



Mastercam®
Getting Started Tutorials



Basic 2D Design

mastercam x getting started tutorials
.....

Basic 2D Design

September 2007

Mastercam® X2 MR2 Basic 2D Design

Date: September 2007

Copyright © 2007 CNC Software, Inc.— All rights reserved.

First Printing: September 2007

Software: Mastercam X2 MR2

ISBN: 1-883310-78-4

IMPORTANT NOTICE!

PLEASE READ THIS STATEMENT AND THE SOFTWARE LICENSE AGREEMENT COMPLETELY BEFORE USING THIS SOFTWARE.

BY CONTINUING TO USE THIS SOFTWARE, YOU (EITHER AN INDIVIDUAL OR A SINGLE ENTITY) INDICATE YOUR INTENTION TO BE BOUND BY AND ACCEPT THE TERMS AND CONDITIONS OF THIS SOFTWARE LICENSE. IF YOU DO NOT AGREE TO THESE TERMS AND CONDITIONS, YOU MAY NOT ACCESS OR OTHERWISE USE THIS SOFTWARE AND WILL IN FACT BE PROHIBITED FROM DOING SO. THIS COMPUTER SOFTWARE MAY BE USED ONLY PURSUANT TO THE TERMS AND CONDITIONS SET FORTH BELOW, AND SOLELY IN CONJUNCTION WITH THE ACCOMPANYING SECURITY MECHANISM (UNLESS OTHERWISE SPECIFIED IN THE "EXCEPTIONS TO SECURITY MECHANISM REQUIREMENTS" SECTION OF SUCH TERMS AND CONDITIONS) WHICH MUST BE PRESENT ON YOUR COMPUTER (OR NETWORK AS APPLICABLE) AT ALL TIMES DURING SUCH USE.

Read This If You Have Received This Software From A Third Party: If you received this Software from someone other than an authorized CNC Software, Inc. reseller, you do **not** have a legal software license. (For example, if you acquired this Software simply by buying a machine or Software from the former owner or from an auction, you do **not** have a valid license.) You should contact CNC Software, Inc. (860-875-5006) in order to obtain a new and valid license. **Use of this Software without a valid software license is unlawful, a violation of the Copyright Act and may expose you to criminal liability under 17 United States Code Sec. 506, including fines and damages.**

Software License

If you have paid a license fee, CNC Software, Inc. ("CNC") a Connecticut corporation with its principal place of business at 671 Old Post Road, Tolland, Connecticut, 06084 hereby grants to you a non-exclusive, non-transferable license (the "License") to use this software program and its accompanying documentation (and, if applicable, to permit your authorized employees to use them), solely in accordance with the terms and conditions of this Software License Agreement. You may use the Software solely for your internal business purposes and solely in conjunction with the accompanying hardware or software device, method, scheme or other security measure provided by CNC which allows a user to access the Software and prevents unauthorized access to the Software (the "Security Mechanism"). The Software, any updates to the Software through purchase or due to enrollment in an authorized software Maintenance program (including any that you download through the Internet), and the Documentation in printed or electronic form shall hereinafter collectively be referred to as the "Software" and are all governed by this License.

Restrictions

You may not use the Software without a Security Mechanism provided by CNC or CNC's suppliers. When CNC or CNC's resellers provide you with a single-user Security Mechanism, the Software may only be used (in executable code form only) on a single computer to which the Security Mechanism is physically attached. In the event CNC or CNC's resellers provide you with a multiple-user Security Mechanism for use over an internal network (a "Network Security Mechanism"), the Software may be used: (a) in executable code form only; (b) only on end-user computers that are connected to the internal network to which the Network Security Mechanism is attached; and (c) only by the number of users and accessed by the number of end-user computers for which licenses were purchased and as further allowed by the Network Security Mechanism. You may physically transfer the Software from one computer equipped with a single-user Security

Mechanism to another only if the Security Mechanism is included in the transfer and is installed with the new computer.

You shall not: (a) copy (except as provided below), adapt, modify the Software; (b) publish, display, disclose or create a derivative work from the Software or any part thereof; (c) de-compile or translate, disassemble, create or attempt to create, by reverse engineering or otherwise, the source code form of the Software from the executable code of the Software; (d) remove any proprietary notices, labels or marks from the Software; (e) sell, rent, lease, distribute or otherwise transfer or provide all or any part of the Software to any person or entity without the prior written consent of CNC; (f) use the Software to provide outsourcing, service bureau, time sharing or other services to any third party; or (g) sublicense, assign, delegate or otherwise transfer your rights in the Software, under the Software License Agreement or any of the related rights or obligations for any reason without the prior written consent of CNC. You shall not circumvent, bypass, modify, reverse engineer, disassemble, disable, alter, enhance or replicate the function of the Security Mechanism in any manner whatsoever. Any attempt to do so shall result in automatic termination of this License without prejudice to all other legal rights and remedies of CNC.

Copying Restrictions

You may make one (1) copy of the Software for backup or archival purposes, provided that you reproduce all proprietary notices of CNC on any such copy.

Non Transferable

You may not transfer or assign the Software or this Software License Agreement or any rights or obligations hereunder. Any attempt to do so will automatically terminate this License without the need for notice. This termination is without prejudice to all other legal rights and remedies of CNC.

Intellectual Property Rights

The Software is and includes intellectual property of CNC. All associated intellectual property rights, including, without limitation, worldwide patent, trademark, copyright and trade secret rights, are reserved. CNC retains all right, title and interest in and copyrights to the Software, regardless of the form or media in or on which the original or other copies may subsequently exist. This Software License Agreement shall not constitute a sale of the Software and no title or proprietary rights to the Software are transferred to you hereby. You acknowledge that the Software is a unique, confidential and valuable asset of CNC, and CNC shall have the right to seek all equitable and legal redress, which may be available to it for the breach or threatened breach of this Software License Agreement including, without limitation, injunctive relief. Unauthorized copying of the Software or failure to comply with the above restrictions shall result in automatic termination of this License and this Software License Agreement without prejudice to all other legal rights and remedies of CNC.

Confidentiality

You acknowledge that the Software contains proprietary trade secrets of CNC and you hereby agree to maintain the confidentiality of the Software using at least as great a degree of care as you use to maintain the confidentiality of your own most confidential information. You agree to reasonably communicate the terms and conditions of this Software License Agreement to those persons employed by you who come into contact with the Software, and to use reasonable best efforts to ensure their compliance with such terms and conditions, including, without limitation, not knowingly permitting such persons to use any portion of the Software for the purpose of deriving the source code of the Software or defeating the Security Mechanism.

Enforcement Obligations

In the event you become aware that any person or entity in your employ or under your control in a manner not authorized by this Software License Agreement is using the Software, you shall immediately use reasonable best efforts to have such unauthorized use of the Software immediately cease. You shall promptly notify CNC in writing of any unauthorized use of the Software of which you become aware.

Limited Warranties

CNC WARRANTS THAT THE MEDIA ON WHICH THE SOFTWARE IS DISTRIBUTED WILL BE FREE OF DEFECTS IN MATERIAL OR WORKMANSHIP FOR A PERIOD OF THIRTY (30) DAYS AFTER PURCHASE. THE FOREGOING LIMITED WARRANTY EXCLUDES DEFECTS ARISING OUT OF ACCIDENT, NEGLIGENCE, MISUSE, FAILURE OF ELECTRIC POWER AND CAUSES OTHER THAN ORDINARY AND AUTHORIZED USE. EXCEPT FOR THE

FOREGOING LIMITED WARRANTY, THE SOFTWARE IS PROVIDED "AS IS, WITH ALL FAULTS." YOUR SOLE REMEDY AND CNC'S SOLE OBLIGATION HEREUNDER SHALL BE, AT CNC'S SOLE OPTION, REPLACEMENT OF THE DEFECTIVE MEDIA OR REFUND OF THE PURCHASE PRICE OF THE SOFTWARE. ANY USE BY YOU OF THE SOFTWARE IS AT YOUR OWN RISK. THIS LIMITED WARRANTY IS THE ONLY WARRANTY PROVIDED BY CNC REGARDING THE SOFTWARE. TO THE MAXIMUM EXTENT PERMITTED BY LAW, CNC DISCLAIMS ALL OTHER WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CNC IS NOT OBLIGATED TO PROVIDE ANY UPDATES TO THE SOFTWARE. SHOULD THE SOFTWARE PROVE DEFECTIVE FOLLOWING ITS PURCHASE, YOU (AND NOT CNC, ITS DISTRIBUTOR, OR RESELLER) ASSUME THE ENTIRE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION AND ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

Note on Documentation: While CNC makes every effort to ensure that its Documentation for the Software is accurate and up-to-date, it cannot guarantee the Documentation at all times represents the latest operation and functionality of the Software. The content of all documentation, in electronic or printed form, for the Software is provided for informational purposes only. The content of the Documentation may be changed without notice to you. CNC **expressly disclaims any warranty or representation that the Documentation is an accurate and/or current reflection of the Software's operation and performance.**

Limitation of Liability

IN NO EVENT WILL CNC, OR ITS EMPLOYEES, SHAREHOLDERS, DISTRIBUTORS OR RESELLERS BE LIABLE TO YOU FOR ANY INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES (INCLUDING WITHOUT LIMITATION, SPECIAL, PUNITIVE OR EXEMPLARY DAMAGES FOR LOSS OF BUSINESS, LOSS OF PROFITS, BUSINESS INTERRUPTION, OR LOSS OF BUSINESS INFORMATION) ARISING OUT OF OR IN CONNECTION WITH THIS SOFTWARE LICENSE AGREEMENT OR THE SUBJECT MATTER HEREOF EVEN IF CNC HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. CNC'S ENTIRE LIABILITY WITH RESPECT TO ITS OBLIGATIONS UNDER THIS SOFTWARE LICENSE AGREEMENT OR OTHERWISE SHALL NOT EXCEED THE AMOUNT OF THE LICENSE FEE PAID BY YOU FOR THE SOFTWARE. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OR LIMITATION OF IMPLIED WARRANTIES OR LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO YOU.

Indemnification

You shall indemnify and hold harmless CNC, its officers, directors, employees, resellers and agents from and against all losses, settlements, claims, actions, suits, proceedings, judgments, awards, damages, liabilities, costs and expenses including, without limitation, reasonable attorneys' fees (collectively "Losses") which arise out of or as a result of any breach of this Software License Agreement by you or your employees, agents, resellers, dealers or sub-dealers and shall reimburse CNC for any and all legal, accounting and other fees, costs and expenses reasonably incurred by any of them in connection with investigating, mitigating or defending any such Losses.

Educational Pricing

If this Software was obtained through or in accordance with a CNC "Educational Pricing" plan, option, grant, schedule or program, it may not be used by anyone, including you, to conduct any computer aided design, computer aided drafting, computer aided machining, or training activities that, directly or indirectly, generate or otherwise result in monetary revenues for the benefit of any individual or any entity, other than the school that originally received this Software.

Termination

This Software License Agreement is effective until terminated. You may terminate this Software License Agreement at any time by returning to CNC all copies of the Software under your control and by returning the Security Mechanism to CNC. CNC may terminate this Software License Agreement if CNC determines, in its sole discretion, that you have violated the terms of this Software License Agreement. Upon termination of this Software

License Agreement, you agree to immediately return to CNC all copies of the Software, return the Security Mechanism to CNC, and certify to CNC in writing that all known copies, including backup copies, have been returned. All provisions relating to confidentiality, proprietary rights, indemnification and non-disclosure shall survive the termination of this Software License Agreement. **You may not transfer this Software to the purchaser of any equipment on which the Software may be resident. You may not transfer this Software via liquidation, bankruptcy, auction, close of business, or any other method that does not involve an authorized Mastercam reseller. This License is for you alone.** In the event you breach the provisions of this Section, CNC shall be entitled to liquidated damages in the amount of Fifteen Thousand Dollars (\$15,000), plus its reasonable attorney's fees and court costs.

General

This Software License Agreement shall be governed by and construed in accordance with the laws of the state of Connecticut, USA without regard for Connecticut's conflicts of law principles. The sole jurisdiction and venue for any litigation arising from or related to this Software License Agreement or the subject matter hereof shall be in an appropriate state or federal court located in Hartford, Connecticut. You hereby submit to the personal jurisdiction of the US District Court for the District of Connecticut and the Superior Court of the State of Connecticut. This Software License Agreement shall constitute the entire agreement between you and CNC with respect to the subject matter hereof. Any waiver or modification of this Software License Agreement shall be valid only if it is in writing and signed by both parties hereto. If any part of this Agreement is found invalid or unenforceable by a court of competent jurisdiction, the remainder of this Agreement shall be interpreted so as to reasonably affect the intention of the parties.

U.S. Government Restricted Rights

The Software provided hereunder is a "commercial item," as that term is defined in 48 C.F.R. 2.101, consisting of "commercial computer software" and "commercial computer software documentation," as such terms are used in 48 C.F.R. 12.212. Consistent with 48 C.F.R. 12.212 and 48 C.F.R. 227.7202-1 through 227.7202-4, the Software made available to the United States of America, its agencies and/or instrumentalities, is provided with only those rights set forth in this Agreement. Use, duplication or disclosure of the Software by the government is subject to the restrictions as set forth in subparagraph (c) (1) and (2) of the Commercial Computer Software-Restricted Rights clause at 48 C.F.R. 52.227-19, as amended, or any successor regulations thereto.

Export Restrictions

You represent and warrant that you will not, without obtaining prior written authorization from CNC and, if required, of the Bureau of Export Administration of the United States Department of Commerce or other relevant agency of the United States Government, export or re-export, directly or indirectly, the Software from the United States to (i) any country destination or entity to which export is restricted by the Export Administration Regulations of the United States Department of Commerce; (ii) any country or entity subject to sanctions administered by the Office of Foreign Assets Control, United States Department of the Treasury; or (iii) such other countries or entities to which export is restricted by any other United States government agency. You further agree that you are solely responsible for compliance with any import laws and regulations of the country of destination of a permitted export or re-export, and any other import requirement related to a permitted export or re-export.

Exceptions to Security Mechanism Requirements

CNC Software programs Mastercam Design LT and Mastercam Demo as well as printed and electronic documentation do not require the use of Security Mechanisms, and the provisions in this Software License Agreement relating to Security Mechanisms do not apply to your use of such programs, provided, however, that such provisions shall apply to your use of all other Software and documentation provided hereunder.

Survival

All provisions of this Software License Agreement relating to confidentiality, non-disclosure, CNC's proprietary rights, disclaimers, and limits of liability, or indemnification by Customer shall survive termination of this License for any reason.

Reservation of Rights

All rights not expressly granted are reserved by CNC.

VIII • BASIC 2D DESIGN

Trademarks

Mastercam® is a registered trademark of CNC.

Windows, Windows 2000, Windows XP, and Windows Vista are registered trademarks of Microsoft Corporation. Mastercam Verify is created in conjunction with MachineWorks Ltd. Mastercam Backplot includes Copyrighted intellectual property rights owned by NWD.

Contents

.....

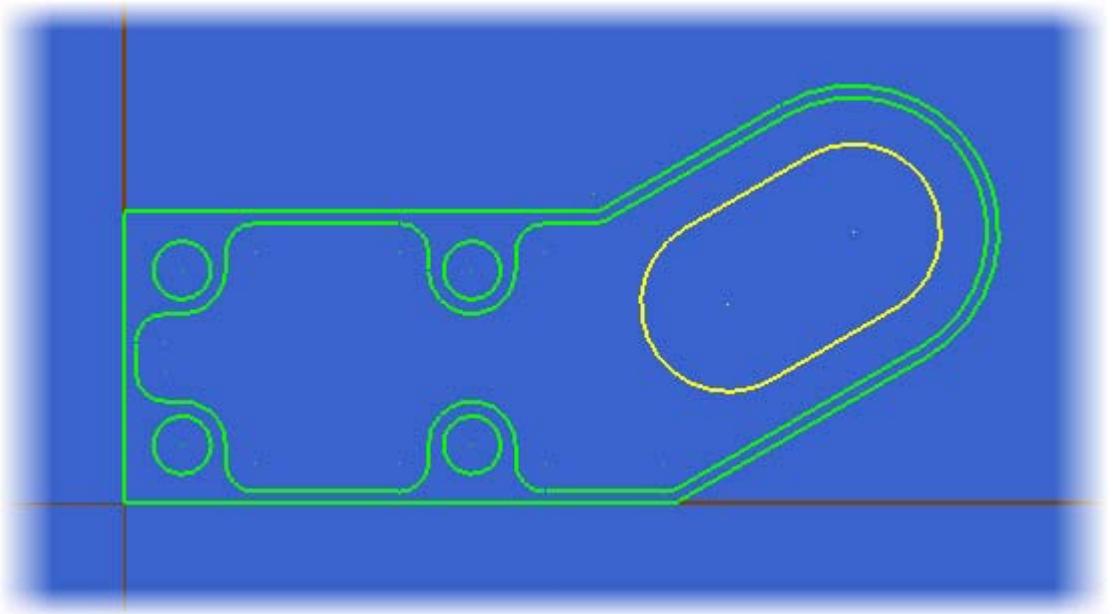
Introduction	1
▶ Tutorial Goals.....	1
▶ Before You Begin.....	1
▶ If You Need More Help.....	3
▶ Additional Documentation.....	3
1. Creating Lines and Arcs	5
▶ Lesson Goals.....	5
▶ Exercise 1: Drawing Vertical Lines.....	5
▶ Exercise 2: Drawing Horizontal Lines.....	7
▶ Exercise 3: Drawing Angled Lines and Circles	8
▶ Exercise 4: Trimming the Outer Contour	10
2. Creating Drill Holes	13
▶ Lesson Goals.....	13
▶ Exercise 1: Drawing the First Drill Hole.....	13
▶ Exercise 2: Creating Additional Holes	14
3. Modifying Geometry.....	17
▶ Lesson Goals.....	17
▶ Exercise 1: Offsetting the Outer Contour.....	17
▶ Exercise 2: Adding Tangent Lines.....	18
▶ Exercise 3: Trimming the Inner Contour.....	20
▶ Exercise 4: Mirroring the Drill Holes.....	22
▶ Exercise 5: Trimming the Mirrored Geometry	23
▶ Exercise 6: Adding Fillets	25
4. Adding a Slot.....	27
▶ Lesson Goals.....	27
▶ Exercise 1: Starting the Slot	27
▶ Exercise 2: Drawing Lines For the Slot	28

- ▶ Exercise 3: Completing the Slot Geometry29
- ▶ Exercise 4: Changing the Slot's Color and Level.....29

Conclusion31

INTRODUCTION

Mastercam provides many functions for creating and editing your part geometry, from simple 2D wireframe to complex 3D surface models. The *Basic 2D Design* module focuses on teaching you the 2D wireframe CAD tools used to draw the following part.



Tutorial Goals

- Draw basic geometry such as lines, arcs, and fillets.
- Set and change entity attributes.
- Select and chain geometry.
- Use AutoCursor and Visual Cues.
- Transform geometry.
- Trim geometry.

Before You Begin

This is a module of the *Mastercam X Series Title Tutorial Series*, which introduce basic Mastercam skills. Other tutorial series, which cover more advanced skills, are:

- *Focus Series*—This series provides more in-depth training on specific or advanced Mastercam features and functions.

- *Exploring Series*—This series explores the application of a single Mastercam product, such as Mill, Wire, or Art.

The Mastercam X tutorial series is in continual development, and we will add modules as we complete them. For information and availability, please contact your local Mastercam Reseller.

General Tutorial Requirements

Because each lesson in the tutorial builds on the mastery of preceding lesson's skills, we recommend that you complete them in order. In addition, the tutorials in this series have the following requirements:

- You must be comfortable using the Windows™ operating system.
- You must have a seat of Mastercam X2 MR2 Design or higher to complete most of the tutorials in the *Getting Started* series. The tutorials cannot be used with Mastercam Demo and Mastercam Student versions. (Refer to the current *Mastercam Installation Guide* for license information. You can find this guide in the \Documentation folder of your Mastercam installation.)
- The *Basic 2D Machining* tutorial requires a seat of Mill Entry or Router Entry. Tutorials in other series may require higher level licenses.
- Part files may accompany a tutorial. They should be stored in a folder with the tutorial or in a location that you prefer.
- You must store tutorial Flash™ videos in the \Videos folder of your Mastercam installation. (Flash videos accompany several tutorial modules and are available for download from www.mastercam.com.)
- You must install Flash Player to display tutorial videos. You can download Flash Player from www.adobe.com/products/flashplayer.
- You must configure Mastercam to work in metric units. The next section includes instructions for setting Mastercam to metric.

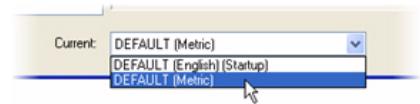
Preparing for a Tutorial

Before you start a tutorial, be sure you have completed the following tasks:

- 1 Start Mastercam using your preferred method:
 - ♦ Double-click Mastercam's desktop icon.
 - Or
 - ♦ Launch Mastercam from the Windows Start menu.
- 2 Select the metric configuration file:
 - a Select **Settings, Configuration** from Mastercam's menu.



- b Choose **DEFAULT (Metric)** from the **Current** drop-down list.
- c Click **OK**.



If You Need More Help

There are many ways to get help with Mastercam, including the following:

- *Mastercam Help*—Access Mastercam Help by selecting **Help, Contents** from Mastercam’s menu bar or by pressing [**Alt+H**] on your keyboard. Also, most dialog boxes and ribbon bars feature a Help button  that opens Mastercam Help directly to related information.
- *Online help*—You can search for information or ask questions on the Mastercam Web forum, located at www.emastercam.com. You can also find a wealth of information, including many videos, at www.mastercam.com and www.mastercamedu.com.
- *Mastercam Reseller*—Your local Mastercam Reseller can help with most questions about Mastercam.
- *Technical Support*—CNC Software’s Technical Support department (860-875-5006 or support@mastercam.com) is open Monday through Friday from 8:00 a.m. to 5:30 p.m. USA Eastern Standard Time.
- *Documentation feedback*—For questions about this or other Mastercam documentation, contact the Technical Documentation department by e-mail at techdocs@mastercam.com.

Additional Documentation

You can find more information on using Mastercam in the following materials, located in the \Documentation folder of your Mastercam installation:

- *Mastercam X2 Installation Guide*
- *Mastercam X2 Getting Started Guide*
- *Mastercam X2 Reference Guide*
- *Mastercam X2 Quick Reference Card*
- *Version 9 to X Function Map*

LESSON 1

Creating Lines and Arcs

Lines and arcs are some of the most standard geometry used in 2D parts. This lesson introduces you to some of Mastercam's line and arc creation methods as you begin drawing the outer shape of the tutorial part.

Lesson Goals

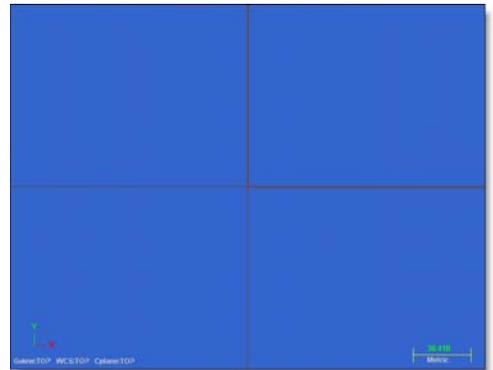
- Draw lines and arcs.
- Work with live entities.
- Trim geometry.

Exercise 1: Drawing Vertical Lines

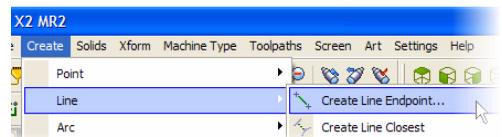
In this exercise, you start creating your part by drawing vertical construction lines.

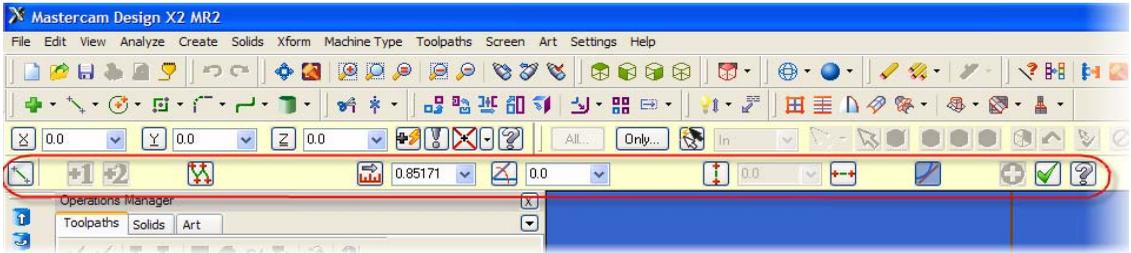
- 1 Press **[F9]** to display the XY axes in the graphics window.

The coordinate axes show the origin and the part orientation to help you visualize the part in 3D space.



- 2 Choose **Create, Line, Create Line Endpoints** from the menu bar. Mastercam displays the Line ribbon bar and prompts you to select the first endpoint.





Ribbon bars display based on what function you are using. Each ribbon bar includes options for the specific task you are doing. The Line ribbon bar has options for creating a line by selecting two endpoints.

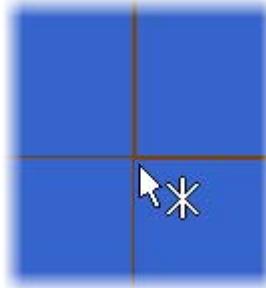
TIP: You can click and drag the yellow prompt window to any position.



Specify the first endpoint

- 3 Select the origin as your first endpoint by moving your cursor to the center of the graphics window where the X and Y axes cross. The cursor changes to an arrow with a star icon next to it.

This is the AutoCursor, which lets you quickly select and enter points. The Visual Cues icon attached to the AutoCursor changes depending what type of geometry you are near. This icon indicates that you are at the origin.



- 4 Click the origin and move your cursor vertically along the Y axis. The Visual Cue changes to the Horizontal/Vertical icon. This confirms that you are drawing a vertical line.



- 5 Click anywhere along the Y axis to set a temporary line length. The line changes to blue and is now considered a *live* entity.

Live entities can be modified by changing values in the ribbon bar until you exit the function, start a new function, begin to create another entity, or click **Apply**. Once you begin another entity or exit the function, the entity becomes *fixed* and is no longer editable through the ribbon bar.



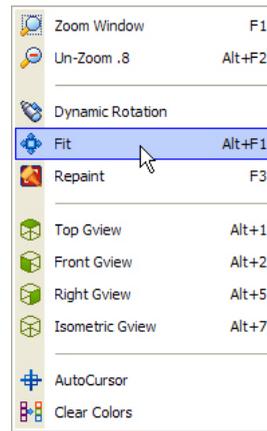
- 6 On the Line ribbon bar, enter **50** for the line length. This creates a 50 mm vertical line.



- 7 Click the **Apply** button on the ribbon bar. The line is now fixed, but you stay in the Line function so you can draw more lines.



- 8 Right-click anywhere in the graphics window, and choose **Fit** from the pop-up menu. This changes the graphics view so all geometry fits in the graphics window.

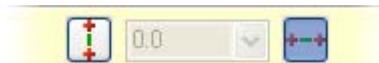
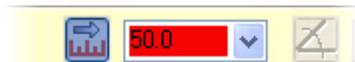


TIP: The right-click menu has many functions that are used often. You can customize this menu to display the functions you use most by choosing **Settings, Customize** and changing the settings on the **Drop downs/ Right mouse button menu** tab. For more information on how to do this, click the **Help** button on the Customize dialog box.

Exercise 2: Drawing Horizontal Lines

In this exercise, you draw additional horizontal construction lines.

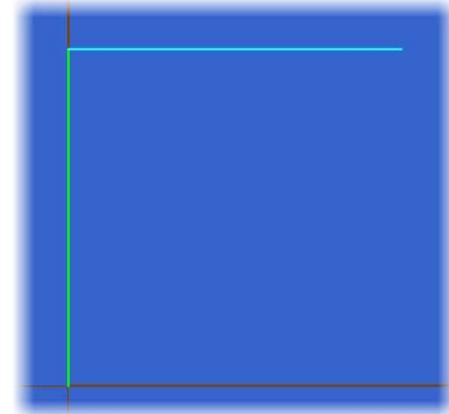
- 1 Click the **Length** button on the Line ribbon bar. This locks the value, which is useful when you want to create multiple lines with the same length. The field also turns red to indicate that it is locked.
- 2 Click the **Horizontal** button. The button remains pressed in. This means that the next line you draw will be horizontal.



- 3 Move your cursor to the top endpoint of the first line. The AutoCursor highlights the line (changes it to yellow) and the Visual Cue changes to indicate an endpoint.
- 4 Click the endpoint. Because your direction and length are fixed, you only have two options - to the left or right of the endpoint. Move your cursor left and right to see the two possible lines.



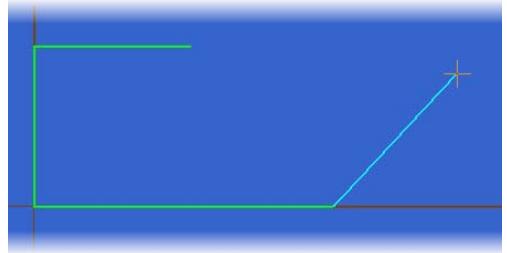
- 5 Click to the right of the first line to set the new line position. Notice that the new line is a live entity.
- 6 Press **[Enter]** twice to complete the line.
- 7 Click **Length** on the ribbon bar again to unlock the field. The next line you draw will be a different length.
- 8 Select the origin again as the first endpoint and drag your cursor to the right along the X axis. You are creating another horizontal line because the **Horizontal** button is still selected.
- 9 Click anywhere to set a temporary length, and type **95** for the length in the ribbon bar.
- 10 Press **[Enter]** twice to complete the line.
- 11 Right-click again in the graphics window and choose **Fit** to see all the lines.



Exercise 3: Drawing Angled Lines and Circles

In this exercise, you draw an angled line, and use the Create Line Parallel function to draw a parallel angled line. You also use the Create Circle Edge Point function to draw a circle using two points.

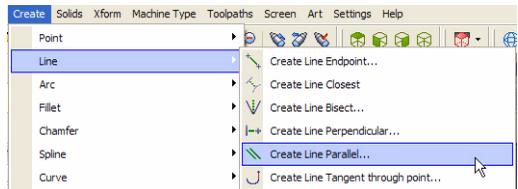
- 1 Deselect **Horizontal**. The next line is at an angle.
- 2 Press [**Page Down**] several times to zoom out from the part. This gives you room to draw the angled line.
- 3 Click the right endpoint of the 95 mm line, and drag your cursor up to the right at an angle.
- 4 Click anywhere to create the live entity.



- 5 Enter **50** for the line length and **30** for the angle.
- 6 Click **Apply** to complete the line.
- 7 Click **OK** to close the Line ribbon bar.

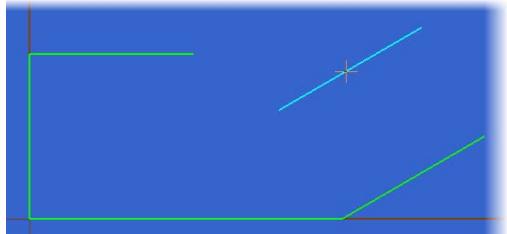


- 8 To draw a line that is parallel to the angled line, choose **Create, Line, Create Line Parallel** from the menu bar. This opens the Line Parallel ribbon bar.



TIP: You can also access the menu bar using the keyboard. Press [**Alt**] to display the shortcut keys for each menu option. For example, you could press **Alt, C, L, A** to access the Create Line Parallel option.

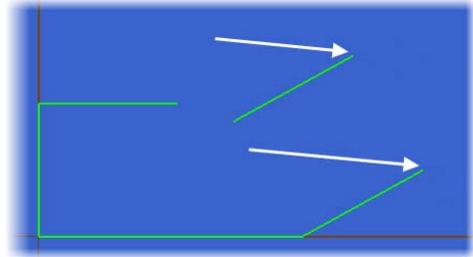
- 9 Select the angled line, and then click anywhere above the line. Mastercam creates a live parallel line entity.
- 10 Enter **50** for the distance and click **OK**.
- 11 To add an arc to the end of the part, choose **Create, Arc, Create Circle Edge Point**.



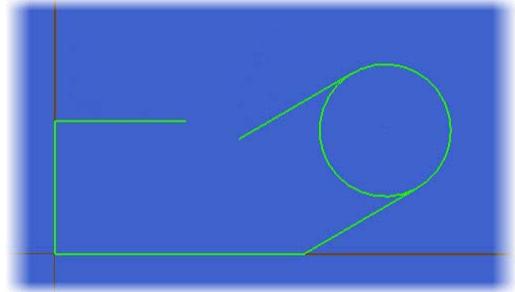
- 12 Select the **Two Point** button on the Circle Edge Point ribbon bar.



- 13 Select the upper endpoints of the two angled lines.



- 14 Click **OK** to complete the arc.



Exercise 4: Trimming the Outer Contour

In this exercise, you trim the construction geometry together to complete the part's outer contour.

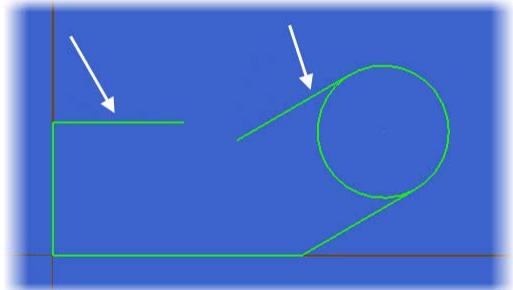
- 1 Choose **Edit, Trim/Break, Trim/Break/Extend**.
- 2 Select the **Trim 2 Entity** button on the ribbon bar.



This function trims two entities to their nearest intersection.

- 3 Select the top horizontal line and the top angled line.

You should select the piece of the entity that you want to keep. In this example, you want to keep the left side of the horizontal line and the top of the angled line.





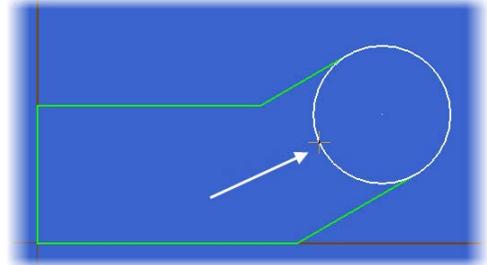
TIP: *If the result does not look correct, choose **Edit, Undo** to remove the trimming, and try selecting the geometry again.*

- 4** To trim the circle to the two angled lines, click the **Divide** button on the ribbon bar.

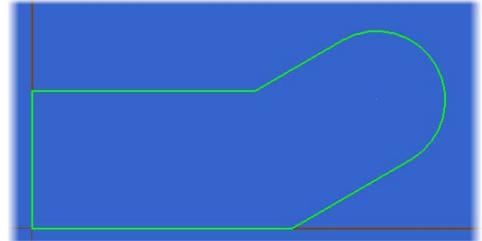


This function divides entities based on the nearest intersection.

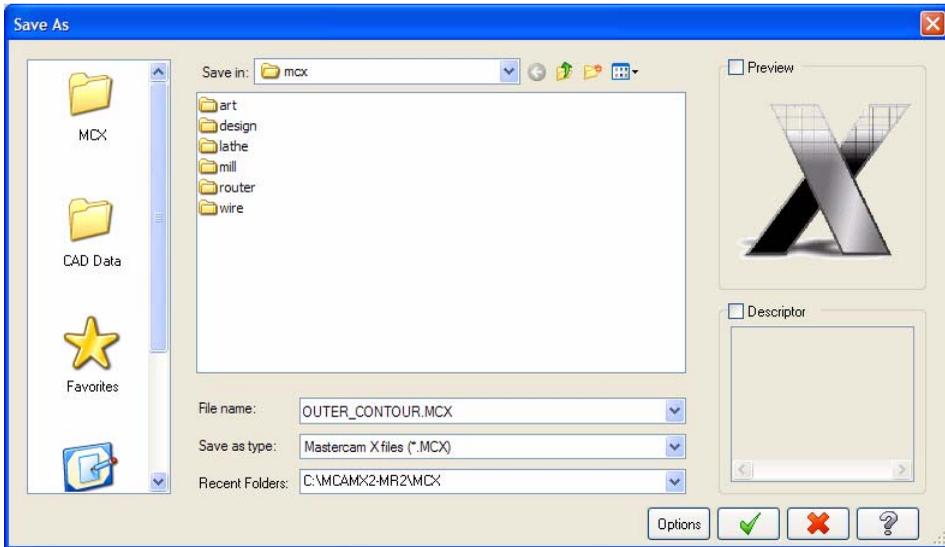
- 5** Select the left-hand side of the circle.



- 6** Click **OK** to complete the trimming. Your part should look like the picture at right.



- 7** Choose **File, Save** to save the geometry you have created. The Save As dialog box displays because you are saving the file for the first time.



8 Type OUTER_CONTOUR.MCX in the **File Name** field.

9 Click **OK** to save the file.

Note: For more information on saving files, refer to the Mastercam online Help.

Now that you have created the basic outline of your part, you will add drill holes in the next lesson.

LESSON 2

Creating Drill Holes

Mastercam makes it easy to quickly add arcs to your part. This lesson focuses on additional methods for drawing circles that can later be used as drill holes.

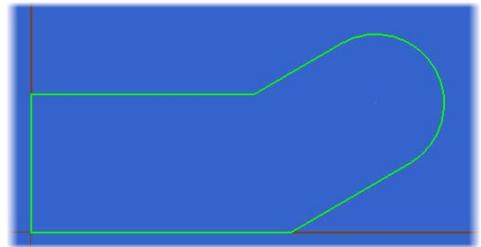
Lesson Goals

- Set entity attributes.
- Use relative positioning.
- Work with AutoCursor.

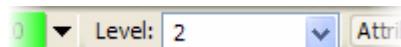
Exercise 1: Drawing the First Drill Hole

In this exercise, you draw a circle using FastPoint mode on a different level.

- 1 Open the tutorial part: `OUTER_CONTOUR.MCX` or continue using the MCX file you created in Lesson 1.



- 2 Click in the **Level** field on the Status bar at the bottom of the screen, and type **2** to start a new level. All new entities will be placed on Level 2.



Levels are an organizational tool in Mastercam that help you control what areas of your part are visible or selectable. For more information on levels, refer to the online Help.

- 3 To draw the first set of holes, choose **Create, Arc, Create Circle Center Point**.
- 4 Press [**Spacebar**] to enter FastPoint mode, which can be accessed whenever a coordinate value is required. A field pops up on the AutoCursor ribbon bar.



The FastPoint field lets you type in point coordinates with or without the corresponding coordinate letters (X, Y, Z).



TIP: You can also enter fractions and formulas in the FastPoint field.

- 5 Type **10, 10** for the first circle center point and press **[Enter]**.
- 6 Move your cursor to the graphics window. A temporary circle displays centered on the point you entered.
- 7 Click to set a temporary diameter and create the live entity.



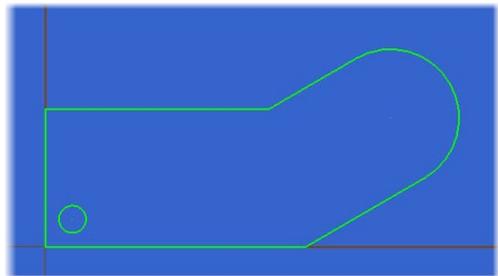
- 8 Enter **10** in the Diameter field on the Circle Center Point ribbon bar, and then click the **Diameter** button to lock the value.



Locking the field lets you draw a second circle with this same diameter.

*Note: The **Radius** field is also locked. When you enter either a radius or a diameter, the other field also updates.*

- 9 Click **Apply** to complete the circle.



Exercise 2: Creating Additional Holes

In this exercise, you draw three additional drill holes using relative positioning and the AutoCursor.

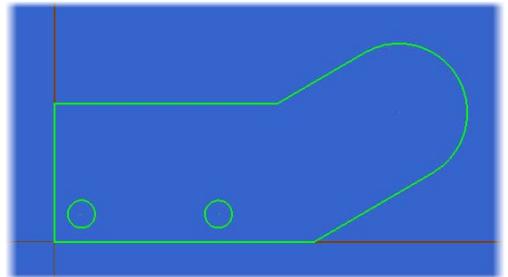
- 1 Hold down the **[Shift]** key, and click the center point of the first circle. The Relative Position ribbon bar displays.

You can now create the second center point relative to the existing point.

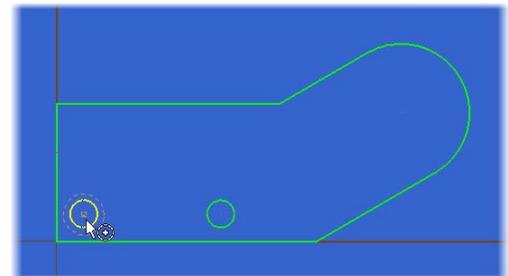


TIP: You can position new points relative to any existing geometry by holding the **[Shift]** key and clicking an existing point.

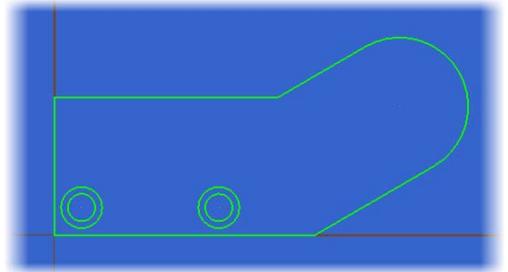
- 2 Type **x50** in the Delta field and press **[Enter]**. The live entity is created, and you return to the Circle Edge Point ribbon bar.
- 3 Click **Apply** to create the second hole.
- 4 Click the **Diameter** button to unlock the value.
- 5 Enter **7.5** for the radius, and re-lock the fields. The next two circles will be the same size.



- 6 To draw the third hole, select the center of the first hole. When you get close, AutoCursor snaps to the center point and displays a Visual Cue. Click the center point, and click **Apply** to make the third circle.



- 7 Click the center point of the right circle to make the last circle.
- 8 Click **OK** to exit the function.
- 9 Choose **File, Save As**.
- 10 Save the file as
OUTER_CONTOUR_WITH_HOLES.MCX.



Two of the circles you completed will be used as drill holes and the other two will be used in the next lesson to create the inner shape of the part.

LESSON 3

Modifying Geometry

Once you have your construction geometry, Mastercam provides many tools for editing and trimming the individual pieces into your final part shape. In this lesson, you use some of these tools, along with some of Mastercam's geometry selection methods.

Lesson Goals

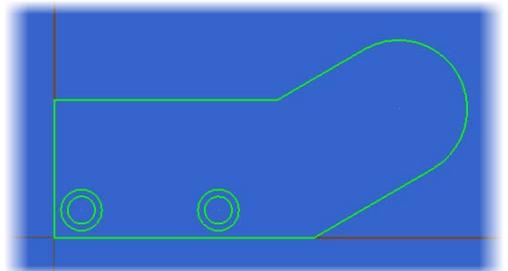
- Offset and mirror geometry.
- Use General Selection.
- Use the data entry calculator and the MRU toolbar.
- Delete duplicate geometry.
- Create fillets.

Exercise 1: Offsetting the Outer Contour

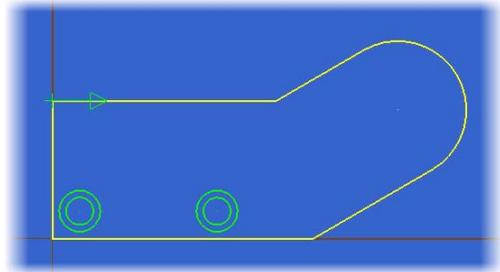
In this exercise, you use the Xform Offset Contour function to begin creating the inner contour of the part.

- 1 Open the tutorial part:
OUTER_CONTOUR_WITH_HOLES.MCX or
continue using the MCX file you created in
Lesson 2.
- 2 Choose **Xform, Xform Offset Contour**. The
Chaining dialog box displays.

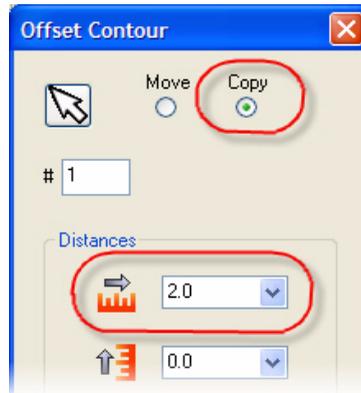
This function uses *chaining*, which lets you select one or more entities linked together by adjoining endpoints. Chaining is different from other selection methods because it associates order and direction with the selected entities. For more information, click the **Help** button on the Chaining dialog box.



- 3 Click anywhere along the outer contour. Mastercam selects and highlights all of the geometry.
- 4 Click **OK** on the Chaining dialog box.



- 5 On the Offset Contour dialog box, make sure that the **Copy** option is selected, and enter **2.0** for the distance.

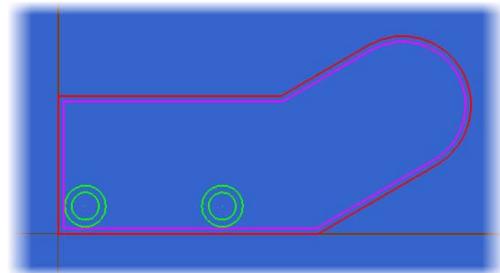


*Note: If the offset contour is displaying on the outside of the selected chain, click the **Direction** button to flip it to the inside.*



- 6 Click **OK**. The original contour is red and the new contour is purple.

Mastercam creates a temporary group from the original geometry (red) and another temporary group from the result (purple). Groups gather entities into a single unit for selection. For more information on groups, refer to the online Help.



Exercise 2: Adding Tangent Lines

In this exercise, you draw perpendicular lines that are tangent to the drill holes.

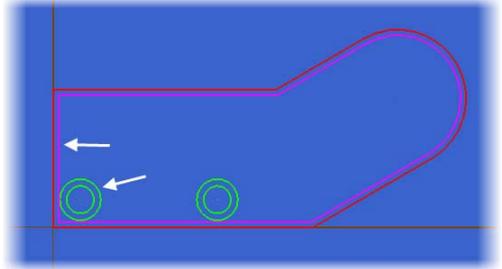
- 1 Choose **Create, Line, Create Line Perpendicular**.

- 2 Select the **Tangent** button on the Line Perpendicular ribbon bar.

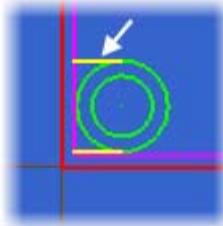


This setting ensures that the new line will be tangent to an arc you select.

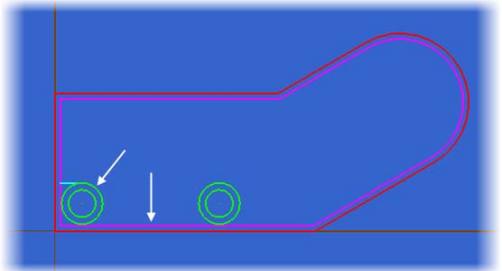
- 3 Click the left outer circle and the left inner line. Mastercam displays two yellow lines as possible solutions.



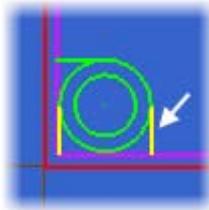
- 4 Click the top yellow line to keep this solution.



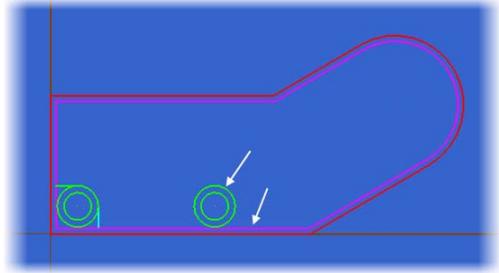
- 5 Click the left outer circle again and the lower inner line. Mastercam again displays two solutions.



- 6 Click the right yellow line.

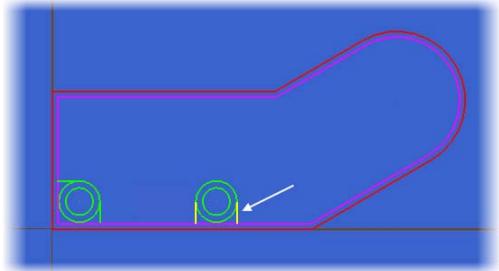


7 Click the right outer circle and the lower inner line. To create tangent lines on either side of the right drill hole, you need to select the same geometry twice.



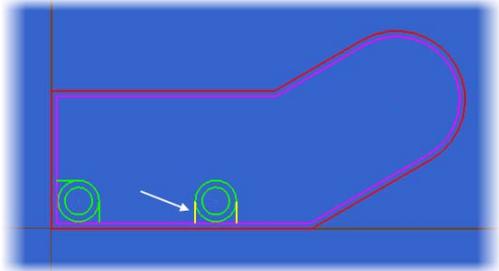
8 Click the right yellow line to keep.

9 Click the right outer circle and the lower line again.

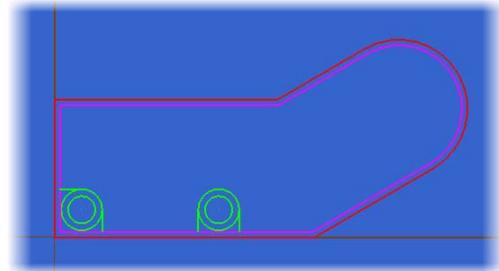


10 Click the left yellow line to keep.

TIP: *If you do not see all four lines, right-click in the graphics window and choose **Repaint**. This refreshes the graphics window.*



11 Click **OK** to complete the lines.



Exercise 3: Trimming the Inner Contour

In this exercise, you trim the geometry around the drill holes.

1 Choose **Edit, Trim/Break, Trim/Break/Extend**.

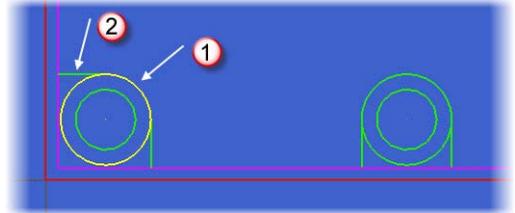


- 2 Click the **Trim 1 entity** button on the ribbon bar.



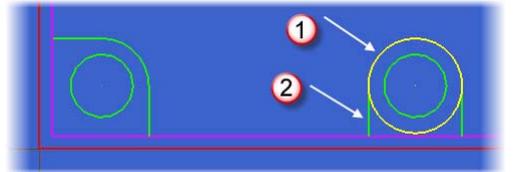
This function allows you to select the entity you want to trim, and then select the location you want to trim to.

- 3 Click the left outer circle.
- 4 Click the top tangent line.



*Note: It is important to select the geometry in this specific order, or the trimming results will be different. If the results do not match the pictures at right, choose **Edit**, **Undo**, and try reselecting the geometry.*

- 5 Click the right outer circle.
- 6 Click the left tangent line.

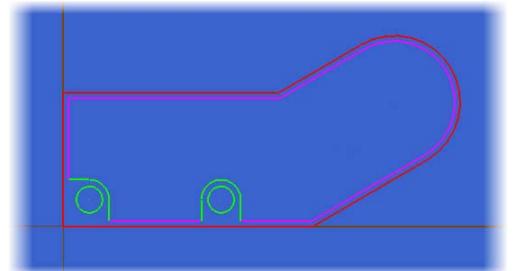


- 7 Click the **Divide** button on the ribbon bar.



Note: You can also press the shortcut key [D].

- 8 Click the following three points:
 - ♦ the inner contour line to the left of the left drill hole.
 - ♦ the inner contour line below the left drill hole.
 - ♦ the inner contour line below the right drill hole.
- 9 Click **OK** to complete the trimming.



Exercise 4: Mirroring the Drill Holes

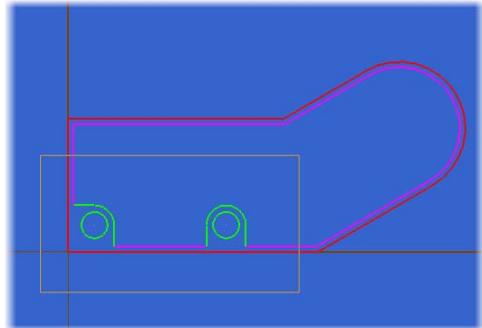
In this exercise, you use General Selection to select a section of the part and mirror the selected area to a position along the top edge of the part.

- 1 Choose **Xform, Xform Mirror**.
- 2 On the General Selection ribbon bar, make sure that the Entity selection drop-down is set to **In**.

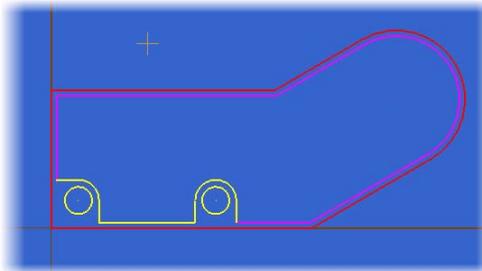
This selects only entities that lie completely in your selection window.



- 3 To select the area of the part that you just created, click and hold the mouse button above and to the left of the left drill hole.
- 4 Drag your mouse down and to the right to draw a selection rectangle.



- 5 Click again to set the lower right corner of the rectangle and complete the selection. The yellow entities are selected.



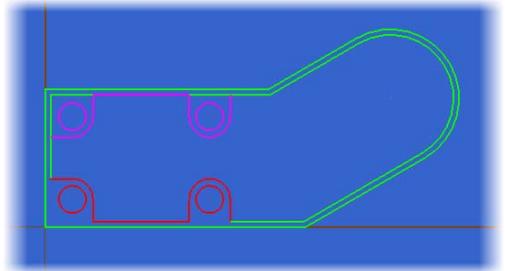
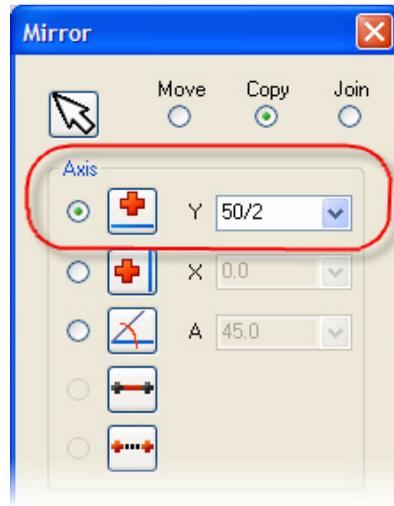
- 6 Click the **End Selection** button on the General Selection ribbon bar to complete the geometry selection and open the Mirror dialog box.



- 7 On the Mirror dialog box, select the first **Axis** option, which mirrors the geometry about the X axis. Make sure that the **Copy** option at the top of the dialog box is selected.
- 8 Enter **50/2** for the Y value and press [Tab]. Mastercam displays a temporary center line at Y25 to show the horizontal axis that will be used to mirror the selected entities.
- Since the left line is 50mm, this Y value mirrors the geometry to the other side of the part.

*Note: All fields that take number values have a built-in calculator that accepts formulas, math equations, and other units of measurement. For more on this function, type **calculator** on the Index tab in Mastercam Help.*

- 9 Click **OK** to mirror the geometry.



Exercise 5: Trimming the Mirrored Geometry

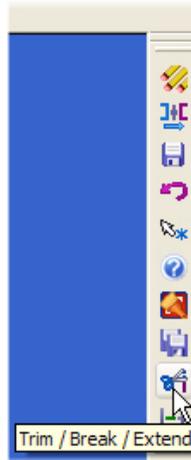
In this exercise, you trim the contour around the mirrored drill holes and delete the resulting duplicate geometry.

- 1 Click the **Trim/Break/Extend** button on the Most Recently Used (MRU) toolbar.

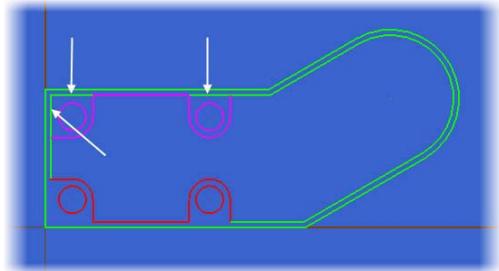
This toolbar shows the last several functions that you used in Mastercam.

- 2 Make sure the **Divide** button is still selected on the ribbon bar.

Mastercam keeps the settings from the last time you used the function.

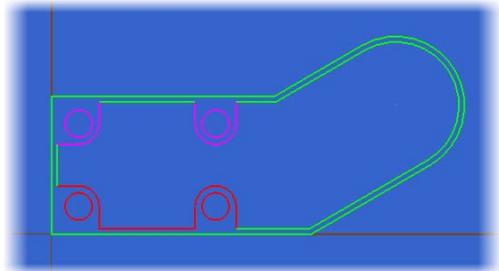


- 3 Click the following three points:
 - ♦ the inner contour line to the left of the top left drill hole.
 - ♦ the inner contour line above the top left drill hole.
 - ♦ the inner contour line above the top right drill hole.



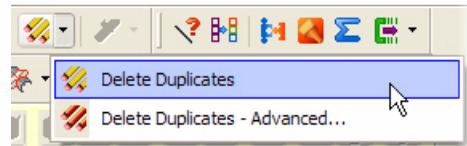
- 4 Click **OK** to complete the trimming
- 5 To remove duplicate geometry, choose **Edit, Delete, Delete Duplicates**. In trimming the lines, a duplicate line was created. The resulting message describes what duplicate geometry was found and removed.

Duplicate entities can make files larger than necessary and make chaining more difficult.

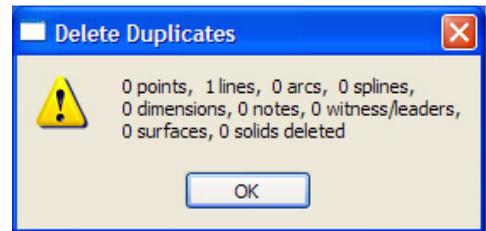




TIP: You can also click the toolbar button to use this function. Click the drop-down arrow next to the button and select **Delete Duplicates**.



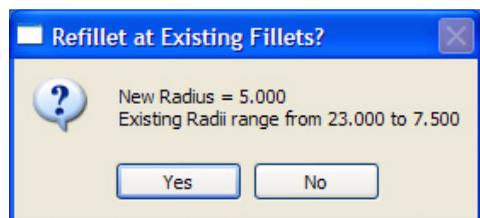
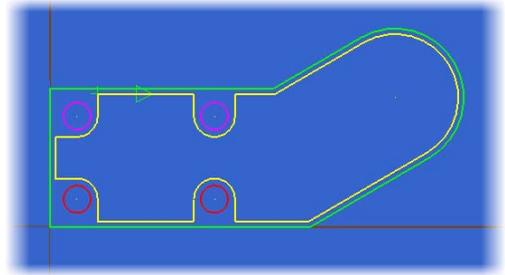
6 Click **OK** to accept the change.



Exercise 6: Adding Fillets

In this exercise, you complete the inner contour by adding fillets to the sharp corners.

- 1 Choose **Create, Fillet, Fillet Chains**.
- 2 Click anywhere along the inner contour. Mastercam highlights the whole contour.
- 3 Click **OK** on the Chaining dialog box. Since you already have some fillets along this contour, Mastercam asks if you want to change the radius on all the existing fillets.
- 4 Click **No** to just add new fillets.
- 5 Click **OK** on the Fillet Chains ribbon bar to accept the new fillets.

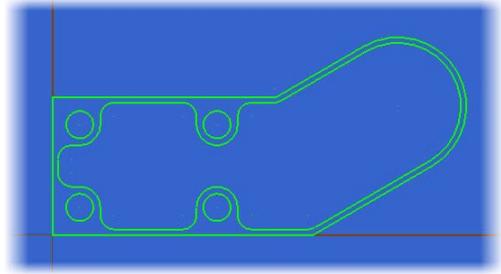


- 6 Right-click in the graphics window, and choose **Clear Colors** to return all geometry to its original color.

*Note: You can also choose **Screen, Clear Colors** from the menu bar.*

- 7 Choose **File, Save As**.

- 8 Save the file as
OUTER_INNER_CONTOURS.MCX.



The outer contour, inner contour, and drill holes are now complete. The last lesson adds a slot to the rounded end of the part.

LESSON 4

Adding a Slot

The final section of the tutorial part is a slot on the rounded end. In this lesson, you will draw the slot and change the color and level of the resulting geometry.

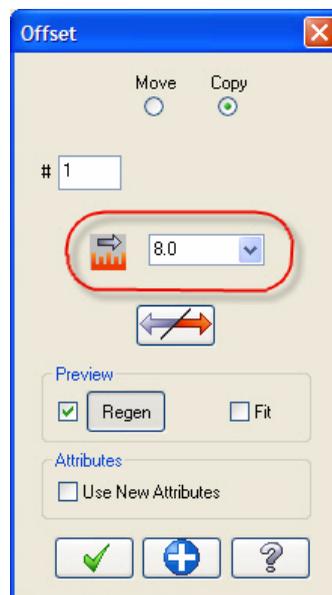
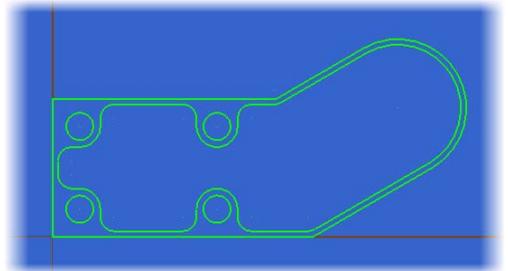
Lesson Goals

- Offset arcs.
- Change entity attributes.

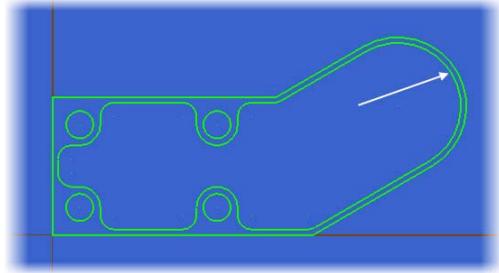
Exercise 1: Starting the Slot

In this exercise, you offset an existing arc to begin the slot.

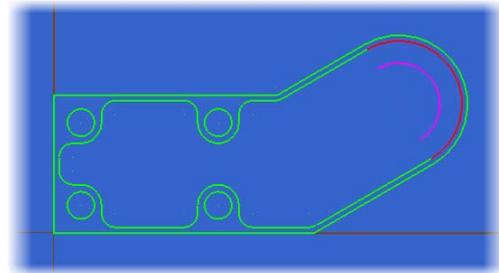
- 1 Open the tutorial part:
OUTER_INNER_CONTOURS.MCX or continue
using the MCX file you created in Lesson 3.
- 2 Choose **Xform**, **Xform Offset**.
- 3 On the Offset dialog box, enter **8** for the
distance. Make sure that the **Copy** option at
the top of the dialog box is selected.



- 4 Select the arc on the rounded end of the inner contour.
- 5 Click inside the arc to indicate the offset direction.



- 6 Click **OK** to create the new arc.



Exercise 2: Drawing Lines For the Slot

In this exercise, you draw lines for the sides of the slot using the first arc's endpoints.

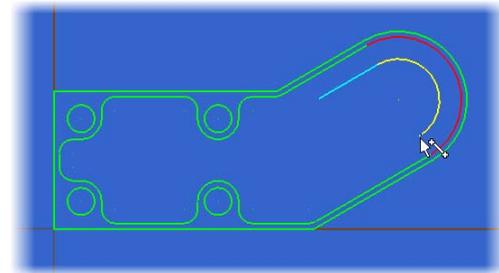
- 1 Choose **Create, Line, Create Line Endpoint**.
- 2 Enter **25** for the length and **210** for the angle in the ribbon bar. Lock both fields because you will draw two lines with the same attributes.



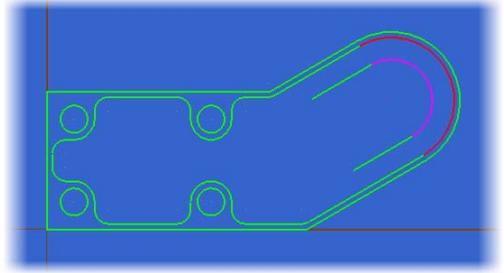
*Note: Make sure the **Tangent** button is deselected.*



- 3 Click the two endpoints of the offset arc that you made in the previous exercise. The AutoCursor snaps to the two endpoints.



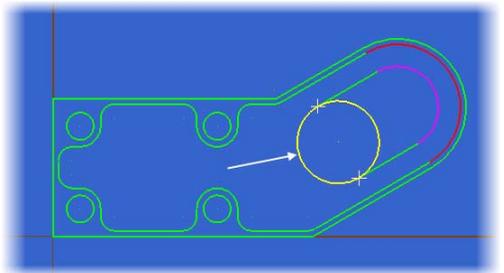
- 4 Click **OK** to complete the lines.



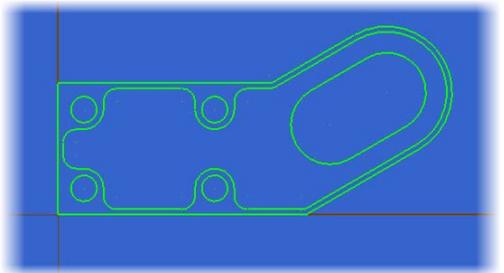
Exercise 3: Completing the Slot Geometry

In this exercise, you use the endpoints of the two lines to make the slot's second arc.

- 1 Choose **Create, Arc, Create Arc Endpoints**.
- 2 In the ribbon bar, enter **15** for the radius.
- 3 Click the line endpoints at the open end of the slot. Mastercam gives you two possible arcs using the selected endpoints and radius.
- 4 Click the arc on the left.
- 5 Click **OK** to complete the arc.



- 6 Choose **Screen, Clear Colors** from the menu bar.

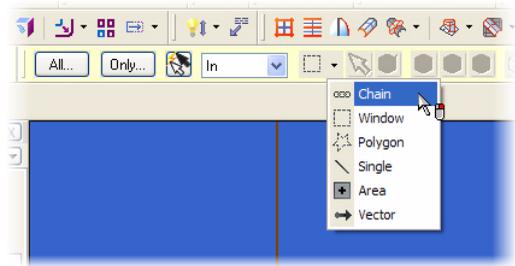


Exercise 4: Changing the Slot's Color and Level

In Lessons 2 and 3, you placed all new geometry on Level 2. In this exercise, you move the whole slot to a new level and change the geometry color.

- 1 On the General Selection ribbon bar, choose **Chain** from the Selection Methods drop-down list.

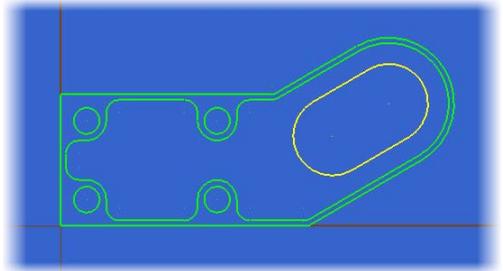
This option selects entities that are connected to other entities.



TIP: The Visual Cue with the red mouse button indicates that if you right-click on an option in the drop-down list, you lock General Selection into that selection method. For more information, refer to the online Help.



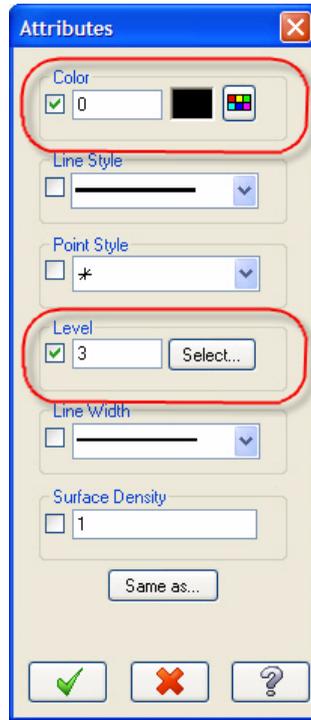
- 2 Select anywhere on the slot. Mastercam highlights the whole slot.
- 3 Right-click the **Attributes** button in the Status bar. The Attributes dialog box displays so you can change one or more entity attributes at the same time.



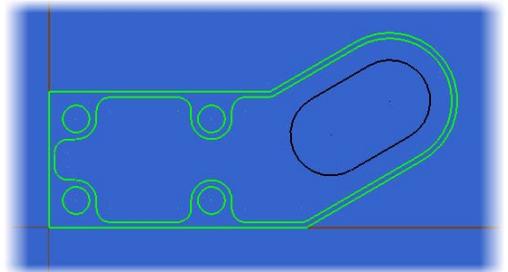
- 4 Select the check box next to the **Color** option, and enter **0** to change the slot to black.
- 5 Select the check box next to the **Level** option, and enter **3** to move the slot geometry to Level 3.

Note: If Level 3 does not already exist, Mastercam creates a new level and moves the geometry there when you close the dialog box. For more information on levels, refer to the online Help.

- 6 Click **OK** to finish the changes.



- 7 Choose **File, Save As**.
- 8 Save the file as `PART_COMPLETE.MCX`.



Conclusion

Congratulations! You have completed the *Basic 2D Design* tutorial. Now that you have mastered the skills in this tutorial, we encourage you to explore Mastercam's other features and functions. Additional tutorials may be available in this or other series. Please contact your authorized Mastercam Reseller for further training.



cmc software, inc.

671 Old Post Road
Tolland, CT 06084 USA
www.mastercam.com

Printed in the USA
Mastercam X2 MR2 Basic 2D Design 1-883310-78-4