# IE 111 Computer Aided Engineering Drawing 

# Geometrical Construction-Coordinate Systems/Basic Entities 

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## General Knowledge of Engineering Drawings

$\square$ In order to prepare an engineering drawing, one should

- Determine paper size $\sqrt{ }$
- Determine drawing scale $\sqrt{ }$
- Develop title block $\sqrt{ }$
- Determine units $\sqrt{ }$
$\square$ We will use ISO/ANSI units and A3 paper size template.


## Drawing Paper

$\square$ Rectangular shape $(x / y=\sqrt{ } 2)$
$\square$ Largest drawing paper size (A0) has an area of $1 \mathrm{~m}^{2}$

| Size | Dimensions (mm) |  | Area $\left(\mathrm{m}^{2}\right)$ |
| :---: | :---: | :---: | :---: |
|  | x | y |  |
| A0 | 1189 | 841 | 1.00000 |
| A1 | 841 | 595 | 0.50000 |
| A2 | 595 | 420 | 0.25000 |
| A3 | 420 | 297 | 0.12500 |
| A4 | 297 | 210 | 0.06250 |
| A5 | 210 | 149 | 0.03125 |

ISO 1101 specifies the standard size of drawings


## A3 Size Template



## Introduction to AutoCAD

- We will use AutoCAD 2000.

In order to run AutoCAD in the computers of AutoCAD
Laboratory, either

- click on the link "AutoCAD 2000" on the left hand side of the screen
- or click "Start", and select All Programs > AutoCAD 2000 > AutoCAD 2000.

As you run AutoCAD, a dialog box opens. Click cancel to close the dialog box.

## AutoCAD Window



## AutoCAD Window

- Some of the toolbars are displayed by default. These are the "Standard" toolbar, "Object Properties " toolbar, "Modify" toolbar, and "Draw" toolbar.



## AutoCAD Window

AutoCAD allows also use of commands. The user may select a toolbar button for a specific task or write a command ruling the task.
$\square$ The command window is placed at the bottom of AutoCAD screen.
$\square$ Command window shows two or three lines of previous prompts, called command history.


The whole command history can be viewed at any time by pressing the key "F2".

## Saving and Closing Workbook

$\square$ In order to save your work you have two choices

- Save
- Save As

If the work was saved previously, one may choose save from the file menu (Menu bar > File > Save). If the work is being saved for the first time, choosing save opens a dialog box for naming the file.
Or you may choose Save As from the file menu in order to rename the work or save it for the first time.
$\square$ In order to close your work you may either

- choose Close from the file menu
- or click on the cross mark at the top right corner of the drawing


## (D) Engineering Geometry

$\square$ Geometry provides
the building blocks for the engineering design process.
$\square$ Engineering geometry is the basic geometric elements and forms used in engineering design.
$\square$ Engineering geometry of an object deals with shape and dimension (location + size).

(Courtesy of Kim Steele/Getty Images.)

## Coordinate Systems

$\square$ In order to define an object geometrically in space, we need coordinates.
$\square$ For example in 3D space, we need three dimensions in order to locate a point, which are the coordinates of that point.
$\square$ These dimensions are distances with respect to a certain point or angles with respect to certain lines in space.

## Cartesian Coordinate System

The coordinate system, in which the positions are the distances from the origin of the coordinate system along principal directions.
$\square$ Origin of the coordinate system is the intersection point of 2 (for 2D) or 3 (for 3D) mutually perpendicular axes.
$\square$ Axes are conventionally denoted as $\mathrm{X}, \mathrm{Y}$, and Z .


## Cartesian Coordinate System

$\square$ Same conventions are also applicable to AutoCAD. The user coordinate system icon shows the axes of Cartesian Coordinate System.
$\square$ Locating the points:


- The origin is intersection of $X$ and $Y$ axes $(0,0)$.
- Any point left of the origin has negative $X$ value, any point below of the origin has negative $Y$ value.
- Always enter the $X$ coordinate first, followed by a comma, then $Y$ coordinate. Use "-" to define negative points. (X,Y), (-X,Y)


## Cartesian Coordinate System

The following figure shows the location of points on the XY plane.

- The 3,5 coordinate indicates a point 3 units in the positive $X$ direction and 5 units in the positive $Y$ direction relative to the origin.
- The -3,5 coordinate represents a point 3 units in the negative $X$ direction and 5 units in the positive $Y$ direction.



## Cartesian Coordinate System

## 3-D Coordinate System

$+Y$

-Y

## Cartesian Coordinate System



Display of Coordinate Axes in a Multiview CAD Drawing

## Cartesian Coordinate System



## Cartesian Coordinate System



Right-Hand Rule


Direction of movement


Right-Hand Screw

## Polar Coordinate System

$\square$ The coordinate system, in which the positions are the distances from the origin and angles from one of the axes.
$\square$ For convention, the distance is radial distance and the angle is measured in counterclockwise direction from the horizontal axis, which is X .
$\square$ Note that counterclockwise direction is the "positive direction".


$\underset{\substack{\text { Cartesian }}}{ }$ Polar
$\Theta=\tan ^{-1} \frac{y}{x}$

Z

## Polar Coordinate System

$\square$ Specifying Points in AutoCAD using Polar Coordinates:

- To specify a point using polar coordinates, enter the distance first followed by a less than symbol (<) and the value of the angle in degrees. (distance<angle)



## Cylindrical Coordinate System



## Spherical Coordinate System

Spherical $\longrightarrow$ Cartesian

| $x=r \cos \theta \sin \phi$ |
| :--- |
| $y=r \sin \theta \sin \phi$ |
| $z=r \cos \phi$ |



$$
\begin{aligned}
& \text { Cartesian } \longrightarrow \text { Spherical } \\
& r=\sqrt{x^{2}+y^{2}+z^{2}} \\
& \theta=\tan ^{-1}\left(\frac{y}{x}\right) \\
& \phi=\cos ^{-1}\left(\frac{z}{r}\right)
\end{aligned}
$$

## Absolute Coordinates

## Values are referenced to the fixed origin.



## Relative Coordinate Systems

- If you don't know the absolute coordinate of a desired point, you can use relative coordinate system.
The relative coordinate is based on the last point defined (Local coordinate system is located at the last point).
$\square$ Relative coordinates work with either Cartesian or Polar coordinates.
$\square$ In order to denote a point in a relative coordinate system we use the symbol "@" in AutoCAD.


## World and User (Local) Coordinates

 Local Coordinate System is a moving system that can be positioned anywhere in $3-\mathrm{D}$ space by the user to assist in the construction of geometry.

## Classification of Geometrical Elements



## Basic Elements - Point

(Approximately
(E) Point nodes at the
end of a line
(F) Point node at the
midpoint of a line

Point - Exact location in space.
Node - intersection of geometric entities, specific locations of a point.
Locus - All possible positions of a point.

## Basic Elements - Point

## - AutoCAD Command "Point"

- The point command creates points within the drawing.
- There are several ways to activate the command.
, Toolbar button
> Selecting from menu bar
> Simply writing the command in the command window.



## Basic Elements - Point

$\square$ By default the points style is dot, which is hard to see in the active window. Point style can be changed from Menu bar > Format > Point Style.

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| Color... |
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| Drawing Limits |
| Rename... |

## Basic Elements - Point

$\square$ Cartesian Cordinate System

- Absolute Coordinate
$\Rightarrow 100,50 \Longrightarrow P_{1}(100,50)$
- Relative Coordinate

$$
>P_{2}(100+20,50+30)=P(120,80)
$$

$\square$ Polar Cordinate System

- Absolute Coordinate

$$
>100<45 \Rightarrow P_{1}\left(r=100, \theta=45^{\circ}\right)
$$

- Relative Coordinate
- @ $100<225 \Longrightarrow P_{2}(0,0)$


## Auxialiary Tools - Grid

The grid is a pattern of dots that exist over the area specified by the limits.
$\square$ The grid helps you;

- align objects and
- visualize the distances between them.


## A3 Size Template with Grids



## Auxialiary Tools - Grid

$\square$ To turn on the grid and set grid spacing;

- From the Tools menu, choose Drafting Settings.
- On the Snap and Grid tab of the Drafting Settings dialog box, select Grid On.
- Enter the value for Grid X Spacing in units.
- To use the same value for vertical grid spacing, press ENTER. Otherwise, enter a new value for Grid Y Spacing.


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| Wizards |  |
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| Tablet |  |
| Customize Menus... |  |
| Options... |  |

## Auxialiary Tools - Grid

$\square$ Alternatively, to turn the grid on or off, click Grid on the status bar. (For settings, right click Grid on the status bar and choose Settings)


## Auxialiary Tools -Snap

$\square$ When Snap is on, the Snap mode restricts the movement of the crosshair to intervals that you have defined. Snap is useful for specifying precise points with the keyboard or pointing device. You control snap precision by setting the $X$ and $Y$ spacing.

## Auxialiary Tools－Snap

－To turn on Snap mode and set snap spacing
－From the Tools menu，choose Drafting Settings．
－On the Snap and Grid tab of the Drafting Settings dialog box，select Snap On．
－Enter the value for Snap X Spacing in units．
－To specify the same vertical snap spacing，press ENTER．Otherwise，enter the value for Snap Y Spacing．
－Under Snap Style \＆Type，select Rectangular Snap and Grid Snap．
－Choose OK．


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## Auxialiary Tools -Snap

I Alternatively, to turn the snap on or off, click snap on the status bar. (For settings, right click snap on the status bar and choose Settings)


## Basic Elements - Line

## Examples of lines


(A)

(B) Point moving in a constant direction

Results in a straight line

(C) Finite line

D) Infinite line

(E) Ray

## Basic Elements - Line

## Line relationships


(A) Parallel line condition

(B) Nonparallel line condition

(C) Perpendicular line condition

(D) Intersecting lines


(E) Tangent condition

(F) Line at the intersection of two planes (Edge)

## Basic Elements - Line



Arc


Circle

intersection between the cylinder and the plane

## Curved Lines

## Basic Elements - Line



## Planar Tangents

## (D) Basic Elements - Line



## Basic Elements - Line

Tangent and Non-Tangent
Conditions in 3-D Geometry


No line drawn at tangency


Line drawn

## Basic Elements - Line



## Tangent Lines

The lines of intersection between each plane and each solid are tangent conditions, as are lines that touch a surface at a single point.

## Basic Elements - Line

Basic types of lines:
-Visible line: edges
—— Visible Edge (thick) (Part outline)
that can be seen in the current view.
DHidden line: edges that can not be seen in the current view.
-Center line: axes of symmetrical part, center of circle, path of motion.


## Basic Types of Lines

-Dimension \& extension line: sizes of parts.
DCutting plane: location of cutting plane in section drawing.

Dimension and
Extension Lines $\longleftrightarrow \stackrel{\text { Light }}{ } 3.000 \longrightarrow$

Cutting Plane Heavy

## Basic Types of Lines

OBreak line: to show where an object is broken to save drawing space or reveal interior features.


SHORT BREAK LINES


ROUND SOLID

LONG BREAK LINES


## Basic Elements - Line

## $\square$ Some lines take precedence over other lines.



Front


Right

## Basic Elements - Line

## - AutoCAD Command "Line"

- Line is the very basic entity involved in a drawing.
- There are several ways to activate the line command in AutoCAD
- Toolbar button
> Selecting from menu bar
> Simply writing the command in the command window.
- When you select the Line command you can directly start the drawing.
> You must specify the starting point of line,
> Than you have two options(specify next point or [Undo])


## Basic Elements - Line

## - AutoCAD Command "Line"

- After specifying the second point, you are given two options for the third point;
> The default option is to specify the next point.
> Close option: If you type Close or C instead of selecting a next point AutoCAD will draw a line connecting from the last point you entered to the first point selected.

betore entering c

after entering C


## Basic Elements - Line

- Cartesian Coordinate System
- Absolute Coordinate
$\triangleright 100,50 \longrightarrow P_{1}(100,50)$
$>120,80$
$P_{2}(120,80)$

- Relative Coordinate
$\begin{array}{ll}\Rightarrow 100,50 & \longrightarrow P_{1}(100,50) \\ > & P_{2}(100+20,50+30)=P_{2}(120,80)\end{array}$



## Basic Elements - Line

- Polar Cordinate System
- Absolute Coordinate
> $100<45\left(r=100, \theta=45^{\circ}\right)$

- Relative Coordinate
> $100<45\left(r=100, \theta=45^{\circ}\right)$
- @100<225 (r=100, $\left.\theta=225^{\circ}\right)$



## Auxialiary Tools -Object Snap

$\square$ When Object Snap is on, you can select/use a defined feature of an object easily.

- End point
- Mid point
- Center
- Parallelity
- Perpendicularity
- Tangency
- Intersection


## Auxialiary Tools－Snap

$\square$ To turn on Object Snap mode and set snapping features －From the Tools menu，choose Drafting Settings．
－On the Object Snap tab of the Drafting Settings dialog box，select Object Snap On．
－Select the required features．
－Choose OK．


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| Clean Screen | Ctrl +0 |
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## Auxialiary Tools -Object Snap

- Alternatively, to turn the object snap on or off, click object snap on the status bar. (For settings, right click snap on the status bar and choose Settings)



## Object Snap Exercise

1. Draw a triangle.
2. Draw perpendicular lines of the triangle.
3. Draw lines which are parallel to the sides.


## Handling Tools - Undo

- Each time you click Undo on the Standard toolbar, AutoCAD undoes one command.
- Some commands have their own undo command. In order to activate undo of a command, write down "u" or "undo" in the command window.
- E.g. If you accidentally write or choose a wrong point while creating a line, the Undo option will help you. Write undo or u


## Handling Tools - Erase

- If you make a mistake or change your drawing you can use Erase command.
- You can choose Erase from Modify pull-down menu or the Erase icon from the Modify tool bar.
$\square$ When you choose Erase icon, you must select the objects you wish to erase. You can select the object with a pick box, a window, a crossing, or a fence.
$\square$ When you select the object you wish to erase, they will be shown with a dashed line.
$\square$ Press Enter when you have finished selecting, the object will then be erased.
- You can use the Undo command to put the object back.
- You can also select an object an click "Del" on the keyboard in order to delete the selected entity.



## Handling Tools - Zoom

$\square$ Zooming increases or decreases apparent size of the image displayed. You can use zoom command to look at a closer view of your drawing or to see it from farther away.
$\square$ You can choose the Zoom command from View pull-down menu or you can pick up one of the Zoom option from the Zoom icon.


## Handling Tools - Zoom

$\square$ The Standard toolbar contains three Zoom icon buttons.
$\square$ Zooming in Real Time: You can use your mouse to zoom in real time, that is, to zoom in or out by moving the cursor. After choosing the command move the cursor up to zoom in, move it down to zoom out.


Zoom icons on the
standard toolbar.

The zoom fly out menu. Left click at the button and hold the mouse button down.

- AutoCAD provides you with several option for zooming. The available options are shown on the Zoom toolbar (also accessible with zoom fly out menu);



## Handling Tools - Zoom

- Zoom All:

The command will display everything within the limits of drawing. The command will display any objects that have been drawn outside the limit area.

- Zoom Window:

The command will ask you to specify a rectangle by choosing the location of two opposite corners. Everything within the rectangle will be displayed largely.

- Zoom Extents:

Zoom all and Zoom Extents are similar commands. Both display all the entities within the drawing. Zoom All always include the entire limits of drawing. Zoom extent shows only the area where the objects have been drawn. Compare following figures;


Zoom All


Zoom Extends

## Handling Tools - Zoom

- Zoom Scale:

The command allows to zoom relative to a value that you enter.

- Zoom In:

Provides the objects on the screen will look bigger.
] Zoom out:
Provides the objects on the screen will look smaller.

## Handling Tools - Pan

$\square$ The pan command is another common way to change a view. The pan command moves the position of the drawing in your screen.

- Select the Pan from View pull-down menu or click the pan icon on the standard tool bar.
$\square$ There are several ways to pan. We will discuss only Real Time Pan.
$\square$ Choosing the Real Time option will cause a hand to appear on the screen in place of the cursor.
- You can then use your mouse to move the drawing around.
- Hold down the left button and move the mouse around until the drawing is in the position you desire.


## Coordinate Exercise 1.dwg

Draw the shape using the coordinate values.


## Coordinate Exercise 2.dwg

Draw the shape with the given dimensions.


## Coordinate Exercise 3.dwg

Draw the shape using line commands.


## Coordinate Exercise 4.dwg

Draw the shape using the dimensions.


## Coordinate Exercise 5.dwg

Draw the shape using the dimensions.


## Coordinate Exercise 6.dwg

Draw the shape using the dimensions. All angles are $45^{\circ}$ or its multiples. Use snap mode.


## English - Turkish Dictionary

| toolbar | Araç çubuğu | cursor | imleç | point | nokta |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Absolute <br> coordinate | Mutlak koordinat | Relative <br> coordinate | Bağıl koordinat | Command history | Komut tarihçesi |
| Cartesian <br> cordinate <br> system | Kartezyen koordinat <br> sistemi | Polar coordinate <br> system | Kutupsal <br> koordinat sistemi | Status bar | Durum çubuğu |
| tool | Araç, alet, gereç | line | Çizgi, doğru | horizontal | yatay |
| vertical | Dikey, düşey | auxiliary | yardımcı | grid | Izgara, alanı <br> karalere bölme |
| snap | Şipşak yaslama | origin | Başlangıç noktası | axes | eksenler |
| pattern | Örüntü, kalıp | align | hizalama | principal | Ana, esas |
| template | şablon | simge | interval | aralık |  |
| undo | Geri al | Kashed line | Kesik çizgi | position | konum |
| handlig | Issleme, elden geçirme, <br> elleçleme | erase | Zoom window | Pencere içine <br> alınanı tam <br> ekranda gösterme |  |
| Zoom in | Büyültme, <br> yakınlaştırma | Zoom out | Küçültme, <br> uzaklaştırma | Zoom all | Tüm alanı tam <br> ekranda gösterme |
| pan | Gezdirme, kaydırma | Real time pan | Gerçek zamanda |  |  |
| kaydırma | Zoom extents | Mevcut şekilleri <br> tam ekranda <br> gösterme |  |  |  |

