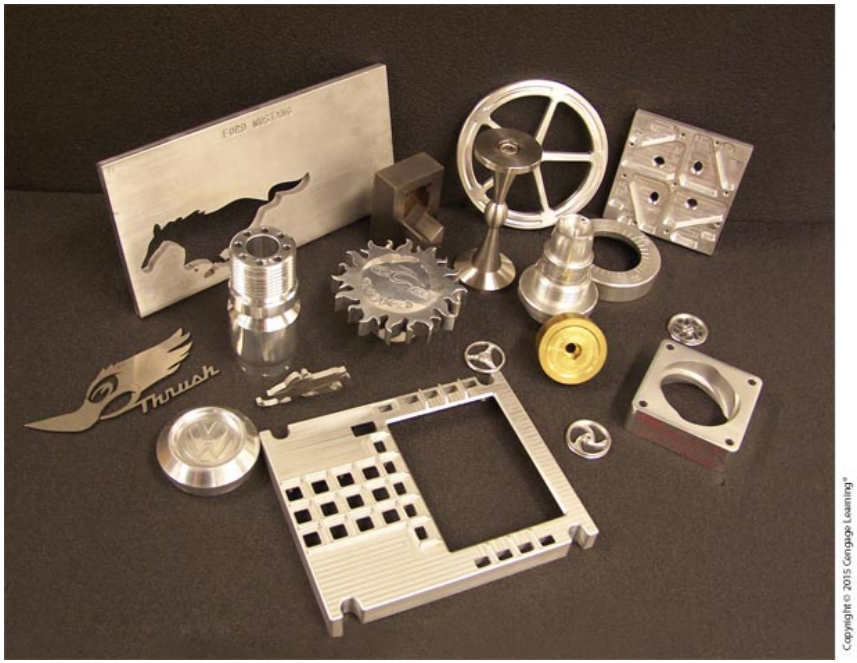
Computer Numerical Control

- Computerized numerical control (CNC) machines
  - Perform complex operations faster, more accurately and consistently



Examples of some workpieces produced by CNC machines.

A CNC lathe.


TL
1
HAAS
Tools are changed manually
Photo courtesy of Haas Automation, Inc.

CNC turning center.

A CNC milling machine.

CNC machining center.

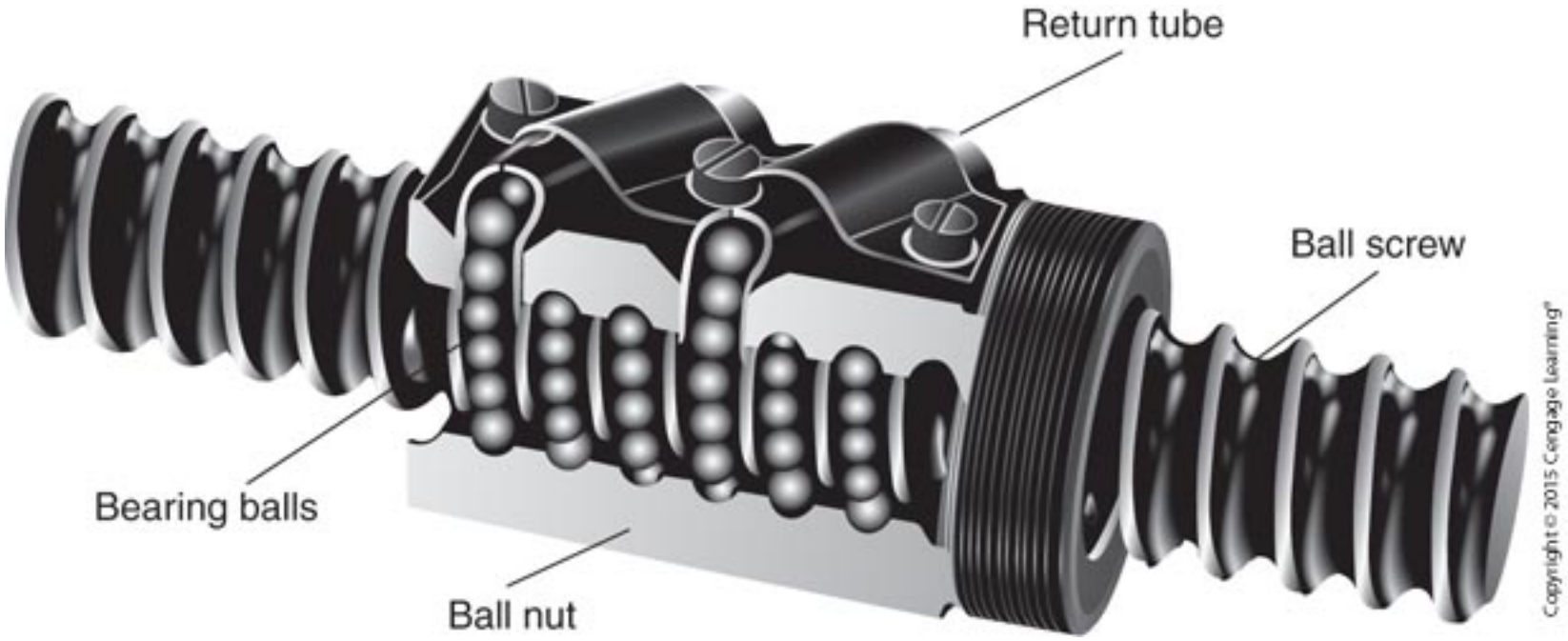
The CNC Machine Control Unit

- CNC program created & stored in MCU (machine control unit)

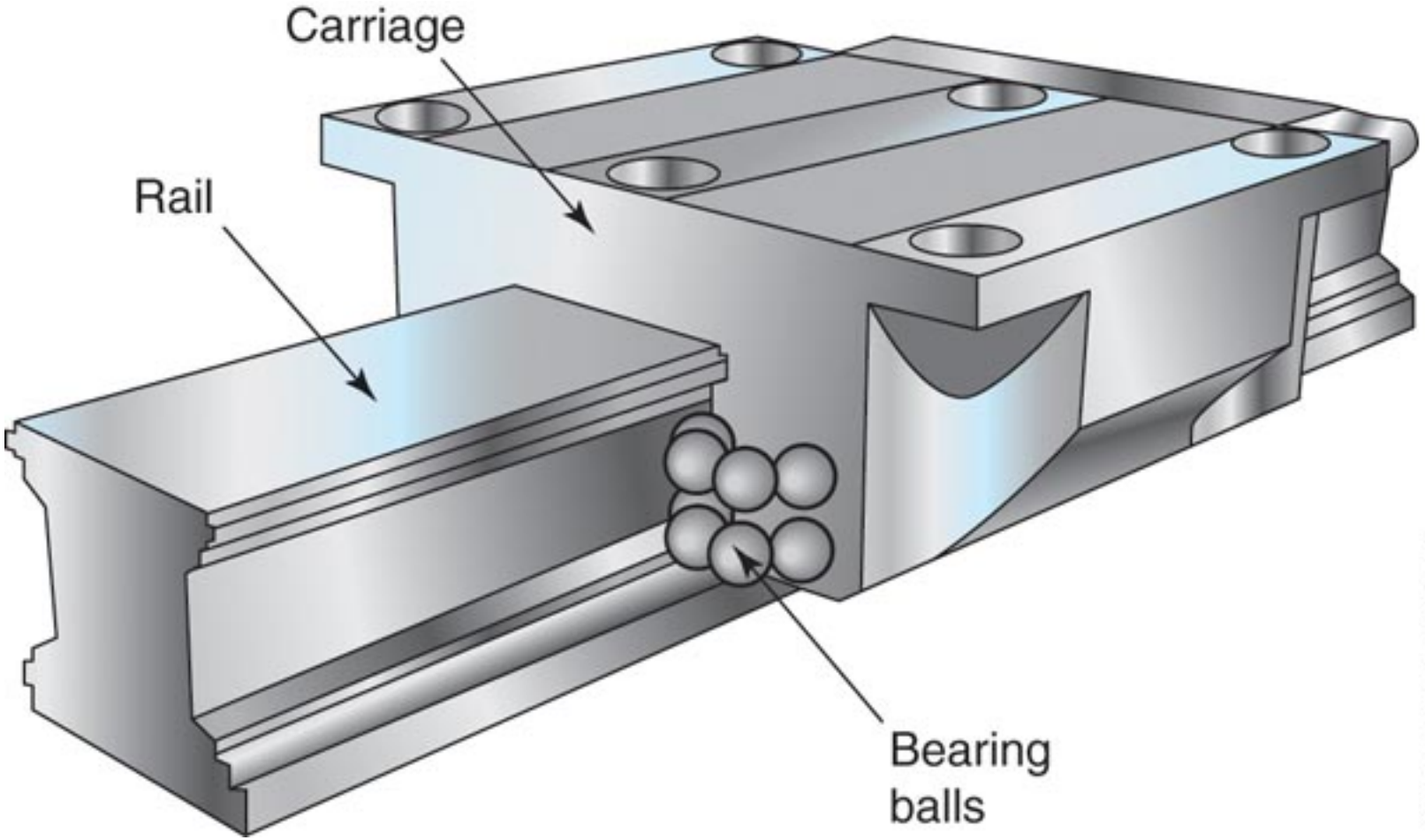
An operator control panel mounted on the exterior of the machine control unit.

CNC Motion Control

- Machine locates axes from programmed commands
- Components: drive screws, CNC guideways, servo motors



A ballscrew assembly.

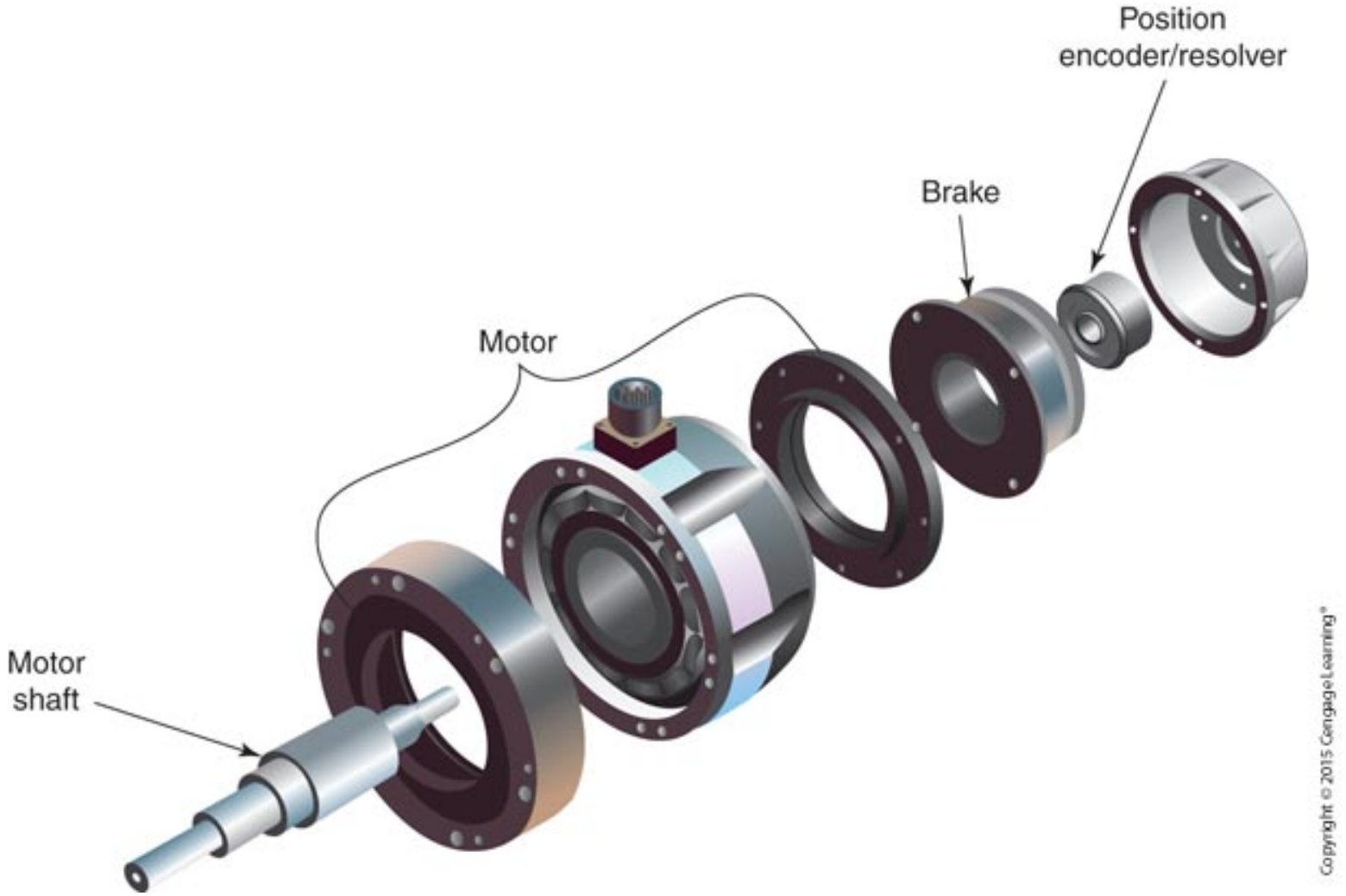


Copyright © 2015 Cengage Learning®

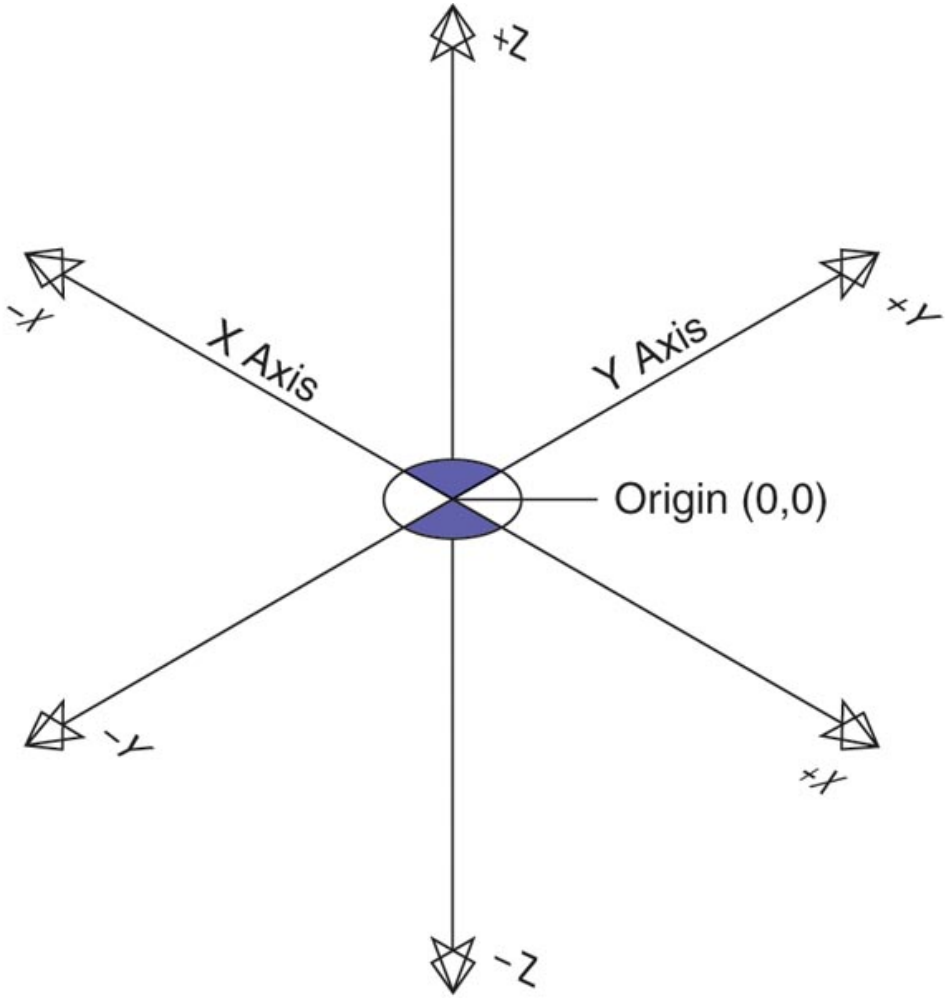
A linear guide assembly and its parts.

Coordinate Systems

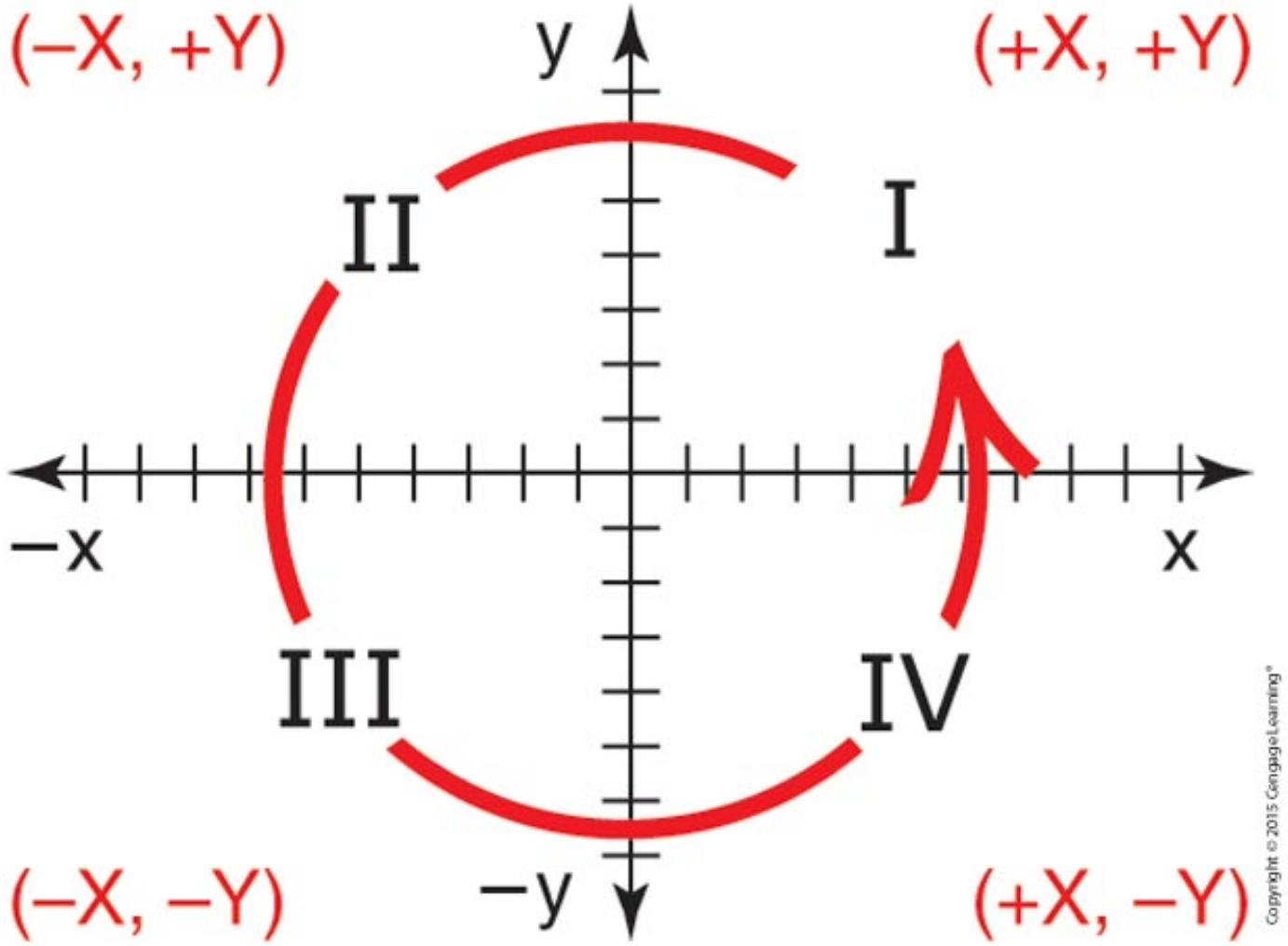
- Programs tell machine function and where to perform it
- Coordinate system maps locations
  - Cartesian/rectangular system maps positive/negative values on X- and Y- axes relative to origin
  - Polar system locates points by angle and distance from origin



The parts of a servo motor.

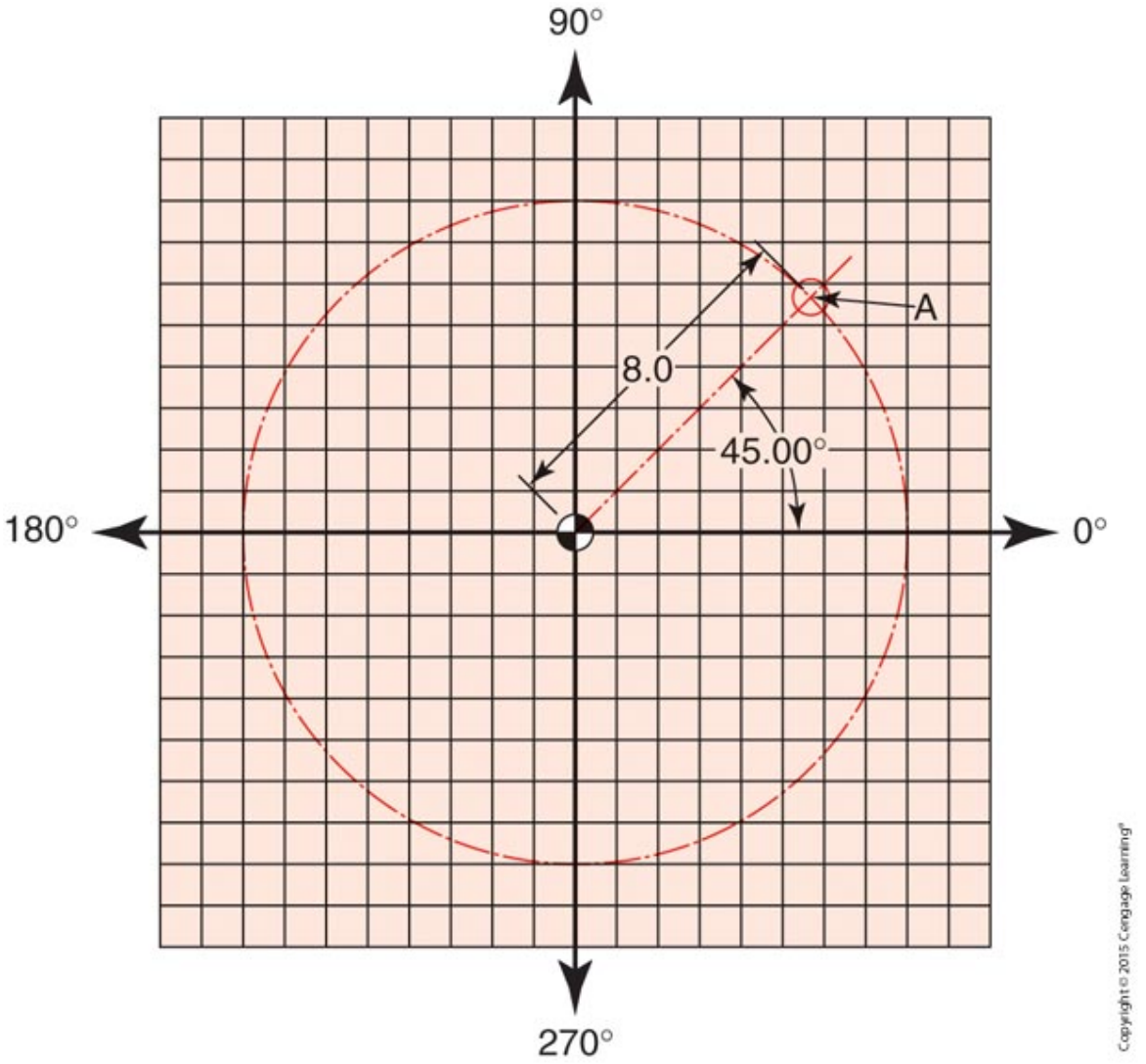


The parts of the Cartesian coordinate system.



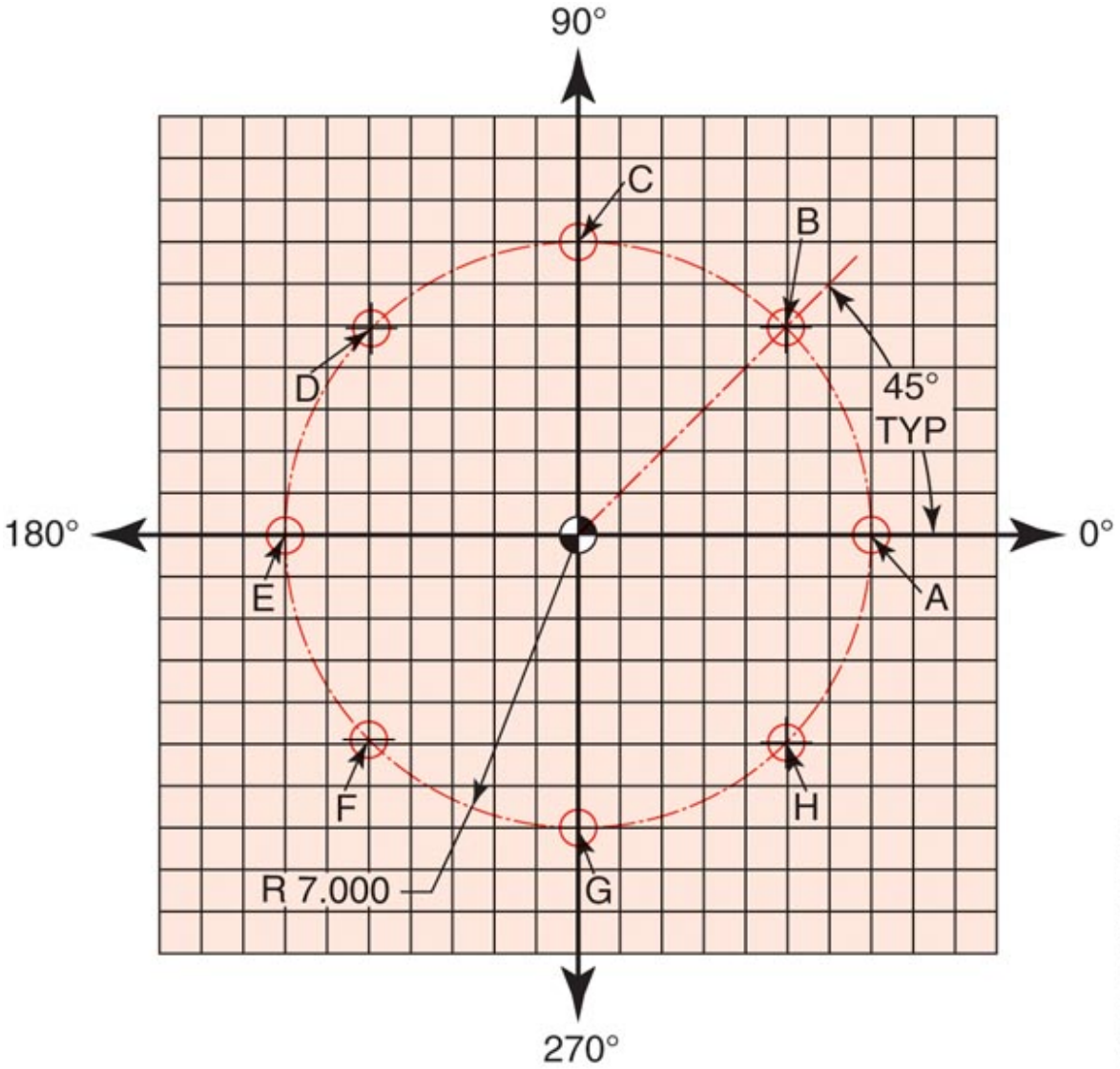
Quadrants separate a coordinate plane into four regions.

A diagram showing the polar coordinate system. When using this system, the X-value specifies the distance from the origin, and the Y-value specifies the angle relative to the zero degree mark. The position “A” shown is located at an angle of 45° and a distance of 8.0" from the origin; when using the polar coordinate system this is written as X8.0 Y45.0



Copyright © 2015 Cengage Learning®

An example of how each position in an eight-hole workpiece can be identified using polar coordinates. The positions for each location are programmed as: (A) X7.0 Y0; (B) X7.0 Y45.0; (C) X7.0 Y 90.0; (D) X7.0 Y135.0; (E) X7.0 Y180.0; (F) X7.0 Y225.0; (G) X7.0 Y270.0; (H) X7.0 Y315.0

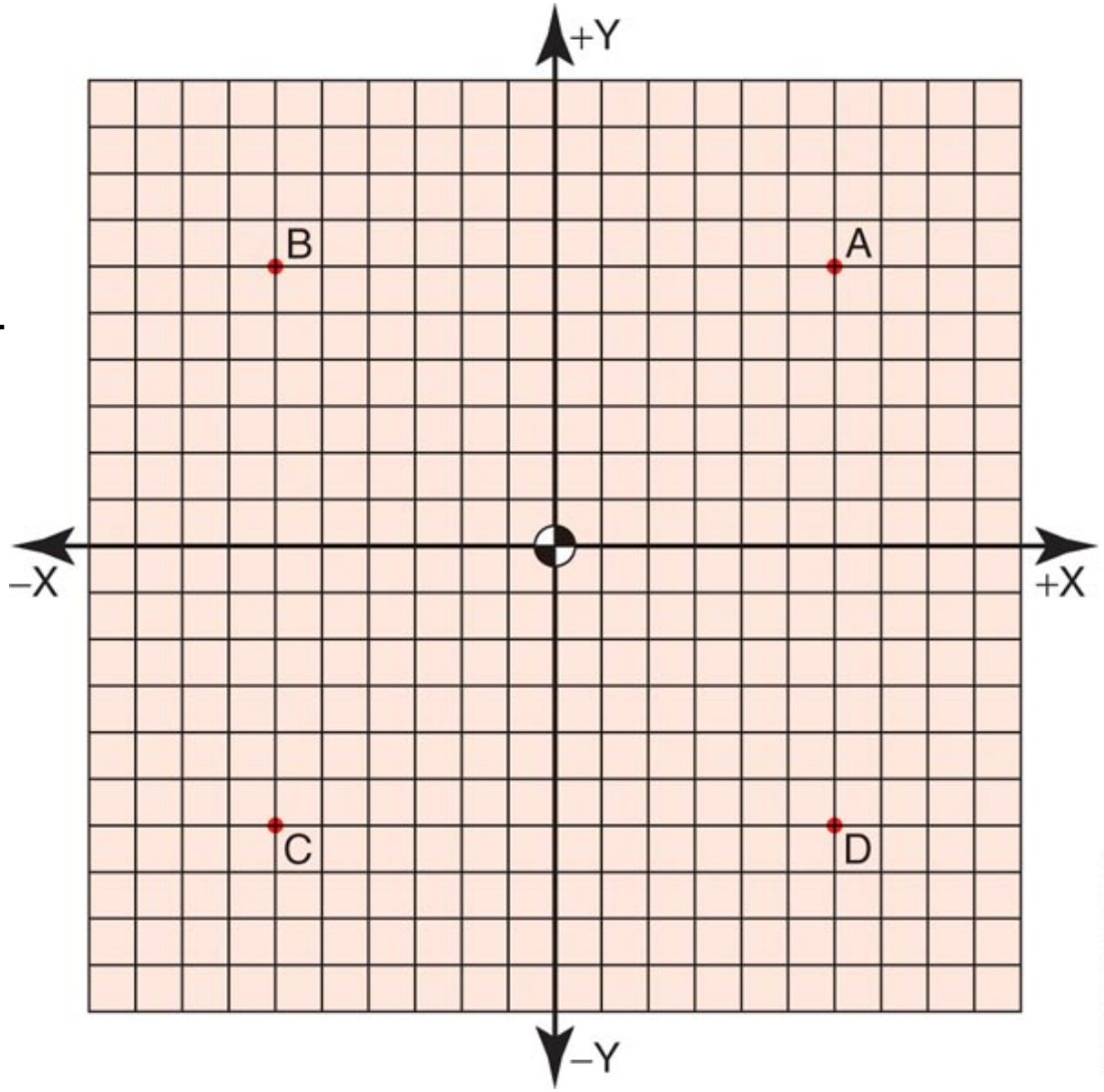


Copyright © 2015 Cengage Learning®

Positioning Systems

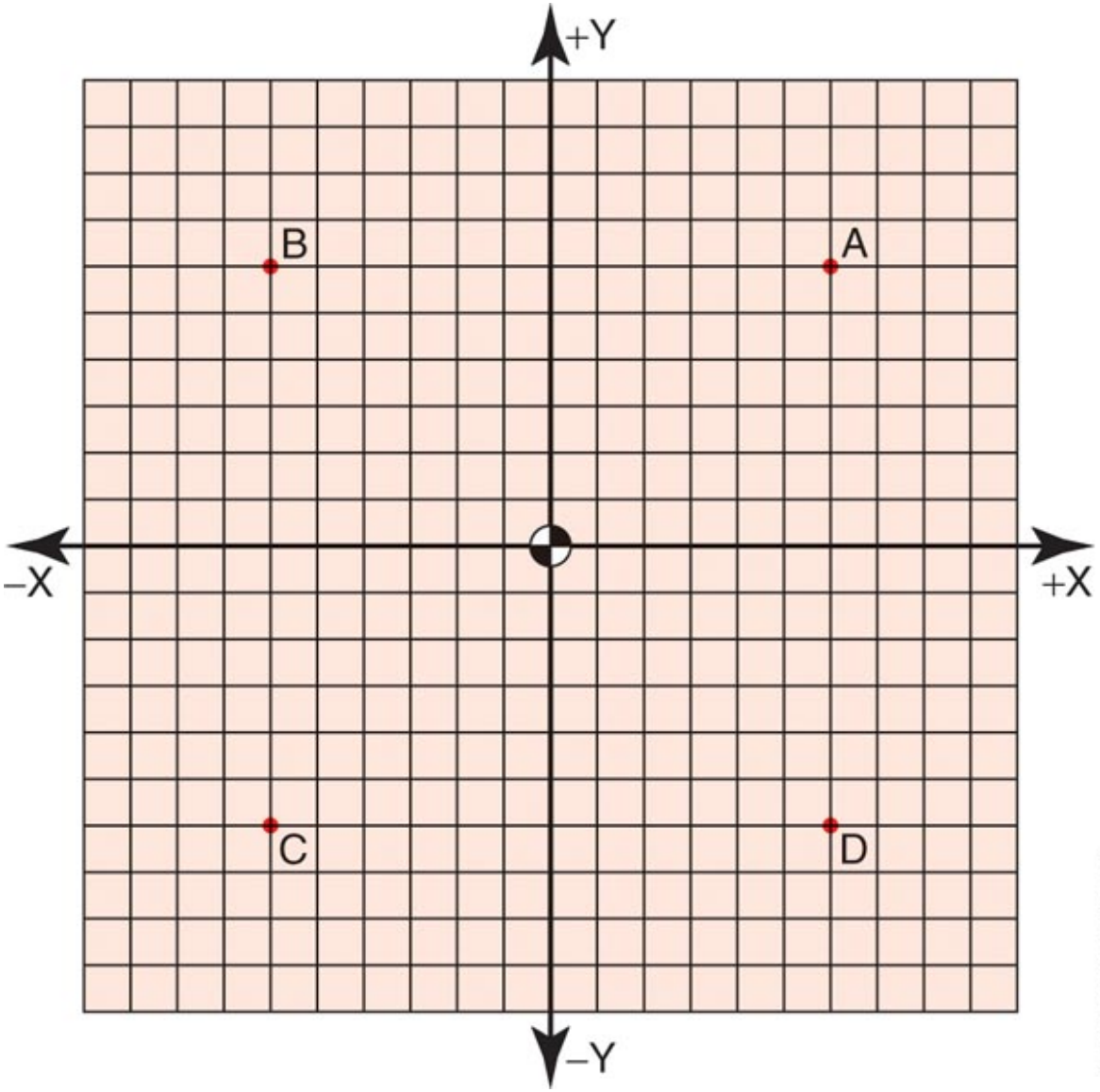
- Absolute positioning system references all positions relative to origin
- Incremental positioning system specifies distance from current position to next

Assume that each block on the grid equals 1". Using the absolute programming method, the coordinates for each identified location are: (A) X6.0 Y6.0; (B) X-6.0 Y6; (C) X-6.0 Y-6; (D) X6.0 Y-6.0.



Copyright © 2015 Cengage Learning®

Assume that each block on the grid equals 1". Using the incremental programming method, assuming the cutting tool is already at position A, the coordinates for each following location are: (B) X-12.0 Y0; (C) X0.0 Y-12; (D) X12.0 Y0.0



Copyright © 2015 Cengage Learning®

Codes

- Codes tell machine what to do at position
  - G-codes: preparatory commands (set mode)
  - M-codes: miscellaneous functions (on/off)
  - Other word address commands
  - Binary

Parameter Number	Bit Number							
	#7	#6	#5	#4	#3	#2	#1	#0
0401	1	1	0	1	0	0	0	1

Copyright © 2015 Cengage Learning®

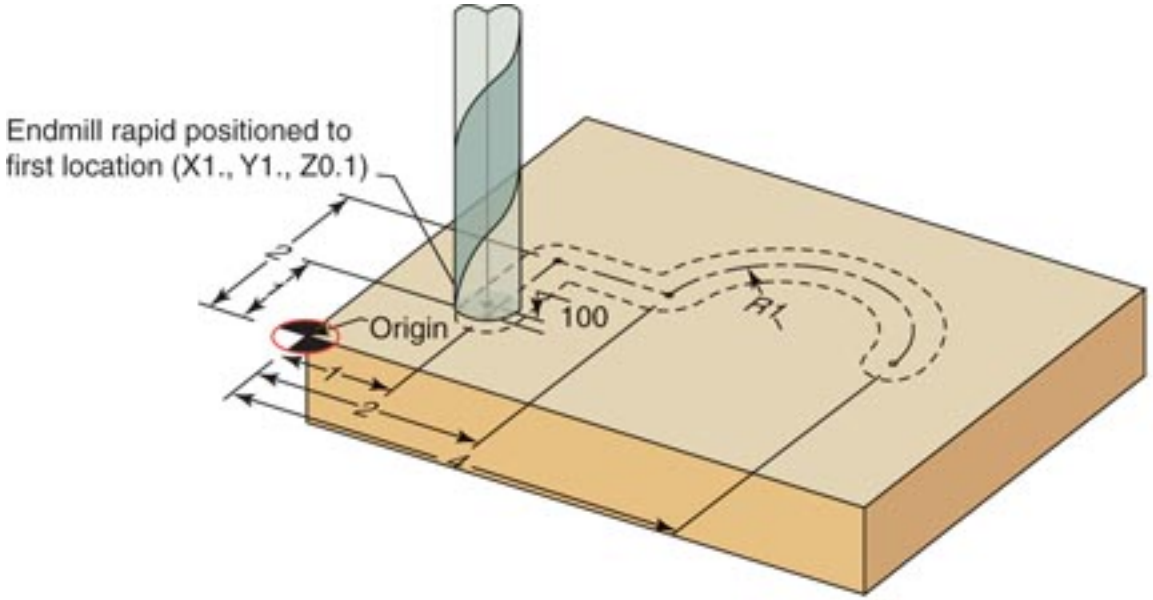
An example of the parameter numbering format. Notice the parameter number is 0401 and the bits are read in sequence from right to left. Each bit can be either a ‘0’ or a ‘1’.

Conversational-Type Programming

- Operator selects function and machine prompts for more information

Parts of a CNC Program

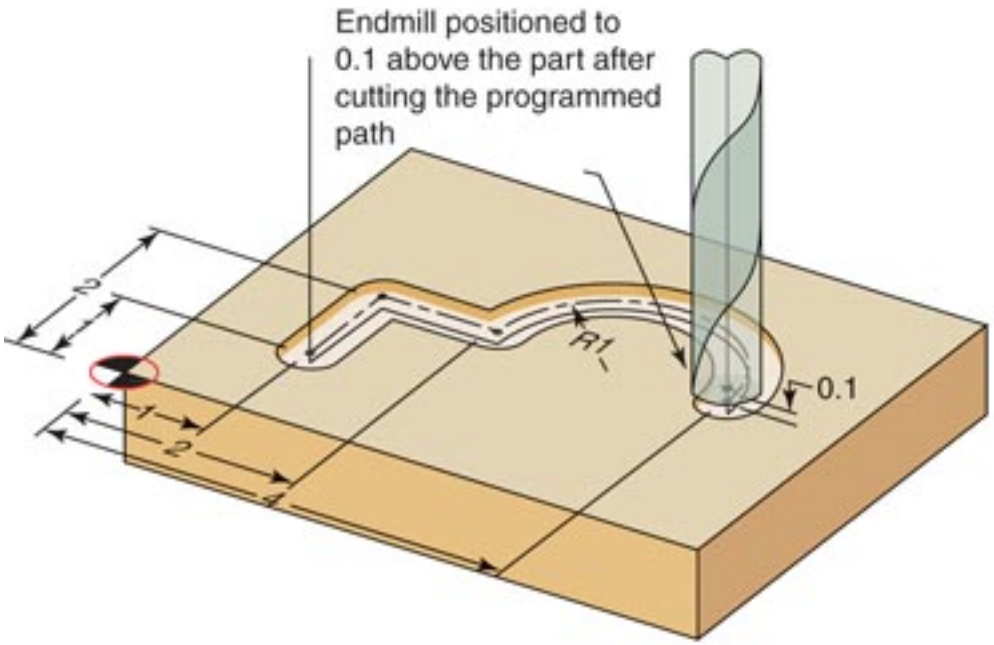
- Safe-start: clears machine for new operation
- Material removal: performs operations
- Program ending: safely positions tool & axes out of the way



O0001 (SAMPLE PROGRAM);	Program number and (operator label). Since this label is within parentheses, it is not read by the machine, only by the operator.
G0G90G20;	Safe start block initiating the modal codes for rapid traverse (G0), absolute programming (G90), and inch units (G20)
M6T1;	Tool change to tool #1
X1.Y1.(POSITION "A");	Rapid to X1. Y1. (Position "A"). Rapid and absolute modes are still modal from above so they do not need to be programmed again here.
Z0.1S4500M3;	Move the Z-axis to 0.1, start spindle in forward direction to 4500 RPM. The Z-axis move is a rapid move because the G0 is still active.

Copyright © 2015 Cengage Learning®

The program begins by the tool being loaded, the spindle being started, and the tool being rapid positioned to the first location.

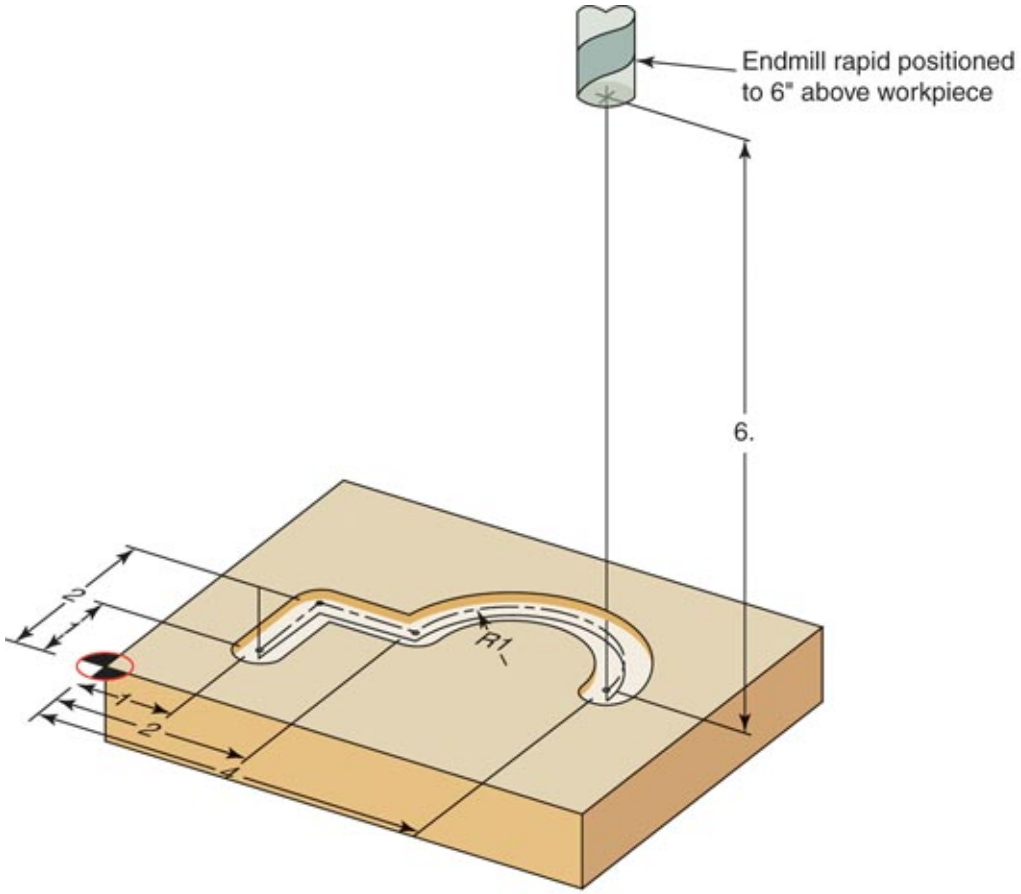


G1Z-0.1F14.0;	Linear axis motion feeds the tool tip to Z-0.1 at a feed rate of 14 inches per minute.
Y2.0 (POSITION "B");	Feed move to Y2.0 (Position "B"). G1-linear is still modal.
X2.0 (POSITION "C");	Feed move to X2.0 (Position "C"). G1-linear is still modal.
G2X4.0 Y2.0 R1.0 (POSITION "D");	Feed move in a CW arc to X4.0, Y2.0 (Position "D"), at a radius of 1.0
G0Z0.1;	Rapid the Z-axis up to Z0.1

Copyright © 2015 Cengage Learning®

The tool is fed to depth and then fed to each location. Once machining is complete, the tool is then retracted to a clearance point above the workpiece.

The tool is rapid positioned to a location far above the workpiece. The coolant is turned off and the program is ended.



G0Z6.0; ← Rapid the Z-axis up to Z6.0. This moves the tool away from part.

M9; ← Turn coolant off

M30; ← End program and reset

Copyright © 2015 Cengage Learning®