ENGINEERING GRAPHICS (SME 4053)

FUNDAMENTALS

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Drawing is a Graphical representation of an object.

Engineering Drawing – A drawing of an object that contains all information like actual shape and size, manufacturing methods, etc., required for its construction.

No construction / manufacturing of any (man-made) engineering objects is possible without engineering drawing.

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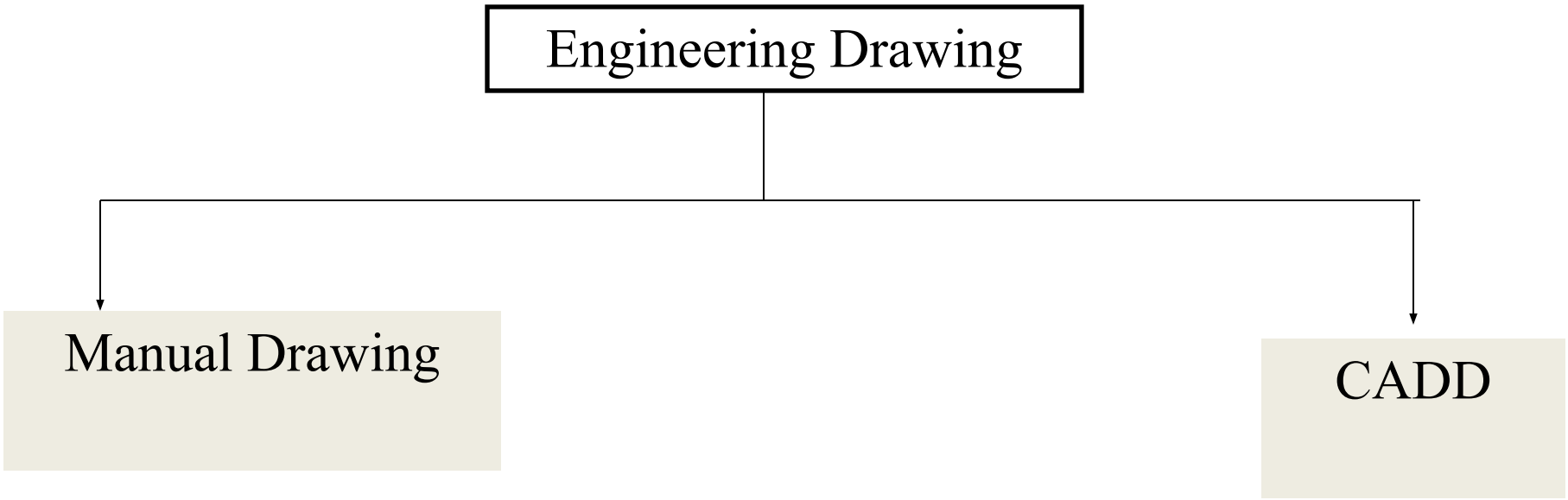

- Computer has a major impact on the methods used to design and create technical drawings.
- Design and drafting on computer are cheap and less time consuming.

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Purpose of studying Engineering Drawing:

- To develop the ability to produce simple engineering drawing and sketches based on current practice.
- To develop the skills to read manufacturing and construction drawings used in industry.
- To develop a working knowledge of the layout of plant and equipment.
- To develop skills in abstracting information from calculation sheets and schematic diagrams to produce working drawings for manufacturers, installers and fabricators.

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Drafting Equipments

1. DRAWING BOARD
2. MINI DRAFTER
3. DRAWING SHEET
4. PENCILS (HB, 2H, 4H, 2B, 4B etc…)
5. NON DUST RUBBER
6. SCALES
7. INSTRUMENT BOX
8. SET SQUARES (30°, 45°, 60° etc..)
9. DRAWING BOARD CLIPS, CLAMPS, PINS, CELLO TAPE
10. PROTRACTOR / PRO CIRCLE / CIRCLE MASTER
11. PENCIL SHARPENER
12. SMALL PAPER KNIFE or STITCHING THREAD etc.,

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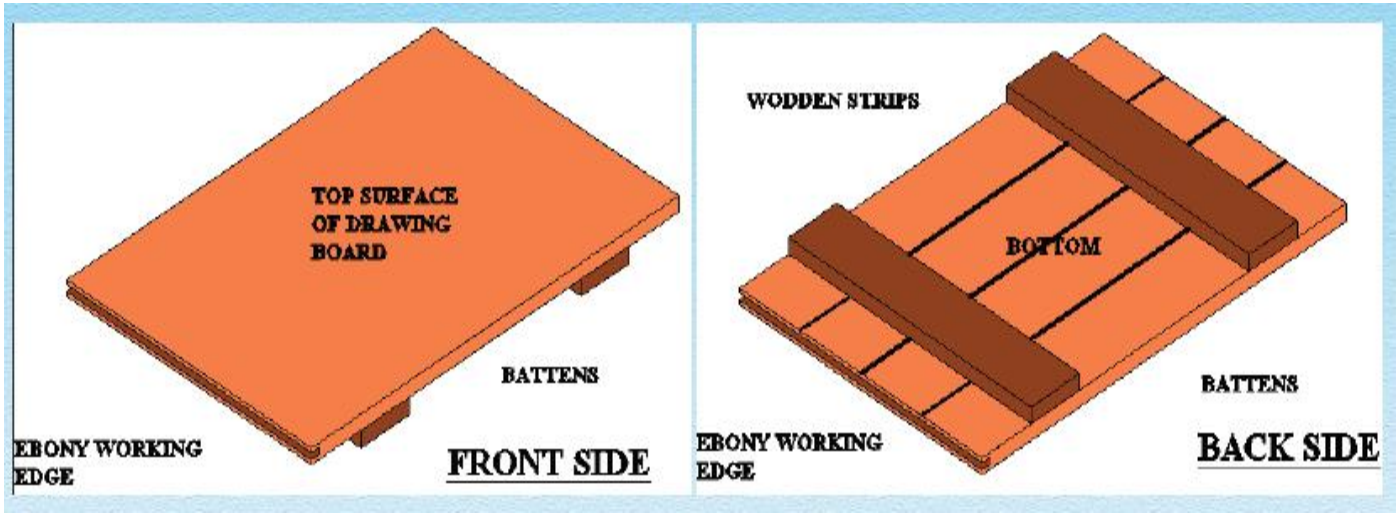
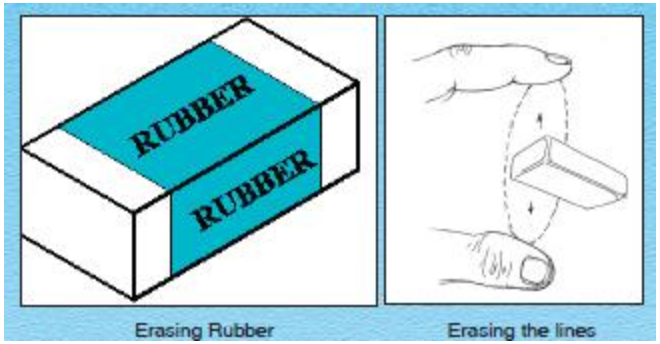
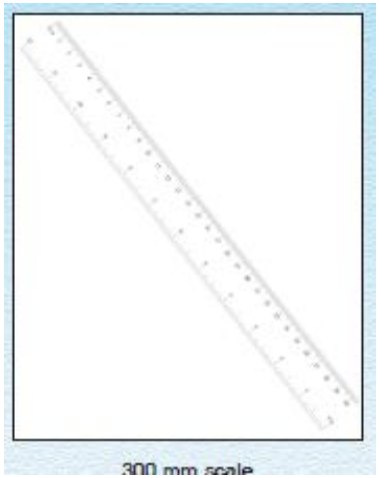
Drafting Aids



Eraser



Scales



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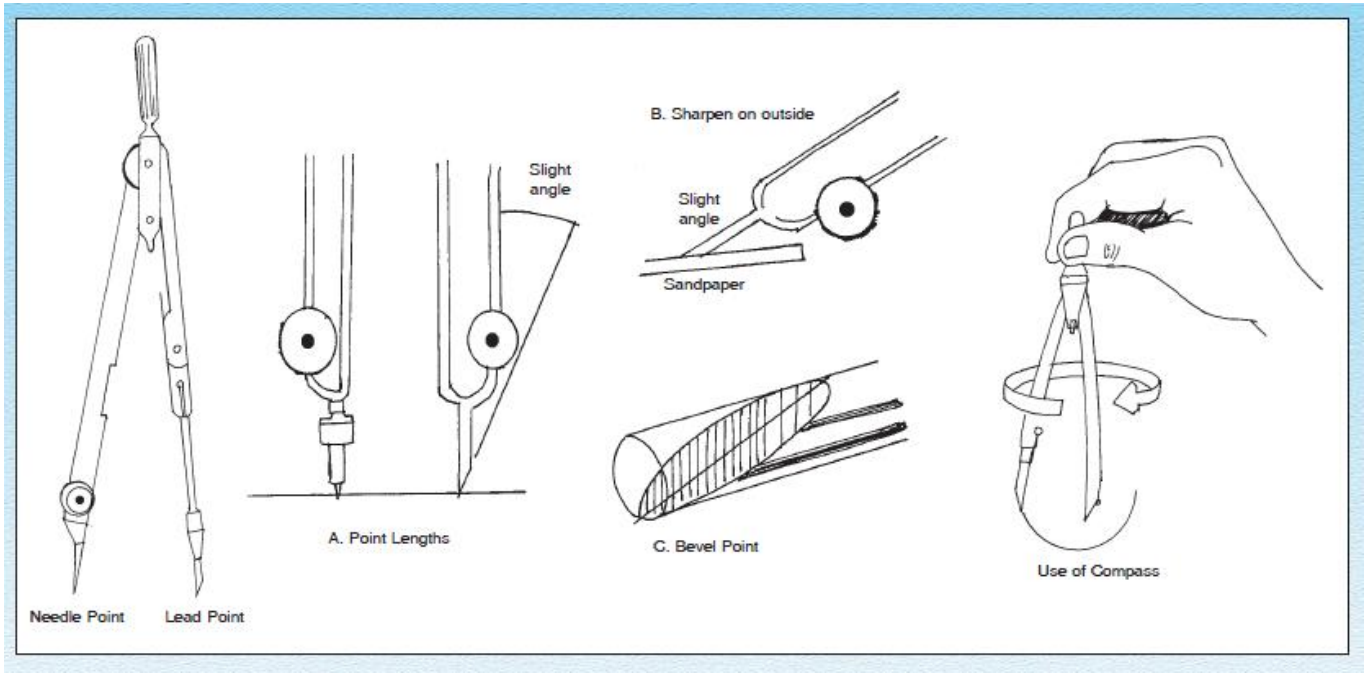
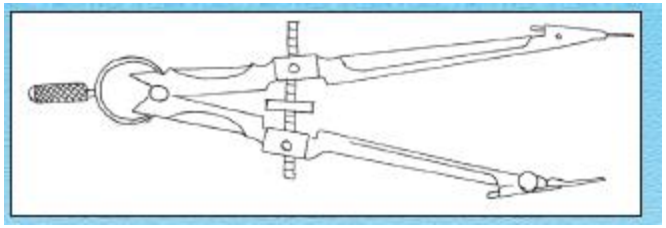
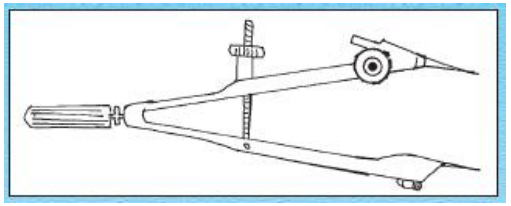
Compass



Bow Compass





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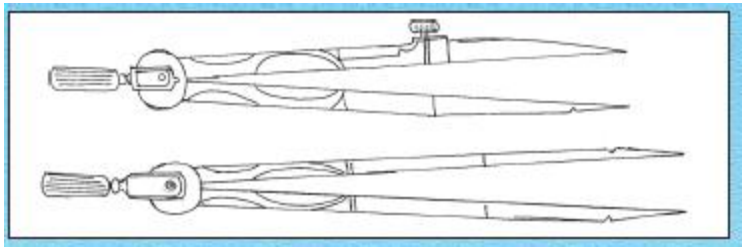
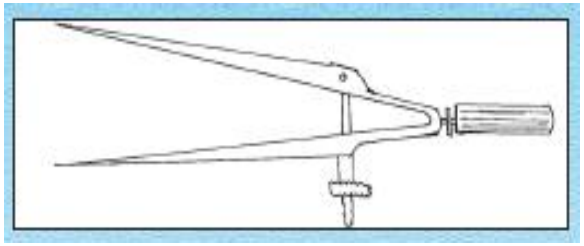
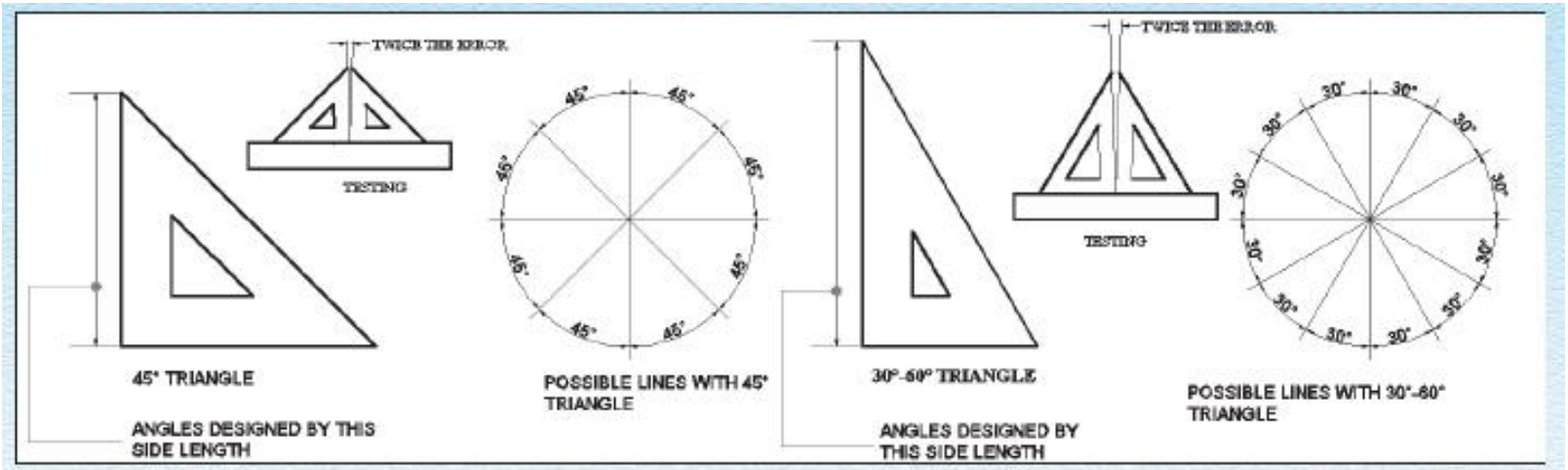
Divider



Bow Divider



Set Squares



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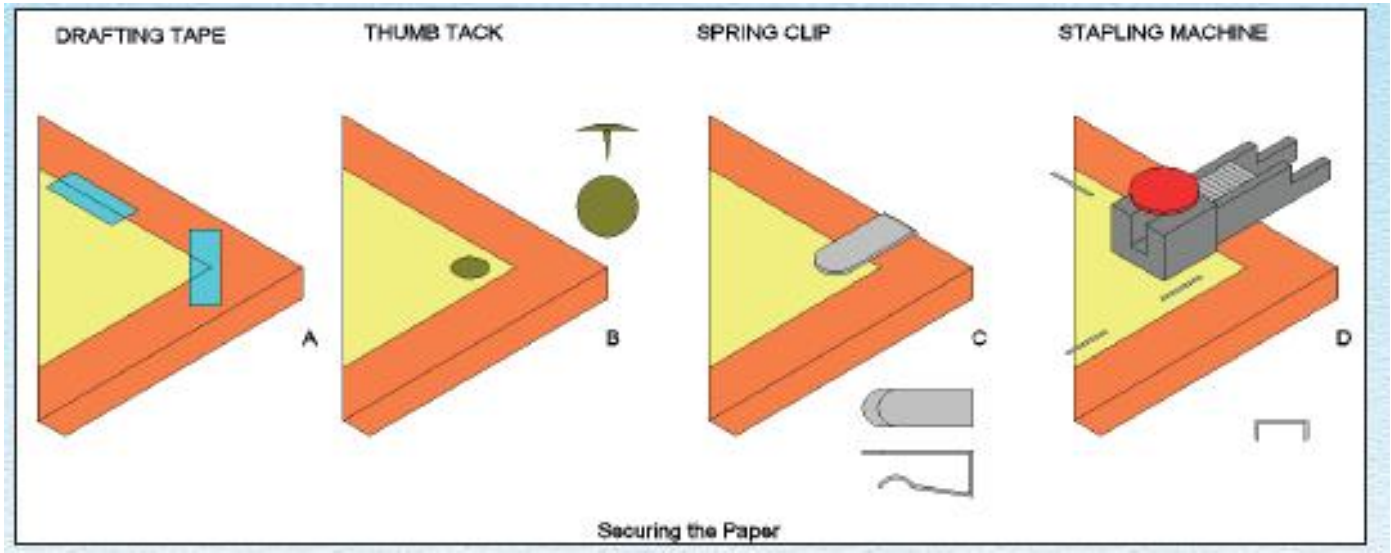
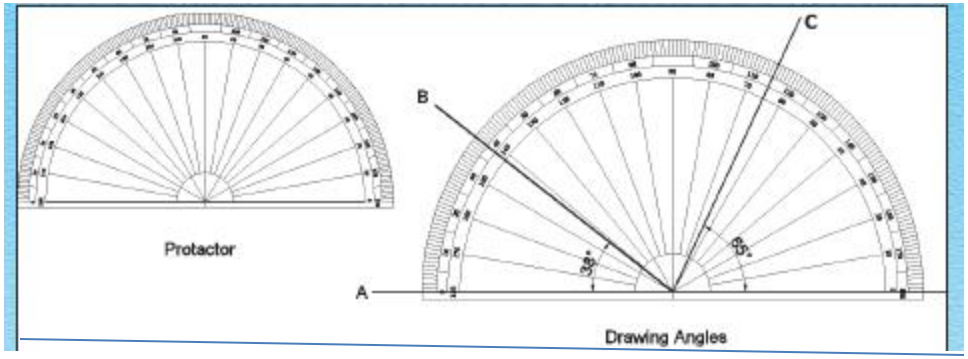
Drawing clips and clamps



Protractor



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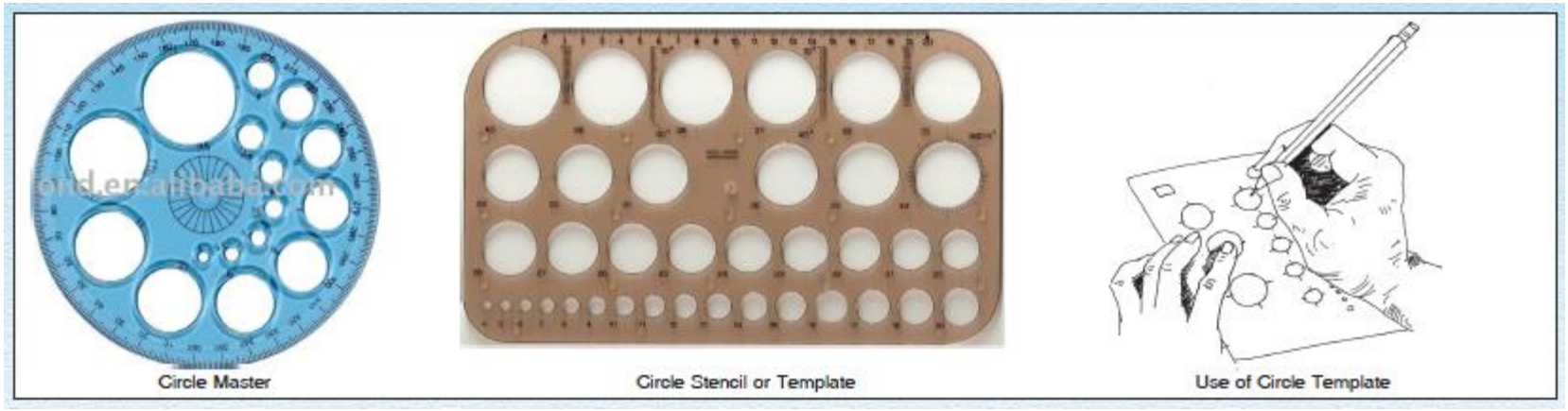
Paper knife and stitching thread

Circle aster or Pro-circle



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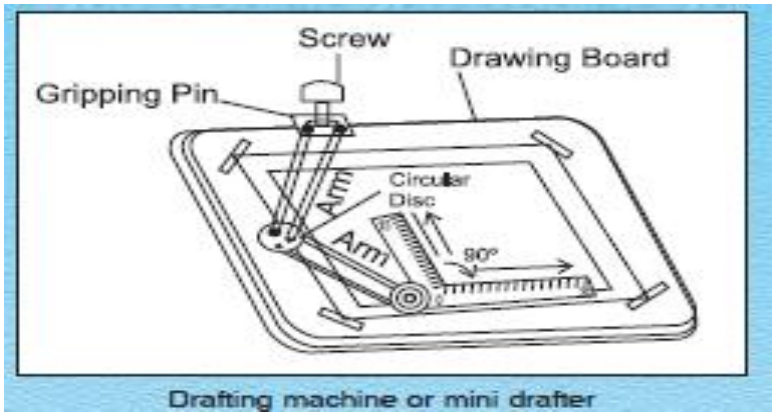
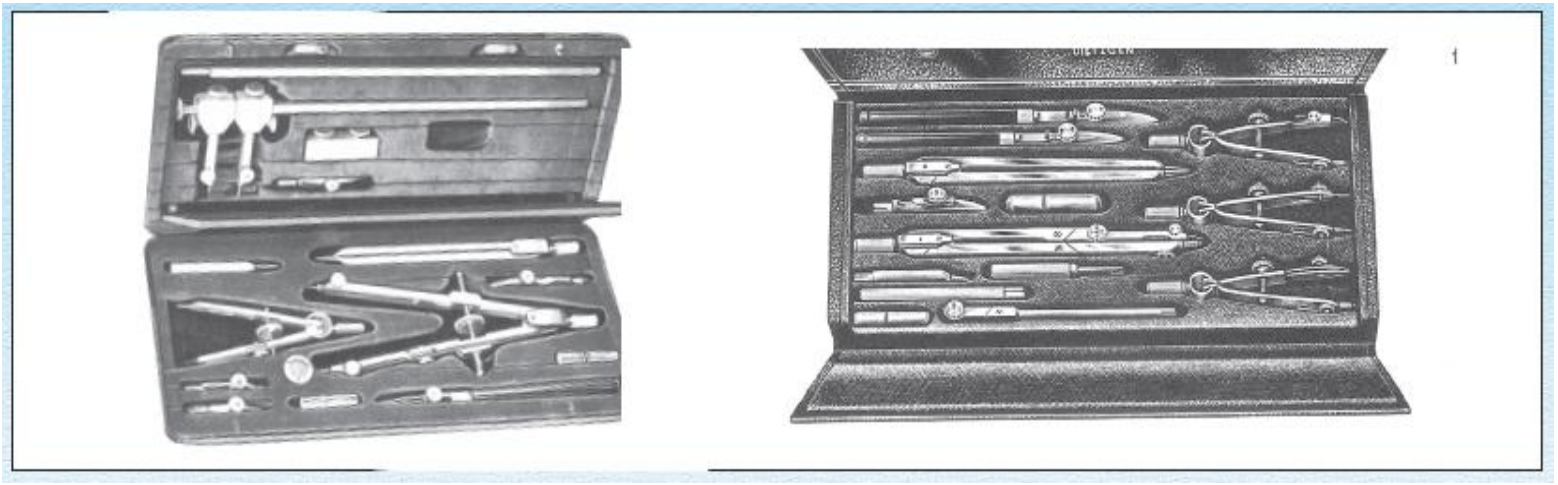
Mini Drafter



Drafting machine or mini drafter

Instrument Box



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Drawing Board

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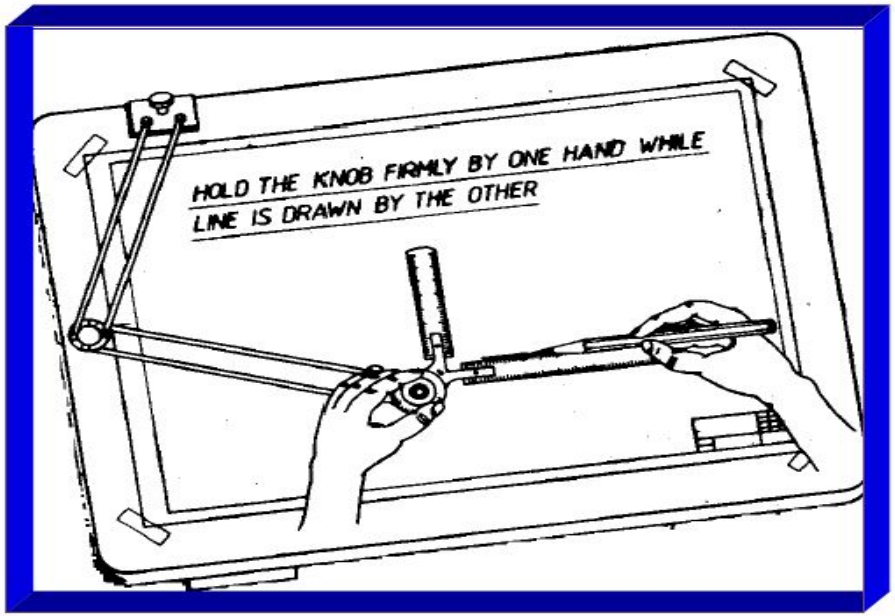
How to clamp a Mini Drafter ?

- Set the protractor head with reference mark indexing zero degree.
- Fix the clamp of the mini-drafter at the top left corner either along the top horizontal edge of the board or along the left vertical edge of the board.



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How to clamp a Mini Drafter ?

- Place the drawing sheet underneath the scales of the mini-drafter.
- Fix the drawing sheet to the drawing board with the scales of the mini-drafter aligned either with the vertical or the horizontal borderlines of the drawing sheet.

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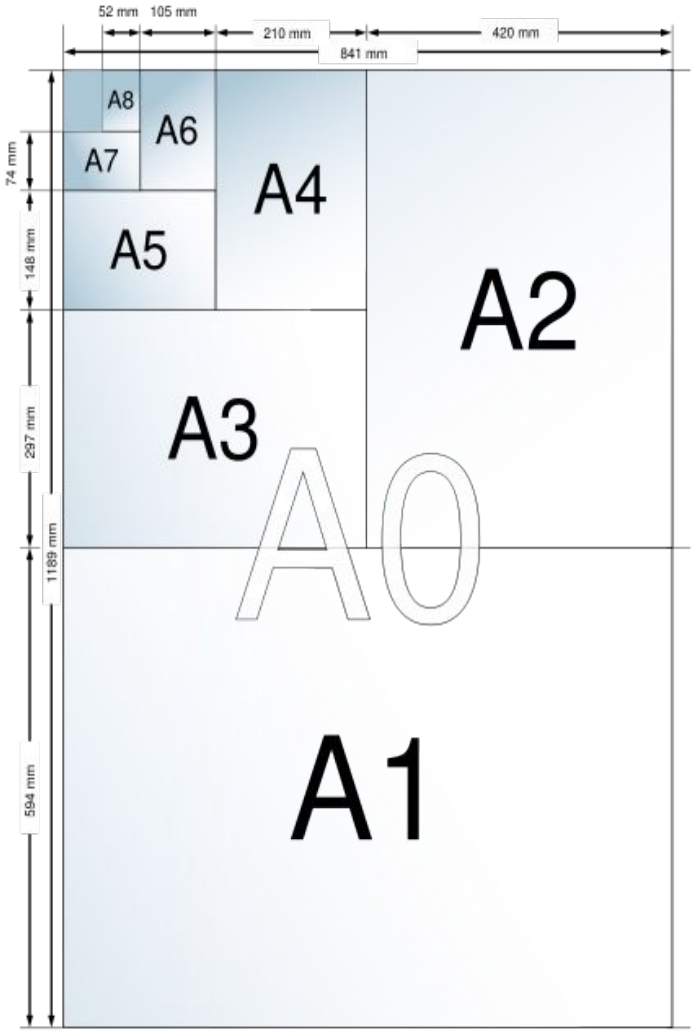
Paper sizes

A Series Formats (mm)	
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297
A5	148 × 210
A6	105 × 148
A7	74 × 105



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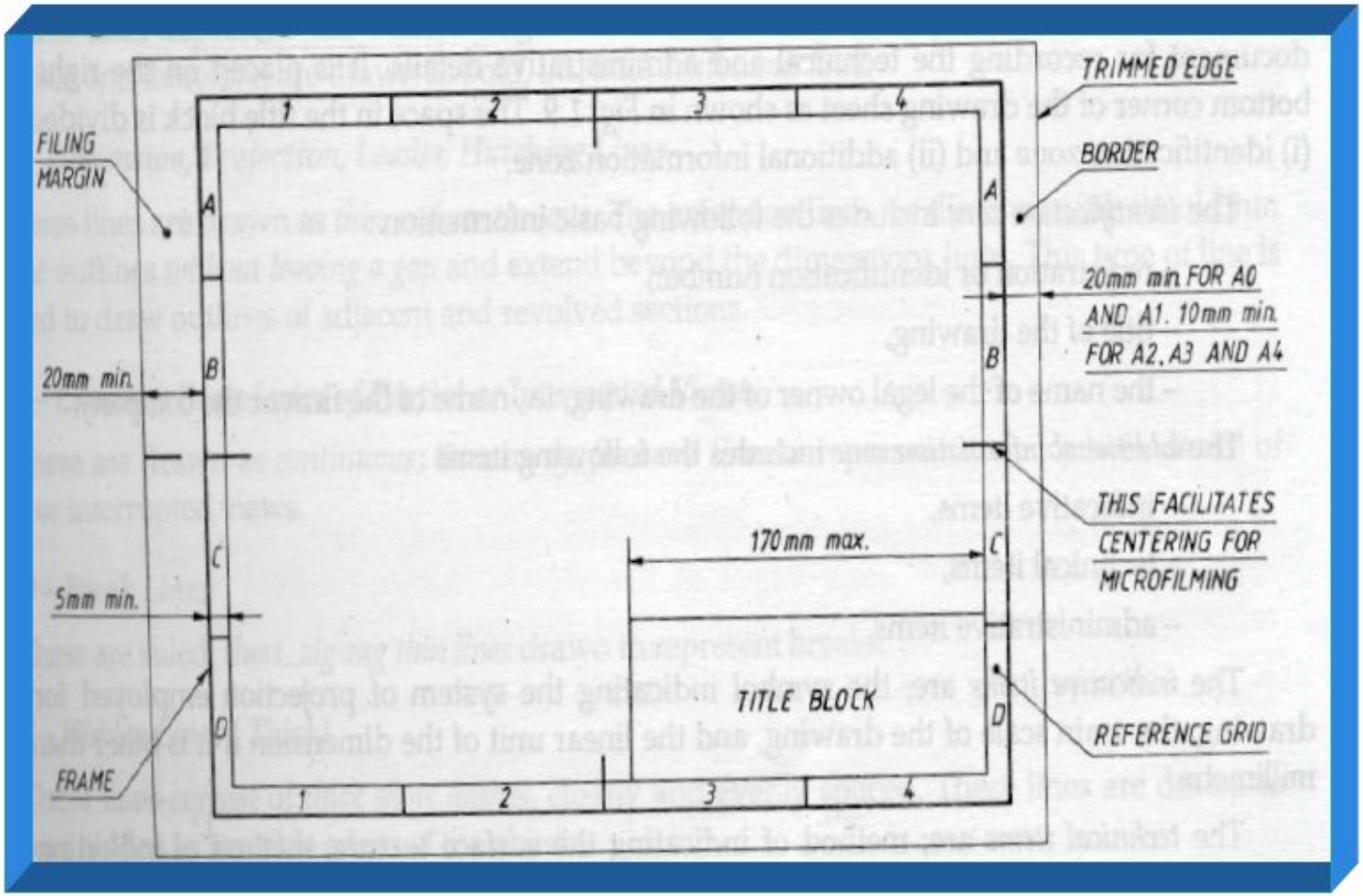
Drawing Sheet



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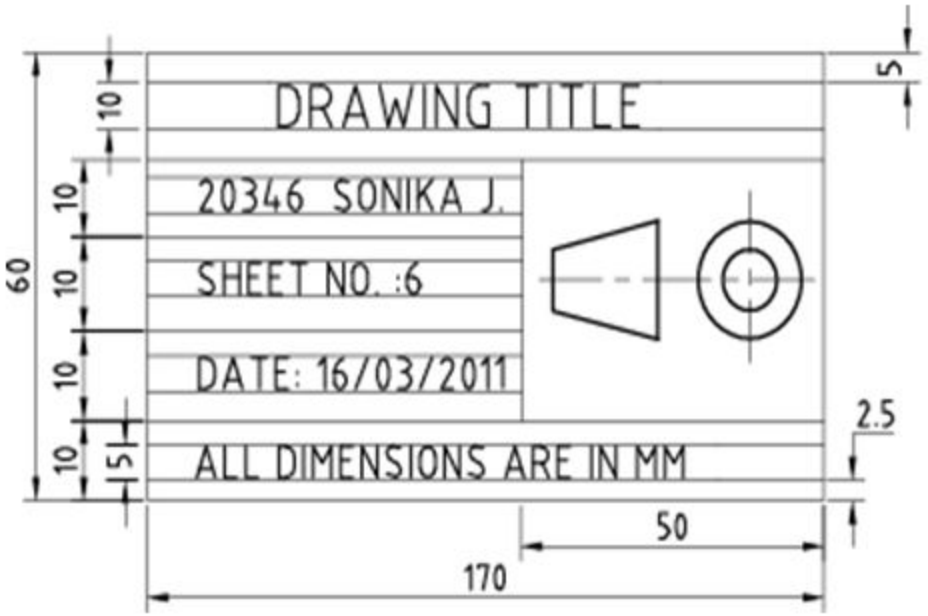
Drawing Sheet Title Block

- Title block of a drawing sheet has title of drawing and other details as given below.



Drawing Standards

ANSI – American National Standards Institute

ANSI Y14.1 1980 (R1987) – Drawing sheet size & format

ANSI Y 14.2M-1979 (R1987) – Line conventions & lettering

ANSI Y14.5M-1982(R1988) – Dimensioning & tolerances

ANSI Y 14.3-1975(R1987) – Multi view & sectional view drawings

ISO – International Standards Organization

JIS – Japanese Standards

BIS – Bureau of Indian Standards

Types of Lines

Drawing of Lines	E.G. / CAD	Thickness	Line
Continuous thick line	H.B. (Thick)	Bold / Thick	
Hidden line	H.B. / Thick	Bold dashing / Thickness dotted line	
Centre line or Axis line	4H / Wide	Long and Small dashes	
Short break line	4H / Wide	Thin free hand line	
Long break line	4H / Wide	Line with kinks	

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Types of Lines

Drawing of Lines	E.G. / CAD	Thickness	Line
Thin Continuous line	4H / Wide	Thin Continuous line	
Chain line	4H / Wide	Long Dashes with double dots in between	
Cutting Plane line or section Plane	4H / Wide	Chain thin, thick at ends and change of direction	
Given line	2H / Extra Wide	Continuous line	
Hatching lines	4H / Wide	Group of parallel thin lines	

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Dimensioning

- Indicating on a drawing, the size of the object and other details essential for its construction and function, using lines, numerals, symbols, notes, etc.
- Dimensions indicated on a drawing should be those that are essential for the production, inspection and functioning of the object and should not be mistaken as those that are required to make the drawing of an object.

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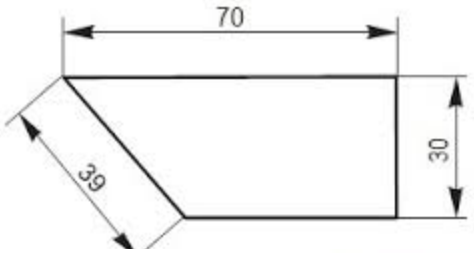
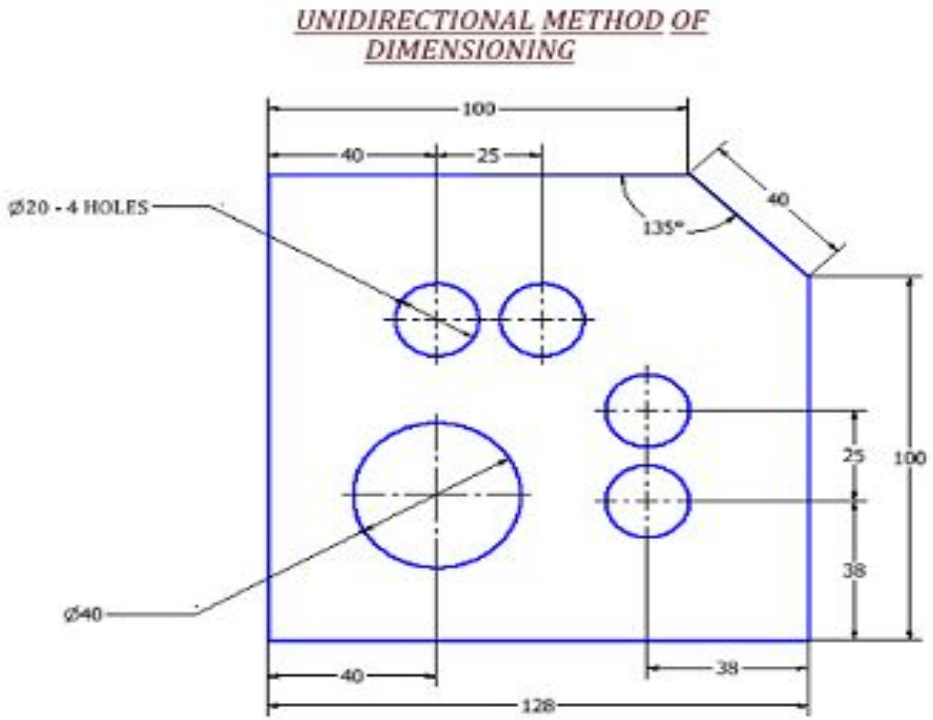
Systems of dimensioning

- Aligned system



- Unidirectional system



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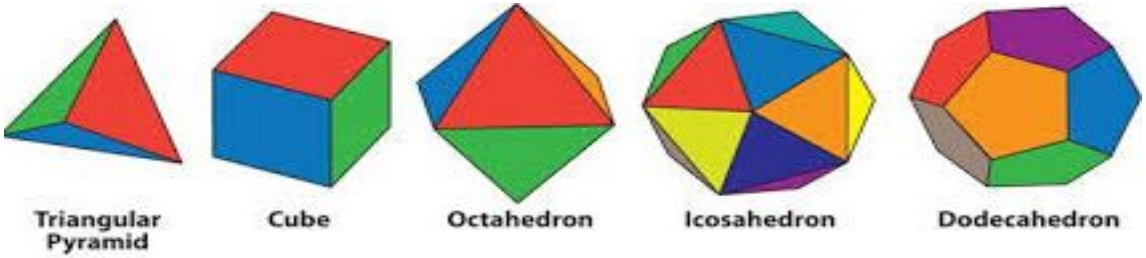

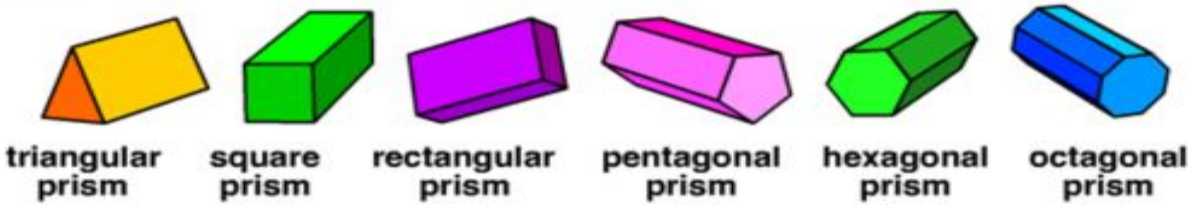

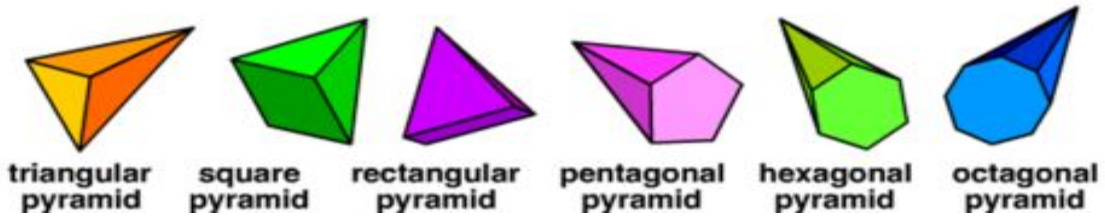

Basic geometric shapes used in drawing

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Scale: It is defined as the ‘ratio of the linear dimension of an element of an object as represented in the original drawing to the real linear dimension of the same element of the object itself.

Representative Fraction (RF) = Drawing size of an object / Its actual size

RF = 1 for Full size scale

RF < 1 for Reduction scale [Recommended scales:- 1:2 /1:5 / 1:10 / 1:20 / 1:50 / 1:100 /1:200 / 1:500]

RF > 1 for Enlarged scale [Recommended scales:- 2:1 / 5:1 / 10:1 / 20:1 / 50:1]

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- Lettering: Writing of titles, sub-titles, dimensions, notes and other important particulars on a drawing is known as lettering.
- Size of letters is measured by the height **h** of the CAPITAL or UPPER CASE letters
- BIS recommended standard heights - 2.5-3.5-5-7-10-14-20 mm.
- Width of the CAPITAL letters = (5/6) x h
- Spacing between letters = (1/5) x h
- Spacing between words = (3/5) x h
- Height of lower case letters = (7/10) x h
- Stem and tail of lower case letters = (3/10) x h
- Inclined letters: 75° to the horizontal

EXERCISE FOR PRACTICE IN CLASS (10 marks)

Write freehand the following, using single stroke vertical letters

1. CAPITAL letters - h = 10 mm - from A to Z

2. Lower case letters - h = 10 mm - from a to z

3. SMALL THINGS MAKE PERFECTION, BUT PERFECTION IS NO SMALL THING (h = 10 mm)

4. standards connect the world (h = 10 mm)

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GEOMETRICAL CONSTRUCTION

EXERCISE FOR PRACTICE IN CLASS (20 marks)

- To divide a straight line of length = 70 mm into 6 equal parts, geometrically.
- To bisect an angle of 45°, geometrically.
- To trisect a right angle, geometrically.

❖ Polygon – A plane figure bounded by straight lines.

❖ Included angle of polygon = 180 – (360/n) ; n = number of sides.

- Draw a regular pentagon of side 30 mm using any special method.
- Draw a regular hexagon of side 30 mm with two of its sides
  (a) vertical (b) horizontal

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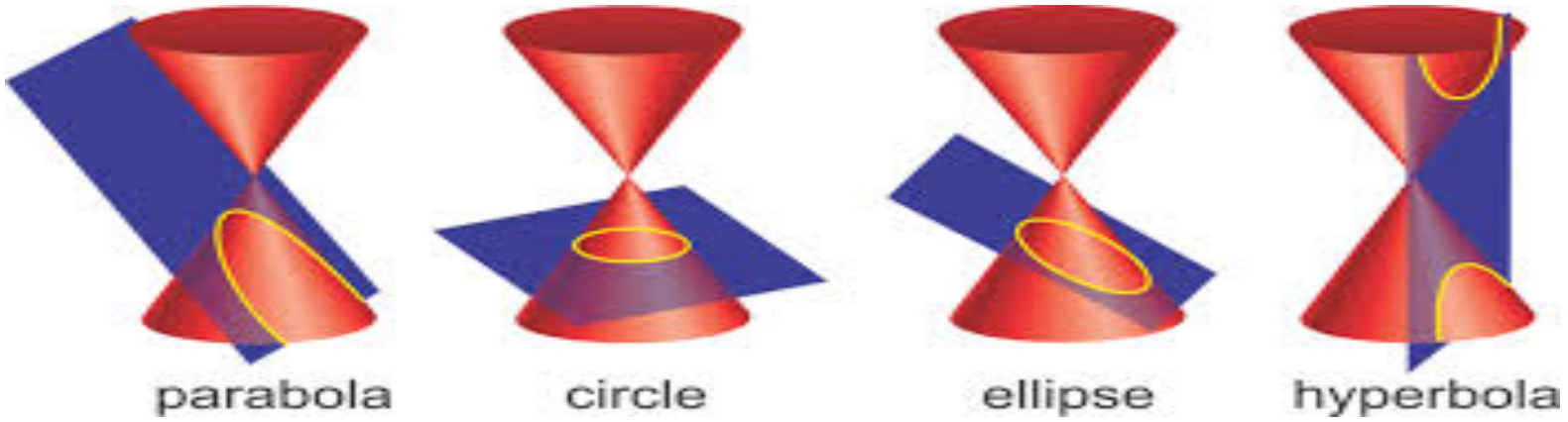
CONIC SECTION

Ellipse, parabola and hyperbola are called conic sections because these curves appear on the surface of a cone when it is cut by some typical cutting planes.



$$Eccentricity, e = \frac{Distance\ from\ the\ focus\ (fixed\ point)}{Distance\ from\ the\ directrix\ (fixed\ line)}$$

Conic Sections: Eccentricity

If $e = 1$, the conic is a **parabola**.
If $e = 0$, the conic is a **circle**.
If $e < 1$, the conic is an **ellipse**.
If $e > 1$, the conic is a **hyperbola**.

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EXERCISE FOR PRACTICE IN CLASS (Each 10 marks)

- Construct an ellipse given the distance of the focus from the directrix as 60 mm and eccentricity as 2/3. Draw a tangent and a normal to the curve at a point on it 20 mm above the axis.

- Construct a parabola given the distance of the focus from the directrix as 50. Draw a tangent and a normal at any point on it.

- Draw a hyperbola given the distance of the focus from the directrix as 55 mm and eccentricity as 1.5. Draw a tangent and normal at any point on it.

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PROJECTION OF POINTS AND PLANES

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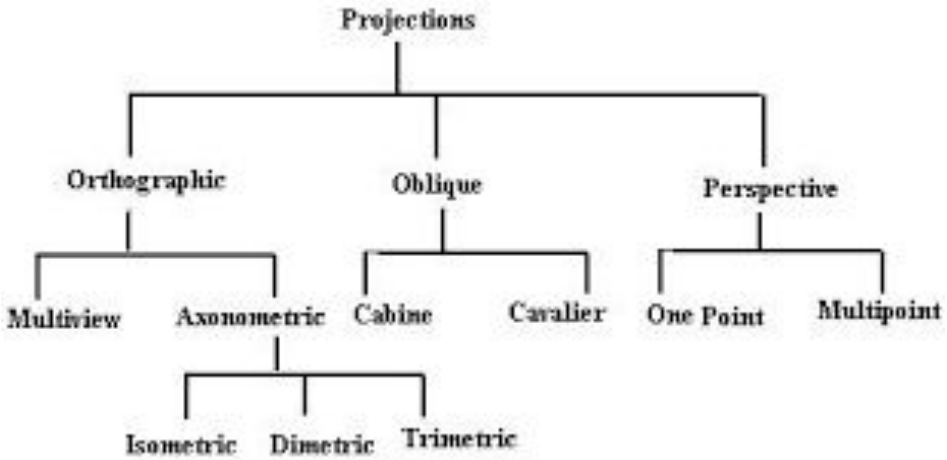
Projection means ‘image of an object’

Classification of projection:



Orthographic projection: If all the projectors are parallel to each other but perpendicular to the planes of projection, then such a projection is known as orthographic projection.

Planes of projection: Vertical Plane (VP) and Horizontal Plane (HP)

VP & HP are transparent and always perpendicular to each other.

The line of intersection of VP & HP is xy or reference line.

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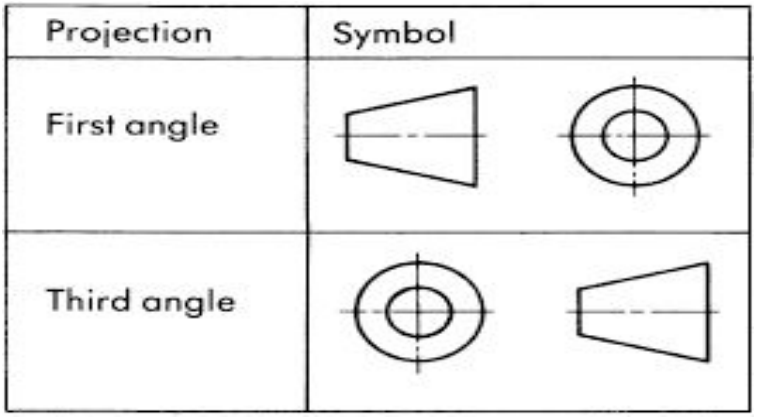
If the planes of projection (VP & HP) are extended beyond the line of intersection, they form four quadrants or dihedral angles. These quadrants are named as I, II, III & IV quadrants.

Quadrant	Position of the point	Front view or elevation	Top view or plan
I	Above the HP In front of the VP	Above the xy line	Below the xy line
II	Above the HP Behind the VP	Above the xy line	Above the xy line
III	Below the HP Behind the VP	Below the xy line	Above the xy line
IV	Below the HP In front of the VP	Below the xy line	Below the xy line



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EXERCISE TO BE PRACTISED IN CLASS (Each 10 marks)

1. Draw the projection of the following points on a common reference line:

a) A point A is 25 mm above the HP and 30 mm in front of the VP.

b) A point B is 20 mm away from both the planes and in the 2nd quadrant.

c) A point C is 25 mm above the HP and 30 mm behind the VP.

d) A point D is 30 mm below the HP and 30 mm behind the VP.

e) A point E is 15 mm below the HP and 12 mm in front of the VP.

2. A point M is 20 mm above the HP and 30 mm behind the VP. Point N is 30 mm in front of the VP and 20 mm below the HP. Draw the projections of M and N, the distance between the projectors being 70 mm. Also find the length of the line joining their plans.

ASSIGNMENT PROBLEMS (Each 10 Marks)

3. Draw the projection of the following points on a common reference line:

a) P, 25 mm below the HP and in the VP.

b) Q, 40 mm behind the VP and in the HP.

c) R, is in both the HP and VP.

d) S, 20 mm above the HP and in the VP.

e) T, 40 mm in front of the VP and in the HP.

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ASSIGNMENT PROBLEMS (contd..)

4. A point P is in both the HP and the VP. Another point Q is 40 mm in front of the VP AND 20 mm above the HP. If the length of the line joining the elevations of the points is 50 mm, draw the projections of the points and find the length of the line joining their plans.
5. A point E is 20 mm below the HP and 30 mm behind the VP. Another point F is in front of the VP and above the HP. The distance between the projectors of the points is 60 mm. Determine the position of the point F if the lengths of the lines joining the plans and elevations of the points E and F are 80 mm and 90 mm respectively.

*

- **Plane:** A plane is a two dimensional entity having length and breadth. A plane may be bounded by straight lines or curved surfaces or both.
- **Different positions of plane:**
  a. Plane perpendicular to both the reference planes.
  b. Plane perpendicular to one and parallel to the other plane.
  c. Plane perpendicular to one and inclined to the other plane.
  d. Plane inclined to both the reference planes. Planes inclined to both the reference planes are said to be oblique planes.

EXERCISE TO BE PRACTISED IN CLASS (Each 10 marks)

6. A square lamina of side 35 mm is parallel to the HP with one of its sides inclined at 40° to the VP. The lamina is 20 mm above the HP. Draw its top and front views.
7. A circular lamina of diameter 60 mm is held vertical with its surface inclined at 45° to the VP. Its centre is 40 mm above the HP and 30 mm in front of the VP. Draw its plan and elevation.
8. A rectangular plate PQRS of 25 x 40 mm rests on the ground on one of its shorter edges inclined at 40° to the VP. Its surface makes 50° to the ground. Draw its top and front views.

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PROJECTION OF LINES AND SOLIDS

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❖ **Straight Line:** A line joining any two points along the shortest route is called a straight line. Thus the two ends of a straight lines are points.

❖ **Different positions of a straight line**

a. Parallel to both the planes
b. Parallel to the HP and perpendicular to the VP
c. Parallel to the VP and perpendicular to the HP
d. Parallel to the VP and inclined at θ degrees to the HP
e. Parallel to the HP and inclined at ϕ degrees to the VP
f. Inclined θ degrees to the HP and ϕ degrees to the VP

❖**Traces of a straight line:** The point of intersection of a line with a plane is called its **trace.**

❖Horizontal Trace: The point of intersection of a line with the HP produced if necessary is termed as the **horizontal trace** of the line and it is represented as HT.

❖Vertical Trace: The point of intersection of a line with the VP produced if necessary is termed as the **vertical trace** of the line and it is represented as VT.

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- **To locate HT**

1. Extend final elevation to meet xy and mark that point as h′
2. From h′, draw a perpendicular to xy.
3. Extend final plan to meet this perpendicular and mark that as HT.

- **To locate VT**

1. Extend final plan to meet xy and mark that point as v
2. From v , draw a perpendicular to xy.
3. Extend final elevation to meet this perpendicular and mark that as VT.

- **Methods used in projection of lines inclined to both the planes**

a. Rotating line method b. Traphezoid method

EXERCISE TO BE PRACTISED IN CLASS (Each 10 marks)

1. A line MN, 70 mm long lies in the VP and has the end M in both the reference planes. It is inclined at 35° to the HP. Draw the projections of the line.
2. One end P of a line PQ, 55 mm long is 35 mm in front of the VP and 25 mm above the HP. The line is inclined 40° to the HP and 30° to the VP. Draw the projections of PQ and locate its traces.

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3. A line PF, 65 mm long has its end P, 15 mm above the HP and 15 mm in front of the VP. It is inclined at 55° to the HP and 35° to the VP. Draw its projection.
4. The distance between the projectors through the VT and HT of a line MN is 100 mm and that between the projectors through the ends is 50 mm. The VT is 40 mm above the HP and the HT is 30 mm in front of the VP. Draw the top and front views of the line. Also find the true length and true inclinations, θ and ϕ.
5. Follow **Traphezoid method**: A line MN has its end M, 10 mm in front of the VP and 15 mm above the HP. The other end N is 50 mm in front of the VP. The front view has a length of 70 mm. The distance between the end projectors is 60 mm. Draw the projections of the line. Find its true length, true inclinations and traces of the line.

ASSIGNMENT PROBLEMS (Each 10 Marks)

6. A line EF, 85 mm long has its end E, 25 mm above the HP and 20 mm in front of the VP. The top and front views of the line having lengths of 55 mm and 70 mm respectively. Draw the projections of the line and find its true inclinations with the HP and the VP.

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ASSIGNMENT PROBLEMS (contd..)

7. A line PQ has its end P, 10 mm above the HP and 20 mm in front of the VP. The end Q is 35 mm in front of the VP. The front view of the line measures 75 mm. The distance between the end projectors is 50 mm. Draw the projections of the line and find its true inclinations and true length of the line by **traphezoid method.**

8. Verify the above answers by rotating line method.

9. One end P of a line PQ 80 mm long is 25 mm above the HP and 20 mm in front of the VP. The line is inclined at 40° to the HP and the top view makes 50° with the VP. Draw the projections of the line and find its true inclination with the VP.

10. The end P of a line PQ is in the HP and 40 mm in front of the VP. The end Q is in the VP. The front view of the line makes an angle of 40° with the horizontal and has a length of 85 mm. Draw the projections of the line and find its true inclinations with the HP and the VP. Also find its true length. Locate also its traces.

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PROJECTION OF SOLIDS

- **Solid:** A solid is a three dimensional object having length, breadth and thickness. It is bounded by plane faces or curved surfaces or combination of plane and curved surfaces.
- **Types of solids:** All geometrical solids are divided into two major types.

  1) Polyhedra 2) Solids of revolution

- Polyhedra is further classified as regular polyhedra, prism and pyramid.
- Solids of revolution are obtained by rotating a plane figure about a fixed axis (Eg. cone, cylinder, sphere).
- **Based on inclination of axis, solids are classified as:**
  - Oblique solids – axis inclined to the base
  - Right regular solids – axis perpendicular to the base
- **Based on the position of cutting plane:**
  - **Frustum of a solid** – when a plane cuts a cone or pyramid parallel to its base and the top portion removed, the remaining portion is called as **frustum.**
  - **Truncated solid** – A solid is said to be truncated when it is cut by a plane inclined to its base and the top portion removed.

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❖ **Different positions of solids: (6 positions listed below)**

- Axis perpendicular to the HP – Top view, front view
- Axis perpendicular to the VP – Front view, top view
- Axis parallel to both the planes – Profile or side view, top view and front view
- Axis inclined to the HP and parallel to the VP

1. Keep the solid with its axis perpendicular to the HP and parallel to the VP and draw the simp positions.
2. Tilt the front view of the above simple position to the given angle θ and get the final front viev
3. From the final front view, get the final top view.

- Axis inclined to the VP and parallel to the HP

1. Keep the solid with its axis perpendicular to the VP and parallel to the HP and draw the simpl positions.
2. Tilt the top view of the above simple position to the given angle ϕ and get the final plan.
3. From the final top view, get the final front view.

- Axis inclined to both the planes.

*

1. Keep the solid with its axis perpendicular to the HP and parallel to the VP and draw the simple positions.
2. Tilt the front view of the above simple position to the given angle θ and get the front view.
3. From this front view, get the top view.
4. Tilt this top view to the given angle ϕ and get the final top view. (Note: For some of the problems, we need to find the apparent inclination of the axis (β) and with this β inclination, reconstruct the top view obtained in step 3 and hence the final top view should be obtained).
5. From the final top view, get the final front view.

*

EXERCISE TO BE PRACTISED IN CLASS (Each 10 marks)

1. A pentagonal prism of base edge 30 mm and axis 60 mm is resting **on one of its base edges** on the HP with its inclined at 30° to the HP. Draw its plan and elevation.
2. A pentagonal prism of base edge 30 mm and axis 60 mm is resting **on one of its base corners** on the HP with its inclined at 30° to the HP. Draw its plan and elevation.
3. Draw the projections of the pentagonal pyramid of base edge 30 mm and axis 60 mm for the following conditions:
   a) When the pyramid is resting on one of its base edges on the HP with its axis inclined at 30° to the HP.
   b) When the pyramid is resting on one of its triangular faces on the HP.
   c) When the pyramid is resting on one of its base edges on the HP with a triangular face perpendicular to both the HP and the VP.
4. A cone of base diameter 50 mm and axis 70 mm is resting on a point of its base on the HP with its axis inclined at 40° to the HP. Draw its projections.
5. A cylinder of diameter 50 mm and axis 70 mm is resting on one of its end generators on the HP with its axis inclined at 30° to the VP. Draw its projections.

*

ASSIGNMENT PROBLEMS (Each 10 marks)

1. A hexagonal prism of base edge 30 mm and axis 60 mm is resting **on one of its base edges** on the HP with its inclined at 40° to the HP. Draw its plan and elevation.
2. A hexagonal prism of base edge 30 mm and axis 60 mm is resting **on one of its base corners** on the HP with its inclined at 30° to the HP. Draw its plan and elevation.
3. Draw the projections of the pentagonal pyramid of base edge 30 mm and axis 60 mm for the following conditions:
   a) When the pyramid is resting on one of its base corners on the HP with its axis inclined at 30° to the HP.
   b) When the pyramid is resting on one of its slant edges on the HP.
   c) When the pyramid is resting on one of its base corners on the HP with a slant edge perpendicular to the HP and parallel to the VP.
4. A cone of base diameter 50 mm and axis 70 mm is resting on one of its end generators on the HP. Draw its projections and find the true inclination of the axis with the HP.
5. A cylinder of diameter 50 mm and axis 70 mm is resting on a point of its base on the HP with its axis inclined at 30° to the HP. Draw its projections.

*

SECTION OF SOLIDS

Need for section of solids: To study the inner details of the object / component .

Definitions:

Cutting plane / Section plane: An imaginary plane which is assumed to cut the object as required is called a cutting plane of section plane.

Cutting planes are generally shown by their traces by using lines made up of alternate long and short dashes, thickened at the ends, bends and changes of direction and thin elsewhere.

Section: The surface produced when a section plane cuts a solid is termed as a section. It is indicated by continuous thin lines inclined at 45° to the axis or to the main outline of the section. Spacing between these hatching lines is uniform and should be chosen in proportion to the size of the hatched section.

Sectional view: The drawing showing that part of the object which is between the plane of projection and the section plane is called a sectional view.

Types of sectional view: 1. Sectional plan or sectional top view 2. Sectional front view or sectional elevation.

Types of section planes:

1. Section plane perpendicular to VP and parallel to HP
2. Section plane perpendicular to HP and parallel to VP
3. Section plane perpendicular to both HP and VP
4. Section plane perpendicular to VP and inclined θ degrees to HP
5. Section plane perpendicular to HP and inclined ϕ degrees to VP

Types of sections: 1. Apparent section and 2. True shape of a section

Apparent section: The projection of the cut section on the plane to which the cutting plane is inclined is said to be the apparent section.

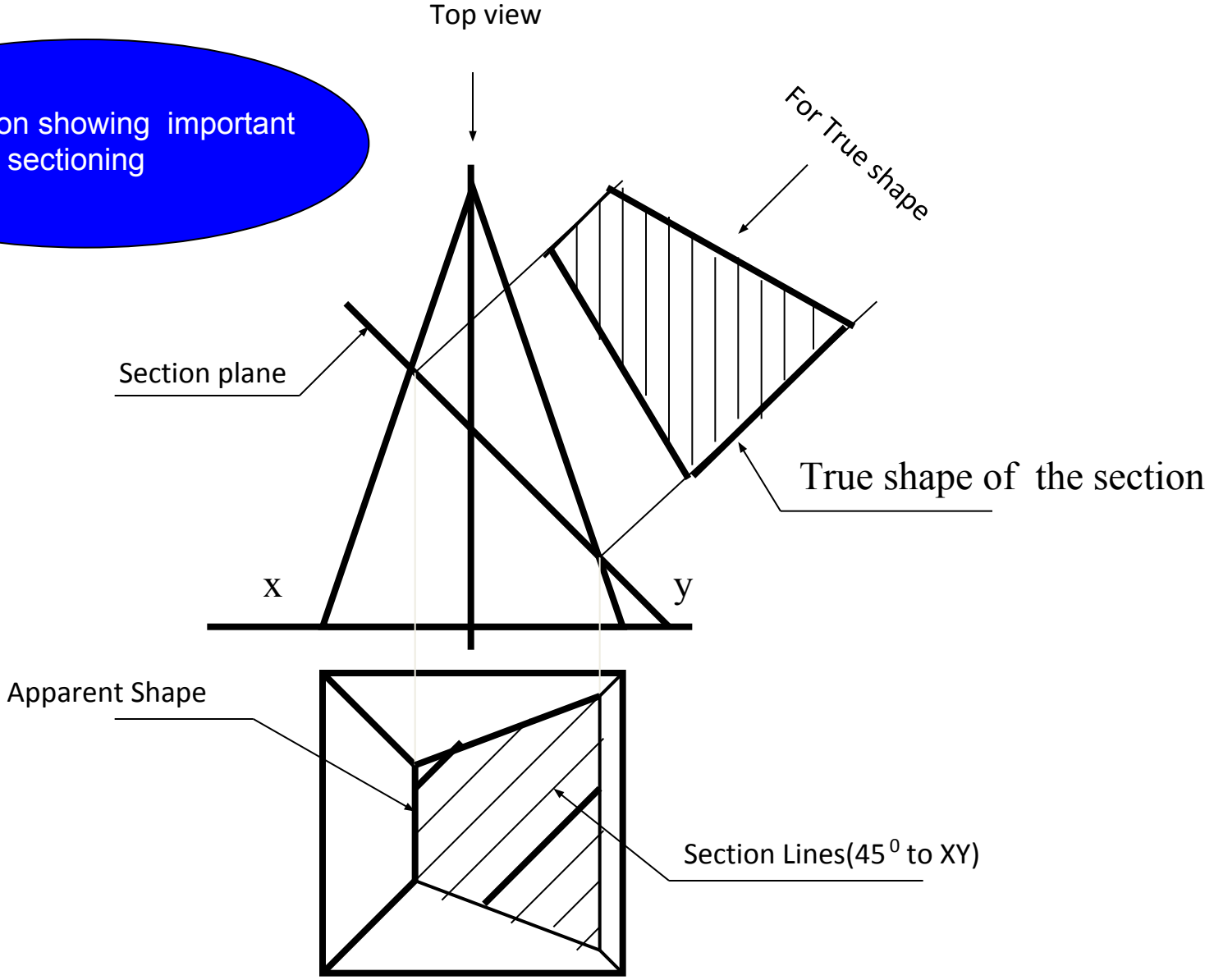
True shape of a section: If the cutting plane is parallel to the HP, the sectioned surface will also be parallel to the HP and hence, the projection of the section on the HP, namely sectional plan, will show the true shape of the section.

When the cutting plane is inclined to the HP or VP, the true shape of the section will be obtained by viewing the object *perpendicular/normal* to the cut surface and drawing the projection of the section on an auxiliary plane parallel to the cut surface.

In simple words, the true form of the cut surface is called true shape of the section and it is obtained by viewing the object normal to the cut surface.

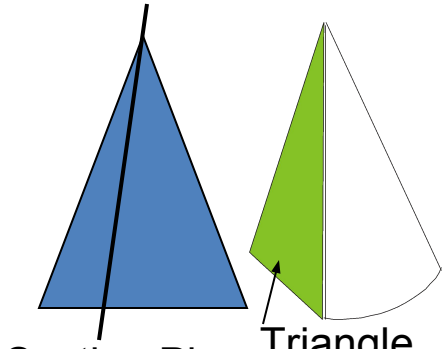
Note: When the cutting plane is perpendicular to both the HP and the VP, the sectional end view / sectional side view will give the true shape of the section.

Illustration showing important terms in sectioning

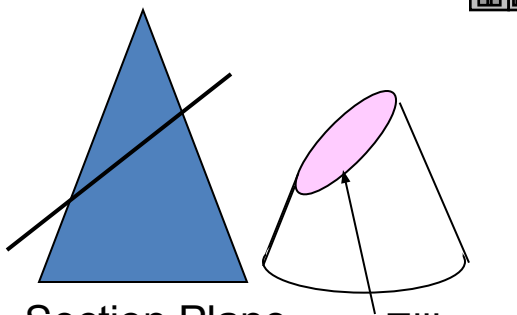


Sectional Plan or Sectional Top View

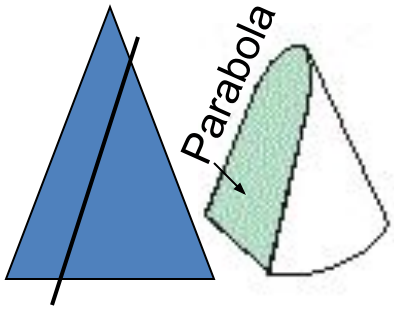
Typical section planes
&
Typical shapes of sections



Section Plane
Through Apex

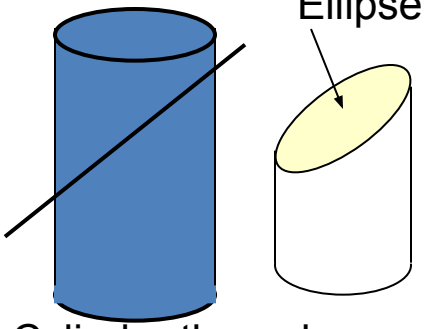


Section Plane
Through Generators

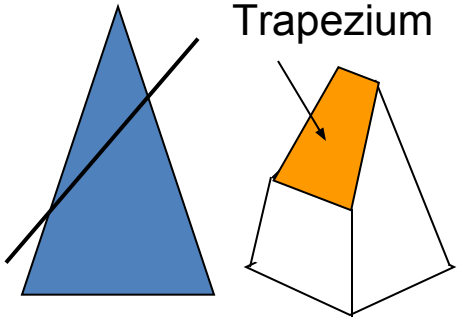


Section Plane Parallel
to end generator.

Section Plane
Parallel to Axis.



Cylinder through
generators.



Sq. Pyramid through
all slant edges

Problems to be solved in class (Each 10 marks)

1. A cube of side 40 mm is placed and cut by a section plane in such a way that the true shape is a regular hexagon. Draw the plan and elevation of the cube and determine the inclination of the cutting plane with the HP.
2. A hexagonal prism of base side 30 mm and axis length 60 mm rests on one of its ends on the HP with two base sides parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP. The cutting plane meets the axis at 25 mm from the top. Draw the front view, sectional top view and true shape of the section.
3. A cylinder of diameter 40 mm and height 50 mm rests on its base on the HP. It is cut by a plane perpendicular to the VP and inclined at 50° to the HP. The cutting plane meets the axis at a distance of 50 mm from the top. Draw the front view, sectional top view and true shape of the section.
4. A cone of base diameter 40 mm and height 50 mm rests on its base on the HP. It is cut by a section plane perpendicular to the VP and inclined at 40° to the HP. The cutting plane meets the axis at 20 mm from the vertex. Draw the sectional plane and true shape of the section.
5. A cone of base diameter 40 mm and height 50 mm rests on its base on the HP. It is cut by a section plane perpendicular to the VP and inclined at 80° to the HP, passing through the apex. Draw the sectional plane and true shape of the section.

Assignment Problems (Each 10 marks)

1. A hexagonal pyramid of base 25 mm and height 50 mm is resting on its base on the HP with two edges of the base perpendicular to the VP. A cutting plane parallel to the HP cuts the pyramid at a height of 20 mm above the base. Draw the front view and sectional top view.
2. A pentagonal pyramid of base side 20 mm and height 55 mm rests on its base on the HP with one of the base edges perpendicular to the VP. It is cut by a plane inclined at 50° to the base. The cutting plane meets the axis at 15 mm above the base. Draw the front view, sectional top view and true shape of the section.
3. A hexagonal pyramid of base side 20 mm and axis 50 mm rests on the HP on its base with two edges parallel to the VP. It is cut by a vertical plane inclined at 30° to the VP and cutting the pyramid at 5 mm from the plan of the axis. Draw the top view, sectional elevation and true shape of the section.
4. A pentagonal pyramid of base side 40 mm and axis 80 mm is resting on its base on the HP with an edge of the base parallel and nearer to the VP. It is cut by a vertical plane inclined at 45° to the VP at a distance 10 mm from the axis. Draw the top view, sectional front view and true shape of the section.
5. A cone of base diameter 40 mm and height 50 mm rests on its base on the HP. It is cut by a section plane perpendicular to the VP and parallel to one of the end generators, 10 mm away from it Draw the sectional plane and true shape of the section.

DEVELOPMENT OF SURFACES

Need for Development of Surfaces: Ship building, fabrication of boilers and chimneys, construction of aeroplanes, automobile body building, fabrication of ducts for air- conditioning, etc., involve extensive sheet metal work. Most of the sheet metal works in engineering industries involve the development of surfaces of solids like cubes, prisms, pyramids, cones, cylinders and spheres. It is mandatory that sheet metal technicians should have a thorough knowledge of preparing developments of various types of surfaces.

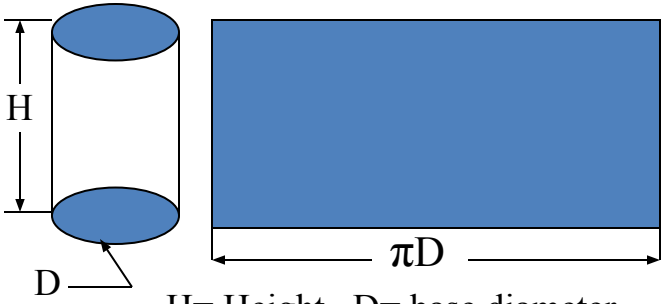
Engineering Applications: Development of surfaces finds application in the sheet metal work for making hoppers, funnels, air conditioning ducts, chimneys, boilers and machine castings. It is also extensively used in major industries like ship building, automobile building and aeroplane building.

Methods of development:

1. Parallel line development – cylinder, prism, cube
2. Radial line development – cone, pyramid
3. Triangulation method - for transiition pieces
4. Approximate method – for doubly curves surfaces like spheres, paraboloid and hyperboloid [Approximate methods are of two types namely zone method and lune method]

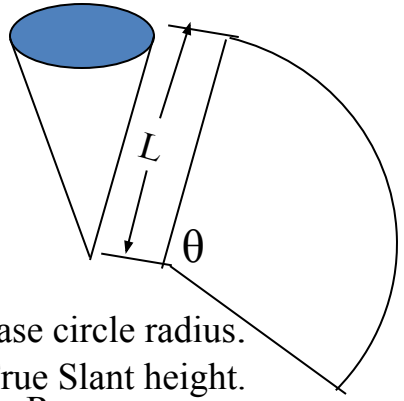
Development of lateral surfaces of different solids.
(Lateral surface is the surface excluding top & base)

Cylinder: A Rectangle



H= Height D= base diameter

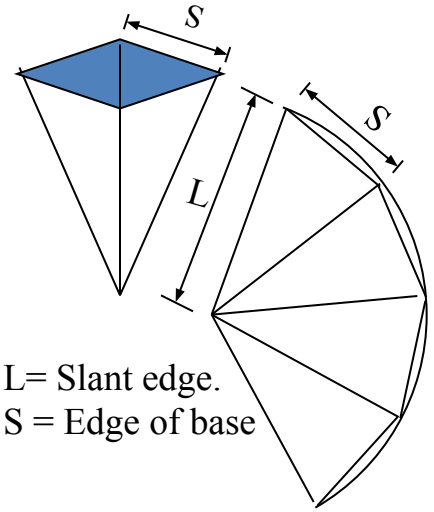
Cone: (Sector of circle)



R=Base circle radius.
L= True Slant height.

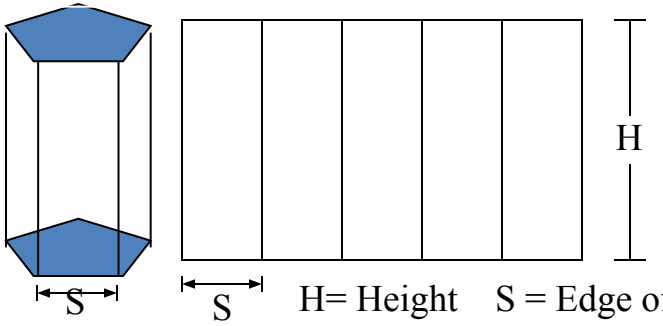
$$\theta = \frac{R}{L} \times 360^0$$

Pyramids: (No.of triangles)



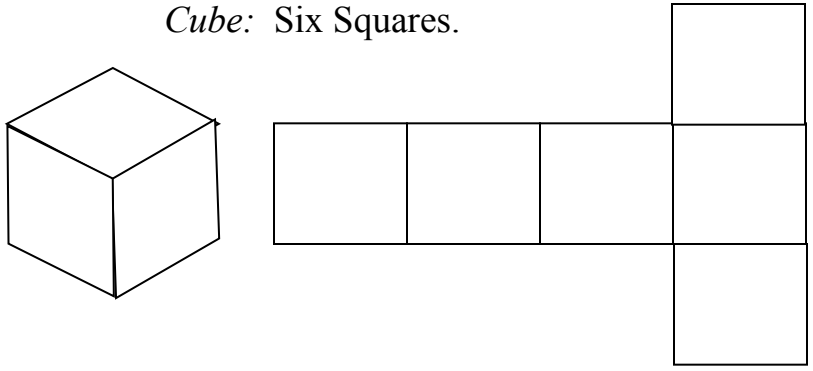
L= Slant edge.
S = Edge of base

Prisms: No.of Rectangles

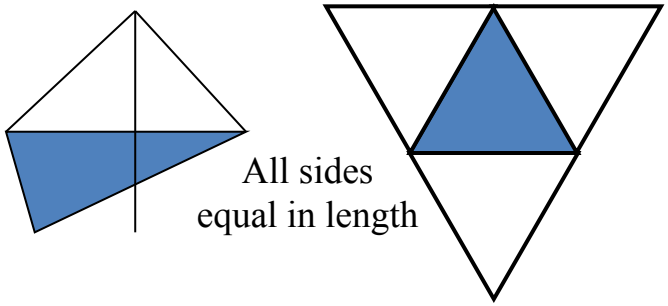


H= Height S = Edge of base

Cube: Six Squares.



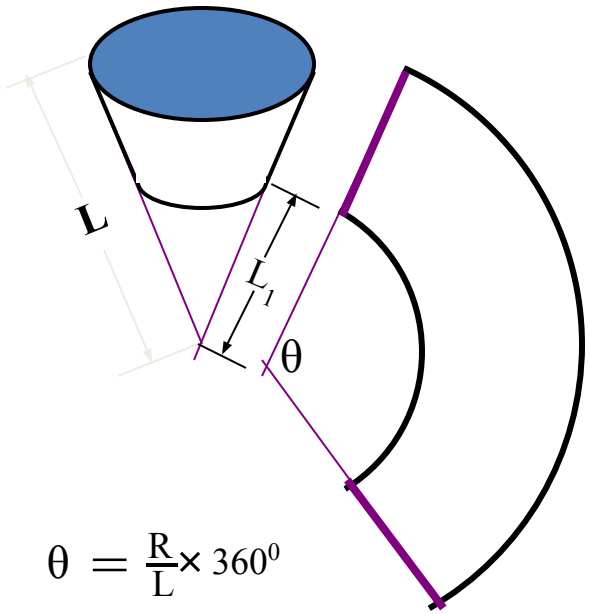
Tetrahedron: Four Equilateral Triangles



All sides
equal in length

FRUSTUMS

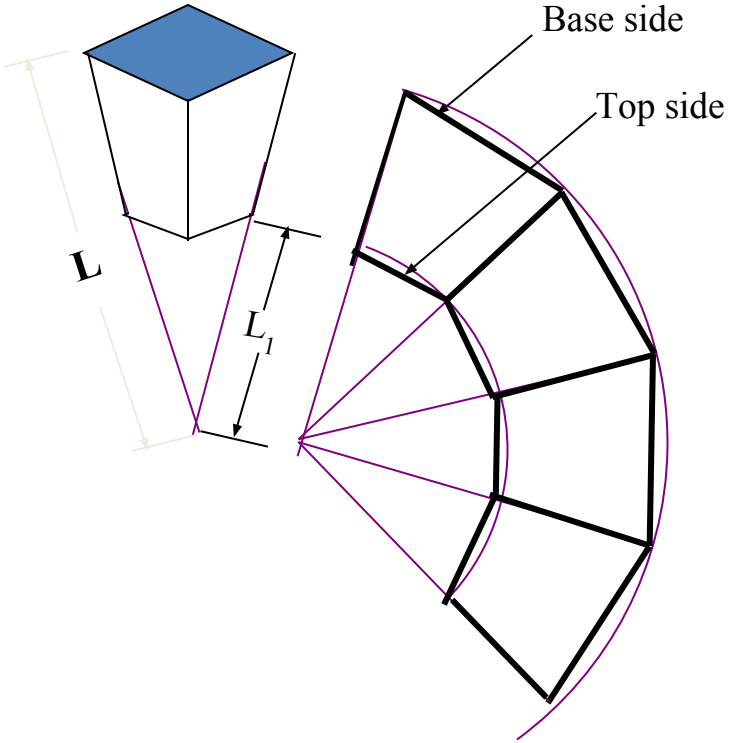
DEVELOPMENT OF FRUSTUM OF CONE



$$\theta = \frac{R}{L} \times 360^0$$

R= Base circle radius of cone
L= Slant height of cone
L_1 = Slant height of cut part.

DEVELOPMENT OF FRUSTUM OF SQUARE PYRAMID



L= Slant edge of pyramid
L_1 = Slant edge of cut part.

Problems to be solved in class (Each 10 marks)

1. A hexagonal prism of base side 20 mm and height 45 mm is resting on its base on the HP with two of its lateral faces parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP. The plane meets the axis at a distance of 20 mm above the base. Draw the development of lateral surfaces of the lower portion of the prism.
2. A pentagonal prism of base side 25 mm and height 60 mm is resting on its base on the HP with a rectangular face parallel to the VP. A hole of diameter 30 mm is drilled centrally through the prism in such a way that the axis of the hole bisects the axis of the prism at right angles. The axis of the hole is perpendicular to the VP. Draw the development of the lateral surfaces of the prism.
3. A cylinder of diameter 40 mm and height 50 mm is resting vertically on one of its ends on the HP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP. The plane meets the axis at a point 30 mm from the base. Draw the development of the lateral surface of the lower portion of the truncated cylinder.
4. A cone of base diameter 60 mm and height 70 mm is resting on its base on the ground. It is cut by a plane perpendicular to the VP and parallel to the HP at a distance 20 mm from the vertex. It is also cut by a plane inclined at 40° to the base and meeting the axis at a point 20 mm from the base. Draw the development of the lateral surface of the cut cone.
5. Draw the development of the lateral surface of the right portion of the cylinder of diameter 50 mm and height 65 mm cut by a plane inclined at 60° to the base and passing through the axis at a height of 40 mm above the base.

Assignment problems (Each 10 marks)

6. A square pyramid of base side 35 mm and axis 60 mm rests on its base on the ground with one of the sides of the base inclined at 30° to the VP. A thread is wound round the surfaces of the pyramid starting from the left extreme point on the base and ending at the same point. Find the shortest length of the string required. Also trace the path of the string in the front and top views.
7. A cone of base diameter 60 mm and height 70 mm is resting on its base on the ground. A thread is tightly wound around the curved surface of the cone starting from left extreme point on the base and ending at the same point. Find the shortest length of the string required. Also trace the path of the string in the front and top views.
8. A cone of base diameter 60 mm and height 70 mm is resting on its base on the ground. It is cut by a plane perpendicular to both the VP and the HP and passing through the cone 10 mm to the left of the axis of the cone. Draw the development of the lateral surface of the right portion of the cone.
9. A circular hole of diameter 30 mm is drilled through a vertical cylinder of diameter 50 mm and height 65 mm. The axis of the hole is perpendicular to the VP and meets the axis of the cylinder at right angles at a height of 30 mm above the base. Draw the development of the lateral surface of the cylinder.
10. A pentagonal pyramid of base 25 mm and height 60 mm is resting on its base on the HP with one of its base side parallel to the VP. It is cut by a plane perpendicular to the VP and parallel to the HP at a distance of 25 mm above the base. Draw the development of the lateral surfaces of the frustum of the pyramid. Also show the plan of the cut surface.

ISOMETRIC PROJECTION

Definition: The term isometric is derived from Greek. Isos means equal; metron means measure. Isometric projection is a system of projection having equality of measure. In other words, equally reduced measure drawing.

Isometric projection is a form of pictorial projection. The other pictorial projections are oblique projection and perspective projection.

In isometric projection, all the three sides of the object are exposed to the viewer.

Principle of isometic projection: The principle of isometric projection is best understood by drawing the front view of a cube when it is resting on one of its corners on the HP with a solid diagonal perpendicular to the VP.

Square faces of the cube appear as rhombus in isometric projection.

Also, circle appear as ellipse, sphere appear as circle is isometric projection.

Isometric axes: The three lines RQ, RS and RV making 120° with each other are called isometric axes.

Isometric lines: Any line parallel to any of these isometric axes is called as isometric line

Non-isometric lines: Any line which is not parallel to any of the isometric axes is said to be a non-isometric line

Isometric planes: Plane formed by using isometric axes and isometric lines are called isometric planes.

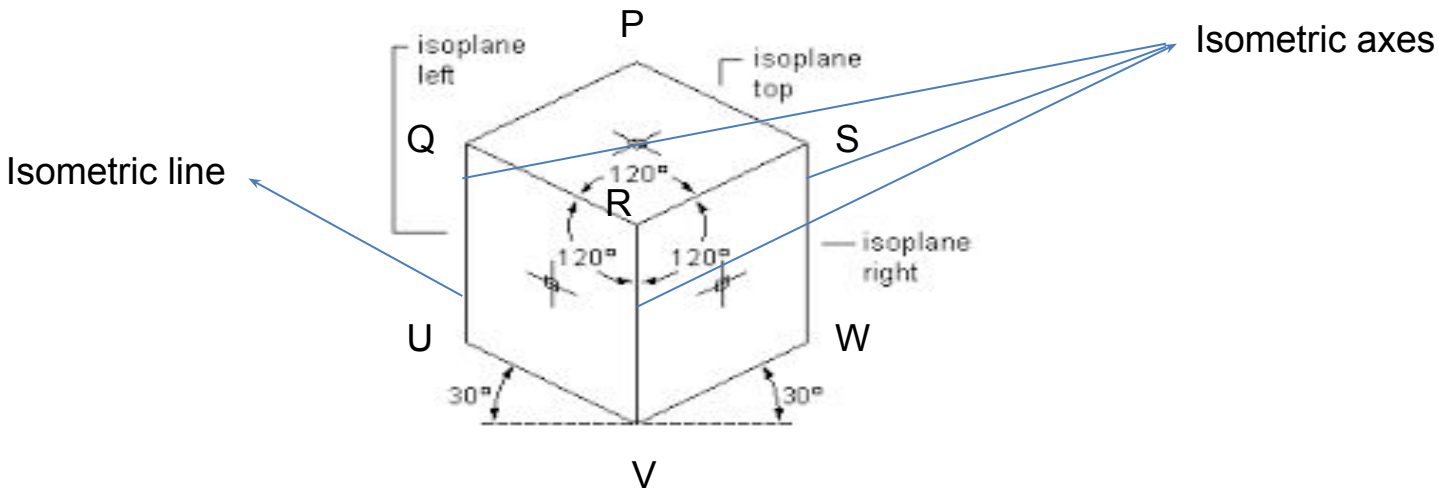


Fig. Isometric axes, isometric lines and isometric planes

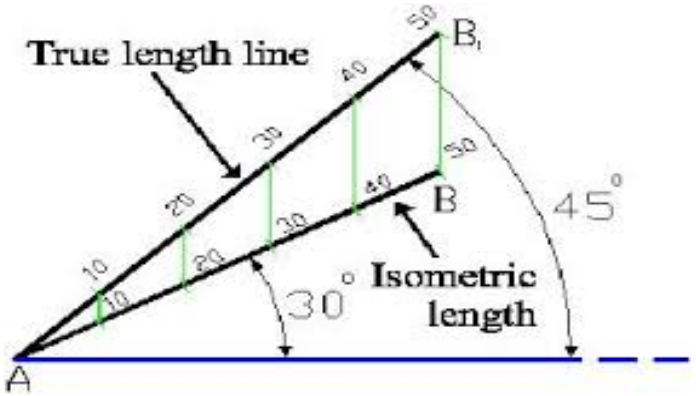


Fig. Isometric scale

Isometric length
---------- = 0.8165
True length

Note: It is mandatory to convert true lengths into isometric lengths before drawing an isometric projection.

Isometric view and isometric projection:

- ❖ Figure drawn with true length is called isometric view or isometric drawing.
- ❖ Figure drawn with isometric length is called isometric projection.

Note: Isometric projection is more time consuming and more difficult than isometric view.

Uses of isometric view / isometric projection:

- ❖ Isometric projection is used to supplement the orthographic views so that even a common man can understand the details of the item represented clearly and quickly.
- ❖ Practice in constructing pictorial drawings will enable one to develop the ability to visualize the shapes of objects and skill in reading and interpreting engineering drawings.
- ❖ Pictorial drawings are widely used in preparing advertisement hoardings, catalogues of products like instruments and furniture.
- ❖ Pictorial drawings of individual elements will help in designing and developing new devices and improvising the existing one.

Isometric view of a circle can be obtained by: 1. Method of points and 2. Four centre method.

Methods used in Isometric view / isometric projection:

1. Box method – for cylinder, prism, cube.
2. Offset or co-ordinate method – for cone and pyramid.

Problems to be solved in class (Each 10 marks)

1. a. Draw the isometric view of a circle of diameter 50 mm using four centre method.

   b. Draw the isometric view of a cylinder of diameter 50 mm and height 70 mm, when the cylinder is resting on its base on HP, using box method.
2. Draw the isometric view of a hexagonal pyramid of base side 15 mm and height 55 mm resting on its base on the HP with two sides of the base parallel to the VP, using offset method.
3. Draw the **isometric projection** of a frustum of a cone of height 30 mm, base diameter 34 mm, top diameter 20 mm when it is centrally placed over a square slab of side 50 mm and thickness 10 mm.
4. Draw the isometric view of a sphere of diameter 16 mm kept centrally over a frustum of a square pyramid of height 25 mm. The frustum has a base side of 25 mm and top side of 20 mm.
5. Three square rods of 30 x 30 mm cross section and lengths 100 mm, 100 mm and 60 mm are so nailed together that they form the letter H. Draw the **isometric projection** of the letter H.

Assignment problems (Each 10 marks)

6. A hemispherical vessel of diameter 90 mm is placed centrally over a cylinder of diameter 60 mm and height 75 mm which in turn kept centrally over a square prism of base side 80 mm and height 20 mm. Draw the **isometric projection** of the disposition of the solids.
7. A hemispherical piece of metal 90 mm in diameter is joined centrally to the end of a cylindrical piece of metal of diameter 60 mm and length 75 mm so as to form a snap headed rivet. Draw the isometric view of the rivet when it is held with the hemispherical head at the top.
8. Draw the isometric view of a cone of base diameter 50 mm and height 80 mm when its axis is horizontal and base vertical.
9. A sphere of radius 30 mm is placed centrally over a square prism of side of base 60 mm and height 80 mm. Draw the **isometric projection** of the solids.
10. A sphere of radius 50 mm is kept centrally over a frustum of a square pyramid of side 120 mm at the bottom and 80 mm at the top and height 100 mm. The frustum of the pyramid rests centrally over a cylindrical slab of diameter 150 mm and thickness 30 mm. Draw the **isometric projection** of the three solids.

ISOMETRIC PROJECTION (3D)

TO

ORTHOGRAPHIC PROJECTION (2D)

Problems to be solved in class (Each 10 marks)

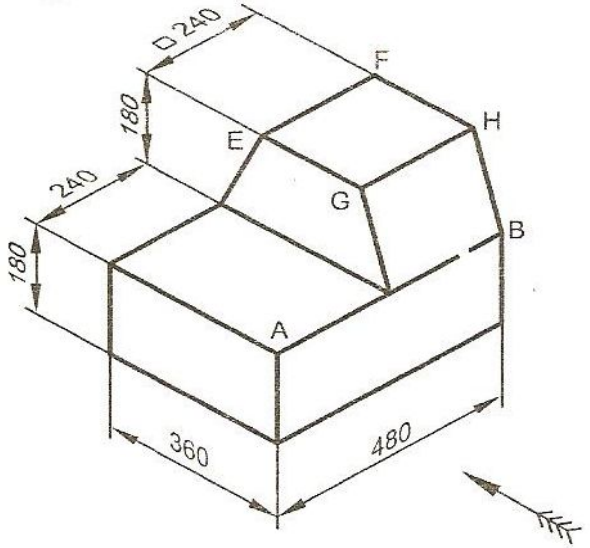


Fig. 1

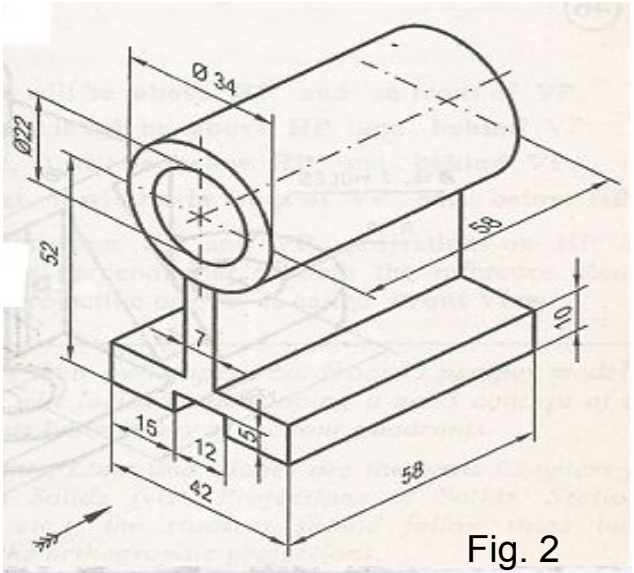


Fig. 2

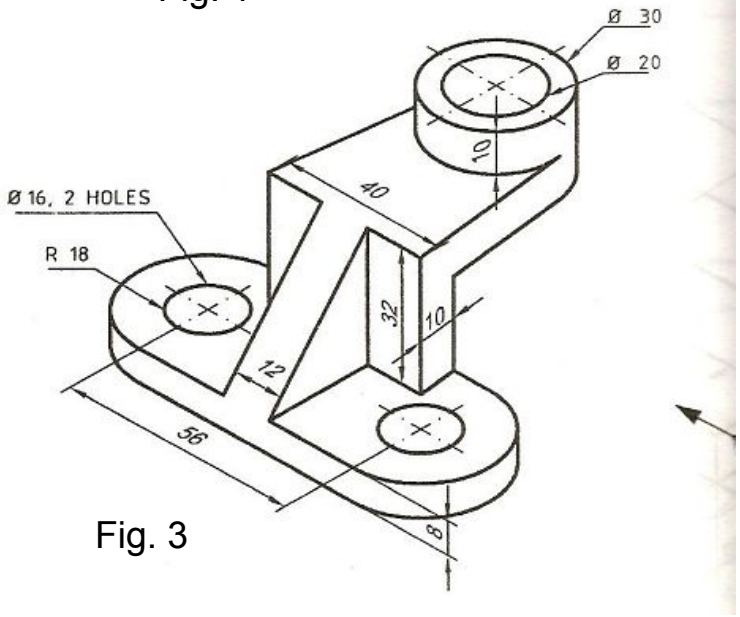


Fig. 3

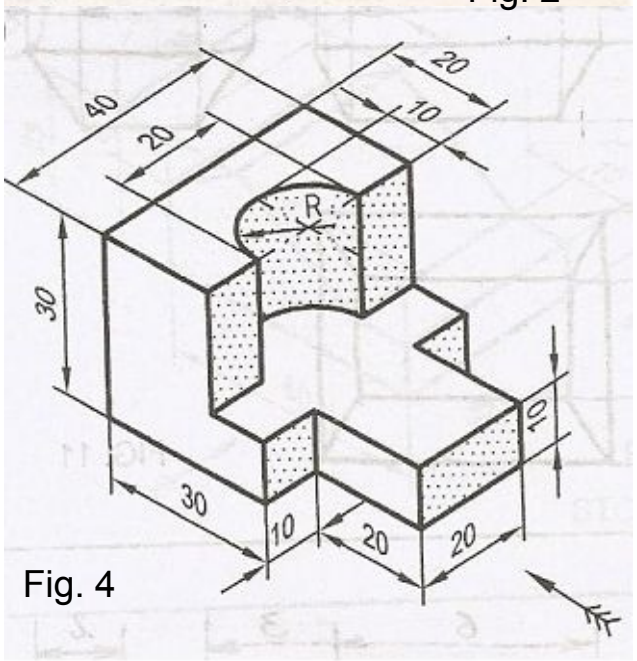


Fig. 4

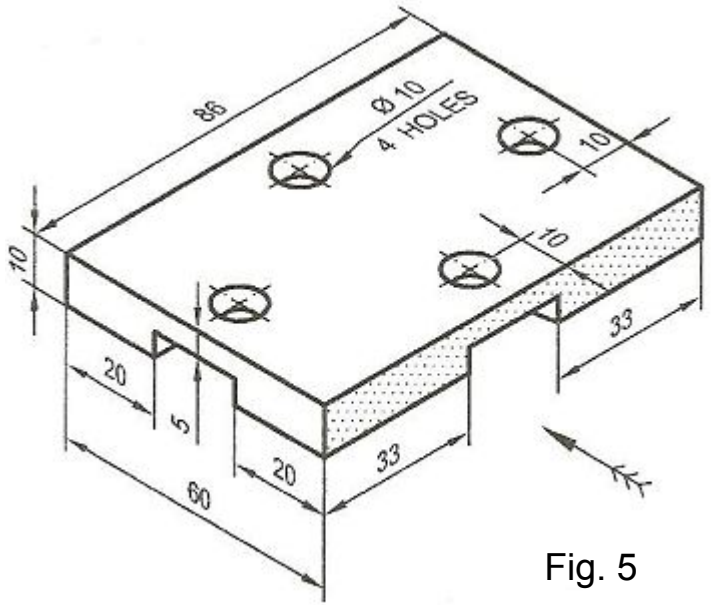


Fig. 5

Assignment problems (Each 10 marks)

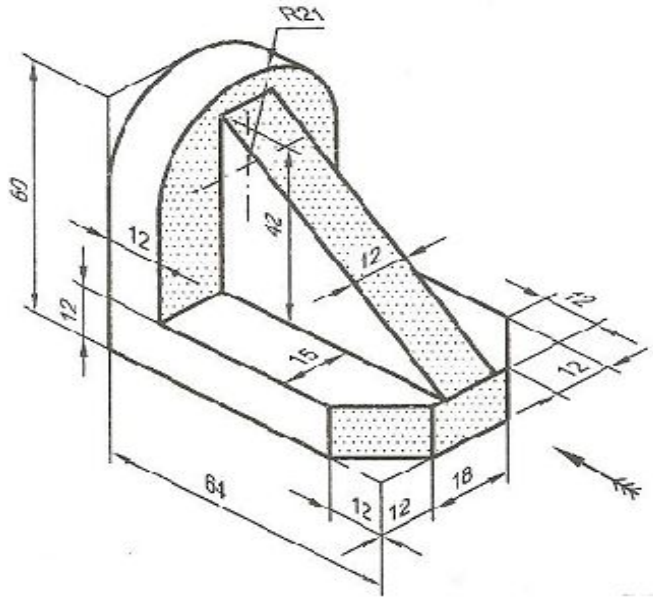


Fig. 6

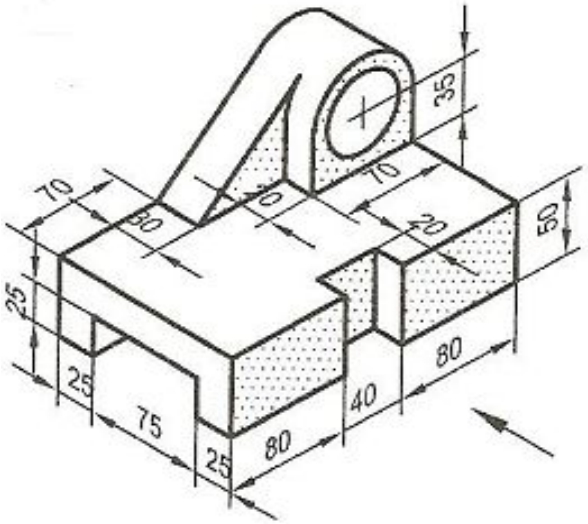


Fig. 7

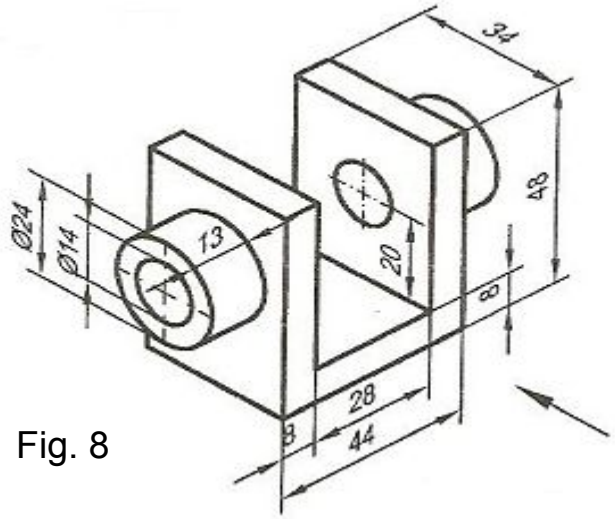


Fig. 8

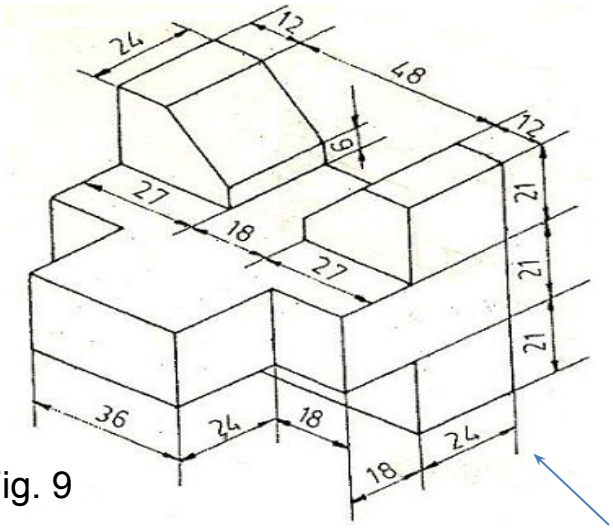


Fig. 9

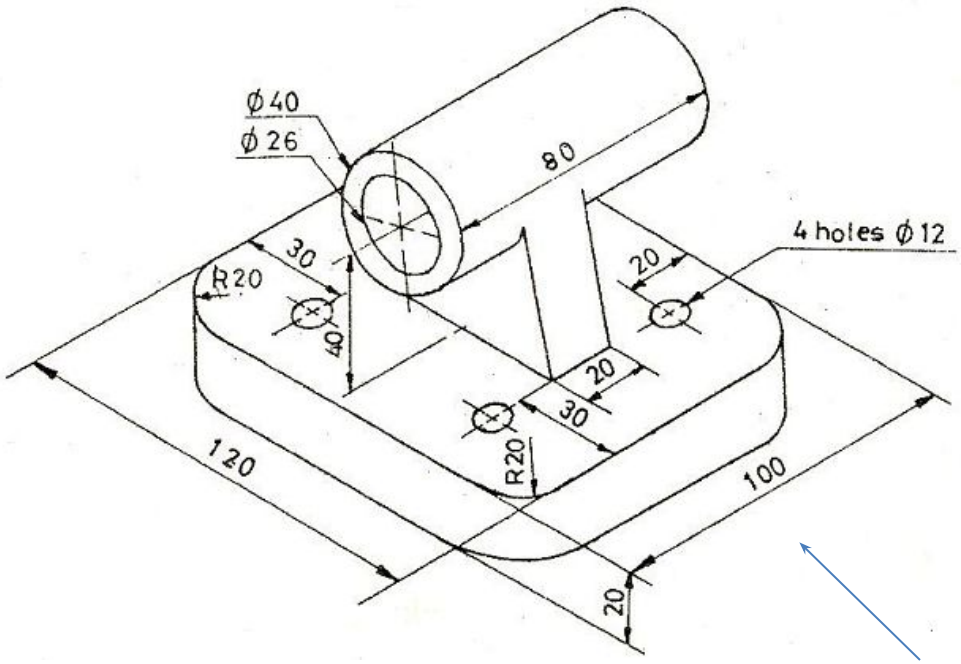


Fig. 10