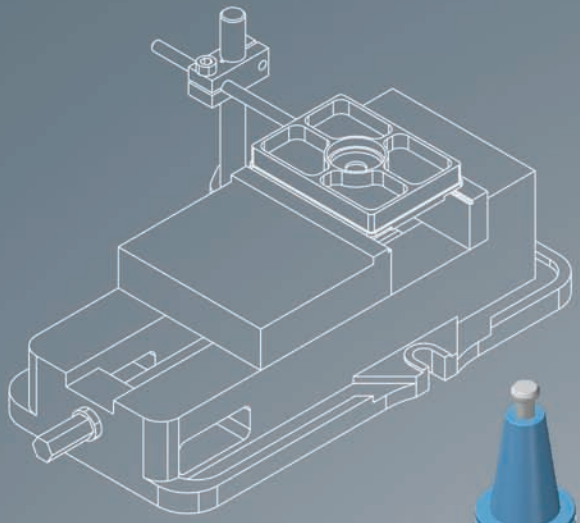
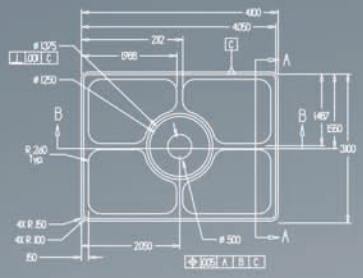
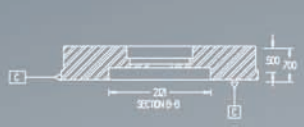
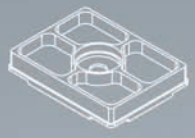
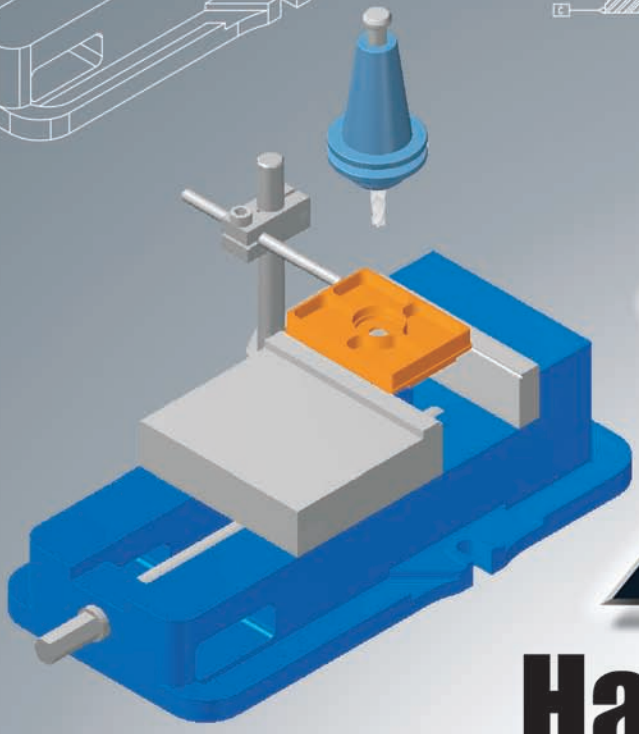




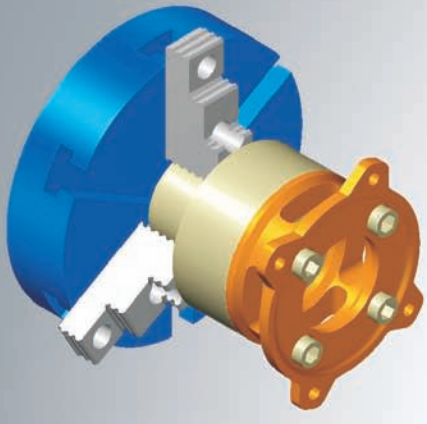






Mastercam X3 Handbook Volume 1

Mill Level 1 & Solids



Mastercam®

When Second Best Won't Cut It®

Mastercam Handbook Volume 1 for Mastercam X3
Date: September 16, 2008

Software: Mastercam X3 Mill & Solids
Authors: In-House Solutions Inc.
ISBN: 978-1-926566-08-5

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This document complies with Mastercam-X3 as of Aug, 2008. Requires Mastercam Mill Level 1. Requires Solids for Chapter 5

Contents

Introduction

Congratulations on your purchase of the Mastercam Handbook Volume 1. This book was developed and tested over several years as part of a course to teach machinists how to program CNC machine tools with Mastercam. It assumes you have a working knowledge of machining and CNC's, including tooling, work-holding, and common G&M codes. No prior experience with computers or CAD/CAM is necessary, but helpful.

The Handbook can be used as the primary resource for a Mastercam class, as a self-study guide, or a shop reference. Mastercam help functions and information on the student CD supplement the material in this book.

A unique feature of this book is the comprehensive, top-down approach it takes to learning. Concepts and essential knowledge are included along with practical applications. This approach means you not only learn how to use Mastercam, but why things are work as they do.

By understanding exactly what you are doing and why each step of the way, you learn to recognize the best approach to problems. Not only will you be better prepared to work effectively, you will gain a solid foundation of knowledge that will help you continue to learn and adapt as technology changes.

Specific recommendations about how to best use Mastercam are included. There are often many ways to accomplish any task. However, you will learn faster and understand the overall picture of what you are doing if you first master fundamentals and standard practices.

In any case where information in this book conflicts with your machine manuals or the methods used at your company or school, ignore the suggestions in this book and use the information in the manuals and established procedures at your facility.

Never operate a CNC Machine without having read and understood the operator and programmer manual, and having received safety and operator training by a qualified person on that machine.

Warning

Contents

This book is divided into ten chapters. Each covers a specific knowledge area. Following is a breakdown of the chapters and what you will find in each:

Chapter 1: Computer Essentials covers the computer knowledge and skills you'll need to operate a CAD/CAM system.

Chapter 2: Mastercam Workspace shows how to use, navigate, and customize the Mastercam workspace.

Chapter 3: CAD Drawing shows how the Mastercam user interfaces works, how to draw basic geometry such as lines, arcs, and points, and how to import/export data between different CAD/CAM systems.

Chapter 4: Advanced CAD Drawing shows how to move, copy, rotate, mirror, and scale geometry, and how draw basic 3D wireframe geometry.

Chapter 5: Solid Modeling introduces how to draw in a 3D Workspace, create basic solid models, and how to organize and manage your drawings.

Chapter 6: Drill Toolpaths shows how to use hole-making functions including drilling, peck drilling, and tapping.

Chapter 7: Contour Toolpaths shows how to create 2D, 3D, Ramp and Remachining contour toolpaths.

Chapter 8: Pocket Toolpaths teaches basic skills to remove excess material.

Chapter 9: Rotary Toolpaths teaches how to create 4th axis indexing and axis substitution toolpaths.

Chapter 10: Change Recognition shows how to identify, isolate, and update changes between part revisions.

Appendices: A-D as shown on the Contents page. App E & F are in PDF format on the student CD only.

Icons

Icons are used to alert, inform, and enhance your learning experience. The following icons are found in the margins of the book:

Remember reminds you of important information that will help you work safely and productively.


Remember

Tips are suggestions from experienced CAD/CAM users that will guide your learning and use of Mastercam.


Tip

Step by Step are detailed instructions on how to use a specific function or perform a task.


Step by Step

On The CD alerts you that a file exists on the CD included with this manual that may be necessary for accomplishing a task.


On The CD

Try It assigns a task you should be able to successfully complete before proceeding further.


Try It

Warning is used to emphasize situations that can cause damage to machines, property, bodily injury or death. Machining can be dangerous. Take these warnings seriously and do not proceed unless you are certain your methods and setup are completely safe.


Warning

In Depth are notes of interest that deepen your understanding and knowledge of a topic.


In Depth

Power User denotes tips that are likely only applicable to the highest level users of Mastercam.


Power User

Conventions

Key words and Mastercam menu items are shown in **bold** the first time they are used.

Columns on the outside edges of each page and note pages at the end of each chapter provide ample space for taking notes.

Useful tips, recommended settings, best practices, and detailed instruction on the most important features are included when possible.

3 CAD Drawing

Objectives

In this chapter, you will learn to draw wireframe geometry. Upon completion of this chapter, you should be able to do the following:

- Define elements of the Cartesian coordinate system.
- Understand the difference between absolute and incremental coordinates.
- Define the four quadrants and the sign of points lying within each.
- Correctly determine the Datum on a part print.
- Create lines, arcs, points, rectangles and other geometric shapes.
- View the part from different perspectives
- Use trim, chamfer and fillet functions.
- Dimension a shop drawing.

Introduction

A computer cannot think. Nor can it scan a drawing and automatically create a usable NC program. The only thing a computer can do is what you, or the person who wrote the software, commands it to do. In this respect, the computer is just like any other tool. It helps you do your job better, and it can make good parts or bad, depending on how you use it.

While the computer cannot think, its ability to process huge volumes of information, quickly and without error, is unmatched.

Every bit of information needed to draw and machine your part is stored in a large database that Mastercam manages for you. What you see on the computer screen is a picture of that database.

You work with the picture, not the lists of numbers that make it possible. Behind the scenes, Mastercam responds to your every input, updating the database and changing the picture to reflect every change immediately.

This way of working with a computer is **Interactive**. You instruct the computer to do something, and it does it. You see the results of your actions and decide to undo, change it, or move on to another task. Instead of acting as a human calculator trying to visualize what the numbers mean, you work with pictures that change on your command.

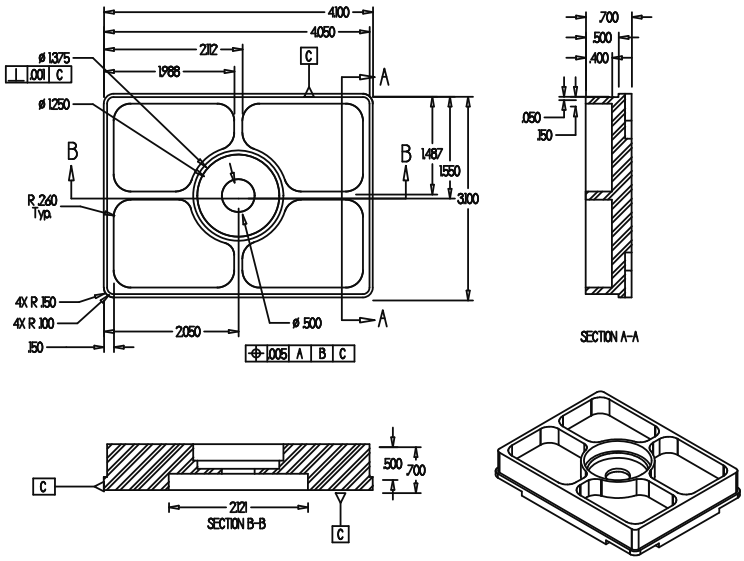
Since humans are visually oriented, this way of working is far more efficient than writing CNC programs by hand. When you do something, you see the results immediately.

Errors are easier to spot. Changes are faster and easier to make. Once you are confident that the machining processes are exactly what you want, the software does the tedious work of writing the CNC program.

With Mastercam, you seldom, if ever, need to use an electronic calculator. Geometry problems are solved using Mastercam's many geometry creations, transformation, and editing tools — not trigonometric calculations.

There is an old saying about computers, "Garbage In, Garbage Out". This means the computer will perform well if you instruct it properly and poorly if you do not.

However, assuming you have done your job well, and your software is setup properly, Mastercam does an excellent job writing CNC programs, even longest and most complex ones, quickly and without a flaw.



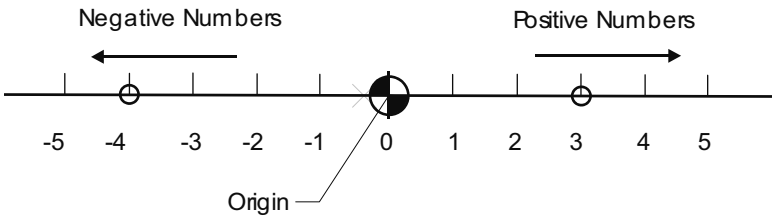
Cartesian Coordinate System

Before learning to draw in Mastercam, review some basic concepts and terms used in CAD/CAM technology:

- Cartesian coordinate system
- Datum
- Planes
- Fundamentals of CAD geometry

For Mastercam to display a part, you must define its exact shape, size and location. Do this by drawing lines, arcs, points, and other geometric entities that precisely describe the part. These geometric entities exist in a Cartesian coordinate system.

A Cartesian coordinate system consists of two or three number lines.



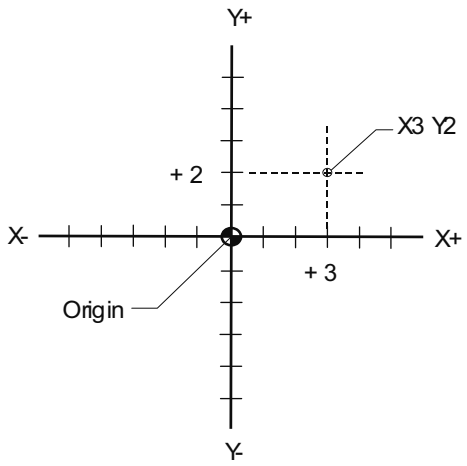
A number line is a line divided into equal segments. Some point on the line is designated as zero. This point is called the Origin. Numbers to one side of the origin are positive. Those on the other side are negative.

Any point on the line is precisely located given its value and sign. In the example, the coordinate "3" lays three units to the right of the origin point. The coordinate "-4" lays four units to the left of the origin.

It is common practice to drop the sign for positive numbers. Thus +3 is written or entered in the computer as 3. However, negative numbers must include the negative sign "-". For example, the number -3 must include the "-" sign.


Remember

A two dimensional Cartesian coordinate system consists of two number lines set at a 90-degree angle to each other. One line is horizontal (left to right) and is labeled the X-axis. The other is vertical (up and down) and labeled the Y-axis. The point where the axes cross is the **Origin**.



Any point in this space, called a **Plane**, or **Construction Plane**, are precisely defined given its axes label, sign, and value. For example, the point "X3Y2" is located by counting, from the Origin, three units along the X+ axis, then up two units parallel to the Y+ axis.

Tip

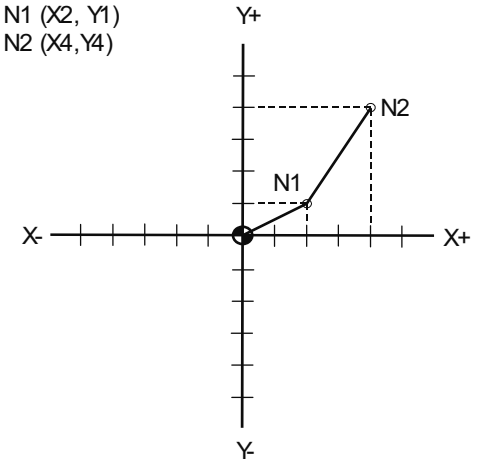
Cartesian coordinates may be written two different ways. One uses the axis label, sign and value.
For example: **X3Y2**

The other writes coordinates as an **Ordered Pair**. Numbers are written in a specific order (X,Y) separated by commas.
For example: **3,2**

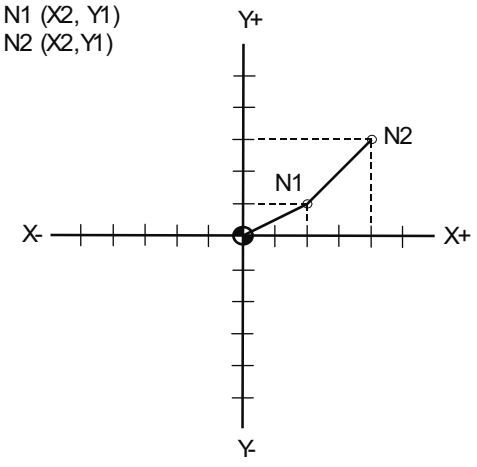
Rectangular Coordinates

Positions within the Cartesian coordinate system may be described using **Absolute**, **Incremental** or **Polar** coordinates.

Absolute coordinates are always in reference to the Origin, regardless of the previous position. Starting at the Origin, the following diagram shows a move to N1 and then to N2, written in absolute coordinates.

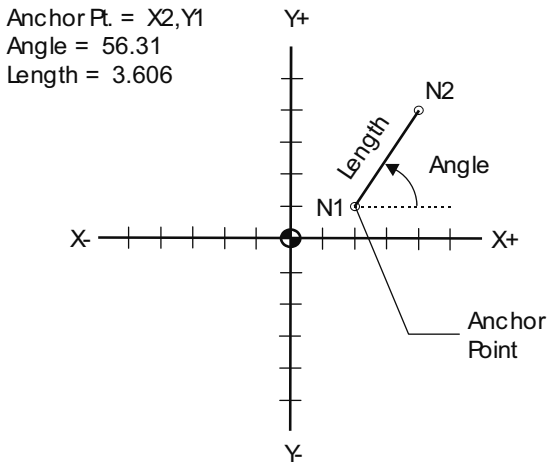


Incremental coordinates (sometimes called Delta or Rectangular coordinates) are always in reference to the current position. For example, starting at the Origin, the following diagram shows a move to N1 and then to N2, written in incremental coordinates.

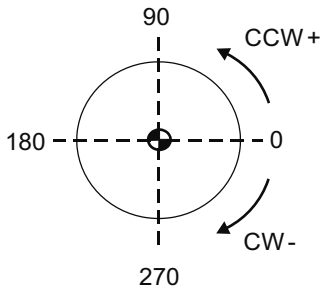


Polar Coordinates

Polar Coordinates are always in reference to a position (called the Anchor Point), a Distance, and Angle. Starting at the position (X2, Y1), the following diagram shows a move to N2, written in polar coordinates.



Angles are measured in degrees from the 3:00 position.

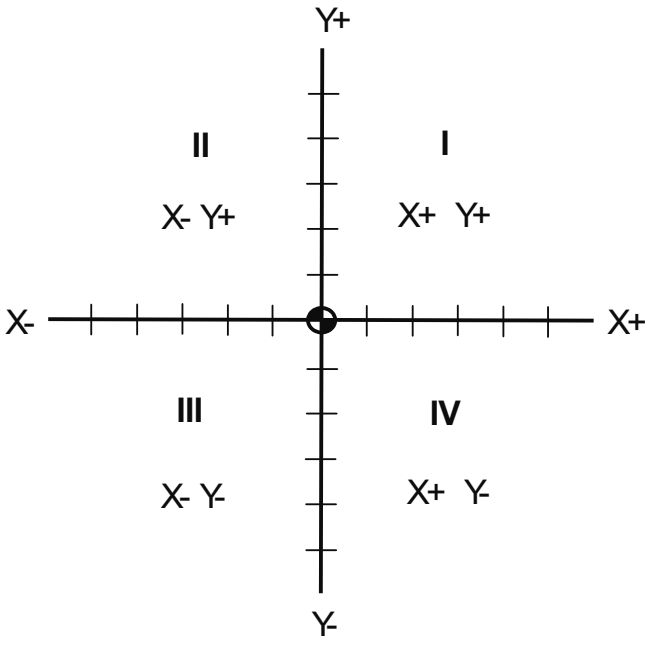


Term	Definition
Angle	CCW angles are positive. CW angles are negative. For example, the angle (315) is the same as (-45).
Anchor Point	Reference position for the polar coordinates.
Degree	$1/360^{th}$ of a full circle.
Minute	$1/60^{th}$ of a degree.
Second	$1/60^{th}$ of a minute. Angles can be expressed in degrees, minutes and seconds, which is abbreviated, DMS.

Quadrants

A Plane can be divided along its axes into four quadrants, starting in the upper-right corner and moving counterclockwise, labelled: I, II, III, IV.

It's important to know which quadrant the part is in because the sign of the coordinates change based on the quadrant. For example, all points in quadrant (I), have positive X and Y values. Points falling in quadrant (II) have negative X and positive Y values, and so on.

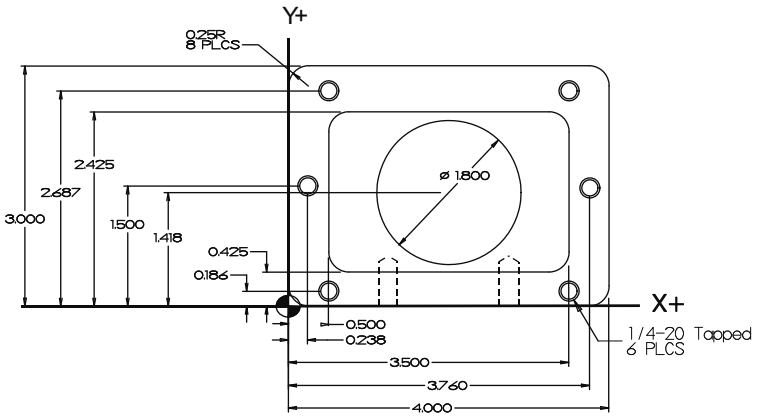


Turn to pages 3-59 and 3-60 at the end of this chapter and complete
- **Exercise 3-1, Cartesian Coordinate System**
- **Exercise 3-2, Incremental Positioning**.

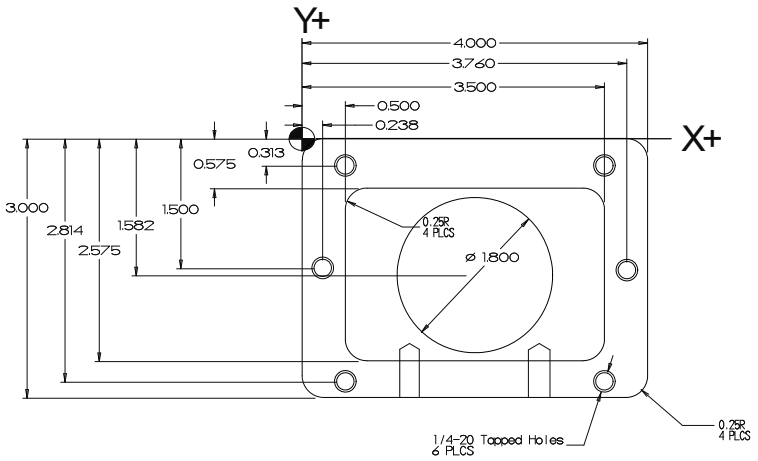
Try It

Datum

The Origin point on a drawing is called the **Datum**. The drawing below shows the datum in the lower-left corner, locating the part in the first quadrant.



The following drawing shows the same part with the datum in the upper-left corner, locating the part in the fourth quadrant.

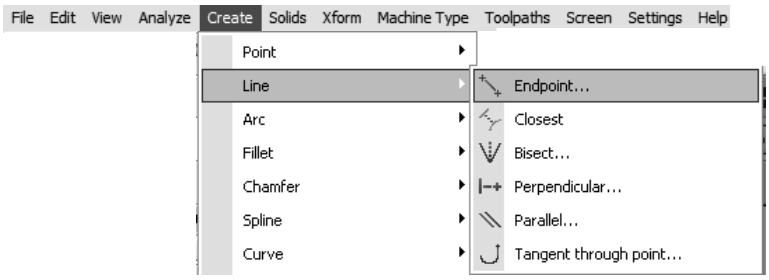


Remember

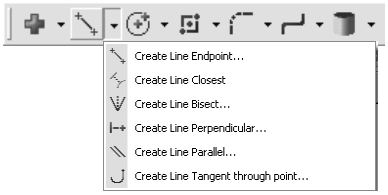
Even though part prints do not show dimensions as negative numbers, you must input negative values when entering coordinates when appropriate. For example, the hole in the upper left corner in the drawing above is at the coordinate: X.5 Y-.313

Create lines by selecting **Create**, **Line** from the Menu.

Create Line



The line options are also available on the **Sketcher** toolbar

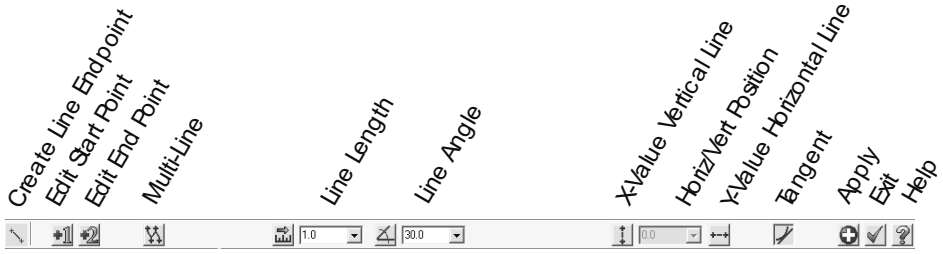


Option	Definition
Create line endpoint	Create a line given its endpoints, length, angle or tangent point.
Create line closest	Create a line representing the shortest distance between two entities.
Create line bisect	Create a bisecting line; a line that splits the angle between two lines equally.
Create line perpendicular	Create a line perpendicular to a line, arc, or spline.
Create line parallel	Create a line parallel to an existing line.

Line Ribbon Bars

The line ribbon bars control values and relations of lines. Line parameters can be changed until the **Apply** or **Exit** buttons are selected to complete its creation. Until then, the entity is said to be "live" and is cyan color. When fully defined, the line changes to the default drawing color.

The ribbon bars change depending on the type of line selected. The **Create line endpoint** option is the most common selection and uses the following ribbon bar.



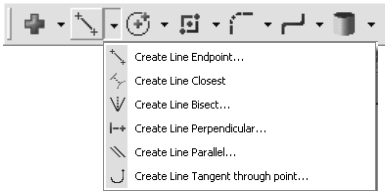
Term	Definition
Create Line Endpoint	Ribbon bar identifier.
Edit Start Point	Change value of start point.
Edit End Point	Change value of end point.
Multi-Line	Create a string of lines.
Line Length	Enter/display length of line.
Line Angle	Enter/display angle of line.
Vertical Line	Draw a vertical line.
Horizontal Line	Draw a horizontal line.
Horizontal/ Vertical Position	X-value of a vertical line, Y-value of a horizontal line. When one of these is active, the horiz/vert position value allows setting the X or Y position of the line.
Tangent	Specify line to be tangent to arc or spline. When this option is active, the line will be tangent to the arc if no other geometric feature, such as an endpoint or quadrant, is selected.
Apply	Create the line but keep ribbon bar open.
Exit	Create line but leave the line create option. Same as selecting the **[ESC]** key.

Creating Lines

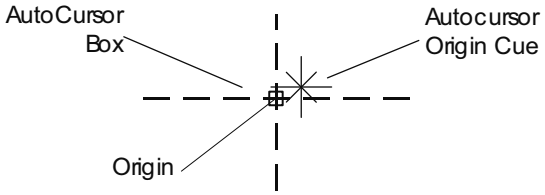
Follow the steps below to create a line given its start point, length, and angle. This exercise is easier if you make the **Screen Grid** visible.


Step by Step

Step 1: Select the **Create line endpoint** function from the main menu or the Sketcher tool bar.



Step 2: Move the mouse near the coordinate system origin until the cursor changes from an arrow to a box, the Origin cue displays, and the small box snaps to the Origin. Click once on the left mouse button.

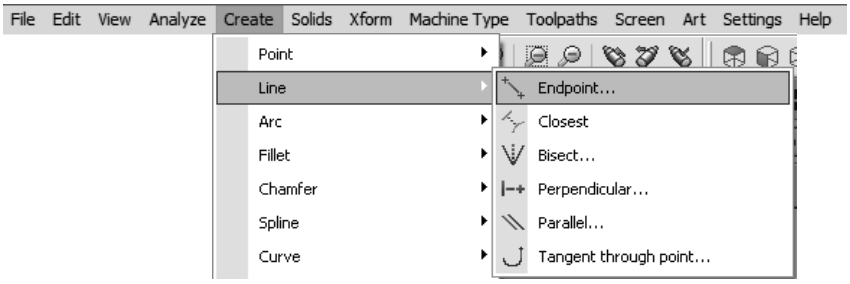


Step 3: Drag the mouse to the right so that the line snaps horizontal and the **Angle** field locks to 0-degrees. Then click once on the left mouse button. A Cyan colored line displays, indicating the line is a "live" entity. Altering parameters on the ribbon bar can still change live entities.

Step 4: Enter **L4** and press **Enter** on the keyboard to set the line length. Finally, click **Apply** to finish the line and remain in this function, or **Exit** to finish the line and leave the function. Notice that the line changes to the active color indicating it is now completely defined.

More Line Options

Other functions on the line drop down menu are shown below:



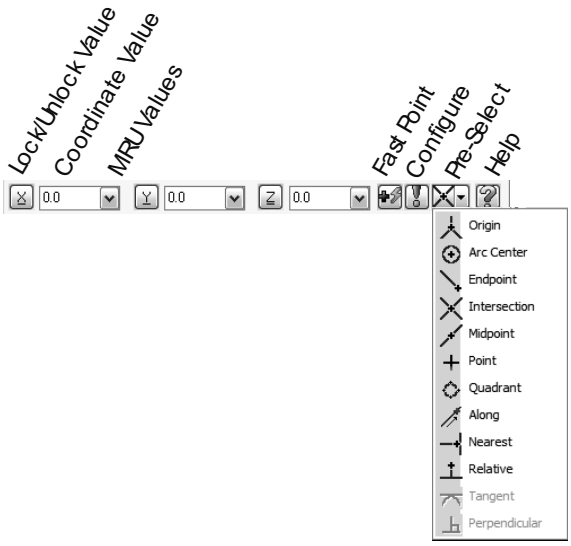
Item	Definition
Create line endpoint	Create a line given its start and/or endpoint, angle, tangent to curve, or other geometric information.
Create line closest	Create a line that is the shortest distance between two entities.
Create line bisect	Create a line that bisects two other lines. When multiple solutions are shown, pick the one you want to keep.
Create line perpendicular	Create a line perpendicular to another line, arc or spline.
Create line parallel	Create a line parallel and at a specified distance from another line.

You should be able to create lines using any of these options by simply following the function prompts. If you have problems, use the on-line help [Alt-H].

AutoCursor Toolbar

During geometry creation, AutoCursor automatically finds and locks (snaps) to geometry features. For example, as the cursor approaches the endpoint of a existing line, the cursor jumps and locks onto it.

An AutoCursor cue appears near the cursor. This cue changes to show the type of geometric feature is located. Click to accept this feature location, or move the cursor to find another feature in the area.



Term	Definition
Lock/Unlock Value	Click the axis label to lock entry in field so it does not change as the cursor moves. Selecting Shift on the keyboard with the axis label does the same.
Coordinate Value	Field entries for X,Y,Z coordinate values.
MRU Values	Click to display the most recently entered values.
Fast Point	This works the same as pressing the spacebar. Enter coordinates as ordered pairs. See the **Tip** on page 2-3 for coordinate entry rules.
Configure AutoCursor	Configures mouse to select or not select one or more AutoCursor items.
Pre-Select AutoCursor	Click a feature on this drop down list to force AutoCursor to only see that feature for the next mouse selection only.
Help	Help on how to use AutoCursor.