Chapter 2:
CNC Fundamentals & Vocabulary

CNC
Learning objectives

- The Cartesian Coordinate System
- Motion Direction of CNC Mill and Lathe
- Types of Coordinate System
- Dimensioning Theory
- CNC Vocabulary

Axis and Motion Nomenclature

CNC Machine Operations

- Different CNC Machine tools may exhibit different machine motions
  - A typical 3-axis CNC Gantry Machine
    - Moves above the stationary work piece (part)
    - Spindle moves at 90^0 in/out of the part
  - A typical CNC lathe machine tool
    - Slides along the part
  - Multi-axis CNC Machines
    - Rotary motion of spindle
  - Stationary CNC machine, but tool is allowed to move in different direction
- Different CNC Machine tools use the same coordinate system
- Modeling a CNC Machine operation:
  - Calculate the tool movement relative to the coordinate system of the stationary part

Axis and Motion Nomenclature

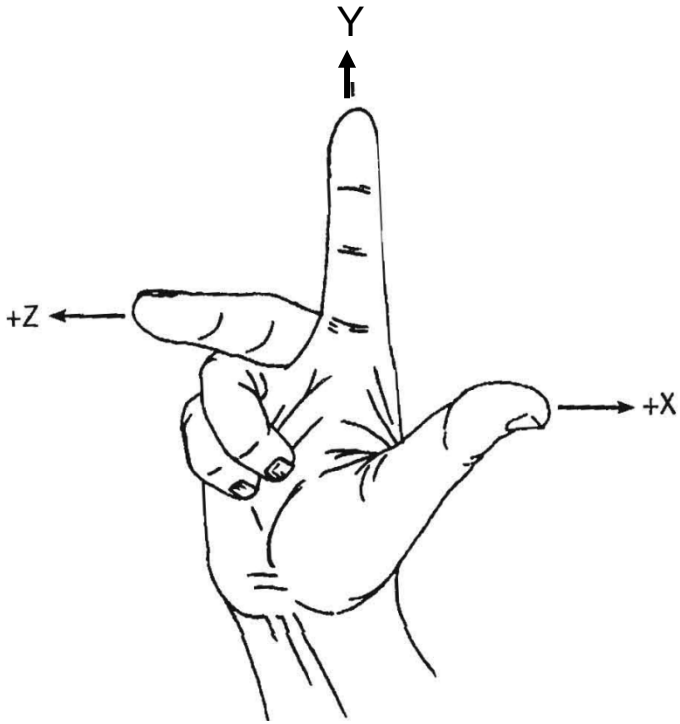
Cartesian System

- **Machine coordinate system is described based on Cartesian system**
  - **X, Y, Z are at 90^0**
- **Cartesian System**
  - **Use Right-hand Rule to designate the primary axis of the machine tool**
    - **The spindle**

3-Axis and Motion Nomenclature

Right-Hand Rule of Coordinates

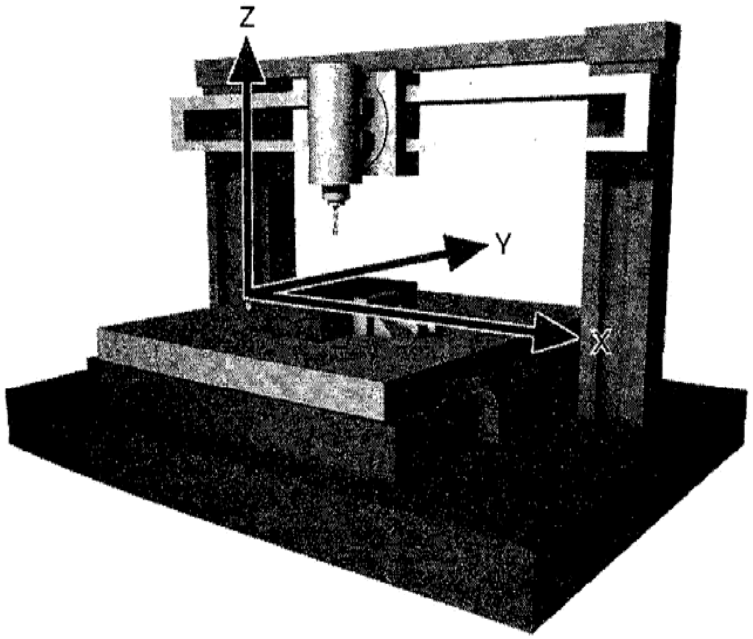
- **Hold the thumb, forefinger and middle finger at 90^0 to each other**
  - **Thumb (X-axis), Forefinger (Y-axis) and Middle finger (Z-axis)**
    - **Each finger points to +ve direction of motion of the CNC tool**
  - **3-axis Milling Machine:**
    - **The +Z-axis points into the spindle**



3-Axis CNC Milling Machine

Direction of Spindle Movement

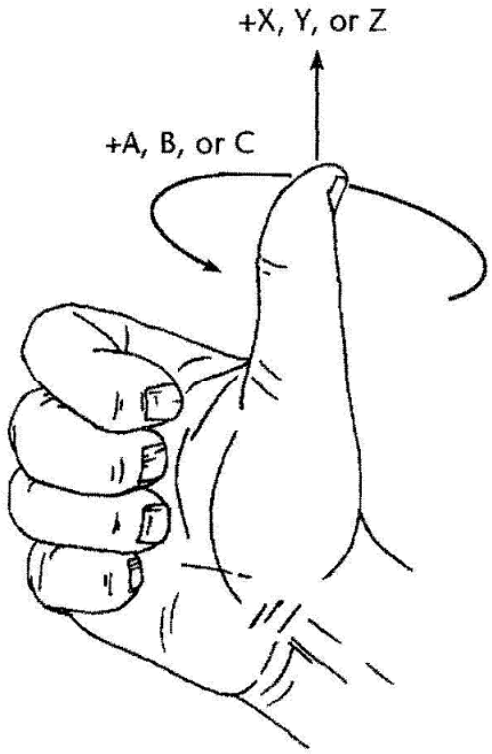
- **The longest travel slide represents the X-axis**
  - **Each finger points to +ve direction of motion of the CNC tool**
  - **The +Z-axis points into the spindle**



Multi-axis CNC Machine

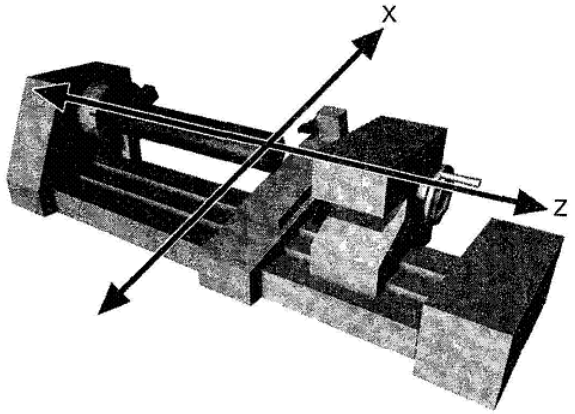
Rotary Motion of Spindle

- **Positive (Clock-wise) of Spindle**
  - **Curl right-hand with thumb pointing out in +ve X, Y or Z axis direction**
  - **The curl of the finger represents the +ve rotation about each axis**

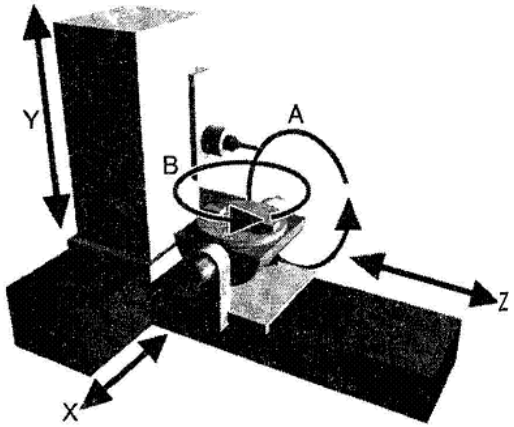


CNC Milling Machines

Examples



Typical CNC lathe



Horizontal Milling Machine
with multi-axis rotary table

CNC Milling Fundamentals
Cartesian Graph for CNC

Assume the 3-D frame of reference

- Reference Point (i.e., Origin): (X0, Y0, Z0)
- Ideally, the tool can move in any of the quadrants

- Coordinate at any time is designated in one of two ways:
- Absolute Coordinate System:
  - Calculate the distance relative to the origin (X0, Y0, Z0)
- Incremental Coordinate System
  - Calculate the distance relative to the last point
- All CNC Machine Tools require a reference point to calculate the coordinates

Options for Determine the Reference Point?

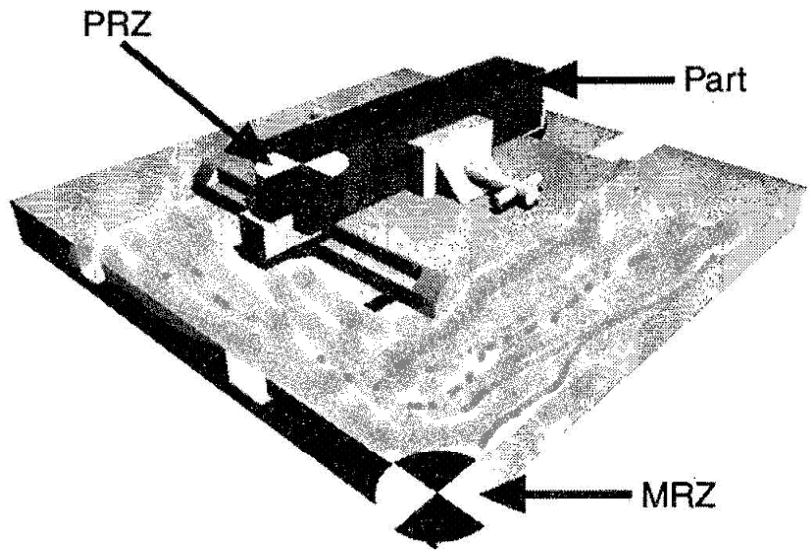
- Choose the point on the actual machine (MRZ)
- **Choose the point on the part - Point Reference Zero (PRZ)**

CNC Machine Reference Point
Point Reference Zero

Assume the reference point (PRZ) is located at:

- Lower Left-Hand Corner of the Part and
- On top of the Part

Hence negative Z-depths are below the surface of the machine



CNC Milling Fundamentals
Absolute Coordinates For Milling

Use the Origin as Reference point

- All points on the part, in the Cartesian graph, are plotted by measuring the (X, Y) distance and Z, if applicable, from the origin
- Coordinates of a point are represented as:
  - (X(+)(-)p, Y(+)(-)q, Z(+)(-)r) Where p, q, r represent the distance along the respective axis
  - (X3.25, Y-7.5, Z-0.5) Note the '+' sign is optional
    - Point is located:
    - 3.25 units along the +X axis
    - 7.5 units along the negative Y axis
    - 0.5 units along the negative Z-axis

Refer to more examples of Absolute Coordinates in Figures 2.11 and 2.12

CNC Milling Fundamentals
Incremental Coordinates For Milling

Use the present position as reference point for the next movement

- All points on the part, in the Cartesian graph, are plotted by measuring the (X, Y) distance between the current point and a known point
  - The first point usually starts from the origin

Using figure 2.13, given reference point 1 (1,3) find the incremental coordinates for:

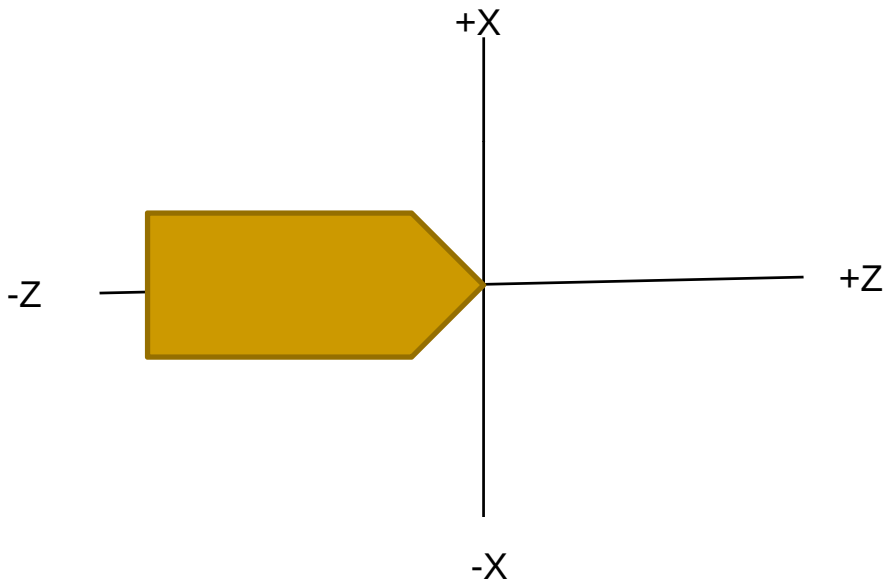
- Point 2 from the previous point 1
- Point 3 from the previous point 2
- Point 4 from the previous point 3
- Point 5 from the previous point 4
- Point 6 from the previous point 5
- Point 7 from the previous point 6

CNC Turning Fundamentals
Cartesian Graph for CNC

In CNC Turning, we have:

- A Primary (horizontal) axis labeled Z
  - On a lathes the z-axis always runs through the spindle
    - Hence part is symmetrical around the Z axis
- Secondary (vertical) axis labeled X
  - The X-axis is perpendicular to the Z axis

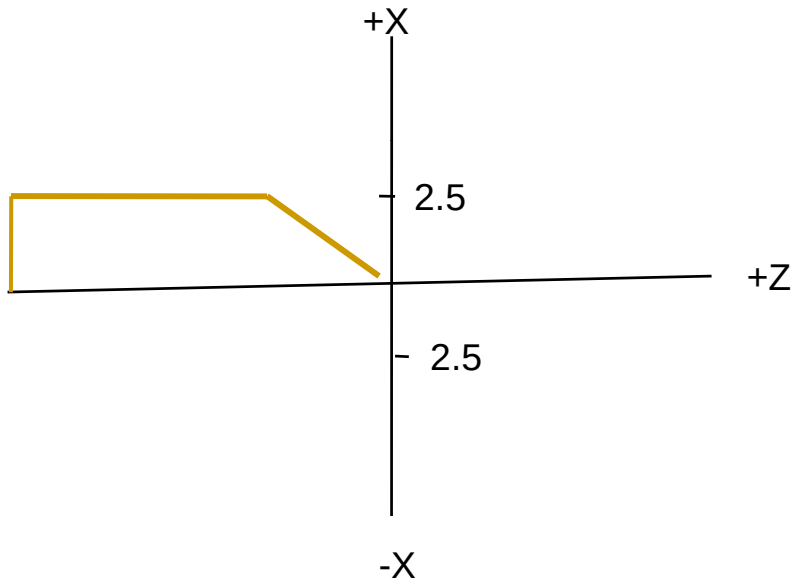
- Use the XZ Cartesian Coordinate System to plot the points
  - Assume the origin is located on the RHS of the part
- Start all measurements with origin as reference point
- Because of symmetry only top part above Z axis required
  - No need to use all 4 quadrants



CNC Turning Fundamentals
Diameter Vs. Radius Programming

Consider a work piece of diameter (along X Axis) 5 units:

- CNCez Diameter Programming Option:
  - To command an absolute move to the outside of part, you would program:
  - X5.0
- CNCez Radius Programming Option:
  - To command an absolute move to the outside of part, you would program:
  - X2.5

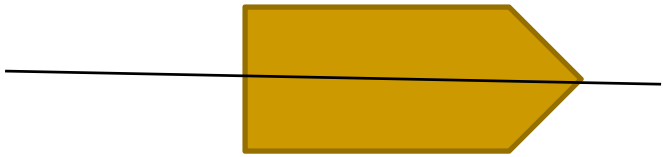


CNC Turning Fundamentals
Absolute Coordinates For Turning

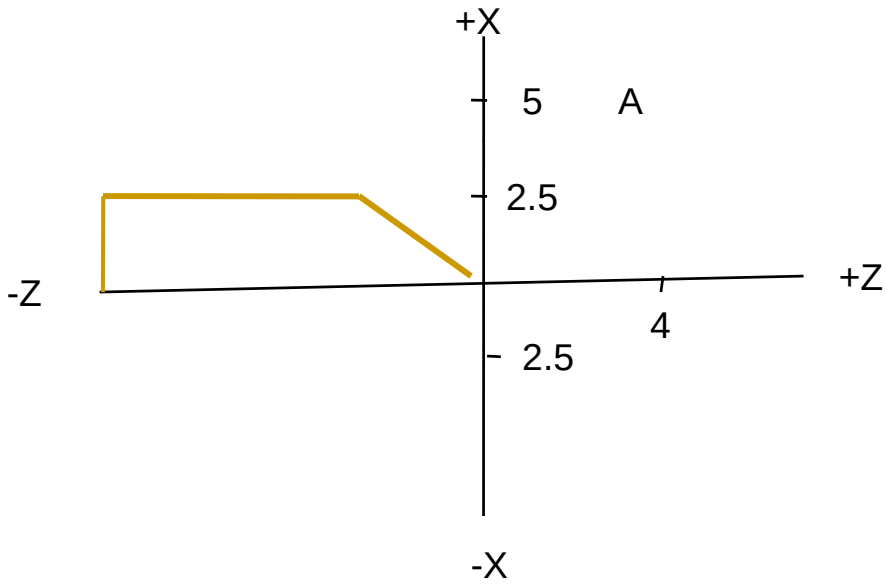
Steps to plot a point (X,Y)

1. Start at Origin (X0, Z0)
2. Travel along the left/right of Z axis until you are below/above the target point
   - Write down the Z value
3. Go up/down to the target point in the X direction
   - Write down the X value

CNC Turning Fundamentals
Finding Absolute Coordinates



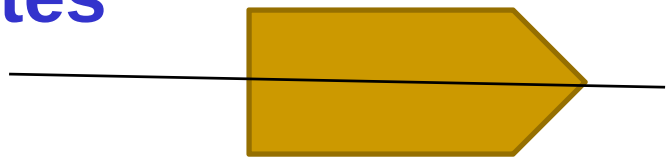
Consider a work piece of diameter (along X Axis) 5 units:



- Find point A:
  1. Start at Origin (X0, Z0)
  2. Travel along the right of Z axis until you are below A
     - Write down the Z value (4)
  3. Go up to the target point in the X direction
- Write down the X value (5)

- Radial XZ coordinates are (X5.0, Z4.0)
- Diametrical XZ coordinates are (X10.0, Z4.0)

CNC Turning Fundamentals
Finding Incremental Coordinates



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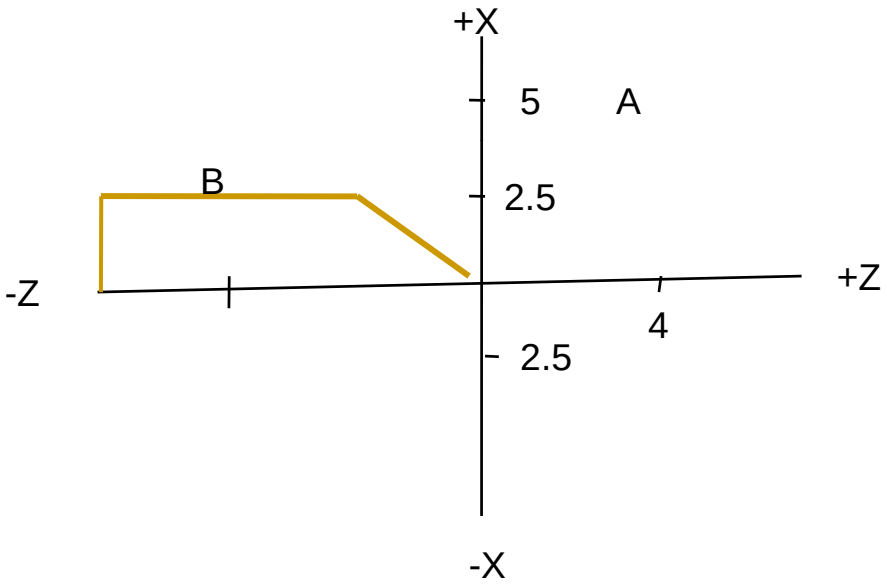

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Next Find Point B starting from A