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Mastercam 2020 Handbook Volume 1

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Table Of Contents

Legend

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.

Extra credit exercises are included on the student CD in PDF format. These will help build your skill to a higher level.

TERMS

The following terms are used throughout this book.

- **Left Click** means to click once on the left mouse button.
- **Click** means the same as left click.
- **Right Click** means to click once on the right mouse button.
- **Scroll** means to roll the mouse scroll wheel, or move the scroll index in a list.
- **Options** are Mastercam functions selected from the main menu.
- **Enter** means to select the <Enter> key on your computer keyboard.
- **Press** means to press on a keyboard key.
- **Choose** means to select a menu option or button.
- **Open/Close** means to open or close a dialog or information box.
- **Dialog Box** is a window that opens to allow for the input of information and the setting of defaults.
- **Panel** is a window that is locked and opens to allow for the input of information and the setting of defaults.
- **Drop Down/Flyout Menus** are menus that expand down, left, right, or up, to reveal more menu lists.
- A **Function** is the same as a menu option or command.
- **Help** means the Mastercam help files loaded with your software.

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 the points lying within each
- Correctly determine the Datum on a part print
- Create lines, arcs, points, rectangles, and other geometric shapes
- Use trim, chamfer, and fillet functions
- Dimension a shop drawing

INTRODUCTION

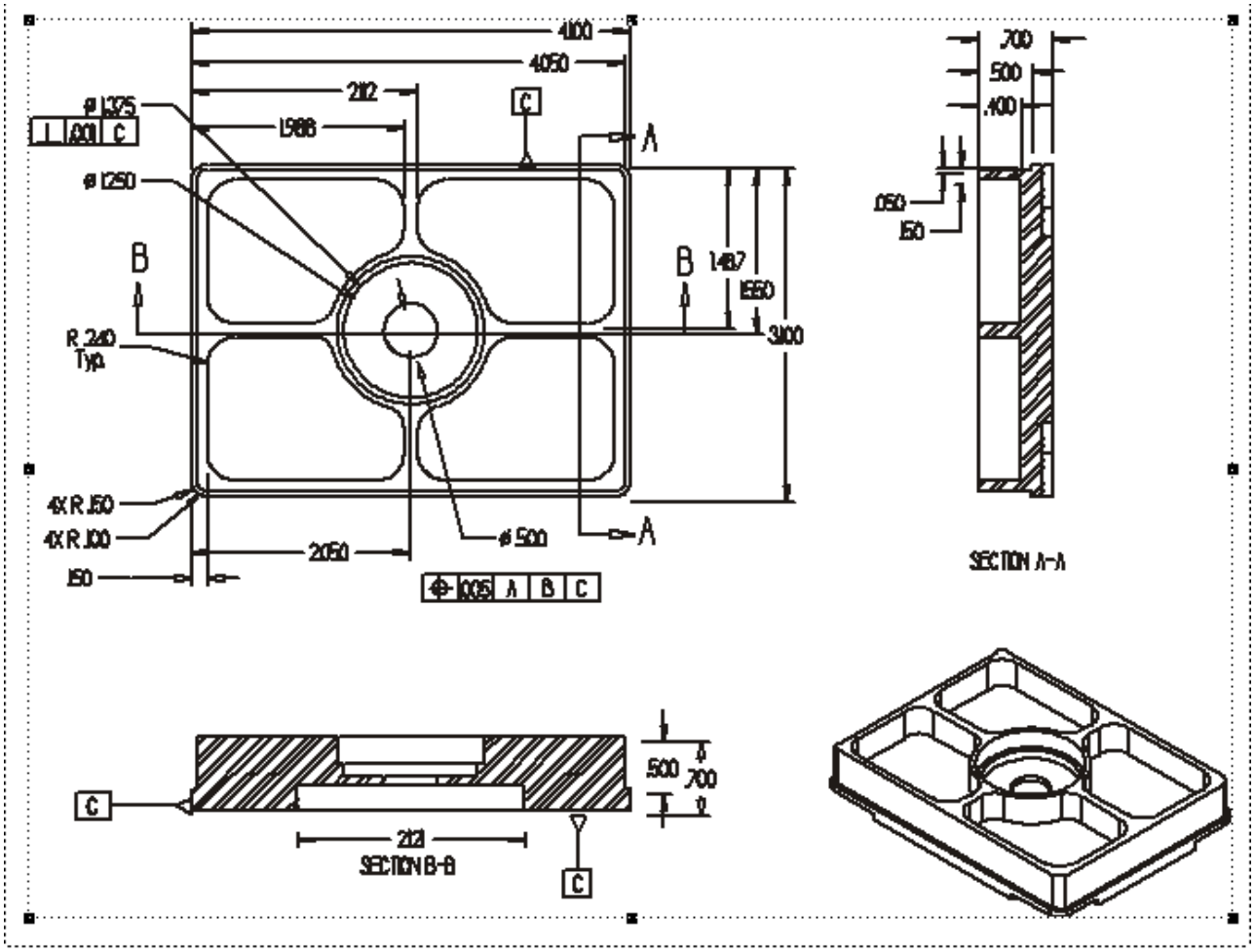
A computer cannot scan a drawing and automatically create a usable NC program; however, the computer can process huge volumes of information quickly and without error. Information needed to draw and machine your part is stored in a large database that Mastercam manages for you, what you see on the computer screen is a picture of that database.

You work with the picture, not the lists of numbers that generate the picture. Behind the scenes, Mastercam responds to every input from you, updating the database and changing the picture to reflect every change immediately. Since humans are visually oriented, this way of working is far more efficient than writing CNC programs by hand, since you see the results immediately. 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 rarely, if ever, need to use an electronic calculator. Geometry problems are solved using Mastercam's many geometry creations, transformation, and editing tools.

When your software is set up properly, Mastercam does an excellent job of writing CNC programs quickly and without a flaw. Figure: 1 shows a part's blueprint.

Figure: 1



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

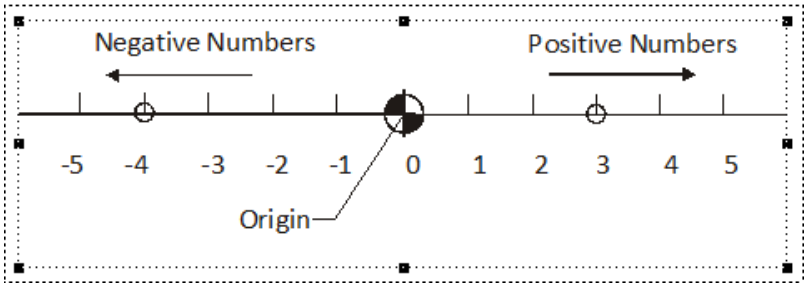
For Mastercam to display a part, you must define its exact shape, size, and location. Do this by drawing lines, arcs, points, and other geometric entities that precisely describe the part. These geometric entities exist in a Cartesian coordinate system.

A Cartesian coordinate system consists of two or three perpendicular number lines (coordinate axis). A number line is a line divided into equal segments. The point on the line designated as zero is called the Origin.

The Cartesian coordinate system allows you to define each point uniquely in a plane using a pair of numerical coordinates, which are the signed distances to the point from the origin, measured in the same unit of length.

Numbers to one side of the Origin are positive, those on the other side are negative as shown in Figure: 2.

Figure: 2

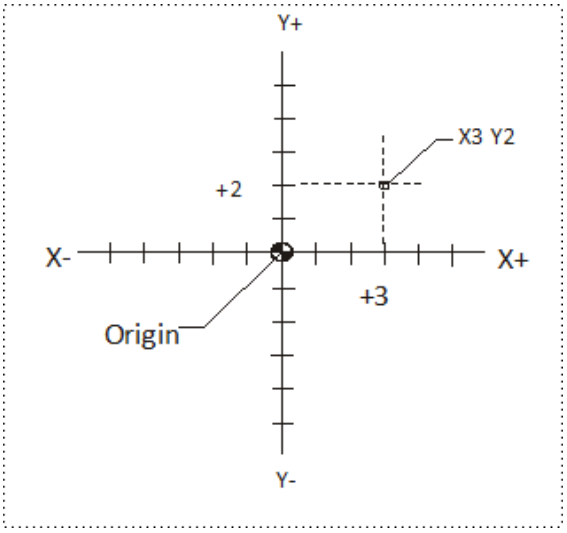


Any point on the line is precisely located given its value and sign. In Figure: 2 the coordinate "3" lays three units to the right of the Origin point. The coordinate "-4" lays four units to the left of the Origin.

Note: 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.

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 as the X-axis. The other is vertical (up and down) and labeled as the Y-axis. The point where the axes cross is the Origin as shown in Figure: 3.

Figure: 3



All points in this space, also called a Plane, or Construction Plane, are precisely defined given its axes label, sign, and value. For example, the point "X3,Y2" is located by counting, from the Origin, three units along the X+ axis, then up two units parallel to the Y+ axis.

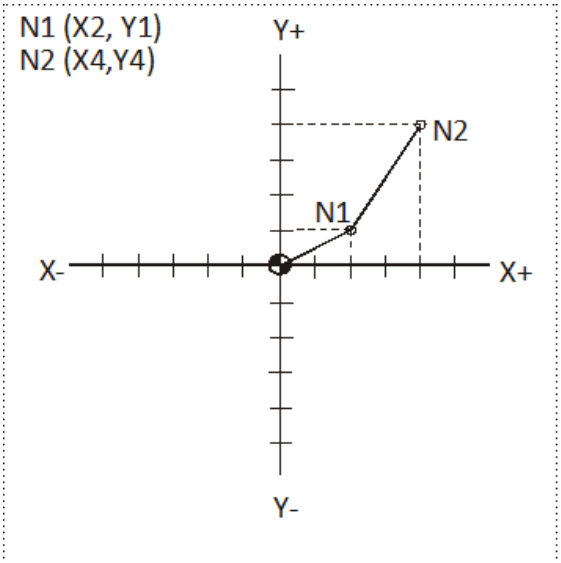
Note: Cartesian coordinates may be written in two different ways. One uses the axis label, sign and value. For example: X3 Y2. The other writes coordinates as an Ordered Pair. Numbers are written in a specific order (X,Y) separated by commas. For example: 3,2.

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

Absolute And Incremental Coordinates

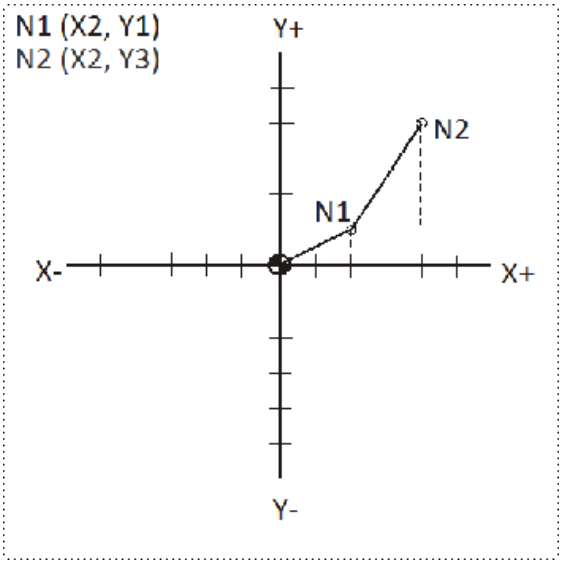
Absolute coordinates are always in reference to the Origin, regardless of the previous position. Starting at the Origin, the following diagram shows a move to N1 and then to N2, written in absolute coordinates as shown in Figure: 4.

Figure: 4



Incremental coordinates (sometimes called Delta or Rectangular coordinates) are always in reference to the current position. For example, starting at the Origin, Figure: 5 shows a move to N1 and then to N2, written in incremental coordinates.

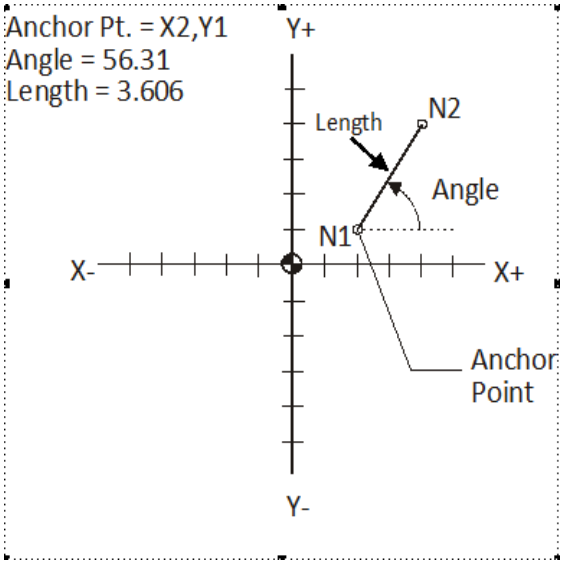
Figure: 5



Polar Coordinates

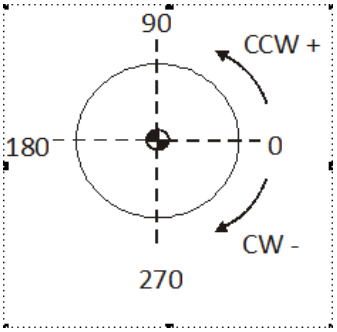
Polar Coordinates are always in reference to a position (called the Anchor Point), a Distance, and Angle. Starting at the position (X2, Y1), Figure: 6 shows a move to N2, written in polar coordinates.

Figure: 6



Angles are measured in degrees from the 3:00 position as shown in Figure: 7.

Figure: 7

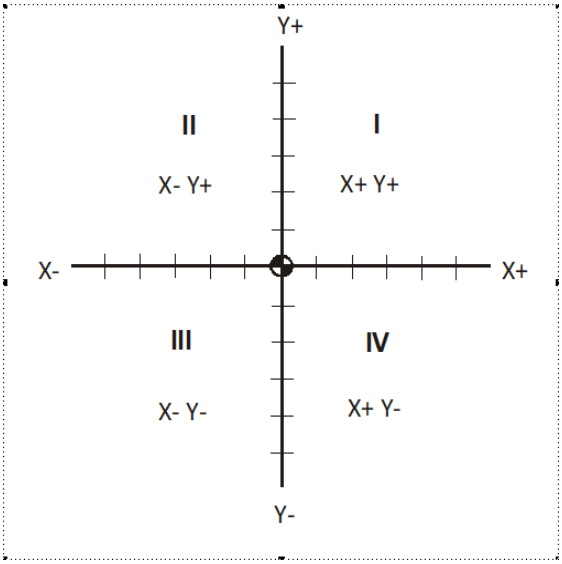


Term	Definition
Angle	CCW angles are positive. CW angles are negative. For example, the angle (315) is the same as (-45).
Anchor Point	Reference position for the polar coordinates.
Degree	1/360th of a full circle.
Minute	1/60th of a degree.
Second	1/60th of a minute. Angles can be expressed in degrees,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

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 changes based on the quadrant. As shown in Figure: 8, 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.

Figure: 8



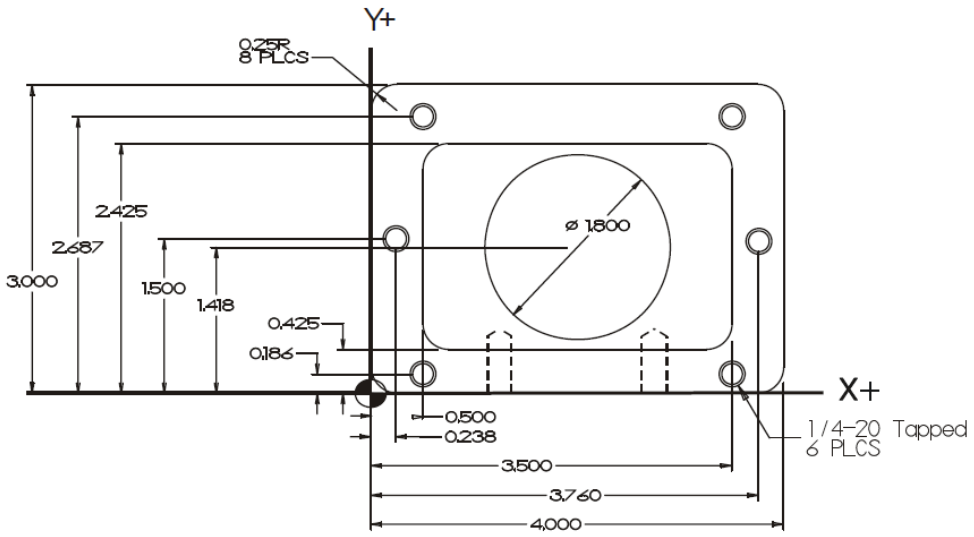
Turn to the end of this chapter and complete;

- Exercise 3-1, Cartesian Coordinate System.
- Exercise 3-2, Incremental Positioning.

DATUM

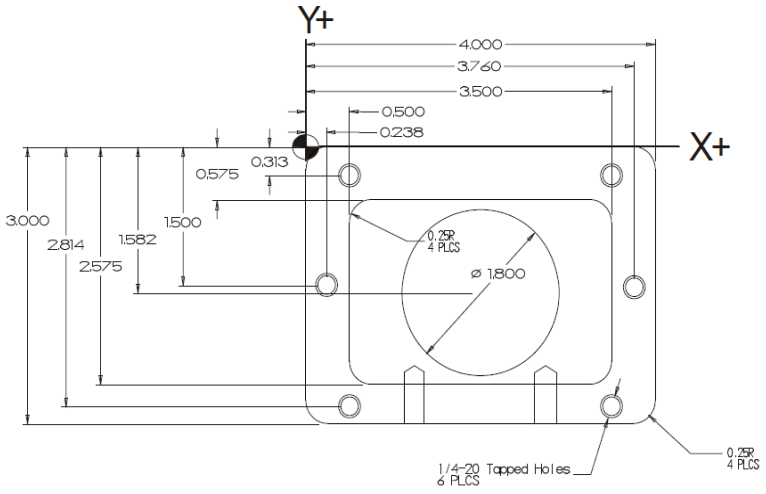
The Origin point on a drawing is called the **Datum**. The drawing below shows the datum in the lower-left corner, locating the part in the first quadrant as shown in Figure: 9.

Figure: 9



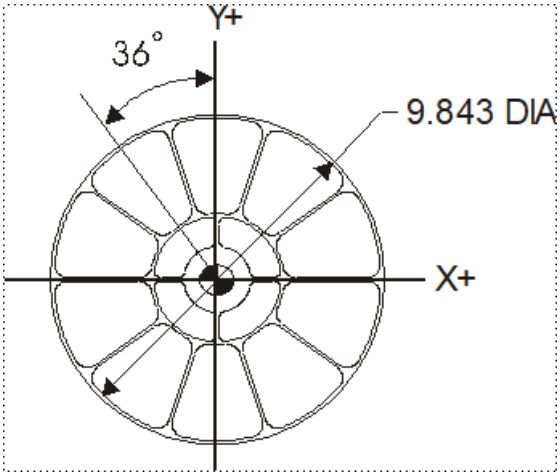
Note: Even though part prints do not show dimensions as negative numbers, you must input negative values when appropriate. For example, the hole in the upper left corner in the drawing below is at the coordinate: X.5 Y-.313.

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



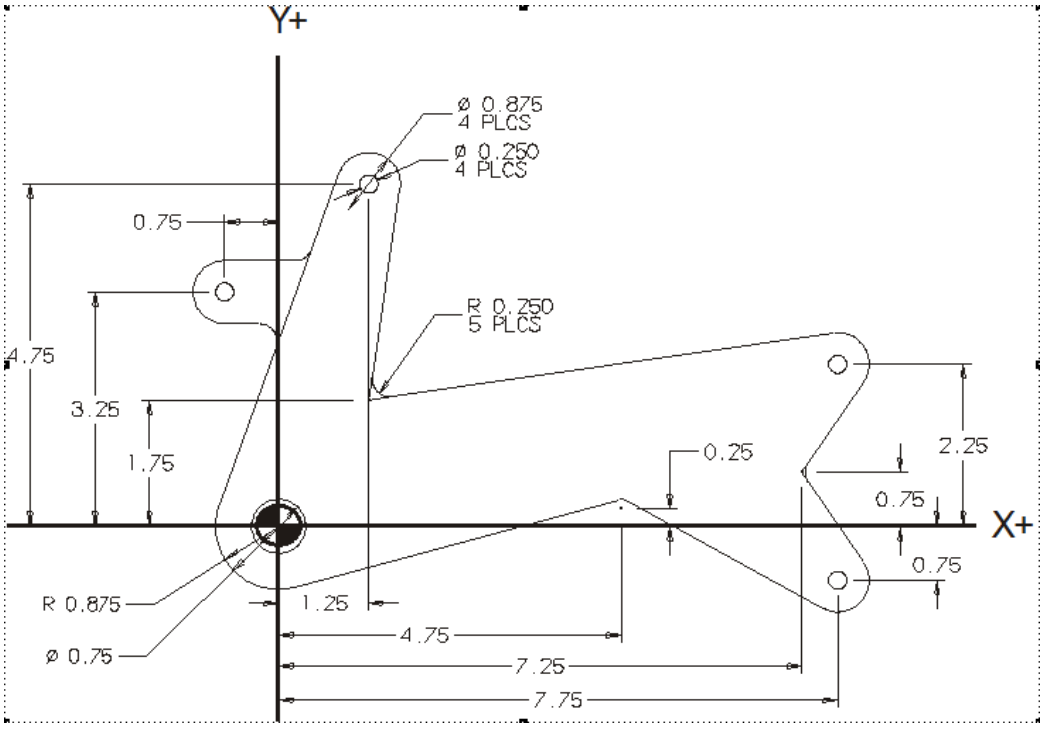
Drawings can span more than one quadrant. For example, it is common to place the Datum at the center of round parts as shown in Figure: 10.

Figure: 10



Since most parts get installed into an assembly, the Datum ensures that critical dimensions are held for proper fit and function. In the example below, the critical dimensions are between hole centers in reference to the 0.75 diameter hole. Thus, the engineer selected the center of this hole as the Datum as shown in Figure: 11.

Figure: 11



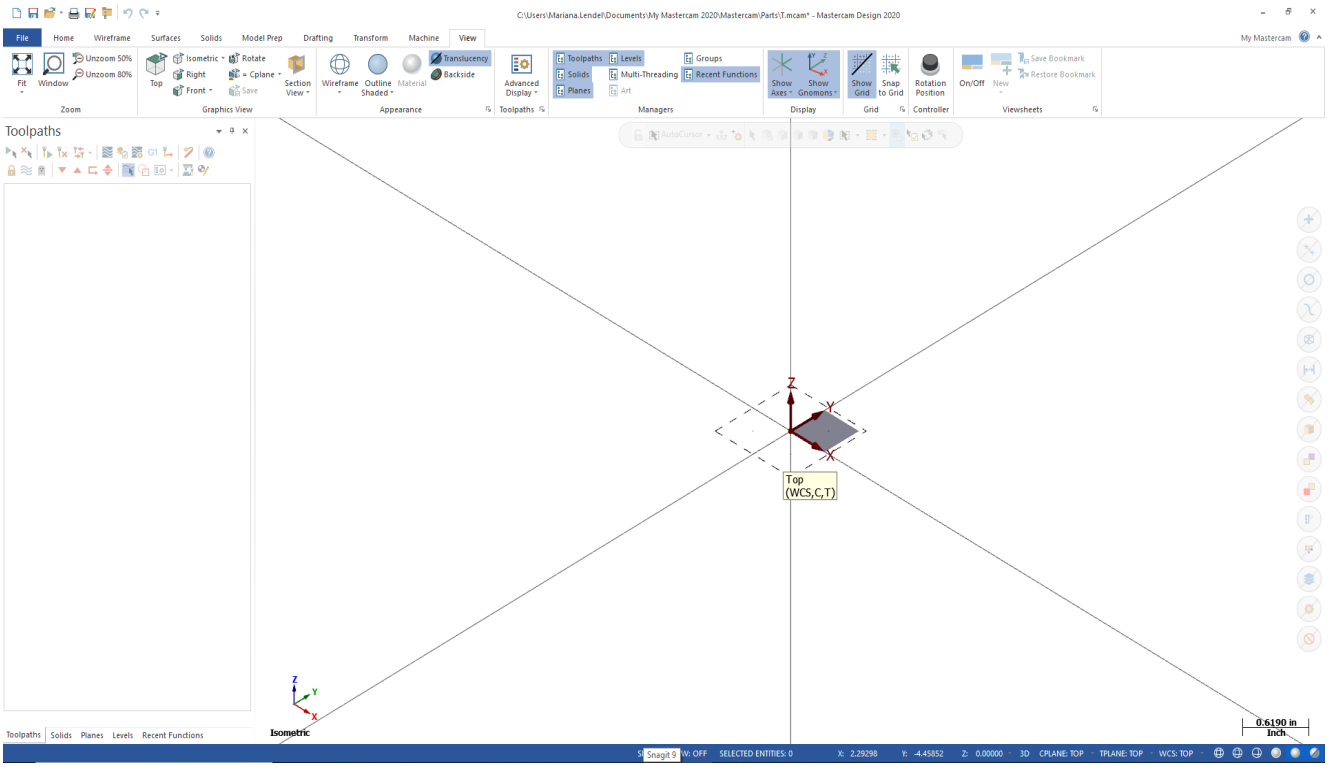
Note: Attention to the datum is essential to part quality. Usually the same datum used to dimension the part is also used for machining.

MASTERCAM COORDINATE SYSTEMS

The **M**astercam **C**oordinate **S**ystem (**MCS**) comprises the total graphic space in which you can work as shown in Figure: 12. It extends, for all practical purposes, infinitely in all directions. Its position and orientation never change.

Within this coordinate system, any number of **Planes**, called **Construction Planes**, can be defined. A **Plane** can be located and oriented anywhere within the coordinate system. **Planes** make drawing easier and are required to define certain 2D entities.

Figure: 12



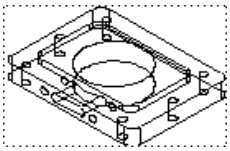
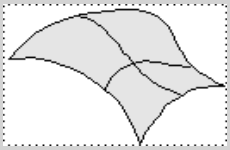
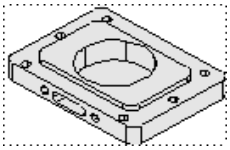
Examples in this chapter use the predefined plane, **Top**. Select the **Top Plane** by clicking on **Plane** on the status bar and picking **Top** from the list.

Note: You can view the coordinate system axes by selecting F9 or File, Configuration, Screen, Display part information. Screen Grid shows the position and orientation of the active Cplane. If active, the Show Gnomons shows the orientation of the XYZ axes in reference to the active plane.

MASTERCAM GEOMETRY

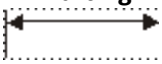
Parts are drawn, or modeled, using geometry. There are three types of geometry used by CAD/CAM software:

- **Wireframe**
- **Surfaces**
- **Solids**

Geometry Type	Description
Wireframe 	• Wireframe geometry consists of curves (lines, arcs, and splines) and points. • Wireframe geometry includes information only about the edges of a part. • Wireframe models cannot be shaded. • Wireframe geometry is adequate to model and machine most prismatic or "2-1/2D" parts -where all contours exist in flat planes.
Surfaces 	• A surface can be thought of as an infinitely thin shell stretched over a wireframe. • Surface geometry includes information about the faces and edges of a part. • There are many types of surfaces; each suited to model a specific type of shape. • Surfaces are used to model complex, freeform (organic) shapes common in the automotive, aircraft, mold, and consumer goods industries. • Surface modeling is covered in the Mastercam Handbook, Volume 2.
Solids 	• Solids contain information about the edges, faces, and interior of the part. • Most mechanical parts are now designed using Solid Modeling software, like MastercamSolids, SolidWorks, SolidEdge, ProEngineer, and others. • Solids are able to model many parts, but some highly sculpted shapes, like car bodies, may still require surfaces. • All Solids start with profiles of wireframe geometry. • Solids are covered in Chapter 5, Solid Modeling.

WIREFRAME GEOMETRY

Wireframe geometry includes the following basic entity types.

Entity	Definition
Point 	A point occupies a single set of coordinates in space. It has no length, depth, or width; it is infinitesimally small.
Line 	A line is an entity defined by any two points in space, called endpoints. Lines have length, but no width or depth; they are infinitely thin.
Arc 	An arc is an entity that is equidistant from a point in space, called a center point. Arcs are "2D" entities, meaning that they must lie on a plane.
Spline 	A Spline is a curve that travels, usually smoothly, through a set of points, called Control Points. There are two types of splines; 2D and 3D. 2D splines are flat entities that must reside on a plane while 3D splines are lying in different planes.
Drafting 	Drafting entities include notes, text, leader lines, witness lines, and hatchs. They are used to annotate a drawing. Drafting text and notes are stored as a special entity type called a font, which allows lettering to be stored in an efficient format.

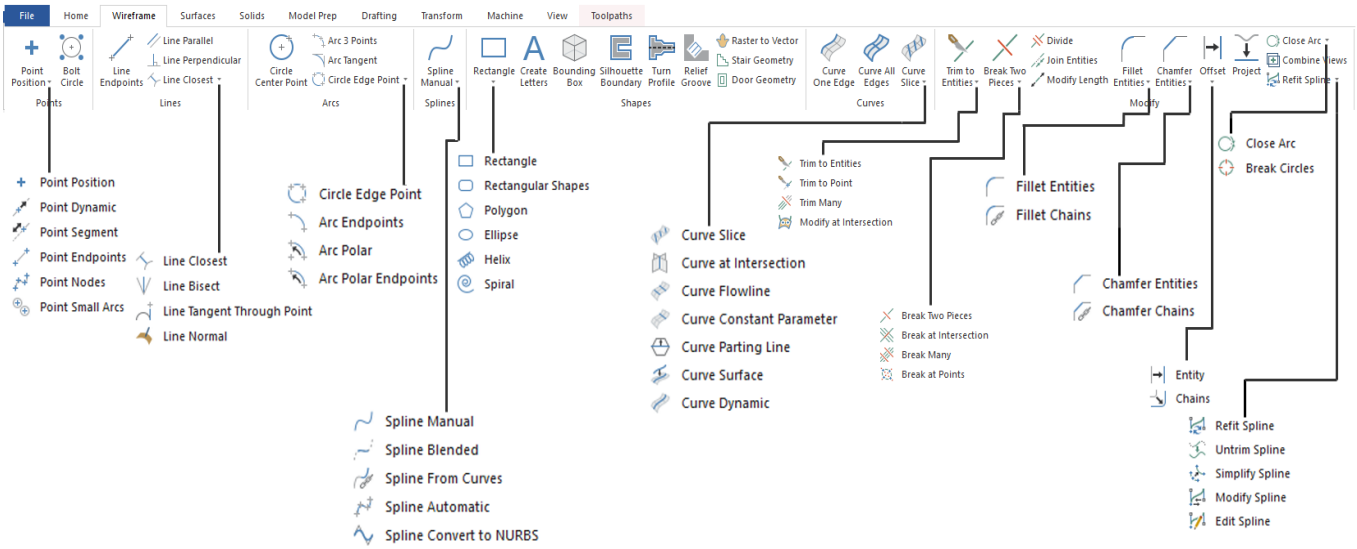
Wireframe geometry includes other geometry types, such as a helix, ellipse, and rectangle. However, these are modeled using one of the basic entity types described above. For example, an ellipse is modeled using a spline, and a rectangle is modeled using four individual lines.

This chapter deals with how to create basic wireframe geometry types listed in the table above. Once you understand these, it will be easy for you to create other types.

Wireframe Geometry Options

Wireframe geometry functions are selectable from the **Wireframe** Tab.
Figure: 13 shows the commands used to create wireframe geometry. The commands are arranged in groups based on entity types or specific activity. The groups are displayed in the ribbon from basic to more complex functions.

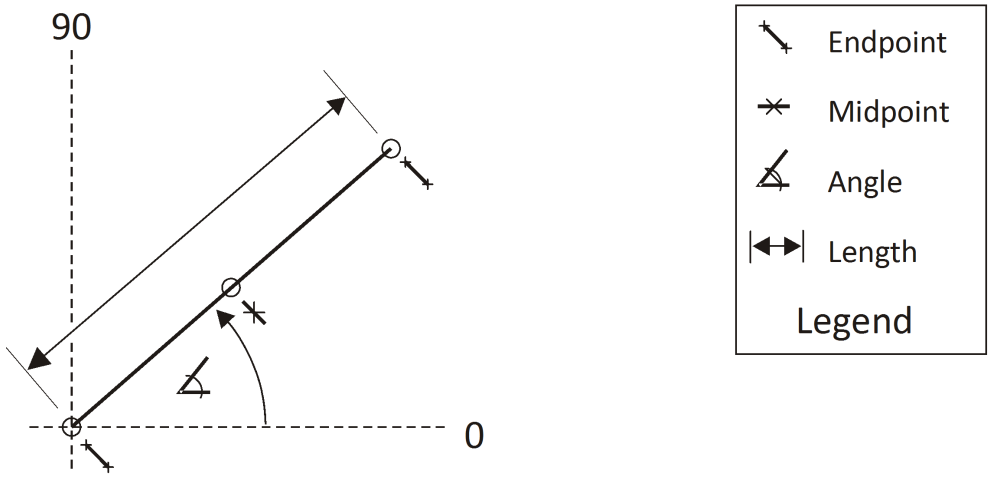
Figure: 13



LINES

A **line** is a geometric entity connecting any two points in space. A line can start and end anywhere in the Mastercam Coordinate System as shownFigure: 14.

Figure: 14



Term	Definition
2D Length	Length of the line in reference to the active view.
3D Line	Full length of the line, regardless of the view. If the line lies in the same plane that it is being viewed, the 2D and 3D lengths are the same.
Angle	The angle of a line is measured from the 3:00 position. Counterclockwise (CCW) angles are positive. Clockwise (CW) angles are negative.
Bisect	A line that splits two other lines equally.
Endpoint	The coordinates of the either end of a line.
Horizontal	A line along or parallel to the X-axis.
Midpoint	Point equidistant from the end points.
Multiline	A series of lines that are connected.
Parallel	A line offset an equal distance from another line.
Perpendicular	A line 90 degrees to another line or arc. Sometimes referred to as a normal line.
Polar line	A line defined by its start point, length and angle.
Start point	Lines have a direction. The Start point is the x,y,z coordinates of the first endpoint.
Tangent	A line that intersects an arc or spline at one point only.
Vertical	A line along or parallel to the Y-axis.

Tangent

Tangent lines touch an arc or spline at one point only as shown in Figure: 15.

Figure: 15

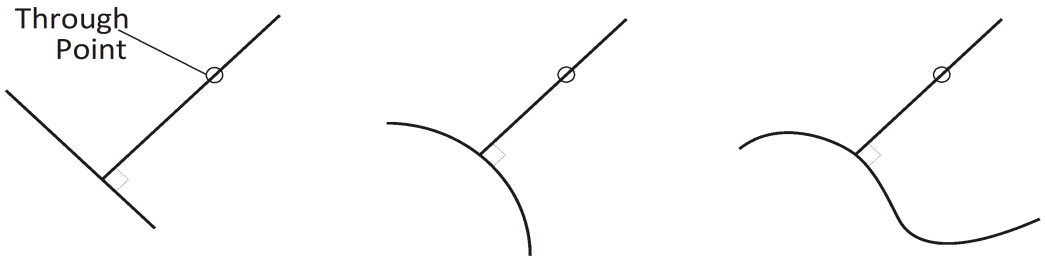
Tangent to Arc Tangent to Spline

Perpendicular

Perpendicular lines pierce a line or curve at a 90 degree angle all around as shown in Figure: 16. In other words, a perpendicular line is a tangent line rotated 90 degrees.

This type of line is also called a Normal line when referring to arcs, splines, or surfaces. Mastercam can create a perpendicular line passing through some point on the curve or a point in space.

Figure: 16

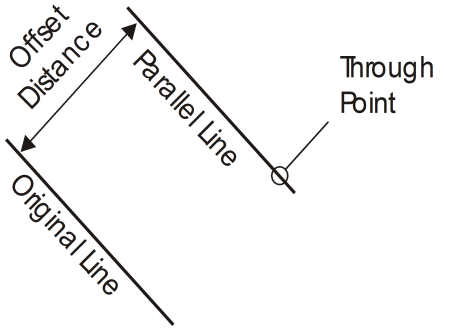


Perpendicular to Line, Arc or Spline

Parallel

Parallel lines are lines that lie in the same plane but never intersect, regardless of how far they are extended, as shown in Figure: 17. Mastercam can define a parallel line given an offset distance from an existing line or a through point.

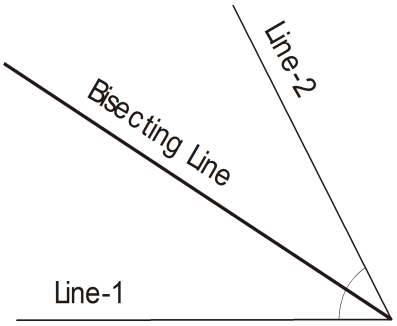
Figure: 17



Bisecting

Bisecting lines split the angle between two existing lines equally as shown in Figure: 18. Mastercam shows multiple solutions and prompts you to select the one you want.

Figure: 18

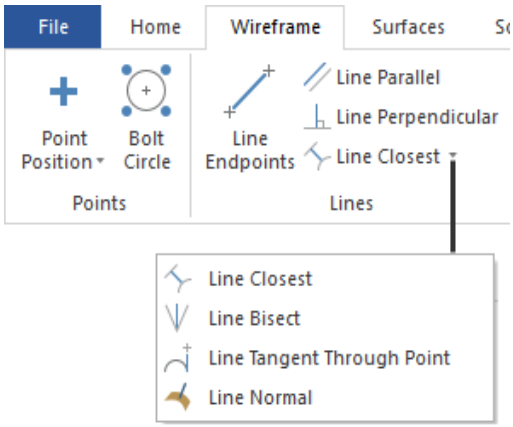


Note: Mathematically, a line has length but no width; it is infinitely thin. When viewed directly along its axis, a line disappears. A line is sometimes referred to as a "straight curve". A line is a 3D entity; it does not have to lie in a 2D construction plane to exist.

Lines

Create lines by selecting the **Wireframe** tab, then selecting the type of the line from the **Lines** group as shown in Figure: 19.

Figure: 19

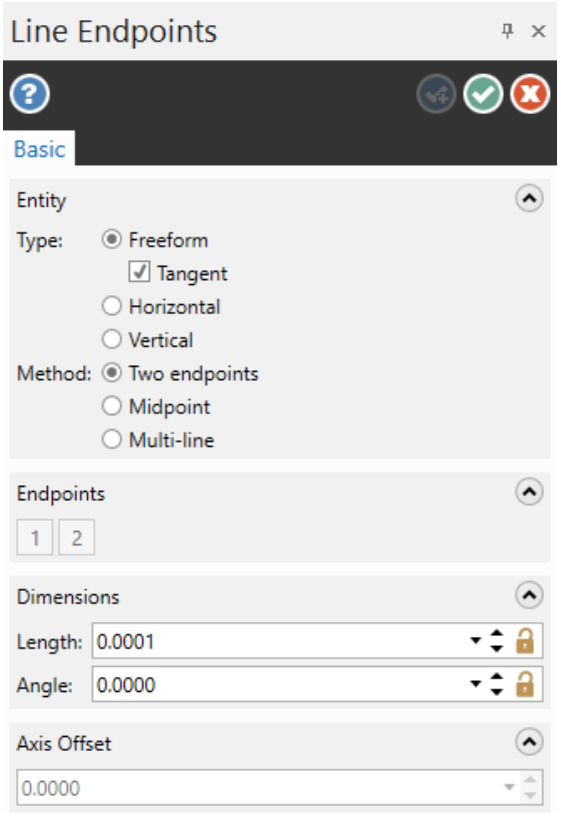


Option	Definition
Line Endpoints	Creates a line given its endpoints, length, angle or tangent point.
Line Parallel	Creates a line parallel to an existing line.
Line Perpendicular	Creates a line perpendicular to a line, arc, or spline.
Line Closest	Creates a line representing the shortest distance between two entities.
Line Bisect	Creates a bisecting line; a line that splits the angle between two lines equally.
Line Tangent Through Point	Creates a line tangent to an arc or spline. Requires the tangent point.
Line Normal	Creates a line perpendicular at the contact point to a surface or to a face.

Line Panels

The **Line panels** control values and relations of lines. Line parameters can be changed until the **OK and Create New operation** or **OK** buttons are selected to complete its creation. Until then, the entity is said to be "live" and is a cyan color. When fully defined, the line changes to the default drawing color. The **Line Endpoint panel** is shown in Figure: 20.

Figure: 20



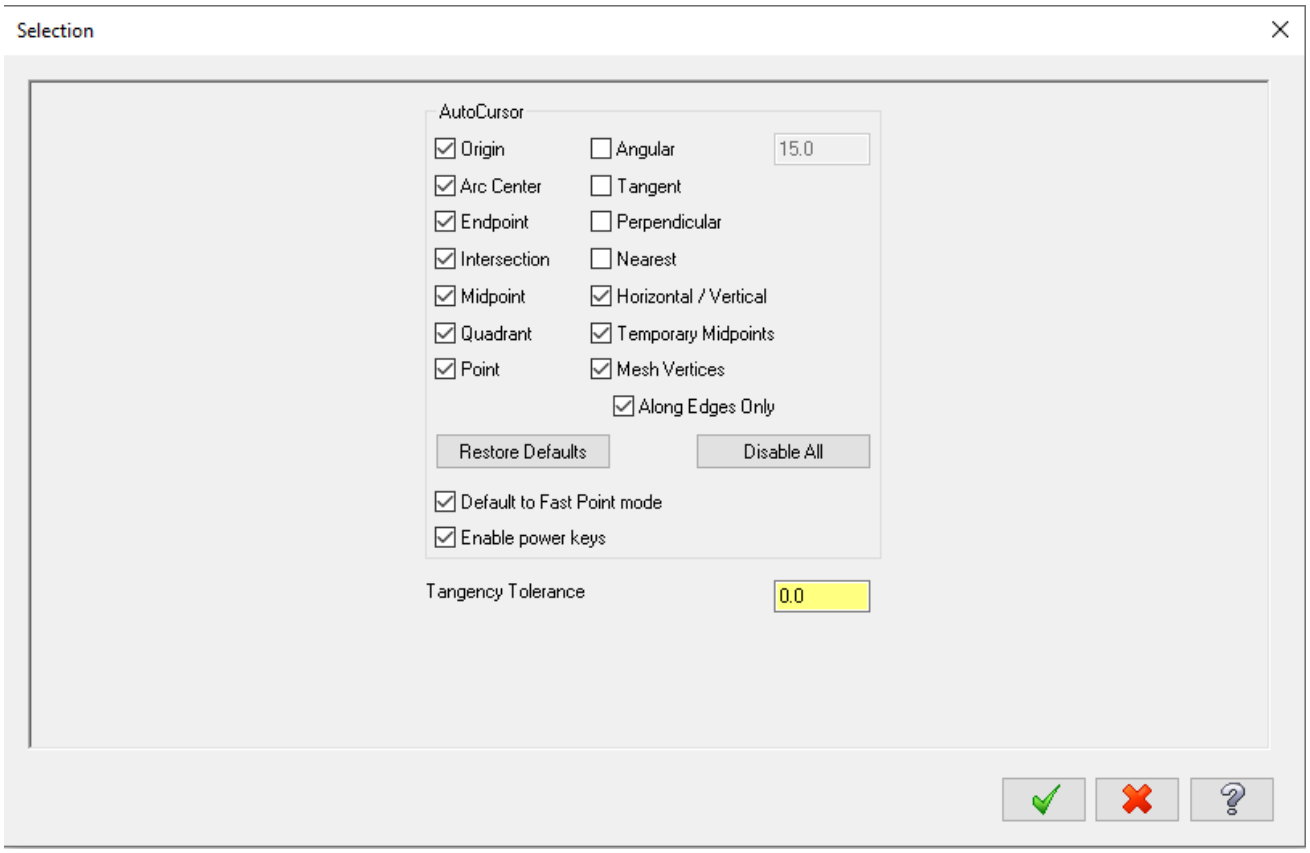
Term	Definition
Line Endpoints	Panel identifier.
Type	**Freeform** allows you to draw the line at any desired angle. **Tangent** specifies a line to be tangent to an arc or spline. When this option is active, the line will be tangent to the arc if no other geometric feature, such as an endpoint or quadrant, is selected. **Horizontal** draws a horizontal line. **Vertical** draws a vertical line. **X axis offset**-value of a vertical line, **Y axis offset**-value of a horizontal line. When either the **Vertical** or **Horizontal** is active, the horizontal/vertical position value allows users to set the X or Y position of the line.
Method	**Two endpoints** allows you to create one line at the time entering the two endpoints. **Midpoint** creates the line starting in middle of it. **Multi-line** creates a string of lines.
Endpoint 1	Changes the value of the start point.
Endpoint 2	Changes the value of the end point.
Length	Enters/displays the length of a line.
Angle	Enters/displays the angle of a line.
Axis Offset	Moves a live line by a defined distance along the X and Y axis.
OK and Create New Operation	Creates the line but keeps the panel open allowing you to continue in the same command.
OK	Creates the line and leaves the line creation option. Selecting OK is the same as pressing the [ESC] key.

Creating Line Endpoints

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.

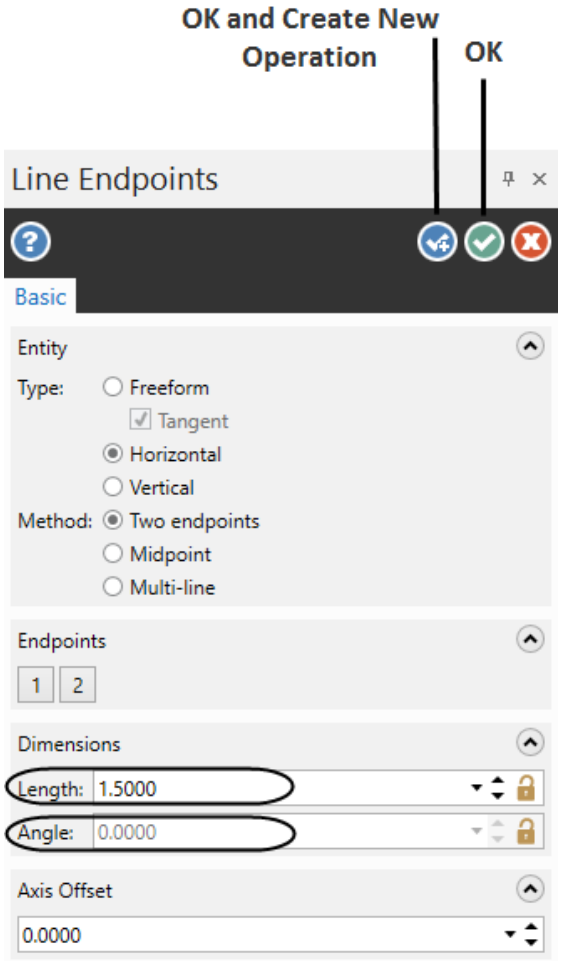
- **Step 1:** Select the **Line Endpoint** function from the **Wireframe** tab.
- **Step 2:** Move the mouse near the coordinate system Origin until the cursor changes from an arrow to a box, the Origin cue displays, and the small box snaps to the Origin. Click once on the left mouse button. Note that this is possible due to the **AutoCursor Settings** (see Figure: 21). To check the **AutoCursor Settings**, from the **General Selection bar**, select the **AutoCursor Configuration** icon.

Figure: 21



- **Step 3:** Drag the mouse to the right so that the line snaps to 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. Press Enter to accept the 0-degree angle. Altering parameters in the Line Endpoints panel can still change live entities.

- **Step 4:** Enter L and set the line length. Finally, click the **OK and Create New Operation** button to finish the line and remain in this function, or the **OK** button to finish the line and leave the function. Notice that the line changes to the active color indicating it is now completely defined.



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