspond to the rate at which the CNC router moves the tool across the part and the RPM (revolutions per minute) that the router bit spins.

Feeds & speeds tables for each tool and material combination are located in a previous section of this guide. Use **50** in/min for all other feed rates.

	Tool 4: 1/2" Compression							
		Ма	terial	_				
	Foam MDF Plywood Hardw							
Cut Feed Rate (IPM)	270 270 190 190							
All other Feed Rates (IPM)	50							
Speed (RPM)	12,000							
Max Cut Depth		2-	1/2"					

**Tip:** Clicking **"Load from Tool"** will auto populate the 'speed' and all feed rates except 'Cut (CF)'.







### 5. Clearance Plane

Establishing a clearance plane determines how far the router bit will be away from the stock during transfers. It is important that the clearance plane is always above the stock so that there is no contact during transfer.

Set the clearance plane **0.5**" above the maximum height (or max Z value) of the stock.

Under cut transfer method, select "Clearance Plane".

### 6. Set Cut Parameters

The "Tolerance" should be set to 0.001.

The "Stock" setting should be set to 0.

For cut direction, select "Conventional (Up Cut)".

Select "**Outside**" or "**Inside**". To cut out parts, select "Outside". To cut out holes or voids within parts, select "Inside".

For open curves, ensure "Use Outside/Inside for Closed Curves" is not selected and select "Right" or "Left" side.

For programming organization, it is advised to keep profile cuts the same width as the tool diameter. Therefore, both **"Total Cut Width"** and **"Step/Cut"** should be set to **"0"**. If a cut is desired to have a greater width than the tool diameter, it is recommended to use a pocketing operation.

### 7. Set Cut Levels

Always locate cut geometry at the "top" of the part.

**"Total Cut Depth"** specifies the total overall desired profile depth. This is divided into two parts: **"Rough Depth"** and **"Finish Depth"**. Input **"Finish Depth"** as **1/8"** (0.125"); **"Rough Depth"** will auto populate.

<u>Tip</u>: If the intent is to cut completely through the stock, it is advisable to add **0.03**" to the total cut depth to account for variations in the stock. In other words, if the stock was 1" thick, input the total cut depth as **1.03**".

"Rough Depth/Cut" and "Finish Depth/Cut" specify the depth of each cut level. The minimum "Rough Depth/Cut" must be 0.25" for a compression bit.







1/2 Axis Profiling					
Cut Levels Entry/Exit	Advanced Cut Para	meters	Cornering Para	meters Cut Pa	Sorting
Control Geometry 100	i reeus a opeed	10 01	curunce riure	Cura	amerers
Clearance Plane Definition			Clears	ance Pla	
Automatic			Olcul		
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Clearance Plane	)			11	
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### 8. Entry/Exit

Select "None" for both entry motions and exit motions . Ensure "Apply entry/exit at each cut level" is unchecked.

### 9. Advanced Cut Parameters

Ensure "Perform Arc Fitting" is selected.

**Bridging** is required for profile cuts. Bridges retain the connection between the stock and piece being milled. The purpose of bridging is to ensure parts don't move during the milling process.

A minimum of (4) bridges per side are required, but more bridges are advisable if the part is very large.

### **10. Cornering Parameters**

The defaults are recommended for corner parameters.

Control Geometry	Tool Fe	teds & Sp weed Out P	eeds Parameters	Clearance Plane	Cut Parameters
	Plates	New Corr	urametero	contening i with	Entry Motions
Uines & Arcs	Along Pat	h 💽	None		,
Approach Moti	00	Lav	es a Arcs		/
	Length (L)	0.25	* *	_	<pre>/ /</pre>
Normal	Tangent	⊖ Sp	ecify		
	Angle (A)	0	*	D	
Former Motion					<
Linear	Length (L)	0.125		Entry Poi	nt on Path
Ciriear	Angle (A)	20	*		
0.0444	During (D)	0.05	*		
Hadial	Hadlus (H)	0.62	w		
Engag	e Ramp Height	0	*		
				Alon	Path 3D Entry
Along Rath Appl	10		Along Re	th Height (H) 0.05	A A
		v			v
<u></u>					Exit Motions
Unes & Arcs	Vivone	Lieu			
Retract Motion			- A C		
Linear	Length (L)	0.25	÷	-	< /
	Angle (A)	20	*		
O Radial	Radius (R)	0.25	*	0	
		0		Evit D	vint on Rath
Retract	Ramp Height	·	w	ExtP	ant on Path
Departure Mot	ion	0.00			
	Length (L)	0.25	-		
Normal	Tangent	⊖ Spec	ily.		
	Angle (A)	0	*		
		-			
Apply entry/exit a	at each cut level	2	Overlap D	ist for Closed Profiles	0





### 11. Set Sorting

Sorting establishes the order that pocketing operations are completed. To optimize job time, it is recommended to set the sorting to "**Minimum Distance Sort**".

### 12. Simulate

Once the tool operation is programmed, it can be visually inspected through a virtual simulation to ensure the desired result. To begin a simulation, select the operation to be simulated under the machining job.

If **"Setup 1"** is selected, all tool operations will be simulated. To start the simulation, select **"Play"** under the simulate tab at the top of the machining browser.

<u>**Tip:**</u> The order of machining operations under setup 1 matters and is organized sequentially. Ensure the machining operation to occur first is located at the top of the list.

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# Part 8 Simulation Overview















# Part 9 Estimating Time & Posting

### 1. Information

Once the tool operations are programmed, right click "Setup 1" and select information.



### 2. Machining Operations Information

Selecting information will display a dialog box showing each tool operation, the tool required for that operation, and machine time. The total machining time will also be displayed.

ops Information								
Name	Status	Tool	Tool #	Cut Feed	Spindle Spe	# of GOTOs	Machining T	
Setup 1								
Standard Drill	Clean	Tool 6: 1/8" Drill	6	30.00 in/min	6000 RPM	9	0.27 min	
Horizontal Roughing	Clean	Tool 3: 1/2" Square End Mill	3	230.00 in/min	12000 RPM	1371	5.15 min	
Parallel Finishing	Clean	Tool 2: 1/4 Ball End Mill	2	170.00 in/min	12000 RPM	9688	9.66 min	
2 1/2 Axis Pocketing	Clean	Tool 1: 1/4" Square End Mill	1	150.00 in/min	12000 RPM	1171	4.37 min	
Engraving	Clean	Tool 7: 1/4" Vee Mill	7	50.00 in/min	12000 RPM	361	1.45 min	
2 1/2 Axis Profiling	Clean	Tool 4: 1/2" Compression	4	270.00 in/min	12000 RPM	94	0.81 min	
						Setup-total	21.70 min	
							Delet	
							Print.	

### 3. Post

The job can be **"posted"**, or converted to G-code, by right clicking **"Setup 1"** and selecting **"Post"**.



### 4. Saving Post

5. Post

Save the posted file in the following format: [year-mm-dd]\_[last name, first name]\_[job #]

Ensure the "TechnoOsai IJ Arcs" is listed as the current post.

After the file is posted, it will automatically open in Notepad.



# 2023-09-15\_Kithas, Kyle\_Job I.nc + File Edit View 6600 679 G90 G40 G80 G17 G27 (Mo,1) T6 M6 G00 X11.5000 G27 (Mo,1) T6 M6 G00 X11.5000 X11.5000 0.000F30.0M3 X11.5000 0.000F30.0M3 X11.5000F30.000 G00 G00 X0.5000 Z3.5000 G300F30.0M3 X0.5000F2.5000 G00 G311.50002-0.0300F30.0M3 X1.5000 Z1.5000 G300F30.0M3 X1.50002-0.0300F30.0M3 X1.5000 Z1.5000 G300F30.0M3 X1.50002-0.0300F30.0M3 X1.5000 Z1.5000 G300F30.0M3 X1.50002-0.0300F30.0M3 X1.5000 Z1.5000 G300F30.0M3 X1.50002-0.0300F30.0M3 X1.5000 Z1.5000 G300F30.0M3 Z1.5000 G300F30.0M3