

C131.976 B7 X1.0262 Y-.0947 Z-2.4448 C130.884 B7 X1.0314 Y-.0636 Z-2.4386 C129.792 B7 X1.0358 Y-.0323 Z-2.4326 C128.701 B7 X1.0396 Y-.0008 Z-2.4268 C127.61 B77 X1.0425 Y.0309 Z-2.4212 C126.519 B77 X1.0448 Y.0627 Z-2.4157 C125.427 B76

QUICK PART SERIES - CHOCOLATE MOLD

April 2019 © 2019 CNC Software, Inc. – All rights reserved. Software: Mastercam 2020

Terms of Use

Use of this document is subject to the Mastercam End User License Agreement. The Mastercam End User License Agreement can be found at:

http://www.mastercam.com/companyinfo/legal/LicenseAgreement.aspx

Be sure you have the latest information!

Information might have changed or been added since this document was published. The latest version of the document is available online or can be obtained from your local Reseller.

A What's New in Mastercam (What's New in Mastercam 20XX.pdf) and ReadMe file (ReadMe.PDF) – installed with each release – include the latest information about Mastercam features and enhancements.

TABLE OF CONTENTS

Introduction	. 5
Tutorial Goals	. 5
General Tutorial Requirements	. 5
Starting Mastercam Quick Part	. 5
Mastercam Part Files	. 6
Material Requirements	. 6
Machine and Tool Requirements	. 6
Accessing the Home Learning Edition	. 7
Heart Mold Design	. 9
Exercise 1: Configuring Mastercam	. 9
Exercise 2: Opening the File and Exploring Levels	10
Exercise 3: Modifying the Solid Model	12
Exercise 4: Creating Geometry for the Mold	17
Exercise 5: Creating the Block for the Mold	.23
Exercise 6: Using Boolean to Create the Mold Impression	.28
Exercise 7: Adding a Containment Boundary	.33
Exercise 8: Adding a Chamfer to the Mold	35
Exercise 9: Adding Stick Slot Geometry	.39
Show Us What You Learned!	55
Fixturing the Stock	57
Exercise 1: Moving the Mold to the Origin	57
Exercise 2: Choosing a Machine and Setting Up Stock	.59
Show Us What You Learned!	63
Rough Mold Programming	.65
Exercise 1: Creating the OptiRough Toolpath	.65
Exercise 2: Verifying the Toolpath	.75
Show Us What You Learned!	81
Finish Mold Programming	83
Exercise 1: Creating the Scallop Toolpath	83

Show Us What You Learned!	93
Slot Programming	95
Exercise 1: Creating the Rough Scallop Toolpath	95
Exercise 2: Creating the Finish Scallop Toolpath for the Slot	104
Show Us What You Learned!	109
Post Processing	111
Exercise 1: Post Processing the Operations	111
Show Us What You Learned!	115
Challenge: Self-Guided Project	117
Conclusion	121

INTRODUCTION

Welcome to *Quick Part Series - Chocolate Mold* tutorial. In this course you will explore how to design and machine a heart-shaped candy mold. Starting with a solid heart provided with this tutorial, you will use wireframe and solid CAD tools to modify the heart to create a candy mold. Using a variety of rough and finish toolpaths, you will program and verify the model to ensure it can be cut successfully. Finally, you will post out your toolpaths to generate NC code and cut the candy mold.

This tutorial will provide you with the basic techniques needed to create the mold, and then from there you can explore Mastercam and challenge yourself to make some other interesting products.

Tutorial Goals

- Understand basic wireframe and solid model design tools and how they can be used to create a complex solid model
- Learn how to program a part using rough and finish toolpaths
- Gain knowledge on how to safely fixture the part
- Explore how to verify the toolpaths with Mastercam Simulator
- Machine the final candy mold

NOTE

Screen colors in the tutorial pictures were modified to enhance image quality; they may not match your Mastercam settings or the tutorial results. These color differences do not affect the tutorial or your results.

General Tutorial Requirements

All Mastercam Project Based Learning tutorials have the following general requirements:

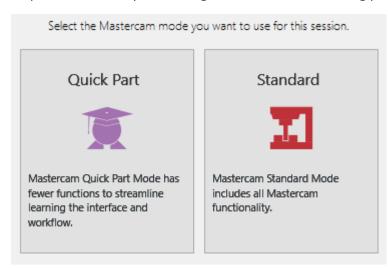
- You must be comfortable using the Windows® operating system.
- Each exercise in the tutorial builds on the mastery of the preceding exercise's skills. We recommend that you complete them in order.
- Additional files may accompany a tutorial. Unless the tutorial provides specific instructions on where to place these files, store them in a folder that can be accessed from the Mastercam 2020 workstation, either with the tutorial or in any location that you prefer.
- All Mastercam tutorials require you to configure Mastercam to work in a default Metric or Inch configuration. The tutorial provides instructions for loading the appropriate configuration file.

Starting Mastercam Quick Part

NOTE

The *Quick Part Series* tutorials assume you are using an Educational license and the Mastercam Quick Part interface. If you are using an Industrial license, disregard this section.

The Quick Part interface is a simplified version of the Mastercam interface, hiding some of the more complex functions. Upon starting Mastercam, the following prompt displays:



Select **Quick Part**. To return to the standard Mastercam interface, you need to close and re-open Mastercam. Then select **Standard**.

Mastercam Part Files

The provided part files are in .mcam format. This allows both Industrial and Educational license users to open the part files. Files saved with an Educational license have an .emcam file extension. This does not affect the completion of the tutorial.

Material Requirements

The following materials are recommended to complete the candy mold project using the suggested machine definition, feeds and speeds, and tooling used in this tutorial. Using different materials will affect the tooling and toolpath settings.

When calculating material requirements, consider a final mold size of 100 mm x 100 mm x 25.4 mm per student.

- Food Contact Grade Plastic UHMW Material, Polyethylene White, 1-inch thick cut into 100 mm x 100 mm x 25.4 mm pieces
- Wilton Cookie Sticks, 0.2 inch diameter x 6 inch long (5 mm diameter x 152 mm long)

Machine and Tool Requirements

WARNING

This tutorial is completed using a specific machine and material. The settings, tooling, feeds, and speeds recommended in this tutorial are based on the use of this equipment, as well as the material to be machined. Your results may differ, based on the machine, its age and prior utilization, and tooling used, as well as the material selected for machining.

This tutorial recommends the following:

- A minimum standard mill, capable of machining hard plastic, with a work envelope of at least 100 mm x 100 mm (4 inch x 4 inch), and a machining envelope that includes Z height of 100 mm (3.93 inch).
- A Machinist's Vise
- 6.0 mm Flat End Mill
- 3.0 mm Ball End Mill

Accessing the Home Learning Edition

The Mastercam Home Learning Edition (HLE) is a free version of Mastercam that lets you practice design and programming skills without having a full Mastercam license. The HLE software lets you save your Mastercam files, but it will not post code.

The HLE is available for free at the following location: https://signup.mastercam.com/demo-hle.

Quick Part Series - Chocolate Mold—4: Introduction

CHAPTER 1 HEART MOLD DESIGN

In this chapter you will use the design functions of Mastercam to create a heart shaped candy mold. You will start with a solid part that you will use to produce a heart-shaped impression into a block that you create using Mastercam design (CAD) tools.

Goals

- Understand levels
- Use wireframe and solid CAD tools to create geometry
- Create block for the mold

Exercise 1: Configuring Mastercam

In this exercise, you open Mastercam and set your system configuration to be metric.

- 1. Start Mastercam using your preferred method:
 - a. Double-click Mastercam's desktop icon.



OR

- b. Launch Mastercam from the Windows Start menu.
- 2. Select the default metric configuration file:
 - a. Click the **File** tab.
 - b. Choose **Configuration** from Mastercam's Backstage View to open the **System Configuration** dialog box.



c. Choose ... \mcamxm.config <Metric> from the Current drop-down list.

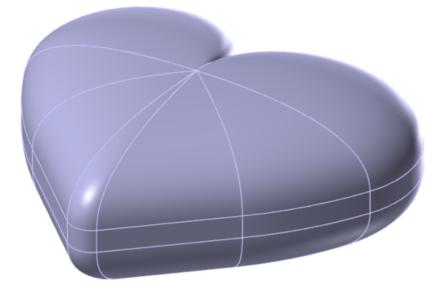
Current:	c:\users\smg\documents\my_mcam20\mcamx.config <inch> <startup> ~</startup></inch>	
	c:\users\smg\documents\my_mcam20\mcamx.config <inch> <startup></startup></inch>	
	c:\users\smg\documents\my mcam20\mcamxm.config <metric></metric>	ſ

d. Click OK.

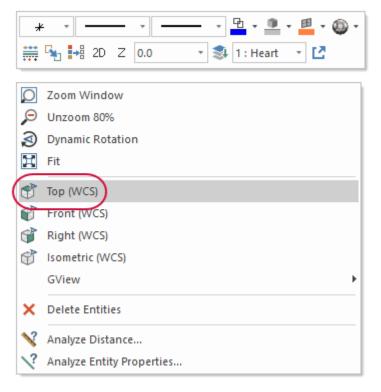
Exercise 2: Opening the File and Exploring Levels

In this exercise, you will open the Heart mm.mcam file provided with this tutorial and explore the Levels Manager.

1. Click File, Open and open the Heart mm.mcam file provided with this tutorial.



- 2. Save the part as Heart mm-XXX.mcam, where XXX represents your initials so that you do not overwrite the original file.
- 3. Right-click the heart and select **Top (WCS)**.



4. Right-click again and select **Fit** to bring the solid to the center of the screen.

5. Click **Levels** to open the Levels Manager. You will see that there are two levels, Level 1 which contains the heart and Level 101 which contains a sample machinist's vice.

Levels					•	д	×	
+ Q 📚 🕏	i 🗠 📃 (0 - (
Num 🔺	Visible	Name		Level Set	Entities			
✔1	х	Heart			36			
101		Vise			4			
\frown								
Number:		1						
		Heart						
Name:		неат						
Level set								
Display:		⊖ Use	ed					
		🔿 Nai	med					
		● Use	ed or nan	ned				
		🔿 Rai	nge					
		1		100				
Toolpaths	Solids P	lanes	Levels	Recent Fur	nctions			

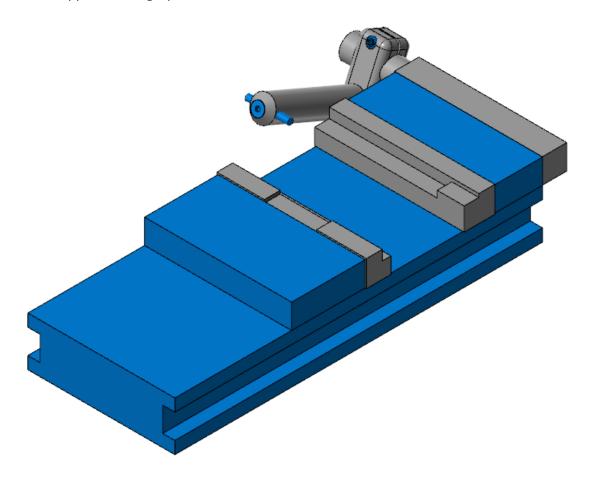
NOTE

Level 1 one is the active level as indicated by the green check in the **Number** column. The active level is always visible as indicated by the **X** in the **Visible** column.

6. Click in the **Visible** column for Level 101 to make the vise show in the graphics window, and then click in the **Number** column for Level 101 to make it the active level.



7. Turn off the visibility for Level 1 by clicking in the **Visible** column to remove the **X**. Only the vise should appear in the graphics window.



8. Before beginning the next exercise, return the active level to Level 1 and hide the vise by clicking in **Visible** column for Level 101. This will ensure you do not accidentally select the vise when creating your mold geometry.



9. Save the file.

Exercise 3: Modifying the Solid Model

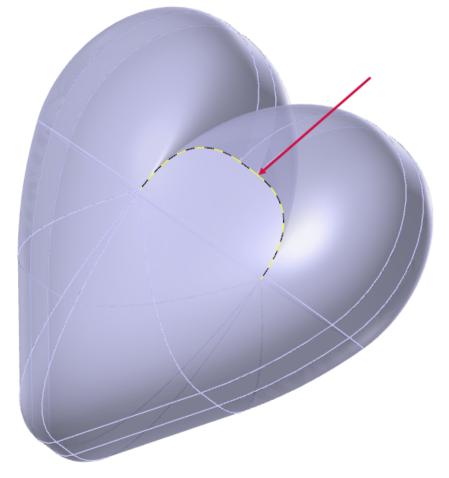
In this exercise, you modify the solid model to eliminate an interior, sharp edge where the heart joins the curves. Softening the sharp edge of the heart will ease the transition between surfaces for a better finish and will make it easier to remove the candy from the mold.

1. Your file Heart mm-XXX.mcam which you saved from the previous exercise should be open in Mastercam.

2. Activate the **Translucency** toggle and set the **2D/3D** toggle on the Status bar to **2D**. Setting your construction mode to 2D will place any geometry you create parallel to the current construction plane (**Top** (**WCS**) at the current system Z depth.



3. Hold down the middle mouse button and rotate the heart until you can see the internal, sharp edge as shown in the following image.

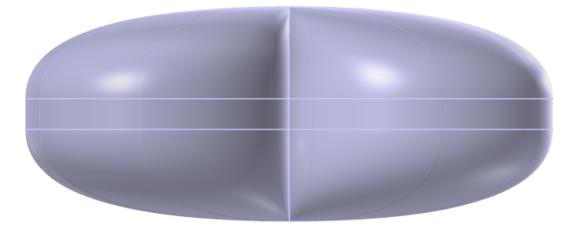


You will use Mastercam's CAD functions to soften this edge.

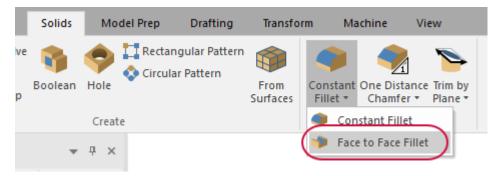
4. Right-click in the graphics window and select GView, Back (WCS).

Q	Zoom Window			
₽	Unzoom 80%			
3	Dynamic Rotation			
Ħ	Fit			
	Top (WCS)			
¢	Front (WCS)			
6	Right (WCS)			
¢	Isometric (WCS)			
	GView 🕨		Named	Þ
×	Delete Entities	۲	Back (WCS)	
• 2		¢	Left (WCS)	
>?	Analyze Distance	S)	Bottom (WCS)	
\?	Analyze Entity Properties	43	Isometric Reverse (WCS)	
		Ø	Trimetric (WCS)	

The model rotates to show the back view.



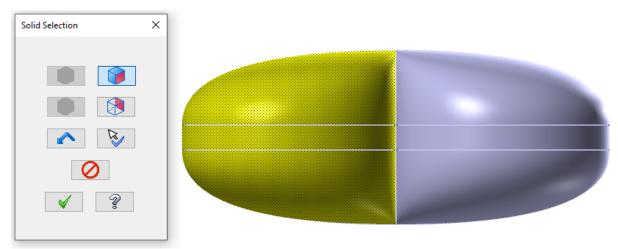
5. On the Solids tab, click Face to Face Fillet.



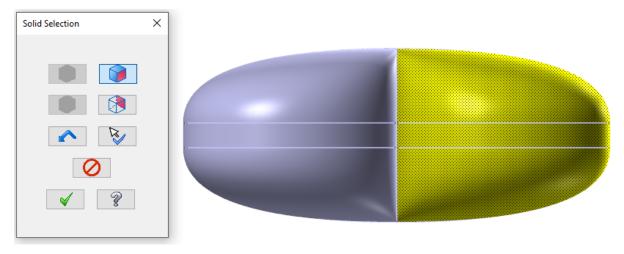
The **Solid Selection** dialog box displays and Mastercam prompts you to select one or more entities

Solid Selection	×
\oslash	
v	

6. Select the three faces on the left side of the model and click **OK** in the **Solid Selection** dialog box.



7. Select the three faces on the right side of the model and click **OK**.

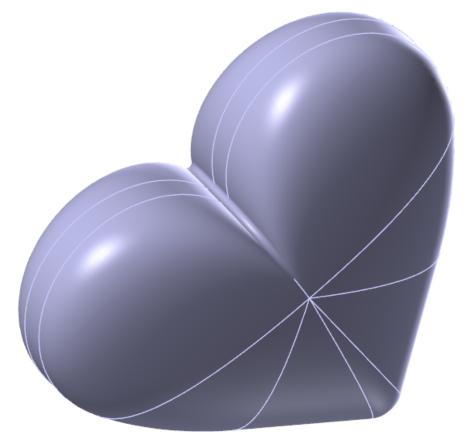


The Face to Face Fillet function panel displays.

8. Choose the **Radius** as the **Method** and enter **1.0** in the **Radius** field. A preview of the results shows in the graphics window.

Face to Face Fillet	д ×
Basic Advanced	3 🛇 😒
Operation	۲
Name: Face to Face Fillet Method: Radius Width Hold line	
Selection 1	۲
Face 1 Face 2 Face 3	
Selection 2	۲
Face 1 Face 2 Face 3	
Radius	۲
1.0	• \$
Width	$\overline{\mathbf{v}}$

9. Click OK (green checkmark). Rotate the solid to see the results.



NOTE Use the **Translucency** and **Shaded** toggles on the **Status Bar** to change your view.

10. Save your file.

Exercise 4: Creating Geometry for the Mold

In this exercise, you will find the center point of the solid heart using the Bounding Box function, and create the wireframe geometry that will become the mold.

- 1. Your file Heart mm-XXX.mcam which you saved from the previous exercise should be open in Mastercam.
- 2. Ensure that the **2D/3D** toggle on the **Status Bar** is set to **2D**. Setting your construction mode to 2D will place any geometry you create parallel to the current construction plane (**Top (WCS)** at the current system Z depth.

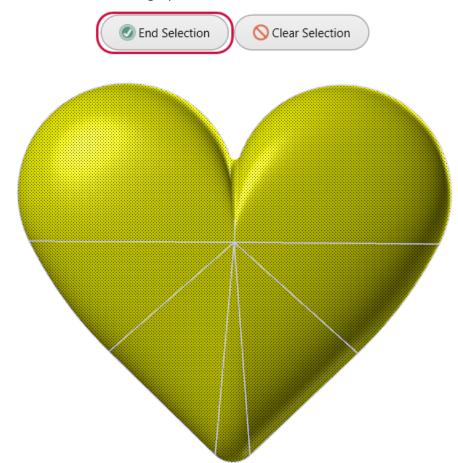


3. Click Translucency on the Status Bar to make the solid heart translucent.

4. On the Wireframe tab, select Bounding Box to open the function panel.



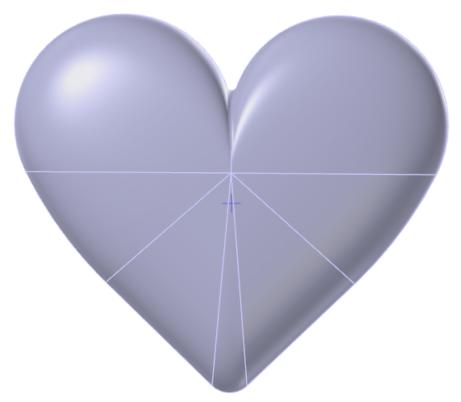
5. Select the heart in the graphics window and click **End Selection**.



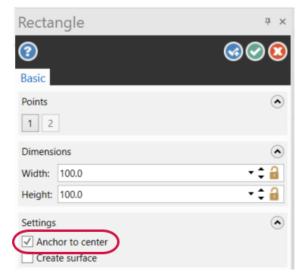
6. In the **Create Geometry** section of the **Bounding Box** function panel, select **Center Point**. This will locate the exact center point of the solid heart.

Bounding Box	ч ×
Basic Advanced	@
Entities	۲
Select: Manual:	
Shape	۲
 Rectangular Cylindrical 	
Rectangular Settings Origin:	۲
Size: X: 86.20029	. *
Y: 75.25343	•••
Z: 0.0	· •
2. 0.0	•
Cylindrical Settings	♥
Push Pull	۲
Arrow values: O Absolute	
Create Geometry	۲
Lines and arcs	
Corner points	
Face center points	
Solids	

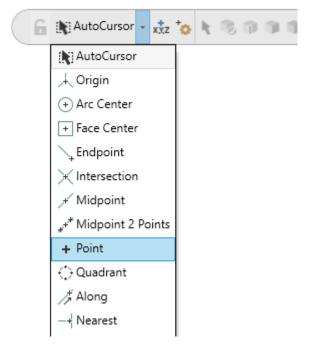
7. Click **OK** in the **Bounding Box** function panel to accept. You will use the bounding box center point in the next step.



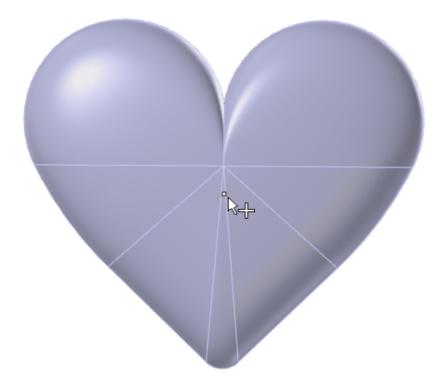
- 8. From the **Wireframe** tab, click **Rectangle** to open the **Rectangle** function panel.
- 9. Select Anchor to center. This will center the rectangle you create around the solid heart.



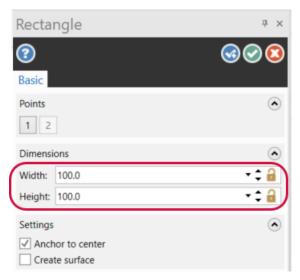
10. On the Selection Bar, choose AutoCursor, Point.



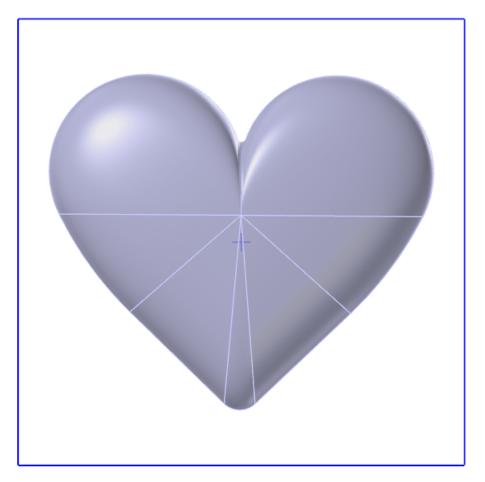
11. Click on the point at the center of the solid heart. This will anchor the rectangle to that point.



12. Enter 100.0 in the Width and Height fields.



13. Click **OK** to create the rectangle that will become the block for the mold

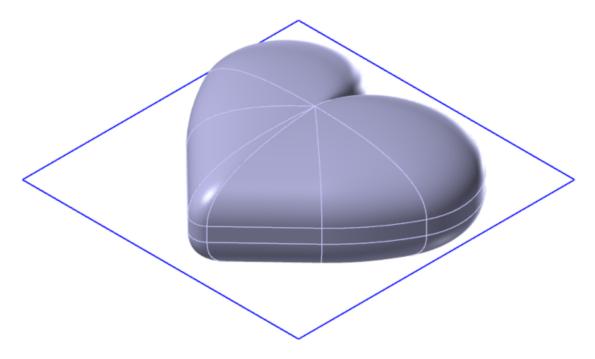


14. Save your file.

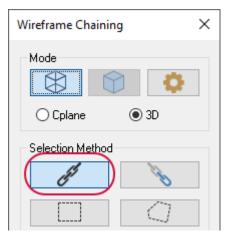
Exercise 5: Creating the Block for the Mold

In this exercise you will create a block for the candy mold by extruding the rectangle you created in the previous exercise.

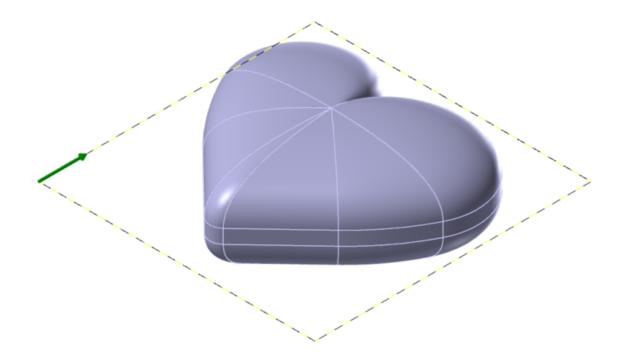
- 1. Your file Heart mm-XXX.mcam which you saved from the previous exercise should be open in Mastercam.
- 2. Right-click in the graphics window and select the **Isometric (WCS)** view.



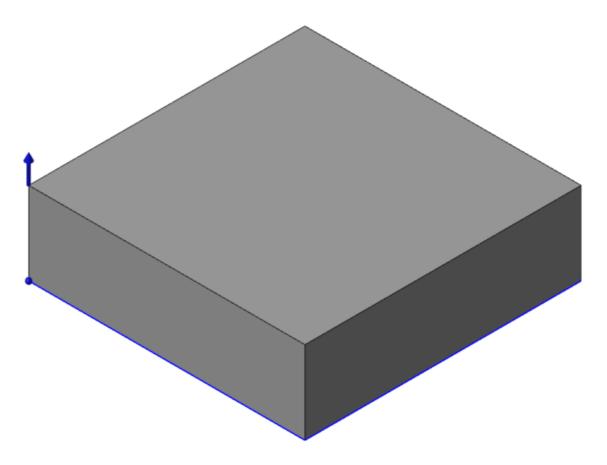
3. Click **Extrude** on the **Solids** tab to open the **Wireframe Chaining** dialog box.



4. Ensure that the **Selection Method** is set to **Chains** and then select the rectangle.



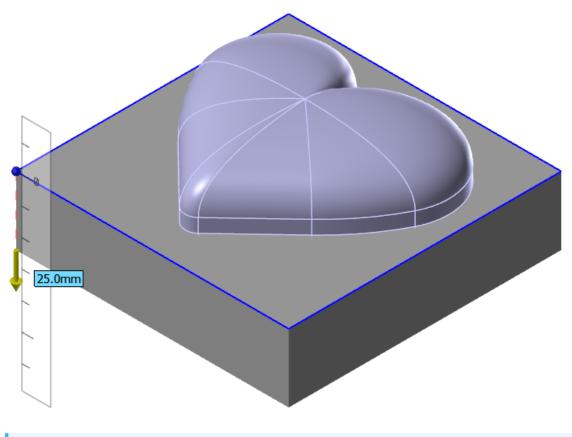
5. Click **OK** in **Wireframe Chaining** dialog box and the **Solid Extrude** function panel opens. The solid may be extruded in a positive direction as shown in the following image.



6. Click **Reverse** in the **Solid Extrude** function panel to change the direction to a negative direction.

Target: Heart	:		\square	
	ngle operation			
Automatic	ally determine operation	n type		
Chains			۲	
Chain 1				
		(+)	20	
Distance			\bigcirc	
Oistance:	50.0		\$	
○ Through al	I			

7. Hover over the arrow until the ruler displays and then click and drag until the distance is **25.0mm**.



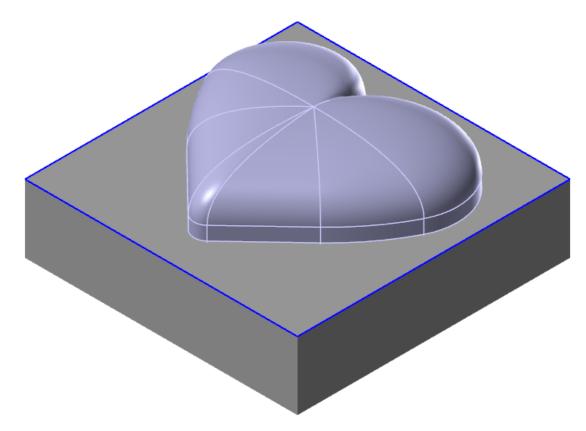


8. Alternately you can enter **25.0** in the **Distance** field of the **Solid Extrude** function panel.

Solid	Extrude	Ψ ×
3		@ ②
Basic	Advanced	
Operat	ion	٢
Name:	Extrude	
Type:	Create body	
	○ Cut body	
	O Add boss	
Target:	Heart	□\$
Cre	ate a single operation	
Aut	omatically determine operation type	
Chains		۲
Chain	1	
		↔ & &
Distanc	e	۲
	ance: 25.0 bugh all h directions	• •
Trin	n to Faces	\overline{ullet}

9. Verify that the **Type** is set to **Create body**.

10. Click **OK** to create the block.

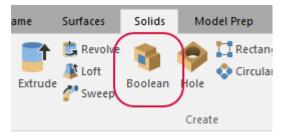


11. Save your file.

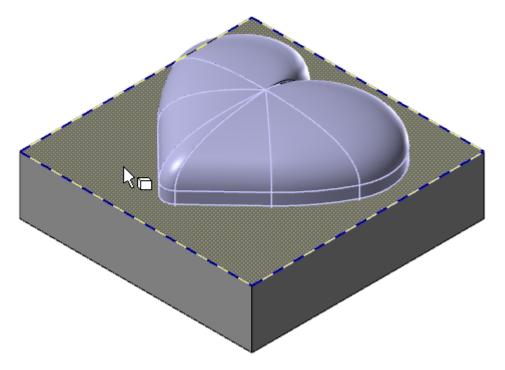
Exercise 6: Using Boolean to Create the Mold Impression

In this exercise you will use the Boolean function to transform the solid heart into the impression that will be your candy mold. When using Boolean, you will identify the target body, which is the block and the tool body, which is the solid heart.

1. Click Boolean on the Solids tab. Mastercam prompts you to select the target body.

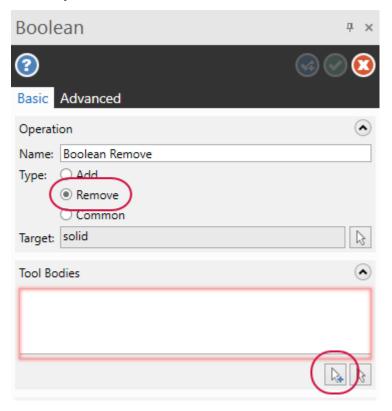


2. Select the top surface of the block to be the target body.

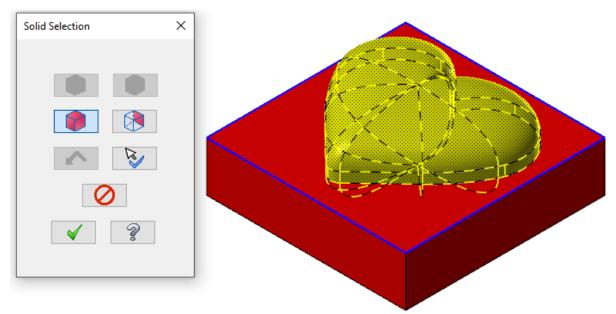


The Boolean function panel opens and Mastercam prompts you to select the tool bodies

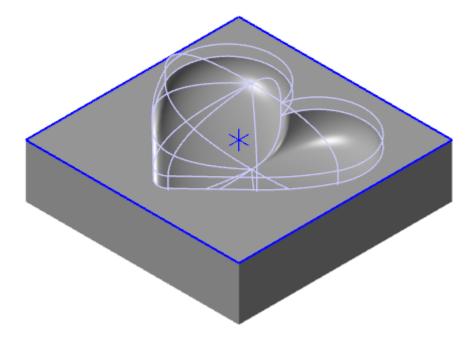
3. In the **Boolean** function panel, select **Remove** and then click **Add Selection**. By choosing **Remove**, the solid heart will be taken away from the block leaving an impression that will become the candy mold.



4. Ensure that the **Body** selection filter is chosen in the **Solid Selection** dialog box, and then select the solid heart



5. Click **OK** in the **Boolean** function panel and the heart is removed from the block.



6. Click the Select all Entities by Color Quick Mask.

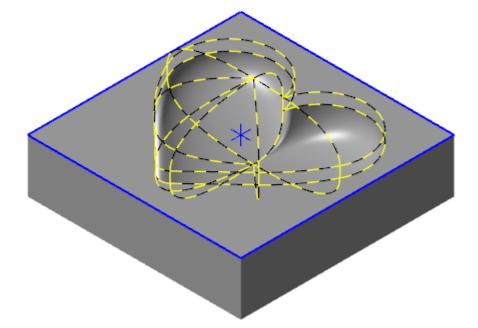


Quick Masks help you to quickly select entities in the graphics window. Many Quick Masks have two functions, Select all entities or Select only entities, (depending on whether you click the right or left side of the button).

7. In the **Select All** dialog box, ensure that **All entities** is chosen and then select the check box for the lavender color

Select	All	×
	All Entities	
	Transform Result	
	Transform Group	
	Group Manager	
_		
	Entities	
	Color	
	Level	
	Width	
	Style	
	Point	
	Miscellaneous	
2	* Ø	
	7	
	56	
	$\wedge \wedge \wedge$	
Su	e as	
Us	e Only Mask	
	⊯ √ ?	

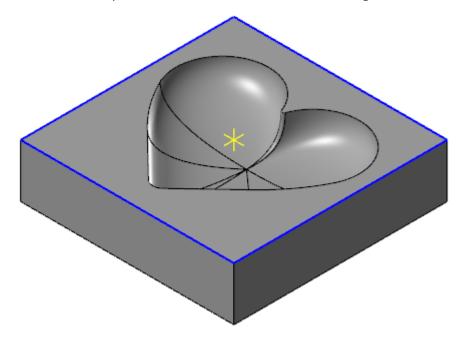
8. Click **OK** and the wireframe heart geometry is selected in the graphics window.



- 9. Press [**Delete**] on your keyboard.
- 10. Click the Select all point entities Quick Mask.



This selects the point that was created from the Bounding Box.



- 11. Press [Delete] on your keyboard to remove the point.
- 12. Save your file.

Exercise 7: Adding a Containment Boundary

A containment boundary is used to limit the areas of the part that can be machined. In this exercise, you will add a wirefame containment boundary to the heart shape. When programming the toolpaths you will set the containment boundary strategy to the **Stay Inside**. This allows the tool to machine the area inside the geometry and not pass through the boundary.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.
- 2. Click the Levels tab to bring the Levels Manager to the forefront.

Display:		⊖ Used ⊖ Named
		Used or named
		O Range
		1 100
Toolpaths	Solids	Plane Levels Recent Functions

3. Click Add a new level, (green plus sign icon).

L	evels				~	д	×
C	🕂 🔍 📚 🛸 🗐 🔅 - 🔞						
	Nu 🔺	Visible	Name	Level Set	Entities		
	🖌 1	х	Heart		5		

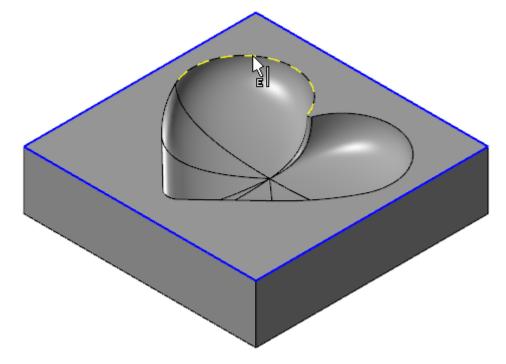
4. Click Add a new level, (green plus sign icon). In the Levels Manager enter Wireframe in the Name field of the new level.

Number:	2
Name:	Wireframe
Level set:	
Display:	⊖ Used
	○ Named
	 Used or named

Notice that level 2 is the active level. The new geometry you will create in this exercise will reside on this level. Ensure that the Vise level (101) is not visible. The Visible column should be empty. If there is an X in the column click it to remove the X and hide the level in the graphics window. 5. On the **Wireframe** tab, click **Curve One Edge**.



6. Press the [Shift] key and select the edge of the heart. This method selects all tangent edges.



7. Click OK in the Curve On One Edge function panel.

Curve On One Edge	ч ×
3	
Basic	
Break Angle	\bigcirc
30.0	▼ [▲]
Mesh Edge Angle	٢
Tolerance: 28.0	• \$
Settings	٢
Fit arcs and lines	

The new wireframe entities appear on level 2 in the Levels Manager.

Levels					Ŧ	д	×	
+ < \$ \$ ∽ 🗄 🔅 • 0								
	Num 🔺	Visible	Name	Level Set	Entities			
	1	х	Heart		5			
C	√ 2	х	Wireframe		8			
	101		Vise		4			

8. Save your file.

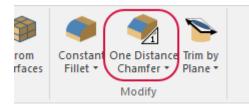
Exercise 8: Adding a Chamfer to the Mold

In this exercise, you will use one of Mastercam's chamfer functions to add a bevel to the edge of the heart impression. Adding a chamfer to the mold edge will make it easier to remove the candy from the mold.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.
- 2. In the Levels Manager, click level **1**, Heart to make it the active level (designated by a green check), and clear the visibility for level **2**, **Wireframe**.



3. On the Solids tab, click One Distance Chamfer.

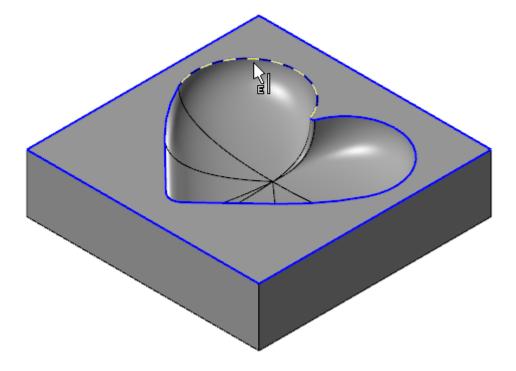


The **Solid Selection** dialog box displays and Mastercam prompts you to select the entities to chamfer.

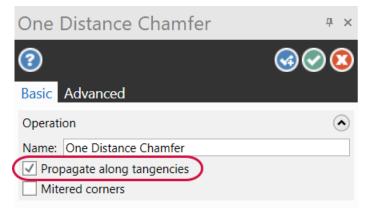
4. Click **Edges** to set the selection filter to only select edges. Deselect **Face**, **Body**, or **From back** if they are selected.

Solid Selection	×
\oslash	
✓	

5. Select one segment of the heart's edge and click **OK** in the **Solid Selection** dialog box.



6. In the **One Distance Chamfer** function panel, select **Propagate along tangencies** to chamfer all edges that are tangent to the one you selected.



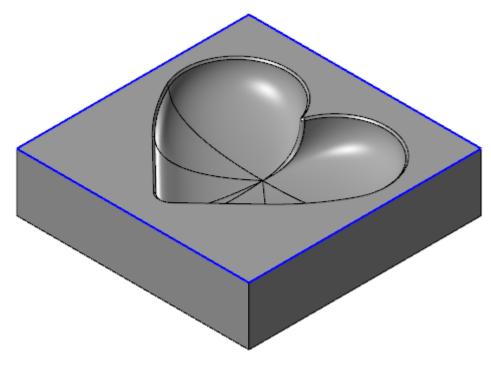
NOTE

You can also hold down the [**Shift**] key when selecting the edge to chamfer and all tangent edges will be selected automatically.

7. Enter a value of **0.75** in the **Distance** field and then click **OK**.

One Distance Chamfer	Ψ ×
②	 ⊗ ⊗
Basic Advanced	
Operation	\bigcirc
Name: One Distance Chamfer	
Propagate along tangencies	
Mitered corners	
Selection	٢
Edge 1	
Edge 2	
Edge 3	-
Distance	۲
0.75	- ÷

The heart has chamfers on all edges. Hold down the middle mouse button and rotate your part to see the all of chamfered edges.



8. Save your file.

Exercise 9: Adding Stick Slot Geometry

In this exercise, you will create the geometry required to machine a slot in the mold to hold a candy stick. The slot will be angled at five degrees to ensure that the stick is firmly embedded in the candy and seals the opening to prevent leakage of the liquid chocolate.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.
- 2. On the **View** tab, click **Show Axes** and **Show Gnomons** to activate them. Use the function's drop downs to choose which axes and gnomons display in the graphics window.



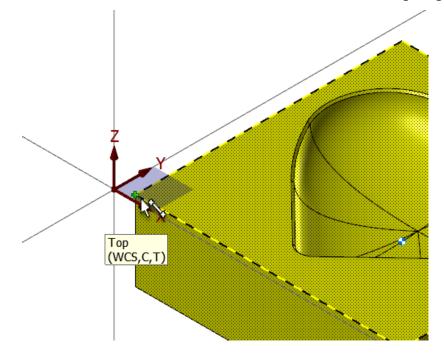
3. Set the **2D/3D** toggle on the **Status Bar** to **3D**.

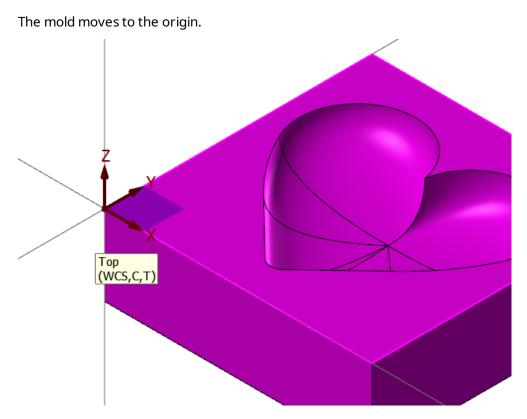


- 4. Right-click in the graphics window and set your view to **Isometric (WCS)**.
- 5. Right-click and choose **Fit** to center your part in the graphics window.
- 6. On the Transform tab, click Move to Origin.



7. Click the lower left corner of the mold as shown in the following image.





The mold color is now purple which is the results color for a transformation.

8. Click Clear Colors on the View tab to return all entities their default colors.



- 9. Select **Show Axes** and **Show Gnomons** to hide them in the graphics window.
- 10. Set that the **2D/3D** toggle on the **Status Bar** is set to **2D**. Setting your construction mode to 2D will place any geometry you create parallel to the current construction plane (**Top (WCS**) at the current system Z depth.

11. In the Planes Manager, click in the **C** column to set your construction plane (Cplane) to **Front**. The construction plane is the plane on which you will create the geometry.

Planes							▼ Ŧ ×
+ - = =	r		× •	S -	💋 - t	2 • 🕐	
Name	G	WCS	С	Т	Offset	Display	Section
🖌 Тор		WCS	\sim				
< Front			(c)	т			
Back			\sim				
Bottom							
Right							
Left							
✓ Isometric	G						
Isometric rev							
Trimetric							

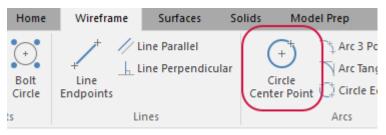
12. In the Levels Manager, click Add a new level.



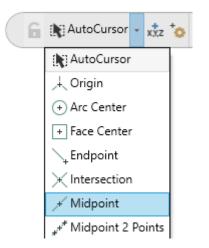
13. Enter **Slot geometry** in the **Name** field of the new level.

Number:	3
Name:	Slot geometry
Level set:	
Display:	⊖ Used
	○ Named

- 14. Right-click in the graphics window and set your view to **Front (WCS)**. Choose **Fit** to center your part in the graphics window.
- 15. On the Wireframe tab, click Circle Center Point.



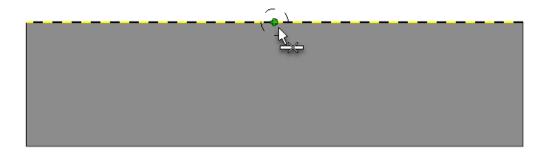
16. Select AutoCursor, Midpoint to set a snap to position.



17. In the **Circle Center Point** function panel, enter **5.5** in the **Diameter** field and then click the **Lock** icon to maintain that diameter.

Circle Center Point	Р Х
Basic	S S 2
Entity Method: Manual Tangent	۲
Center Point Reselect	۲
Size	٢
Radius: 2.75	- ↓ 🔒
Diameter: 5.5	• ‡ 🔒
Settings	۲
Create surface	

18. Hover over the top edge of the mold until the center point displays and click to set the location of the circle.

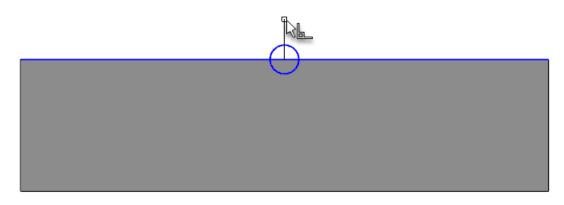


19. In the **Circle Center Point** function panel, unlock the diameter and then click **OK**.

NOTE

The function panel will maintain settings from session to session, unlocking the diameter before closing is a good practice.

- 20. On the Wireframe tab, click Line Endpoints.
- 21. Click the center point of the circle and drag up approximately 5 mm. Click to set the second endpoint.

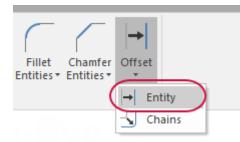


22. In Line Endpoint function panel, enter a Length of 5.23 and an Angle of 90.

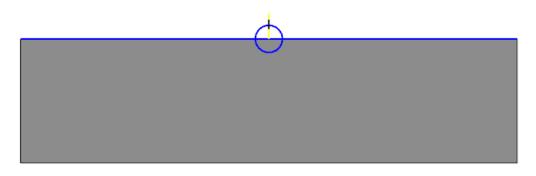
Line Endpoints	Ψ ×
Basic	⊗⊘0
Entity	۲
Type: Freeform Tangent Horizontal Vertical Method: Midpoint Multi-line	
Endpoints 1 2	۲
Dimensions	۲
Length: 5.23	- ‡ 🔒
Angle: 90.0	- ‡ 🔒

23. Click **OK** to accept the values.

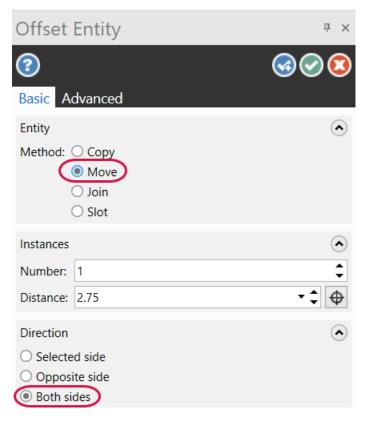
24. On the **Wireframe** tab, click **Offset Entity**.



25. Select the line you just drew and then click to the left in the graphics window to indicate the direction to offset.



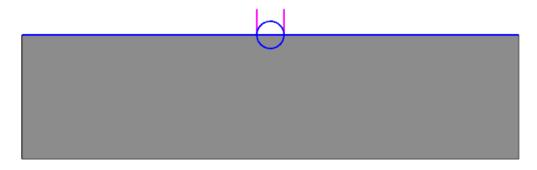
26. On the **Offset Entity** function panel, choose **Move** and **Both sides** for the **Direction**.



27. In the **Distance** field, right-click and select **R** = **Radius of an arc**.

	X = X coordinate of a point	
	Y = Y coordinate of a point	
	Z = Z coordinate of a point	
	R = Radius of an arc	
	D = Diameter of an arc	
	L = Length of an entity	
	S = Distance between 2 points	
	H = Solid hole diameter	
	Q = Quick drill tables	
	B = Tap tables	
	Angle	•
	Cut	Ctrl+X
	Сору	Ctrl+C
	Paste	Ctrl+V
_		

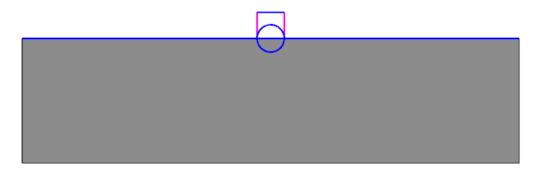
28. Select the arc. The lines move to be tangent to the arc.



- 29. Click **OK** in the **Offset Entity** function panel.
- 30. On the Wireframe tab, click Line Endpoints. Ensure that the Method is Two endpoints.

Line E	ndpoints	Ψ ×
?		
Basic		
Entity		۲
Type:	 Freeform 	
	✓ Tangent	
	○ Horizontal	
	○ Vertical	
Method:	Two endpoints	
	○ Midpoint	
	○ Multi-line	

31. Draw a line between the two endpoints of the lines and click **OK**.



32. Right-click in the graphics window and click **Clear Colors** to return the purple results color to the default color.



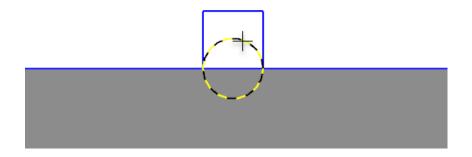
33. On the Wireframe tab, click Divide.



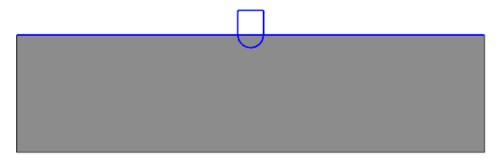
34. In the **Divide** function panel, choose **Trim**.



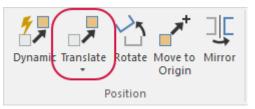
35. Click the top of the arc to remove that section.



36. Click **OK** in the **Divide** function panel. The geometry should look like the following image.



37. On the **Transform** tab, click **Translate**. You will be using the Translate function to move the geometry into the proper position.



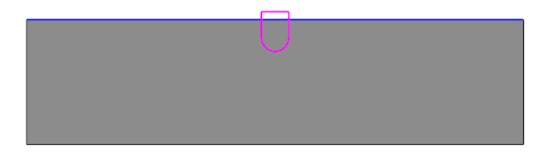
38. Select the geometry you created and then click **End Selection**.

End Selection	O Clear Selection

39. In the **Translate** function panel select **Move** as the **Method** and enter **-3.64** in the **Y** axis field. Entering a negative value places the circle below the Y axis.

Translate	ч ×
Basic Advanced	< <> <> <
Entity Method: Copy Move Join	۲
Selection Reselect	۲
Instances	\odot
Delta X: 0.0 Y: -3.64 Z: 0.0	• • • • • • • • • • • • • • • • • • •
Vector From/To	\bigcirc
Polar	♥
Direction	\odot

40. Click **OK** to accept the values.



41. On the Transform tab, click Translate.

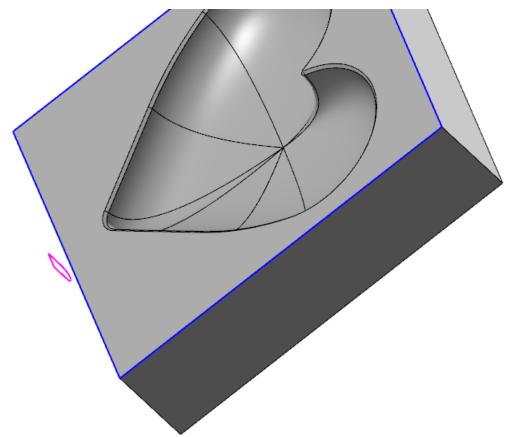
42. Click the **Quick Mask**, **Select all results entities** to quickly select the geometry you just moved.



43. In the **Translate** function panel, enter **1.76** in the **Z** field to move the geometry forward.

Translate	₽ ×
3	
Basic Advanced	
Entity	
Method: O Copy	
Selection	۲
Reselect	
Instances	۲
Number: 1	÷
Distance: Between Total	
Delta	۲
X: 0.0	▼ ‡
Y: 0.0	*
Z: 1.76	▼ ‡
Vector From/To Reselect	٢

44. Click **OK**. Rotate your part to view the geometry.



45. In the Planes Manager, set the construction plane to **Right**.

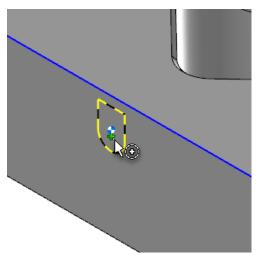
Planes							▼ Ŧ ×
+ + ⊨ + Q + =	r		•	s.	💋 - t	3 • 🛛	
Name	G	WCS	С	Т	Offset	Display	Section
🗸 Тор		WCS					
Front							
Back							
Bottom							
Right			С	Т)		
Left							
 Isometric 	G						
Isometric rev							
Trimetric							

- 46. On the **Transform** tab, click **Rotate**.
- 47. Select the geometry by clicking the entities or use the **Quick Mask**, **Select all results entities**, and then click **End Selection**.

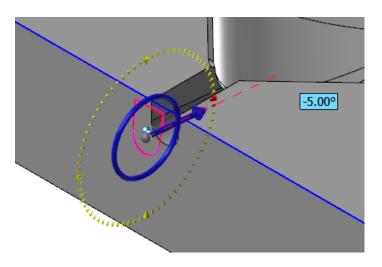
48. In the Rotate function panel, click Rotation Center Point Reselect.

Rotate	Ψ ×
2	G 🛇 😢
Basic Advanced	
Entity Method: Copy Move Join	
Selection Reselect	۲
Rotation Center Point Reselect	۲

49. In the graphics window, click the center point of the original arc which appears as a green AutoCursor point, (not the blue and white rotation point).



50. Hover over the Dynamic Gnomon until it highlights and then click and rotate it to **-5.00** degrees, or enter the value in the on-screen field and press **[Enter]**.



ΝΟΤΕ

Alternately, you can also enter -5.00 in the Angle field of the Rotate function panel.

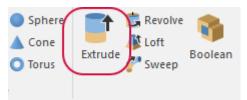
51. Choose **Move** in the **Rotate** function panel and click **OK**.

Rotate		Ψ ×
(?)		G O S
Basic A	dvanced	
Entity		
Method:	Copy Move Join	
Selection		۲
Reselec	t	
Rotation (Center Point	
Reselec	rt	
Instances		۲
Number:	1	*
Angle:	-5.0	- +
Distance:	 Angle between 	
	Total sweep	
Method:	 Rotate Translate 	
Remov	e	
Reset		

52. Right-click and choose **Right (WCS)** to verify the results.

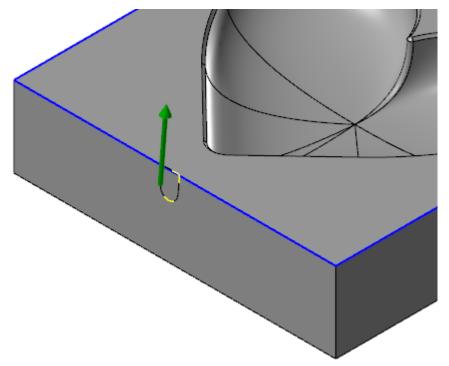


- 53. Return the view to Isometric (WCS).
- 54. On the **Solids** tab, click **Extrude**.



The Wireframe Chaining dialog box displays.

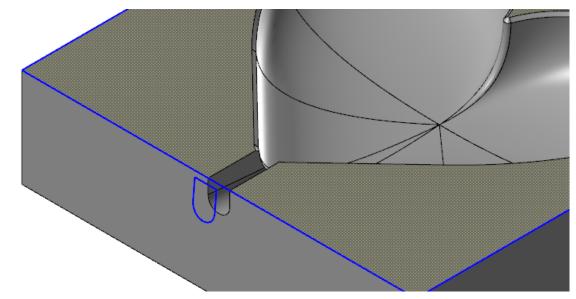
55. Select the geometry and then click **OK**.



56. In the **Solid Extrude** function panel, choose **Cut Body** as the **Type**, and enter a **Distance** of **25.0**.

Solid Extrude	4 ×
3	@ @ (2)
Basic Advanced	
Operation	٢
Name: Extrude Cut	
Type: O Create body	
Cut body	
O Add boss	
Target: solid	
Create a single operation	
Automatically determine operation type	
Chains	۲
Chain 1	
	↔ & &
Distance	\bigcirc
Distance: 25.0	•
	 • •
Distance: 25.0	ی ج ک

57. Click OK.



- 58. Return to the Levels Manager and notice that the four entities you just created on level **3**, **Slot geometry**. Experiment with the visibility to see what shows in the graphics window.
- 59. Save your file.

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. You can use an STL file in a Solids Boolean remove operation.
 - a. True
 - b. False
- 2. The 2D construction mode places geometry parallel to the current construction plane.
 - a. True
 - b. False
- 3. Which Solid Boolean option combines two solids into one solid?
 - a. Add
 - b. Remove
 - c. Common
- 4. Which Solid Boolean option leaves an impression of one solid in another solid?
 - a. Add
 - b. Remove
 - c. Common
- 5. Which of the following does **not** set the size of the fillet in the Face to Face Fillet function?
 - a. Diameter
 - b. Radius
 - c. Width
- 6. Which function on the Transform tab changes the angle of an entity or a group of entities.
 - a. Dynamic
 - b. Translate
 - c. Rotate
 - d. Project
- 7. List some characteristics in a model that can hurt the chances of a casting being successfully released from the mold.

Quick Part Series - Chocolate Mold—1: Heart Mold Design



Selection of the proper fixture is important to successful machining. The choice of fixture involves consideration of the size of the piece to be machined, and the ability to machine around the exterior and the interior of the piece successfully, while avoiding the fixture itself.

For this tutorial, the fixture selected is a standard machinist's vise. The vise is elevated on parallels to allow machining of the exterior and interior of the part.

Goals

- Explore the machinist vice provided with this tutorial
- Understand fixturing options
- Experiment with moving your part to the machine origin

Exercise 1: Moving the Mold to the Origin

In this exercise, you will move the candy mold to the origin for the provided machinist vice on the default the mill machine.

WARNING

This project is completed using a specific machine and machinist vise model provided with this tutorial. The setup and fixturing of your machine may vary.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous chapter should be open in Mastercam.
- 2. On the **View** tab, click **Show Axes** and **Show Gnomons** to activate them. Use the function's drop downs to choose which axes and gnomons display in the graphics window.



3. Set the **2D/3D** toggle on the Status bar to **3D**.



- 4. Right-click in the graphics window and set your view to **Isometric (WCS)**.
- 5. Choose **Fit** to center your part in the graphics window.

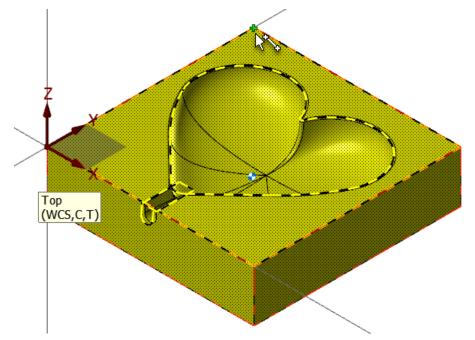
6. In Levels Manager, make the **Heart**, **Wireframe**, and **Slot** geometry levels visible and make level **1** the active level.

Levels	•	д	×							
+ 9, 📚 🛸 🗄 🔅 * 🔞										
Num 🔺	Visible	Name	Level Set	Entities						
✓ 1	Х	Heart		5						
2	х	Wireframe		8						
3	х	Slot geometry		4						
101		Vise		4						

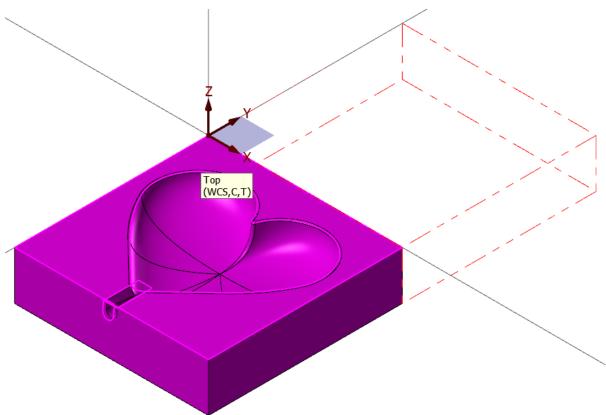
7. On the Transform tab, click Move to Origin.



8. Click the upper left corner of the mold as shown in the following image.



9. The mold moves to the origin.



- 10. The mold color is now purple which is the results color for a transformation. Click **Clear Colors** on the **View** tab to return all entities their default colors.
- 11. You can click **Show Axes** and **Show Gnomons** to hide them in the graphics window.

Exercise 2: Choosing a Machine and Setting Up Stock

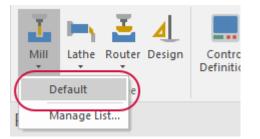
In this exercise, you will choose a machine and setup your stock.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.
- 2. Ensure that the **2D/3D** toggle on the Status bar is set to **3D**.
- 3. Click the **Planes** tab to bring the Planes Manager to the forefront.

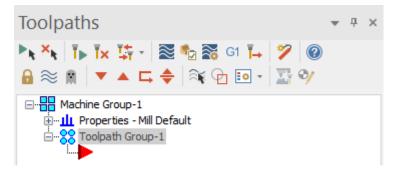
4. Click in the WCS column for the Top plane and then click the Set your current WCS, construction plane, and tool plane with their origins to the selected plane.

Planes									
+ * ▶ * ♀ (═♪ 🗄 🌣 * 🔄 * 💋 * 🕃 * 🔘									
Name	G	WCS	С	Т	Offset	Display	Section		
🖌 Тор	(WCS)с	Т					
Front									
Back									
Bottom									
Right									
Left									
✓ Isometric	G								
Isometric rev									
Trimetric									

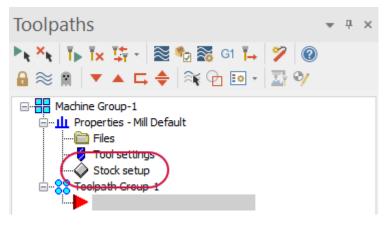
5. On the Machine tab, choose the Default mill machine from the drop-down.



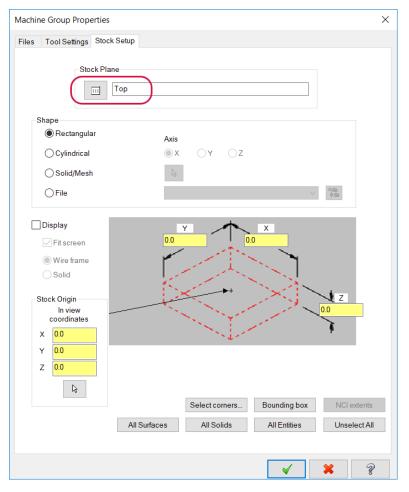
6. Click the **Toolpaths** tab to bring the **Toolpaths Manager** to the forefront. Note that **Machine Group 1** is the **Mill Default MM**.



7. Expand the **Properties** group.



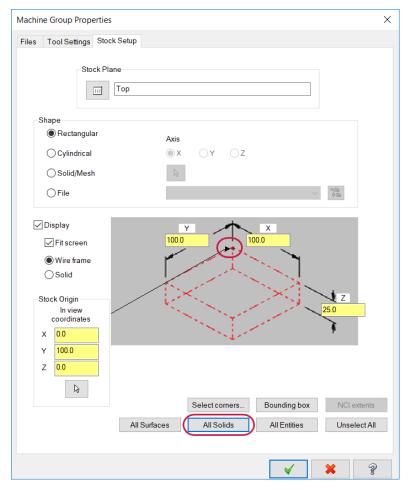
8. Click **Stock setup** to open the **Stock Setup** page of the **Machine Group Properties** dialog box. Confirm that the **Stock Plane** is set to **Top**.



NOTE

If the **Stock Plane** is incorrect, you can click the icon and choose the correct plane from the **Plane Selection** dialog box.

9. In the illustration, choose the top, back point to set the Stock Origin and then click All Solids.



The values in the Y, X, and Z fields update to the measurements corresponding to the stock you created (100.0, 100.0, 25.0).

- 10. Click **OK**.
- 11. Save your file.

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. If you do not need to cut the outside edge of a part, a vise can be used to hold the stock.
 - a. True
 - b. False
- 2. You can machine (cut) on the outside of the stock only if the cut depth does not go deeper than the amount of stock sticking out above the vise jaws.
 - a. True
 - b. False
- 3. The Move to Origin function...
 - a. Moves the origin to a specific location on the part
 - b. Moves the part to the origin
 - c. None of the above
- 4. In Stock Setup, the only way to enter the size of the stock is to manually type in the value.
 - a. True
 - b. False
- 5. In Stock Setup, you can display the stock in the graphics window to confirm the orientation and location of the part.
 - a. True
 - b. False
- 6. What are some benefits of a vise versus hold-down clamps when machining a part?
- 7. What should you consider when you use a vise to hold a part?
- 8. List some things you can do to ensure that your part will more easily release from your mold?

Quick Part Series - Chocolate Mold—2: Fixturing the Stock

CHAPTER 3 ROUGH MOLD PROGRAMMING

A roughing toolpath is typically used to remove large areas of unwanted material to produce a shape that is similar to the final shape. Using a roughing toolpath followed by a finish toolpath can reduce the time it takes to machine a part.

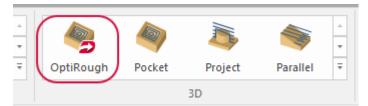
Goals

- Program a rough toolpath
- Understand the concepts of machining and avoidance geometry
- Understand and apply a containment boundary to a toolpath
- Explore tool libraries including filtering by tool type
- Experiment with toolpath verification using Mastercam Simulator

Exercise 1: Creating the OptiRough Toolpath

In this exercise, you will program a OptiRough toolpath to rough out the heart mold.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous chapter should be open in Mastercam.
- 2. Right-click and choose Fit and set your view to Isometric (WCS).
- 3. In the Levels Manager, make sure the Heart and Wireframe levels are visible.
- 4. On the Mill Toolpaths contextual tab, click OptiRough in the 3D group.

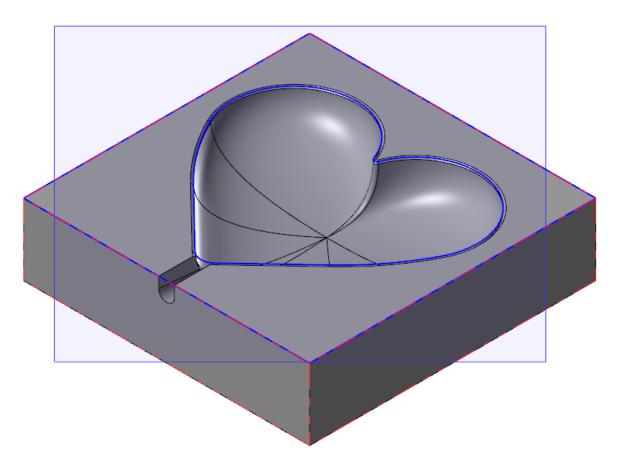


The **Model Geometry** page of the **Dynamic OptiRough** dialog box displays.

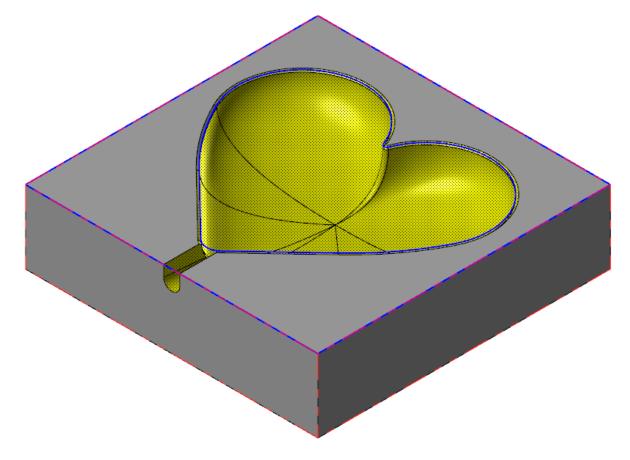
5. Click Select entities in the Machining Geometry section.

🗊 									
Model Geometry	Machining Geometry	/			Avi	oidance Geometr	y		
Toolpath Control	Name	Entities	Wall Stock	Floor Stock		Name	Entities	Wall Stock	Floor Stock
Holder	machining	0	1.0	1.0		avoidance	0	0.0	0.0
O Stock Cut Parameters									
Transitions									
Steep / Shallow									
Linking Parameters									
Arc Filter / Tolerance									
Planes									
Coolant									
Canned Text Misc∀alues									
Misc Values Axis Control									
Avis Combination									
ick View Settings									
ool 20. FLAT END									
ool Diameter 20									
omerRadius 0									
eed Rate 7.1625									
pindle Speed 3500									
oolant Off									
ool Length 0 ength Offset 229	<			>	<				>
iameterOffset 229									N
plane/Tpla Top		×.	+				F	+	6
ormula File Default.Formula									
	🔽 Display Remainde	er	15						
= edited									
= disabled							V	X (

6. Select the heart and slot geometry. You can select each section or use window select as shown in the following image.



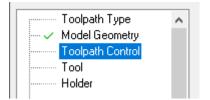
7. Rotate the part and make sure that all parts of the mold to be machine are selected.



- 8. Click End Selection to return to the Model Geometry page.
- For a rough toolpath you will designate a certain amount of stock to leave on the part. This stock will be removed with the finish toolpaths. Double-click the Wall Stock and Floor Stock fields of Machining Geometry to activate them and enter 1.0.

🎙 🗊 📙 🚮 🗐 🖷	\$	
Toolpath Type	Machining Geometry	
Toolpath Control	Name Entities Wall Stock Floor	r Stock
Holder	machining 21 1.0 1.0	

10. Click the **Toolpath Control** page in the tree control.

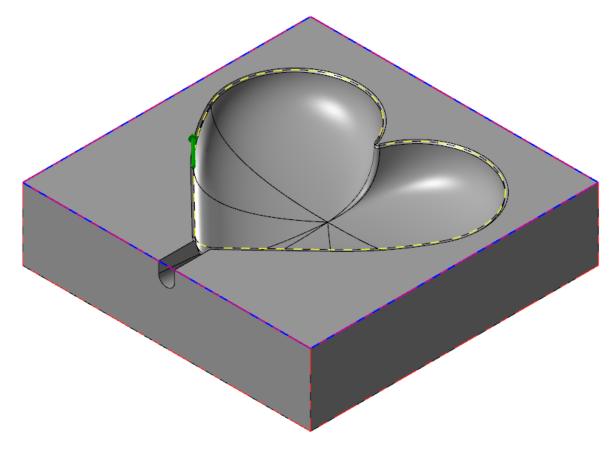


11. In this page you will choose the containment boundary to limit the area that will be machined. Click the **Boundary chains** select arrow.



The Wireframe Chaining dialog box displays.

12. Hold down the [Shift] key and select a segment of the containment boundary wireframe. [Shift+click] selects all tangent segments.



- 13. Click **OK** to close the **Wireframe Chaining** dialog box and return to the **Toolpath Control** page.
- 14. Select **Stay inside** for the **Strategy** to keep the toolpath inside the selected machining geometry.

15. Select **Center** to **Compensate to**. This results in a toolpath in which the center of the tool travels to the containment boundary.

Surface High Speed Toolpaths - D	ynamic OptiRough					×
🌹 🇊 🔒 👪 🗐 🗃 🍽						
Toolpath Type Model Geometry Toolpath Control Tool Holder O Stock Cut Parameters Transitions Steep / Shallow Linking Parameters Arc Filter / Tolerance Planes Coolant Canned Text Misc Values Axis Control Axis Control Axis Control Axis Control	Containment boundary Boundary chains: Include silhouette boundary Strategy: From outside Stay inside Contain: Tool tip	(1) <table-cell></table-cell>		-(
Quick View Settings	 Tool contact point 					
Tool 20. FLAT END Tool Diameter 20 Comer Radius 0	Compensate to: Inside		Approximate start point	ß		
Corner Radius 0 Feed Rate 7.1625	Outside		Curves			
Spindle Speed 3500 Coolant Off	Offset distance:	0.0		(0)	8	
Tool Length 0 Length Offset 229	✓ Include tool radius		Points			
Diameter Offset 229 Cplane / Tpla Top Formula File Default Formula Axis Combinat Default (1)	Total offset distance:	0.0		(0)	•	
✓ = edited						
🧭 = disabled			 ✓ 	×	0	?

Surface High Speed Toolpaths - I	Dynamic OptiRough					×
🎙 🗊 🔒 🖬 🗏 🗃						
1						
Toolpath Type ✓ Model Geometry ✓ Toolpath Control Tool Holder	# Assembly Tool	Name HolderN Dia.	Cor. r L Corne	iameter: 20.0 r radius: 0.0		
Stock						
Transitions				Tool #: 229	Length offset:	229
				Head #: <mark>-1</mark>	Diameter offset:	229
Arc Filter / Tolerance Planes Coolant Canned Text Misc Values Aris Control				RCTF	· ·	CW ~
Avis Combination	<		> Fe	ed rate: 7.1625		
Quick View Settings		Right-click fo	ir options	FPT: 0.0005	cs	219.9183
Tool 20. FLAT END Tool Diameter 20 Corner Radius 0	Select library tool	-	Plun	nge rate: 7.1625 Force tool change	Retract rate:	7.1625 tract
Feed Rate 7.1625 Spindle Speed 3500	Tool inspection / change	- 10000 0	Comment			
Coolant Off Tool Length 0	Force retract every	10000.0 Millime	ters			^
Length Offset 229 Diameter Offset 229		40.0 Minutes	3			~
Cplane / Tpla Top Formula File Default.Formula Axis Combinat Default (1)	To batch					
✓ = edited	,					
 e disabled 				~	*	?

16. Click the **Tool** page in the tree control.

17. Click **Select library** tool to open the **Tool Selection** dialog box.

18. Deselect the Filter Active checkbox and then click Filter.

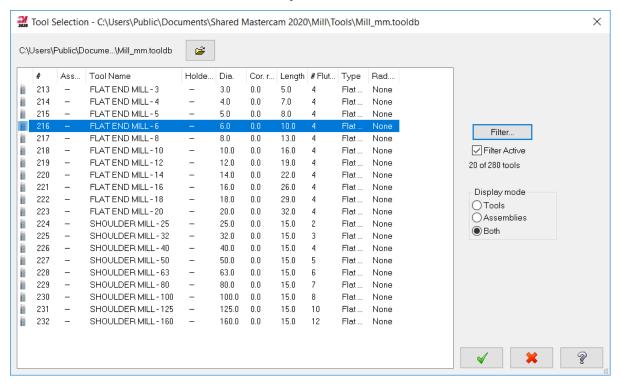
2020	Tool S	Selection - C:	\Users\Publi	c\Document	s\Share	d Maste	ercam 20	020\Mil	I\Tools\	Mill_mm.to	oldb		Х
C:1	Users\	Public\Docum	e\Mill_mm.to	ooldb 🖆	7								
	#	Assembly	Tool Name	Holder N	Dia.	Cor. r	Length	# Flut	Туре	Rad	^		
23	1	-	NC SPOT	-	6.0	0.0	17.0	1	Spot	None			
	2	-	NC SPOT	-	8.0	0.0	22.0	1	Spot	None			
	3	_	NC SPOT	-	10.0	0.0	26.0	1	Spot	None			
8	4	-	NC SPOT	-	12.0	0.0	30.0	1	Spot	None		Filter	
81	5	-	NC SPOT	-	16.0	0.0	34.0	1	Spot	None		Filler	
	6	-	NC SPOT	-	20.0	0.0	40.0	1	Spot	None		Filter Active	
	7	-	HSS/TIN	-	2.0	0.0	20.0	1	Drill	None		280 of 280 tools	
2	8	-	HSS/TIN	-	2.5	0.0	26.0	1	Drill	None			
44	~				0.0	~ ~	~~~~	-	— ••	• •			

The **Tool List Filter** dialog box displays.

19. Clear the filters by clicking **None**.

Tool List Filter						Tool Diameter
						Ignore ~
10000.00201	V		l			Radius Type
		4	Ų	Ũ		Tool Material
U	2	Ŵ				 ✓ Carbide ✓ User Def 1 ✓ Ti Coated ✓ User Def 2
4			l.	9		All None Copy job setup matl
		All	None			
	ation maskin	-	Unit mask			
No op	peration ma:	sking 🗸	No unit m	asking	\sim	
Reset all						✓¥?

- 20. Choose the Endmill1 Flat filter and then click OK.
- 21. Select the FLAT END MILL 6 from the library of tools and click OK.



- Tool diameter: 6.0 # Tool Name Holder N... Assembly... Dia. Cor. r... L Corner radius: 0.0 216 FLAT EN... 0.0 6.0 1 Tool name: FLAT END MILL - 6 Tool #: 216 Length offset: 216 Head #: 0 Diameter offset: 216 Spindle direction: CW RCTF Feed rate: 12500.0 Spindle speed: 12000 < > CS 226.2017 FPT: 0.75 Right-click for options Retract rate: 2000.0 Plunge rate: 1000.0 Filter... Select library tool... Filter Active Rapid Retract Force tool change Tool inspection / change Comment 10000.0 Millimeters Force retract every 40.0 Minutes To batch
- 22. Enter the following values for the tool.

CAUTION These values may vary depending on your machine and material.

23. Click the Cut Parameters page in the tree control.

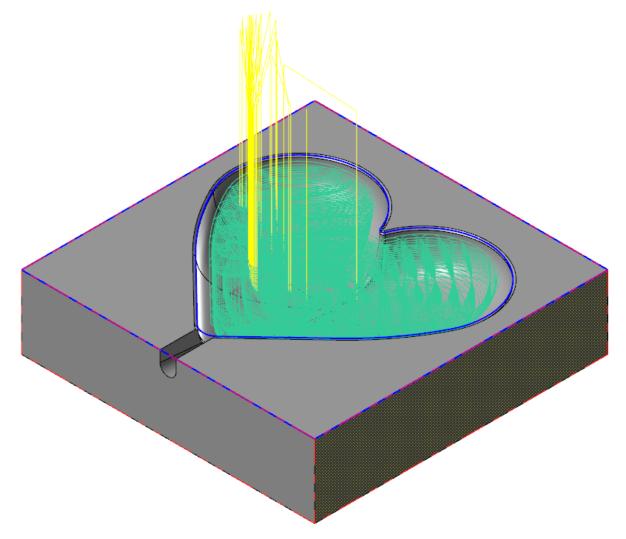
24. Select the **Stepup** checkbox and enter the following values for the **Passes**.

Cut style Cut method Conventional feed rate Tip compensation Optimize stepups Optimize stepdowns	Climb ~ 12500.0 Tip ~ By depth ~		
Stepdown Stepup Mill vertical walls Minimum toolpath radius	% 4.5 % 0.6 % 0.6	Motion > Gap size, retract Never Gap size Distance % of tool diameter	✓30.0500.0
Motion < Gap size, micro lift Micro lift distance Back feedrate	0.25		

NOTE

The slope of the surface you are machining determines the Stepup value. The more vertical the surface the lower the Stepup value.

25. Click **OK**. (All other pages retain the default settings.) The toolpath appears on your part.



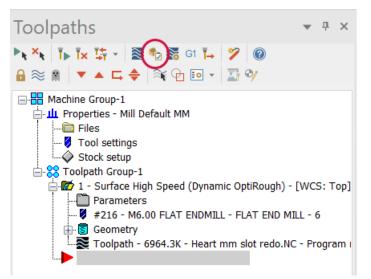
26. Save your file. In the next exercise you will verify the toolpath.

Exercise 2: Verifying the Toolpath

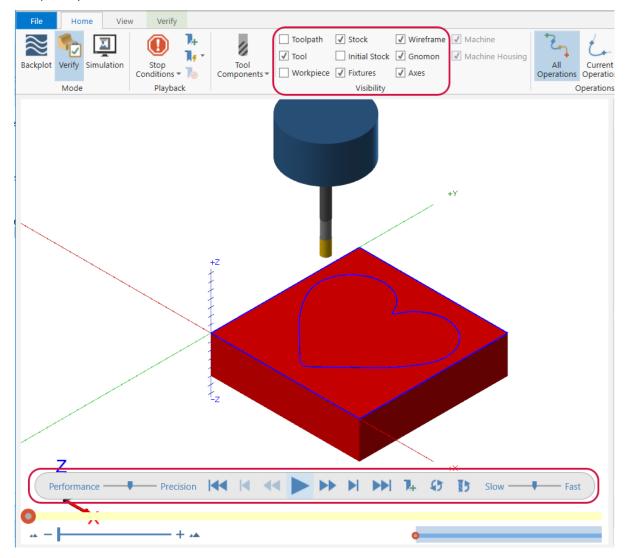
In this exercise, you will use Mastercam Simulator to view and verify the Dynamic OptiRough toolpath.

1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.

2. In the Toolpaths Manager, click Verify.



The part opens in Mastercam Simulator.



3. Select the **Visibility** checkboxes on the ribbon to experiment with what shows in the graphics window.

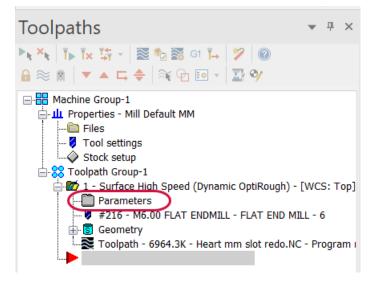
4. Use the playback bar at the bottom of Mastercam Simulator to run the simulation. The simulation shows that the toolpath has many very shallow passes and the total time for the OptiRough toolpath is lengthy.

4	Toolpath Info	
	Feed Length	23973.428
	Feed Time	3min 15.81s
	Min/Max X	10.187 / 89.809
	Min/Max Y	15.757 / 84.348
	Min/Max Z	-8.569 / 50.000
	Rapid Length	2124.842
	Rapid Time	10.20s
	Total Length	26098.444
(Total Time	3min 26.08s

NOTE

Your Toolpath Info time may vary.

- 5. Close the **Mastercam Simulator** dialog box and return to Mastercam to make adjustments to the OptiRough toolpath.
- 6. In Toolpaths Manager, click **Parameters** for the Dynamic OptiRough toolpath.



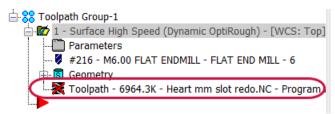
7. Click the Cut Parameters page in the tree control.

	Toolpath Type	^
	Model Geometry	
	Toolpath Control	
	Tool	
	Holder	
0	Stock	
	Cut Parameters	
	Transitions	
	Steep / Shallow	
+	Linking Parameters	

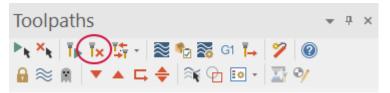
- 8. Enter a larger **Stepdown** value which determines the spacing between adjacent passes.
- 9. Enter a larger **Stepup** value as shown in the following image.

Passes		
Stepover	75.0	% 4.5
Stepdown	75.0	¥ 4 .5
🗹 Stepup	15.0	\$ 0.9
🗌 Mill ver	tical walls	

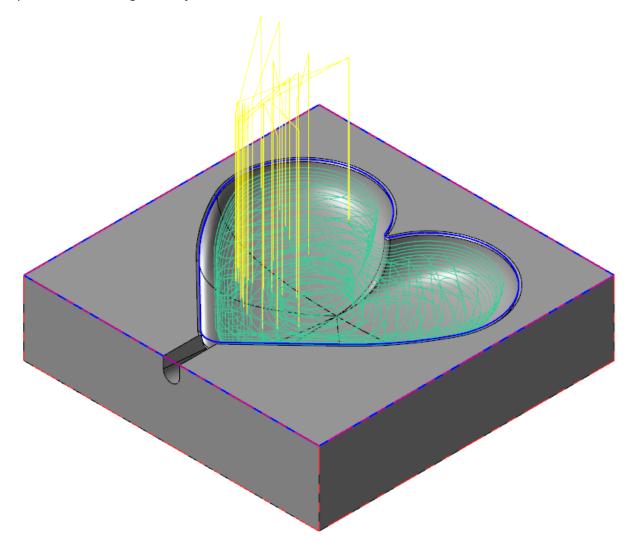
- 10. Click **OK**.
- 11. In the Toolpaths Manager you will notice that the Dynamic OptiRough toolpath is marked dirty, indicating that it must be regenerated.



12. Click Regenerate all dirty toolpaths on the Toolpaths Manager toolbar.

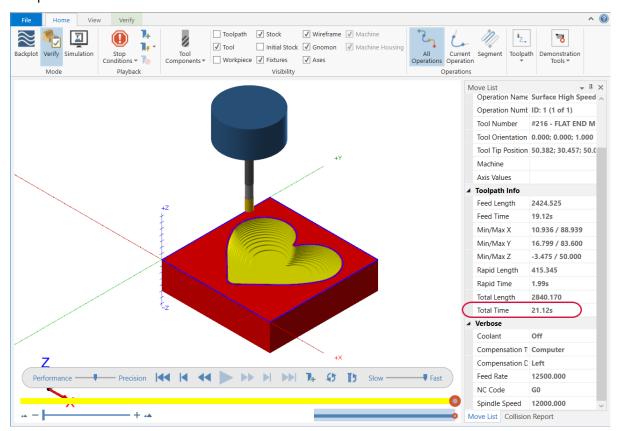


The regenerated toolpath shows in the graphics window. Note that the number of toolpath passes has been significantly reduced.



13. Click **Verify** to return to Mastercam Simulator.

14. Run the simulation again and see that the total time has been reduced but the results are still acceptable.



15. Save your file.

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. A finishing toolpath always follows a roughing toolpath.
 - a. True
 - b. False
- 2. Verify only simulates toolpath motion.
 - a. True
 - b. False
- 3. Once they are created, toolpaths can not be modified.
 - True
 - False
- 4. When you create a roughing toolpath, you must enter a stock to leave amount.
 - a. True
 - b. False
- 5. The cutting tool for a roughing toolpath must be same size or less than the smallest, inside radius of the surface you are cutting.
 - a. True
 - b. False
- 6. The primary purpose of a roughing toolpath is to remove large areas of unwanted material.
 - a. True
 - b. False
- 7. Roughing toolpaths can reduce the amount of time it takes to completely machine a part.
 - a. True
 - b. False

Quick Part Series - Chocolate Mold—3: Rough Mold Programming

CHAPTER 4 FINISH MOLD PROGRAMMING

Finish toolpaths remove a small amount of material and produce the final surface quality of the part. Typically a finish toolpath follows a roughing toolpath, but that is not required.

When a finish toolpath is used in conjunction with a roughing toolpath, the finish toolpath removes the material designated as stock to leave on walls or floors of the part. Programming a part using rough and finish toolpaths usually produces a part in the least amount of time.

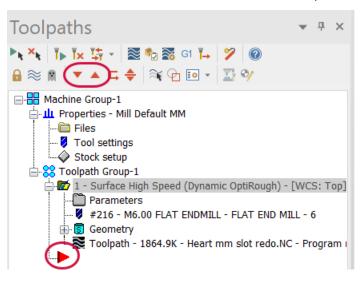
Goals

- Program a finish toolpath
- Understand the concepts of machining and avoidance geometry
- Understand and apply a containment boundary to a toolpath
- Explore tool libraries including filtering by tool type
- Experiment with toolpath verification using Mastercam Simulator

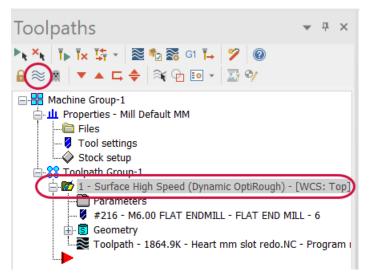
Exercise 1: Creating the Scallop Toolpath

In this exercise, you will program a finish toolpath on top of the OptiRough toolpath to create a smooth finish on the mold surface.

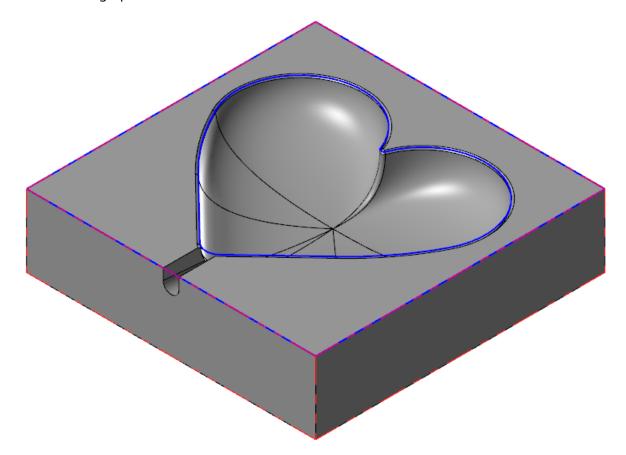
- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous chapter should be open in Mastercam.
- 2. Right-click and choose Fit and set your view to Isometric (WCS).
- 3. In the Levels Manager, make the heart and the wireframe containment boundary levels visible.
- 4. In Toolpaths Manager, verify that the red insert arrow is below the OptiRough toolpath. Use the **Move insert arrow** controls to move the arrow up and down in the Toolpaths Manager.



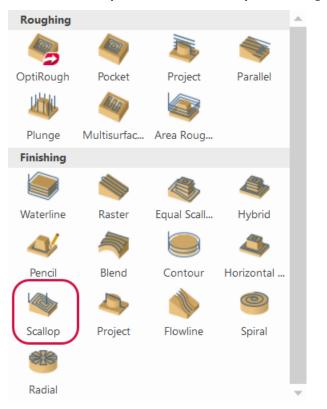
5. Select the Dynamic OptiRough toolpath. A green check on the folder indicates that it is selected.



6. Click **Toggle display on selected operations** as shown in the previous image. The toolpath is hidden in the graphics window.



7. On the **Mill Toolpaths** tab, click **Scallop** in the 3D group.



NOTE

Click the expander button in the 3D group to view the entire toolpath gallery.

Project	Parallel 🗐
	Project

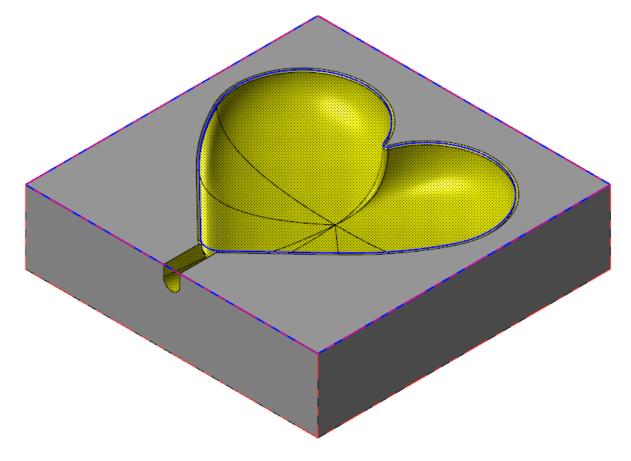
The **Model Geometry** page of the **Scallop** dialog box displays.

8. Click Select entities in the Machining Geometry section.

<	>
	r + 🔖
🗹 Display Remainder	15

9. Use window select to select the heart and slot geometry.

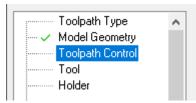
10. Rotate the part and make sure that all parts of the mold to be machine are selected.



- 11. Click End Selection to return to the Model Geometry page.
- 12. The finish toolpath will remove the stock to leave amounts that were entered for the OptiRough toolpath. Click **Reset stock values** to return **Wall Stock** and **Floor Stock** to **0.0**.

-Mac	hining Geometry			
	Name	Entities	Wall Stock	Floor Stock
	machining	20 🤇	0.0	0.0
<				>
	(r) +	k
	· · · · · · · · · · · · · · · · · · ·			

13. Click the **Toolpath Control** page in the tree control.



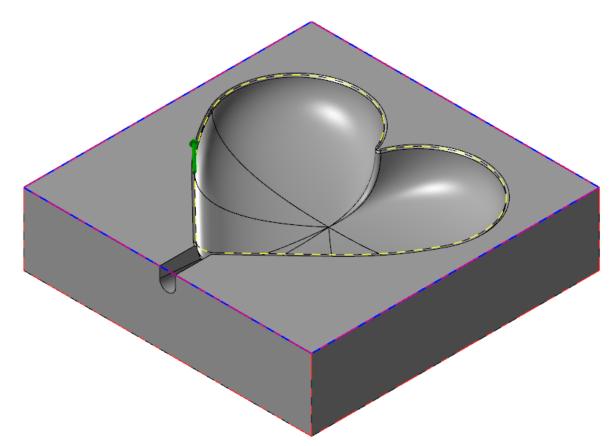
In this page you will choose the containment boundary to limit the area that will be machined.

14. Click the **Boundary chains** select arrow.



The **Wireframe Chaining** dialog box displays.

15. Select the containment boundary wireframe.

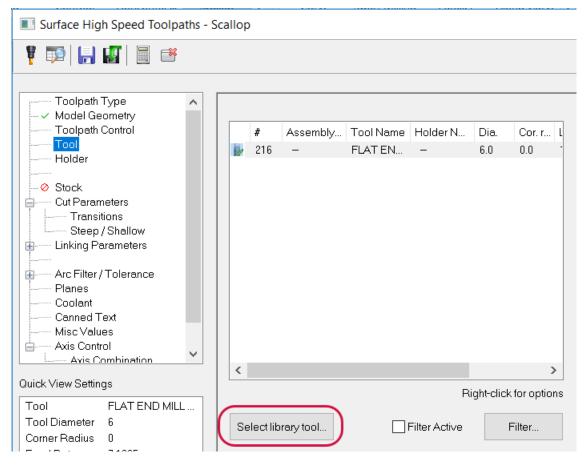


16. Click **OK** to close the **Wireframe Chaining** dialog box and return to the **Toolpath Control** page.

17. Select Center to Compensate to.



- 18. Click the **Tool** page in the tree control.
- 19. Click Select library tool.



20. Deselect the Filter Active checkbox and then click Filter.

Filter
Filter Active
280 of 280 tools

The **Tool List Filter** dialog box displays.

21. Clear the filters by clicking **None**.

Tool List Filter

-To	Tool Types								
				l					
				Ų	Ũ				
	b	2	Ŵ			ļ			
	6		Ş						
	All None								

- 22. Choose the Endmill2 Sphere filter and then click OK.
- 23. Select the BALL-NOSE END MILL 3 from the library of tools and click OK.

	#	Ass	Tool Name	Holde	Dia.	Cor. r	Length	# Flut	Туре	Rad	
C	233	-	BALL-NOSE END MILL - 3	-	3.0	1.5	8.0	4	Ball	Full)
2	234	-	BALL-NOSE END MILL - 4	-	4.0	2.0	11.0	4	Ball	Full	
21	235	-	BALL-NOSE END MILL - 5	-	5.0	2.5	13.0	4	Ball	Full	
22	236	_	BALL-NOSE END MILL - 6	-	6.0	3.0	13.0	4	Ball	Full	
	007				7.0	25	100	A	• •	- "	

24. Enter the following values for the tool.

CAUTION

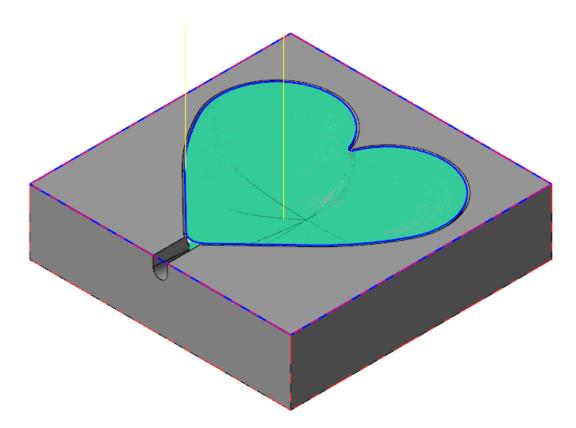
These values may vary depending on your machine and material.

	# 216 233	Assembly _ _	Tool Name FLAT EN BALL-NO	Holder N –	Dia. 6.0 3.0	Cor. r 0.0 1.5	L .	Tool diameter: Comer radius: Tool name: Tool #: Head #:	1.5 BALL-NOSE 233	END MILL - 3 Length offset: Diameter offset:		
<						> < for optior	-	Feed rate: FPT:	12500.0	Spindle direction: Spindle speed: CS	CW 31830 300.0	~
Se		rary tool spection / cha		Filter Active	-	Filter		Plunge rate:	1000.0 I change	Retract rate:	2000.0 tract	
	Forc	e retract every		10000.0 40.0	Millir Minu	neters tes						< >

- 25. Click the **Cut Parameters** page in the tree control.
- 26. Deselect **Expand inside to out** to have the toolpath cut from the perimeter of the heart toward the center.

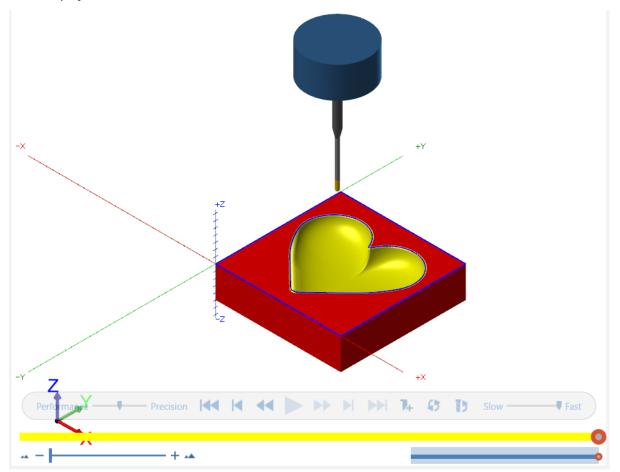
Cut style Cut method	One Way V	
Tip compensation	Ţip ∼	

27. Click **OK**. (All other pages retain the default settings.) The toolpath appears on your part.



28. In the Toolpaths Manager, click **Verify** and open Mastercam Simulator.

29. Use the playback bar to run the simulation.



30. Save your file.

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. When finishing, you must use a cutting tool the same radius or smaller than the smallest, inside radius of the surface you are cutting to clean-up any unmachined areas.
 - a. True
 - b. False
- 2. You can use the same tool to both rough and finish cut.
 - a. True
 - b. False
- 3. Your stepover should be less than 10% of your cutter's diameter to get the best surface finish, .
 - a. True
 - b. False
- 4. You can always achieve a perfectly smooth finish with one finish toolpath.
 - a. True
 - b. False
- 5. Typically, the cutter you would use to get the smoothest surface on a finish toolpath would be:
 - a. Flat endmill
 - b. Drill Bit
 - c. Ball endmill
 - d. Spherical endmill
 - e. Both C and D
- 6. The Finish Scallop toolpath does not have a stock to leave option .
 - a. True
 - b. False
- 7. When you set the cut parameters of a Finish Scallop toolpath, you can control whether the cutting motion starts from the center and moves in or the perimeter and moves out.
 - a. True
 - b. False
- 8. List some benefits of using Verify to review your toolpaths?

Quick Part Series - Chocolate Mold—4: Finish Mold Programming

CHAPTER 5 SLOT PROGRAMMING

The slot is a long narrow shape that will be programmed using a rough and finish Scallop toolpath. Using the Toolpaths Manager **Copy** function, you will quickly create the finish toolpath based on the rough toolpath with minimal edits required.

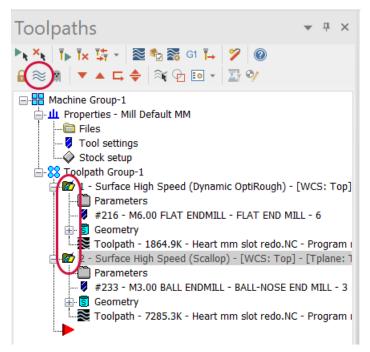
Goals

- Program a rough Scallop toolpath
- Use Copy to quickly create a finish Scallop toolpath
- Create a containment boundary using Wireframe tools
- Explore tool libraries including filtering by tool type
- Experiment with toolpath verification using Mastercam Simulator

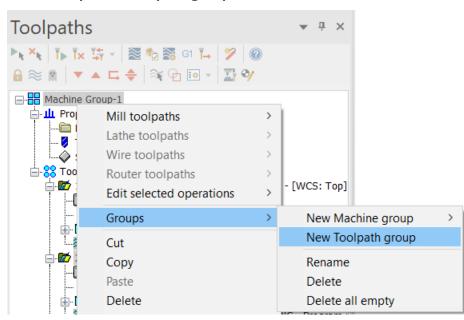
Exercise 1: Creating the Rough Scallop Toolpath

In this exercise, you will create a containment boundary for the slot area of the mold and then program a rough Scallop toolpath.

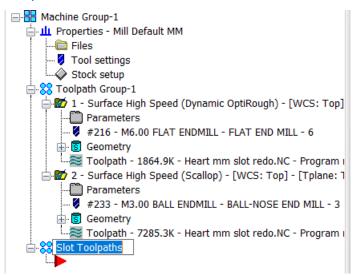
- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous chapter should be open in Mastercam.
- 2. Right-click and choose **Fit** and set your view to **Isometric (WCS)**.
- 3. In the Levels Manager, make the heart and the containment boundary levels visible.
- 4. Select both toolpaths and then click **Toggle the display of selected operations** or press [Alt+T] to hide the toolpaths in the graphics window.



5. Adding a new toolpath group will help you organize the file. Right-click **Machine Group-1** and select **Group**, **New Toolpath group**.



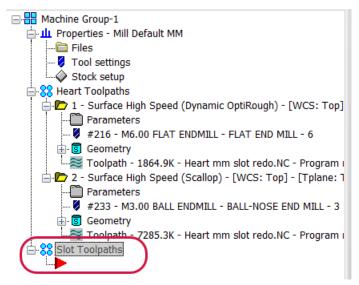
6. In Toolpaths Manager enter **Slot Toolpaths** for the name of the new group. Press [**Enter**] to accept.



7. Right-click Toolpath Group-1 and select Groups, Rename.

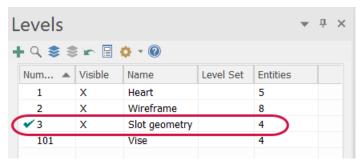
Stock setup	-1		
☐-177 1 - Surfa 177 Paran 197 #216	Mill toolpaths Lathe toolpaths	>	Тор]
⊕- ड Geom ≋ Toolp 2 - Surfa 1 Paran	Wire toolpaths Router toolpaths Edit selected operations	>	pram i ane: 1
♥ #233 ⊕ ⑤ Geom	Groups	>	New Machine group
🗔 🗃 Toolp	Cut		New Toolpath group
😑 器 Slot Toolpatl	Сору		Rename
	Paste		Delete
	Delete		Delete all empty

- 8. Enter Heart Toolpaths for the new name.
- 9. Ensure that the red insert arrow is below the **Slot Toolpaths** group.

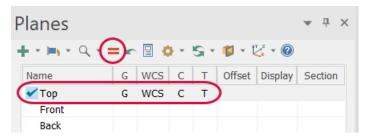


In the next steps you are going to create a containment boundary to keep the machining inside the slot.

10. On the Levels Manager, make level **3 Slot geometry** the active level and turn on the visibility.



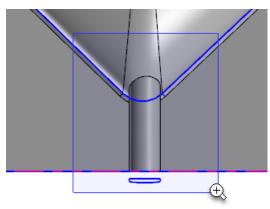
11. In Planes Manager, make the Top plane active and then click **Set your current WCS**, construction plane, and tool plane with their origins to the selected plane.



- 12. Right-click in the graphics window and set your view to **Top (WCS)**.
- 13. On the View tab, click Window.



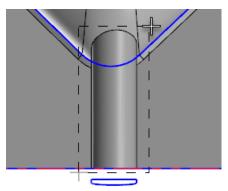
14. Window select the slot area to magnify that region.



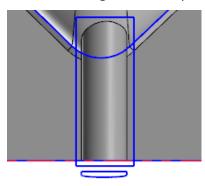
15. On Wireframe tab, click Rectangle.



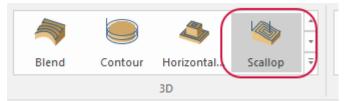
16. Draw a rectangle around the slot geometry as shown in the following image.



The rectangle can be placed any where on the Z plane. It will be used as a containment boundary when machining from the top.



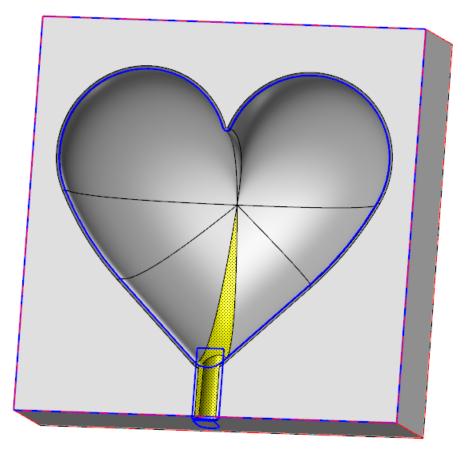
17. On the **Mill Toolpaths** tab, click **Scallop** in the 3D group.



18. On the Model Geometry page, click Select entities in the Machining Geometry section.



19. Select the slot surfaces and any surfaces tangent to the slot.



- 20. Click **End Selection** to return to the **Model Geometry** page.
- 21. For a rough toolpath you will designate a certain amount of stock to leave on the part. This stock will be removed with the finish toolpath. Double click the **Wall Stock** and **Floor Stock** fields of Machining Geometry to activate them and enter **1.0**.

🎙 🗊 🔒 👪 🛛		*				
Toolpath Type	^		Machining Geometry			
Toolpath Control			Name	Entities	Wall Stock	Floor Stock
Holder			machining	6	1.0	1.0
🤣 Stock						

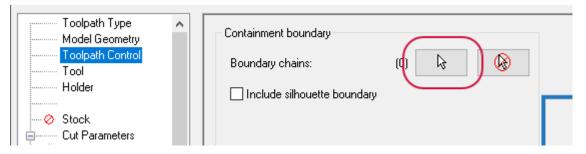
22. Click the **Toolpath Control** page in the tree control.

	Toolpath Type	^
-	Model Geometry	
	Toolpath Control	
	Tool	
	Holder	

.

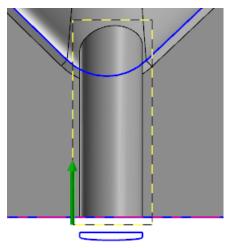
In this page you will choose the containment boundary to limit the area that will be machined.

23. Click the **Boundary chains** select arrow.



The **Wireframe Chaining** dialog box displays.

Hold down the [Shift] key and select a segment of the containment boundary wireframe. [Shift+click] selects all tangent segments.



24. Click **OK** to close the **Wireframe Chaining** dialog box and return to the **Toolpath Control** page.

25. Select **Inside** to **Compensate to**. This forces the tool to machine inside the containment boundary.

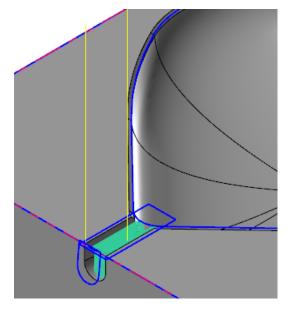
Containment boundary Boundary chains: (1)	
Include silhouette boundary	
Strategy:	
Closed offsets	
○ Trimmed offsets	
Contain:	
Tool tip	
○ Tool contact point	
Compensate to:	Approximate start point
Center	
◯ Outside	Curves

- 26. Click the **Tool** page in the tree control.
- 27. Select the **BALL-NOSE ENDMILL 3** as the tool and enter the values shown in the following image.

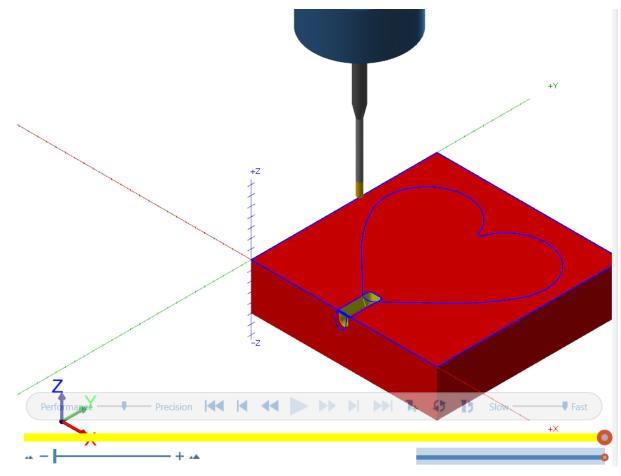
216 – FLAT	Name Holder N FEN – -NO –	Dia. Cor. r L 6.0 0.0 3.0 1.5	Corner radius:	1.5 BALL-NOSE 233	END MILL - 3 Length offset: Diameter offset:	
<		>	Feed rate:	12500.0	Spindle direction: Spindle speed: CS	CW ~ 12000 113.1008
Select library tool	Riț	ght-click for options Filter	Plunge rate:	1000.0	Retract rate:	2000.0
Tool inspection / change Force retract every To batch	 10000.0 40.0 	Millimeters Minutes	Comment			^ ~

CAUTION These values may vary depending on your machine and material.

28. Click **OK**. (All other pages retain the default settings.) The toolpath appears on your part.



29. In the Toolpaths Manager, select **Toolpath 3** and click **Verify**. Only the selected toolpaths will be verified in Mastercam Simulator.



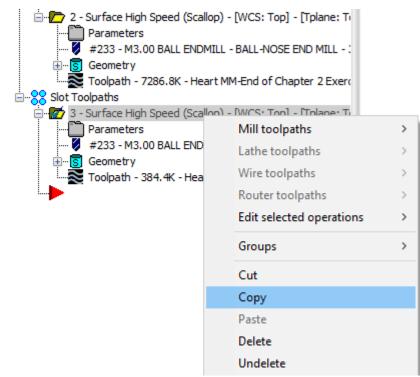
30. Use the playback tools to view the simulation and then close Mastercam Simulator.

31. Save the file.

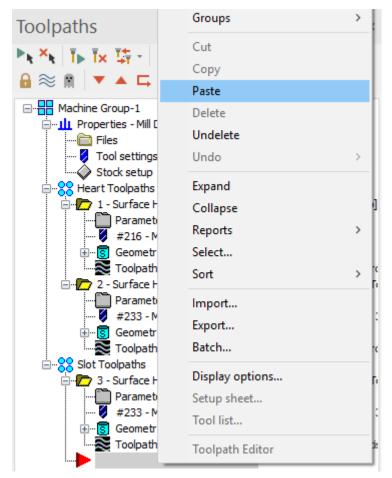
Exercise 2: Creating the Finish Scallop Toolpath for the Slot

In this exercise, you will copy the rough Scallop toolpath and make modifications so it can be used as a finish toolpath.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous exercise should be open in Mastercam.
- 2. In Toolpaths Manager, right-click **Toolpath 3** and choose **Copy**.



3. Ensure that the red insert arrow is below **Toolpath 3** and then right-click and choose **Paste**.



Toolpath 4, which is a duplicate of Toolpath 3 appears in the Toolpaths Manager.



4. Click Parameters for Toolpath 4.



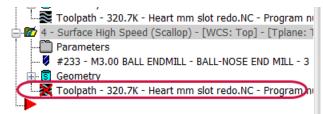
5. Open the Model Geometry page.

🎙 🗊 🔚 🚮 🗐 🦉				
Toolpath Type	Machining Geometry			
Toolpath Control	Name	Entities	Wall Stock	Floor Stock
Holder	machining	6	1.0	1.0

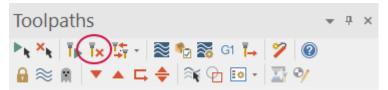
6. The finish toolpath will remove the stock to leave amounts that were entered for the rough Scallop toolpath. Click **Reset stock values** to return **Wall Stock** and **Floor Stock** to **0.0**.



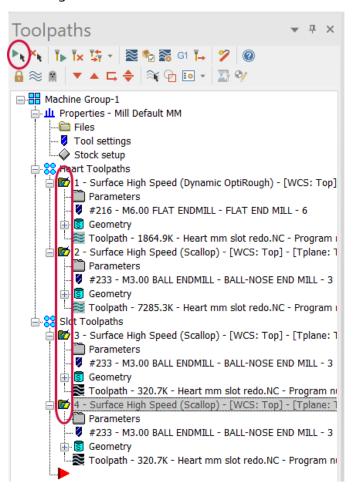
- 7. Click **OK**. (All other pages retain the default settings.)
- 8. In the Toolpaths Manager, **Toolpath 4** is marked dirty, indicating that it must be regenerated.



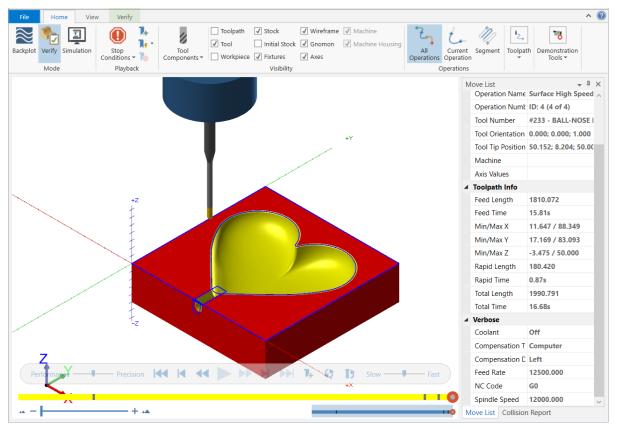
9. Click **Regenerate all dirty toolpaths** on the Toolpaths Manager toolbar.



10. In the Toolpaths Manager, click **Select all operations**. Each toolpath will have a green check indicating it is selected.



11. Click Verify to open Mastercam Simulator.



12. Play the simulation through then use the **Visibility** controls on the ribbon to change what you see. Experiment with the playback controls at the bottom of the screen to move forward and backward through the simulation.

NOTE

Click the help icon in the upper corner of Mastercam Simulator to learn more about the program.

- 13. Close Mastercam Simulator when you are done.
- 14. Save the file. You are now ready to send your file to the post processor and create the NC program.

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. You can use filters to narrow the type and number of tools you see in the tool library.
 - a. True
 - b. False
- 2. What is the best way to reuse a toolpath?
 - a. Copying and pasting it in the Toolpaths Manager
 - b. Exporting the parameters into an Excel file and reimporting the operation with a different name into your part file.
- 3. You must select toolpath geometry one entity at a time.
 - a. True
 - b. False
- 4. You can select machining surfaces and set stock to leave values on the Model Geometry page of a toolpath dialog box.
 - a. True
 - b. False
- 5. Which of the following is not a compensation option for Containment Boundary?
 - a. Inside
 - b. Above
 - c. Center
 - d. Outside
- 6. The only way to tell how long an operation will take to complete is to run it on the machine.
 - a. True
 - b. False
- 7. Describe how you could get a better view of an issue with a deep cut that you notice when you are using Verify. Make sure you mention the controls you would use.

Quick Part Series - Chocolate Mold—5: Slot Programming



Post processing, or posting, refers to the process by which the toolpaths in your part file are converted to a format that can be understood by your machine tool's control (for example, G-codes). A program called a post processor, or post, reads your part file and writes the appropriate NC code. Generally, every machine tool or control requires its own post processor, customized to produce code formatted to meet its exact requirements.

In this chapter you will explore post processing using the default mill machine chosen for this project. If you use a different machine, it will require a different post.

Goals

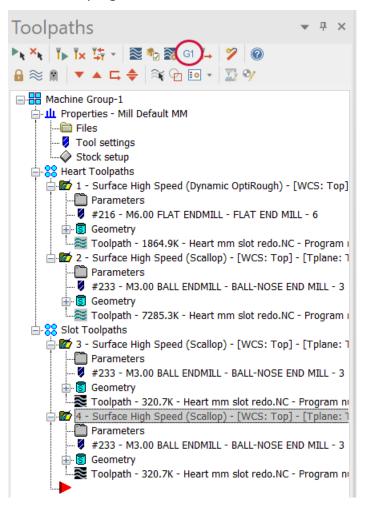
- Understand post processing concepts
- Explore Code Expert and the NC code

Exercise 1: Post Processing the Operations

In this exercise, you will send the completed file to post processor. The post processor creates a machine-readable NC program from the Mastercam file.

- 1. Your file, Heart mm-XXX.mcam, which you saved from the previous chapter should be open in Mastercam.
- 2. Verify that all of the toolpaths are selected in Toolpaths Manager.

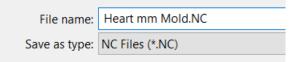
3. Click **G1** to post the toolpaths for the selected operations. The post processor creates a machinereadable NC program from the Mastercam file.



The **Post processing** dialog box displays. The name of the post processor for the machine you have chosen displays as the **Active post** field in read-only mode.

Post processing	×
Active post:	Select Post
Output part file descriptor	Properties
NC file	
O 0verwrite	Edit
Ask	NC extension:
Send to machine	Communications
NCI file	
◯ Overwrite ◉ Ask	Edit
×	* ?

- 4. Click **OK**. The **Save As** dialog box opens.
- 5. Name your NC file and click **Save**.



The file opens in Mastercam Code Expert.

	1 in 11	Editor	He	eart mm Mold.NC - I	Mastercam 2020	Code Expert	t				- 🗆	\times
File Ho	ome View	NC Functions										^ (
🗅 🏦 Inse	ert Block Numbers	船 Insert Block Skip	🚡 Send File	44			4					1
	nove Block Numbers	s Bemove Block Skip	👔 Send									1
To Rem	nove Spaces	Remove Comments	Receive	First Previous Ne	xt Last Ma	rk First	Previous Next	Last	Single Multi Stream		ign No ncs Configu	
G	Editing	_	Communi 🕞	Syncs			Tools			play	Utilit	
			Communiti	Syncs			10013		013	piay	Utili	
eart mm Mo	old.NC × Start	Page										►
1	* 00000 (HEART											
3		- MM MOLD) I-YY - 27-02-19 TI	MP-UU.MM - 17	.06)								
4		- C:\USERS\CAT\ON			OCUMENTS\ SA	MDT.F DART	SIMV PARTS	HEADTS	HEADT MM S	CALLOR F	TNAT. MCAM	a
5		C:\USERS\CAT\DOCU							(112)1111 1411 1	Children 1	1111111111111111	·
6		ALUMINUM MM - 20		2020 (1210)								
7	· · · · · · · · · · · · · · · · · · ·	AT END MILL - 6	1 A A A A A A A A A A A A A A A A A A A									
8		LL-NOSE END MILL										
9	N100 G21		- , ,									
10	N110 G0 G17	G40 G49 G80 G90										
11	N120 T216 M	16										
12	N130 G0 G90	G54 X36.981 Y51.	676 A0. S1200	0 м3								
13	N140 G43 H2											
14	N150 Z7.049											
15	N160 G1 Z6.											
16	N170 X36.99	¥51.671 z6.349										
17	N180 X37.01	6 Y51.657 Z6.152										
18		9 Y51.633 Z5.959										
19		8 Y51.599 Z5.772										
20	N210 X37.19	3 Y51.557 Z5.592										
21	N220 X37.28	4 Y51.506 Z5.422										
22	N230 X37.38	9 Y51.446 Z5.263										
23	N240 X37.50	7 Y51.38 Z5.117										
24	N250 X37.63	7 Y51.306 Z4.985										
25		8 Y51.227 Z4.869										
26	N270 X37.92	8 Y51.142 Z4.769										
27	N280 X38.08	6 Y51.052 Z4.687										
28	N290 X38.25	1 Y50.959 Z4.623										
29		¥50.864 z4.579										
30		8 Y50.771 Z4.542	F10000.									
	N320 X38.80	4 Y50.697 Z4.505										
31	N330 X39.00	7 Y50.645 Z4.468										
												Þ
31												
31	nts											•

6. Use the Code Expert controls to explore the NC code.

NOTE

Click the help icon in the upper corner of Mastercam Code Expert to learn more about the program

SHOW US WHAT YOU LEARNED!

Can you answer these questions?

- 1. The post processor creates a machine-readable NC program from the Mastercam file.
 - a. True
 - b. False
- 2. You must post all of the operations in the Toolpaths Manager.
 - a. True
 - b. False
- 3. Posted NC programs consist mainly of X, Y and Z values that represent point locations in on the CNC machine.
 - a. True
 - b. False
- 4. Describe how you transfer the information in your Mastercam file to your machine?

Quick Part Series - Chocolate Mold—6: Post Processing

CHAPTER 7 CHALLENGE: SELF-GUIDED PROJECT

Now that you have a basic understanding of designing and programming a mold in Mastercam, it's time to make one of your own. For this self-guided project, you will be creating a mold in Mastercam with a maximum size of 100 mm x 100 mm x 25.4 mm. The model you use for your mold may be obtained from a number of online resources including GrabCAD (www.grabcad.com) and the SOLIDWORKS CAD model library (https://my.solidworks.com/cadmodels/explore) or created on your own using the powerful CAD features found in Mastercam.

Successful completion of this self-guided project will demonstrate the following skills in Mastercam:

- How to use Mastercam's wireframe and solid model design tools to create a machinable, solid model.
- Programming a part with roughing and finishing toolpaths.
- Securing stock to the machine.
- Confirming toolpath operations with Mastercam Simulator (Verify).

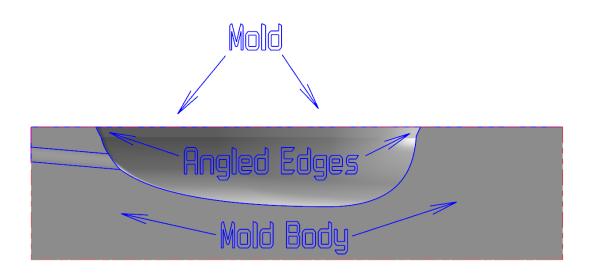
As part of this project, you will be expected to prepare a brief presentation. The presentation should be no longer than 5 minutes and clearly outline the steps that you have taken to complete the project, including which ideas you explored, what new technology you learned to facilitate the process, projects that you experienced and how you overcame them, and how you improved the project from inception through to the finished product.

This self-guided project will be evaluated against the following categories:

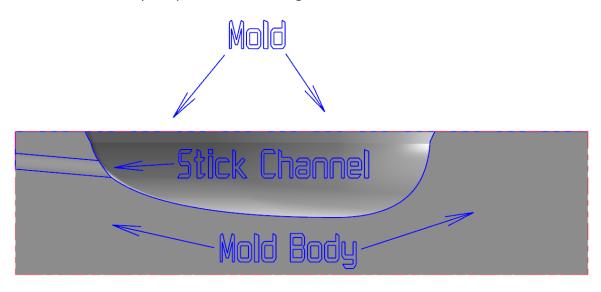
- Creativity the process and ability to explore and express multiple ideas in a unique way.
- Initiative the ability to overcome projects independently and with a positive attitude.
- Iteration the ability to develop the product with progressive improvement over time.
- Continued Learning the ability to attempt new techniques as part of the project.
- Presentation the ability to articulate and explain the process and project.

MOLD MODEL TIPS

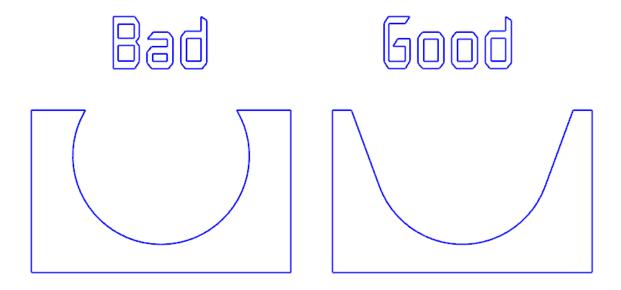
- **Use draft** when possible to make removing your part easier. A good mold would be shaped like an upside-down pyramid, where the widest part is at the top and the narrowest at the bottom. A good example of a mold is an ice cube try, where there is a taper from the top down and inward to the bottom.
- Add an angled or tapered edge to the top to help release the mold part from the mold body if the walls of the mold are very steep.



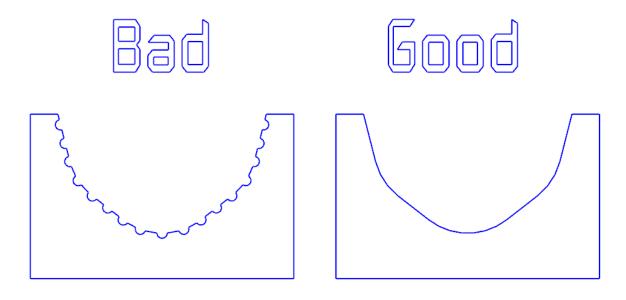
• **Put a stick in it!** A stick in the mold can be useful in pulling the part cleanly out of the mold. Remember, you will have to create and cut a channel add this stick to your mold, and you'll need to consider how to keep the part material leaking out.



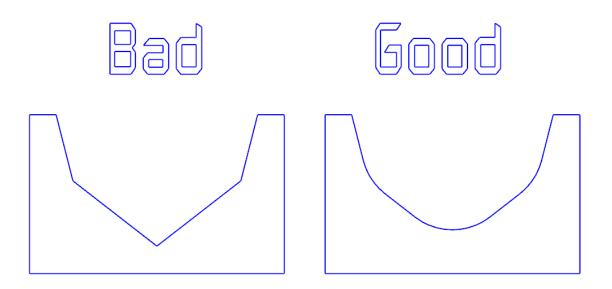
• Avoid models with undercuts. An undercut is when the top of the model is narrower than the bottom.



• Avoid textured surfaces. The smoother the surface, the easier it will be to remove the part from the mold. Textured surfaces will grip your material. It is likely that your part will not release cleanly from the mold and could be damaged in the process.



• Avoid sharp corners and knife-edges. Use fillets and chamfers to soften these when they can't be avoided.



- **Be flexible!** Rigid material can make it difficult to remove a part from your mold, even in the best of circumstances. Consider using a flexible mold body like silicone or even a multiple piece mold so that the part can be removed without damage.
- Use a release agent. A mold may be the perfect shape to release and they part could still not come out easily or at all. Consider coating your mold with a release agent, such as petroleum jelly, baby powder, nonstick spray or anything else the will help keep the mold and part from holding on to each other. Keep in mind, any possible physical or chemical affects your release agent will have on the finished part!
- **Consider shrinkage.** Shrinkage is a measurement based on change and is represented as either a ratio or as a percentage. Most materials will expand when heated and will shrink when cooled. This can cause the part to either pull away from the mold and make it easier to release, or cause the mold to tighten around the part and make it harder to release. It is not uncommon when making a candy with a mold, to chill the mold after the part material is added to help the candy shrink and release from the mold.

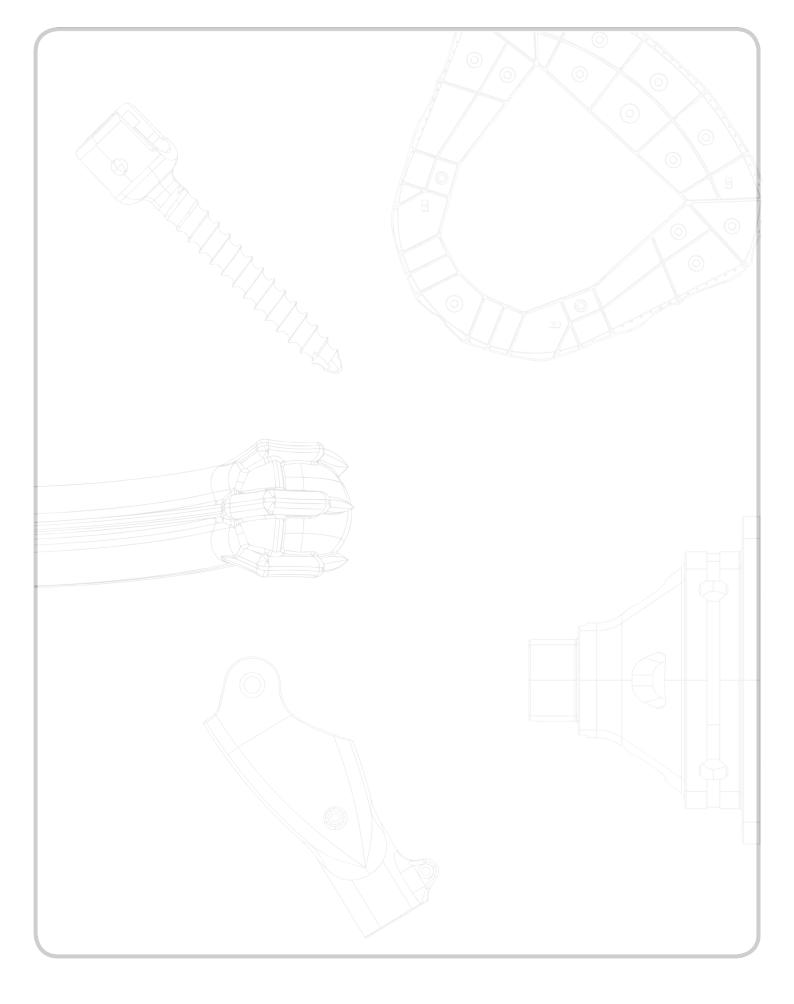
If the finished part must be a specific size, you may need to be scale the mold for shrinkage so that the part is the correct size. Use the following equation to determine the difference between the mold and part dimension is:

Ratio = (mold – part) /mold % = (mold – part) (100%) / mold

CONCLUSION

Congratulations! You have completed the *Quick Part Series - Chocolate Mold*! Now that you have mastered the skills in this tutorial, explore Mastercam's other features and functions.

You may be interested in other tutorials that we offer. Mastercam tutorials are being constantly developed, and we will add more as we complete them. Visit our website, or select **Help**, **Tutorials** from the **File** tab.



CNC Software, Inc. 671 Old Post Road Tolland, CT 06084



Mastercam® is a registered trademark of CNC Software, Inc. ©1983-2019. All rights reserved. All other trademarks are property of their respective owners.

