Concordia UNIVERSITY

Montreal, Quebec, Canada

Mechanical Engineering Drawing

MECH 211

LECTURE 2

The design process

- A design is created after analysis, full understanding of requirements and constraints and synthesis

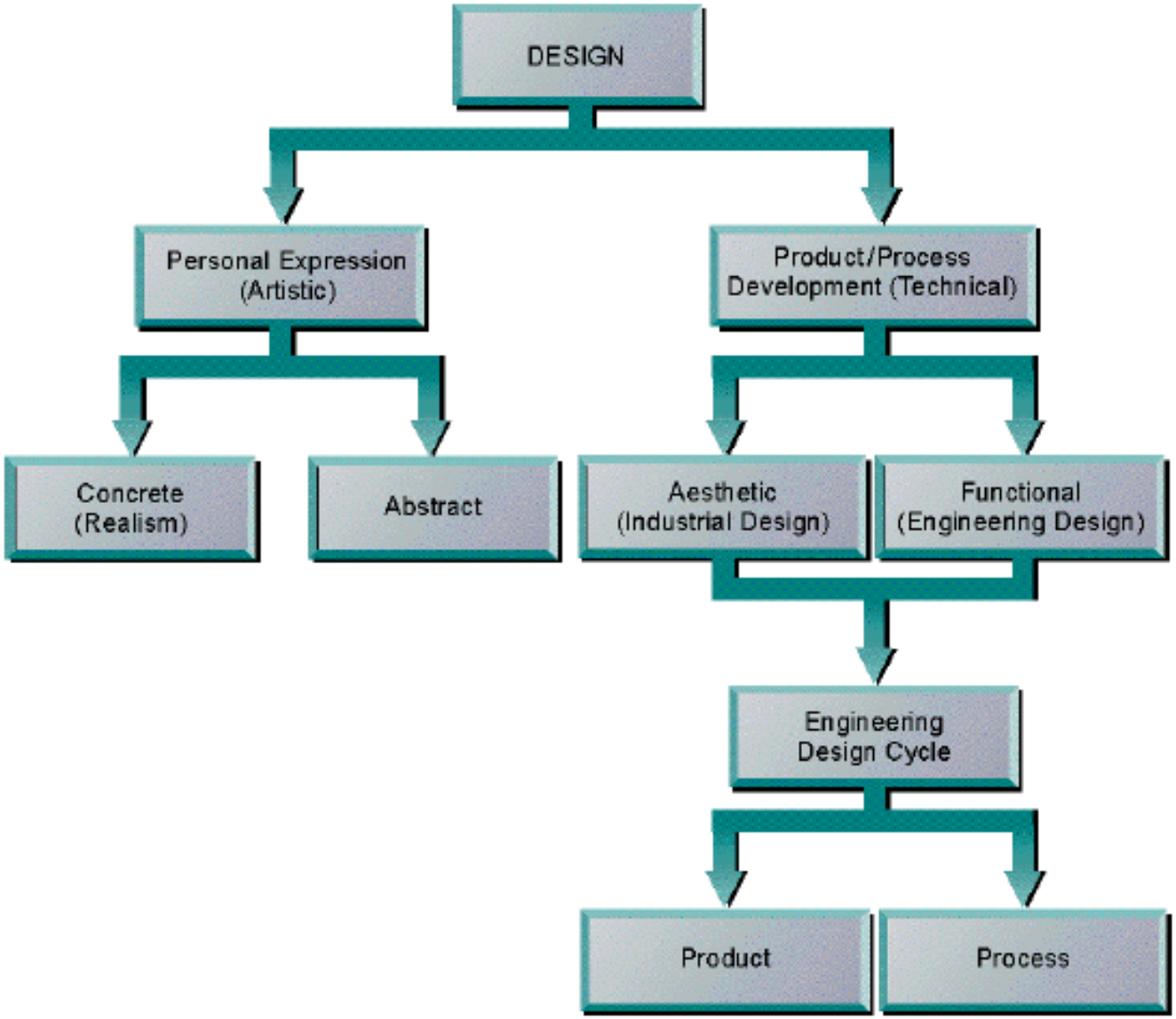
- Two individuals may not come with the same solution to the same problem

  - Example: Connect two straight pipes ND 4” to avoid leaking of the gas and to permit easy maintenance of the segment

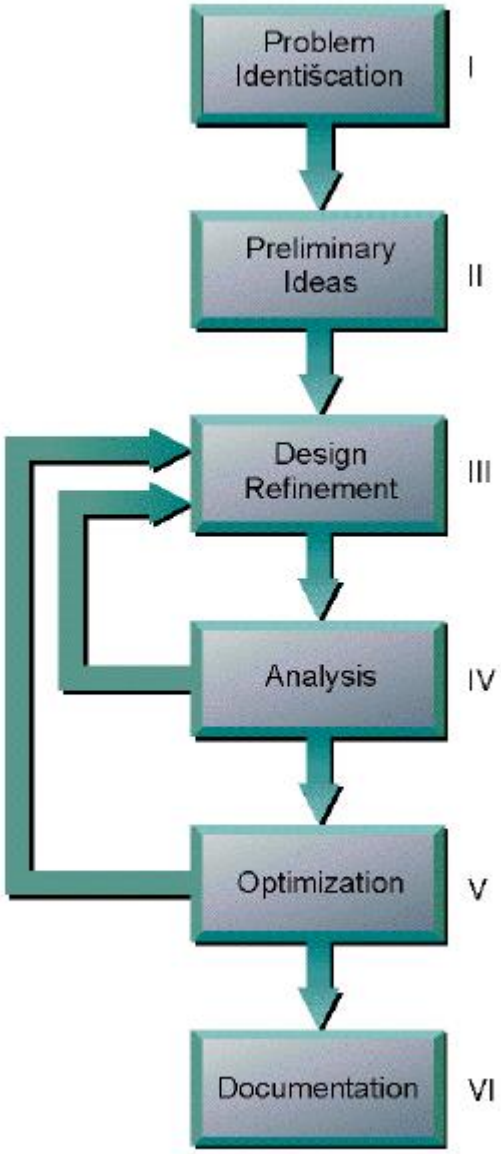
Solutions to the problem

- Multiple: flanges, clips, clamps, seals, etc.

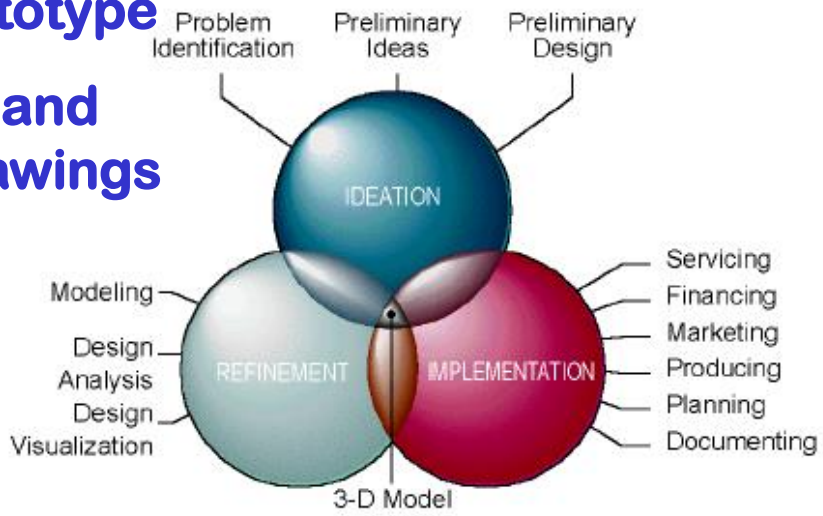
The design process



The design process

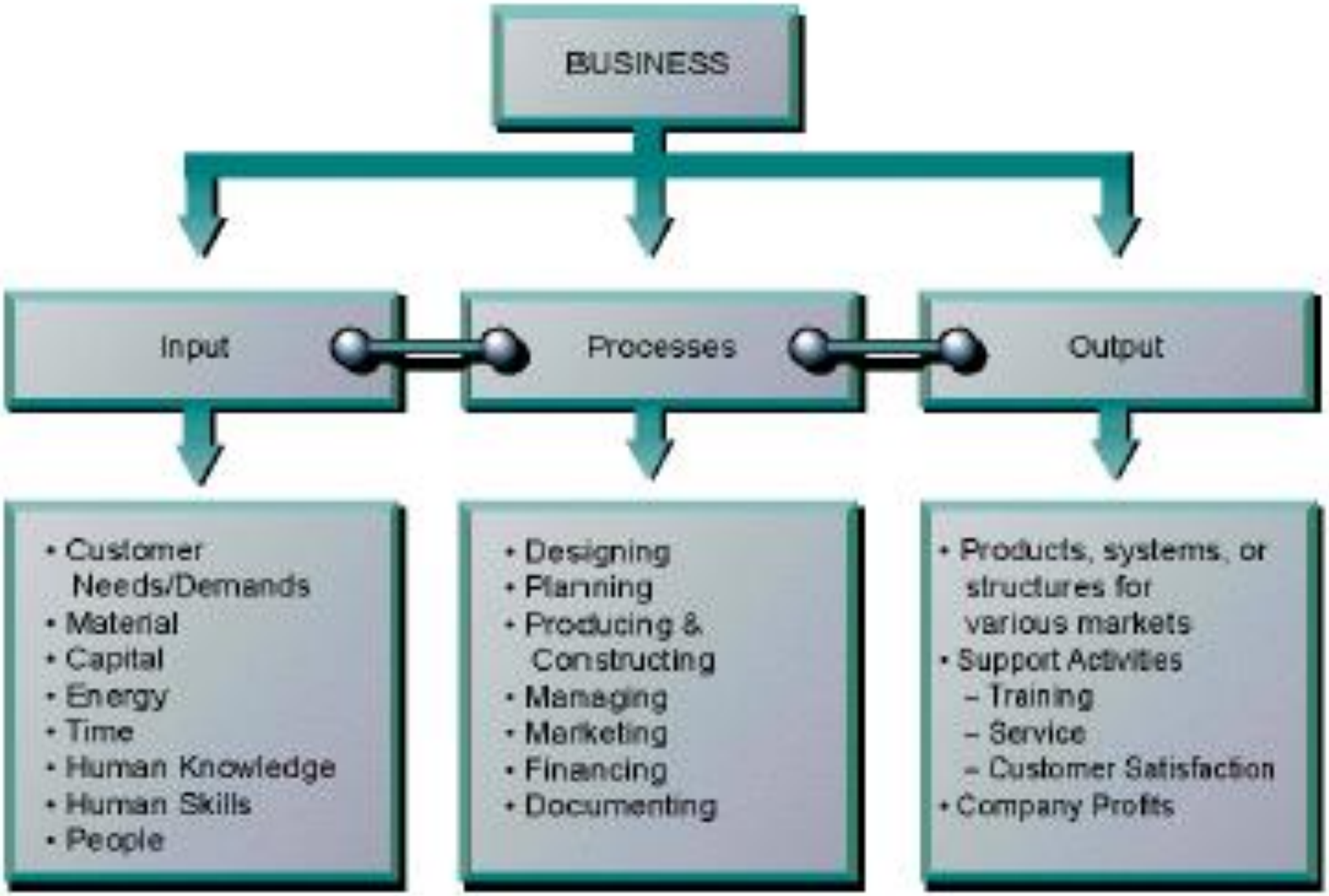


1. **Problem Defn.**
2. **Concept and ideas**
3. **Solutions**
4. **Models/Prototype**
5. **Production and working drawings**

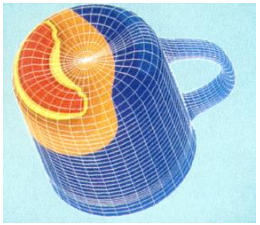


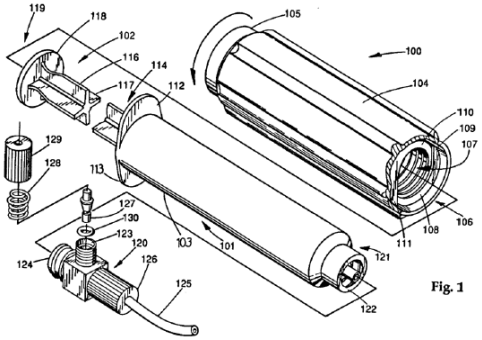
Concurrent engineering approach

The design process



Drawings in product development





Designer

Sketches

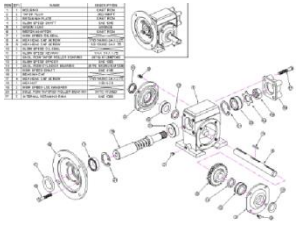
Functional Drawings

Vendors/ Customers

Mechanical Engineer

Prod. drawings

Production Shops



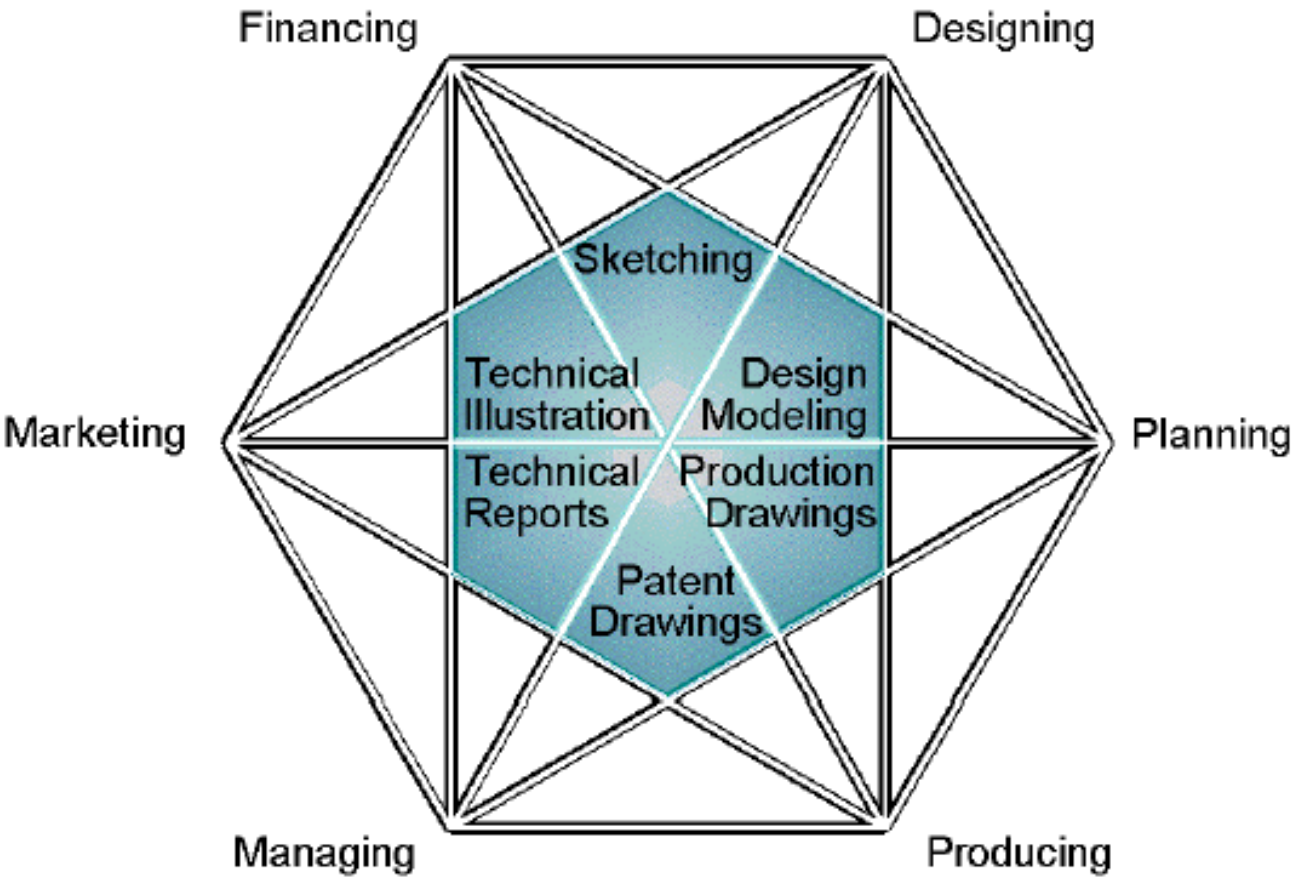
Assembly Drawings

Assembly Drawings

Quality Assurance

Assembly

Drawings in product development



Content of the lecture

- Drawing instruments and practices
- Graphic constructions – more during the tutorial period
- Computer Aided Design (CAD) Tools
    - CAD comprehensive tools
    - Demonstration on AutoCAD

Assignments

- This week you will start to solve assignments
- The problem numbers and page numbers are given in the web (for edition 8) along with the due date for submission.
- Draw on paper the solution
- Submit the hard-copy to the relevant TA

Tutorials

- There is no scheduled AUTOCAD lab for this course
- However you can do practice with AutoCAD during the tutorials and or in any free time you have.
- Most ENCS labs are equipped with AutoCAD.

Anatomy of Engg. Laboratory

- Starting 2007, there is a lab component for this course
- The schedule and venue for the lab is available in the course outline
- Safety is of utmost importance
- So is your preparation for what you have to do during your scheduled time in the lab

Drawing instruments

- Depending on the practice condition
- Basic representations performed by free hand sketching – require paper and pencil
- To-scale sketching requires drafting tools
- Component design – CADS tools
  - Changes could be fast operated
  - Solid model is created
  - Analysis is carried out with minimal effort
  - Easy portable

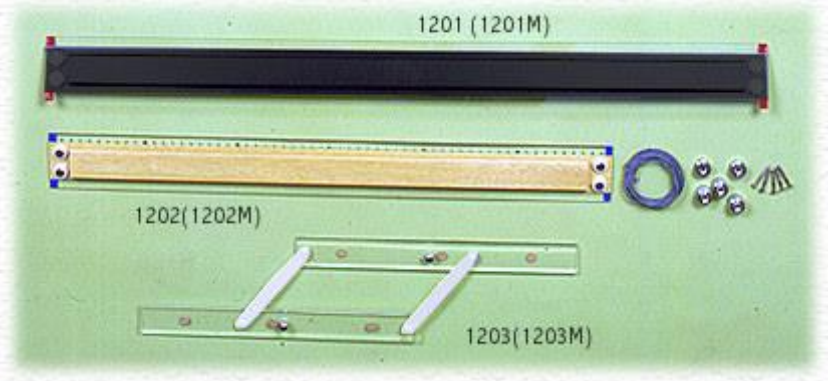
Drafting tools

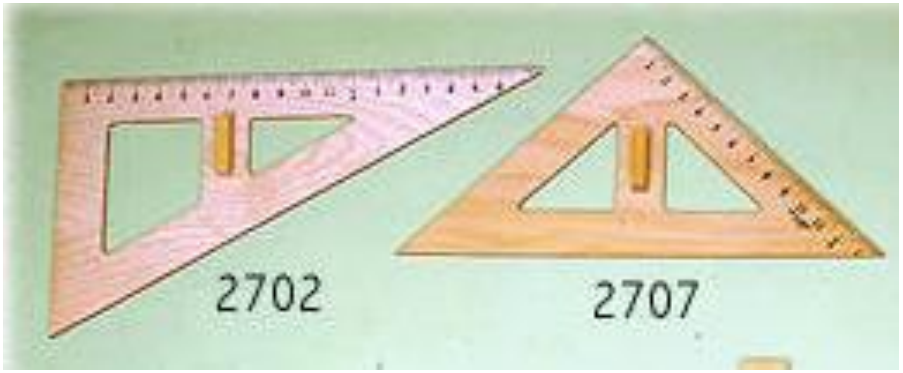
- Engineering drafting tools

Parallel rulers, Squares (30º/60º)

- Draw straight lines
- Provide support to squares for lining (hatching)

- Draw straight perpendicular lines
- Draw parallel lines to a specific direction



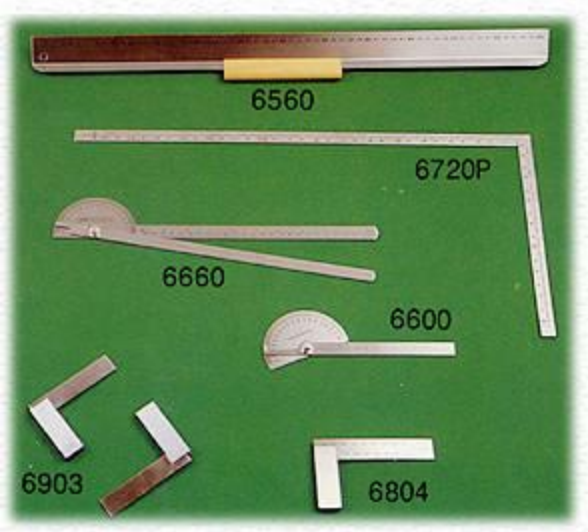


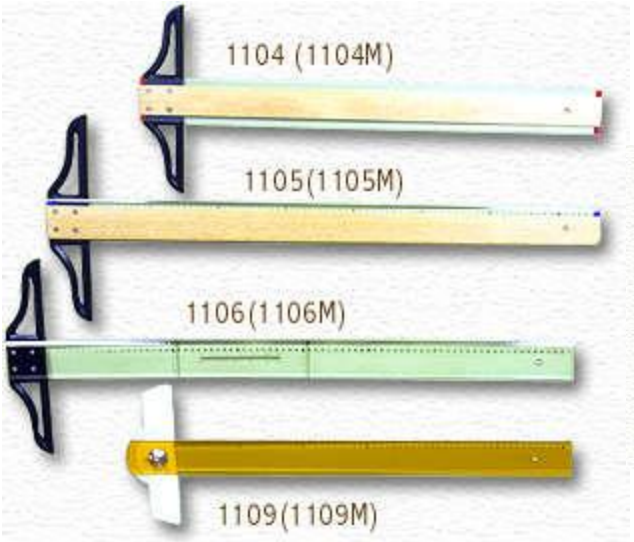
Compasses, dividers

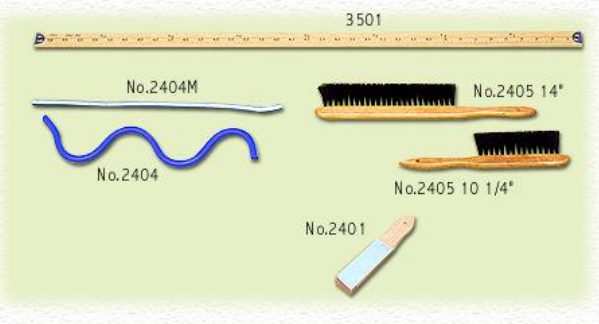
- Draw circles, arcs
- Used to perform geometric constructions: divisions, measurements, copying of dimensions
- Used to draw specific angles:
  - 30º, 60º, 45º, 90º

Protractors, T-squares, splines

- Measure angles, maintain a fixed direction, connect two lines by a curve







Why learn to use drafting tools?

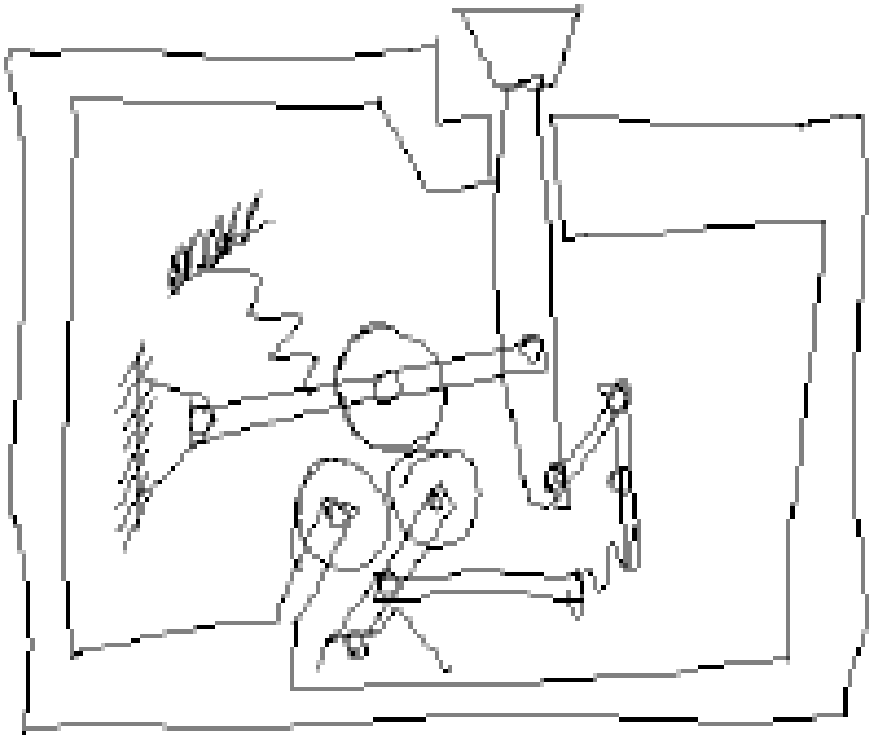
- CAD Tools are not easily available – computer, power and software are needed
- Some jobs could be easier performed using graphics tools
- Hand drawing is another skill that the designer needs to acquire
- Enhances the designer capability to perform better quality free hand sketching

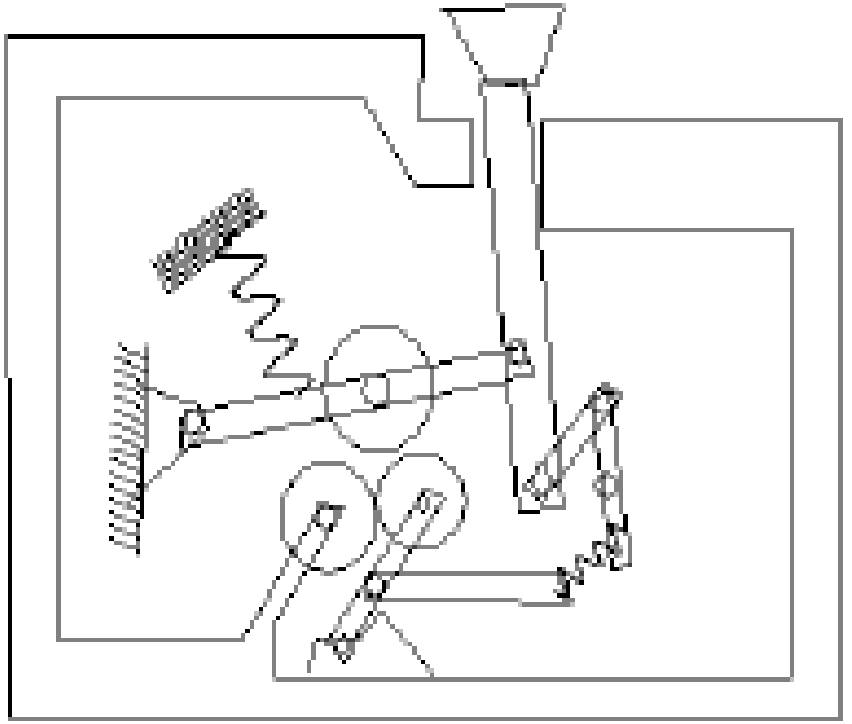
Why free-hand sketching?

- Perform a sketch without rulers, triangles or compasses, only by free hand
- Ideation, conceptual proofing, technical dialogue – all require free-sketching capabilities
- Often, the first conceptual sketches are carried out outside an office
- Added skills to the designer
- Include within the sketch all the needed information or to convey or to understand when reviewing, an idea.

Free Hand Sketching

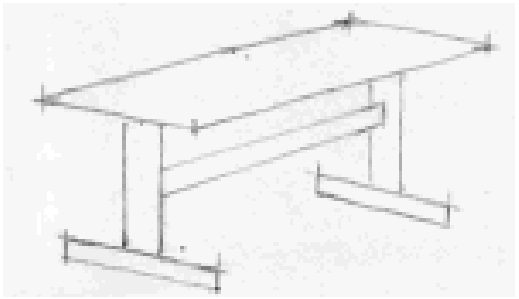
- Example:

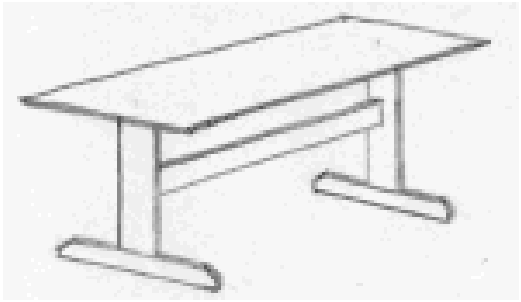


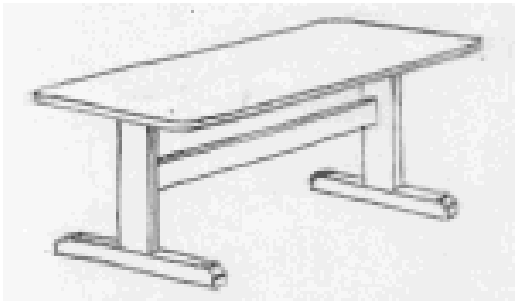


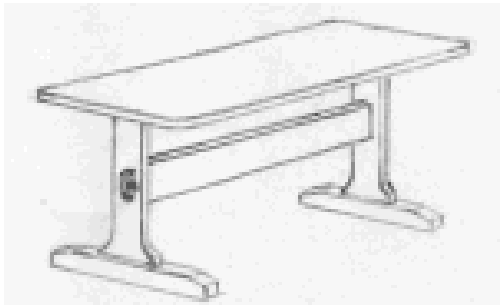
Free Hand Sketching

- Sketches could be performed for various level of detailing



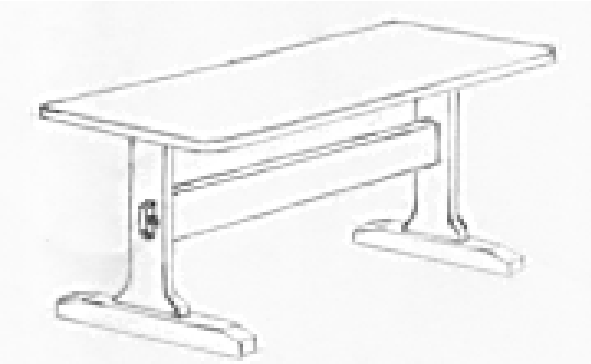


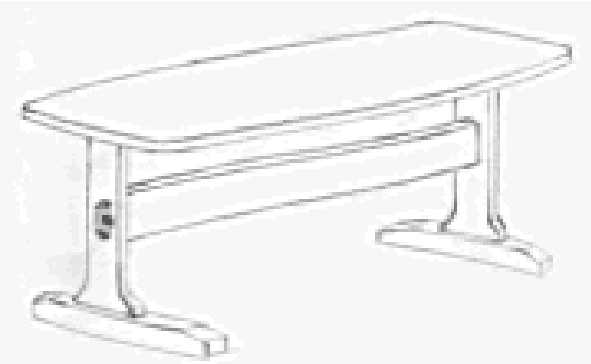


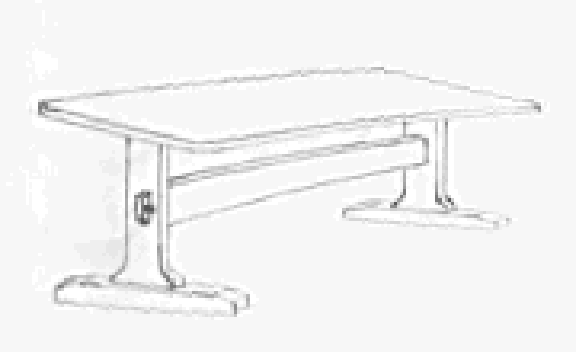


Free Hand Sketching

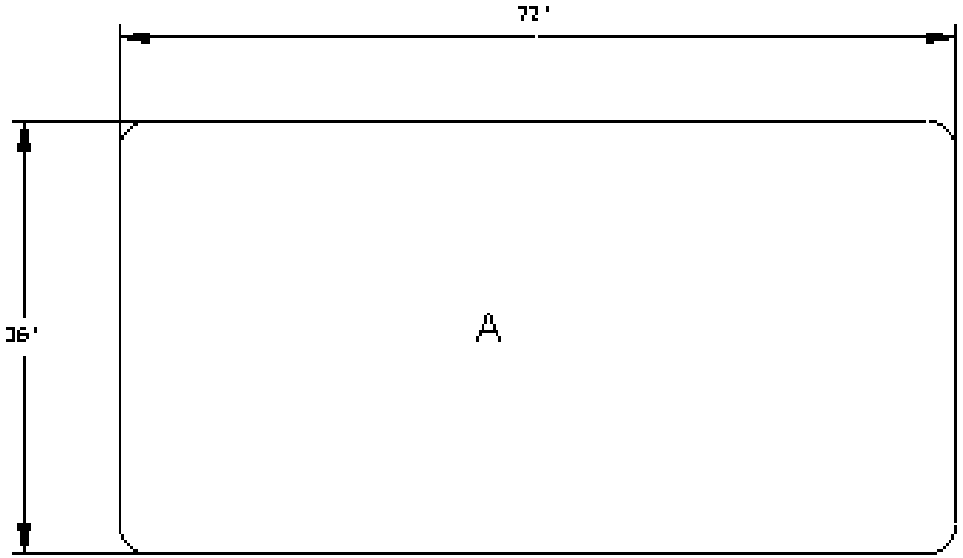
- Projection type is also important







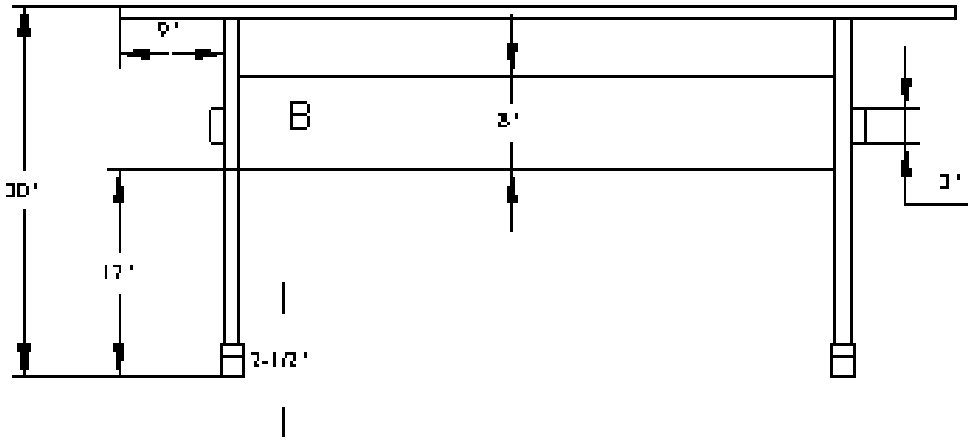
Free Hand Sketching

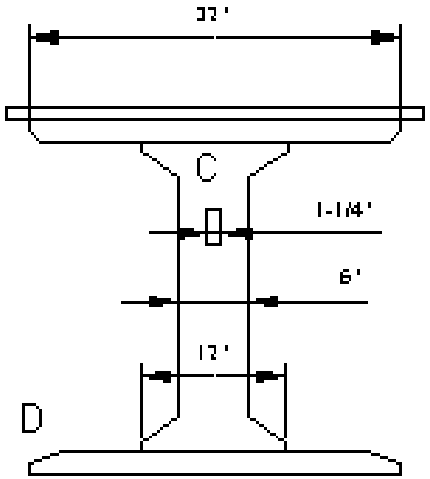


TRESTLE TABLE
(3/16/2002)

- The ultimate objective – the working drawing production

SCALE: 1/8" = 1"





Free Hand Sketching

- How to practice?
- Select objects that you could sketch for various levels of detailing – DRAW IT!
- Try to represent one of your ideas on a new product (say, a car, a boat, an airplane, etc.).
- After production, ask one of your colleagues to have a look and tell you what he understands out from your sketch

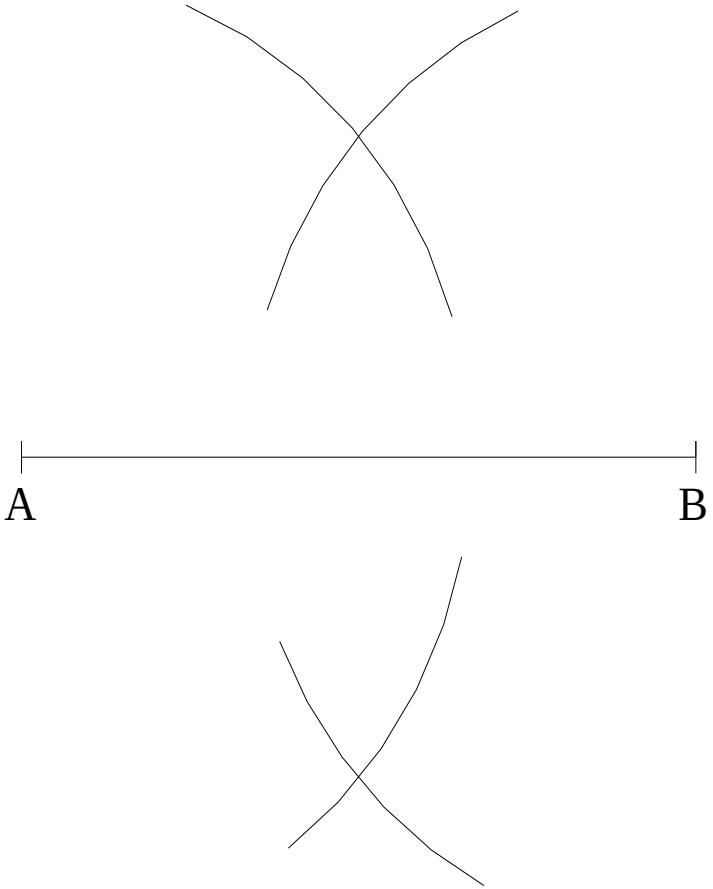
Graphic constructions

- EXAMPLES: Making use of the drawing tools only, draw:
  - Line perpendicular to a segment passing through the middle point
  - Bisection line of an angle
  - Tri-section lines of a 90° angle
  - A hexagon inscribed into a given circle
  - A point on a segment that divides the line in a given ratio

Example-Graphic construction

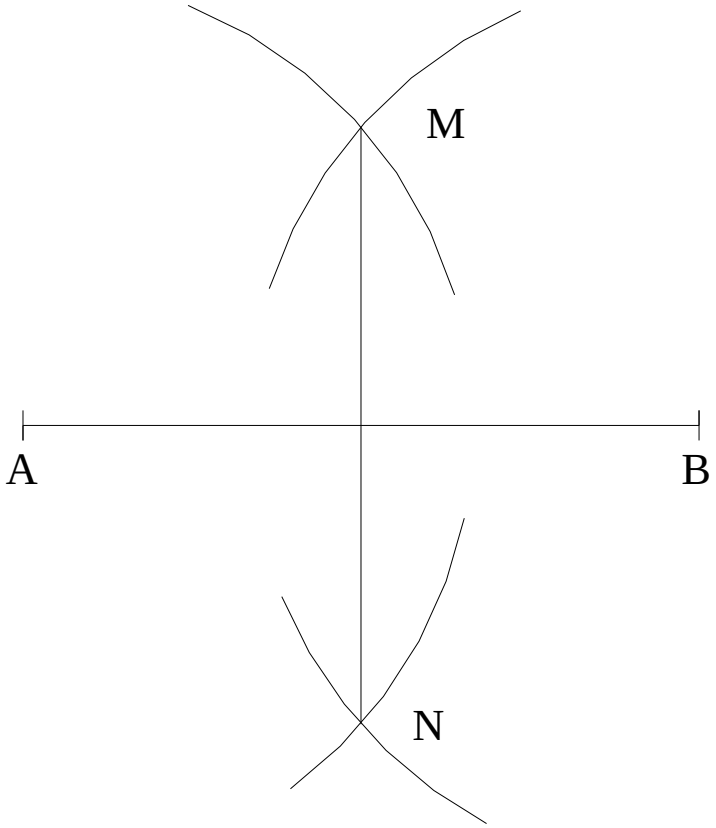
- Given the segment AB, Draw line perpendicular to the direction AB passing through the centre of the segment AB

Example-Graphic construction



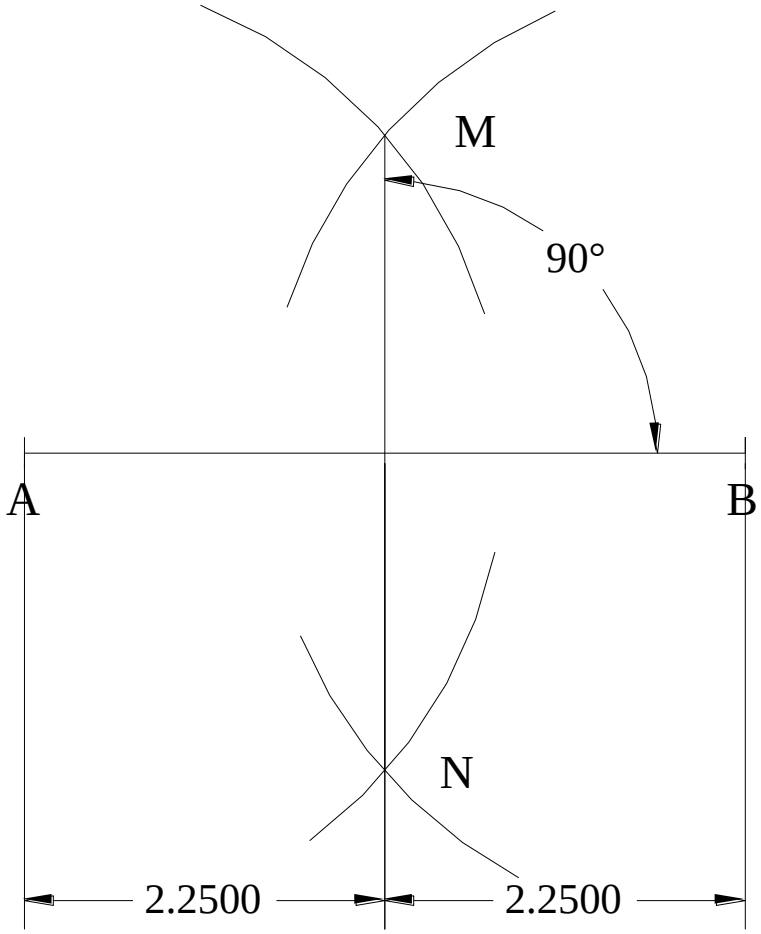
- Given the segment AB, Draw line perpendicular to the direction AB passing through the centre of the segment AB
- With compass in the point A and B opened larger than half of the segment draw two arcs above and below the segment
- Maintain the opening of the compass do not change it while moving

Example-Graphic construction



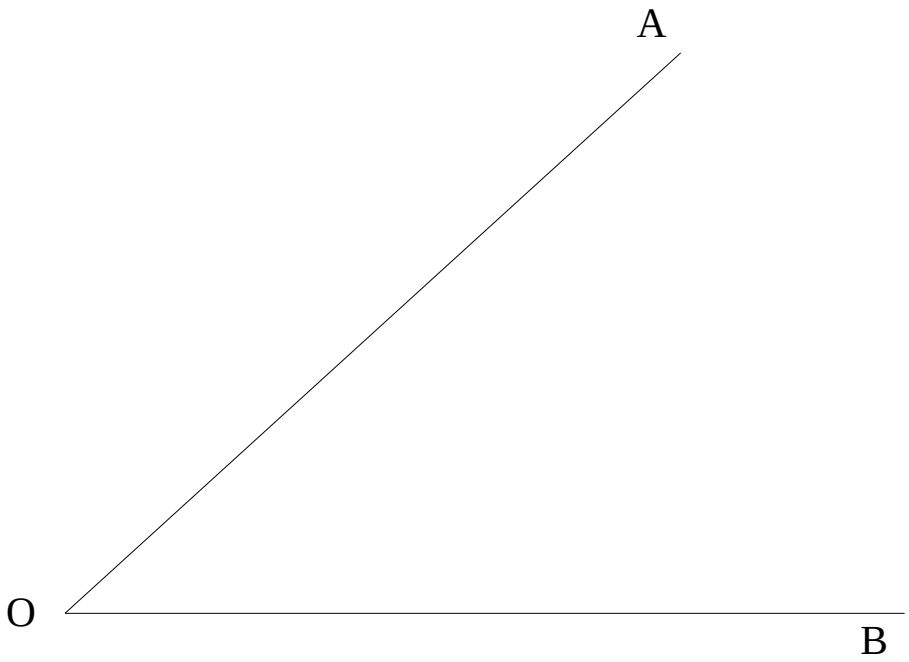
- Given the segment AB, Draw line perpendicular to the direction AB passing through the centre of the segment AB
- With compass in the point A and B opened larger than half of the segment draw two arcs above and below the segment
- Maintain the opening of the compass do not change it while moving
- Line MN is the line that is asked for

Example-Graphic construction



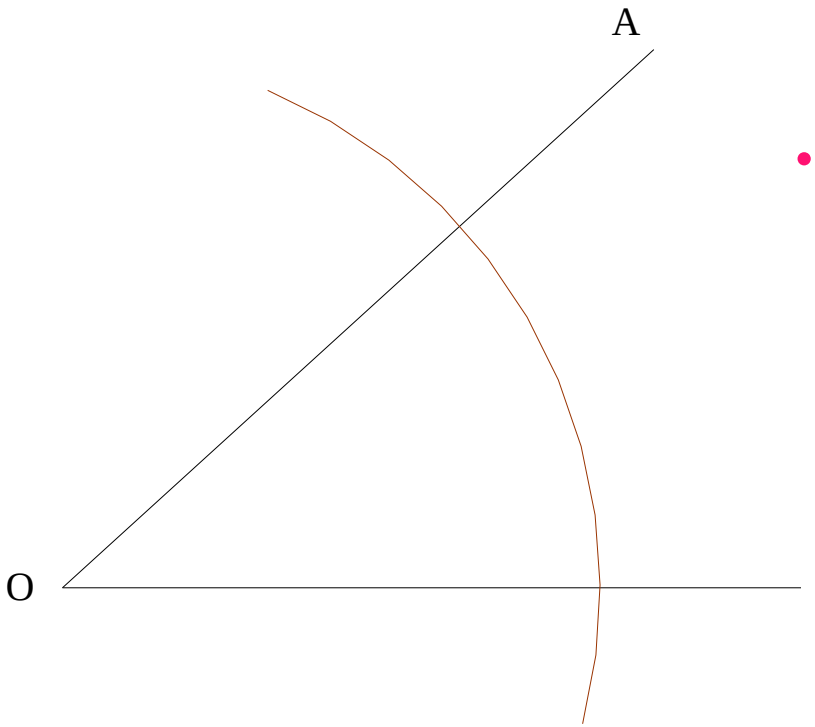
- Given the segment AB, Draw line perpendicular to the direction AB passing through the centre of the segment AB
- With compass in the point A and B opened larger than half of the segment draw two arcs above and below the segment
- Maintain the opening of the compass do not change it while moving
- Line MN is the line that is asked for

Example 2 -Graphic construction



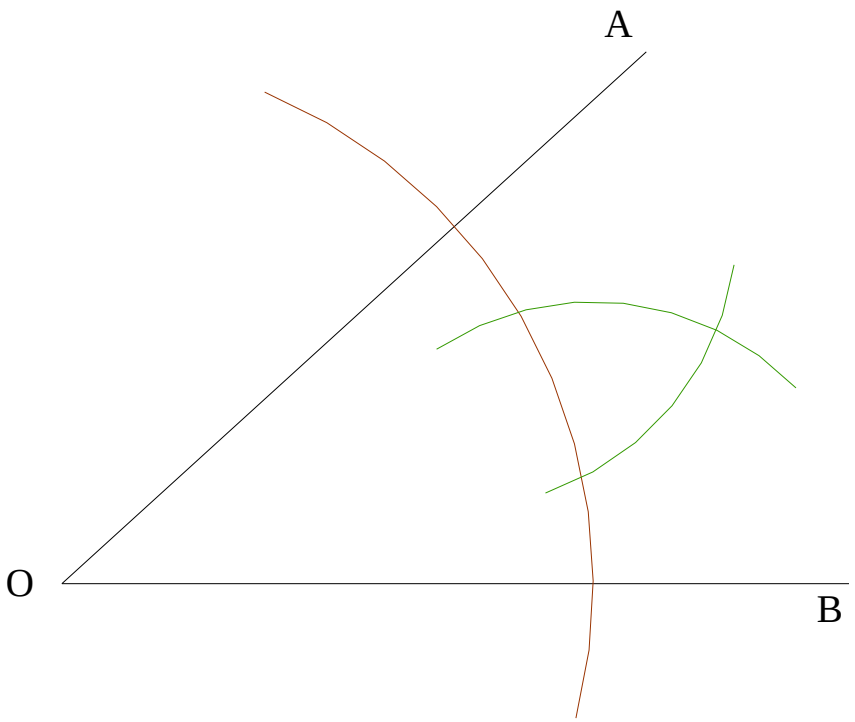
- Given an angle, find the line that passes through point O and divides the angle in two equal parts

Example 2 -Graphic construction



- Given an angle, find the line that passes through point O and divides the angle in two equal parts
- With a convenient opening in the compass draw and arc with centre in O and that intersects OA and OB

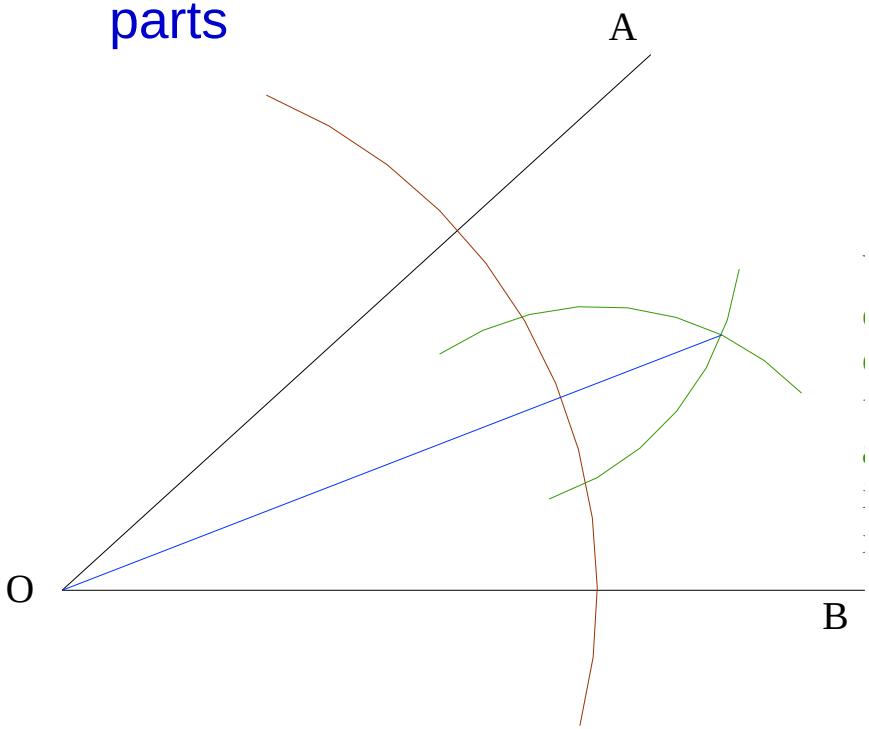
Example 2 -Graphic construction



- Given an angle, find the line that passes through point O and divides the angle in two equal parts
- With a convenient opening in the compass draw and arc with centre in O and that intersects OA and OB
- With same or another convenient opening in compass, larger than half of the arc size, draw two arcs with centers located in the previous points of intersection

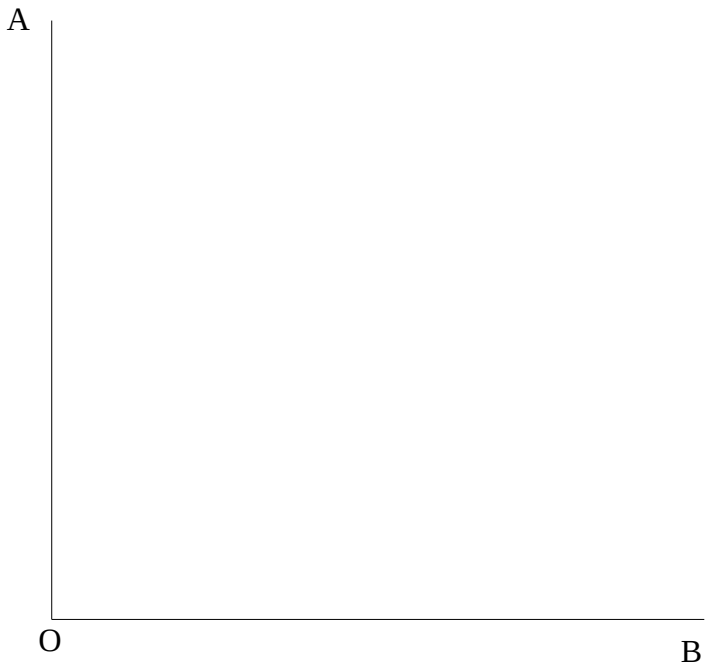
Example 2 -Graphic construction

- Given an angle, find the line that passes through point O and divides the angle in two equal parts



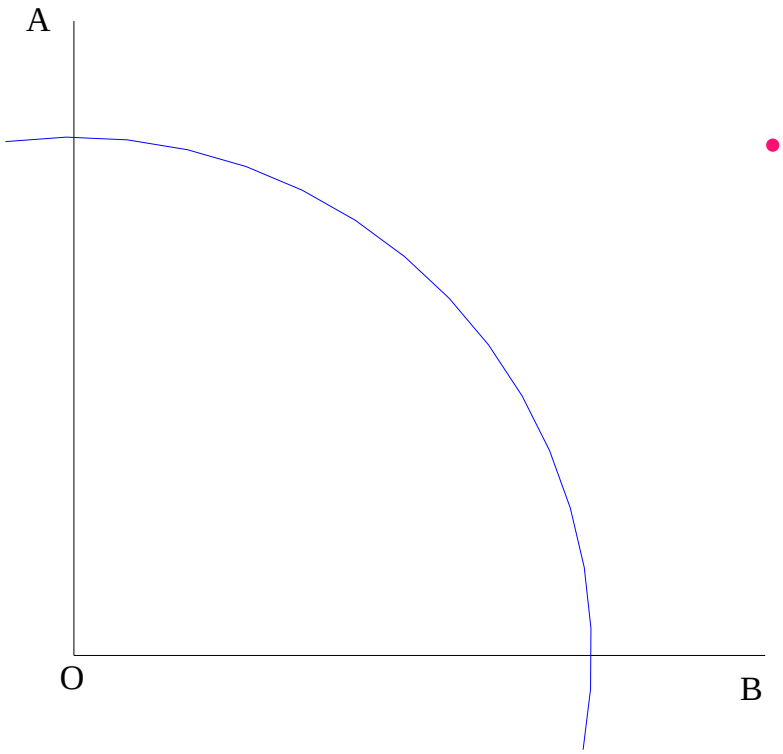
- With a convenient opening in the compass draw a continuous arc with centre in O and that intersects both OA and OB through shortest distance
- With same or another convenient opening in compass, larger than half of the arc size, draw two arcs with centers located in the previous points of intersection
- The line that connects the point O with the last intersection point, as shown in figure is the bisectory line of the angle

Example 3 -Graphic construction



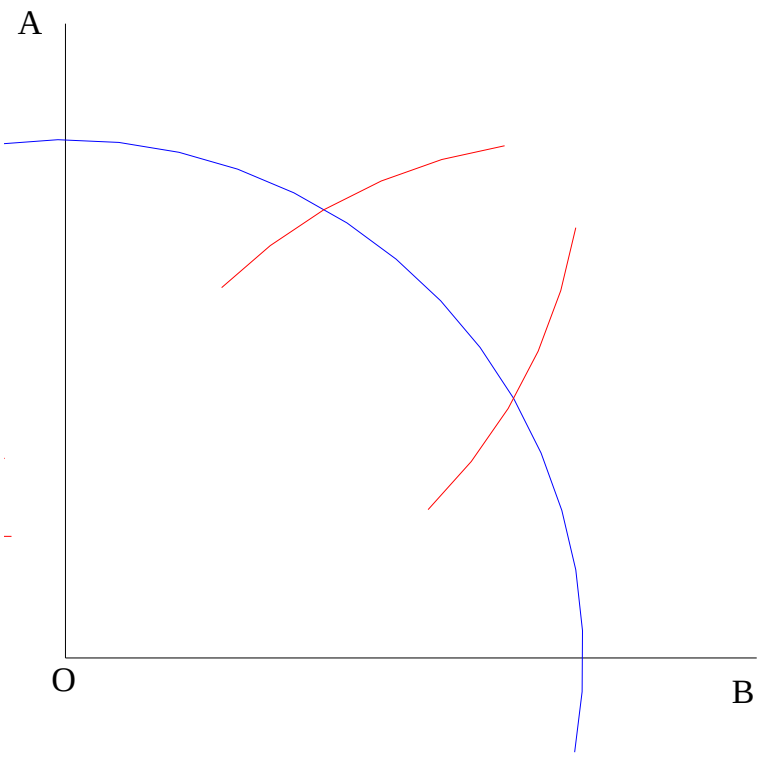
- Given the 90° angle, find two lines that pass through point O and divides the angle in three equal parts (30° each)

Example 3 -Graphic construction



- Given the 90° angle, find two lines that pass through point O and divides the angle in three equal parts (30° each)
- With a convenient opening in the compass draw a continuous arc with centre in O and that intersects both OA and OB through shortest distance

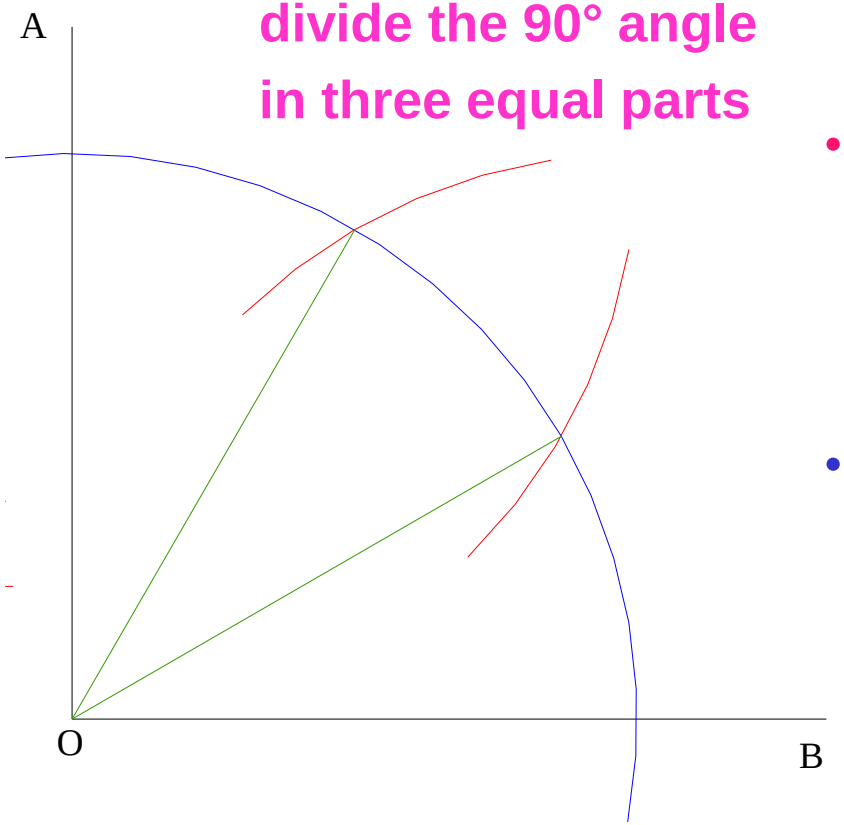
Example 3 -Graphic construction



- Given the 90° angle, find two lines that pass through point O and divides the angle in three equal parts (30° each)
- With a convenient opening in the compass draw a continuous arc with centre in O and that intersects both OA and OB through shortest distance
- Maintaining the same opening of the compass, draw arcs to cut the previously drawn arc with centre at the intersections of the arc with OA and OB respectively

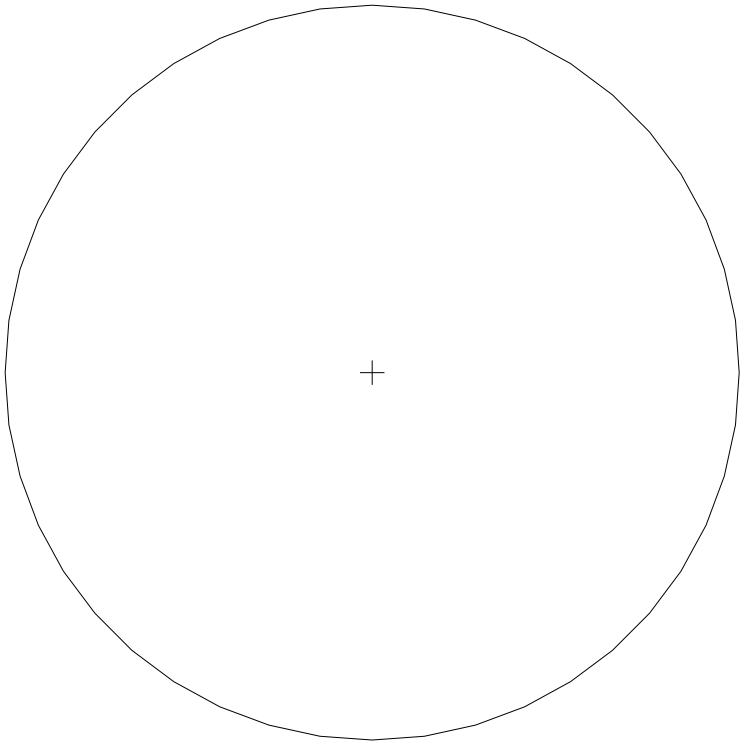
Example 3 -Graphic construction

The two segments divide the 90° angle in three equal parts



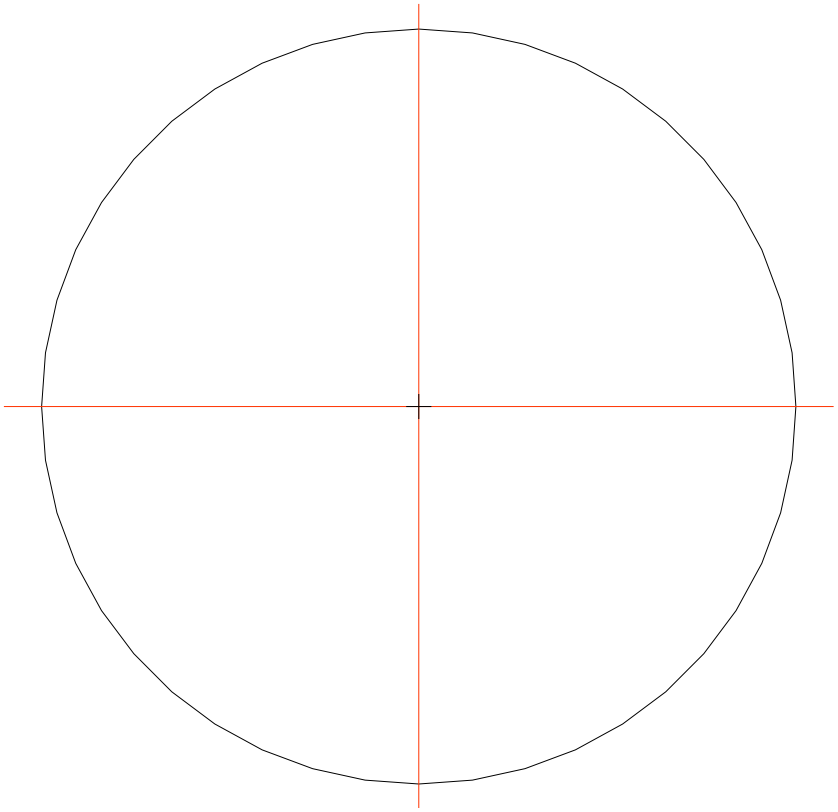
- Given the 90° angle, find two lines that pass through point O and divides the angle in three equal parts (30° each)
- With a convenient opening in the compass draw a continuous arc with centre in O and that intersects both OA and OB through shortest distance
- Maintaining the same opening of the compass, draw arcs to cut the previously drawn arc with centre at the intersections of the arc with OA and OB respectively
- The two segments divide the 90° angle in three equal parts

Example 4 -Graphic construction



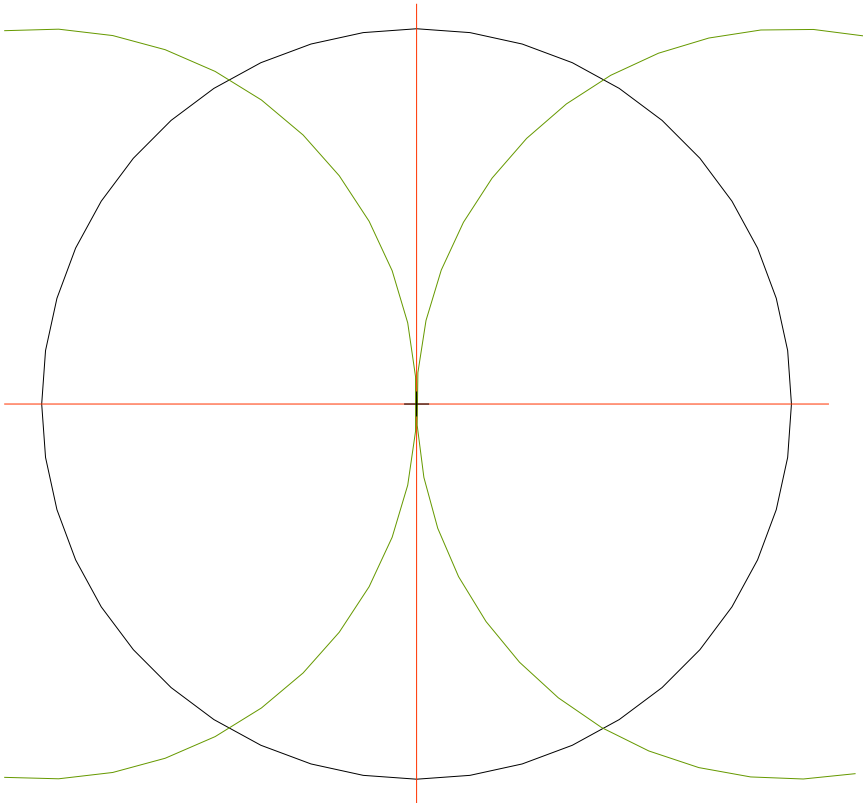
- Given the circle of radius R, inscribe a hexagon inside the circle

Example 4 -Graphic construction



- Given the circle of radius R, inscribe a hexagon inside the circle
- Draw two perpendicular diameters that pass through the centre of the circle. Select one of the diameters as the reference. Two of the sides of the hexagon will be perpendicular to the other diameter

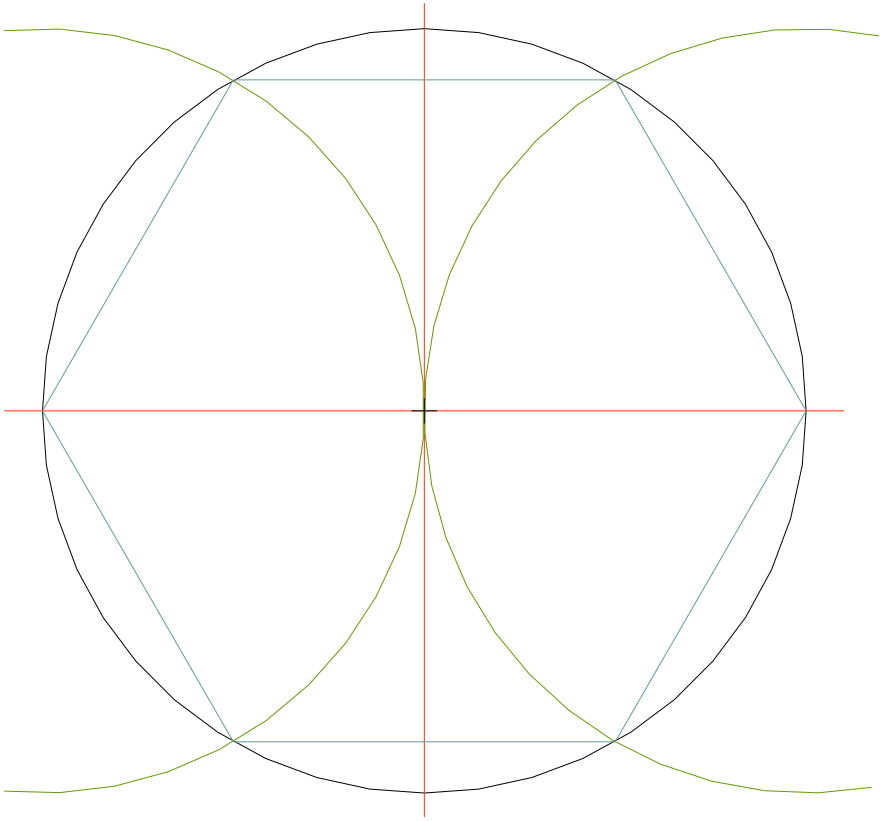
Example 4 -Graphic construction



- Given the circle of radius R, inscribe a hexagon inside the circle
- Draw two perpendicular diameters that pass through the centre of the circle. Select one of the diameters as the reference. Two of the sides of the hexagon will be perpendicular to the other diameter
- From the intersection of the reference diameter with the circle, draw two arcs of same opening as the circle to intersect the given circle in 4 points

Example 4 -Graphic construction

- Given the circle of radius R, inscribe a hexagon inside the circle

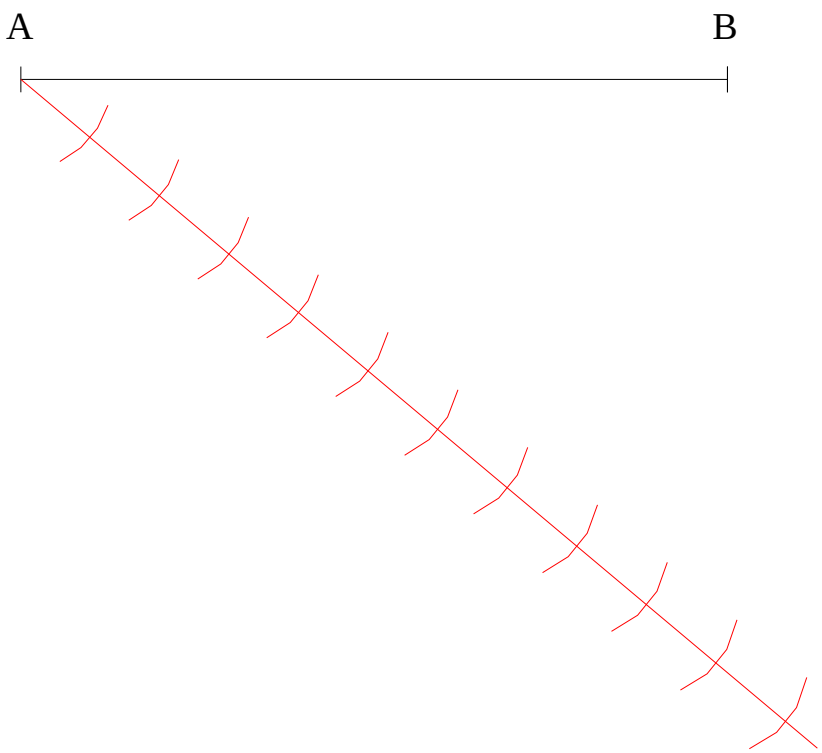


- Draw two perpendicular diameters that pass through the centre of the circle. Select one of the diameters as the reference. Two of the sixes of the hexagon will be perpendicular to the other diameter
- From the intersection of the reference diameter with the circle, draw two arcs of same opening as the circle to intersect the given circle in 4 points
- The four points of intersection and two centre of the arcs will form the hexagon when connected in order

Example 5 -Graphic construction

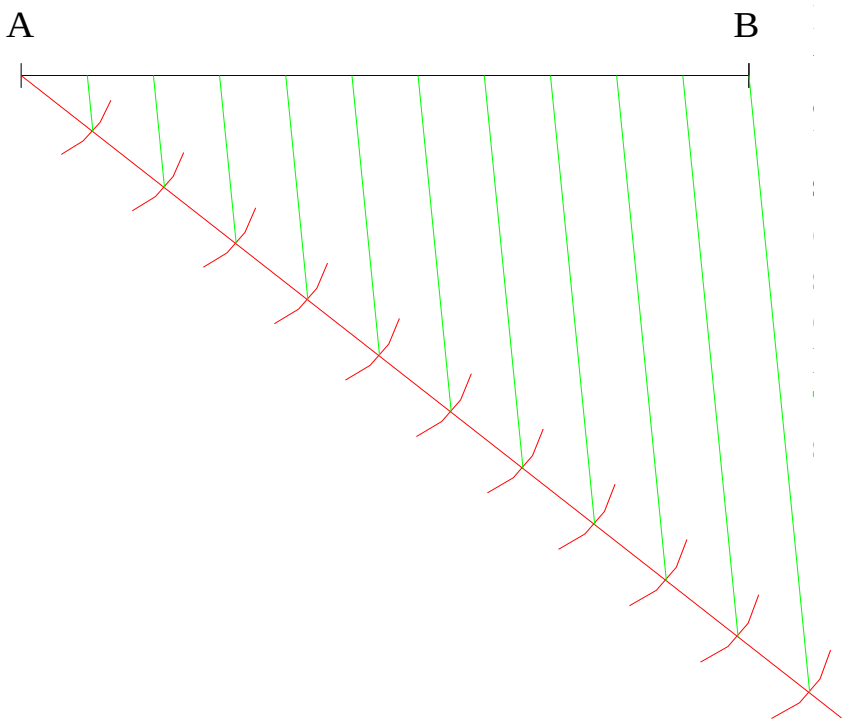
- Given the segment AB, find the point D such that the ratio of AD/BD is 5/6

Example 5 -Graphic construction



- Given the segment AB, find the point D such that the ratio of AD/BD is 5/6
- Ratio of 5/6 requires 11 equal segments to be built. Draw a line of convenient direction passing though either A or B. the line should be long enough to accommodate 11 equal segments of appropriate length

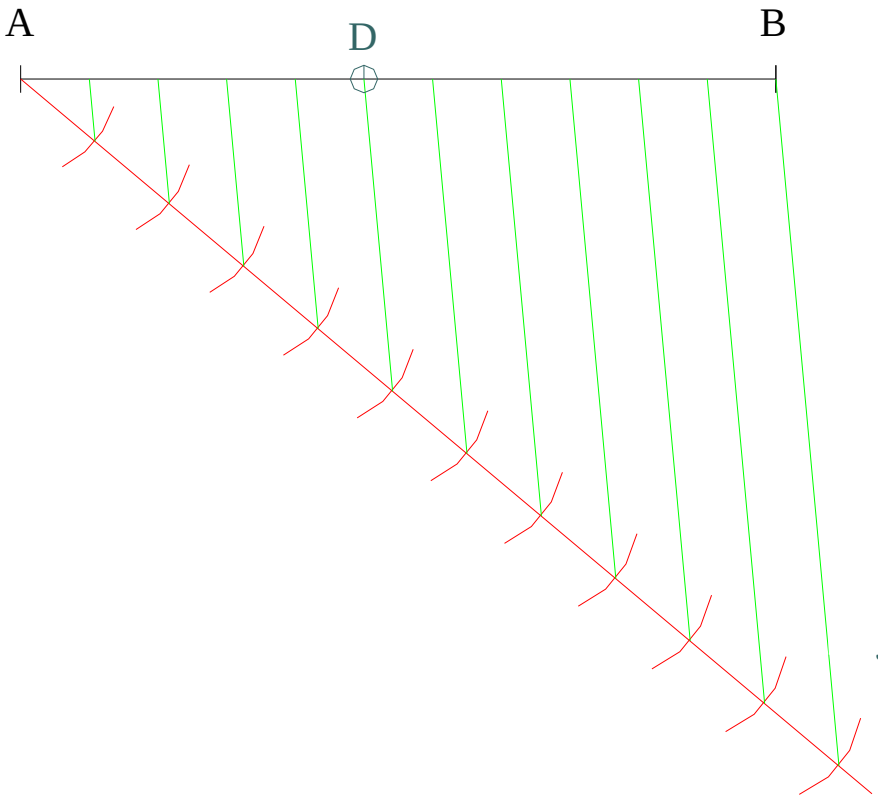
Example 5 -Graphic construction



- Given the segment AB, find the point D such that the ratio of AD/BD is 5/6
- Ratio of 5/6 requires 11 equal segments to be built. Draw a line of convenient direction passing though either A or B. the line should be long enough to accommodate 11 equal segments of appropriate length
- Connect the end of the last drawn segment of the auxiliary line to the other end of the line. Draw parallel lines to the previously described line. The parallel lines divide the segment AB into 11 equal segments

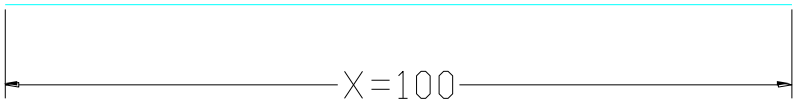
Example 5 -Graphic construction

- Given the segment AB, find the point D such that the ratio of AD/BD is 5/6



- Ratio of 5/6 requires 11 equal segments to be built. Draw a line of convenient direction passing though either A or B. the line should be long enough to accommodate 11 equal segments of appropriate length
- Connect the end of the last drawn segment of the auxiliary line to the other end of the line. Draw parallel lines to the previously described line. The parallel lines divide the segment AB into 11 equal segments
- Locate point D on the line AB such that AD = 5 segments while BD = 6 segments

Laying out an Angle

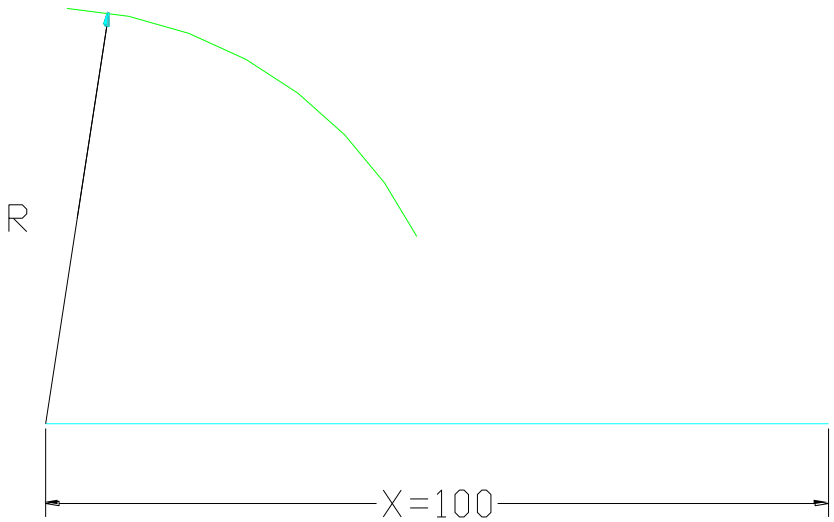


- Draw the line X to any convenient length (preferably 100 units)
- Find the Sine of the angle θ in the table of natural sine - Multiply that by the value length of the X (in this case 100) - Use this as Radius R

Laying Out An Angle.
Sine Method.

$$R = X\sin\theta$$
$$\theta = 33°16'$$
$$R = 100 \times \sin 33°16'$$
$$R = 100 \times 0.5485364$$
$$R = 54.85364$$

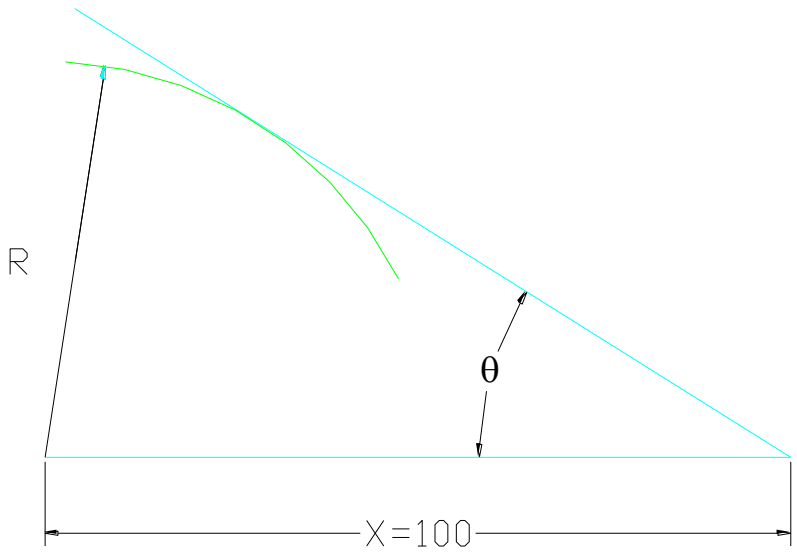
Laying out an Angle



Laying Out An Angle.
Sine Method.

- Draw the line X to any convenient length (preferably 100 units)
- Find the Sine of the angle θ in the table of natural sine - Multiply that by the value length of the X (in this case 100) - Use this as Radius R
- Strike an arc R = 54.85364

Laying out an Angle

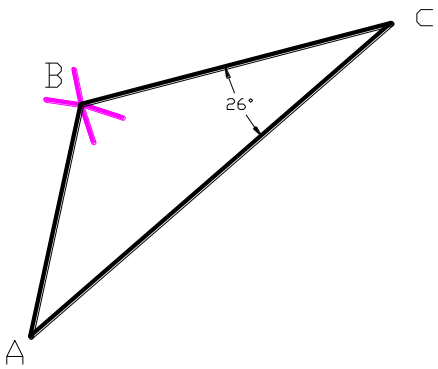


Laying Out An Angle.
Sine Method.

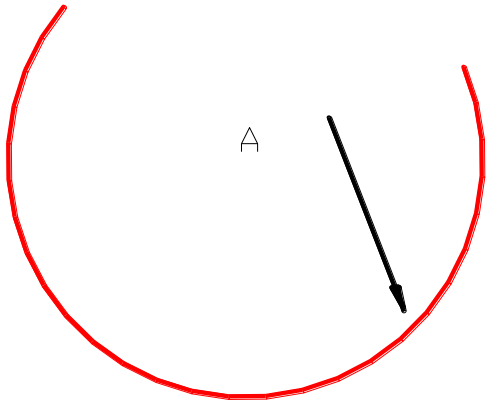
- Draw the line X to any convenient length (preferably 100 units)
- Find the Sine of the angle θ in the table of natural sine - Multiply that by the value length of the X (in this case 100) - Use this as Radius R
- Strike an arc R = 54.85364
- Draw the other side of the angle tangent to the arc

Transfer a Triangle

- Set of any side of the given triangle, such as ABC, in the new location. Start from the selected location of point of choice
- Draw an arc with the center in A of radius B



(a)



(b)

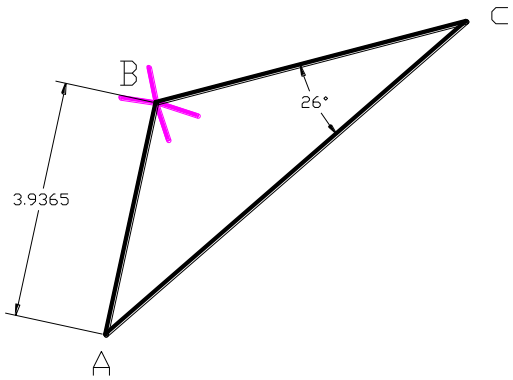
Transfer a Triangle

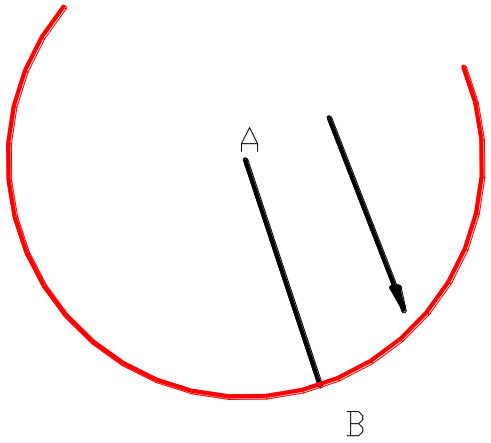
Set of any side of the given triangle, such as ABC, in the new location.

Start from the selected location of point of choice

Draw an arc with the center in A of radius AB (3.9365)

From A draw a line of the specified direction until intersects the arc





(a)

Transfer a Triangle

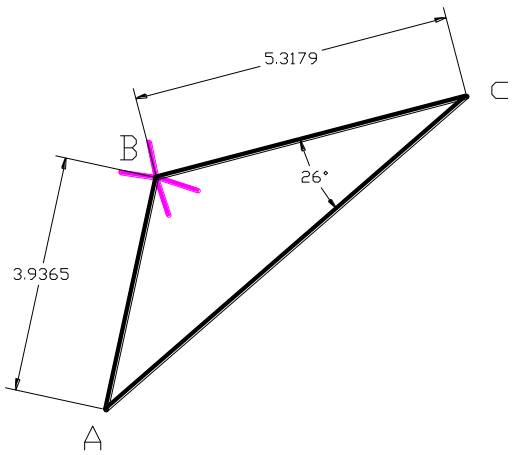
Set of any side of the given triangle, such as ABC, in the new location.

Start from the selected location of point of choice

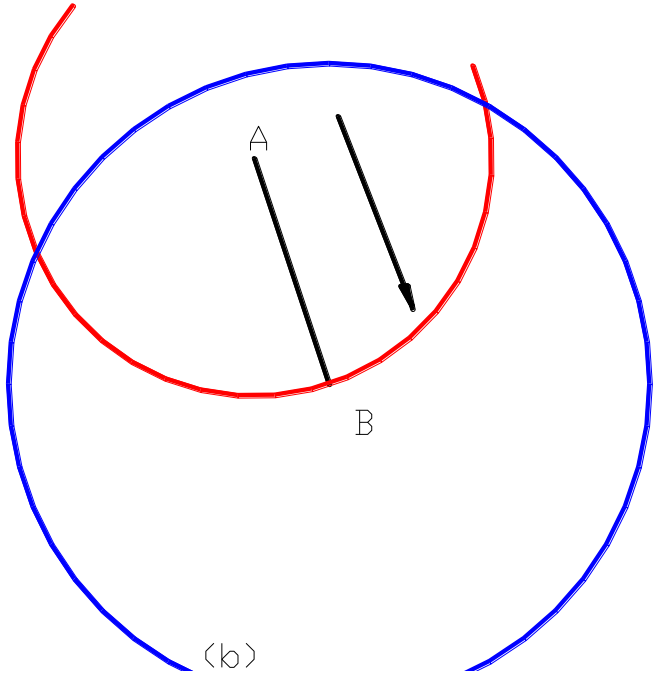
Draw an arc with the center in A of radius AB (3.9365)

From A draw a line of the specified direction until intersects the arc

From that point B, draw an arc with the centre in B of radius BC (5.3179)



(a)



(b)

Transfer a Triangle

Set of any side of the given triangle, such as ABC, in the new location.

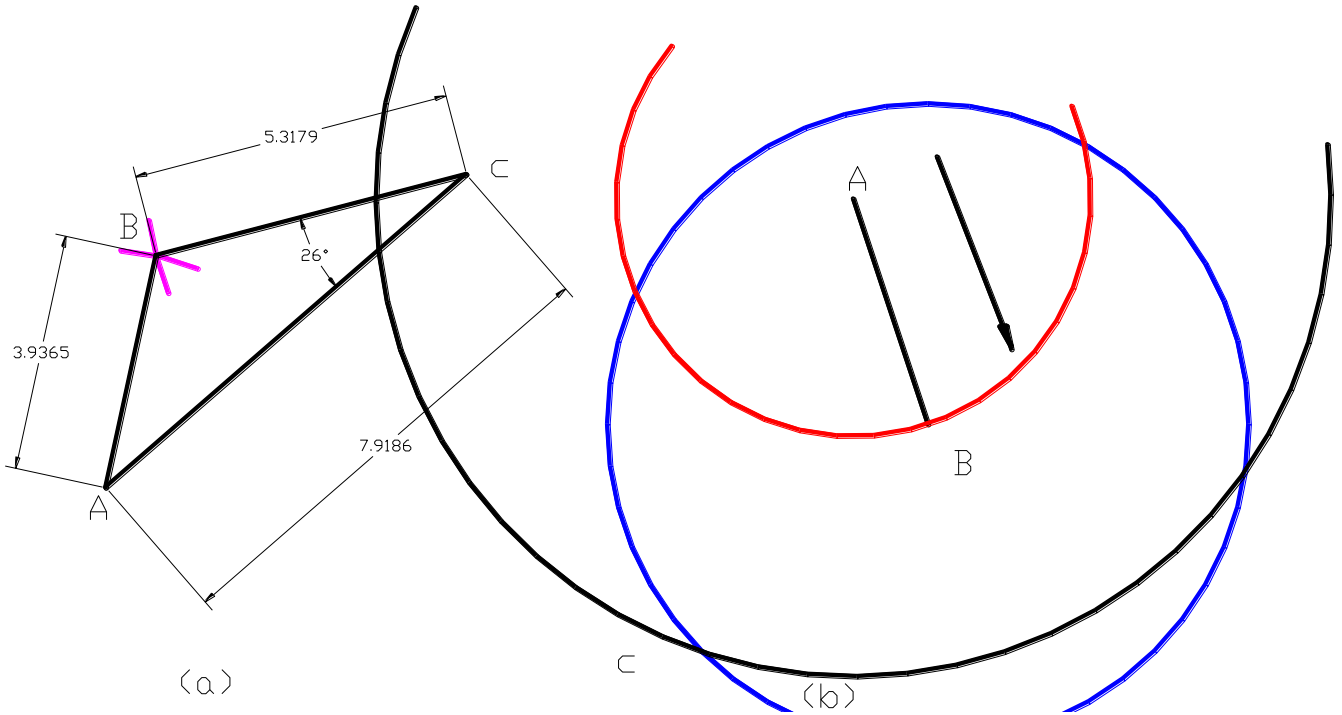
Start from the selected location of point of choice

Draw an arc with the center in A of radius AB (3.9365)

From A draw a line of the specified direction until intersects the arc

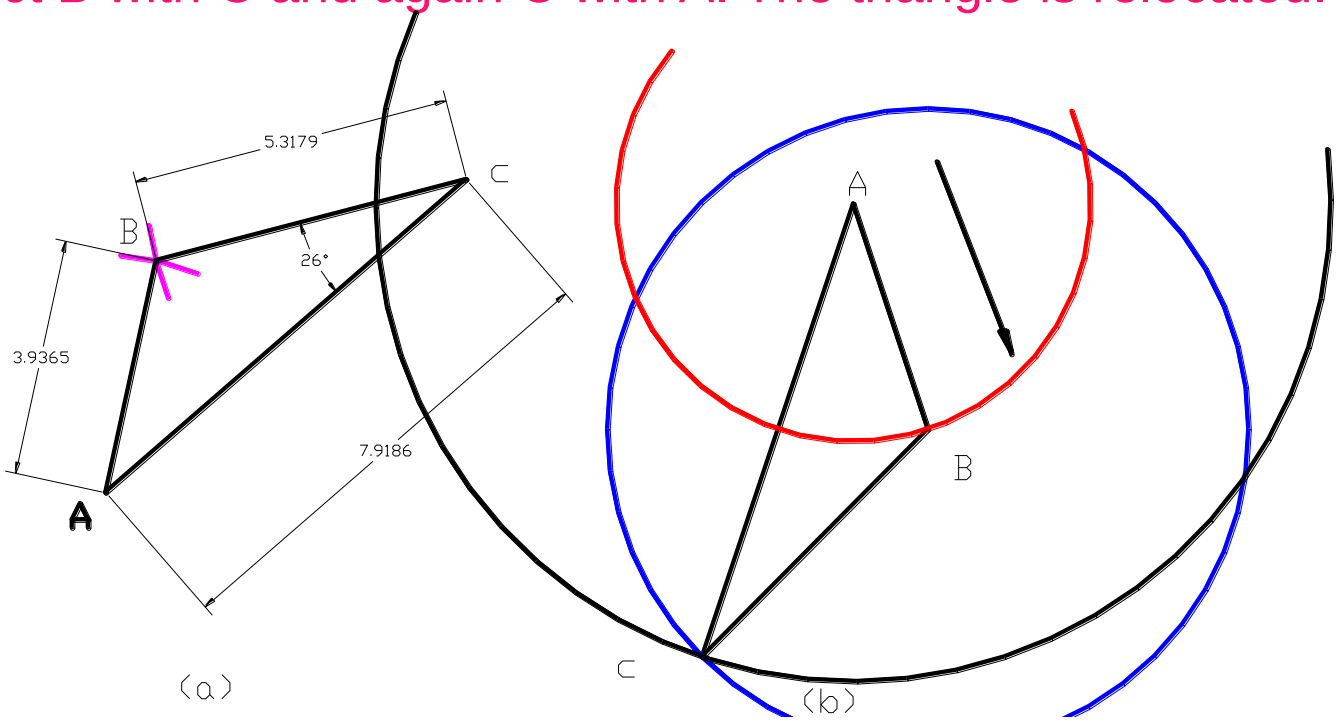
From that point B, draw an arc with the centre in B of radius BC (5.3179)

From A draw an arc with centre in A of radius AC (7.9186)

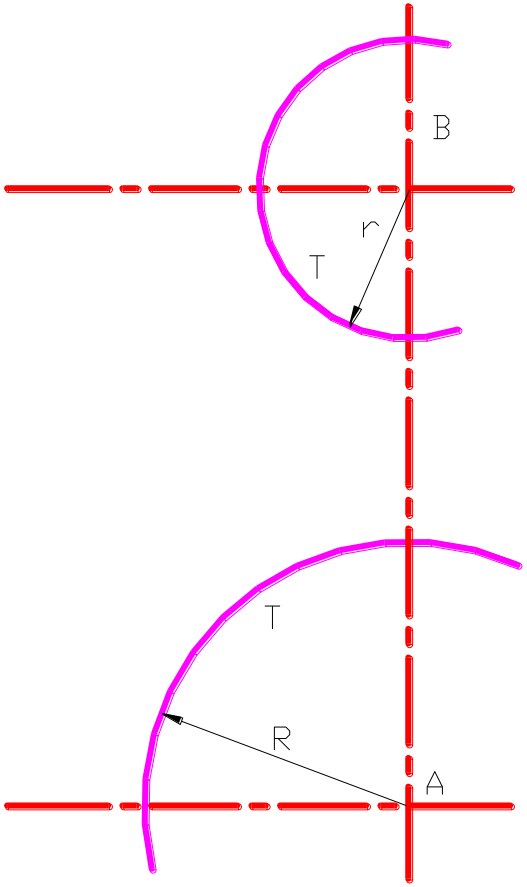


Transfer a Triangle

Set of any side of the given triangle, such as ABC, in the new location.
Start from the selected location of point of choice
Draw an arc with the center in A of radius AB (3.9365)
From A draw a line of the specified direction until intersects the arc
From that point B, draw an arc with the centre in B of radius BC (5.3179)
From A draw an arc with centre in A of radius AC (7.9186)
Connect B with C and again C with A. The triangle is relocated.



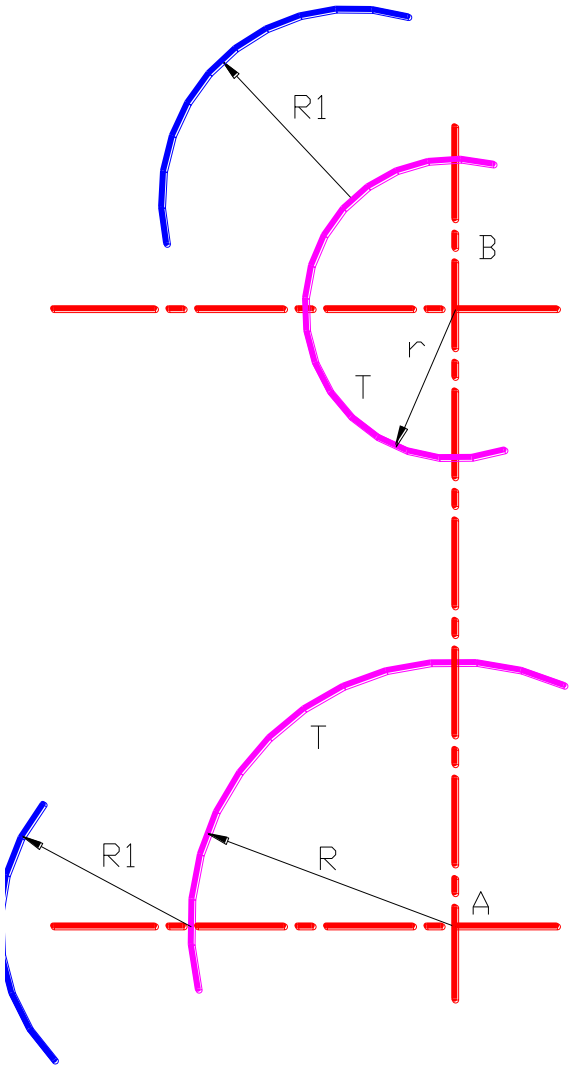
Draw an Arc Tangent to Two Arcs



To draw a circular arc from a given Radius R tangent to two given circular arcs

Given the circular arcs with centers A and B, and radius R and r, respectively

Draw an Arc Tangent to Two Arcs

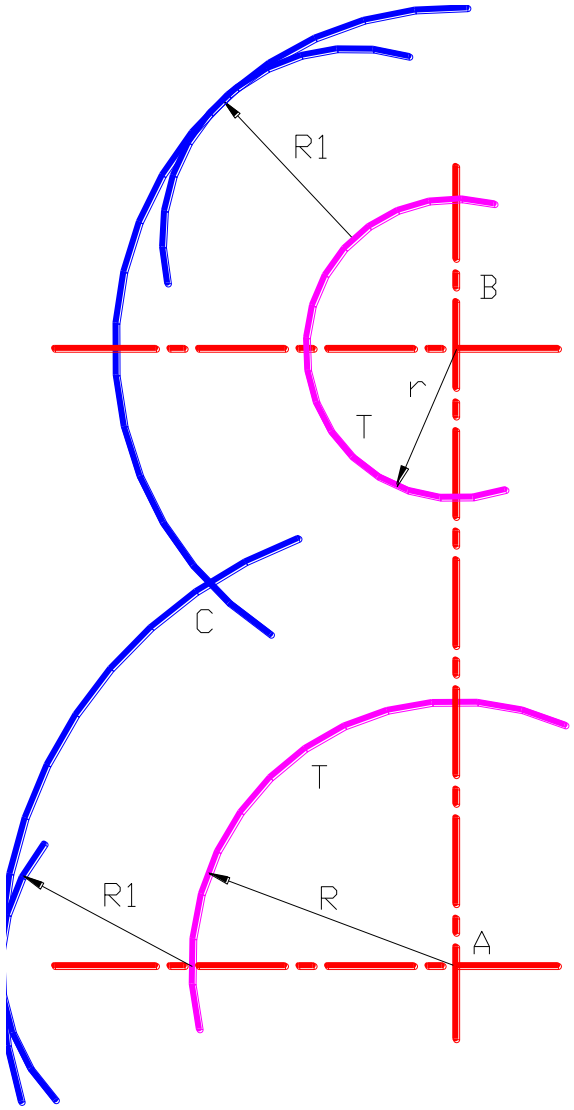


To draw a circular arc from a given Radius R1 tangent to two given circular arcs

Given the circular arcs with centers A and B, and radius R and r, respectively

Using any point in the first arc as centre and R1 as radius strike arc parallel to first arc. Using any point in the second arc as centre and R1 as radius strike an arc parallel to the second arc

Draw an Arc Tangent to Two Arcs



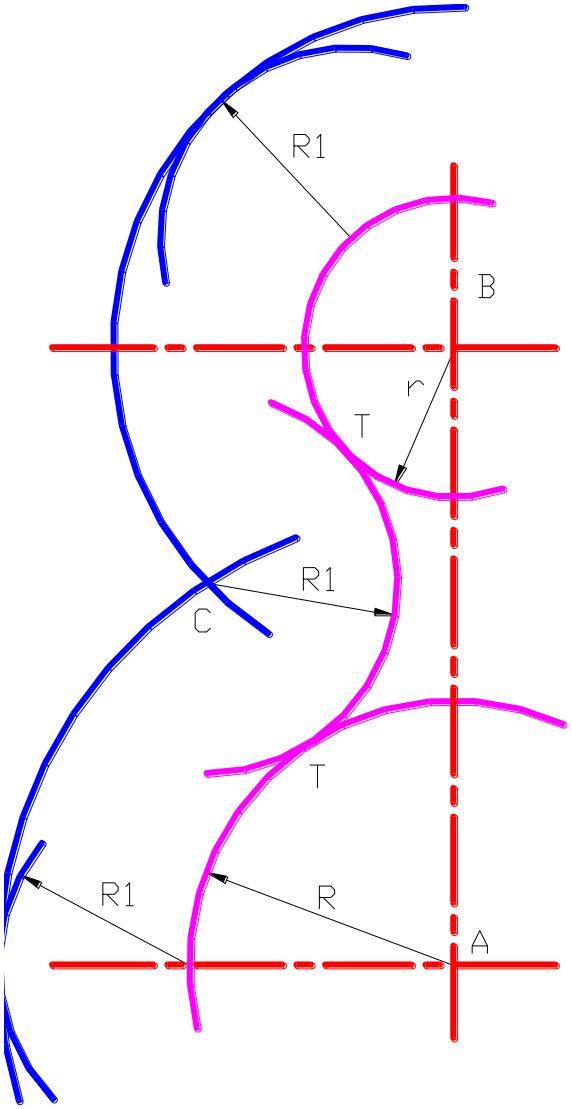
To draw a circular arc from a given Radius R1 tangent to two given circular arcs

Given the circular arcs with centers A and B, and radius R and r, respectively

Using any point in the first arc as centre and R1 as radius strike arc parallel to first arc. Using any point in the second arc as centre and R1 as radius strike an arc parallel to the second arc

Using A as centre and R1 + R as radius strike arc parallel to first arc. Using B as centre and R1 + r as radius strike an intersecting arc parallel to the second arc

Draw an Arc Tangent to Two Arcs



To draw a circular arc from a given Radius R1 tangent to two given circular arcs

Given the circular arcs with centers A and B, and radius R and r, respectively

Using a point in the first arc as centre and R1 as radius strike an arc. Using a point in the second arc as centre and R1 as radius strike an arc

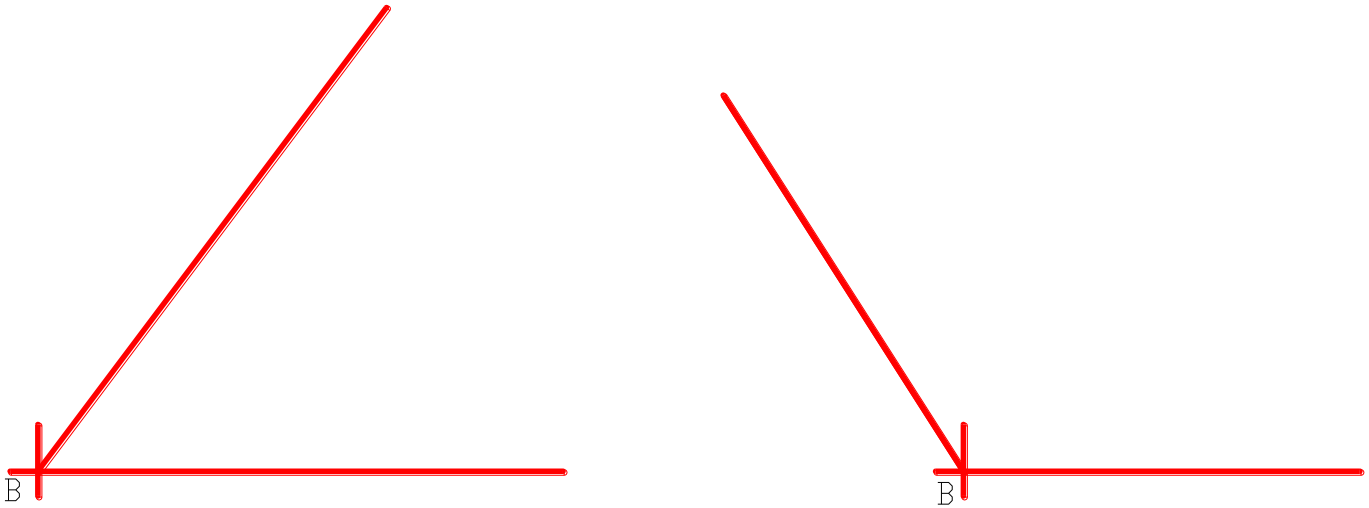
Using A as centre and R1 + R as radius strike arc parallel to first arc. Using B as centre and R1 + r as radius strike an arc parallel to the second arc

Since the intersecting arcs are R1 away from the given arcs, C will be centre of the tangent arc. Mark the points of tangency T and T that line on the lines of AC and BC

Draw an Arc Tangent to Two Lines

Draw a circular arc of radius R tangent to two lines

Given the two lines, not at right angles, and the radius R

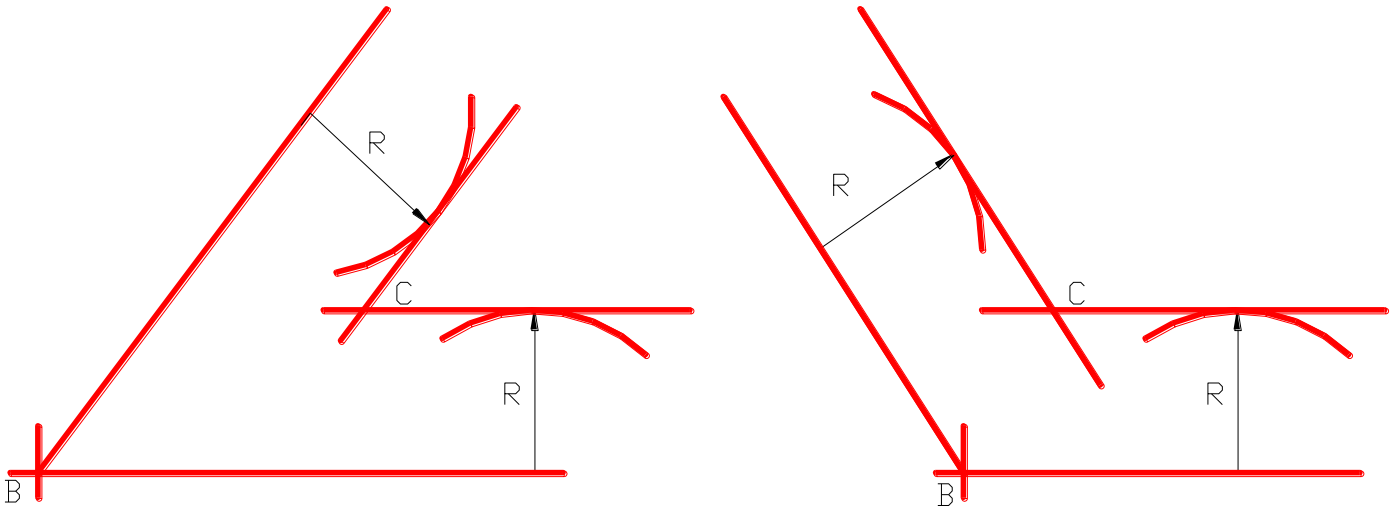


Draw an Arc Tangent to Two Lines

Draw a circular arc of radius R tangent to two lines

Given the two lines, not at right angles, and the radius R

Draw lines parallel to given lines at distance R. because the point of intersection of these lines is at distance R from the both lines, it will be centre for the required arc



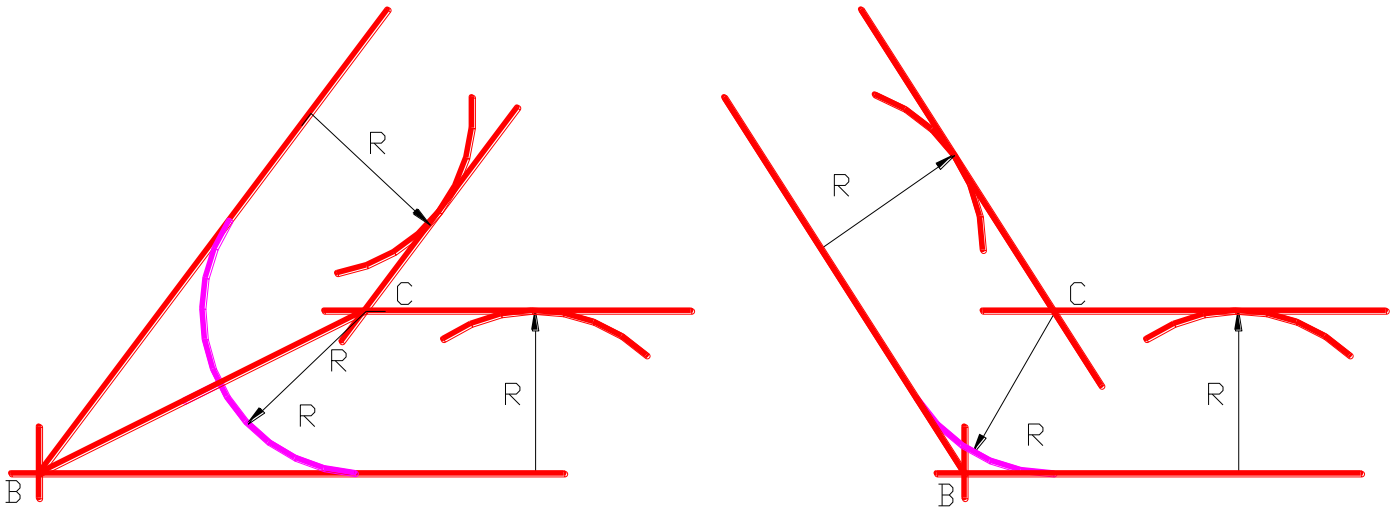
Draw an Arc Tangent to Two Lines

Draw a circular arc of radius R tangent to two lines

Given the two lines, not at right angles, and the radius R

Draw lines parallel to given lines at distance R. because the point of intersection of these lines is at distance R from the both lines, it will be centre for the required arc

Draw arc of Radius R



Draw an Arc Tangent to Two Lines

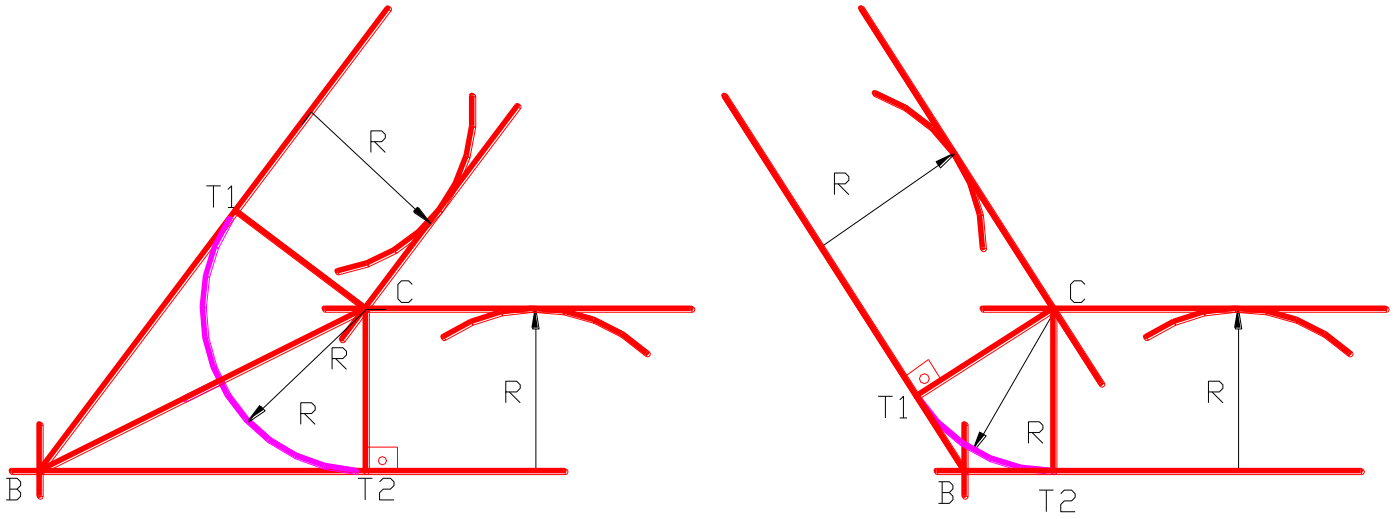
Draw a circular arc of radius R tangent to two lines

Given the two lines, not at right angles, and the radius R

Draw lines parallel to given lines at distance R. because the point of intersection of these lines is at distance R from the both lines, it will be centre for the required arc

Draw arc of Radius R

Mark the points of intersection T1 and T2 are found @ the intersection of the perpendiculars from C to sides of the angle



Computer Aided Design

- ADVANTAGES
  - Create a traceable record in the documentation
  - Integration of analysis, manufacturing, cost analysis
  - Solid modeling - assembly and interference analysis
  - Easy portable and shareable documentation
- DISADVANTAGES
  - More effort in design
  - No more drafting personnel (?)

Computer Aided Design

- Types of CAD tools
  - Comprehensive – with integrated modules for stress analysis, thermal analysis – etc (Ex: CATIA, Pro ENGINEER, IDEAS)
  - Drafting – low end CAD tools (AutoCAD)
- Cost is proportional to the capability of the tool – 85% of companies use low end CAD tool

Computer Aided Design

INTRODUCTION
TO
AutoCAD

CAD Software

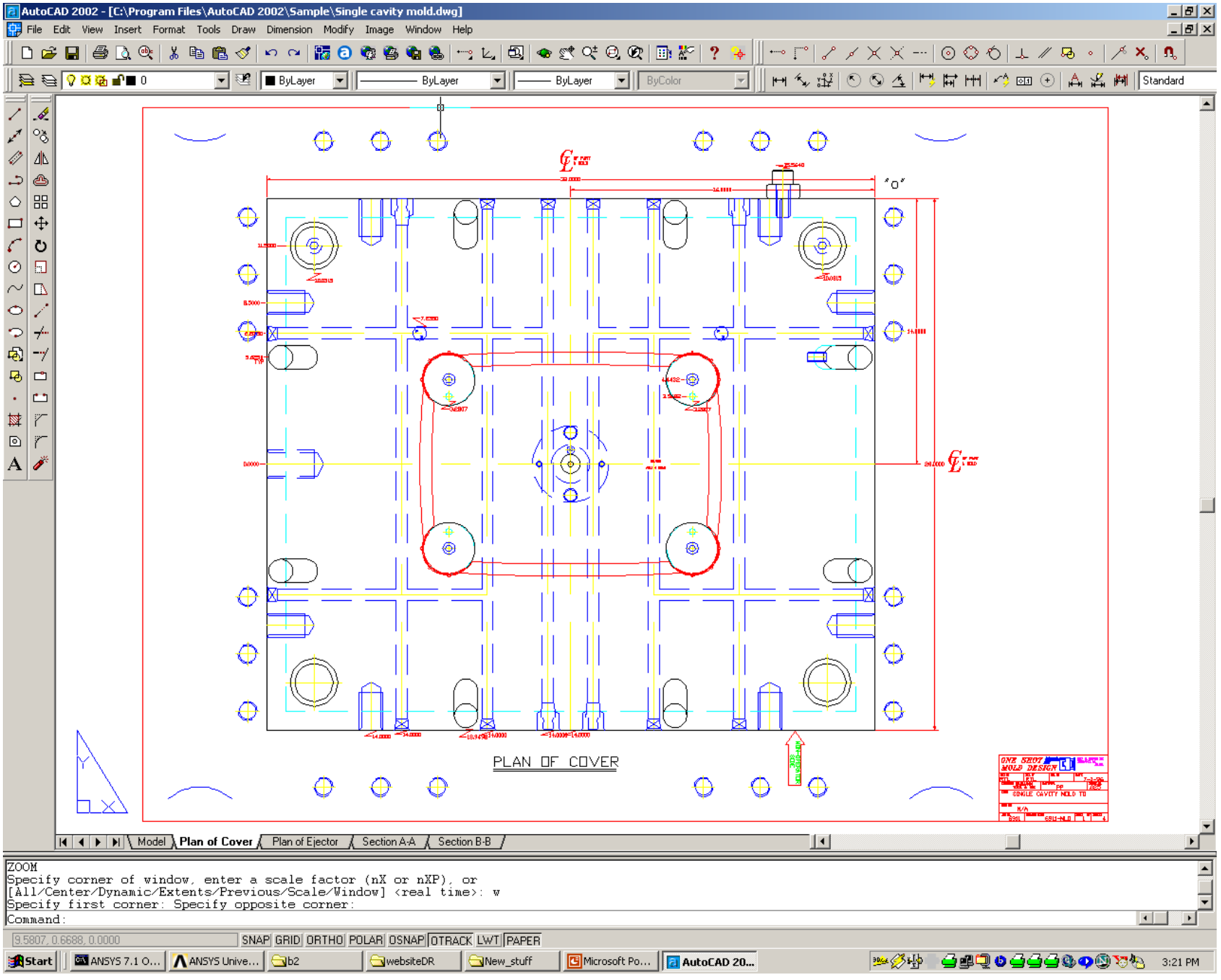
- Aimed to ease the design
  - Better quality drawings (accuracy 10^{-14} of a unit)
  - Easier to operate modifications
  - Convenient archiving
  - Structured organization of the documentation
  - Portability and exchange
  - Synergy
  - Integrated approach on design, analysis, optimization, etc.

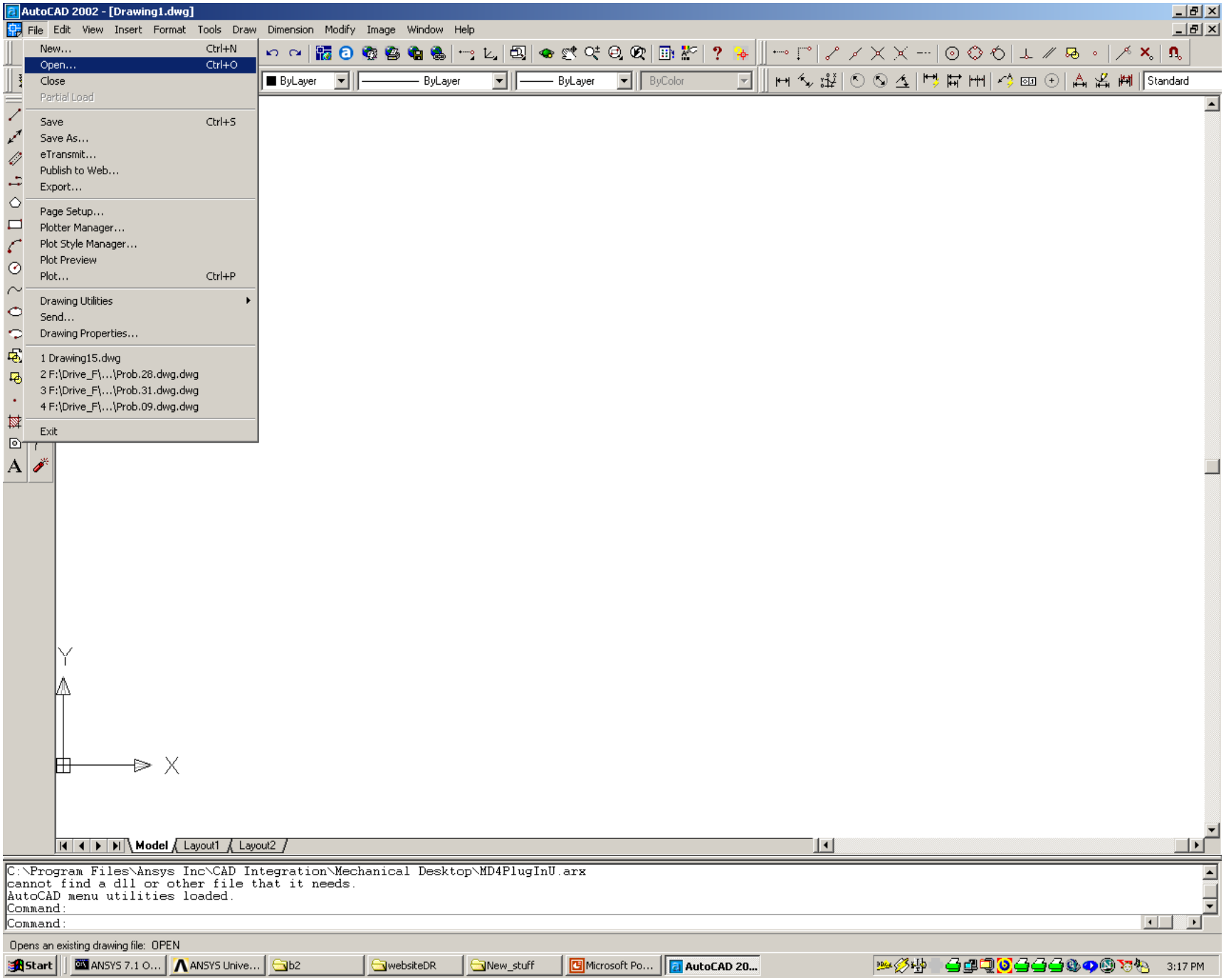
CAD Software

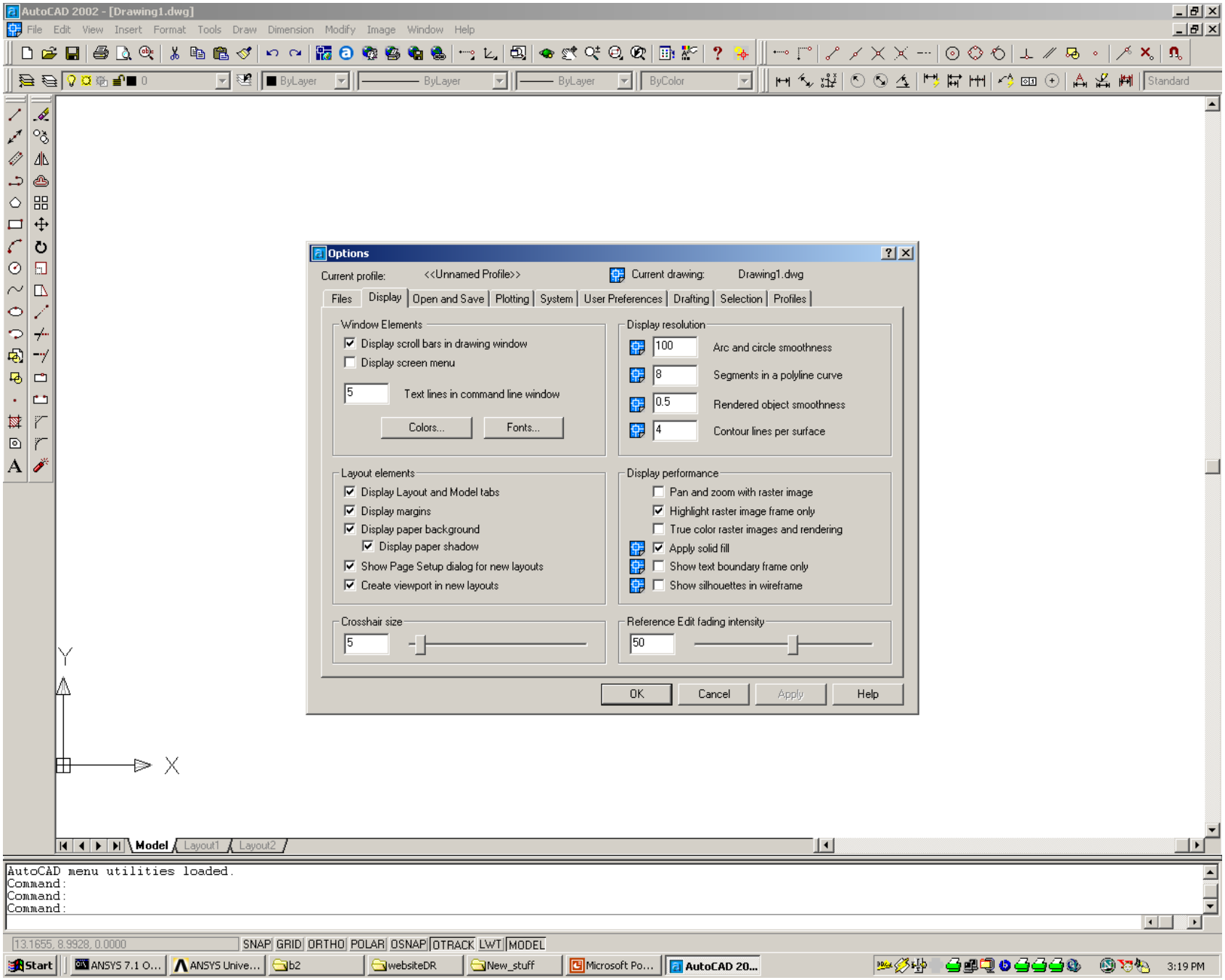
- Disadvantage
  - Requires special training
  - Difficult to be used in the preliminary ideation process (free hand sketching)
  - Require expensive software and computing equipment
  - If not used to the entire capability, such CAD tools are more liability than advantage

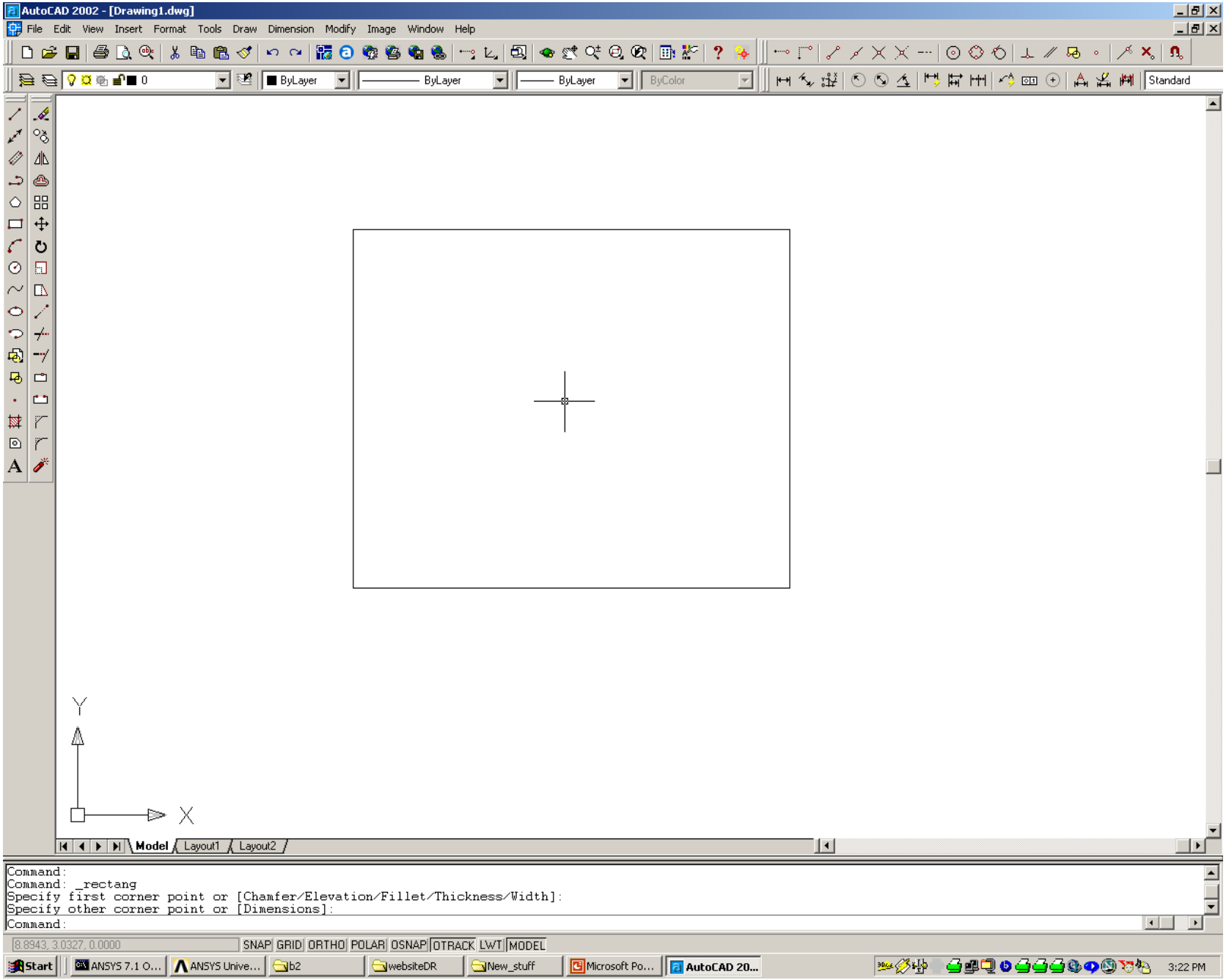
CAD Software

- Basic introduction to AutoCAD
- Used by many small industries – cost based decision
- Requires other pieces of software to be able to integrate the design with the analysis


AutoCAD 2002 - [C:\Program Files\AutoCAD 2002\Sample\Single cavity mold.dwg]
File Edit View Insert Format Tools Draw Dimension Modify Image Window Help
ByLayer
ByLayer
ByLayer
ByColor
Standard
PLAN OF COVER
Model
Plan of Cover
Plan of Ejector
Section A-A
Section B-B
ZOOM
Specify corner of window, enter a scale factor (nX or nXP), or
[All/Center/Dynamic/Extents/Previous/Scale/Window] <real time>: w
Specify first corner: Specify opposite corner:
Command:
SNAP GRID ORTHO POLAR OSNAP OTRACK LWT PAPER
Start
ANSYS 7.1 O...
ANSYS Unive...
b2
websiteDR
New_stuff
Microsoft Po...
AutoCAD 20...
3:21 PM


AutoCAD 2002 - [Drawing1.dwg]
File Edit View Insert Format Tools Draw Dimension Modify Image Window Help
New... Ctrl+N
Open... Ctrl+O
Close
Partial Load
Save Ctrl+S
Save As...
eTransmit...
Publish to Web...
Export...
Page Setup...
Plotter Manager...
Plot Style Manager...
Plot Preview
Plot... Ctrl+P
Drawing Utilities
Send...
Drawing Properties...
1 Drawing15.dwg
2 F:\Drive_F\...\Prob.28.dwg.dwg
3 F:\Drive_F\...\Prob.31.dwg.dwg
4 F:\Drive_F\...\Prob.09.dwg.dwg
Exit
ByLayer
ByLayer
ByLayer
ByColor
Standard
Y
X
Model
Layout1
Layout2
C:\Program Files\Ansys Inc\CAD Integration\Mechanical Desktop\MD4PlugInU.arx
cannot find a dll or other file that it needs.
AutoCAD menu utilities loaded.
Command:
Command:
Opens an existing drawing file: OPEN
Start
ANSYS 7.1 O...
ANSYS Unive...
b2
websiteDR
New_stuff
Microsoft Po...
AutoCAD 20...
3:17 PM


AutoCAD 2002 - [Drawing1.dwg]
File Edit View Insert Format Tools Draw Dimension Modify Image Window Help
Options
Current profile: <<Unnamed Profile>>
Current drawing: Drawing1.dwg
Files Display Open and Save Plotting System User Preferences Drafting Selection Profiles
Window Elements
Display scroll bars in drawing window
Display screen menu
5
Text lines in command line window
Colors...
Fonts...
Display resolution
100
Arc and circle smoothness
8
Segments in a polyline curve
0.5
Rendered object smoothness
4
Contour lines per surface
Layout elements
Display Layout and Model tabs
Display margins
Display paper background
Display paper shadow
Show Page Setup dialog for new layouts
Create viewport in new layouts
Display performance
Pan and zoom with raster image
Highlight raster image frame only
True color raster images and rendering
Apply solid fill
Show text boundary frame only
Show silhouettes in wireframe
Crosshair size
5
Reference Edit fading intensity
50
OK
Cancel
Apply
Help
Model
Layout1
Layout2
AutoCAD menu utilities loaded.
Command:
Command:
Command:
13.1655, 8.9928, 0.0000
SNAP GRID ORTHO POLAR OSNAP OTRACK LWT MODEL
Start
ANSYS 7.1 O...
ANSYS Unive...
b2
websiteDR
New_stuff
Microsoft Po...
AutoCAD 20...
3:19 PM


AutoCAD 2002 - [Drawing1.dwg]
File Edit View Insert Format Tools Draw Dimension Modify Image Window Help
ByLayer
ByLayer
ByLayer
ByColor
Standard
Model
Layout1
Layout2
Command:
Command: _rectang
Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]:
Specify other corner point or [Dimensions]:
Command:
8.8943, 3.0327, 0.0000
SNAP GRID ORTHO POLAR OSNAP OTRACK LWT MODEL
Start
ANSYS 7.1 O...
ANSYS Unive...
b2
websiteDR
New_stuff
Microsoft Po...
AutoCAD 20...
3:22 PM