IE 111
Computer Aided Engineering Drawing

Geometrical Construction-Drawing Simple Geometric Objects

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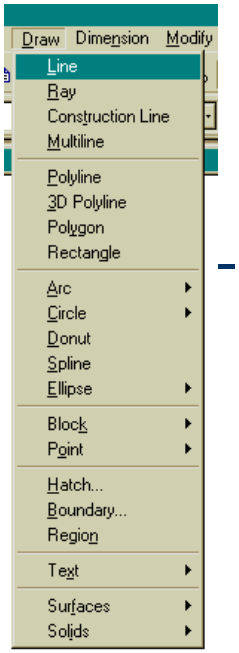
Basic Elements

- Very basic entities in sketching are
  - Line✓
  - Circle
  - Ellipse
  - Spline
- Any geometry can be constructed using these elements.
- To facilitate drawing we may also need
  - Polyline (related with line)
  - Rectangle (related with line)
  - Polygon (related with line)
  - Arc (related with circle)

Basic Elements - Polyline

- AutoCAD Command "Polyline"
  - A polyline is a connected sequence of line or arc segments created as a single object.
  - There are several ways to activate the polyline command in AutoCAD
    - Toolbar button
    - Selecting from menu bar
    - Simply writing the command in the command window.
  - When you select a Polyline, all segments react as one unit. This will help you when you edit your drawings.

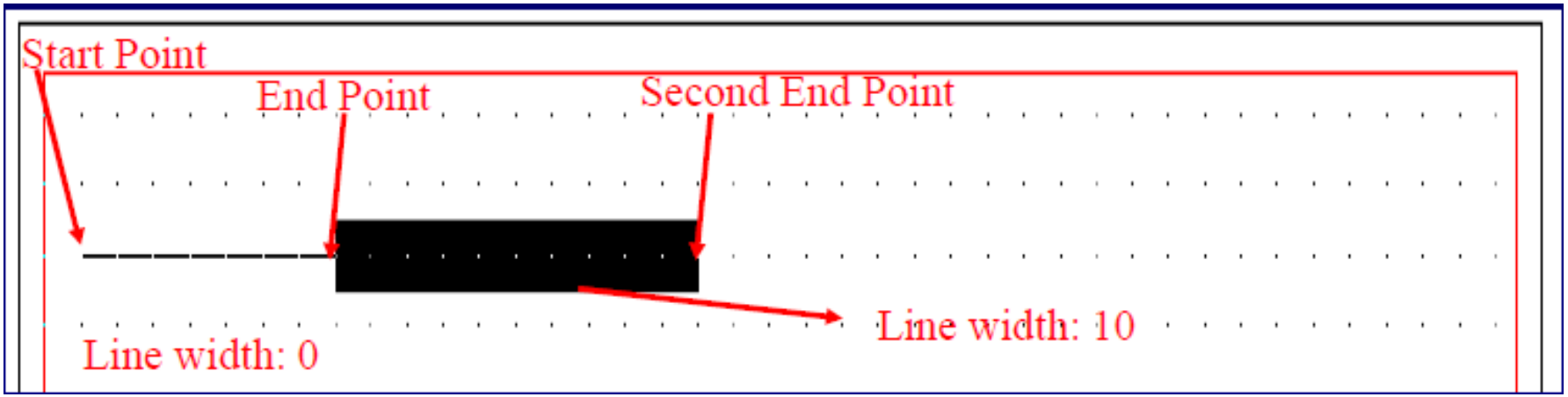
Polyline icon on the draw tool bar



Basic Elements - Polyline

- When you click the pline command you must specify the start point at first;
  - Specify start point:
- Then
  - Specify next point or [Arc/Close/Halfwidth/Length/Undo/Width]:
    - If you want to draw a line you must specify the next point
    - If you want to draw an arc write "A"
    - If you want to close the drawing write "C" (after drawing 2 segments)
    - The width option enables you to specify the width of the segment. When you write "W" you will be asked to input starting and end width.
    - The segment can start at one width and end another.
    - The default value will be shown in brackets.
    - The starting width will be the value when the last time Pline command was used.

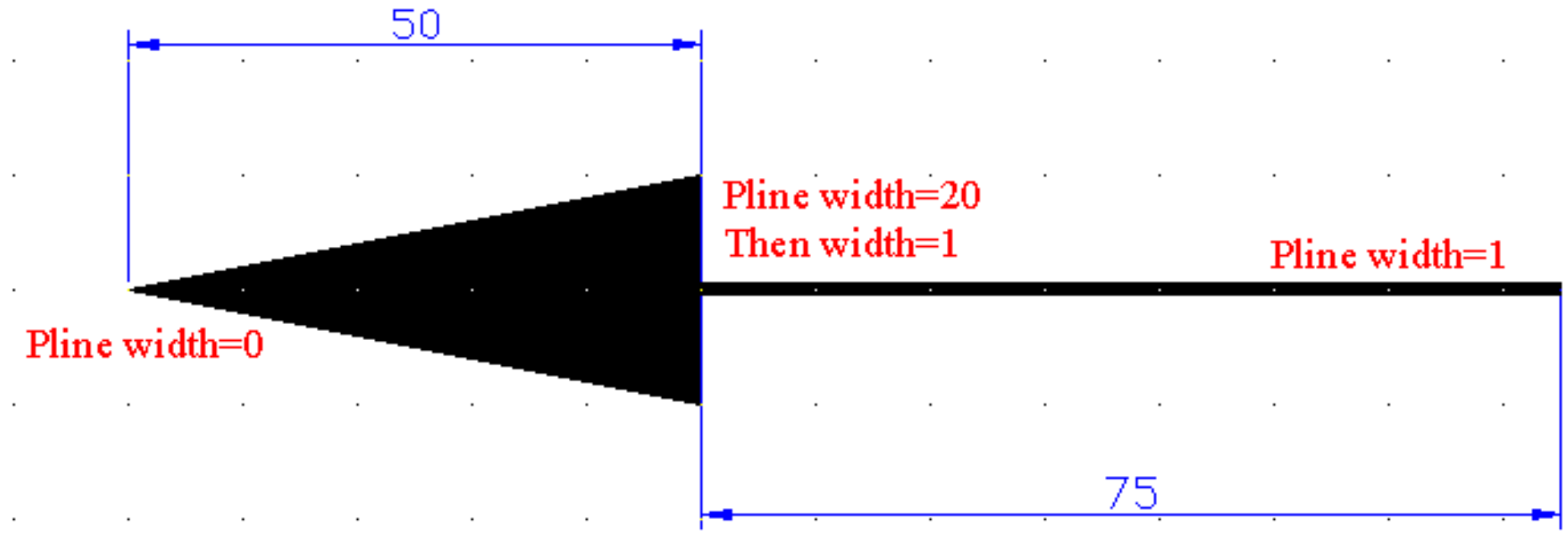
Basic Elements - Polyline



Basic Elements - Polyline

- The "Halfwidth" option works just like the Width option.
  - The only difference is that instead of writing the full width of the polyline, you write half of the width.
- Choosing the "Arc" option provides an arc, we will discuss it later.
- Use the "Length" option to input a distance rather than a set of coordinates for the next point of the polyline.
  - The new line will be drawn at the same angle as previous polyline.

Basic Elements - Polyline

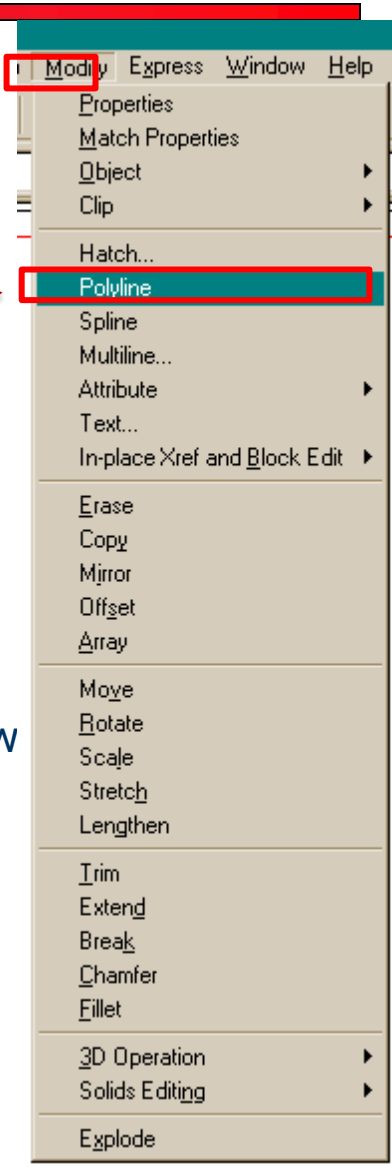


Basic Elements – Polyline/Editing

Modify 2 Toolbar

Edit Polyline

- It is used to edit the polylines.
- When you click PEDIT icon, you will be asked to select a polyline (You can also select the PEDIT command from modify pull-down menu). After selecting polyline the command line displays sub options;
  - Enter an option Close/Join/Width/Editvertex/Fit/Spline/ Decurve/Ltypegen/Undo]:
- The different sub option perform following tasks:
  - "Close": If the polyline is open, this option will draw a polyline from the first point drawn to the last point.

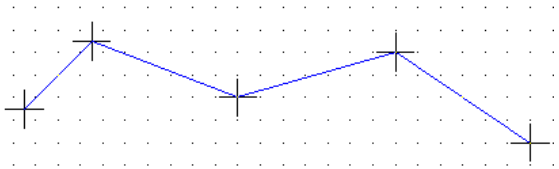


Basic Elements – Polyline/Editing

- "Join": It is used to join polylines and lines together so that they act together.
- "Width": Used to edit the polyline's width. You can type the desired value.
- "Edit Vertex": Used to relocation of the polyline end point.

Basic Elements – Polyline/Editing

- "Fit": It is used to change a polyline from a straight line into a curved line passing through the points.
- "Spline": A spline is simply a line chart that plots a fitted curve through each data point in a series.
- "Decurve": Removes the curves on polylines that were constructed with the Fit or Spline sub option.

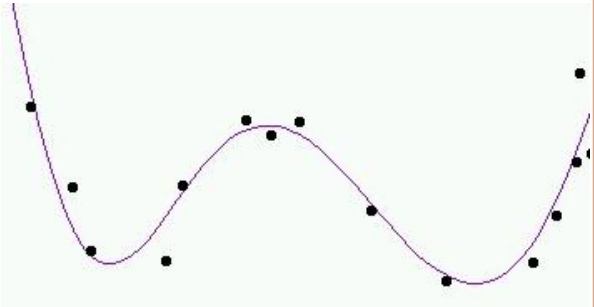


Polyline

Bezier

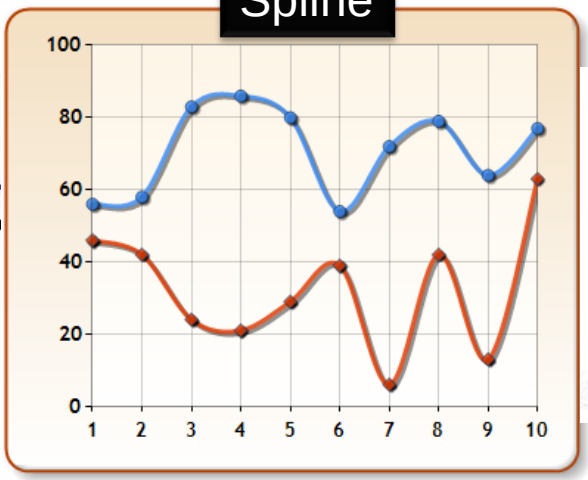
Mathematics

Fit

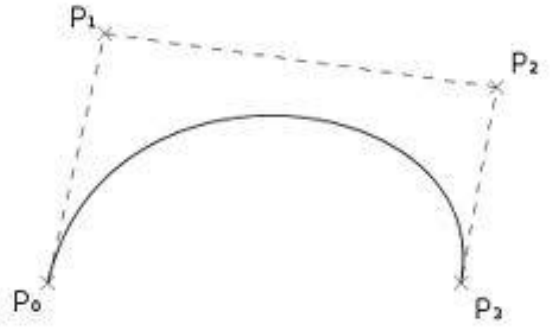


AutoCAD-Polyline

Spline

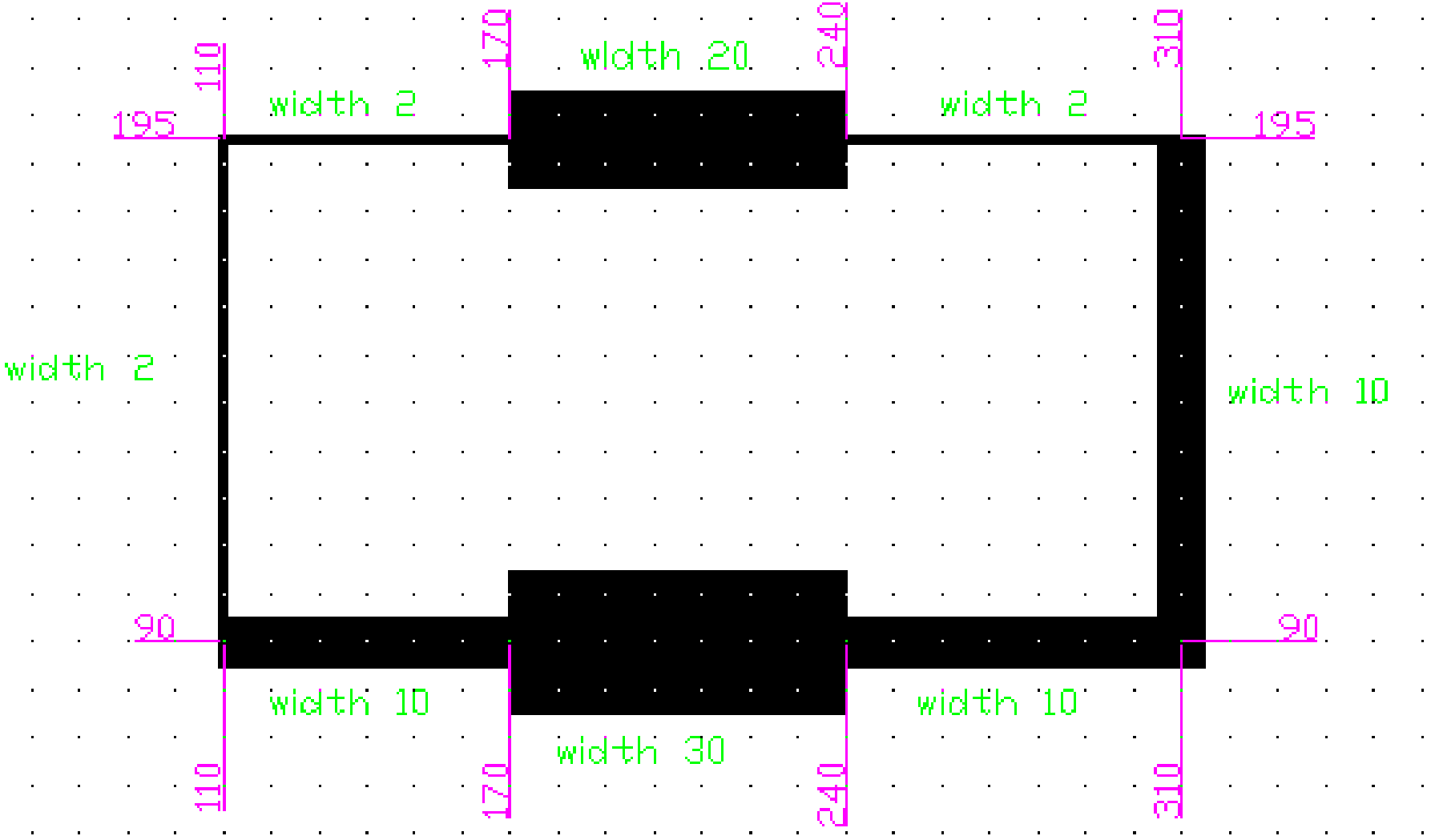


Fit Points

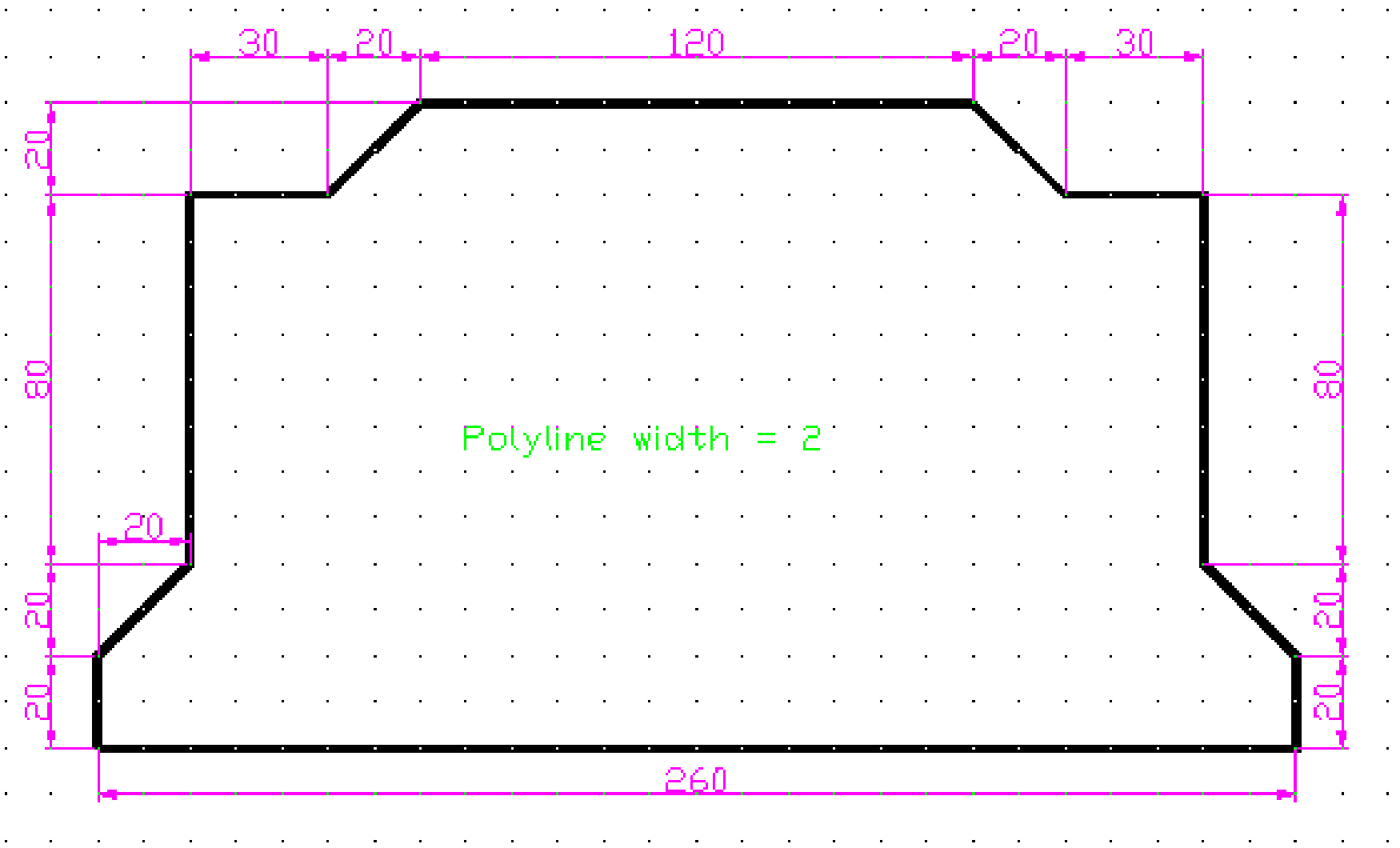


Spline – Control Vertices

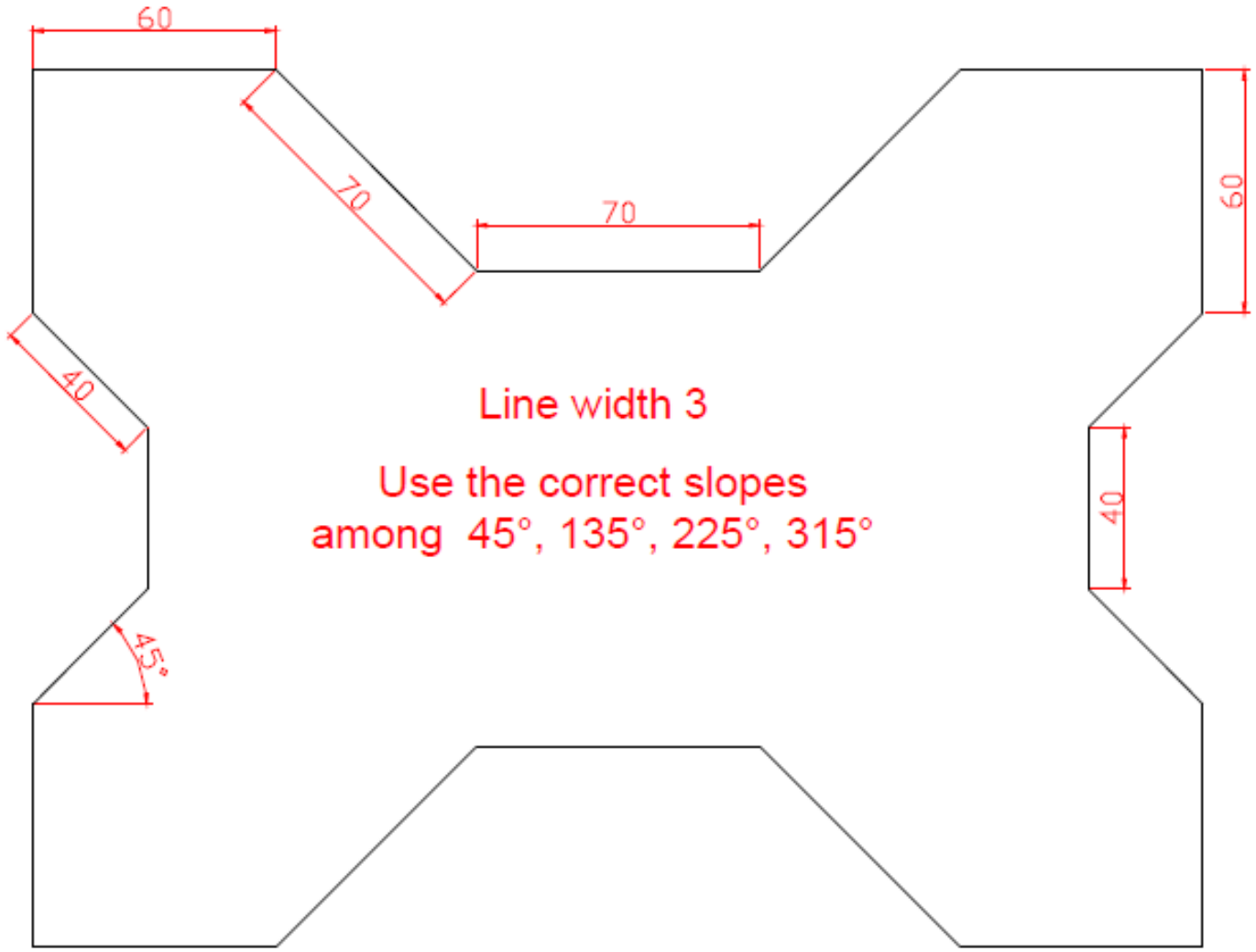
Polyline Example 1.dwg



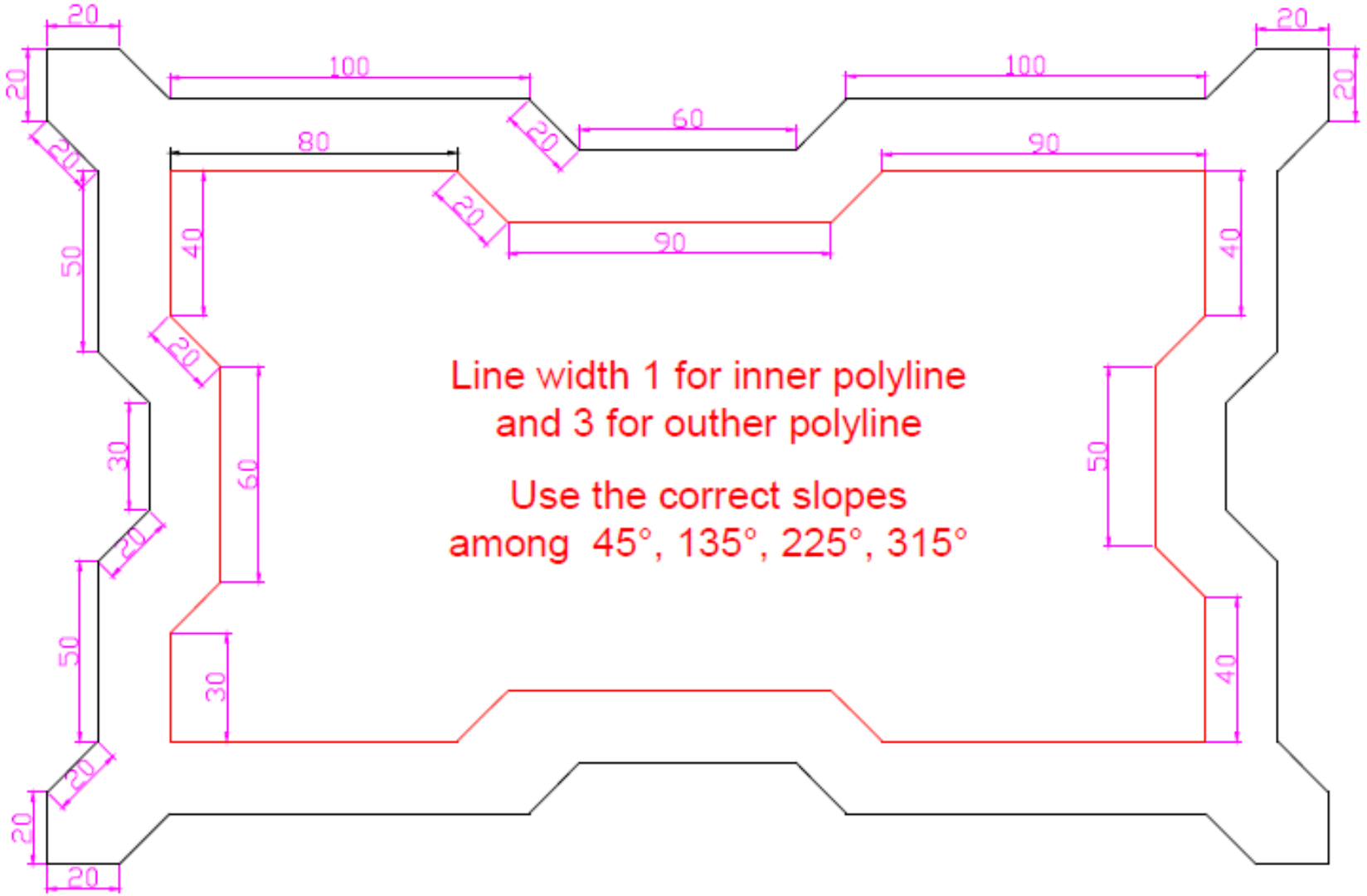
Polyline Example 2.dwg



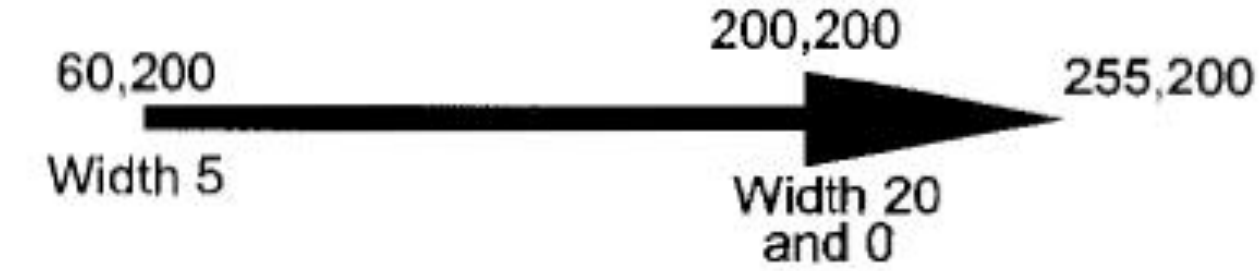
Polyline Exercise 3_1.dwg

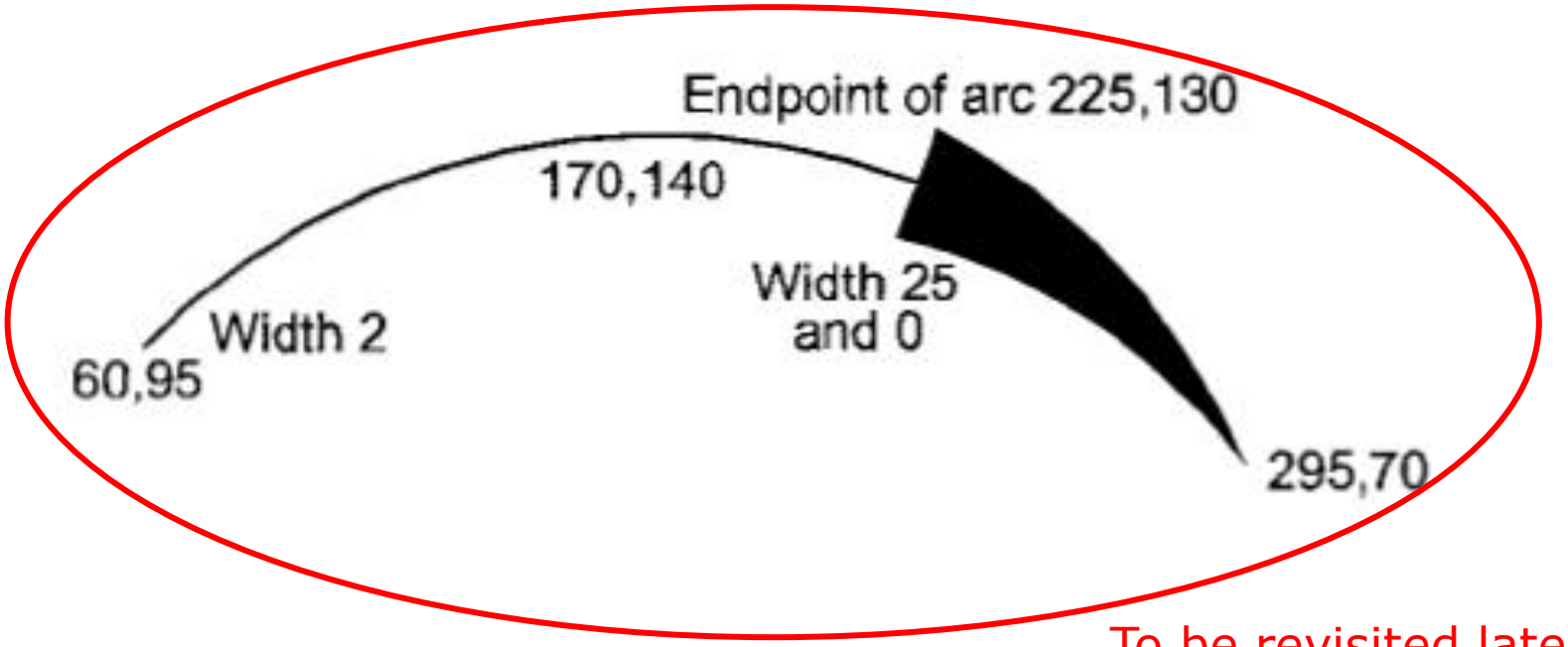


Polyline Exercise 3_2.dwg



Basic Elements – Polyline/Examples



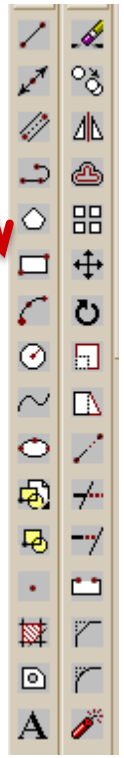


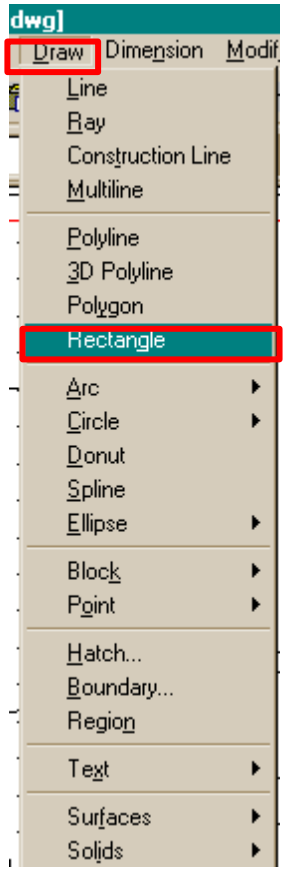
To be revisited later

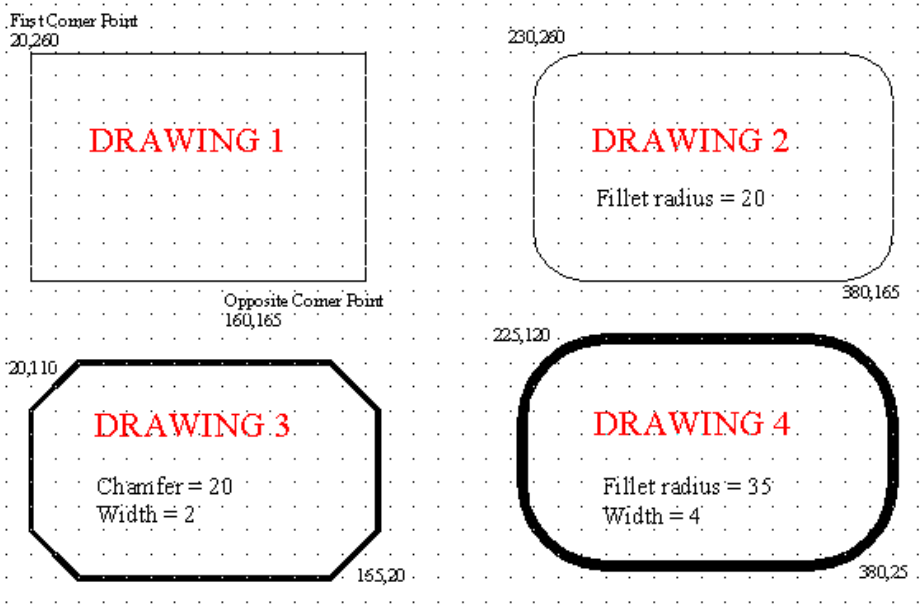
Basic Elements – Rectangle

- Select the Rectangle Command.
- Define first corner point of rectangle, and other corner point of rectangle.
- Rectangles can be drawn with
  - Various line widths,
  - *Chamfered* corners
  - *Filleted* corners.

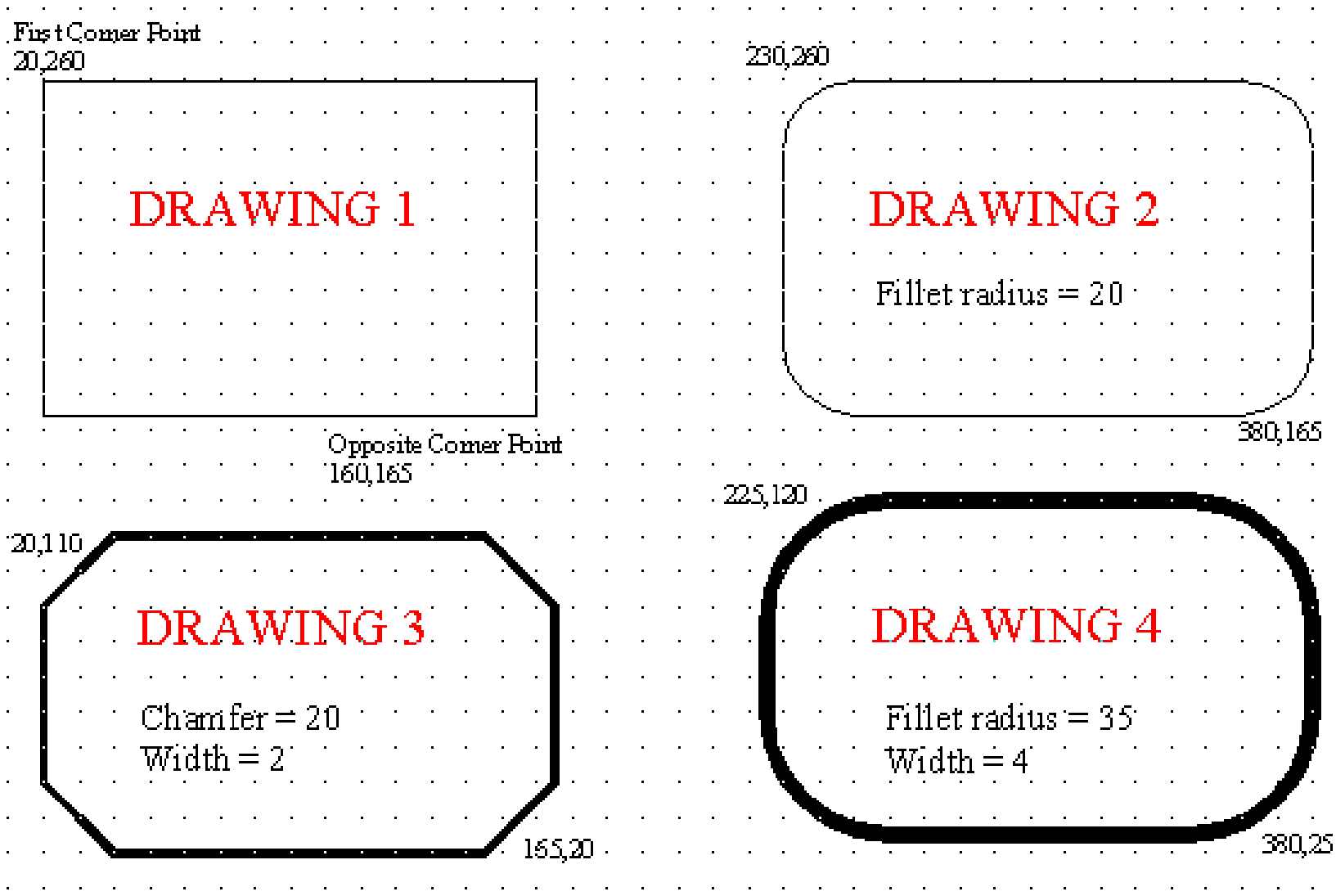
Rectangle icon



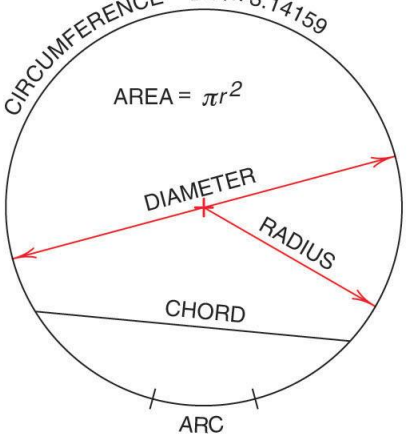




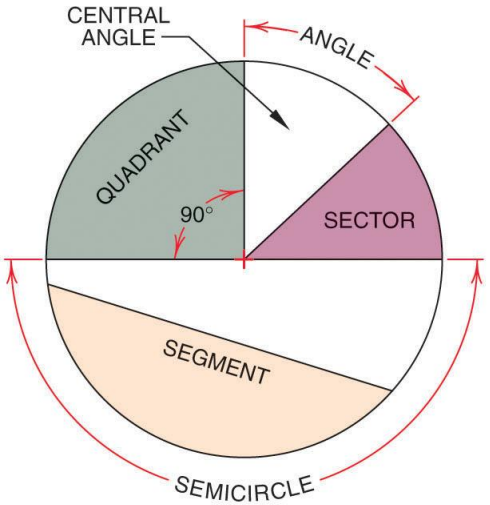
Basic Elements – Rectangle/Examples



Basic Elements – Circle



(A)



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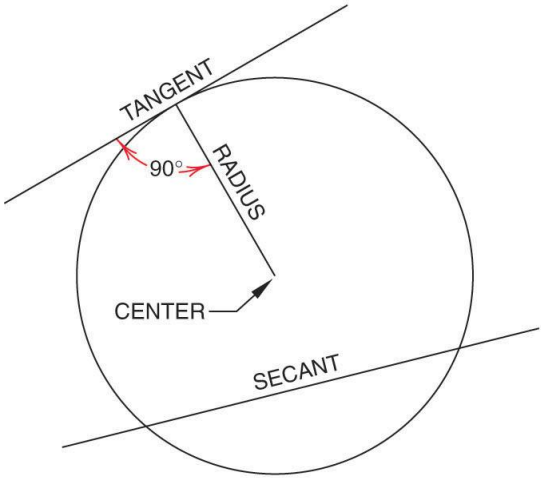

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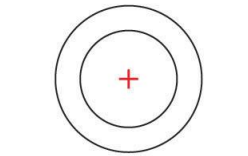
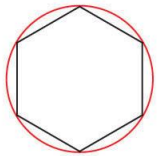
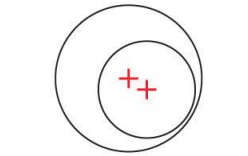


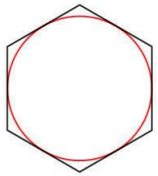
CONCENTRIC CIRCLES



CIRCUMSCRIBED CIRCLE



ECCENTRIC CIRCLES



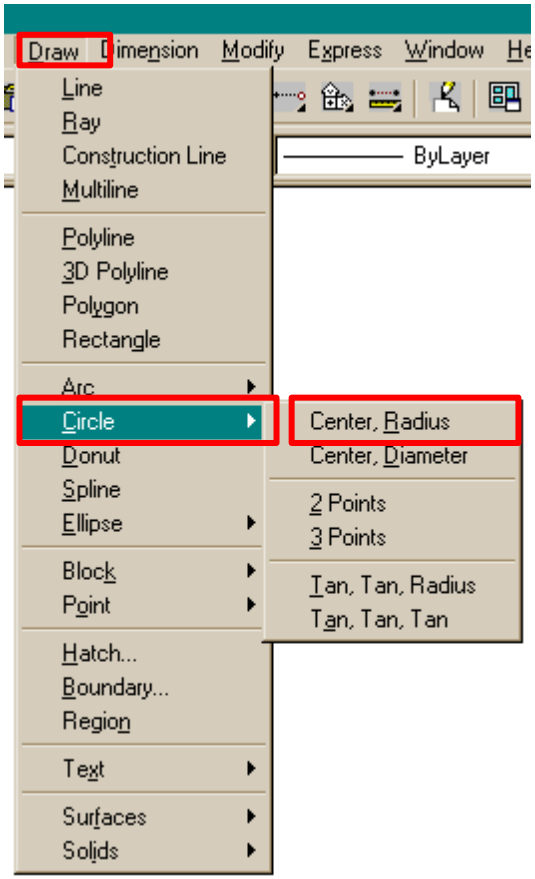
INSCRIBED CIRCLE

(D) (E)

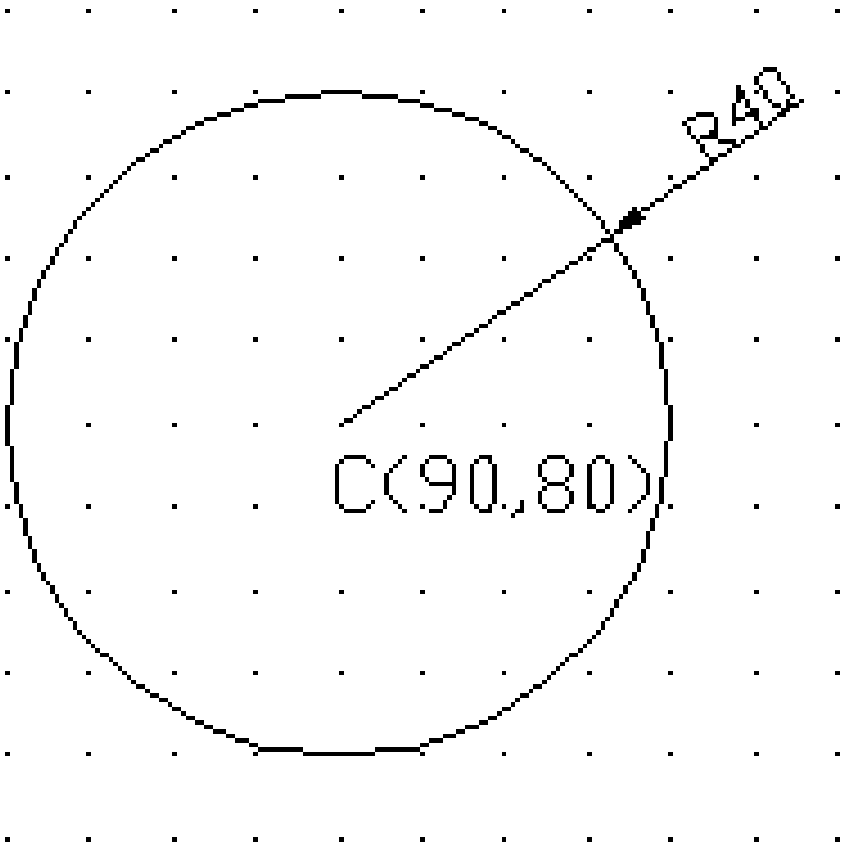
Basic Elements – Circle

Circle icon

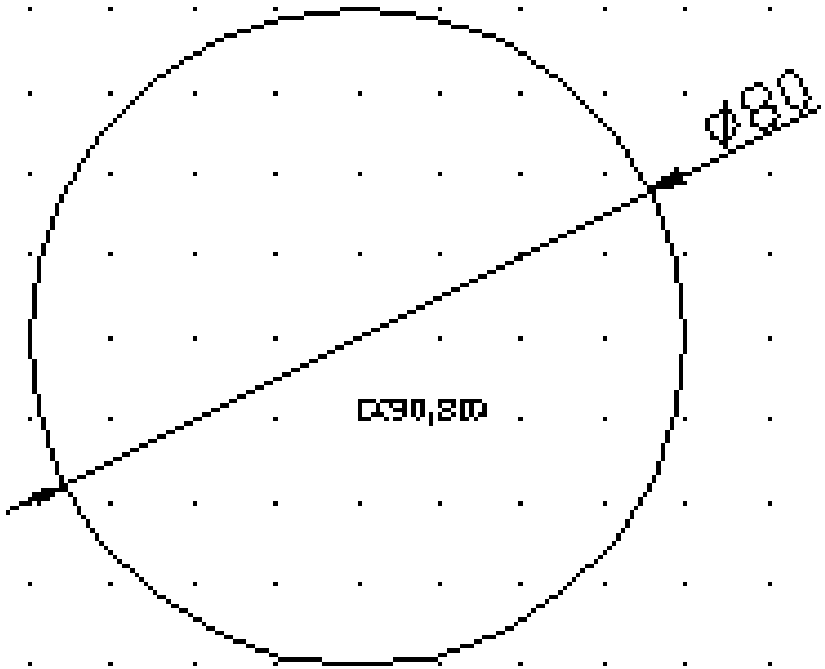
- AutoCAD provides six option for drawing circles
  - Center point, radius (i.e. the default option)
  - Center, diameter
  - 2 point
  - 3 point
  - Tan, Tan, Radius
  - Tan, Tan, Tan
- The decision on which one is the best for your application will depend on the information you know about the circle.



Basic Elements – Circle

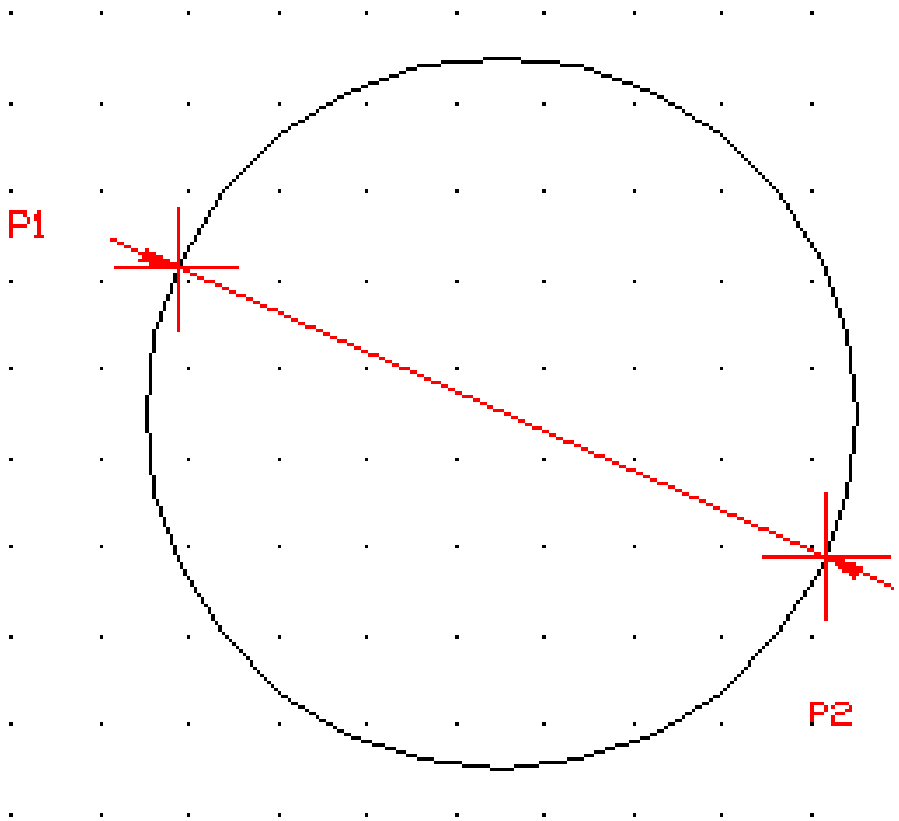


Center, Radius

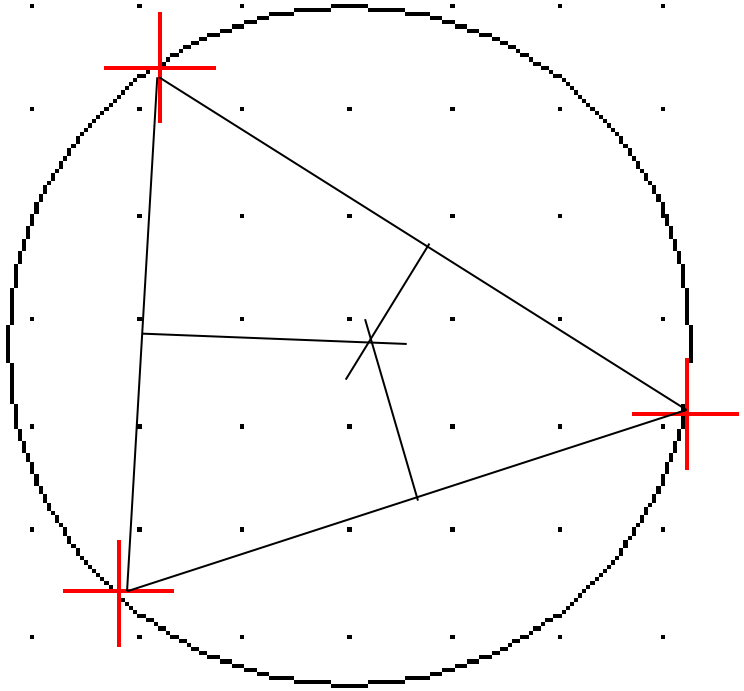


Center, Diameter

Basic Elements – Circle

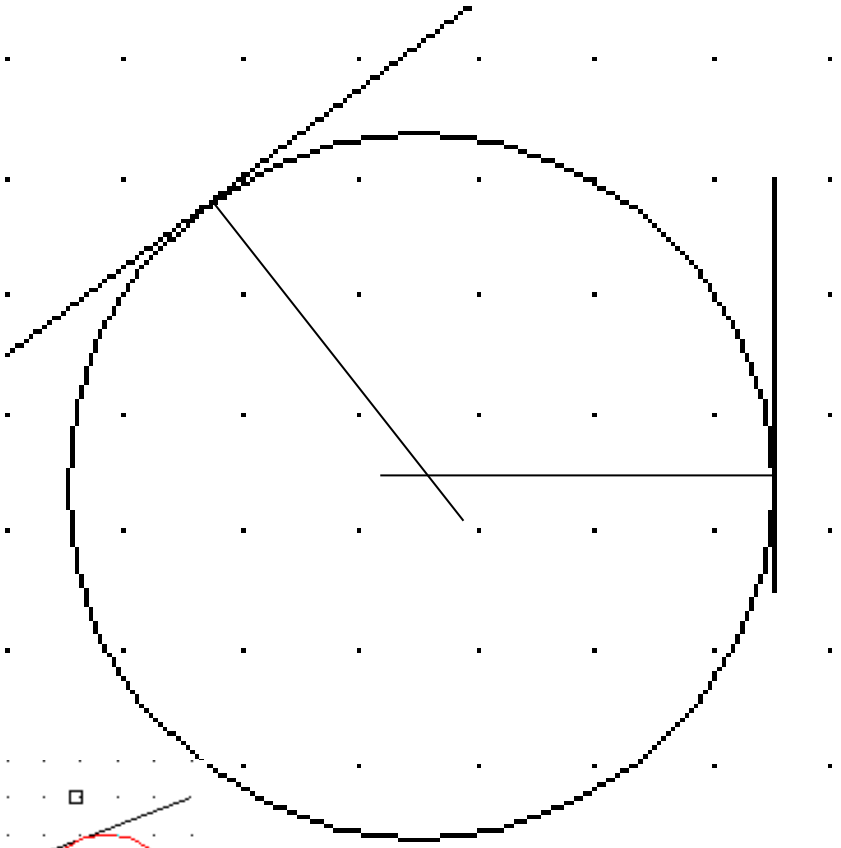


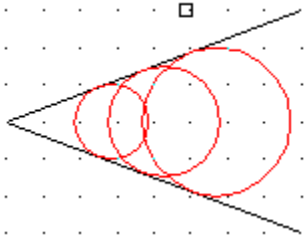
2 Point



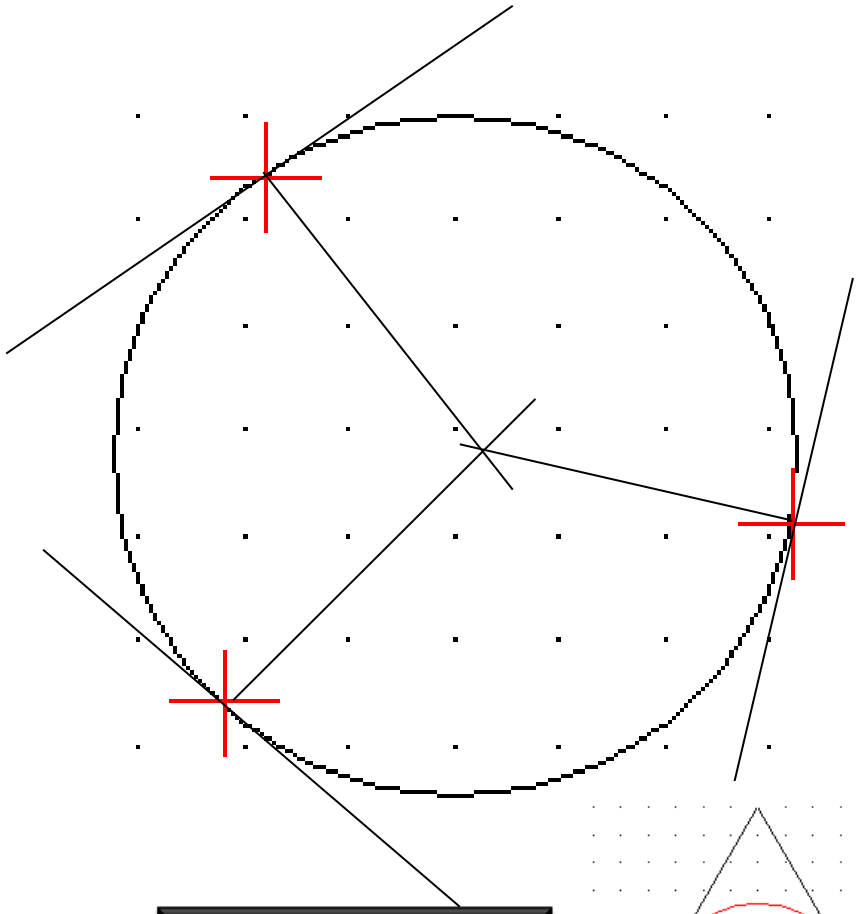
3 Point

Basic Elements – Circle

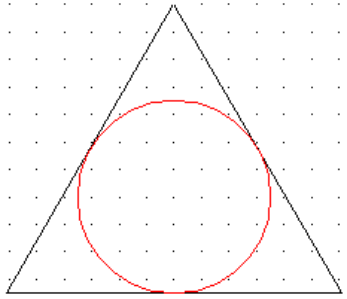




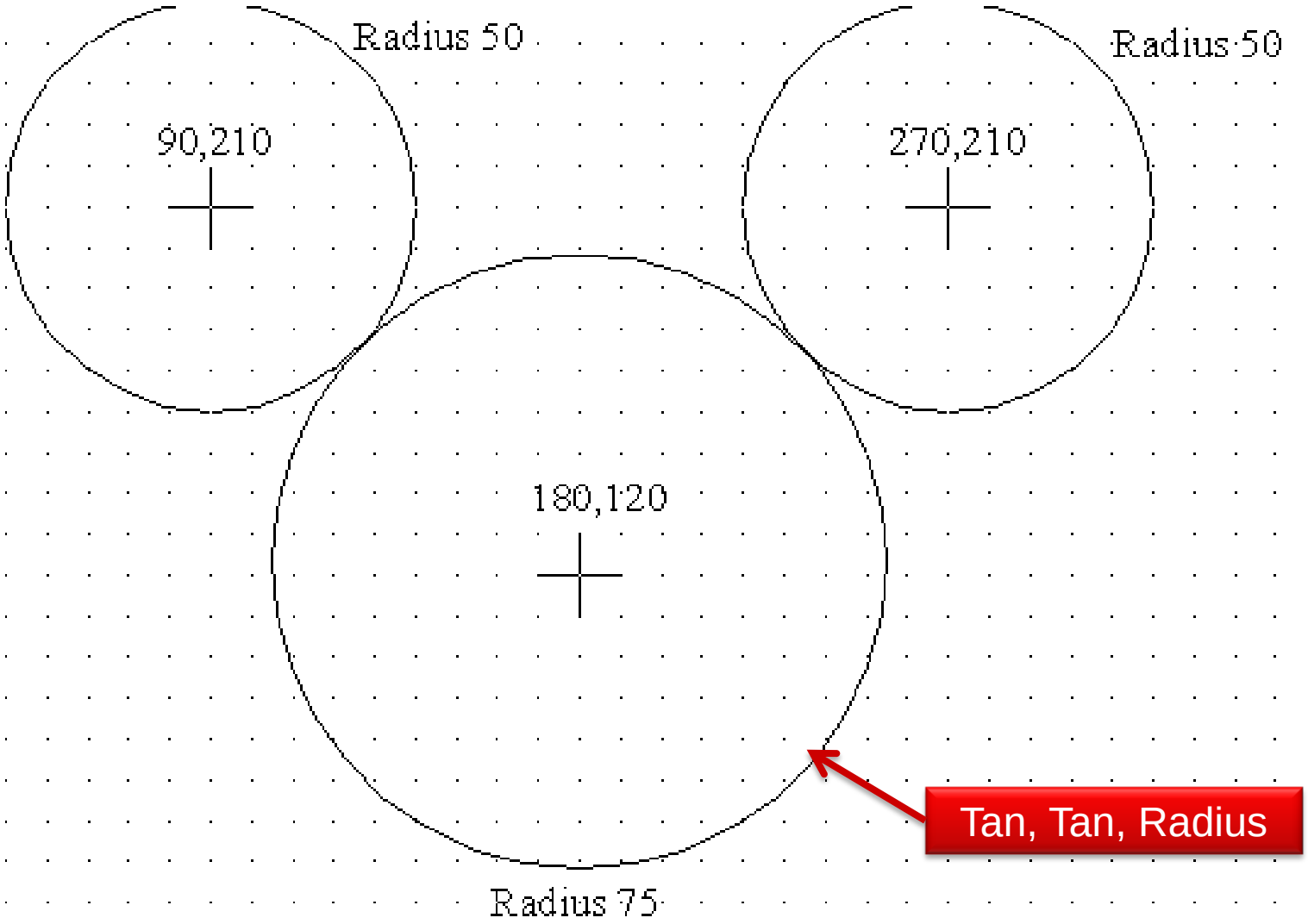
Tan, tan, radius



Tan, tan, tan

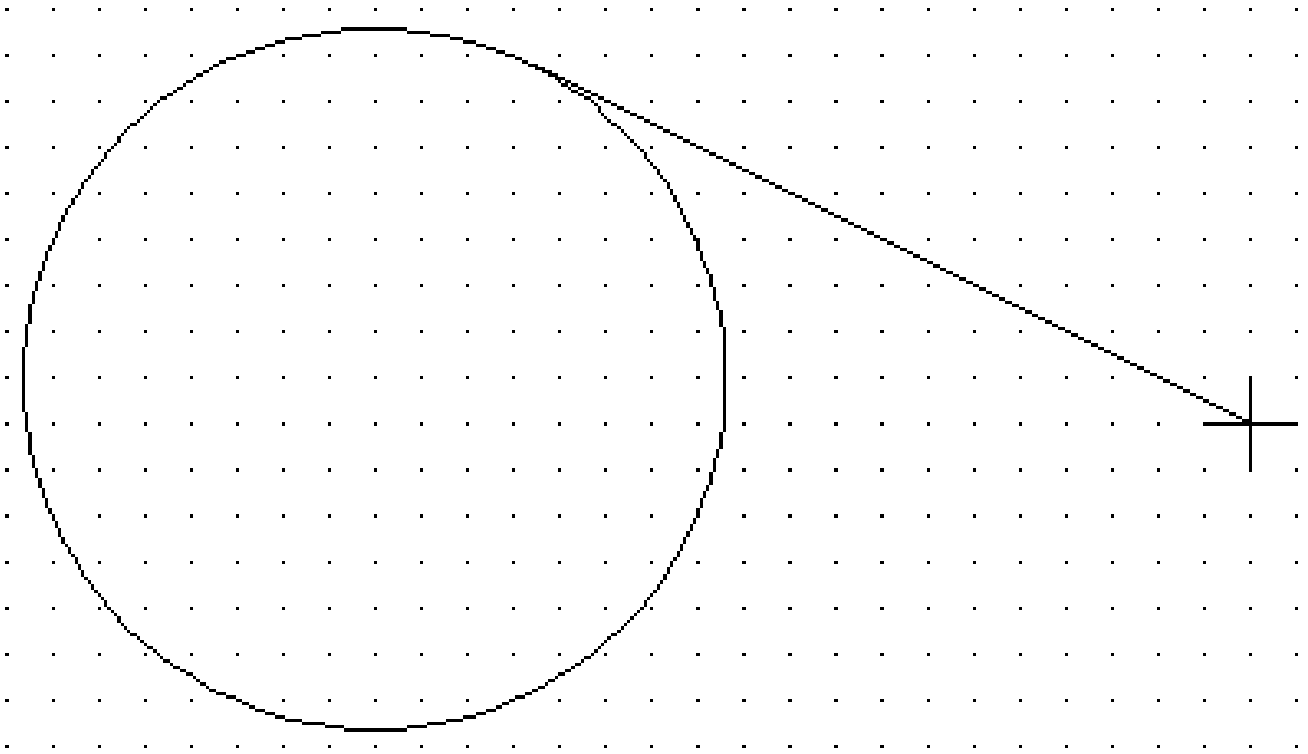


Basic Elements – Circle/Examples



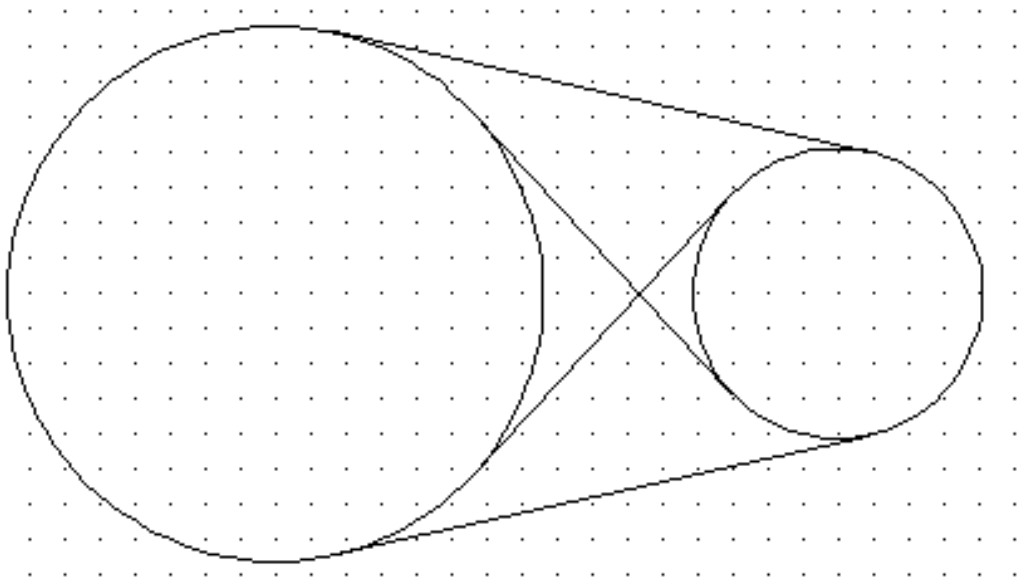
Drawing Tangent from a Point to a Circle

- Command: 'Line'
- While holding 'Shift', right click and then select 'tangent' in the menu
  (or just right click, first select 'snap overrides' and then 'tangent' in the menu)
- Click a point on the circle and then the point.



Drawing Tangent from a Circle to a Circle

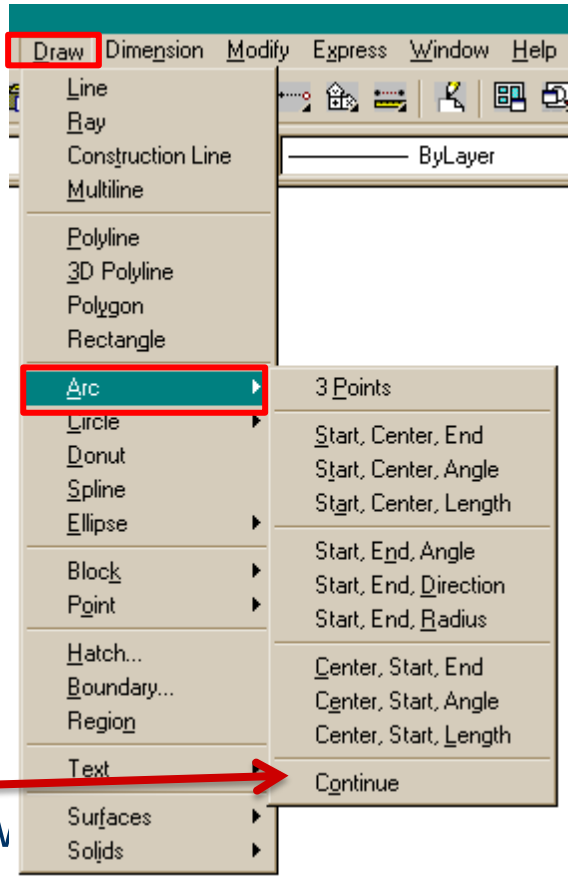
- Command: 'Line'
- While holding 'Shift', right click and then select 'tangent' in the menu
  (or just right click, first select 'snap overrides' and then 'tangent' in the menu)
- Click a point on the circle 1
- While holding 'Shift', right click and then select 'tangent' in the menu again
  (or just right click, first select 'snap overrides' and then 'tangent' in the menu)
- Click a point on the circle 2



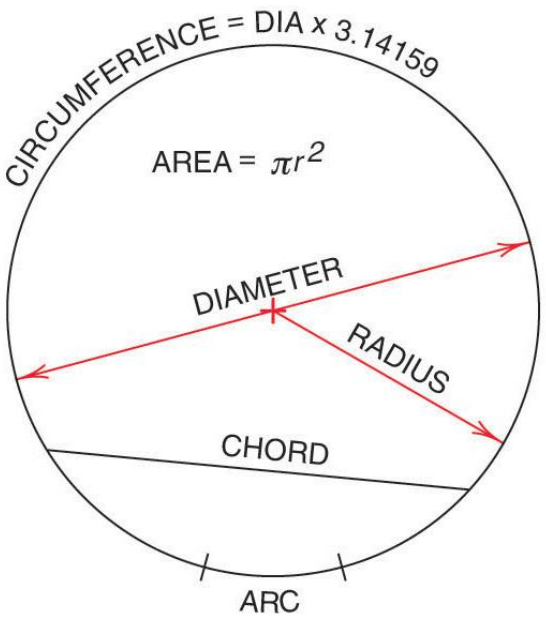
Basic Elements – Arc

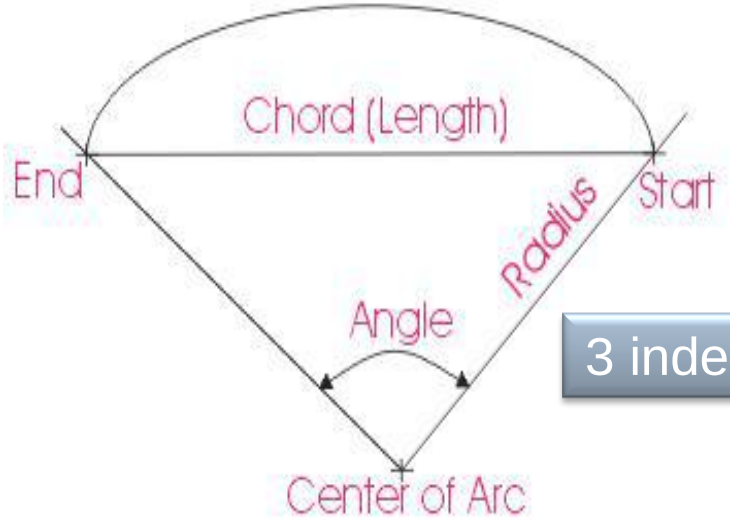
- To create arcs, you can specify various combinations of
  - Center
  - End point
  - Start point
  - Radius
  - Angle
  - Length
  - Direction
- The 3 Point option is the default if you access the command through the arc icon.
- If you do not change the setup, arcs are usually created in a counterclockwise direction.
- The Continue option is used to attach a new arc to the last arc or line drawn.

Arc icon



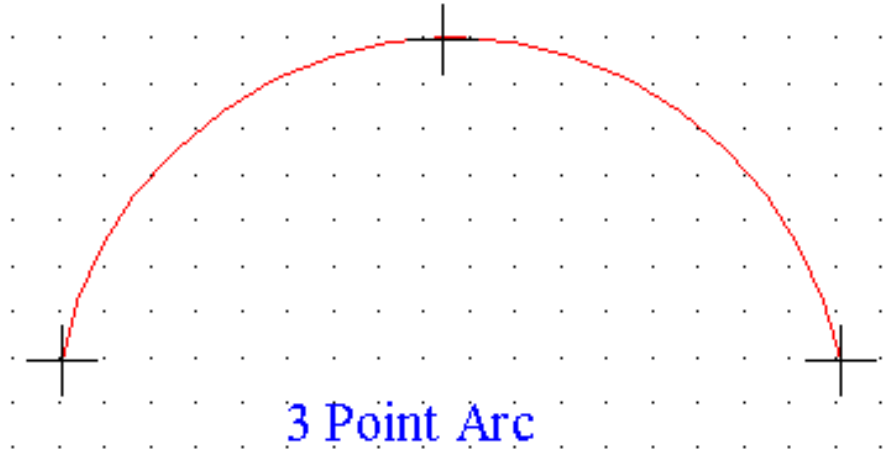
Basic Elements – Arc

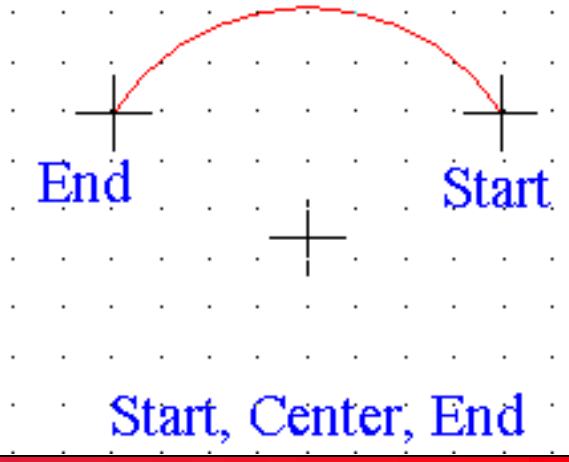




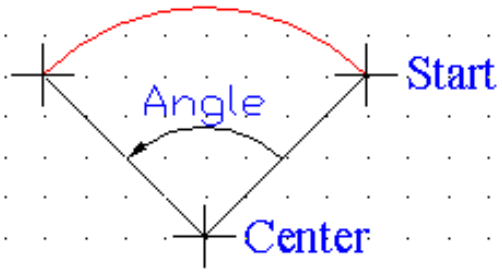
Components of an arc

3 independant parameter

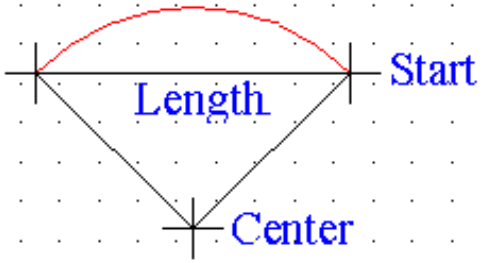




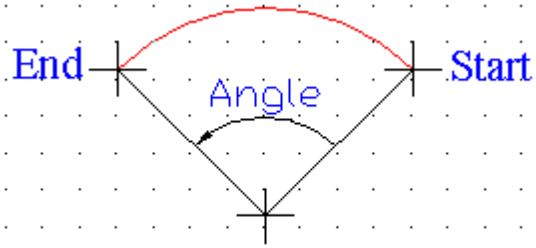
Basic Elements – Arc



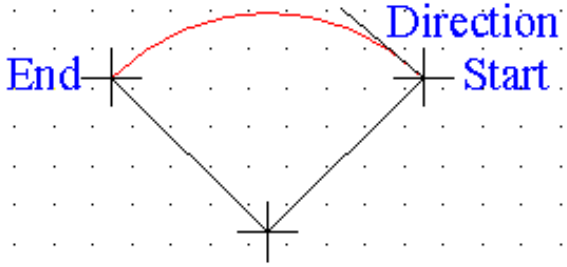
Start, Center, Angle



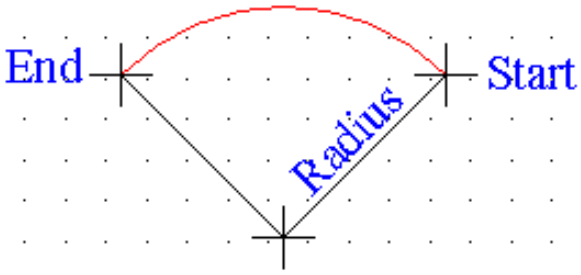
Start, Center, Length



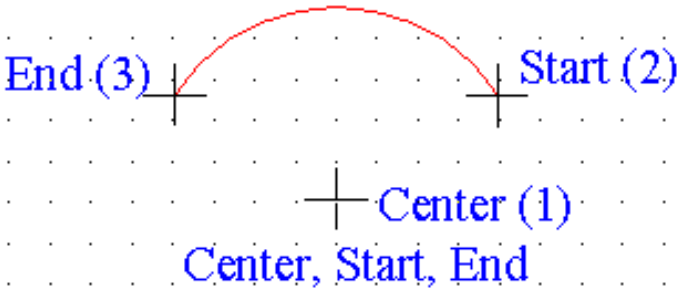
Start, End, Angle



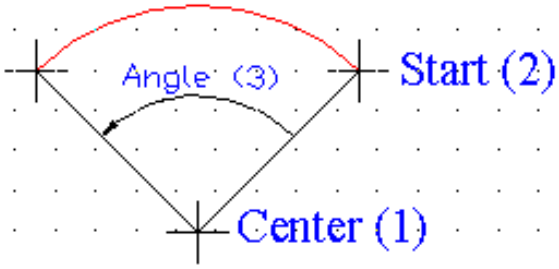
Start, End, Direction



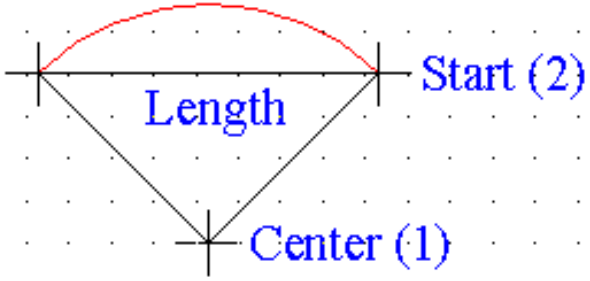
Start, End, Radius



Center, Start, End

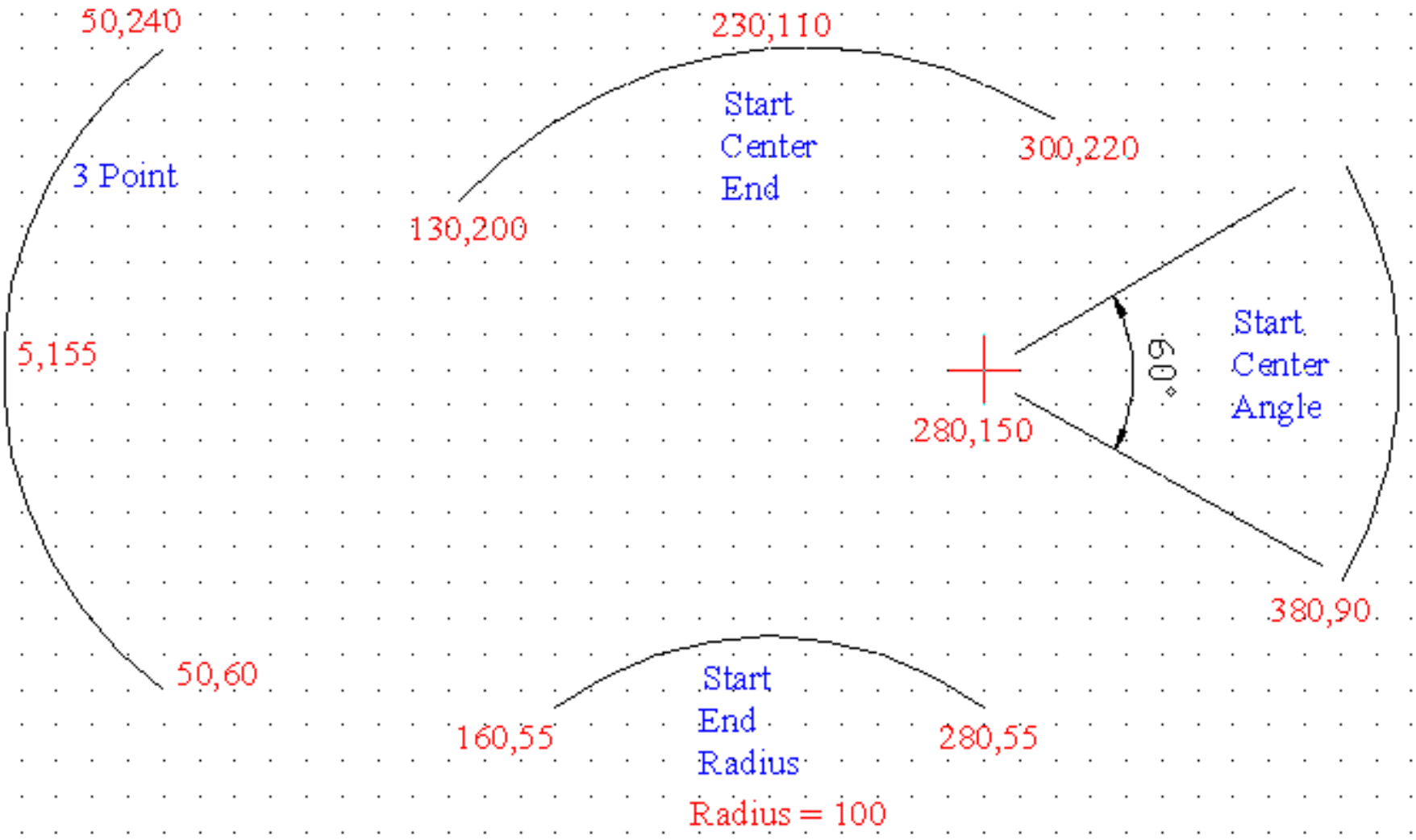


Center, Start, Angle



Center, Start, Length

Basic Elements – Arc/Examples

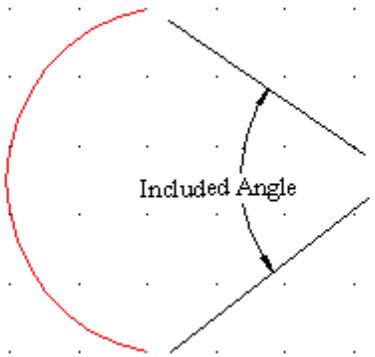


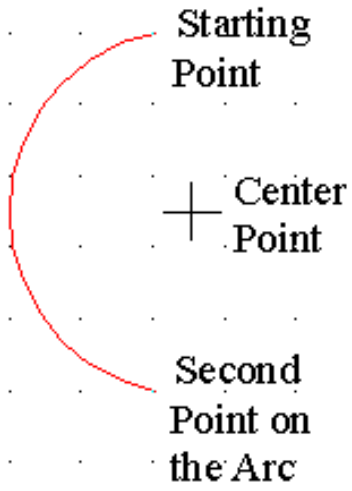
Basic Elements – Drawing Arc with Polyline

- The polyline tool can also be used to construct arcs.
- It is especially useful when the arc will be connected with the lines.
- If you wish to draw an arc write A on the command line.
- When you choose pline following prompts will display in the command line;
  - Command: _pline
  - Specify start point:
  - Current line-width is 1.0000
  - Specify next point or Arc/Close/Halfwidth/Length/Undo/Width]: A
  - Specify endpoint of arc or
  - [Angle/CEnter/CLose/Direction/Halfwidth/Line/Radius/Second pt/Undo/Width]:
- The Close, Halfwidth, Undo, and Width are the same options you encountered in the line command.

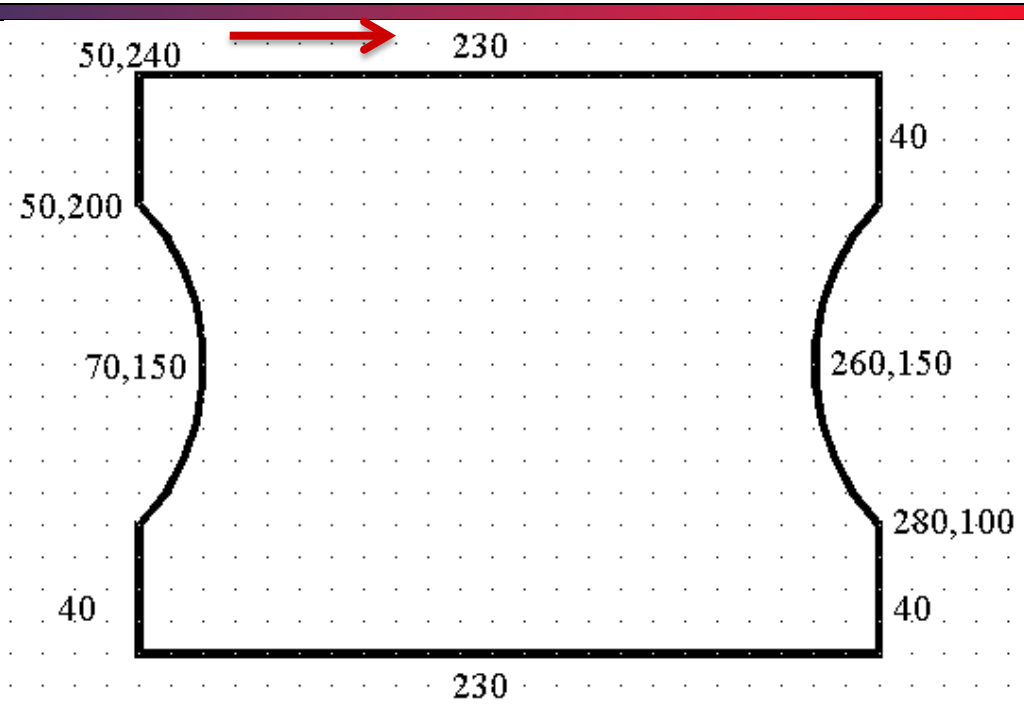
Basic Elements – Drawing Arc with Polyline

- Angle Option lets the user specify the included angle that forms the arc. You must specify an included angle and then an endpoint.
- Center Option will request the center and the end point of the arc.
- Radius Option requires the radius and the endpoint of the arc.
- Second Point Option allow the user to simply pick the point where the arc will end. You must enter a second point of the arc and then endpoint.



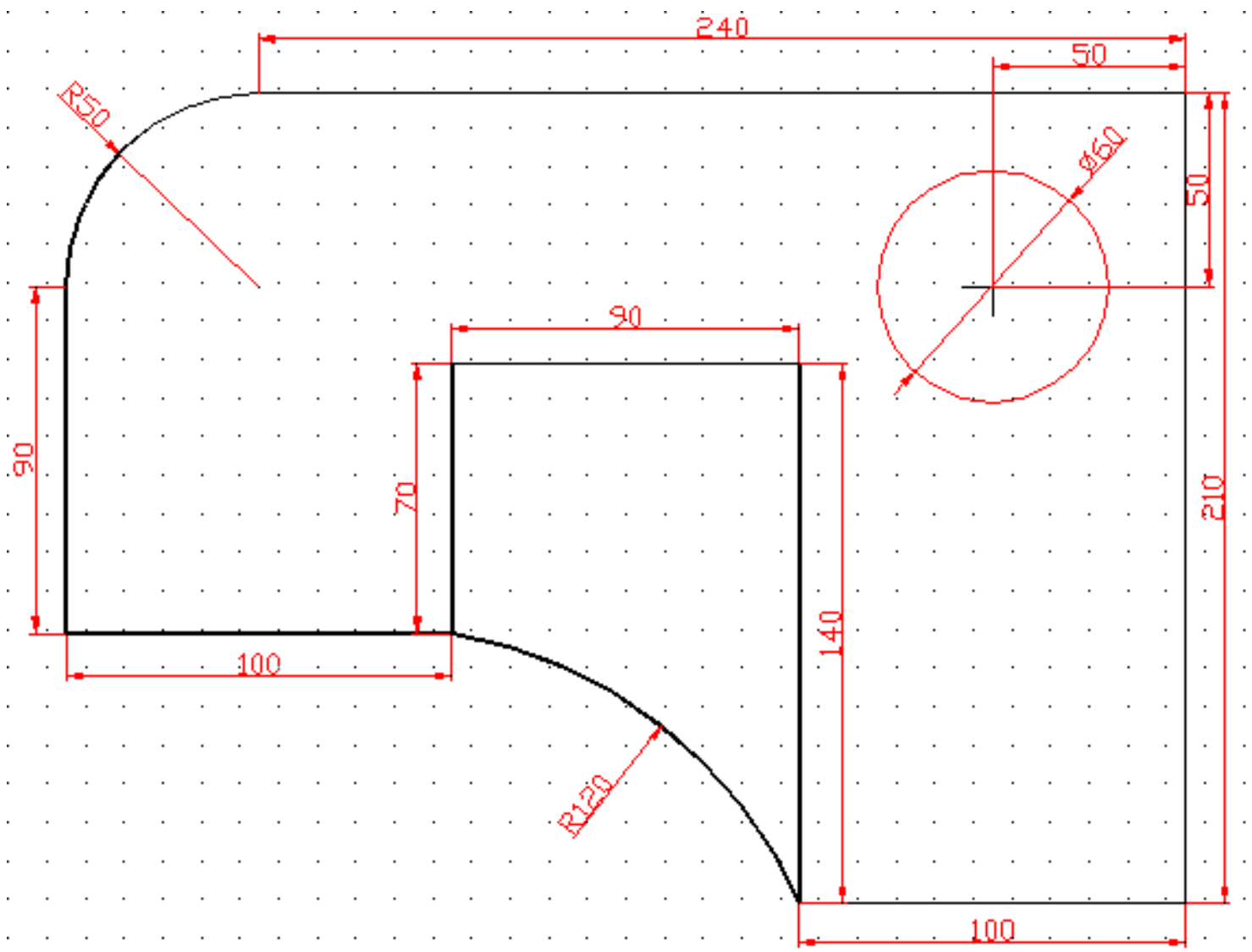


Basic Elements – Drawing Arc with Polyline

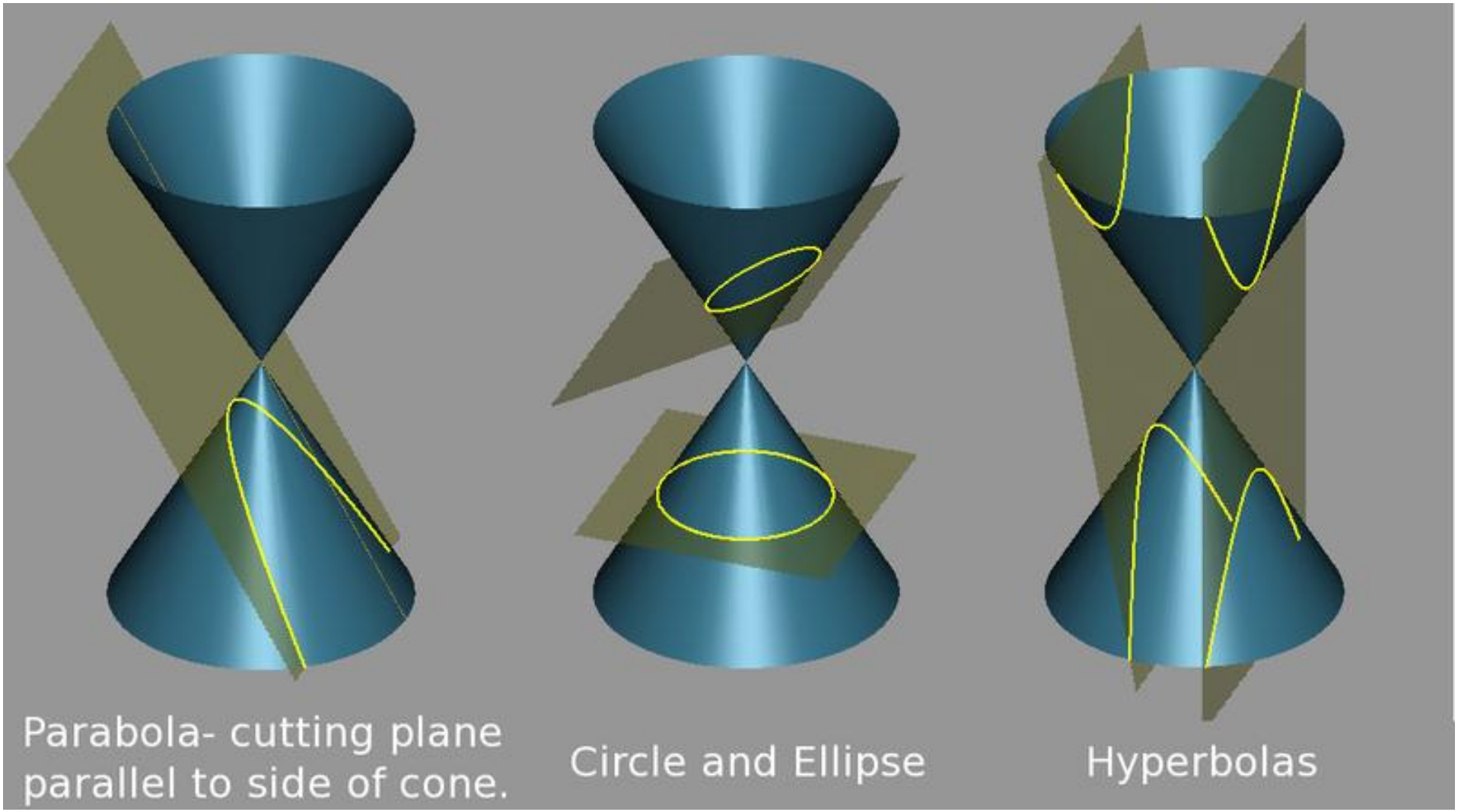


- Draw the shape with Polyline Command (File Name: Arc with Polyline) ;
  - Rules;
    - Start from 50,240 point.
    - Select line width 2mm both starting and ending points.
    - Use relative rectangular coordinate system.
    - Choose appropriate option to draw arc with polyline command.

Polyline Exercise 3.dwg

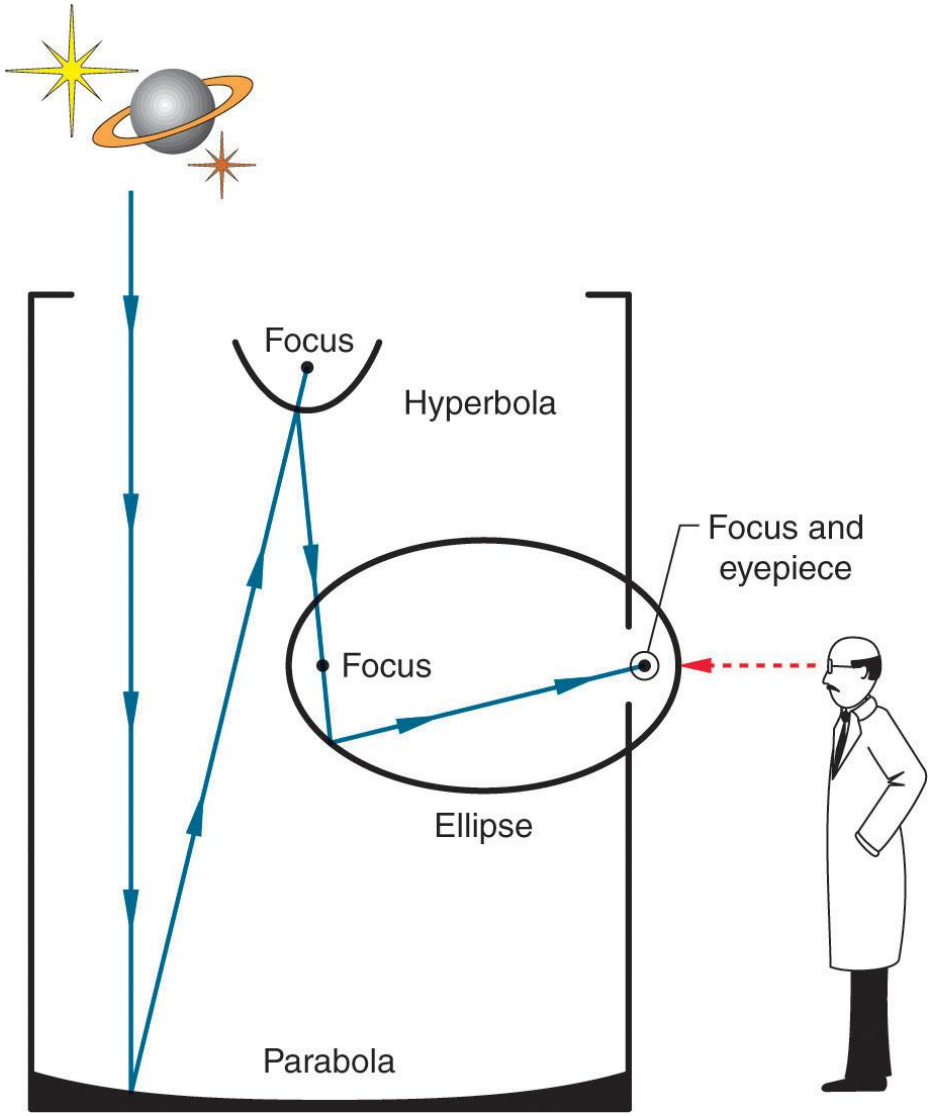


Basic Elements – Conic Curves



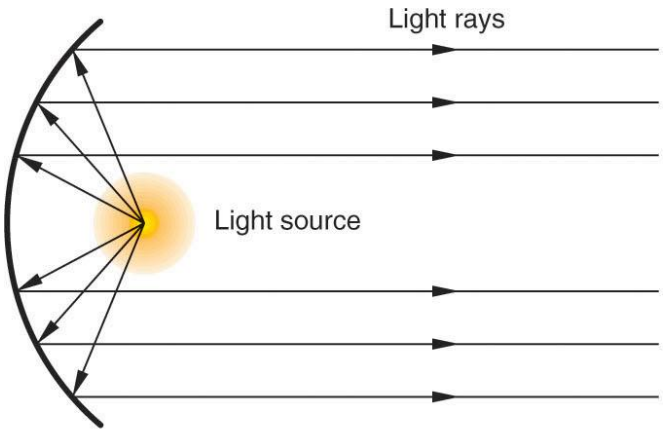
Basic Elements – Conic Curves

Telescope

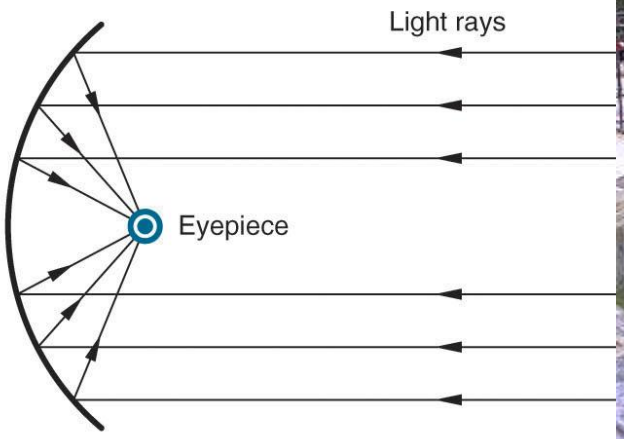


Basic Elements – Conic Curves

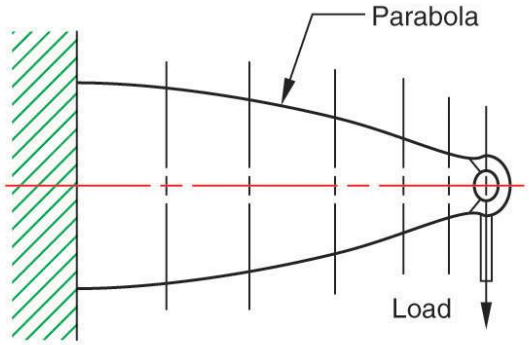
Parabola



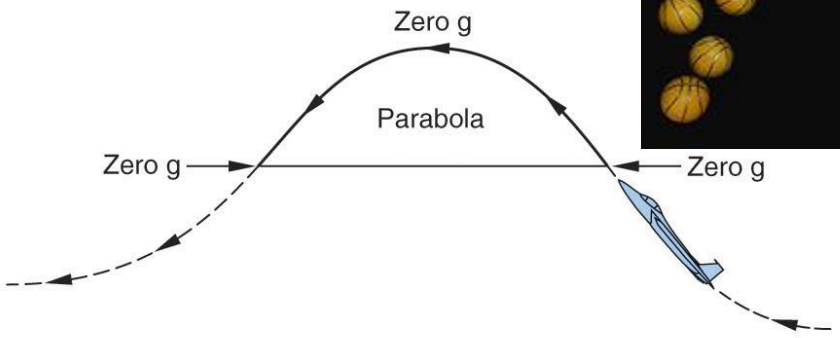
Searchlight mirror



Telescope mirror



Beam of uniform strength



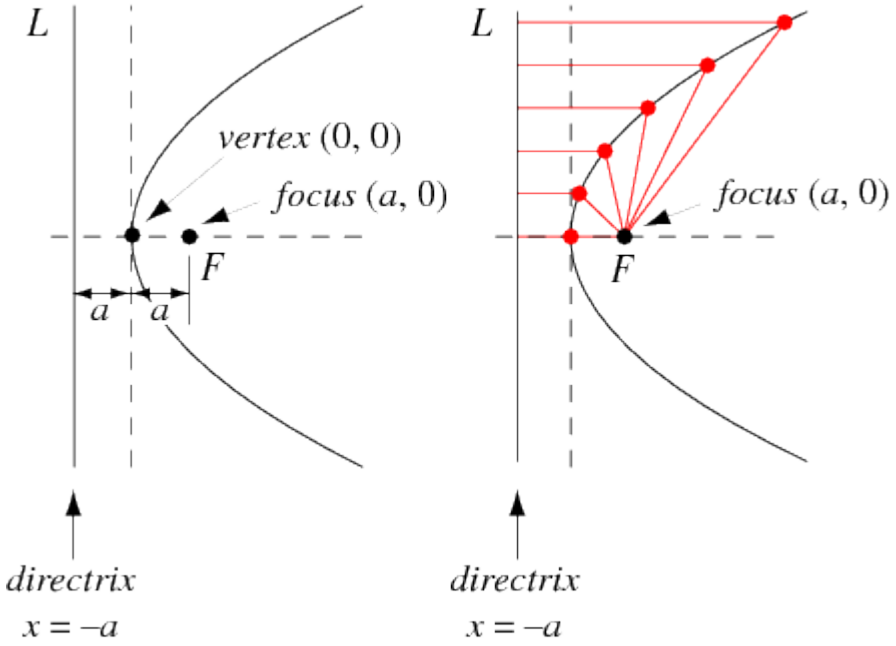
Weightless flight trajectory

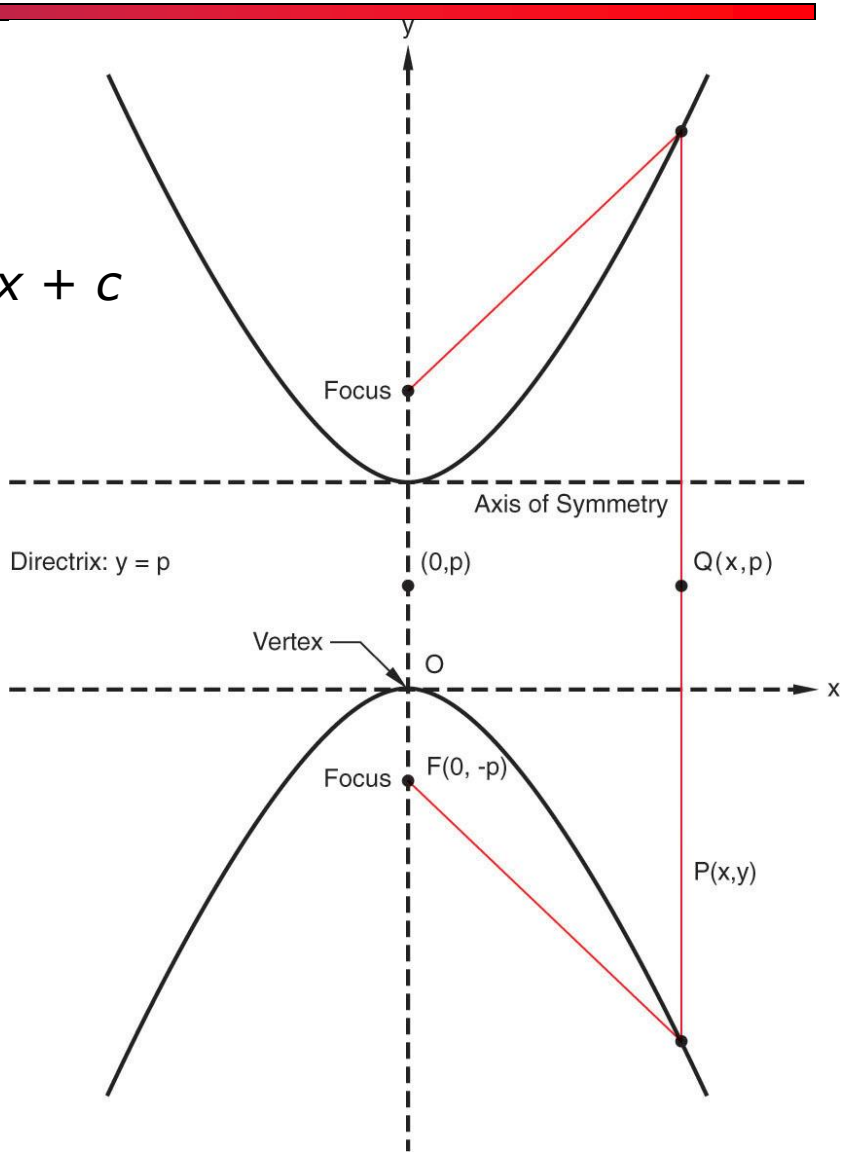
Basic Elements – Conic Curves

Parabola

A point on parabola is equidistant to directrix and focus.

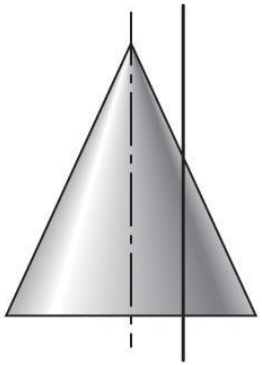
$y = ax^2 + bx + c$

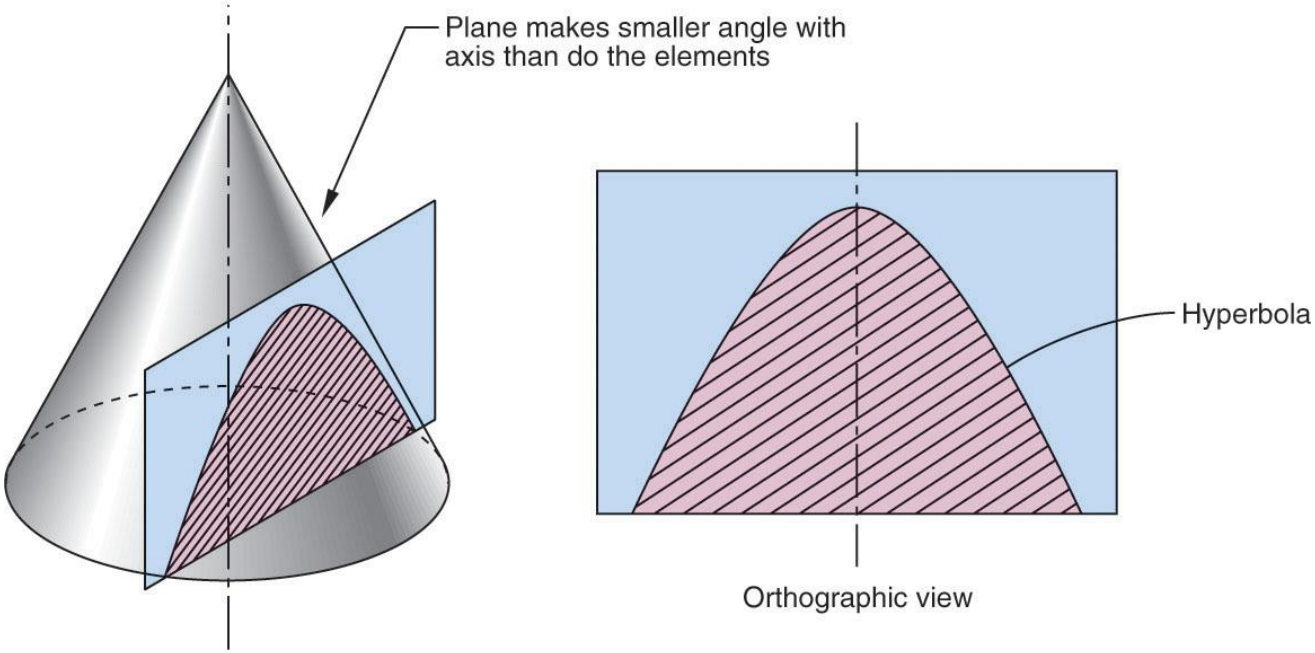




Basic Elements – Conic Curves

Hyperbola

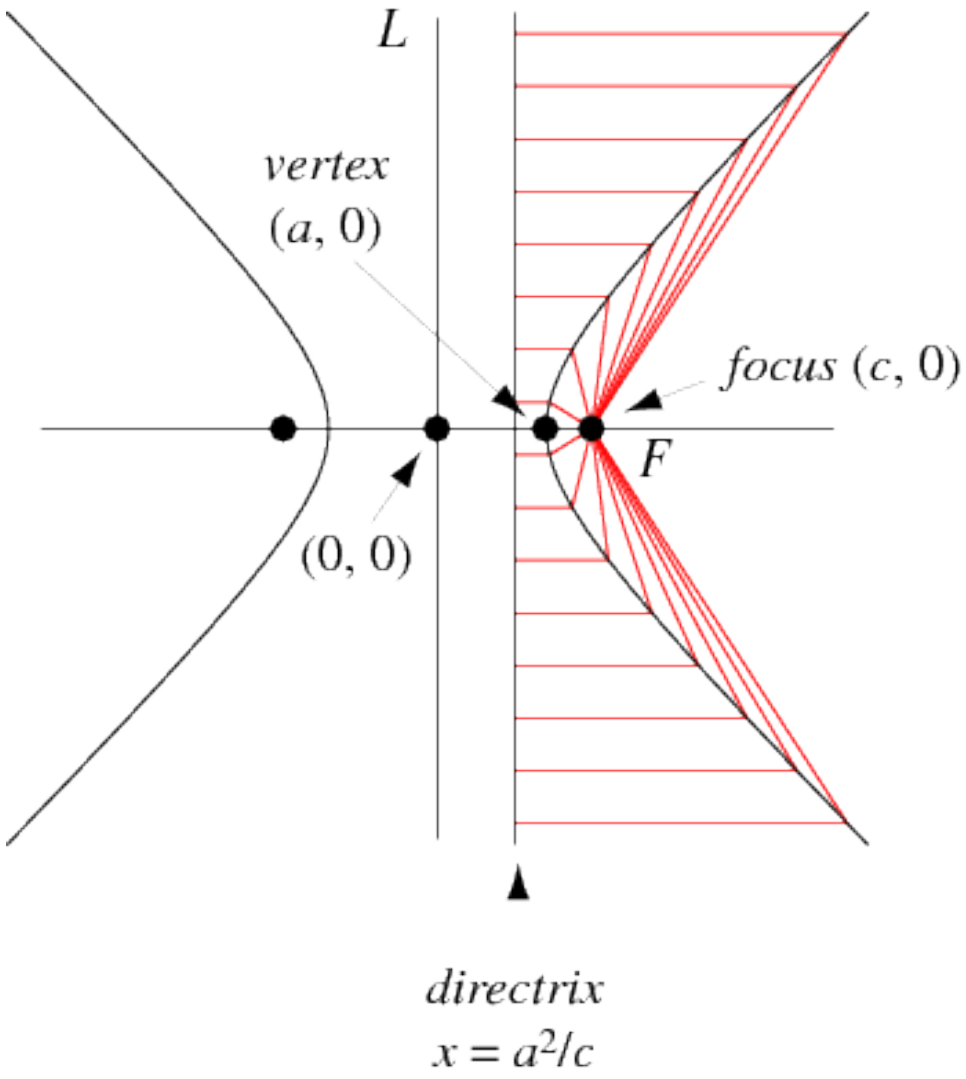




Basic Elements – Conic Curves

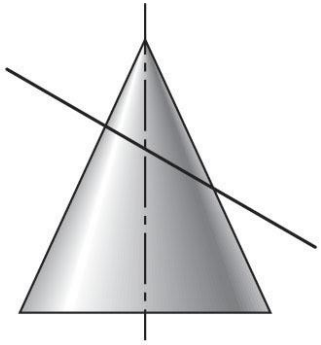
Hyperbola

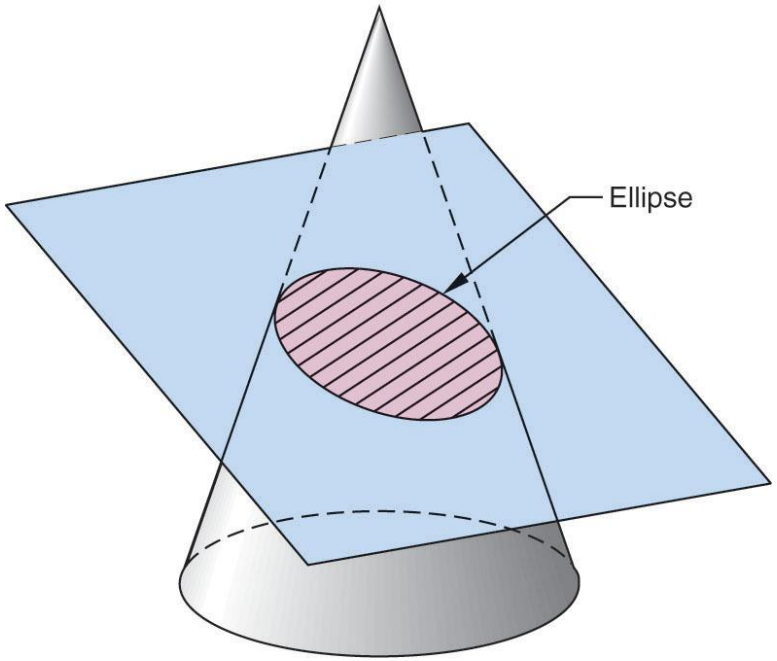
$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1.$$



Basic Elements – Conic Curves

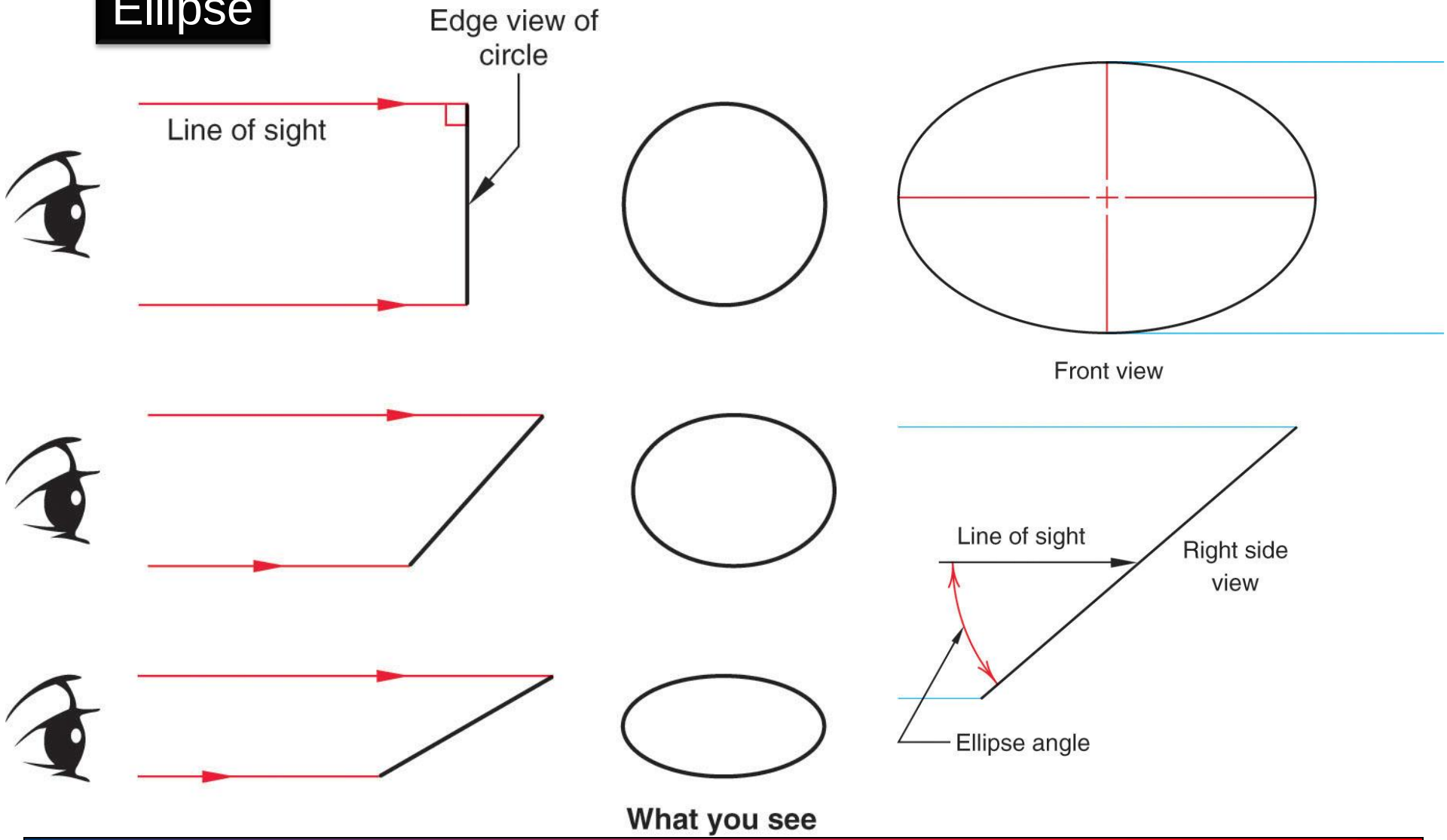
Ellipse





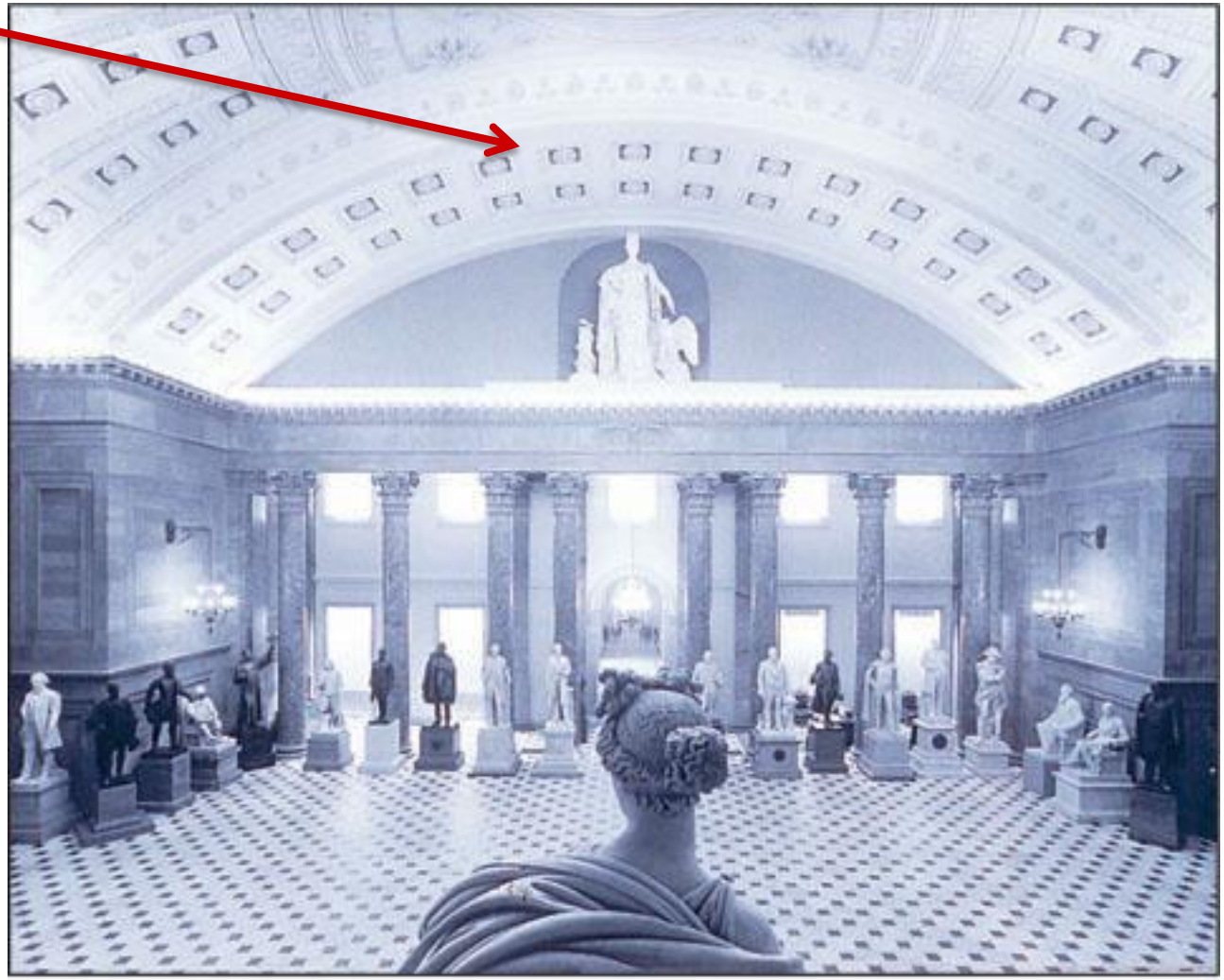
Basic Elements – Conic Curves

Ellipse



Basic Elements – Conic Curves

Ellipse

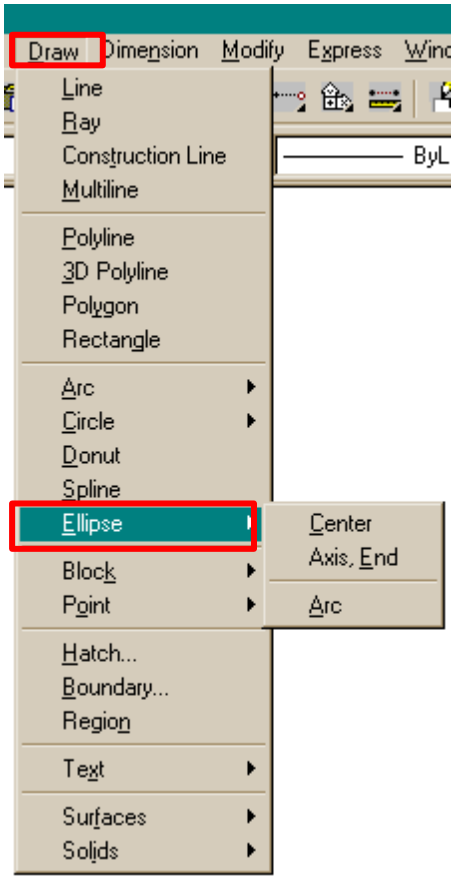


(© Photri Inc.)

Capitol Building in Washington, D.C.

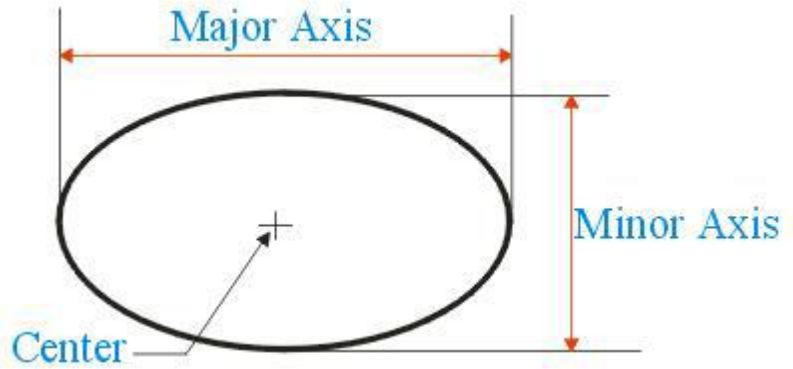
Basic Elements – Ellipse

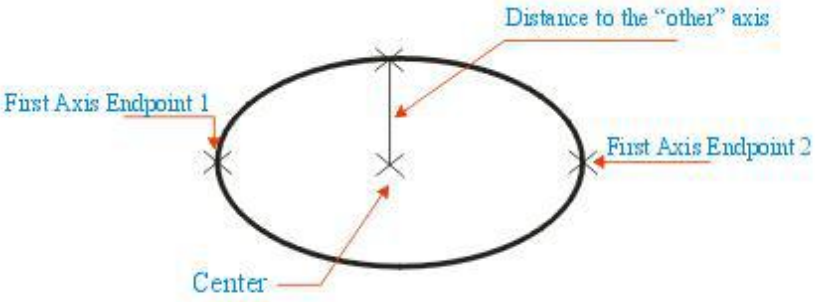
- An ellipse is drawn by selecting the ellipse icon from the draw toolbar or from Draw pull-down menu.
- Three option exist:
  - Axis Endpoint (i.e. default if you access the command through the arc icon)
  - Center
  - Arc

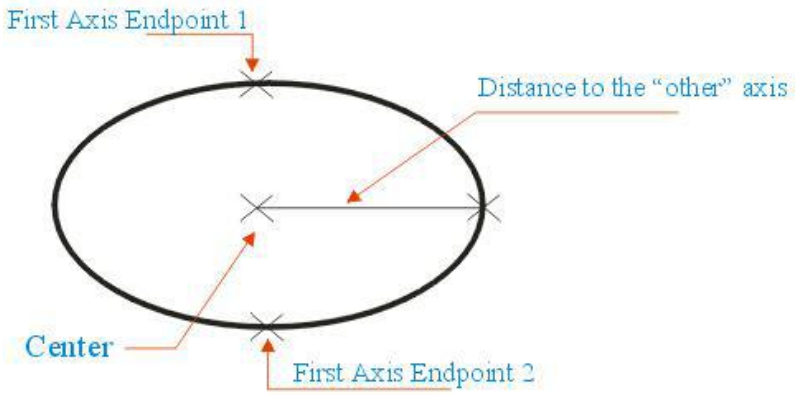


Basic Elements – Ellipse

- Ellipse have a major and a minor axis.
- The Axis Endpoint option asks you to specify the endpoints of the one axis of the ellipse.
- These endpoints may define either major or the minor axis.
- AutoCAD then request the distance from the center point of the first axis to the endpoint of the second axis.
- These three points will define your ellipse.

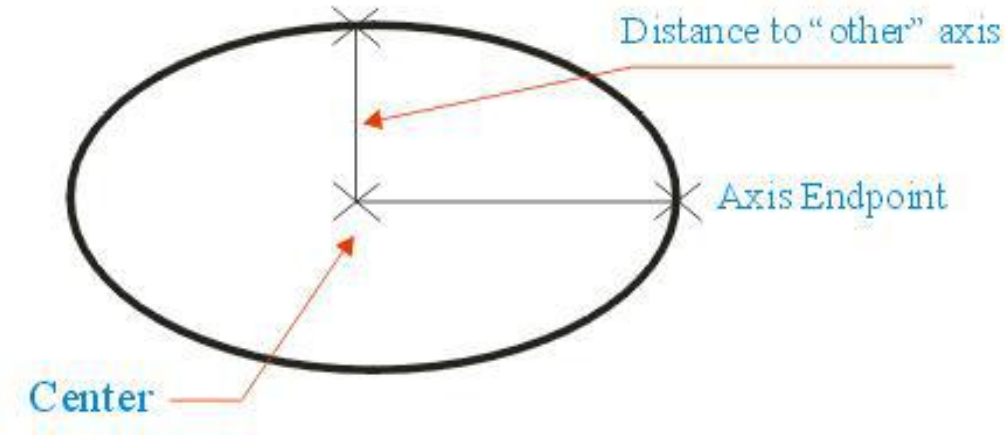




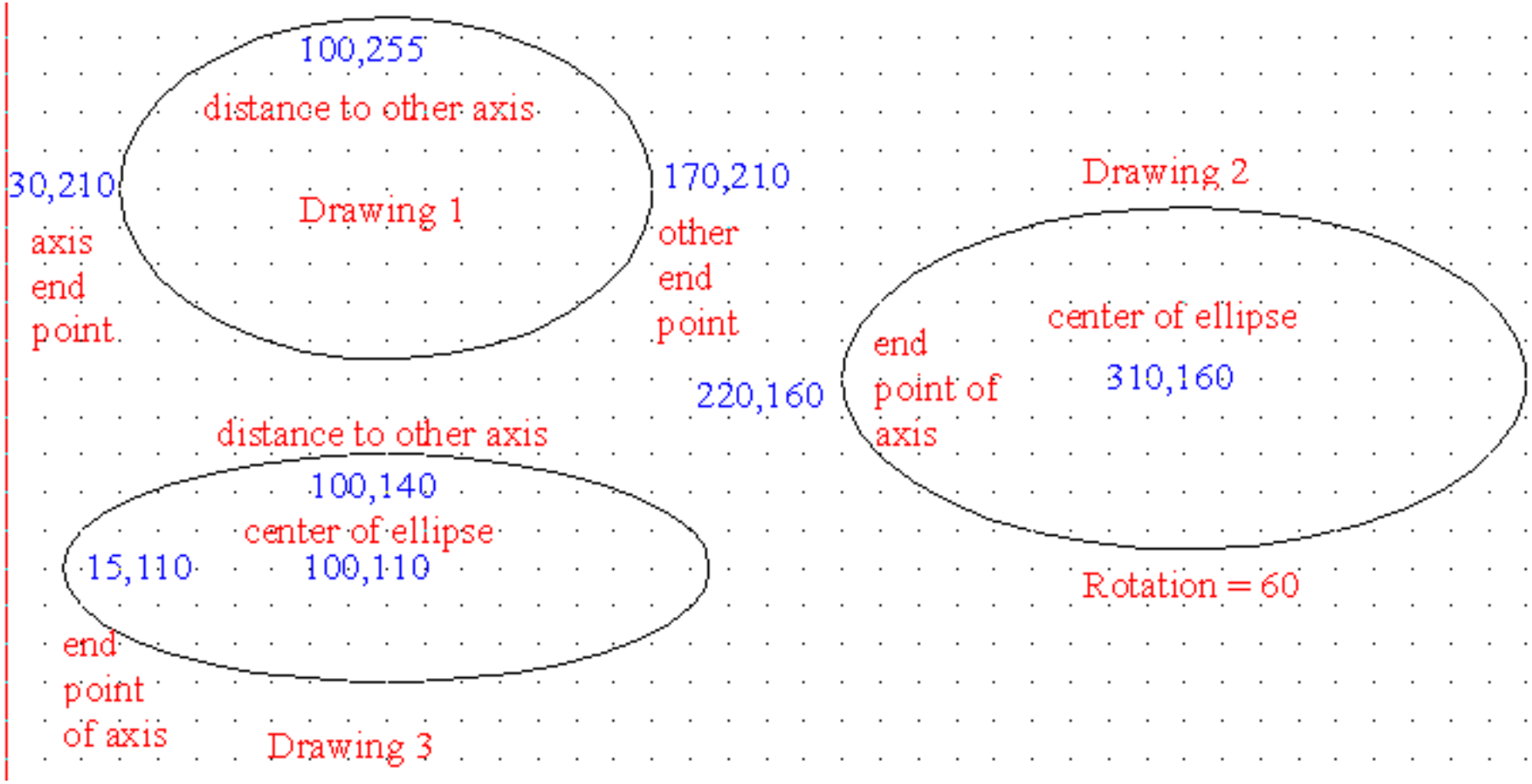


Basic Elements – Ellipse

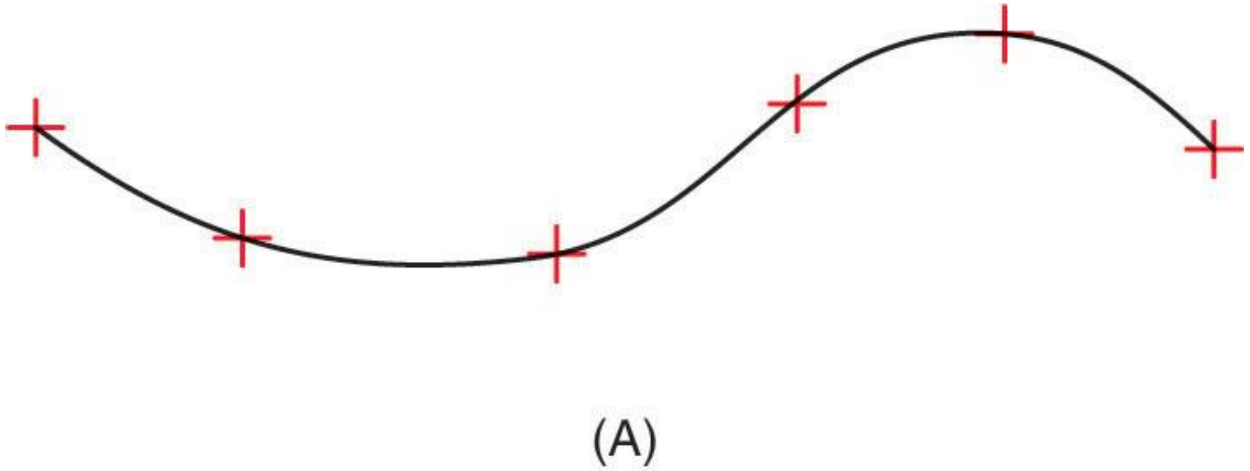
- Another way to construct an ellipse with AutoCAD is to use the Center option.
- You can select this option from the Pull-down menu or you can access this option by typing C at the command line after clicking ellipse icon.
- When you have selected the center of the ellipse, you must specify the endpoint of the axes.
- AutoCAD then asks for the distance to the other axis.



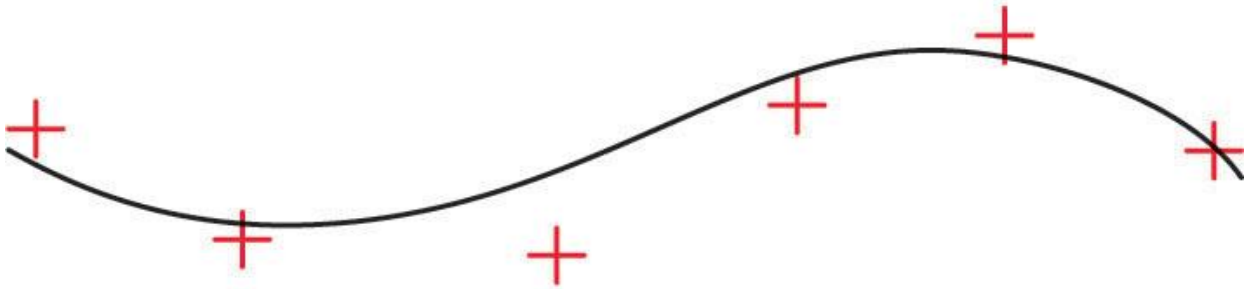
Basic Elements – Ellipse/Examples



Basic Elements – Freeform Curves



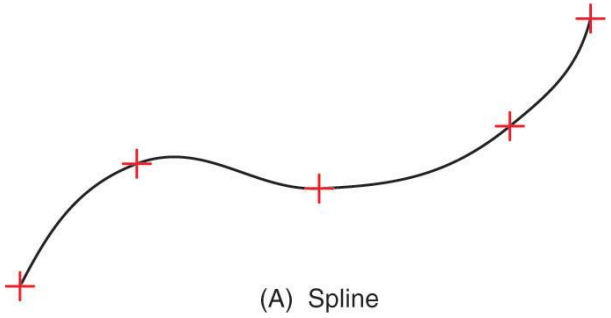
(A)

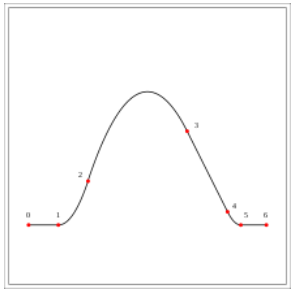


(B)

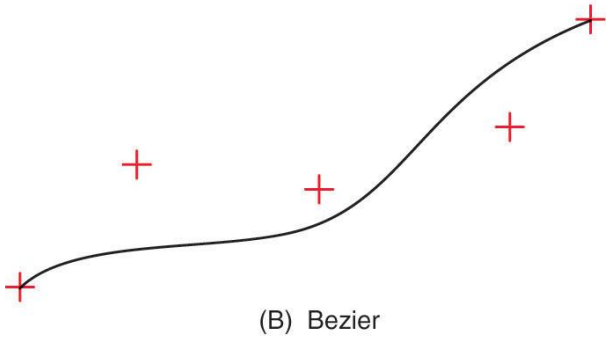
Basic Elements – Freeform Curves

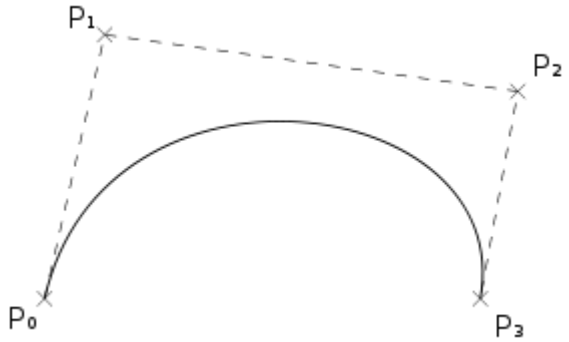
Spline - Piecewise polynomial real function



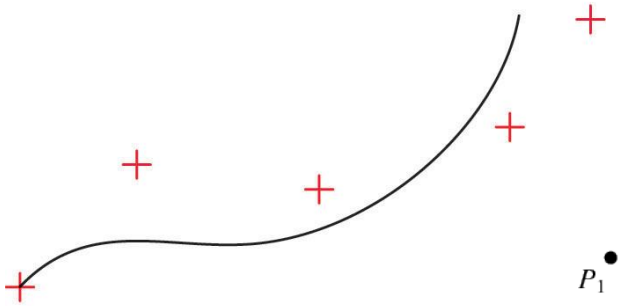


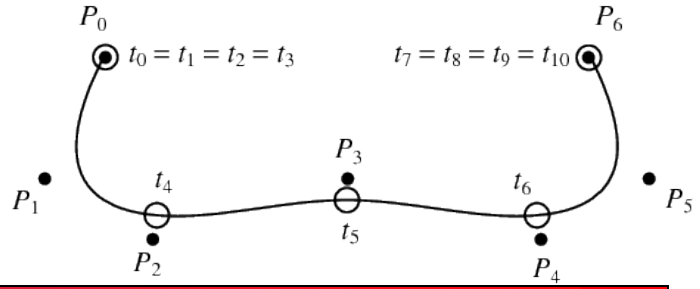
Bezier - in its most common form is a simple cubic equation





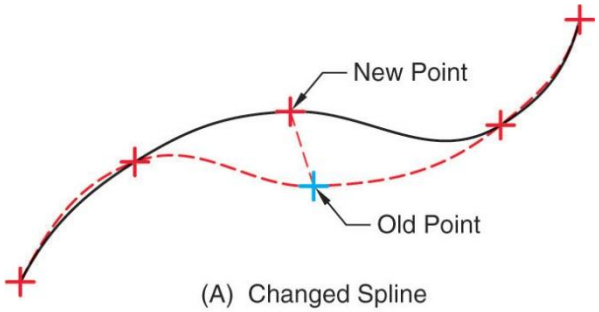
B-Spline – Generalized Bezier curve



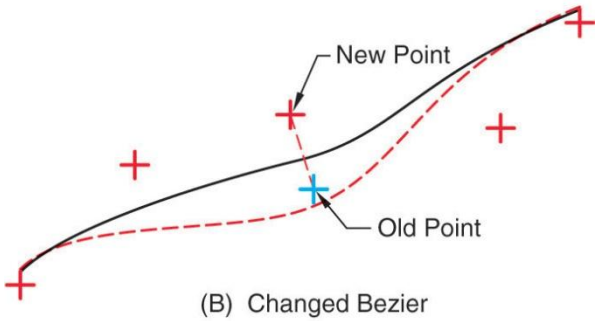


Basic Elements – Freeform Curves

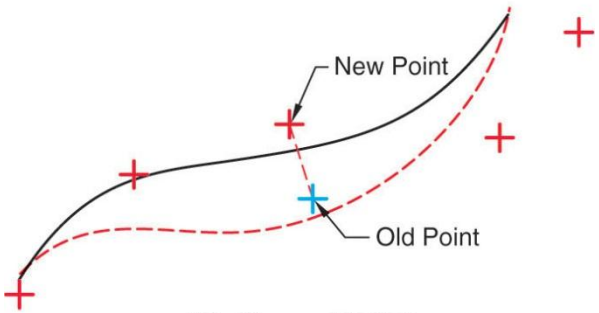
Result of changing control points



(A) Changed Spline



(B) Changed Bezier

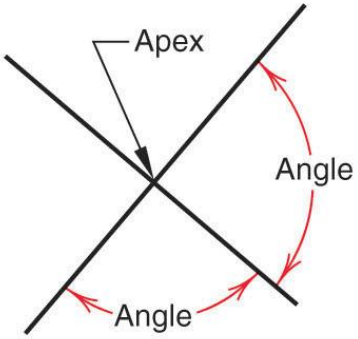


(C) Changed B-Spline

Basic Elements – Freeform Curves

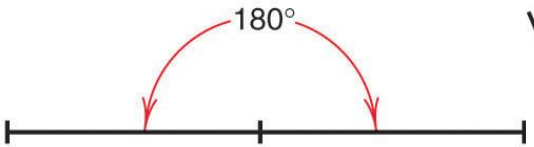
(Courtesy of Chevrolet Division, General Motors Corporation.)

Angles



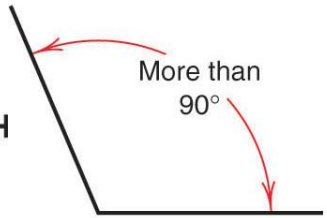
Two intersecting lines

(A)



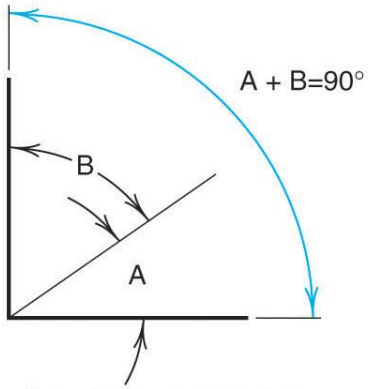
Straight

(B)



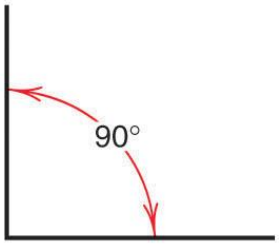
Obtuse

(E)



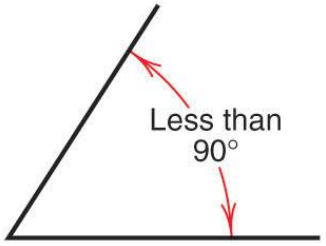
Complementary angles

(F)



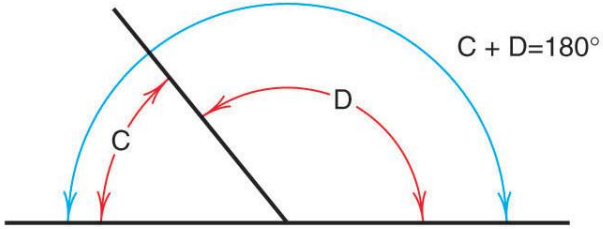
Right

(C)



Acute

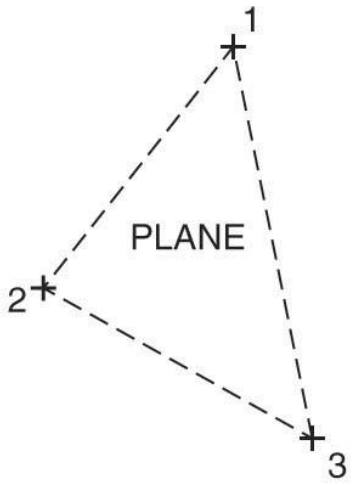
(D)



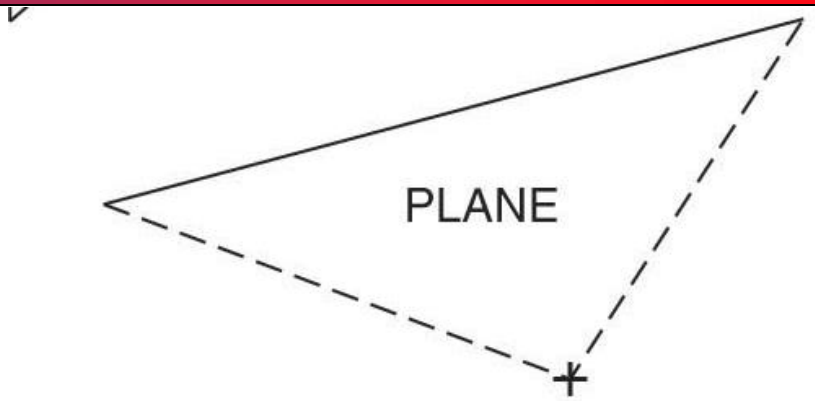
Supplementary angles

(G)

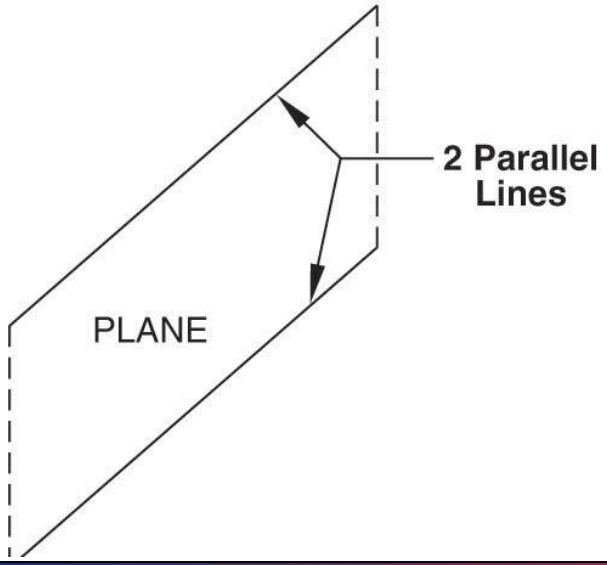
Planes

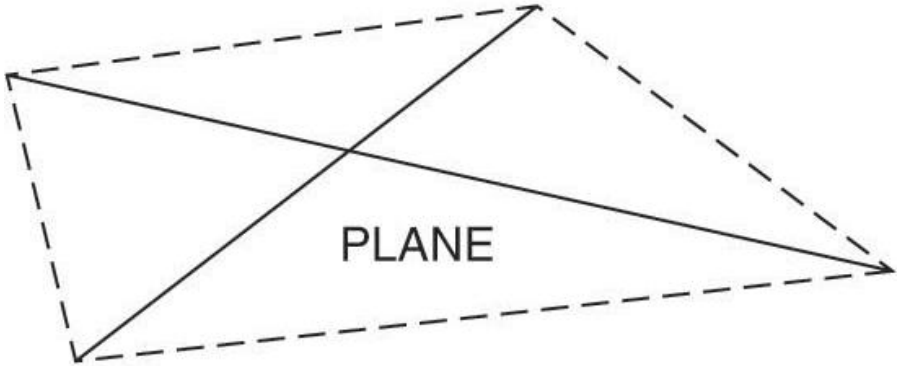


3 Points



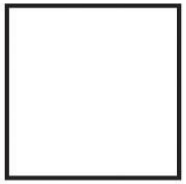
Line and a Point





2 Intersecting Lines

Planes



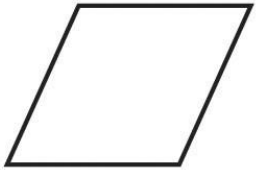
Square

(A)

Rectangle

(B)

A quadrilateral with both pairs of opposite sides parallel and all sides the same length, i.e., an equilateral parallelogram.



Rhombus

(C)

Rhomboid

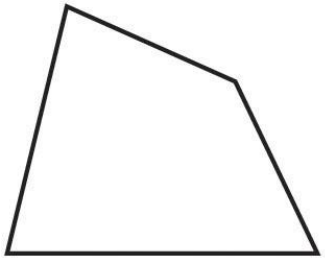
(D)

A parallelogram in which adjacent sides are of unequal length.

A quadrilateral with one pair of parallel sides

Trapezoid

(E)



Trapezium

(F)

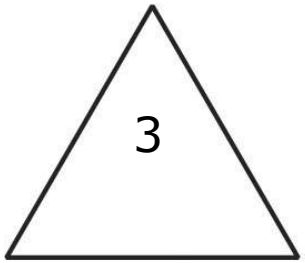
UK

A quadrilateral with no sides parallel

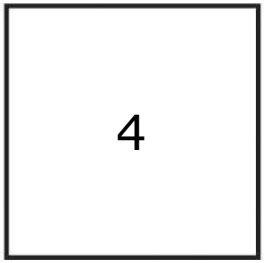
Planes

Regular Polygons

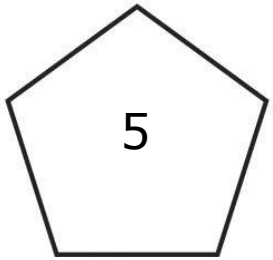
(Equilateral)



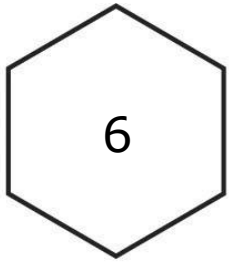
Triangle
(equilateral)



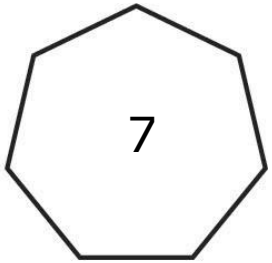
Square



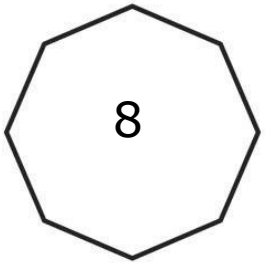
Pentagon



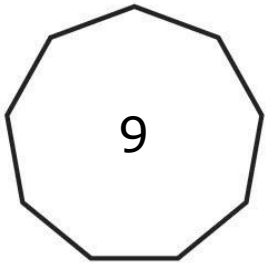
Hexagon



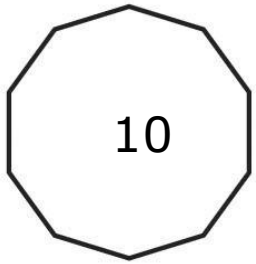
Heptagon



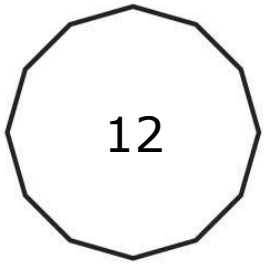
Octagon



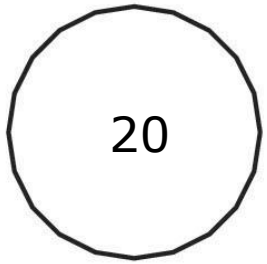
Nonagon



Decagon



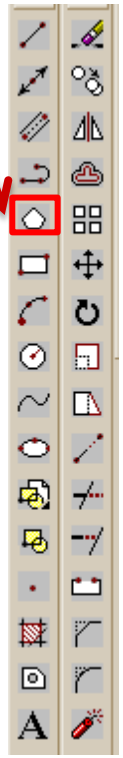
Dodecagon



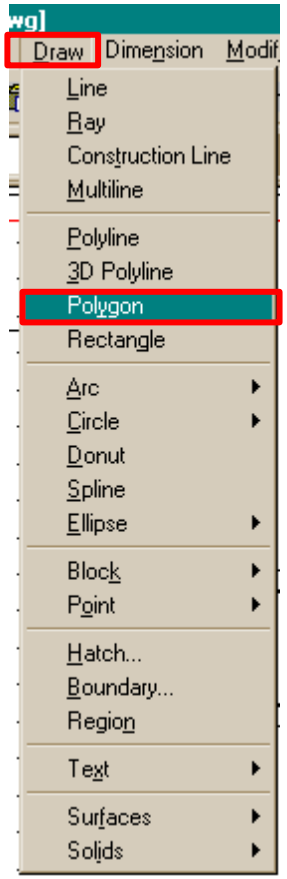
Icosagon

Basic Elements – Polygon

Polygon icon

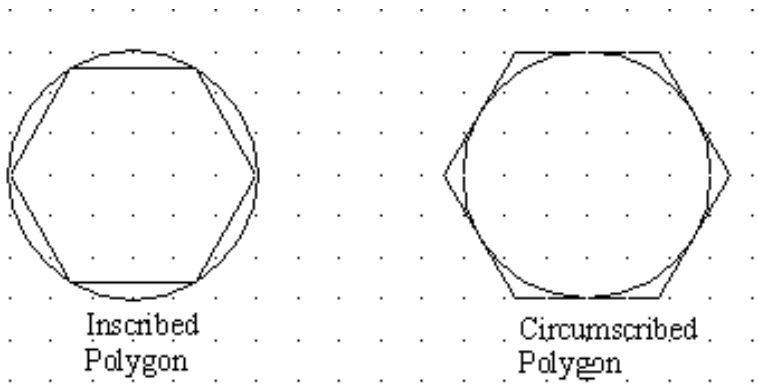


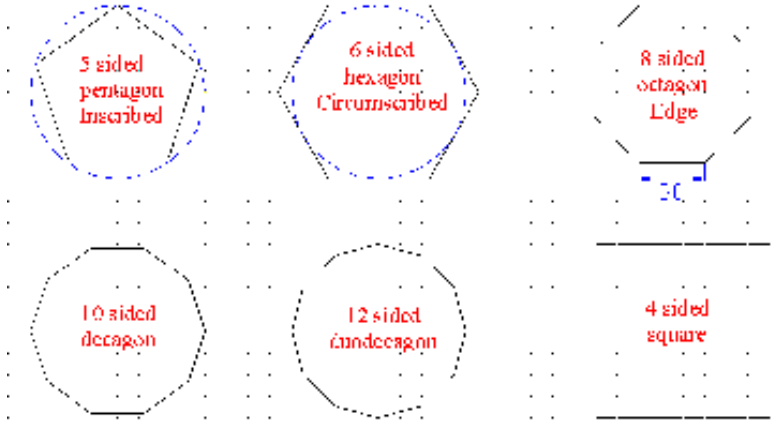
- With Polygon command you can draw regular polygons that have 3 to 1024 sides.
- When you click the polygon icon the AutoCAD will ask you the number of sides of the polygon.
  - Enter number of sides < >:
- The value within the brackets < > will be the default value based on the last time the command was used.
- After you have determined the number of sides of the polygon you will have following options;
  - Center (i.e. default option)
  - Edge



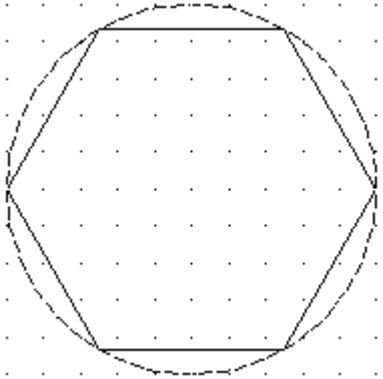
Basic Elements – Polygon

- After choosing the center or edge of the polygon you will be asked to enter an option[Inscribed in circle/Circumscribed about circle]<I>:
- This means that you must decide whether you want to crate your polygon within the circle or around the circle. The default value is I.
- After that you will be asked to specify radius of circle.

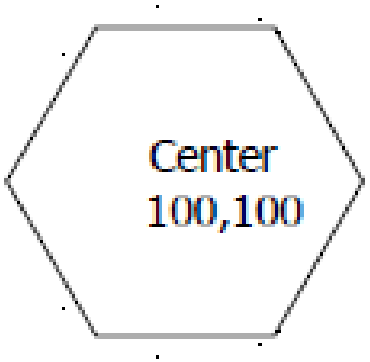




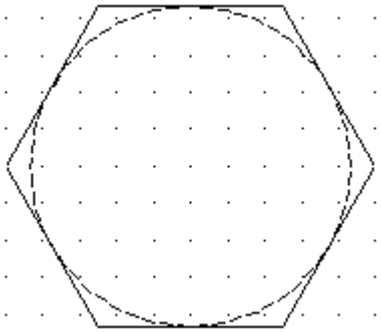
Basic Elements – Polygon/Examples



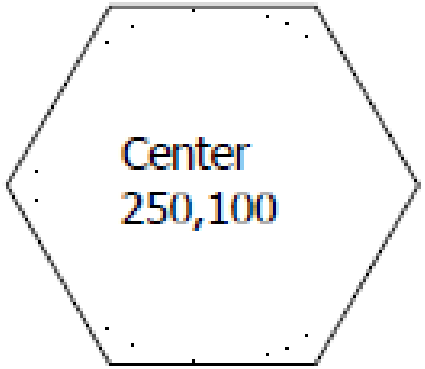
Radius 50



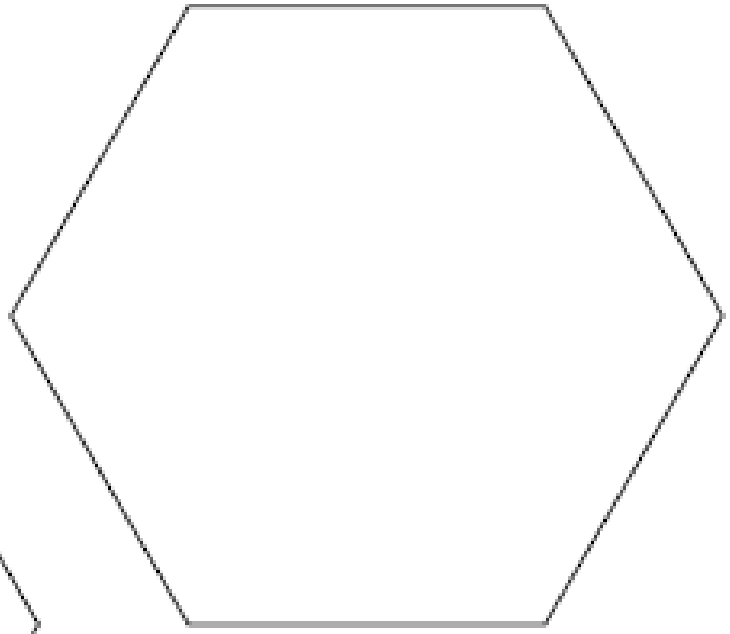
Inscribed in circle



Radius 50

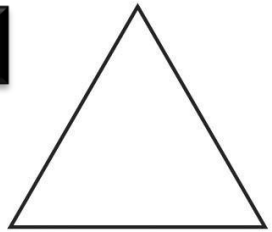


Circumscribed by circle



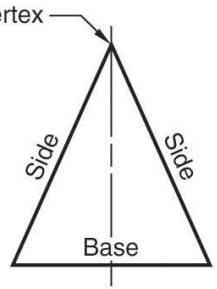
Planes

Triangles



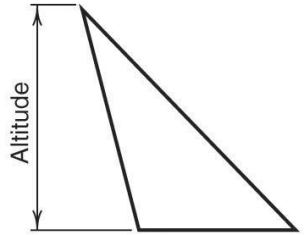
Equilateral triangle
All sides equal;
all angles equal.

(A)



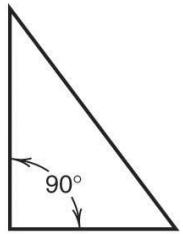
Isosceles triangle
2 sides equal;
2 angles equal.

(B)



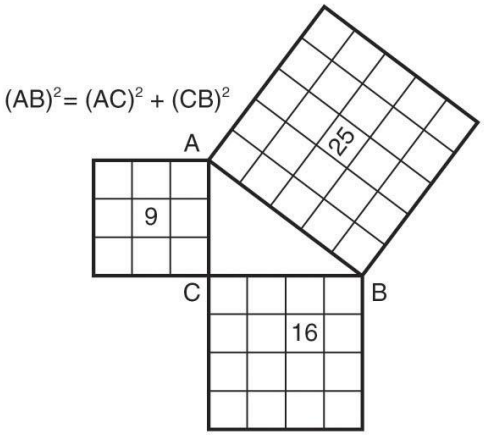
Scalene triangle
No sides or
angles equal.

(C)



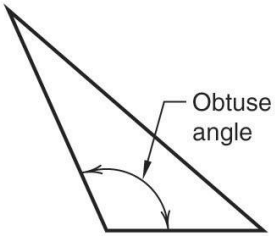
Right triangle
One 90° angle.

(D)



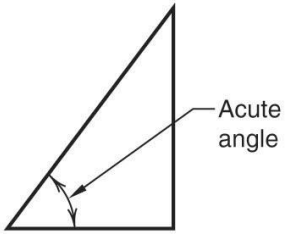
Theorem of
Pythagoras

(E)



Obtuse
triangle

(F)

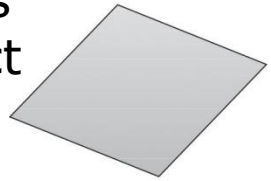


Acute
triangle

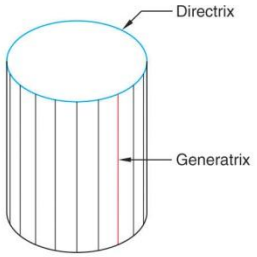
(G)

Surfaces

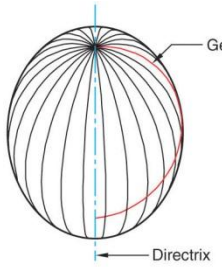
Outer faces of an object



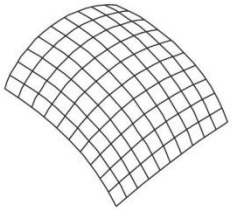
(A)
Planar Surface



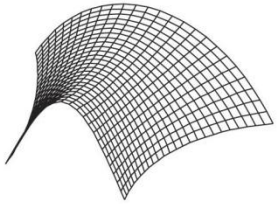
(B)
Single-Curved Surface



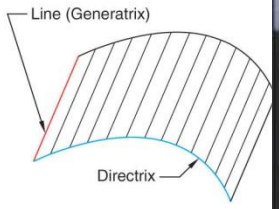
(C)
Double-Curved Surface



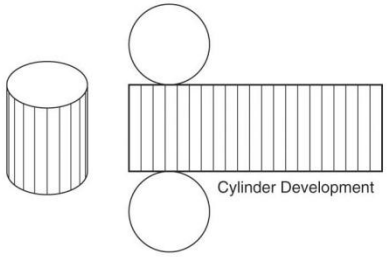
(D)
Warped Surface



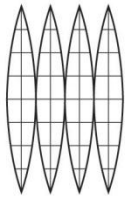
(E)
Freeform Surface



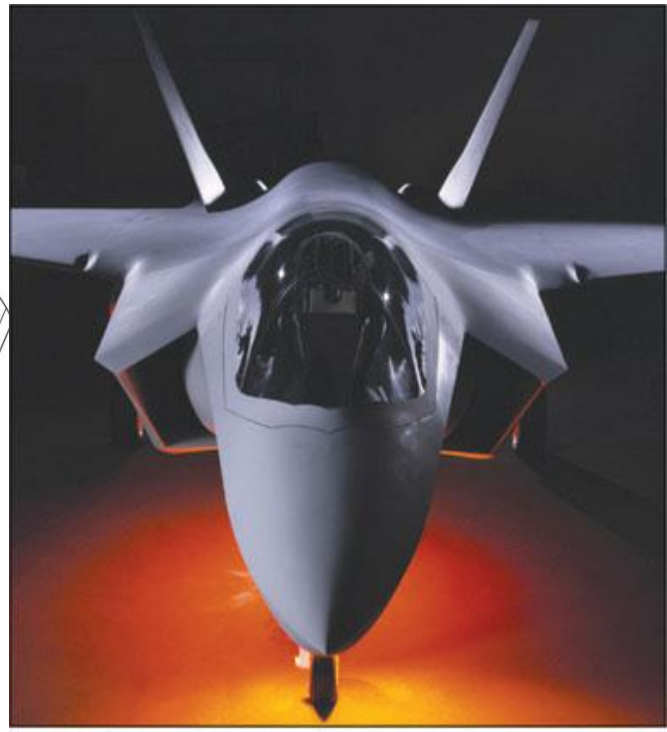
(F)
Ruled Surface



(G)
Developable Surface
(unfoldable without distorsion)

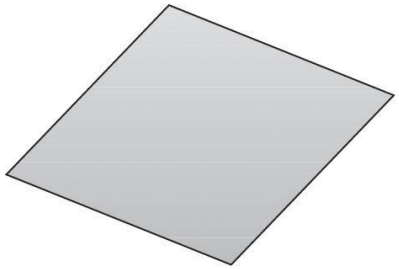


(H)
Undevelopable Surface

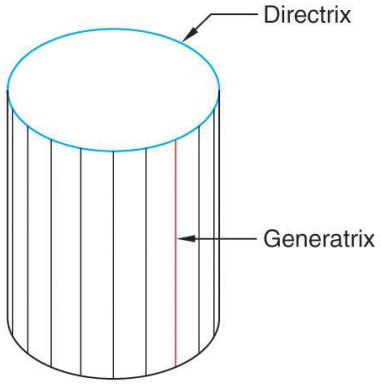


(Courtesy of Lockheed Martin.)

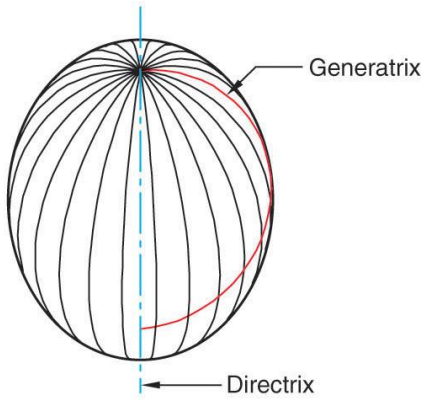
Surfaces



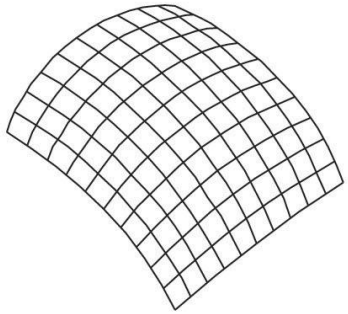
(A)
Planar Surface



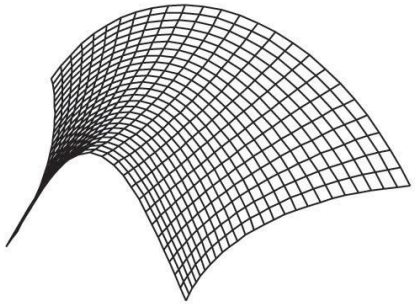
(B)
Single-Curved Surface



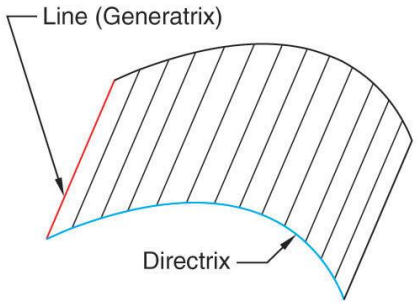
(C)
Double-Curved Surface



(D)
Warped Surface

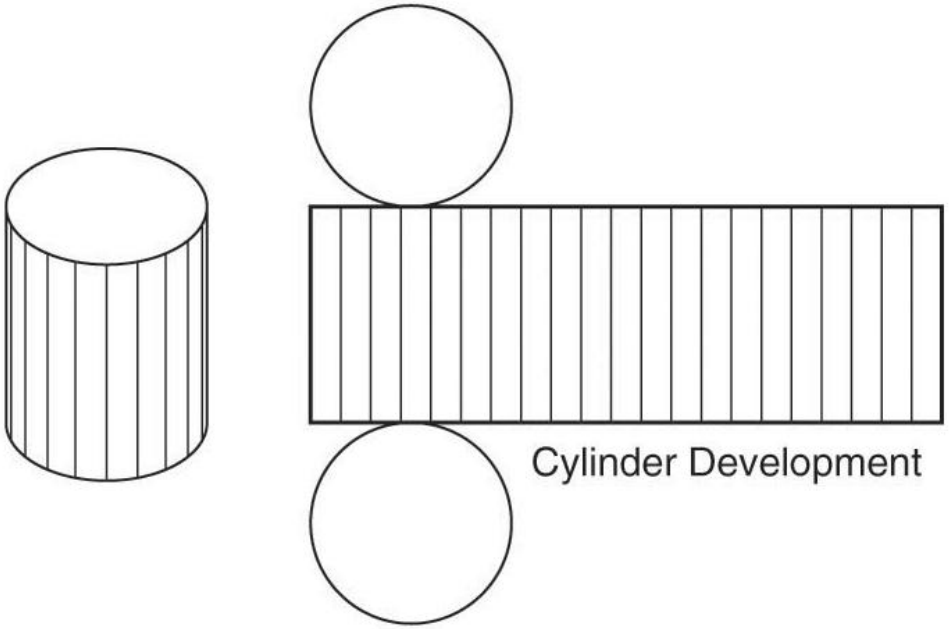


(E)
Freeform Surface

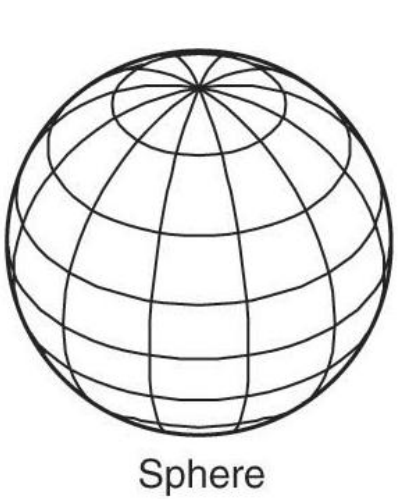


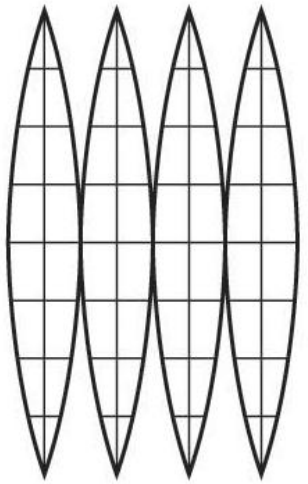
(F)
Ruled Surface

Surfaces

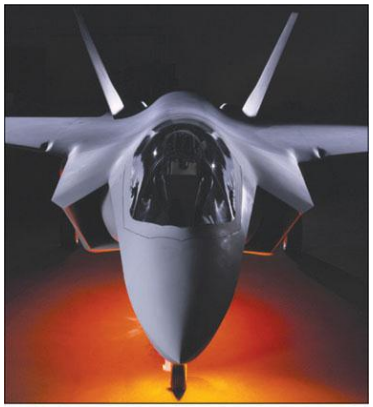


(G)
Developable Surface
(unfoldable
onto a plane)





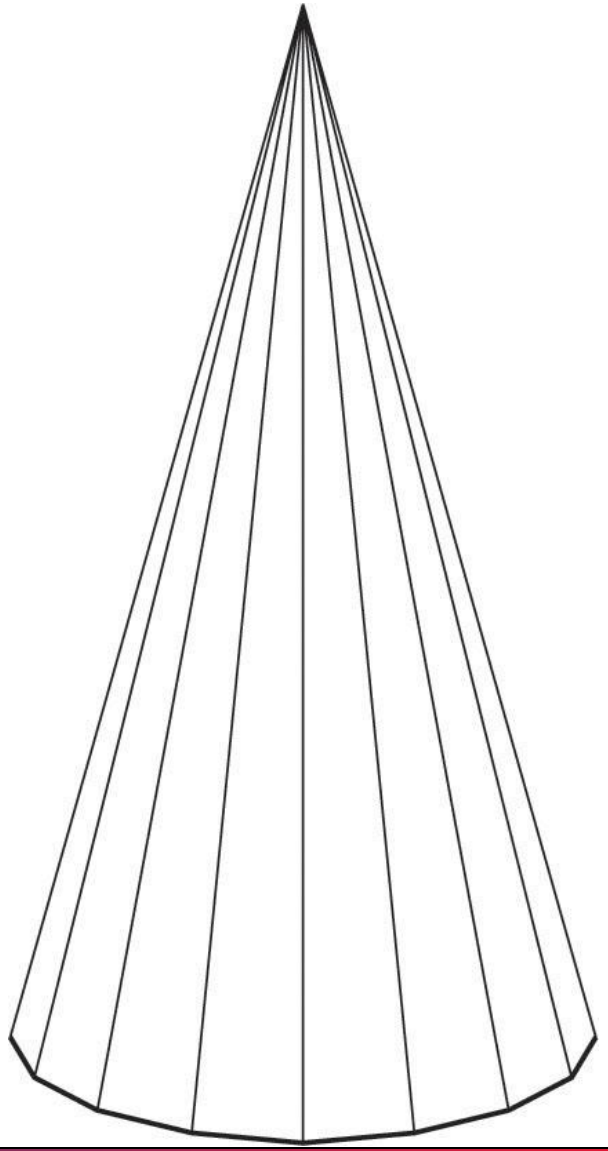
(H)
Undevelopable Surface



(Courtesy of Lockheed Martin.)

Single Curved Surfaces

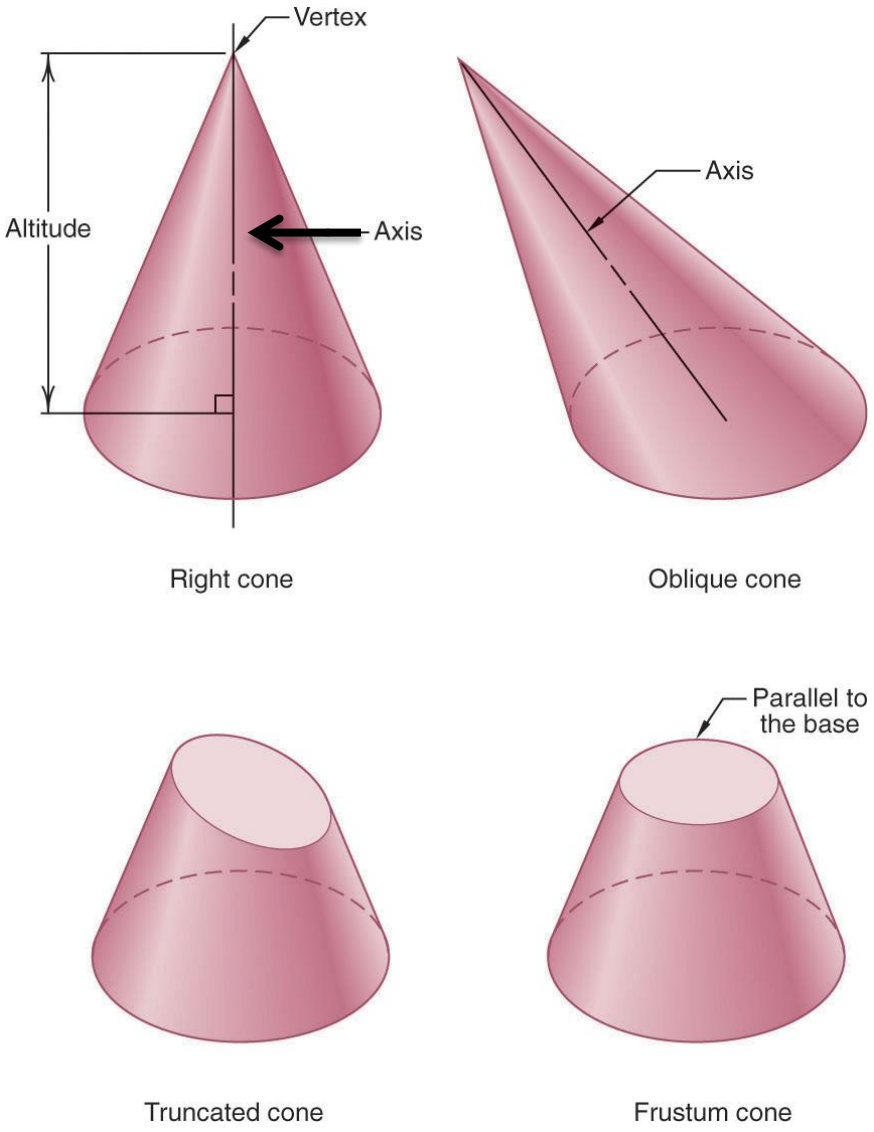
Cones



Faceted representation of a cone

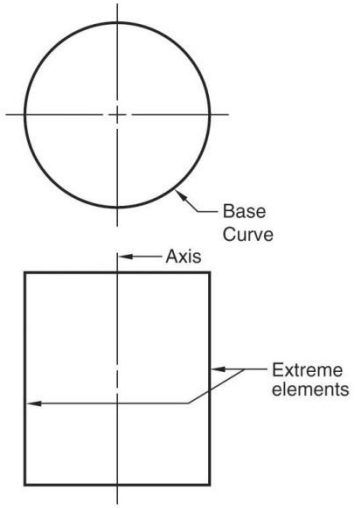
Single Curved Surfaces

Cones

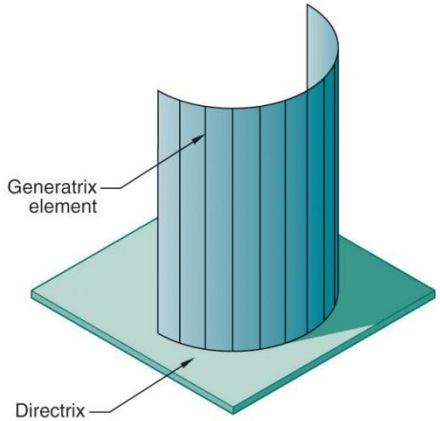


Single Curved Surfaces

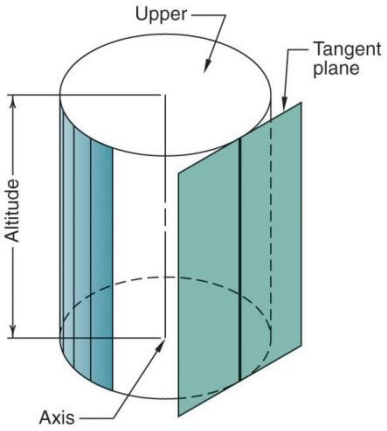
Cylinders



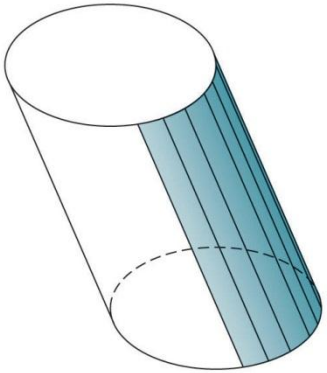
Multiview drawing of a right cylinder



Cylindrical surface



Right circular cylinder

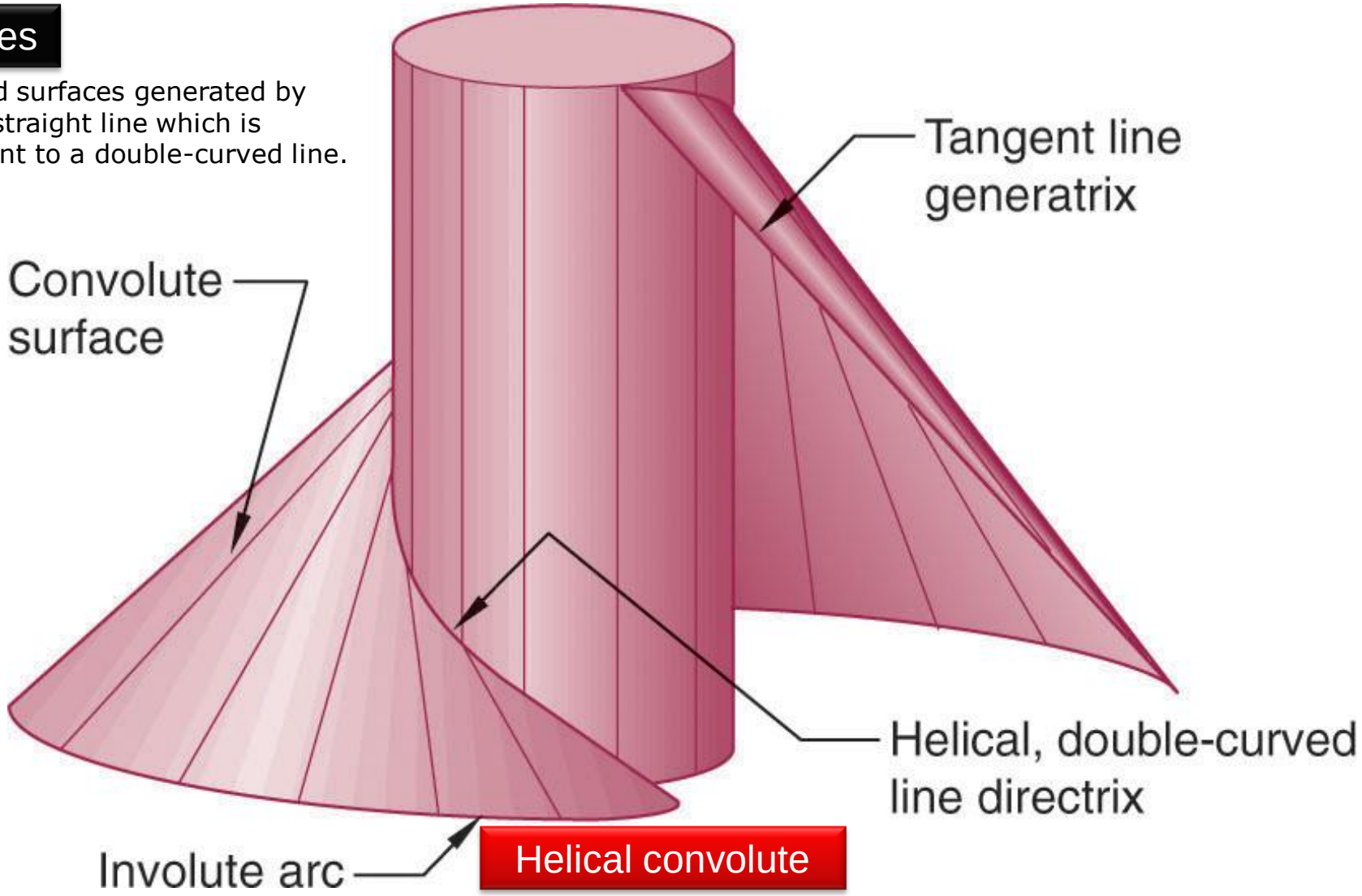


Oblique elliptical cylinder

Single Curved Surfaces

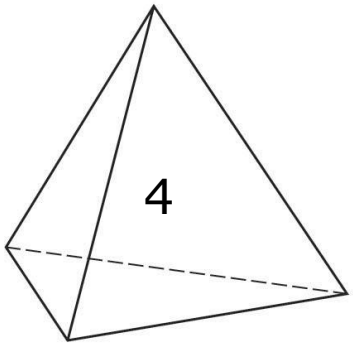
Convolutes

Single-curved surfaces generated by moving of a straight line which is always tangent to a double-curved line.

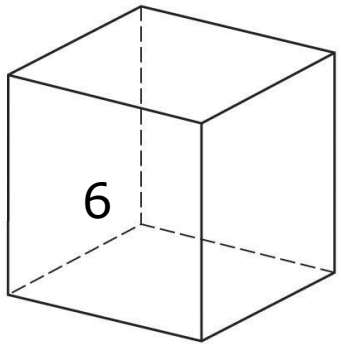


Polyhedra

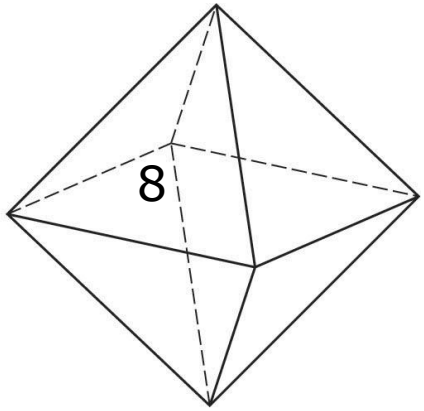
A polyhedron is a 3-D object with multiple polygonal sides.



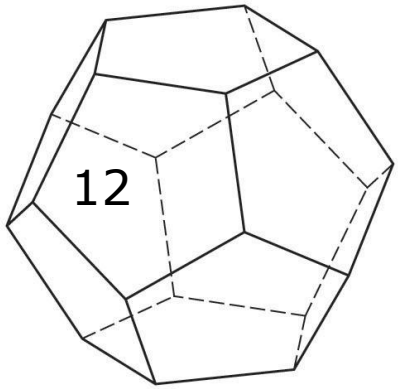
Tetrahedron



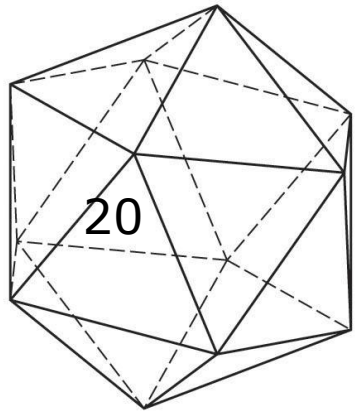
Hexahedron (cube)



Octahedron



Dodecahedron



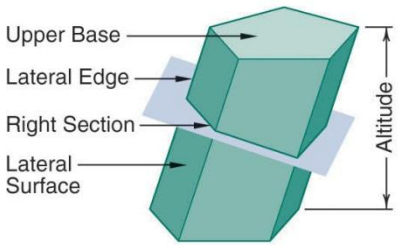
Icosahedron

Regular Polyhedra

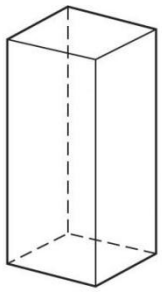
Polyhedra

Prisms

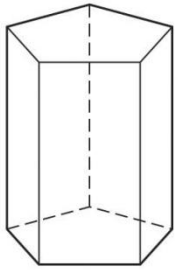
Polyhedra with two equal parallel faces



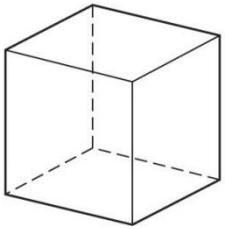
Oblique pentagonal prism



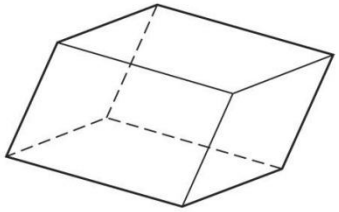
Right prism



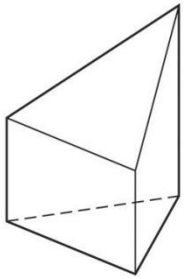
Right pentagonal prism



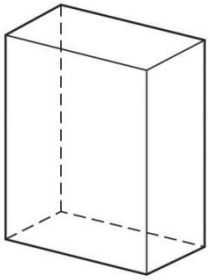
Cube



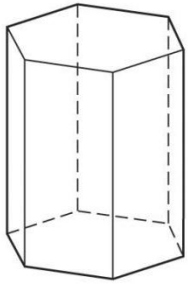
Oblique parallelepiped



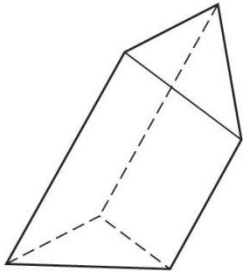
Truncated prism



Right rectangular prism



Right hexagonal prism

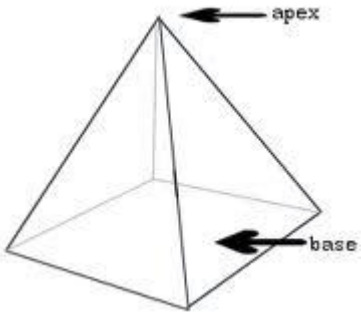


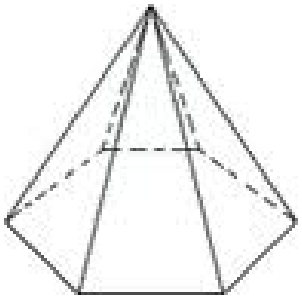
Truncated oblique triangular prism

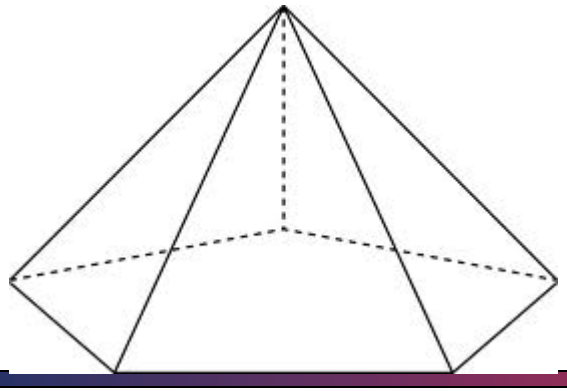
Polyhedra

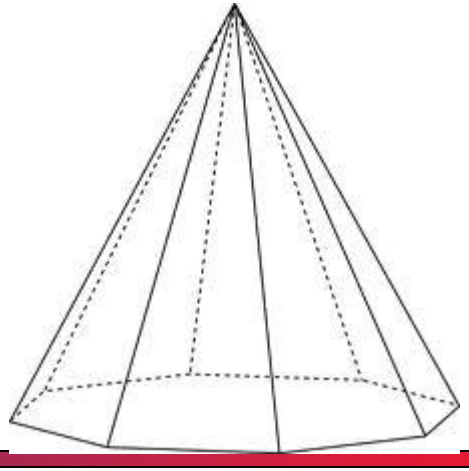
Pyramids

Polyhedra with polygonal base and lateral faces having a common intersection point, called vertex.



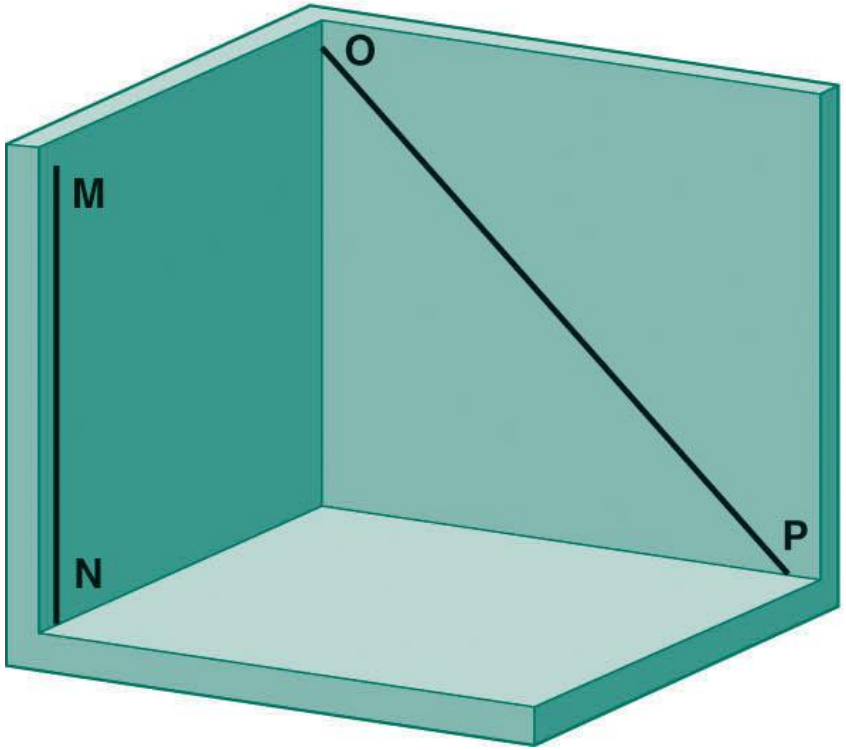


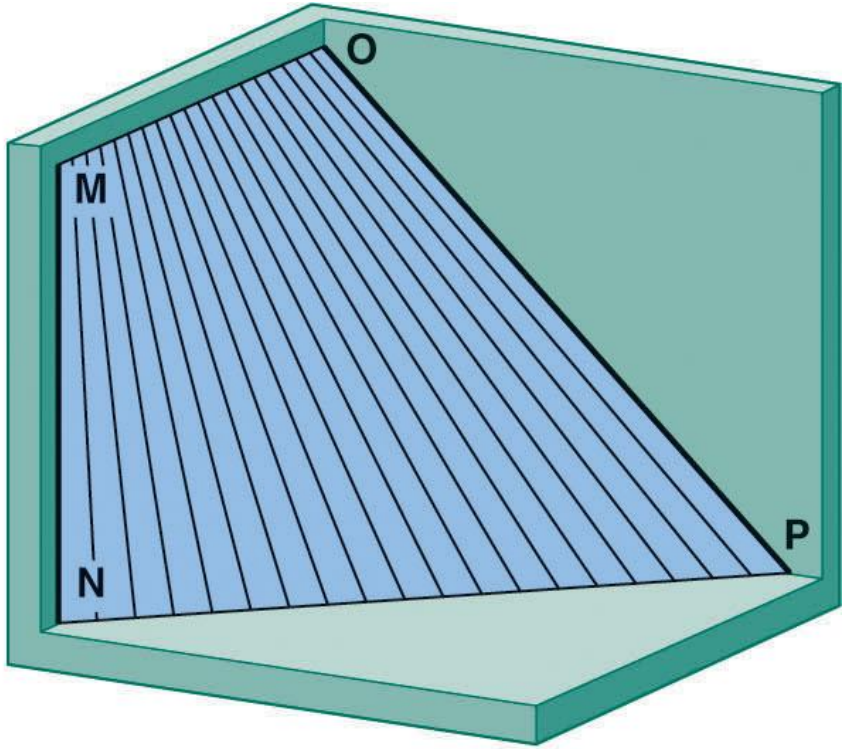




Warped Surfaces

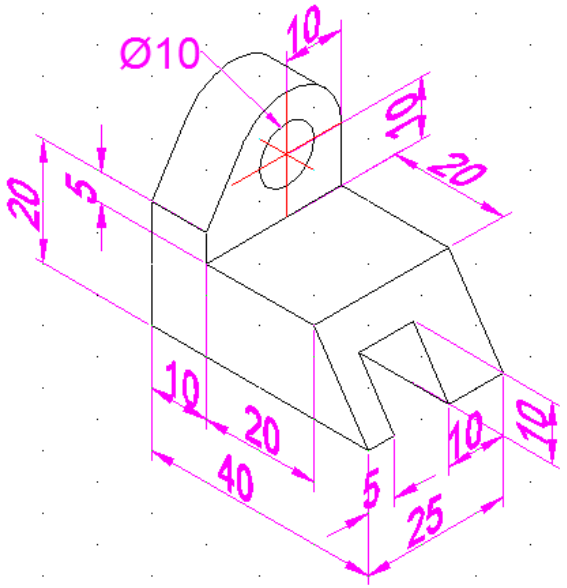
Two consequtive positions of the line are skewed (not in the same plane)

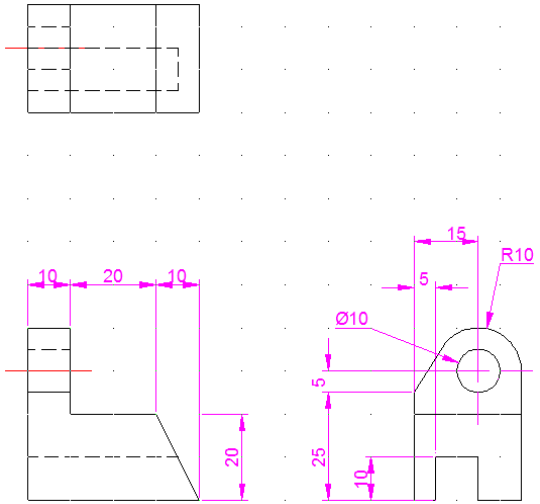




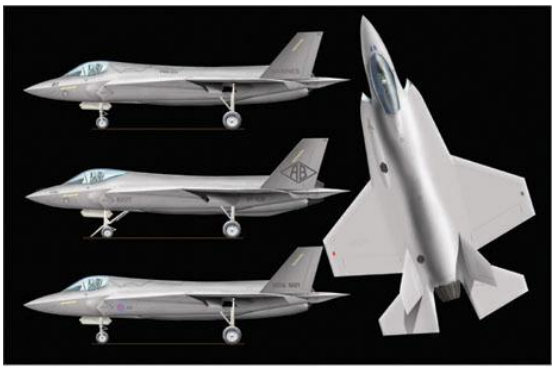
3-D Modeling

2-D Modeling versus 3-D Modeling

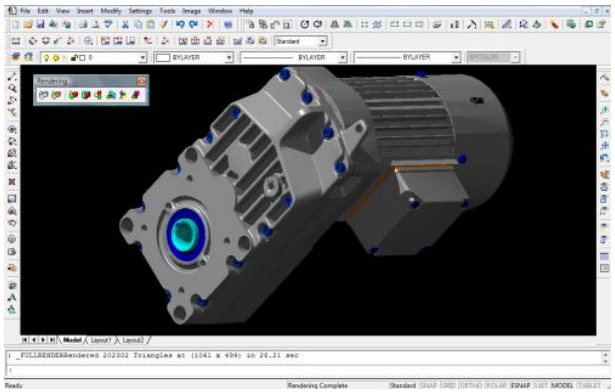


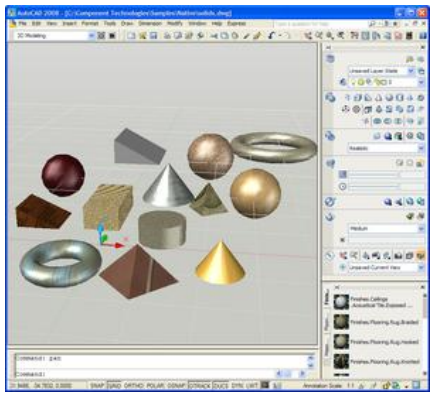


Just a drawing of the object



(Courtesy of Lockheed Martin.)

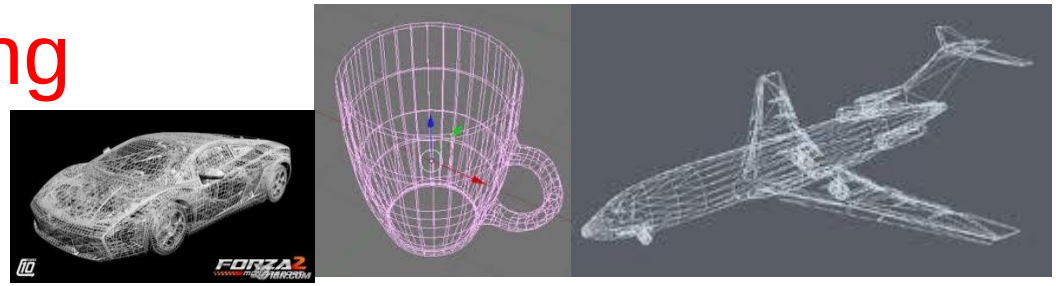




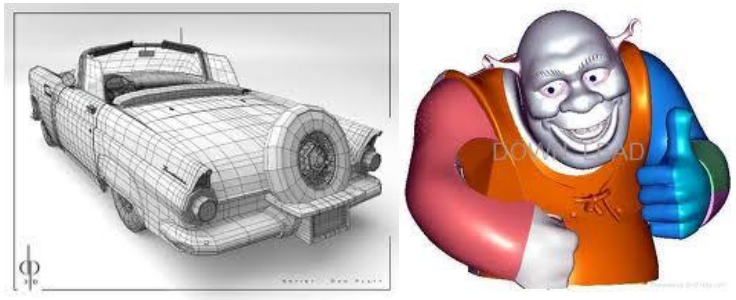
Like a Real Object

Primary Aproaches of 3-D Modeling

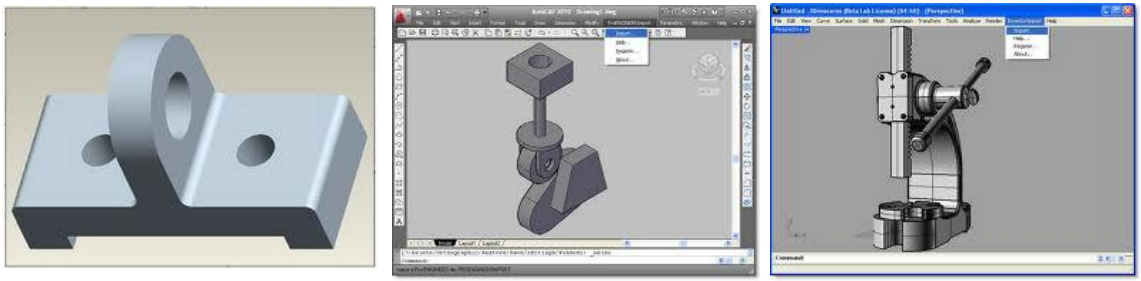
- Wireframe Modeling



- Surface Modeling



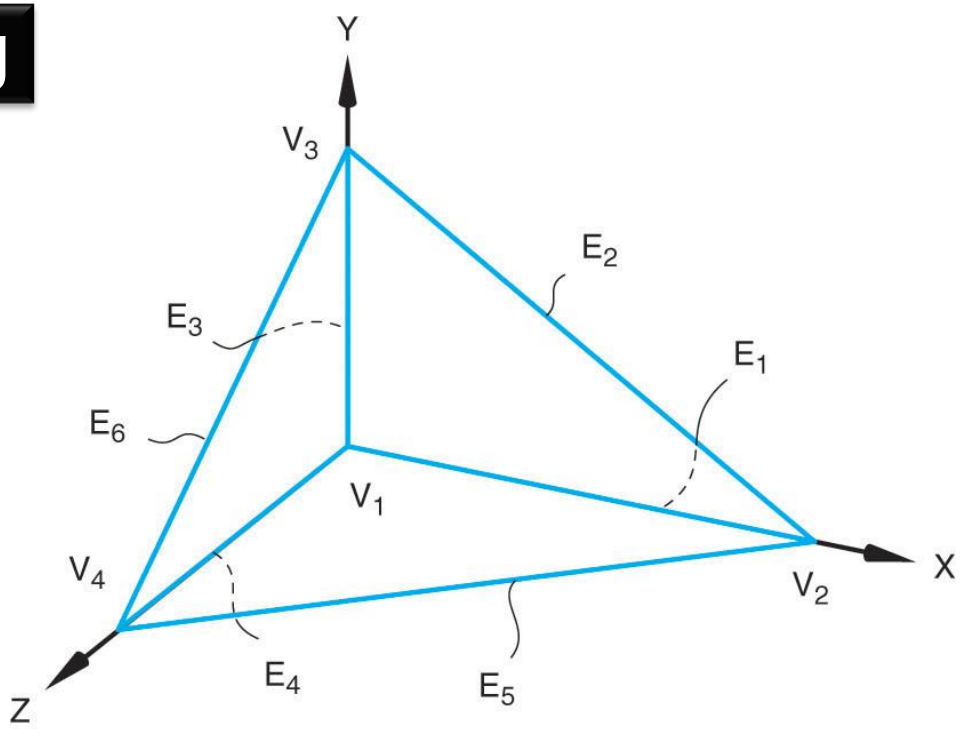
- Solid Modeling



3-D Modeling

Wireframe Modeling

The vertex and edge list of a wireframe model



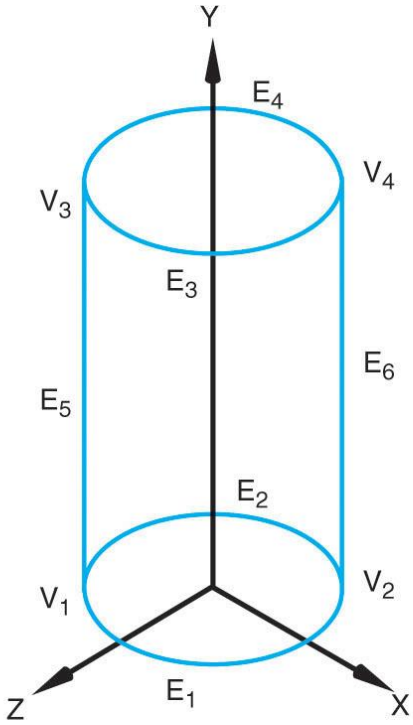
Vertex List	
V_1	(0, 0, 0)
V_2	(1, 0, 0)
V_3	(0, 1, 0)
V_4	(0, 0, 1)

Edge List	
E_1	$<V_1, V_2>$
E_2	$<V_2, V_3>$
E_3	$<V_3, V_1>$
E_4	$<V_1, V_4>$
E_5	$<V_2, V_4>$
E_6	$<V_3, V_4>$

3-D Modeling

Wireframe Modeling

A wireframe model using circular and linear edges

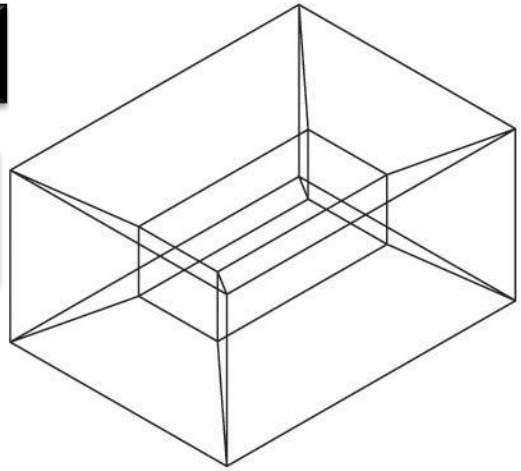


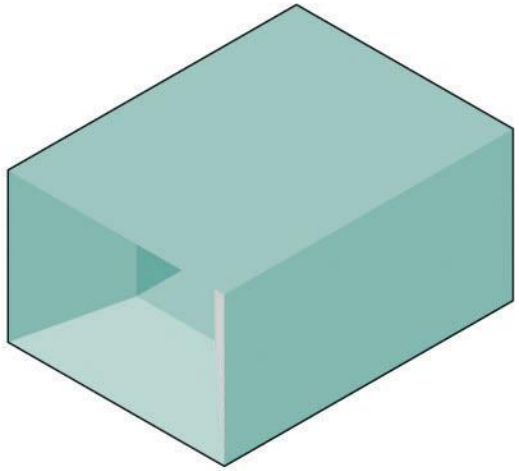
Vertex List	Edge List	Type
V_1 (–1, 0, 1)	$E_1 < V_1, V_2 >$	Circular
V_2 (1, 0, –1)	$E_2 < V_2, V_1 >$	Circular
V_3 (–1, 5, 1)	$E_3 < V_3, V_4 >$	Circular
V_4 (1, 5, –1)	$E_4 < V_4, V_3 >$	Circular
	$E_5 < V_1, V_3 >$	Linear
	$E_6 < V_2, V_4 >$	Linear

3-D Modeling

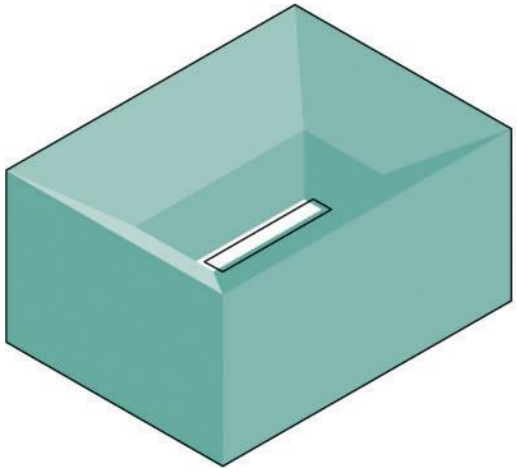
Wireframe Modeling

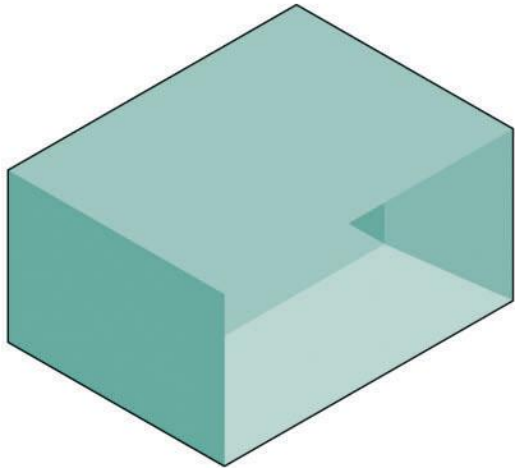
Example of a wireframe model lacking uniqueness





The same edge and vertex list can describe different objects, depending on how the faces are interpreted.

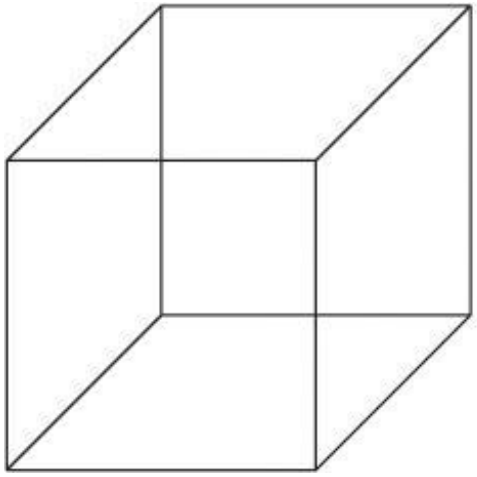


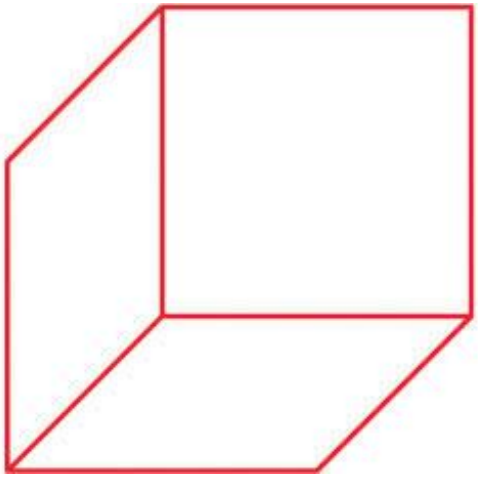


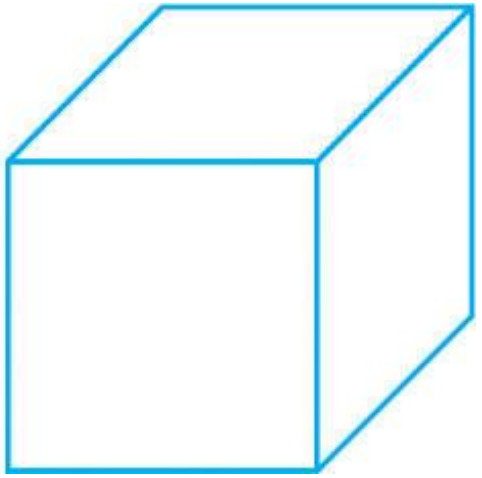
3-D Modeling

Wireframe Modeling

A wireframe model with an ambiguous orientation: the Necker cube





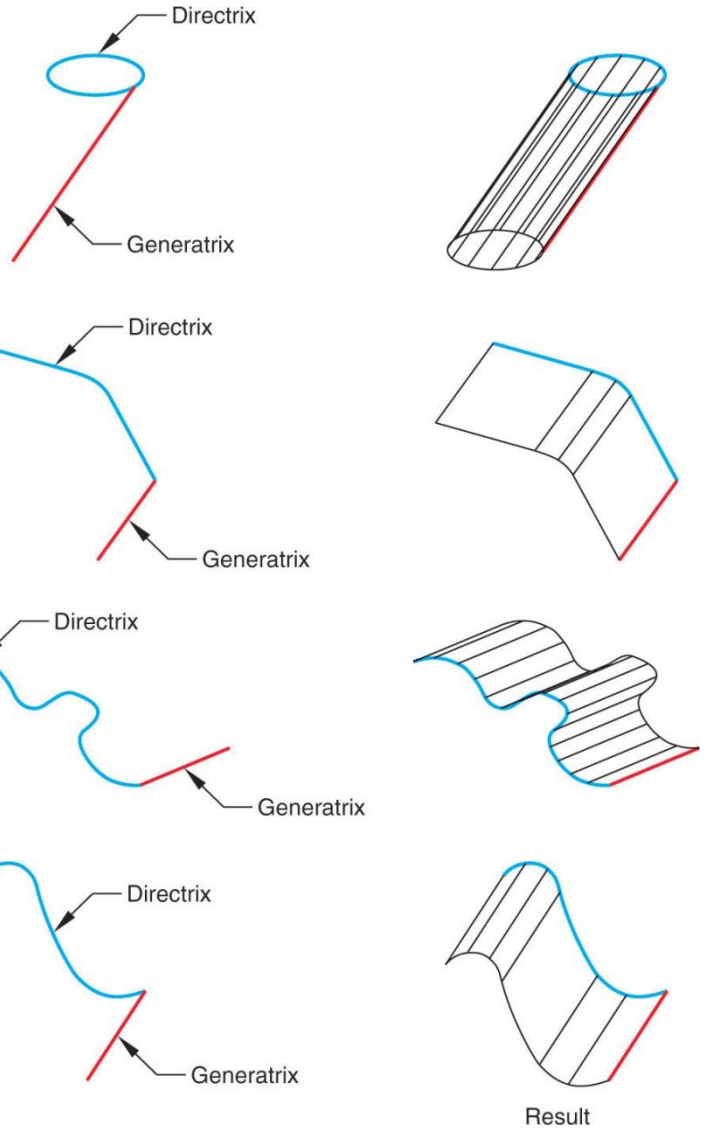


Which face is in front and which is in back?

Surface Modeling

Swept surfaces

Generating swept surfaces by sweeping generator entities along director entities.

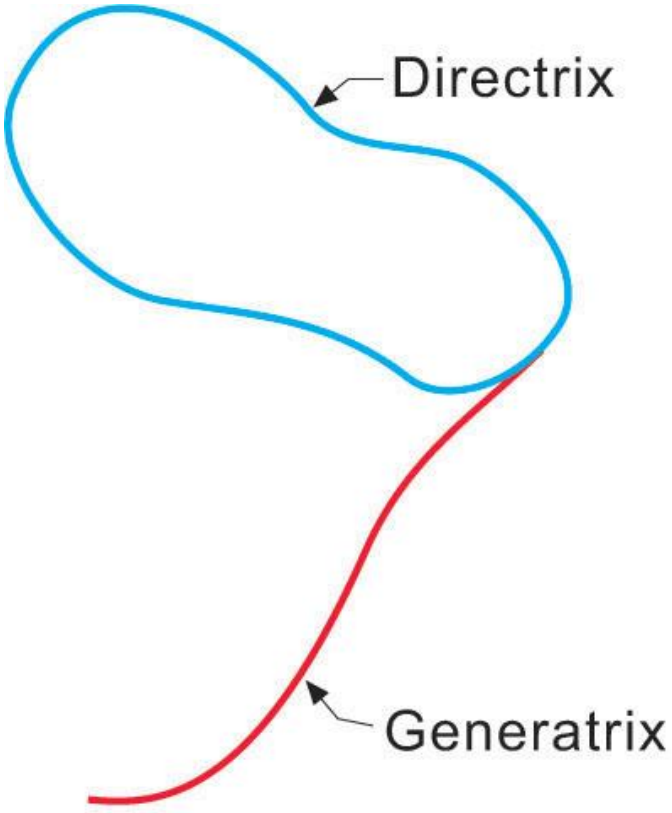


3-D Modeling

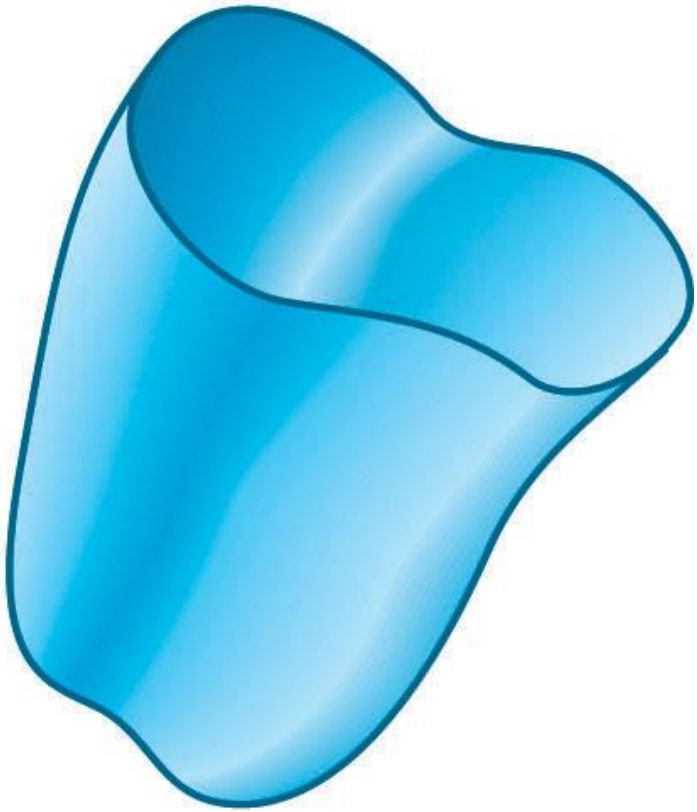
Surface Modeling

Complex surface

A more complex surface can be created by sweeping directrix along a curved generatrix.



(A)

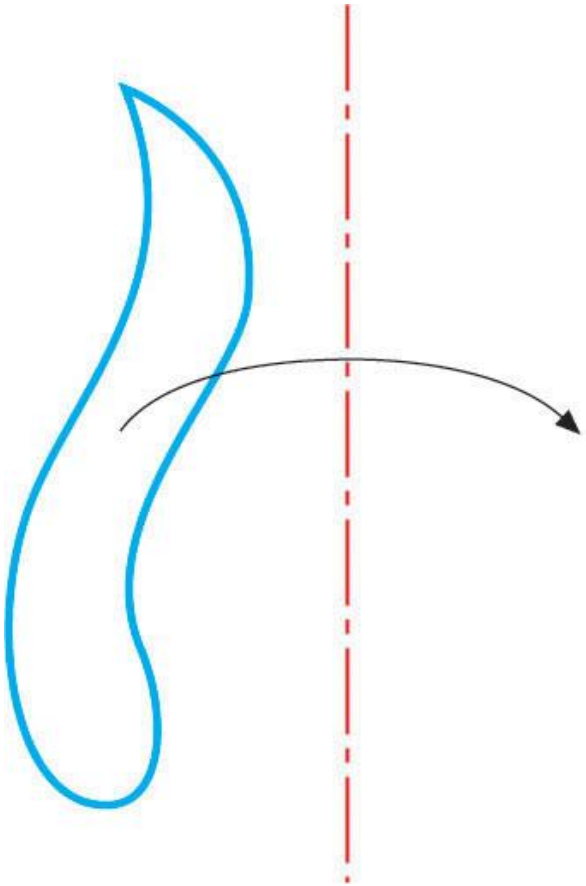


(B)

Surface Modeling

Revolved surface

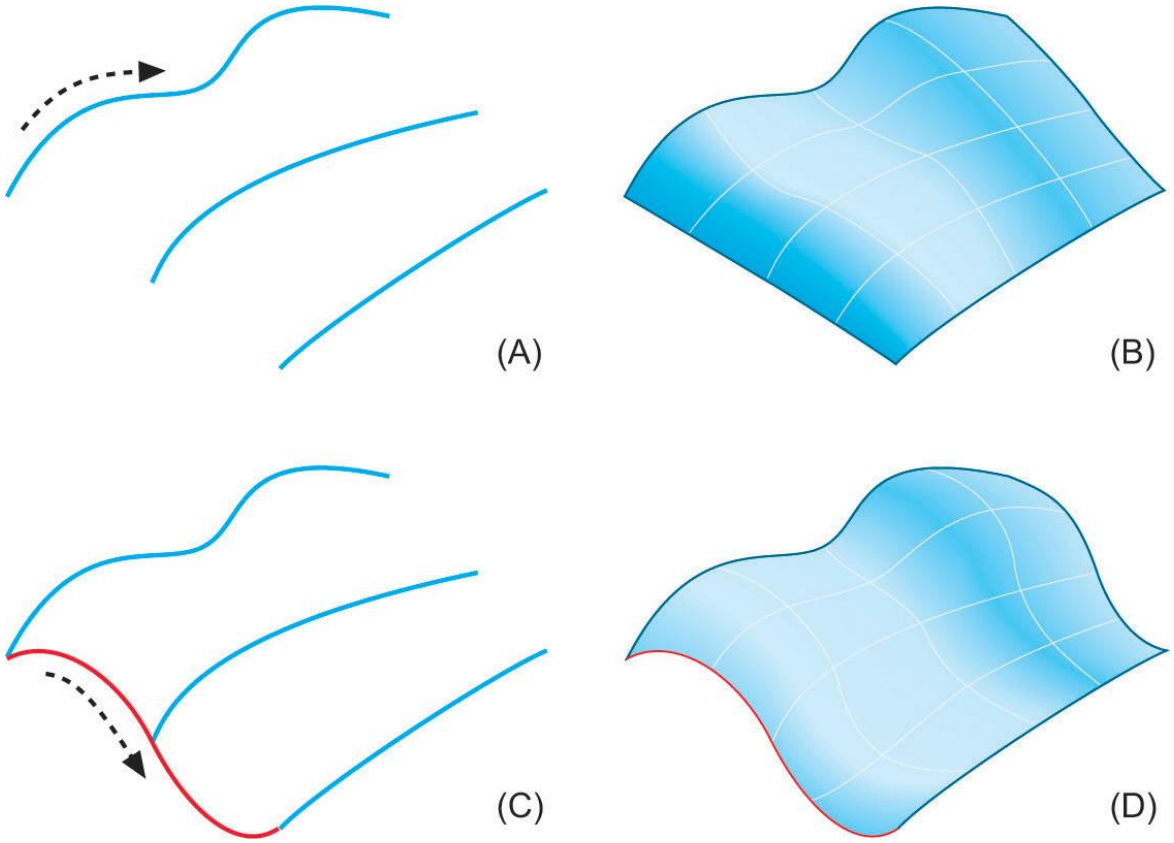
A directrix can be rotated about an axis between 1 and 360 degrees.



Surface Modeling

Lofting to define a surface

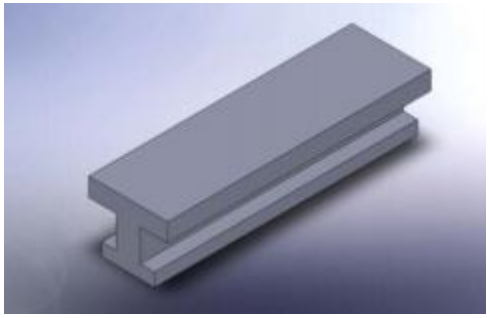
Lofting uses two or more directrix curves to define a surface.

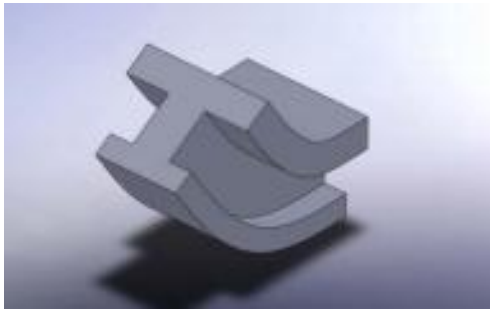


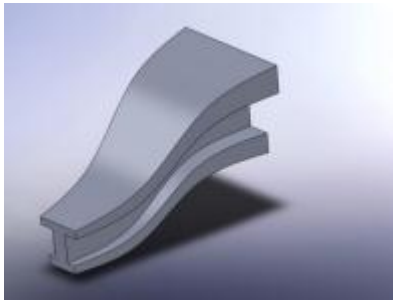
3-D Modeling

Solid Modeling

- Extrude
  - Constant cross-section
  - along a straight line
- Revolve
  - Constant cross-section
  - around an axis of revolution
- Sweep
  - Constant cross-section
  - along a space curve
- Loft
  - Multiple cross-sections
  - along a space curve







English – Turkish Dictionary

spline	Şerit, eğri cetveli	**polyline**	Çoklu çizgi	**polygon**	çokgen
rectange	dikdörtgen	**arc**	yay	**width**	(Çizgi) kalınlığı
vertex	Tepe noktası	**edit**	düzenleme	**fit**	uyma
decurve	Eğriyi kaldırma	**side**	kenar	**center**	merkez
circle	Çember, daire	**tangent**	teğet	**chord**	kiriş
radius	yarıçap	**diameter**	çap	**secant**	Eğriyi kesen çizgi
angle	açı	**ellipse**	elips	**chamfer**	Pah kırma
fillet	Kavis, köşe yuvarlatma	**default**	varsayılan	**Minor axis**	Küçük eksen
slope	eğim	**inscribed**	İçine çizili	**circumscribed**	Dışına çizili
circumference	çevre	**area**	alan	**join**	birleştirme
direction	istikamet	**Start point**	Başlama noktası	**End point**	Bitiş noktası