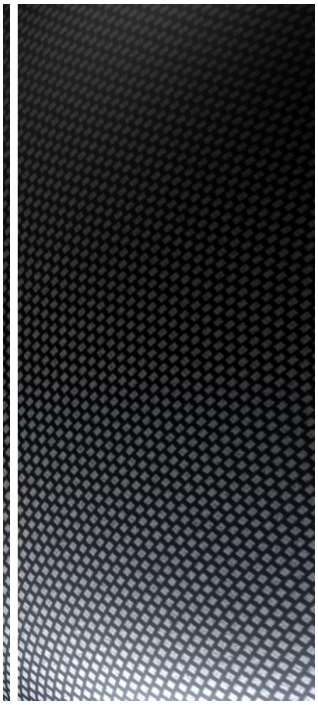
Automation (21-541)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 7

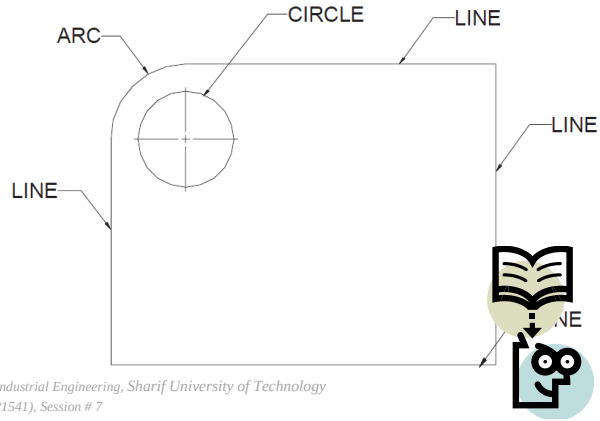


Session Schedule

- *Computer-Aided Design (CAD)*
  - *Introduction*
    - *Graphic primitives*
  - *Geometric modeling*
    - *Geometric modeling techniques*

Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *A drawing is created by an assembly of points, lines, arcs, circles.*
  - *The drawing entities that a user may find in a typical CAD package include :*
    - *point*
    - *line*
    - *construction line, multi-line, polyline*
    - *circle*
    - *spline*
    - *arc*
    - *ellipse*
    - *polygon*
    - *rectangle*

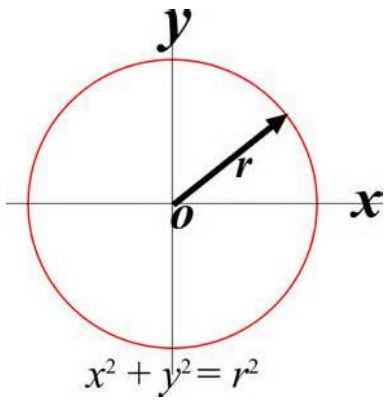


Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *DDA algorithm (Digital Differential Analyzer)*
  - *The digital differential analyzer generates lines from their differential equations.*
  - *The DDA works on the principle that X and Y are simultaneously incremented by small steps proportional to the first derivatives of X and Y.*
  - *In the real world of limited precision displays, addressable pixels only must be generated.*

Computer-Aided Design (CAD)

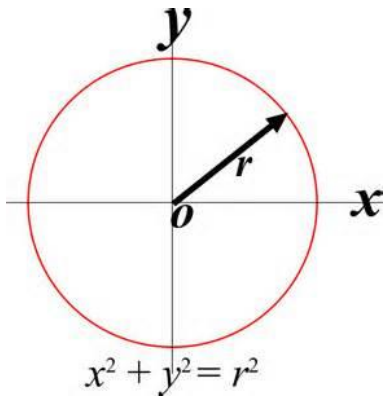
- *Graphic primitives:*
  - *Procedure DDA (X1, Y1, R : integer) ;*



Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *Procedure DDA (X1, Y1, R : integer) ;*
  - *As begin*
  - *For(int tetha=0;tetha<360;thetha++)*

```
{
        Plot(X1+R*cos(theta),Y1+R*sin(theta))
}
```



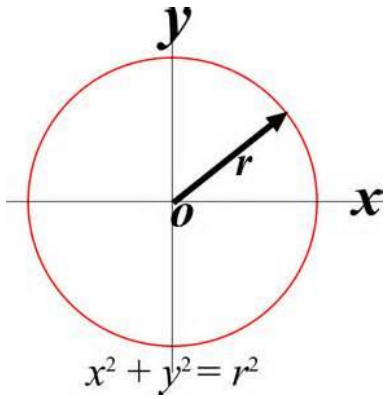
Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *Procedure DDA (X1, Y1, R : integer) ;*
  - *As begi*
  - *DTetha=*
  - *For(int tetha = π;thetha+=Dtetha)*

{

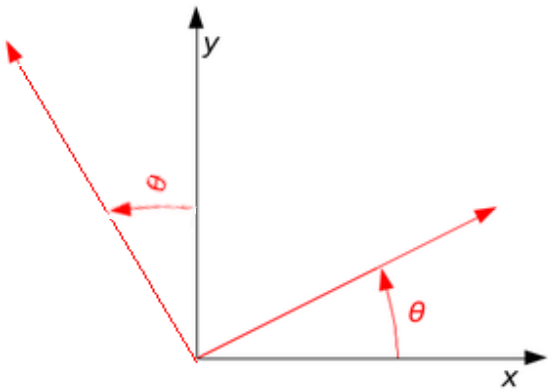
*Plot(X1),Y1+R*sin(theta))*

}



Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *Procedure DDA (X1, Y1, R : integer) ;*
  - $R(\theta) = \begin{bmatrix} Cos\theta & Sin\theta \\ -Sin\theta & Cos\theta \end{bmatrix}$



Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *Procedure DDA (X1, Y1, R : integer) ;*
  - *As begin:*
  - *Tetha=1/R;*
  - *X=R*Cos(Tetha); Y=R*Sin(Tetha);*
  - *For(int i=0; i<2*Pi*R; i+=(1/R))*

```
{
        plot(truncate(X+X1±0.5), truncate(Y+Y1±0.5));
        Xtemp=X*Cos(Tetha)-Y*Sin(Tetha);
        Ytemp= X*Sin(Tetha)+Y*Cos(Tetha);
        X=Xtemp; Y=Ytemp;
}
```


Homework: AT:G:03:#

- *Extend the simple program of group HW3 for plotting geometric objects. You should use your CIM data base structure to maintain the geometric data.*
  - *A simple interface can be applied to plot the geometric objects.*
  - *You should provide your second module/procedure to plot a circle by getting the required center Cartesian location and radius s in a 2D space.*
- *The HW should be sent to Fvalilai@Sharif.edu till Sunday, 11th of Aban (Nov, 2nd ,2014)*
- *Email subject: "AT:G:03:#"*

Computer-Aided Design (CAD)

- *Graphic primitives:*
  - *Transformations*
    - *Scaling*

$$\begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

    - *Translation*

$$\begin{bmatrix} 1 & 0 & 0 & -T_x \\ 0 & 1 & 0 & -T_y \\ 0 & 0 & 1 & -T_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

    - *Rotation*

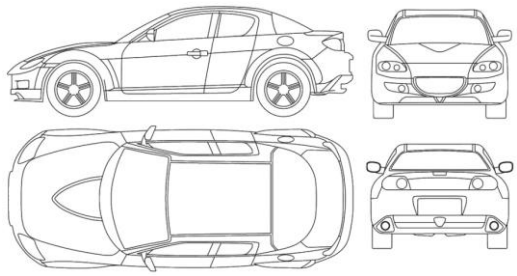
$$R_z = \begin{bmatrix} Cos\theta & Sin\theta & 0 & 0 \\ -Sin\theta & Cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

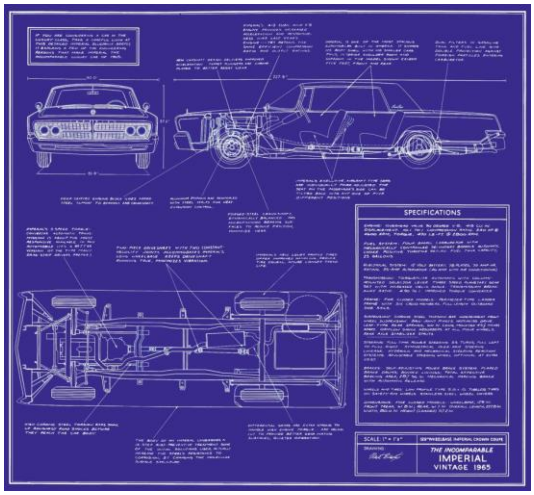
$$R_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & Cos\phi & Sin\phi & 0 \\ 0 & -Sin\phi & Cos\phi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_y = \begin{bmatrix} Cos\varphi & 0 & -Sin\varphi & 0 \\ 0 & 1 & 0 & 0 \\ Sin\varphi & 0 & Cos\varphi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Computer-Aided Design (CAD)

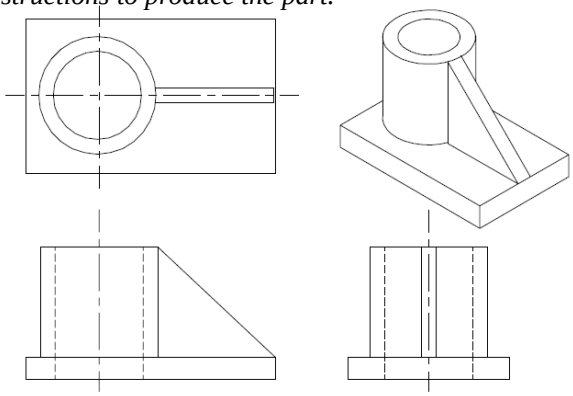
- *Geometric modeling :*
  - *Product development activity starts with the design of the product.*
  - *Manufacturing of machine parts and components is carried out with the help of drawings.*





Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *The machine operator is provided with the drawing of the finished part and an operation sheet which gives step by step instructions to produce the part.*
  - *Drawings are also required for*
    - *Process planning,*
    - *Tool design,*
    - *Production planning,*
    - *CNC programming,*
    - *Inspection,*
    - *Assembly,*
    - *Costing*

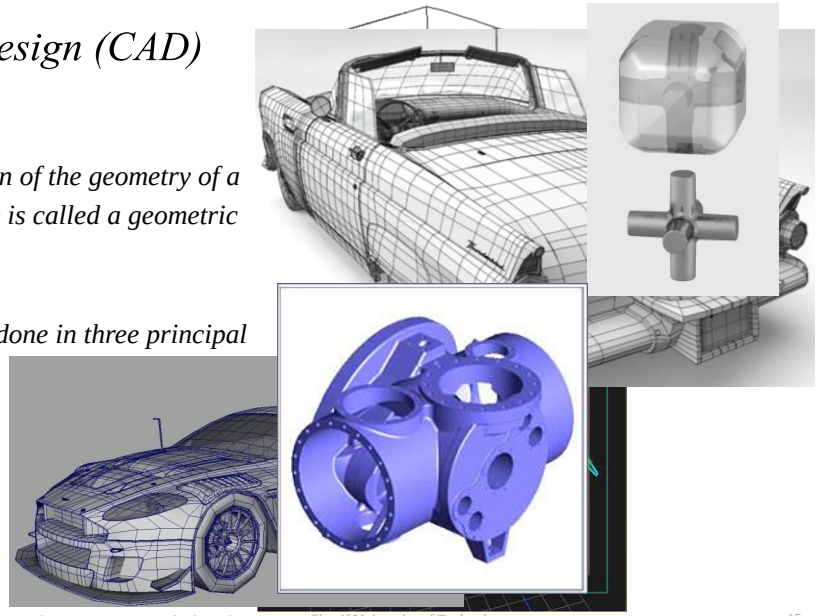


Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *In addition to production drawings of components, the design department has to create*
    - *Layout drawings,*
    - *Assembly drawings,*
    - *and tool drawings (Jigs, fixtures, templates, special tools, inspection fixtures).*
  - *In addition to component drawings, it is usually necessary to create hundreds of tool drawings and jig and fixture drawings for manufacture, assembly and inspection.*

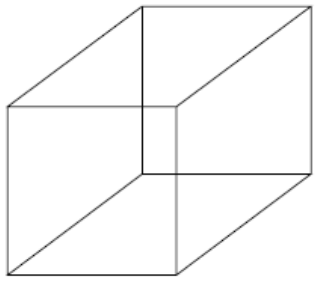
Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *Computer representation of the geometry of a component using software is called a geometric model.*
  - *Geometric modeling is done in three principal ways:*
    - *Wire frame modeling*
    - *Surface modeling*
    - *Solid modeling*



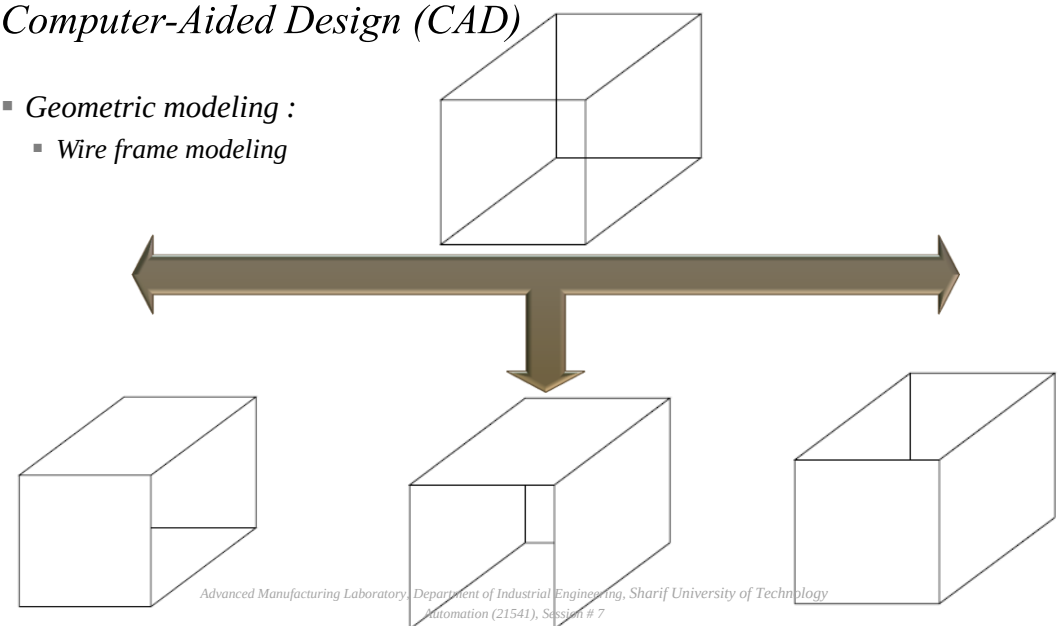
Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *Wire frame modeling*
    - *In wire frame modeling the object is represented by its edges.*
    - *In the initial stages of CAD, wire frame models were in 2-D. Subsequently 3-D wire frame modeling software was introduced.*



Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *Wire frame modeling*



Computer-Aided Design (CAD)

- *Geometric modeling :*
  - *Wire frame modeling*

2 - D Models	3-D Wire Frame Models
Ends (vertices) of lines are represented by their X and Y coordinates	Ends of lines are represented by their X, Y and Z coordinates.
Curved edges are represented by circles, ellipses, splines etc. Additional views and sectional views are necessary to represent a complex object with clarity.	Curved surfaces are represented by suitably spaced generators. Hidden line or hidden surface elimination is a must to interpret complex components correctly.
3-D image reconstruction is tedious.	2-D views as well as various pictorial views can be generated easily.
Uses only one global coordinate system	May require the use of several user coordinate systems to create features on different faces of the component.