GOVT. TOOL ROOM AND TRAINING CENTRE
KARNATAKA

REFERENCE NOTES

ENGINEERING DRAWING-II

SUBJECT CODE: DTDM IIS 204

FOR
: DIPLOMA IN TOOL AND DIE MAKING
: DIPLOMA IN PRECISION MANUFACTURING

SL .NO	UNIT NAME
1	**Review** ☞ Review - Lines, Lettering, Angle Of Projection & Types Of Sectioning ☞ Auxiliary Views - What Is Auxiliary View? When To Choose Auxiliary Views? With Some Examples. ☞ Development Of Solids – Introduction, Development Of Cubes, Calculations & Related Practice ☞ Development Of Solids –Development Of Prisms, Calculations & Related Practice ☞ Development Of Solids –Development Of Cylinders, Calculations & Related Practice ☞ Development Of Solids –Development Of Pyramids, Calculations & Related Practice ☞ Development Of Solids –Development Of Cones, Calculations & Related Practice ☞ Surface Roughness - What Is Surface Roughness? Symbols Used For Indication. Indications Added To The Symbols, Ex: (Direction Of Lay). Details Of The Characteristics, Ex: (Roughness Grade)
2	**Preparation Of Assembly Drawing, Detail Drawing & Part List** ☞ Knuckle Joint ☞ Pipe Vice ☞ Tool Maker's Clamp ☞ Screw Jack ☞ Universal Coupling ☞ Tennon & Fork ☞ Plumber Block ☞ Exercise :- Minivice

UNIT 1: REVIEW

Lines and Lettering

1. Introduction

Since Engineering drawings convey technical information, for correct interpretation, they have to be drawn by lines of standard thickness and types, with standard lettering practice, and to they recommended standard scales. This chapter covers the Indian and international standard practices of line conventions and types, recommended style and size of letters, and the selection of scales.

2. Lines

Thickness of lines

Two thicknesses of lines are used in engineering drawings. They are thick and thin lines. The thicknesses of thick and thin lines are in the ratio of 2:1. The thickness of lines must be chosen according to the type and size of the drawing from any one of the six groups given in table.

Group	Line Thickness		Lettering Dimension Figures, And Symbols
	THICK	THIN	
0.35	0.35	0.18	0.25
0.50	0.50	0.25	0.35
0.70	0.70	0.35	0.50
1.00	1.00	0.50	0.70
1.40	1.40	0.70	1.00

Types Of lines

For general engineering drawings, the types of lines recommend by the Bureau of Indian standards shown.

In case where other types of thickness of lines are used for special cases, for example, electrical and pipe work drawings, or if lines specified in the table are used for applications other than those detailed in the last column, the conventions adopted must be explained by notes on the drawing concerned.

TYPE	ILLUSTRATION	APPLICATION
A	Continuous THICK	Visible outlines, visible edges
B	Continuous THIN	Dimension lines, Projection lines, Leader lines, Imaginary lines of intersections, Outlines of revolved sections.
C	Continuous THIN Freehand 	Boundaries Or Limits of Partial Or Interrupted views
D	Continuous THIN Zig-Zag 	
E	Dashes THICK	Hidden outlines Hidden edges
F	Dashes THIN	
G	Chain THIN	Centre Lines, Lines of symmetry, Trajectories.
H	Chain THIN and THICK at end & Changes Of Direction 	Cutting Planes
J	Chain THICK	Indication of surface to which special requirements applies.
K	Chain THIN Double Dash	Outlines of adjacent parts, Alternate and extreme positions of movable parts, Centroidal lines, Initial Outlines.

Type A – Outline of Parts

These lines represent the visible edges of the objects, hence should be outstanding in appearance and therefore, are drawn as bold, i.e., thick continuous lines.

Type B – Dimension, Projection, Leader, hatching lines

These lines should be drawn thin and continuous. The extension lines for

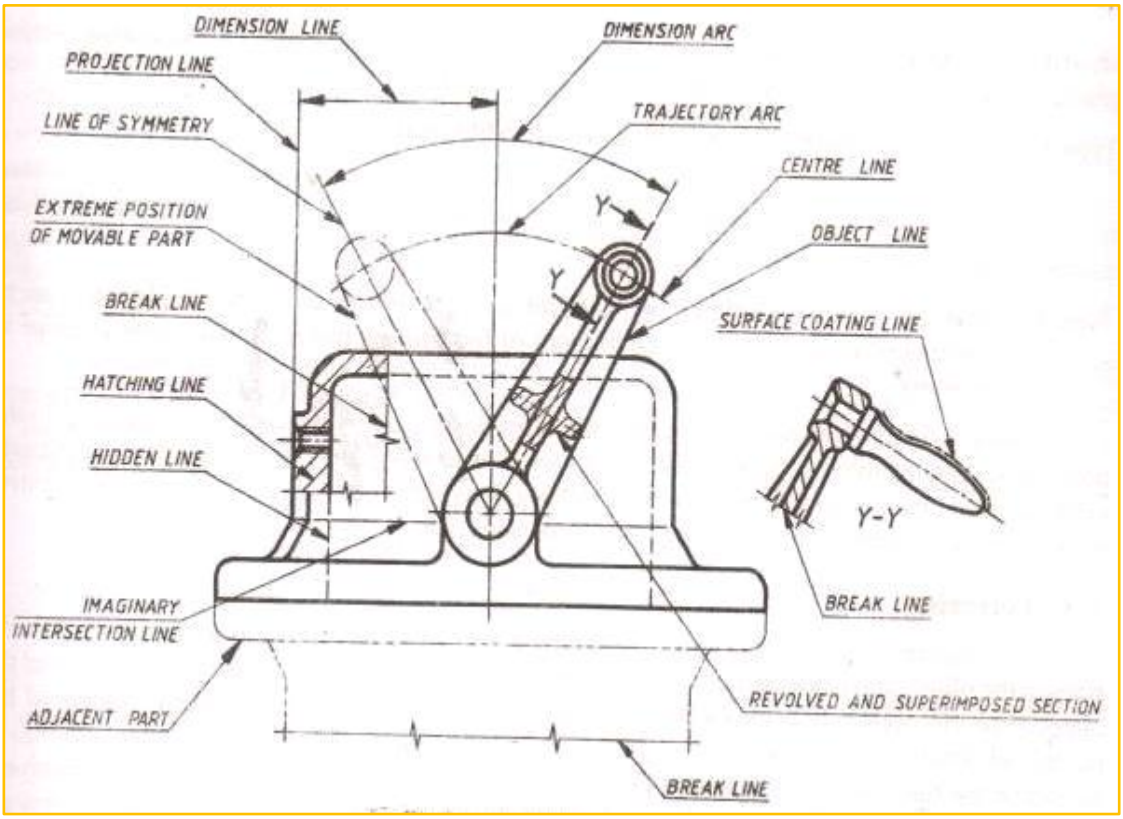
dimensioning should run from the outlines without leaving a gap and extend beyond the dimension lines. These types are also used to draw the outlines of adjacent and revolved sections.

Type C - Limits or Boundaries Of Partial Or Interrupted Views

These are drawn as continuous, thin, wavy, freehand lines to represent limits or boundaries of partial or interrupted views.

Type D – Break Lines

These are ruled, short, zig-zag thin lines drawn to represent breaks.



Type E – Hidden Lines (Thick)

These lines consist of thick short dashes, closely and evenly spaced. These lines are drawn to represent hidden or invisible edges of the objects.

Type F – Hidden Lines (Thin)

These lines consist of thick short dashes, closely and evenly spaced. These lines are drawn to represent hidden or invisible edges of the objects. Although thick lines

of type – E are recommend for representing the hidden edges, thin lines of type – F are preferred.

Type G - Centre Lines, Lines of Symmetry, trajectories, Pitch Circles

These are long, thin, chain lines with alternately long and short dashes of proportion ranging from 6:1 to 4:1 and evenly spaced. The proportion once selected should be maintained throughout the drawing. The centre lines are extended by a short distance beyond the outline. These lines are also drawn to represent the lines of symmetry, trajectories, pitch circles, etc.

Type H – Cutting Plane Lines

These are long chain lines, thickened at the ends and thin elsewhere, with alternately long and short dashes of proportion ranging from 6:1 to 4:1 and evenly spaced. The corners where the section plane changes direction are made thick for a short length.

Type J – Lines to Indicate Surfaces Which Require Additional Treatment

These are long thick lines with alternately long and short dashes of proportion ranging from 6:1 to 4:1 and evenly spaced. These are drawn to indicate surfaces which are to receive additional treatment like anodizing, plating, etc.

Type K – Lines to Indicate Outlines of Adjacent Parts, Extreme Position of Movable Parts, Centroidal Lines, Parts Situated In Front of Cutting Planes, Initial Outlines Prior to Forming

These are thin lines with a long and two short dashes alternately and evenly placed in the proportion ranging from 6:1 to 4:1. These lines are used to represent the outlines of adjacent parts, extreme positions of movable parts in the assembly drawings, parts situated in front of the cutting planes, initial outlines prior to forming, centroidal lines, etc...

LETTERING

Lettering is also part of an Engineering Drawing which is very much important. Writing of notes, title, subtitle, marking dimension are called lettering.

1. Lettering should be perfectly legible, uniform & clear.
2. For lettering work apart from pencil, no instrument should be used & it should be

done free hand with speed.

3. Lettering should be of rapid execution.
4. Mostly capital letters (upper case) are used. In some cases small letters (lower case) are also used as per requirement.
5. Various forms of alphabets are used for particular lettering purpose. Both sloping & vertical type letters & numerals are in use. Sloping letters are drawn at an angle of 15° towards right side, or an inclination of 75° to the horizontal as per the recommendation of BIS.

SINGLE STROKE LETTER

Single stroke letters are obtained in a single stroke of the pencil. These letters may be vertical or inclined at an angle of 15°.

Lettering should be done as per the recommendation of IS: 9609-1983

The width of the letters & numerals depend on its height. The range of standard height for the lettering as per the IS in the progressive ratio of "Square root 2". They are

1.8 - 2.5 - 3.5 – 5 – 7 – 10 – 14 & 20mm.

They are two standard ratios available based on line thickness''.

1. Type A = Line thickness d = h/14
2. Type B = line thickness d = h/10

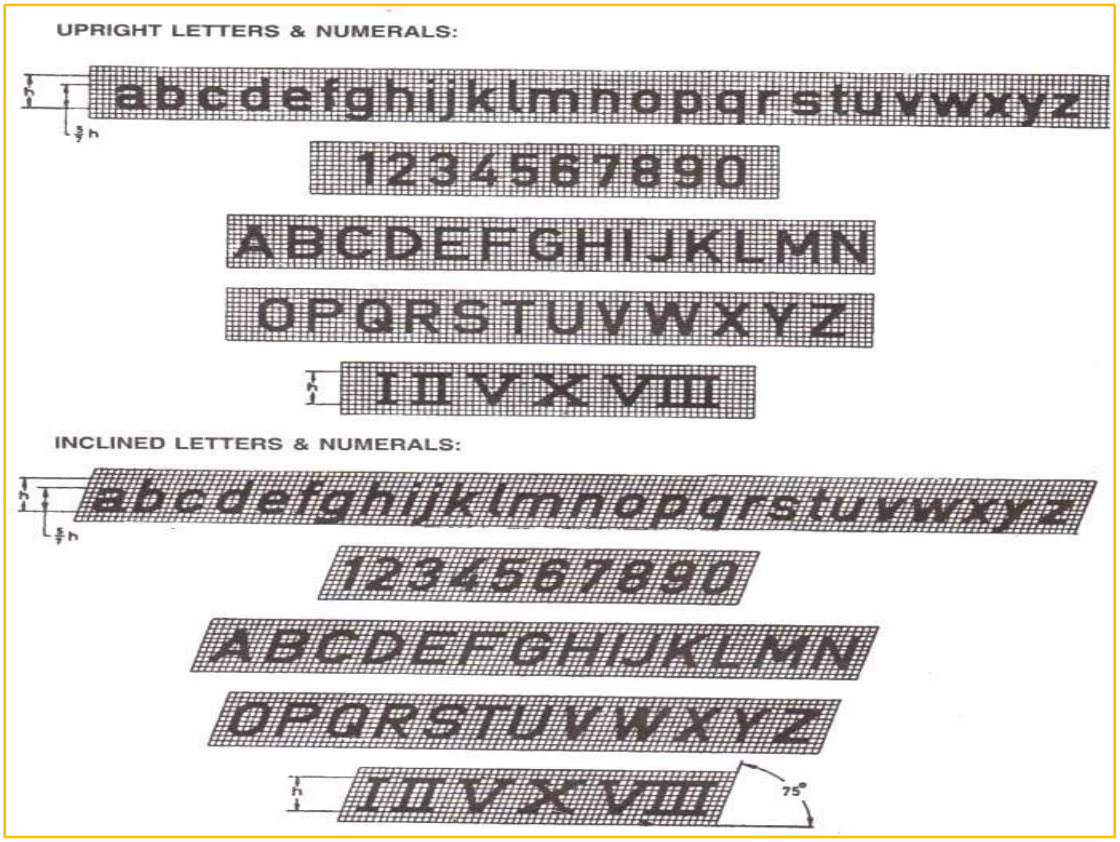
RECOMMENDED SIZE OF LETTERS & NUMERALS:

1	Drawing No in the title block & main title, letters denoting cutting plane	6, 8, 10, 12 & 14mm
2	Sub title & headings	3, 4, 5 & 6mm
3	Notes, dimension, schedules, legends & materials	2, 3, 4 & 5mm

LETTERING

Both the upright and inclined letters and numerals are suitable for general use. All letters should be capital letters except where small letters are accepted internally for abbreviation.

For inclined letters the recommended inclination is 75° Letters and Numerals are designated by their height.



Classifications of letter styles

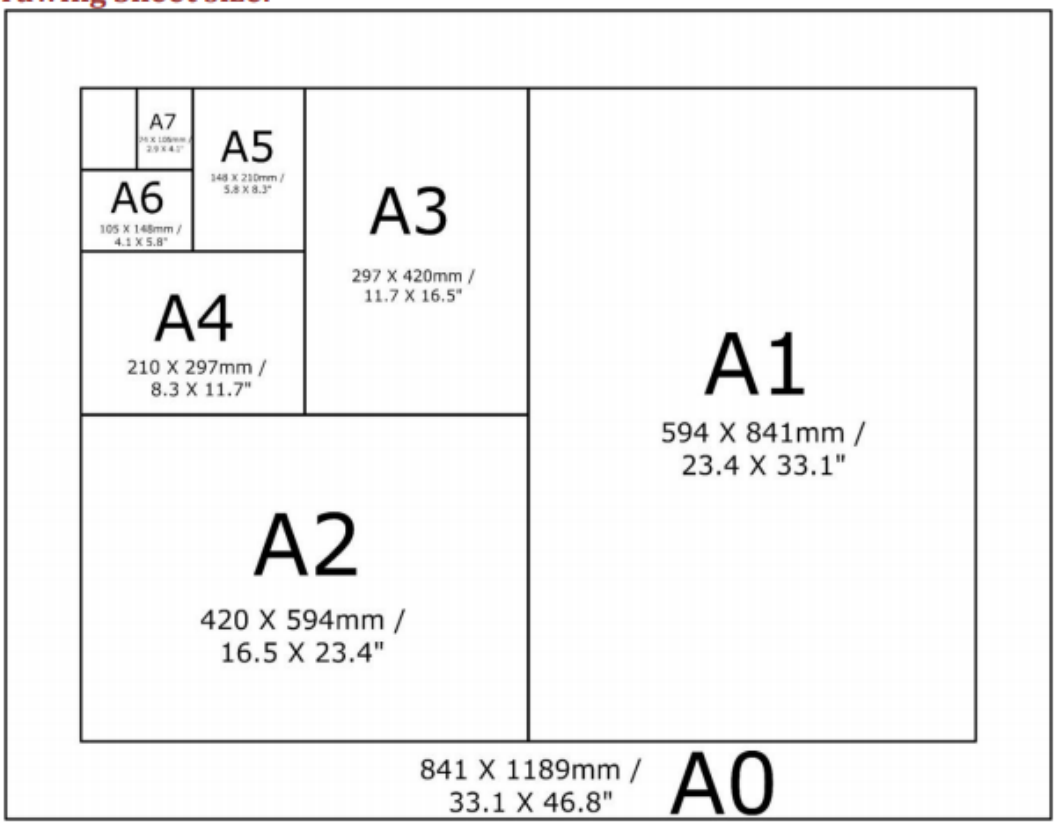
Now-a-days there are various styles of letters used in the heart of lettering & each approximate for same particular use.

"Old Roman" style is the basic standard for all these styles.

A variation of this style is as follows:-

Name	Description	Model
GOTHIC	Letter have elementary stroke of even width	A B C D E F a b c d e f
ROMAN	Letters have elementary stroke "accented" or consisting of heavy & light lines	A B C D E F a b c d e f
ITALIC	All slanting letters classified as Italic. They may be further designated as Roman italics, Gothic italics & Test italics.	*A B C D E F* *a b c d e f*
TEXT	Text style includes all styles of old English. German text, Bradley text or others of various trade names are too illegible for commercial purpose.	𝔄 𝔅 ℭ 𝔇 𝔈 𝔉 𝔊 𝔞 𝔟 𝔠 𝔡 𝔢 𝔣 𝔤

Drawing Sheet size:

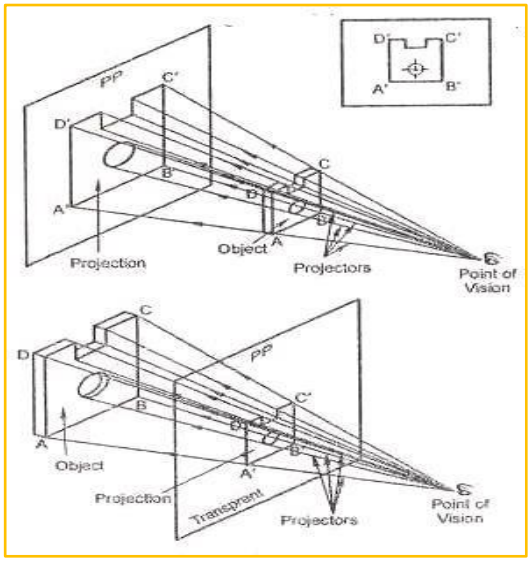


Angle of Projection

Projection

A projector projects the object on the screen by light rays. When an object is placed in front of screen and light thrown in the object, assuming the light rays to be parallel and perpendicular to the screen is called projection. The plane in which projection of object obtained is called plane of projection.

In Isometric Projection, only one view of the object is given which does not represent its real surface. Hidden parts are also to be imagined. The direction from which the object is to be viewed is shown by an arrow. Generally arrow for the front view may be given. Other views may be taken accordingly. Isometric view represents length, width & depth of the three dimensions.



Orthographic Projection

If the projectors are perpendicular to the plane of projection is called Orthographic projection. Using these orthographic projections, true shape of an object can be obtained by two or three views.

Principle of Orthographic Views

1. Front View or Elevation

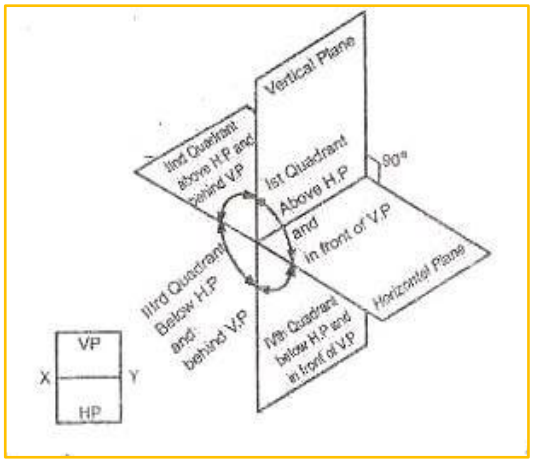
Front view of an object is obtained by looking at the object from its front. It can be projected on V.P

2. Top View or Plan

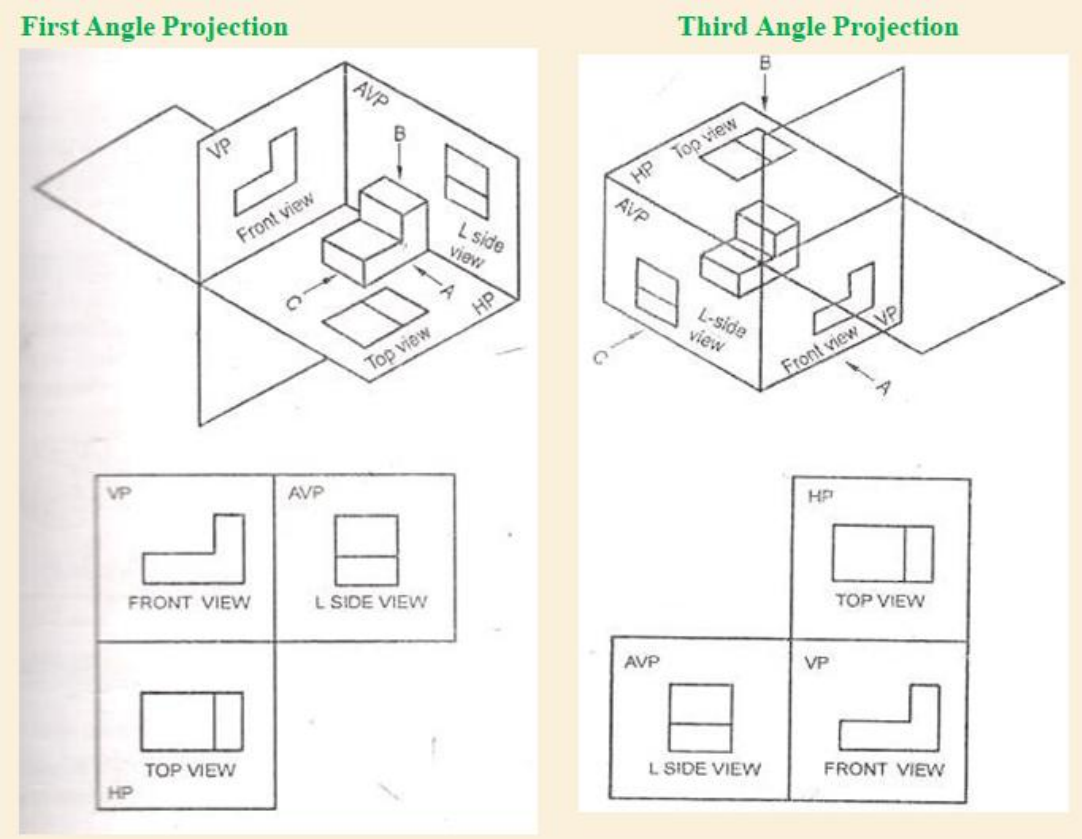
Top view of an object is obtained by looking the object from its top. It can be projected on a H.P

3. Side View

Side view of an object is obtained by looking at the object from one of its side. This side view may be right or left side view and can be projected on profile plane (P.P)



1st Quadrant – Above H.P & in front of V.P
2nd Quadrant – Above H.P & behind V.P
3rd Quadrant – Below H.P & behind V.P
4th Quadrant – Below H.P & in front of V.P



Assumed that, the object is placed in first quadrant view from

Arrow A – Front view of the object obtained in vertical plane (V.P)

Arrow B – Top view of the object obtained in horizontal plane (H.P)
Arrow C – Left side view of the object obtained in auxiliary vertical plane (A.V.P)

Second and Fourth Angle Projection

When the object is placed in 2nd & 4th quadrant the horizontal plane & vertical plane will get super imposed due to the front view and top view of the object looking like a one up on the other. So, this method is not used. If the object is placed in third quadrant, front view will be obtained on VP, Top view is HP & left side view on AVP.

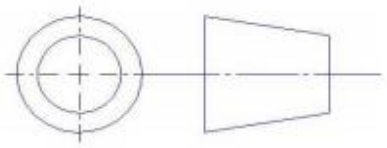
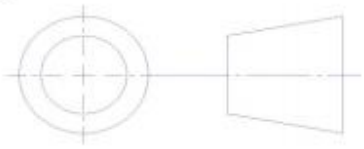
In Engineering drawing why 2nd and 4th angle projection systems are not used?

In 2nd and 4th angle projection system, the top and front views are overlap to

each other. In 2nd angle projection system, the plane is in between object and observer. When we turn the adjacent plane by 90 degree to see the top view, the front and top views are overlap to each other. The same problem occurs in 4th angle of projection. The only difference is that in 4th angle of projection the object is in between the observer and plane.

General guidelines to be followed while drawing orthographic projection.

1. It is necessary to find the length, breadth & height of object.
2. Suitable scale should be selected.
3. While making front view, the longest face of the object or arrow shown face should be taken.
4. While making spacing between the views, the length & width of the drawing sheet should be considered
5. Spacing between the views should be uniform (minimum 30mm)
6. Both visible & hidden circles should have centre line of middle
7. If hidden line coincide with a centre line, draw a clear dashed line
8. The drawing should have title block in which necessary details should be furnished.
9. It necessary to have complete dimensioning

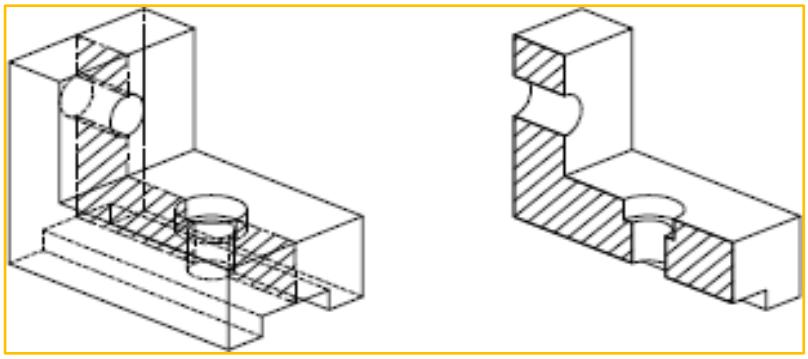
First angle projection	Third angle projection
1. The object is placed on first quadrant. 2. The top view (Plan) is placed below the front view. 3. The bottom view placed above the front view. 4. The right hand side view is placed on left hand side of front view. 5. The left hand side view is placed on right hand side of front view. 6. The rear view is place left or right side of front view. 7. Symbol. 	1. The object is placed on third quadrant. 2. The top view (Plan) is placed on above the front view. 3. The bottom view is placed below the front. 4. The right hand side view is placed on right hand side of the front view. 5. The left hand side view is placed on left hand side of front view. 6. The rear view is place left or right side of the front view. 7. Symbol 

SECTIONING

SECTIONAL VIEWS

In an Orthographic view the hidden line are used to show the visible feature of the object. If an object is complex in nature, then there are too many hidden lines in the drawing & it is very much difficult to the construction of the object. In such case, the views are made in section which is called sectional views. Using sectional views, details of drawing can be shown clearly & reading of drawing will be easier.

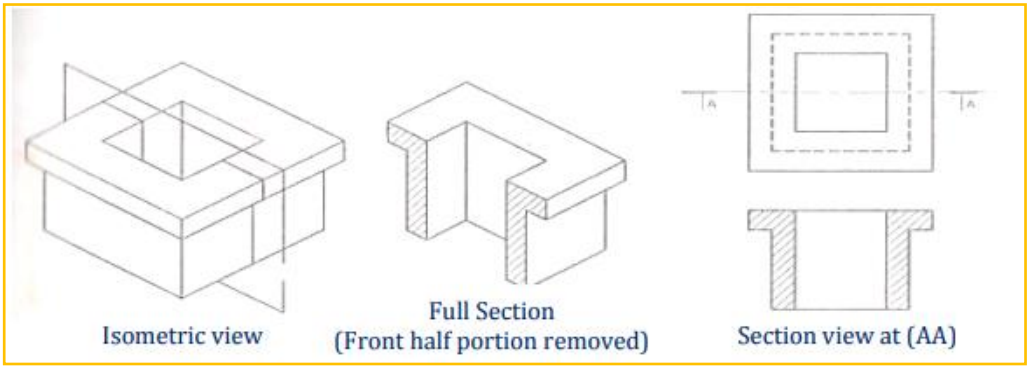
When all objects is cut by an imaginary line then it is called cutting plane or section plane. It is assumed to be parallel to the plane of which the view is projected. Cutting plane should be like centre line, but dark at both ends & arrow indicated on both sides.



Types of section

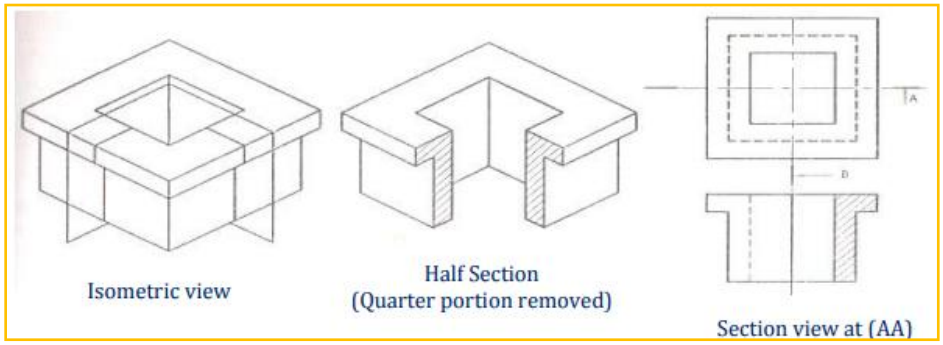
Full section:

When an object is cut by a straight cutting plane & divided into equal parts, then it is called **Full section.**



Half section:

When object is symmetrical, then it is not necessary to draw full section view. In such case, the front quarter portion of the object is imagined to be removed; the remaining object is set to be in **half section.**

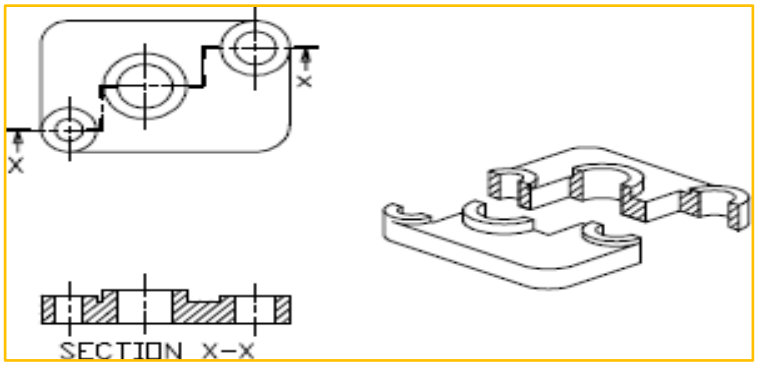


Offset Section:

Offset section is used; when a full section are half section is not use full to reveal all the internal details of an object. To get more details of an irregular object cutting plane is offset & offset section view will be drawn. Even the offset section view will be like a full section, hatching area will not be in the same plane.

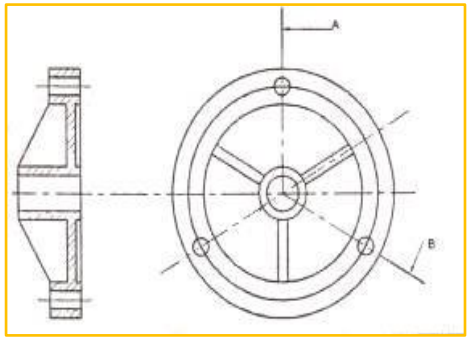
Isometric View

Section at AB



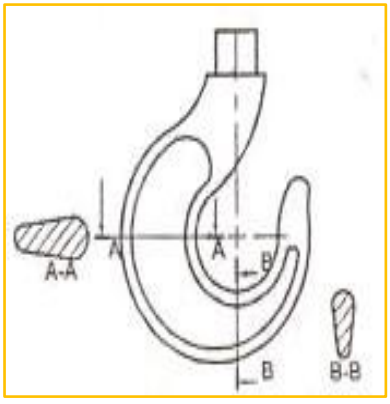
Aligned Section:

When the cutting plane of an object is not straight are vertical & at an angle of the main section plane, then the cutting plane is bent at different planes so as the pass through the features .These features are aligned to a vertical position and then projected to the plane of section view.



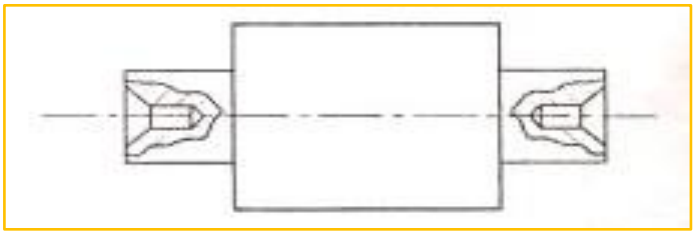
Removed Section:

When it is not possible to show the removed section when in the object due to less space or requiring clearer, then the revolved section drawn separately outside the view is called removed section**.**



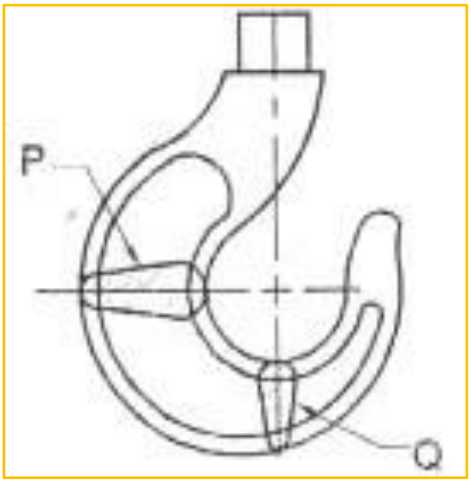
Broken Section:

Broken section is used to shown the internal detail particular portion of on object only.



Revolved section

A section taken directly on an outside view of an object is called revolved section. This method is used, where an object has varying cross section.

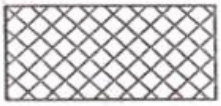
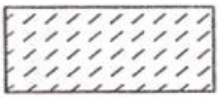
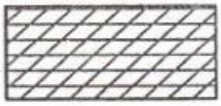
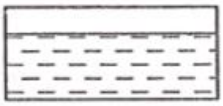
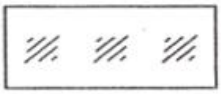
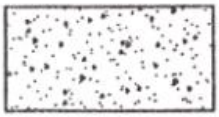


Section Lines:

Normally section line will be drawn 45degree inclined. Vertical or horizontal lines are also used as section line as per position of object is placed.

Section line should be not be shown for rib, web, rivet, bolt, nut, shaft, ball, roller, key & pin even though they are placed at section plane.

Conventional Representation of Material

Type	Convention	Material
Material		Steel, Cast iron, Aluminium, Alloy etc.
		Lead, Zinc, Tin, White material
Packing& Insulating Material		Porcelain, Stoneware, marble, etc.
		Asbestos, Paper, Cork, Linoleum, Fibre, Synthatetic resin products, Filling materials etc.,
Liquid		Water, kerosene, oil, Petrol etc.
Glass		Glass
Wood		Wood, Plywood
Concrete		Concrete
Stack lamination		

Questions & Answers

1. Only_____method of projection is recommended by BIS.
   (a) First angle (*b*) Third angle (c) Second Angle
2. As far as possible dimensions should be placed___the view of the drawing.
   (a) Outside (*b*) Inside (c) Center
3. Dimension line_____be used as extension line.

(a) Should (*b*) Should not (c) None of these

4. Projection and dimension lines are drawn as____lines.
(a) Thick (*b*) Thin (c) Both

5. When several arcs of same size are dimensioned___leaders are used.
(a) Separate (*b*) Extended

6. A radius of 25 mm is indicated on the drawing as____.
(*a*) R 25 (*b*) 25R (c) Ø25

7. In aligned and uni-directional method of dimensioning, horizontal dimension line is _____for placing the dimension.
(a) Broken (*b*) Not broken (c) None of these

8. Hatching lines are drawn at an angle of____to the axis or to the main outline of the sections.
(*a*) 60° (*b*) 45° (*c*) 30°

9. In the orthographic projection, the projectors are____to the plane of projection.
(a) Parallel (*b*) Perpendicular (*c*) Inclined

10. To draw a side view, an auxiliary vertical plane is imagined to be placed_.
(a) Perpendicular to both H.P and V.P.
(b) Perpendicular to H.P and parallel to V.P.
(c) Perpendicular to V.P and parallel to H.P.

11. The number of mutually perpendicular planes that may surround an object in space is_.
(a) Four (*b*) Three (*c*) Six

12. In the third angle projection, the object is imagined to be placed__.
(a) Below H.P and behind V.P. (*b*) Above H.P and in front of V.P.
(*c*) Above H.P and behind V.P.

13. In the first angle projection, the view obtained on the auxiliary vertical plane (AVP) placed to the right of the object is called__.
(a) View from the left (*b*) View from the right
(*c*) View from below.

14. In the third angle projection, to obtain the view from left, the AVP is assumed to be on the___of the object.
(a) Right side (*b*) Left side (*c*) Top.

15. Sectional views reveal_____.
(a) Inner details (*b*) External features
(*c*) Overall size of the object

16. To obtain full section,_____of the object is imagined to be removed.

(a) One fourth (*b*) One third (*c*) One half

17. In half sectional view,_____of the object is imagined to be removed.
(a) One half (*b*) One fourth (*c*) One third

18. _____and_____should not be shown in section.
(a) Web (*b*) Key
(*c*) Shaft along axis (*d*) Shaft across the axis

ANSWERS:-

1. (a) First angle
2. (a) Outside
3. (b) Should not
4. (b) Thin
5. (a) Separate
6. (a) R 25
7. (b) Not broken
8. (b) 45°
9. (b) Perpendicular
10. (a) Perpendicular to both H.P and V.P.
11. (c) Six
12. (a) Below H.P and behind V.P.
13. (a) View from the left
14. (b) Left side
15. (a) Inner details
16. (c) One half
17. (b) One fourth
18. (a) Web & (c) Shaft along axis

Answer the following Questions:-

1. What are the different types of line? & mention their applications.
2. What is Projection? & Explain First & Third angle projections with an example.
3. Write the conventional representation of followings:-
   a) Steel b) Glass c) Wood d) Concrete e) Liquid f) Lead
4. List out any four standard sheet sizes.
5. Write the following in stroke inclined letter of height 36mm

2. AUXILIARY VIEWS

Auxiliary views

Any view obtained by a projection on a plane other than the horizontal, frontal, and profile projection planes is an auxiliary view. A primary auxiliary view is projected onto a plane that is perpendicular to one of the principle planes of projection and is inclined to the other two. A secondary auxiliary view is projected from a primary auxiliary view onto a plane that is inclined to all three principle projection planes.

An auxiliary view is an orthographic view taken in such a manner that the lines of sight are not parallel to the principle projection planes (frontal, horizontal or profile) there are an infinite number of possible auxiliary view of a given object.

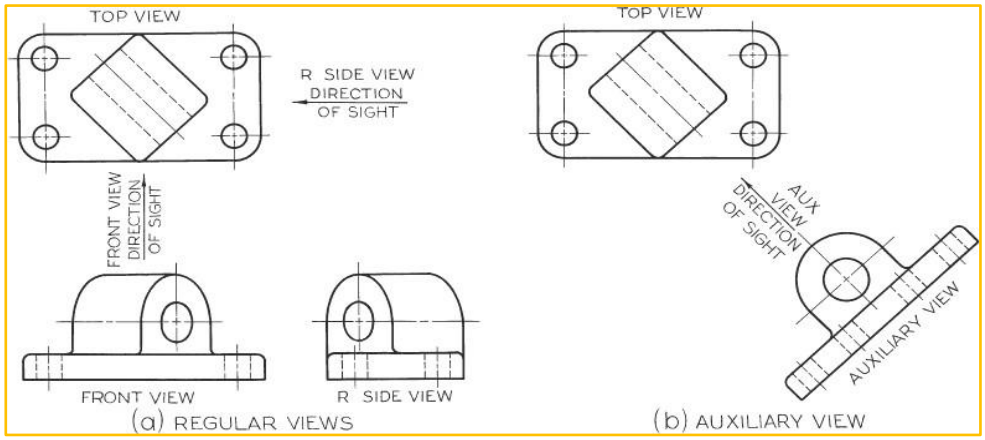
Principle faces of the object are not parallel to PP.

Why auxiliary view:-

- Inclined planes and oblique lines do not appear true length or true size in an of the principle plane of projection.
- To determine the true length of an oblique line or the true size of an inclined plane an auxiliary view must be created.
- The auxiliary view shows the true shape and size and circular shapes.

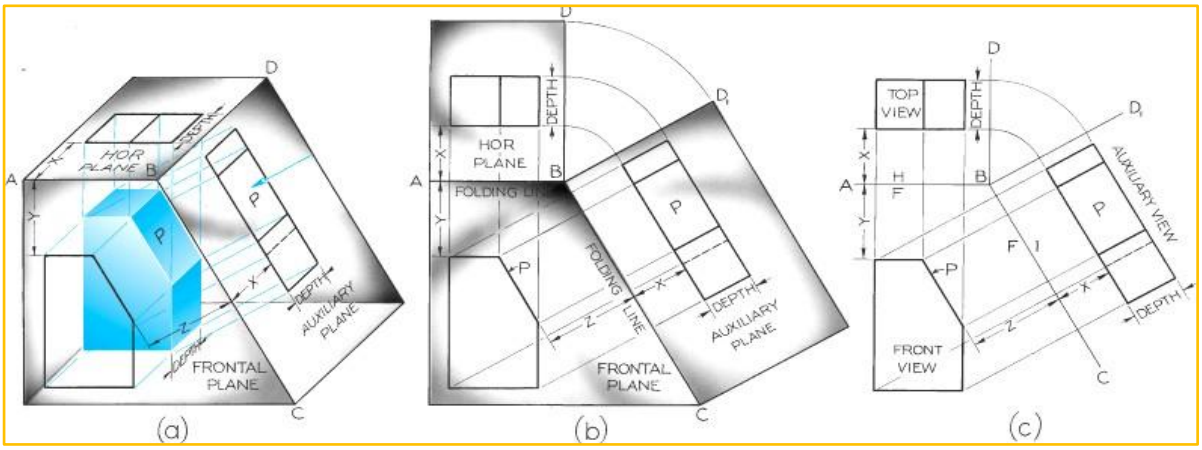
Step of drawing

1. Select the face that is to be drawn as
    a) A true surface.
    b) A true length line.
    c) And end view of a line.
2. Draw – construction lines perpendicular to the surface line point of intersect these lines should go in direction for enough that view.
3. Draw a folding line at an appropriate distance these will act as a reference plane.
4. Transfer distance from another view (adjacent view) this view will typically be the view adjoining the view that the auxiliary.
5. Complete the view draw visible and hidden lines as seen from the direction of projection line.



Auxiliary Plane

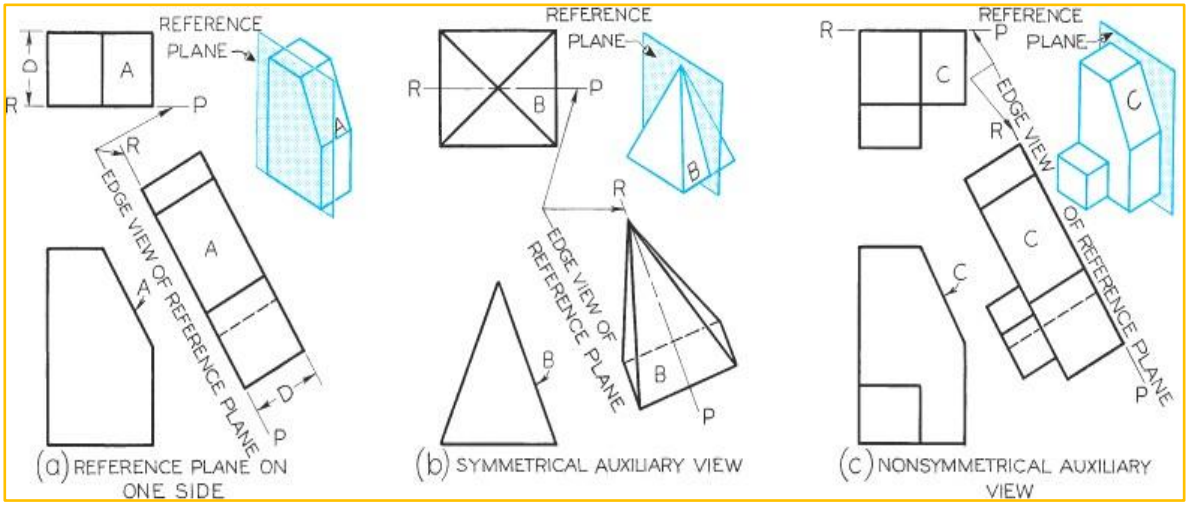
The object shown below has an inclined surface (P) that does not appear in its true size and shape in any regular view. To show the true size (TS) of the inclined surface the direction of sight must be perpendicular to the inclined plane. Or using the glass box model, the auxiliary plane is aligned parallel to the inclined surface P to give a true size view of it. The auxiliary plane in this case is perpendicular to the frontal plane of projection and hinged to it.



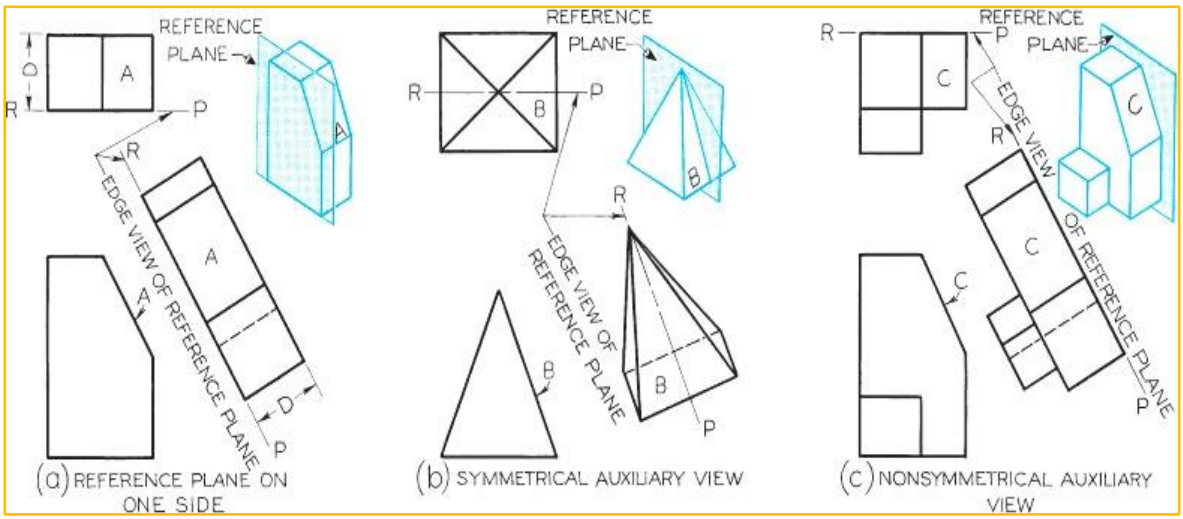
Reference planes

Instead of using one of the planes of projection, you can use reference plane parallel to the plane of projection and touching or cutting thorough the object.

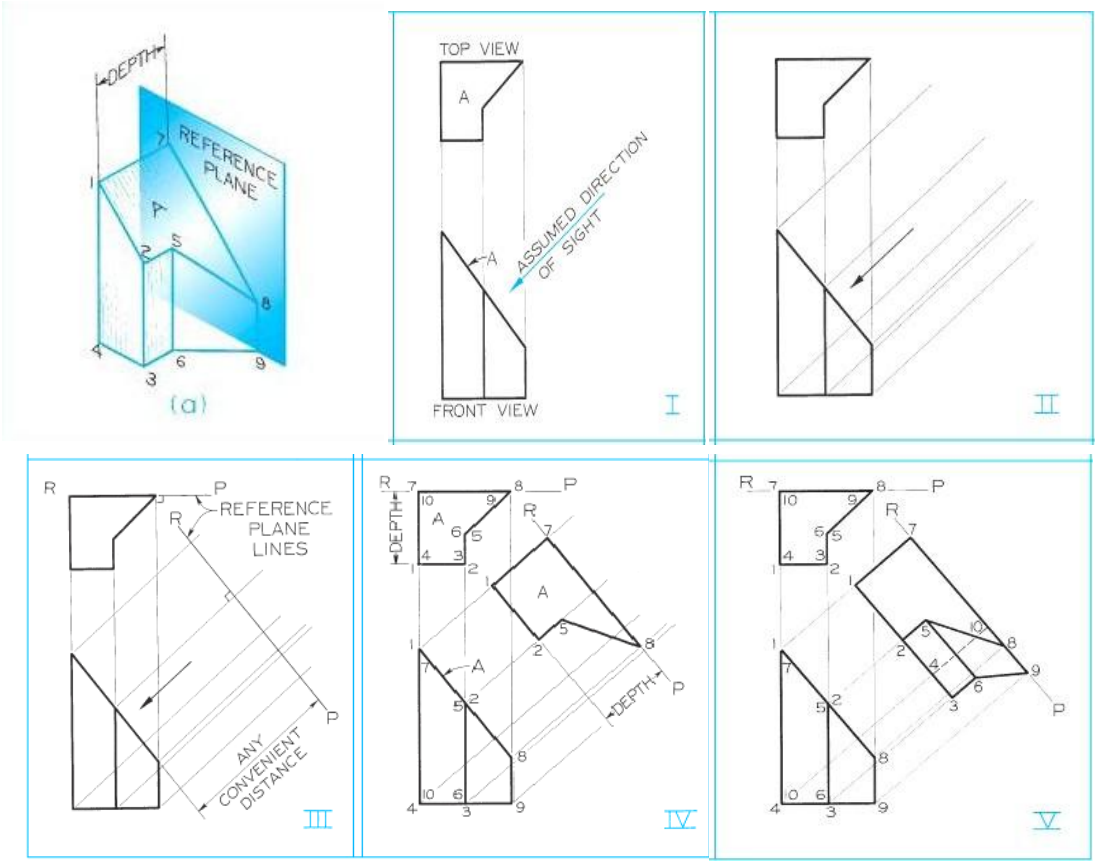
In this figure a reference plane is aligned with the front surface of the object. This plane appears on edge, or as a line, in the top and auxiliary views. Make the reference plane using light lines similar to construction lines. You can use a reference plane that coincides with the front surface of the object as shown



When an object is symmetrical, it is useful to select the reference plane to cut through the object, as shown in fig. (b). this way you only have to make half as many measurements to transfer dimensions because they are the same of each side of the reference plane. We can also use the back surface of the object, as fig. (c), or any intermediate point that would be advantageous.

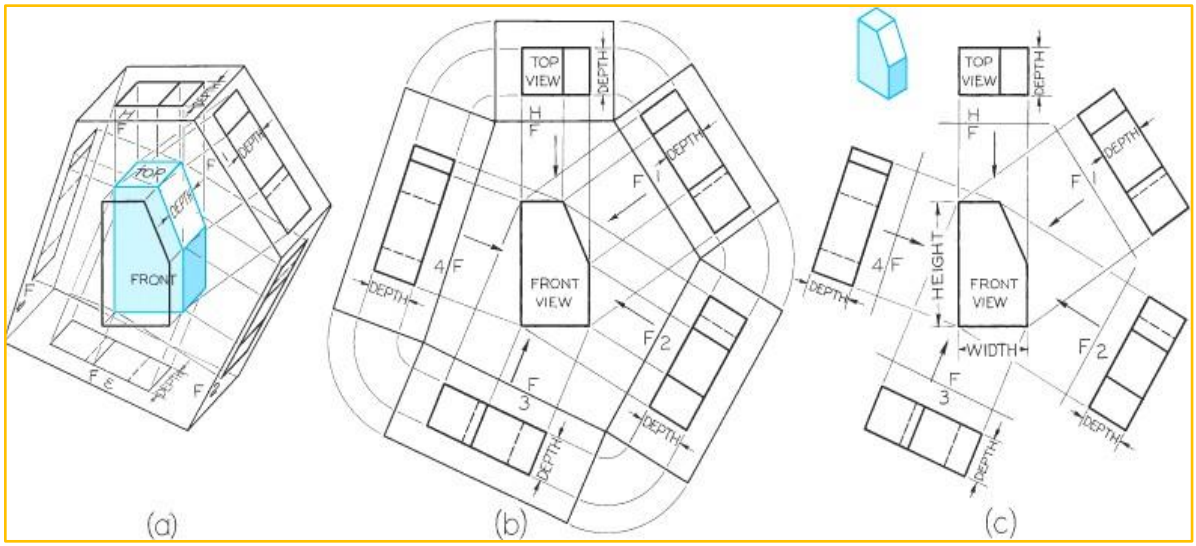


Hands on Projecting Auxiliary Views Using a Reference Plane



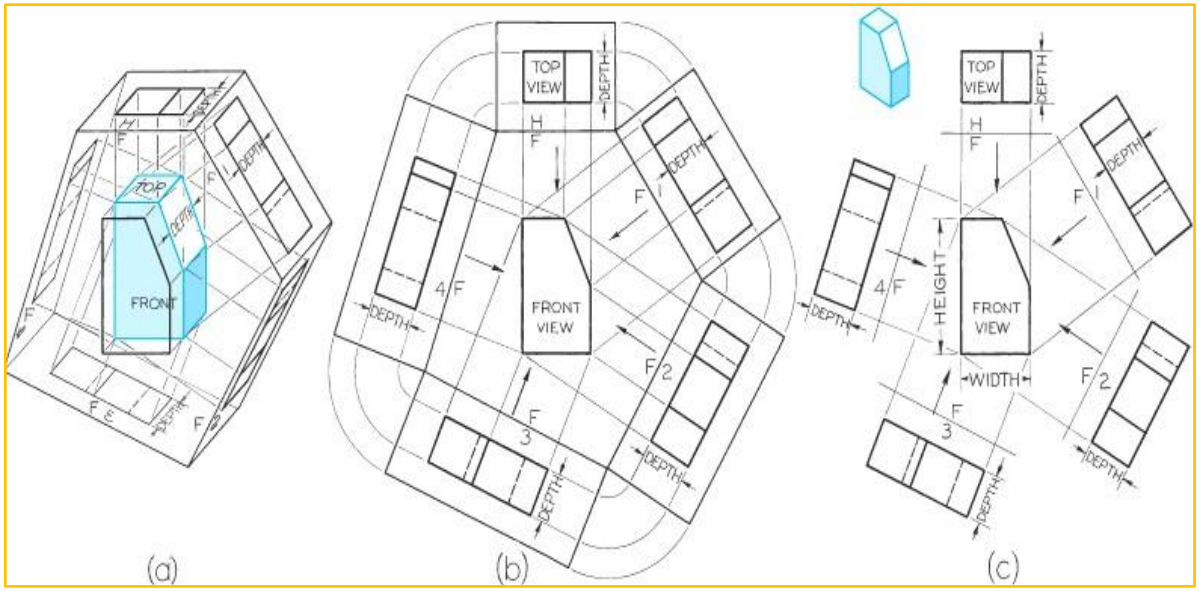
Classification of Auxiliary Views

Auxiliary views are named for the principle dimension shown in the auxiliary view. For instance, the auxiliary views in figure below are depth auxiliary views since they show the objects depth. Any auxiliary view projected from the front view, also known as a front adjacent view, is a depth auxiliary view.



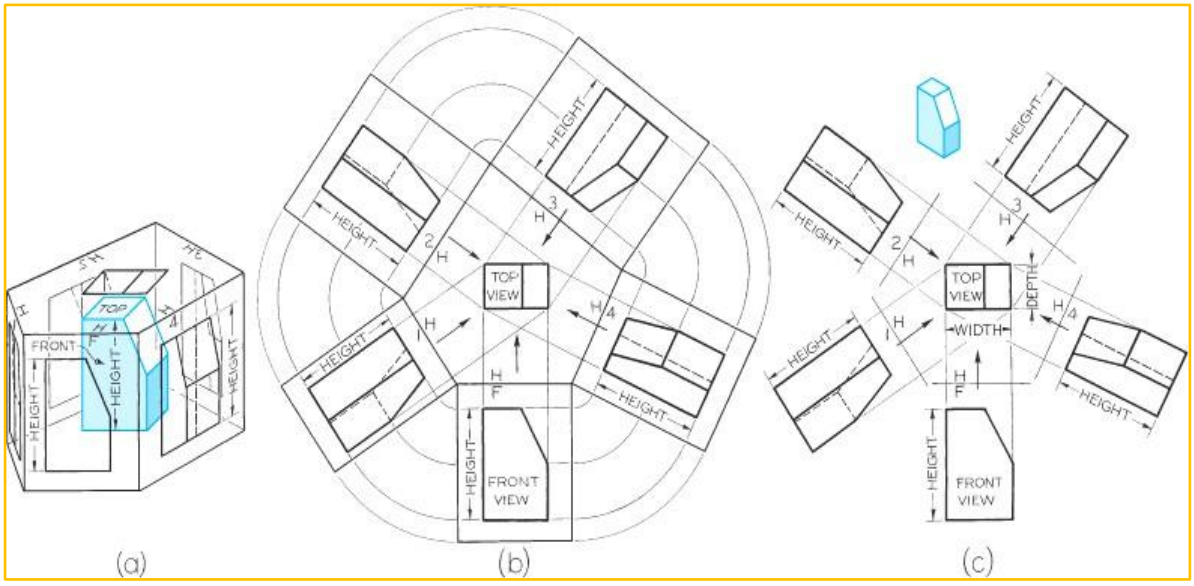
Depth Auxiliary Views

An infinite number of auxiliary planes can be hinged perpendicular to the front plane (F) Of projection. The horizontal plane is included to show that it is similar to the others. All these views show the object's depth and therefore are all depth auxiliary views.



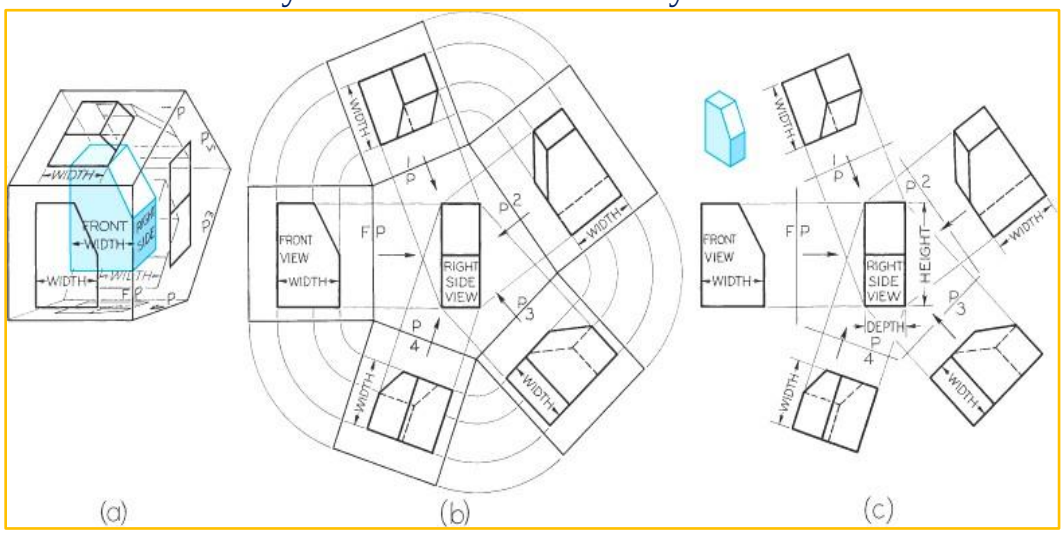
Height Auxiliary Views

An infinite number of auxiliary planes can be hinged perpendicular to the horizontal plane (H) of projection. The front view and all these views show the height of the object. Therefore all these auxiliary views are height auxiliary views.

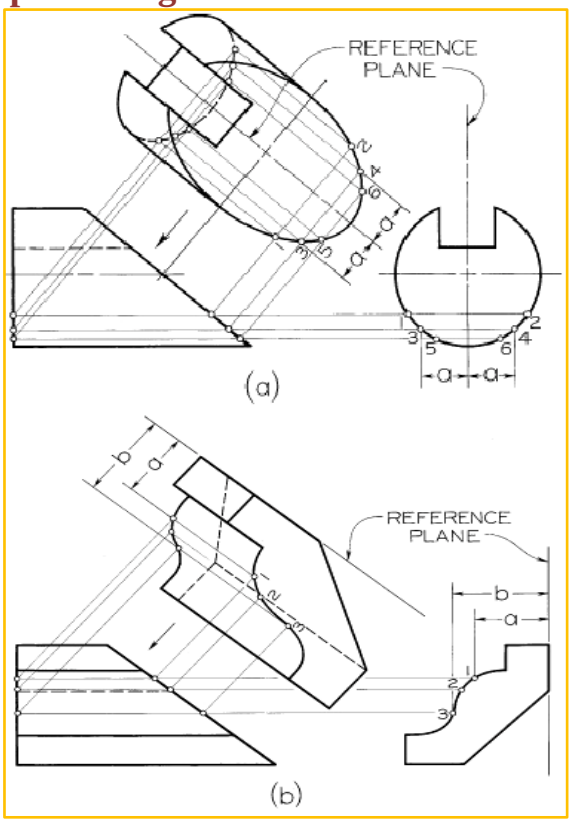


Width Auxiliary Views

An infinite number of auxiliary planes can be hinged perpendicular to the profile plane (P) of projection. The front view and all these views show the width of the object. Therefore all these auxiliary views are width auxiliary

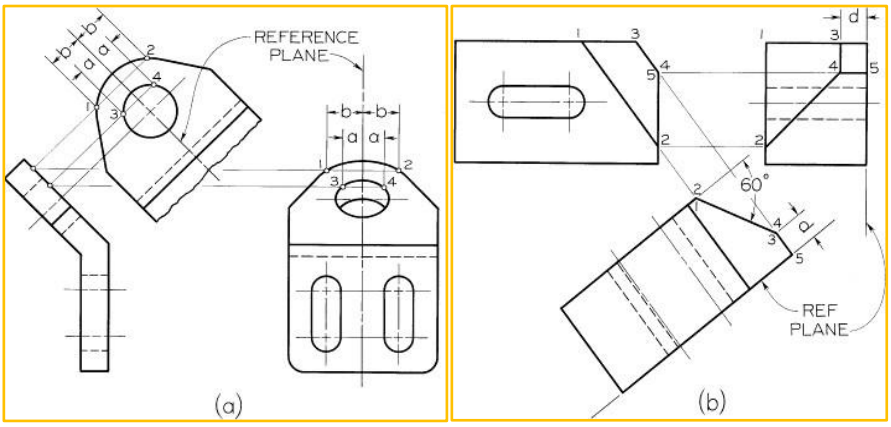


Step by Step Showing True Size of an Inclined Elliptical Surface



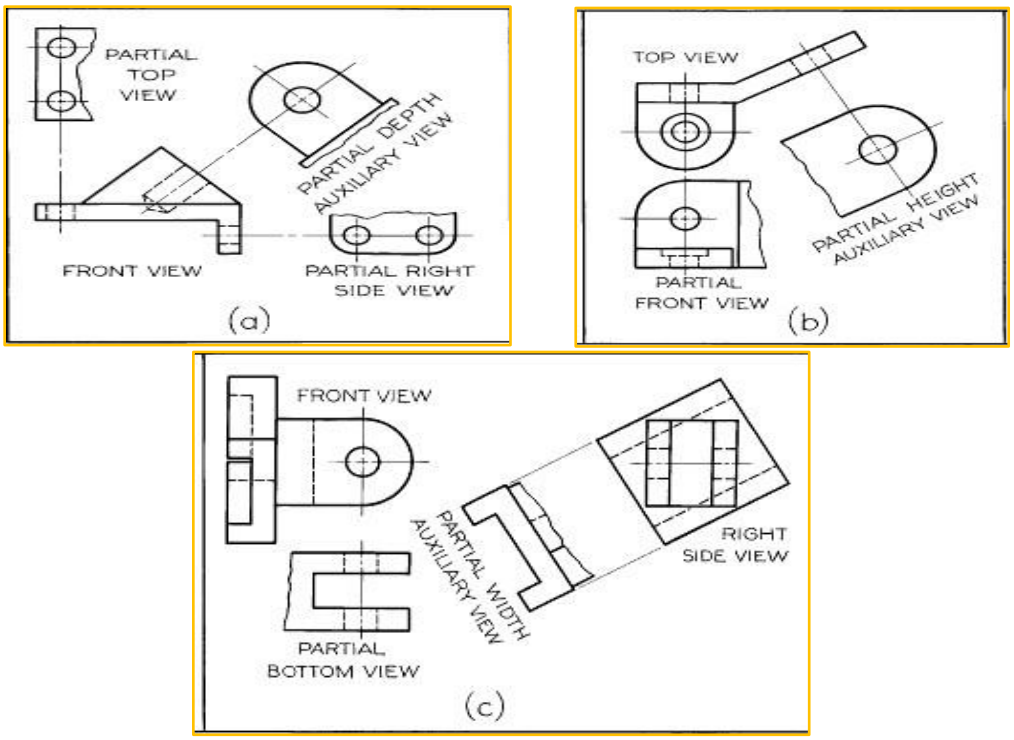
Reverse Construction

To complete the regular views, it is often necessary to first construct an auxiliary view where critical dimension will be shown true size. For example, in this figure, the upper portion of the right-side view cannot be constructed until the auxiliary view is drawn. First, points are established on the curves and then projected back to the front view, as shown.



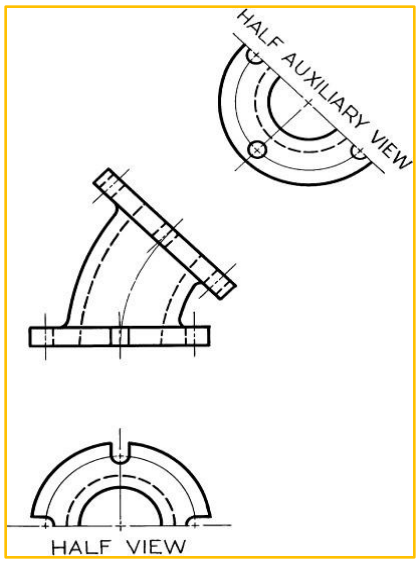
Partial Auxiliary Views

Partial views are often sufficient and easier to read. Partial regular views and partial auxiliary views are shown below. Usually a break line is used to indicate the imaginary break in the views. Do not draw a break line coinciding with a visible line or hidden line.



Half Auxiliary Views

If an auxiliary view is symmetrical, and if it is necessary to save space on the drawing or to save time, only half of the auxiliary view may be drawn, as shown below. In this case, half of a regular view is also shown since the bottom flange is also symmetrical.

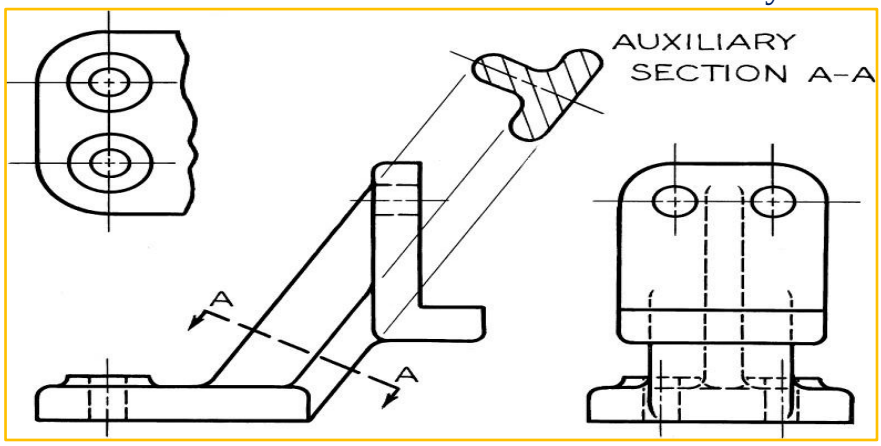


Hidden Lines in Auxiliary Views

Generally, hidden lines should be omitted in auxiliary views, unless they are needed to clearly communicate the drawing's intent. For practice, show all hidden lines, especially if the auxiliary view of the entire object is shown. Later, when you are familiar with drawing auxiliary views, omit hidden lines when they do not add needed information to the drawing.

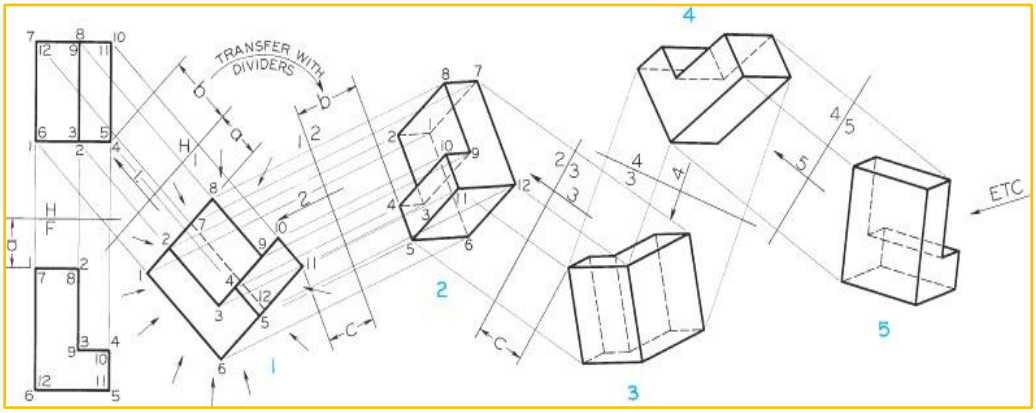
Auxiliary Sections

An auxiliary section is simply an auxiliary view in section. A typical auxiliary section is shown below. In this example, there is not sufficient space for a revolved section, though a removed section could have been used instead of an auxiliary section



Successive Auxiliary

In figure below, auxiliary view 1 is a primary auxiliary view projected from the top view. From a primary auxiliary view 1 a secondary auxiliary view 2 can be drawn; then from it a third auxiliary view 3, and so on. N infinite number of such successive auxiliary views may be drawn.



Note once again two adjacent views are perpendicular to each other, i.e., projected off perpendicularly.

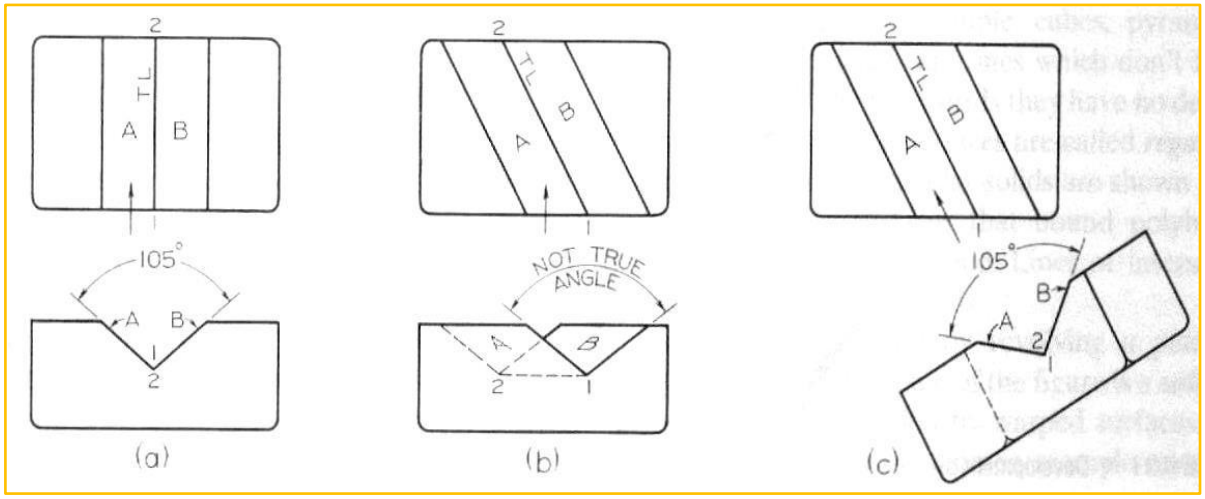
Uses of Auxiliary Views

Generally, auxiliary views are used to show the true shape or true angle of features that appear distorted in the regular views. Auxiliary views are often used to produce views that show the following:

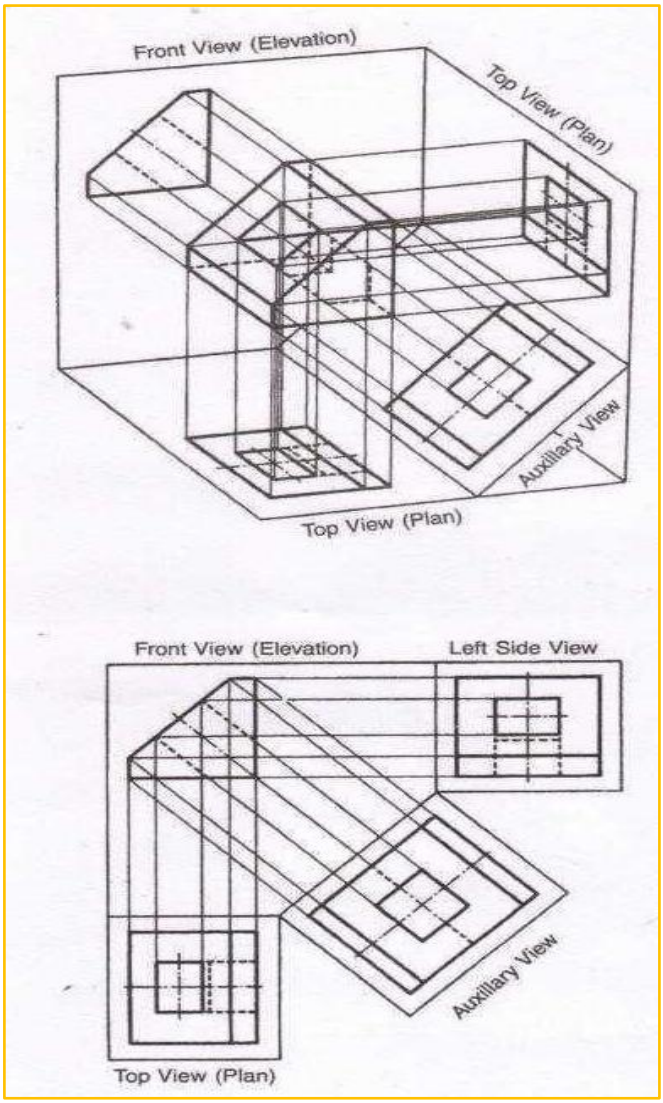
1. True length of line (TL)
2. Point view of line (PV)
3. Edge view of plane (EV)
4. True size of plane (TS)
5. True size of angle between a line and a plane or a plane and a plane

Dihedral Angles

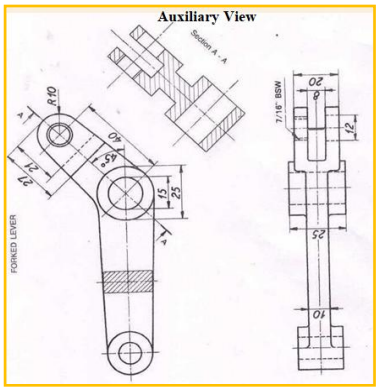
The angle between two planes is called a dihedral angle. Auxiliary views often need to be drawn to show the true size of dihedral angles.



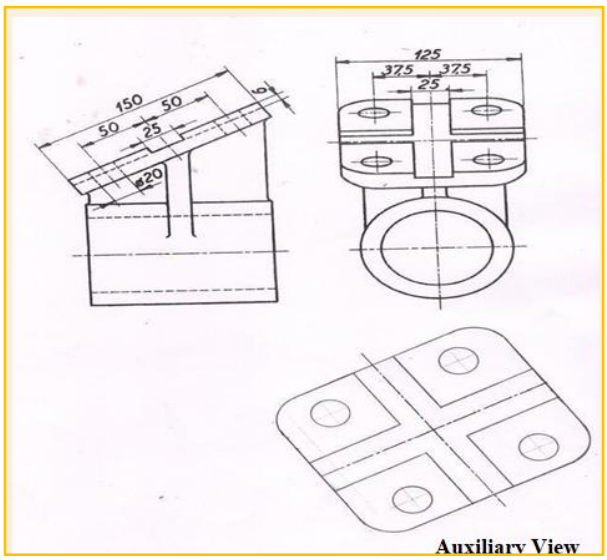
Some Example: 1



Example 2



Example 3



Summary

- Auxiliary views show true size and shape of inclined or oblique surfaces.
- Used when a surface is not parallel to any of the six principal view
- When not parallel, the surface is shown shorter than its true length
- The three classification of auxiliary views are width, height, and depth
- The auxiliary views are classified according to the principal dimension shown in the view
- An auxiliary section is cut on an auxiliary plane-on an angle.

Questions & Answers

1. Auxiliary views are necessary to show the____size of the slant surfaces

2. Auxiliary view is also called as:

   a) Top view b) Side view
   c) Special View d) Front view

3. The True length of the slant edge of pyramid can be measured from the:

   a) Front View b) Top view
   c) Auxiliary view d) Side view

4. Principle faces of the object are not_____to Principle Projection

   a) Parallel b) Perpendicular

c) Right angle d) none of these

5. The angle between two planes is called a_____angle.
   a) Included b) dihedral
   c) Right angle d) none of these

6. Short Note on:
   a) Auxiliary view
   b) Auxiliary Plane
   c) True length of line (TL)
   d) Reference Plane

Answers

1. True
2. c) Special View
3. c) Auxiliary view
4. a) Parallel
   b) Dihedral

3. DEVELOPMENT OF SOLIDS

In industrial world, an engineer is frequently confronted with problems where the development of surfaces of an object has to be made to help him to go ahead with the design and manufacturing processes. For example, in sheet metal work, it plays a vital role, thus enabling a mechanic to cut proper size of the plate from the development and then to fold at proper places to form the desired objects, namely, boilers, boxes, buckets, packing boxes, chimneys, hoppers, air-conditioning ducts etc.

"**The development of surface of an object means the unrolling and unfolding of all surfaces of the object on a plane.**"

"If the surface of a solid is laid out on a plain surface, the shape thus obtained is called the development of that solid." In other words, the development of a solid is the shape of a plain sheet that by proper folding could be converted into the shape of the concerned solid.

Importance of Development:

Knowledge of development is very useful in **sheet metal work**, **construction of storage vessels**, **chemical vessels**, **boilers**, and **chimneys**. Such vessels are manufactured from plates that are cut according to these developments and then properly bend into desired shaped. The joints are then **welded or riveted**.

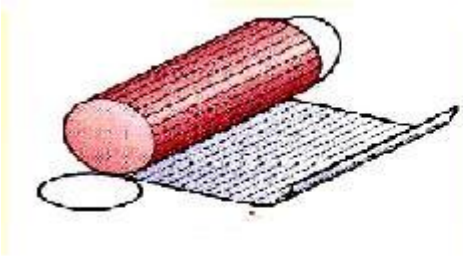
Principle of Development:

Every line on the development should show the true length of the corresponding line on the surface which is developed.

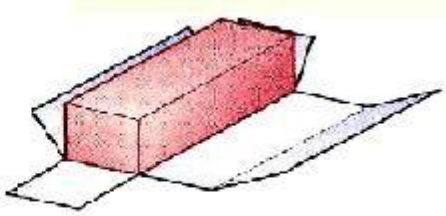
Methods of Development:

(a) Parallel-line development
(b) Radial-line development
(c) Triangulation development
(d) Approximate development

Parallel line development uses parallel lines to construct the expanded pattern of each three-dimensional shape. The method divides the surface into a series of parallel lines to determine the shape of a pattern. Example: Prism, Cylinder.

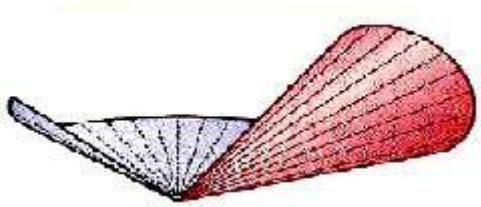


Cylinder



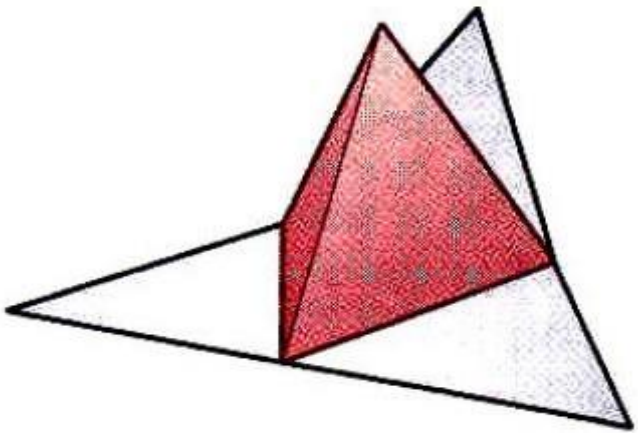
Prism

Radial line development uses lines radiating from a central point to construct the expanded pattern of each three-dimensional shape. Example: Cone, Pyramid.



Cone

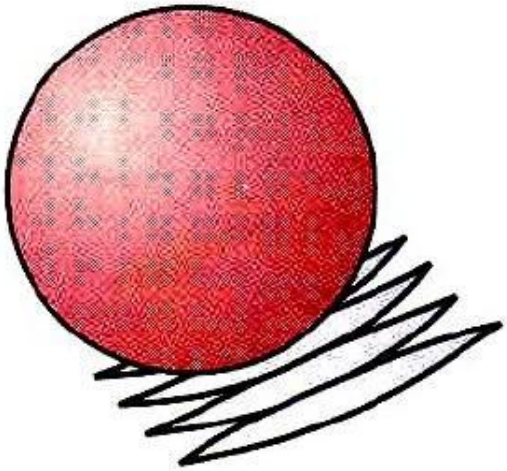
Triangulation developments are made from polyhedrons, single curved surfaces, and wrapped surfaces. Example: Tetrahedron and other polyhedrons.



Tetrahedron

Approximate development, the shape obtained is only approximate. After joining, the part is stretched or distorted to obtain the final shape. Example:

Sphere.



Development of Cubes

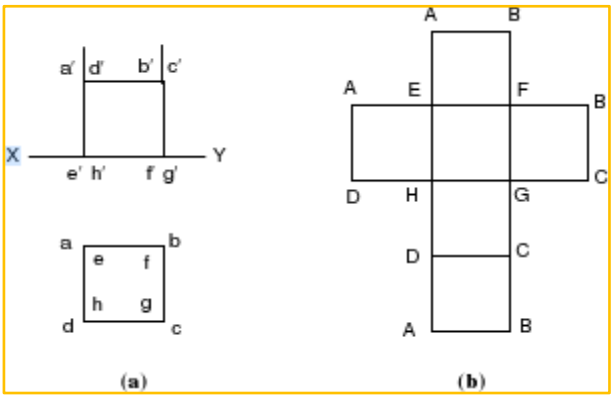
The cube is regular polyhedra consisting of six equal faces, each a square.

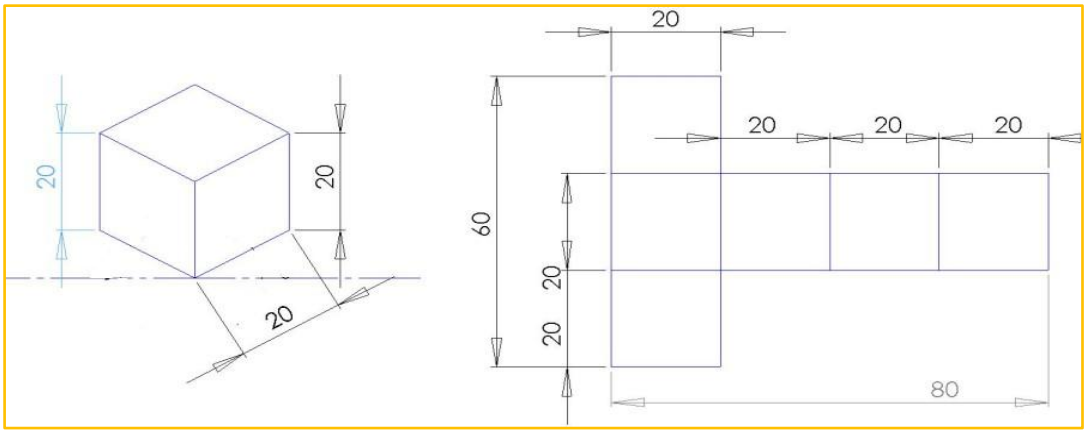
Procedure

(a) Draw the elevation and plan of a cube resting on its base in HP with two of its vertical faces parallel to VP as shown in Figure

(b) Mark the top and the bottom face as a, b, c, d and e, f, g, h, respectively, in plan and elevation.

(c) Note carefully the corners of the cube which are lettered. Develop the surface along the edges EF, FG, GH, EH and DC to get the complete development of the cube as in Figure




20
20
20
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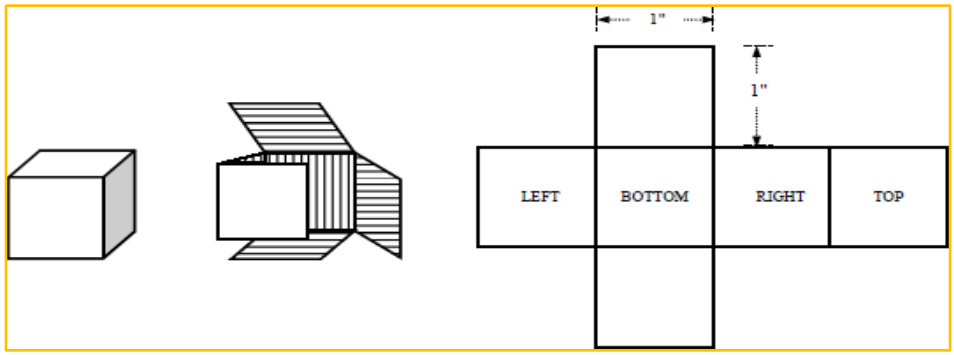
60
80


1"
1"
LEFT
BOTTOM
RIGHT
TOP

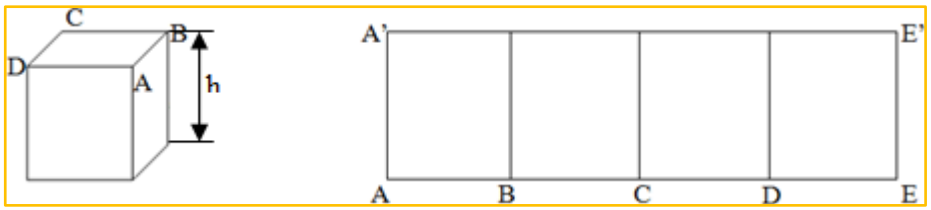
4. DEVELOPMENT OF PRISMS

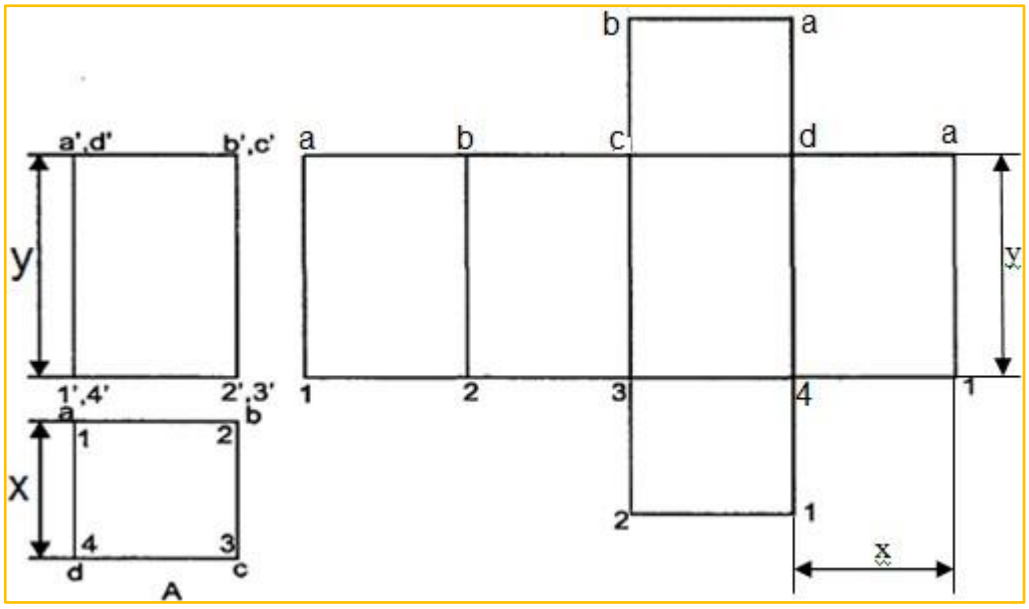
SQUARE PRISMS:-

Square prism has 6 equal square faces.

Draw AE equal to the 4 times the side of ABCD i.e. AE = 4 x AB Now Divide AE into 4 equal parts is AB, BC, CD, DE

Draw AA'. BB' ….⊥r to AE at A B C D E such that the height AA', BB' are all equal to h. Now A E' A' represents the development of the square prism





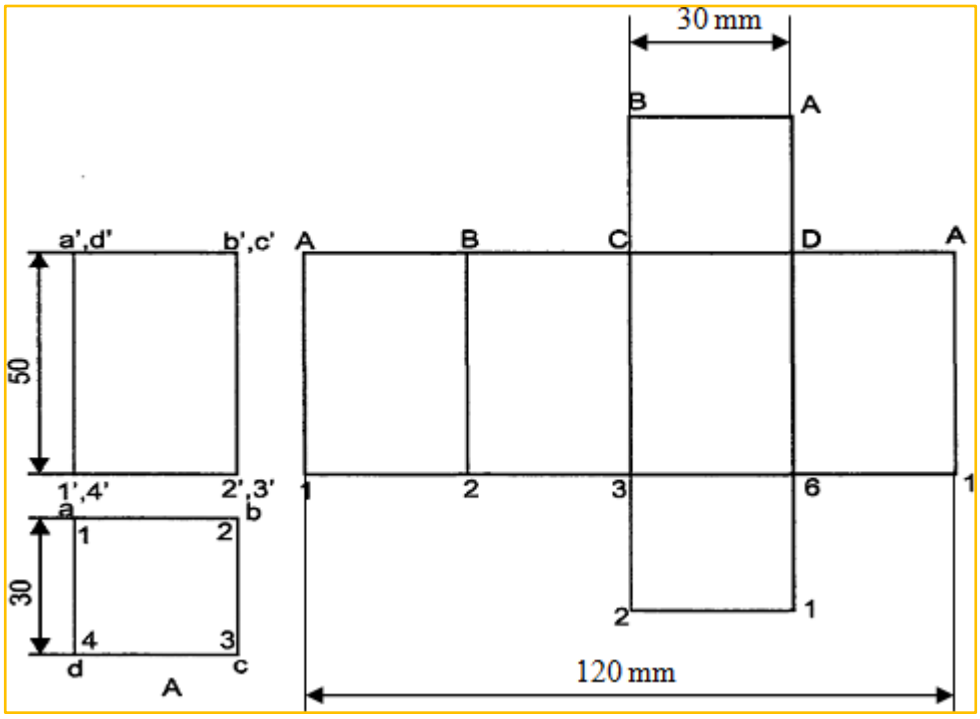
1. Assume the prism is resting on its base on H.P. with an edge of the base parallel to V.P and draw the orthographic views of the square prism.
2. Draw a line 1-1 (equal in length to the circumference of the square prism) I.e. 4 times the sides. Divide the line 1-1 into four equal parts 1 2 , 2 3 , 3 & 4-1 .

3. Erect perpendiculars through 1,2,3 etc., and mark 1-a, 2-b, 3- c , 4-d equal to the height of the prism y .

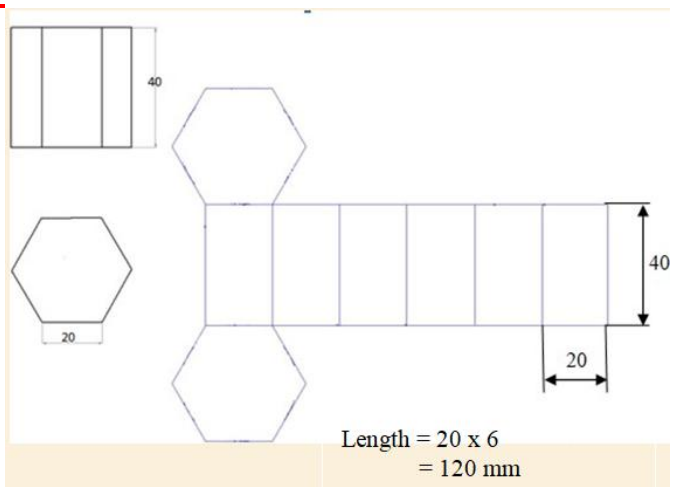
Add the bottom and top bases 1234 and ABCD by the side of any of the base edges.

Problem: -

Draw the development of a square prism of side 30 mm & height of 50mm.



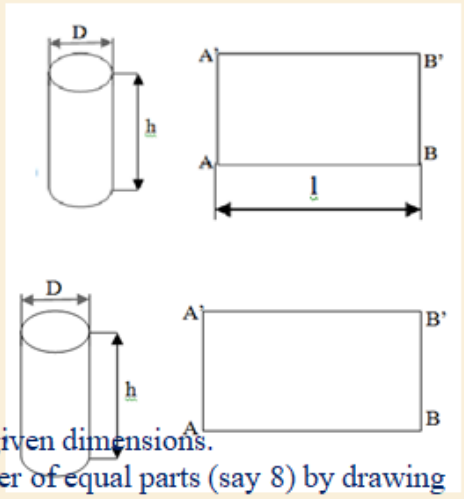
HEXAGON PRISM



5. DEVELOPMENT OF CYLINDERS

Step 1: In the front view, draw the stretch-out line aligned with the base of the cylinder and equal in length to the circumference of the base circle. At each end of this line, construct vertical lines equal in length to the height of the cylinder.

Step 2. Add the bottom and top circles.



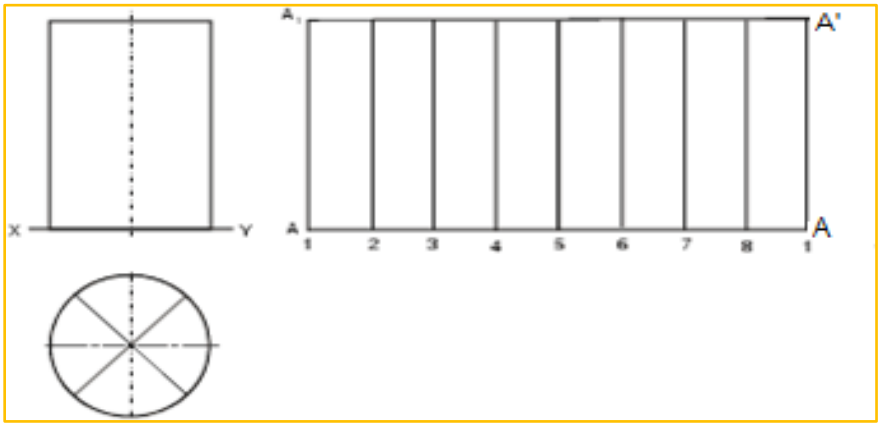
Length (l) = π x D
Height = h

Draw AB = Circumference of circle = π x D
Draw AA' & BB' ⊥r to AB at A&B,
Height of AA' = BB' = h

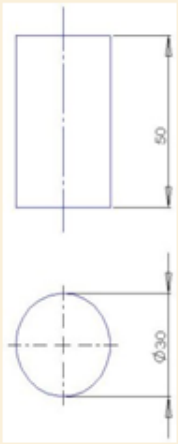
Development of a Cylinder

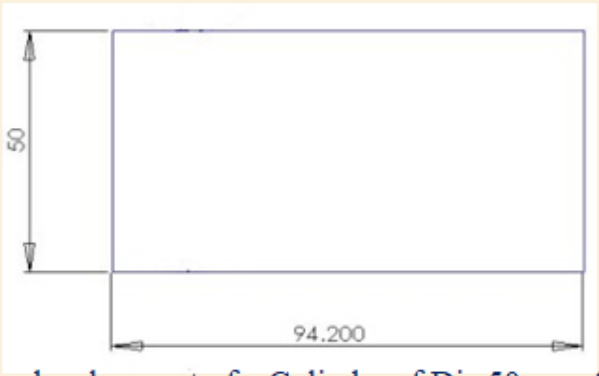
Procedure

(a) Draw a plan and elevation of a cylinder with the given dimensions.
(b) Divide a circle (of the plan) & divide it into number of equal parts (say 8) by drawing diameters.
Project these divisions in the elevation. Each line in the elevation represents a generator.
Fig 1.6
(c) Draw horizontal lines on the side of the elevation. These lines are called stretch-out lines (A A and A1, A1). The length of these lines is equal to the circumference of the cylinder π × D, where D is the diameter of the cylinder.
(d) Divide the stretch-out line into the same number of equal parts in which the plan circle has been divided (here, eight parts).
(e) The rectangle (A A A1 A1), so obtained, is the development of the lateral surface of the cylinder.



Problem 1. : - Draw the development of a Cylinder of Dia 30 mm & height of 50mm.



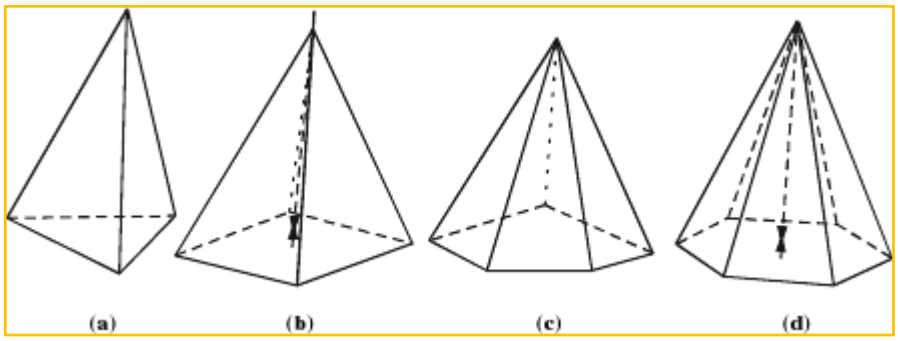


Length = π X D
= 3.14 X 30
= 94.20mm

Problem 2. : - Draw the development of a Cylinder of Dia 50 mm & height of 80mm.

6. DEVELOPMENT OF PYRAMIDS

A pyramid is a geometric solid with slant surfaces as isosceles triangles meeting at a point called apex and a base called polygon. A right and regular pyramid is that whose axis is perpendicular to the base and the base is a regular polygon. A right regular triangular, square, pentagonal and hexagonal pyramid is shown in Figures (a), (b), (c) and (d) respectively.

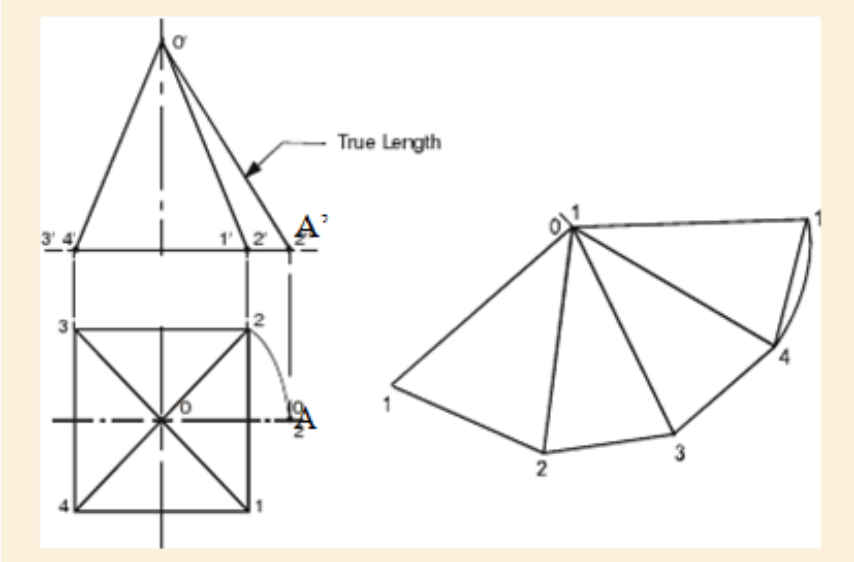


Development of the Surface of a Square

Pyramid Procedure

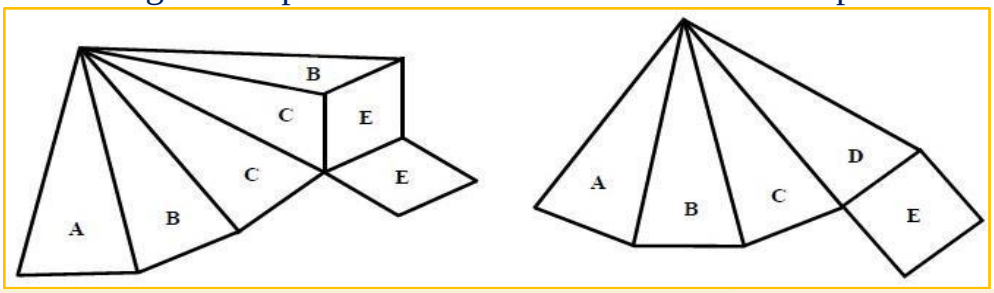
(a) Draw the front and top view of the square pyramid.

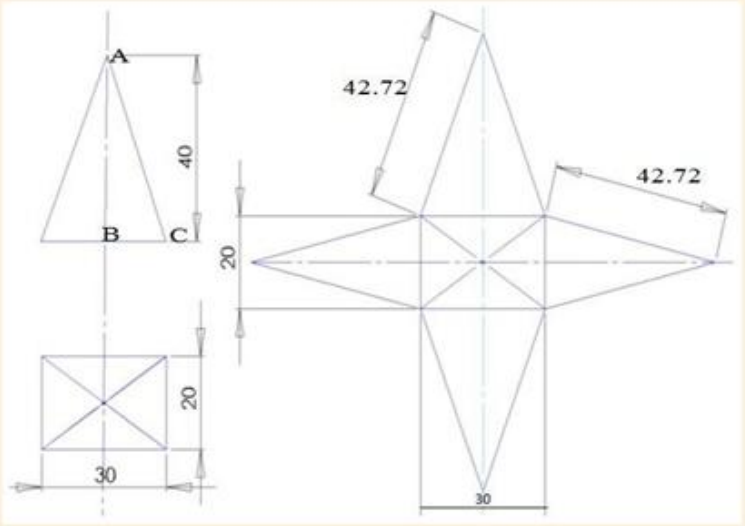
(b) For determining the true length of the slant edge 2-0, by rotating the line 0-2 about 0 till it becomes parallel to HP. Say, the new position is 0-A.



Project A in the elevation and on the locus (horizontal line) of A'. The new point of intersection is A' with 0″. The length 0'-A' is the true length of the slant edge 0.2.
With radius equal to the true length of the slant edge'' draw an arc of a circle. Select any point 1 on the arc and join it with 01. With 1 as the centre and the radius equal to the base side of the pyramid (i.e. 50 mm), cut four divisions on the arc of the circle and mark them 1, 2, 3, 4 etc. Join 1, 2, 3 and 4 with 01. Join 1 with 2, 2 with 3, 3 with 4 and 4 with 1 by straight lines. These four isosceles triangles represent the lateral development of the pyramid.

Pyramid has triangular shaped faces & each faces meets at the apex or vertex.





Slant Height

$AC^2 = AB^2 + BC^2$

$AC^2 = 40^2 + 15^2$

$AC^2 = 1600 + 225$

$AC^2 = 1825$

$AC = \sqrt{1825}$

$AC = 42.72mm$

7. DEVELOPMENT OF CONES

Let l = true slant height of the cone. This length is measured from the view in which the cone is projected as a triangle.
Let r = radius of the base of the cone.

Θ = angle subtend by the arc AB = $\frac{360 \text{ X Radius of base circle}}{\text{Slant hight}}$

Now with o as center & radius R (slant height) draw an arc of circle such that the arc subtends an angle of Θ at o.

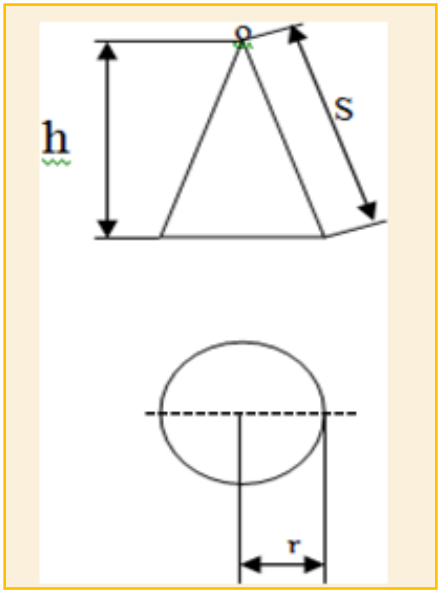
Introduction:-

The development of the lateral surface of a cone is a sector of a circle, the radius and length of the arc are equal to the slant height and circumference of the base of the cone respectively. The included angle of the sector is given by **(r / s) x 360°**, where r is the radius of the base of the cone and s is the true length.

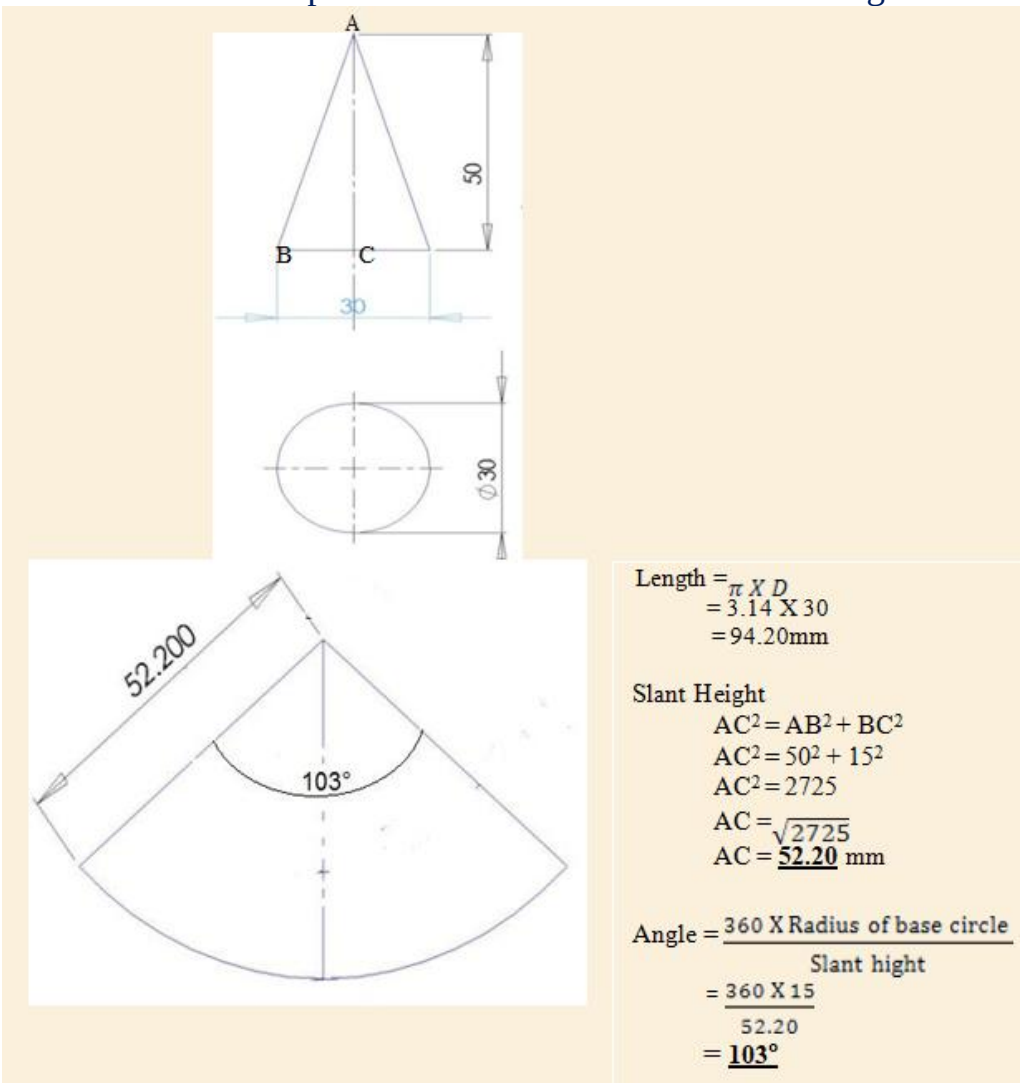
Constructions:-

Consider a cone of base radius r & height h.
Draw the front & top view of the cone.
Let S be the Slant height of the cone. This length is measured from the view in which the cone is projected as a triangle.
Draw an arc with radius equal to true slant height S. Such that the arc subtend an angle of

Θ = r/s x 360°



Problem 1 : - Draw the development of a Cone of Dia 30 mm & height of 50mm.



Length = $\pi X D$
= 3.14 X 30
= 94.20mm

Slant Height
$AC^2 = AB^2 + BC^2$
$AC^2 = 50^2 + 15^2$
$AC^2 = 2725$
$AC = \sqrt{2725}$
AC = **52.20** mm

$$\text{Angle} = \frac{360 \text{ X Radius of base circle}}{\text{Slant hight}}$$
$$= \frac{360 \text{ X } 15}{52.20}$$
= **103°**

Summary:-

If a solid is wrapped by thin papers in such a way that the paper does not have wrinkles and also it is not overlapping anywhere, then remove the paper and spread it on a plain surface. The shape of the paper is called the lateral development of that solid or pattern. If the development of the top and the bottom of the solid is also included, then it is called the total development of the surface.

Question & Answers

1. The developed length of the hexagonal prism of 40mm side is:
   a) 6 X 40 mm b) 5 X 40 mm
   c) 3 X 40 mm d) 4 X 40 mm

2. Inclined angle of hexagon is___
   a) 30° b) 60°
   c) 120° d) 150°

3. The recommended method of dimensioning of sphere with diameter 80mm is a) 80 Ø S b) Ø 80 S
   c) S 80 Ø d) S Ø 80

4. Isometric view of sphere is:
   a) Parabola b) Ellipse
   c) Circle d) Hyperbola

5. The solid having a polygon for a base & triangular lateral faces inter sectioning at a vertex is:
   a) Pyramid b) Prism
   c) Cone d) None of the above

6. A circle in isometric projection appears as_____

7. The developments of surface of a cube consist ofequal squares.

8. The developed length for 80mm diameter cylinder is

Answers

1. 6 X 40 mm 5. Pyramid
2. 120° 6. Ellipse
3. S Ø 80 7. 6
4. Ellipse 8. L= 251.2mm

Exercise:-

1. Development of given cone 60mm diameter of base and height 70mm.
2. Draw the development of a Cone of Dia. 20 mm & height of 45mm

8. SURFACE ROUGHNESS

Definition

The irregularities on the surface are in the form of succession of hills & valleys of varying in height & spacing during machining or manufacturing process. These irregularities are termed as surface roughness.

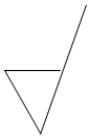
Factor effecting the surface Roughness

1. Vibrations
2. Material of the work piece
3. Type of machining
4. Type form material & sharpness of cutting tool
5. Cutting Condition feed, depth of cut
6. Type of coolant used

Indications of surface roughness

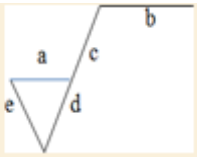
- Surface roughness obtained by manufacturing process

- Surface texture obtained by material removed by machining operation (turning, drilling & milling)



- Surface texture obtained by without removal of material (eg :- casting surfaces, welding faces)

Meaning of complete surface finish symbol



a- Roughness value in μ
b- Machining method
c- Sampling length
d - Direction of lay
e- Machining allowance

Roughness value Ra (mm)	Roughness grade number	Roughness symbol
50	N12	
25 12.5	N11 N10	
6.3 3.2 1.6	N9 N8 N7	
0.8 0.4 0.2	N6 N5 N4	
0.1 0.05 0.025	N3 N2 N1	

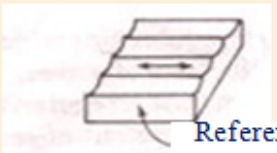
LAY

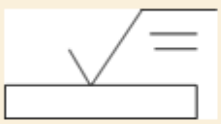
Is the direction of the predominant surface pattern produced by the tool marks or scratches, it is determined by the method of production used.

Symbols used to indicate the direction of lay are given below.

= Lay parallel to the boundary line of nominal surface that is, lay parallel to line representing surface to which symbol used.

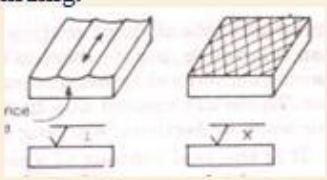
Eg:- Parallel shaping, end view of turning and O.D grinding





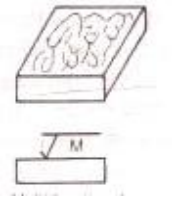
= Lay perpendicular to boundary line of nominal surface that is, lay perpendicular to the line representing surface to which the symbol is applied.

X = Lay angular in both direction to the line representing the surface to which symbol is applied.
Eg: - Traversed end mill, side wheel grinding.

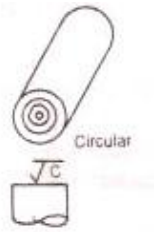


Perpendicular Angular

M = Lay multidirectional.
Ex: - Lapping supper fishing, Honing



C = Lay approximately circular related to the center of the surface to which the symbol is applied.
Ex: - Facing on lathe.



R = Lay approximately radial relative to the centre of the surface to which the symbol is applied.
Ex: - Surface ground on a turn table, fly cut & indexed on end mill.

Questions & Answers

1. Surface roughness is indicated by____.
   (a) Rt (*b*) Ra (c) ra
2. Surface flatness is measured by____.
   (a) Micrometer (*b*) Feeler gauge (*c*) Optical flat
3. Roughness value Ra is given in____units.
4. The Ra value for turning is_____to_____.
5. The Ra value for honing is_____.
   (*a*) 0.025 (*b*) 0.4 (*c*) 0.015
6. The roughness value for lapping is .
   (*a*) 0.012 (*b*) 0.06 (*c*) 0.04
7. The roughness value for super finishing is to_____.
8. The roughness value for forging is____to_____.
9. The roughness grade for 50 µm is____.
10. The roughness value for grade N2 is_.
11. Two triangles indicate_____.
    (*a*) Fine finish (*b*) Rough finish (c) Finish

ANSWERS-

1. (*b*) Ra
2. (*c*) Optical flat
3. Micron
4. 0.32 to 25
5. (*a*) 0.025
6. (*a*) 0.012
7. 0.016 to 0.32
8. 1.6 to 2.8
9. N 12
10. 0.05
11. (*a*) Fine finish

I. Match the Following: Questions

Sl. no	Side A		Side B
1	M	a	Crossed in two slant direction relative to the plane of projection
2	X	b	Parallel to plane of projection
3	=	c	Roughness value 12.5 µm
4	N10	d	Hexagon
5	N5	e	Multi - Directional
6	Solid having 6 equal faces	f	Roughness value 0.4 µm
7	Solid having 5 equal faces	g	Used in vehicle transmission system
8	Screw jack	h	Pentagon
9	Pipe vice	i	To lift loads
10	Universal Coupling	j	Used in plumbing works
11	Unidirectional System	k	Sampling length 2.5 mm
12	Reduced Scale	l	1:3
13	Parallel dimensions	m	Perpendicular to the plane of projection
14		n	45°
15		o	System of dimension
16	Hatching line	p	Indication of dimensions
17	_____	q	Ra value in µm < 0.025
18	Arrow Head	r	1:2
19	____	s	0.2 mm
20	Continuous thin	t	Surface roughness without removal of material

I. Match the Following Answers

Side B

1. **e**. (Multi – Directional)
2. **a**. (Crossed in two slant direction relative to the plane of projection)
3. **b**. (Parallel to plane of projection)
4. **c**. (Roughness value 12.5 µm)
5. **f**. (Roughness value 0.4 µm)
6. **d**. (Hexagon)
7. **h**. (Pentagon)
8. **i**. (To lift loads)
9. **j**. (Used in plumbing works)

10. **g**. (Used in vehicle transmission system)
11. **o**. (System of dimension)
12. **r.** (1:2)
13. **p**. (Indication of dimensions)
14. **q**. (Ra value in µm < 0.025)
15. **t**. (Surface roughness without removal of material)
16. . **n**. (45°)
17. **k**. (Sampling length 2.5 mm)
18. **l**. (1:3)
19. **m.** (Perpendicular to the plane of projection) 20. **s.** (0.2 mm)

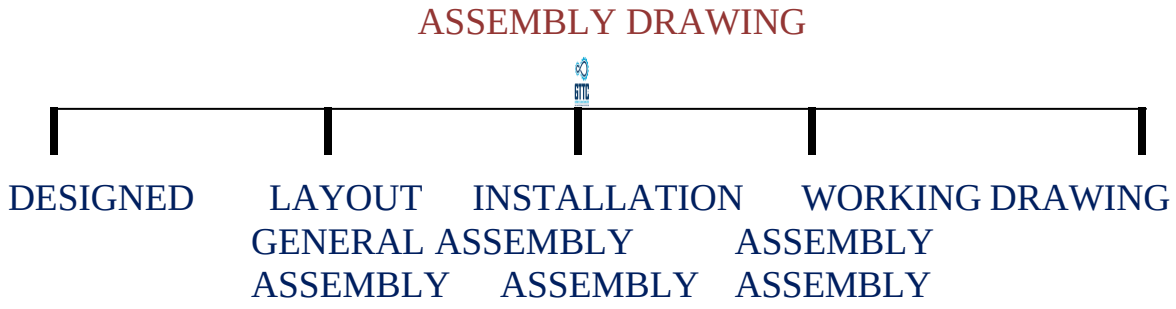
UNIT 2: ASSEMBLY DRAWING

INTRODUCTION

• A drawing which displays the parts of a machine or a machine unit assembled in their relative working positions is known as assembly drawing.

• The assembly drawing would be such that it should satisfy: (i) Manufacturing requirements (ii) Operational requirements (iii) Maintenance requirements.

The assembly drawings are classified according to their use as shown below:



• **Designed assembly**: This assembly drawing is prepared at the design-stage on a larger scale.

• **Layout assembly**: This is an assembly drawing showing how the parts are assembled with their basic proportions (dimensions).

• **Installation assembly**: This is prepared for the installation or erection of a machine. This is also sometimes known as an outline assembly.

• **Working drawing assembly**: A complete set of working drawings of a machine comprises of detailed drawings, giving all necessary information for the production of individual parts and assembly drawing showing the location of each part. The

assembly drawing should be ready before the detailed drawings are accepted as finished and the blue-prints are made.

• **General assembly**: It comprises of the detailed drawings of the individual parts, sub- assembly and the assembly drawings of the machine.

Norms to be observed in preparing assembly drawings

• (i) **Selection of views**: The main or important view which is usually in section should show all the individual parts and their relative locations. Additional views are shown only when they add necessary information.

(ii) **Sectioning**: The parts should be sectioned according to the requirements (i.e. half-section or partial section) to show important assembly details. Code of the BIS (SP:46-1988) for general engineering drawings must be observed

• (iii) **Dotted lines**: The dotted lines should be omitted from the assembly drawing when a proper section is taken. If the view of a part is drawn by the half-section, then in un section portion of the view, the dotted lines may be drawn to clarify details of the part.

• (iv**) Dimensions**: The overall dimensions and centre-to centre distances showing the relationship of parts to the machine as a whole, are sometimes shown.

• (V) Detailed dimensions are given on working assembly drawings when the detailed drawings are not prepared.

Bill of Materials

• **Bill of materials**: Each part of the machine is identified on assembly drawing by the leader line and number, which are used in the detail drawing and in the bill of material. The height of the number may be approximately 5 mm and encircled by 9 mm diameter. Leader lines are drawn radially touching the respective parts.

• The bill of materials also shows the following:

(a) Number of parts
(b) Material of parts
(f) Shop processes required for one unit
(g) Name of the company

(c) Standard norm for (h) Designed by, drawn by standard components an checked
(d) Scale (i) Any special remark.
(e) Method of projection

• The table containing above information must be prepared as shown in the illustrative problems.

Suggested approach

• Preparing an assembly form exploded view is easy task as clue to the position and sequence is available

• For preparing from orthographic view of the individual components some skill is Needed

The suggested approach is
• Functional Matching or Mapping
• Geometrical mapping
Dimensional mapping

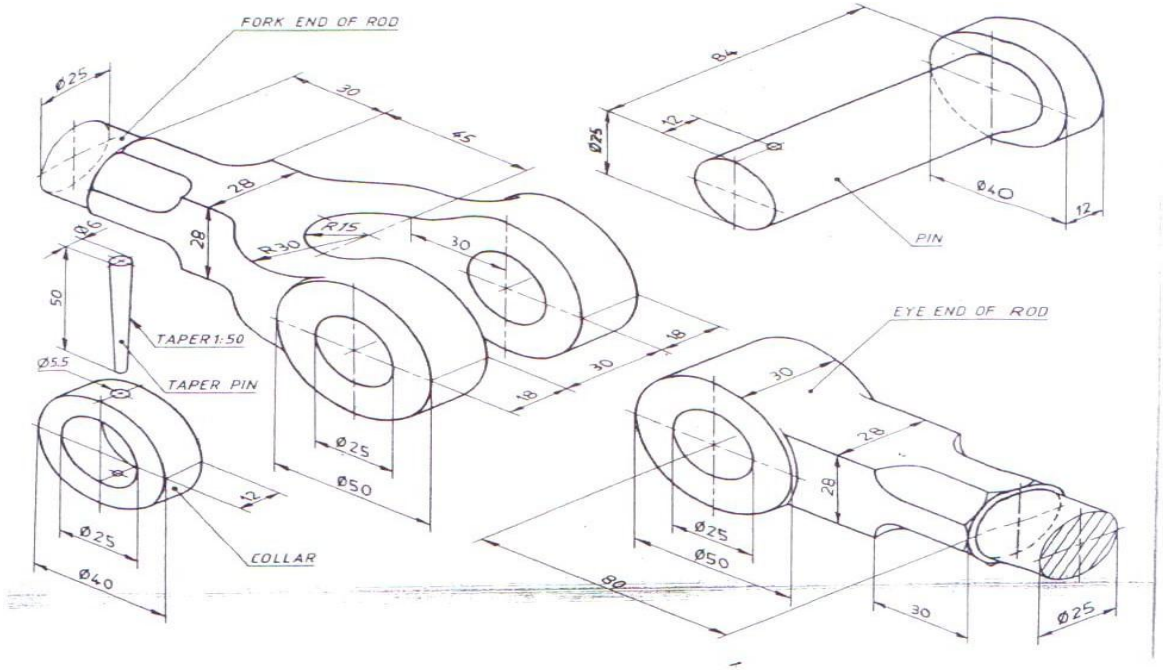


Fig. 4.1 Knuckle Joint

Sequences of preparing the assembly drawing

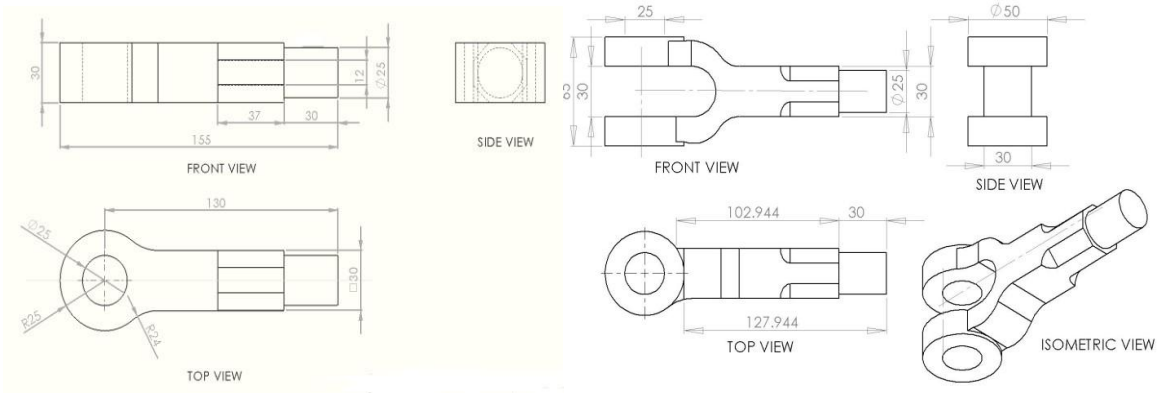
- (i) Study functional requirements of each component and their inter relationship.
- Learn the actual working of a machine.
- (ii) Study carefully the views of each component in the detail drawing and decide the relative location of each part for the proper functioning of the machine.
- (iii) Decide the mating dimensions between two components which are required to be assembled.
- iv) Prepare free-hand sketch of the main view or an important view (generally front-elevation). Add additional views, if necessary.
- (v) Select a suitable scale for the entire assembly drawing.
- (vi) Lay out the views of the assembly drawing so that it become easier to understand.
- (vii) Prepare the bill of materials.
- (viii) Label each component by the leader-line and number it.
- (ix) Show overall dimensions.
- (x) Draw the section-lines according to the convention

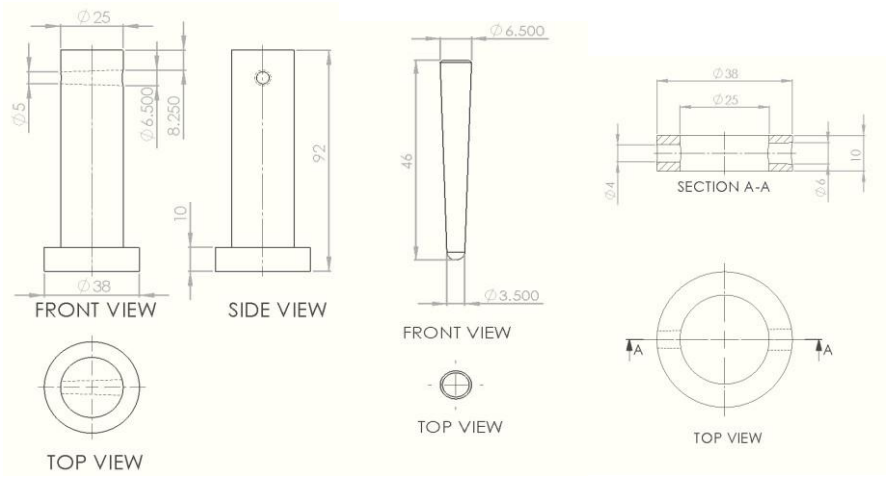
(xi) Show required fits and tolerances between the two mating components.(Where it is necessary)

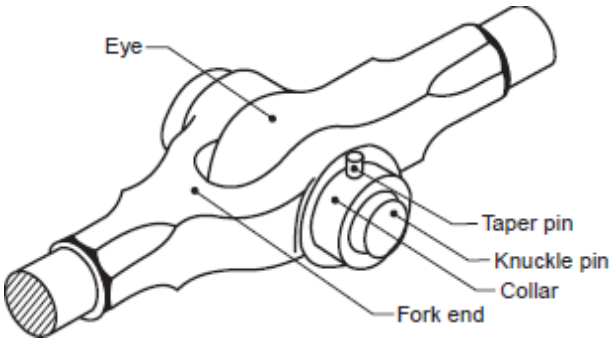
KNUCKLE JOINT ASSEMBLY

A knuckle joint is a pin joint used to fasten two circular rods. In this joint, one end of the rod is formed into an eye and the other into a fork (double eye). For making the joint, the eye end of the rod is aligned into the fork end of the other and then the pin is inserted through the holes and held in position by means of a collar and a taper pin once the joint is made, the rods are free to swivel about the cylindrical pin.

Knuckle joints are used in suspension links, air brake arrangement of locomotives, etc.

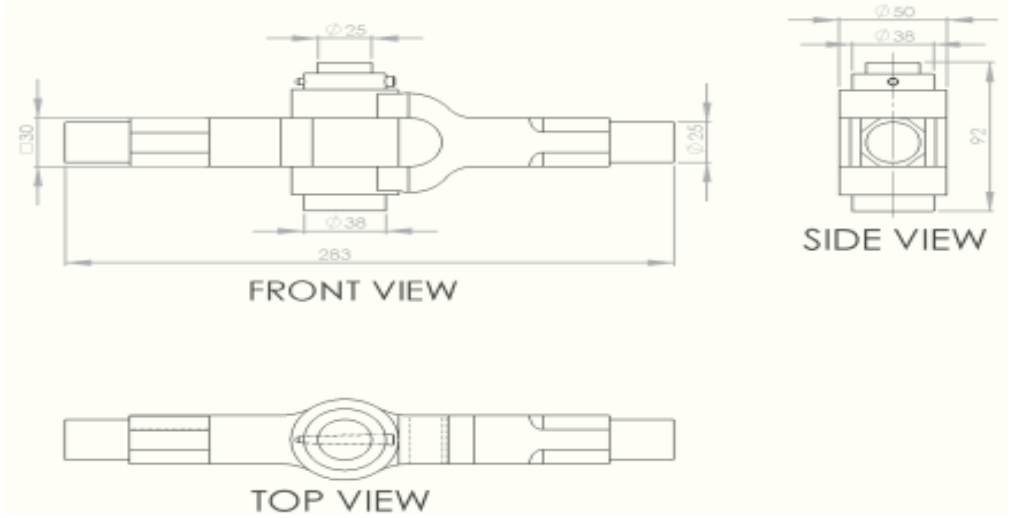




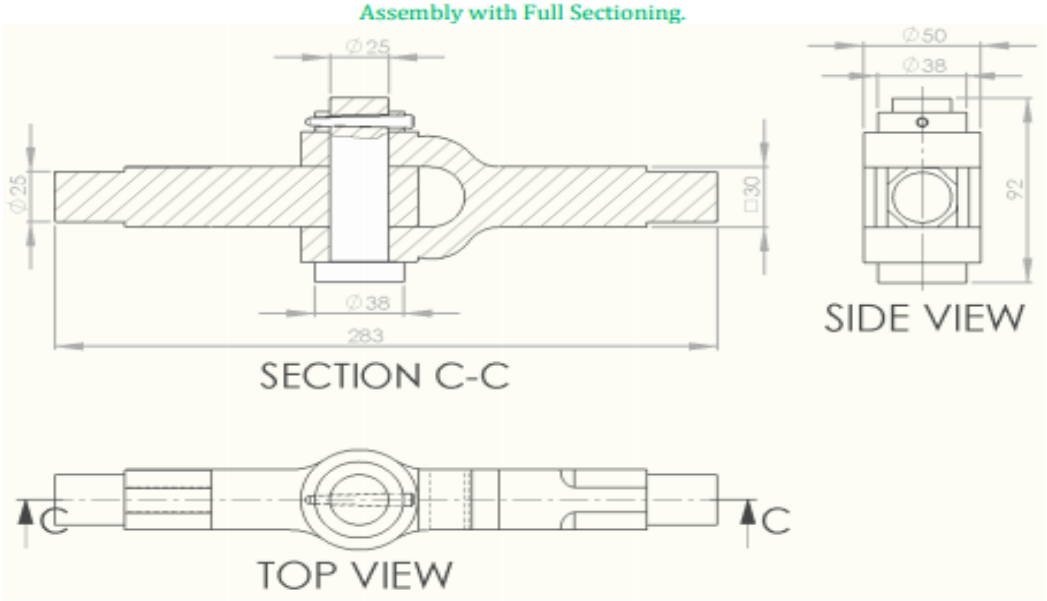


Assembly without Sectioning

Assembly without Sectioning



Assembly with Full Sectioning.

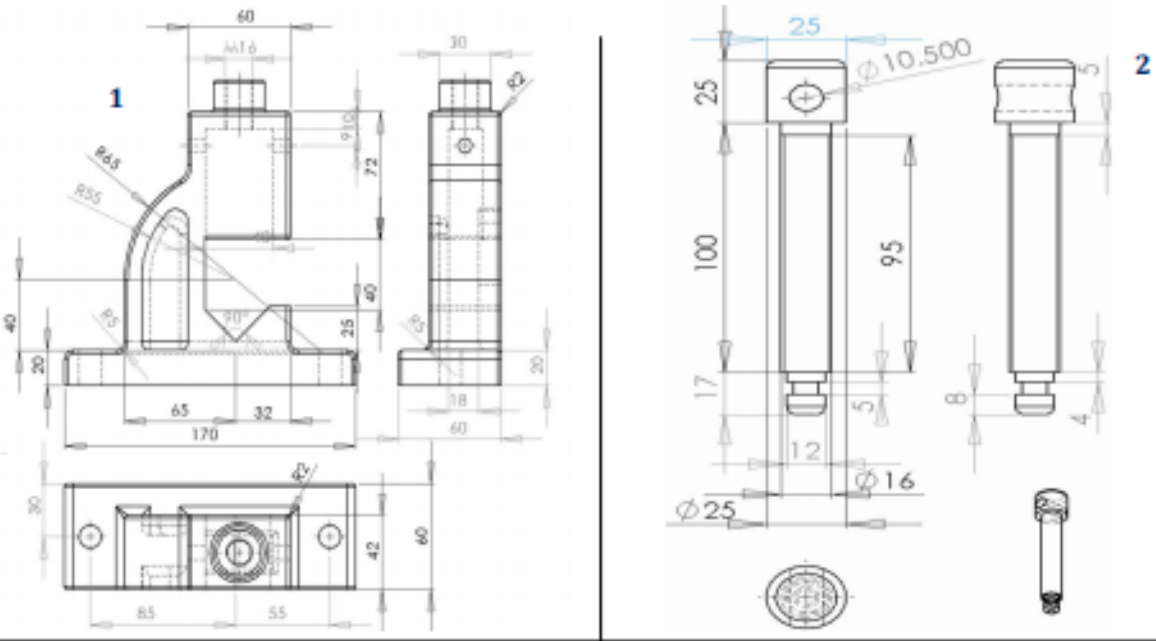


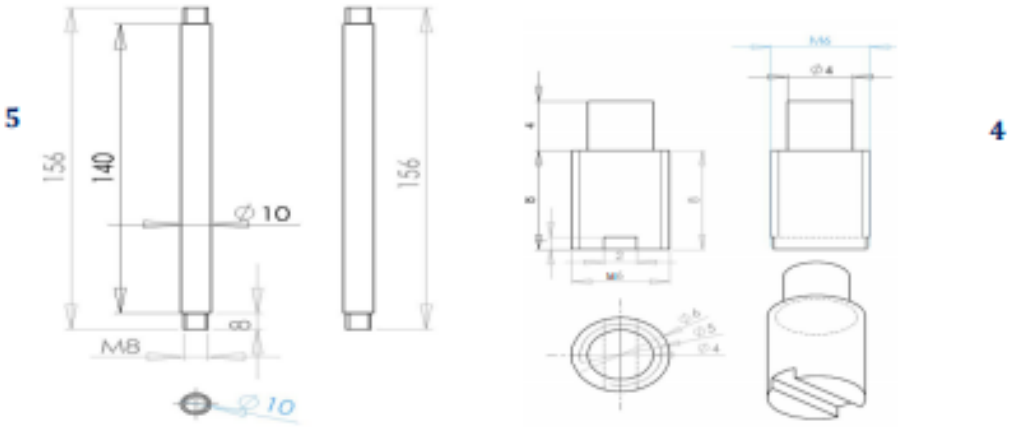
Pipe Vice

Application:

As the name suggests pipe vice is used for holding pipes & round bars for cutting, threading operation.

It is generally used in plumbing work. The main Body of pipe vice is made of cast iron. The movable jaw will move while rotating a screw rod to hold the work piece. V notches are provided for increasing the gripping power.



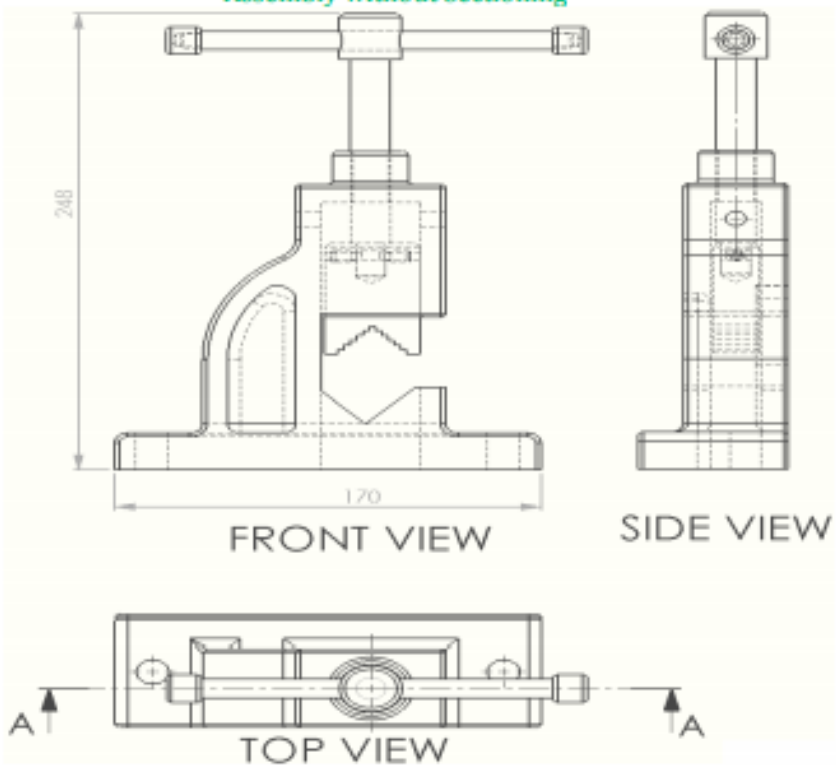


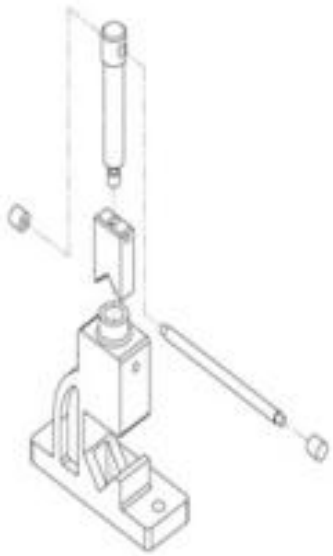
Part List:-

6	2	HANDLE BAR CAP
5	1	HANDLE BAR
4	2	SET SCREW
3	1	MOVABLE JAW
2	1	SCERW ROD
1	1	VICE BASE
SL / NO	QTY NO	DESCRIPTION

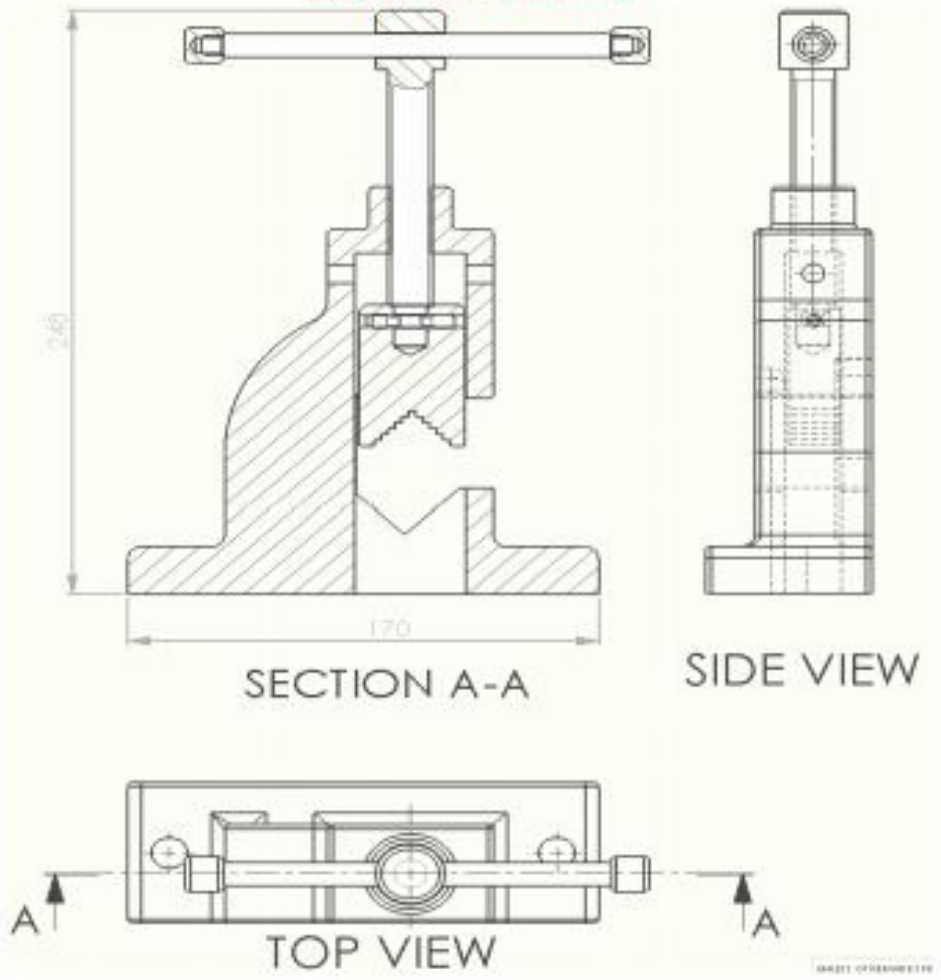
Pipe vice Assembly

Assembly without Sectioning

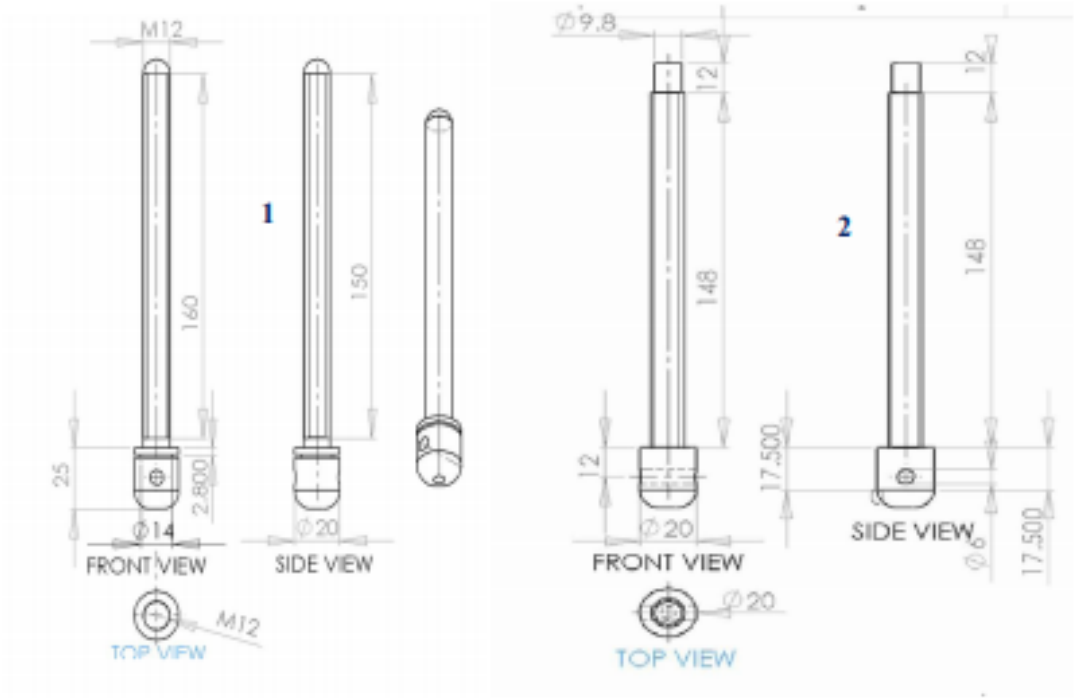


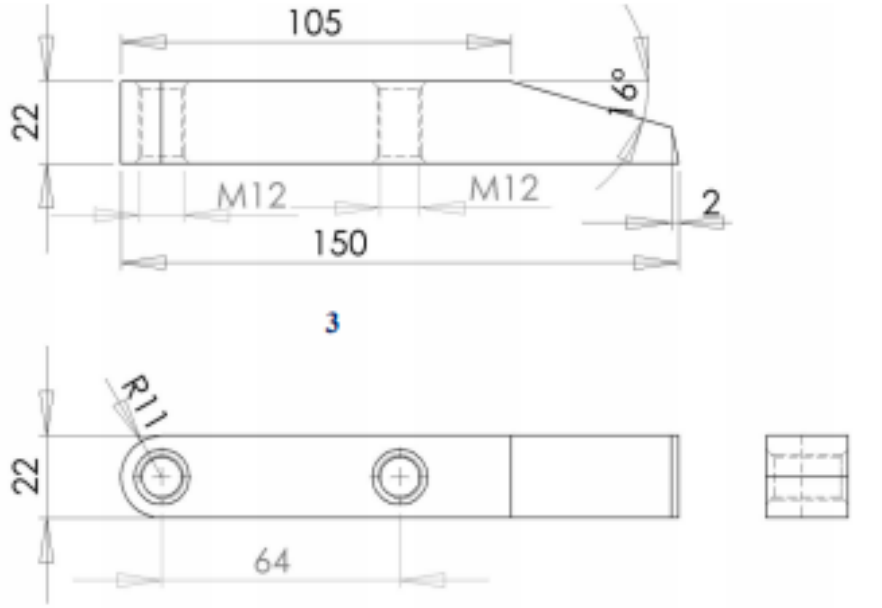


Assembly with Sectioning

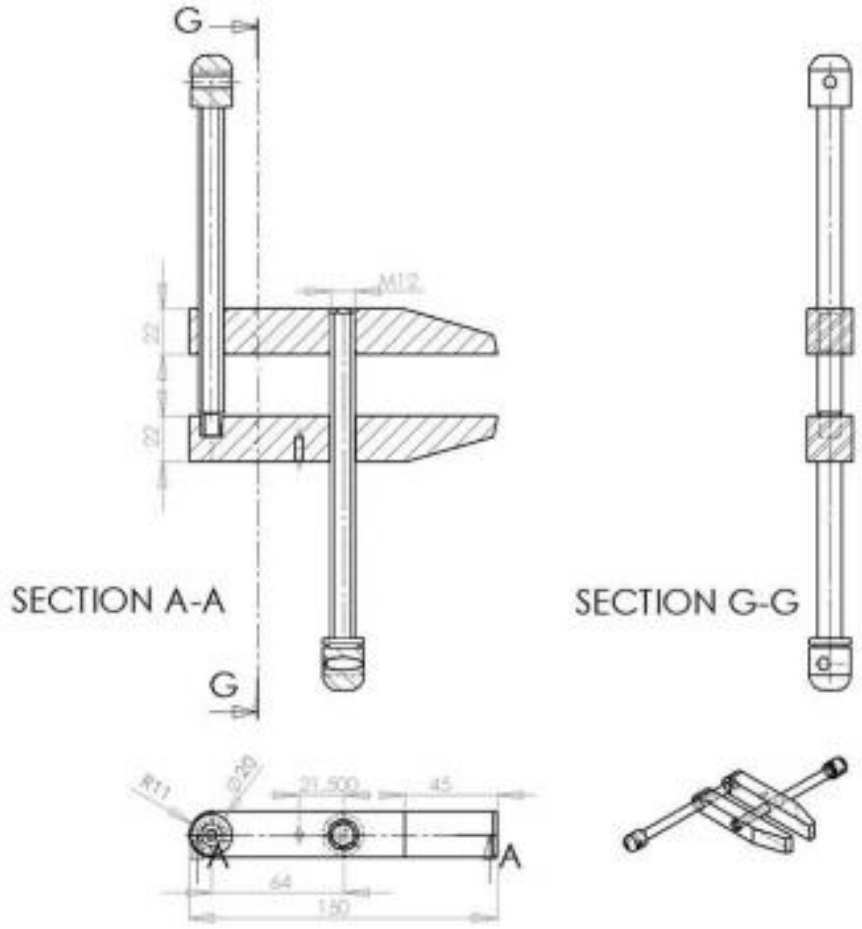


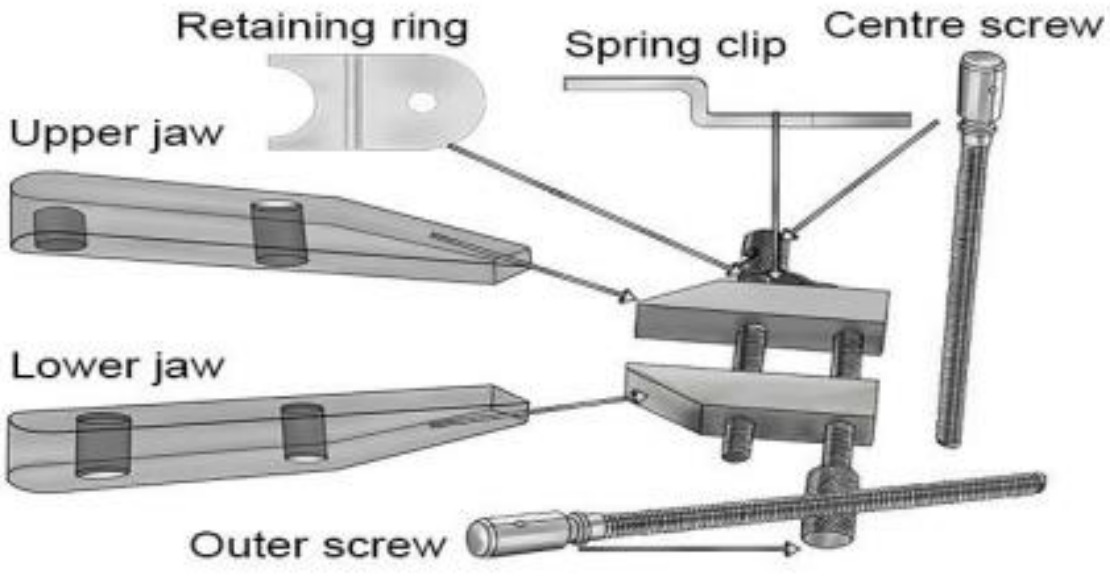
Tool maker's Clamp



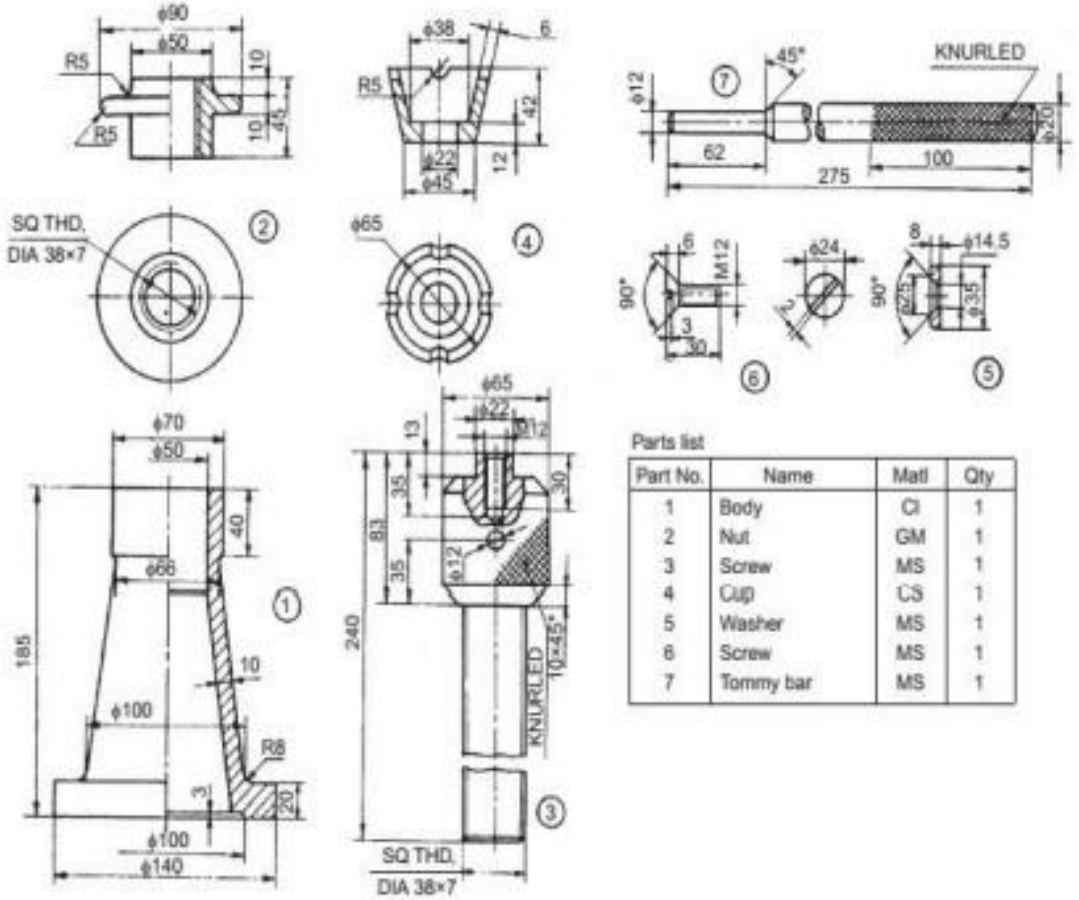


3	2	JAW
2	1	SCREW SPINDLE
1	1	SCREW SPINDLE
SL/NO	QTY NO	DESCRIPTION


G
M12
22
22
SECTION A-A
SECTION G-G
G
R11
Ø20
21.500
45
A
64
150


Retaining ring
Spring clip
Centre screw
Upper jaw
Lower jaw
Outer screw

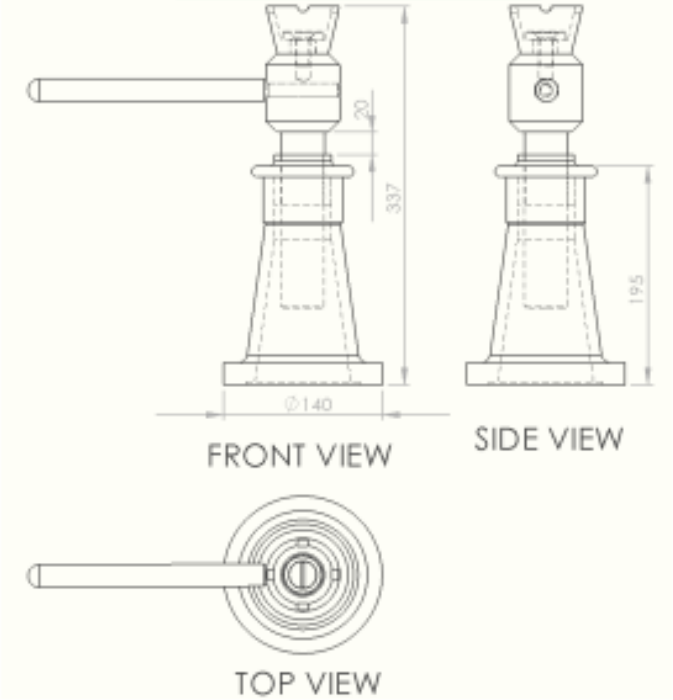
Screw jack



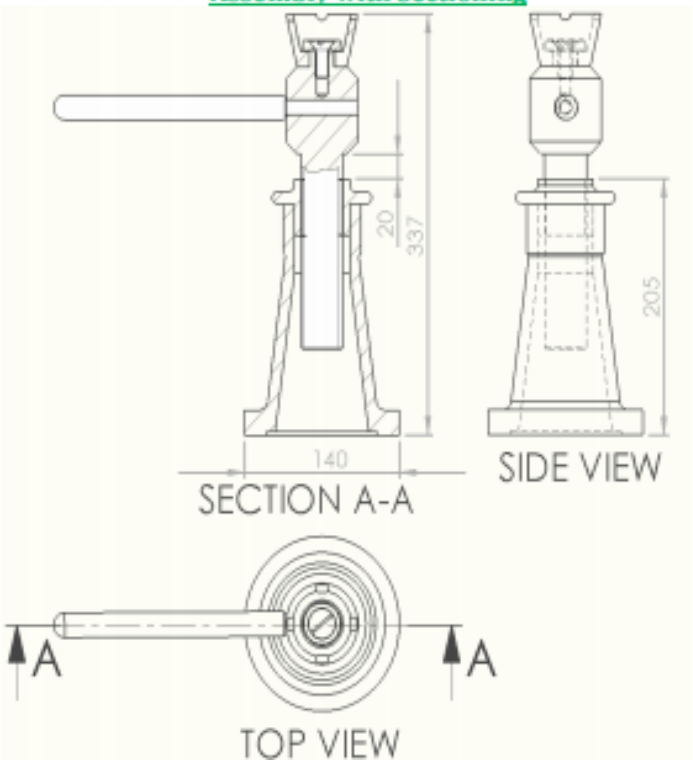
Parts list

Part No.	Name	Matl	Qty
1	Body	CI	1
2	Nut	GM	1
3	Screw	MS	1
4	Cup	CS	1
5	Washer	MS	1
6	Screw	MS	1
7	Tommy bar	MS	1

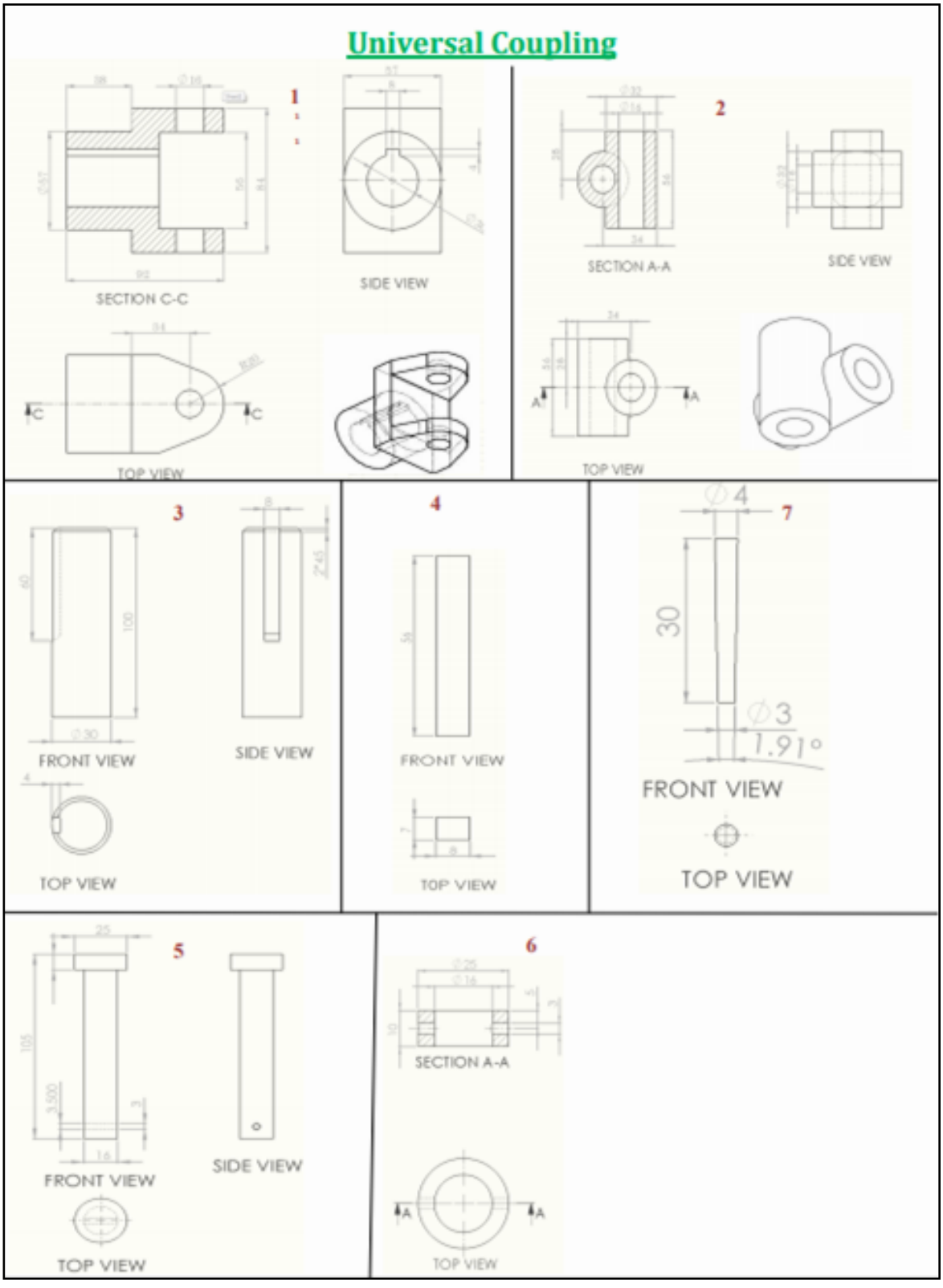
Assembly without Sectioning



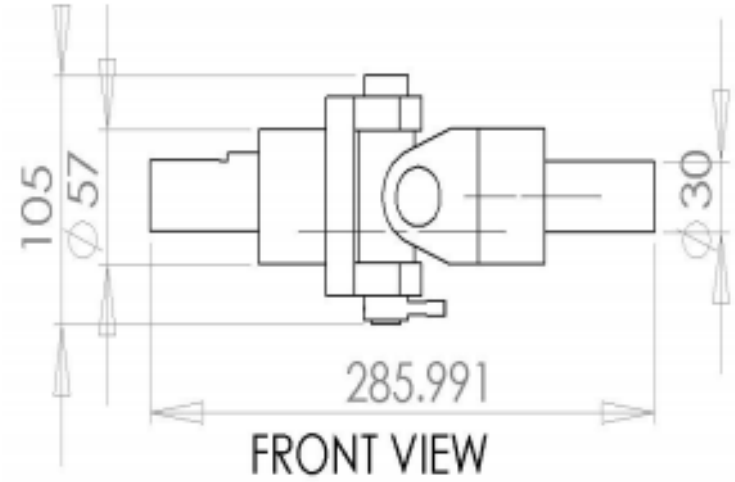
Assembly with Sectioning



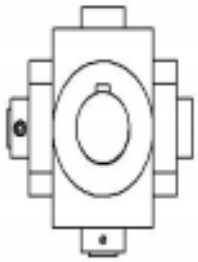
Universal Coupling



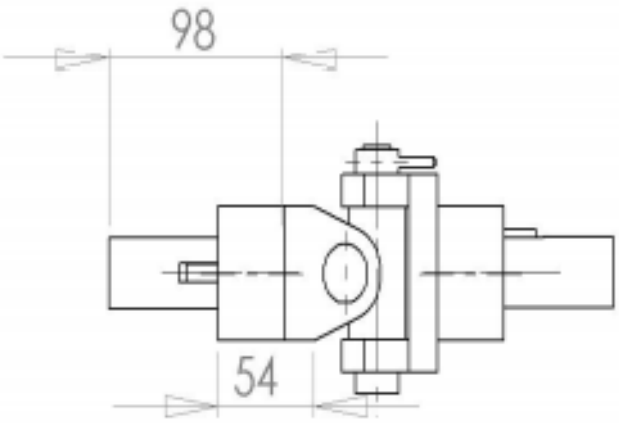
It is a rigid coupling that connects two shafts, whose axes intersect if extended. It consists of two forks which are keyed to the shafts. The two forks are pin joined to a central block, which has two arms at right angle to each other in the form of a cross .The angle between the shafts may be varied even while the shafts are rotating.



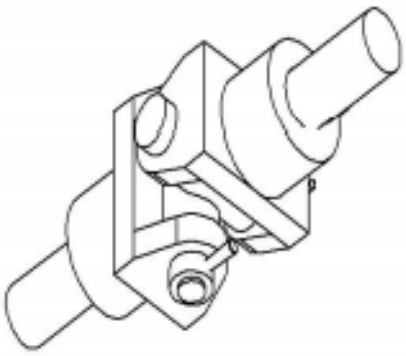
FRONT VIEW



SIDE VIEW



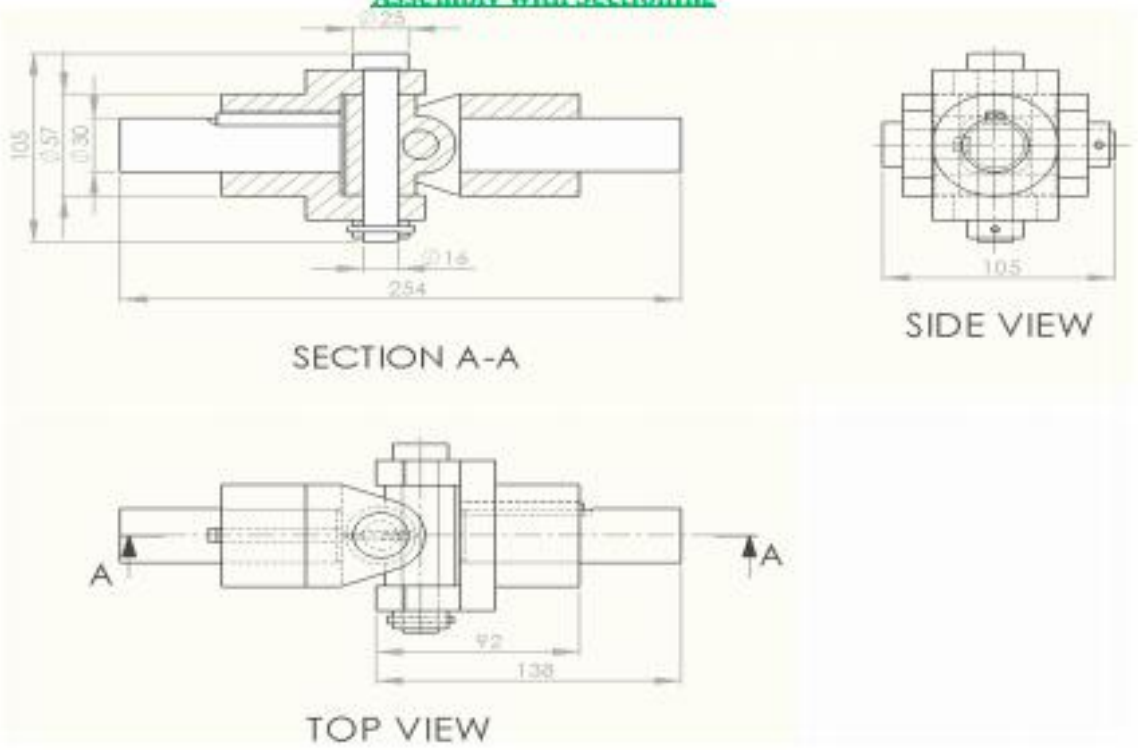
TOP VIEW

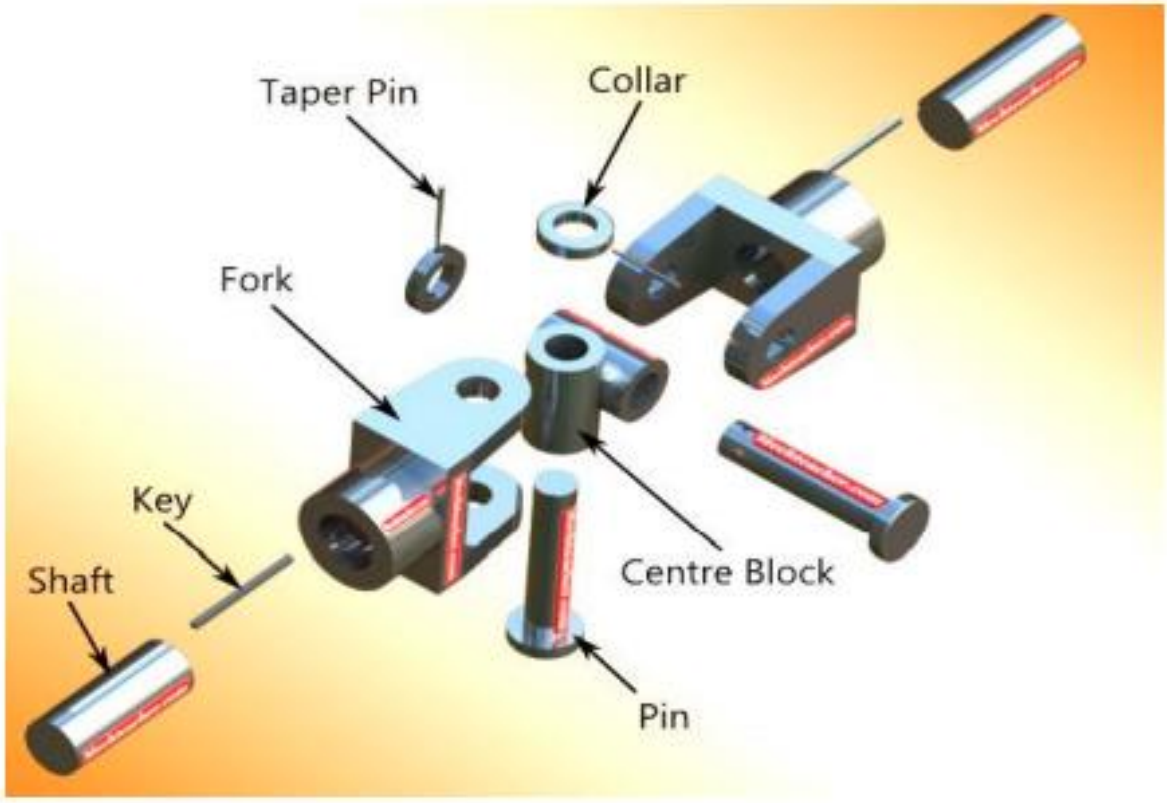


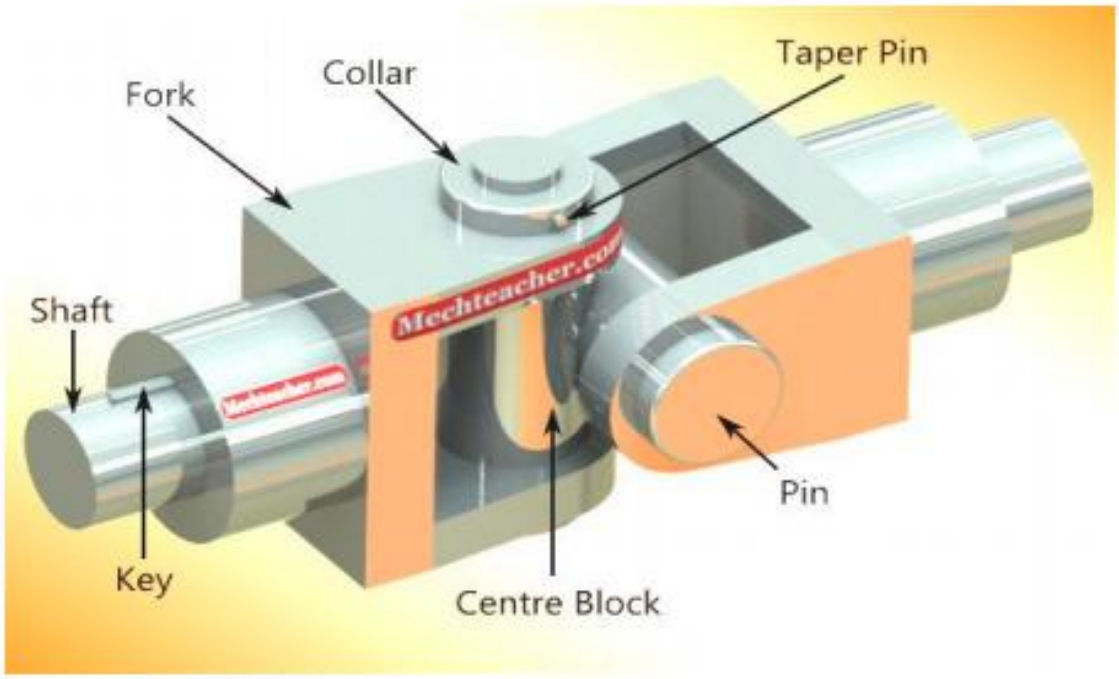
ISOMETRIC VIEW

SL NO	QTY NO	DESCRIPTION
7	2	TAPER PIN
6	2	COLLAR
5	2	PIN
4	2	PARALLEL KEY
3	2	SHAFT
2	1	CENTRE
1	2	FORK

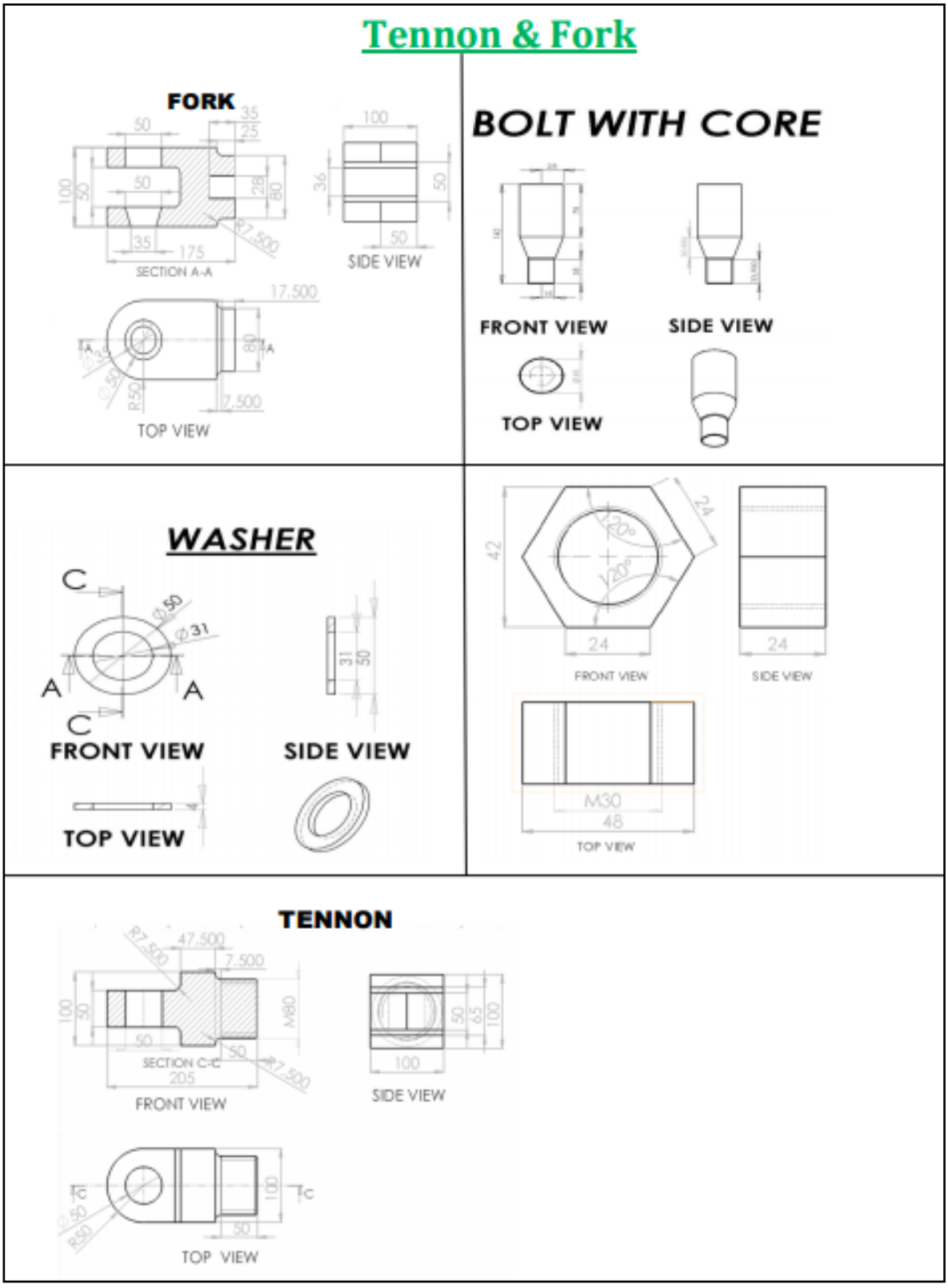
Assembly with Sectioning



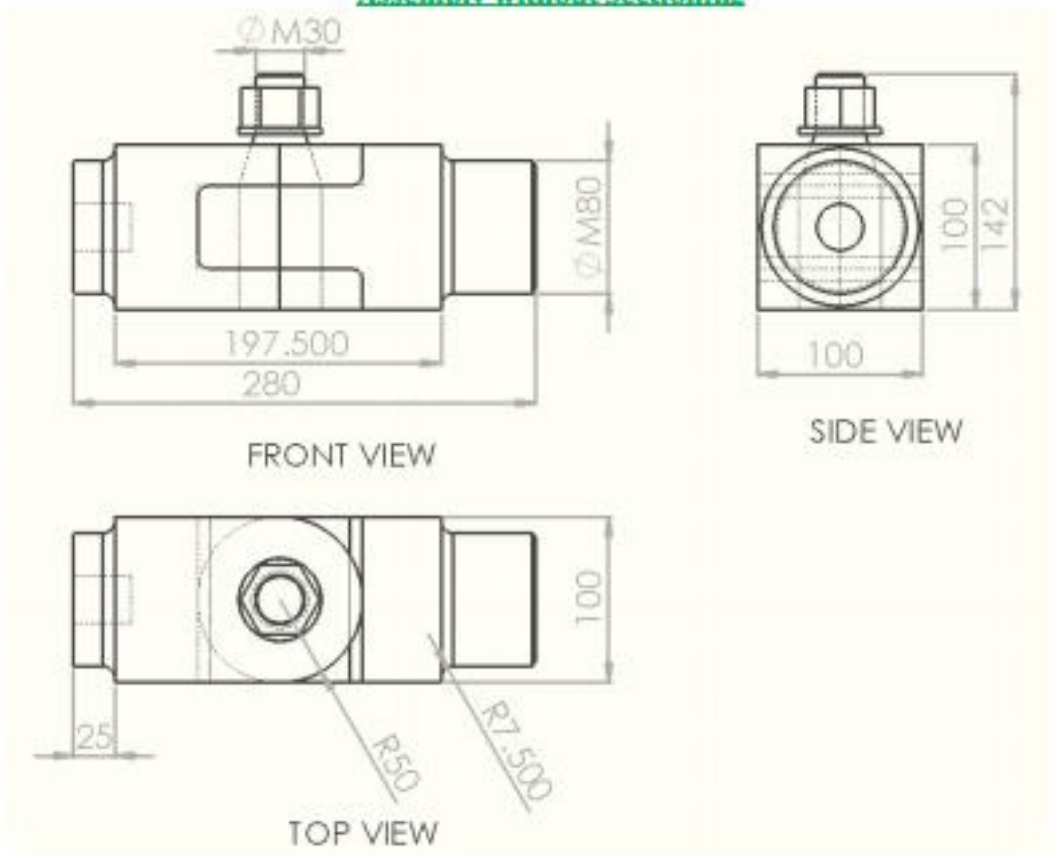



Taper Pin
Collar
Fork
Shaft
Mechteacher.com
Pin
Key
Centre Block

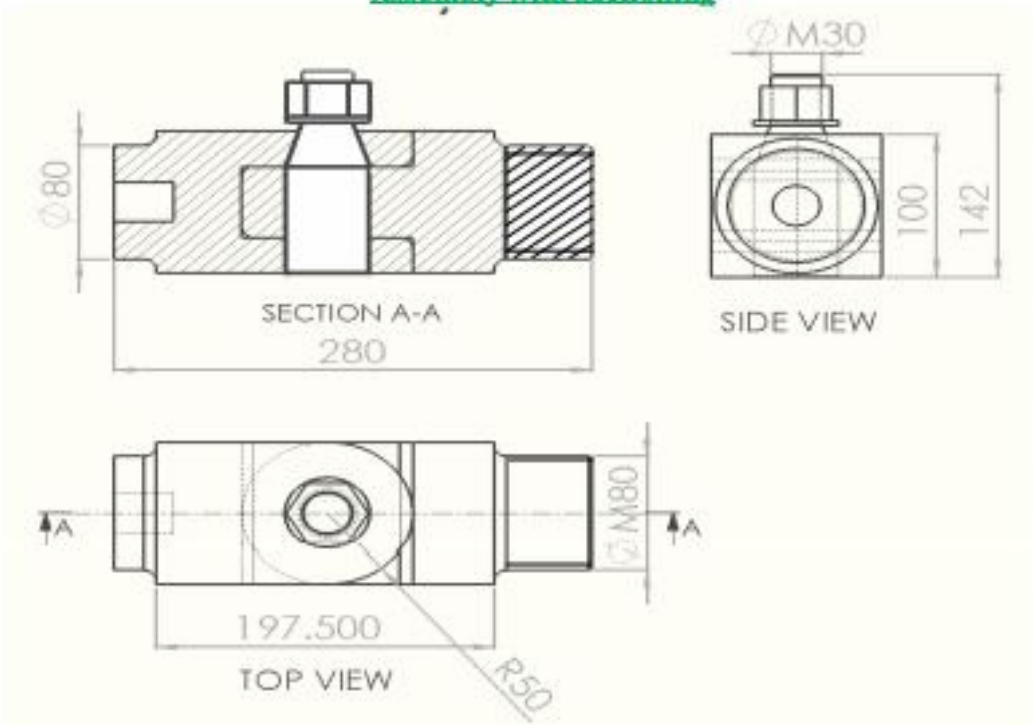
Tennon & Fork


FORK
SECTION A-A
SIDE VIEW
TOP VIEW
BOLT WITH CORE
FRONT VIEW
SIDE VIEW
TOP VIEW
WASHER
FRONT VIEW
SIDE VIEW
TOP VIEW
FRONT VIEW
SIDE VIEW
TOP VIEW
TENNON
SECTION C-C
FRONT VIEW
SIDE VIEW
TOP VIEW

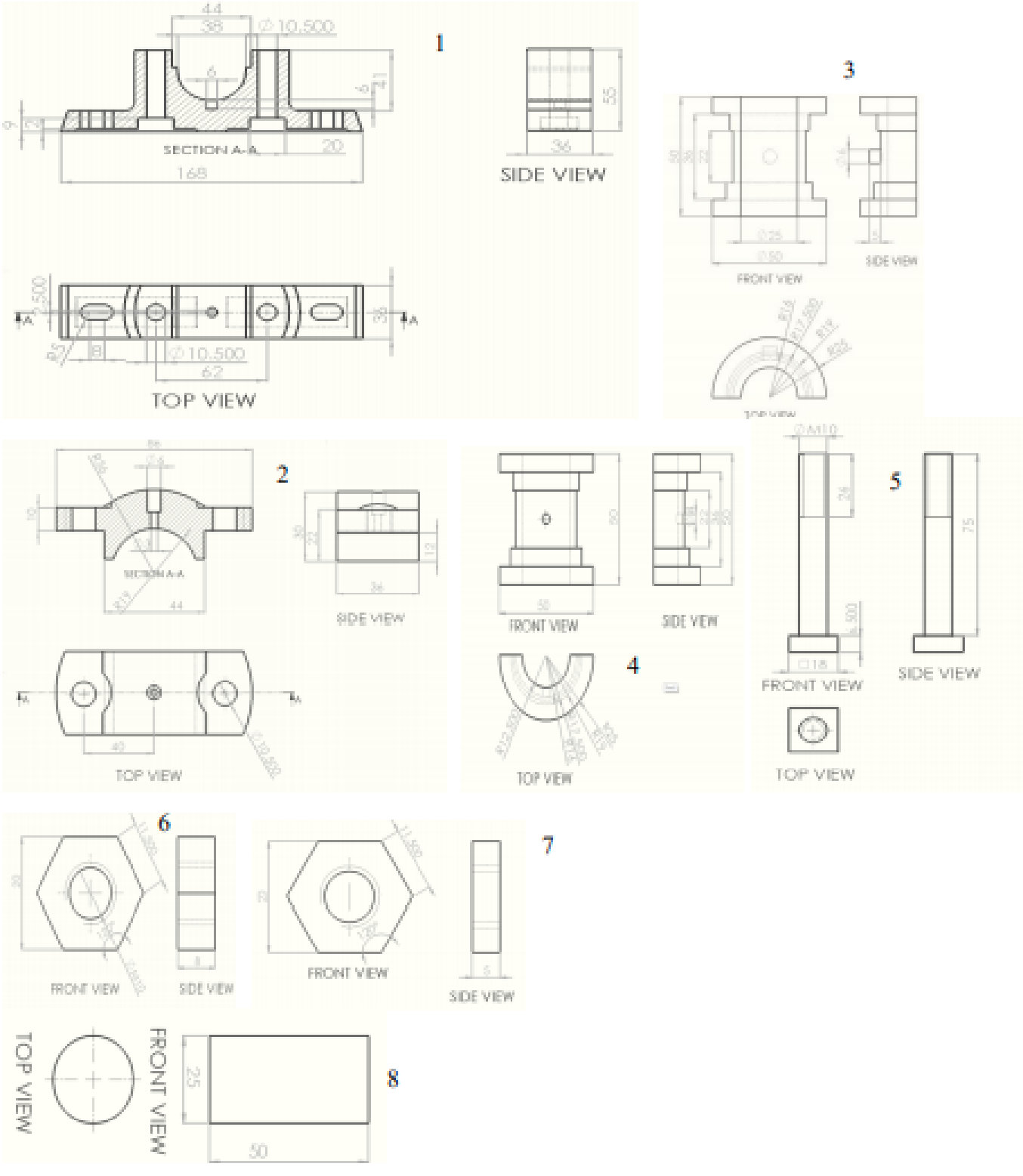
Assembly without Sectioning



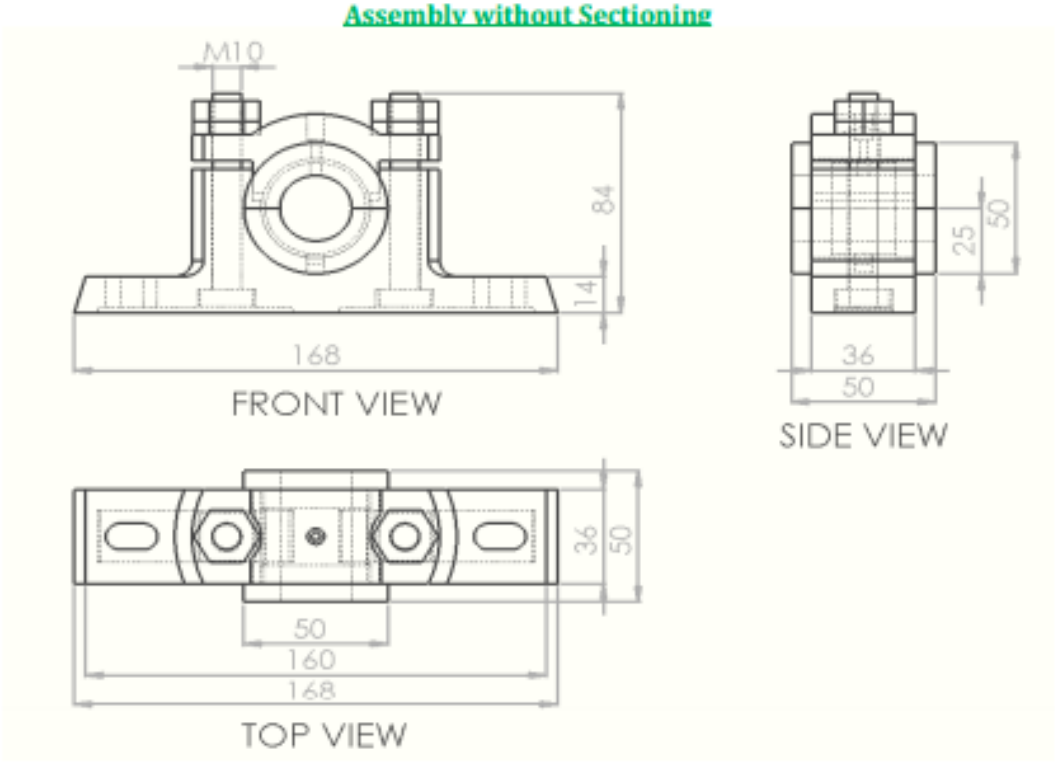
Assembly with Sectioning



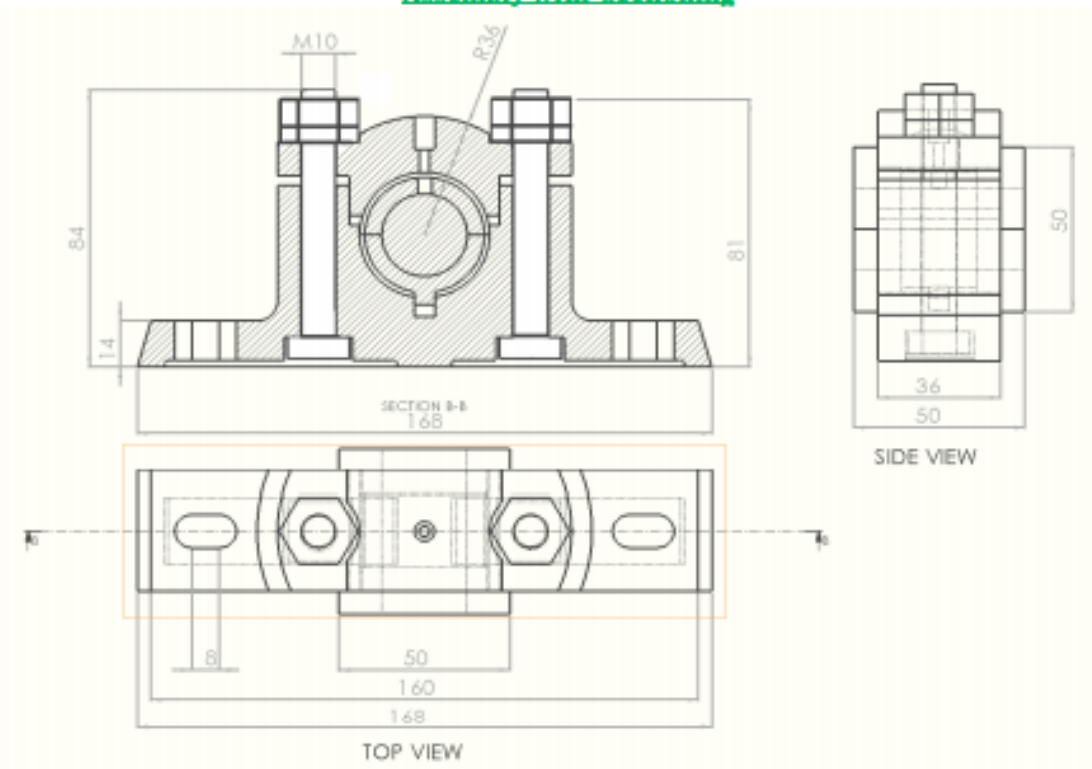
Plumber Block



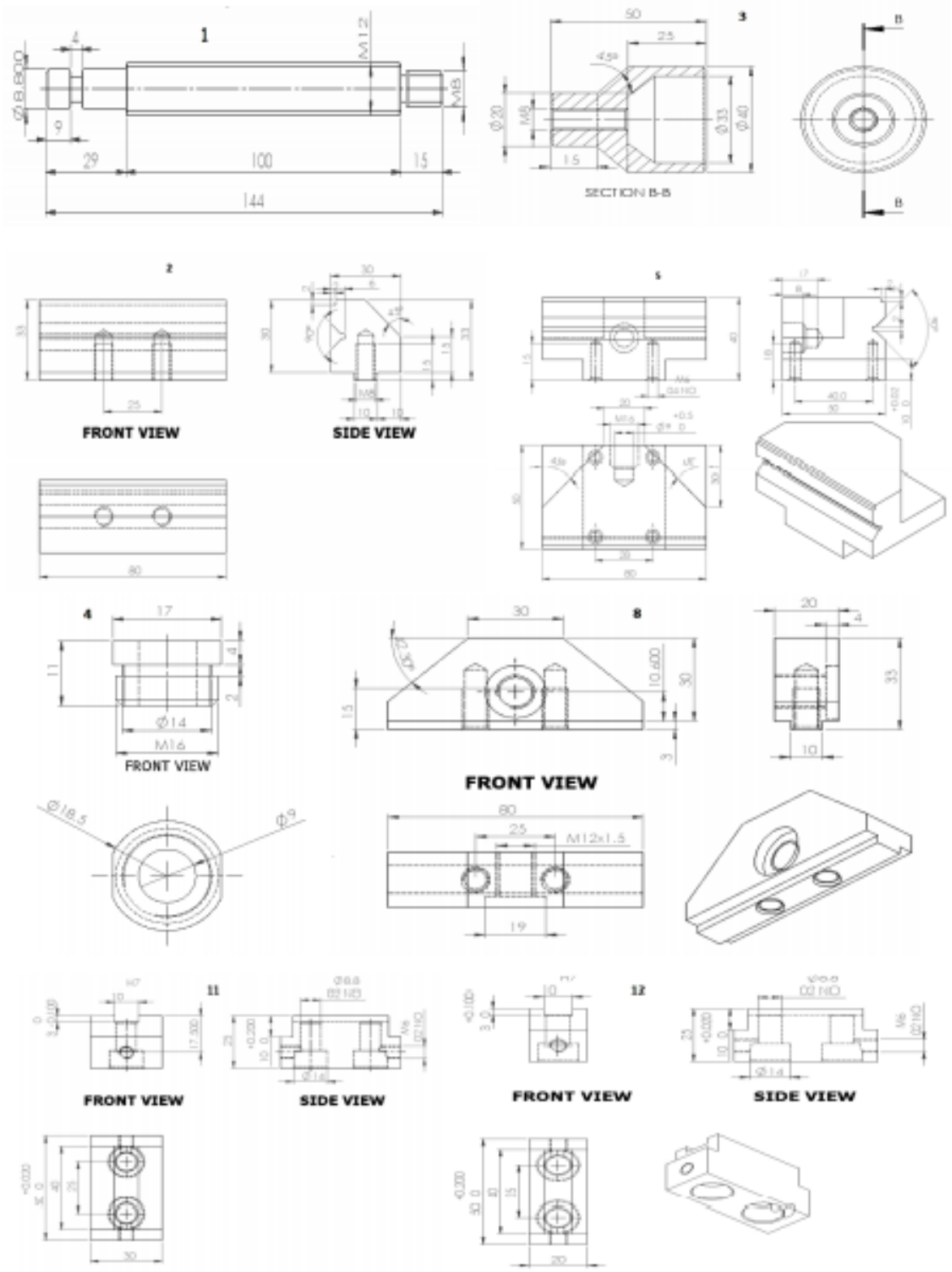
Assembly without Sectioning

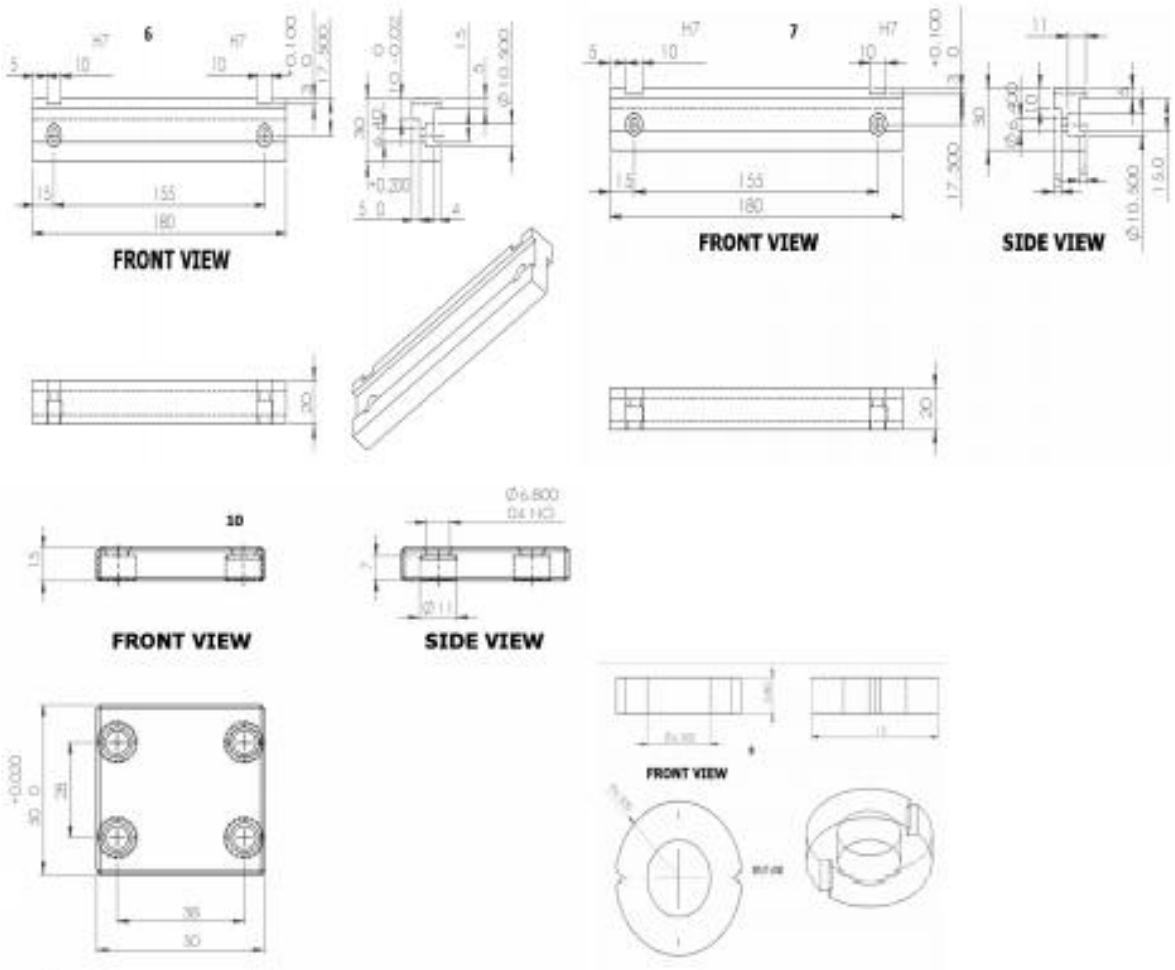


Assembly with Sectioning



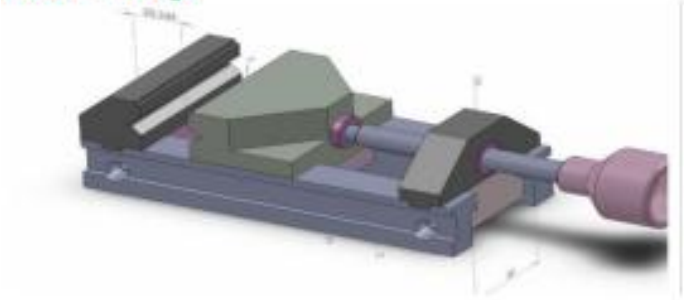
EXERCISE: - MINI VICE

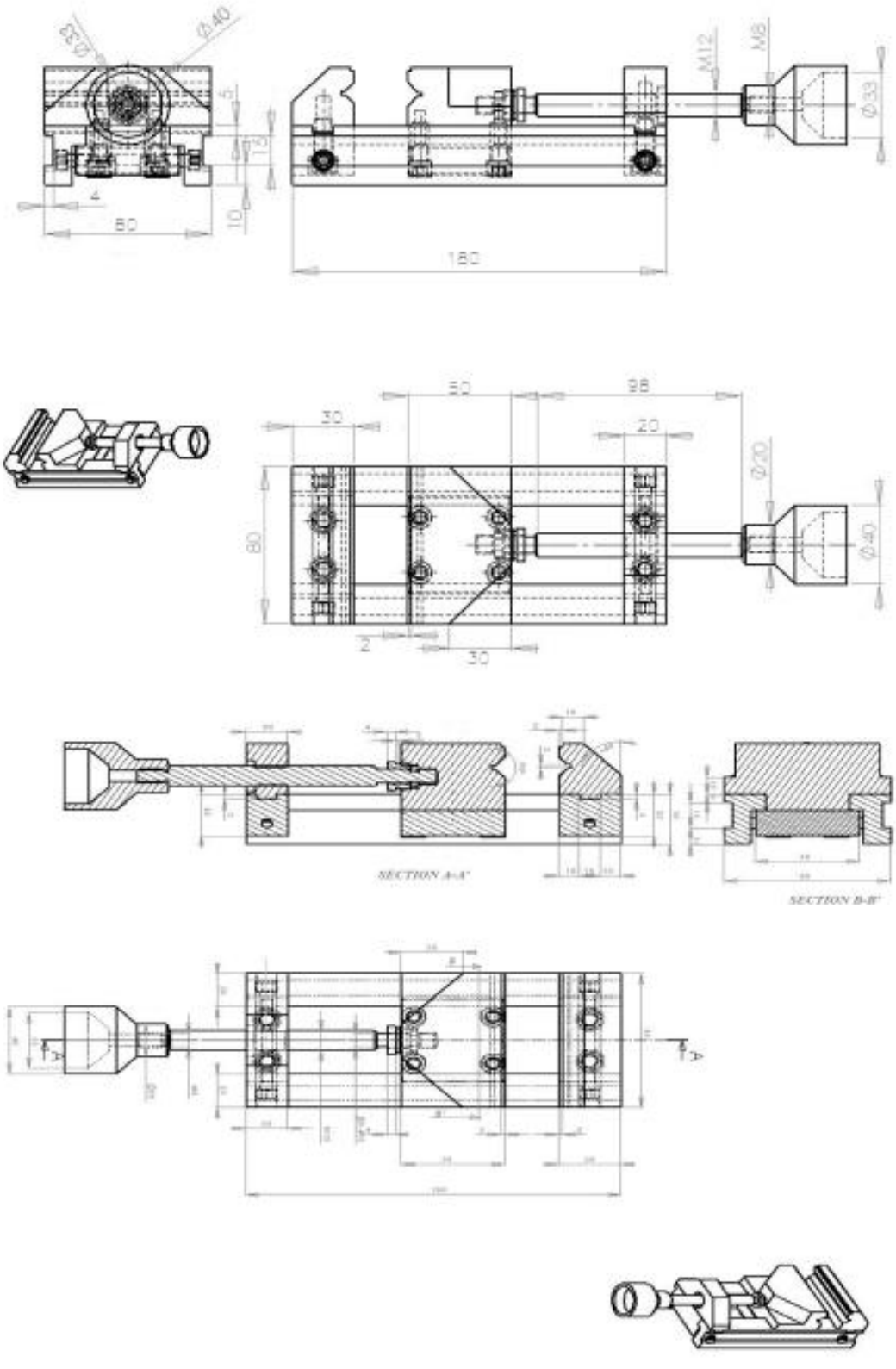




Part No	Description	Material	No Off		Part No	Description	Material	No. Off
01	Draw Bolt	OHNS	1		07	Rails 2	OHNS	1
02	Fixed Jaw	OHNS	1		08	Rest Plate	OHNS	1
03	Knob	Mild Steel	1		09	Split Washer	OHNS	1
04	Lock Nut	Mild Steel	1		10	Square Plate	Mild Steel	1
05	Movable Jaw	OHNS	1		11	T - Clamp 1	Mild Steel	1
06	Rail 1	OHNS	1		12	T-Clamp 2	Mild Steel	1

Assembly.




Ø30
Ø40
M12
M6
Ø33
80
180
50
98
30
20
Ø30
Ø40
80
2
30
SECTION A-A'
SECTION B-B'

SUMMARY OF ENGINEERING DRAWING

The aim of this course is to provide students with knowledge and skills in engineering design and drawings. Students will be able to, under supervision, prepare for, perform and confirm geometric construction; explain fits, limits and tolerances.

To prepare engineering students for communication of technical ideas in modern, technology-intensive industry through their ability to make and read engineering drawings, use of computers and instruments to make drawings as well as develop their skills in technical sketching.

The end goal of an engineering drawing is to convey all the required information that will allow a manufacturer to produce that component.

Common Features:-

Drawings convey the following critical information:

- *Geometry* – the shape of the object; represented as views; how the object will look when it is viewed from various angles, such as front, top, side, etc.
- *Dimensions* – the size of the object is captured in accepted units.
- *Tolerances* – the allowable variations for each dimension.
- *Material* – represents what the item is made of.
- *Finish* – specifies the surface quality of the item, functional or cosmetic. For example, a mass-marketed product usually requires a much higher surface quality than, say, a component that goes inside industrial machinery.

Bibliography:-

1. Engineering Drawing (Vol I & II) - K R Gopala Krishna.
2. Engineering Drawing - A K Xavier & S Radhakrishnan.
3. Engineering Drawing - N D Bhat.
4. Machine Drawings - K R Gopala Krishna
5. Machine Drawings - K L Narayana, P Kannaiah & K Venkata Reddy