B.E. –I & II SEM ENGINEERING GRAPHICS

UNIT -I

INTRODUCTION

Drawing:

- The way of conveying the ideas through the systematic lines on the paper.
- The art of representation of an object by systematic lines on a paper.

Classification:

1. Artistic Drawing (Free-hand or Model Drawing):

The art of representation of an object by the artist by his imagination or by keeping the object before him.

e.g. paintings, cinema posters, advertisement boards, etc.

2. Engineering Drawing (Instrument Drawing):

The art of representation of engineering objects.

e.g. buildings, roads, machines, etc.

Types of Engineering Drawing:

i. **Geometrical Drawing:**

e.g. geometrical objects - rectangle, square, cube, cone, cylinder, etc.

a. **Plain Geometrical Drawing:**

Two dimensional drawing having only length and breadth.

e.g. square, triangle, etc.

b. **Solid Geometrical Drawing:**

Three dimensional drawing having length, breadth and thickness.

e.g. cube, prism, etc.

ii. **Mechanical Engineering or Machine Drawing:**

e.g. mechanical engineering objects – machines, machine parts, etc.

iii. **Civil Engineering Drawing:**

e.g. civil engineering objects – roads, buildings, bridges, dams, etc.

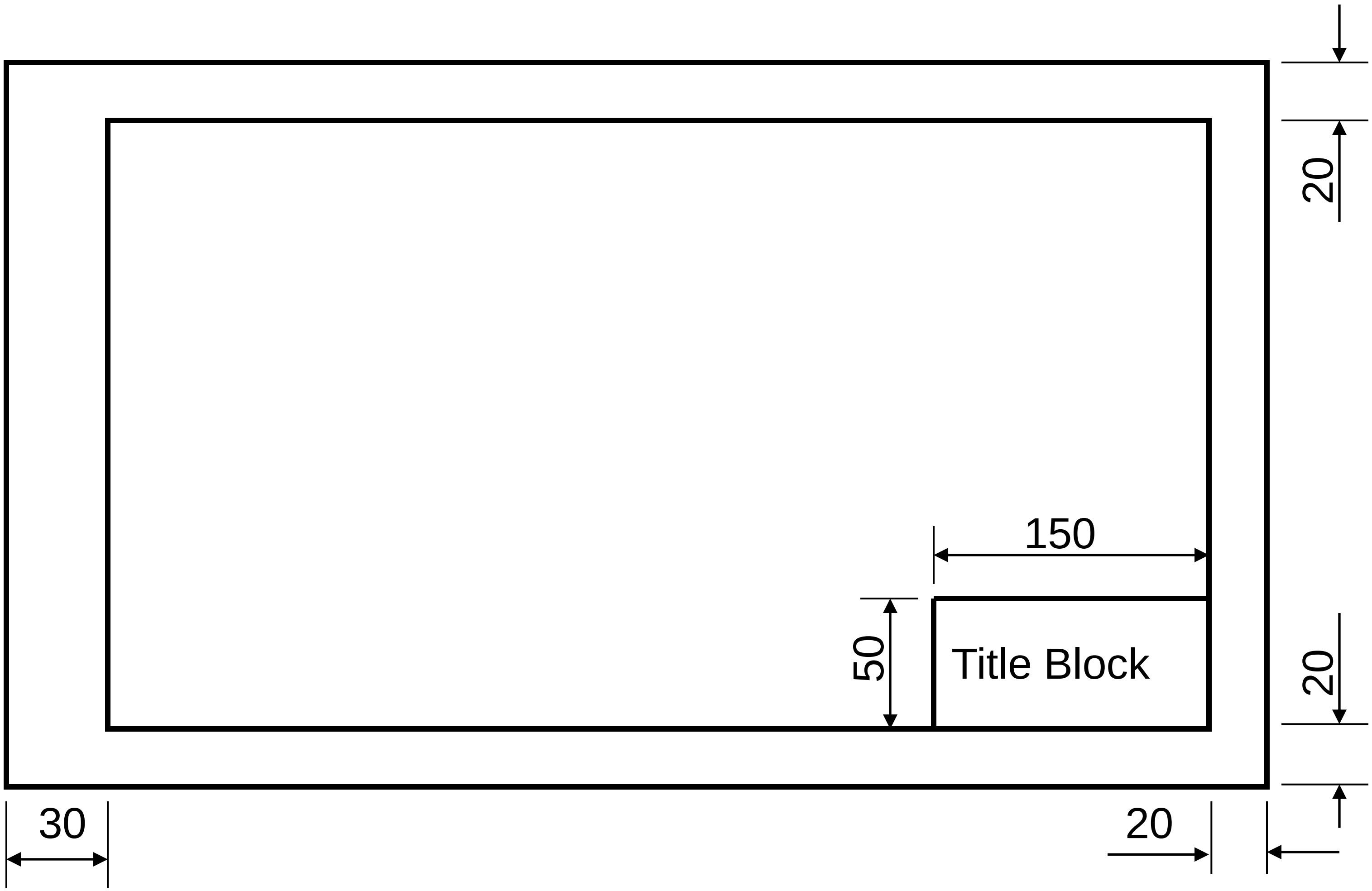
iv. **Electrical & Electronics Engineering Drawing:**

e.g. electrical and electronics objects – transformers, wiring diagrams.

Drawing Instruments and Other Drawing Materials:

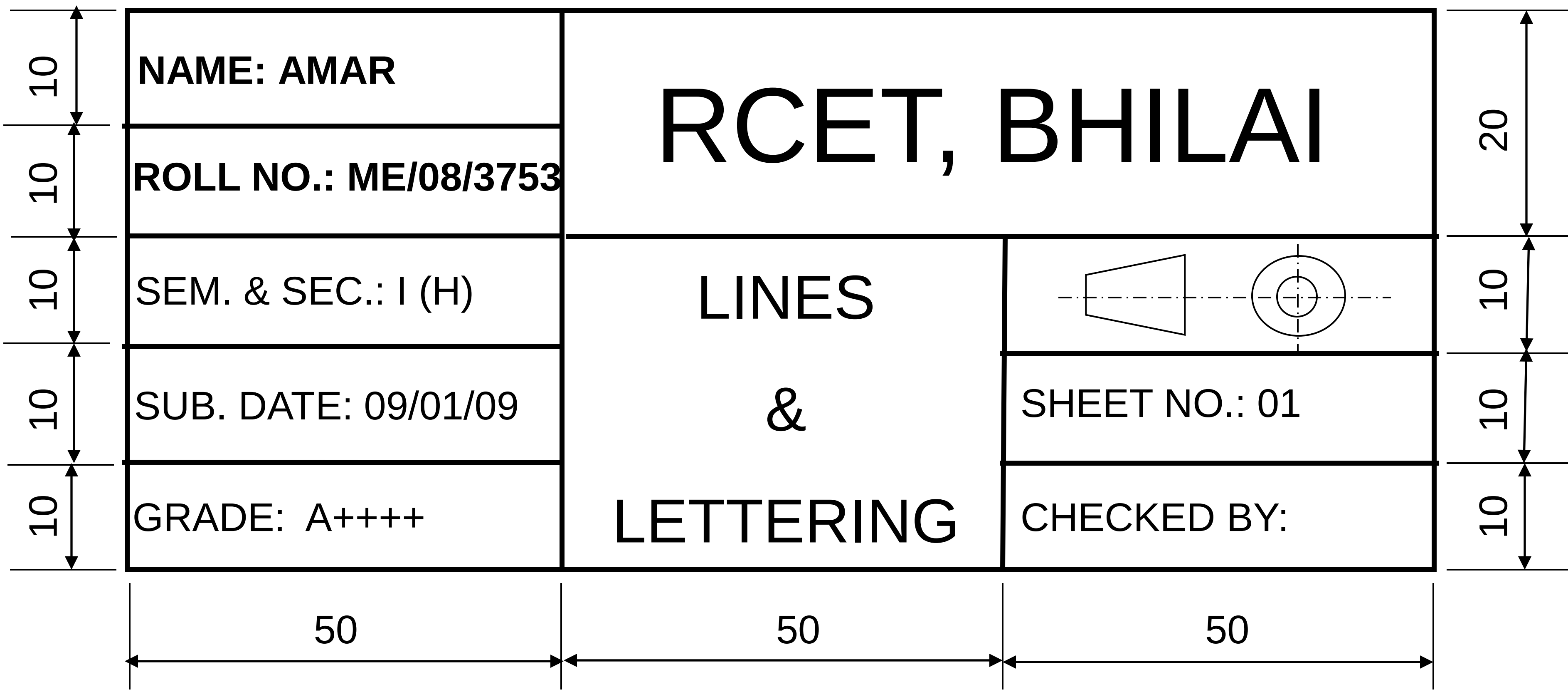
1. Drawing Board
2. Drawing Sheet
3. Drawing Sheet Holder
4. Set-squares – 45^o and 30^o – 60^o
5. Large size Compass
6. Small bow Compass
7. Large size Divider
8. Small bow Divider
9. Scales – 6” and 12”
10. Protractor
11. French Curve
12. Drawing Pencils – H, 2H, HB
13. Sand Paper
14. Eraser (Rubber)
15. Drawing Pins and Clips
16. Cello Tape
17. Duster or Handkerchief
18. Drafting Machine / Mini Drafter
19. Sketch Book (Medium size)
20. Roller Scale
21. Pencil Sharpener
22. Sheet Folder

Layout of Drawing Sheet



All the dimensions are in millimeters.

Title Block (Sample)



NOTES:

All the dimensions are in millimeters.

Name and Roll No. should be written by ink-pen.

LINES

Line Thickness:

Thickness varied according to the use of pen or pencil and the size & type of the drawing.

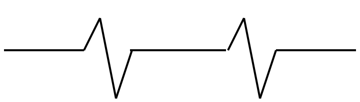
For pencil, the lines can be divided into two line-groups:

Line-group (mm)	Thicknes s	Lines
0.2	Medium	Out lines, dotted lines, cutting plane lines
0.1	Thin	Centre lines, section lines, dimension lines, extension lines, construction lines, leader lines, short-break lines and long-break lines.

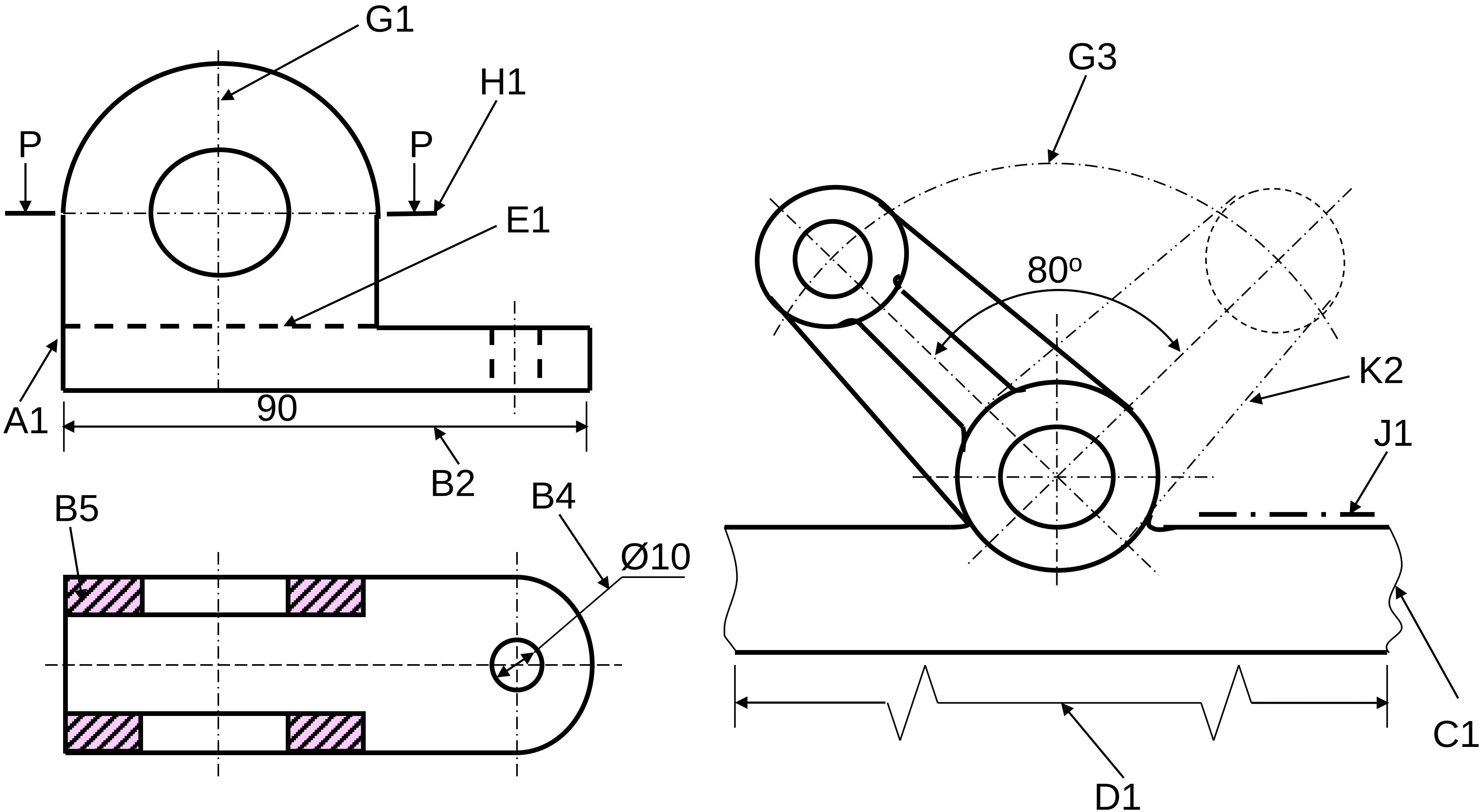
Important Notes:

In the finished drawing, all lines except construction lines should be dense, clean and uniform. Construction lines should be drawn very thin and faint and should be hardly visible.

Types of Lines

Lines		Description	General Applications	
A		Continuous thick	A1 A2	Visible outlines Visible edges
B		Continuous thin (straight / curve)	B1 B2 B3 B4 B5 B6 B7	Imaginary lines of intersection Dimension lines Projection lines Leader lines Hatching or section lines Outlines of revolved sections in plane Short centre lines
C		Continuous thin (free-hand)	C1 C2	Limits of partial or interrupted views and sections Short-break lines
D		Continuous thin (straight with zigzags)	D1	Long-break lines

Lines		Description	General Applications	
E		Dashed thick	E1 E2	Hidden outlines Hidden edges
F		Dashed thin	F1 F2	Hidden outlines Hidden edges
G		Chain thin	G1 G2 G3	Centre lines Lines of symmetry Trajectories
H		Chain thin, thick at ends and changes of direction	H1	Cutting planes
J		Chain thick	J1	Indication of lines or surfaces to which a special treatment applies
K		Chain thin double-dashed	K1 K2 K3 K4	Outlines of adjacent parts Alternative and extreme positions of movable parts Centroidal lines Parts situated in front of the cutting plane



Application of various types of lines according to B.I.S.

Lettering

Writing of titles, dimensions, notes and other important particulars on a drawing

Classification:

1. **Single-stroke Letters:**

   The thickness of the line of the letter is obtained in one stroke of the pencil.

   Recommended by B.I.S.

   It has two types:

   i. Vertical

   ii. Inclined (slope 75^o with the horizontal)

- The ratio of height to width varies but in most of the cases it is 6:5.
- Lettering is generally done in capital letters.
- The lower-case letters are generally used in architectural drawings.

- The spacing between two letters should not be necessarily equal.
- The letters should be so placed that they do not appear too close together too much apart.
- The distance between the words must be uniform and at least equal to the height of the letters.
- Lettering, except the dimension figures, should be underlined to make them more prominent.

Size of Alphabets for Drawing:

Main titles --6-8 mm

Sub titles --3-6 mm

Notes, dimension figures, etc. --------------3-5 mm

Drawing no. -----------------------------------10-12 mm

2. Gothic Letters:

Stems of single-stroke letters are given more thickness (vary from 1/5 to 1/10 of the height of the letters).

Mostly used for main titles of ink-drawings.

d

d/2

ABCDEFGHIJKLMN

OPQRSTUVWXYZ

1234567890

abcdefghijklmnopqrs

tuvwxyz

Dimensioning

The art of writing the various sizes or measurement on the finished drawing of an object.

Types of Dimensioning:

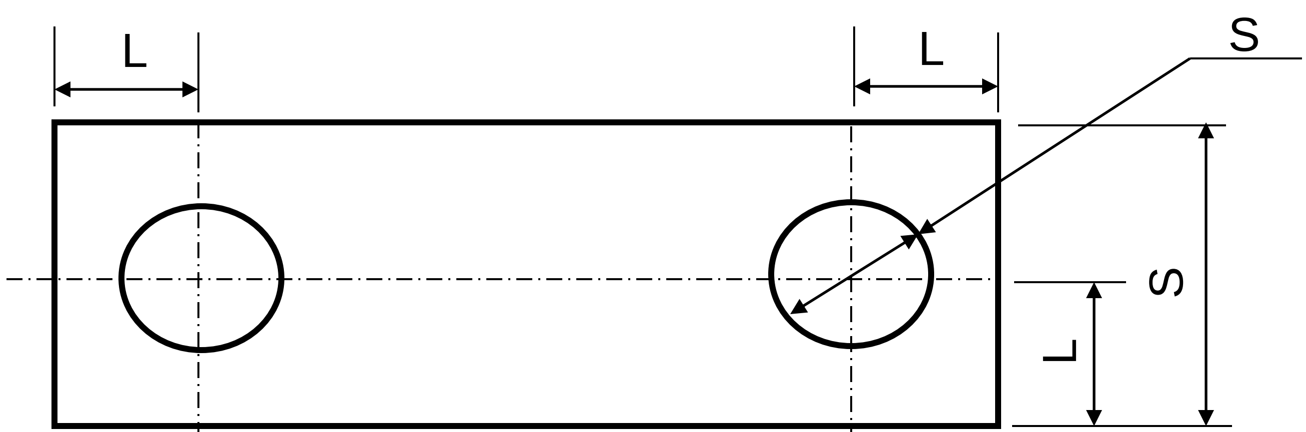
i. Size or Functional Dimensions (S):

It indicates sizes.

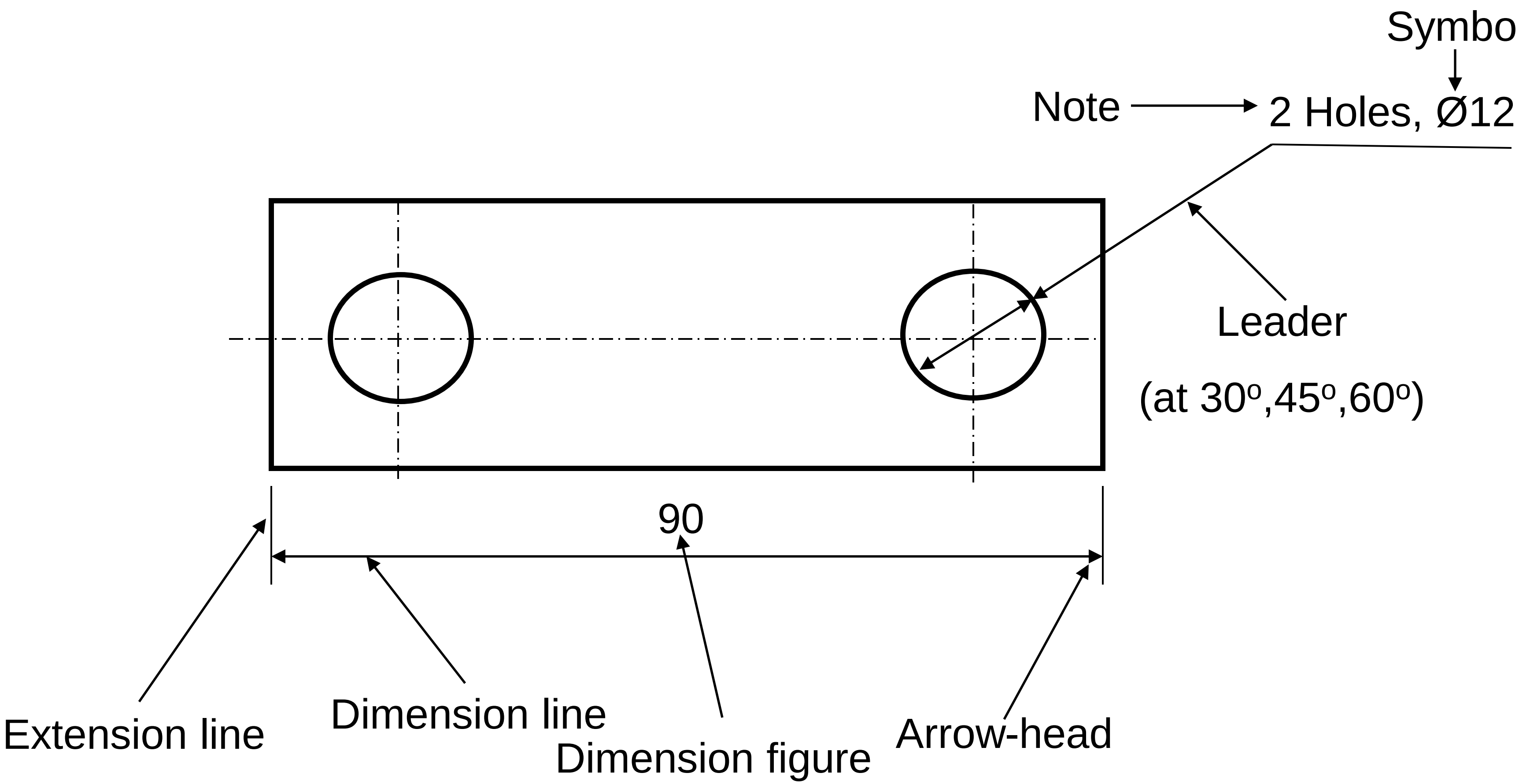
e.g. length, breadth, height, diameter, etc.

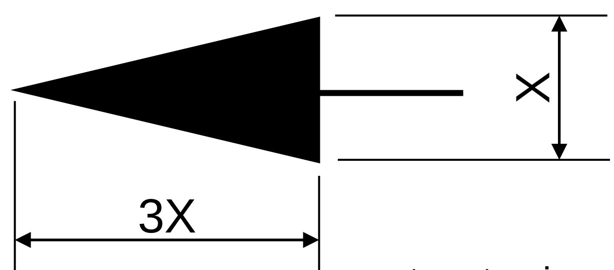
ii. Location or Datum Dimensions (L):

It shows location or exact position of various constructional details within the object.



Notations of Dimensioning





Arrow-head

1. **Dimension line:**

   Thin continuous line used to indicate the measurement.

2. **Extension line:**

   Thin continuous line extending beyond the outline of the object.

3. **Arrow-head:**

   Used to terminate the dimension line. Length : width ratio is 3:1.

   Space filled up.

4. **Note:**

   Gives information regarding specific operation relating to a feature.

5. **Leader:**

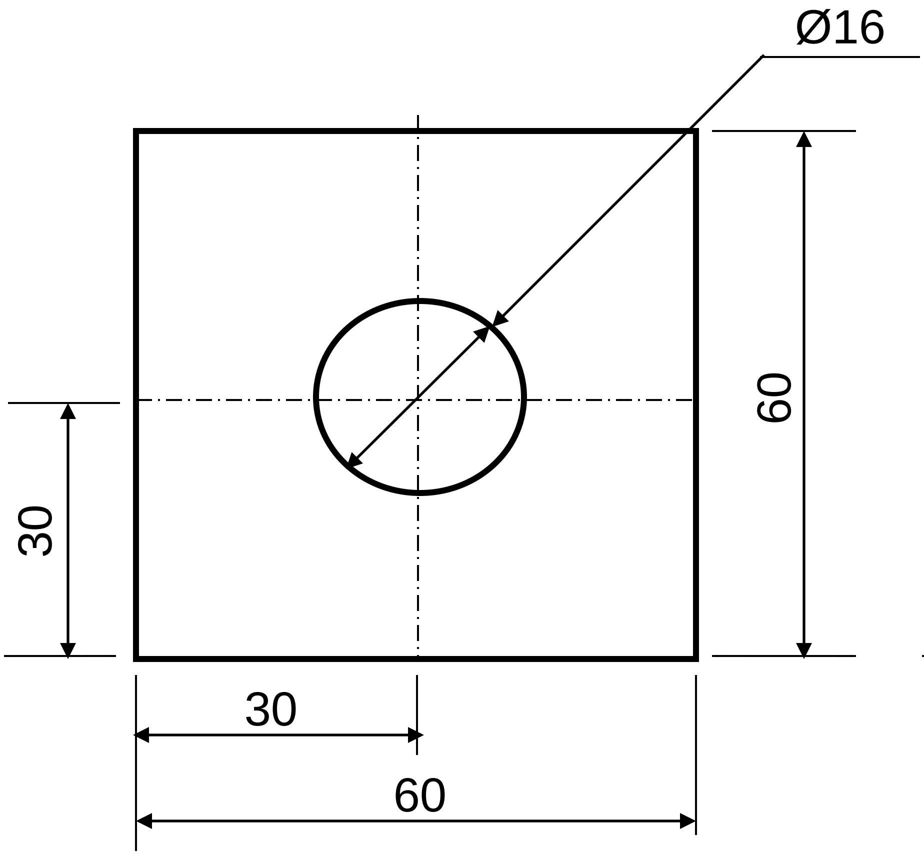
   Thin continuous line connecting a note or a dimension figure with the feature to which it is applied. Terminated by arrow-head or dot.

6. **Symbol:**

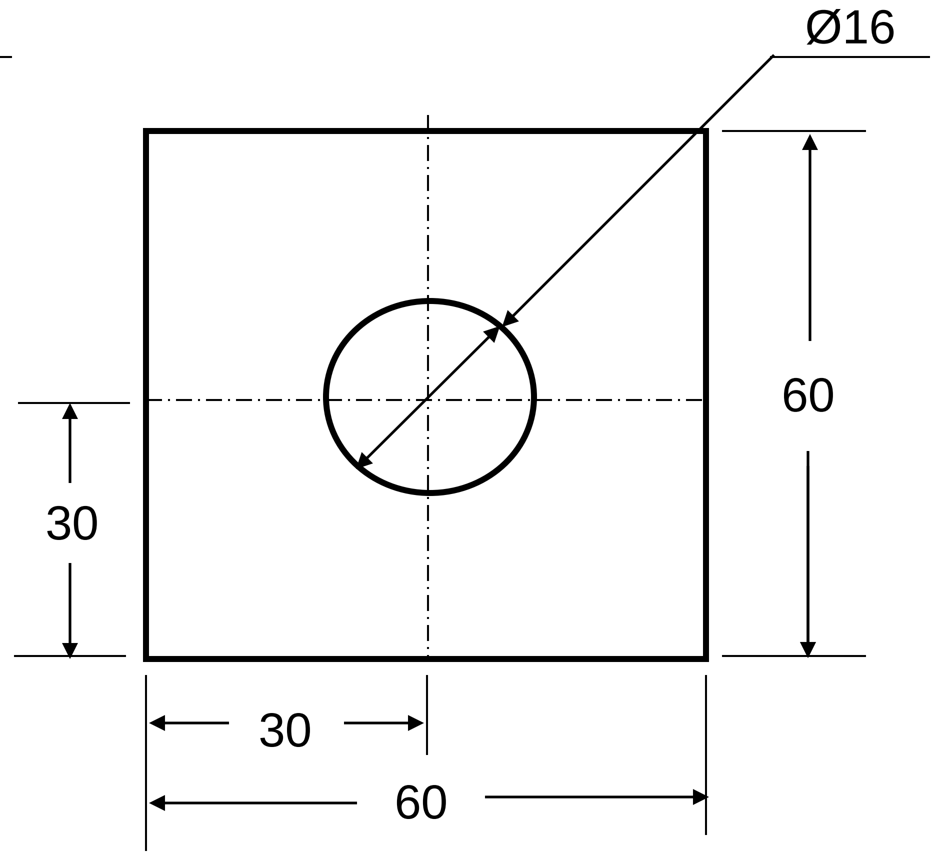
   The representation of any object by some mark on the drawing.

   It saves time and labour.

System of Placing Dimensions



Aligned System



Unidirectional System

System of Placing Dimensions

1. **Aligned System:**

   All the dimensions are so placed that they may read from the bottom or the right hand edges of the drawing sheet.

   All the dimensions are placed normal and above the dimension line.

   Commonly used in Engineering Drawing.

2. **Unidirectional System:**

   All the dimensions are so placed that they may read from the bottom edge of the drawing sheet.

   Dimension lines are broken near the middle for inserting the dimensions.

   Commonly used on large drawing – aircrafts, automobiles.

Units of Dimensioning

As for as possible all dimensions should be given in millimeters omitting the abbreviation mm.

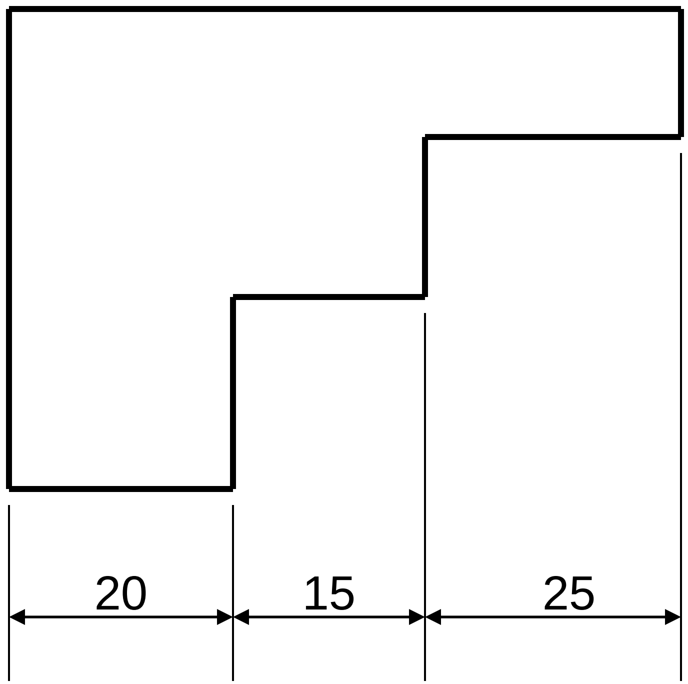
If another unit is used, only the dimension figures should be written. But a foot note such as ‘All the dimensions are in centimeters’ is inserted in a prominent place near the title box.

e.g. 15.50

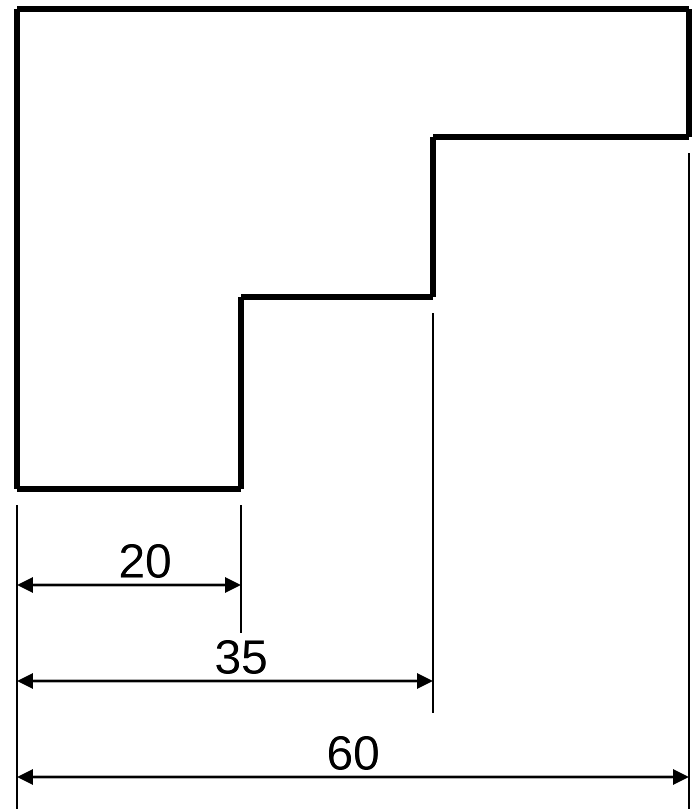
0.75 (Zero must precede the decimal point.)

15.50 ± .75 (Zero is omitted.)

The ways of Placing the Dimensions in a Series

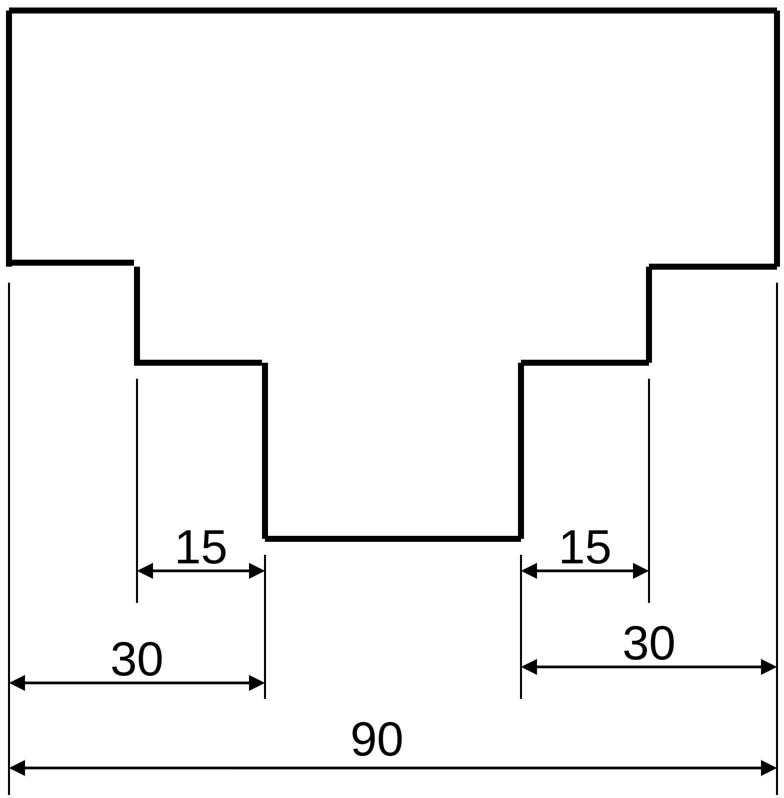


Chain

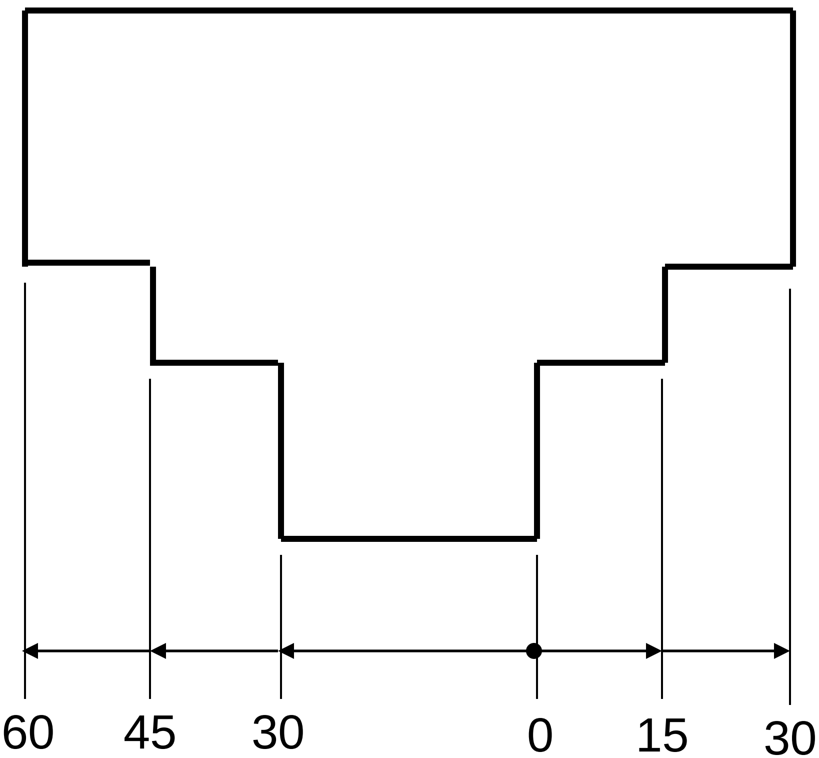


Parallel

The ways of Placing the Dimensions in a Series



Combined



Progressive

The ways of Placing the Dimensions in a Series

1. **Chain Dimensioning:**

   Dimensions are arranged in a straight line.

2. **Parallel Dimensioning:**

   All the dimensions are shown from a common base line.

   The smaller dimension is placed nearer the view.

3. **Combined Dimensioning:**

   Chain and parallel dimensioning used simultaneously.

4. **Progressive Dimensioning:**

   One datum or surface is selected which reads as zero. All the dimensions are referred to that point or surface.

Some Important Rules for Dimensioning

1. All the dimensions necessary for the correct functioning of the part should be expressed directly on the drawing.

2. Every dimension should be given, but none should be given more than once.

3. A dimension should be placed on the view where its use is shown more clearly.

4. Dimensions should be placed outside the view, as for as possible.

5. Mutual crossing of dimension lines and dimensioning between hidden lines should be avoided. Also it should not cross any other line of the drawing.

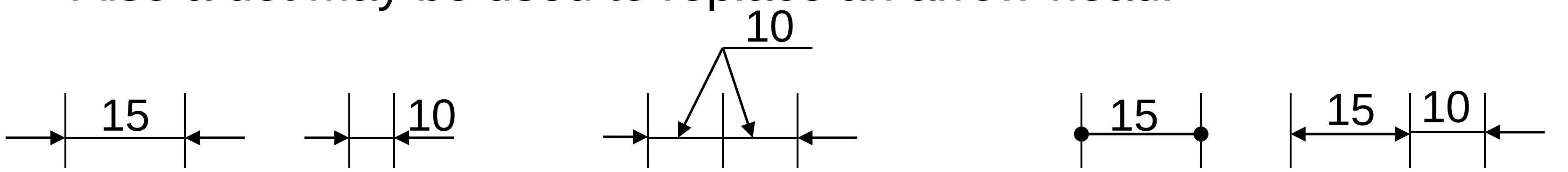
6. An outline or a centre line should never be used as a dimension line. A centre line may be extended to serve as an extension line.

7. Aligned system of dimensioning is recommended.

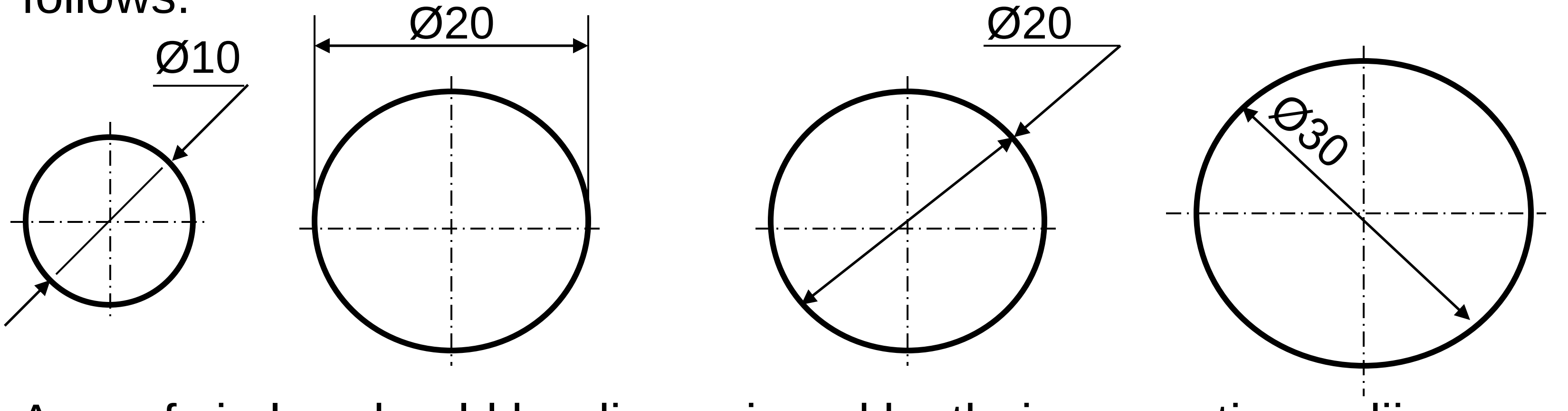
8. Dimension lines should be drawn at least 8 mm away from the outlines and from each other.

9. The extension line should be extended by about 3 mm beyond the dimension line.

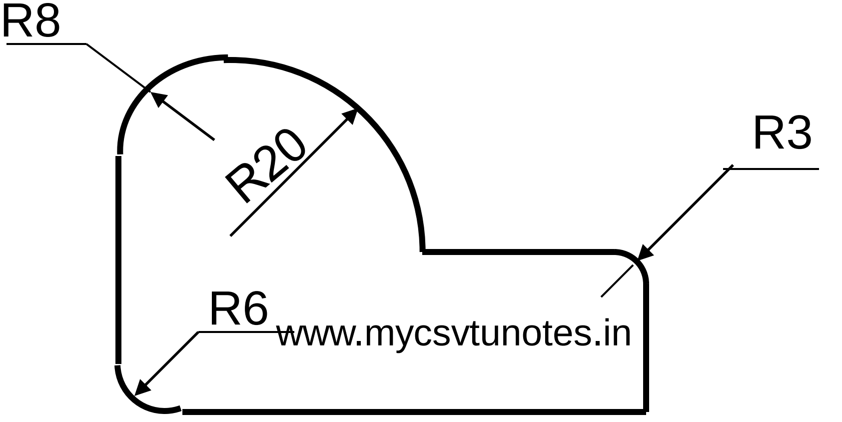
10. When the space is too narrow, the arrow-head may be placed outside. Also a dot may be used to replace an arrow-head.



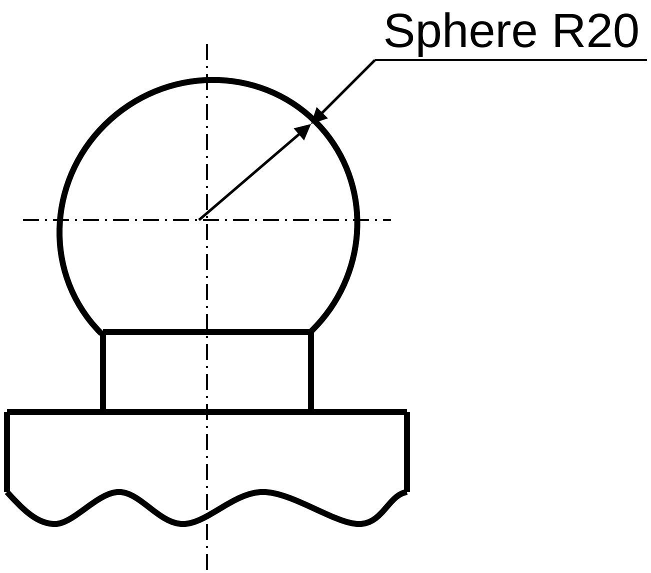
11. The various methods of dimensioning different sizes of circles are as follows:

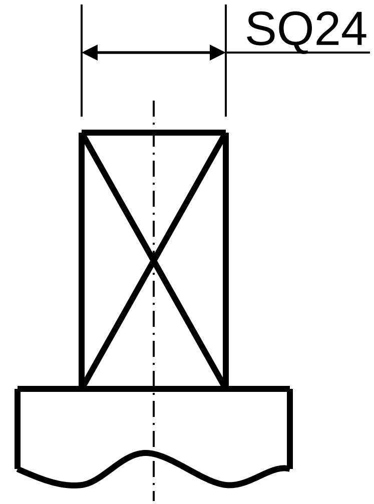


12. Arcs of circles should be dimensioned by their respective radii.

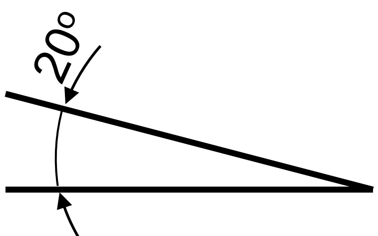


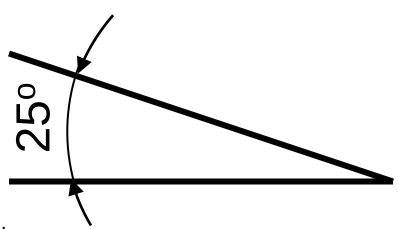
13. Radii of a spherical surface and square cross section of a rod is shown as below:

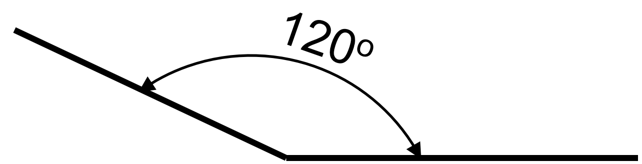


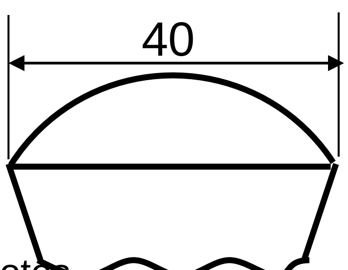


14. Angular dimension may be given as follows:

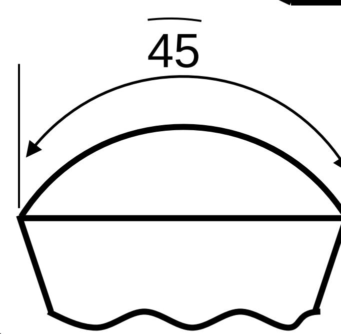






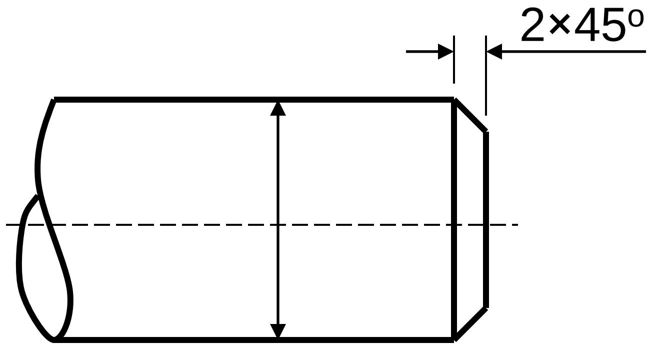


Length of Chord

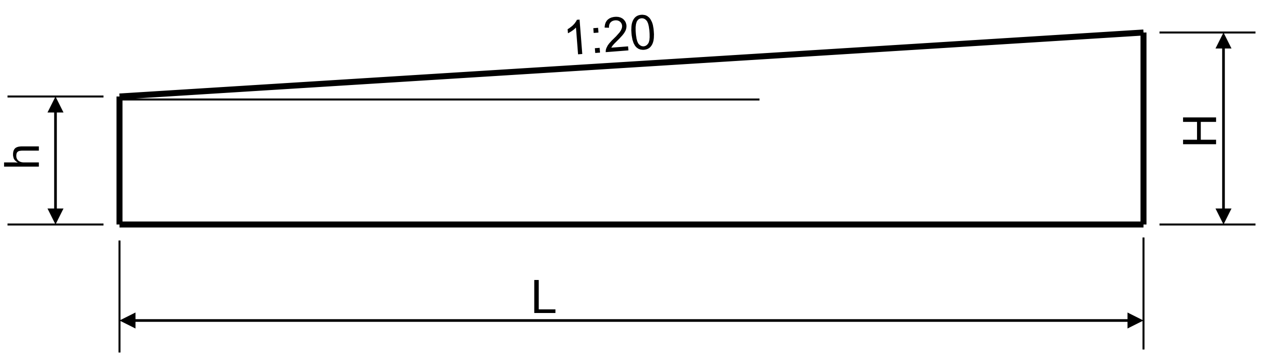


Length of Arc

15. Method of dimensioning of Chamfer:



16. Dimensioning of Tapered Surface:



Slope or Taper = (H-h)/L

SCALES

INTRODUCTION

- A ***scale*** is defined as the ratio of the linear dimensions of element of the object as represented in a drawing to the actual dimensions of the same element of the object itself.

SIZES OF THE SCALES

- Drawing drawn of the same size as the objects, are called full-size drawings and the scale used is known as ***full-size scale.***

- It may not be always possible to prepare full size drawings .They are, therefore, drawn proportionality smaller or larger.
- When drawings are drawn smaller than the actual size of the object (as in case of building, bridge, large machines etc.) the scale used is said to be a ***reducing scale*** (1:5) .
- Drawing of small machine parts, mathematical instruments, watches etc. are made larger than their real size. These are said to be drawn on an ***enlarging scale*** (5:1).

REPRESETATIVE FRACTION

The ratio of the length of the drawing to the actual length of the object represented is called the representative fraction (i.e. R.F.).

$$\text{R.F.} = \frac{\text{Length of the drawing}}{\text{Actual length of object}}$$

EXAMPLE

- When a 1 cm long line in a drawing represents 1 metre length of the object , the R.F. is equal to

- [1 cm / 1 metre] = [1 cm / 100 cm]

  = 1/100

- And the scale of the drawing of the drawing will be 1:100 or 1/100 full size.

SCALES ON DRAWING

When an unusual scale is used , it is constructed on the drawing sheet . To construct a scale the following information is essential:

(1) RF of the scale

(2) The unit which it must represent, for example millimeter, centimeter, feet and inches etc.

(3) The maximum length which it must show.

The length of the scale is determined by the formula:

Length of the scale = R.F. × Maximum length

- It may not be always possible to draw as long a scale as to measure the longest length in the drawing . The scale is there fore drawn 15 cm to 30 cm long, longer length being measured by marking them off in parts

TYPES OF SCALES

- The scales used in practice are classified as under:

  (1) **Plain scales**

  (2) **Diagonal scales**

  (3) Comparative scales

  (4) Vernier scales

  (5) Scale of Chord

PLAIN SCALES

- A Plain scale consist of a line divided into suitable number of equal parts or units, the first of which is subdivided into smaller parts. Plain scales represent either two units or a unit and its sub division .

- (1)The zero should be placed at the end of the first main division, i.e. between the unit and its sub divisions.

- (2) From the zero mark, the units should be numbered to right and its sub divisions to the left.
- (3)The names of the units and the sub divisions should be stated clearly below or at the respective ends.
- (4) The name of the scale (i.e. scale, 10) or its RF should be mentioned below the scale.

EXAMPLE

Construct a scale of 1:4 to show centimeters and long enough to measure up to 5 decimeters

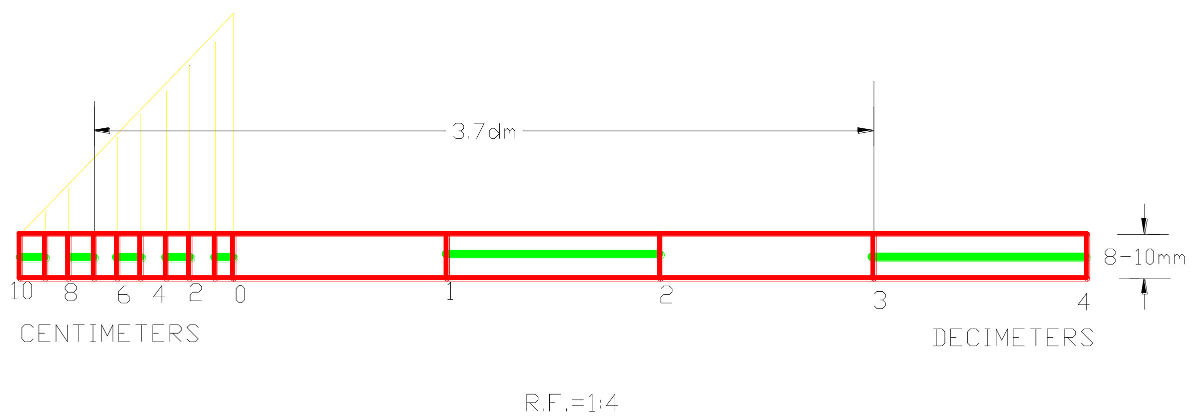
PROCEDURE

- (1)Determine the **RF** of the scale. Here it is **1:4**
- (2)Determine the length of the scale
  length of the scale = RF × max. length
  =[1:4] × 5 dm = 12.5 cm
- (3)Draw a line of 12.5 cm long and divide it into 5 equal divisions, each representing 1dm

(4) Mark 0 the end of the first division and 1,2,3and 4 at the end of each subsequent division to its right.

(5) Divide the first division into 10 equal sub division , each representing 1 cm.

(6) Mark cms to the left of 0 as shown in figure.



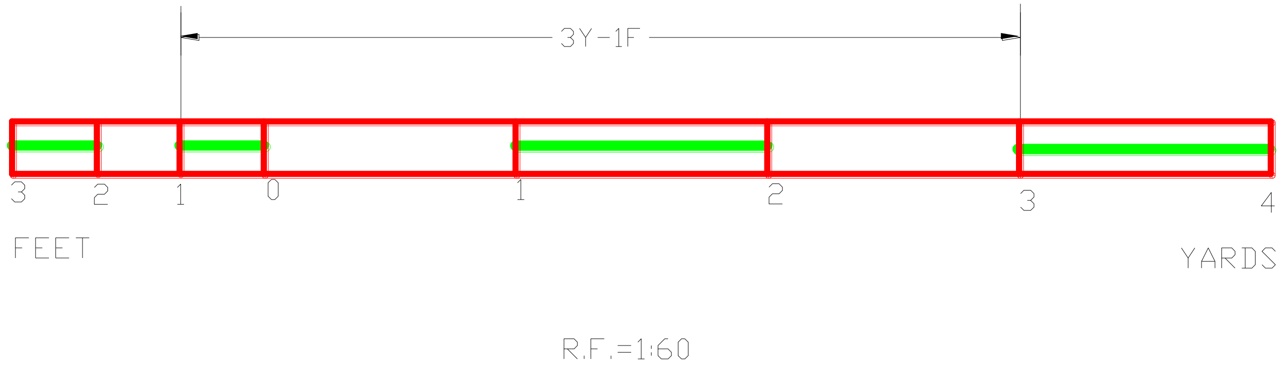
EXAMPLE

Construct a scale of R.F.1/60 to read yards and feet , and long enough to measure up to 5 yards.

PROCEDURE

- Length of the scale = R.F.× max. length
  = [1/60] × 5 yard = 3 inches
- Draw a line 3 inches long and divide it into 5 equal parts.
- Divide the first part into 3 equal divisions.
- Mark the scale as shown in figure.

FINAL DRAWING



DIAGONAL SCALES

- A Diagonal scale is used when very minute distances such as 0.1 mm etc. are to be accurately measured or when measurements are required in three units.

- For example, dm, cm, and mm or yard , foot and inch.

PRINCIPLE OF DIAGONAL SCLAE

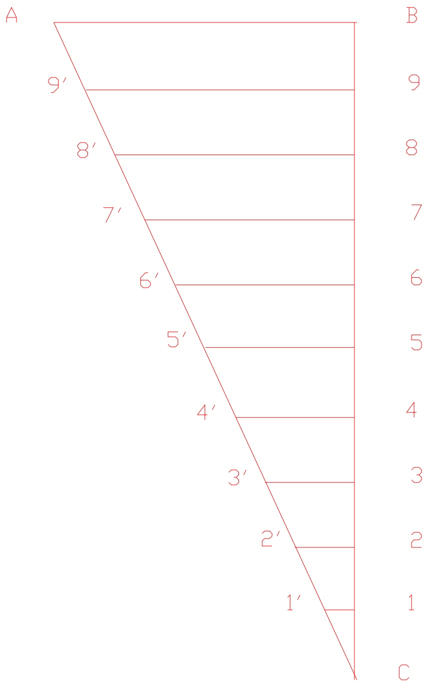
- To obtain division of a given short line AB in multiples of 1/10 its length, e.g. 0.1AB, 0.2 AB.
- At any end ,say B , draw a line perpendicular to AB and along it, step-off ten equal division of any length , starting from B and ending at C.
- Number the division points 9,8,7----1.
- Join A with C.

- Through the points 1,2,etc.draw lines parallel to AB and cutting AC at 1',2' etc. it is evident that triangles 1'1C,2'2C----ABC are similar.

- Since C5 = 0.5BC, the line 5'5 = 0.5AB. Similarly ,1'1=0.1 AB,2'2=0.2AB etc.

- Thus each horizontal line below AB becomes progressively shorter in length by 1/10 AB giving lengths in multiple of 0.1 AB.

PRINCIPLE OF DIAGONAL SCLAE



EXAMPLE-1

Construct a diagonal scale of 3:200 showing metres , decimetres and centimetres and to measure up to 6 metres.

PROCEDURE FOR DIAGONAL SCALE

- Length of the scale =[2/6] X 6m = 9 cm.
- Draw a line AB 9 cm long and divide it into 6 equal parts. each part will show a metre.
- Divide the first part AO into 10 equal divisions, each showing decimetre or 0.1 m.
- At A erect a perpendicular and step off along it 10 equal divisions of any length , ending at D. complete the rectangle ABCD.
- Erect perpendiculars at metre divisions 0,1,2,3 and 4.

- Draw horizontal lines through the division points on AD.
- Join D with the end of the first division along AO, viz. the point 9.
- Through the remaining points I.e.8,7,6 etc. draw lines parallel to D9.
- In triangle OFE, FE represents 1 dm or 0.1m. Each horizontal line below FE progressively diminishes in length by 0.1FE. Thus , the next line below FE is equal to 0.9FE and represents 0.9 A 1dm = 0.9dmor 0.09m or 9 cm.
- Any length between 1 CM OR 0.01M and 6 m can be measured from this scale.

EXAMPLE-2 Construct a diagonal scale of R.F.1:4000 to show metres and long enough to measure up to 500 metres.

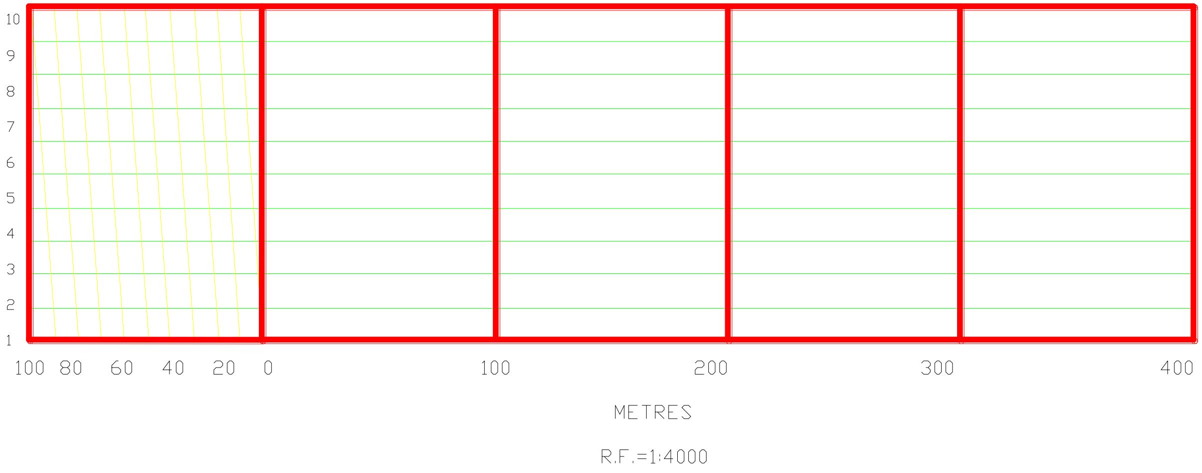
PROCEDURE

- Length of the scale =[1/4000] X 500m = 12.5 cm. Draw a line 12.5 cm long and divide it into 5 equal parts, each part will show 100 metre.

- Divide the first part into ten equal divisions, each divisions will show 10 metres.

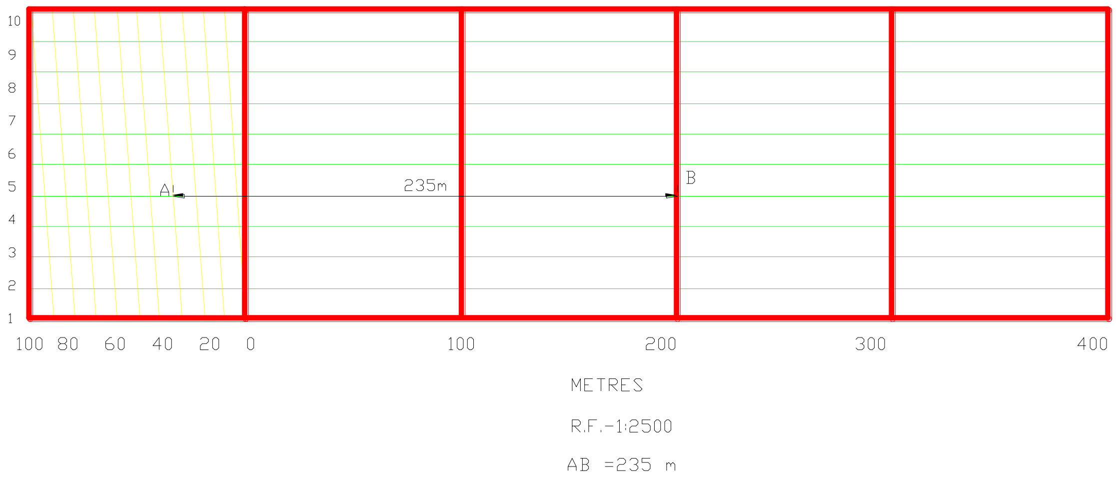
- At the left hand end, erect a perpendicular and on it, step off 10 equal divisions of any length. Draw the rectangle and complete the scale as explained earlier.

FINAL DRAWING



Example -3

The area of a field is 50,000 sq. m. the length and the breadth of the field, on the map is 10cm and 8 cm respectively . Construct a diagonal scale which can read up to one metre. Mark the length of 235 metre on the scale . What is the RF of the scale?



PROCEDURE

- Area of the field = 50,000 sq. m.
- Area of the field on the map = 10cm X 8cm = 80cm^2

1 sq. cm = 50000 / 80 = 625 sq. m.

Now RF =1 cm / 25 m =1 / 2500

Length of the scale = [1/ 2500] X [500 X 100] = 20 cm

Take 20 cm length and divide it into 5 equal parts. Complete the scale as explained earlier.

PROBLEMS FOR SHEET NUMBER :- 3

Q1. The distance between Vadodara and Surat is 130 km. A train covers this distance in 2.5 hours. Construct a plain scale to measure time up to a single minute. The R.F. of the scale is 1/260000. Find the distance covered by the train in 45 minutes.

Q2. On a building plan, a line 20 cm long represents a distance of 10m. Devise a diagonal scale for the plan to read up to 12 m, showing meters, decimeters and centimeters. Show on your scale the lengths 6.48m and 11.14m.

PROBLEMS FOR SHEET NUMBER :- 3

Q3. A room of 1728 m^3 volume is shown by a cube of 216 cm3 volume. Find R.F. and construct a plain scale to measure up to 42 m. Mark a distance of 22 m on the scale.

Q4. A car is running at a speed of 50 km/hr. Construct a diagonal scale to show 1 km by 3 cm and measure up to 6 km. Mark also on the scale the distance covered by the car in 5 minutes 28 seconds.

CURVES

Curves used in Engineering Practice:

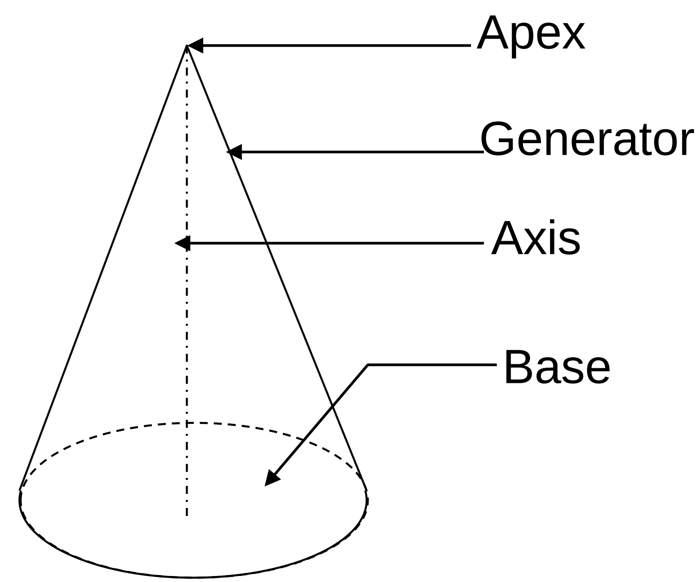
1. **Conic sections**
2. **Cycloidal curves**
3. **Involute**
4. Evolutes
5. Spirals
6. Helix

CONIC SECTIONS

The sections obtained by the intersection of a right circular cone by a cutting plane in different position relative to the axis of the cone are called **Conics** or **Conic sections**

The conic section can be defined by two ways:

1. By cutting a right circular cone with a sectional plane.
2. Mathematically, i.e., with respect to the loci of a point moving in a plane.



RIGHT CIRCULAR CONE

Definition of conic sections by cutting a right circular cone with a sectional plane.

Circle

When the cutting plane AA is perpendicular to the axis and cuts all the generators

Ellipse

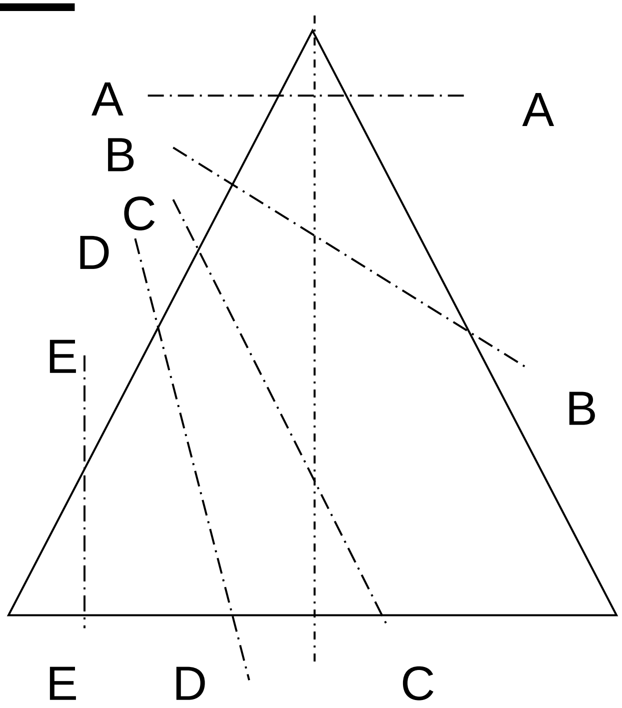
When the cutting plane BB is inclined to the axis of the cone and cut all the generators on one side of the apex

Parabola

When the cutting plane CC is inclined to the axis of the cone and parallel to one of the generator.

Hyperbola

When the cutting plane DD makes a smaller angle with the axis than that of the angle made by the generators of the cone.



AA GIVES CIRCLE

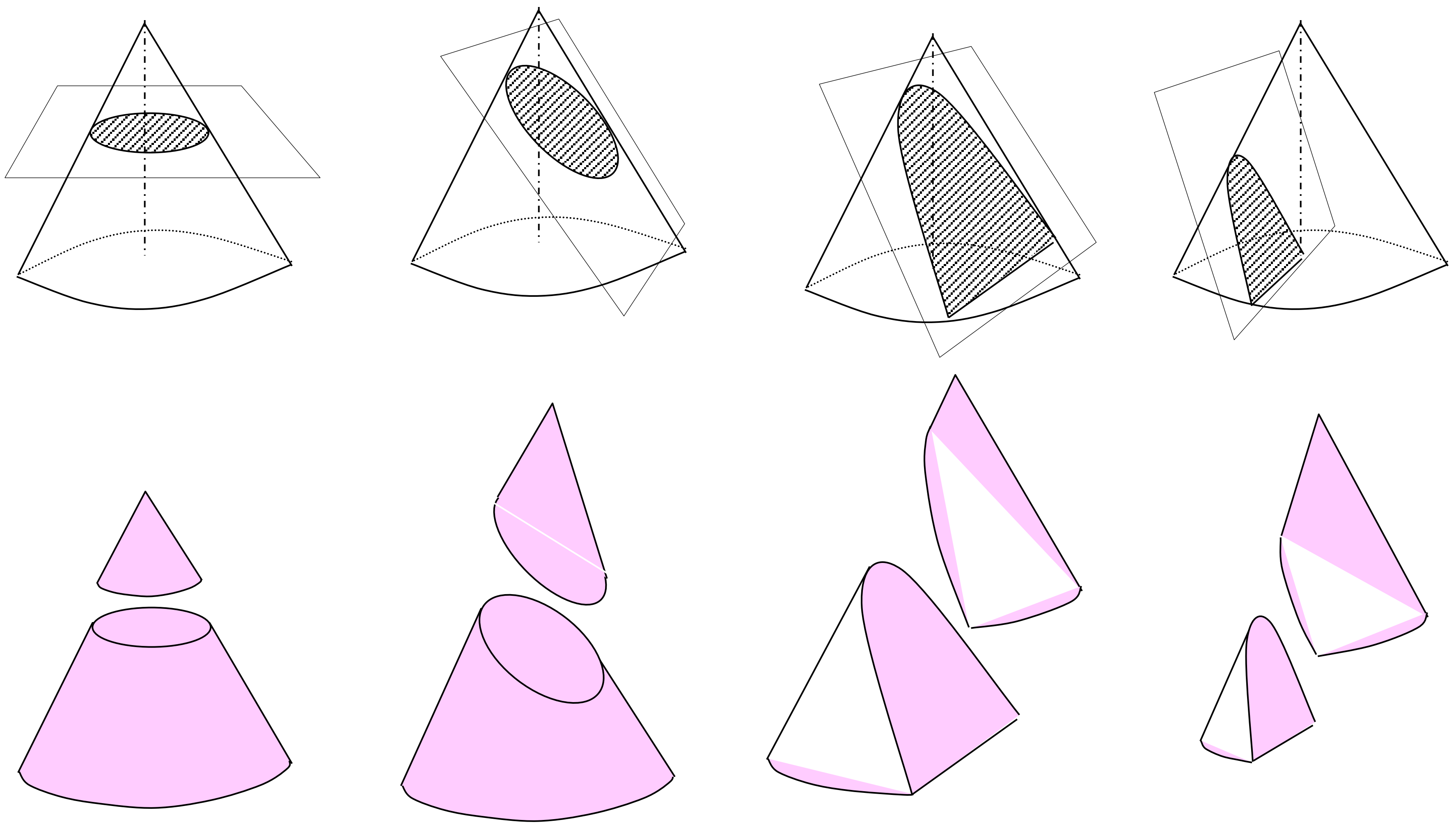
BB GIVES ELLIPSE

CC GIVES PARABOLA

DD GIVES HYPERBOLA

EE GIVES RECTANGULAR HYPERBOLA

CONIC SECTIONS



CIRCLE

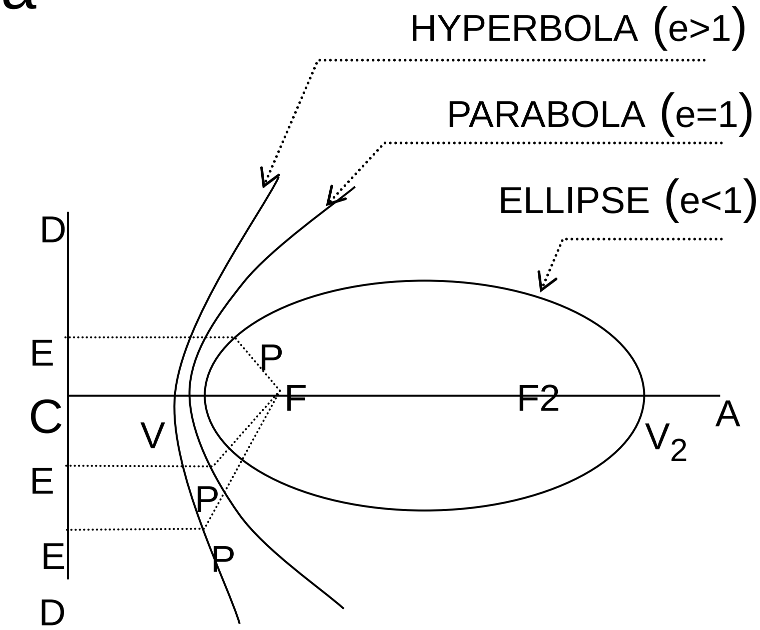
ELLIPSE

PARABOLA

HYPERBOLA

Definition of conic sections mathematically, i.e., with respect to the loci of a point moving in a plane.

Conic: It is defined as the locus of a point moving in a plane in such a way that the ratio of its distance from a fix point **(focus)** to a fixed straight line **(directrix),** is always constant. The ratio is called e**ccentricity.**



CA =AXIS
V = VERTEX
F = FOCUS
DD = DIRECTRIX

$$\frac{PF}{PE} = e = ECCENTRICITY$$

Ellipse

Eccentricity is always less than 1

Parabola

Eccentricity is always equal to 1

Hyperbola

Eccentricity is always greater than 1

ELLIPSE

Mathematically a ellipse can be described by an equation $(x^2/ a^2) + (y^2 / b^2) =1$; (where a & b are semi-major and semi-minor axis respectively)

Use of elliptical curves is made in

Arches

Bridges

Dams

Man-holes etc.

Method of Construction of Ellipse

1. General method (Eccentricity method)
2. Arc of circle method
3. Concentric circle method
4. Oblong method

NOTE: Use 1 method when e and CF is given
Use any method out of rest when major and minor axis are given

GENERAL METHOD (ECCENTRICITY METHOD)

Construct an ellipse when the distance of the focus from the directrix is equal to 50 mm and eccentricity is 2/3

- Draw any vertical line AB as directrix.
- At any point C in it, draw the axis.
- Mark a focus F on the axis such that CF=50 mm.
- Divide CF into 5 equal divisions
- Mark the vertex V on the third division- point from C.

(Thus e = VF/VC = 2/3)

CONT…

- A scale is now constructed on the axis which will directly give the distances in the required ratio.
- At V draw a perpendicular VE equal to VF. Draw a line joining C and E.
- Thus in triangle CVE, VE / VC = VF / VC = 2/3
- Mark any point 1 on the axis and through it, draw a perpendicular through 1 at points P_1 and P_1'
- Similarly, mark points 2, 3 etc. on the axis and obtain points P_2 and P_2', P_3 and P_3' etc.
- Draw a smooth curve through these points, which is ***ellipse***. It is a closed curve having two foci and two directrices.

<u>GENERAL METHOD (ECCENTRICITY METHOD)</u>

Construct an ellipse when the distance of the focus from the directrix is equal to 50 mm and eccentricity is 2/3

The sum of the distances of any point on the curve from the two foci is equal to the major axis.

Let AB – Major Axis; CD – Minor Axis

F_1 & F_2 – Foci

Points A,P,C etc. are on the ellipse curve.

According to the definition,

$$AF_1 + AF_2 = PF_1 + PF_2 = CF_1 + CF_2 \text{ etc.}$$

But $AF_1 + AF_2 = AB$, the major axis

Therefore, $PF_1 + PF_2 = AB$

The distance of the sum of the ends of the minor axis from the foci is equal to the major axis.

$$CF1 + CF2 = AB$$

But $CF_1 = CF_2$

Therefore, CF1 = CF2 = (1/2)AB

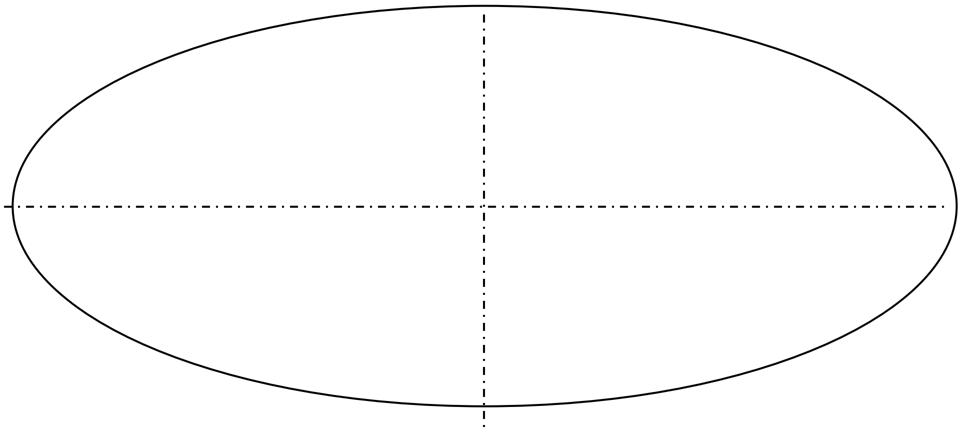
ARC OF CIRCLE METHOD

Construct an ellipse, given the major and minor axes.

- Draw a line AB equal to the major axis and a line CD equal to the minor axis, bisecting each other at right angles at O.
- With the centre C and radius equal to half AB,. Draw arcs cutting AB at F1 and F2, the foci of the ellipse.
- Mark a number of points 1, 2, 3 etc. on AB.
- With centers F1 and F2, and radius equal to A1, draw arcs on both sides of AB.

CONT…

- With same centres and radius equal to B1, Draw arcs intersecting the previous arcs at four points marked P1.
- Similarly with radii A2 and B2, A3 and B3 etc. obtain more points.
- Draw a smooth curve through these points. This curve is the required ellipse



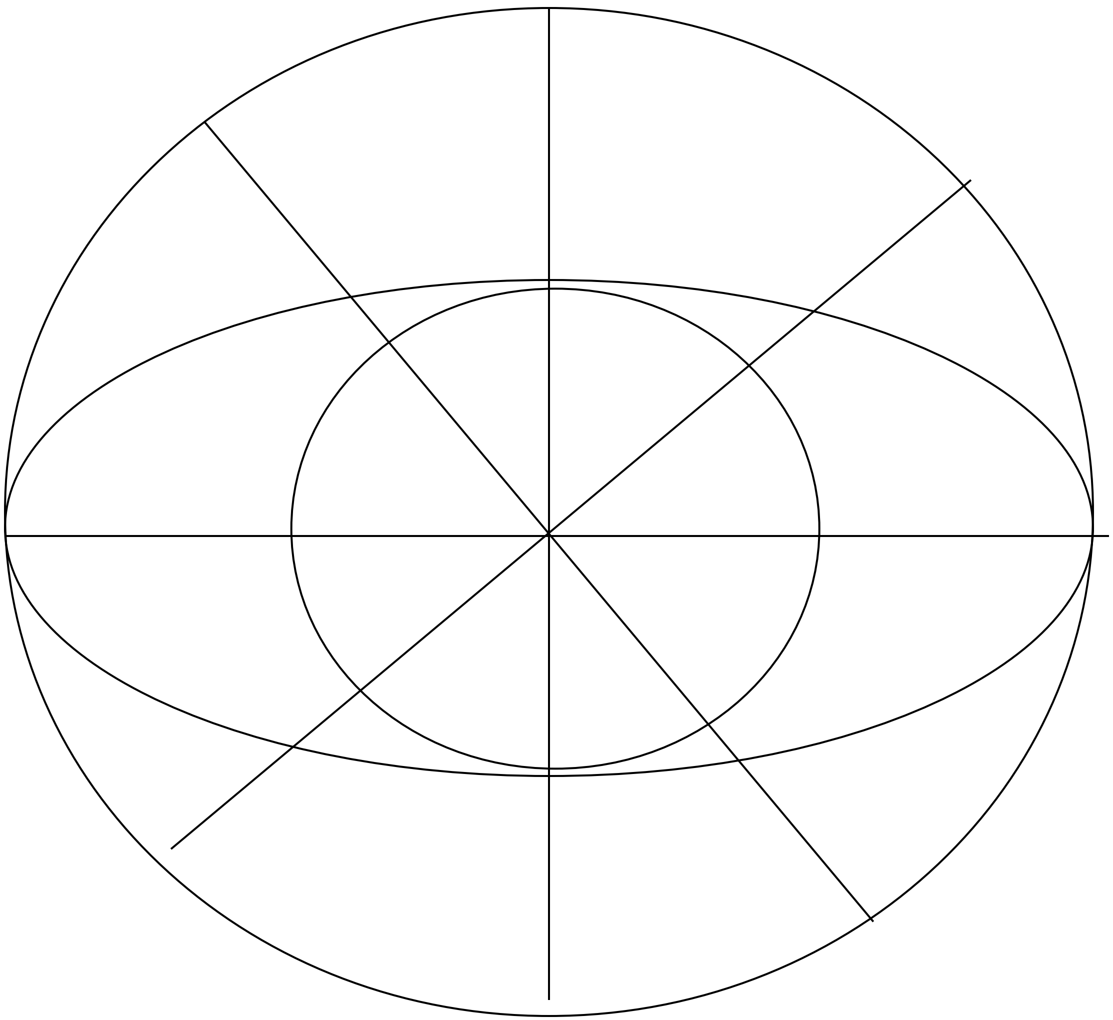
CONCENTRIC CIRCLE METHOD

Construct an ellipse, given the major and minor axes.

- Draw the major axis AB and the minor axis CD, intersecting at O.
- With centre O draw two circle with diameters AB and CD respectively.
- Divide major axis circle in equal no of parts, say 12 and mark points 1,2,3…
- Join each point (1,2,3…) with centre O, these lines cut minor axis circle, mark those point 1’,2’,3’…

CONT…

- Draw a line from point 1, parallel to CD
- Draw a line from point 1’, parallel to AB
- Both lines intersect at a point P1, is on the required ellipse
- Repeat the construction through all the points(2,3,4….) and (2’,3’,4’….)
- Draw a smooth curve joining P1, P2, P3… is required ellipse



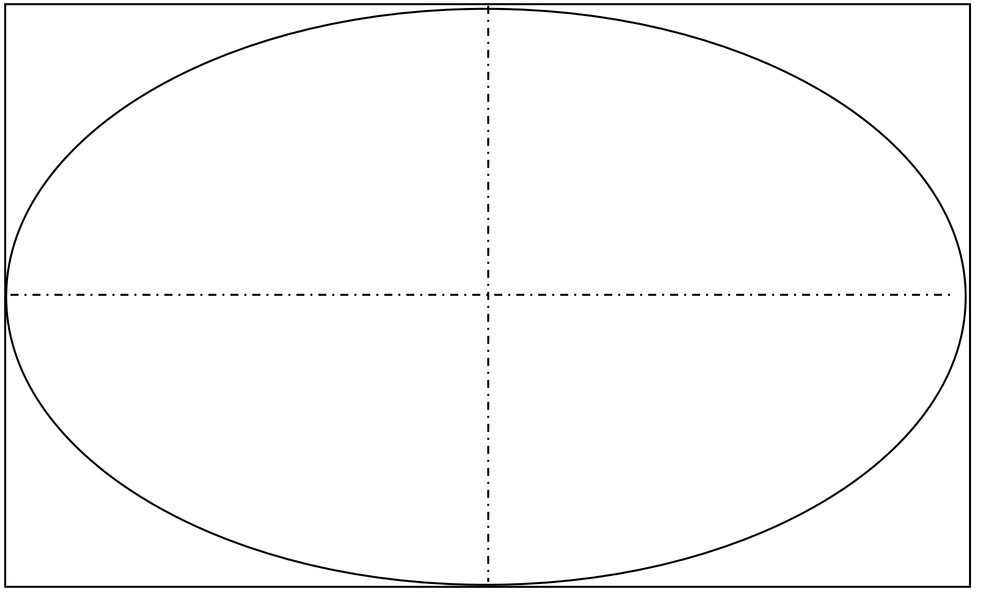
OBLONG METHOD

Construct an ellipse, given the major and minor axes.

- Draw the two axis AB and CD intersecting at O.
- Construct oblong EFGH having its side equal to the two axes
- Divide semi major axis AO in equal no of parts say 4 and AE into same no of equal parts, numbering them from A toward O as 1, 2 and 3. and toward E as 1’, 2’ and 3’
- Draw lines joining 1’, 2’, 3’ with C.

CONT…

- From D, draw lines through 1, 2 and 3 intersecting C1’, C2’, C3’ at points P1, P2, P3 respectively.
- Draw the curve through A, P1, P2…. C. It will be one quarter of the ellipse.
- As the curve is symmetrical about two axis, remaining points of ellipse may be located by drawing parallel lines from P1, P2, P3 with axes and taking equidistance from the axes.



Normal and Tangent to an Ellipse:

The normal to an ellipse at any point on it bisects the angle made by angles joining that point with the foci.

The tangent to the ellipse at any point is perpendicular to the normal at that point.

PARABOLA

Mathematically a parabola can be described by an equation $y^2 = 4ax$ or $x^2 = 4ay$

<u>Use of parabolic curves is made in</u>

Arches

Bridges

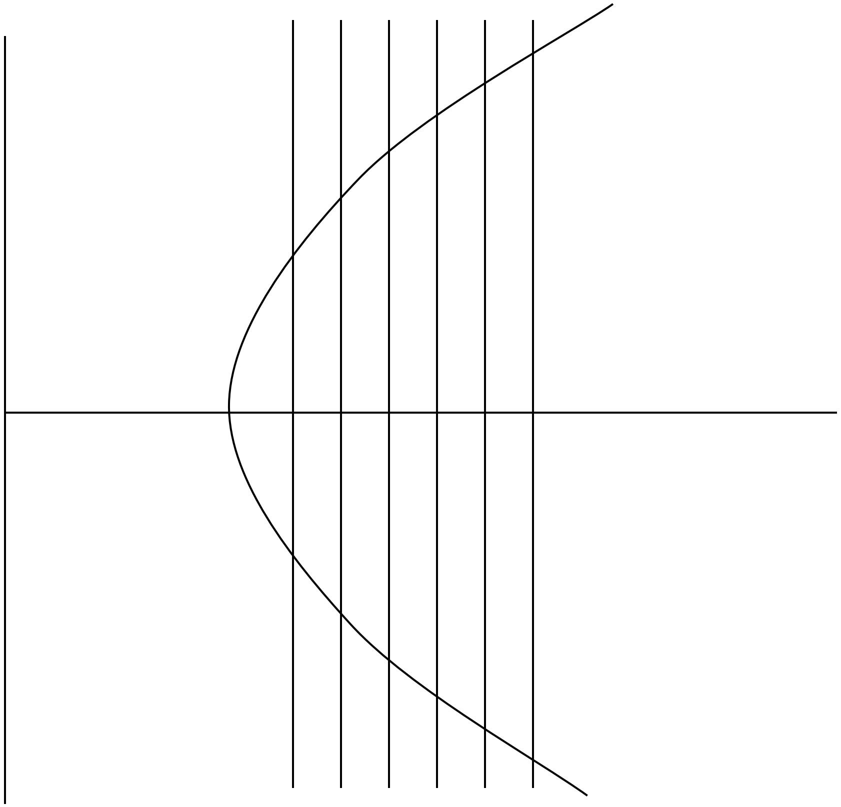
Sound reflectors

Light reflectors etc.

GENERAL METHOD

To construct a parabola, when the distance of the focus from the directrix is 50 mm

- Draw the directrix is AB and the axis CD
- Mark focus F on CD, 50 mm from C.
- Bisect CF in V the vertex (because eccentricity =1)
- Mark a number of points 1, 2, 3 etc. on the axis and through them, draw perpendicular to it.
- With center F and radius equal to C1, draw arc cutting the perpendicular through 1 at P1 and P1'
- Similarly locate points P2 and P2', P3 and P3' etc. on both side of the axis
- Draw a smooth curve through these points. This curve is the required parabola. It is a open curve



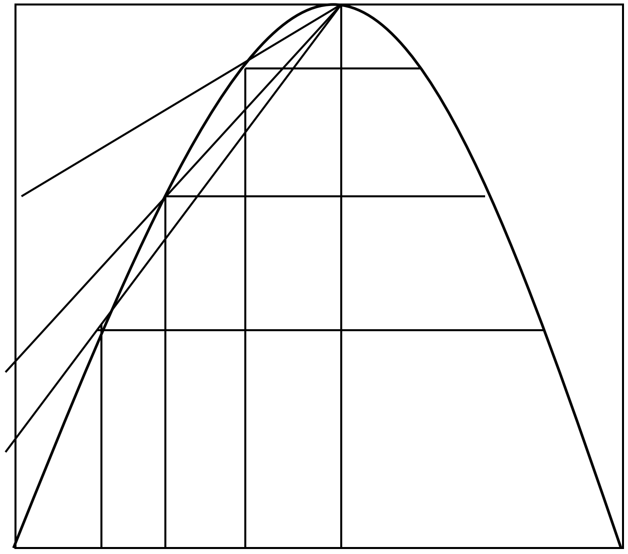
RECTANGLE METHOD

To construct a parabola given the base and the axis

- Draw the base AB.
- At its mid point E, draw the axis EF at right angles to AB
- Construct a rectangle ABCD, making side BC equal to EF.
- Divide AE and AD into the same number of equal parts and name them as shown (starting from A).

CONT…

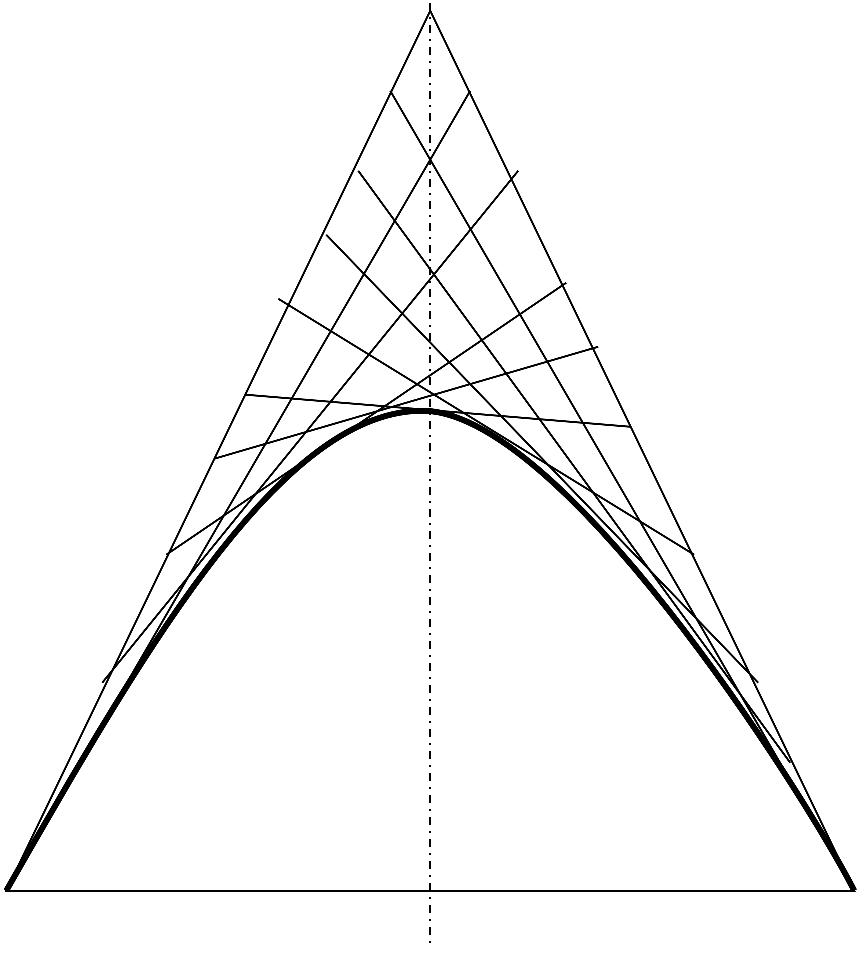
- Draw line joining F with points 1, 2 and3. Through 1’, 2’ and 3’, draw perpendiculars to AB intersecting F1, F2 and F3 at points P1, P2 and P3 respectively.
- Draw a curve through A, P1, P2 etc. it will be a half parabola.
- Repeat the same construction in the other half of the rectangle to complete the parabola by locating the points by drawing lines through the points P1, P2 etc. parallel to the base and making each of them of equal length on both the sides of EF.



TANGENT METHOD

To construct a parabola given the base and the axis

- Draw the base AB and the axis EF.
- Produce EF to O so that EF = FO.
- Join O with A and B. Divide lines OA and OB into the same number of equal parts, say 8.
- Mark the division point from A to O and O to B.
- Draw line joining 1 with 1’, 2 with 2’ etc. Draw a curve starting from A and tangent to lines 1-1’, 2-2’ etc. This curve is the required parabola.



Hyperbola

Mathematically hyperbola can be described by

$$\mathbf{X^2/a^2 - y^2/b^2 = 1}.$$

Application: The hyperbolic curves are used for design of water channels, cooling towers, radars etc.

General method of Construction of a Hyperbola

Problem

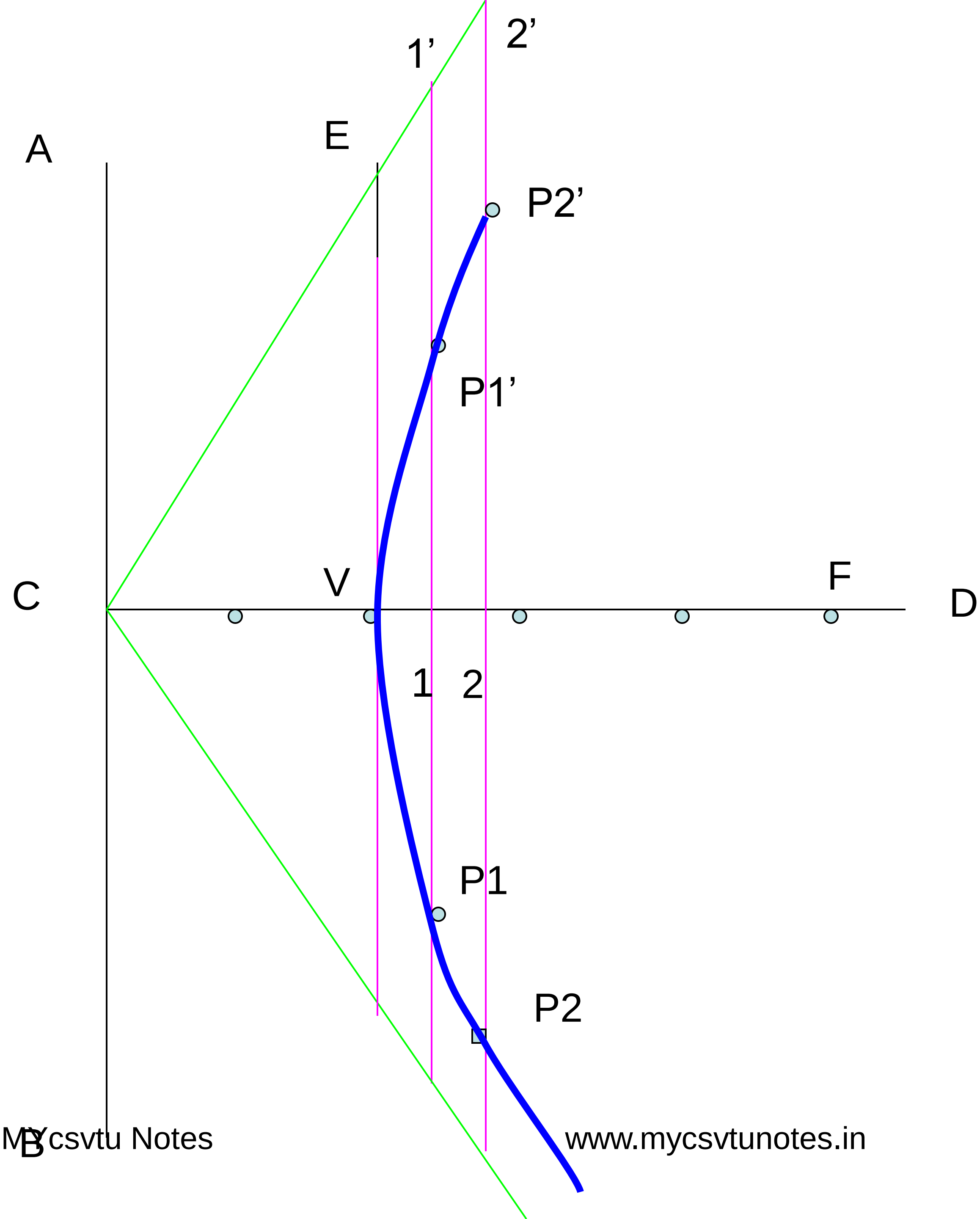
Construct a hyperbola, when the distance of the focus from the directrix is 65 mm and eccentricity is *3/2.*

Method of Construction

- Draw the directrix AB and the axis CD
- Mark the focus F on CD and 65 mm from C.
- Divide CF into 5 equal divisions and mark V the vertex, on the second division from C.
- Thus eccentricity is VF/VC=3/2.
- To construct the scale for the ratio 3/2 draw a line VE perpendicular to CD such that VE = VF. Join C with E.
- Thus, in triangle CVE, VE/VC = VF/VC = 3/2.

Cont…

- Mark any point 1 on the axis and through
- it ,draw a perpendicular to meet CE produced at 1'.
- With centre F and radius equal to 1-1', draw arcs intersecting the perpendicular through 1 at P_1 and P_1'.
- Similarly, mark a number of points 2,3 etc. and obtain points P_2 and P_2', P_3 and P_3' etc.
- Draw the hyperbola through these points.


2'
1'
E
A
P2'
P1'
C
V
F
D
1
2
P1
P2
B

Rectangular Hyperbola

Definition : It is a curve traced out by a point moving in such a way that the product of its distances from two fixed lines at the right angle to each other is a constant. The fixed lines are called asymptotes. This line graphically represents the Boyle's law, P*V = C, a constant.

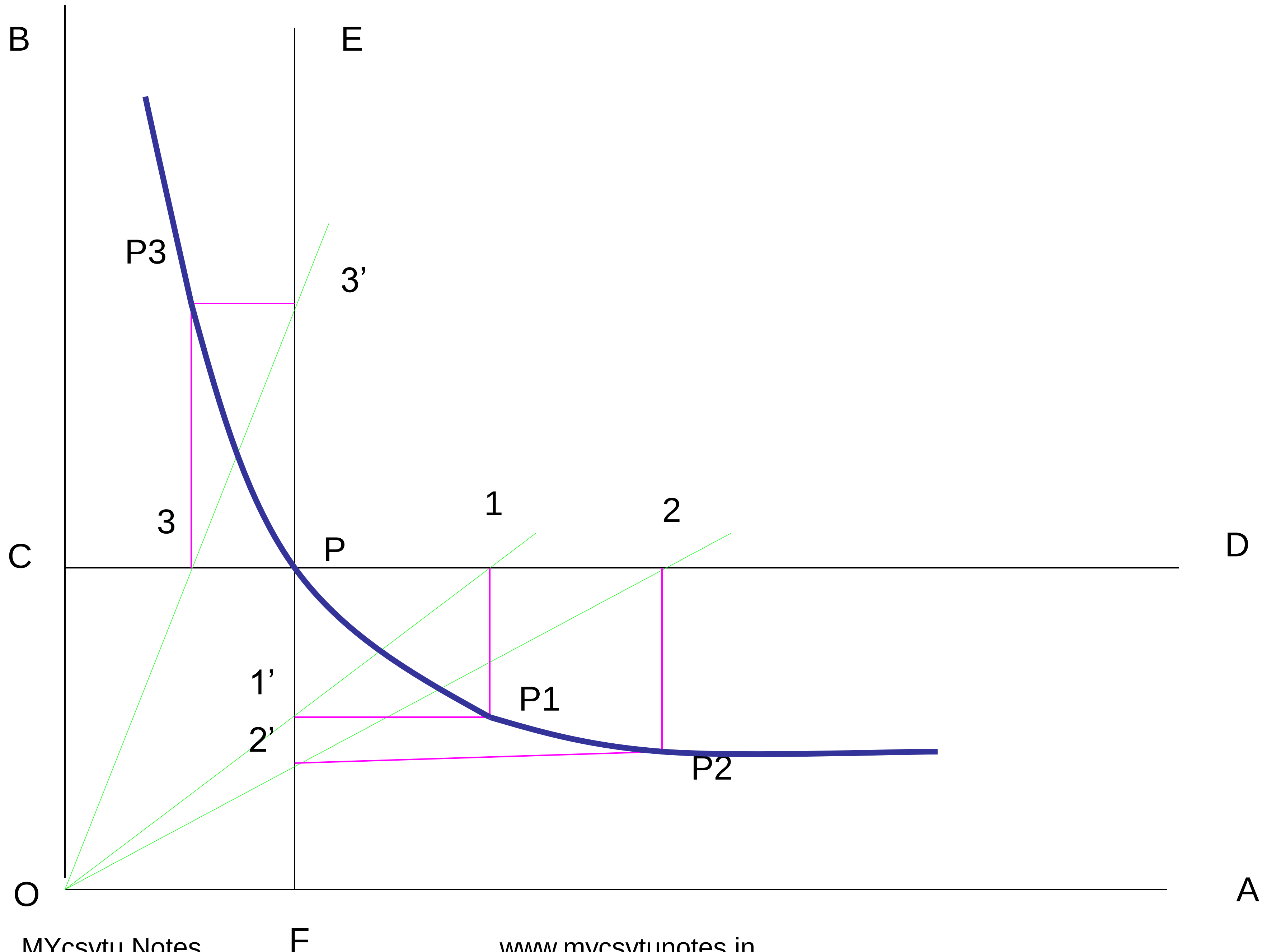
Problem : To draw a rectangular hyperbola, given the position of a point P on it, say 30 mm from vertical line and 40 mm from horizontal line.

Method of Construction

- Draw lines OA and OB at right angles to each other.
- Mark the position of the point P.
- Through P draw lines CD and EF parallel to OA and OB respectively.
- Along PD, mark a number of points 1,2,3..etc. not necessarily equidistant.
- Draw lines O1,O2 … etc. cutting PF at points 1’,2’ ..etc.

Cont.…

- Through point 1, draw a line parallel to OB and through 1', draw a line parallel to OA, intersecting each other at a point P_1.
- Obtain other points in the same manner.
- For locating the point , say $P_{3,}$, to the left of P, the line O3 should be extended to meet PE at 3'. Draw the hyperbola through the points P_3, P,P_1…etc.
- A hyperbola, through a given point situated between two lines making any angle between them, can similarly be drawn.


B
E
P3
3'
3
1
2
C
P
D
1'
P1
2'
P2
O
A
F

Cycloid

- **Definition**: Cycloid is a curve generated by a point on the circumference of a circle which rolls along a straight line. It can be described by an equation, $y = a(1 - \cos\theta)$ or $x = a(\theta - \sin\theta)$.
- **Problem** : To construct a cycloid, given the diameter of the generating circle, say 50 mm.

Method of Construction

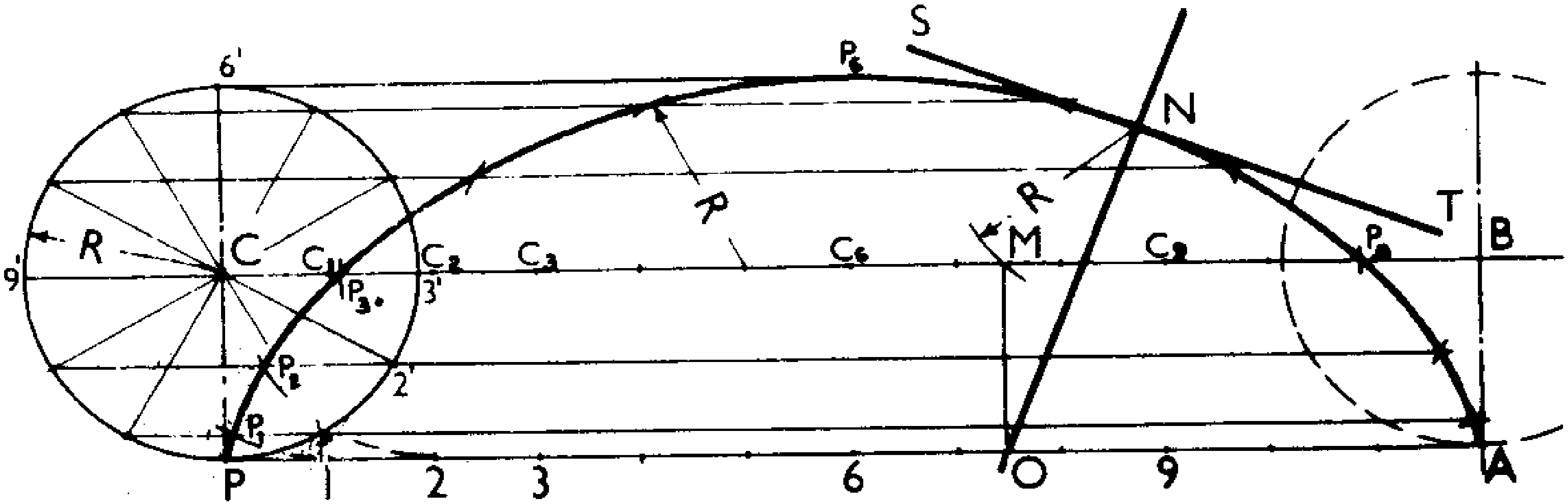
- With centre C and given radius R, draw a circle. Let P be the generating point.
- Draw a line PA tangential to and equal to the circumference of the circle.
- Divide the circle and the line PA into the same number of equal parts, say 12, and mark the division points as shown.
- Through C, draw a line CB parallel and equal to PA.
- Draw perpendiculars at points 1,2,….etc. cutting CB at points C_1, C_2..etc.

Cont….

- Assume that the circle starts rolling to the right. When point 1' coincides with 1, centre C will move to C_1. In this position of the circle, the generating point P will have moved to the position P_1 on the circle, at a distance equal to P_1' from point 1. It is evident that P_1 lies on the horizontal line through 1' and at a distance R from C_1.
- Similarly, P_2 will lie on the horizontal line through 2' and at the distance R from C_2.

Cont…..

- Through the points 1’, 2’..etc. draw the lines parallel to PA.
- With centers C_1, C_2..etc. and radius equal to R, draw arcs cutting the lines through 1’,2’…etc. at points P_1,P_2..etc.respectively.
- Draw the smooth curve through points P, P_1, P_2,…..A. This curve is the required cycloid.



Cycloid

Normal and Tangent to a Cycloid curve

- The rule for drawing a normal to all cycloidal curves :
- The normal at any point on a cycloidal curve will pass through the corresponding point of contact between the generating circle and the directing line or circle.
- The tangent at any point on a cycloidal curve is perpendicular to the normal at that point.

Method of Construction

- To draw a normal and a tangent to a cycloid at a given point N on it.
- With centre N and radius equal to R, draw an arc cutting CB at M.
- Through M, draw a line MO perpendicular to the directing line PA and cutting it at O. O is the point of contact and M is the position of the centre of the generating circle, when the generating point P is at N.
- Draw a line through N and O. This line is the required normal.
- Through N, draw a line ST at right angles to NO. ST is the tangent to the cycloid.

Epicycloid and Hypocycloid

- The curve generated by a point on the circumference of a circle, which rolls without slipping along another circle outside it, is called an epicycloid.
- The epicycloid can be represented mathematically by
- $x = (a + b) \cos\theta - a \cos\theta\{ [(a + b)/a] \theta\}$,
- $y = (a + b) \sin\theta - a \sin \theta\{ [(a + b)/a] \theta\}$ where *a* is the radius of the rolling circle.
- When the circle rolls along another circle inside it, the curve is called hypocycloid. It can be represented mathematically $x = a \cos^3 \theta$, or $y = a \sin^3 \theta$.

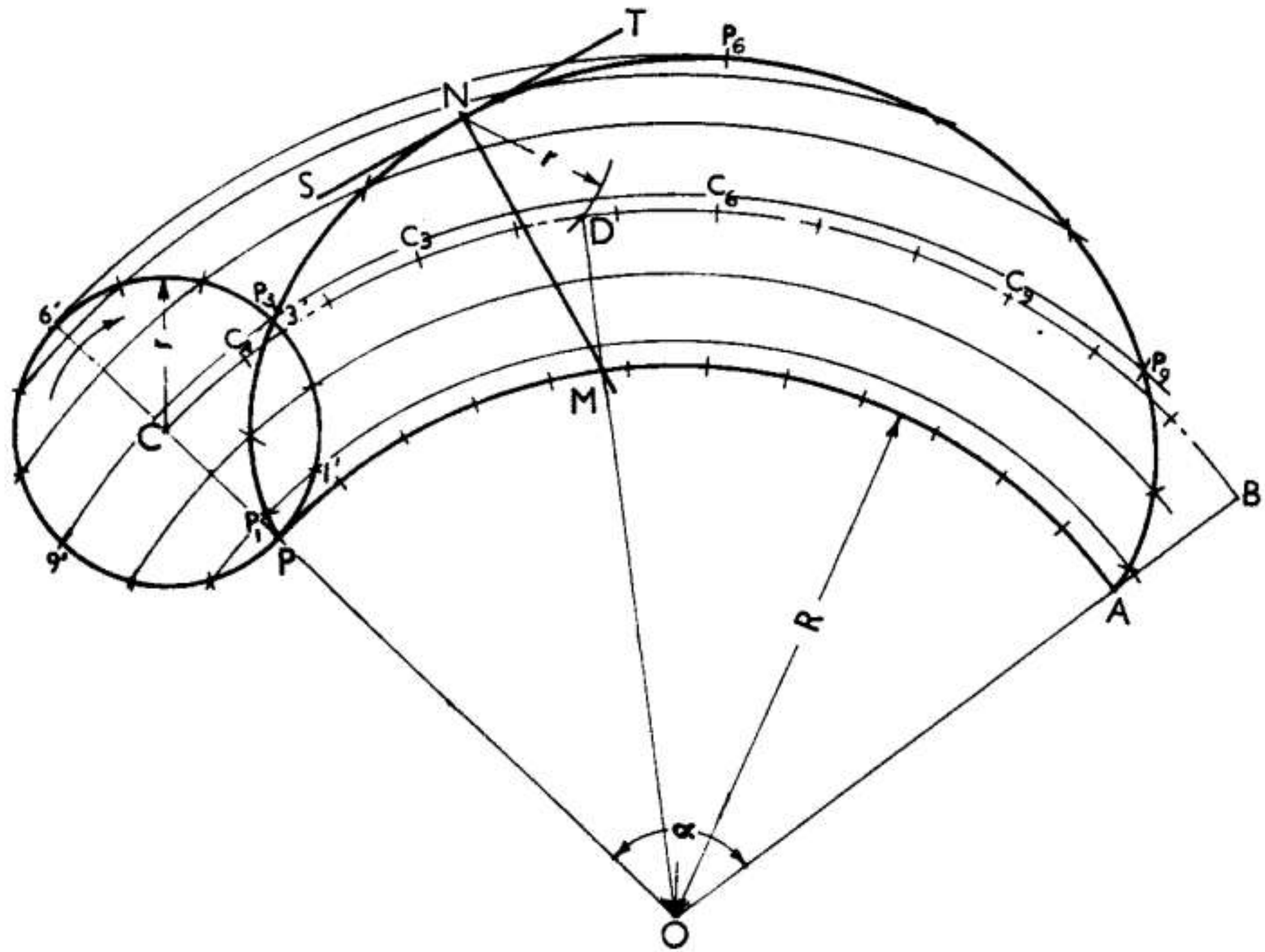
Method of drawing Epicycloid

- **Problem** : To draw an epicycloid and a hypocycloid, given the generating and directing circles of radii r = 25 mm and R = 87.5 mm respectively.

- **Method** : With centre O and radius R, draw the directing circle (only a part of it may be drawn).
- Draw a radius OP and produce it to C, so that CP = r.
- With C as centre draw the generating circle. Let P be the generating point.
- In one revolution of the generating circle, the point P will move to a point A, so that the arc PA is equal to the circumference of the generating circle.

Cont…..

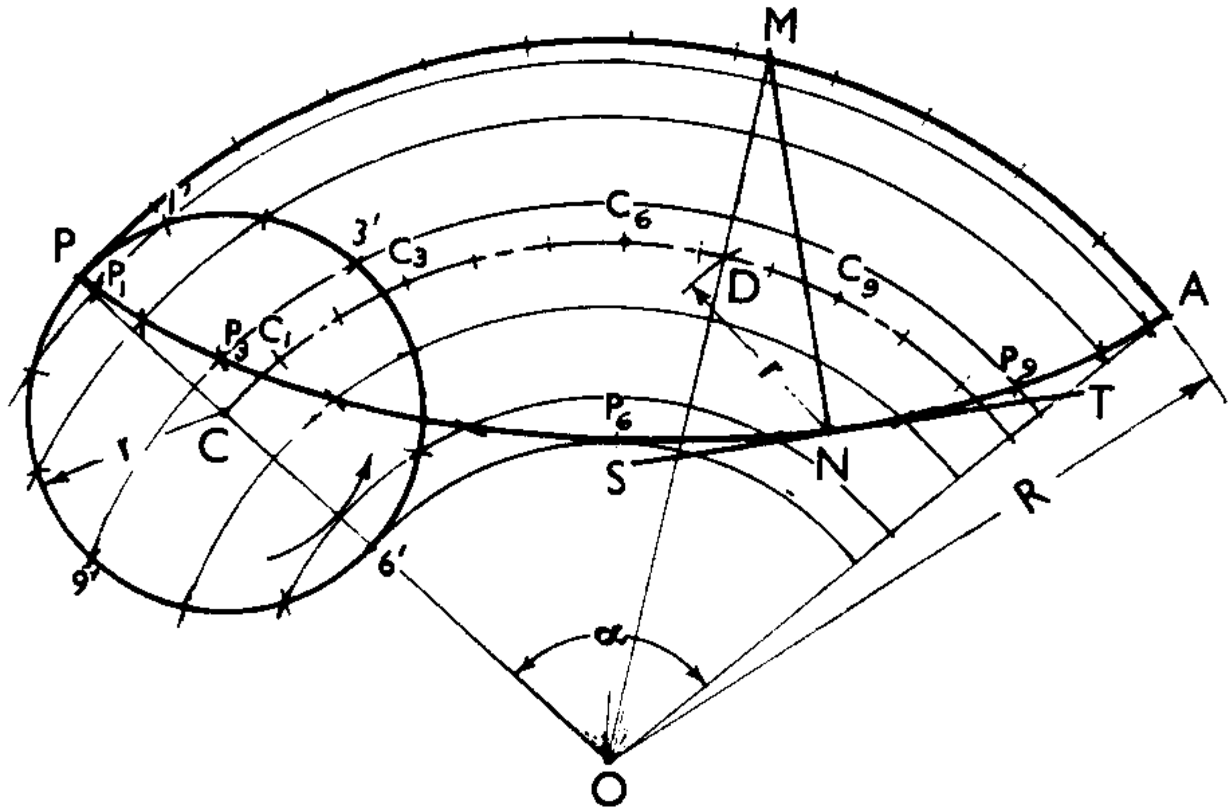
- The position of A may be located by calculating the angle subtended by the arc PA at the centre O, by formula,
- (<POA/360 °) = (arc PA/circumference of directing circle) =(2 π r / 2 π R) = r/R, <POA = 360°* r/R.
- Set off this angle and obtain the position of A.
- With centre O and radius equal to OC, draw an arc intersecting OA produced at B. This arc CB is the locus of the centre C.
- Divide CB and generating circle into twelve equal parts.
- With centre O, describe arcs through points 1’,2’ 3’…….etc.
- With centers C_1, C_2,C_3 etc. and radius equal to r, draw arcs cutting the arcs through 1’,2’, 3’, etc. at the points P_1, P_2, P_3,……etc.
- Draw the required epicycloid through the points P, P_1,P_2, P_3,…..A.



Epicycloid

Hypocycloid

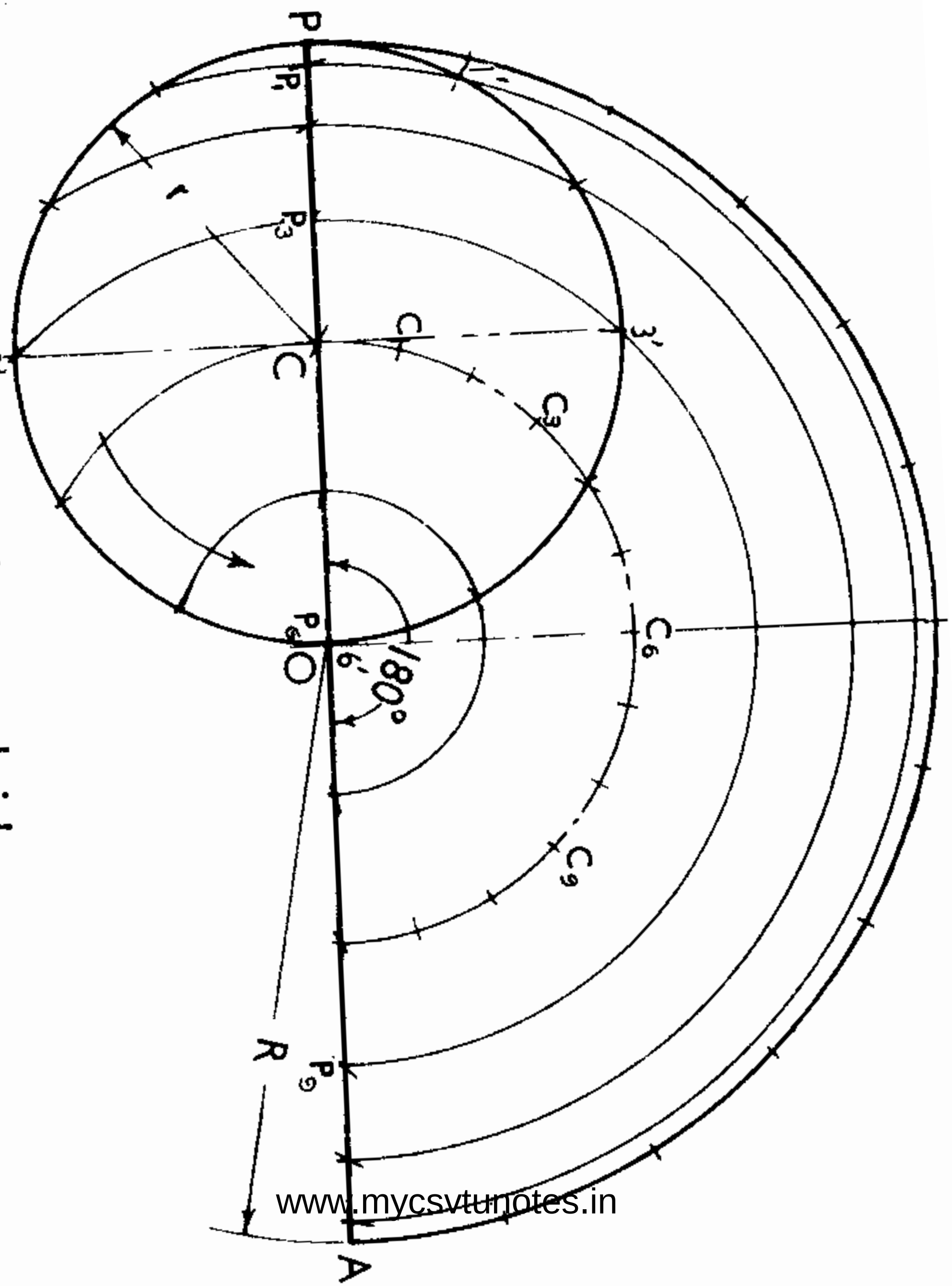
- The method for drawing hypocycloid is same as that of epicycloid. Note that the centre C of the generating circle is inside the directing circle.



Hypocycloid

Hypocycloid - When radius of generating circle is half the directing circle

- When the diameter of the rolling circle is half the diameter of the directing circle, the hypocycloid is a straight line and is a diameter of the directing circle



Hypocycloid

Normal and Tangent to an Epicycloid and a Hypocycloid

- **Problem** : To draw normal and tangent to an epicycloid and a hypocycloid at any point N in each of them.
- With centre N and radius equal to r, draw an arc cutting the locus of the centre C at a point D.
- Draw a line through O and D, cutting the directing circle at M.
- Draw a line through N and M. This is the required normal. Draw a line ST through N and at right angle to NM. ST is the required tangent.

Involute

- Then involute is a curve traced out by an end of a piece of thread unwound from circle or polygon, the thread being kept tight.
- It may also be defined as a curve traced out by a point in a straight line which rolls without slipping along a circle or polygon.
- Involute of a circle is used as a teeth profile of gear wheel.
- Mathematically it can be described by $x = r \cos \theta + r \theta \sin \theta$, $y = r \sin \theta + r \theta \cos \theta$, where "r" is the radius of a circle.

Involute of a Circle

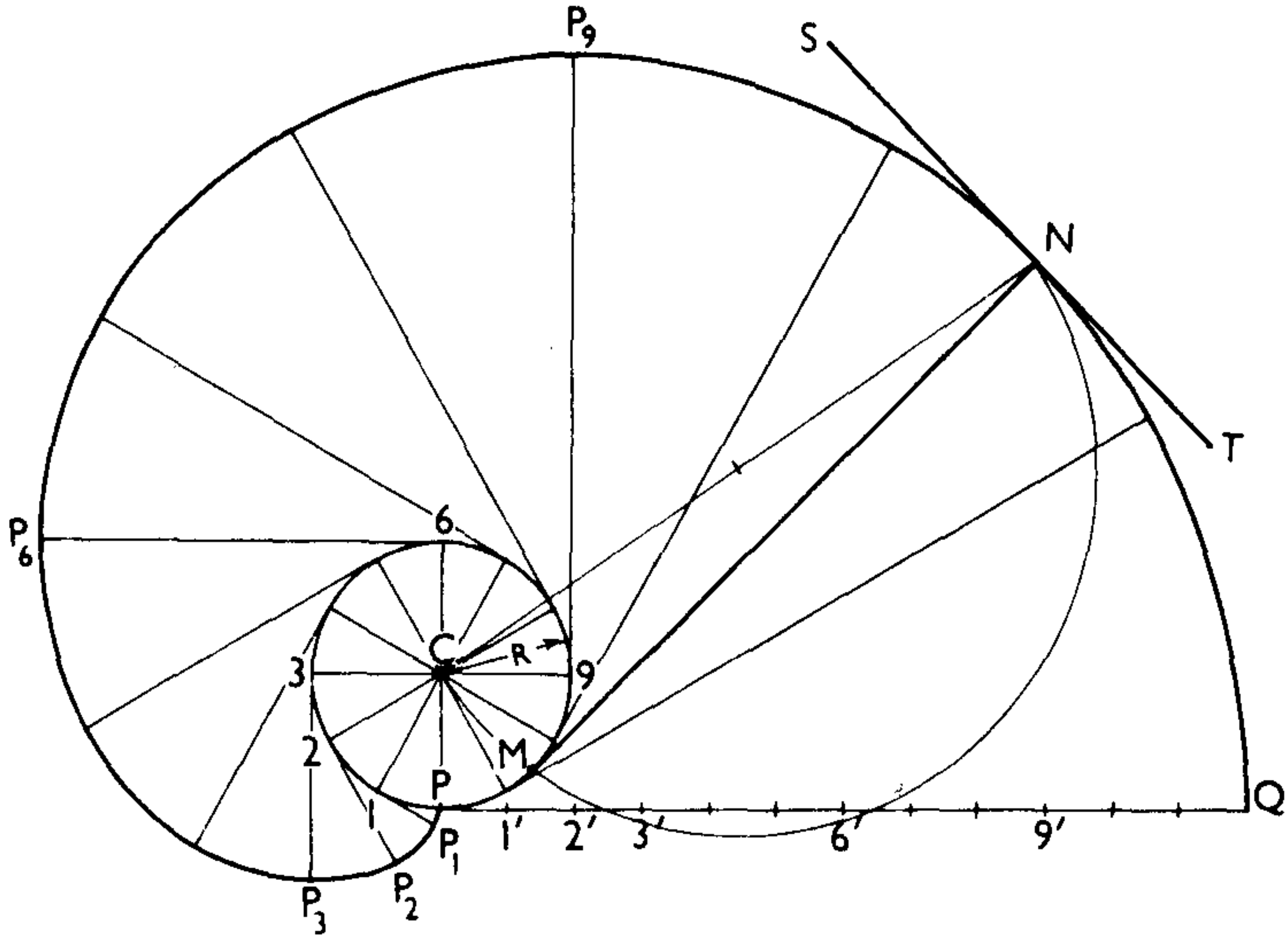
- **Problem** : To draw involute of given circle of radius 25 mm.
- With centre C, draw the given circle. Let P be the starting point, i.e. the end of the thread.
- Suppose the thread to be partly un wound, say upto point 1. P will move to position P_1 such that $1P_1$ is tangent to the circle and is equal to the arc 1P. P_1 will be a point on involute.

Method of Construction

- Draw a line PQ, tangent to the circle and equal to the circumference of the circle.
- Divide PQ and the circle into 12 equal parts.
- Draw tangents at points 1,2,3,……etc. and mark on them points P_1, P_2, P_3, ……etc. such that $1P_1$ = P1’,$2P_2$ = P2’, $3P_3$ =P3’…etc.
- Draw the involute through the points P,P_1, P_2, P_3,….etc.

Normal and Tangent to the Involute

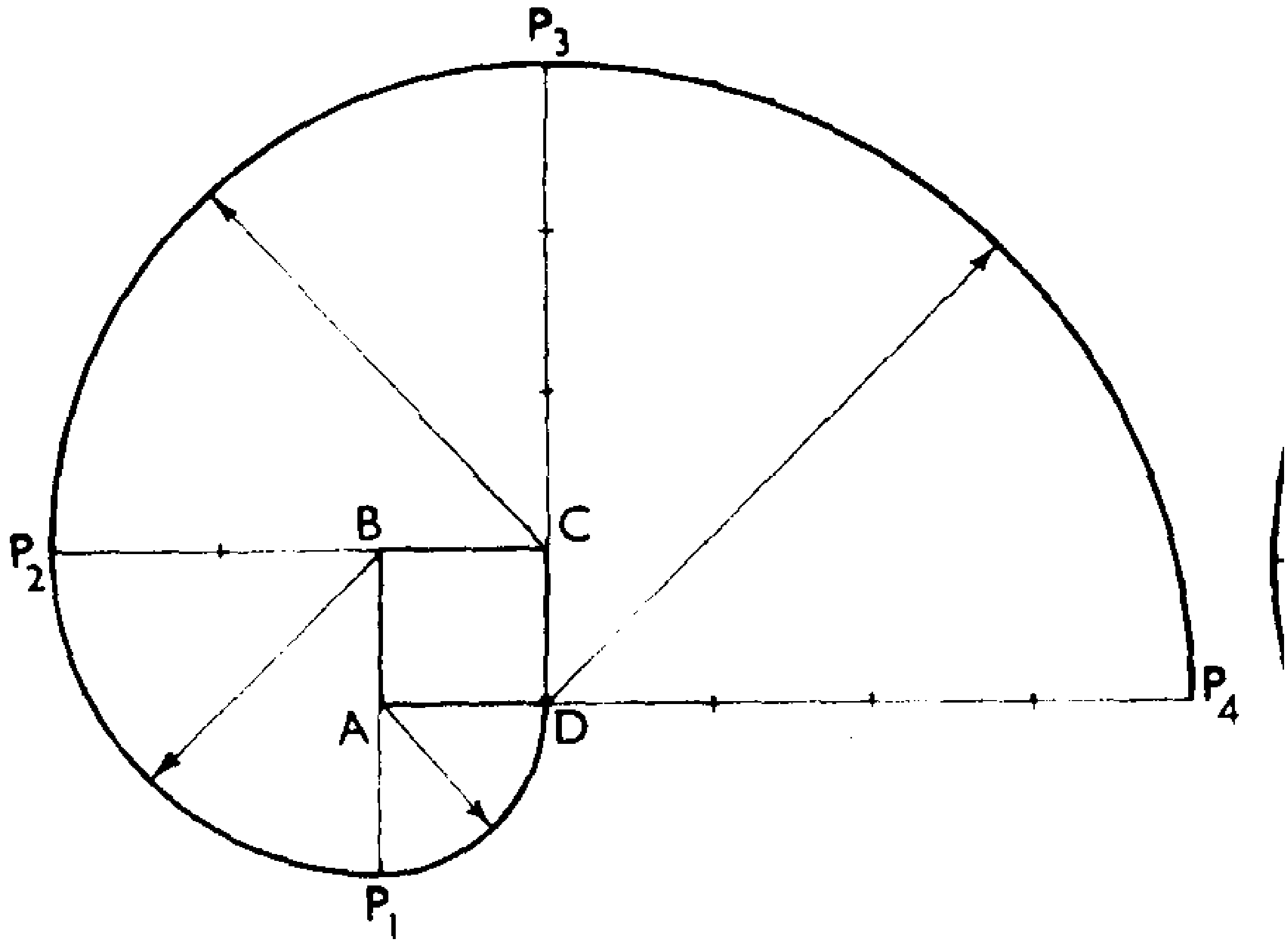
- **Problem** : To draw normal and tangent to the involute of a circle at a point N on it.
- Draw a line joining centre C with N.
- With CN as the diameter draw a semicircle cutting the circle at M.
- Draw a line through M and N. This line is the required normal. Draw a line ST, perpendicular to NM and passing through N. ST is the required tangent to the involute.



Involute

Involute to a given Square

- Let ABCD be the given square of side 25 mm.
- With centre A and radius AD, draw an arc to cut the line BA – produced at a point P_1.
- With centre B and radius BP_1 (i.e. BA+AD) draw an arc to cut the line CB – produced at a point P_2.Similarly with centers C and D and radii CP_2 (i.e. CB+BA+AD) and DP_3 (i.e. CB+BA+AD+DC = perimeter) respectively, draw arcs to cut DC – produced at a point P_3 and AD – produced at point P_4.
- The curve thus obtained is the involute of the square.



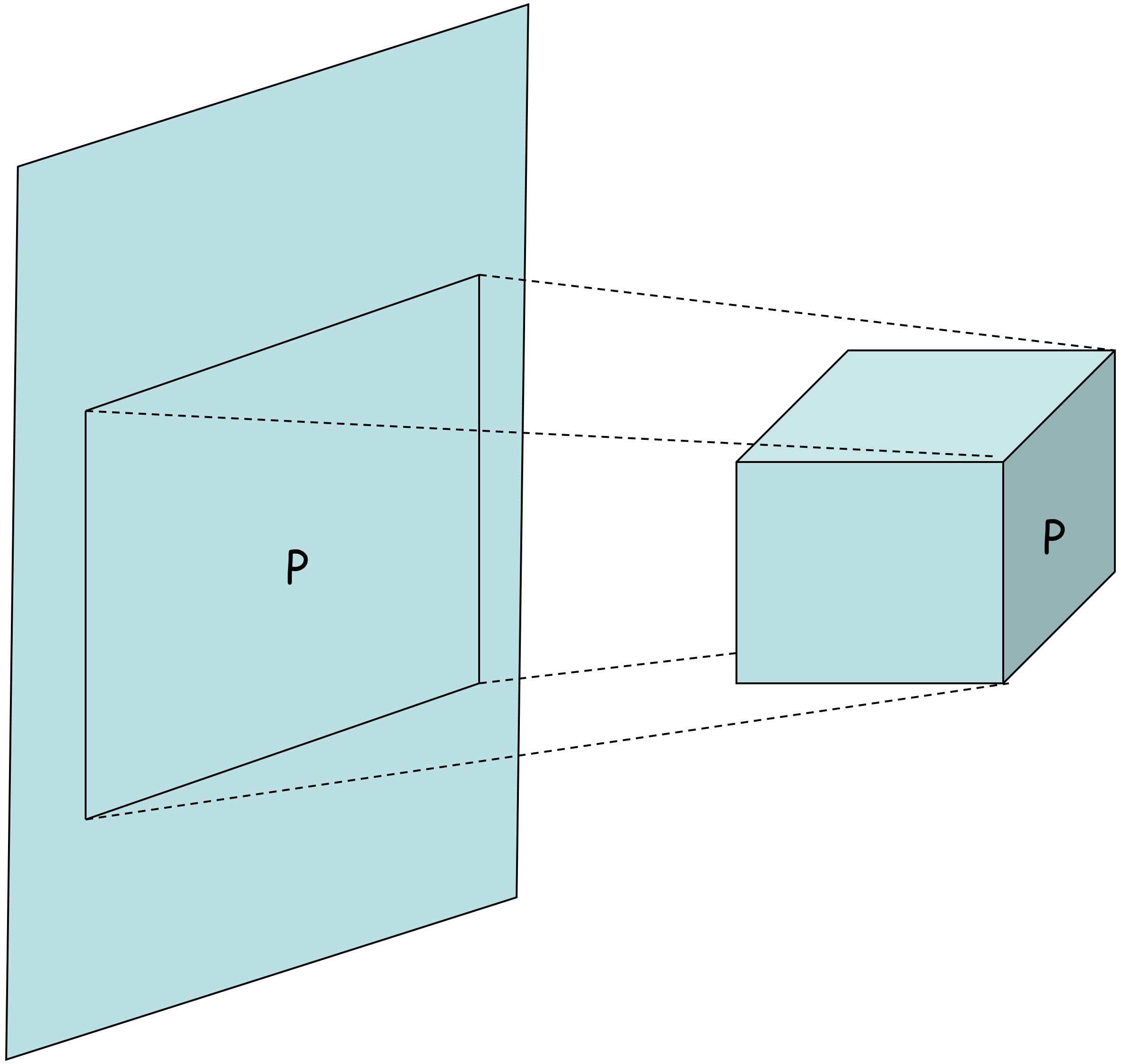
Involute to a square

ORTHOGRAPHIC PROJECTION

UNIT -II

PROJECTION

- If straight lines are drawn from various points on the contour of an object to meet a plane, the object is said to be projected on that plane. The figure formed by joining, in correct sequence, the points at which these lines meet the plane, is called ***the projection of the object***.
- The lines from the object to the plane are called ***projectors.***



Projection

Methods of Projection

1. Orthographic Projection
2. Isometric Projection
3. Oblique Projection
4. Perspective Projection

In the methods 2,3 & 4 represent the object by a pictorial view as eyes see it.

In these methods of projection a three dimensional object is represented on a projection plane by one view only.

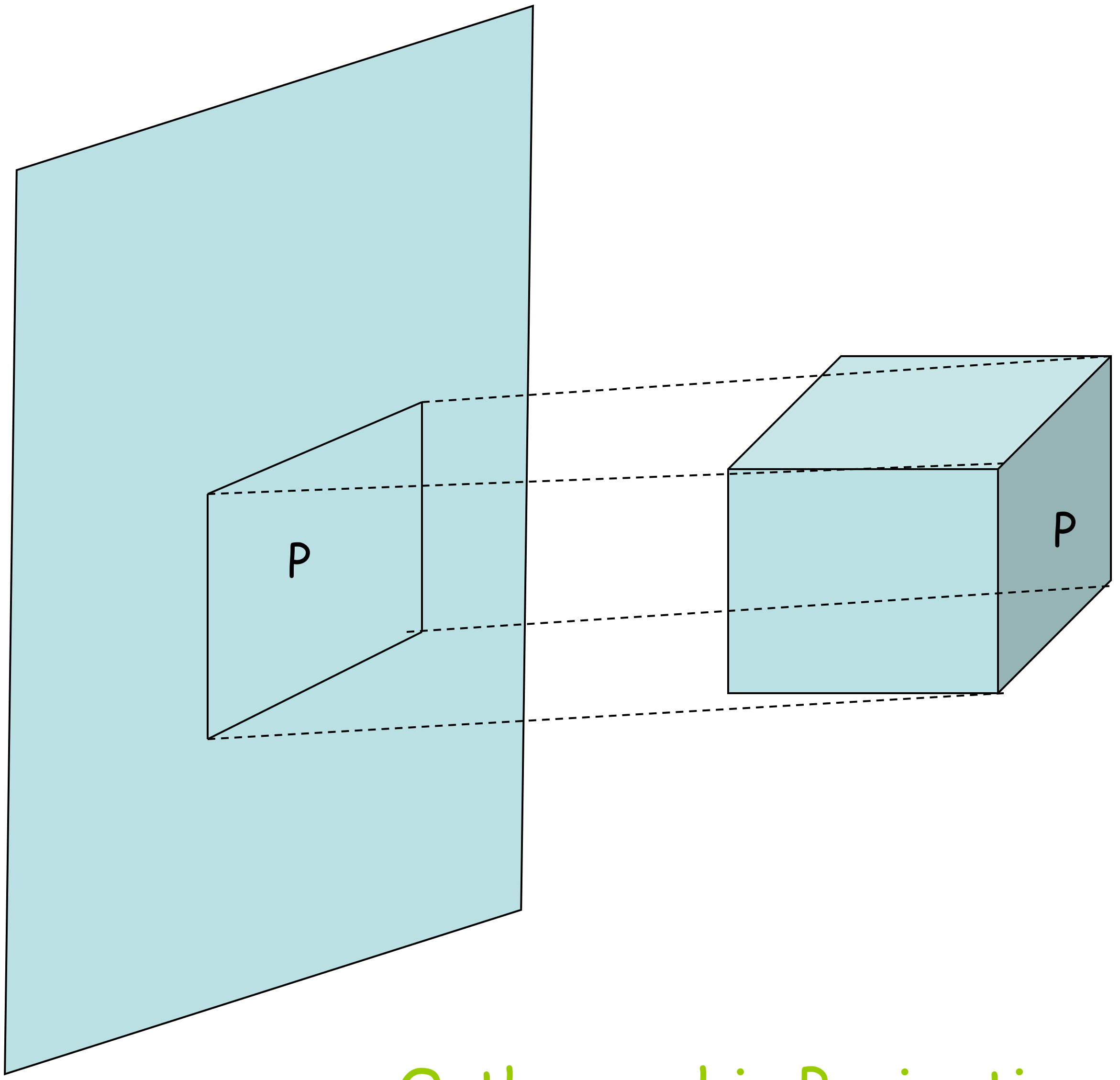
While in the orthographic projection an object is represented by two or three views on the mutual perpendicular projection planes.

Each projection view represents two dimensions of an object.

For the complete description of the three dimensional object at least two or three views are required.

ORTHOGRAPHIC PROJECTION

When the projectors are parallel to each other and also perpendicular to the plane, the projection is called ***orthographic projection.***

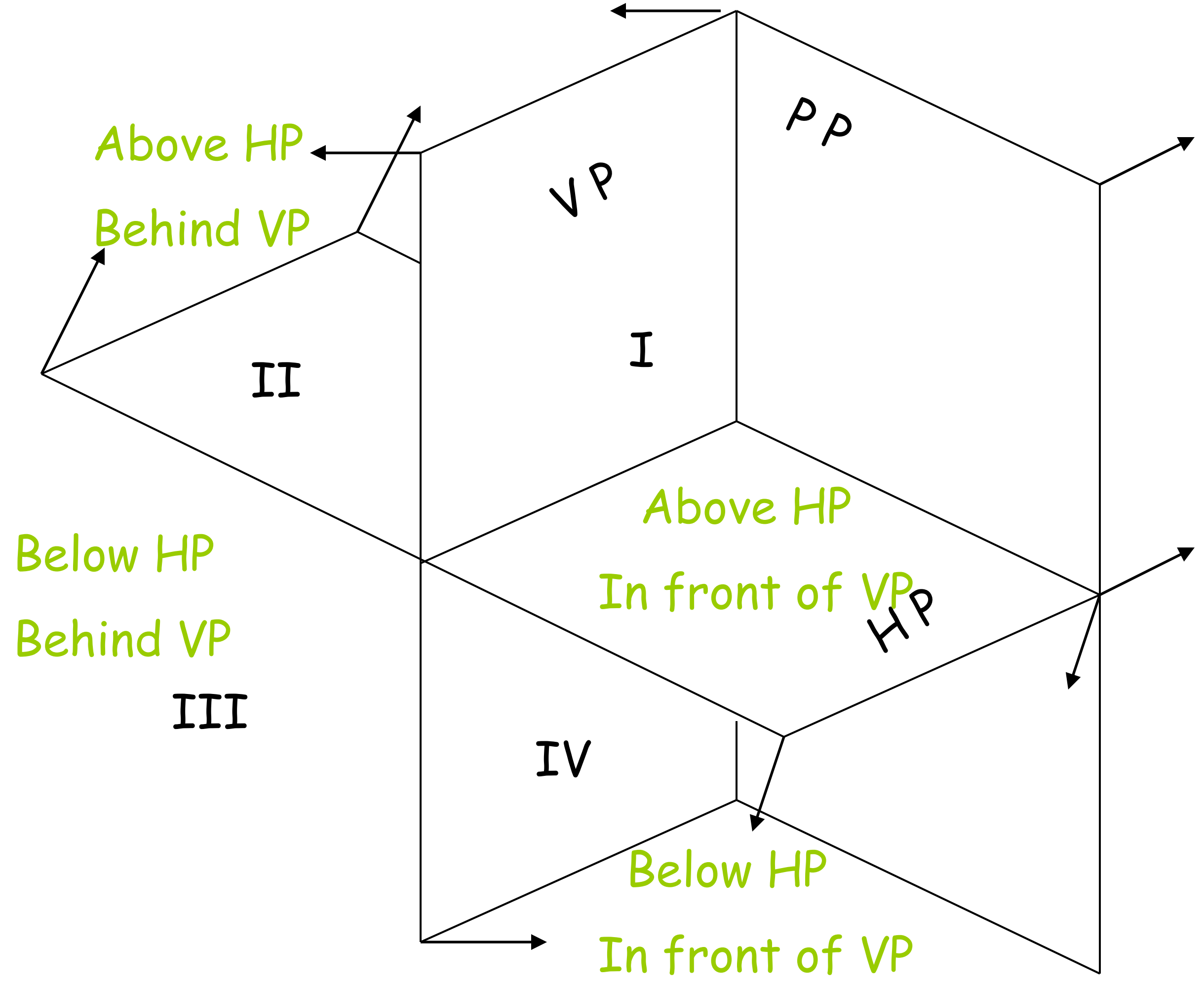


Orthographic Projection

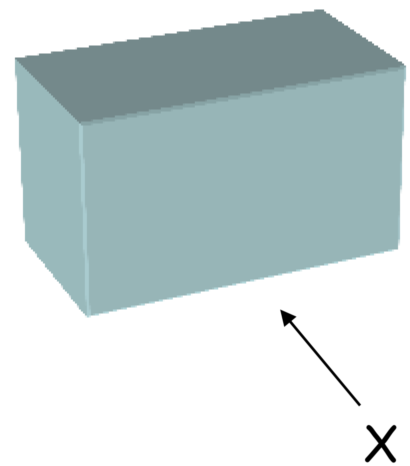
METHODS OF ORTHOGRAPHIC PROJECTION

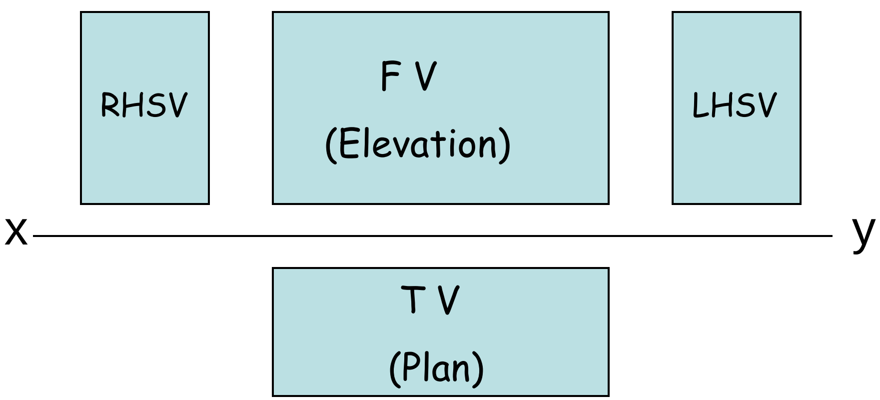
1) First-angle Projection Method (FAPM)
2) Third-angle Projection Method (TAPM)

FOUR QUADRANTS

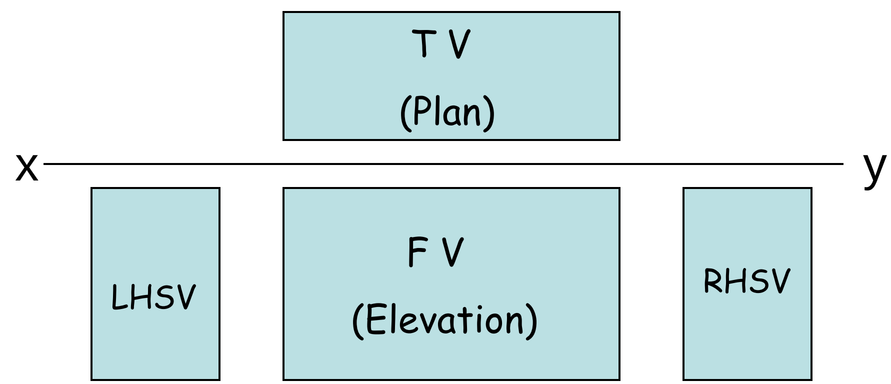


1st and 3rd quadrant always open outside.





First-angle projection



Third-angle projection

DIFF. BETWEEN FAPM & TAPM

In First-angle projection method,

Object in first quadrant

Sequence : Observer-Object-Plane

Plane : Non-transparent

Recommended by BIS from 1991

TV below FV & RHSV on LHS of FV

In Third-angle projection method,

Object in third quadrant

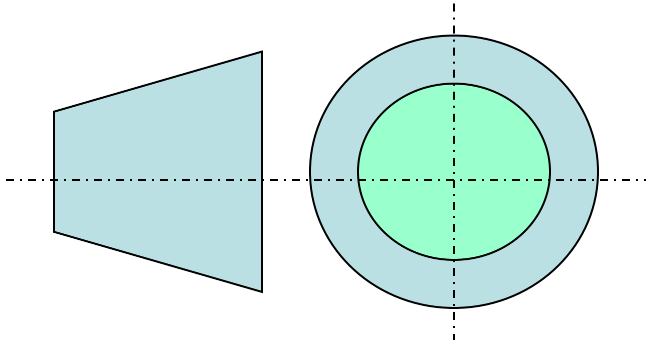
Sequence : Observer-Plane-Object

Plane : Transparent

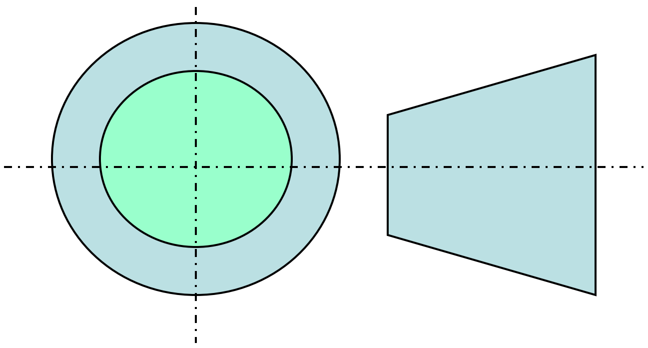
Used in USA

TV above FV & RHSV on RHS of FV

SYMBOLS



First-angle projection



Third-angle projection

CONVENTIONS USED

- Actual points, ends of lines, corners of solids etc. in space – A,B,C, …..
- Top views – a, b, c, …..
- Front views – a’, b’, c’, …..
- Reference line - xy

PROJECTIONS OF POINTS

A point may be situated, in space, in any one of the four quadrants formed by the two principal planes of projection or may lie in any one or both of them.

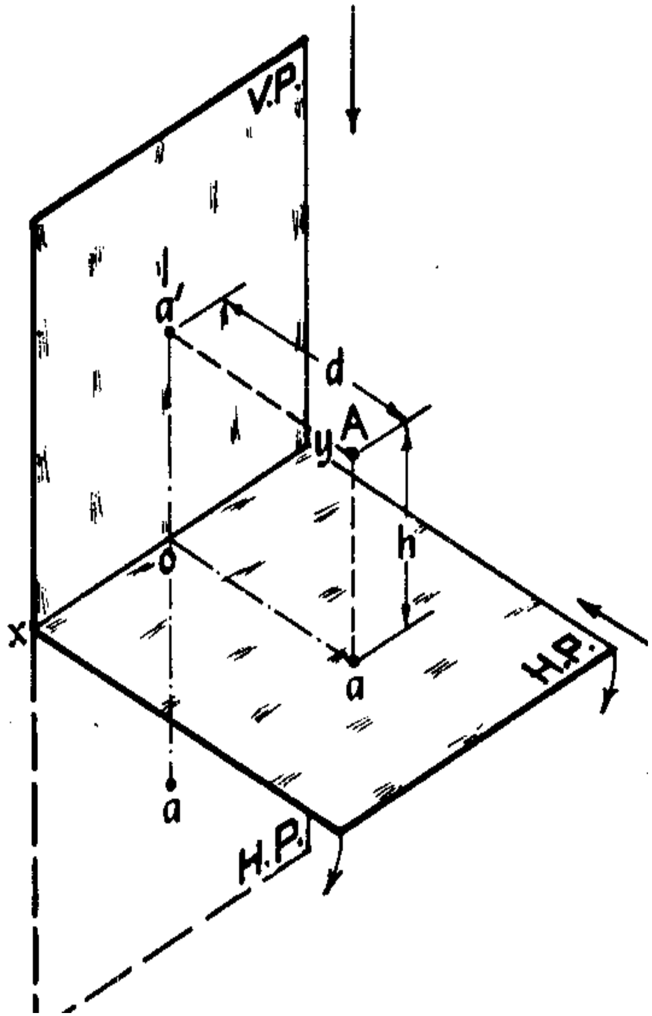
Its projections are obtained by extending projectors perpendicular to the planes.

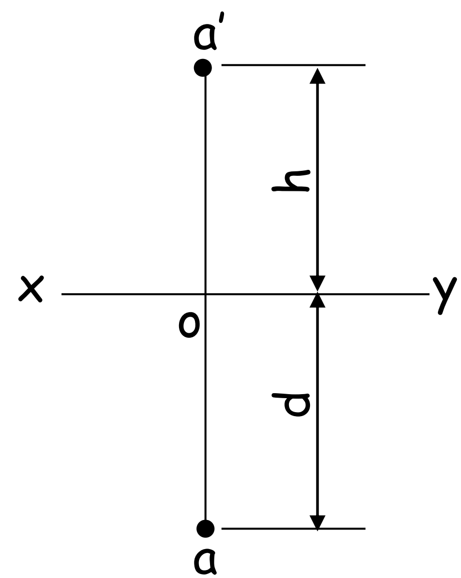
One of the planes is then rotated so that the first and third quadrants are opened out. The projections are shown on a flat surface in their respective positions either above or below or in *xy*.

Four Cases:

1. The point is situated in the first quadrant.
2. The point is situated in the second quadrant.
3. The point is situated in the third quadrant.
4. The point is situated in the fourth quadrant.

A POINT IS SITUATED IN FIRST QUADRANT

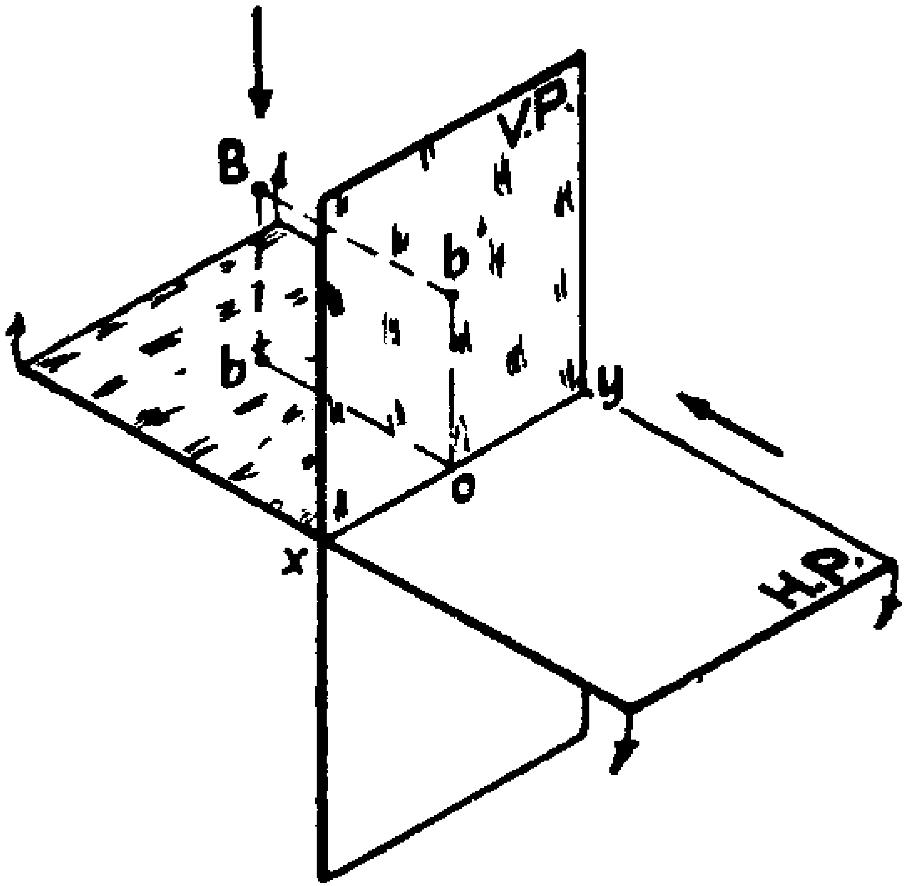


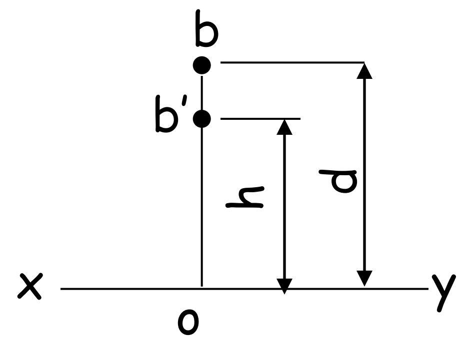


The pictorial view shows a point A situated above the H.P and in front of the V.P., i.e. in the first quadrant. a' is its front view and a the top view. After rotation of the plane, these projections will be seen *as shown in fig. (ii). The front view a' is above xy and the top view* a below it.

The line joining a' and a (which also is called a projector), intersects *xy* at right angles at a point o. It is quite evident from the pictorial view that a'o = Aa, i.e. the distance of the front view from *xy* = the distance of A from the H.P viz. h. Similarly, ao = Aa', i.e. the distance of the top view from *xy* = the distance of A from the V.P viz. d.

A POINT IS SITUATED IN SECOND QUADRANT

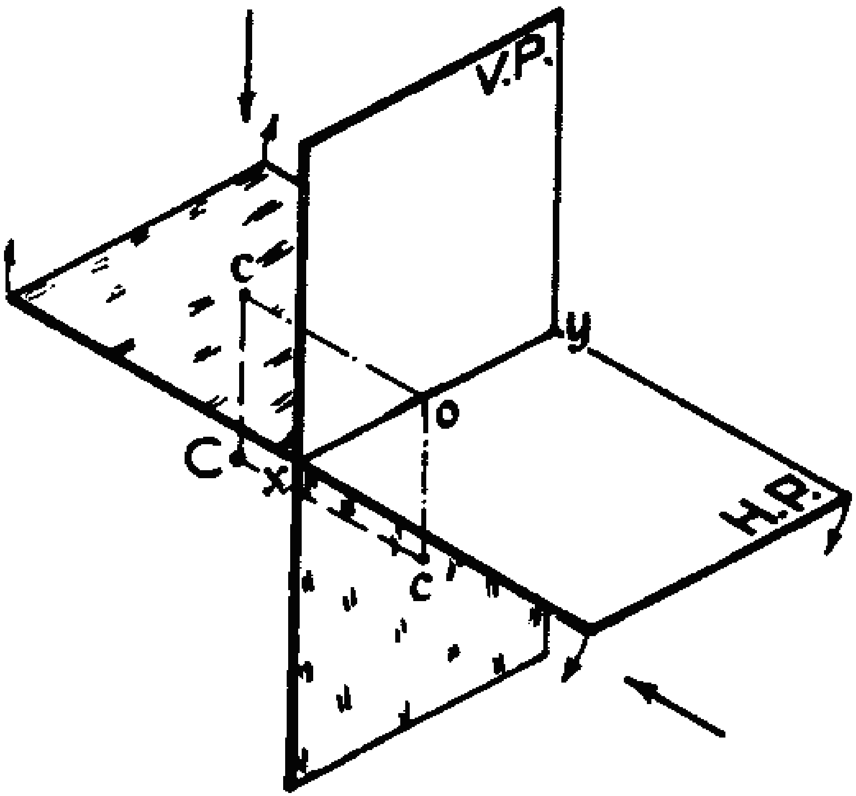


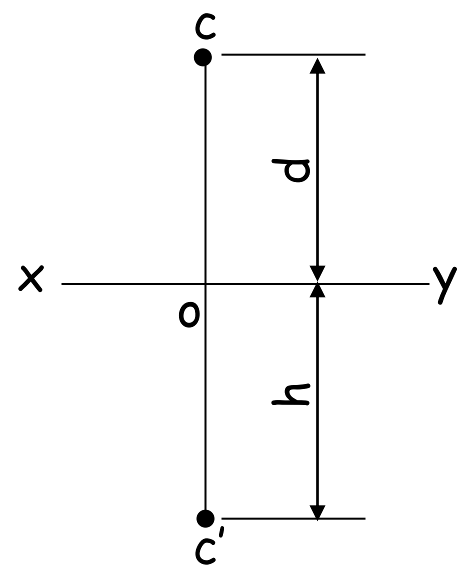


- A point *B in* (fig.) is above the H.P and behind the V.P., i.e. in the second quadrant. *b' is* the front view and *b* the top view.

- When the planes are rotated, both the views are seen above *xy.* Note that *b'o* = *Bb* and *bo* = *Bb'.*

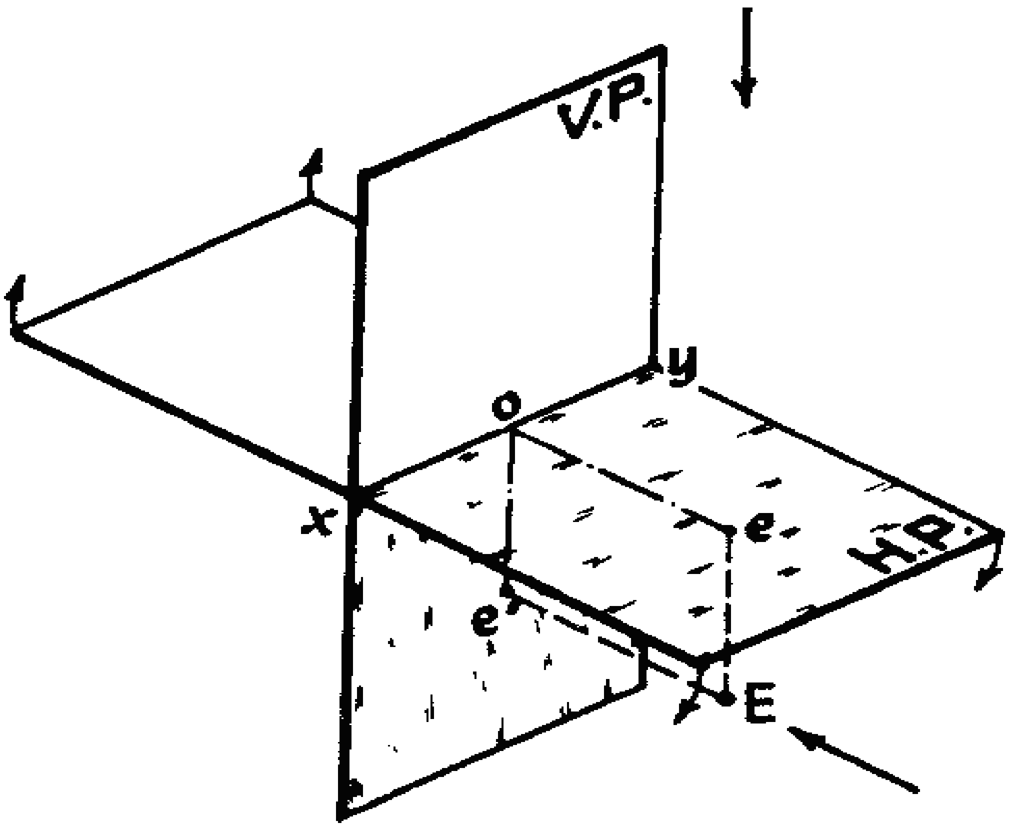
A POINT IS SITUATED IN THIRD QUADRANT

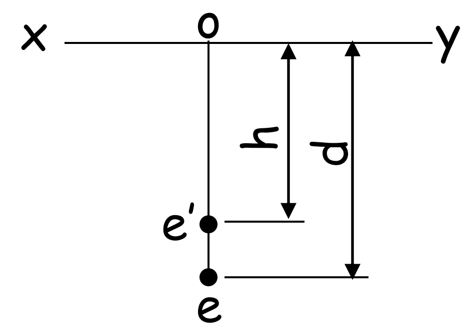




- A point C in (fig.) is below the H.P and behind the V .P. i.e. in the third quadrant. Its front view c' is below *xy* and the top view c above *xy.*
- Also co = Cc and
- *co = Cc'.*

A POINT IS SITUATED IN FOURTH QUADRANT





- A point E in (fig.) is below the H.P. and in front of the V.P., i.e. in the fourth quadrant. Both its projections are below *xy,* and e'o = Ee and eo = Ee'.

Prob.1. Draw the projections of the following points on the same ground line, keeping the projectors 25 mm apart.

A, in the H.P. and 20 mm behind the V.P.

B, 40 mm above the H.P. and 25 mm in front of the V.P

C, in the V.P. and 40 mm above the H.P.

D, 25 mm below the H.P. and 25 mm behind the V.P.

E, 15 mm above the H.P. and 50 mm behind the V.P.

F, 40 mm below the H.P. and 25 mm in front of the V.P.

G, in both the H.P. and the V.P

Prob.2. A point P is 15 mm above the H.P. and 20 mm in front of the V.P. Another point Q is 25 mm behind the V.P. and 40 mm below the H.P. Draw projections of P and Q keeping the distance between their projectors equal to 90 mm. Draw the straight lines joining (i) their top views and (ii) their front views.

Prob.3. The two points A and B are in the H.P. The point A is 30 mm in front of the V.P., while B is behind the V.P. The distance between their projectors is 75 mm and the line joining their top views makes an angle of 45^0 with xy. Find the distance of the point B from the V.P.

Prob.4. A point P is 20 mm below H.P. and lies in the third quadrant. Its shortest distance from xy is 40 mm. Draw its projections.

Prob.5. A point A is situated in the first quadrant. Its shortest distance from the intersection point of H.P., V.P. and auxiliary plane is 60 mm and it is equidistant from the principal planes. Draw the projections of the point and determine its distance from the principal planes.

Prob.6. A point 30 mm above xy line is the plan-view of two points P and Q. The elevation of P is 45 mm above the H.P. while that of the point Q is 35 mm below the H.P. Draw the projections of the points and state their position with reference to the principal planes and the quadrant in which they lie.

PROJECTION OF STRAIGHT LINES

A straight line is the shortest distance between the two points. Hence, the projections of a straight line may be drawn by joining the respective projections of its ends which are points.

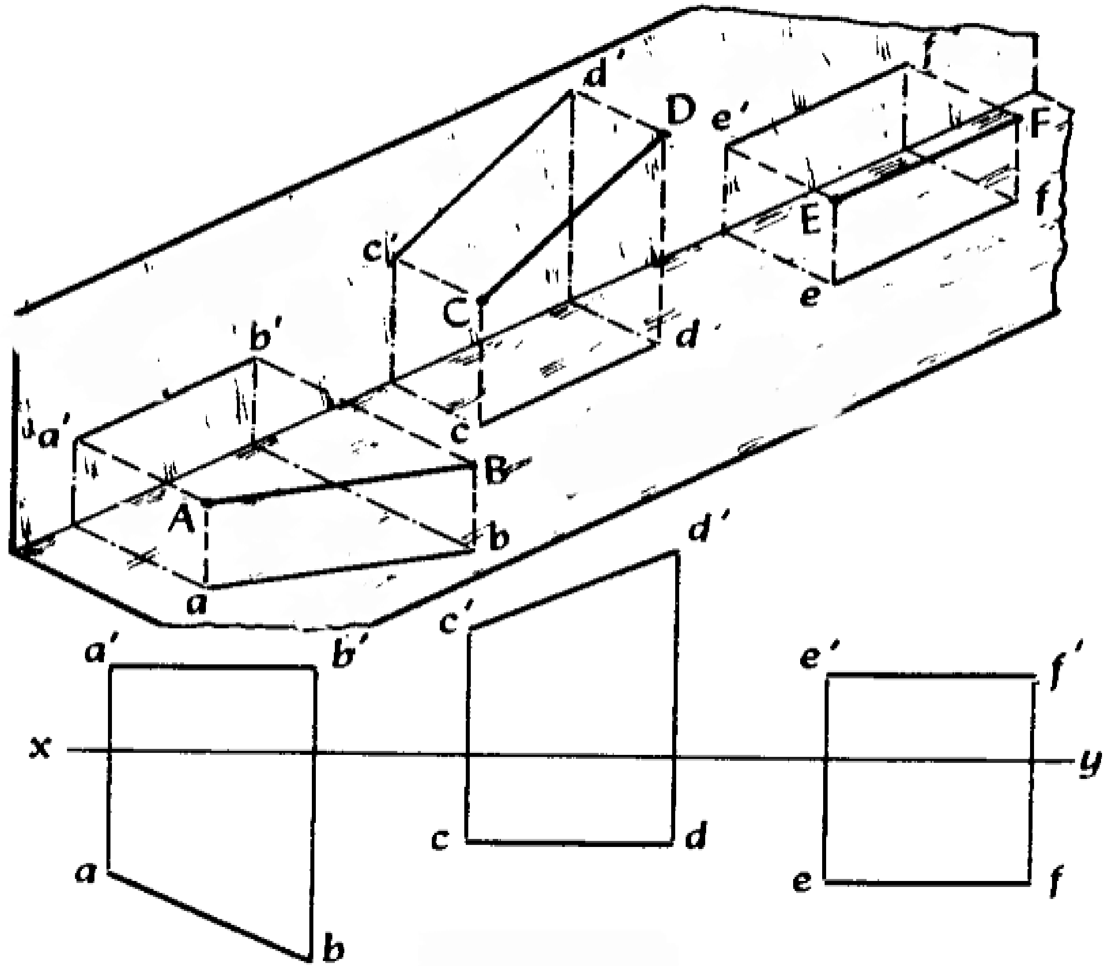
The following are the important positions which a straight line can take with respect to two reference planes:

1) Straight line parallel to both the planes.
2) Straight line contained by one or both the planes.
3) Straight line perpendicular to one of the planes.
4) Straight line inclined to one plane and parallel to the other.
5) Straight line inclined to both the planes.
6) Straight line inclined to both the planes with one end on the xy line.
7) Straight line contained by a plane perpendicular to both the reference planes.

LINE PARALLEL TO BOTH THE PLANES

ef is the top view and *e'f'* is the front view; both are equal to EF and parallel to *xy*.

Hence, when a line is parallel to a plane , its projection on that plane is equal to its true length; while its projection on the other plane is parallel to the reference line.



d'
D
e'
f
F
f
c'
E
C
e
b'
d
a'
c
B
A
b
d'
a
c'
a'
b'
e'
f'
x
y
c
d
a
e
f
b

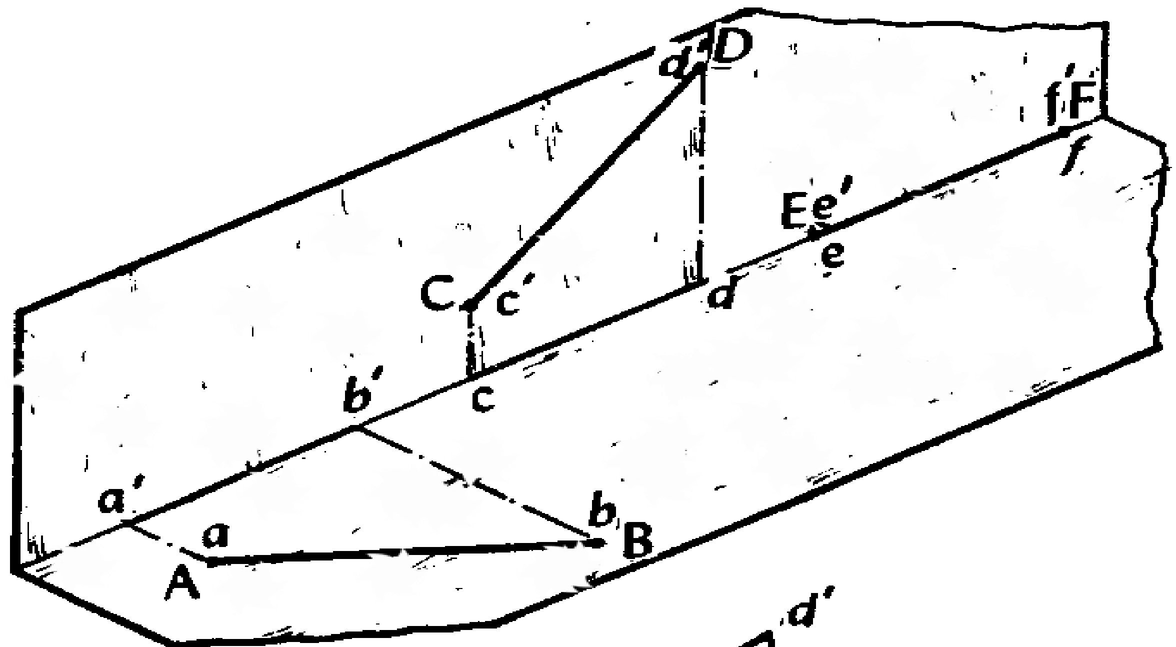
LINE CONTAINED BY ONE OR BOTH THE PLANES

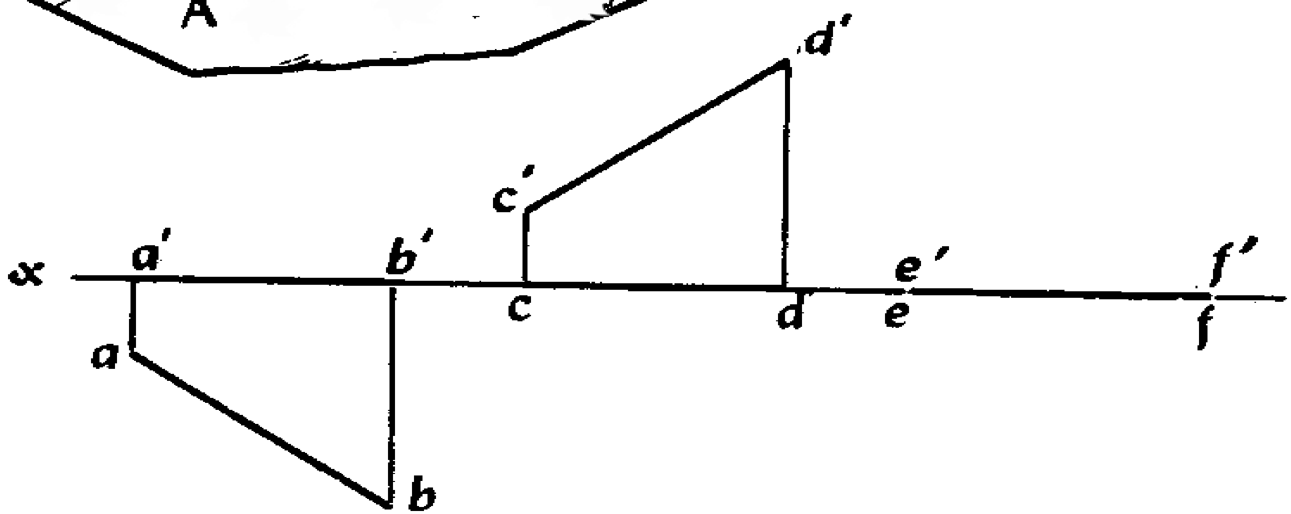
- Line AB is in the H.P. Its top view *ab* is equal to AB; its front view *a'b'* is in *xy*.

- Line CD is in the V.P. Its front view *c'd'* is equal to CD; its top view *cd* is in *xy*.

- Line EF is in both the planes. Its front view *e'f'* and the top view *ef* coincide with each other in *xy*.

- Hence, when a line is contained by a plane, its projection on that plane is equal to its true length; while its projection on the other plane is in the reference line.


d'D
f'F
f
Ee'
e
C
c'
d
b'
c
a'
a
b
B
A


d'
c'
x
a'
b'
e'
f'
c
d
e
f
a
b

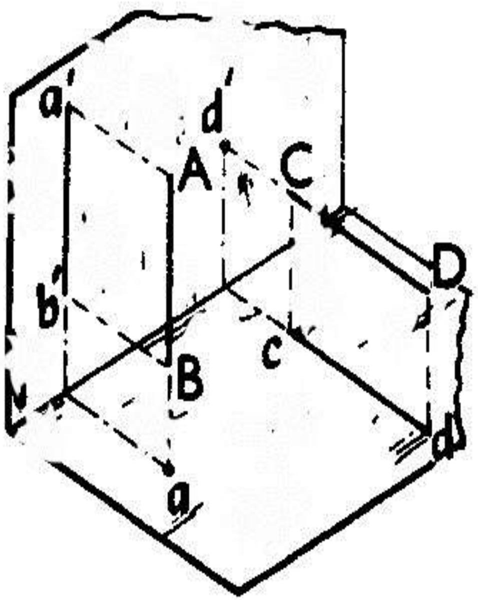
LINE PERPENDICULAR TO ONE OF THE PLANES

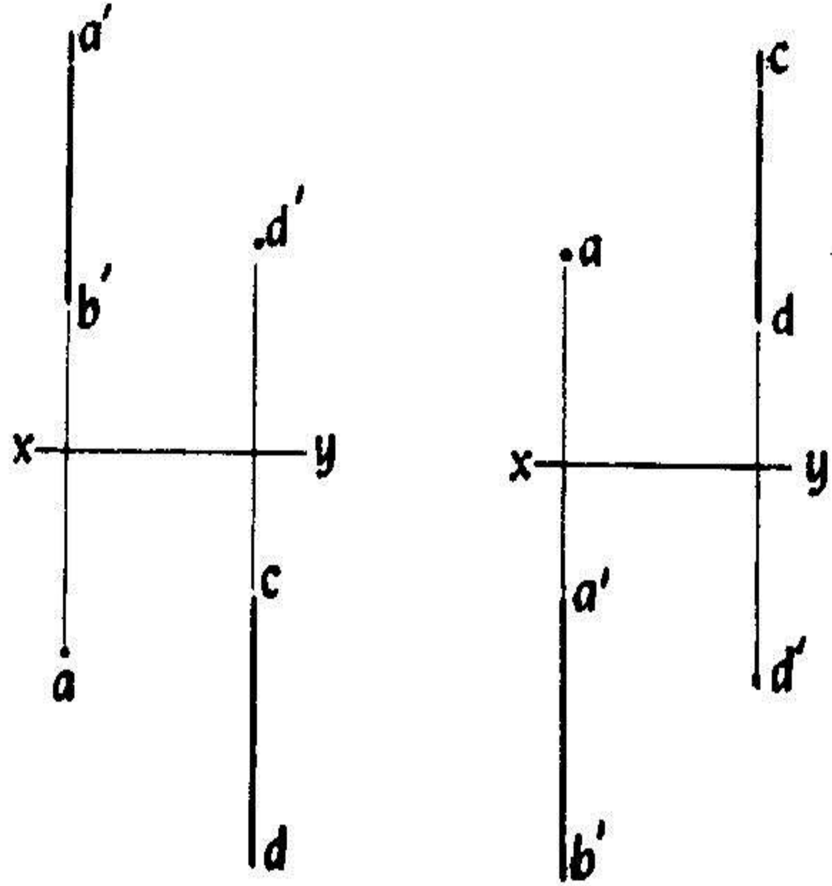
When a line is perpendicular to one reference plane, it will be parallel to the other.

a) Line AB is perpendicular to the H.P. The top views of its ends coincide in the point *a*. Its front view *a'b'* is equal to AB and perpendicular to *xy*.

b) Line CD is perpendicular to the V.P. The point d' is its front view and the line *cd* is the top view. *cd* is equal to CD and perpendicular to *xy*.

- Hence, when a line is perpendicular to a plane its projection on that plane is a point; while its projection on the other plane is a line equal to its true length and perpendicular to the reference line.
- In first angle projection method, when top views of two or more points coincide, the point which is comparatively farther away from *xy* in the front view will be visible; and when their front view coincide, that which is farther away from *xy* in the top view will be visible.
- In third angle projection method, it is just the reverse. When top views of two or more points coincide the point which is comparatively nearer *xy* in the front view will be visible; and when their front views coincide, the point which is nearer in the top view will be visible.





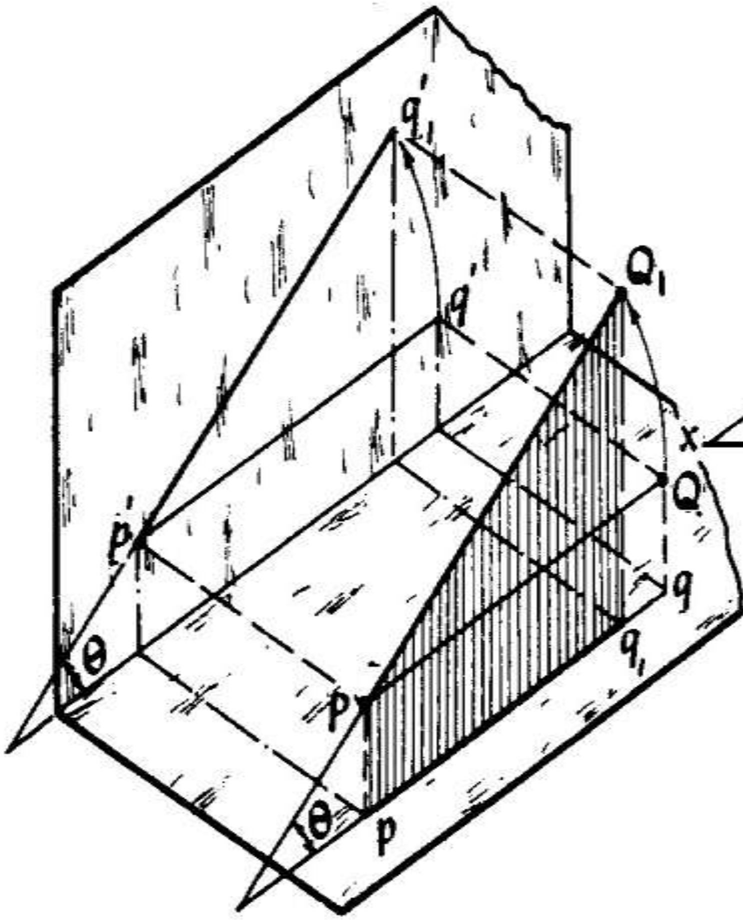
(Third-angle projection)

LINE INCLINED TO ONE PLANE AND PARALLEL TO OTHER

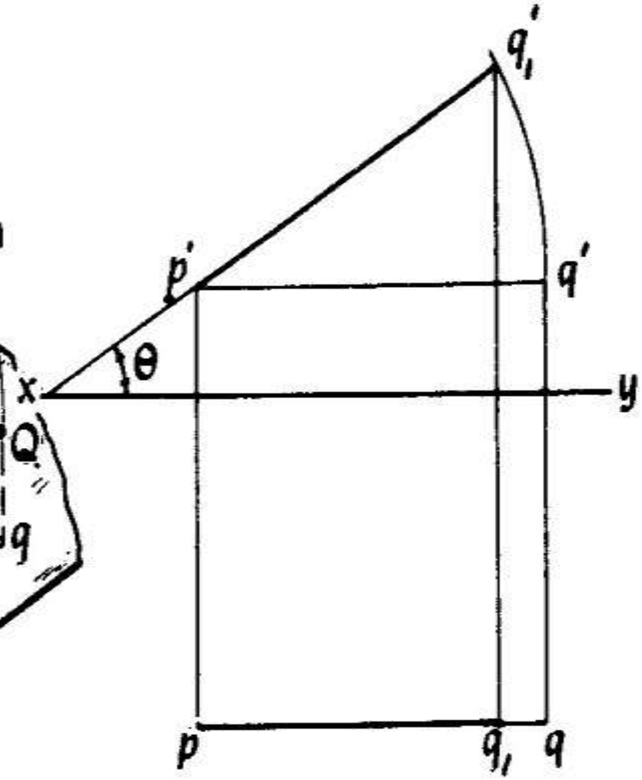
- The inclination of a line to a plane is the angle which the line makes with its projection on that plane.

- Line PQ_1 is inclined at an angle θ to the H.P. and is parallel to the V.P. The inclination is shown by the angle θ which PQ_1 makes with its own projection on the H.P., viz. the top view pq_1.

- The projections may be drawn by first assuming the line to be parallel to both H.P. and the V.P. Its front view p’q’ and the top view pq will both be parallel to xy and equal to the true length. When line is turned about the end P to the position PQ_1 so that it makes the angle θ with the H.P. while remaining parallel to the V.P., in the front view the point q’ will move along an arc drawn with the p’ as centre and p’q’ as radius to a point q_1’ so that p’q_1’ makes the angle θ with xy. In the top view q will move towards p along pq to a point q_1 on the projector through q_1’. p’q_1’ and pq_1 are the front view and the top view respectively of the line PQ_1.

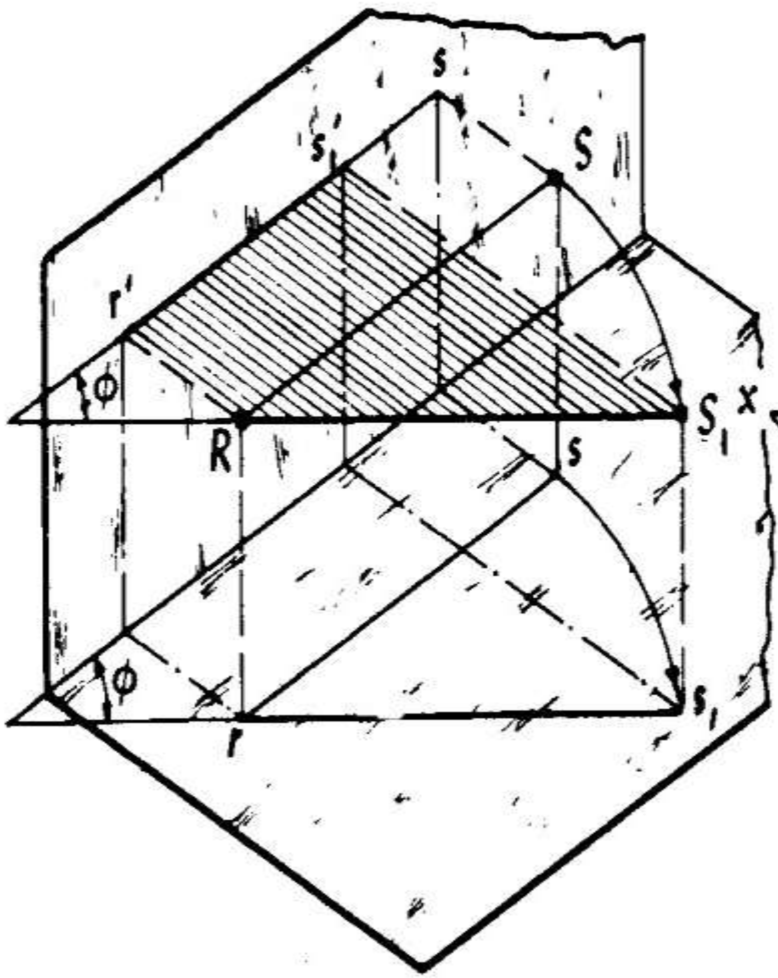


(i)

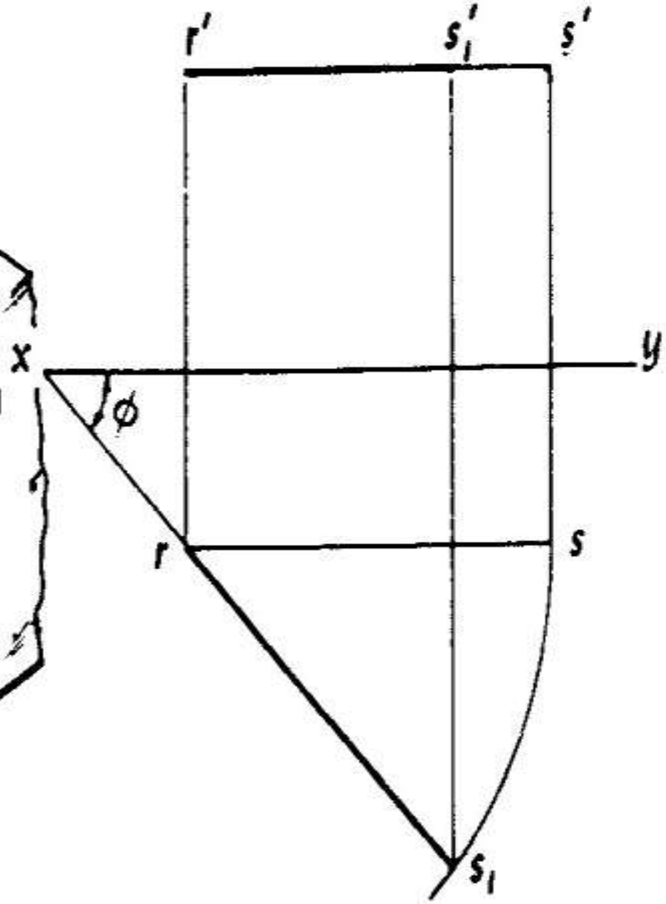


(ii)

- Line RS_1 is inclined at an angle Ø to the V.P. and is parallel to the H.P. The inclination is shown by the angle Ø which RS_1 makes with its projection on the V.P., viz. the front view $r's_1'$. Assuming the line to be parallel to the H.P. and the V.P., its projection r's' and the rs are drawn parallel to xy and equal to its true length.
- When the line is turned about its end R to the position RS_1 so that it makes the angle Ø with the V.P. while remaining parallel to the H.P., in the top view. The point s will move along an arc drawn with r as centre and rs as radius to a point s_1 so that rs_1 makes the angle Ø with xy. In the front view, the points' will move towards r' along the line r's' to a point s_1' on the projector through s_1.
- rs_1 and $r's_1'$ are the projections of the line RS_1.



(i)



(ii)

- Therefore, when the line is inclined to the H.P. and parallel to the V.P., its top view is shorter than the true length, but parallel to the xy; its front view is equal to its true length and is inclined to the xy at its true inclination with the H.P. And when the line is inclined to the V.P. and parallel to the H.P., its front view is shorter than its true length but parallel to xy; its top view is equal to its true length and is inclined to xy at its true inclination with the V.P.

- Hence, when a line is inclined to one plane and parallel to the other, its projection on the plane to which it is inclined, is a line shorter than its true length but parallel to the reference line. Its projection on the plane to which it is parallel, is a line equal to its true length and inclined to the reference line at its true length.

1. A 100 mm long line is parallel to and 40 mm above the H.P. Its two ends are 25 mm and 50 mm in front of the V.P. respectively. Draw its projections and find its inclination with the V.P.
2. A 90 mm long line is parallel to and 25 mm in front of the V.P. Its one end is in the H.P. while the other is 50 mm above the H.P. Draw its projections and find its inclination with the H.P.
3. The top view of a 75 mm long line measures 55 mm. The line is in the V.P., its one end being 25 mm above the H.P. Draw its projections.

4. The front view of a line, inclined at 30^o to the V.P. is 65 mm long. Draw the projections of the line, when it is parallel to and 40 mm above the H.P., its one end being 30 mm in front of the V.P.

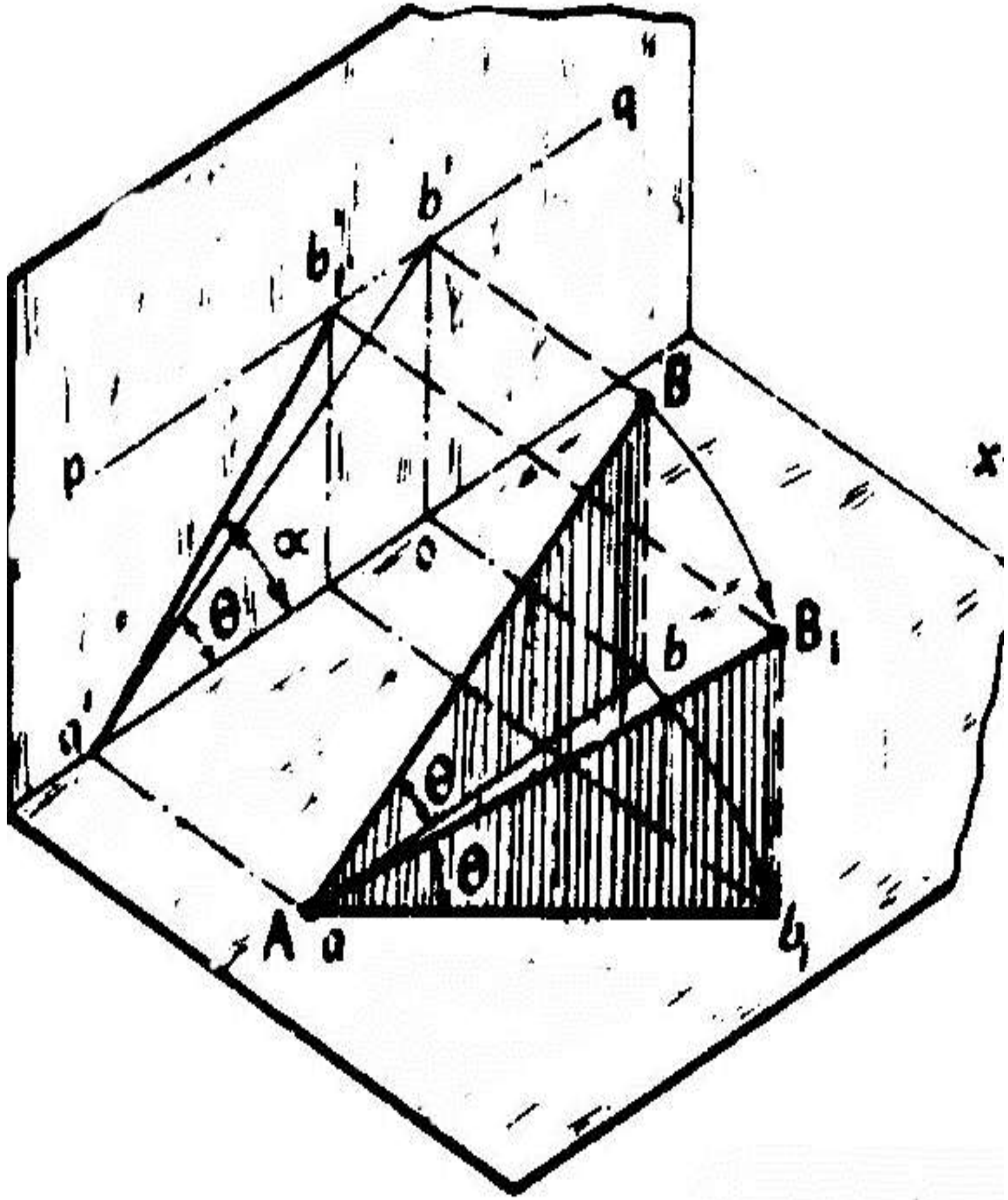
5. A vertical line AB, 75 mm long, has its end A in the H.P. and 25 mm in front of the V.P. A line AC, 100 mm long, is in the H.P. and parallel to the V.P. Draw the projections of the line joining B and C, and determine its inclination with the H.P.

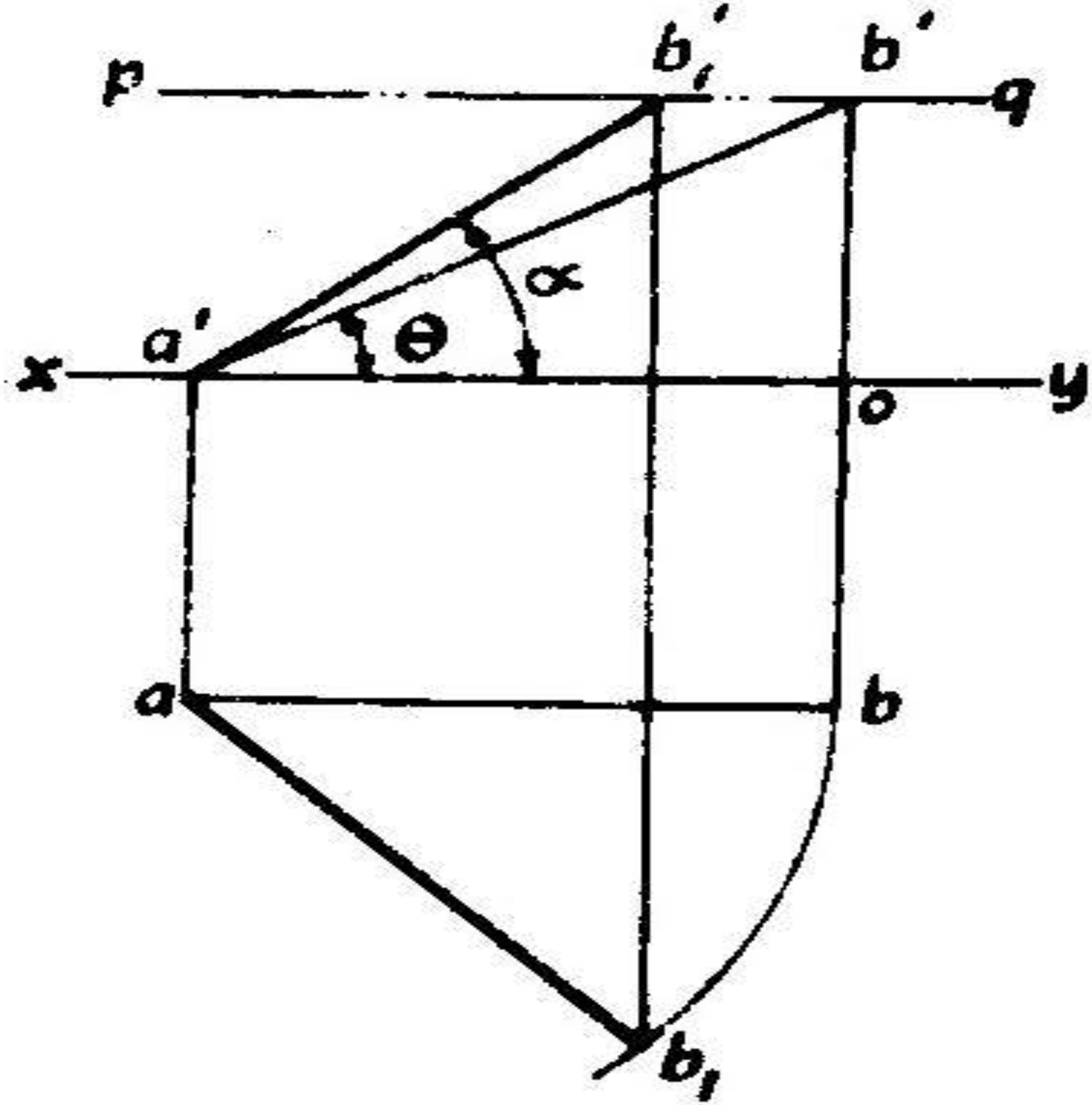
6. Two pegs fixed on a wall are 4,5 m apart. The distance between the pegs measured parallel to the floor is 3.6 m. If one peg is 1.5 m above the floor, find the height of the second peg and the inclination of the line joining the two pegs, with the floor.

LINE INCLINED TO BOTH THE PLANES

Problem:

The line AB, is inclined at θ with H.P. and is parallel to the V.P. The end A is in the HP. Draw its projections.

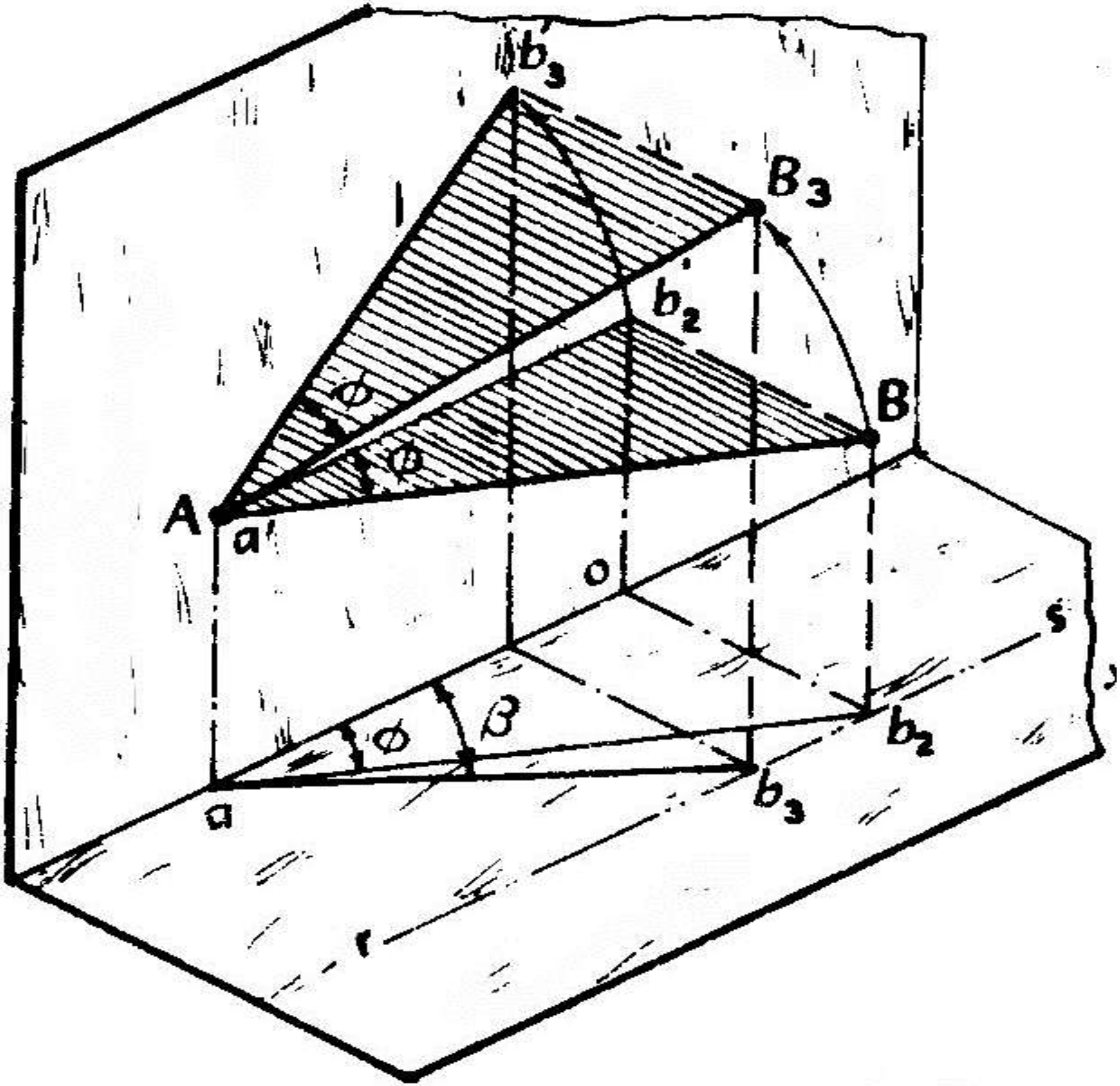

q
b'
b₁'
B
p
x
α
θ₁
o
B₁
b
a'
θ
θ
A
a
b₁

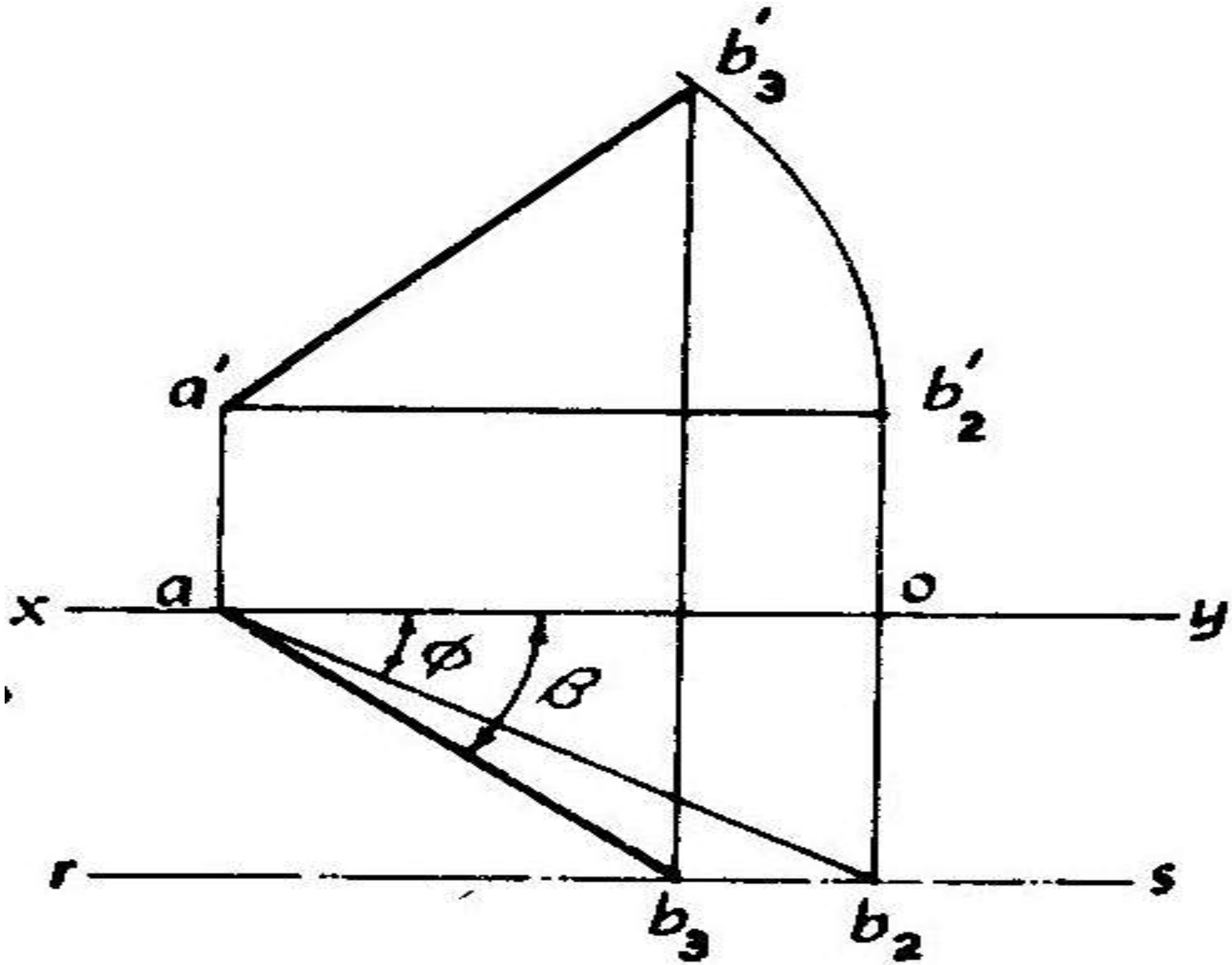

p
b_1'
b'
q
α
a'
θ
x
y
o
a
b
b_1

- From previous lecture, we understood that as long as the inclination of *AB* with the H.P is constant (i) its length in the top view, viz. *ab* remains constant, and (ii) in the front view, the distance between the loci of its ends, viz. b' o remains constant.
- In other words if (i) its length in the top view is equal to *ab,* and (ii) the distance between the paths of its ends in the front view is equal to *b' o,* the inclination of *AB* with the H.P will be equal to *θ.*
- *Let us first determine the lengths of AB in the top view and the front view and the paths of its ends in the front view and the top view.*
- *(i) Assume AB to be parallel to the V.P and inclined at θ to the H.P. AB is shown in the pictorial view as a side of the trapezoid ABba [fig.(a)]. Draw the front view a' b' equal to AB [fig.(b)] and inclined at θ to xy. Project the top view ab parallel to xy. Through a' and b', draw line pq parallel to xy. ab is the length of AB in the top view and, pq is the paths of B in the front view.*

Problem:

The same line AB, is inclined at Φ with V.P. and is parallel to the H.P. The end A is in the V.P. Draw its projections.


b'3
B3
b'2
B
φ
φ
A
a'
o
s
β
φ
b2
b3
a
r



b_3'
a'
b_2'
x
a
o
y
ϕ
β
r
s
b_3
b_2

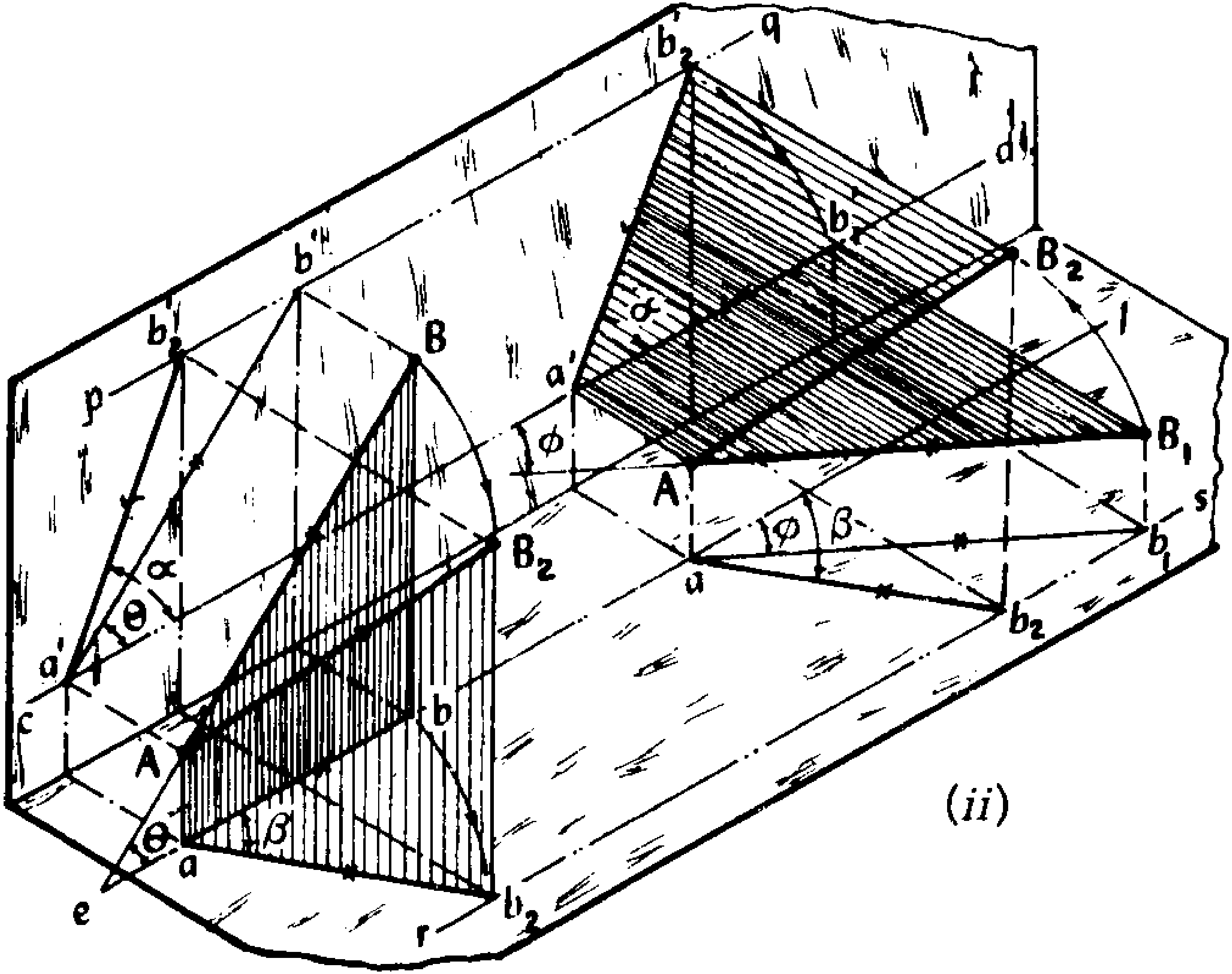
- *Similarly, in previous lecture , we find that as long as the inclination of AB with the V.P is constant (i) its length in the front view, viz. a' b_2' remains constant, and (ii) in the top view, the distance between the loci of its ends, viz. b_2 o remains constant.*

- *The reverse of this is also true, viz. (i) if its length in the front view is equal to a' b_2', and (ii) the distance between the paths of its ends in the top view is equal to b_2 0, the inclination of AB with the V.P will be equal to Φ.*

- *(ii) Again, assume ABA (equal to AB) to be parallel to the H.P. and inclined at Φ to the V .P. In the pictorial view [fig.(a)], AB, is shown as a side of the trapezoid ABA b_1' a'. Draw the top view ab, equal to AB [fig.(b)] and inclined at Φ to xy. Project the front view a' b_1' parallel to xy. Through a and b_1, draw lines of and rs respectively parallel to xy. a' b_1' is the length of AB in the front view and, of and rs are the paths of A and B respectively in the top view.*

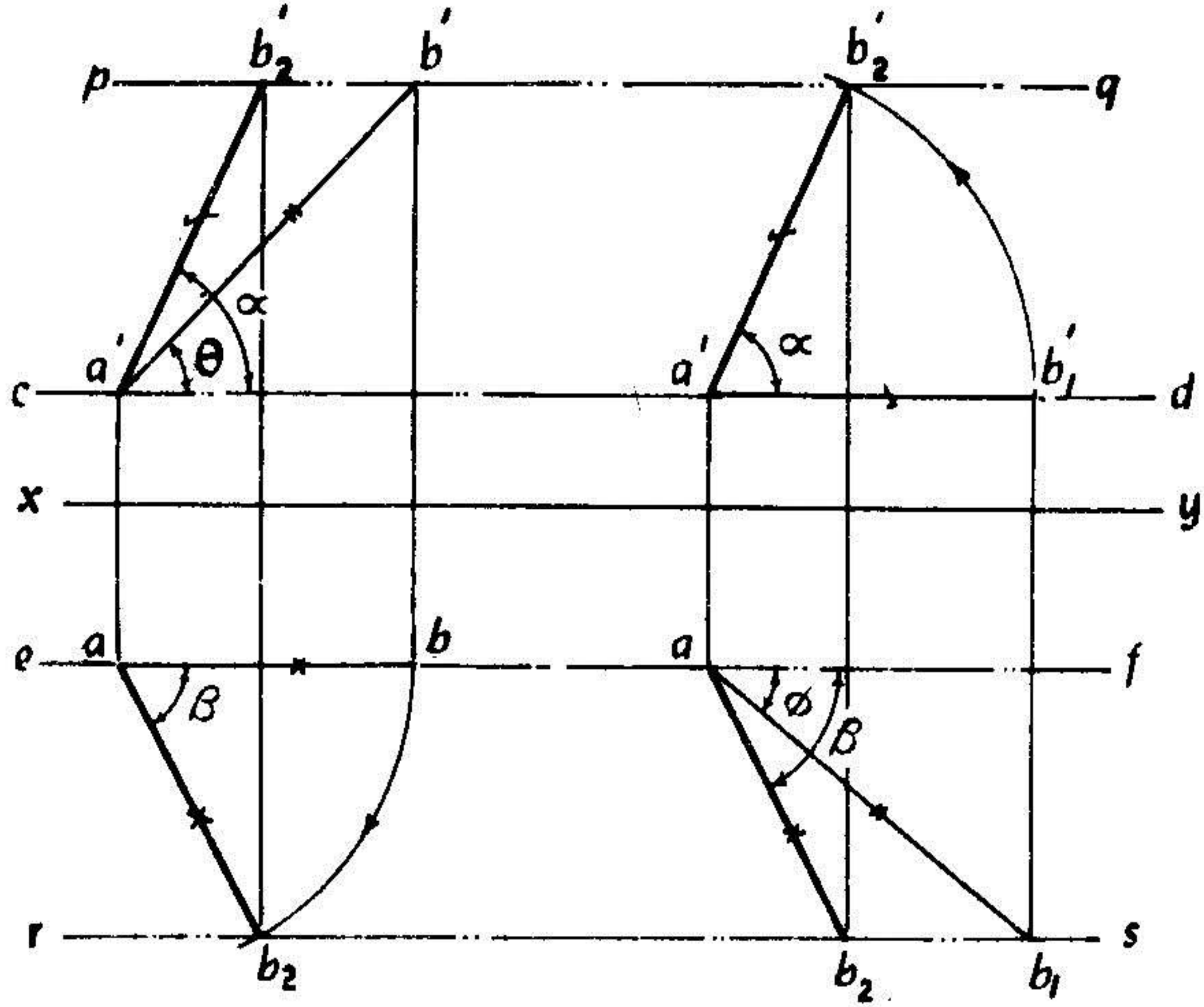
Problem:

The line AB, its inclinations is θ with H.P. and Φ with the V.P. Draw its projections.



(ii)

(i)

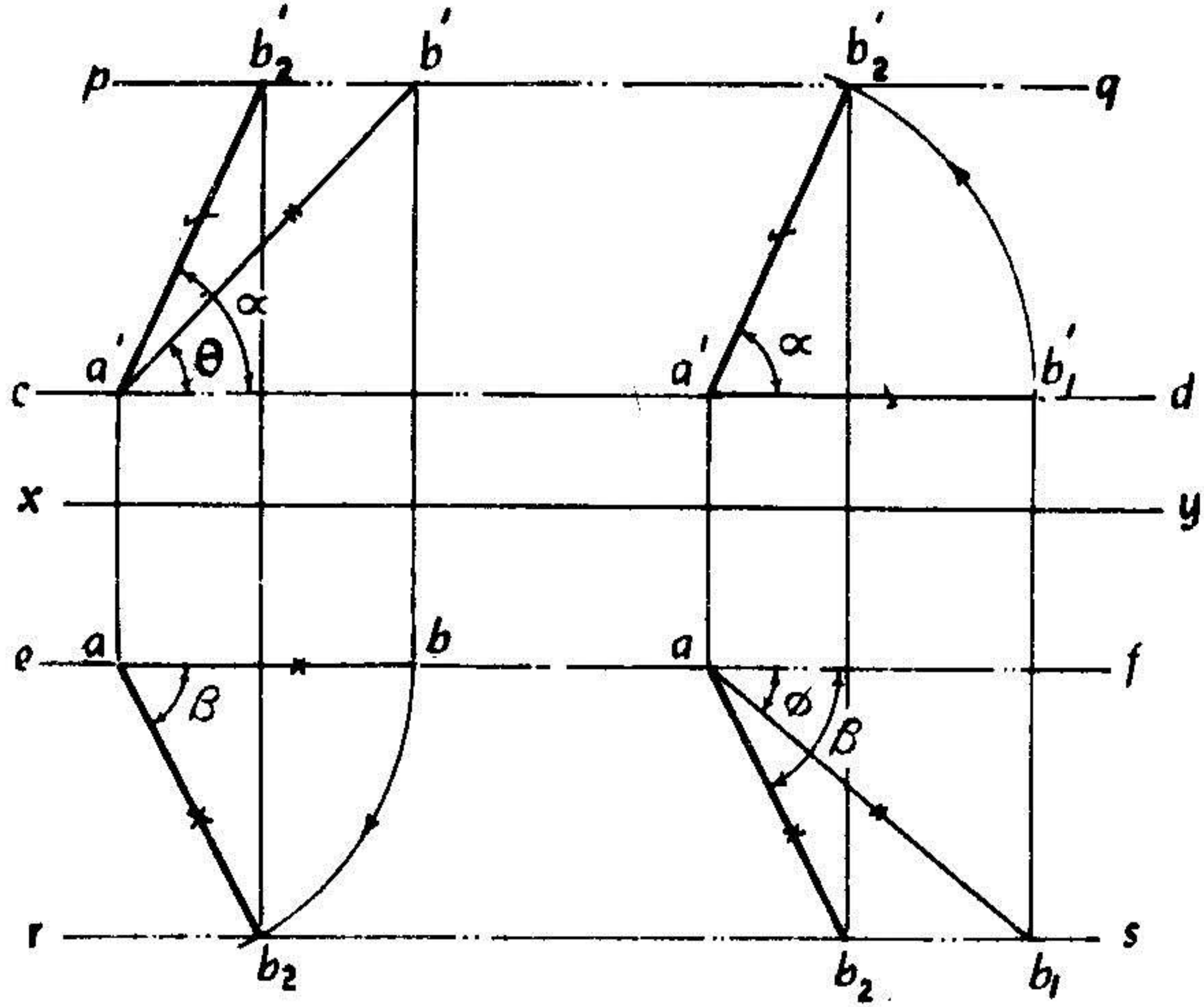


p
b_2'
b'
b_2'
q
α
θ
a'
c
a'
α
b_1'
d
x
y
e
a
b
a
f
β
ϕ
β
r
b_2
b_2
b_1
s

(i) (ii)

- In case (i) [fig.(i)] ,if the side Bb is turned about Aa , so that b comes on the path rs, the line AB will become inclined at *Φ to the V.P. Therefore, with a as centre and radius equal to ab ,draw an arc cutting rs at a point b_2 . Project b_2 to b_2' on the path pq, draw lines joining a with b_2 , and a' with b_2' . Ab_2 and a' b_2' are the required projections. Check that a' b_2'=a' b_1'.*

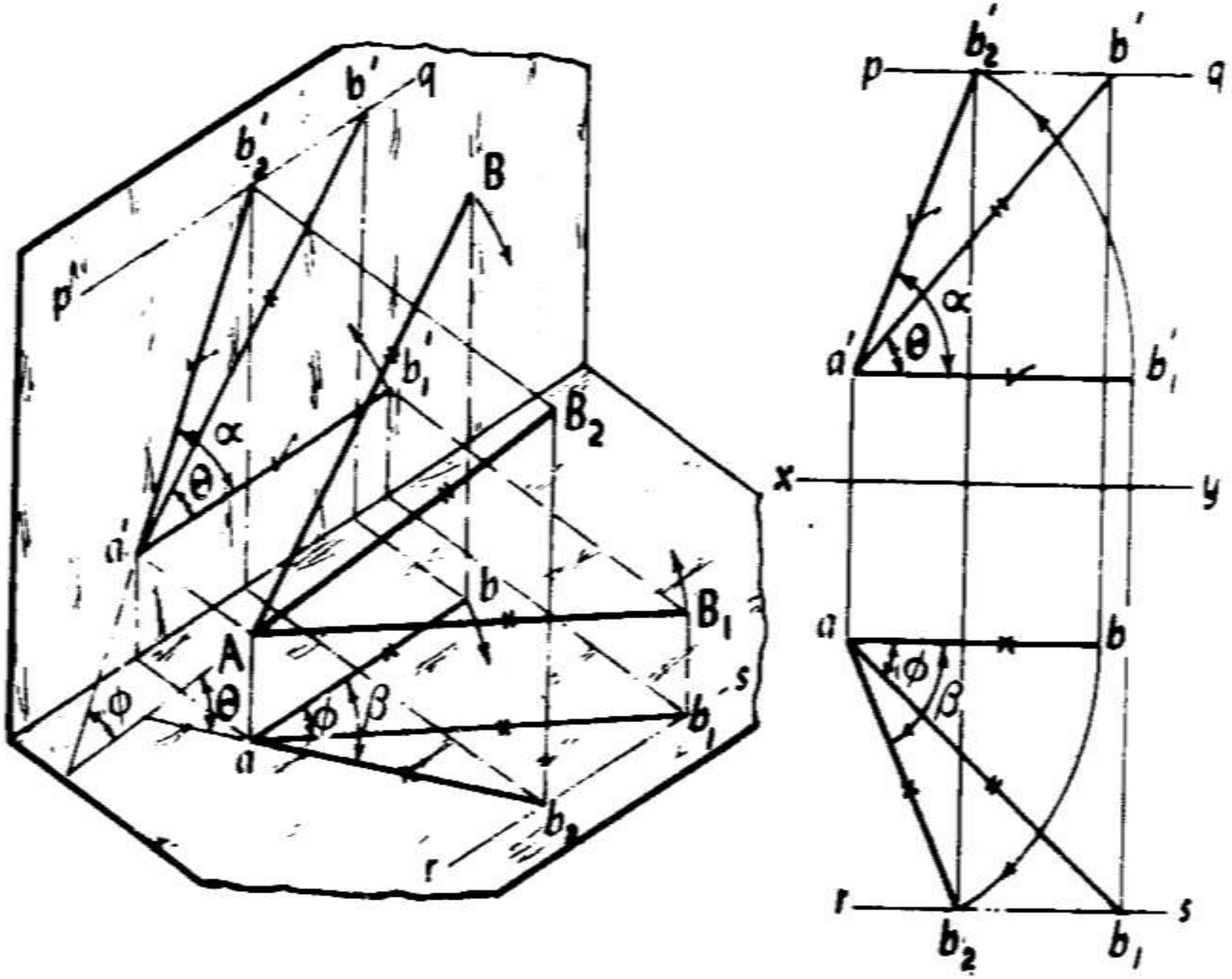
- *Similarly in case (ii) [fig. (ii)] , if the side B_1b_1 is turned about Aa' till b_1' is on the path pq, the line AB_1 will become inclined at θ to the H.P. hence with a' as centre [fig. (ii)] and radius equal to a'b_1',sraw an arc cutting pq at a point b_2' to b_2 in the top view on the path rs. draw lines joining a with b_2, and a' with b_2' . Ab_2 and a' b_2' are the required projection . Check that ab_2 = ab.*



(i) (ii)

- We may now arrange *(i) ab* (the length in the top view) between its paths *of* and *rs*, and *(ii)* $a'\ b_1'$ (the length in the front view) between the paths *cd* and *pq*, keeping them in projection with each other.

COMBINED IN ONE FIGURE

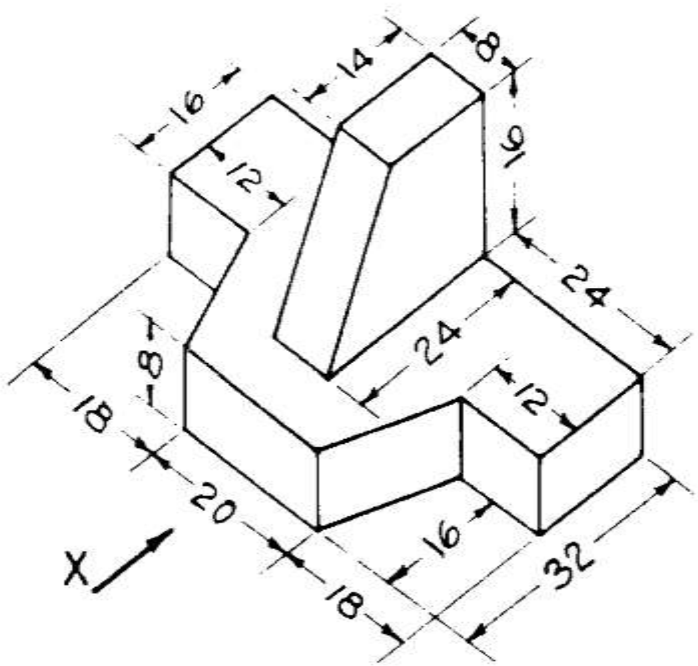


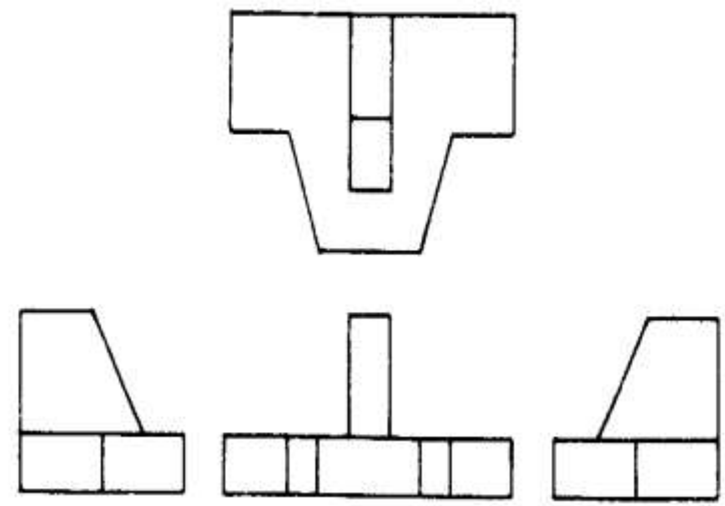
- First , determine (i) the length ab in the top view and the path pq in the front view and (ii) the length a' b_1' in the front view and the path rs in the top view then , with a as centre and radius equal to a' b_1' draw an arc cutting pq at a point b_2'.

- Draw lines joining a with b_2 and a' with b_2' , ab_2 and a' b_2' are the required projections. check that b_2 and b_2' lie on the same projector.

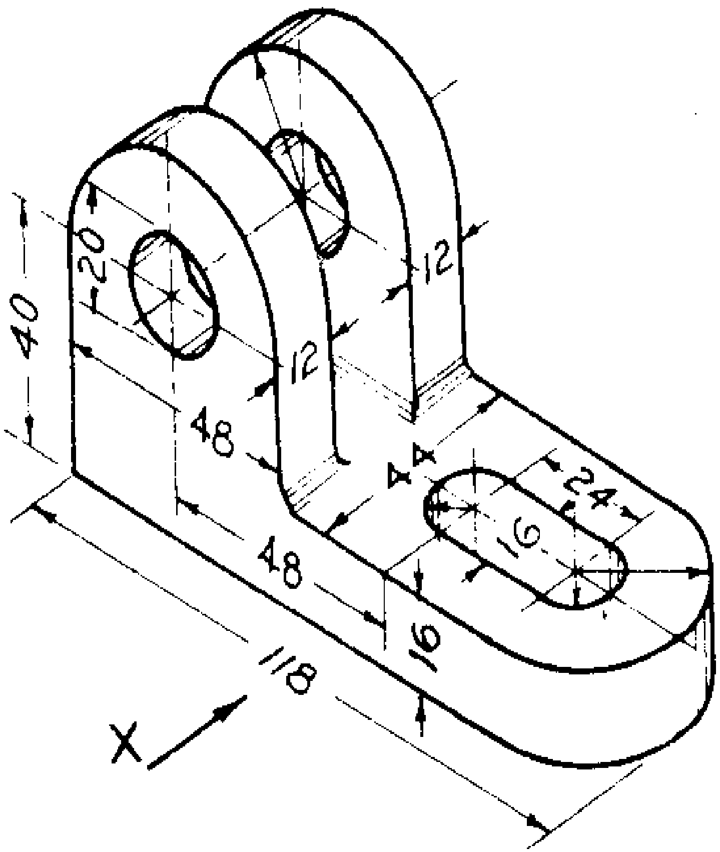
- It is quite evident from the figure that the apparent angles of inclination a and b are greater than the inclinations θand Φ respectively

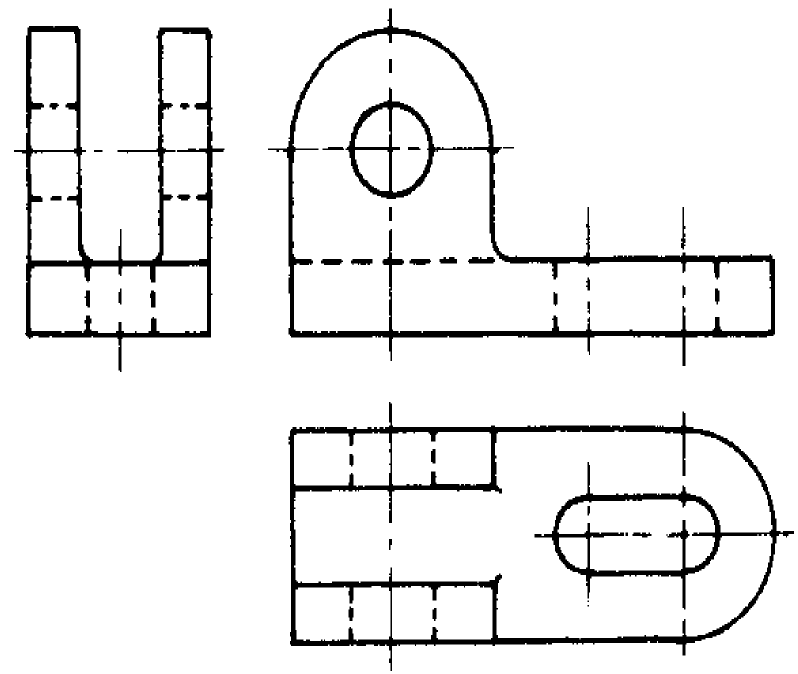
Problem 20-6. *Draw the following views of the block shown pictorially in fig. 20-23(i). Use third-angle projection method. (i) Front view. (ii) Top view. (iii) Both side views.*



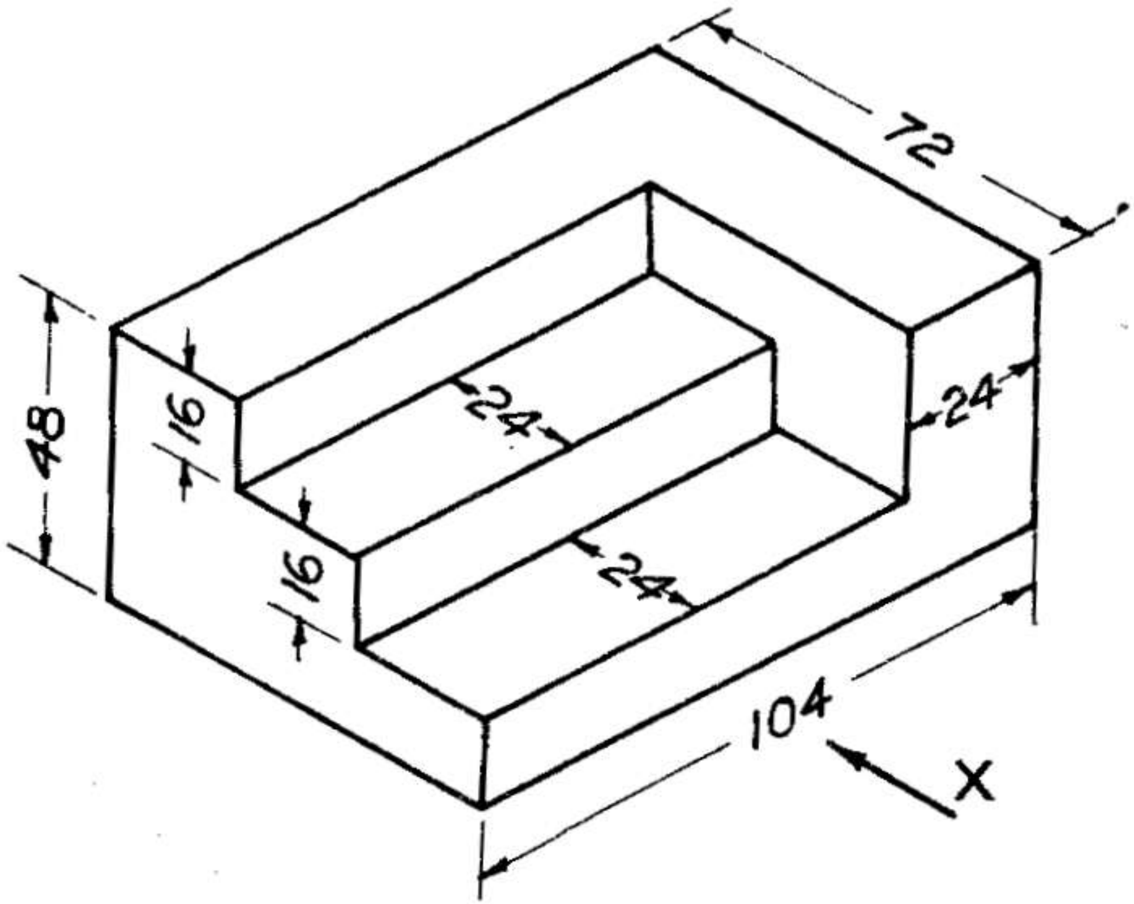


Problem 20-5. *Draw the following views of the object shown pictorially in fig. 20-22(i). (i) Front view. (ii) Top view. (iii) Side view from the right.*

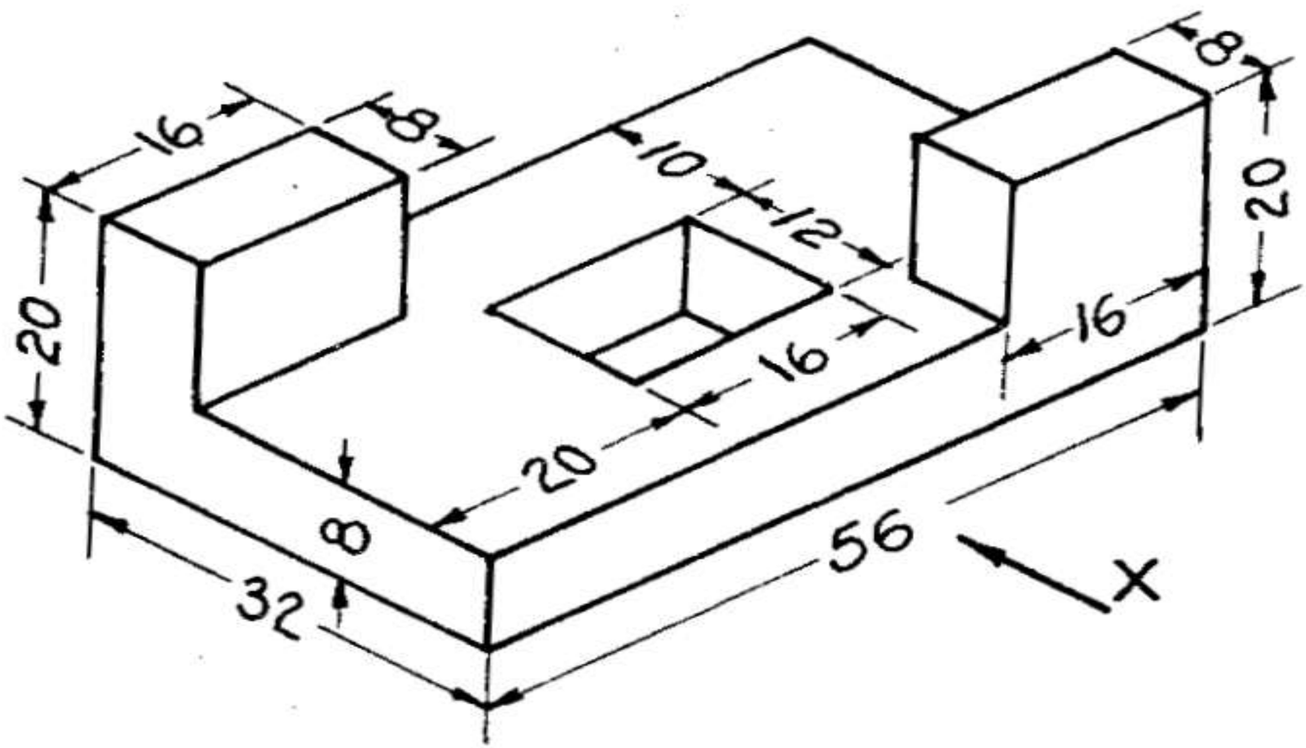




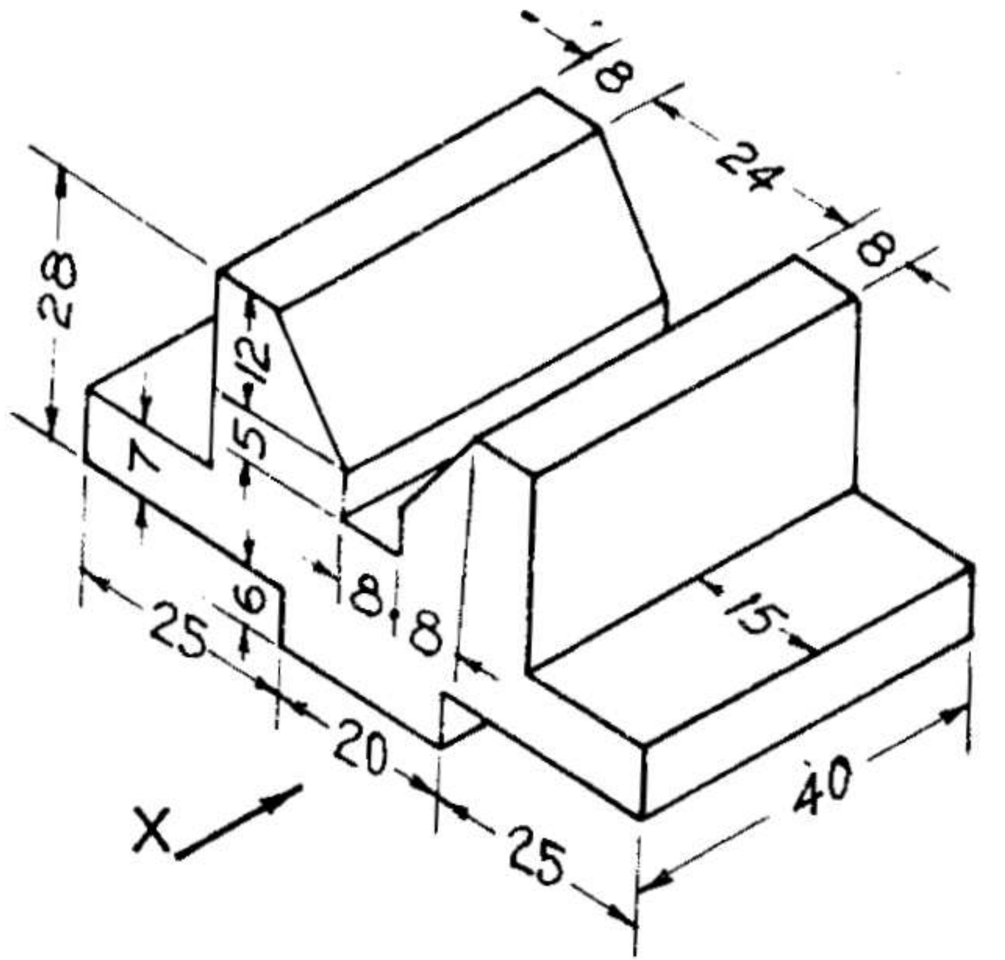
Problem No. 01: Draw the front view, top view and side view from left of the figure shown below.



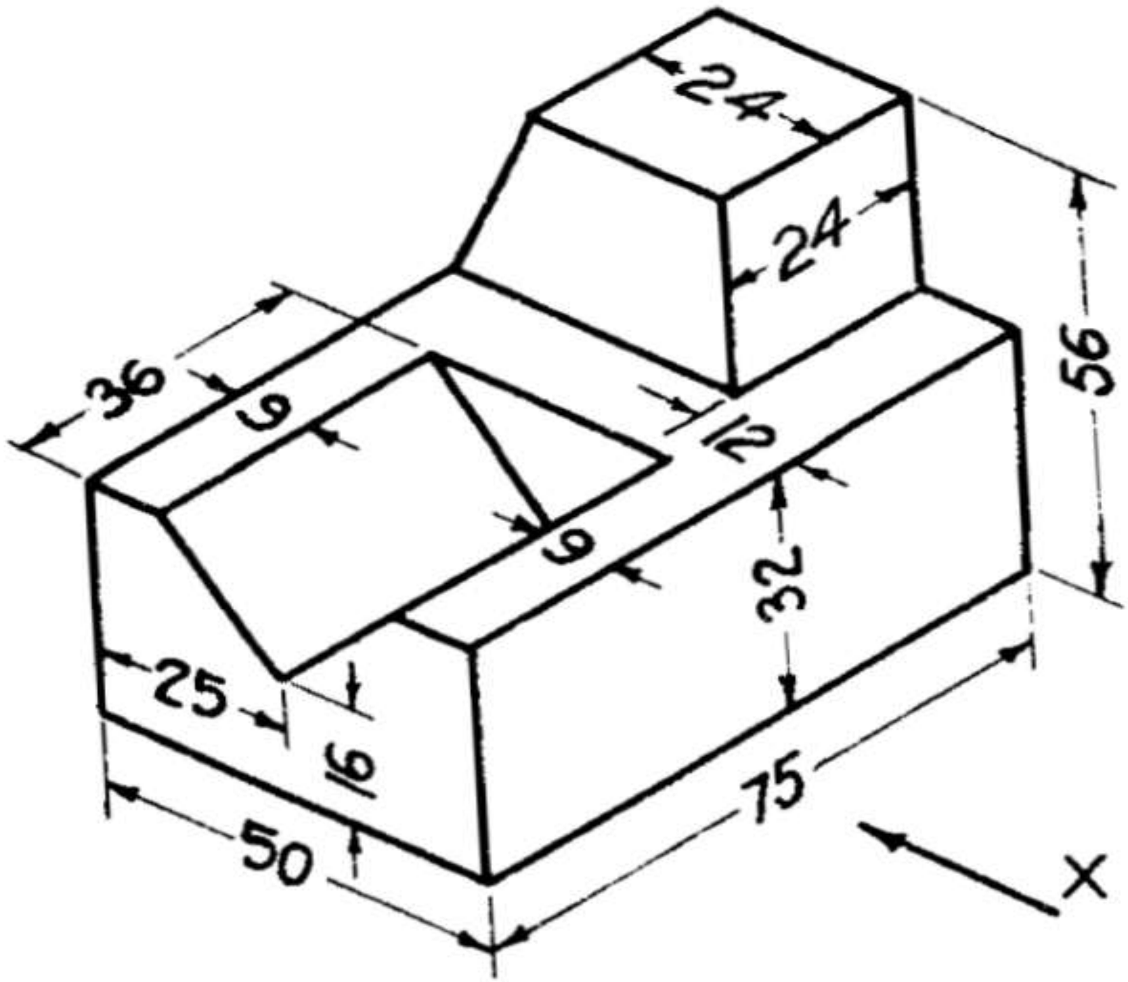
Problem No. 02: Draw the front view, top view and side view of the figure shown below.



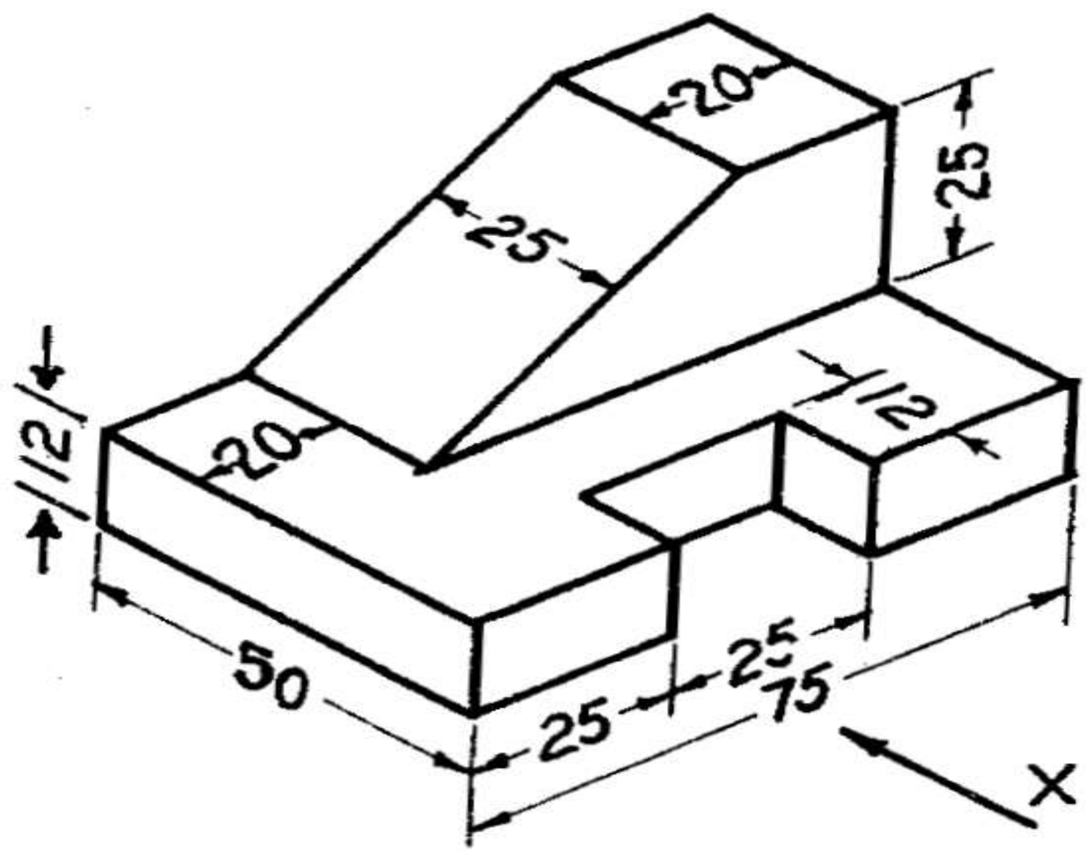
Problem No. 03: Draw the front view, top view and side view of the figure shown below.



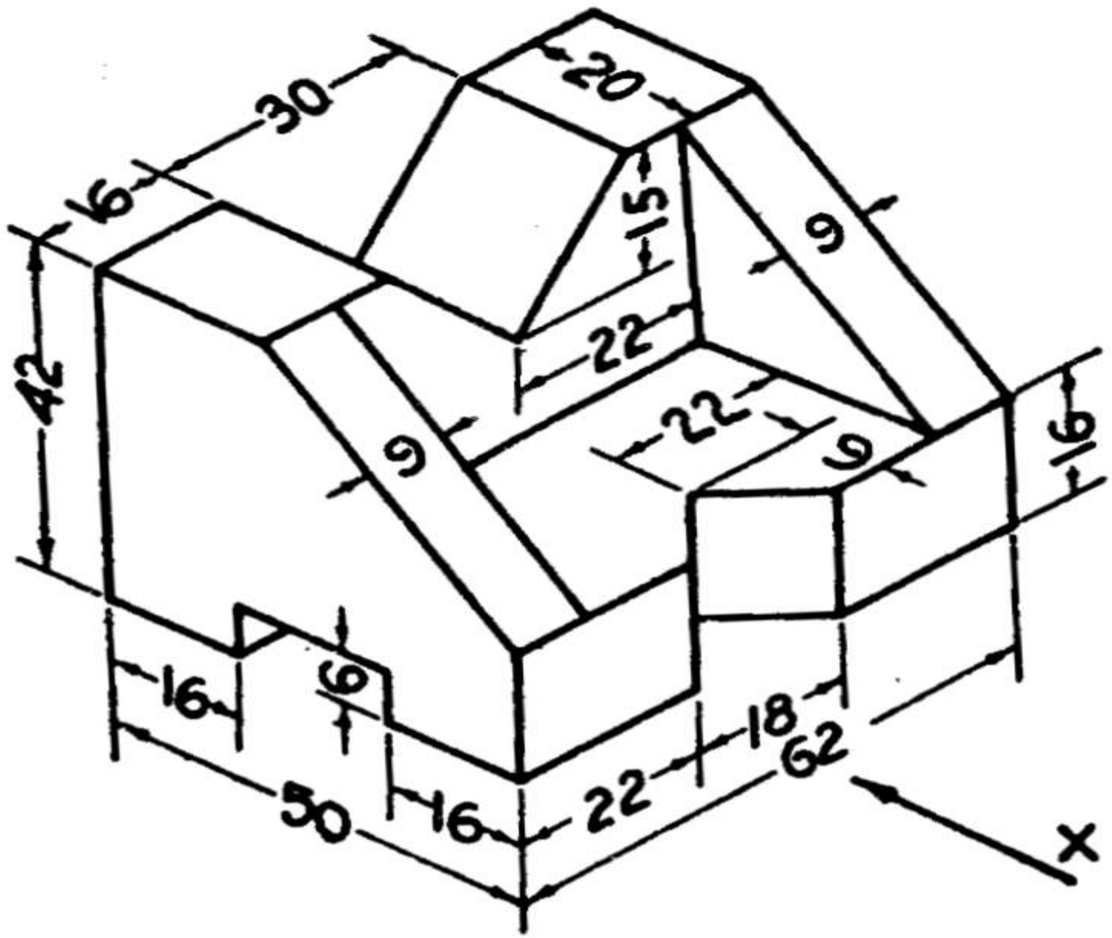
Problem No. 04: Draw the front view, top view and side view from left of the figure shown below.



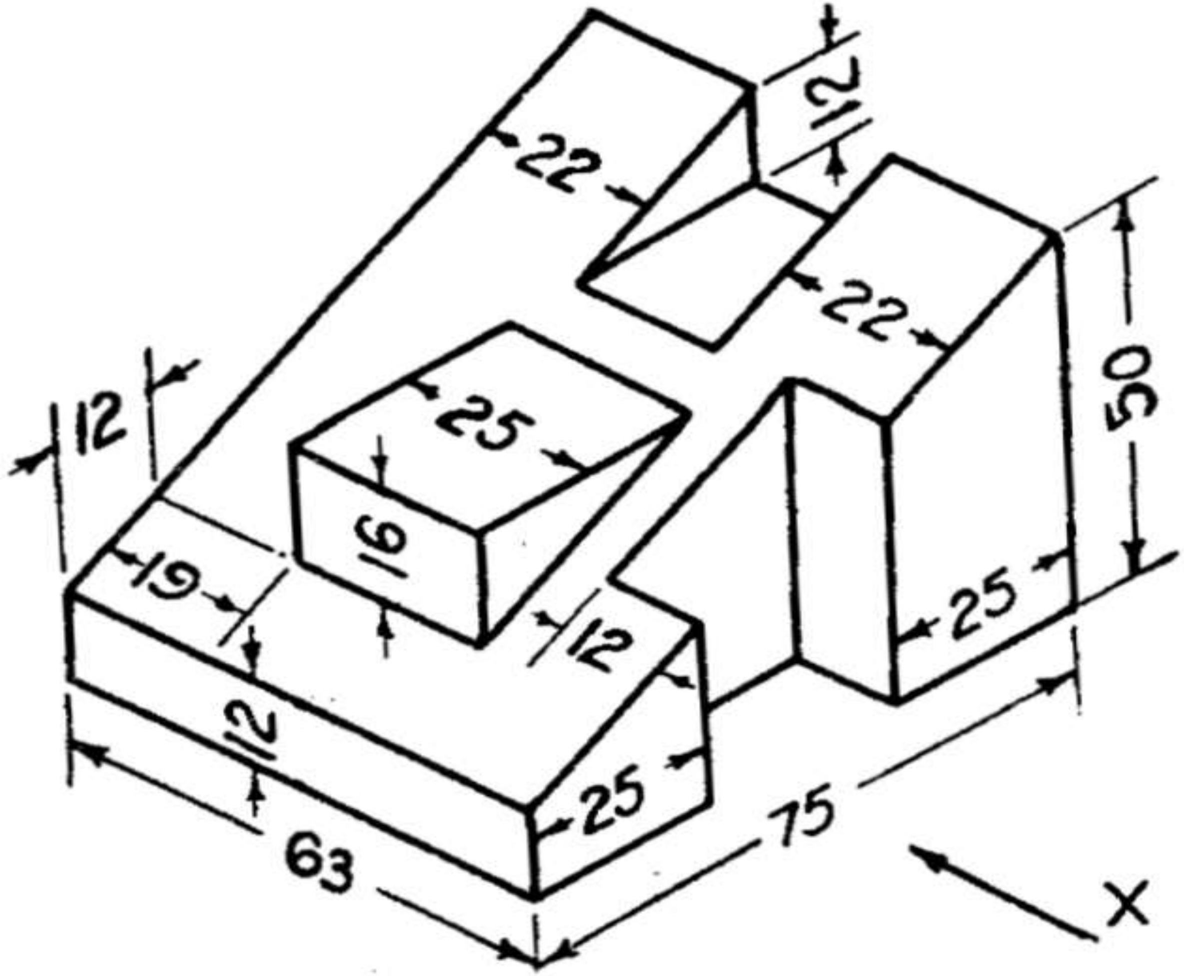
Problem No. 05: Draw the front view, top view and side view from left of the figure shown below.



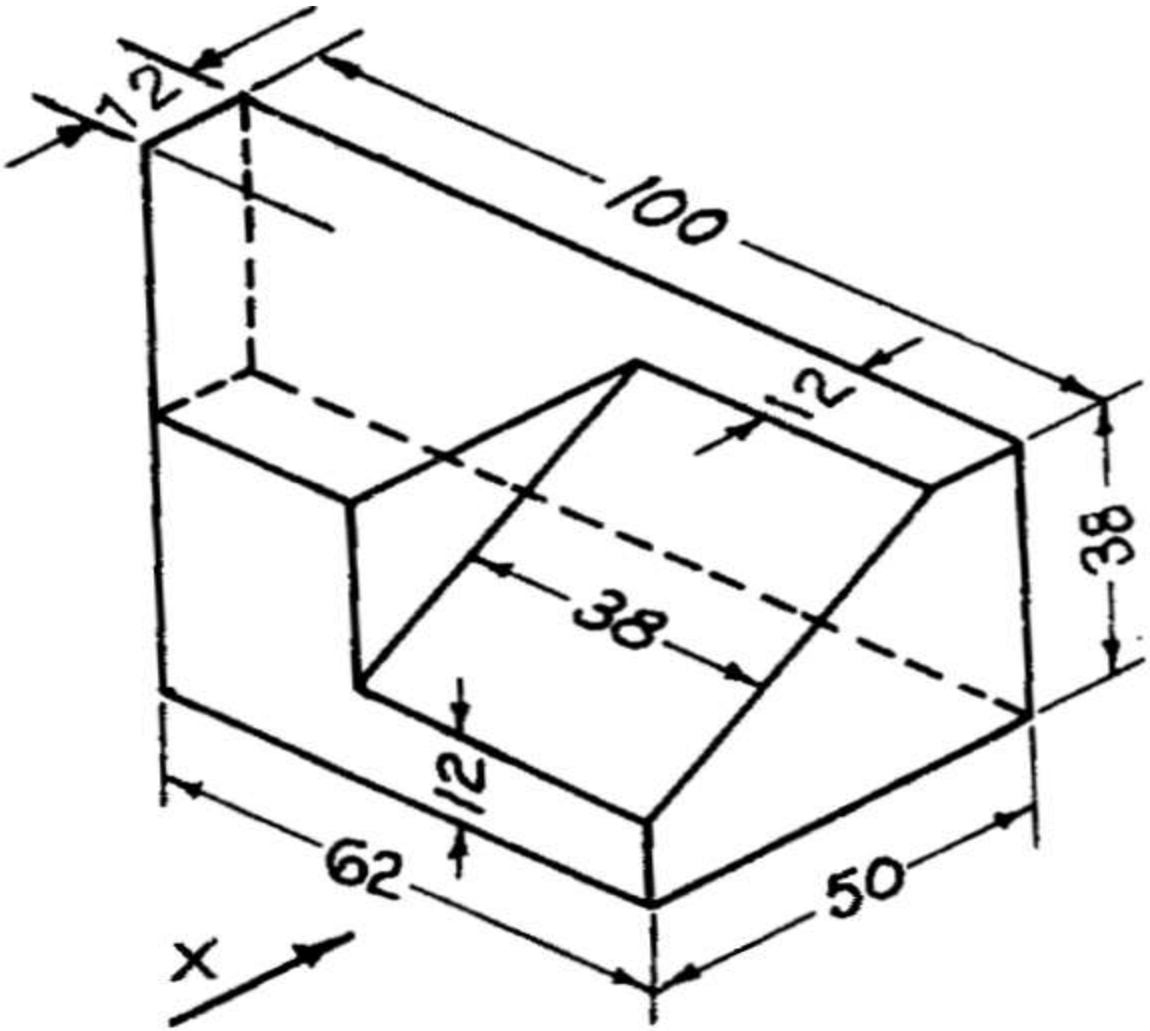
Problem No. 06: Draw the front view, top view and side view from left of the figure shown below.



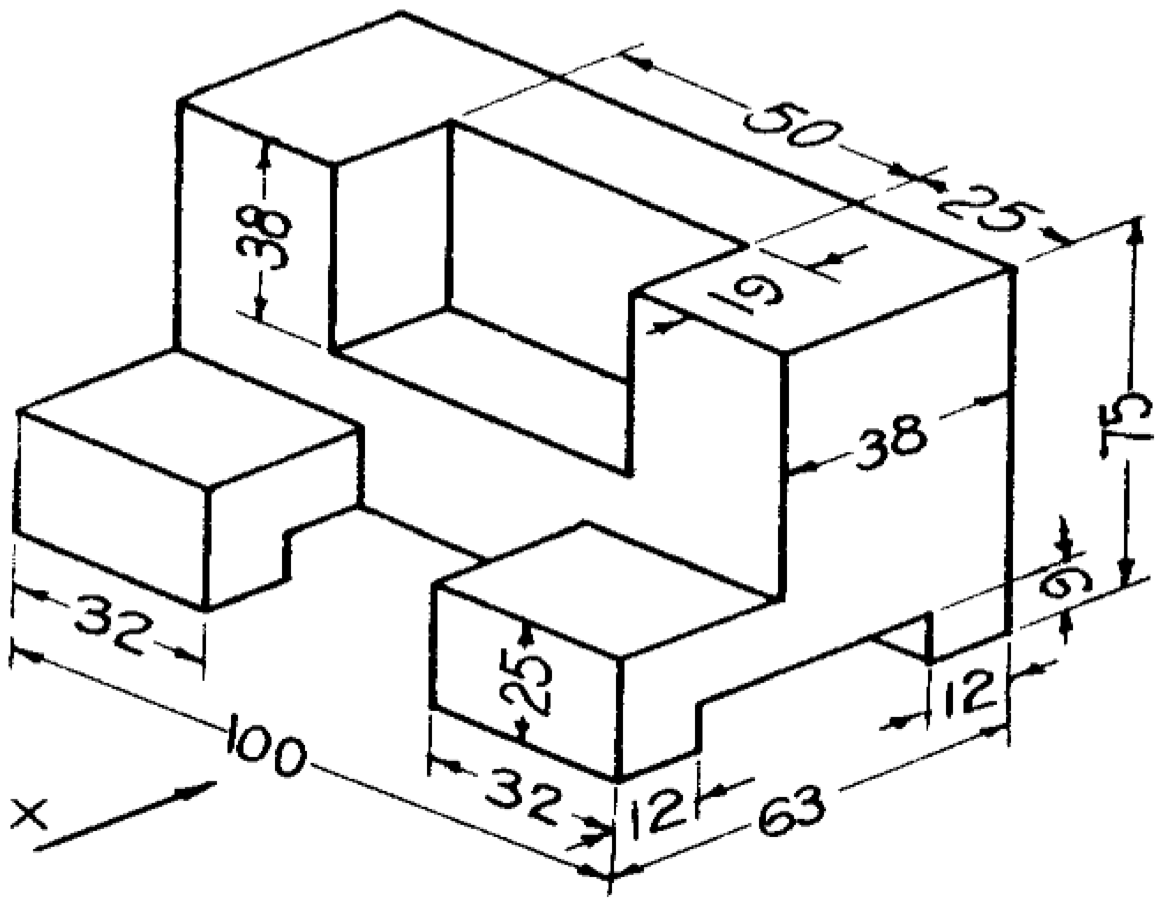
Problem No. 07: Draw the front view, top view and both side view of the figure shown below.



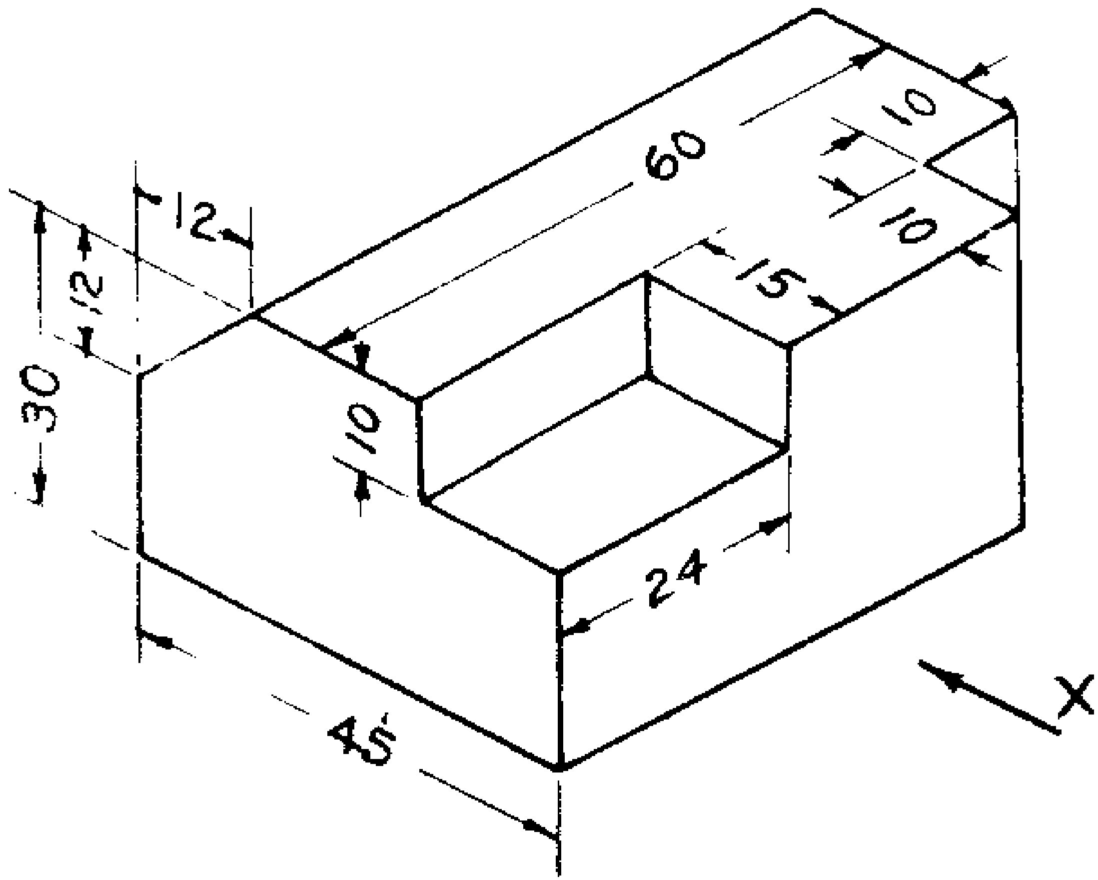
Problem No. 08: Draw the front view, top view and side view from left of the figure shown below.



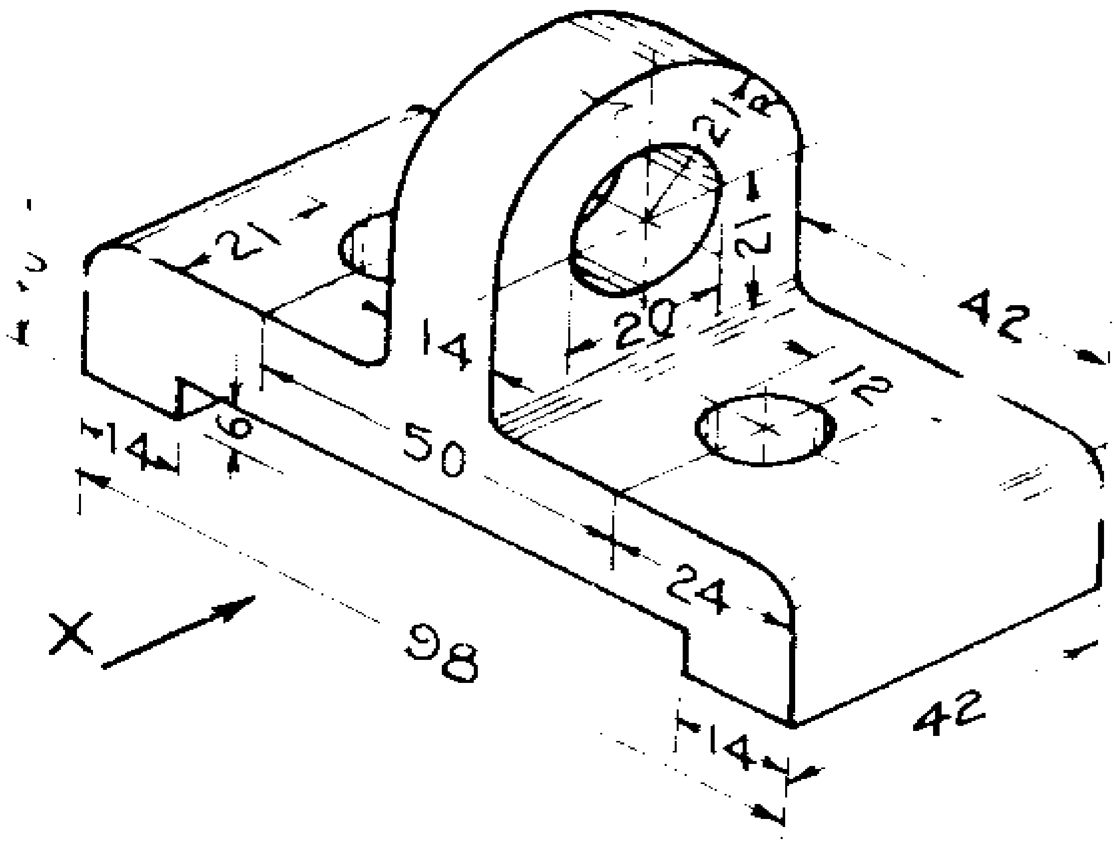
Problem No. 09: Draw the front view, top view and side view from right of the figure shown below.



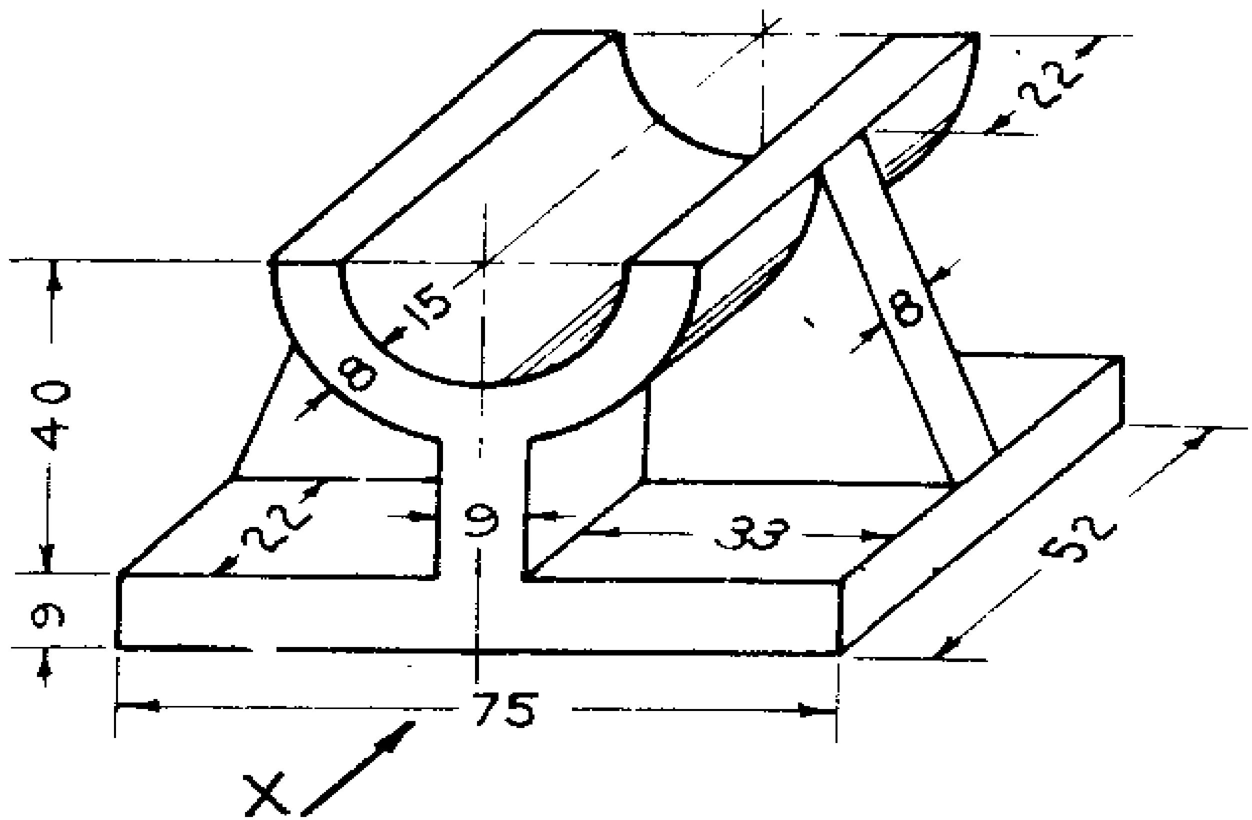
Problem No. 10: Draw the front view, top view and both side view of the figure shown below.



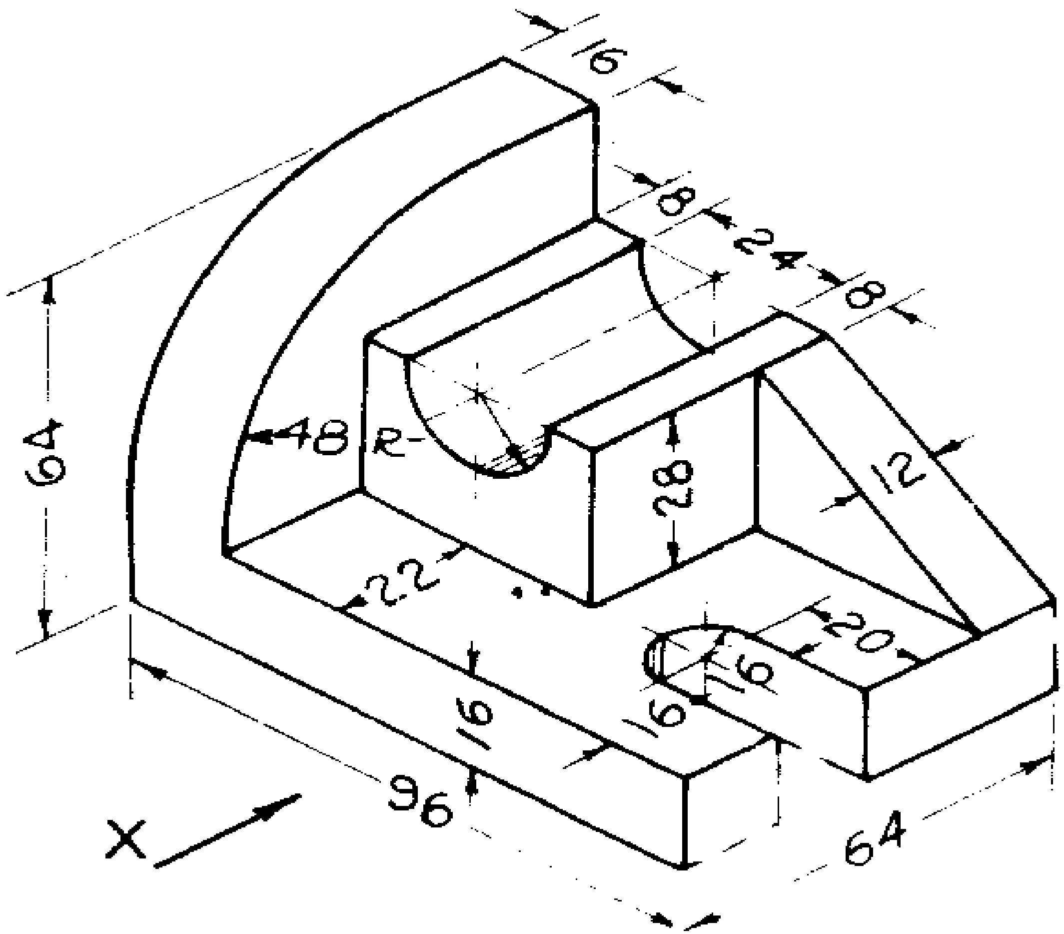
Problem No. 11: Draw the front view, top view and side view of the figure shown below.



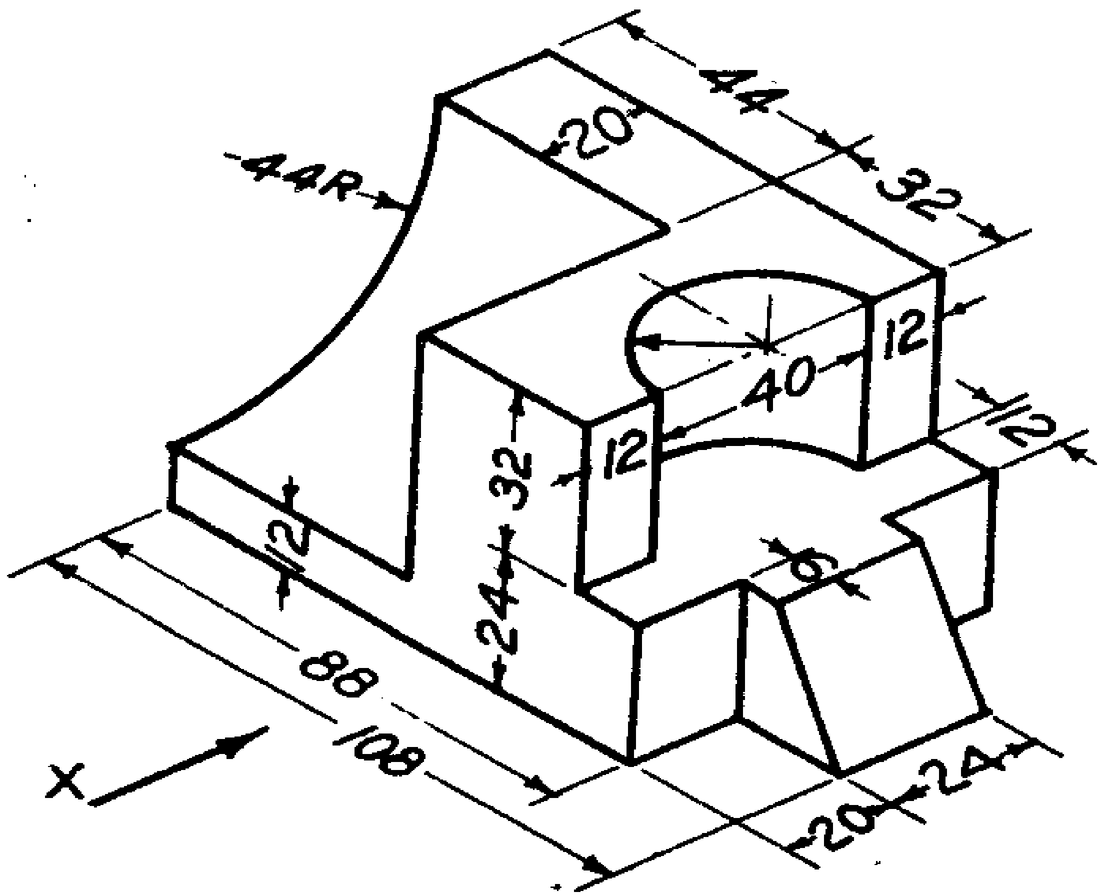
Problem No. 12: Draw the front view, top view and side view from right of the figure shown below.



Problem No. 13: Draw the front view, top view and side view from right of the figure shown below.



Problem No. 14: Draw the front view, top view and both side view of the figure shown below.



UNIT -III

PROJECTIONS OF PLANES

Plane figures or surfaces have only two dimensions, viz. length and breadth. They do not have thickness. A plane figure may be assumed to be contained by a plane, and its projection can be drawn, if the position of that plane with respect to the principal planes of projection is known.

TYPES OF PLANES:

Planes may be divided into following two types:

1. **PERPENDICULAR PLANES.**
2. **OBLIQUE PLANES.**

1. **PERPENDICULAR PLANES:** These planes can be divided into the following sub – types:

i. Perpendicular to both the reference planes.

ii. Perpendicular to one plane and parallel to other.

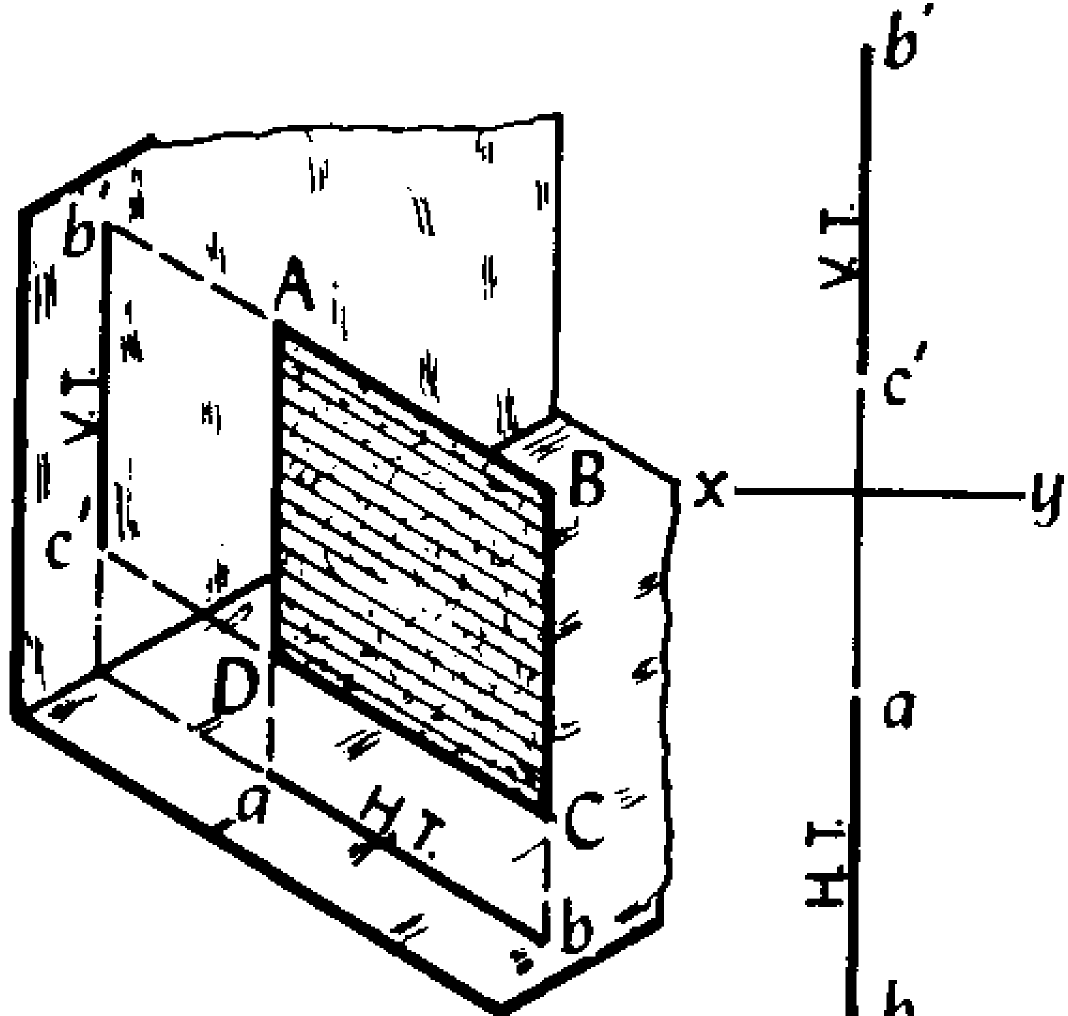
iii. Perpendicular to one plane and inclined to other.

2. **OBLIQUE PLANES:** Planes which are inclined to both the reference planes.

i. PLANE PERPENDICULAR TO BOTH THE REFERENCE PLANES

- A square ABCD is perpendicular to both the reference planes. Its H.T. and V.T. are in a straight line perpendicular to xy.

- The front view b'c' and the top view ab of the square are both lines coinciding with the V.T. and the H.T. respectively.


b'
A
V.T.
c'
B
D
a
H.T.
C
b
x
y
b'
V.T.
c'
a
H.T.
b

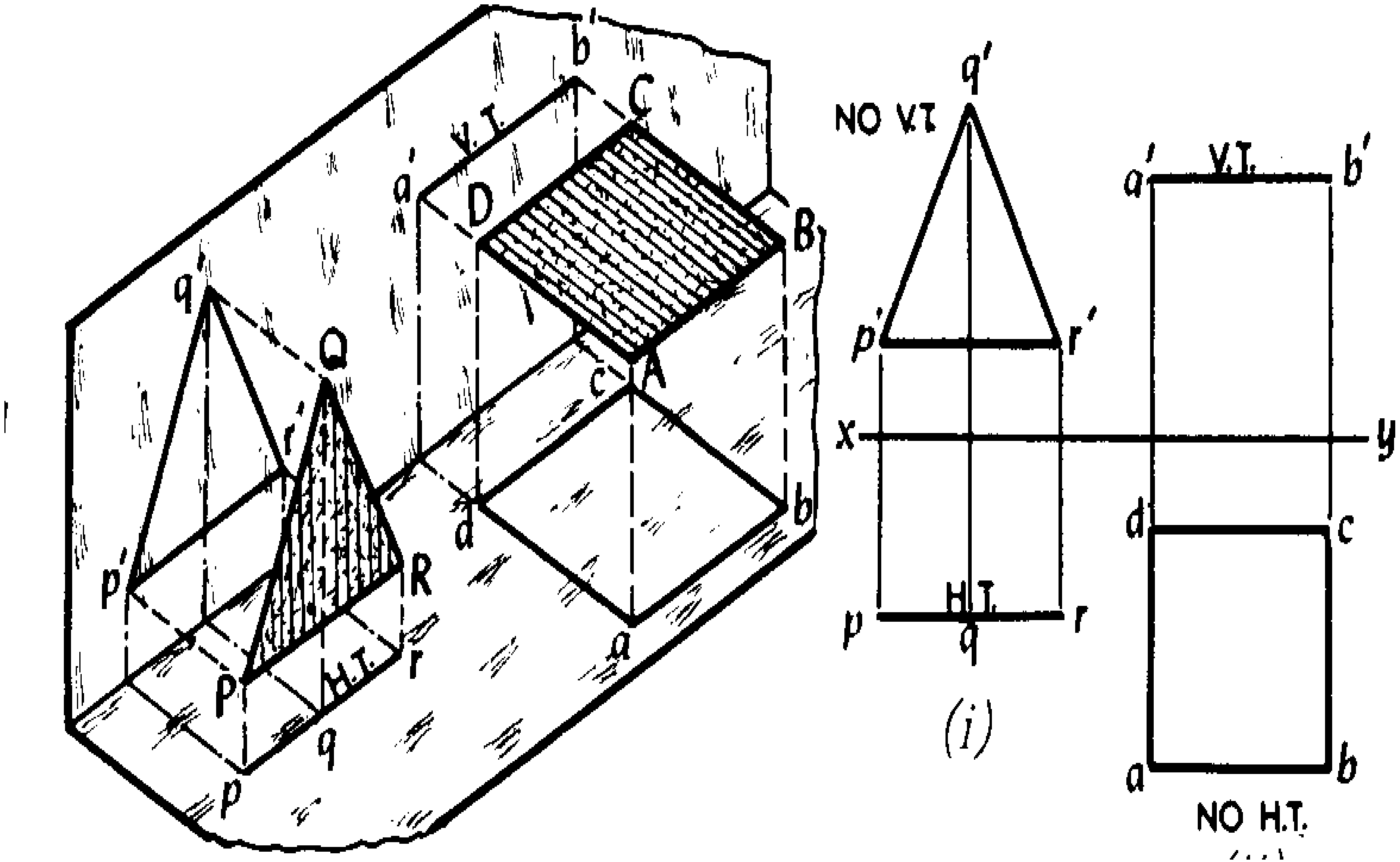
ii. PERPENDICULAR TO ONE OF THE PLANE AND PARALLEL TO OTHER PLANE:

a. PLANE PERPENDICULAR TO THE H.P. AND PARALLEL TO THE V.P.

- A triangle PQR is perpendicular to the H.P. and is parallel to the V.P. Its H.T. is parallel to xy. It has no V.T.
- The front view p'q'r' shows the exact shape and the size of the triangle.
- The top view pqr is a line parallel to the xy. It coincides with the H.T.

b. PLANE PERPENDICULAR TO THE V.P. AND PARALLEL TO THE H.P.

- A square ABCD is perpendicular to the V.P. and parallel to the H.P. Its V.T. is parallel to the xy. It has no H.T.
- The top view abcd shows the true shape and true size of the square. The front view a’b’ is a line, parallel to xy.
- It coincides with the V.T.

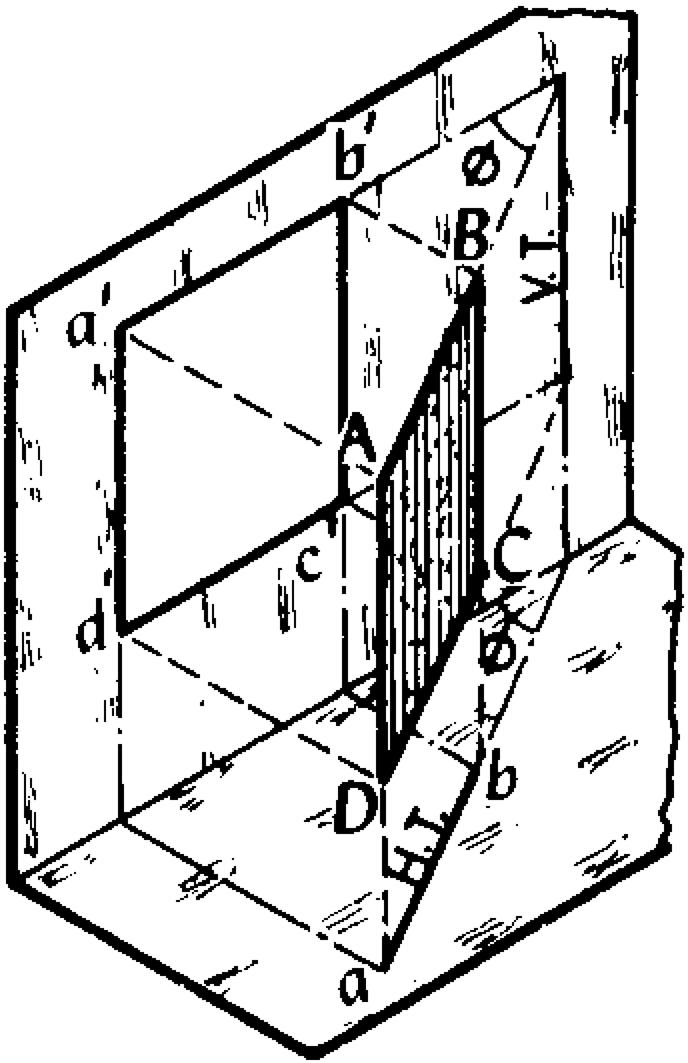


NO V.T
V.T.
H.T.
NO H.T.
x
y
q'
p'
r'
p
q
r
a'
b'
a
b
c
d
A
B
C
D
P
Q
R
(i)

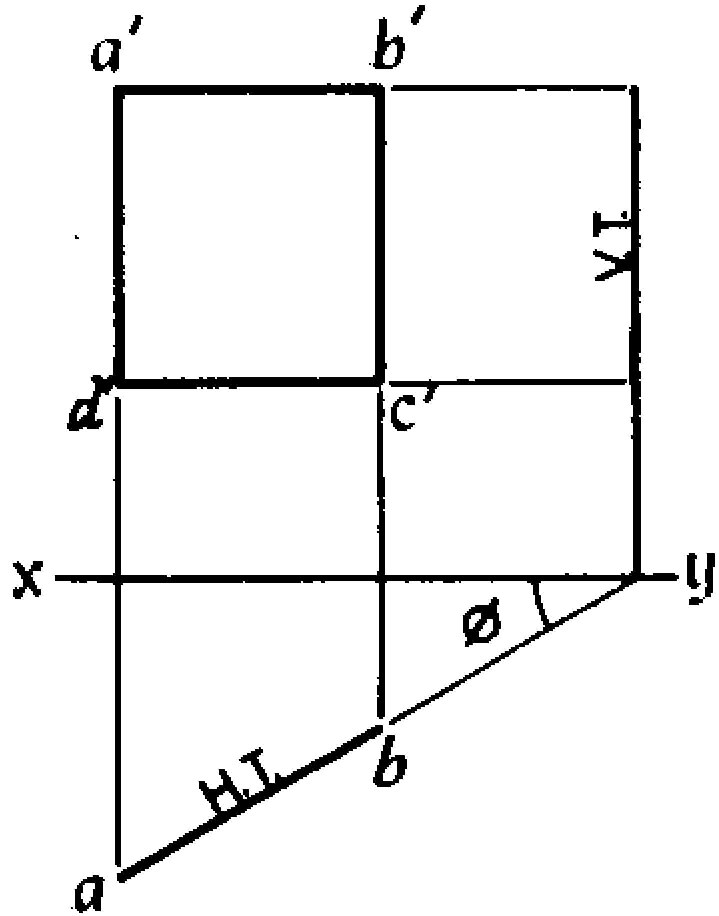
iii. Plane perpendicular to one plane and inclined to other plane

a. PLANE PERPENDICULAR TO THE H.P. AND INCLINED TO THE V.P.

- A square ABCD is perpendicular to the H.P. and inclined at an angle of Ø to the V.P. Its V.T. is perpendicular to xy. Its H.T. is inclined at an angle Ø to the xy.
- Its top view ab is a line inclined at Ø to xy. The front view a'b'c'd' is smaller than ABCD.



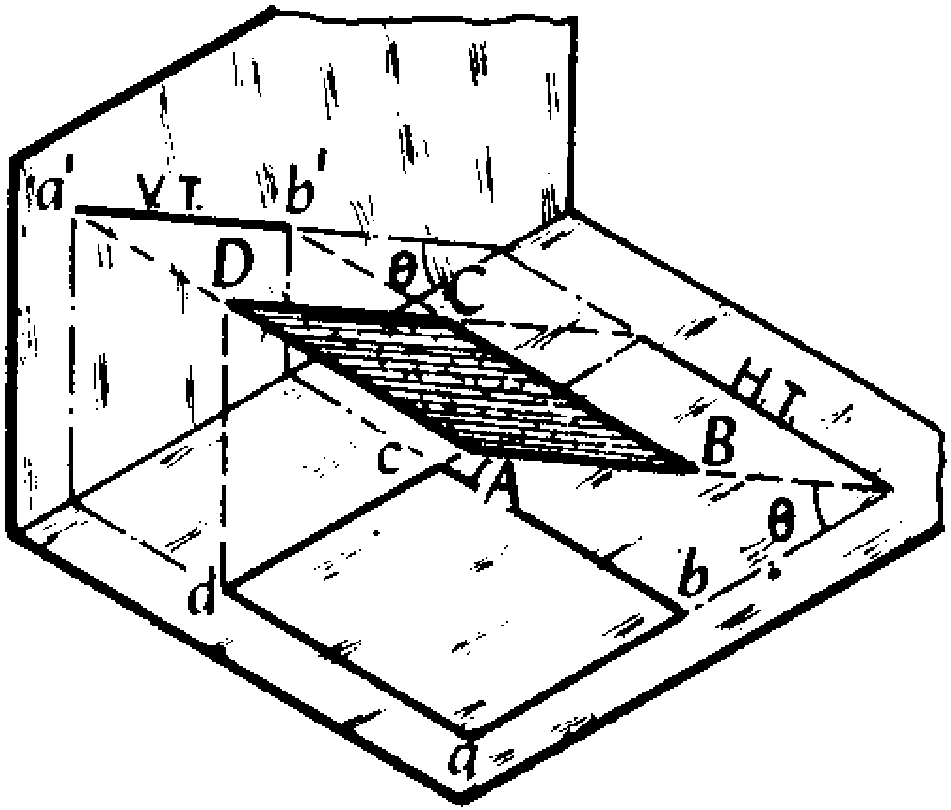
a'
b'
ø
B
V.T.
A
c'
c
C
d'
ø
D
b
H.T.
a

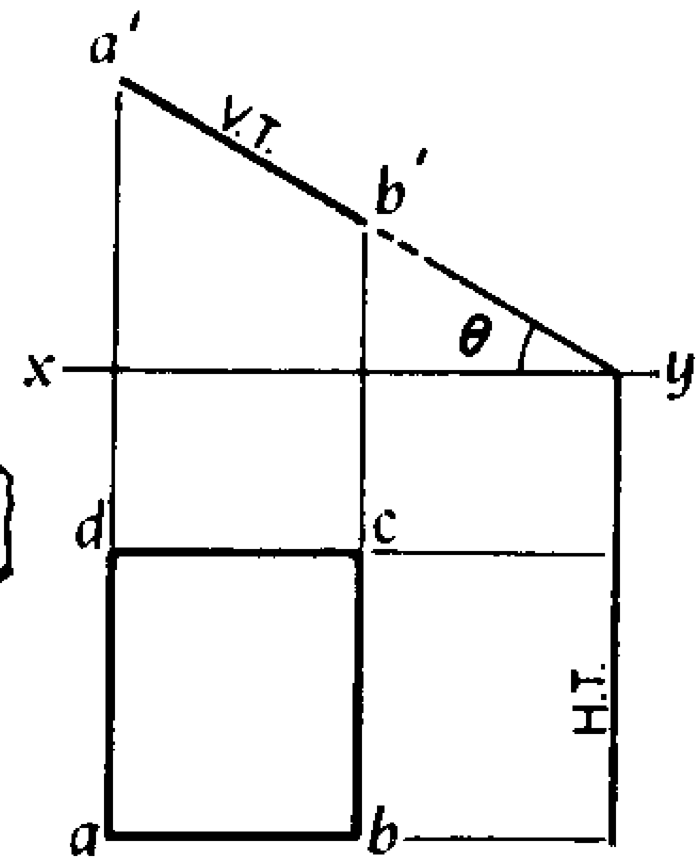


a'
b'
V.T.
d'
c'
x
y
ø
b
H.T.
a

b. PLANE PERPENDICULAR TO THE V.P. AND INCLINED TO THE H.P.

- A square ABCD is perpendicular to the V.P. and inclined at an angle θ to the H.P. Its H.T. is perpendicular to xy. Its V.T. makes an angle θ with xy. Its front view a'b' is a line inclined at θ to xy. The top view abcd is a rectangle which is smaller than the square ABCD.


a'
V.T.
b'
D
θ
C
H.T.
B
c
A
θ
d
b
a


a'
V.T.
b'
θ
x
y
d
c
H.T.
a
b

TRACES OF PLANES

- A plane extended if necessary, will meet the reference planes in lines, unless it is parallel to any one of them. These lines are called the traces of the plane.
- The line in which the plane meets the H.P. is called the horizontal trace or the H.T. of the plane.
- The line in which it meets the V.P. is called its vertical trace or the V.T. A plane is usually represented by its traces.

GENERAL CONCLUSIONS

Traces:

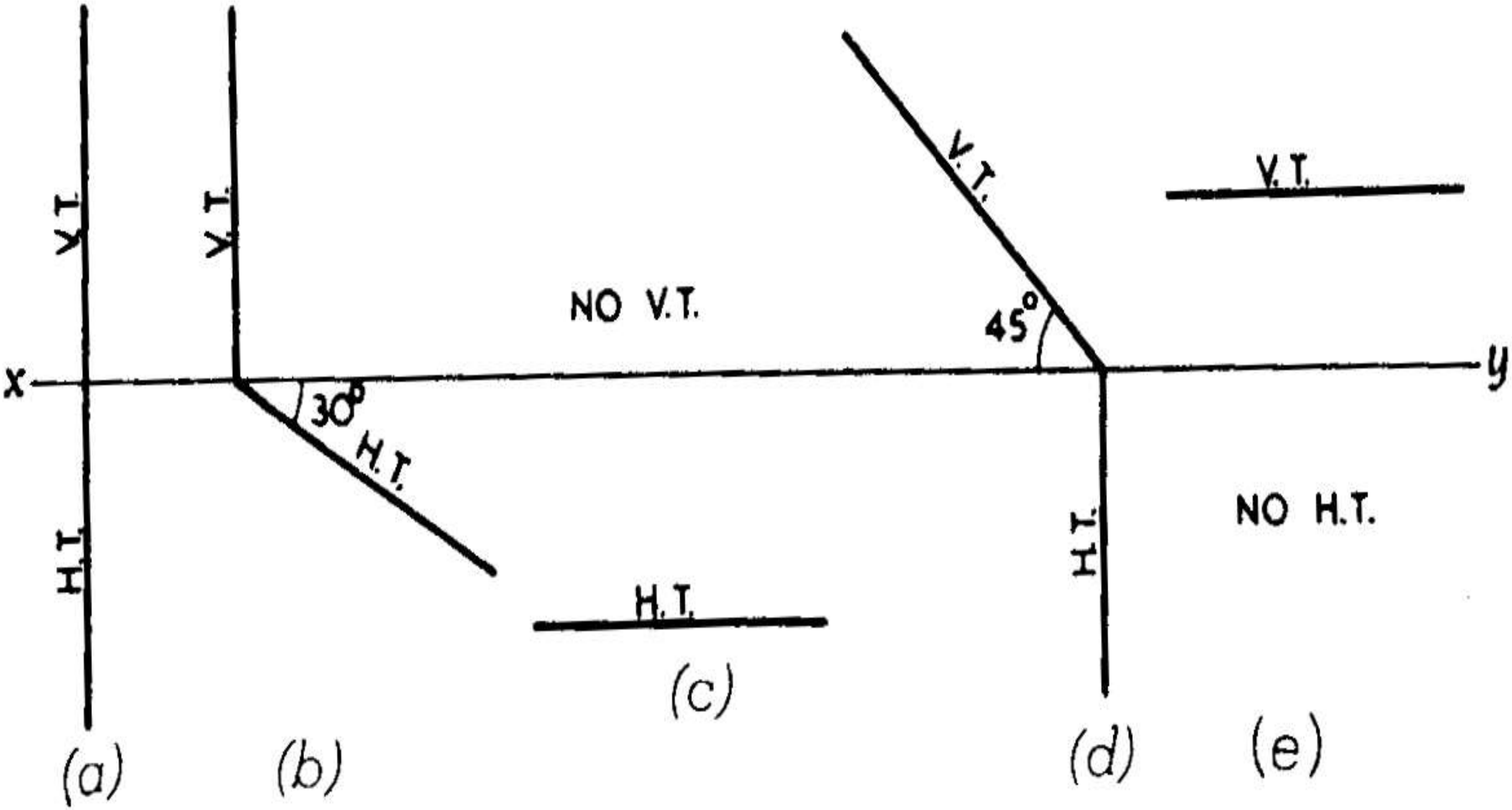
a. When a plane is perpendicular to both the reference planes, its traces lie on a straight line perpendicular to xy.

b. When a plane is perpendicular to one of the reference planes, its trace upon the other plane is perpendicular to xy (except when it is parallel to the other plane).

c. When a plane is parallel to a reference plane, it has no trace on that plane. Its trace on the other reference plane, to which it is perpendicular, is parallel to xy.

d. When a plane is inclined to the H.P. and perpendicular to the V.P., its inclination is shown by the angle which it makes with xy. When it is inclined to the V.P. and perpendicular to the H.P. its inclination is shown by the angle which it makes with the xy.

e. When a plane has two traces, they, produced if necessary, intersect in xy (except when both are parallel to xy as in case of some oblique plane).


V.T.
V.T.
NO V.T.
V.T.
V.T.
45°
x
y
30°
H.T.
H.T.
H.T.
NO H.T.
H.T.
(a)
(b)
(c)
(d)
(e)

GENERAL CONCLUSIONS

Projections:

a. When a plane is perpendicular to a reference plane, its projection on that plane is a straight line.

b. When a plane is parallel to a reference plane, its projection on that plane shows its true shape and size.

c. When a plane is perpendicular to one of the reference planes and inclined to the other, its inclination is shown by the angle which its projection on the plane to which it is perpendicular, makes with xy. Its projection on the plane to which it is inclined, is smaller than the plane itself.

Projections of planes parallel to one of the reference planes:

a. The projection of the plane on one of the reference plane parallel to it will show its true shape. Hence, beginning should be made by drawing that view. The other view which will be a line, should then be projected from it.

b. When the plane is parallel to the H.P.: The top view should be drawn first and the front view should be projected from it.

c. When the plane is parallel to the V.P.: The front view should be drawn first and the top view should be projected from it.

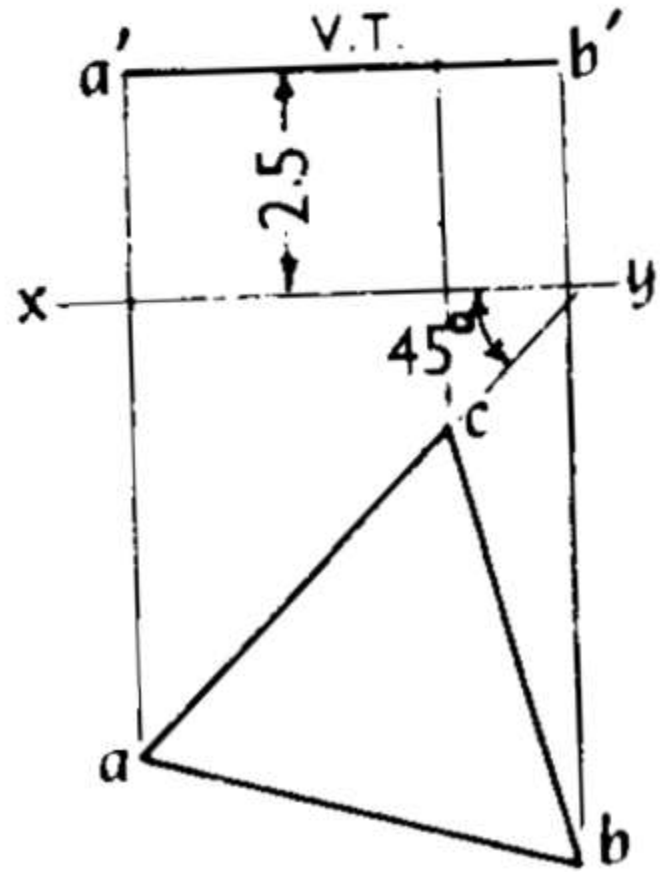
Projections of planes inclined to one of the reference plane and perpendicular to the other:

a. When a plane is inclined to a reference plane, its projection may be obtained in two stages. In the initial stage, the plane is assumed to be parallel to that reference plane to which it has to be made to be inclined. It is then tilted to the required inclination in the second stage.

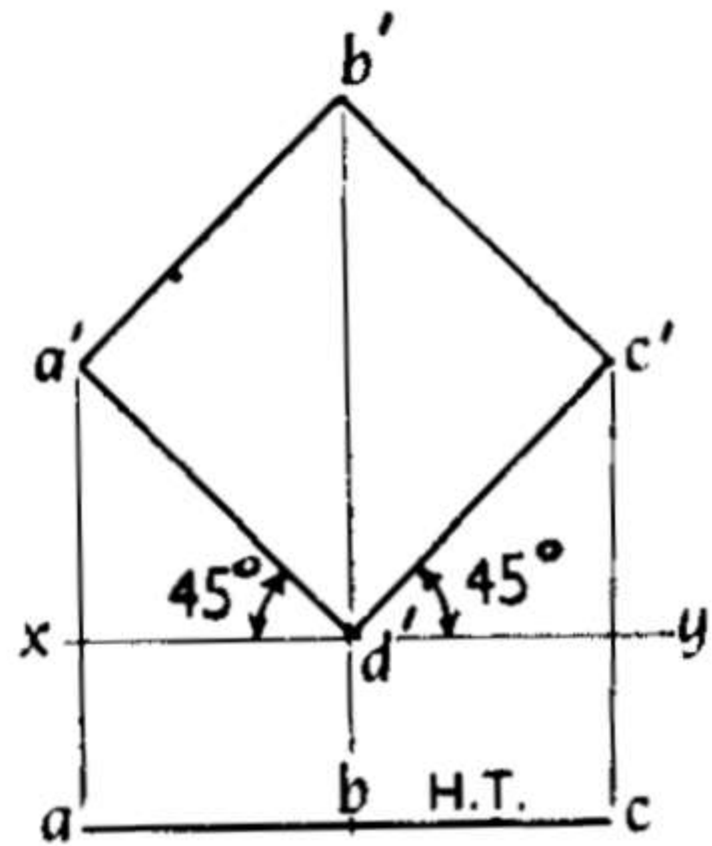
b. Plane, inclined to the H.P. and perpendicular to the V.P.: When the plane is inclined to the H.P. and perpendicular to the V.P., in the initial stage, it is assumed to be parallel to the H.P. Its top view will show the true shape. The front view will be a line parallel to xy. The plane is then tilted so that it is inclined to the H.P. The new front view will be inclined to xy at the true inclination. In the top view the corners will move along their respective paths (parallel to xy).

c. Plane inclined to the V.P. and perpendicular to the H.P.: In the initial stage, the plane may be assumed to be parallel to the V.P. and then tilted to the required position in the next stage.

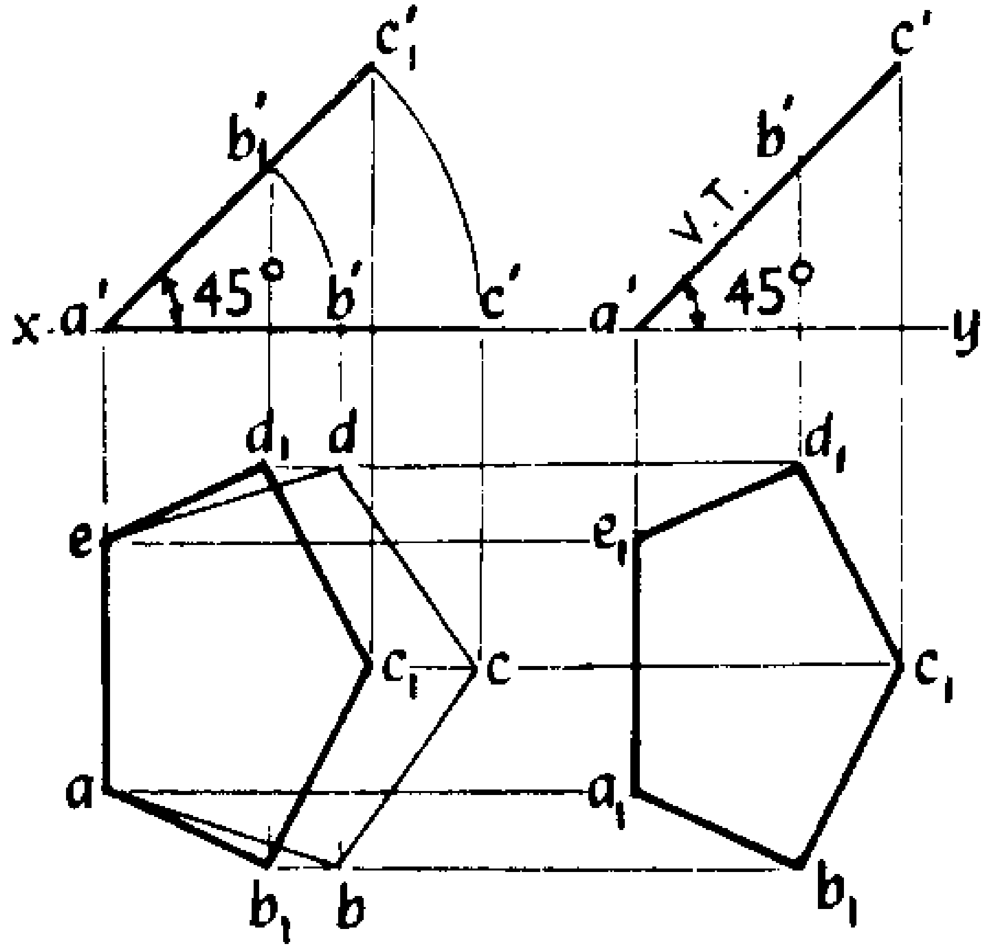
Prob.S1: An equilateral triangle of 5 cm side has its V.T. parallel to and 2.5 cm above xy. It has no H.T. Draw its projections when one of its sides is inclined at 45º to the V.P.



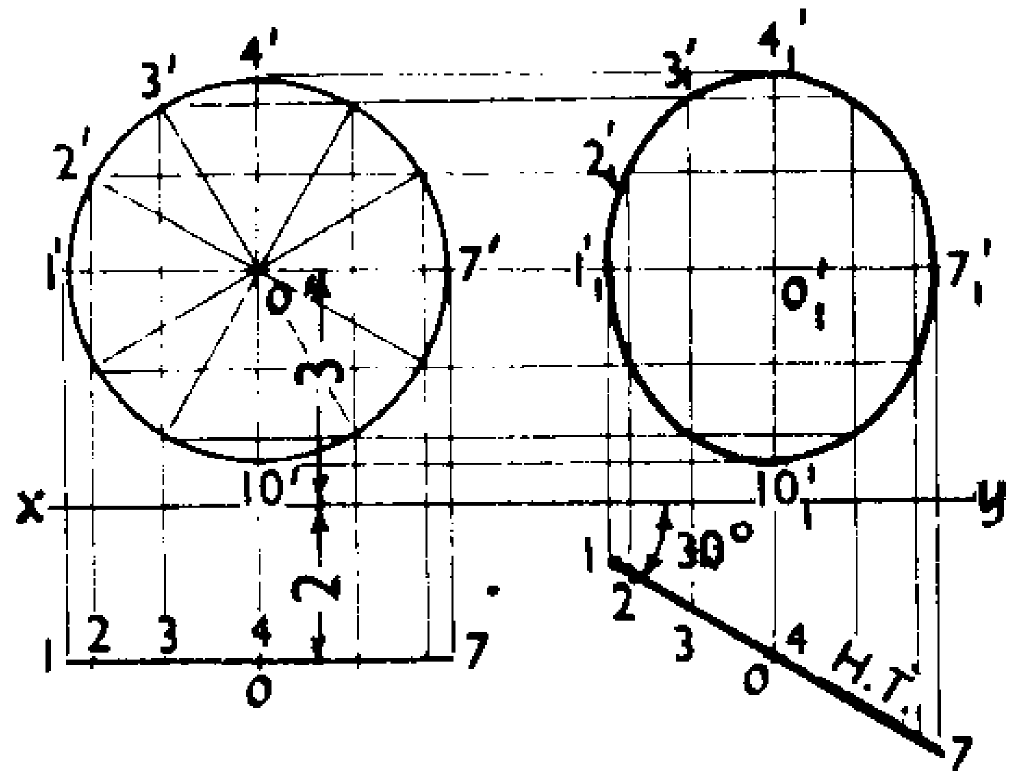
Prob.S2: A square ABCD of 40 mm side has a corner on the H.P. and 20 mm in front of the V.P. All the sides of the square are equally inclined to the H.P. and parallel to the V.P. Draw its projections and show its traces.



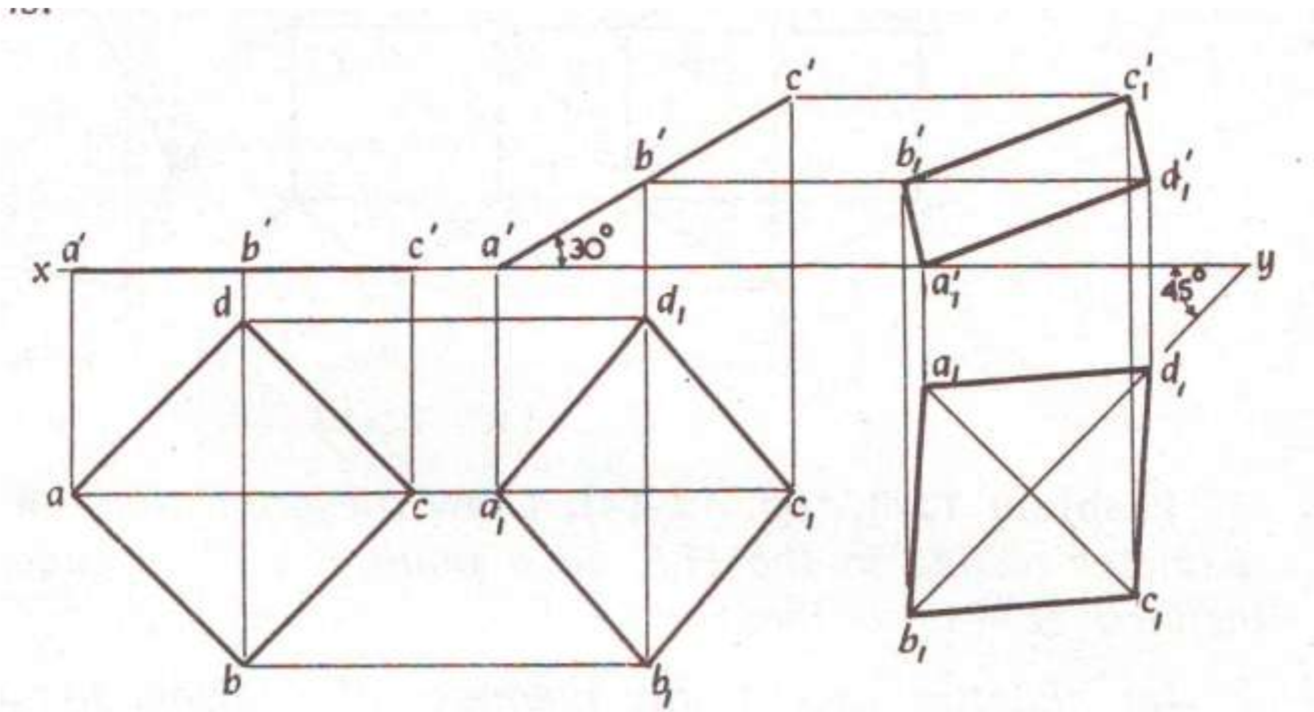
Prob.S3: A regular pentagon of 25 mm side has one side on the ground. Its plane is inclined at 45^o to the H.P. and perpendicular to the V.P. Draw its projections and show its traces.



Prob.S4: Draw the projections of a circle of 5 cm diameter, having its plane vertical and inclined at 30^o to the V.P. Its centre is 3 cm above the H.P. and 2 cm in front of the V.P. Show also its traces.

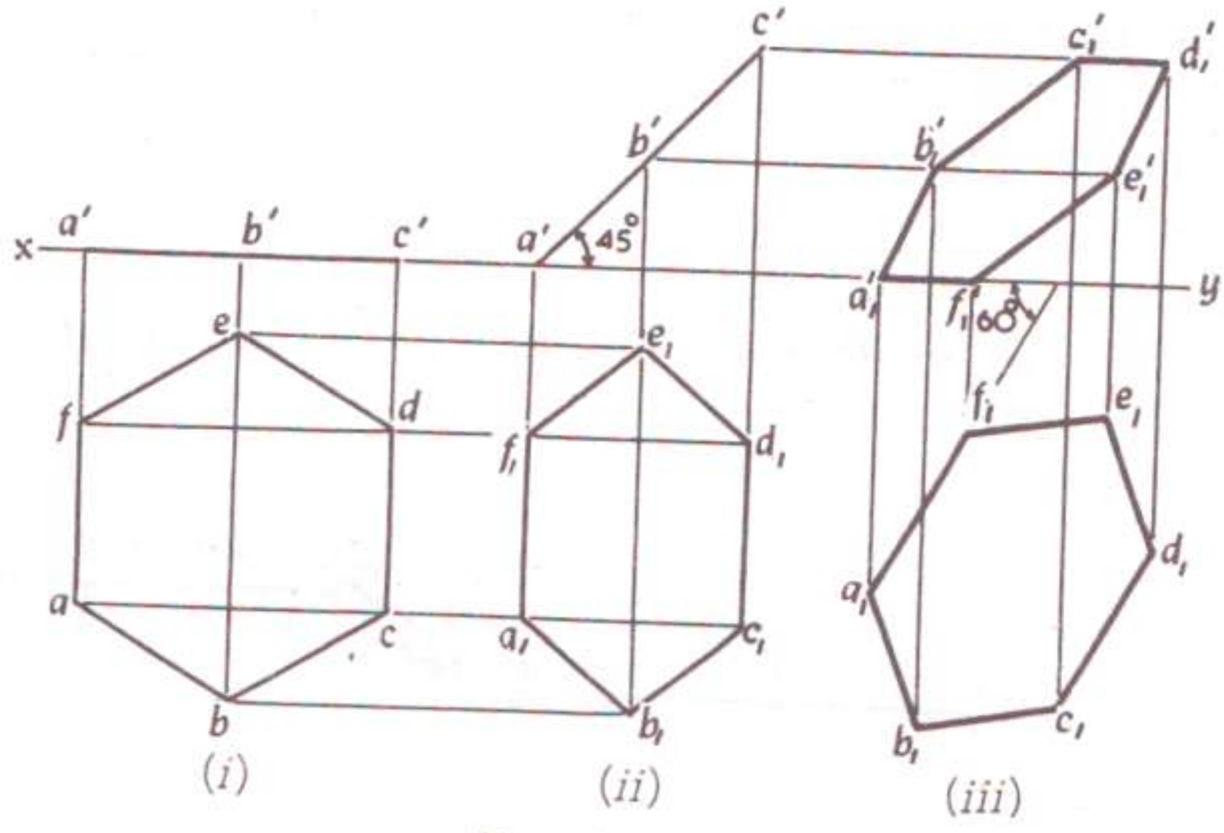


Prob. S5: *A* square *ABCD of 50* mm *side has its corner A in the H.P., its diagonal AC inclined* at 30° to the *H.P. and the diagonal BD inclined* at *45° to the V.P. and parallel* to *the H.P. Draw its projections.*

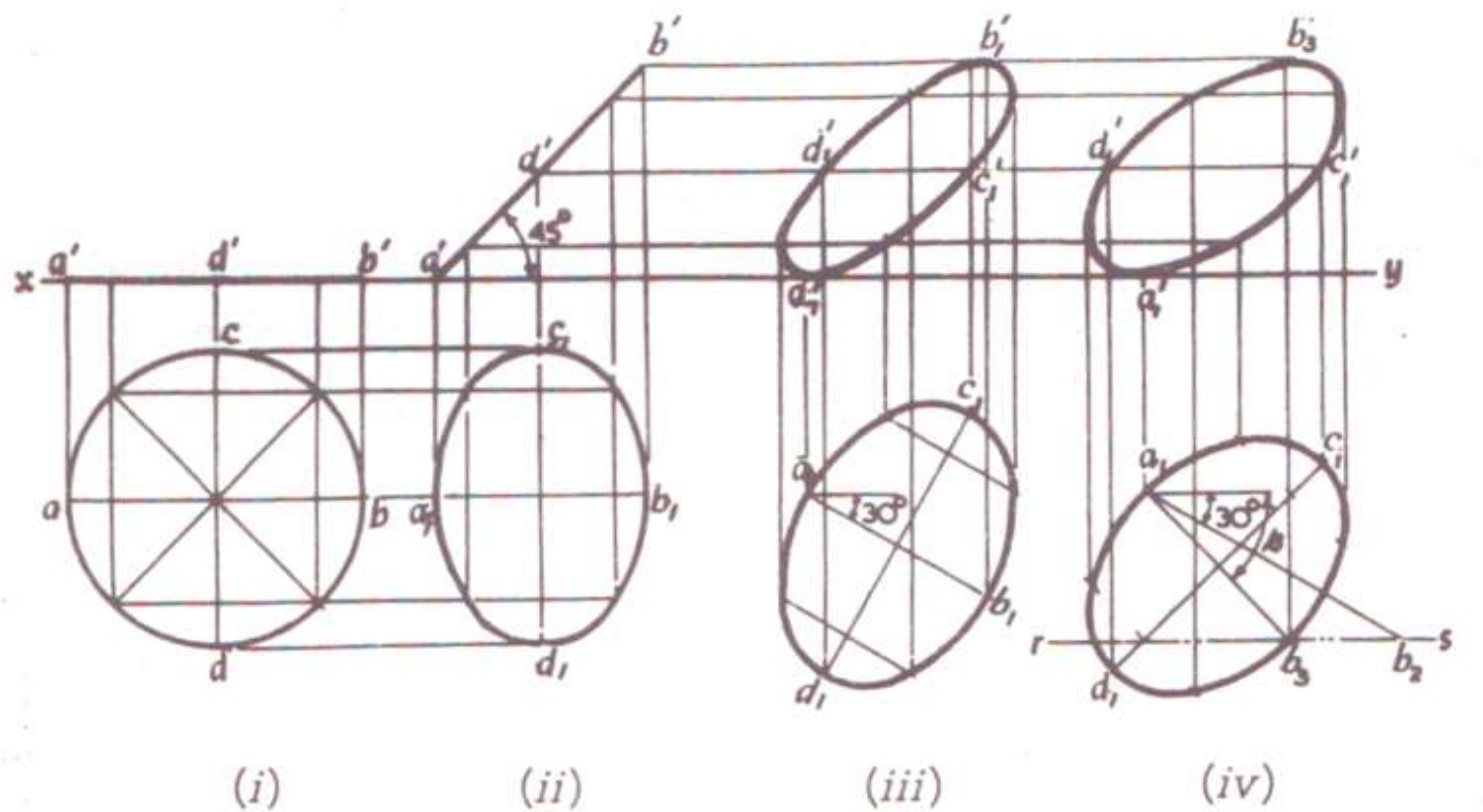


(i) (ii) (iii)

Prob. S6: *Draw the projections of a* regular hexagon *of* 25 mm *side, having one of its sides in the H.PP and inclined at 60° to the V.P.,* and its surface *making an angle of 45° with the H.P.*



Prob. S7: *Draw the projections of a circle of 50 mm diameter resting in the H.PP on a point A on the circumference, its plane inclined at 45° to the H.P. and (a) the top view of the diameter AB making 30° angle with the VP.; (b) the diameter AB making 30° angle with the V.P.*



1. Draw an equilateral triangle of 75 mm side and inscribe a circle in it. Draw the projections of the figure, when its plane is vertical and inclined to 30^0 to the V.P. and one of the sides of the triangle is inclined at 45^0 to the H.P.
2. A regular hexagon of 40 mm side has a corner in the H.P. Its surface is inclined at 45^0 to the H.P. and the top view of the diagonal through the corner which is in the H.P. makes an angle of 60^0 with the V.P. Draw its projections.
3. Draw the projections of a regular pentagon of 40 mm side, having its surface inclined at 30^0 to the H.P. and a side parallel to the H.P. and inclined at an angle of 60^0 to the V.P.

4. Draw the projections of a rhombus having diagonals 125 mm and 50 mm long, the smaller diagonal of which is parallel to both the principal planes, while the other is inclined at 30° to the H.P.

5. Draw a regular hexagon of 40 mm side, with its two sides vertical. Draw a circle of 40 mm diameter in its centre. The figure represents a hexagonal plate with a hole in it and having its surface parallel to the V.P. Draw its projections when the surface is vertical and inclined at 30° to the V .P. Assume the thickness of the plate to be equal to that of a line.

6. Draw the projections of a circle of 75 mm diameter having the end *A* of the diameter *AB* in the H.P., the end *B* in the V.P., and the surface inclined at 30° to the H.P and at 60° to the V.P.

7. A semi-circular plate of 80 mm diameter has its straight edge in the V.P and inclined at 45° to the H.P. The surface of the plate makes an angle of 30° with the V.P. Draw its projections.

8. The top view of a plate, the surface of which is perpendicular to the V.P and inclined at 60° to the H.P is a circle of 60 mm diameter. Draw its three views.

9. A plate having shape of an isosceles triangle has base 50 mm long and altitude 70 mm. It is so placed that in the front view it is seen as an equilateral triangle of 50 mm sides and one side inclined at 45° to *xy.* Draw its top view.

10. Draw a rhombus of diagonals 100 mm and 60 mm long, with the longer diagonal horizontal. The figure is the top view of a square of 100 mm long diagonals, with a corner on the ground. Draw its front view and determine the angle which its surface makes with the ground.

11. A composite plate of negligible thickness is made-up of a rectangle 60 mm x 40 mm, and a semi-circle on its longer side. Draw its projections when the longer side is parallel to the H.P and inclined at 45° to the V.P., the surface of the plate making 30° angle with the H.P.

12. A 60° set-square of 125 mm longest side is so kept that the longest side is in the H.P making an angle of 30° with the V .P. and the set-square itself inclined at 45° to the H.P. Draw the projections of the set-square.

13. A plane figure is composed of an equilateral triangle *ABC* and a semi-circle on *AC* as diameter. The length of the side *AB is* 50 mm and is parallel to the V.P. The corner *B is* 20 mm behind the V.P. and 15 mm below the H.P. The plane of the figure is inclined at 45° to the H.P. Draw the projections of the plane figure.

14. An equilateral triangle *ABC* having side length as 50 mm is suspended from a point 0 on the side *AB* 15 mm from *A* in such a way that the plane of the triangle makes an angle of 60° with the V.P. The point 0 is 20 mm below the H.P and 40 mm behind the V .P. Draw the projections of the triangle.

15.PQRS and *ABCD* are two square thin plates with their diagonals measuring 30 mm and 60 mm. They are touching the H.P with their corners P and *A* respectively, and touching each other with their corresponding opposite corners R and C. If the plates are perpendicular to each other and perpendicular to V.P also, draw their projections and determine the length of their sides.

PROJECTIONS OF SOLIDS

A solid has three dimensions, viz. length, breadth and thickness. To represent a solid on a flat surface having only length and breadth, at least two orthographic views are necessary. Sometimes, additional views projected on auxiliary planes become necessary to make the description of solid complete.

TYPES OF SOLIDS

Solids may be divided into two main groups:

1. **Polyhedra**
2. **Solids of revolution**

1. **Polyhedra:** A polyhedron is defined as a solid bounded by planes called faces.

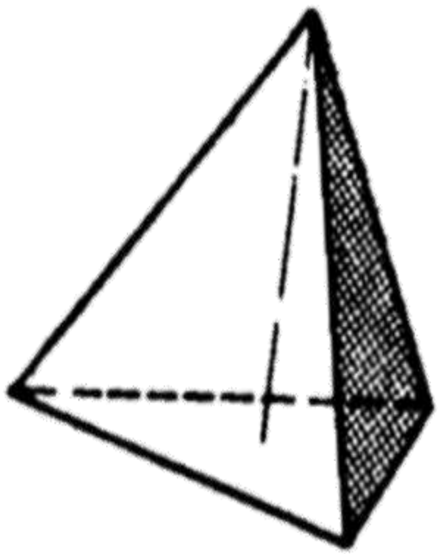
   When all the faces are equal and regular, the polyhedron is said to be regular.

   There are seven regular polyhedra as below:

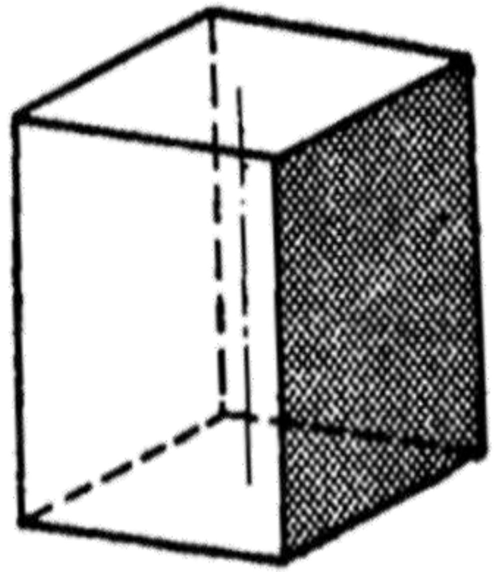
   a) Tetrahedron: It has four equal faces, each an equilateral triangle.

   b) Cube or hexahedron: It has six faces, all equal squares.

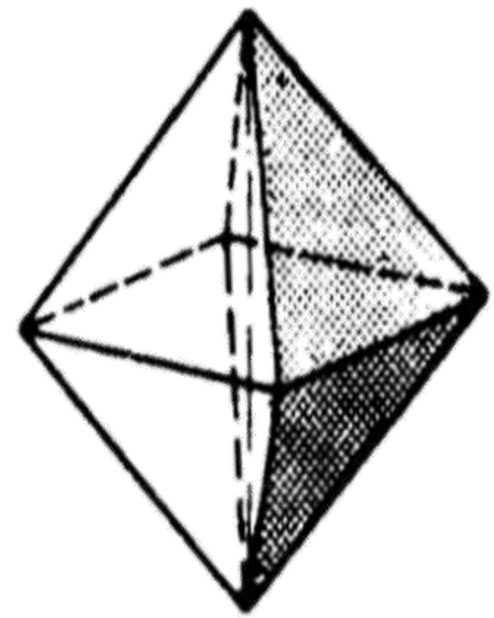
   c) Octahedron: It has eight equal equilateral triangles as faces.



Tetrahedron



Cube



Octahedron

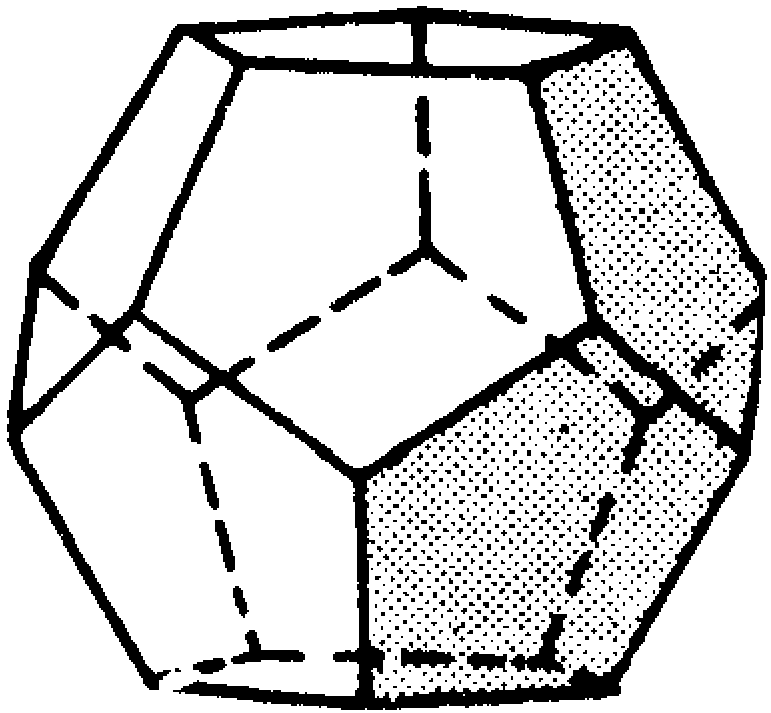
d) Dodecahedron: It has twelve equal and regular pentagons as faces.

e) Icosahedron: It has twenty faces, all equal equilateral triangles.

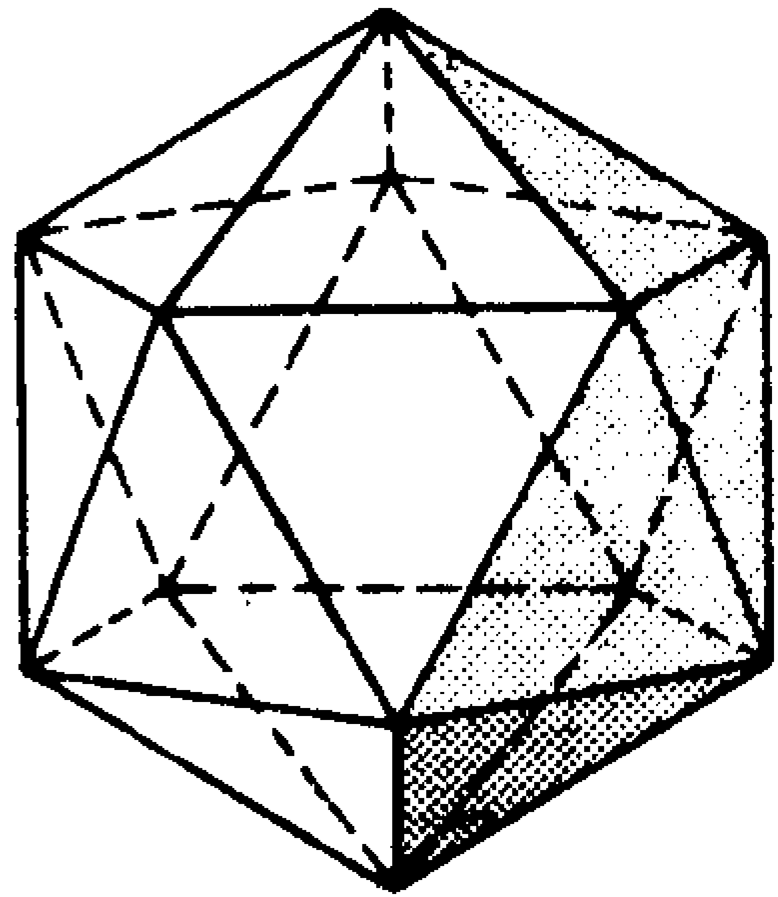
f) Prism: This is a polyhedron having two equal and similar faces called its ends or bases, parallel to each other and joined by other faces which are rectangles or parallelograms.

The imaginary line joining the centers of bases is called as the axis.

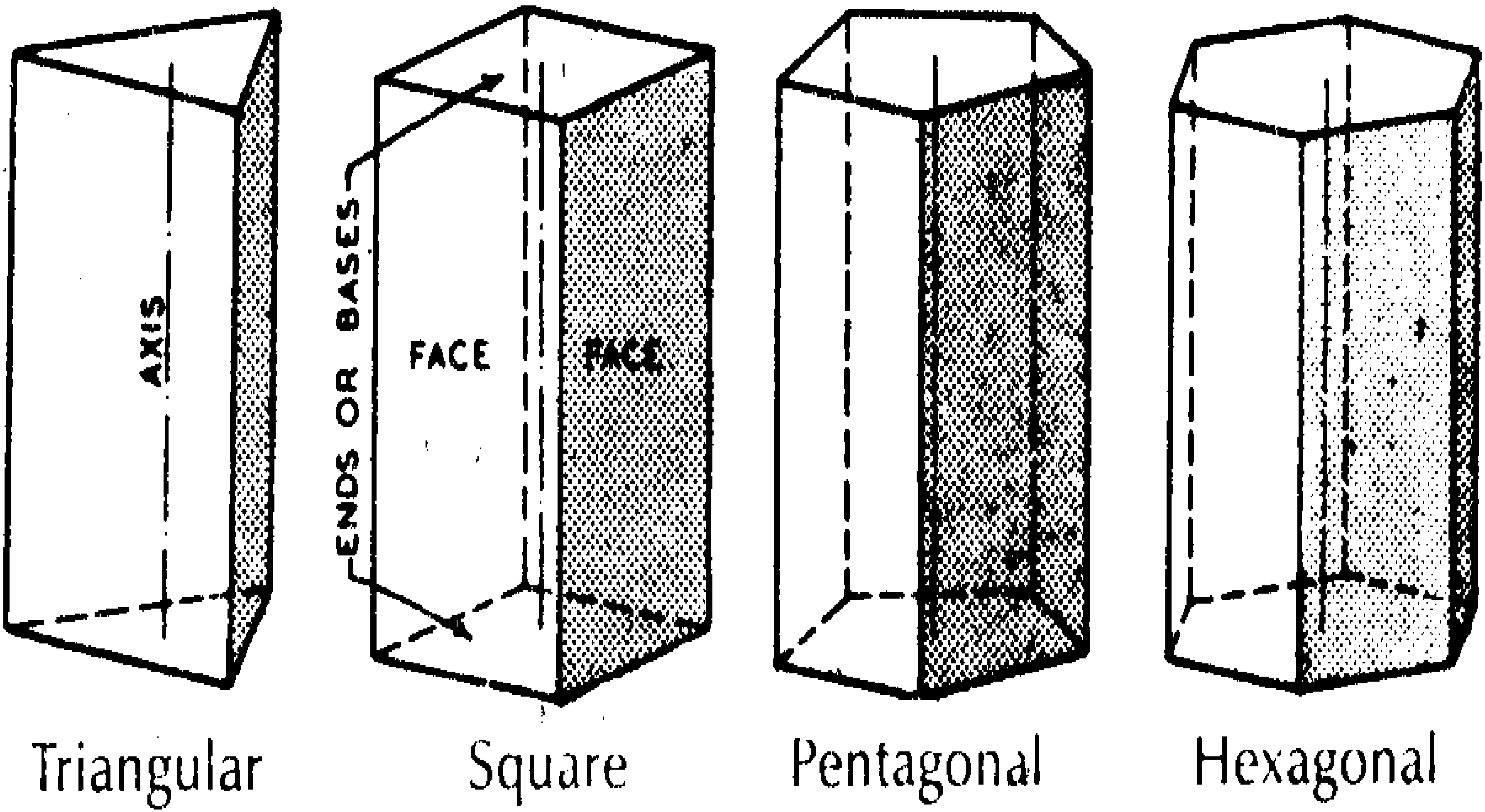
A right and regular prism has its axis perpendicular to the bases. All its faces are equal rectangles.



Dodecahedron



Icosahedron


AXIS
ENDS OR BASES
FACE
FACE
Triangular
Square
Pentagonal
Hexagonal

Prisms

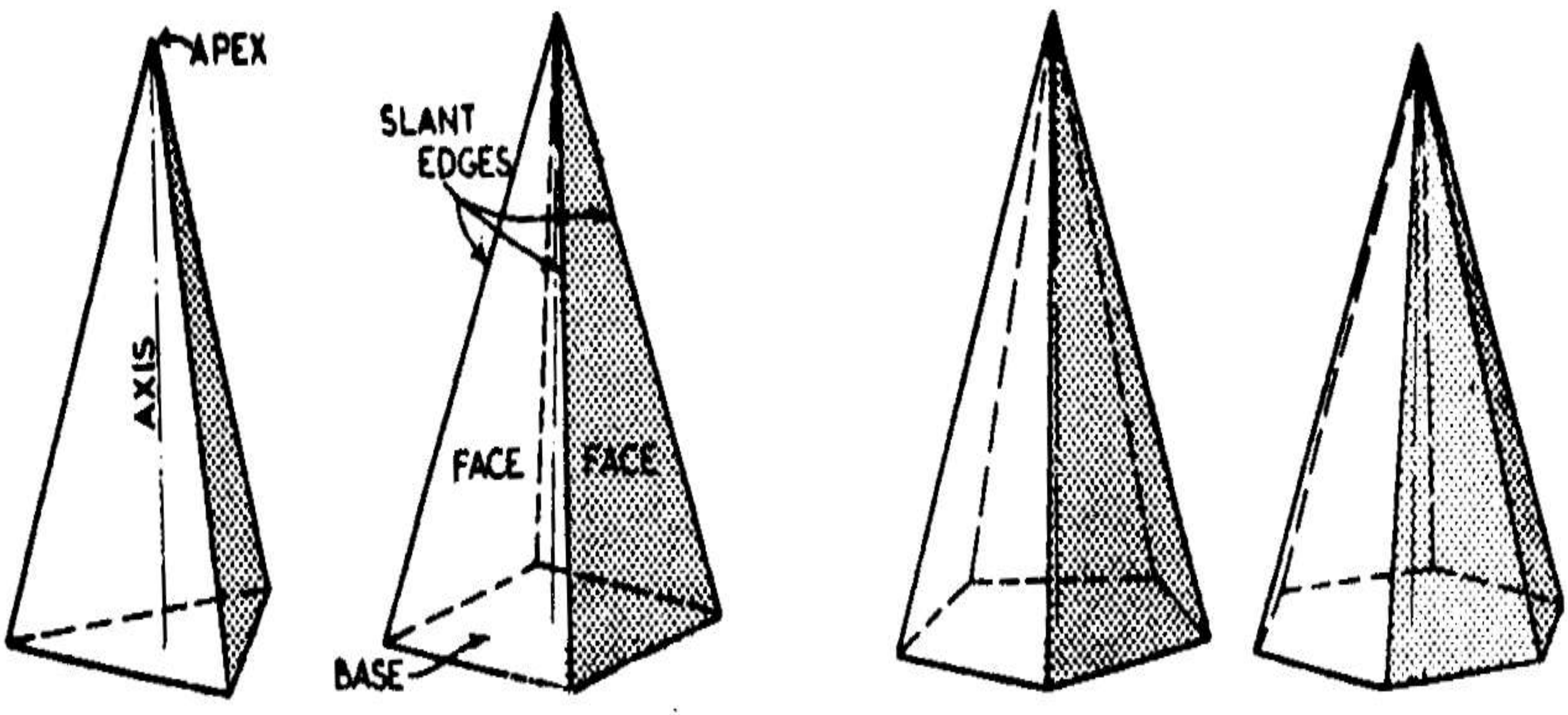
g) Pyramid: This is a polyhedron having a plane figure as a base and a number of triangular faces meeting at a point called the vertex or apex.

The imaginary line joining the apex with the centre of the base is its axis.

A right and regular pyramid has its axis perpendicular to the base which is a regular plane figure. Its faces are all equal isosceles triangles.

Oblique prisms and pyramids have their axes inclined to their bases.

Prisms and pyramids are named according to the shape of their bases, as triangular, square, pentagonal, hexagonal etc.



Triangular Square Pentagonal Hexagonal

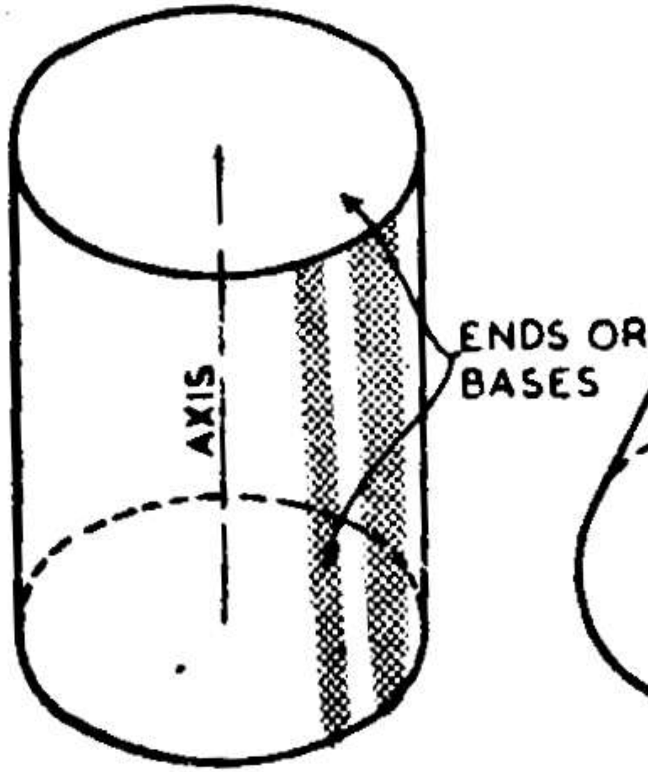
Pyramids

2. SOLIDS OF REVOLUTION

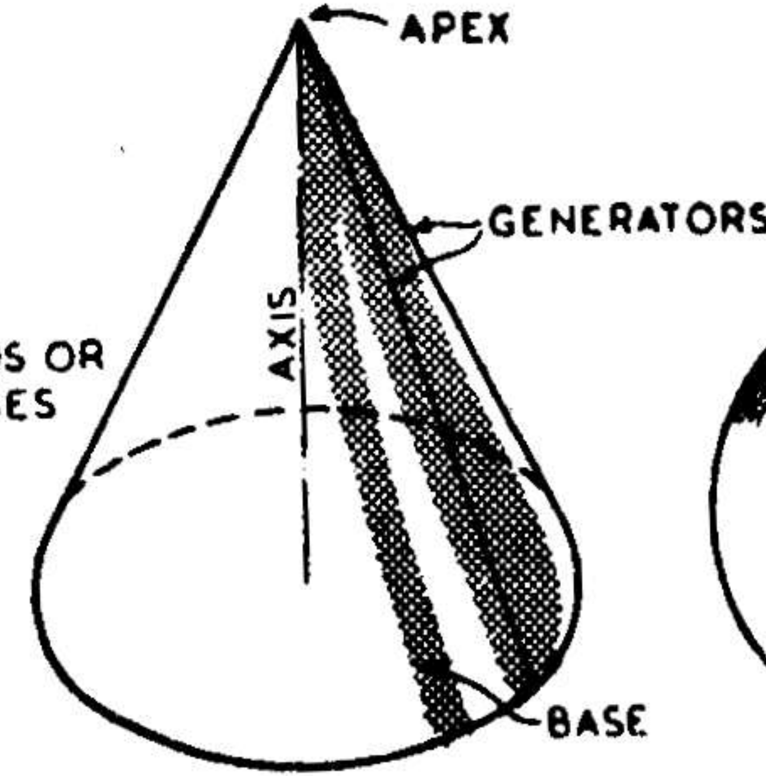
a) Cylinder: A right circular cylinder is a solid generated by the revolution of a rectangle about one of its side which remains fixed. It has two equal circular bases. The line joining the centers of the bases is the axis. It is perpendicular to the bases.

b) Cone: A right circular cone is a solid generated by the revolution of a right – angled triangle about one of its perpendicular sides which is fixed.

It has one circular base. Its axis joins the apex with the centre of the base to which it is perpendicular. Straight lines drawn from the apex to the circumference of the base circle are all equal and are called generators of the cone. The length of the generator is the slant height of the cone.



Cylinder



Cone

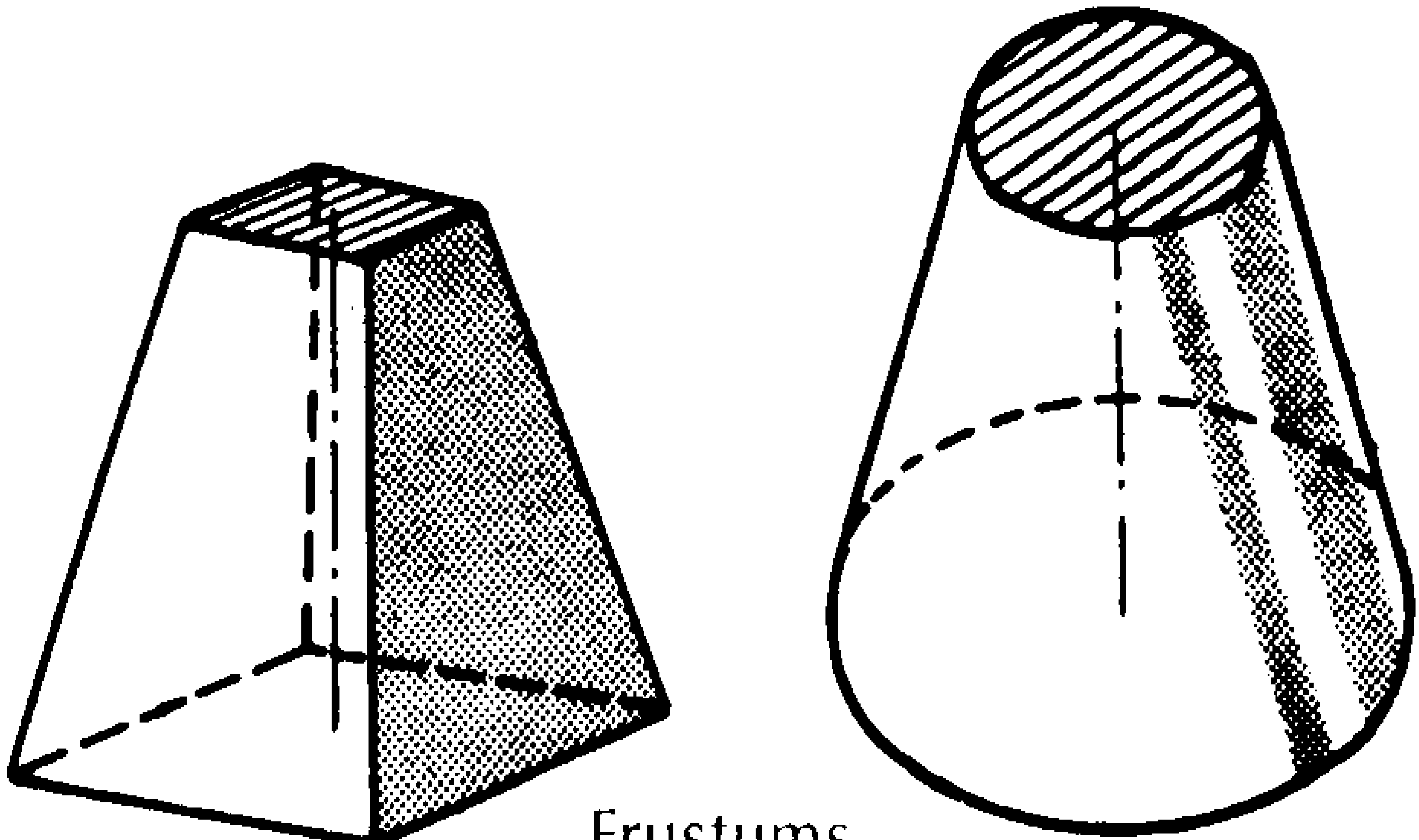
Sphere

c) Sphere: A sphere is a solid generated by the revolution of a semicircle about its diameter as the axis. The mid point of the diameter is the centre of the sphere. All points on the surface of the sphere are equidistant from its centre.

Oblique cylinders and cones have their axes inclined to their bases.

d) Frustum: When a pyramid or cone is cut by a plane parallel to its base, thus removing the top portion, the remaining portion is called its frustum.

e) Truncated: When a solid is cut by a plane inclined to the base it is said to be truncated.



Frustums

PROJECTIONS OF SOLIDS

1. Projections of solids in simple positions.

   a) Axis perpendicular to the H.P.
   b) Axis perpendicular to the V.P.
   c) Axis parallel to both the H.P. and the V.P.

2. Projections of solids with axes inclined to one of the reference planes and parallel to the other.

   a) Axis inclined to the V.P. and parallel to the H.P.
   b) Axis inclined to the H.P. and parallel to the V.P.

3. Projections of solids with axes inclined to both the H.P. and the V.P.

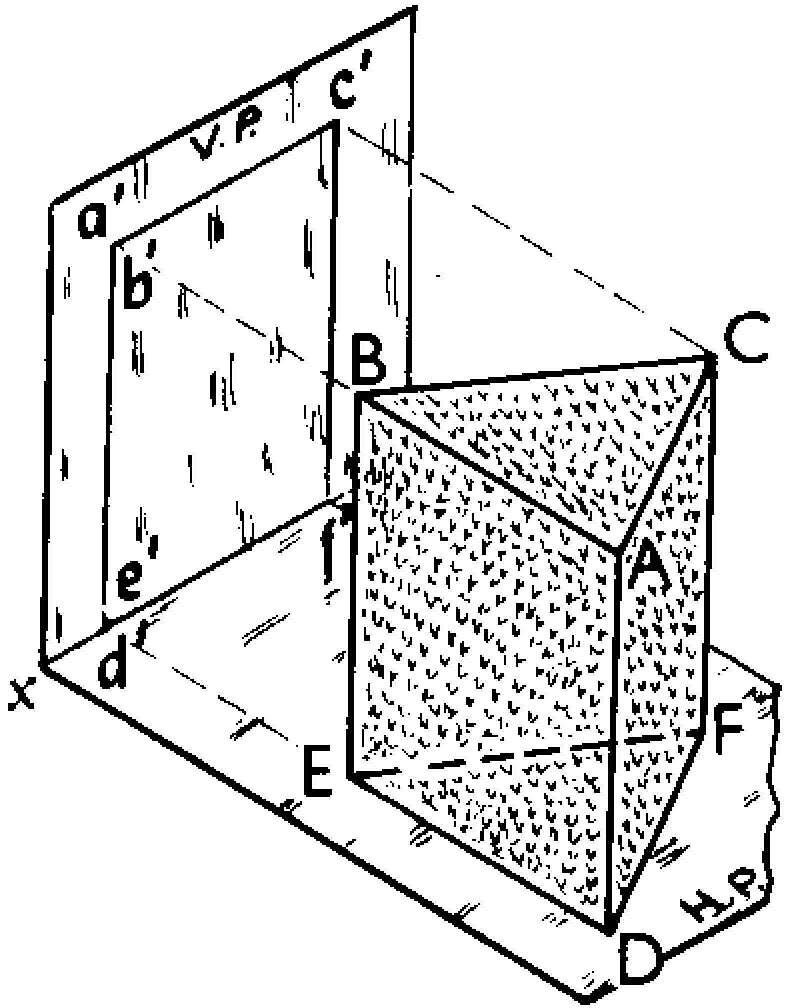
1. PROJECTIONS OF SOLIDS IN SIMPLE POSITIONS:

- A solid in a simple position may have its axis perpendicular to one reference plane or parallel to both.
- When the axis is perpendicular to one reference plane, it is parallel to the other.
- Also, when the axis of the solid is perpendicular to a plane, its base will be parallel to that plane.
- We have already seen that when a plane is parallel to a reference plane, its projection on that plane shows its true shape and size.
- Therefore, the projection of a solid on the plane to which its axis is perpendicular, will show the true shape and size of its base.

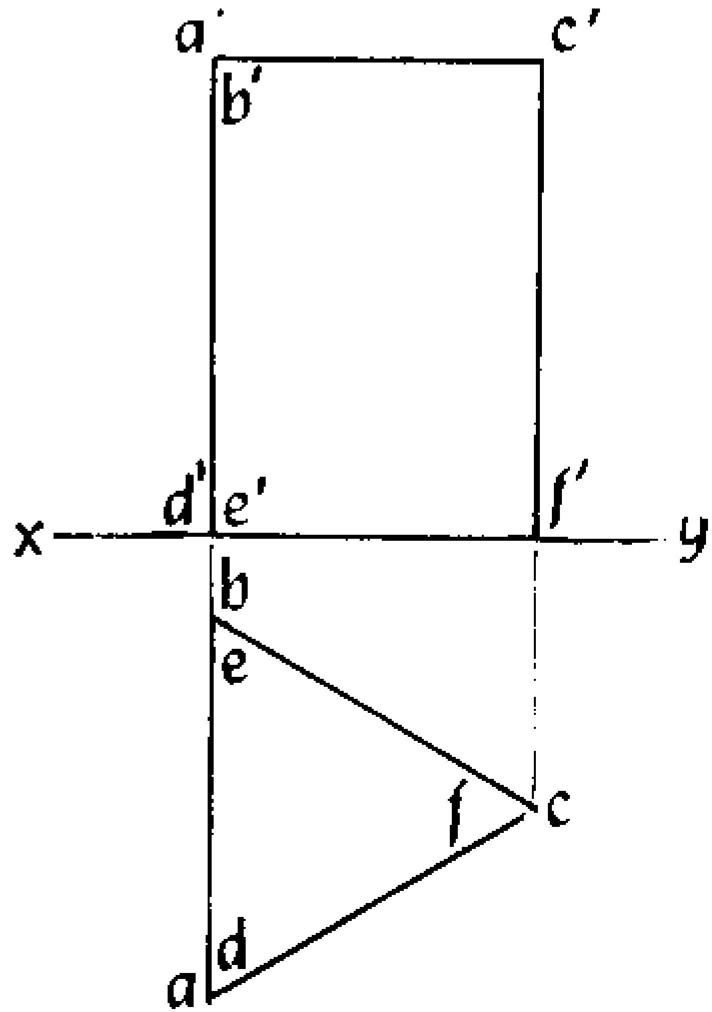
- Hence, when the axis is perpendicular to the ground, i.e. to the H.P., the top view should be drawn first and the front view should be projected from it.
- When the axis is perpendicular to the V.P., beginning should be made with the front view. The top view should be projected from it.
- When the axis is parallel to both the H.P. and the V.P., neither the top view nor the front view will show the actual shape of the base.
- In this case, the projection of the solid on an auxiliary plane perpendicular to both the planes, viz. the side view must be drawn first.
- The front view and the top view are then projected from the side view. The projection in such cases may also drawn in two stages.

Problem 01:

Draw the projections of a triangular prism, base 40 mm side and axis 50 mm long, resting on one of its bases on the H.P. with a vertical face perpendicular to the V.P.



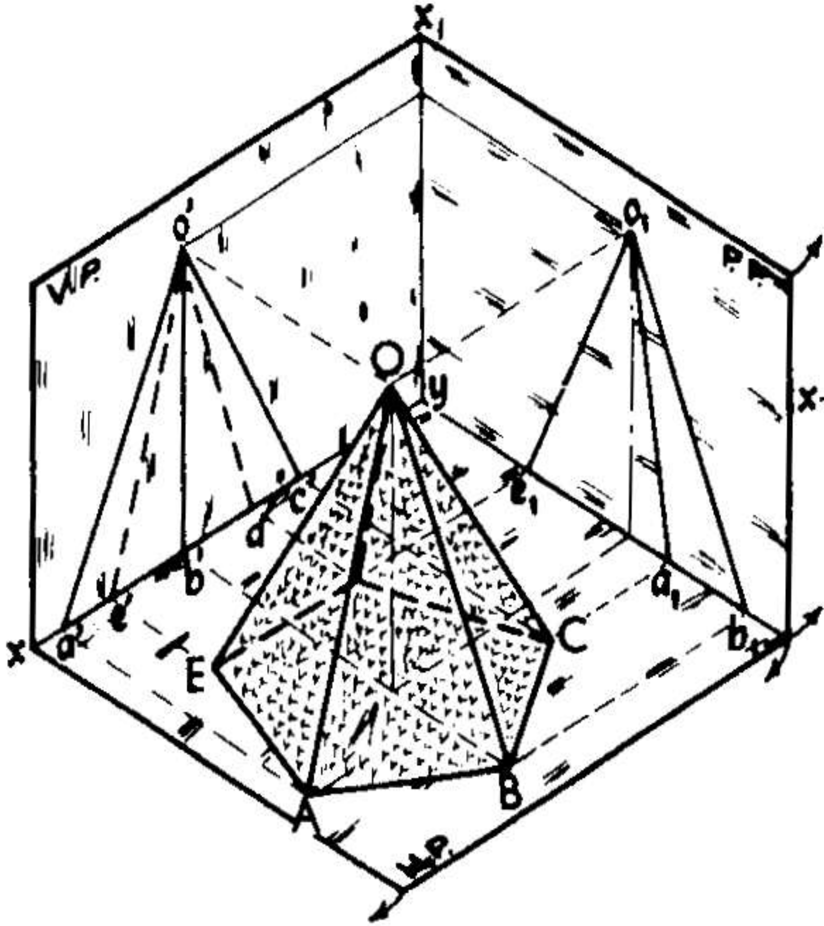
a'
c'
V.P.
b'
B
C
e'
f'
A
d'
x
F
E
D
H.P.

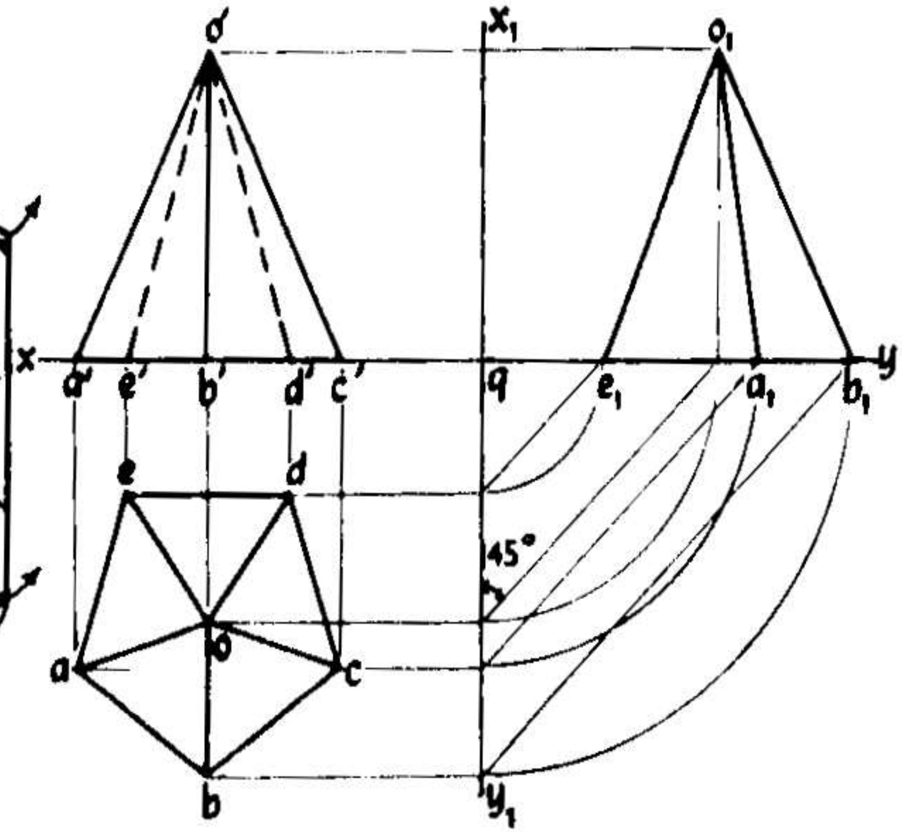


a'
c'
b'
d'
e'
f'
x
y
b
e
c
f
d
a

Problem 02:

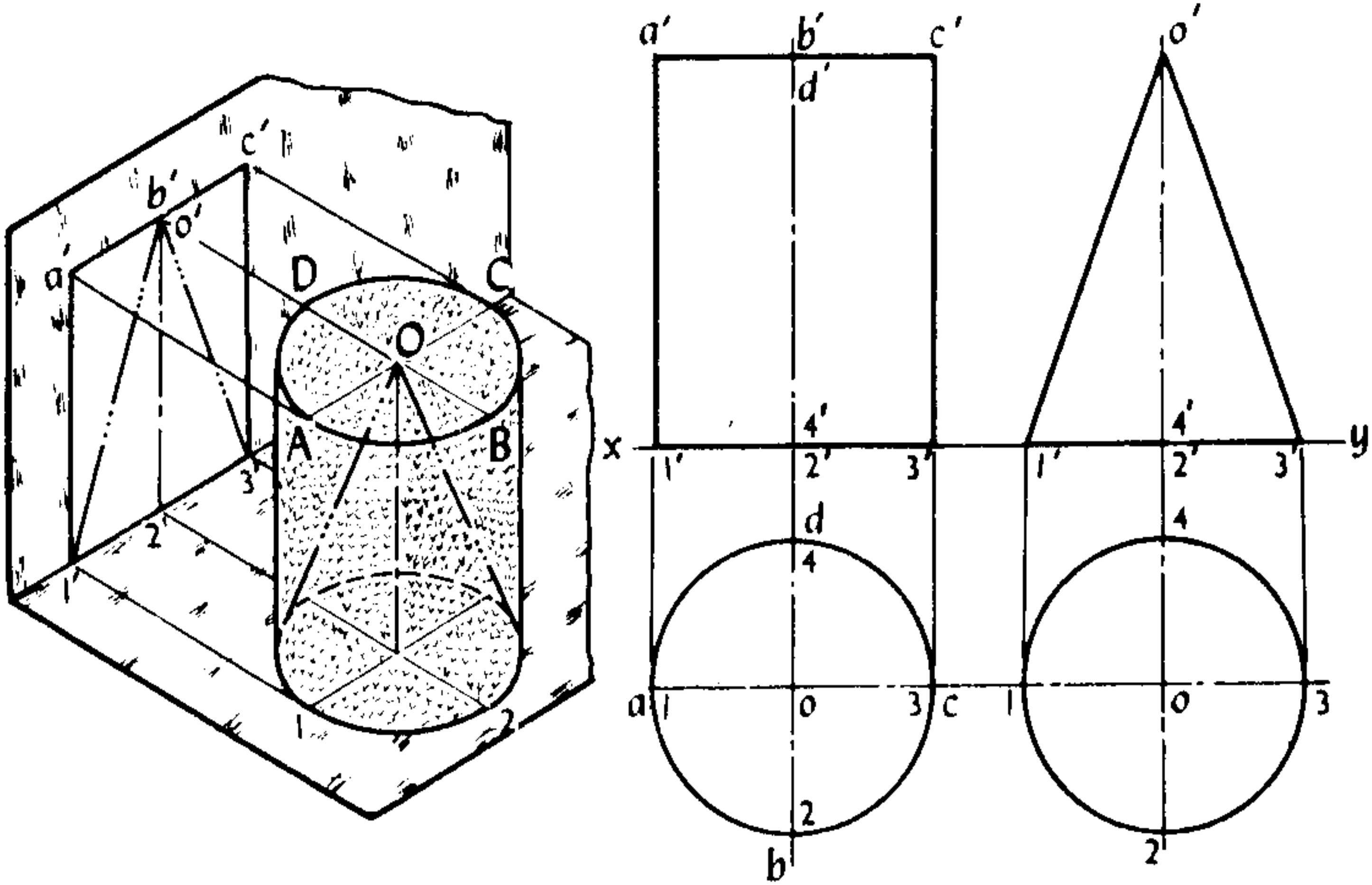
Draw the projections of a pentagonal pyramid, base *30 mm* edge *and* axis 50 mm *long, having its base on the H.PP and an edge of* the base *parallel to the V.P.* Also *draw its side view.*


X1
V.P.
o'
o1
P.P.
O
y
c'
d'
b'
e'
e1
a1
b1
a'
x
E
C
A
B
H.P.


o'
x1
o1
x
y
a'
e'
b'
d'
c'
q
e1
a1
b1
e
d
45°
a
o
c
b
y1

Problem 03:

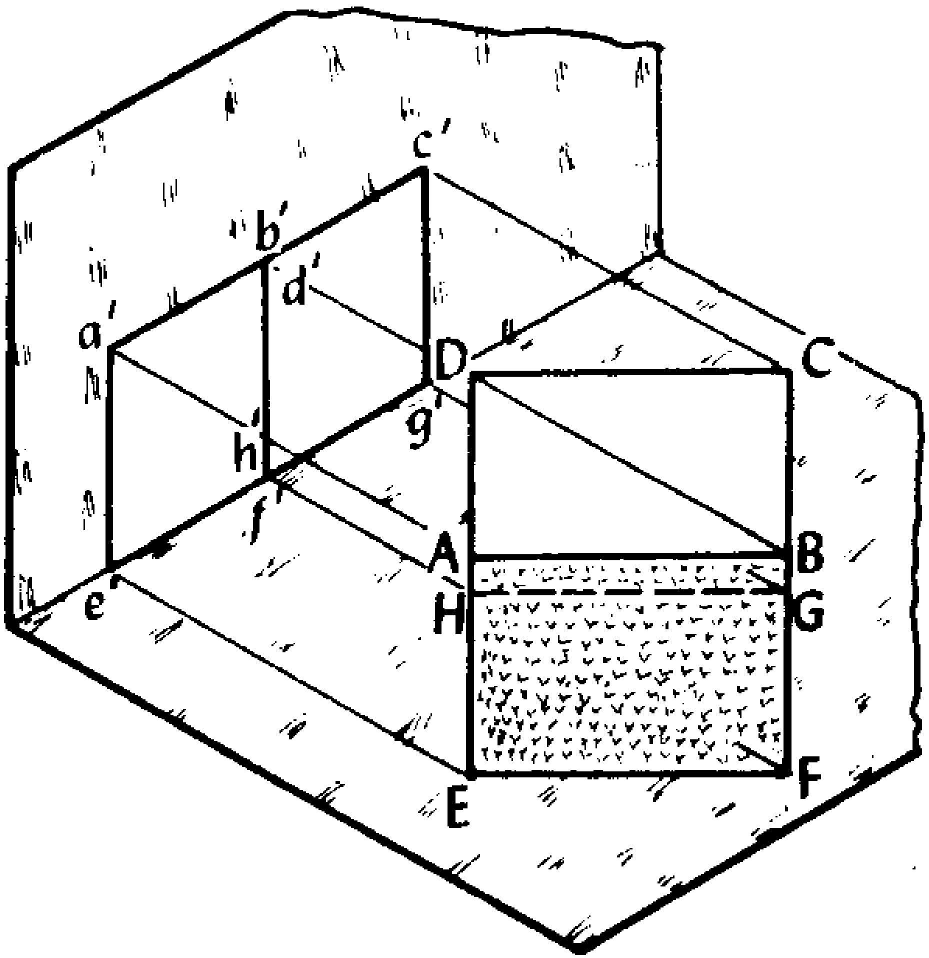
Draw the projections of (i) a cylinder, base *40 mm diameter and axis 50 mm long, and (ii) a* cone, base 40 mm *diameter and axis* 50 *mm long, resting on* the H.P on *their respective* bases.

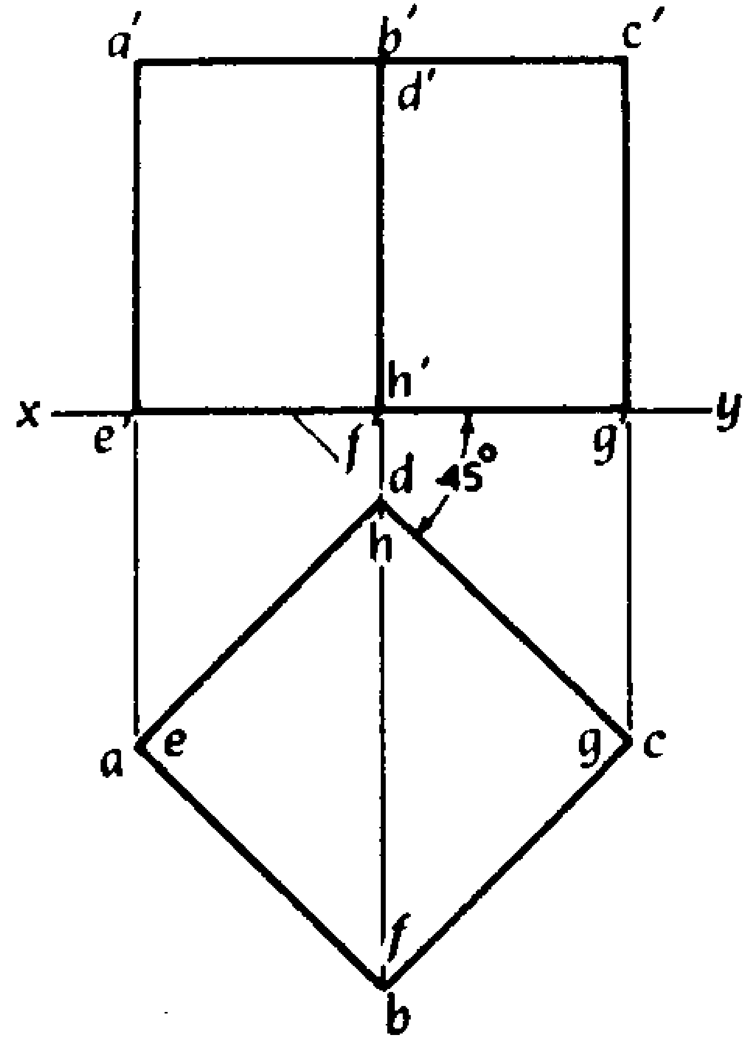


(i) (ii) (iii)

Problem 04:

A cube *of 50 mm long edges* is resting on *the H. P. with its vertical faces equally inclined to the V.P. Draw its projections.*


c′
b′
d′
a′
D
C
h′
g′
f′
A
B
e′
H
G
E
F

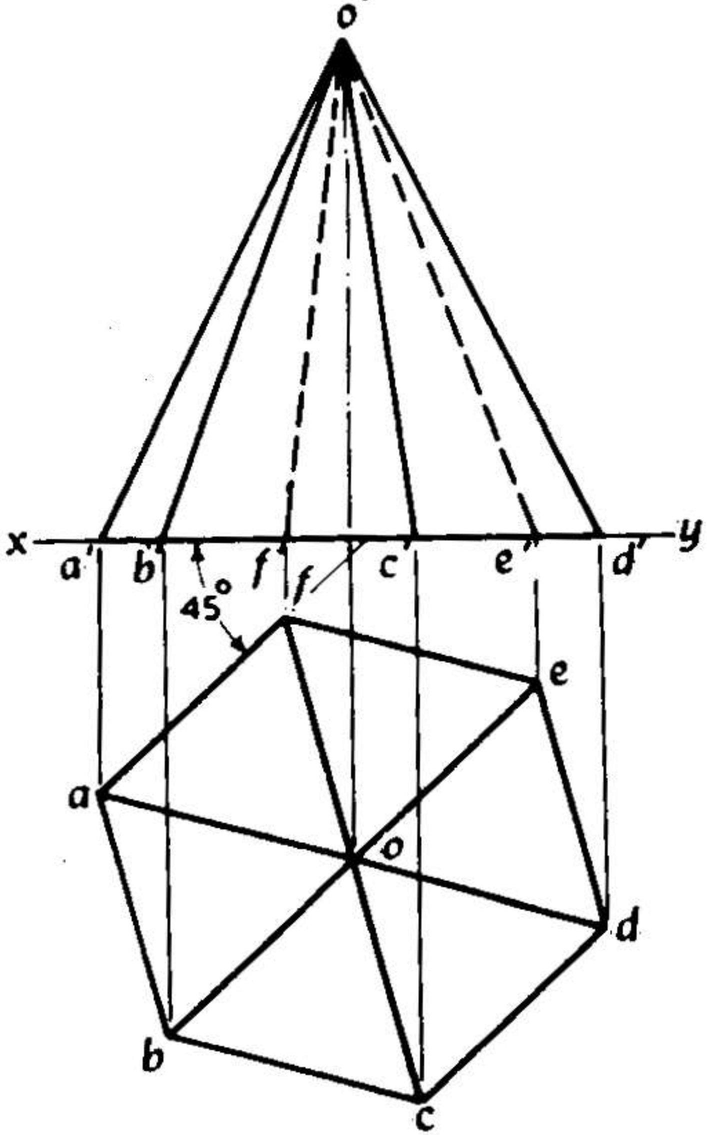

a′
b′
c′
d′
h′
x
y
e′
f′
g′
d
45°
h
a
e
g
c
f
b

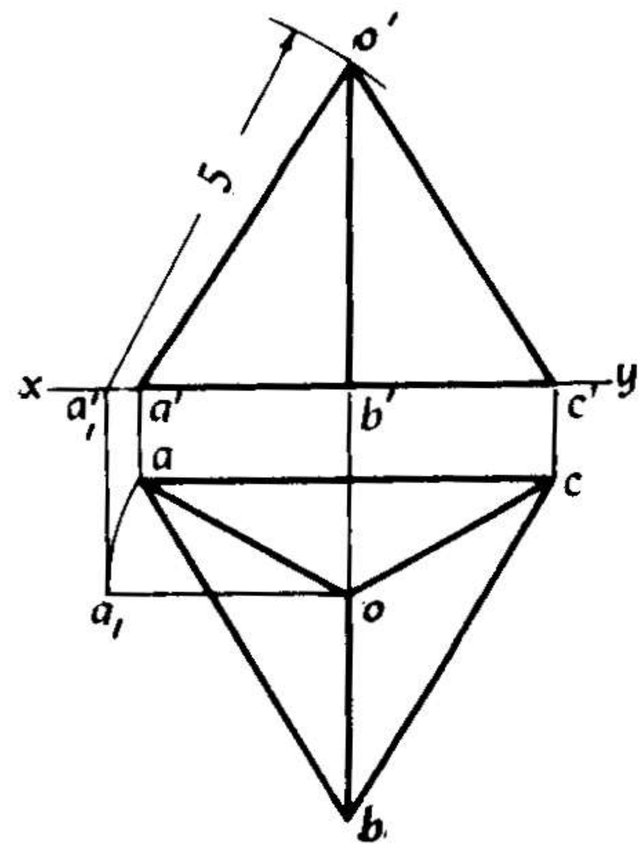
Problem 05:

Draw the projections of a hexagonal *pyramid, base 30 mm side and axis 60 mm long, having its base on the H.PP* and one *of the edges of the* base *inclined* at *45° to* the VP.

Problem 06:

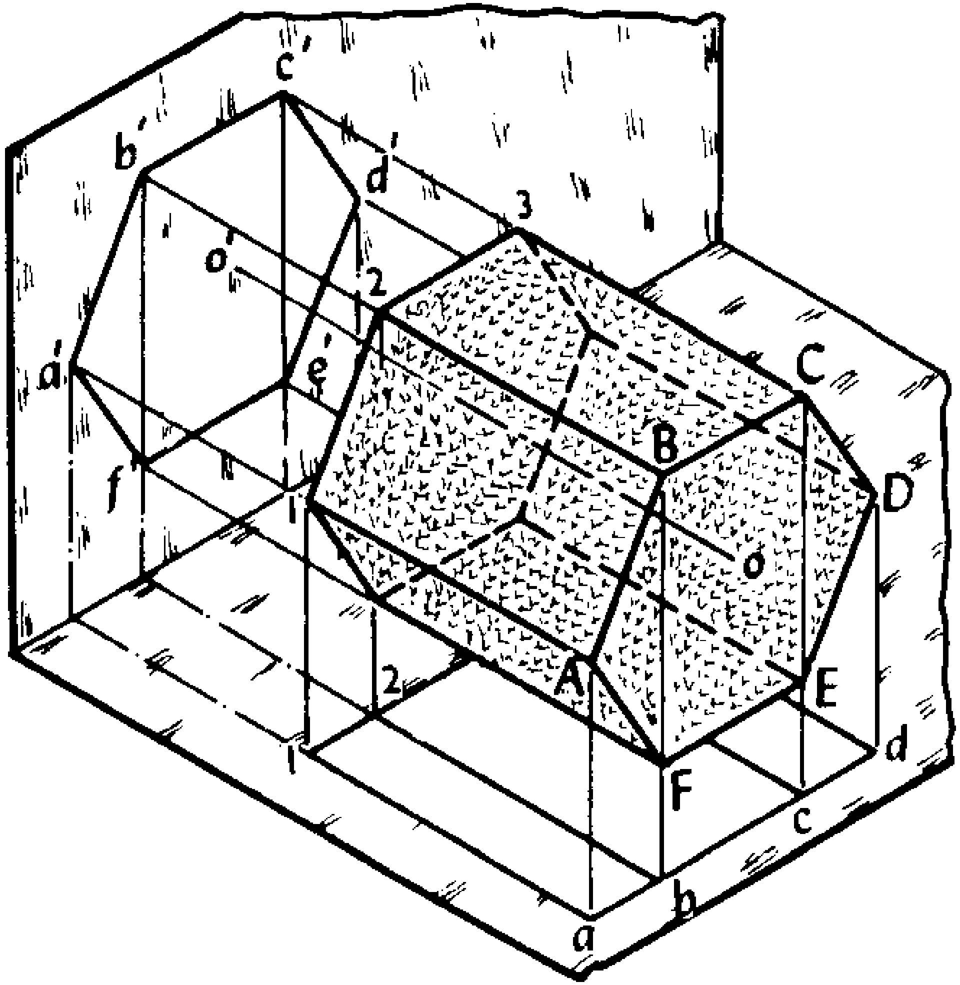
A tetrahedron of 5 cm long edges *is resting on the H.P. on one of its faces, with an edge of that face parallel to the V.P. Draw its projections and measure the distance of its apex from the ground.*


o'
x
y
a'
b'
f'
f
c'
e'
d'
45°
a
b
c
d
e
o

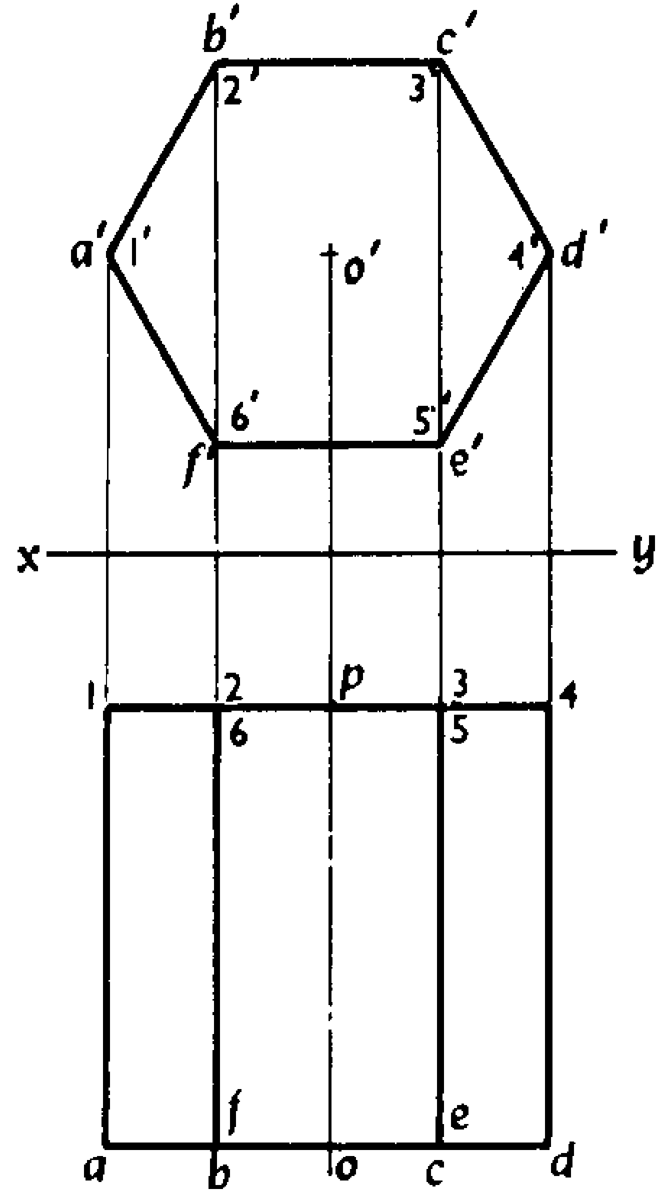

o'
5
x
y
a_1'
a'
b'
c'
a
c
a_1
o
b

Problem 07:

A hexagonal prism has one of its rectangular faces *parallel to the H. P. Its axis is perpendicular to the V.P. and 3.5 cm above the ground. Draw its projections when the* nearer *end is 2 cm in front of the V.P. Side of base 2.5 cm long; axis 5 cm long.*



c'
b'
d'
3
o'
2
a'
e'
C
B
f'
1
D
o
2
A
E
1
d
F
c
b
a



b'
c'
2'
3'
a'
1'
o'
4'
d'
6'
5'
f'
e'
x
y
1
2
p
3
4
6
5
f
e
a
b
o
c
d

Problem 08:

A square *pyramid,* base *40* mrn side *and axis* 65 mm *long, has its* base *in the V.P. One edge of* the base *is inclined at 30° to the H.P. and a* corner contained by *that* edge *is on the H.P. Draw its projections.*

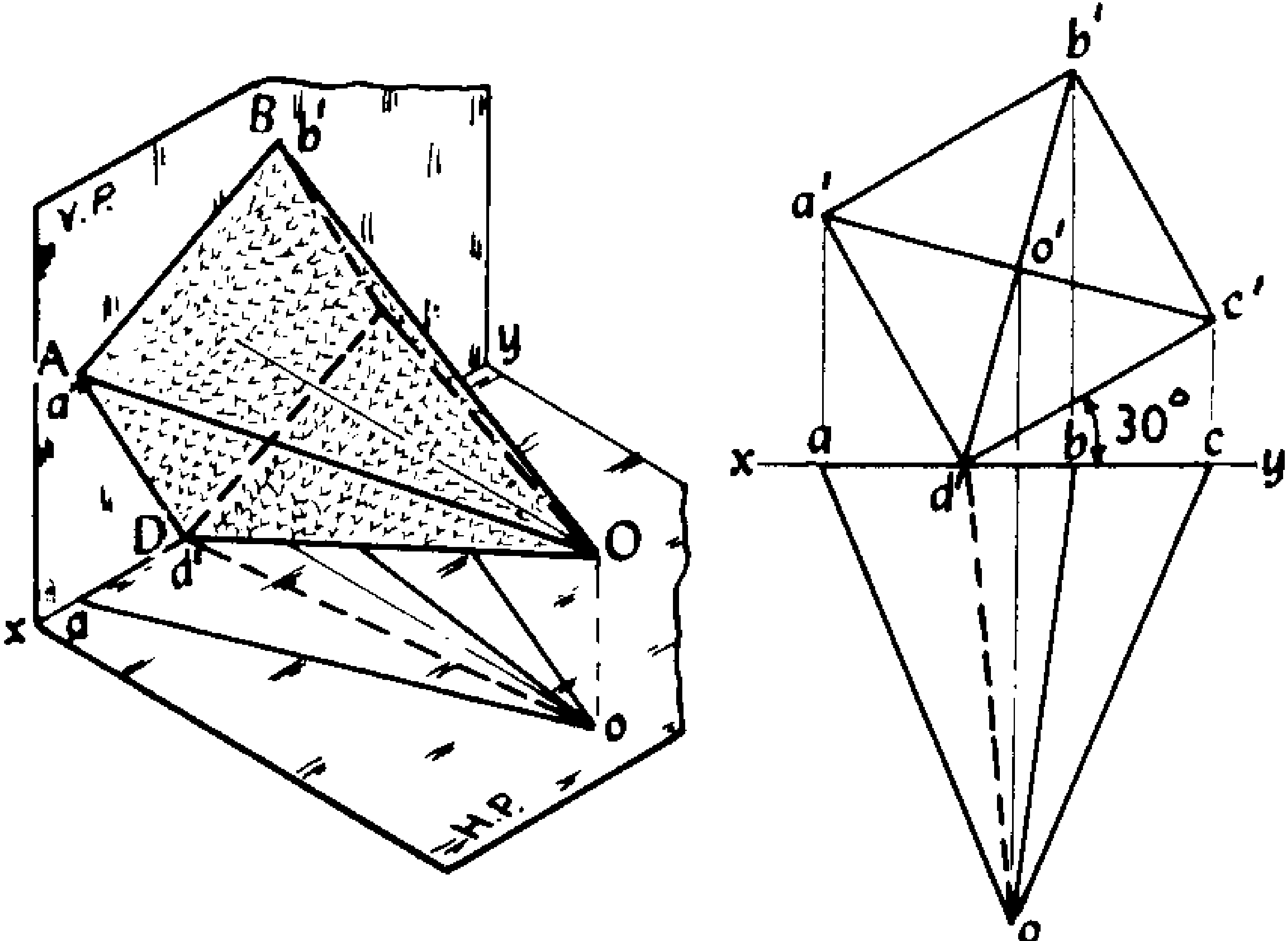
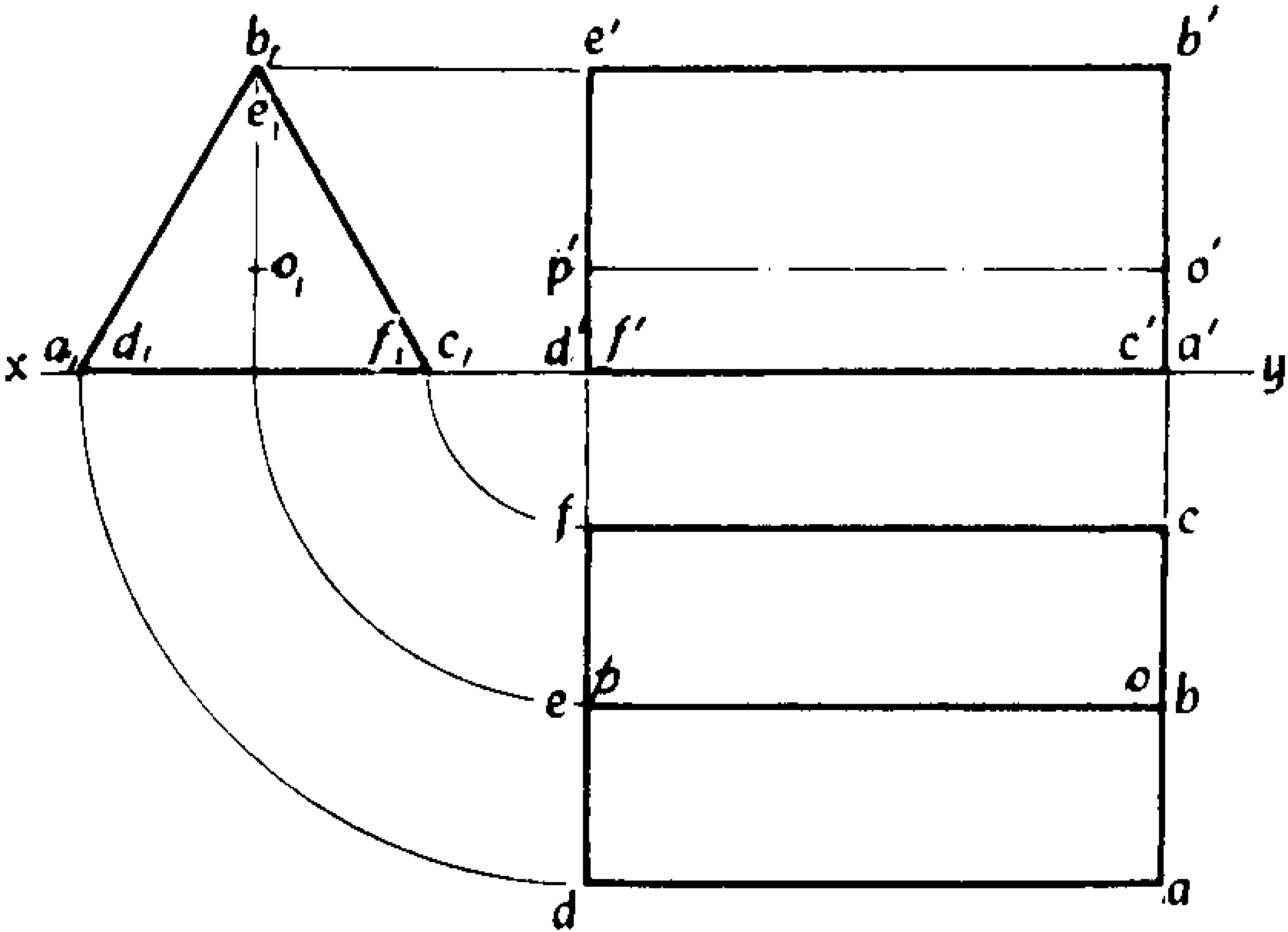


Fig. 13-10

Problem 09:

A triangular prism, base *40 mm side and height* 65 *mm* is resting on *the H.P. on one of its rectangular* faces *with the axis parallel* to *the V.P. Draw its projections.*



b1
e'
b'
e1
o1
p'
o'
x
a1
d1
f1
c1
d'
f'
c'
a'
y
f
c
e
p
o
b
d
a

Exercises XIII (i)

Draw the projections of the following solids, situated in their respective positions, taking a side of the base 40 mm long or the diameter of the base 50 mm long and the axis 65 mm long.

1. A hexagonal pyramid, base on the H.P and a side of the base parallel to and 25 mm in front of the V.P.
2. A square prism, base on the H.P., a side of the base inclined at 30° to the V.P and the axis 50 mm in front of the V.P.
3. A triangular pyramid, base on the H.P and an edge of the base inclined at 45° to the V.P.; the apex 40 mm in front of the V.P.
4. A cylinder, axis perpendicular to the V.P and 40 mm above the H.P., one end 20 mm in front of the V.P.

Exercises XIII (i)

5. A pentagonal prism, a rectangular face parallel to and 10 mm above the H.P., axis perpendicular to the V.F and one base in the V.P.

6. A square pyramid, all edges of the base equally inclined to the H.P and the axis parallel to and 50 mm away from both the H.P. and the V.P.

7. A cone, apex in the H.P axis vertical and 40 mm in front of the V.P.

8. A pentagonal pyramid, base in the V.P and an edge of the base in the H.P.

2. Projections of solids with axes inclined to one of the reference planes and parallel to the other:

When a solid has its axis inclined to one plane and parallel to the other, its projections are drawn in two stages.

(a) In the initial stage, the solid is assumed to be in simple position, i.e. *its axis perpendicular* to *one of the planes.*

If the axis is to be inclined to the ground, i.e. the H.P., it is assumed to be perpendicular to the H.P in the initial stage. Similarly, if the axis is to be inclined to the V.P., it is kept perpendicular to the V.P in the initial stage.

Moreover

(i) if the solid has an edge of its base parallel to the H.P or in the H.P or on the ground, that edge should be kept perpendicular to the V.P; if the edge of the base is parallel to the V.P or in the V.P., it should be kept perpendicular to the H.P.

(ii) If the solid has a corner of its base in the H.P or on the ground, the sides of the base containing that corner should be kept equally inclined to the V.P; if the corner is in the V.P., they should be kept equally inclined to the H.P.

(b) Having drawn the projections of the solid in its simple position, the final projections may be obtained by one of the following *two* methods:

I. **Alteration of position:** The position of one of the views is altered as required and the other view projected from it.

II. **Alteration of reference line or auxiliary plane:** A new reference line is drawn according to the required conditions, to represent an auxiliary plane and the final view projected on it.

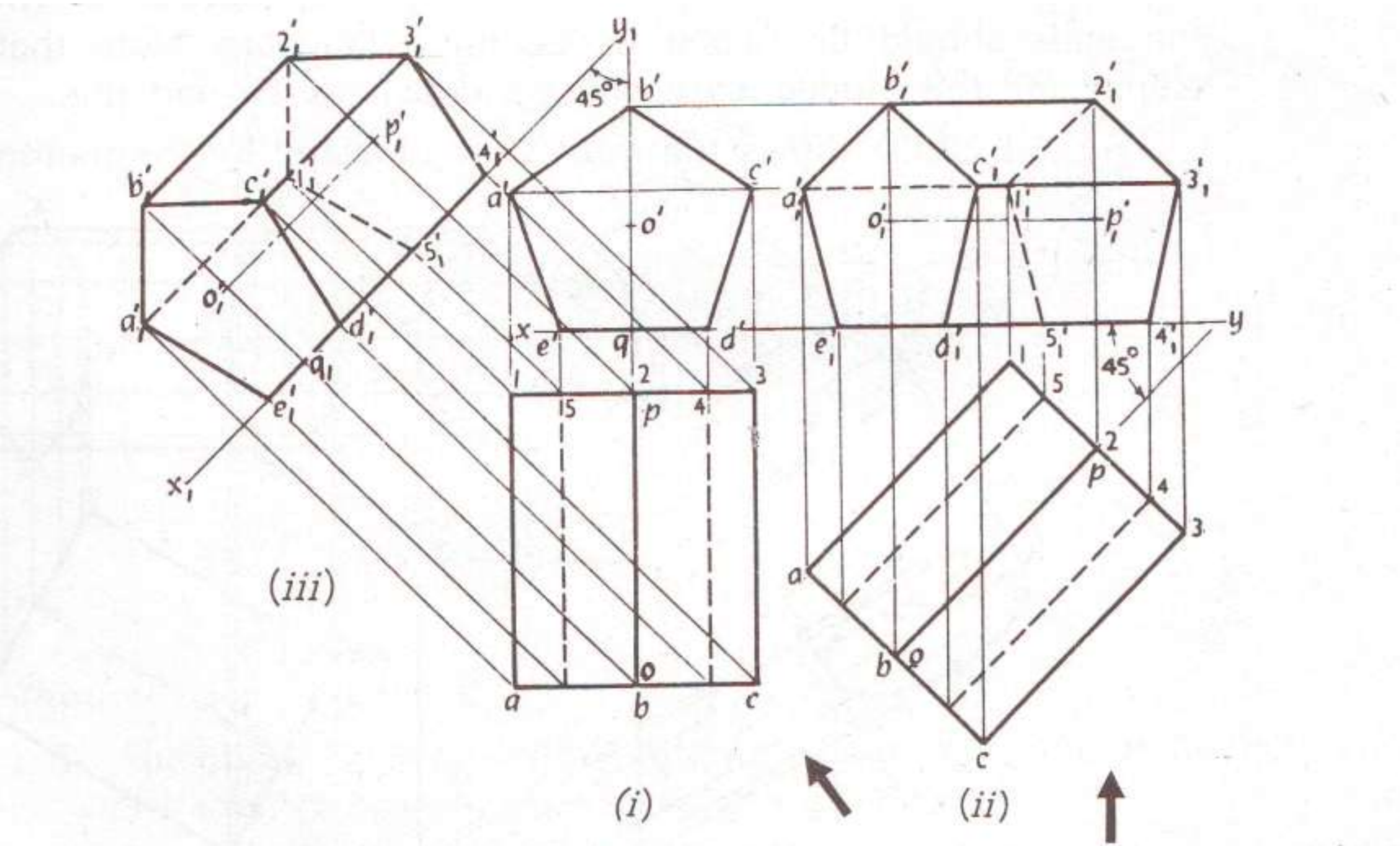
- In the first method, the reproduction of a view accurately in the altered position is likely to take considerable time, specially, when the solid has curved surfaces or too many edges and corners.

- In such cases, it is easier and more convenient to adopt the second method.

- Sufficient care must however be taken in transferring the distances of various points from their respective reference lines.

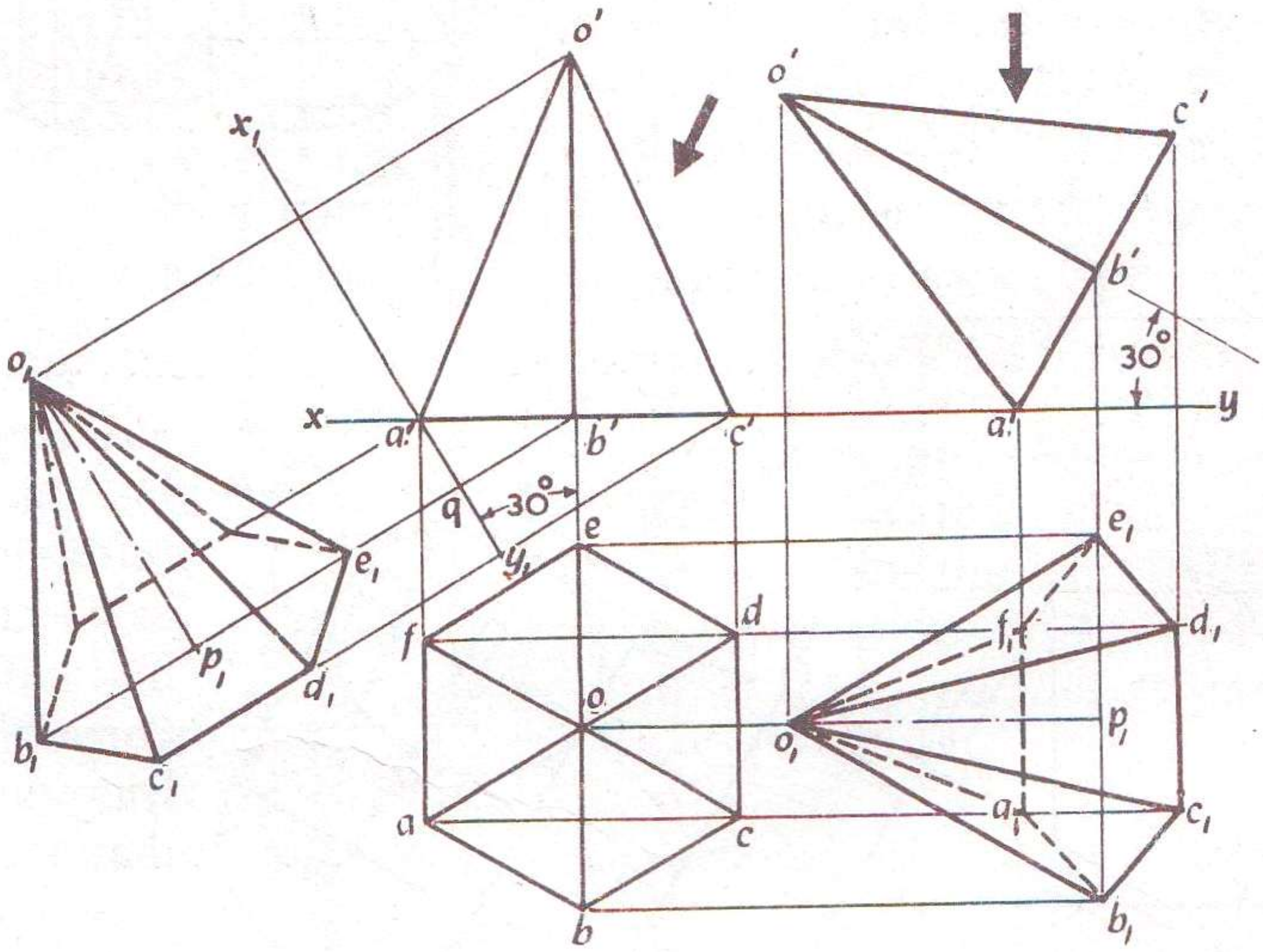
Problem 10:

Draw the projections of a pentagonal prism, base 25 mm side and axis 50 mm long, resting on one of its rectangular faces on *the H.P., with* the axis *inclined* at *45° to* the *V.P.*


(iii)
(i)
(ii)

Problem 11*:*

A hexagonal pyramid, base 25 *mm side and axis 50 rnm long, has an edge of its* base on *the ground. Its axis is inclined* at *30° to the ground and parallel to the V.P. Draw its projections.*

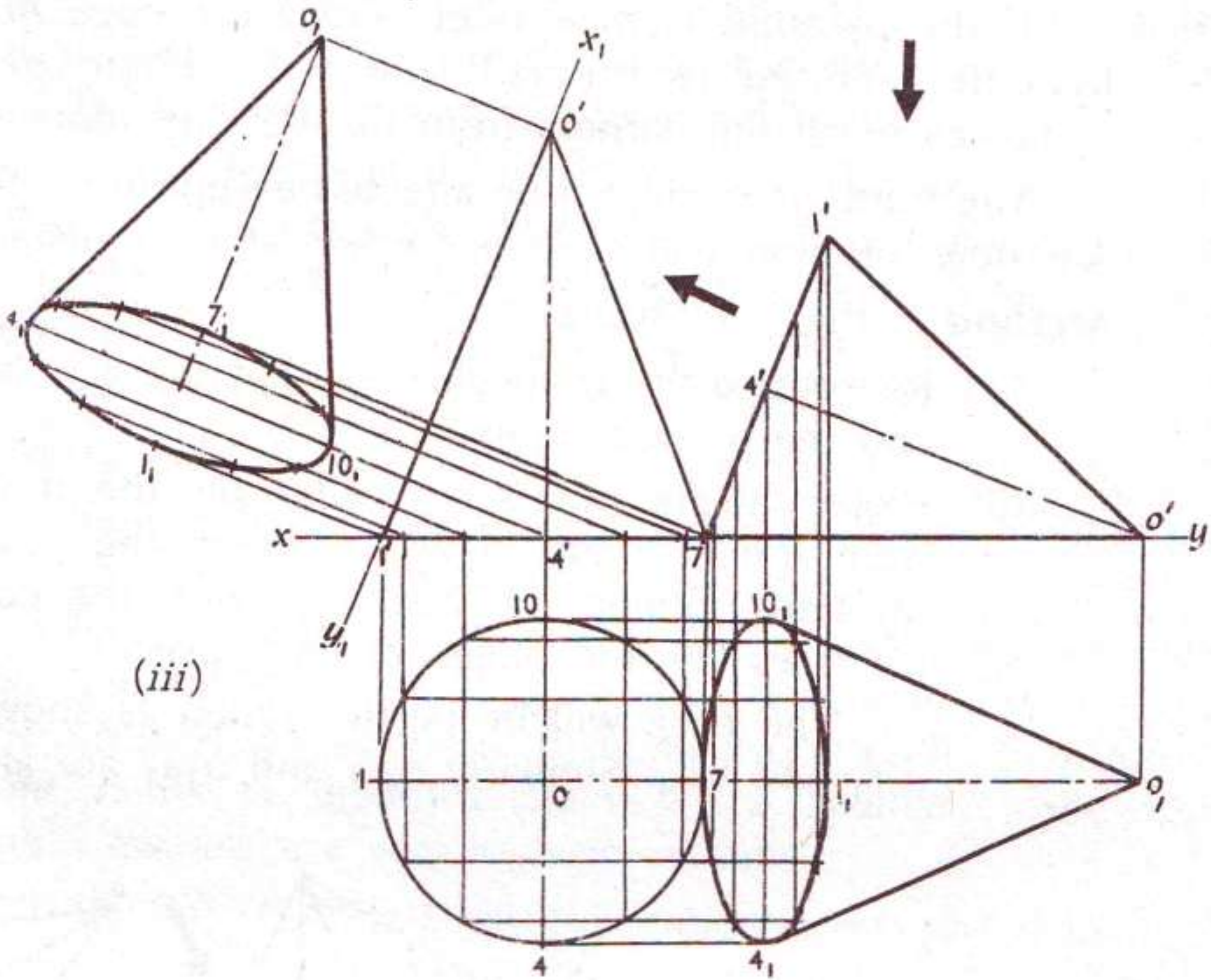


o'
x₁
o'
c'
b'
30°
o₁
x
a'
b'
c'
a'
y
a'
q
30°
e
e₁
y₁
e₁
d
f
f₁
d₁
p₁
d₁
o
b₁
o₁
p₁
c₁
a
c
a₁
c₁
b
b₁

(iii) (i) (ii)

Problem 12:

Draw the *projections of a* cone, base *75 mm diameter and axis 100 mm long, lying on the H. P. on one of its generators with* the axis *parallel to the V.P.*



(i) (ii)

3. Projections of solids with axes inclined to both the H.P. and the VP.:

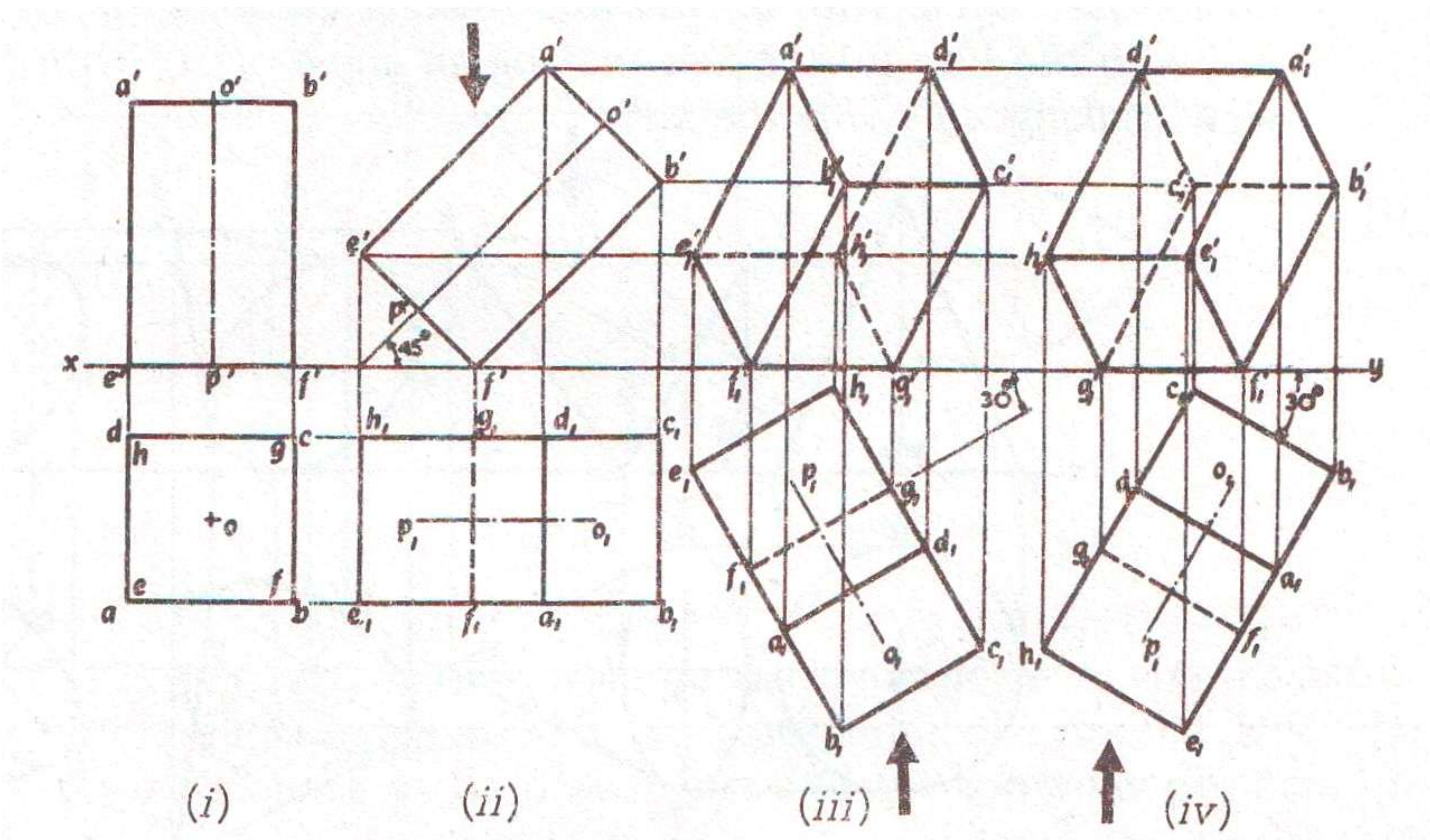
The projections of a solid with its axis inclined to both the planes are drawn in three stages:

(i) *Simple position*
(ii) *Axis inclined to one plane and parallel* to *the other*
(iii) *Final position.*

The second and final positions may be obtained either by the alteration of the positions of the solid, i.e. the views, or by the alteration of reference lines.

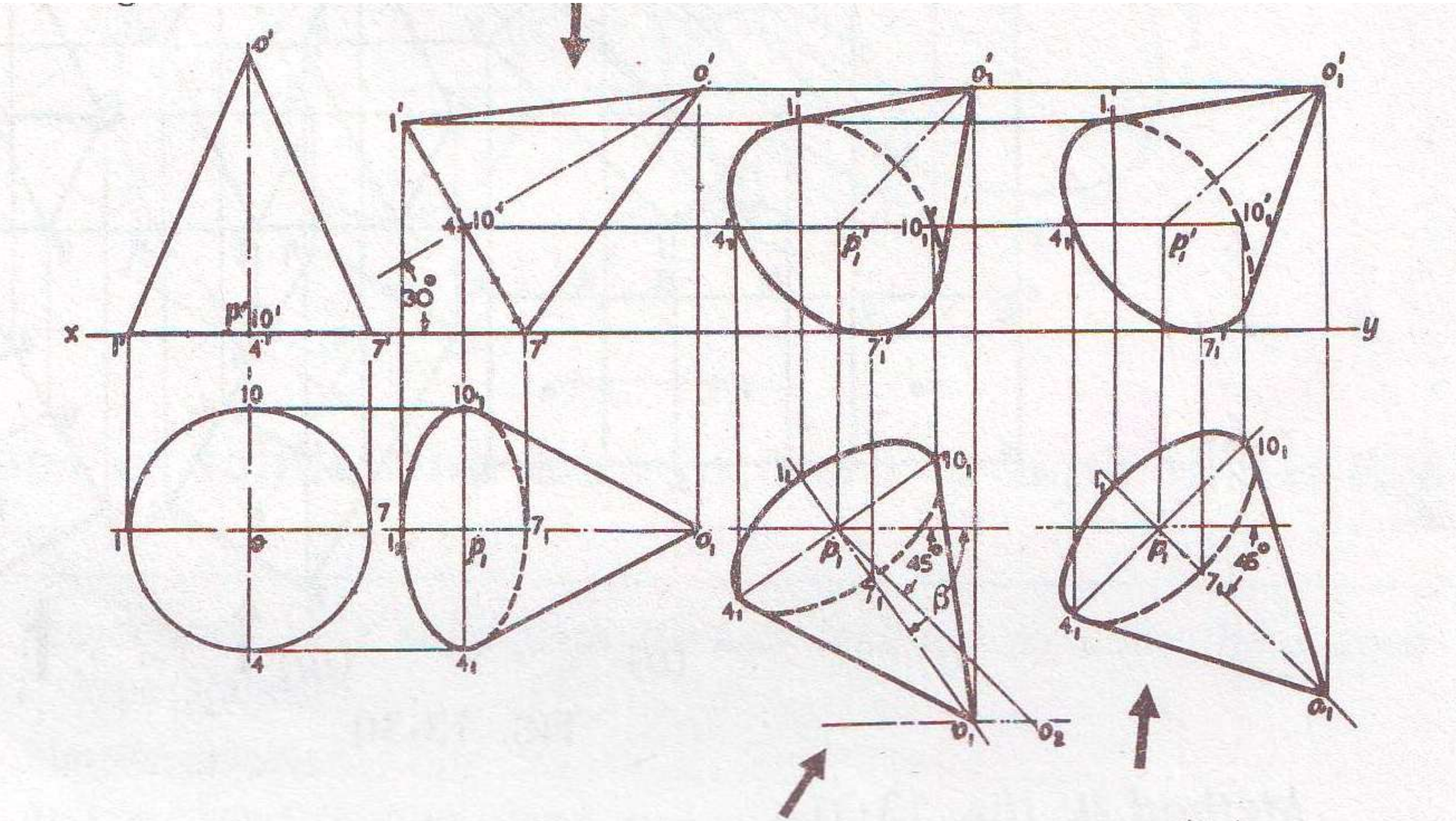
Problem 13:

A *square prism, base 40 mm side and height 65 mm,* has its axis *inclined at 45° to the H.P. and has an* edge *of its base, on the H.P and inclined at 30º to the V.P. Draw its projections.*


x
y
45°
30°
30°
(i)
(ii)
(iii)
(iv)

Problem 14:

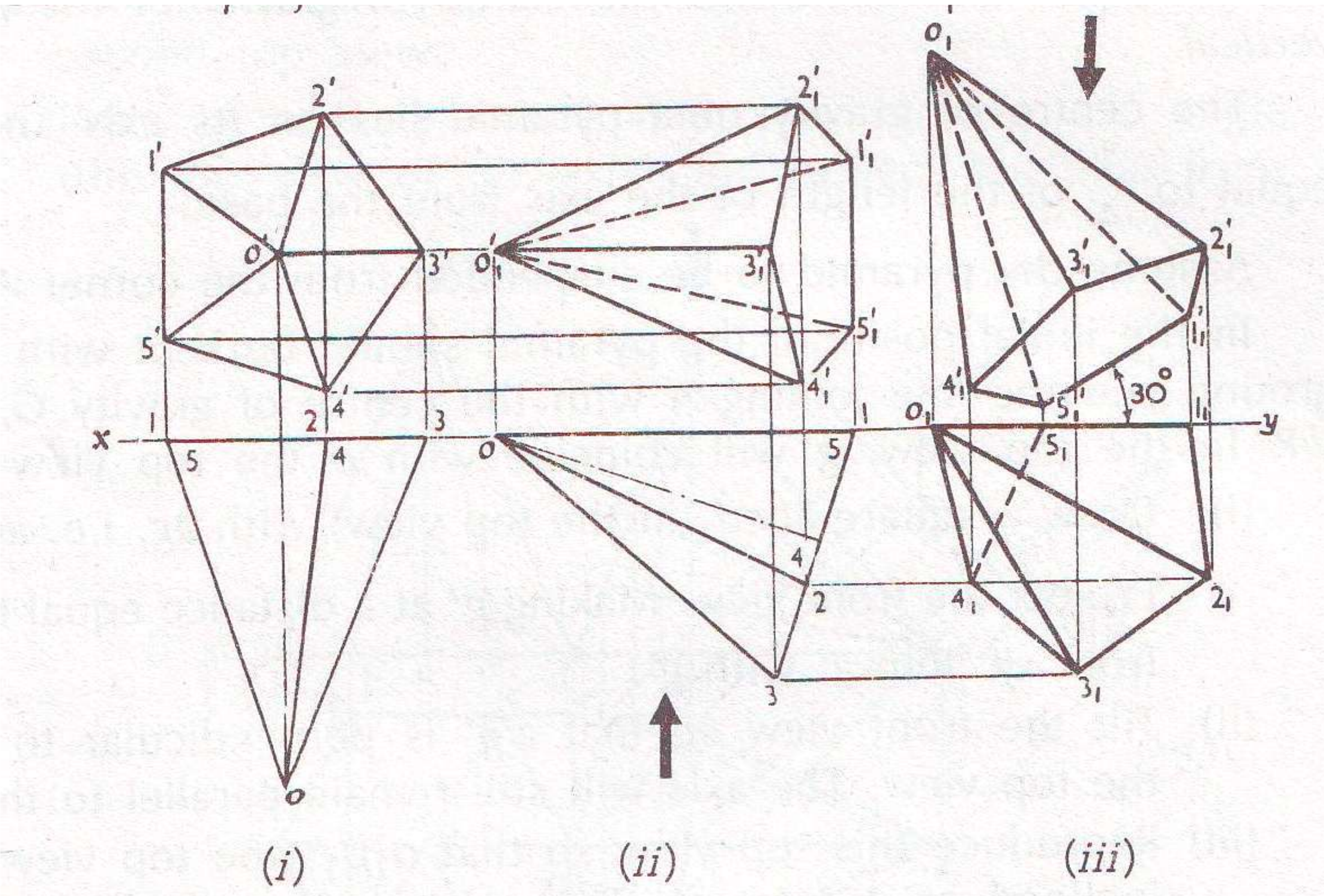
Draw the projections of a cone, base *45 mm diameter and* axis *50 mm long, when it is resting on the* ground on *a point on its* base *circle with (a) the axis making an* angle *of 30° with the H.P. and 45° with the VP; (b) the axis making an angle of 30° with the H.P. and its top view making 45° with the V.P.*



(i) (ii) (iii) (iv)

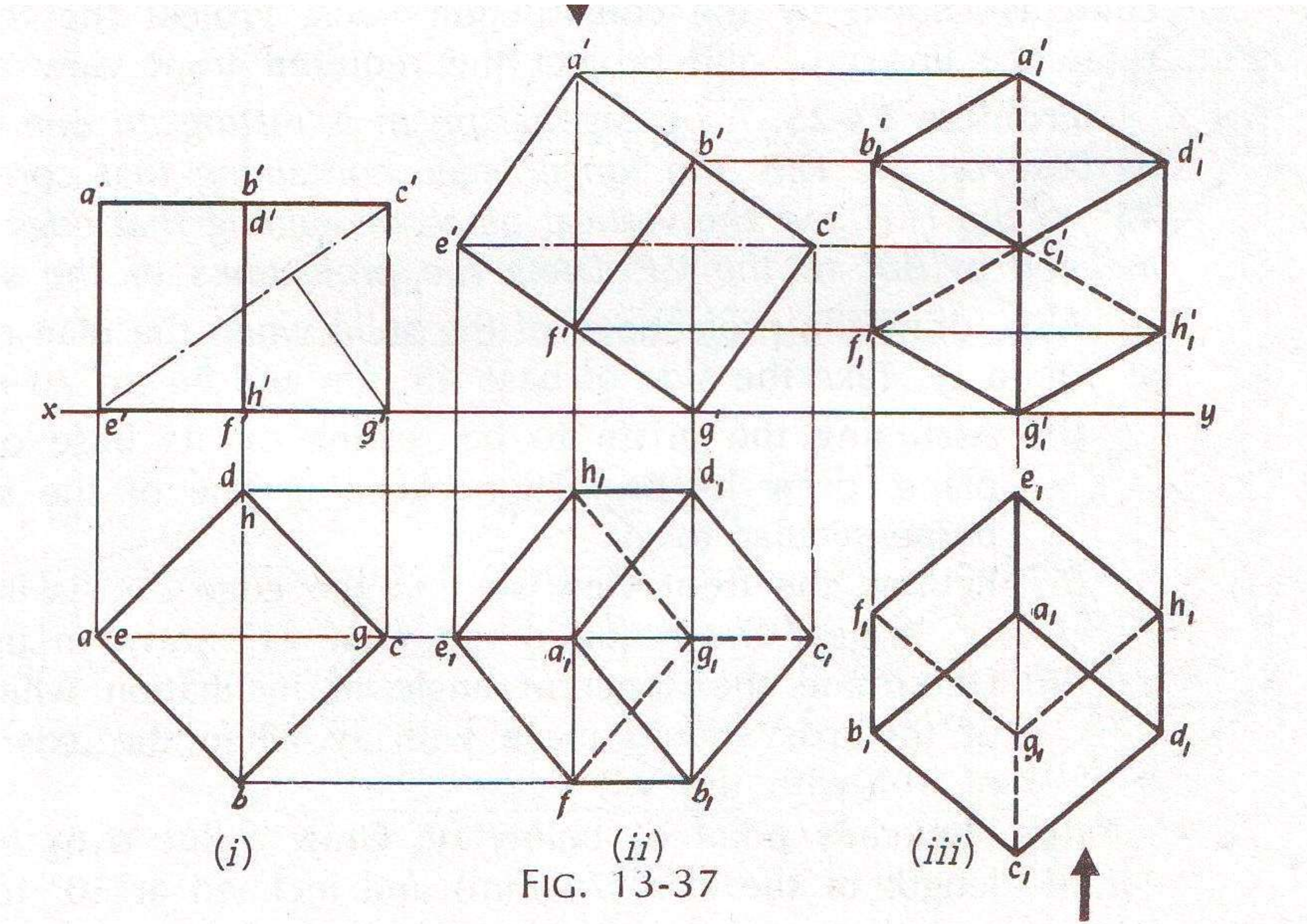
Problem 14:

A pentagonal pyramid, base 25 *mm side and axis 50 mm long* has one *of its triangular* faces *in* the *V.P. and the edge of* the base *contained by* that face makes an angle *of 30° with the H.P. Draw its projections.*


2'
1'
o'
3'
5'
4'
x
1
2
3
5
4
o
(i)
$2'_1$
$1'_1$
o'_1
$3'_1$
$5'_1$
$4'_1$
o
1
5
4
2
3
(ii)
o'_1
$3'_1$
$2'_1$
$1'_1$
$4'_1$
$5'_1$
30°
o_1
1_1
y
5_1
4_1
2_1
3_1
(iii)

Problem 15:

Draw the projections *of* a cube *of 25 mm long* edges *resting on the H.P on one of its* corners *with a solid diagonal perpendicular to the V.P.*

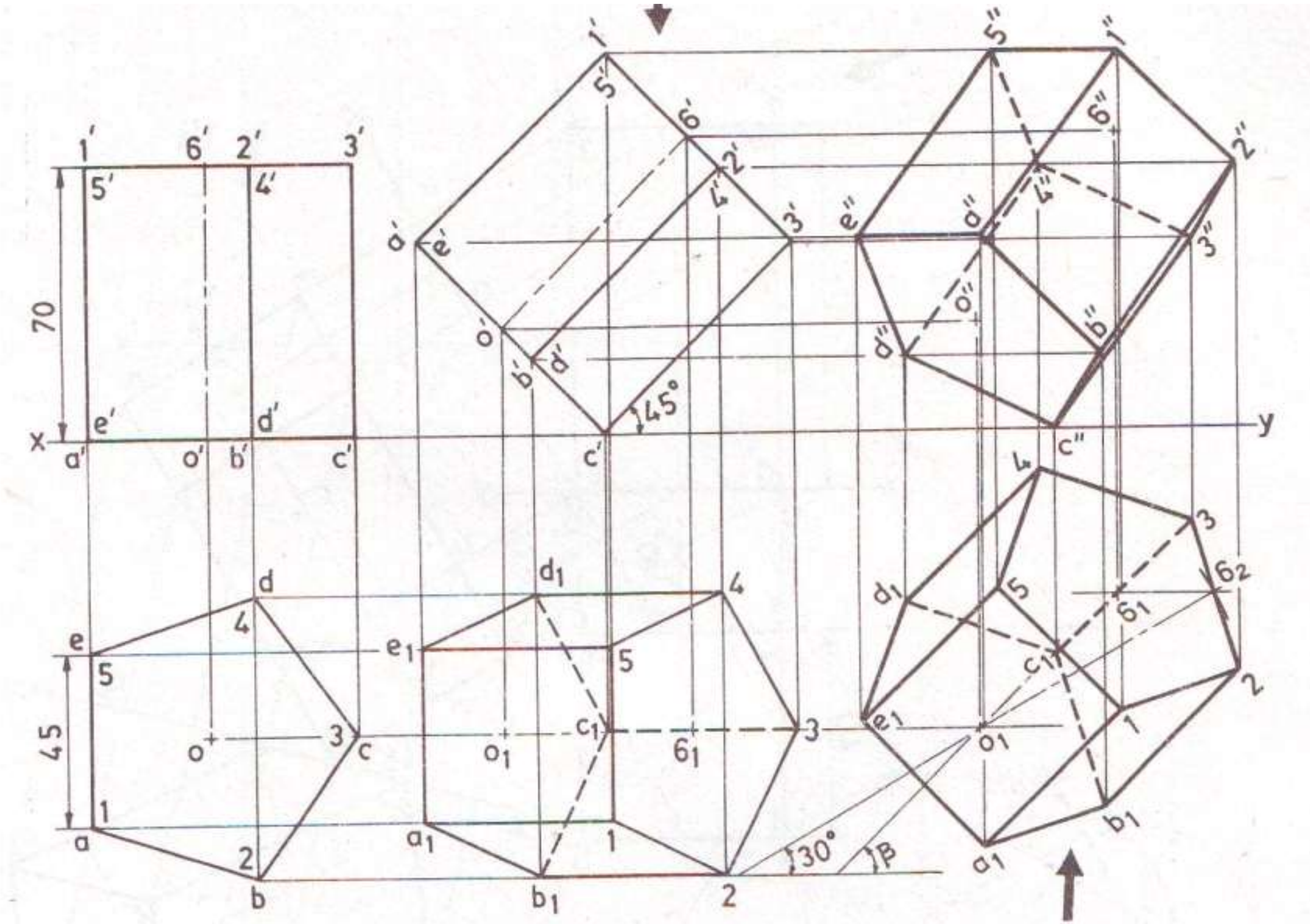


a'
b'
c'
d'
h'
x
e'
f'
g'
d
h
a
e
g
c
b
(i)
a'
b'
e'
c'
f'
g'
h1
d1
e1
a1
g1
c1
f
b1
(ii)
a1'
b1'
d1'
c1'
f1'
h1'
y
g1'
e1
f1
a1
h1
b1
g1
d1
c1
(iii)

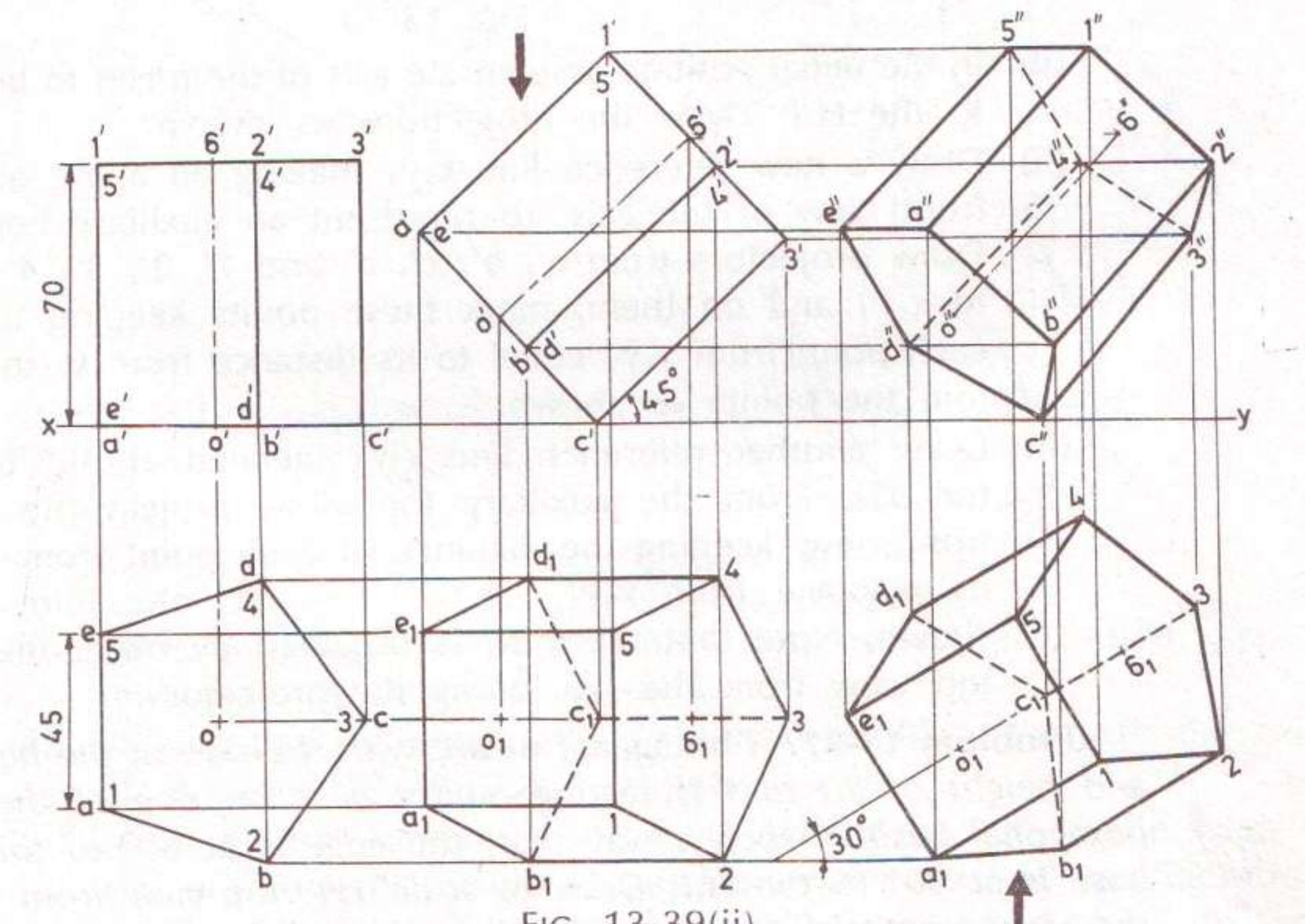
FIG. 13-37

Problem 16:

A pentagonal prism is resting on one of the *corners of* its base on *the H.P. The longer edge containing that corner is inclined at 45°* to *the H.P. and* the *vertical* plane *containing* that edge *and the* axis are *inclined* at 30° to *the V.P. Draw the projections of the solid.* Also, draw the projections of the solid when the plan of axis is inclined at 30° to *xy.* Take the side of base 45 mm and height 70 mm



1'
6'
2'
3'
5'
4'
70
e'
d'
x
a'
o'
b'
c'
5'
6'
2'
4'
3'
a'
e'
o'
b'
d'
45°
c'
5"
1"
6"
2"
e"
a"
4"
3"
o"
b"
d"
c"
y
d
e
4
5
45
o
3
c
1
a
2
b
d1
4
e1
5
o1
c1
61
3
a1
1
b1
2
30°
β
4
3
d1
5
62
61
c1
2
e1
o1
1
b1
a1


1'
6'
2'
3'
5'
4'
70
x
e'
d'
a'
o'
b'
c'
c'
45°
y
c''
1'
5'
6'
2'
4'
a'
e'
3'
o'
b'
d'
5''
1''
6'
4''
2''
e''
a''
3''
o''
b''
d''
d
4
e
5
45
o
3
c
1
a
2
b
d1
4
e1
5
o1
c1
61
3
a1
1
b1
2
4
d1
3
5
61
c1
e1
o1
2
1
30°
a1
b1
FIG. 13-39(ii)

1. A rectangular block 75 mm x 50 mm x 25 mm thick has a hole of 30 mm diameter drilled centrally through its largest faces. Draw the projections when the block has its 50 mm long edge parallel to the H.P and perpendicular to the V.P. and has the axis of the hole inclined at 60' to the H.P.
2. Draw the projections of a square pyramid having one of its triangular faces in the V.P and the axis parallel to and 40 mm above the H.P. Base 30 mm side; axis 75 mm long.
3. A cylindrical block, 75 mm diameter and 25 mm thick, has a hexagonal hole of 25 mm side, cut centrally through its flat faces. Draw three views of the block when it has its flat faces vertical and inclined at 30° to the V .P. and two faces of the hole parallel to the H.P.

4. Draw three views of an earthen flower pot, 25 cm diameter at the top,15 cm diameter at the bottom, 30 cm high and 2.5 cm thick, when its axis makes an angle of 30° with the vertical.

5. A tetrahedron of 75 mm long edges has one edge parallel to the H.P. and inclined at 45° to the V.P while a face containing that edge is vertical. Draw its projections.

6. A hexagonal prism, base 30 mm side and axis 75 mm long, has an edge of the base parallel to the H.P and inclined at 45° to the V.P. Its axis makes an angle of 60° with the H.P. Draw its projections.

7. A pentagonal prism is resting on a corner of its base on the ground with a longer edge containing that corner inclined at 45° to the H.P and the vertical plane containing that edge and the axis inclined at 30° to the V.P. Draw its projections. Base 40 mm side; height 65 mm.y

8. Draw three views of a cone, base 50 mm diameter and axis 75 mm long, having one of its generators in the V.P and inclined at 30° to the H.P., the apex being in the H.P.

9. A square pyramid, base 40 mm side and axis 90 mm long, has a triangular face on the ground and the vertical plane containing the axis makes an angle of 45° with the V.P. Draw its projections.

10. A frustum of a pentagonal pyramid, base 50 mm side, top 25 mm side and axis 75 mm long, is placed on its base on the ground with an edge of the base perpendicular to the V.P. Draw its projections. Project another top view on a reference line parallel to the line which shows the true length of the slant edge. From this top view, project a front view on an auxiliary vertical plane inclined at 45° to the top view of the axis.

11. Draw the projections of a cone, base 50 mm diameter and axis 75 mm long, lying on a generator on the ground with the top view of the axis making an angle of 45° with the V.P.

12. The front view, incomplete top view and incomplete auxiliary top view of a casting are given in fig. 13-47. Draw all the three views completely in the third-angle projection.

SECTIONS OF SOLIDS

- Invisible features of an object are shown by dotted lines in their projected views. But when such features are too many, these lines make the views more complicated and difficult to interpret.
- In such cases, it is customary to imagine the object as being cut through or sectioned by planes.
- The part of the object between the cutting plane and the observer is assumed to be removed and the view is then shown in section.

- The imaginary plane is called a ***section plane*** or *a* ***cutting plane****.*
- The surface produced by cutting the object by the section plane is called the ***section****.*
- It is indicated by thin section lines uniformly spaced and inclined at 45°.
- The projection of the section along with the remaining portion of the object is called *a* ***sectional view****.* Sometimes, only the word section is also used to denote a sectional view.

- **True shape of a section:** The projection of the section on a plane parallel to the section plane will show the true shape of the section.
- Thus, when the section plane is parallel to the H.P or the ground, the true shape of the section will be seen in ***sectional top view***.
- When it is parallel to the V.P, the true shape will be visible in the ***sectional front view***.
- *But when the section plane is inclined, the section has to be projected on an auxiliary plane parallel to the section plane, to obtain its true shape.*
- *When the section plane is perpendicular to both the reference planes, the sectional side view will show the true shape of the section.*

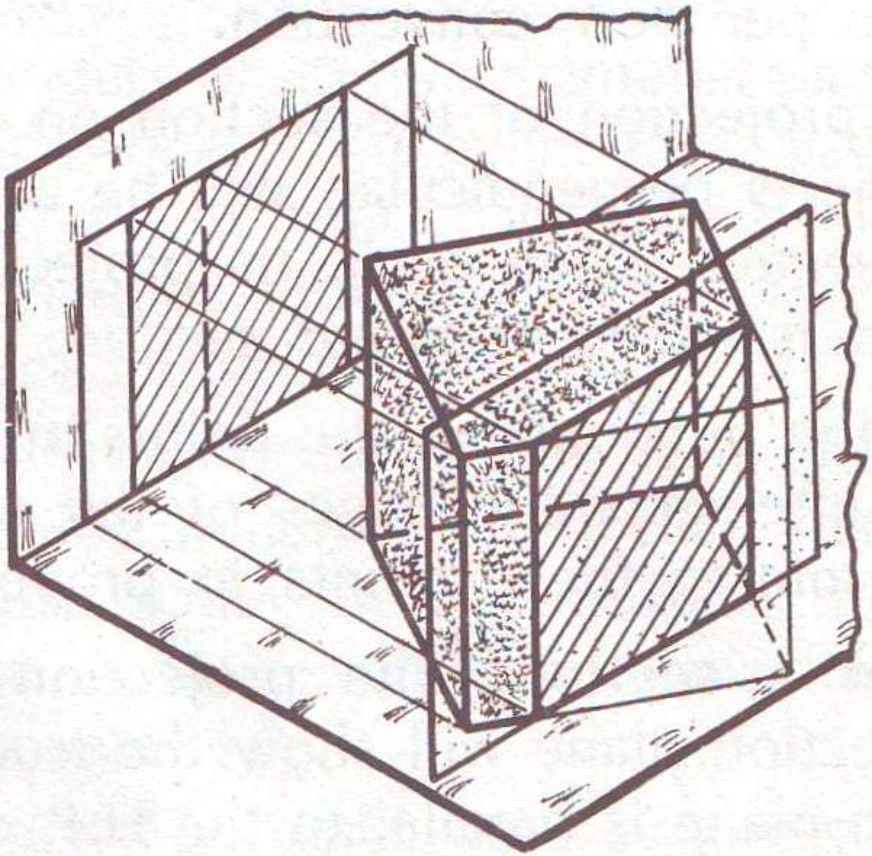
These are illustrated according to the position of the section plane with reference to the principal planes as follows:

(a) Section plane parallel to the V.P.
(b) Section plane parallel to the H.P.
(c) Section plane perpendicular to the H.P. and inclined to the V.P.
(d) Section plane perpendicular to the V.P. and inclined to the H.P.

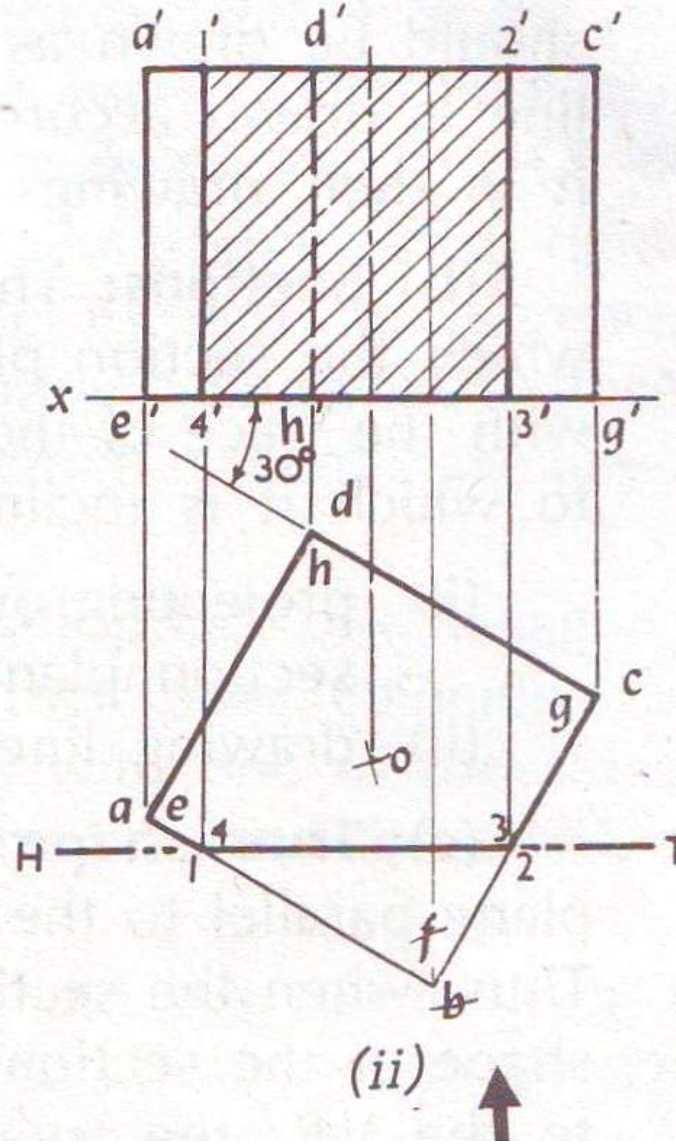
Problem 01:

A cube of 35 mm long edges is resting on the H.P. on one of its faces *with a vertical face inclined at 30° to the V.P. It is cut by a* section plane *parallel* to the *V.P. and 9 mm away from the* axis *and further away from* the *V.P. Draw its* sectional *front view and* the *top view.*

1)].



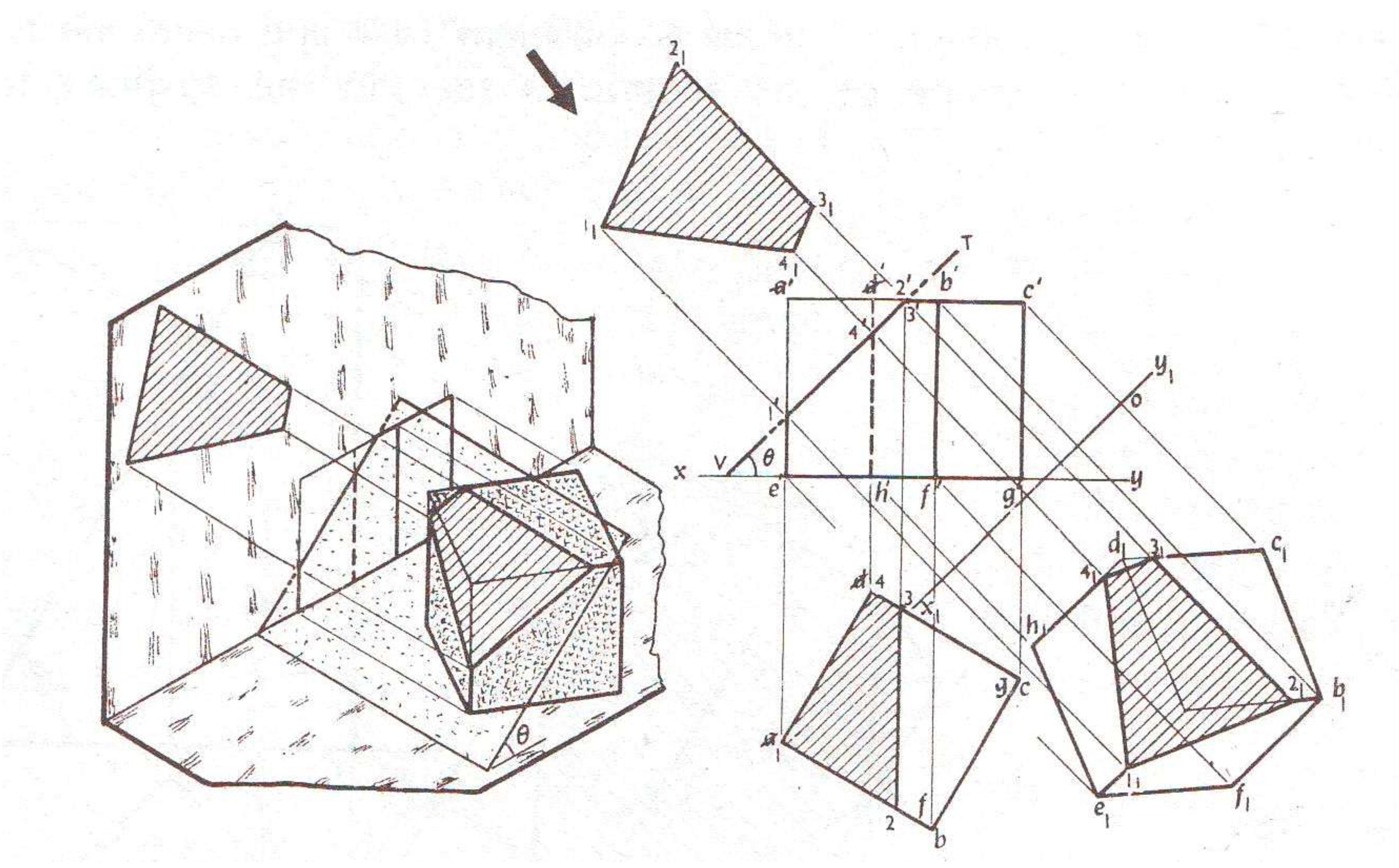
(i)



(ii)

Problem 02:

A cube in the same *position* as *in problem 01 is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P.* and passing *through the top end of the axis. (i) Draw its front view, sectional top view and true shape of the section. (ii) Project another top view on an auxiliary plane, parallel to the section plane.*



x
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a'
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2'
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4'
1'
e
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o
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a
b
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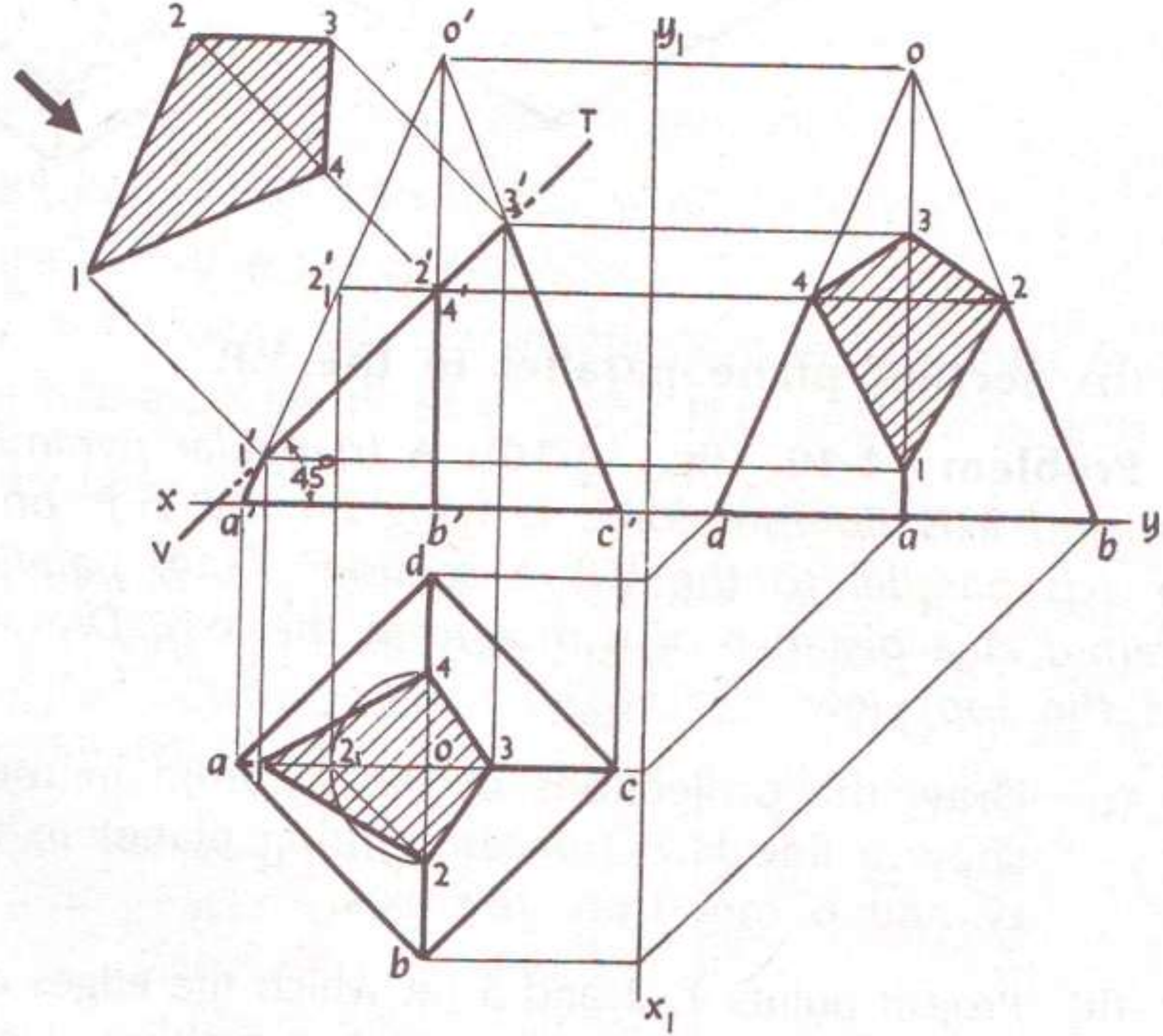
d
f
g
1
2
3
4
a_1
b_1
c_1
d_1
e_1
f_1
h_1
1_1
2_1
3_1
4_1

Problem 03:

A square pyramid, base 40 mm side and axis 65 mm long, has its base on the H.P. and all the edges of the base equally inclined to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and bisecting the axis. Draw its sectional top view, sectional side view and true shape of the section.


2
3
o'
y_1
o
T
4
3'
3'
1
2'
2'
4'
3
4
2
1'
45°
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x
V
a'
b'
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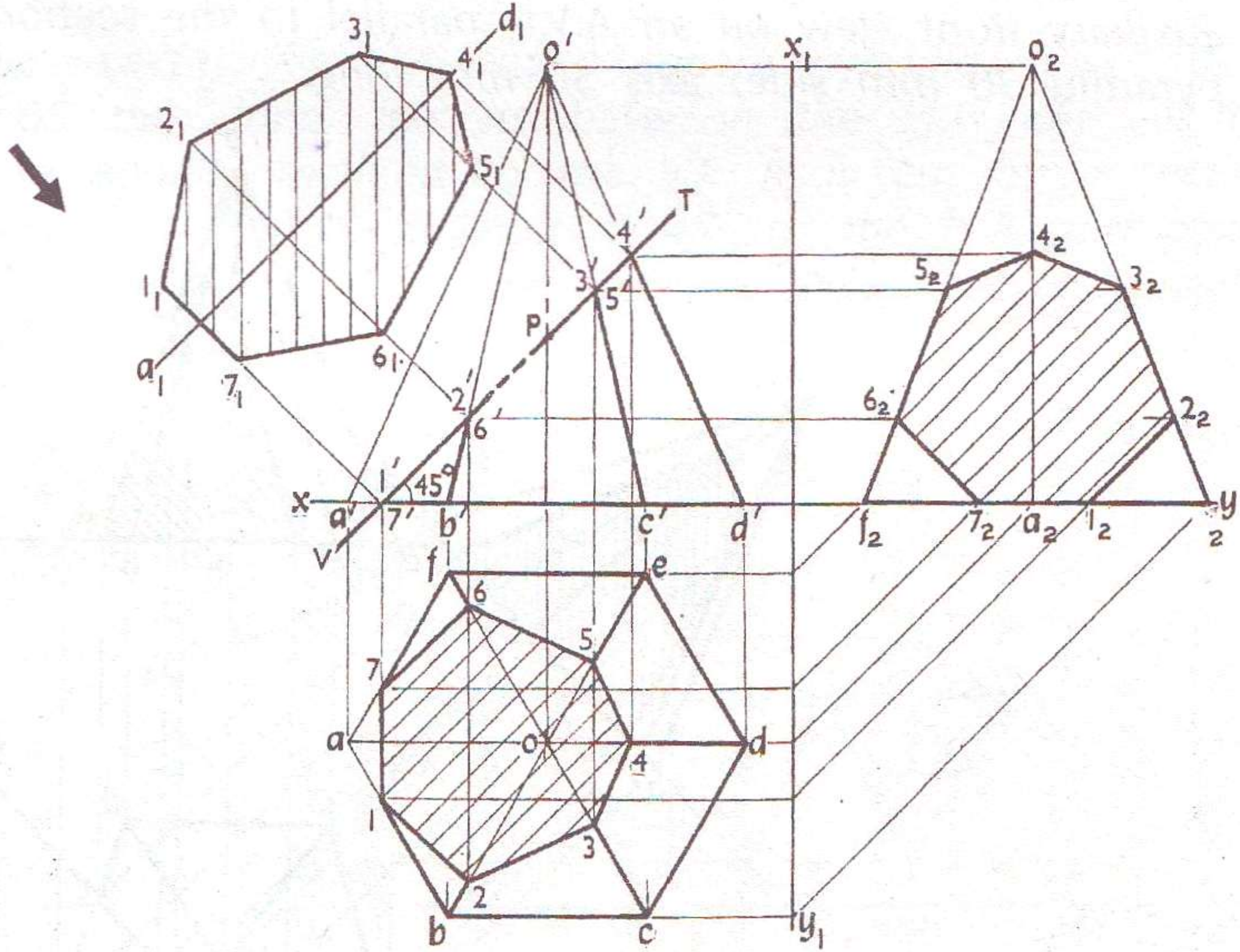
d
a
b
y
d
4
a
1
2_1
o
3
c
2
b
x_1

Problem 04:

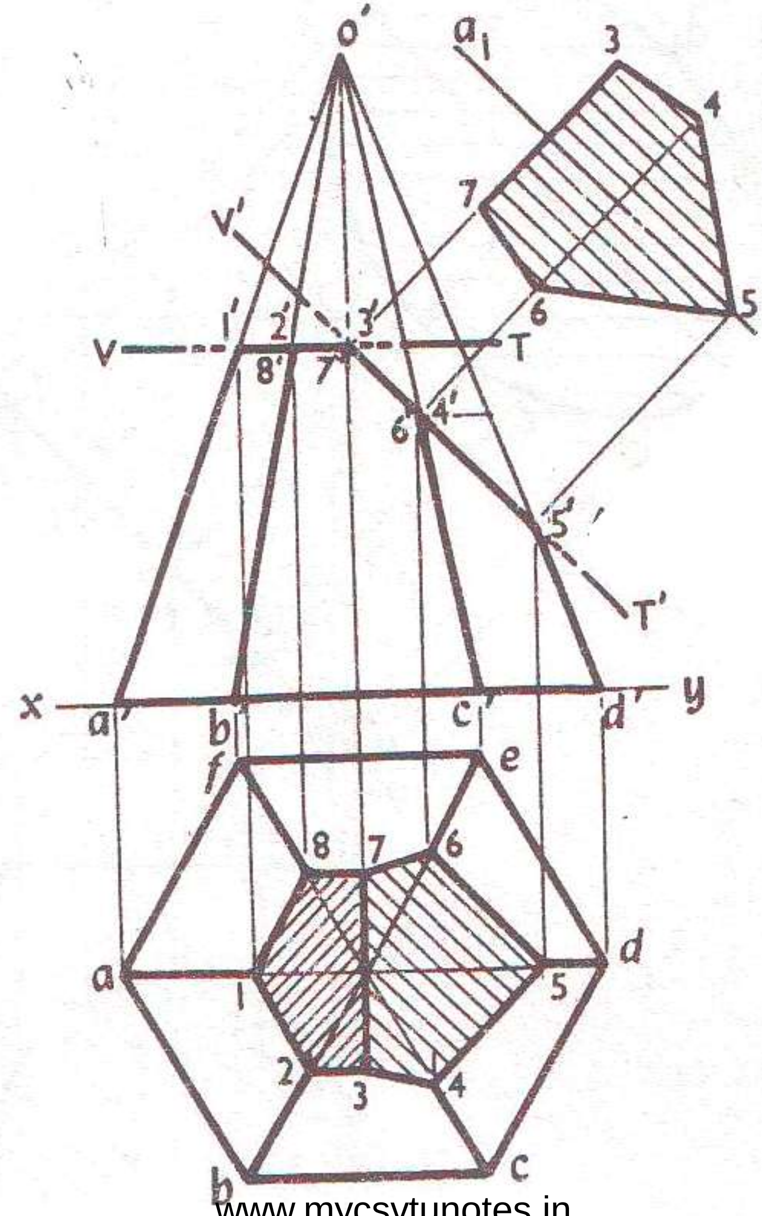
A hexagonal pyramid, base 30 mm side and axis 65 mm long, is resting on its base on the H.P. with two edge *parallel to the V.P. It is cut by a section plane, perpendicular to the V.P. inclined at 45° to the H.P. and intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view, sectional side view and true shape of the* section.



d_1
3_1
4_1
o'
x_1
o_2
2_1
5_1
T
$4'$
4_2
5_2
3_2
1_1
$3'$
$5'$
p'
a_1
7_1
6_1
$2'$
6_2
2_2
$6'$
$1'$
45°
x
a'
$7'$
b'
c'
d'
f_2
7_2
a_2
1_2
y
2
V
f
e
6
5
7
a
o
4
d
1
3
2
b
c
y_1

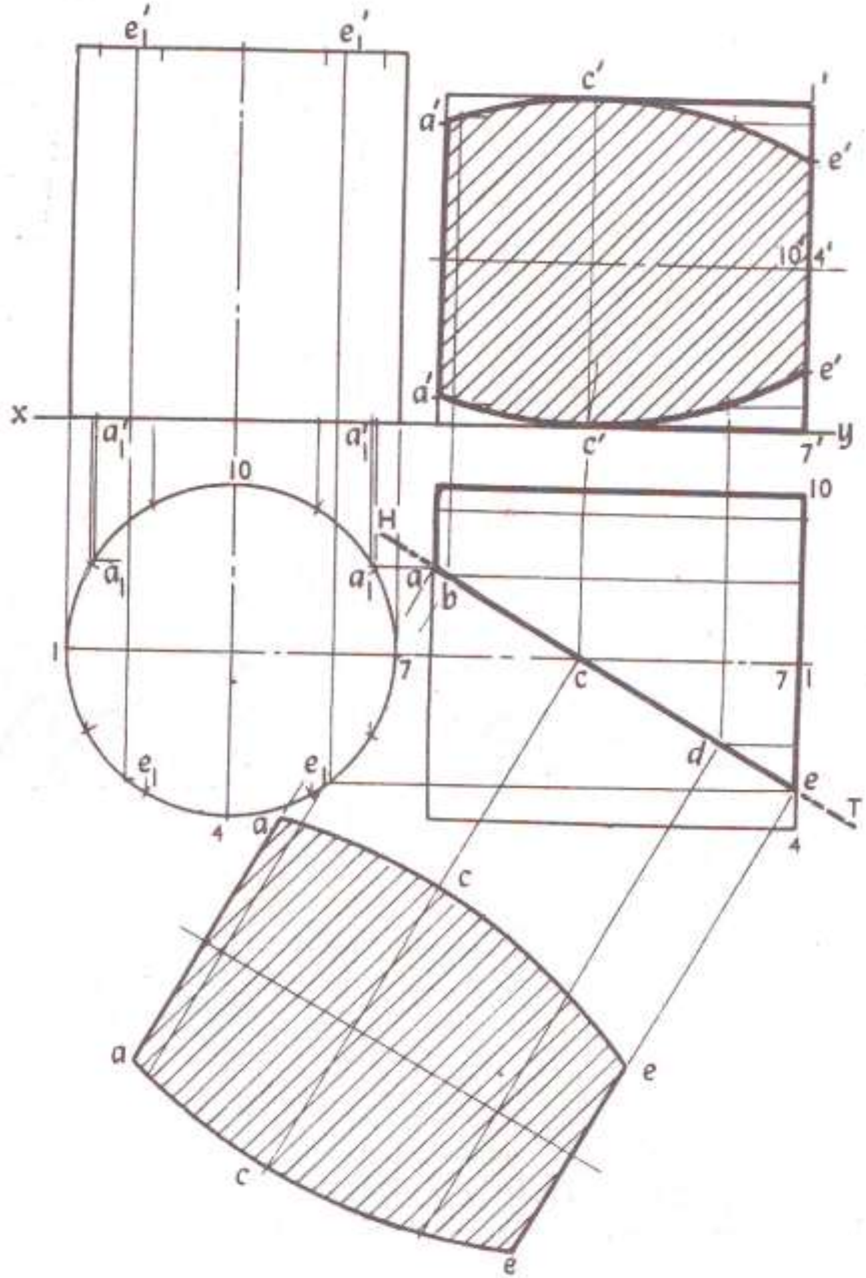
Problem 05:

A hexagonal pyramid, base *30 mm side and axis 75 mm long, resting on its* base *on the H.P. with two of its* edges *parallel to the V.P. is cut by two section planes, both perpendicular to the V.P. The horizontal* section *plane cuts the axis at a point 35 mm from the apex. The other plane which* makes an *angle of 45° with the H.P.,* also *intersects the axis at the* same *point. Draw the front view, sectional top view, true shape of the section.*


o'
a1
3
4
7
V'
5
6
1'
2'
3'
V
T
8'
7'
4'
6'
5'
T'
x
y
a'
b'
c'
d'
f
e
8
7
6
d
a
1
5
2
3
4
b
c

Problem 06:

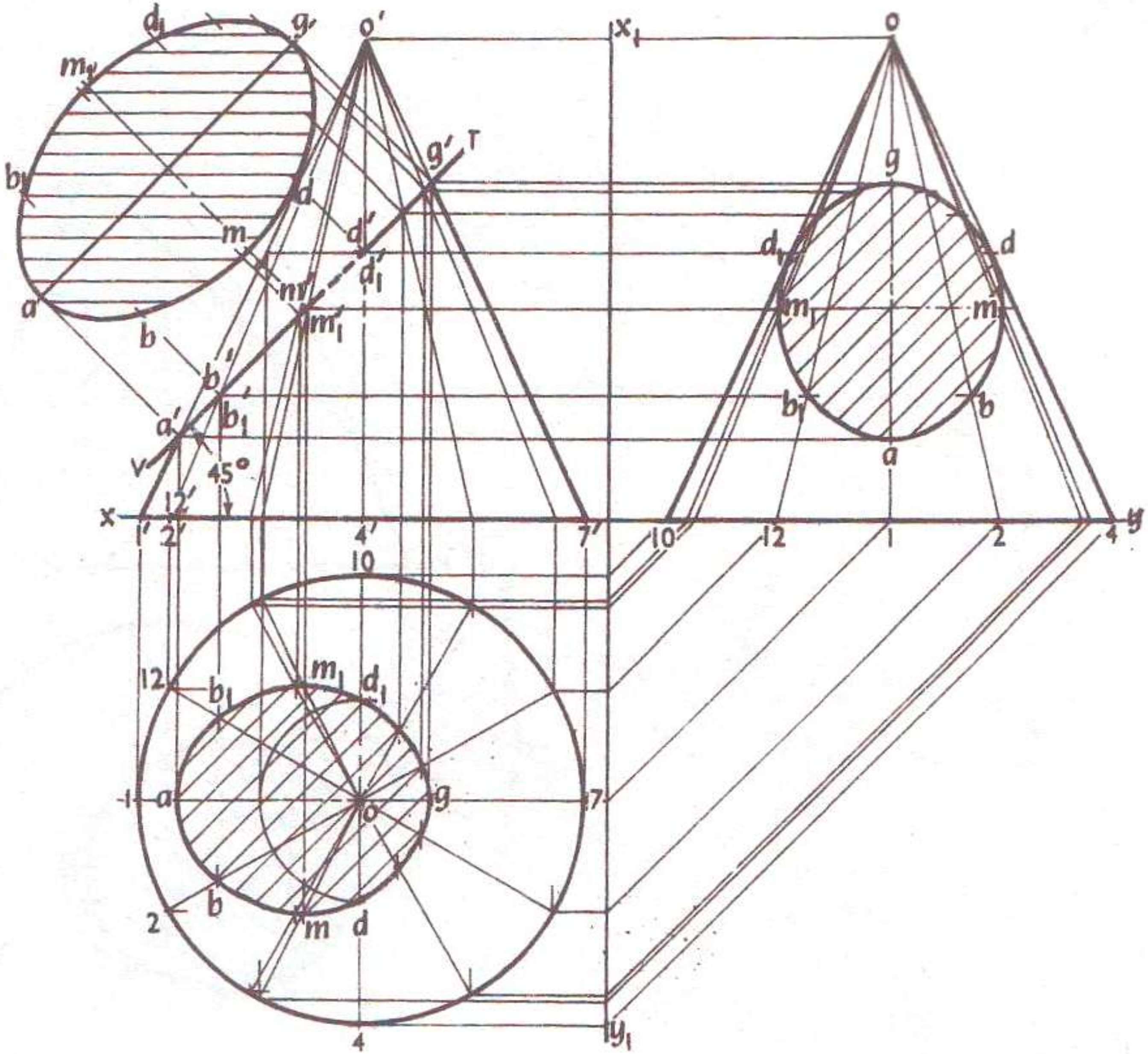
A cylinder, 55 mm diameter and 65 mm long, has its axis parallel to both the H.P. and the V.P. It is cut by a vertical section plane inclined at 30° to the V.P., so that the axis is cut at a point 25 mm from one *of its ends and both* the bases *of the cylinder are partly cut. Draw its sectional front view and true shape of the section.*



e_1'
e_1'
c'
$1'$
a'
e'
$10'$ $4'$
a'
e'
x
y
a_1'
a_1'
c'
$7'$
10
10
H
a_1
a_1'
a
b
1
7
c
7
1
d
e_1
e_1
e
T
4
4
a
c
a
e
c
e

Problem 06:

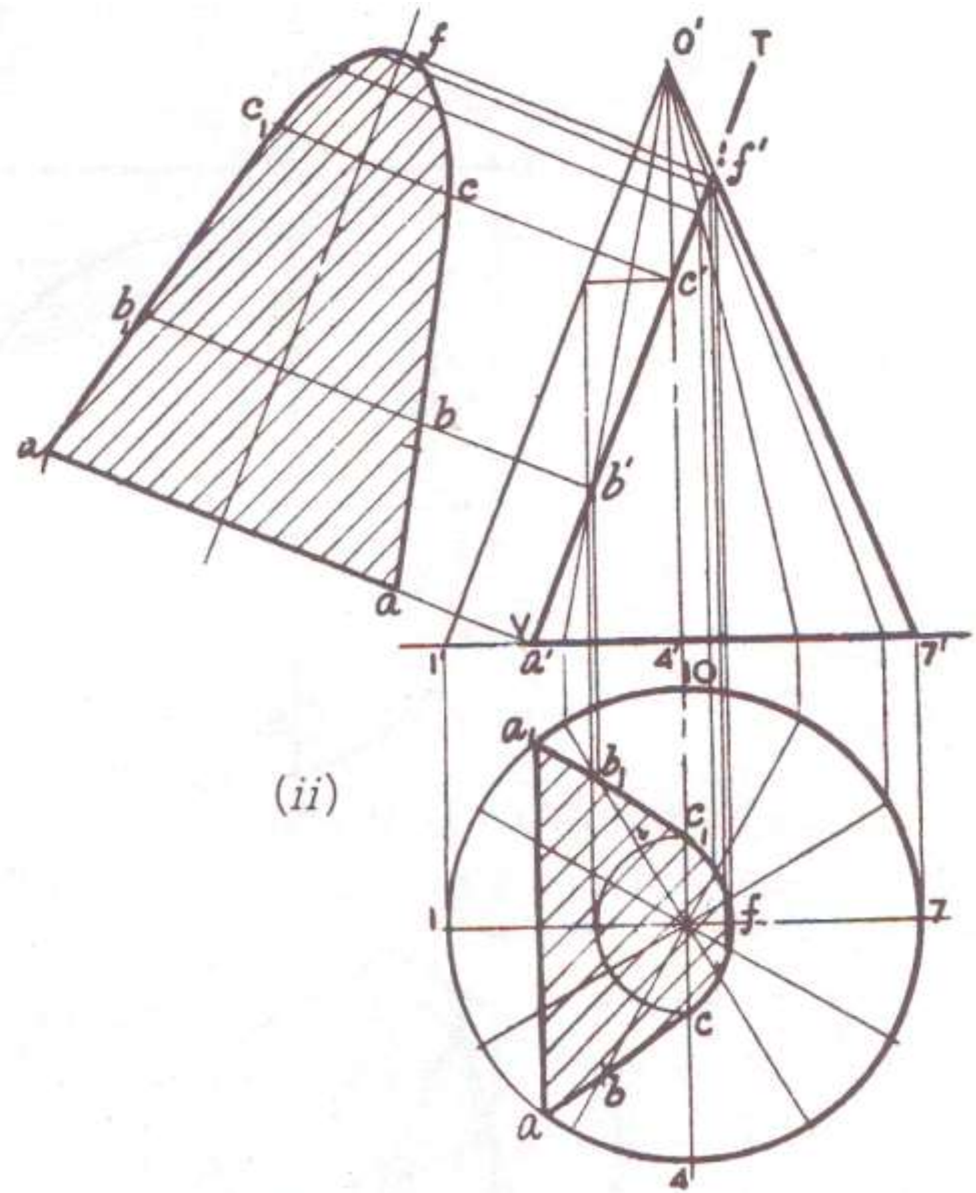
A cone, base 75 mm diameter and axis 80 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and cutting the axis at a point 35 mm from the apex. *Draw its front view, sectional top view, sectional side view and true* shape *of the section.*



d1
g'
o'
x1
o
m1
g'
T
b1
d
d'
g
m
d1'
d1
d
m1'
m1'
m1
m
a
b
b'
b1'
b1
b
a'
V
45°
a
12'
X
1'
2'
4'
7'
10
12
1
2
4
y
10
12
b1
m1
d1
1
a
o
g
7
2
b
m
d
4
y1

Problem 07:

The cone in same position as in problem 06, is cut by a section plane perpendicular to the V.P. and parallel to and 12 mm away from one of its end generators. Draw its front view sectional top view and true shape of the section.



(ii)

EXERCISE: XIV

1. A cube of 50 mm long edges is resting on the H.P with a vertical face inclined at 30° to the V.P. It is cut by a section plane, perpendicular *to the V.P., inclined at 30° to the H.P and passing through a point on the axis, 38 mm above the H.P. Draw the sectional top view, true* shape of the section and development of the surface of the remaining portion of the cube.

2. A hexagonal prism, side of base *35* mm and height *75* mm is resting *on one of its corners on the H.P with a longer edge containing that corner inclined at 60° to the H.P and a rectangular face parallel to the V.P. A horizontal section plane cuts the prism in two equal halves.*

(i) Draw the front view and sectional top view of the cut prism.

(ii) Draw another top view on an auxiliary inclined plane which makes an angle of 45° with the H.P.

3. A pentagonal prism, side of base 50 mm and length 100 mm has a *rectangular face on the H.P. and the axis parallel to the V.P. It is cut by a vertical section plane, the H.T. of which makes an angle of* 30° with xy and bisects the axis. Draw the sectional front view, top view and true shape of the section.

4. A hollow square prism, base *50* mm side (outside), length *75* mm and *thickness 9 mm is lying on the H.P. on one of its rectangular faces,* with the axis inclined at 30° to the V.P. A section plane, parallel to the *V.P. cuts the prism, intersecting the axis at a point 25 mm from one* of its ends. Draw the top view and sectional front view of the prism.

5. A cylinder, 65 mm diameter and 90 mm long, has its axis parallel to the H.P and inclined at 30° to the V.P. It is cut by a vertical section plane in such a way that the true shape of the section is an ellipse having the major axis 75 mm long. Draw its sectional front view and true shape of the section.

6. A cube of *65* mm long edges has its vertical faces equally inclined to the V.P. It is cut by a section plane, perpendicular to the V.P., so that the true shape of the section is a regular hexagon. Determine the inclination of the cutting plane with the H.P and draw the sectional top view and true shape of the section.

7. A vertical hollow cylinder, outside diameter 60 mm, length 85 mm and thickness 9 mm is cut by two section planes which are normal to the V.P and which intersect each other at the top end of the axis. The planes cut the cylinder on opposite sides of the axis and are inclined at 30° and 45° respectively to it. Draw the front view, sectional top view and auxiliary sectional top views on planes parallel to the respective section planes.

8. A square pyramid, base 50 mm side and axis 75 mm long, is resting, on the H.P on one of its triangular faces, the top view of the axis making an angle of 30° with the V.P. It is cut by a horizontal section plane, the V.T. of which intersects the axis at a point 6 mm from the base. Draw the front view, sectional top view.

9. A pentagonal pyramid, base 30 mm side and axis 75 mm long, has its base horizontal and an edge of the base parallel to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 60° to the H.P and bisecting the axis. Draw the front view and the top view, when the pyramid is tilted so that it lies on its cut-face on the ground with the axis parallel to the V.P. Show the shape of the section by dotted lines.

10. A tetrahedron of 65 mm long edges is lying on the H.P. on one of its faces, with an edge perpendicular to the V.P. It is cut by section plane which is perpendicular to the V.P. so that the true shape of the section is an isosceles triangle of base 50 mm long any altitude 40 mm. Find the inclination of the section plane with the H.P. and draw the front view, sectional top view and the true shape of the section.

11. A hexagonal pyramid, base 50 mm side and axis 100 mm long, is lying on the H.P. on one of its triangular faces with the axis parallel to the V.P. A vertical section plane the H.T. of which makes an angle of 30° with the reference line, passes through the centre of the base and cuts the pyramid, the apex being retained. Draw the top view, sectional front view, true shape of the section.

12. A cone, base 75 mm diameter and axis 75 mm long, has its axis parallel to the V.P. and inclined at 45° to the H.P. A horizontal section plane cuts the cone through the mid-point of the axis. Draw the front view, sectional top view and an auxiliary top view on a plane parallel to the axis.

13. A cone, base 65 mm diameter and axis 75 mm long, is lying on the H.P on one of its generators with the axis parallel to the V.P. A section plane which is parallel to the V.P. cuts the cone 6 mm away from the axis. Draw the sectional front view.

14. The cone in above problem 13 is cut by a horizontal section plane passing through the centre of the base. Draw the sectional top view and another top view on an auxiliary plane parallel to the axis of the cone.

UNIT-IV

DEVELOPMENT OF SURFACES

- Imagine that a solid is enclosed in a wrapper of thin material, such as paper. If this covering is opened out and laid on a flat plane, the flattened-out paper is the development of the solid. Thus, when surfaces of a solid are laid out on a plane, the figure obtained is called its development.

- The knowledge of development of surfaces is essential in many industries such as automobile, aircraft, ship building, packaging and sheet-metal work. In construction of boilers, bins, process-vessels, hoppers, funnels, chimneys etc., the plates are marked and cut according to the developments which, when folded, form the desired objects.

- Only the surfaces of polyhedra (such as prisms and pyramids) and single-curved surfaces (as of cones and cylinders) can be accurately developed. Warped and double-curved surfaces are undevelopable. These can however be approximately developed by dividing them up into a number of parts.

METHODS OF DEVELOPMENT:

(i) Parallel-line development: It is employed in case of prisms and cylinders in which stretch-out-line principle is used.

(ii) Radial-line development: It is used for pyramids and cones in which the true length of the slant edge or the generator is used as radius.

(iii) Triangulation development: This is used to develop transition pieces. This is simply a method of dividing a surface into a number of triangles and transferring them into the development.

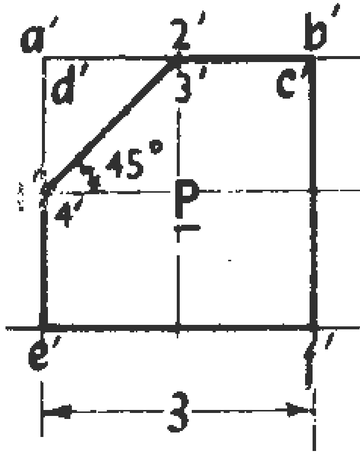
(iv) Approximate method: It is used to develop objects of double curved or warped surfaces as sphere, paraboloid, ellipsoid, hyperboloid and helicoid.

DEVELOPMENTS OF LATERAL SURFACES OF RIGHT SOLIDS:

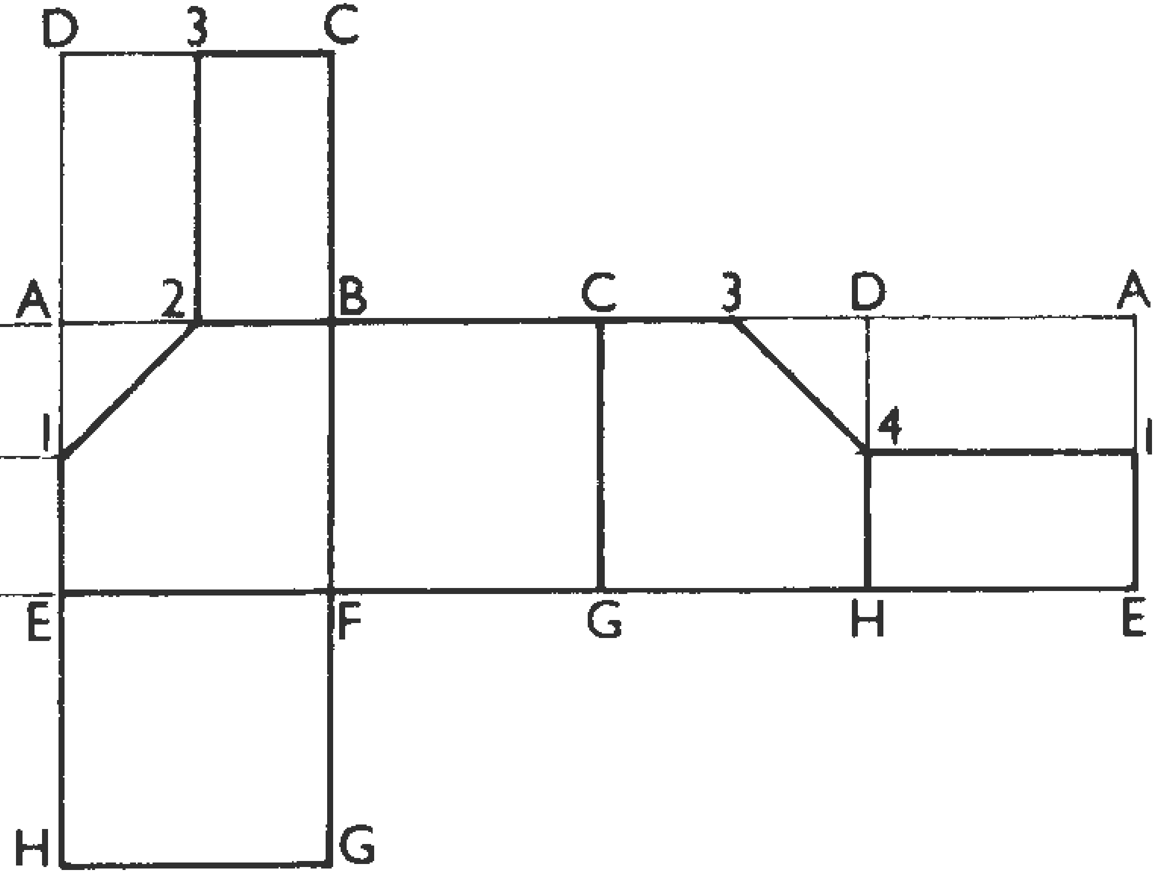
Problem 01:

Draw the development of the surface of the part P of the cube, the front view of which is shown in the figure.

Name all the corners of the cube and also the points at which the edges are cut.



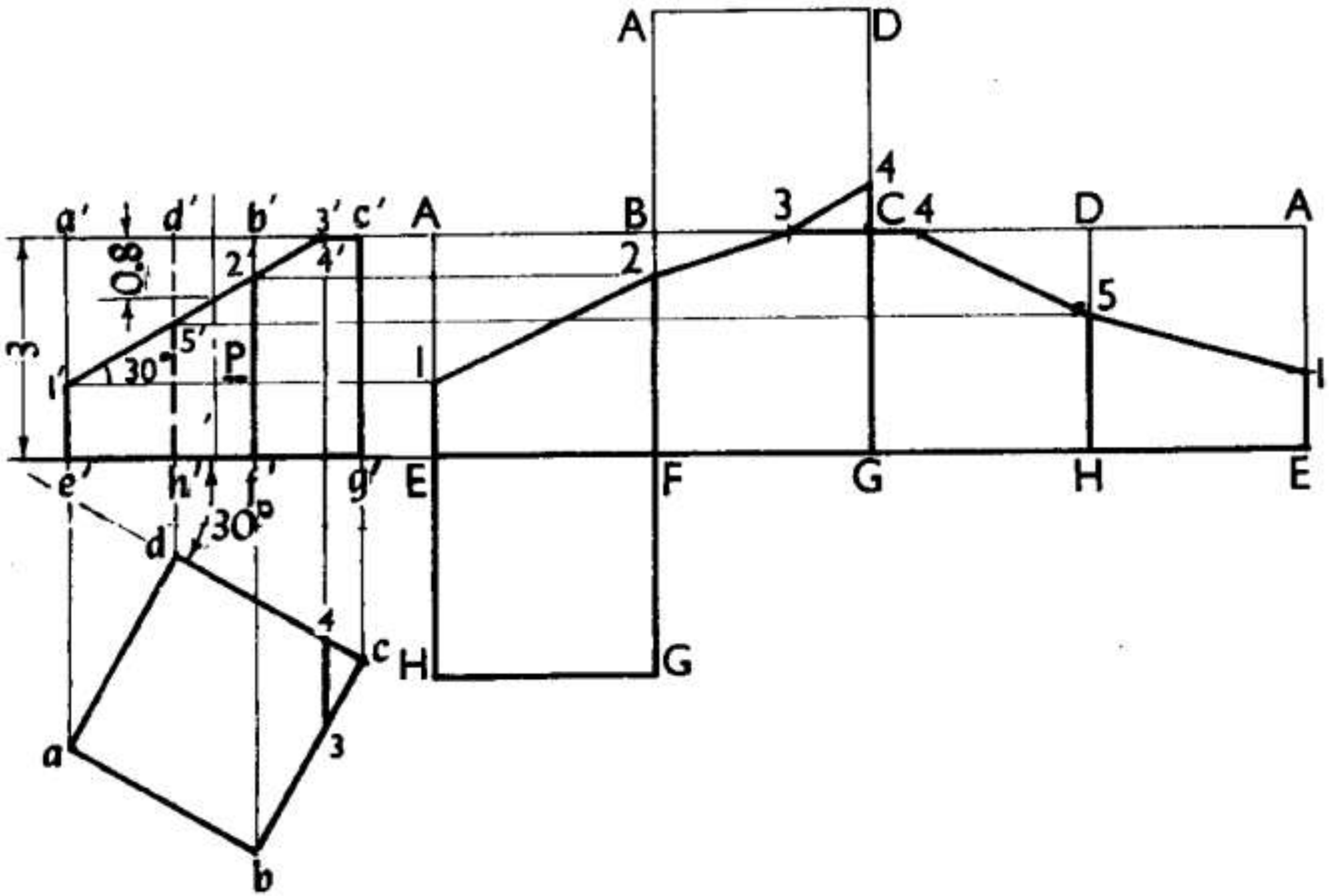
(i)



(ii)

Problem 02:

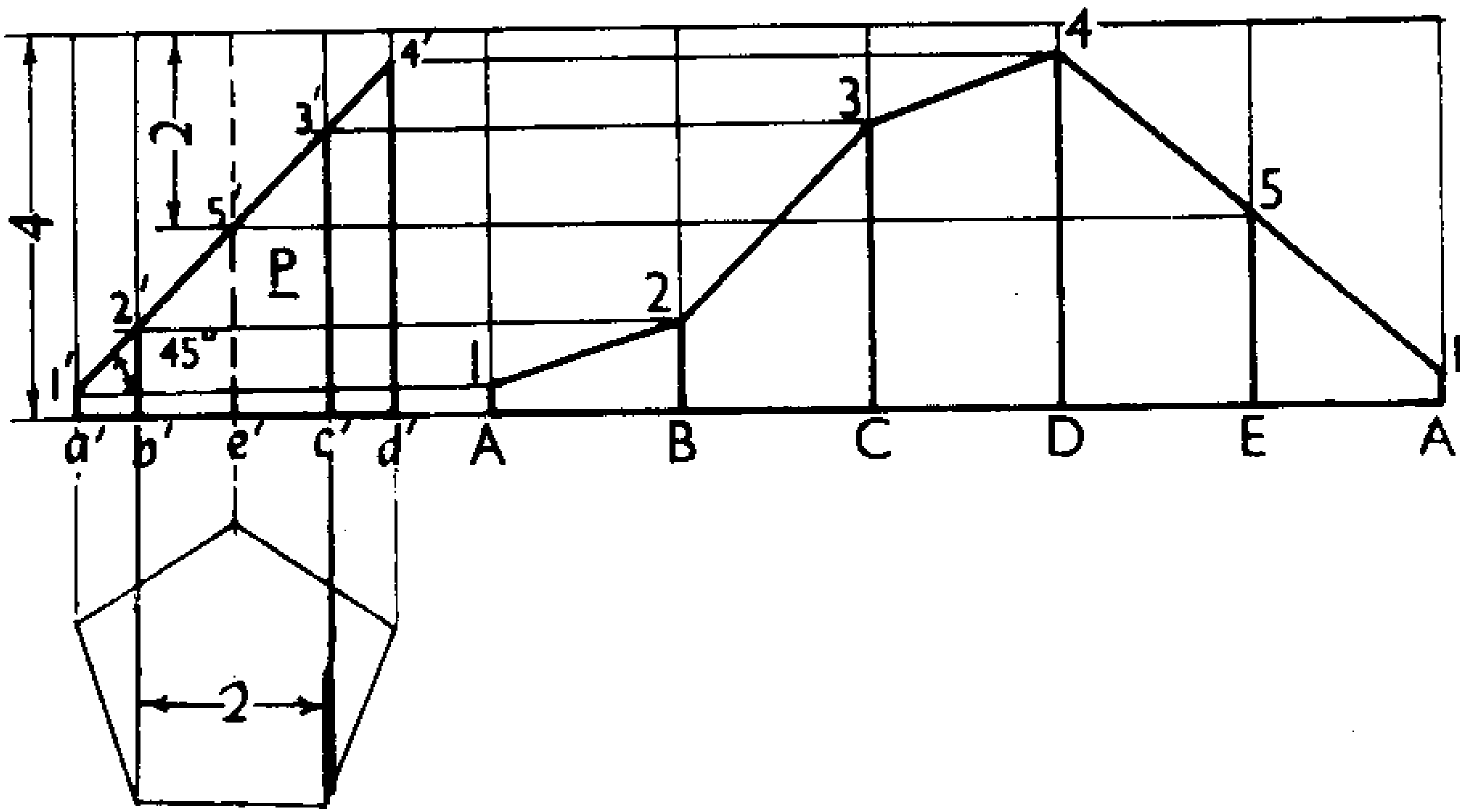
Draw the development of the surface of the part P of the cube shown in two views in the figure.



(i)

(ii)

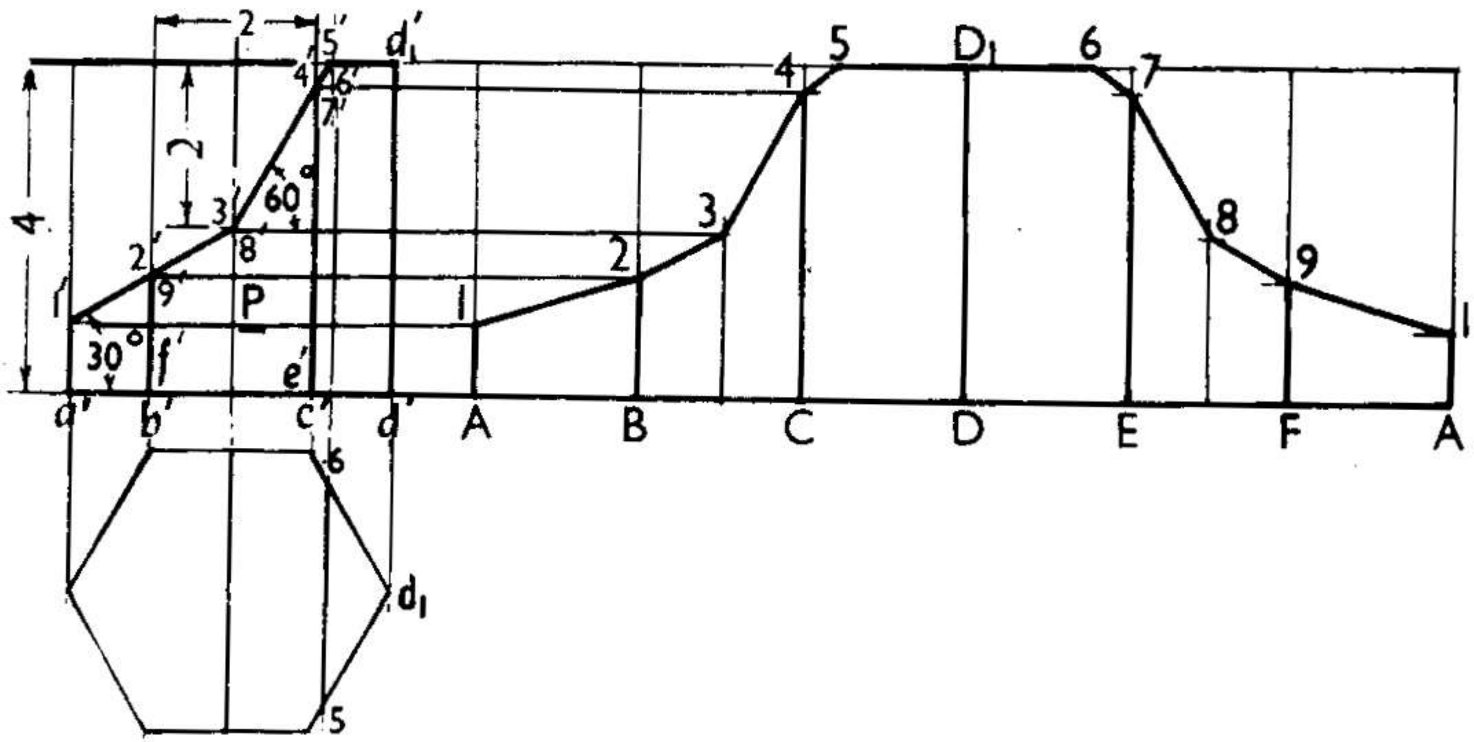
Problem 03:



(i) (ii)

Problem 04:

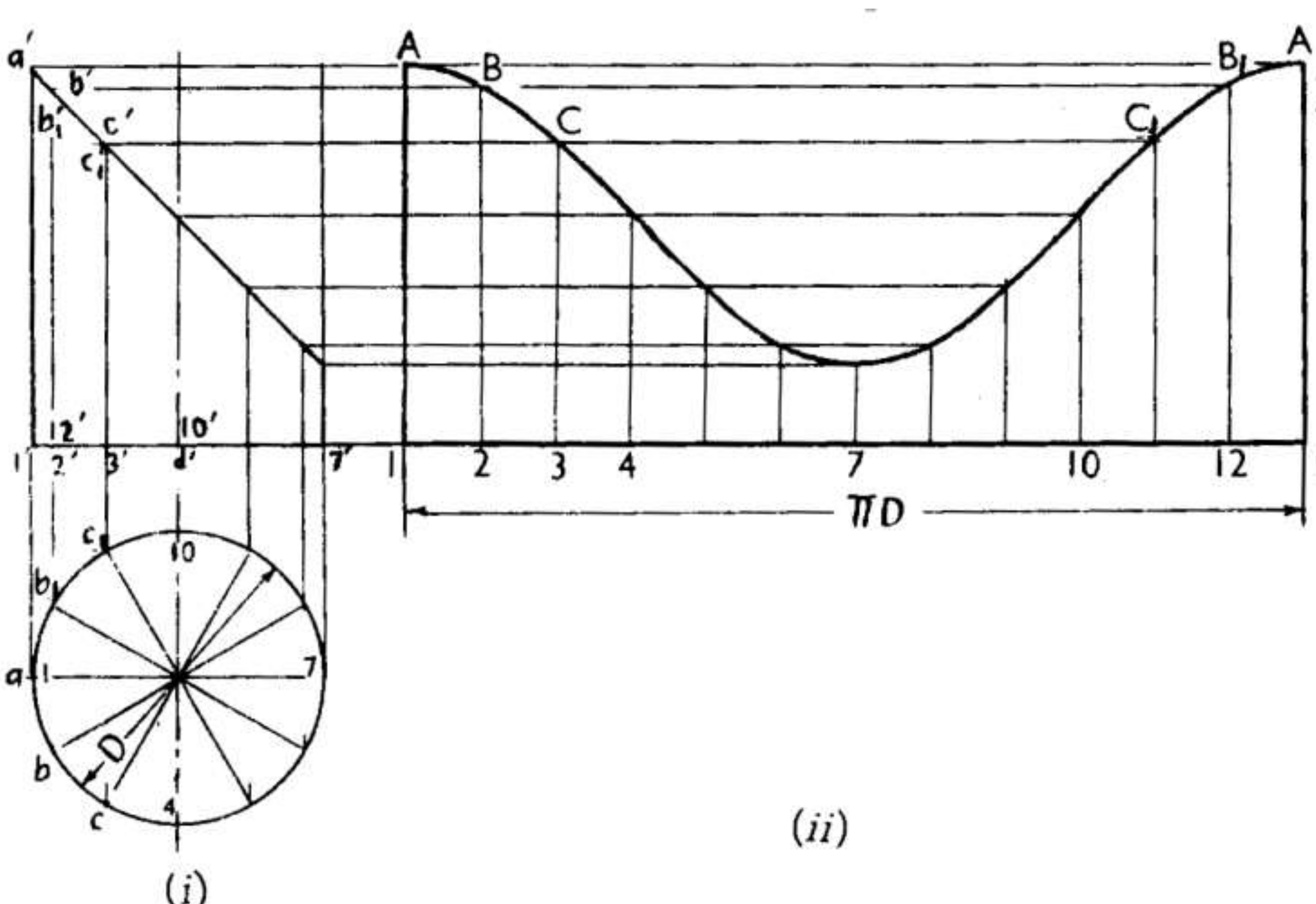
Draw the development of the lateral surface of the part P of the pentagonal prism shown in two views in the figure.



(i)

(ii)

Problem 05:



a'
b'
b'1
c'
c'1
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B
C
B1
A
C1
12'
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1
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1
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c
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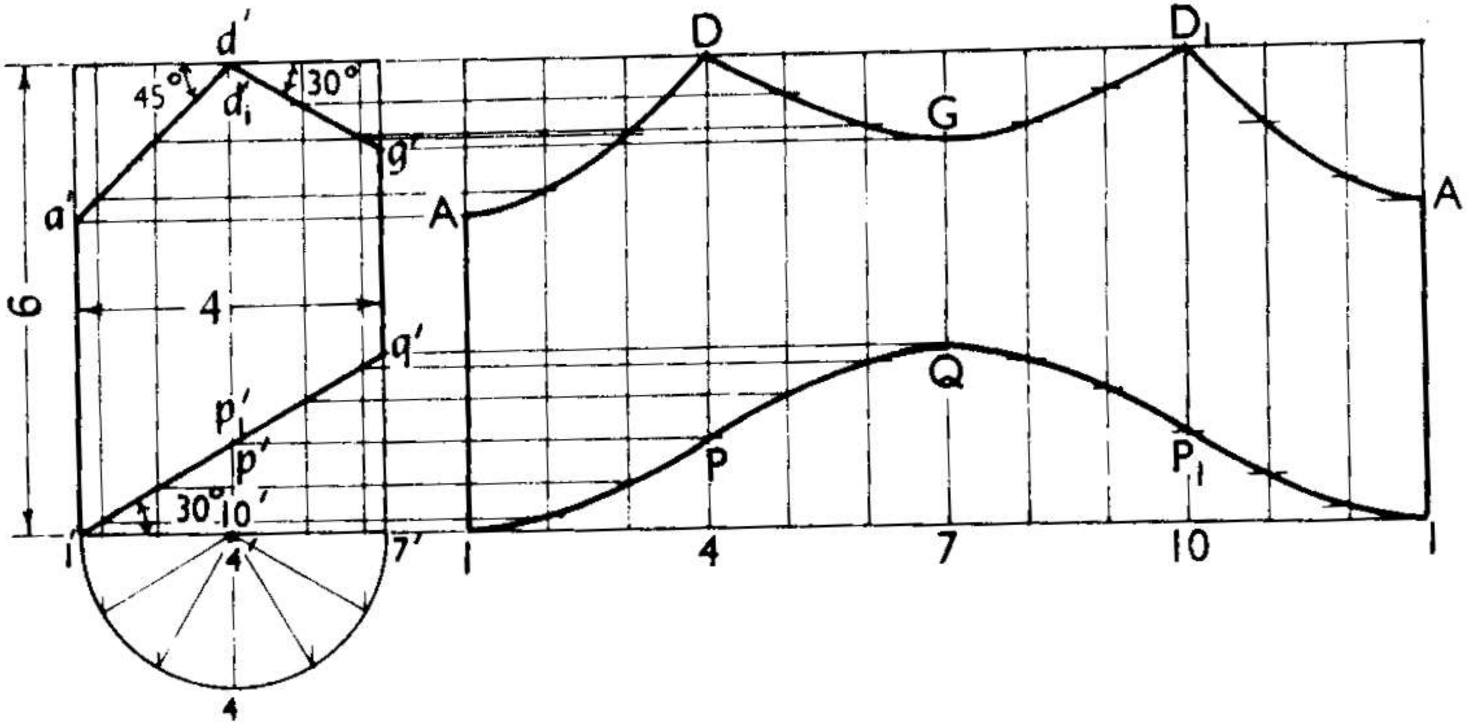
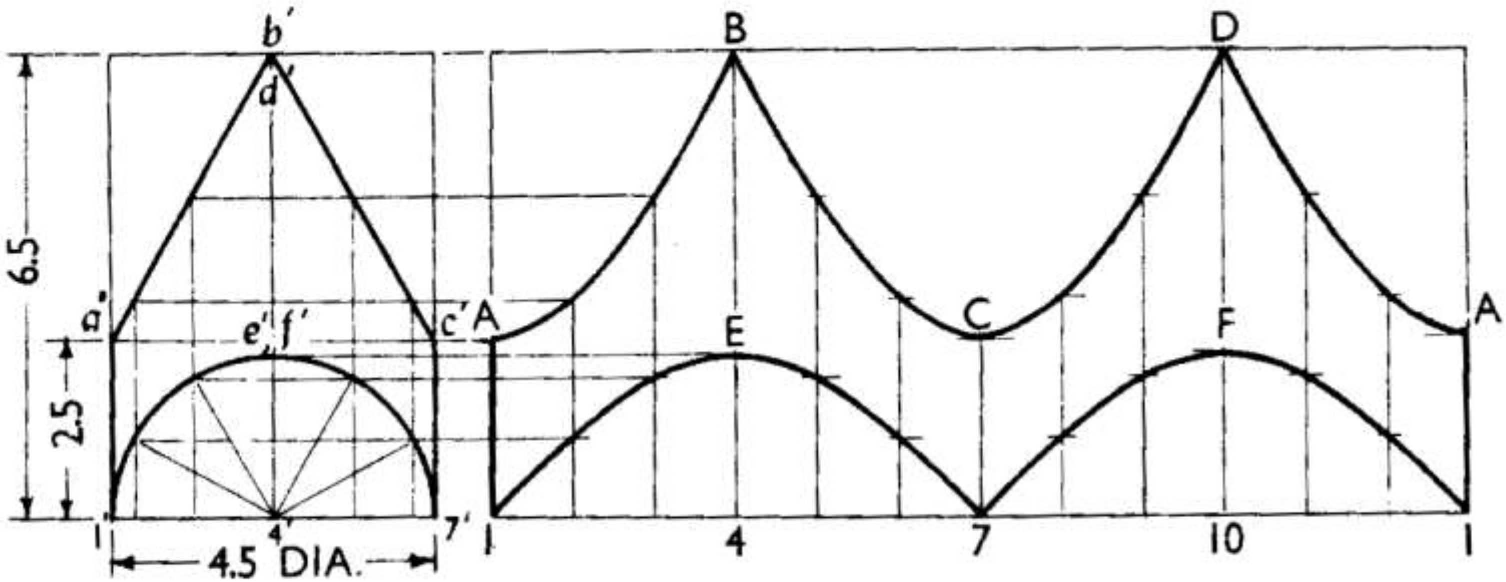
(i)
(ii)

Problem 06:



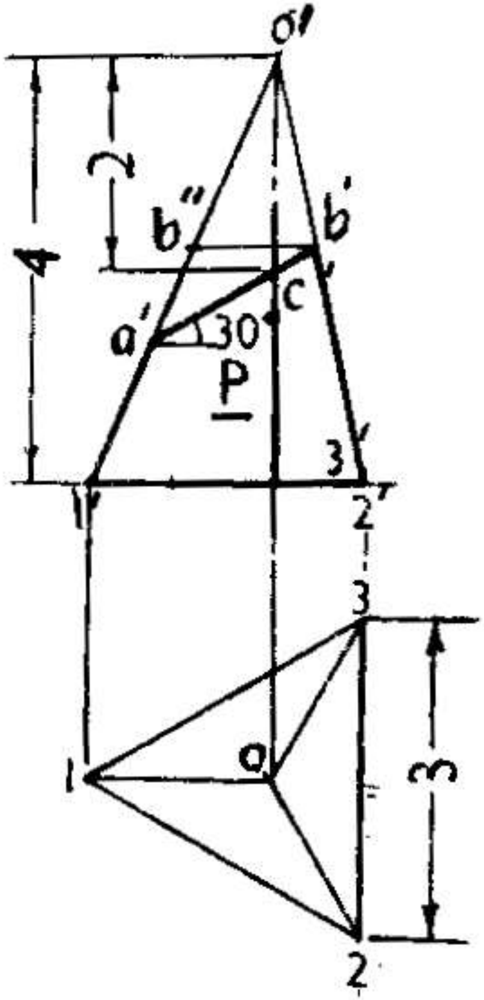
(i) (ii)

Problem 07:

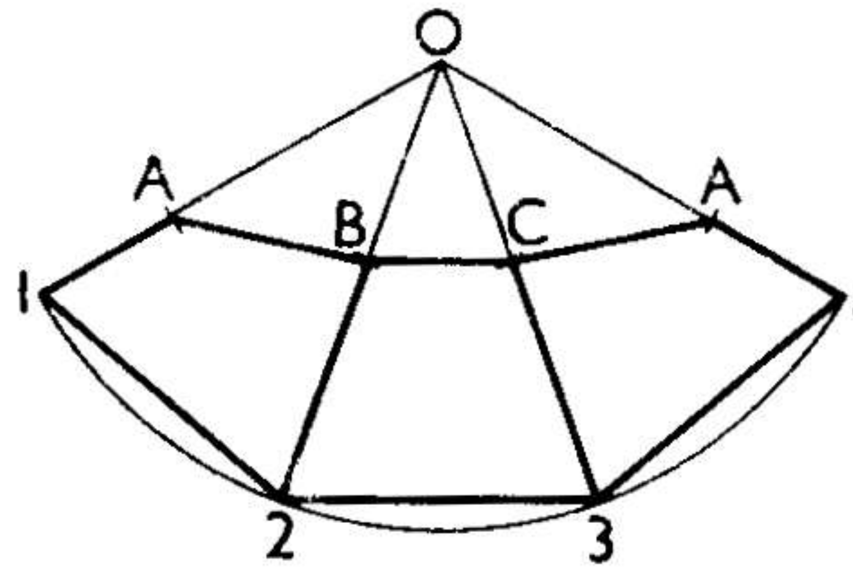


(i) (ii)

Problem 08:

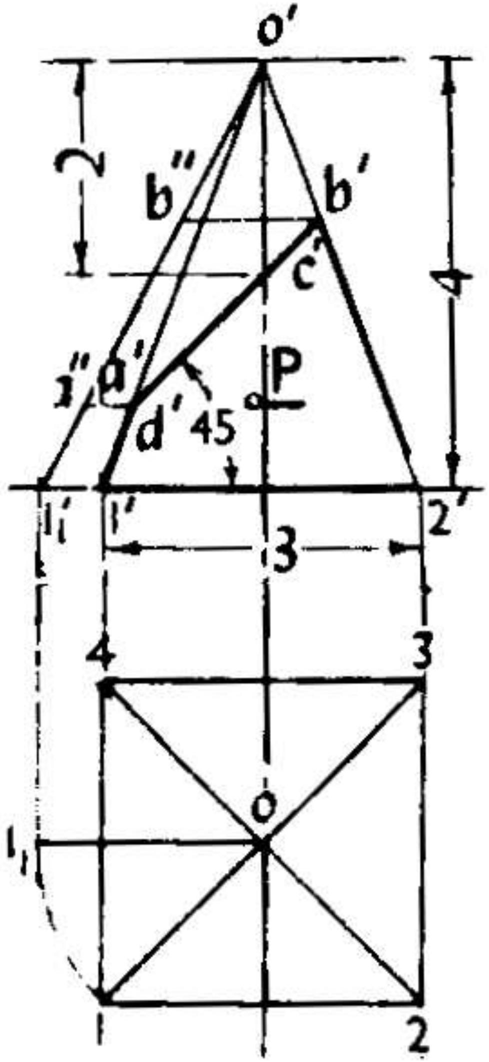


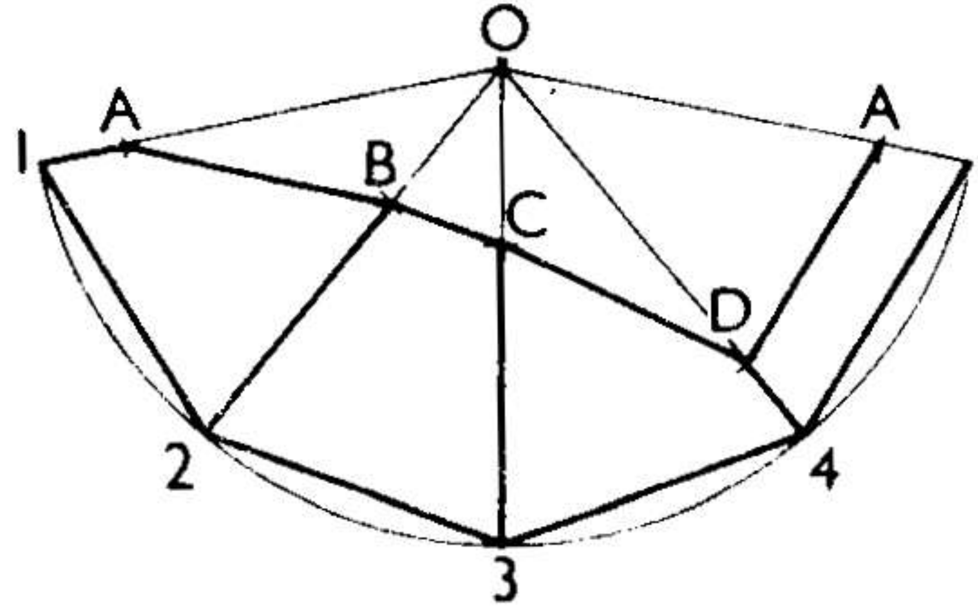
(i)



(ii)

Problem 09:

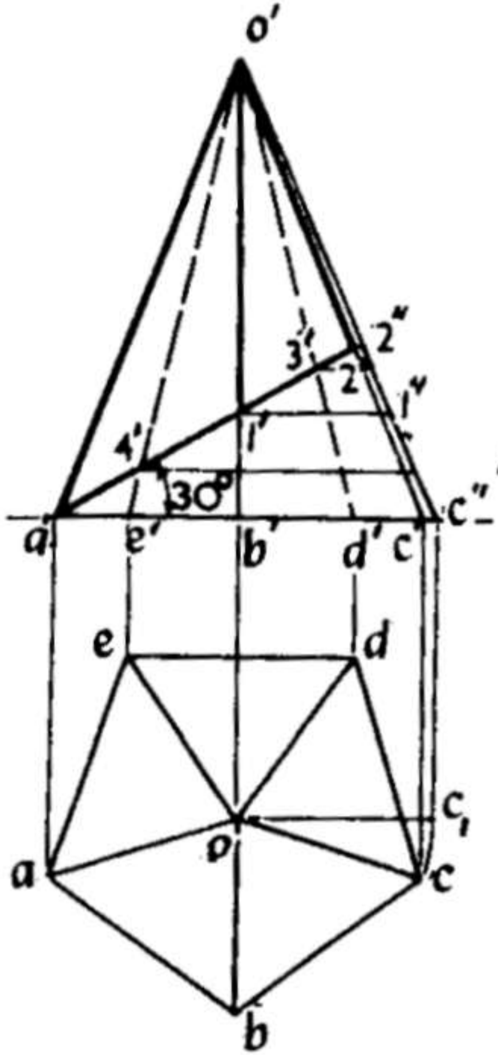




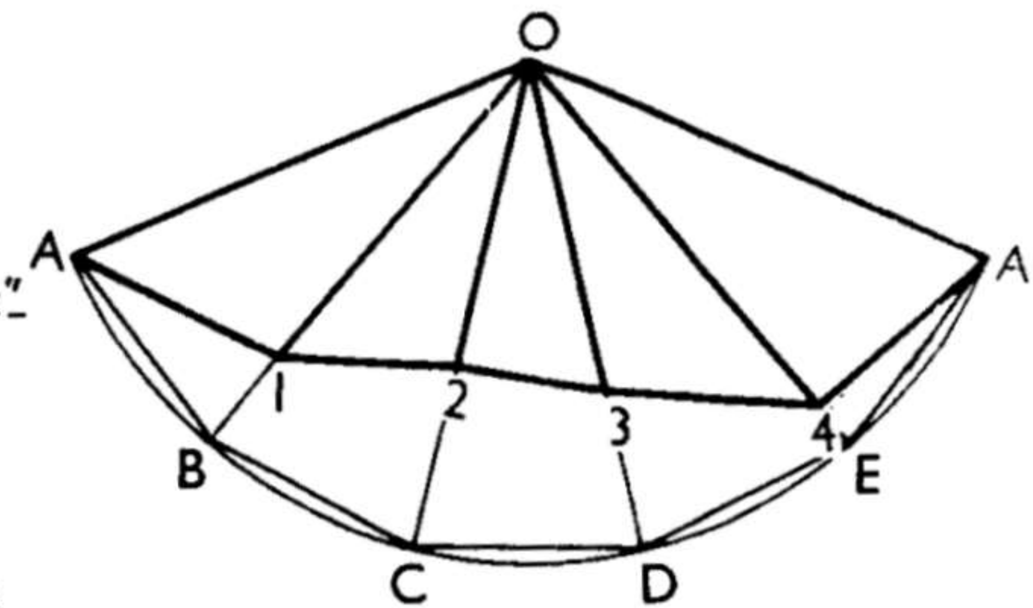
(ii)

(i)

Problem 10:

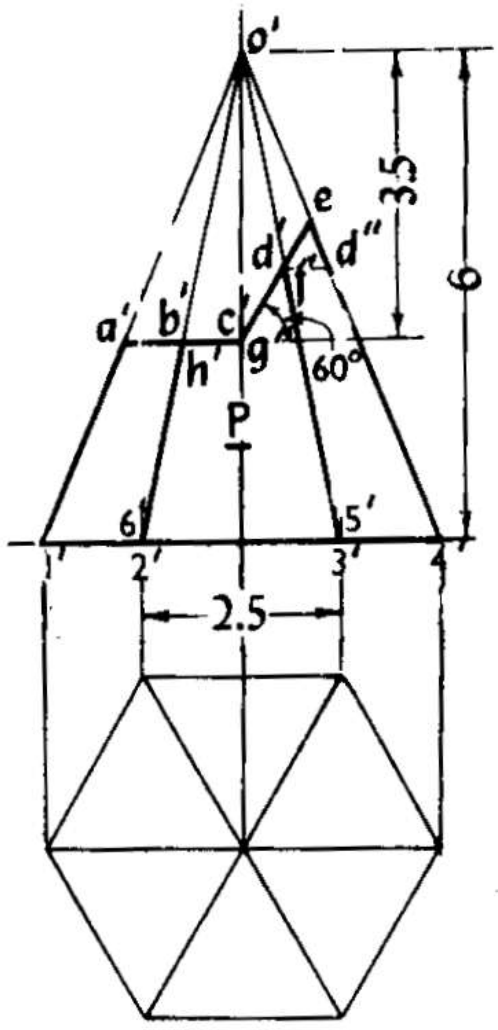


(i)

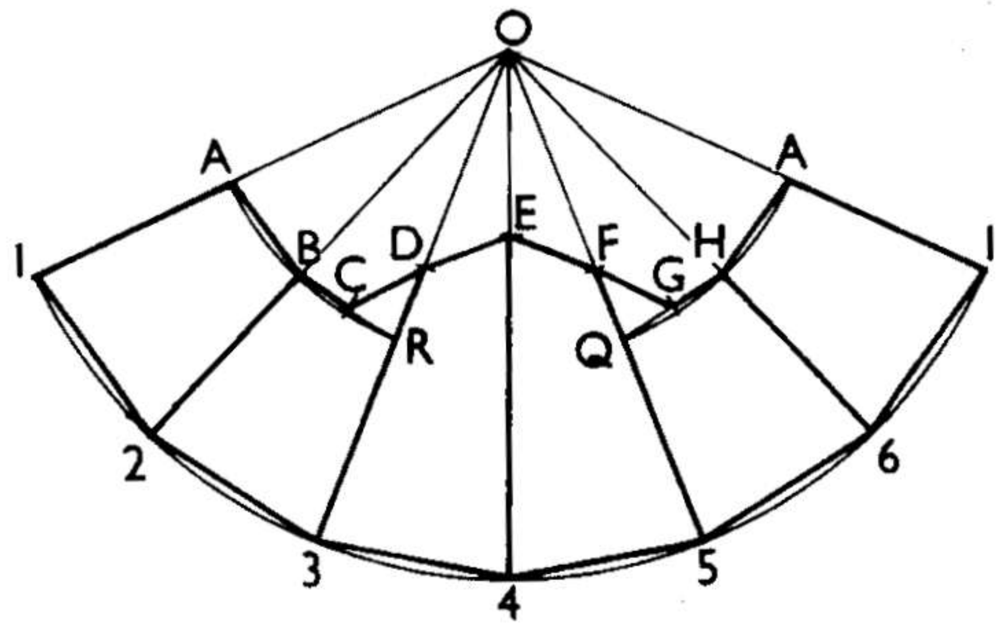


(ii)

Problem 11:



(i)

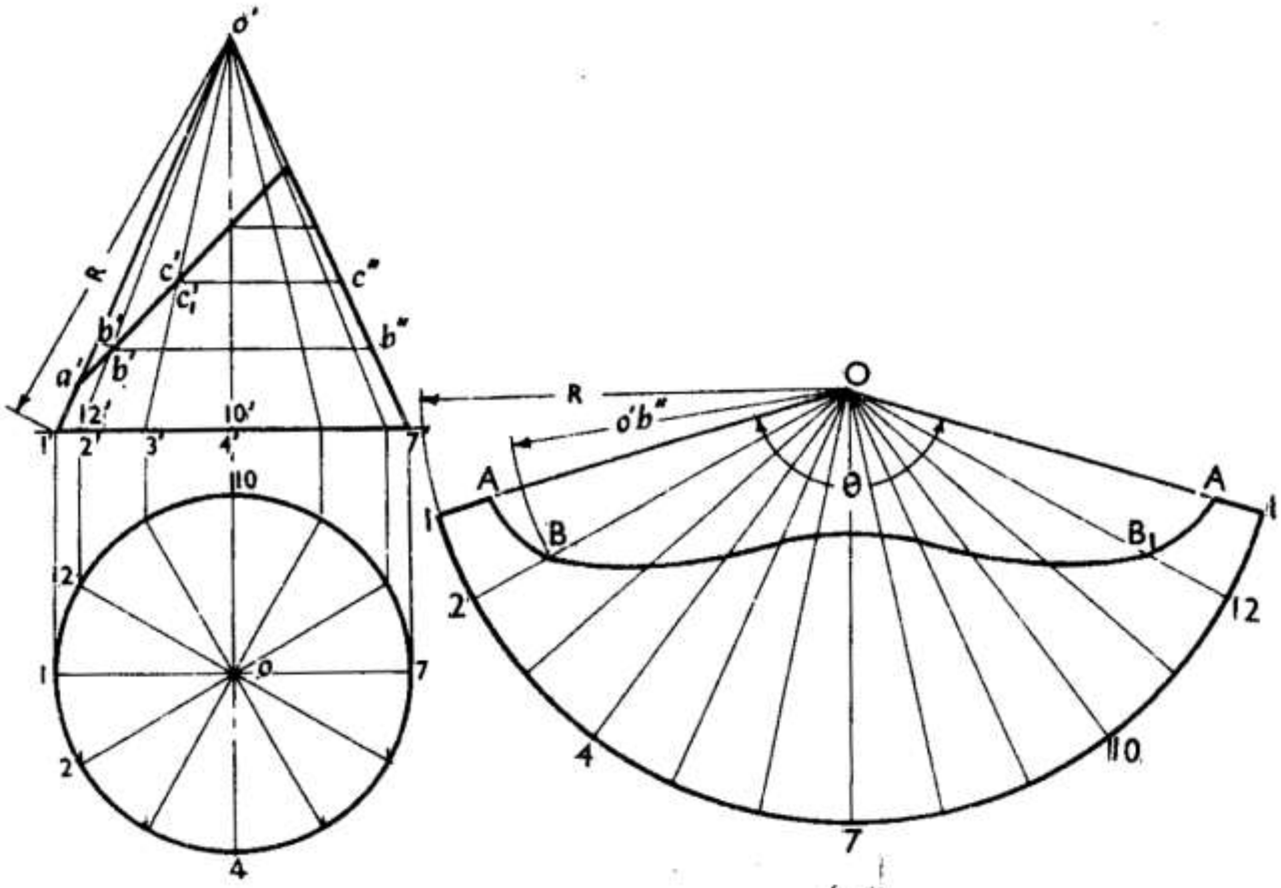


(ii)

Calculate the subtended angle θ by the formula,

$$\theta = 360^\circ \times \frac{\text{radius of the base circle}}{\text{slant height}}$$

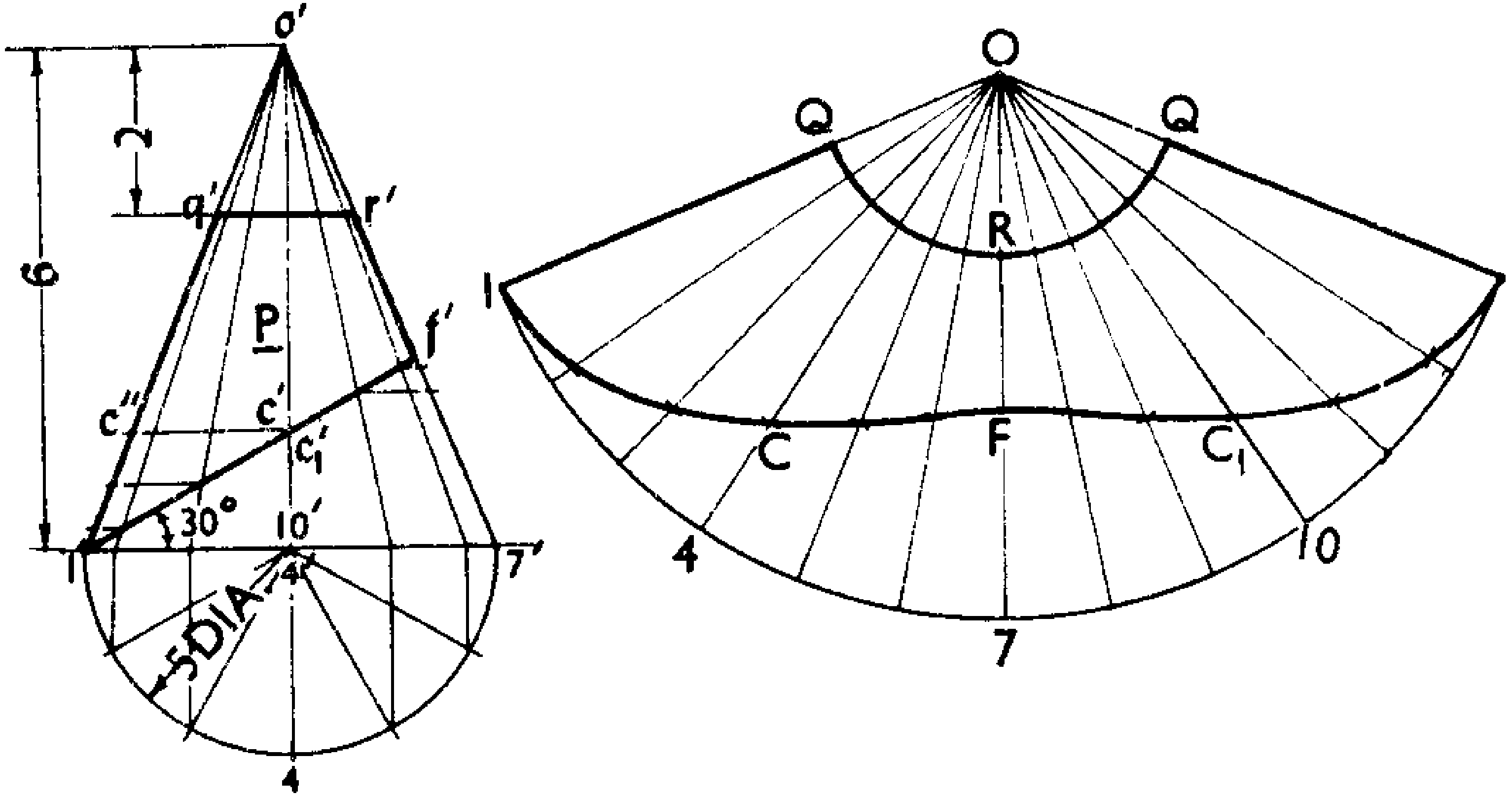
Problem 12:



(i)

(ii)

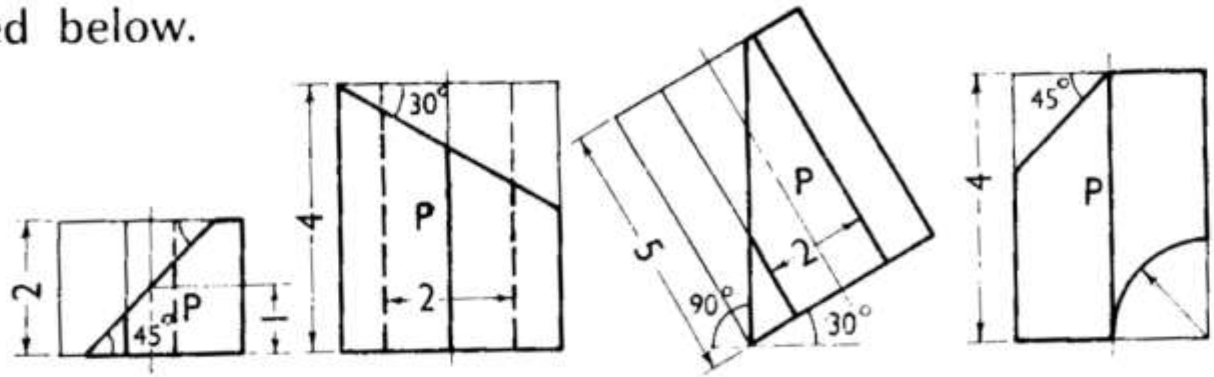
Problem 13:



(i) (ii)

EXERCISE XV:

1. Draw the development of the lateral surface of the part *P* of each of the solids, the front views of which are shown in fig. 15-40 and described below.



(*a*) (*b*) (*c*) (*d*)

FIG. 15-40

(a) A cube, one vertical face inclined at 30° to the V.P.
(b) A pentagonal prism, a side of the base parallel to the V.P.
(c) A hexagonal prism, two faces parallel to the V.P.
(d) A square prism, length of the side of the base 20 mm and all faces equally inclined to the V.P.

2. Draw the development of the lateral surface of the part *P* of each of the cylinders, the front views of which are shown in fig. 15-41.

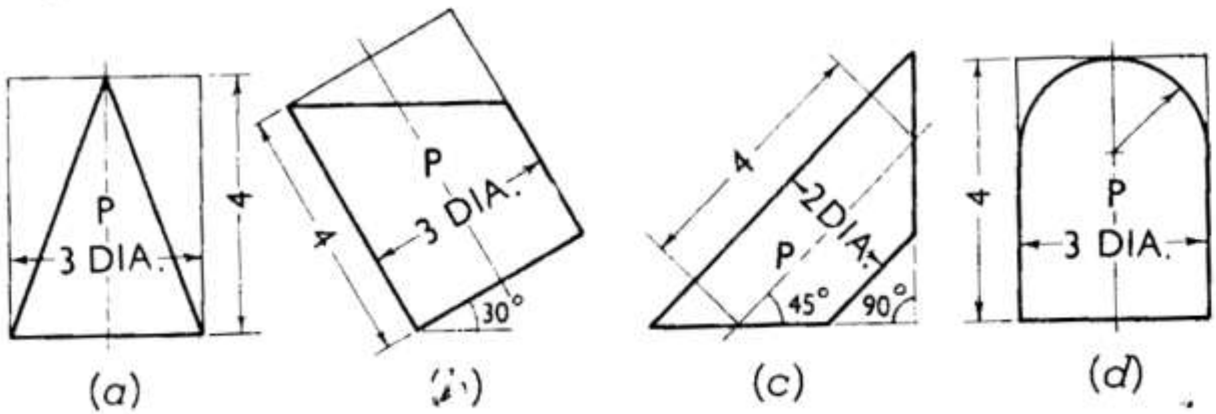


FIG. 15-41

3. Draw the development of the lateral surface of the part *P* of each of the pyramids, the front views of which are shown in fig. 15-42, and described below.

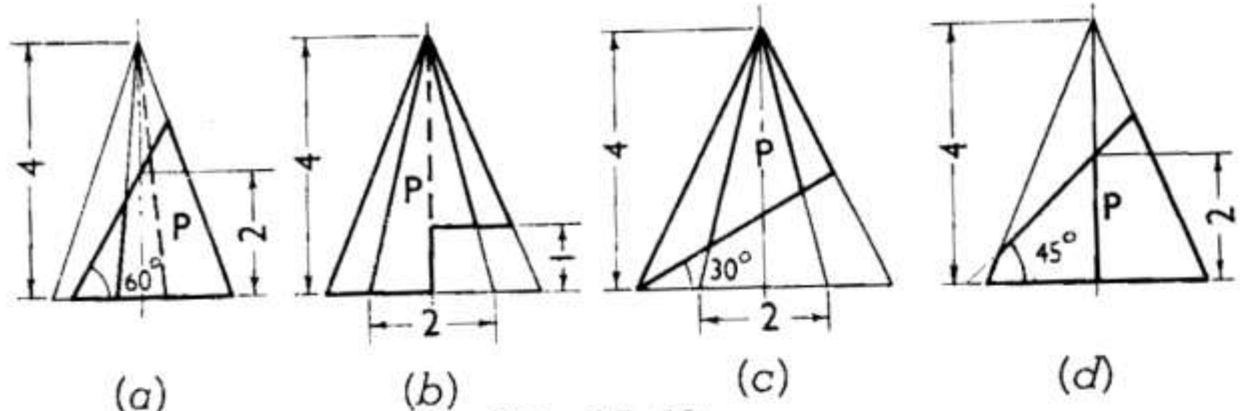
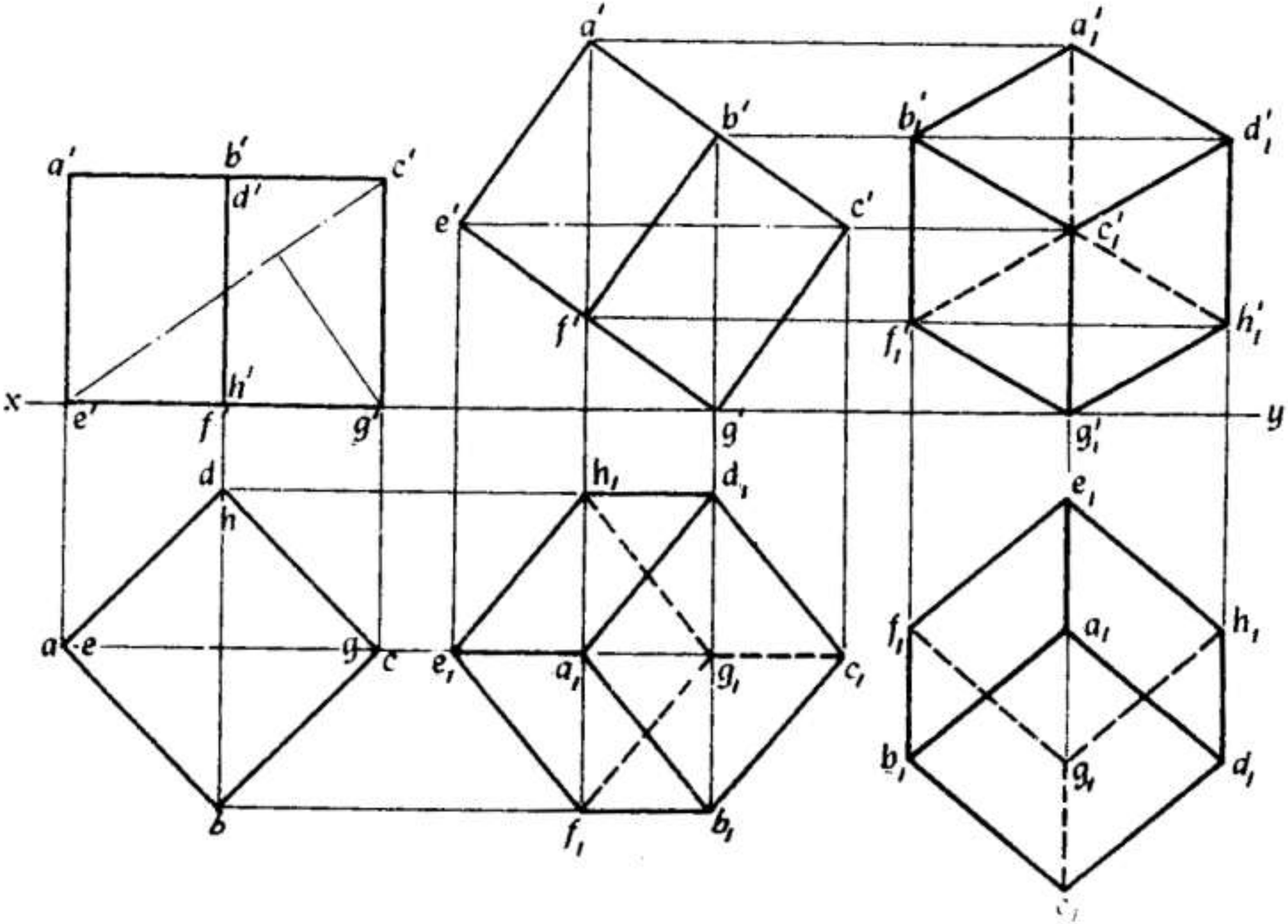


FIG. 15-42

ISOMETRIC PROJECTION

- Isometric projection is a type of pictorial projection in which the three dimensions of a solid are not only shown in one view, but their actual sizes can be measured directly from it.
- If a cube is placed on one of its corners on the ground with a solid diagonal perpendicular to the V.P., the front view is the isometric projection of the cube.


a'
b'
c'
d'
x
e'
f
h'
g'
d
h
a
e
g
c
b
e'
f'
g'
h1
d1
e1
a1
g1
c1
f1
b1
a1'
b1'
d1'
c1'
f1'
h1'
g1'
y
e1
f1
a1
h1
b1
g1
d1

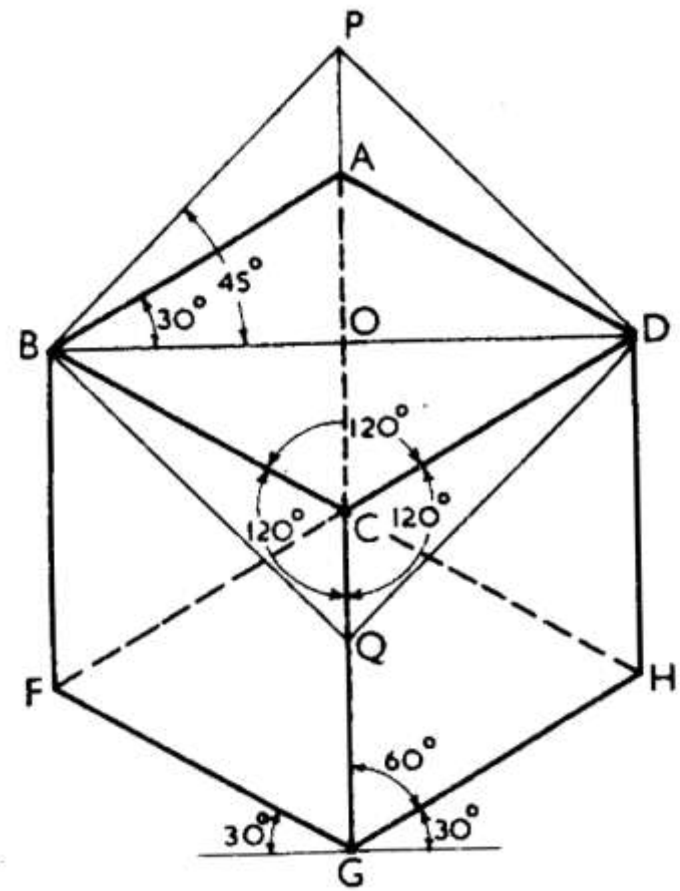
(i) (ii) (iii)

CB, CD, CG – Isometric axes

Lines parallel to these axes – Isometric lines

Planes representing the faces – Isometric planes

Construct a square BQDP around BD as a diagonal. Then BP shows the true length of BA.



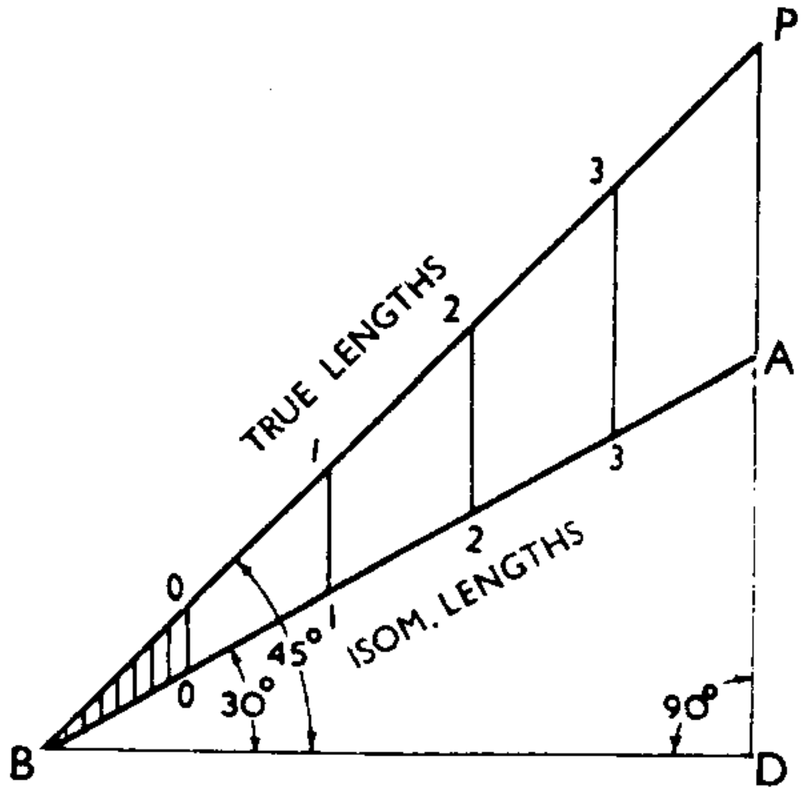
$$In\ \Delta\ ABO,\ \frac{BA}{BO}=\frac{1}{COS30^{O}}=\frac{2}{\sqrt{3}}$$

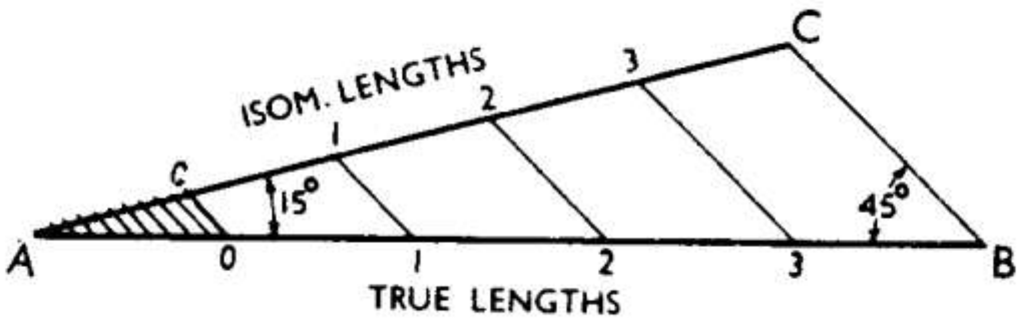
$$In\ \Delta\ PBO,\ \frac{BP}{BO}=\frac{1}{COS45^{O}}=\frac{\sqrt{2}}{1}$$

$$\frac{BA}{BP}=\frac{2}{\sqrt{3}}\times\frac{1}{\sqrt{2}}=0.815$$

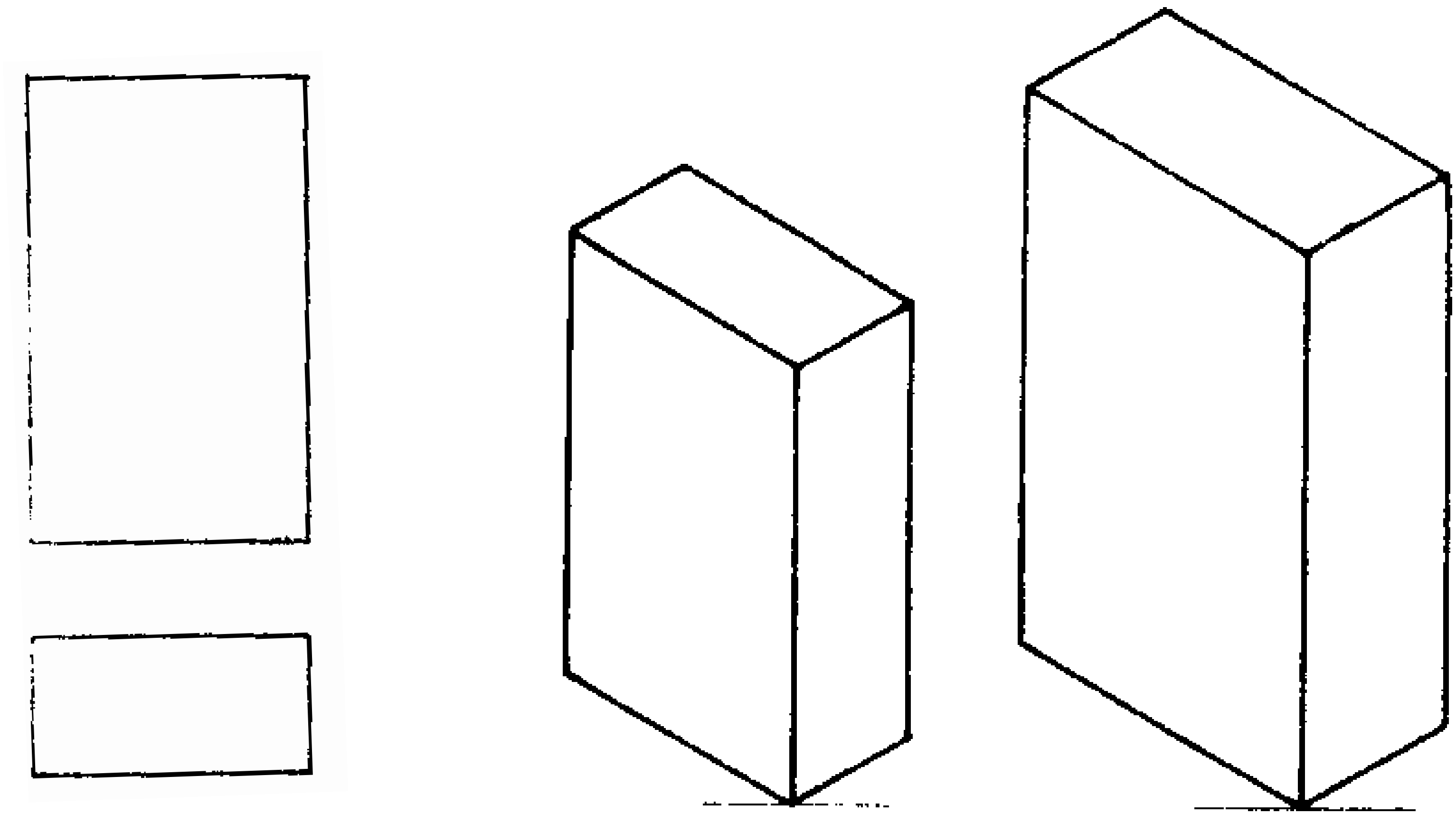
$$\therefore\ \frac{Isometric\ length}{True\ length}=0.815\cong\frac{9}{11}$$

Isometric scale:

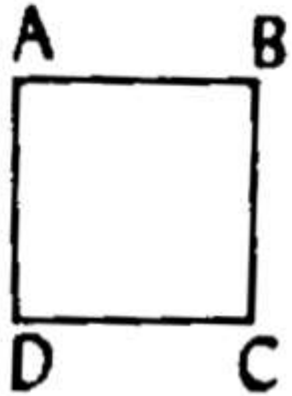


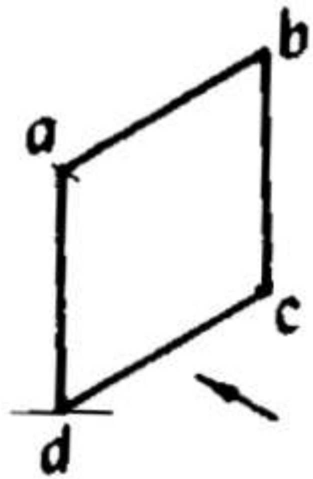


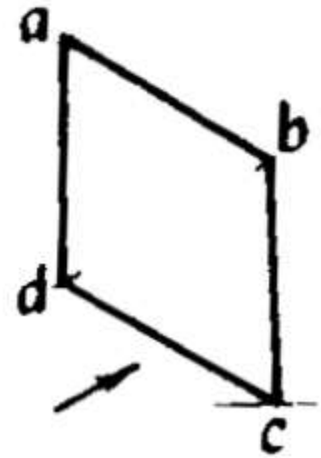
Isometric projection v/s Isometric drawing (Isometric view)

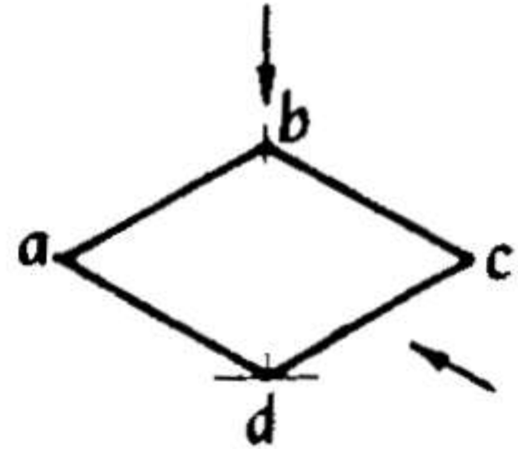


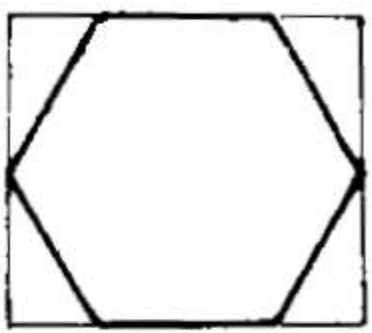
Isometric drawing of planes or plane figures

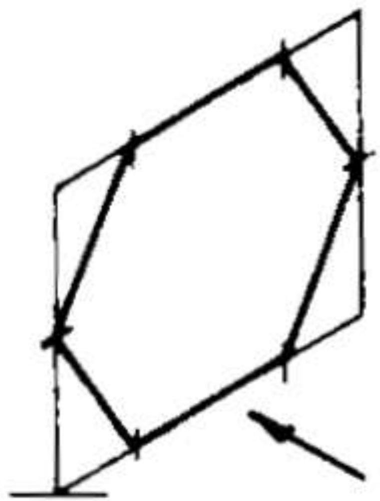


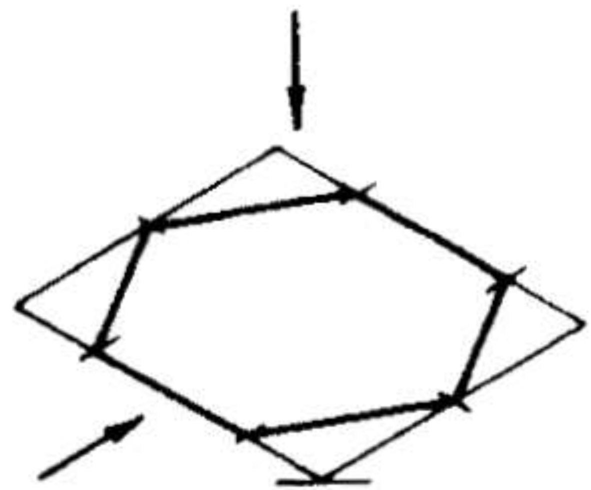




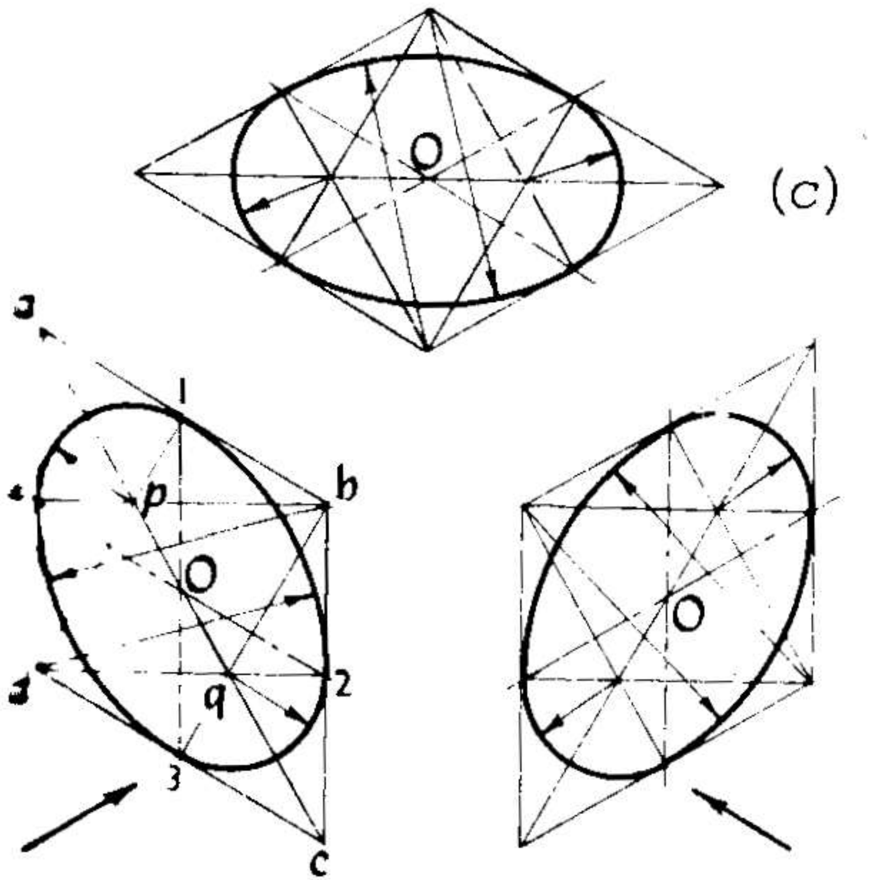




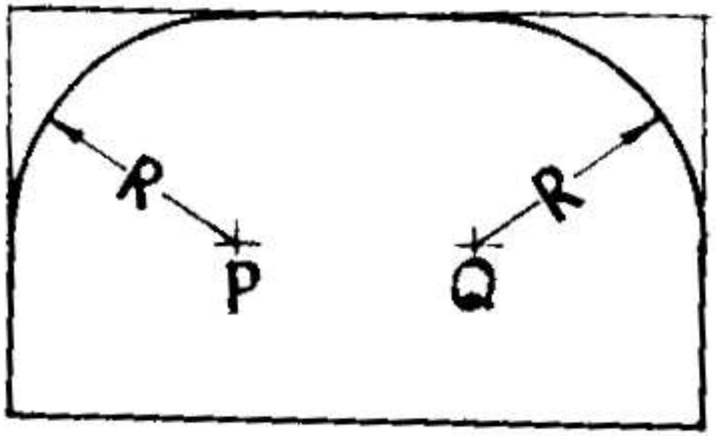


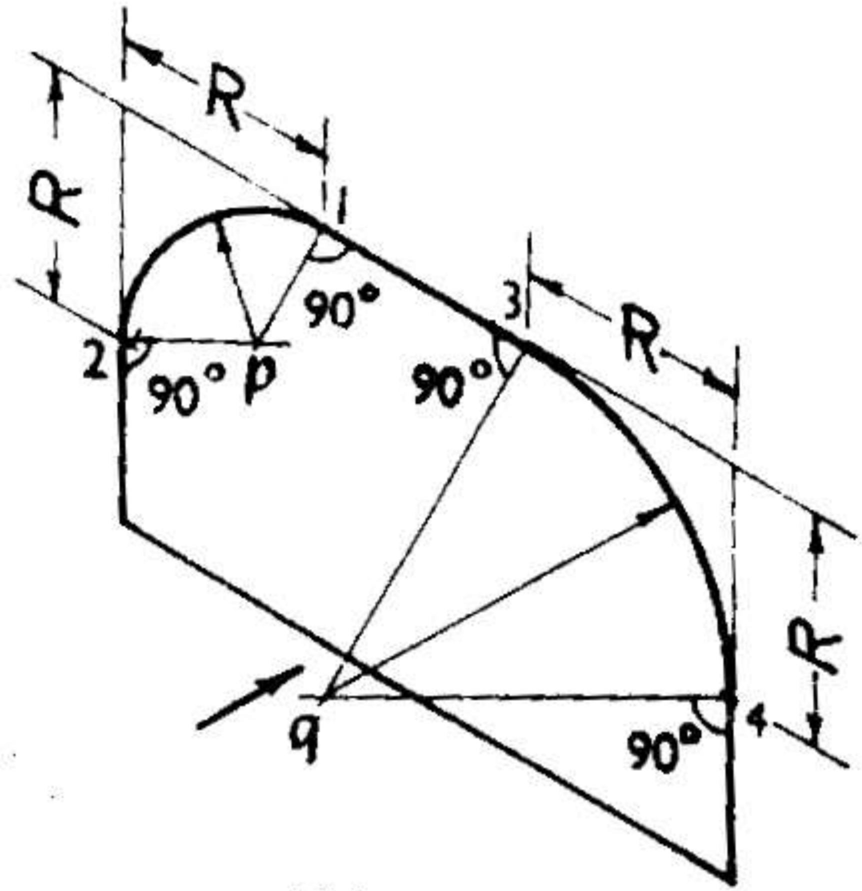


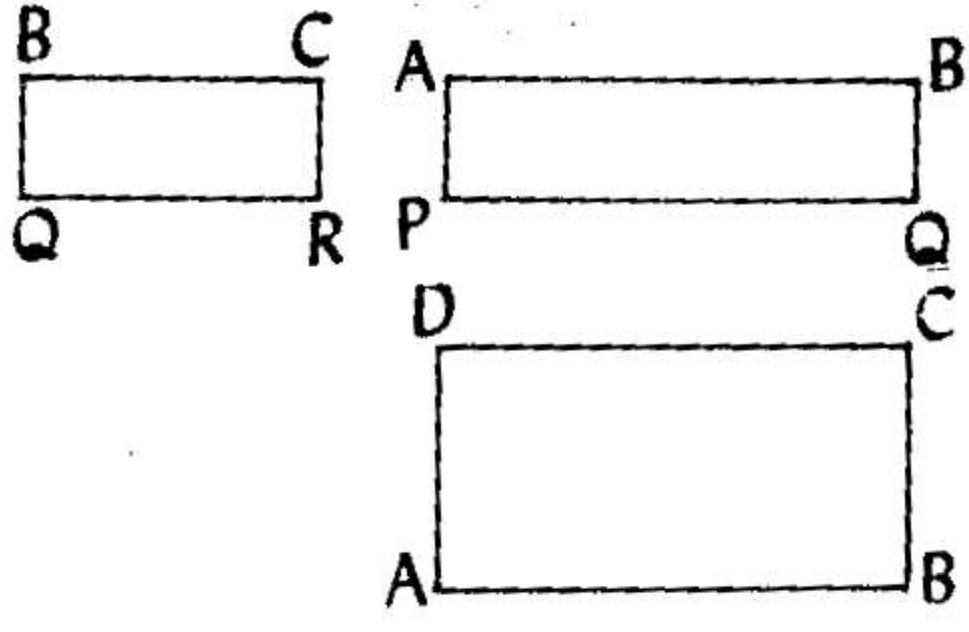
Four centre method of drawing Isometric projection of Circle

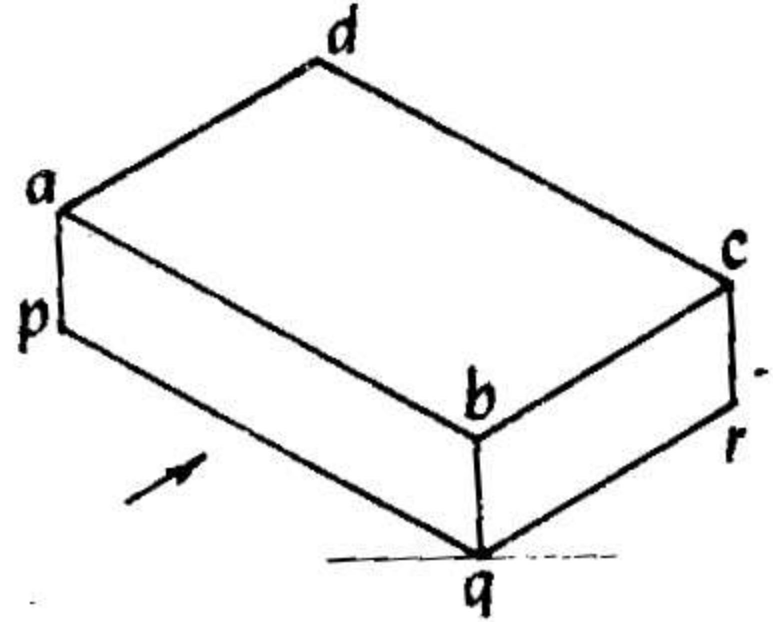


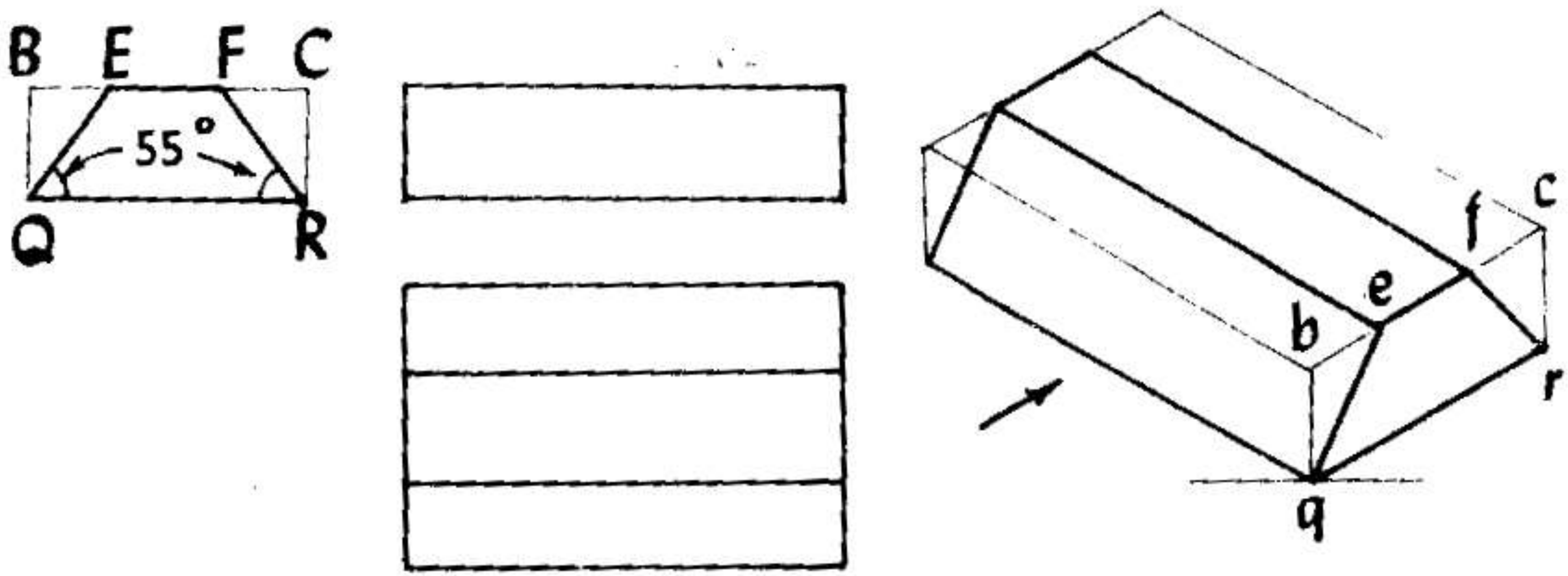
(a) (b)

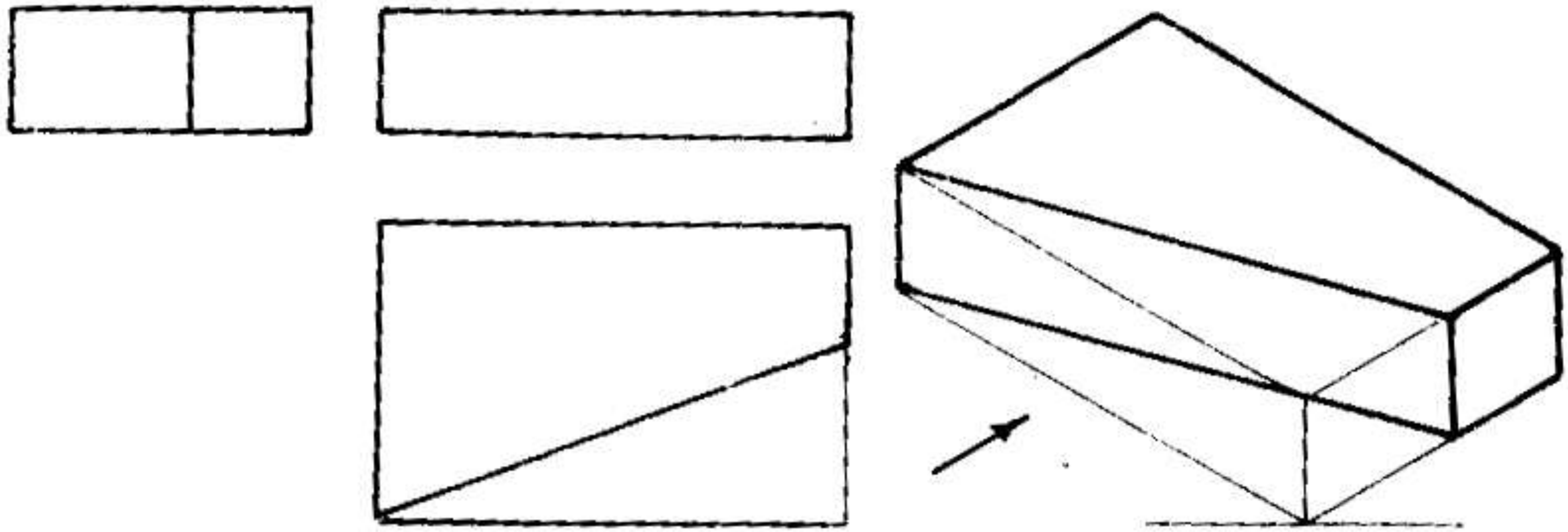

R
R
P
Q

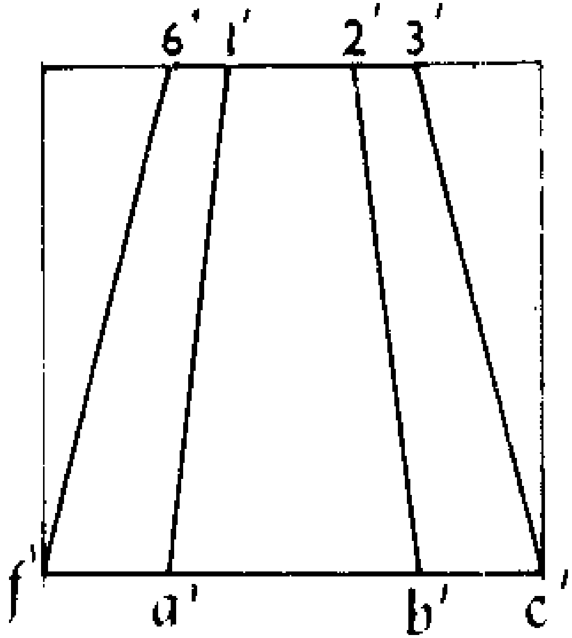

R
R
1
90°
2
90°
p
3
90°
R
R
q
90°
4

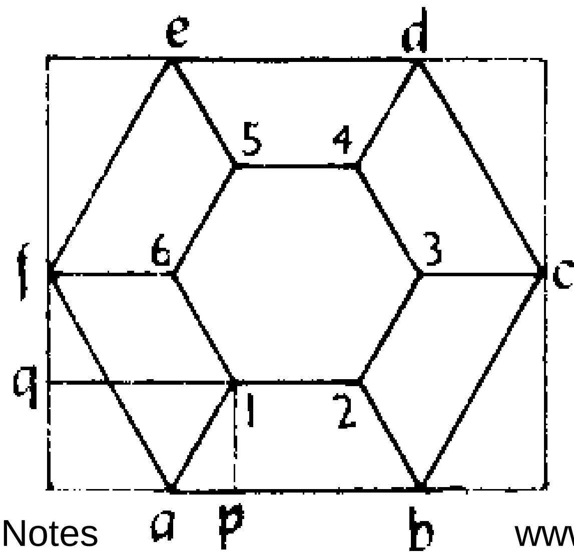

B C
Q R
A B
P Q
D C
A B

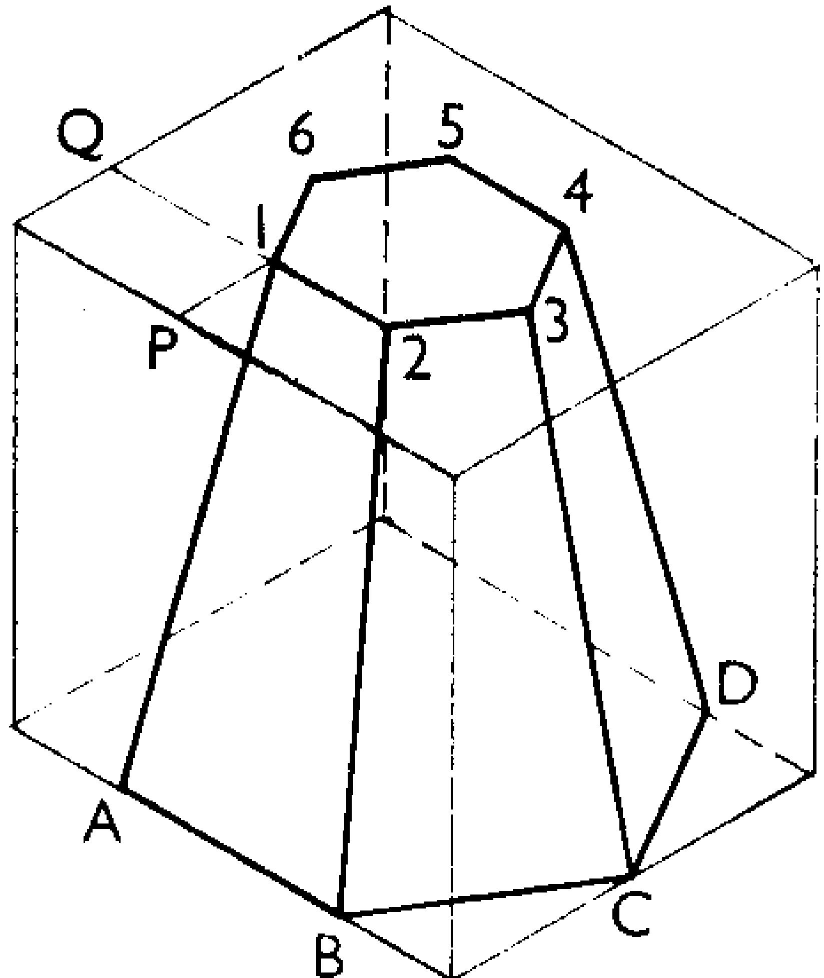

d
a
c
p
b
r
q

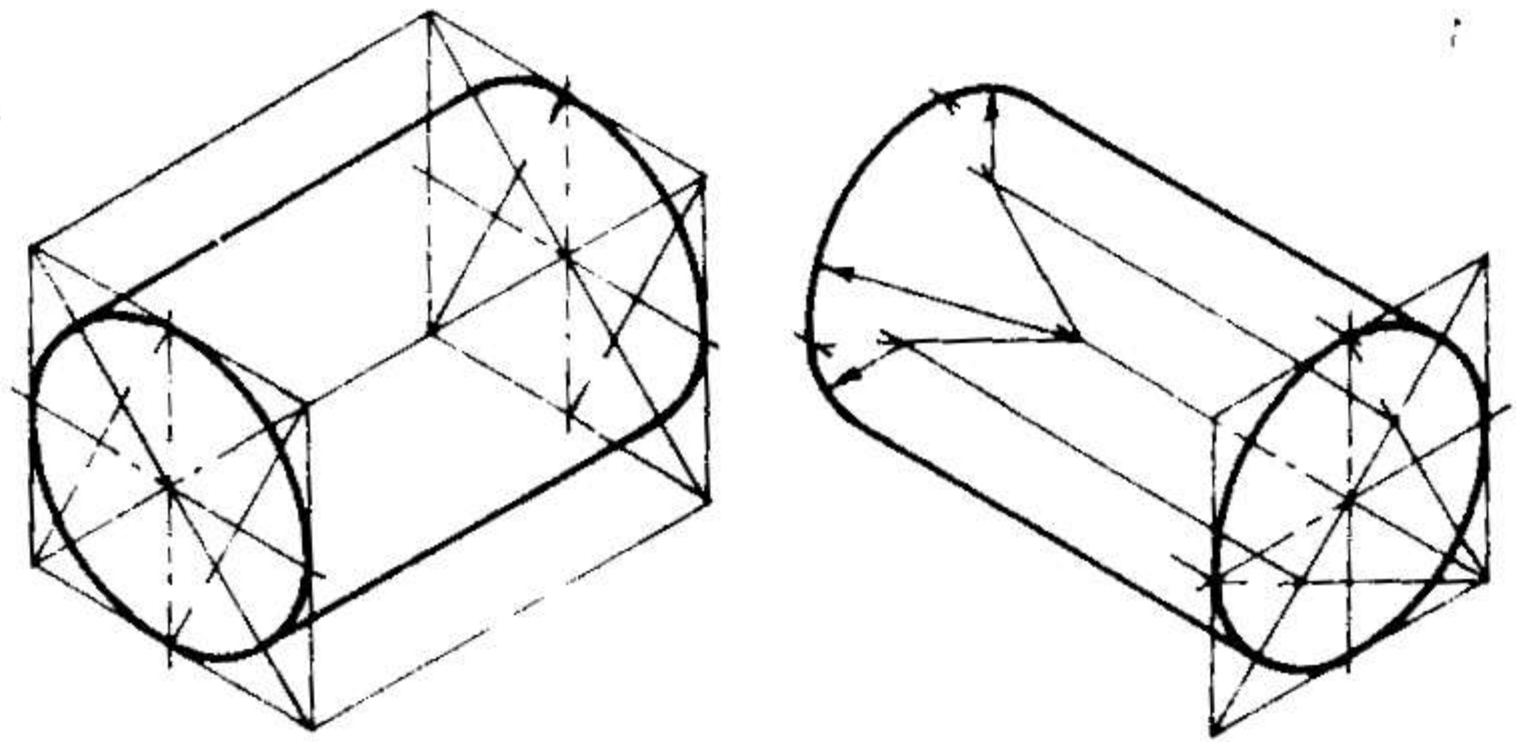

B E F C
55°
Q R
c
f
e
b
r
q

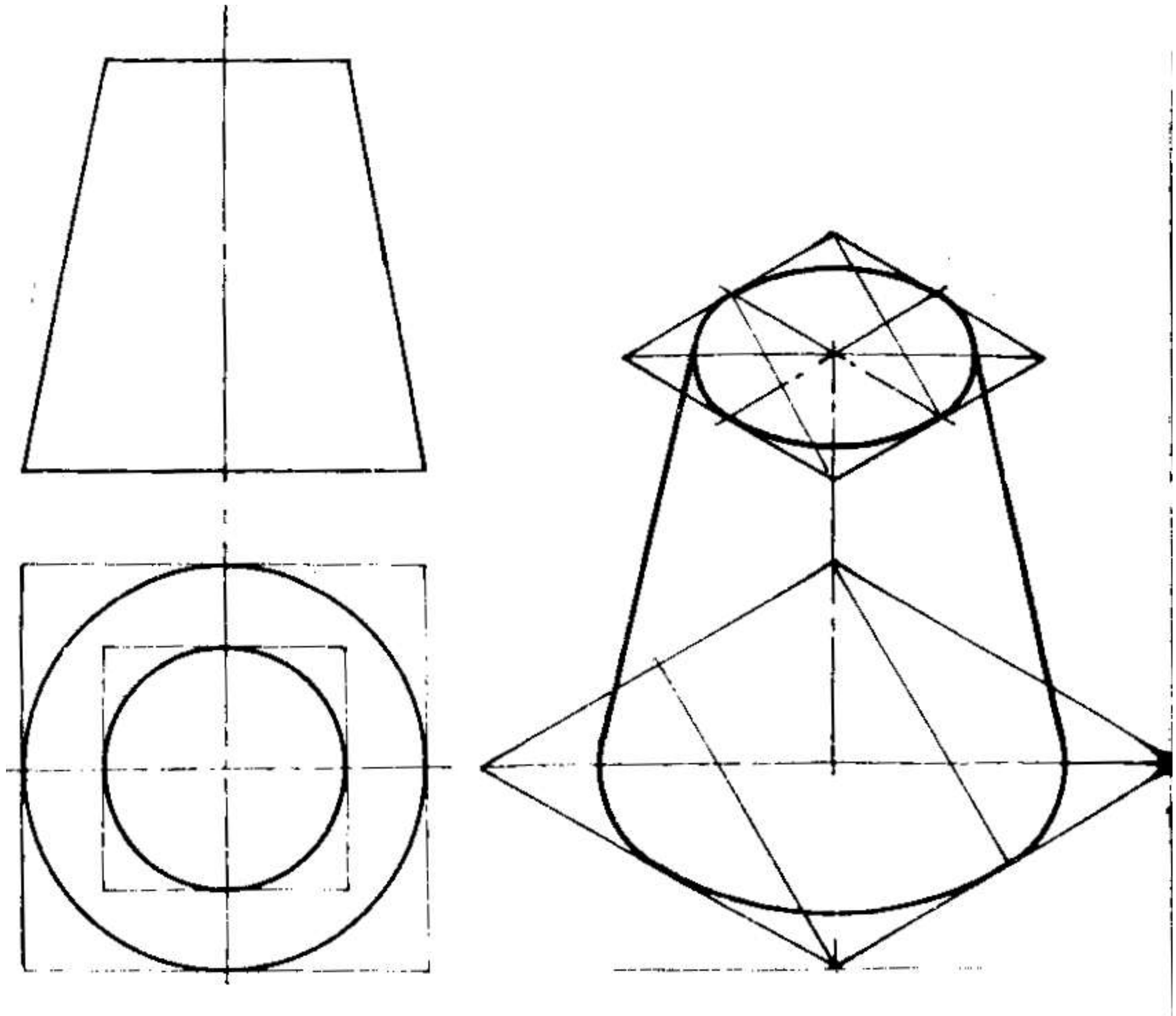


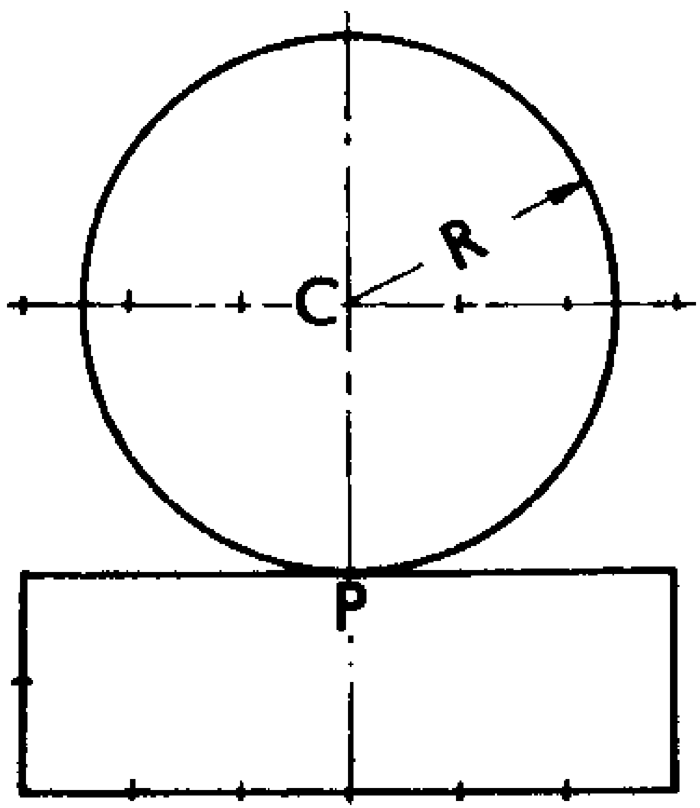

6'
1'
2'
3'
f'
a'
b'
c'


e
d
5
4
f
6
3
c
q
1
2
a
p
b

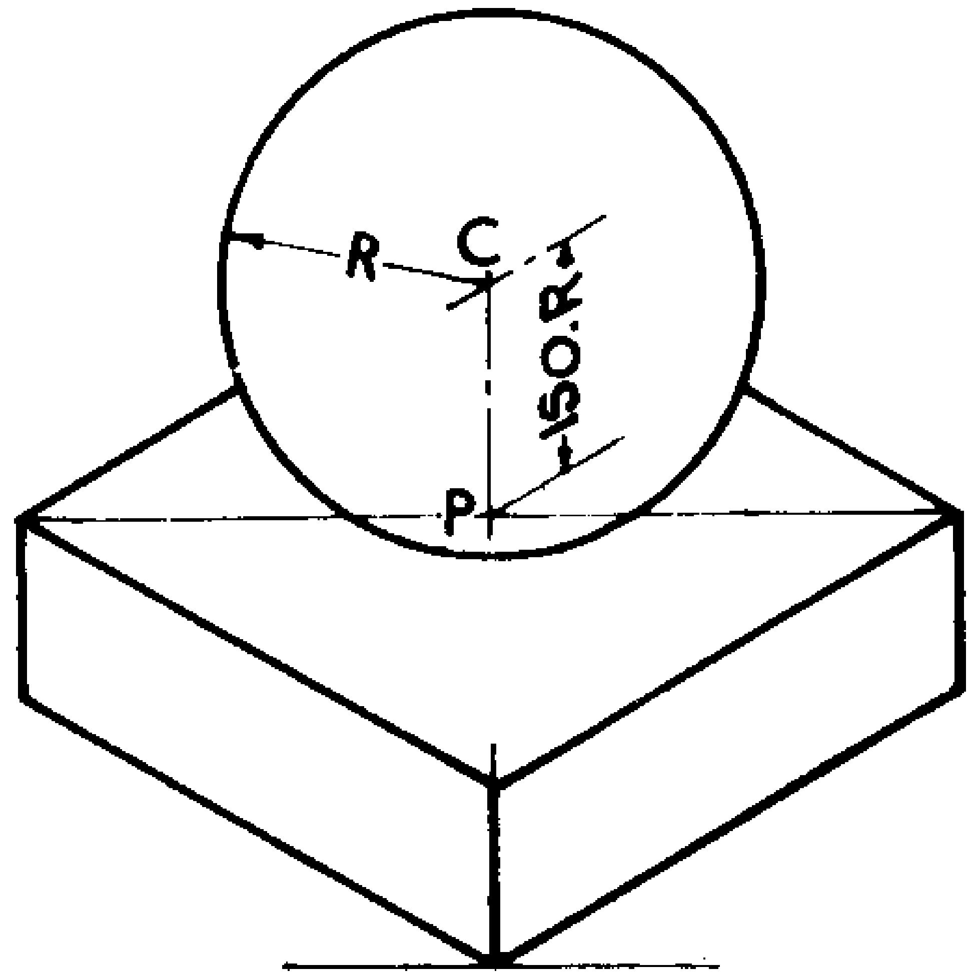

Q
6
5
4
1
3
P
2
D
A
C
B



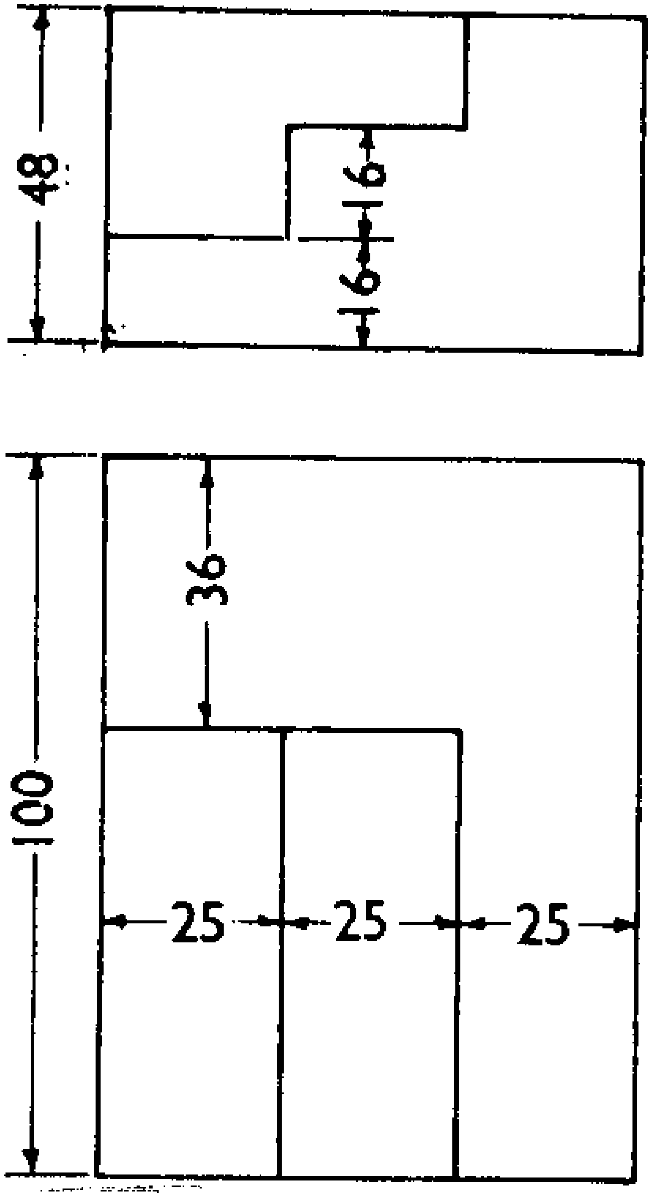


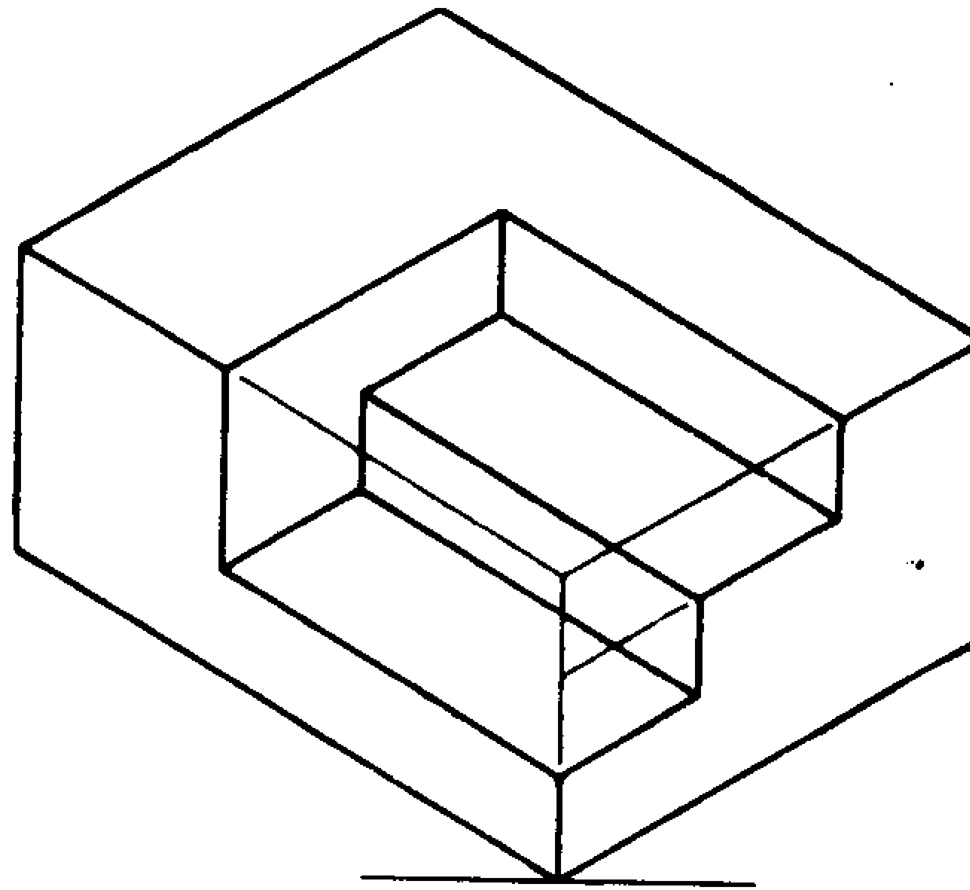


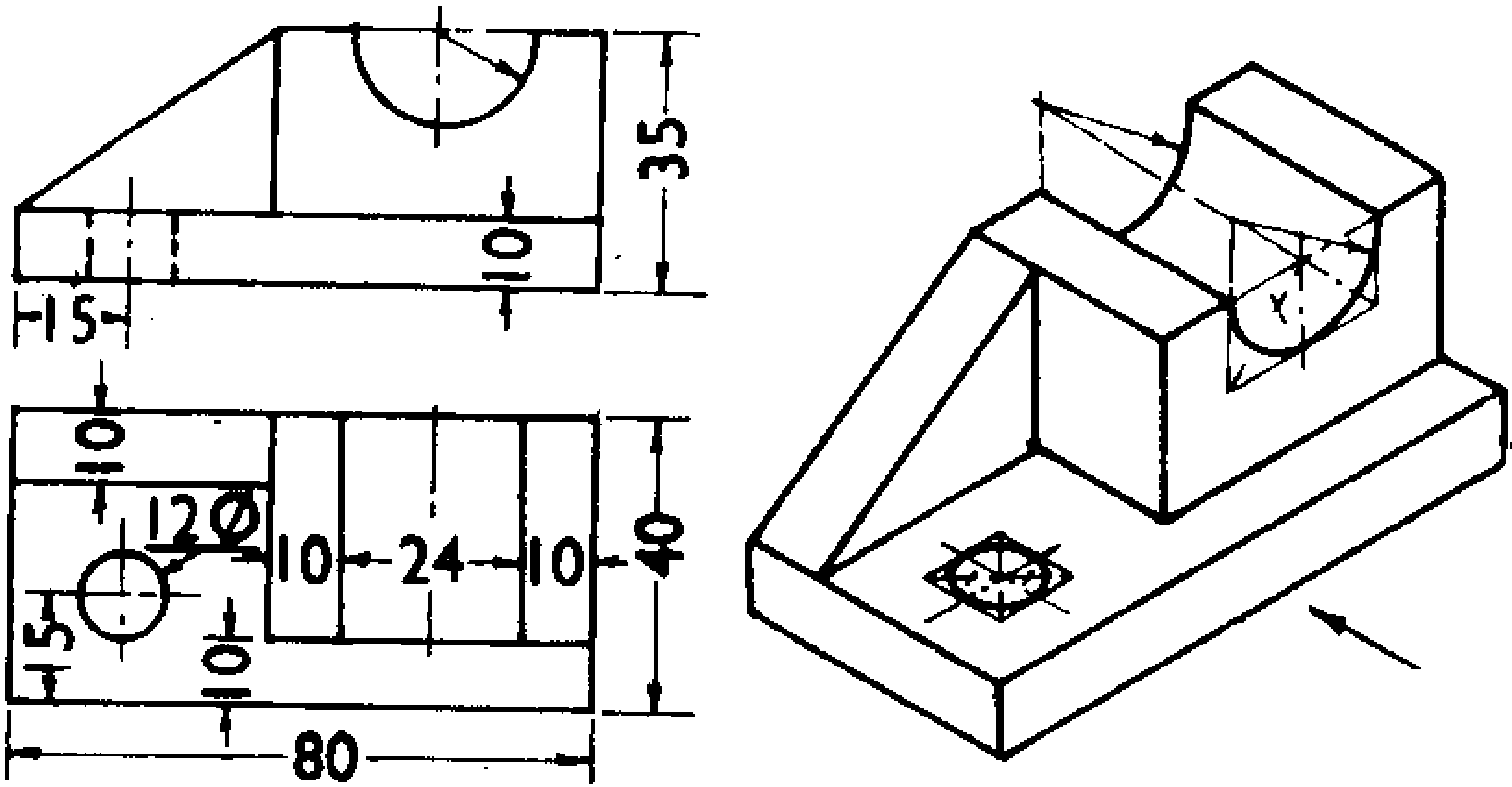
R
C
P

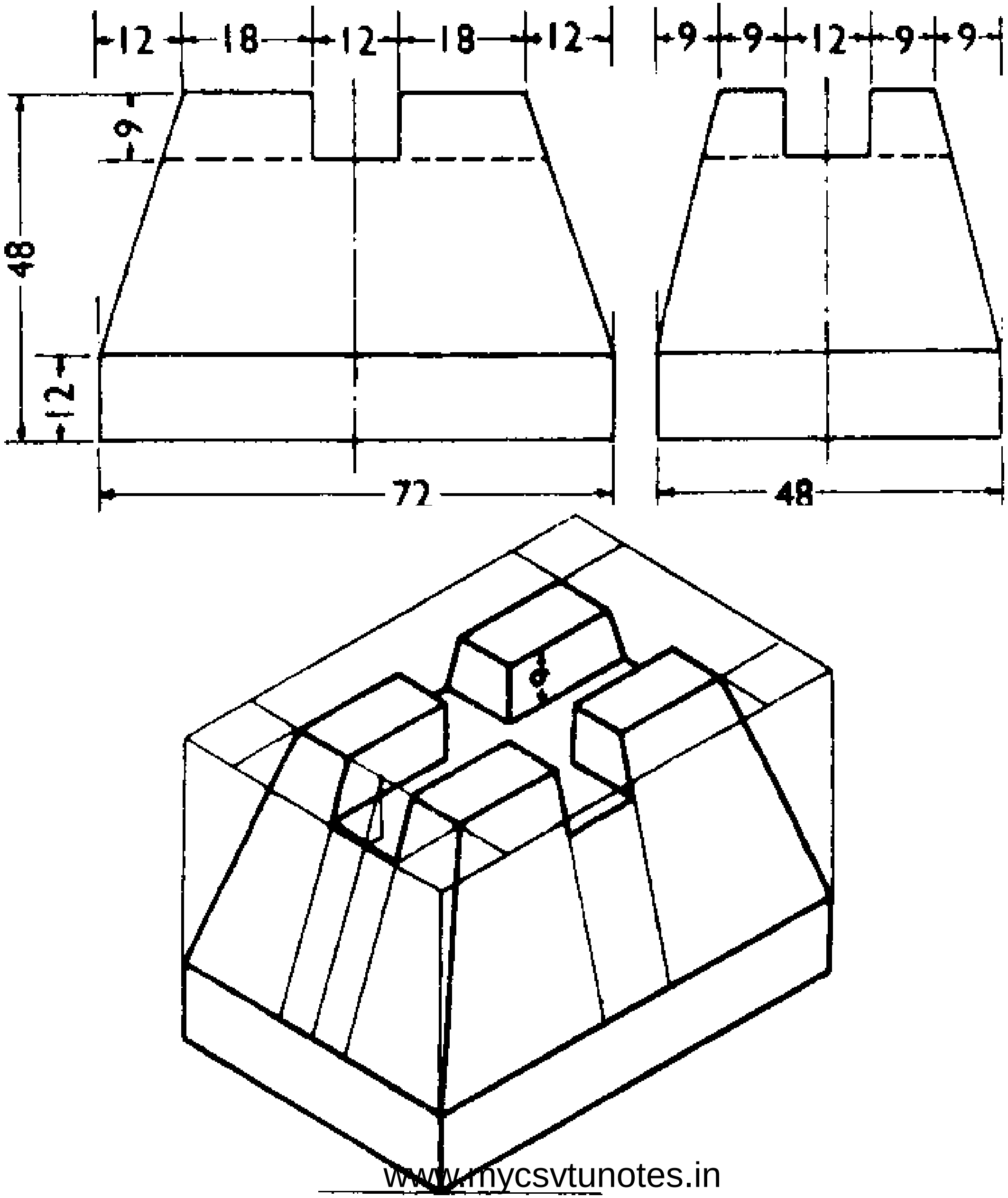


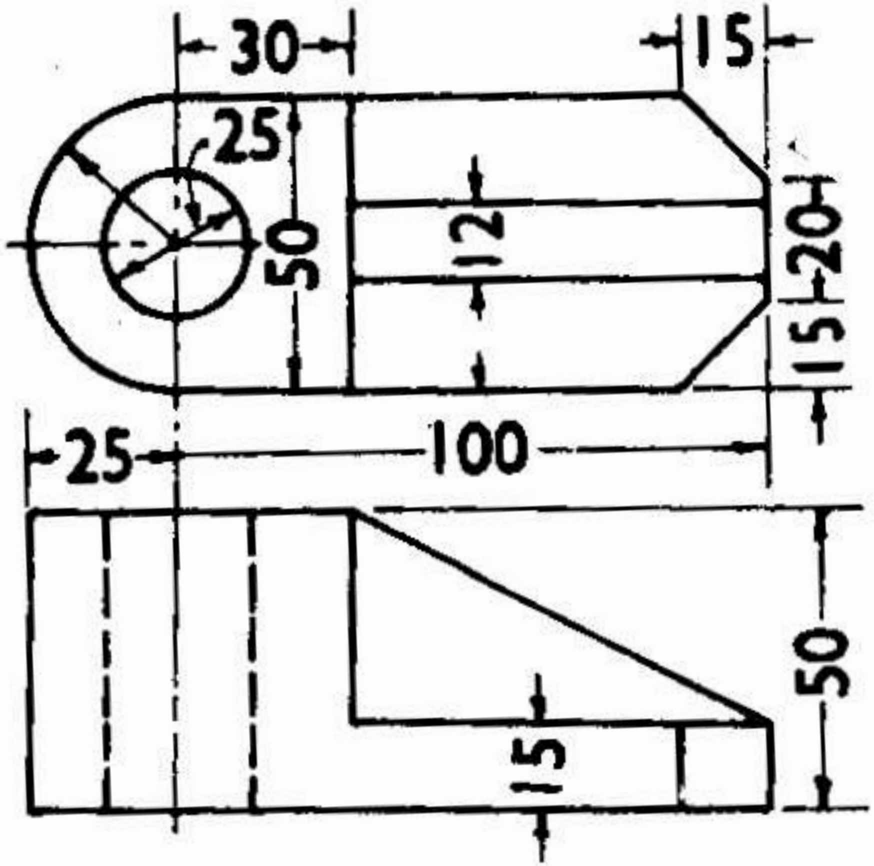
R
C
ISO.R.
P

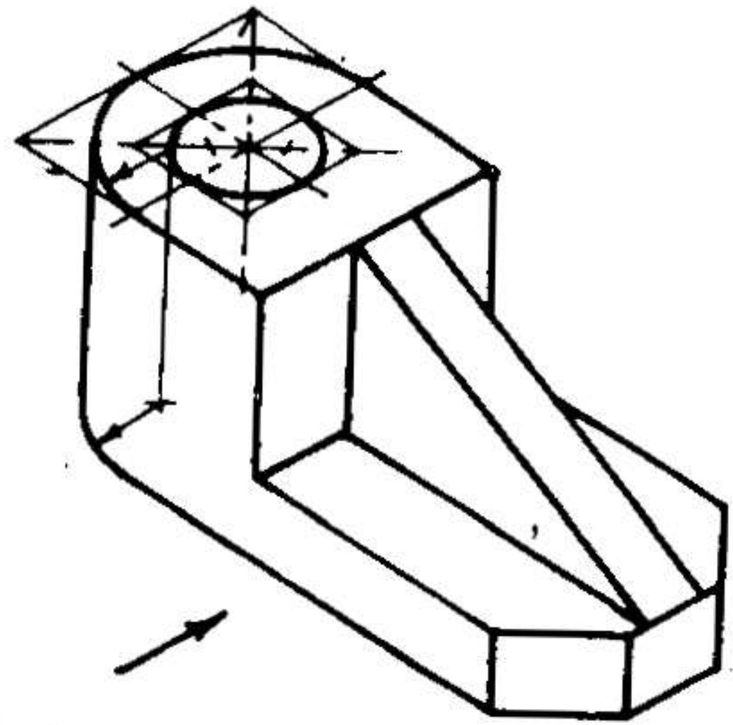

48
16
16
36
100
25
25
25

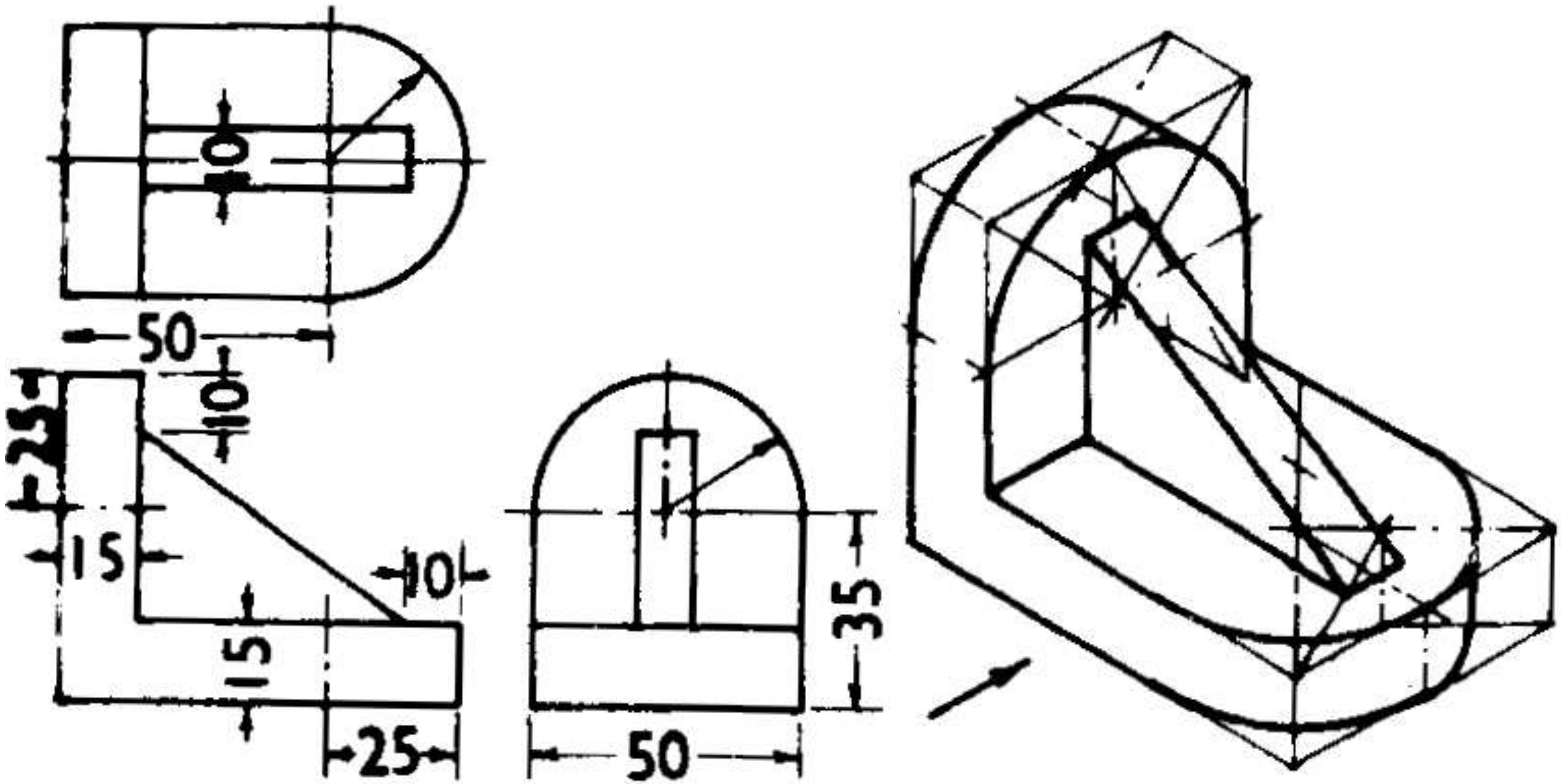


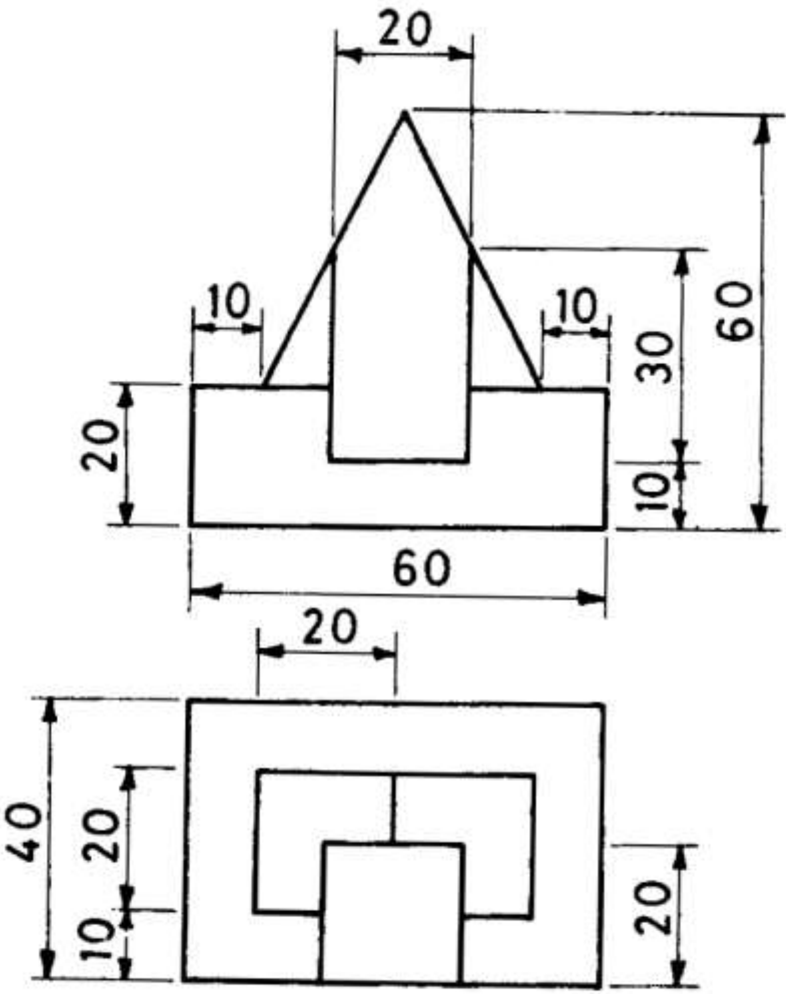

35
10
15
10
12 Ø
10
24
10
40
15
10
80

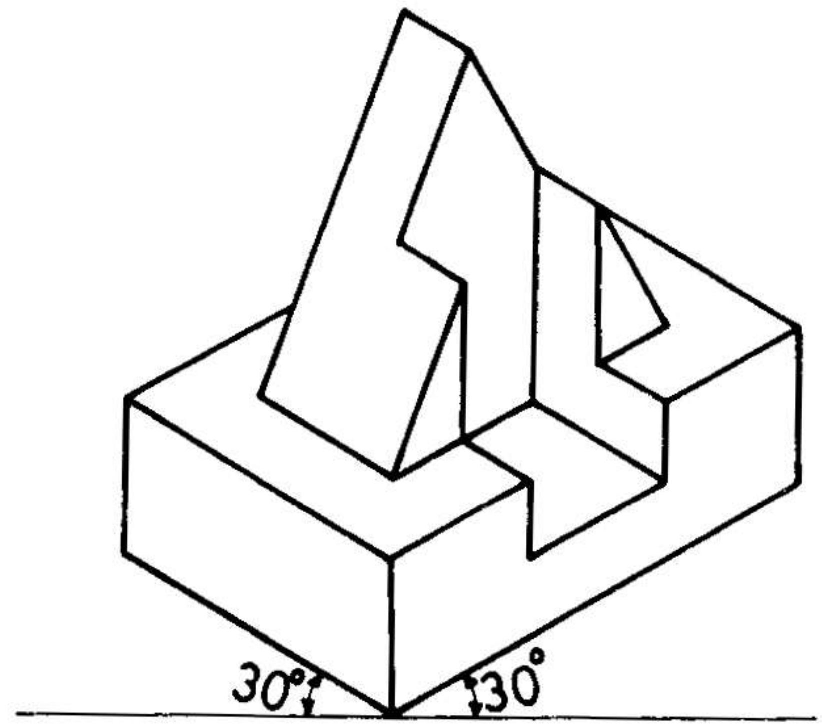

12
18
12
18
12
9
9
12
9
9
9
48
12
72
48


30
15
25
50
12
20
15
25
100
50
15




10
50
10
25
15
10
15
25
50
35


20
10
10
30
60
20
10
60
20
40
20
10
20


30°
30°

Problem 01:

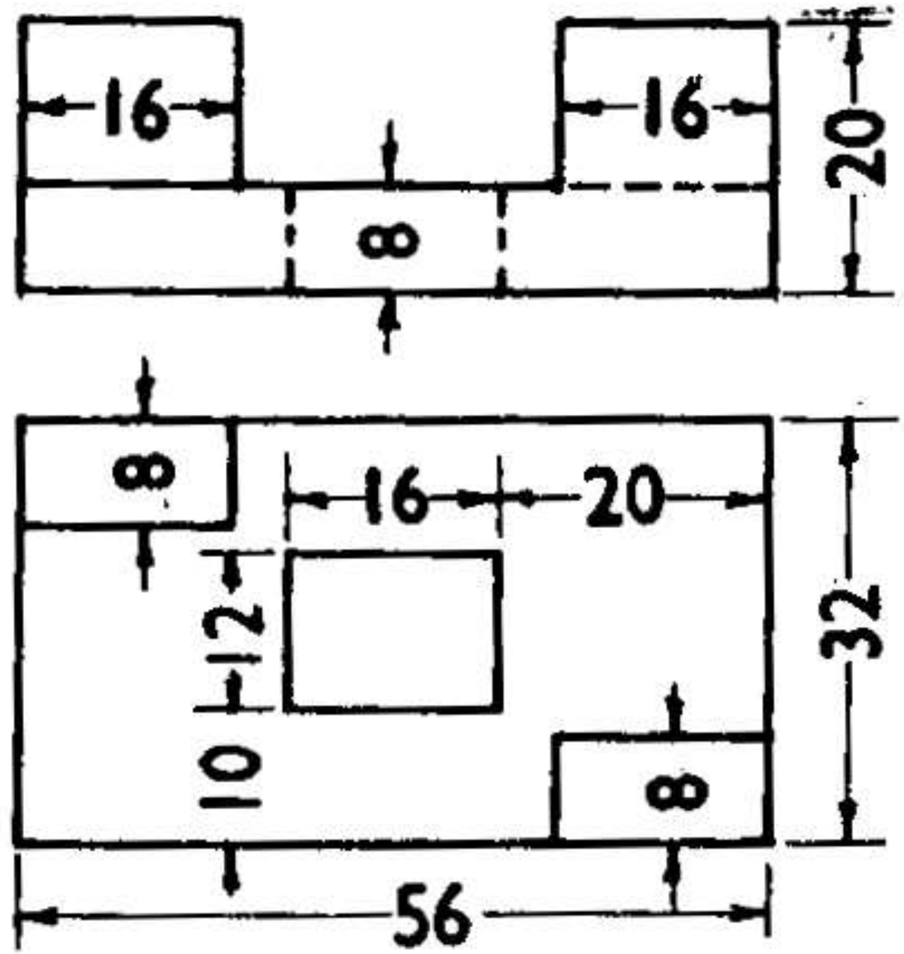


FIG. 17–79

Problem 02:

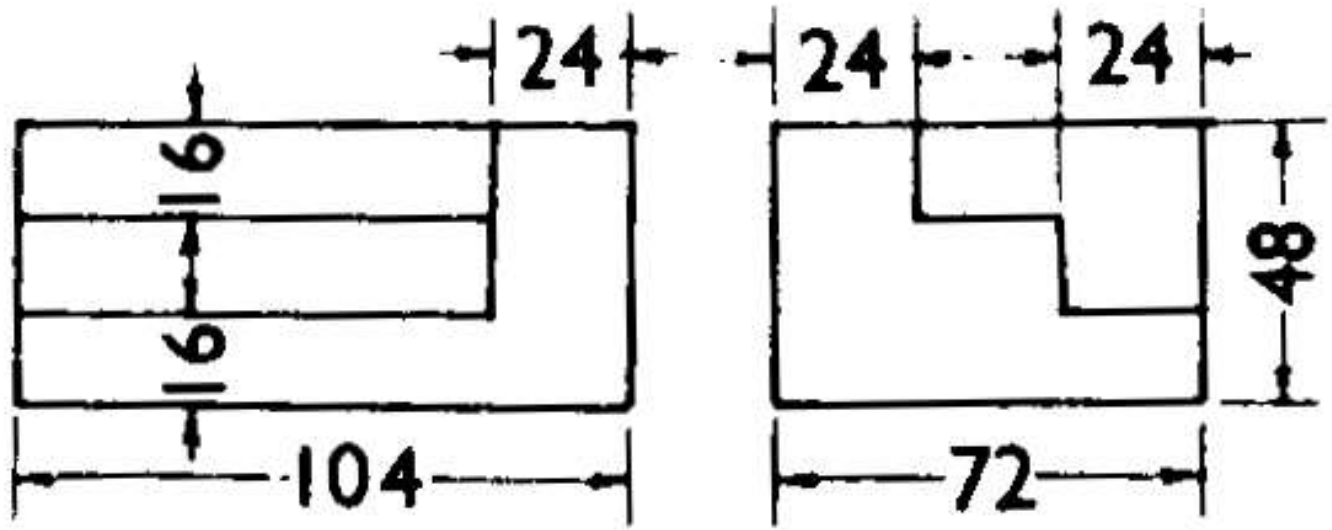


FIG. 17–80

Problem 03:

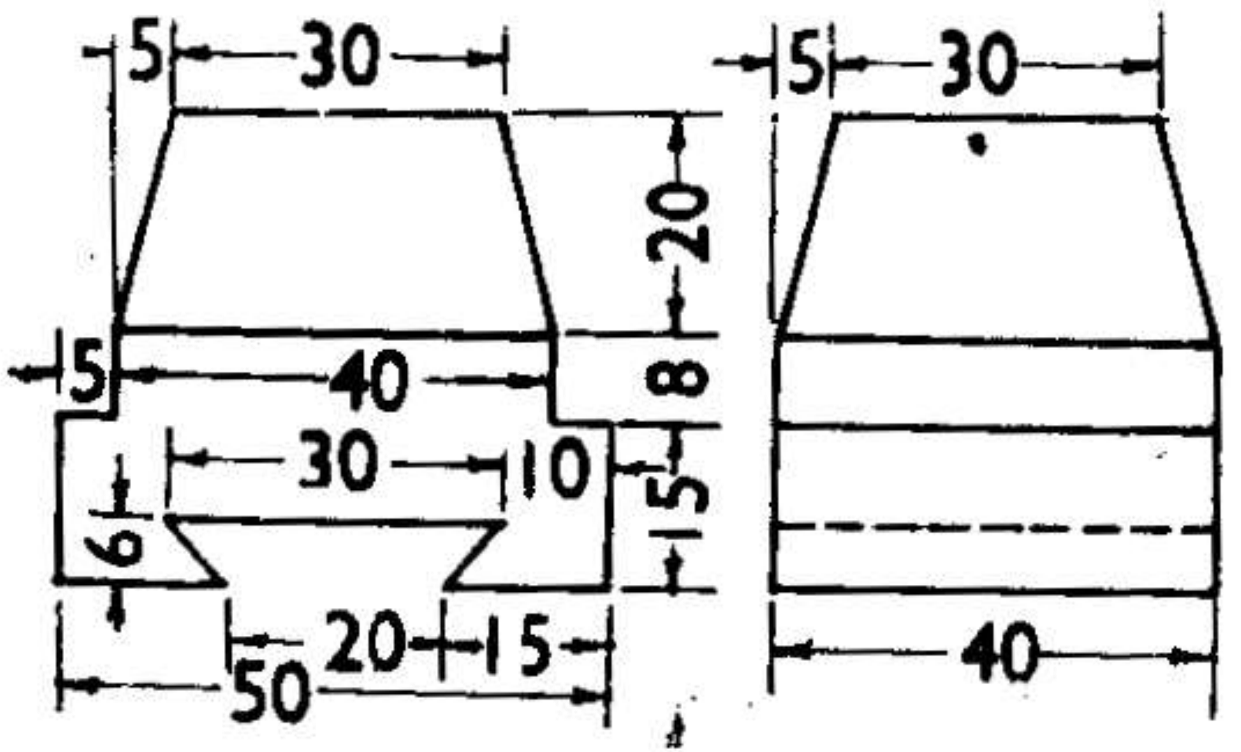
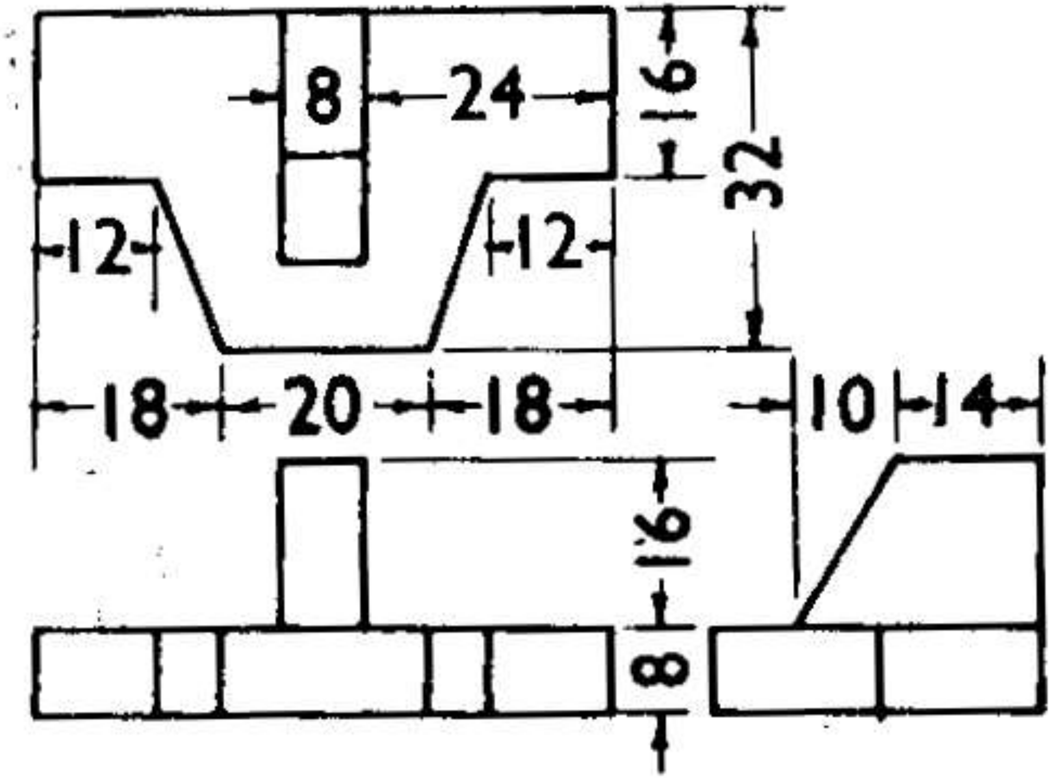


FIG. 17–83

Problem 04:



(Third-angle projection)
FIG. 17–78

Problem 05:

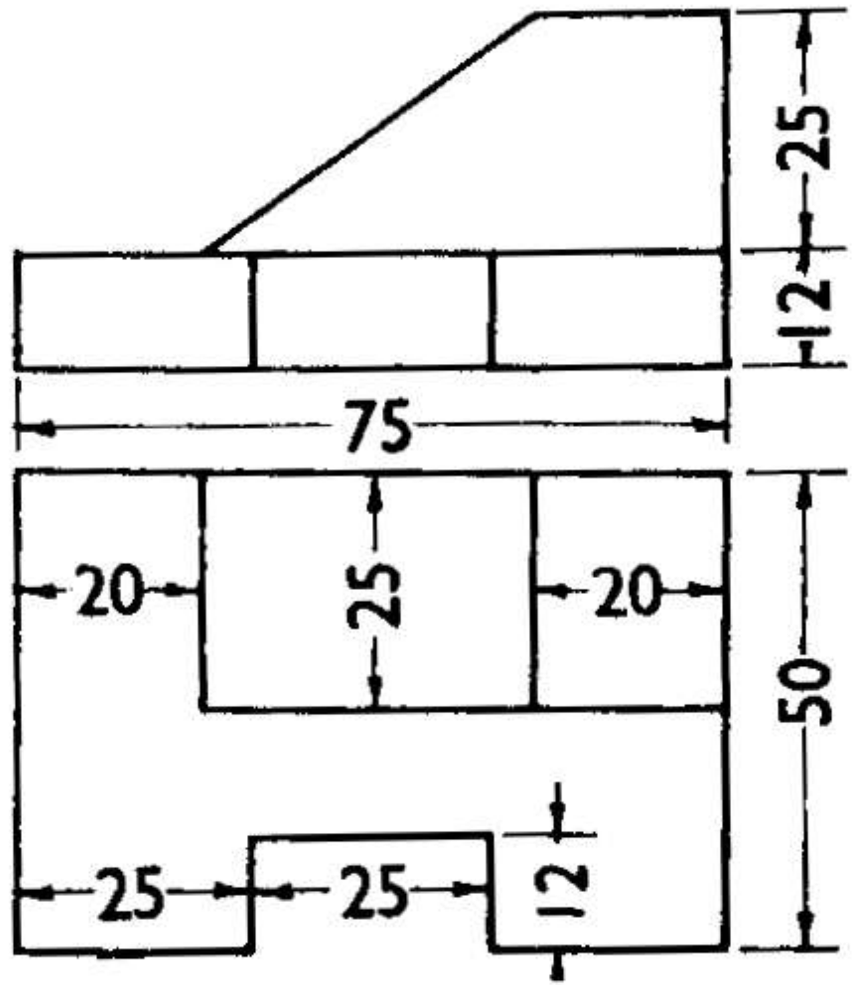


FIG. 17–77

Problem 06:

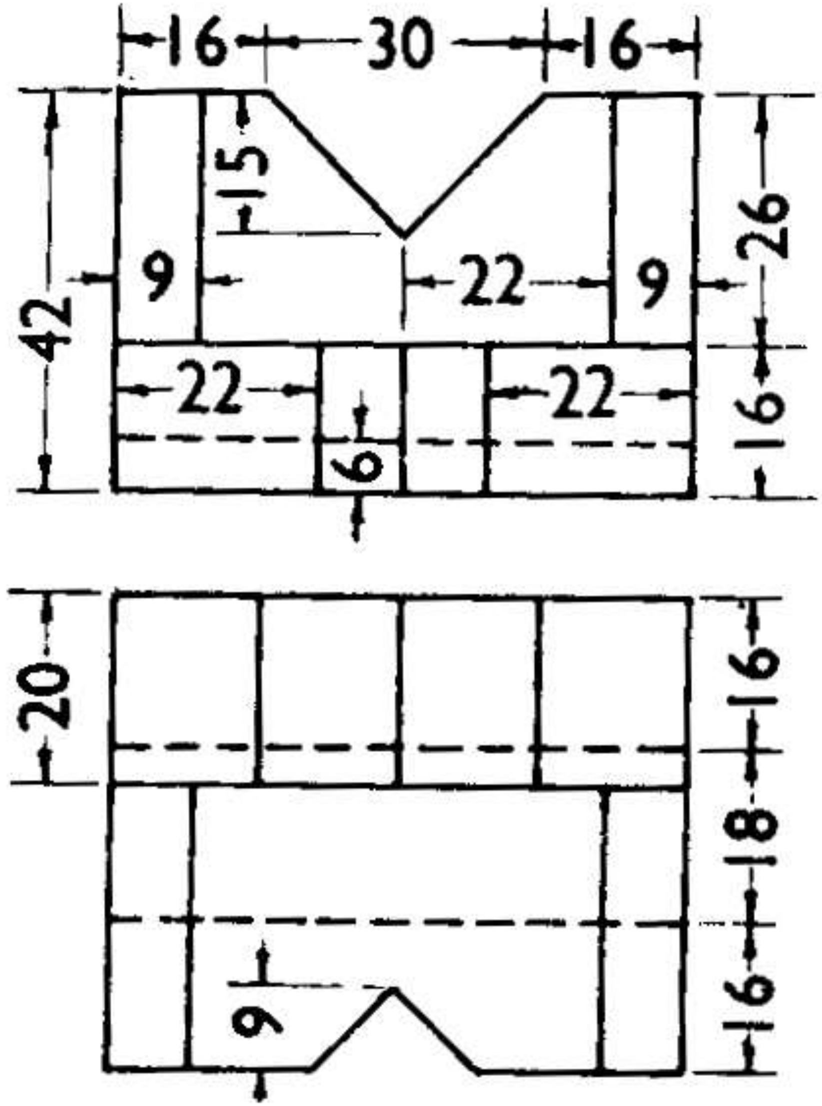


FIG. 17–84

Problem 07:

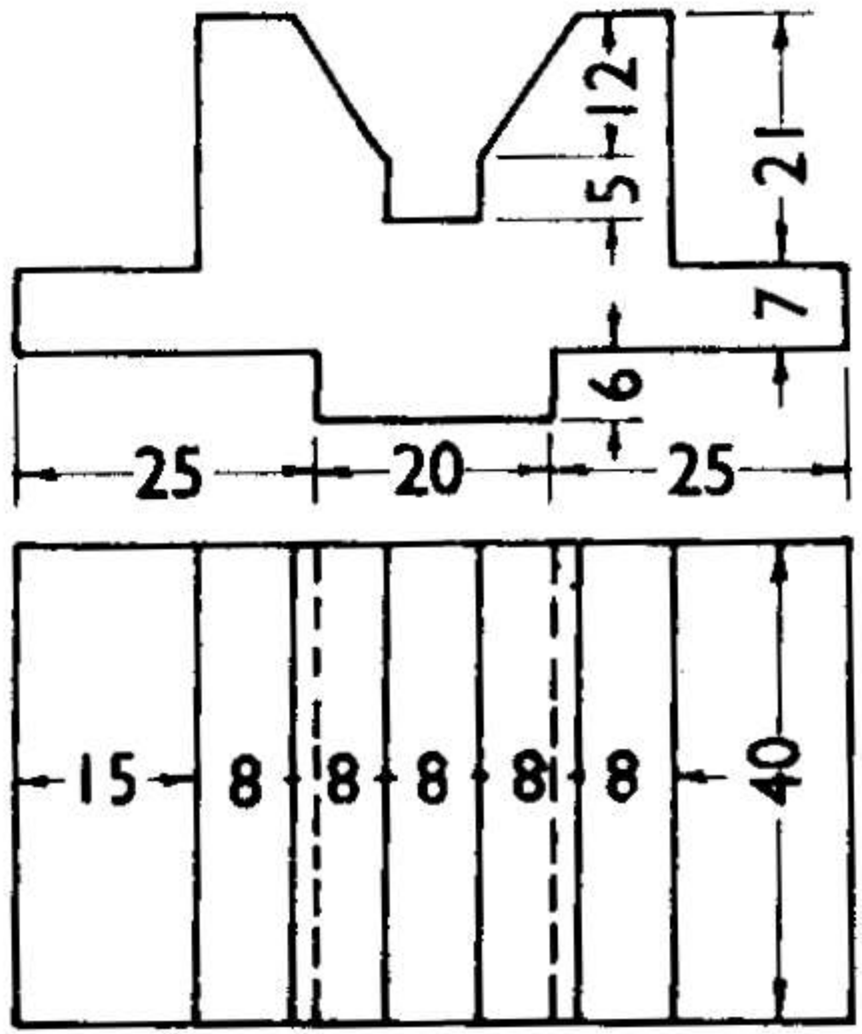


FIG. 17–76

UNIT -V

COMPUTER AIDED DRAWING

COMPUTER AIDED DRAWING (CAD)

Computer Aided Drawing /Drafting is a process of preparing a drawing of an object on the screen of a computer.

There are various types of drawings required in different fields of engineering and science.

- In the field of mechanical engineering the drawing of machine components and layouts are prepared.
- In the field of civil engineering plans and layouts of buildings are prepared.
- In all other fields of engineering use of computer is made for drawing and drafting.

The use of CAD process provides enhanced graphics capabilities which allows any designer to

- Conceptualize his ideas
- Modify the design very easily
- Perform animation
- Make design calculations
- Use colures, fonts and other aesthetic features

- In modern CAD systems, Interactive (two-way) computer graphics (ICG) is used.
- The ICG denotes a user oriented system in which the computer is employed to create, transform and display data in the form of pictures or symbols.
- The image is constructed out of basic geometric element – points, lines circles etc.
- It can be modified according to the demand of the designer enlarged, reduced in size, moved to another location on screen ,rotated and other transformations also can be performed.

BENEFITS OF CAD

- Improved productivity in drafting.
- Shorter preparation time for drawing.
- Reduced manpower requirements.
- Customer modifications in drawing are easier.
- More efficient operation in drafting.
- Low wastage in drawing.
- Minimized transcription errors in drawing.
- Improved accuracy of drawing.
- Assistance in preparation of documentation
- Better designs can be evolved.

Cont….

BENEFITS OF CAD

- Revisions are possible.
- Colures can be used to customize the product.
- Production of orthographic projections with dimensions and tolerances.
- Hatching of all sections with different filling patterns.
- Preparation of assembly or sub-assembly drawings.
- Preparation of part list.
- Machining and tolerance symbols at the required surfaces.
- Hydraulic and pneumatic circuit diagrams with symbols.
- Isometric views.

LIMITATIONS OF CAD

- It require large amount of computer memory.
- The size of the software package is large.
- Skill and judgment are required to prepare the drawing.
- Huge investment.

CAD SOFTWARES

The CAD software is an interpreter or translator which allows the user to perform specific type of application or job related to CAD.

Following are the various type of software used for drafting:

- Corel draw
- Microsoft office
- Photo Finish
- Paint
- Page Maker
- Uni-Graphics
- Auto-CAD
- Micro-Station
- Corel-CAD
- Pro-E
- IDEAS
- CATIA

AutoCAD

- AutoCAD package is suitable for accurate and prefect drawing of engineering designs.

- The drawing of machine parts, isometric views and assembly drawings are possible in Auto-CAD.

- This package is suitable for 2 D & 3 D drawings.

- The Auto-CAD is used by the designers, painters, Civil, Mechanical, Electrical, Electronics, Civil engineers in their field.

- Line, curves, text and filling point are the essential elements used for preparation of any drawing on the screen.

- Computer aided drafting is done by the operators by placing the mouse pointer at the desired location and then executing the command to draw the graphic elements using different methods.

AutoCAD package utilize four areas on the screen:

(I) Drawing area, (II) Command area, (III) Menu area, (IV) Tool boxes.

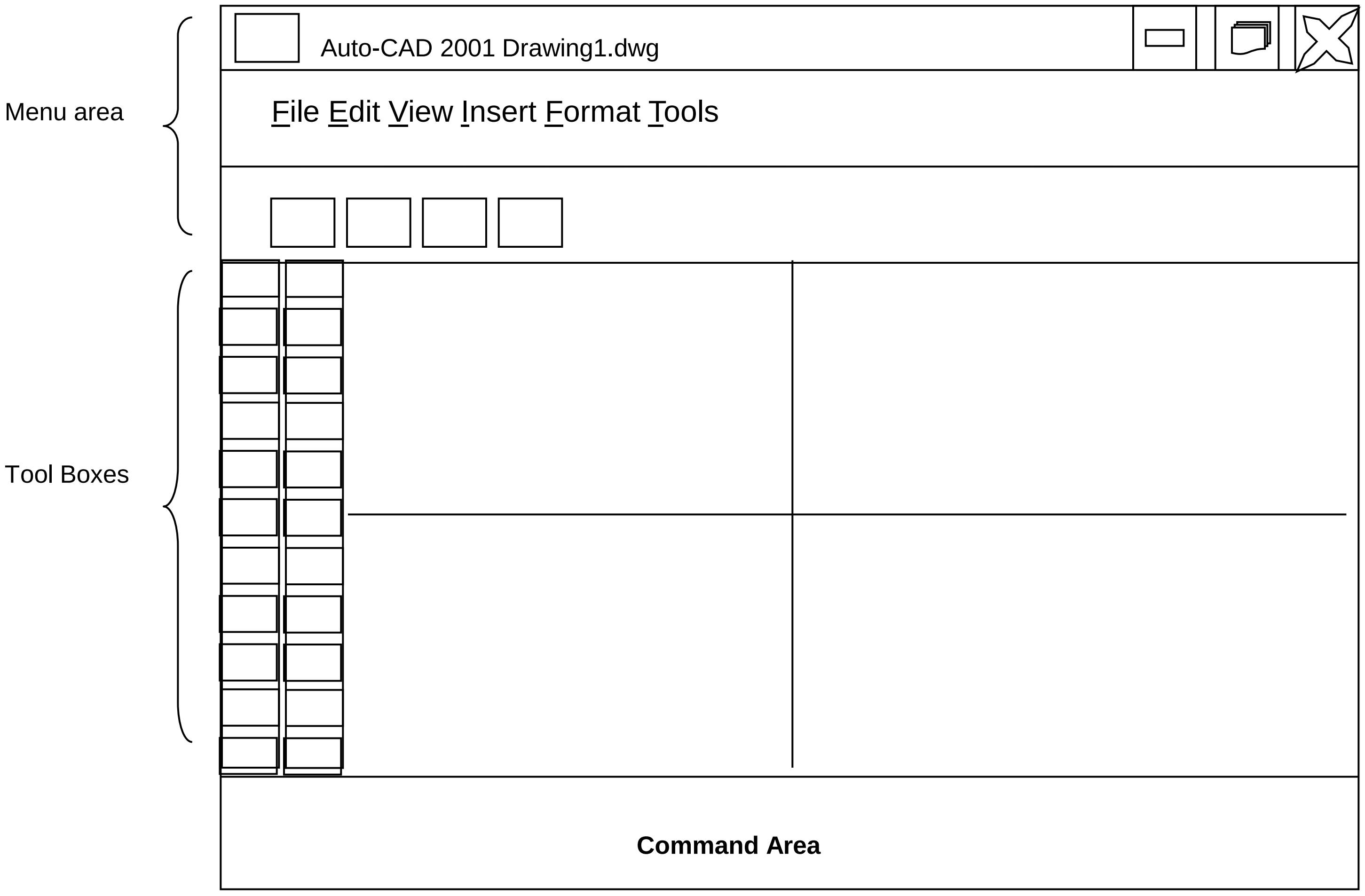


Fig 1.1

- **Drawing area**: To provide space to prepare a drawing.
- **Command area**: To allow the entry of various commands for preparing the drawings.
- **Menu area**: It consists number of dialog boxes which can be utilized for preparing the drawings.
- **Tool boxes**: To allow selection of various options for the drawing.

- The drawing is prepared in the drawing area by sequence of individual commands supplied in command area or selection in menu in windows.

- The Auto-CAD drawing area provides cross hairs, which are the two lines at right angles and the crossing point is a point of selection.
- The cross hairs are connected to mouse and the crossing point can be scrolled up-down and right-left.
- The operation of drawing can either be performed by menus operated by mouse or by using commands.

There are different types of menus used in Auto-CAD package:

(I) Window menus

(II) Pull-down menus

(III) Icon menus

(IV) Dialog boxes

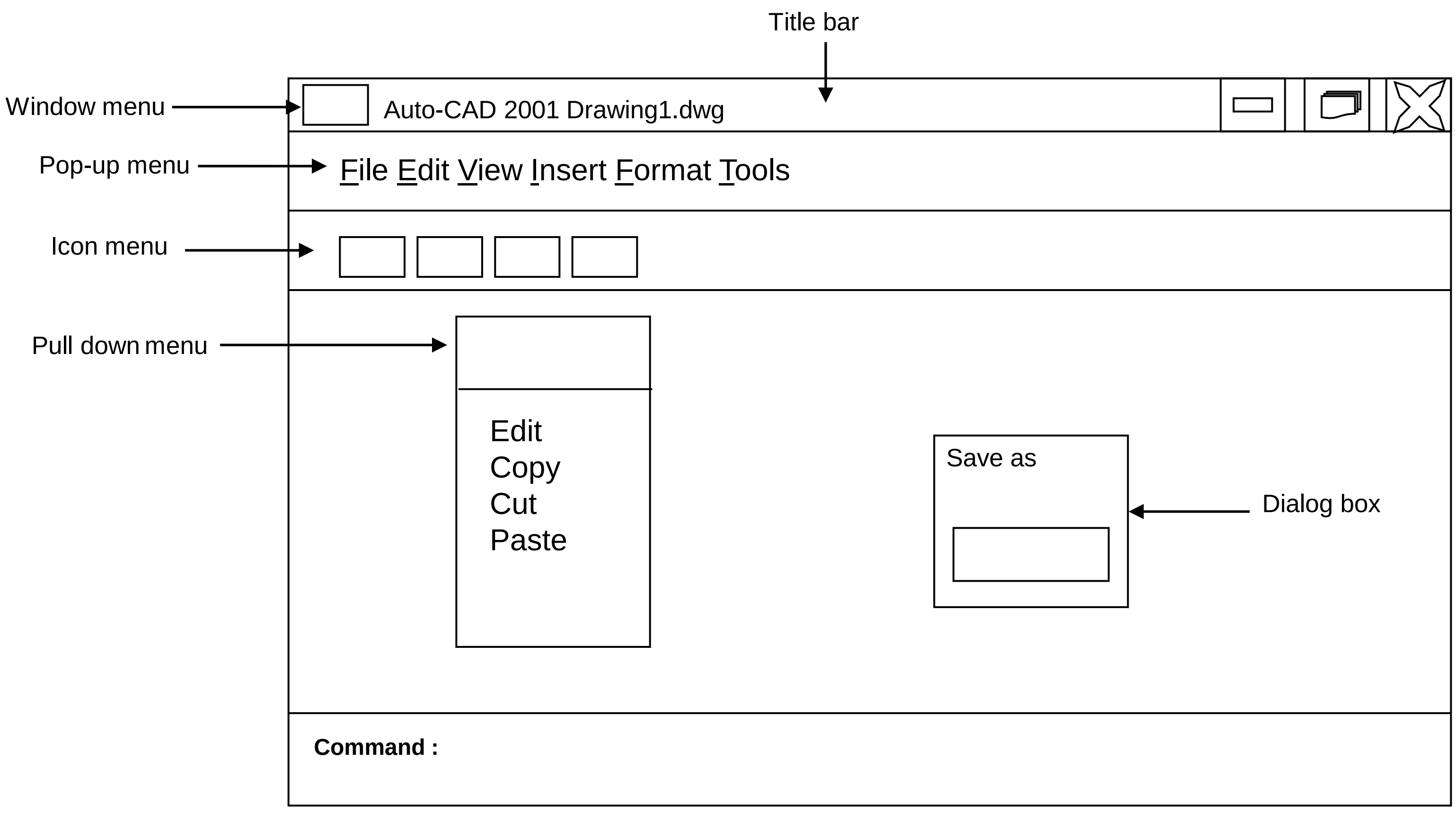


Fig.1.2

The major functions performed by CAD system are:

- Basic setup of drawing
- Drawing of objects using various elements
- Changing of properties of object
- Transformations on object
- Text
- Dimensioning
- Filling of objects with different patterns
- Creating libraries

- ✓ The drawing area of Auto-CAD is designated by x and y co-ordinates measured in terms of decimal values.
- ✓ The screen area can be reduced or enlarged by use of the ‘Zoom’ tool and the display of drawing can be reduced or enlarged on the screen.

Auto-CAD provides two drawing environment for creating laying out your drawing:

(I) Model space

(II) Paper space

- ✓ Auto-CAD usually allows creating drawing, called a model, in full scale in an area known as **model space** without regard to the final layout or size when the drawing is plotted on paper.

- ✓ When the printing is carried out, it is possible to arrange the elements of drawing on “sheet of paper “in paper space. Conceptually, paper space represents the paper on which the drawing is to be plotted.

UTILITY COMMANDS

The utility commands are those commands which control the basic functions of AutoCAD.

- **HELP**: Lists all the Auto-CAD commands.
- **END**: Returns to the main menu and updates (saves) the drawings file.
- **QUIT**: Returns to the main menu without updating the drawing file.
- **SAVE**: Saves the current drawing and remains in the drawing editor screen for further editing.
- **LIMITS**: Allows changing the upper and lower limits of the drawing area while working on a drawing.

For example to set the screen for A3 size (420x297), following steps are to be carried out:

Command: limits ↵
ON/OFF/⟨lower left corner⟩ ⟨0.000, 0.000 or current⟩ : ↵
Upper right corner ⟨12.000, 9.000⟩ : 420,297 ↵
This will set the drawing screen of A3 size.

Note: ↵ Sign shows “press enter”.

GRIDS: It displays a dot grid in the current view port.

Command: grid ↵

Grid spacing (x) or ON/OFF/Snap/Aspect/<current>: specify a value or enter an option.

Snap- Sets the grid spacing to the current snap interval as set by the snap command.

Aspect- Sets the grid to a different spacing in x & y.

SNAP: It restricts cursor movement to specified intervals.

Command: snap ↵

Snap spacing or ON/OFF/Aspect/Rotate/Style/<current>: specify a distance, enter an option or press enter.

Spacing- Activates snap mode with the value you specify.

Rotate- Sets the rotation of the snap grid.

Style- format of the snap grid, standard or isometric.

ORTHO: Constrains cursor movement to the horizontal or vertical.

OSNAP: Allows to select specify points on an object.

e.g. endpoints, midpoints, intersection etc.

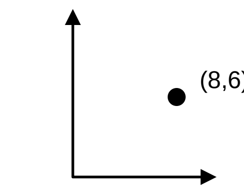
POLAR: Allows cursor movement to the horizontal or vertical.

DRAW/BASIC COMMANDS OF AutoCAD

(Drawing Entities)

POINT

Plot a point at the location (8, 6)
Command: point ↵
Point: 8, 6 ↵

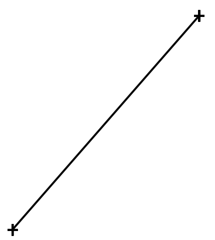


LINE

Lines can be drawn by any one of the following three methods using LINE command.

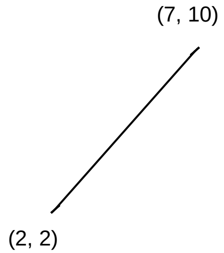
(a) Using Absolute Co-ordinates:

Drawing a line from point (5, 5) to point (10, 10).
Command: Line ↵
From point: 5, 5(select the point by mouse or Enter the Co-ordinates by keyboard) ↵
To Point: 10, 10 ↵
To Point: ↵



(b) Using Relative Co-ordinates

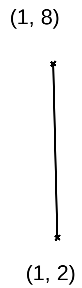
Draw a line from point (2, 2) to point 5 units in X-axis and 8 units in Y-axis relative to first co-ordinate.



Command: Line↵
From point: 2, 2↵
To point: @ 5, 8↵
To point: ↵

(c) Using Polar Co-ordinates

Draw a line from point (1, 2) to a length of 6 units at 90 degree.



Command: Line↵
From point: 1, 2↵
To point:@6<90↵
To point: ↵

PLINE

A polyline is a connected sequence of line and arc segments.

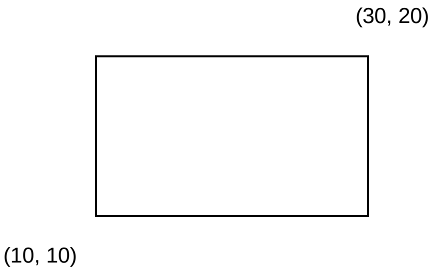
Draw a thick line of width 2 units from (8, 4) to (6, 7) using pline command.

Command: pline↵
From point: 8, 4↵
Arc/close/Half width/length/undo/width/< Endpoint of line> : width↵
Width: 2↵
Next point: 6, 7↵
Next point: ↵

A box drawn by using pline will act as one object instead of four discrete lines.

RECTANGLE

Draw a rectangle defined by diagonal points (10, 10) and (30, 20).



Command: Rectang↵
First Corner: 10, 10 ↵
Second Corner: 30, 20 ↵

CIRCLE

Circle can be drawn by any one of following five methods using circle command.

(a) Using Centre and Radius:

Draw a circle with centre (6, 6) and radius 5 units.

Command: circle↵
3P/2P/TTR/<centre point> : 6, 6 ↵
Diameter/<radius> : 5 ↵

(b) Using Centre and diameter:

Draw a circle with centre (6, 17) and diameter 10 units.

Command: circle↵
3p/2p/TTR/<centre point> : 6, 17 ↵
Diameter/<radius> : D ↵
Diameter: 10 ↵

(c) Using given three points: (3P)

Draw a circle with using given three points (5, 30), (7, 26), (10, 25).

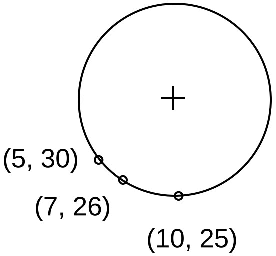
Command: circle↵

3P/2P/TTR/<centre point> : 3 P ↵

First point: (5, 30) ↵

Second point: (7, 26) ↵

Third point: (10, 25) ↵



(d) Using given two points: (2P)

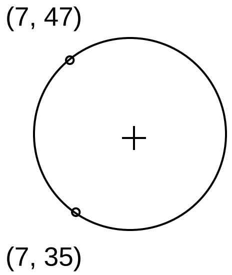
Draw a circle with using given two points (7, 35) & (7, 47).

Command: circle↵

3P/2P/TTR/<centre point> : 2 P ↵

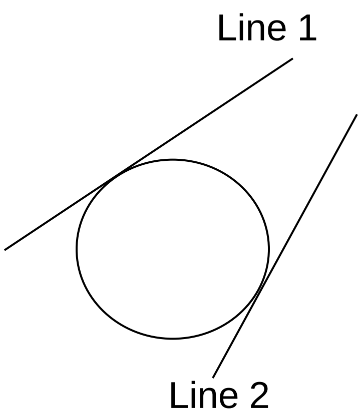
First point on diameter: (7, 35) ↵

Second point on diameter: (7, 47) ↵



(e) Using Tangent, Tangent and Radius (TTR):

Draw a circle with radius 2 units and two existing line as tangents.



Take:
For line 1: (16, 4) to point (19, 9)
For line 2: (20, 2) to point (21, 7)

Command: circle↵
3P/2P/TTR/<centre point> : TTR ↵
Enter Tangent spec: line 1 (pick up using mouse)
Enter Tangent spec: line 2 (pick up using mouse)
Radius: 2↵

(“Spec” means specifications)

ELLIPSE:

ELLIPSE can be drawn by any one of following two methods using ellipse command.

(a) Using first axis end points and other axis distance:

Draw an ellipse using major axis end point (10, 20) (65, 20) and minor axis end point (35, 35).

Command: ellipse ↲

<Axis end point 1>/ Centre: 10, 20↲

Axis end point 2: 65, 20↲

<Other axis distance>/ Rotation: 35, 35↲

(b) Using Centre of ellipse axis, end point and other axis distance:

Draw an ellipse using with centre (100, 20), major axis end point (125, 20) and minor axis end point (100, 35).

Command: ellipse ↵
<Axis end point 1>/ Centre: C↵
Centre of ellipse: 100, 20 ↵
Axis end point 2: 125, 20↵
<Other axis distance>/ Rotation: 100, 35↵

Note: Also the ellipse can be drawn by using arc, Isocircle, rotation & perimeter options

ARC

Arcs are partial circles and can be drawn in eight different methods using ARC command. Some of them are follows:

(a) Using three given points

Draw an arc using the given three points: (75, 50), (55, 90), (105,110).

Command: arc ↵

Centre/<Start point>: 75, 50 ↵

Centre/end/<Second point>: 55, 90 ↵

End point: 105,110 ↵

(b) Using Start points, centre and end point (SCE)

Draw an arc using start point (240, 20), centre point (250, 60) and end point (250,100).

Command: arc ↵

Centre/<Start point>: 240, 20 ↵

Centre/end/<Second point>: C ↵

Centre point: 250, 60 ↵

Angle/length of chord/<end point>: 250,100↵

(c) Using Start points, centre and length of chord (SCL)

Draw an arc using start point (140, 10), centre point (100, 10) and chord length 45 units.

Command: arc ↵

Centre/<Start point>: 140, 10 ↵

Centre/end/<Second point>: C ↵

Centre point: 100, 10 ↵

Angle/length of chord/<end point>: L↵

Length of chord: 45↵

(d) Using Start points, end point and Radius (SER)

Draw an arc using Start points (230, 80), end point (190, 80) and radius 22 units.

Command: arc ↵

Centre/<Start point>: 230, 80 ↵

Centre/end/<end point>: E ↵

End point: 190, 80 ↵

Angle/Direction/Radius/<centre point>: R↵

Radius: 22↵

Polygon

The polygon command draws regular polygons with 3 to 1024 sides. Any polygon can be drawn by following three method using polygon commands.

(a) Using radius of given circle in which polygon is inscribed:

Draw a polygon of eight sides with centre (50, 50) inscribed in a circle of radius 40 units.

Command: polygon ↵

Number of sides: 8 ↵

Edge/<centre of polygon>: 50, 50 ↵

Inscribed in circle/circum-scribed about circle (I/C): I ↵

Radius of circle: 40↵

(b) <u>Using radius of given circle in which polygon is circumscribed:</u>

Draw a polygon of eight sides with centre (140, 50) circumscribed in a circle of radius 40 units.

Command: polygon ↵

Number of sides: 8 ↵

Edge/<centre of polygon>: 50, 50 ↵

Inscribed in circle/circle-scribed about circle (I/C): C ↵

Radius of circle: 40↵

(C) <u>Using Edge method</u>

Draw a polygon of ten sides using “Edge method”. The first end point of the edge is (90,100) and Second end of the edge is (120,100).

Command: polygon ↵

Number of sides: 10 ↵

Edge/<centre of polygon>: E ↵

First end point of edge: 90,100 ↵

Second end point of edge: 120,100 ↵

EDIT COMMANDS AND OTHER ADDITIONAL COMMANDS

These commands are used to edit or modify the drawing.

1) ERASE- This command removes objects from a drawing.
Command: erase↵
Select objects: click on objects↵

2) MOVE: This command displaces objects to a specified distance in a specified direction.

Command: move↵
Select objects: click on objects↵
Base point or displacement: specify a base point↵
Second point or displacement: specify a point or↵

3) COPY: - This command is similar to move command, but it places copies of the related object at the specified displacements.

Command: copy↵
Select objects: click on objects↵
<Base point or displacement>/multiple: specify a point for a single copy or enter m for multiple copies↵
<Second point of displacement>: specify a point or P↵
(For placement multiple copies)

4) ROTATE: - This command moves object about a base point.

Command: rotate↵
Select objects: click on objects↵
Base point: specify a point↵
<Rotation angle>/Reference: Specify an angle or enter or specify a point↵

5) MIRROR: - This command creates a mirror image of objects.

Command: mirror↵
Select objects: click on objects↵
First point of mirror line: Specify a point↵
Second point: Specify a point↵
Delete old objects? <N>: Enter Y or N, or↵

6) SCALE: This command enlarges or reduces selected objects equally in X, Y, Z direction.

Command: Scale↵
Select objects: click on objects↵
Base point: specify a point↵
< Scale factor>/ Reference: specify a scale or enter R.
Scale factor>1 – Enlarges the objects.
Scale factor<1 – Shrinks the objects.
Reference length<1>: specify a distance or↵
New length: specify a distance ↵

If the new length is longer than the reference length, the objects are enlarged.

7) ARRAY: This command creates multiple copies of objects in pattern.

Command: array↵

Rectangular or polar array (R/P) <current>: enter an option or ↵

Option:

I) RECTANGULAR: – Creates an array defined by a number of rows and columns of copies of selected objects.

II) POLAR - Creates an array defined by specifying a center point about which the selected object is replicated. (Angle: + = CCW. -CW)

8) BREAK: - This command creates part of objects or splits on object into two.

Command: break↵

Select objects: click on objects or specify the first break point on an object↵

Enter second point (or F for first point): Specify the second break point or enter F↵

9) TRIM: - This command trims objects at a cutting edge defined by other objects.

Command: trim↵
Select cutting edges: Click on cutting edges (lines) ↵
Select edges: Click on object to be trimmed.
<Select object to trim>/project/ edge/undo: select an object, enter an option or ↵

10) DIMENSIONING
The dimensions are inserted in the drawing by use of Dim command. There are various types of dimensions used their AutoCAD.

(I) **Linear Dimensions:** Horizontal, Vertical, aligned (for inclined dimensions), Rotated (for inclined dimensions).
(II) **Angular dimensions:** For angular dimensioning of objects.
(III) Radial dimensions: For radial dimensioning of arc or circle.
(IV) **Diametral dimensions:** For diametral dimensioning of circle.
(V) **Ordinate dimensions:** For ordinate dimensioning of objects.

For dimensioning of objects, the first point and second point has to be specified. The dimension text must be written and then the position of dimension must be specified.

(I) Linear Dimensioning

Command: Dim↵

Dim (HOR/VER/ALIGNED/ROT): HOR↵

First extension line origin: (select corner P using cursor)

Second extension line origin (Text/angle): (select corner Q)

Dimension line location (Text/Angle): (select the position of dim. Line using cursor)

Dimension text: 8↵

Dim: Exit↵

Command: Dim↵

Dim: ROT↵

Dimension line angle <0>:115↵

(Note- 0^0 for horizontal & 90^0 for vertical dimensions)

First extension line origin: (select the point)

Second extension line origin: (select the point)

Dimension line location < text/angle>: (select the location)

Dimension text<5.5>:↵

(II) Angular dimensioning:

Command: Dim↵

Dim: Angular ↵

Select First line: (Pick point 1)

Select Second line: (Pick point 2)

Dimensions are line location (text/angle): (Pick point 3)

Dimension text: 45

Enter text location: (pick a location for dimension text)

Command: Dim↵

Dim: Leader↵

Leader start (specify starting point, A)

To Point: (specify the end point, B)

To Point: (specify the next point, C)

Dimension text: R6↵

(III) Dimetral Dimensioning

Dim: Dia↵

Select arc or circle: (pick point P)

Dimension text: %%C8↵ (% % C for ∅ symbol)

Enter leader length for text: (pick Q and then R and press enter)

(IV) Radius Dimensioning

Dim: Radius↵

Select arc or circles :(pick point P)

Dimension Text: R5↵

11) Text

This command creates text on the drawing with a variety of character patterns or fonts. These fonts can be stretched, compressed, oblique, mirrored or aligned in a vertical column by applying a style to the font.

Command: Text↵

Justify/style/<start point>: specify a point or enter an option

The start point is the default.

12) Layer

A layer is like an overlay that allows us to separate different types of information. AutoCAD allows an unlimited number of layers on new drawings the default layer is 0.

This command creates new layer, selects the current layer, sets the color and line type for designated layers, turns layers on and off, locks or unlocks layer, freezes or throws layers and lists defined layers.

Command: layer↵

?/make/set/new/on/off/color/Ltype/Freeze/Thaw/lock/unlock: enter an option.

Problem:

Draw the figure of Bracket and Open Bearing using AutoCAD.

Solution:

<u>To draw Bracket</u>

Command: line↵

From point: 11, 3 ↵

To point: @ 47.5<0↵

To point: @ 2.5, 2.5↵

To point: @ 10<90↵

To point: @ 17.5<180↵

To point: @10<90↵

To point: @ 17.5<0↵

To point: @10<90↵

To point: @ -2.5, 2.5↵

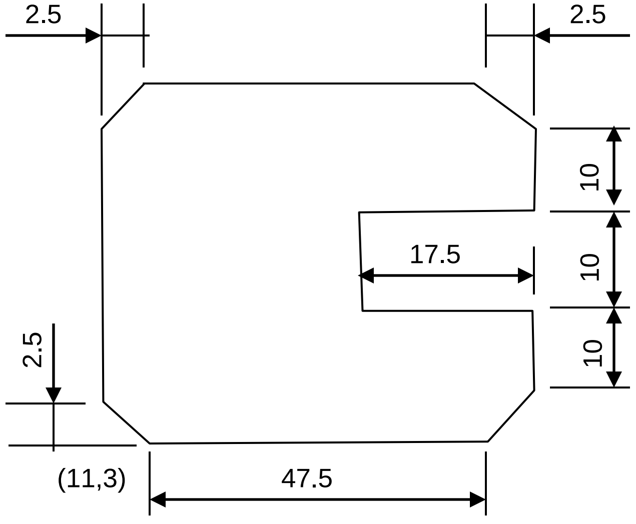
To point: @ 47.5<180↵

To point: @ -2.5, - 2.5↵

To point: @30<270↵

To point: @ 2.5, -2.5↵

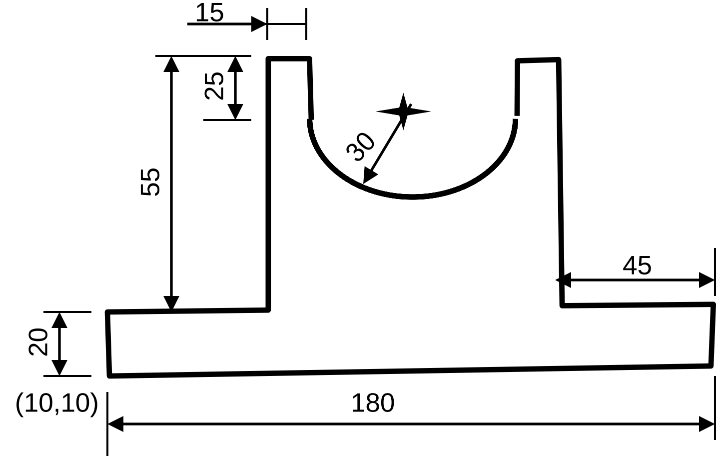
To point: ↵



BRACKET

To draw the Open Bearing

Command: line↵
From point: 10, 10 ↵
To point: @180<0↵
To point: @20<90↵
To point: @45<180↵
To point: @55<90↵
To point: @15<180↵
To point: @25<270↵
To point: ↵
Command: arc↵
Centre/<start point>: 130, 60↵
Centre/end/<second point>: E↵
End point: 70, 60↵
Angle/direction/radius/<centre point>: A↵
Included Angle:-180↵
Command: line↵
From point: 70, 60 ↵
To point: @25<90↵
To point: @15<180↵
To point: @55<270↵
To point: @45<180↵
To point: @20<270↵
To point: ↵



OPEN BEARING