



CNC & CAM 101



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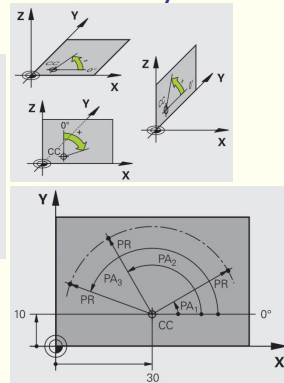
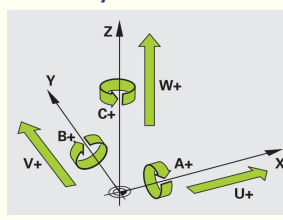
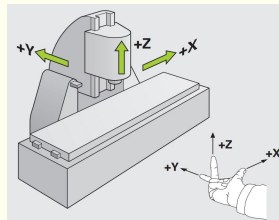
Fundamentals of CNC

- Improved automation:
 - Unattended operation of CNC machines
 - Operator intervention can be reduced or eliminated.
 - Reduced operator fatigue
 - Fewer mistakes caused by human error
 - Consistent and predictable machining time
 - Fast change-overs
- Heart of CNC:
 - Automatic, precise, and consistent motion control



Fundamentals of CNC

- Coordinate system:
 - Rectangular or "Cartesian" coordinate system
 - Polar coordinate system

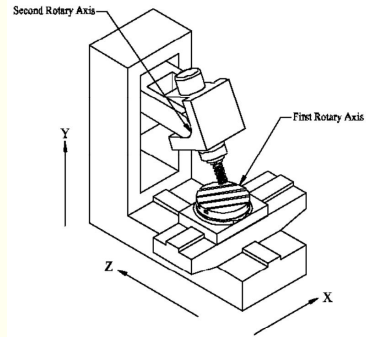
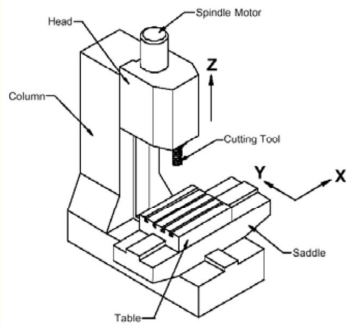


- Program zero-point, also called work zero, part zero, or program origin



Fundamentals of CNC

- Two or more directions of motions, i.e. axes
 - Linear or Rotary



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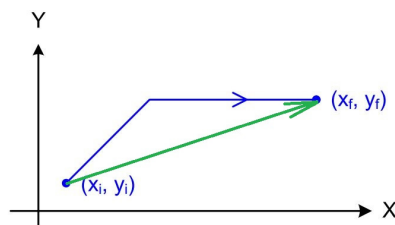
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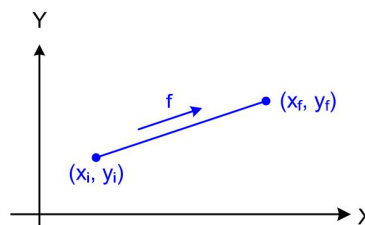
Fundamentals of CNC

- Motion type:
 - Rapid, Linear

G0 Xx_f Yy_f Zz_f



G1 Xx_f Yy_f Zz_f Ff



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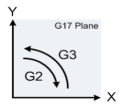
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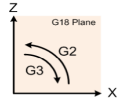
Fundamentals of CNC

- Motion type:
 - Circular



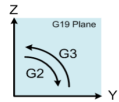
XY Plane:

$$G17 \ G \begin{Bmatrix} 2 \\ 3 \end{Bmatrix} \ Xx \ Yy \ \begin{Bmatrix} Rr \\ li \ Jj \end{Bmatrix} \ Ff$$



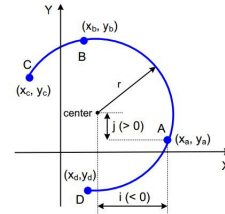
ZX Plane:

$$G18 \ G \begin{Bmatrix} 2 \\ 3 \end{Bmatrix} \ Xx \ Zz \ \begin{Bmatrix} Rr \\ li \ Kk \end{Bmatrix} \ Ff$$



YZ Plane:

$$G19 \ G \begin{Bmatrix} 2 \\ 3 \end{Bmatrix} \ Yy \ Zz \ \begin{Bmatrix} Rr \\ Jj \ Kk \end{Bmatrix} \ Ff$$

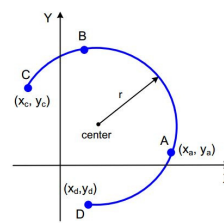


A→B:

$$G90 \ G17 \ G3 \ Xx_b \ Yy_b \ li \ Jj \ Ff$$

$$G91 \ G17 \ G3 \ Xx'_b \ Yy'_b \ Rr \ Ff$$

$$\text{where } x'_b = x_b - x_a \\ y'_b = y_b - y_a$$



A→C (angle > 180°):

$$G90 \ G17 \ G3 \ Xx_c \ Yy_c \ R-r \ Ff$$

$$G90 \ G17 \ G2 \ Xx_d \ Yy_d \ Rr \ Ff$$

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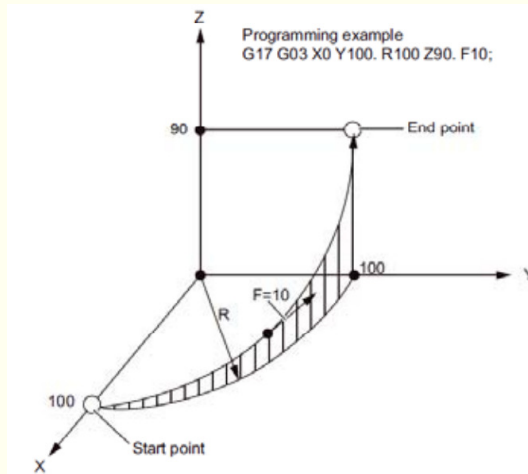
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Fundamentals of CNC

- Motion type:
 - Helical
 - Superimposed 2 motions:
 - Plane circular
 - Vertical linear



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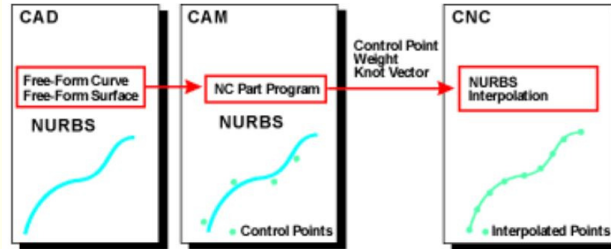
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Fundamentals of CNC

- Motion type:
 - NURBS



```

G00 Z.1
W0070 X-1.75 Y-.75
N0080 G01 Z-.2421 F10.
N0090 X-1.6953 Z-.2358
N0100 G06.2 P.0000
N0110 G06.2 P.0000 K0. X-1.6953 Y-.75 Z-.2358 F10.
N0120 K0. X-1.6544 Z-.2211
N0130 K0. X-1.5752 Z-.2225
N0140 K0. X-1.4053 Z-.2067
N0150 K.0313 X-1.3031 Z-.1982
N0160 K.0781 X-1.1215 Z-.1847
N0170 K.125 X-.8727 Z-.1758
N0180 K.1563 X-.8082 Z-.1672
N0190 K.2188 X-.6144 Z-.1593
N0200 K.2656 X-.4354 Z-.1541
N0210 K.3125 X-.248 Z-.1506
N0220 K.375 X-.0656 Z-.1489
N0230 K.4219 X.102 Z-.1492

```

Start NURBS (G06.2)
Order=4 (P)
Knot Vector (K)
Control Points (X,Y,Z)

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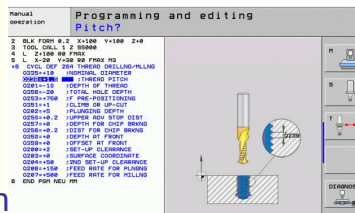
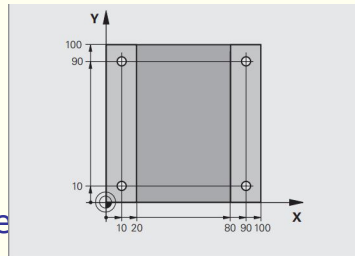
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Methods of CNC Programming

- Manual programming:
 - Arithmetic calculations longhand as opposed to on an electronic calculator
 - Simple, repetitive jobs
 - Editing of NC file (at G-code level) to correct mistakes
- Conversational (Shopfloor) Programming:
 - Created at the CNC machine
 - Single-purpose CAM system



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Methods of CNC Programming

- CAM programming:
 - Keeps the programmer from having to do math calculations
 - Easy to program different kinds of machines with the same CAM software
 - General steps:
 - Import CAD model
 - Stock definition
 - Tool definition
 - Toolpath strategies and cutting parameters
 - Simulation and verification
 - Post processing
 - Setup sheet generation

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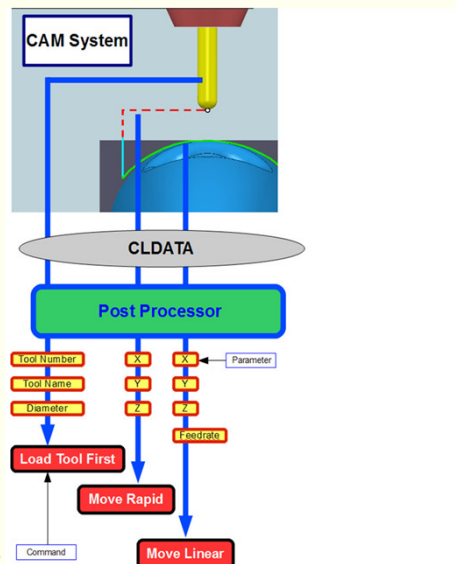
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Methods of CNC Programming

- CAM programming:

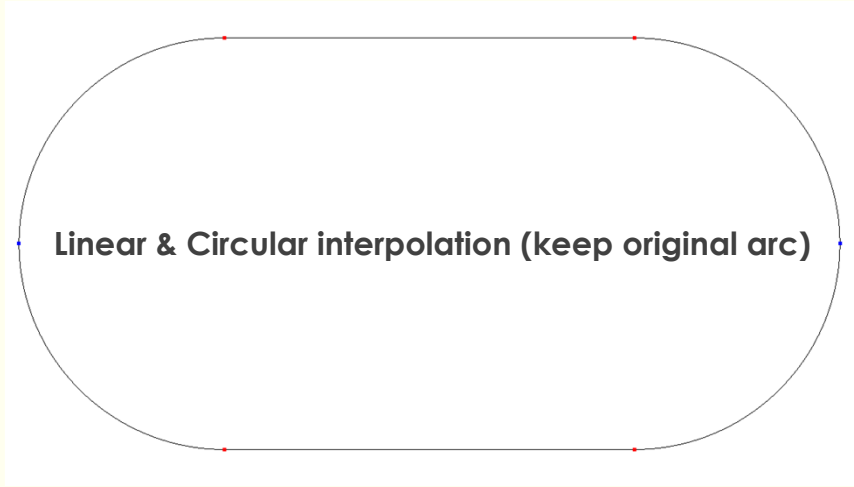


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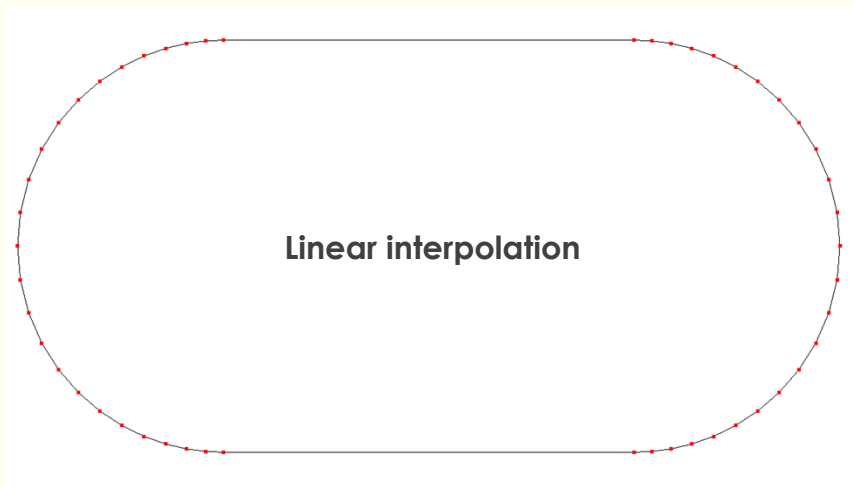
Feedrate: 10000mm/min

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Feedrate: 10000mm/min

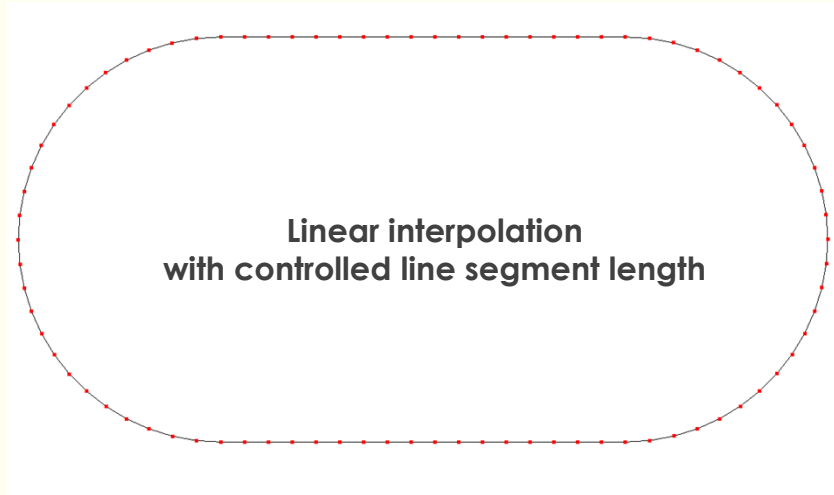
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Feedrate = 10000mm/min

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Actual Machining = 28s

Toolpath Length = 2.80m
Radius of arc = 4mm
Estimated cutting time = 16s

Actual Machining = 25s

Toolpath Length = 3.51m
Radius of arc = 8mm
Estimated cutting time = 21s

Actual Machining = 22s

Toolpath Length = 3.94m
Radius of arc = 12.84mm
Estimated cutting time = 22s

Actual Machining = 25s

Feedrate = 10000mm/min

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