ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

CNC Turning

Module 1: Introduction to CNC Turning

PREPARED BY

Academic Services

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Module Objectives

Upon the successful completion of this module, the student will be able to:

1. Define the term CNC.
2. Recognize the advantages and disadvantages of CNC.
3. Differentiate between Cartesian and Polar coordinate systems used in CNC programming.
4. Recognize the turning machine axes.
5. Identify the positive and negative movement directions on the turning CNC machines.
6. Describe the difference between absolute and incremental dimensioning methods.

Module Contents

1. Introduction

CNC stands for **C**omputer **N**umerical **C**ontrol. It is the technology of controlling a machining operation using a computer program, which is called Numerical Control (NC) Program. In other words, a computer rather than a person will directly control the machine tool.

The most important computerized machine tools that are used extensively in the industry are:

- CNC Turning (Lathe) machine. Fig. 1.1
- CNC Milling machine. Fig. 1.2

Fig. 1.1: CNC Lathe machine

2. Advantages of CNC

- Increased speed at which parts are produced (productivity).
- Producing the same quality for all work parts.
- Better dimensional accuracy which gives exact and correct dimensions.
- Increased ability to produce difficult parts.
- Less scrap.

Fig. 1.2 CNC milling machine

3. Disadvantages of CNC

- High initial cost
- Need high qualified operator.

4. Coordinate Systems

In order to shape metal by machine tools, the cutting tool should move in contact with the workpiece at certain specific points, while the workpiece or cutting tool is rotating.

Coordinate system is required to define the movement on the machine.

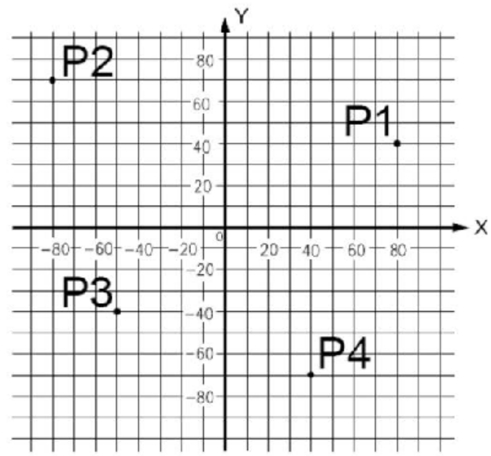

Fig. 1.3 (A): 2D Cartesian Coordinate System

Basically there are two common coordinate systems:

- Cartesian coordinate system.
- Polar Coordinate system.

4.1 Cartesian coordinate system:

Is used to describe the position of a point in the space.

- When dealing with 2 dimensions (2D), the two-dimensional coordinate system is used; Fig. 1.3 -A
- When dealing with three dimensions (3D), the three-dimensional coordinate system is used; Fig. 1.3-B

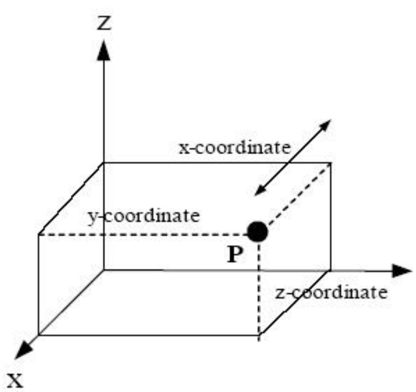

Fig. 1.3 (B): 3D Cartesian Coordinate System

Example 1:

Locate points P1 through P4 on the coordinate system shown in Fig. 1.4

P1	X = 80	Y = 60
P2	X = -80	Y = 20
P3	X = -50	Y = -60
P4	X = 60	Y = -70

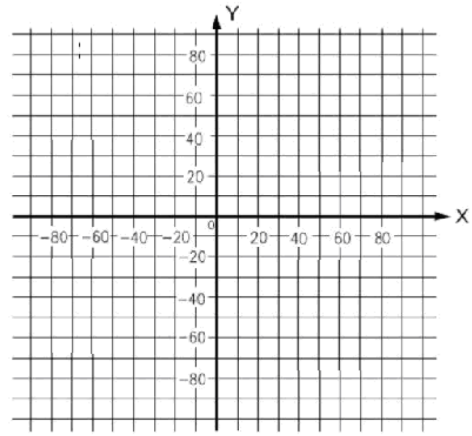

Fig. 1.4: coordinates of points P1 to P4

4.2 Polar Coordinate System:

The point is located by its distance (radius r) to the point of origin and its angle (alpha α) to a specified axis. The angle is positive if it is measured in counterclockwise direction starting from positive X-axis; Fig. 1.5-A.

The angle is negative if it is measured in the clockwise direction; Fig 1.5-B.

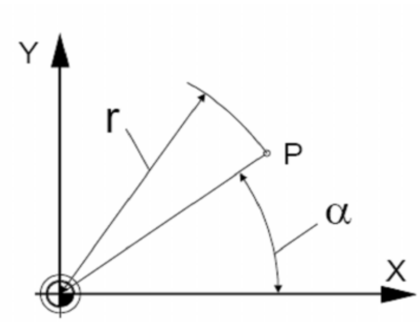

Fig. 1.5 (A): Positive angle.

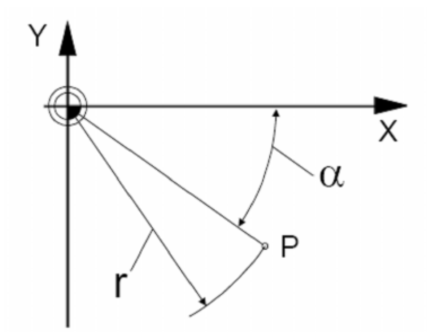

Fig. 1.5 (B): Negative angle.

5. CNC Lathe (turning) Machines' coordinate system:

To ensure that the control system of the machine will read the specified coordinates correctly to indicate the position of the workpiece; the machine tool has its own "coordinate system".

The following points are part of this system.

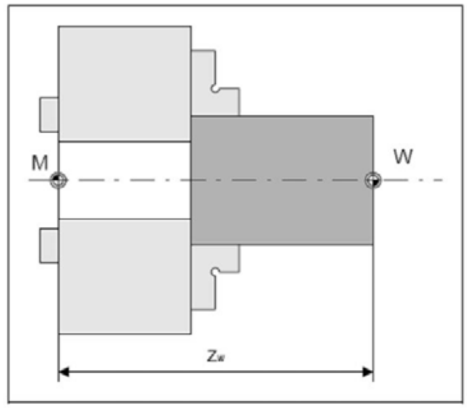

Fig. 1.6:Machine zero point and Workpiece zero point

5.1 Machine Zero Point (M):

The origin of the coordinate system. It is defined by the manufacturer and cannot be changed. In general, the machine zero point M is located in the center of the work spindle nose for CNC lathes.

Fig. 1.6 and 1.7 show (M) machine zero point for lathe machine and its symbol.

(a) (b)

Fig. 1.7: (a) Left: “M” Machine zero point symbol. (b)Right: “W” Workpiece zero point symbol.

5.2 Workpiece Zero Point (W):

The workpiece zero point (W) is the origin of the work part-based coordinate system. Its location is specified by the programmer. The ideal location of the work part zero point allows the dimensions to be directly taken from the drawing. In case of turning the workpiece zero point is generally in the center of the left or right side of the completed part. Fig. 1.6 and 1.7 show (W) workpiece zero point and its symbol.

5.3 Turning Machine axes:

CNC Turning machine has at least 2 controllable feed axes, marked as X and Z; Fig. 1.8

- When the cutting tool moves toward and backward the machine spindle, this is called movement along Z axis.
- When the cutting tool moves in cross direction to the longitudinal axis of the workpiece, this is called movement along X axis.
- Positive Z direction is when the tool moves away from the workpiece in Z axis.
- Positive X direction is when the tool moves away from the work part in X axis.

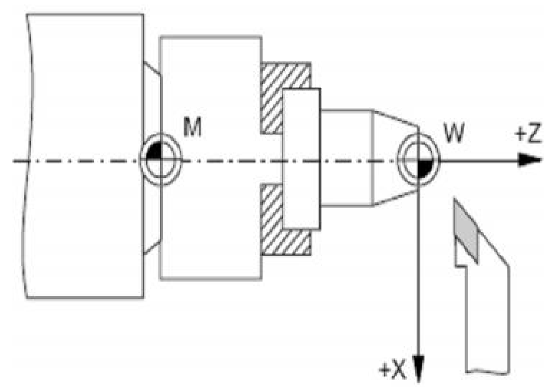

Fig. 1.8: Axes on turning machine

6. Dimensioning

To machine a workpiece we need a technical drawing on which we should illustrate the required dimensions to make the required shape. To dimension the workpiece we need to specify a certain point on it, from which we should take the measurement. This point is the origin point. The origin point on the workpiece is called **Workpiece zero point (W)**.

There are two types of dimensioning:

6.1 Absolute Dimensioning:

All measurements are taken from the workpiece zero point. Fig 1.9 -A.

In the drawings for CNC turning absolute system considers the value of X as the diameter value not the radius.

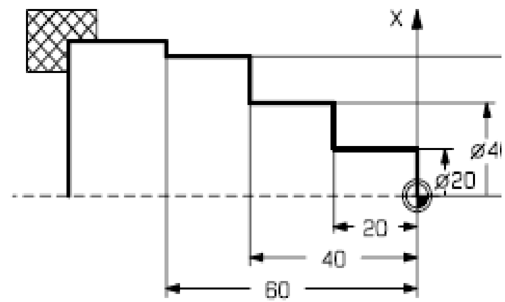

Fig. 1.9 (A): Absolute dimensioning

6.2 Incremental Dimensioning:

Uses incremental values that are always measured from the current point to the next point. Fig. 1.9 -B.

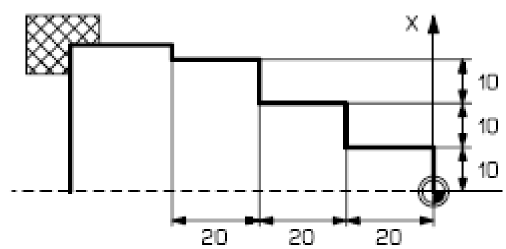

Fig. 1.9 (B): Incremental dimensioning

7. Cutting Speeds and Feeds:

7.1 Cutting speed (CS):

The cutting speed is the speed at which the circumference of the work part moves along the cutter, see Fig.1.10. The magnitude of cutting speed is determined by the:

1. Material of the work part.
2. Material of the cutting tool.
3. Infeed (surface quality roughing, finishing).

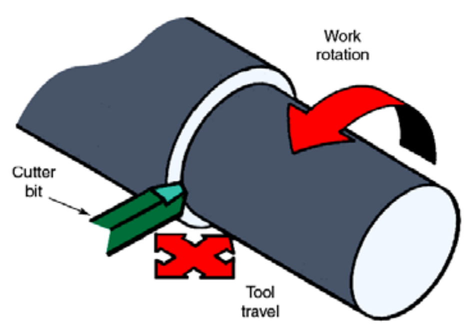

Fig. 1.10: Speed and Feed

The cutting speed is chosen from **tabulated values.**

Table 1.1 shows the recommended CS values for HSS cutting tools.

Table 1.1: Recommended cutting speeds for HSS cutting tools.

	Turning and Boring		Threading
	Rough cut	**Finish cut**	
Material	m/min	m/min	m/min
Machine steel	27	30	11
Tool steel	21	27	9
Cast iron	18	24	8
Bronze	27	30	8
Aluminium	61	93	18

7.2 Rotational speed (n):

Once the cutting speed is chosen, the rotational speed has to be calculated. The following formula can be used to calculate the rotational speed:

$$n = \frac{CS}{\pi d}$$

Where,

CS: the cutting speed in (m/min).

d: the work part diameter in (m).

n: the rotational speed in revolution per minute (RPM).

π: Constant = 3.14

Fig. 1.11

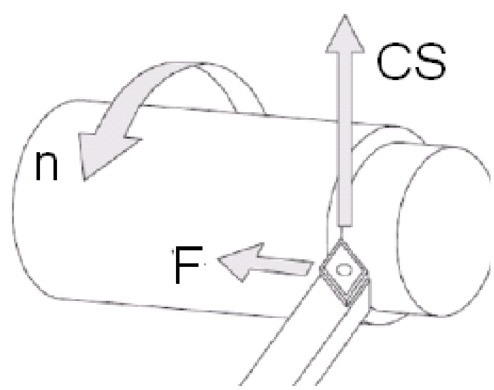

Fig. 1.11: Cutting speed and rotational speed

Example 1:

Student's Notes:

Calculate the rotational speed (n) if 12 mm diameter workpiece made of aluminum is to be machined (finishing cut). The cutting tool is made of HSS?

Solution:

- From table 1.1 the cutting speed for aluminum under finishing cut = 93 m/min
- The diameter = 12/1000 = 0.012 m

$$n = \frac{CS}{\pi d}$$

= 93/ (3.14 *0.012)

= 2468 RPM

Example 2:

Calculate the rotational speed (n) if 40 mm diameter workpiece made of bronze is to be machined (finishing cut). The cutting tool is made of HSS?

Solution:

7.3 Feed

The *feed* of a lathe may be defined as the distance the cutting tool advances along the length of the work for every revolution of the spindle. For example, if the lathe is set for a 0.4 mm feed, the cutting tool will travel along the length of the work 0.4 mm for every complete turn that the work makes. So the unit of feed (F) is mm/rev. Table 1.2

Table 1.2: Recommended Feeds for HSS tools.

Material	Rough cuts	Finish cuts
Machine steel	0.25–0.5	0.07–0.25
Cast iron	0.4–0.65	0.13–0.3
Bronze	0.4–0.65	0.07–0.25
Aluminium	0.4–0.75	0.13–0.25

7.4 Depth of cut

Depth of cut is the difference in height between machined surface and the work surface. See Fig.1.12

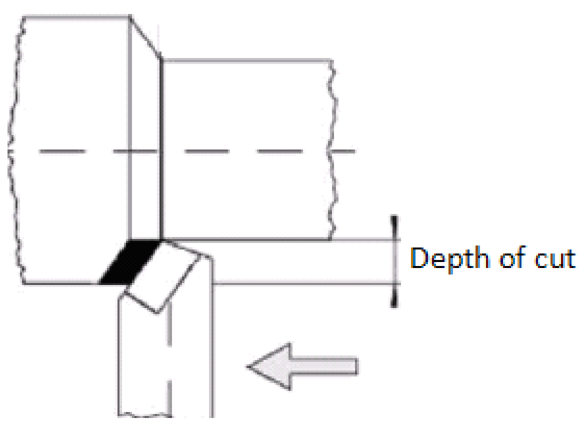

Fig. 1.12: Depth of cut

Student's Notes:

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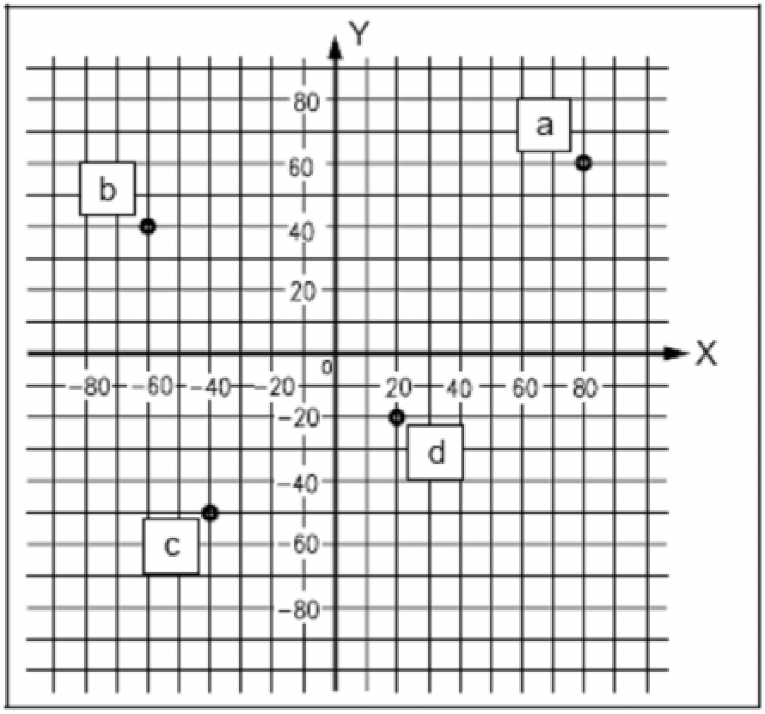
Work Sheet

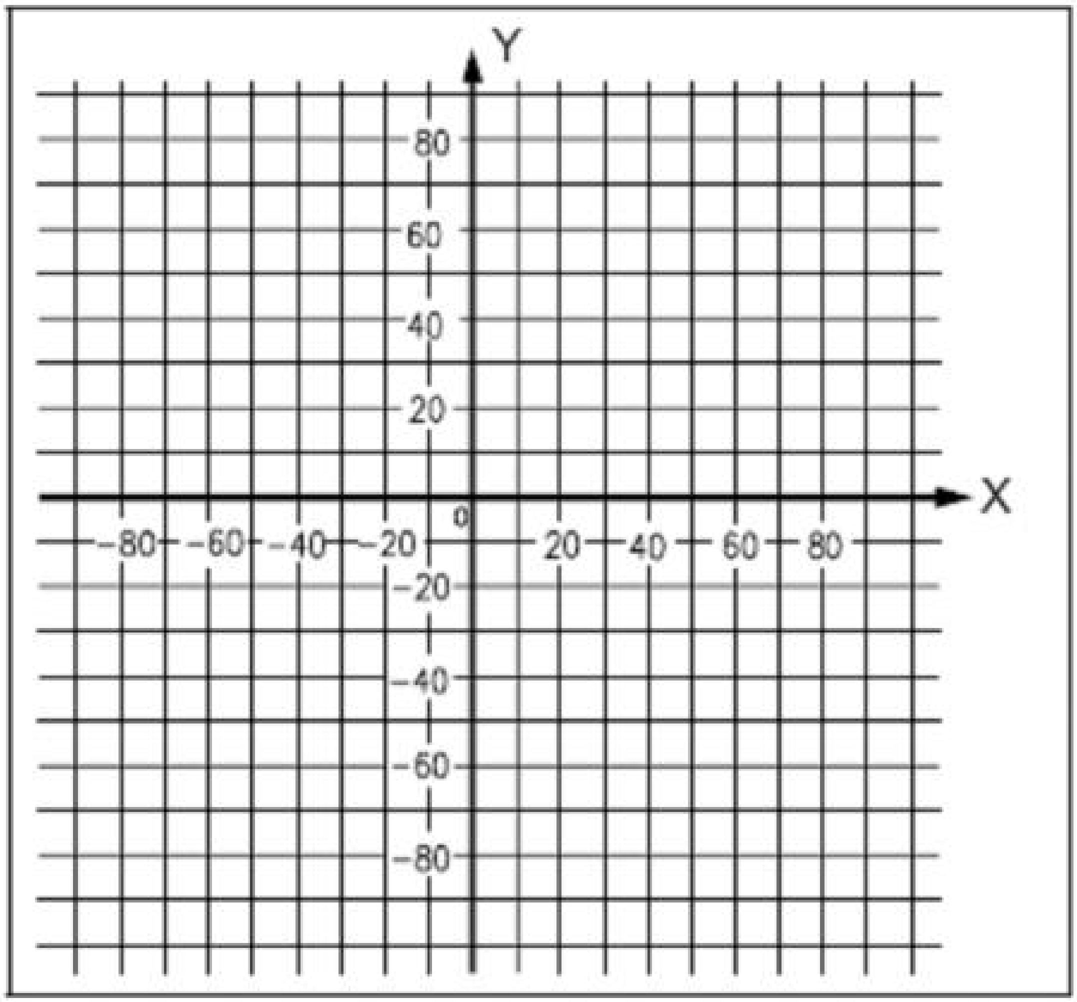
1. Fill in the table with the coordinates of the points shown on the 2-D Cartesian coordinate system shown below.



	a	b	C	D
X				
Y				

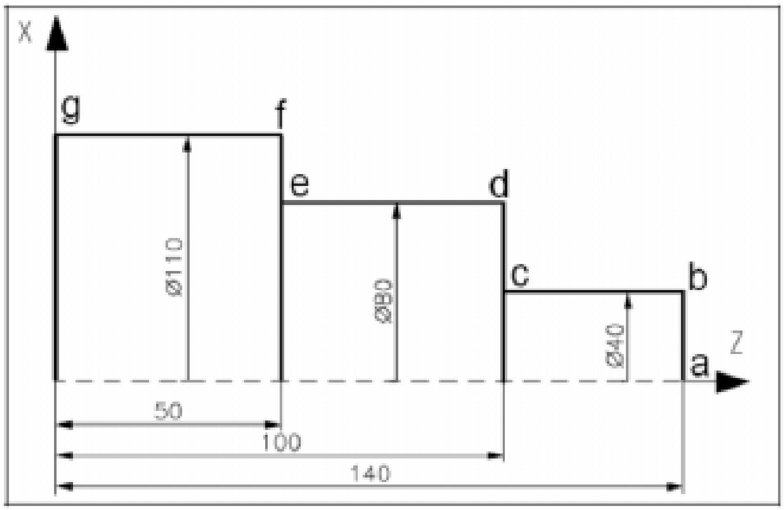
2. Use the coordinates table below, to locate the points "a" through "d" on the 2-D Cartesian coordinate system shown in the figure.

	a	b	c	D
X	10	-80	40	-30
Y	20	-30	-70	50



3. Enter the Cartesian coordinates of the points "a" to "g" in the table.

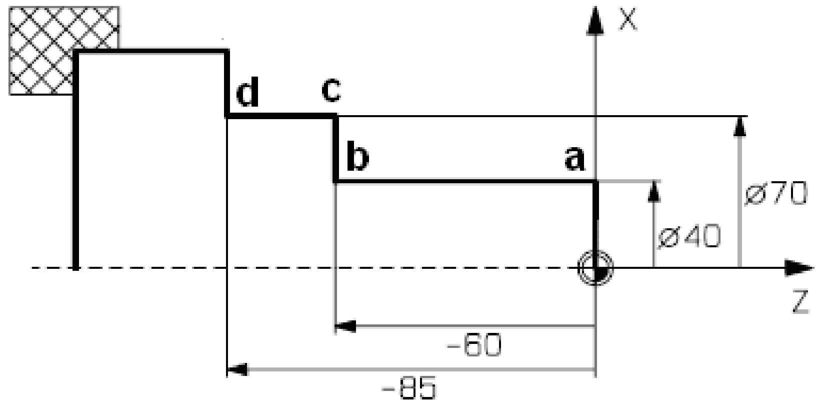
   Determine the corresponding diameter values of the X-coordinates.



	a	b	c	d	e	f	g
X							
Z							

4. Enter the Cartesian coordinates of the points "a" to "d" in the table.

   Determine the corresponding diameter values of the X-coordinates.



	a	b	c	d
X				
Z				

5.Write (T) for true and (F) for false following statements:

a) Moving on a turning machine on the X-axis from the center of the workpiece to the end is a positive direction. (   )

b) Workpiece zero point is defined by the manufacturer and cannot be changed. (   )

c) In incremental dimensioning all measurements are taken from workpiece zero point. (   )

d) Moving on a turning machine towards the chuck on the Z-axis is a positive direction. (   )

References:

1. CNC Technology – NCADU
2. CNC programming, principles and Applications – Michael Mattson
3. MTS – Teachware – CNC basics