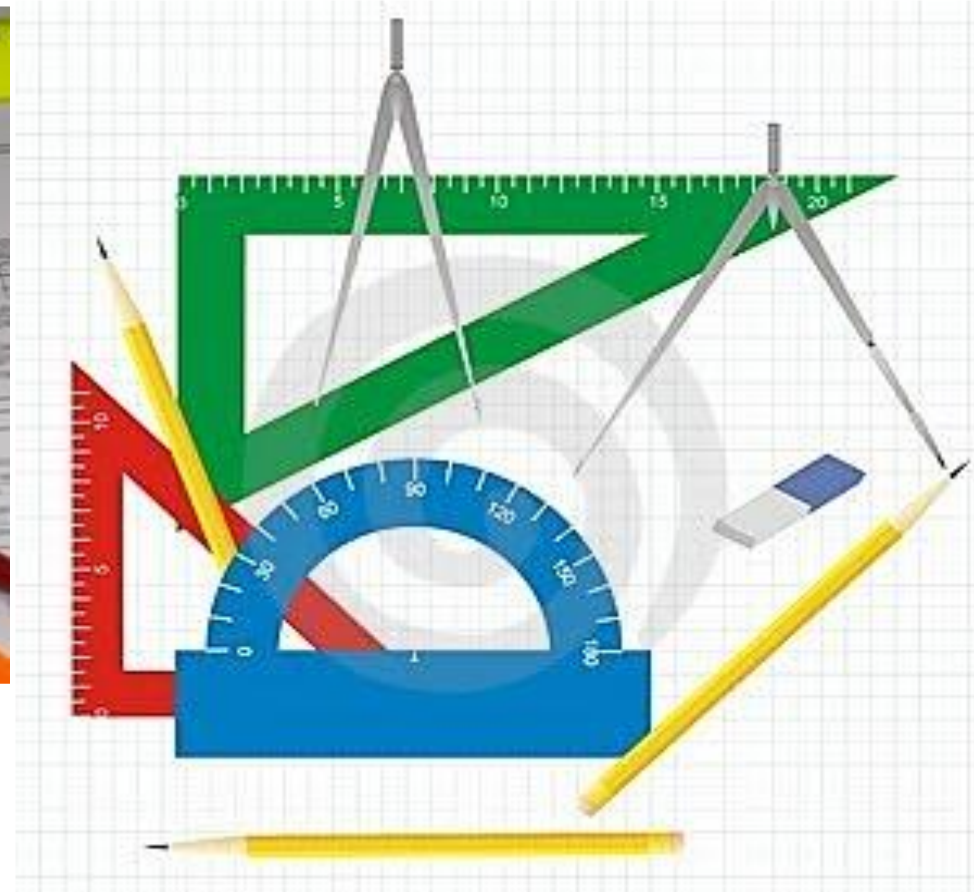


GE6152 - ENGINEERING GRAPHICS

OBJECTIVES

1. To develop in students graphic skill for communication of
   - **Concepts,**
   - **Ideas** and
   - **Design of engineering products**

and expose them to existing national standards related to technical drawings.

Concepts and conventions

1. Importance of graphics in engineering applications.

2. Use of drafting instruments.

3. BIS conventions and specifications.

4. Size, layout and folding of drawing sheets.

5. Lettering and dimensioning.

What is Engineering Drawing?

1. **ENGINEERING DRAWING IS THE LANGUAGE OF ENGINEERS.**

2. By means of Engineering Drawing one can express the shape, size, finish etc. of any object accurately and clearly.

Methods of Expression

There are **three methods** of writing the graphic languages.

1. Freehand
2. With hand-held instruments
3. By computer

Methods of Shape Description

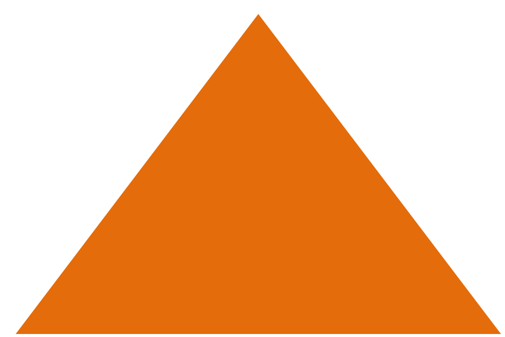
1. **Two Dimensional** Drawings or Plane Geometrical drawings.

2. **Three Dimensional** Drawings or Solid Geometrical drawings.

Plane Geometrical drawings

Plane Geometrical drawing is the drawing which represents the objects having two dimensions.

Ex : Representing square, triangle etc. on a drawing sheet.



Solid Geometrical drawings

Solid Geometrical drawing is the drawing which represents the objects of three dimensions.

Ex : Representing cone, sphere etc. on a drawing sheet.

Engineering Drawing Instruments

1. Drawing board

2. Drawing sheets

3. Mini-drafter/Drafting machine

4. Instrument box

Engineering Drawing Instruments

5. Set-squares (45° triangle and 30° - 60° triangle)

6. Protractor

7. Scales (celluloid/card-board - M1, M2. . . . Me)

8. Drawing Pencils (HB, H and 2H Grades)

Engineering Drawing Instruments

9. Eraser

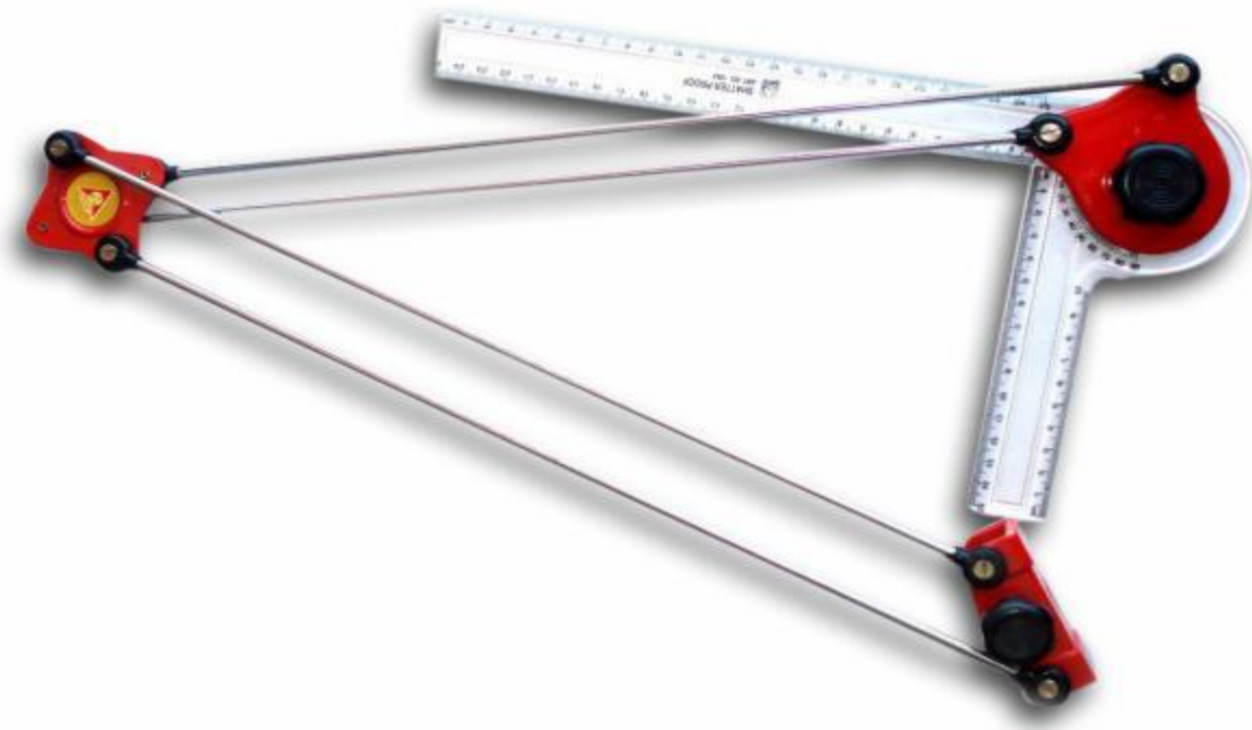
10. Clips or Adhesive tape (cello-tape)

11. Sharpener and Emery paper

12. French curves

Drawing board

Mini-drafter/Drafting machine

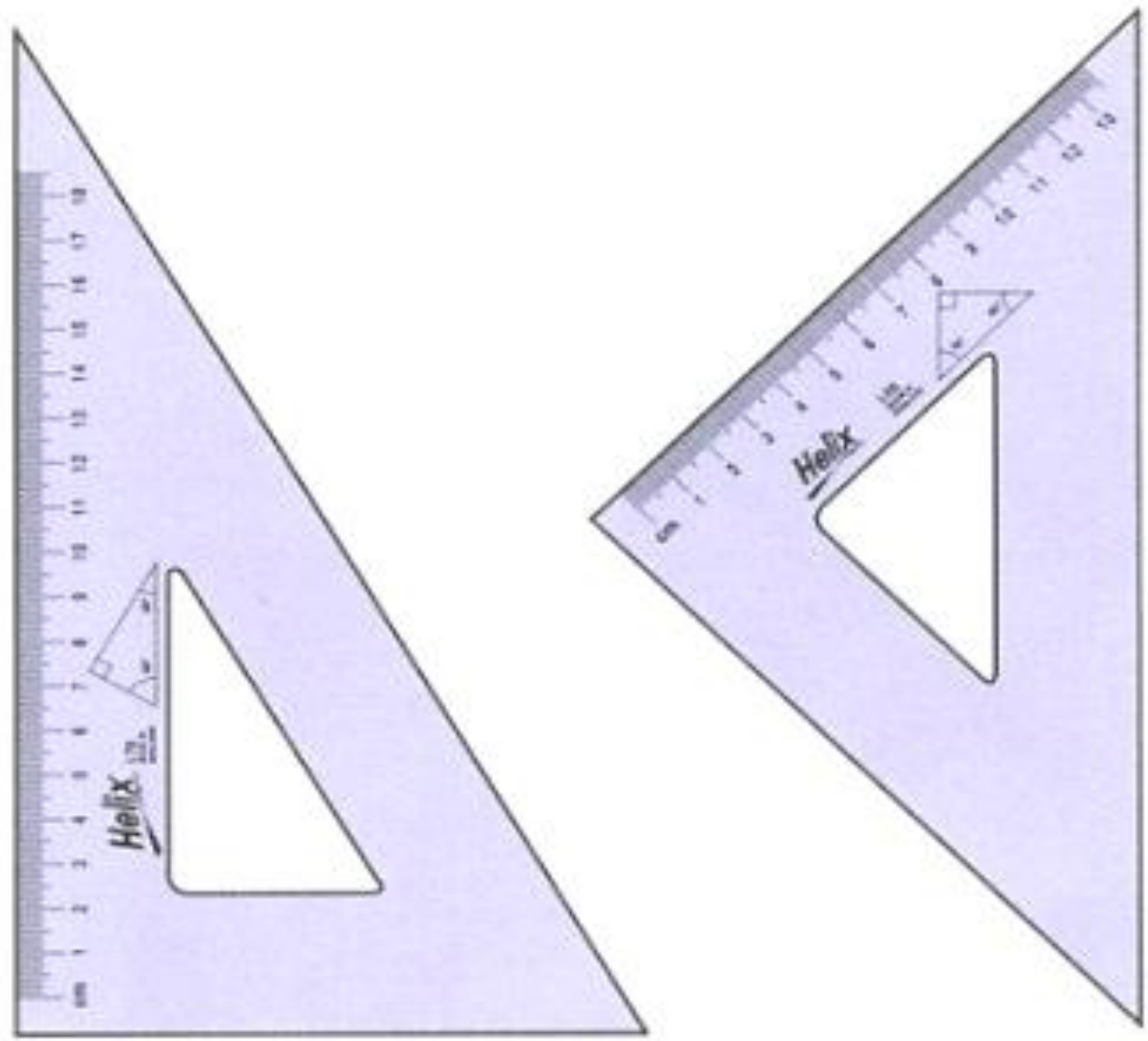


Drawing sheet Standard Sizes

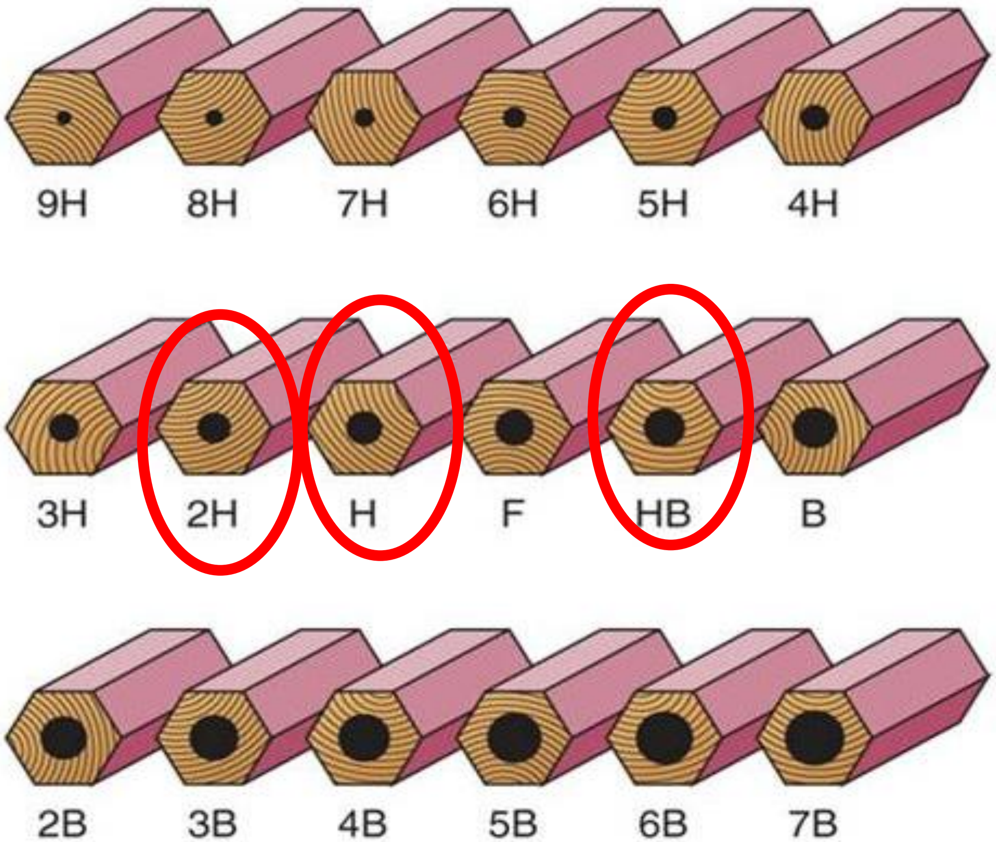
Designation	Dimensions, mm	
	Length	Width
A0	1189	841
A1	841	594
A2	594	420
A3	420	297
A4	297	210

Instrument box

Set-squares



Drawing Pencils



HARD

The hard leads are used for construction lines on technical drawings.

MEDIUM

The medium grades are used for general use on technical drawings. The harder grades are for instrument drawings and the softer for sketching.

SOFT

Soft leads are used for technical sketching and artwork but are too soft for instrument drawings.

Drawing Pencils

1. **HB** - (Soft grade) Used for drawing thick outlines like borderlines, lettering and arrow heads.

2. **H**-Used for finishing lines, outlines, visible lines and hidden lines.

3. **2H** - (Hard grade) Used for construction lines, dimension lines, centre lines and section lines.

French curves

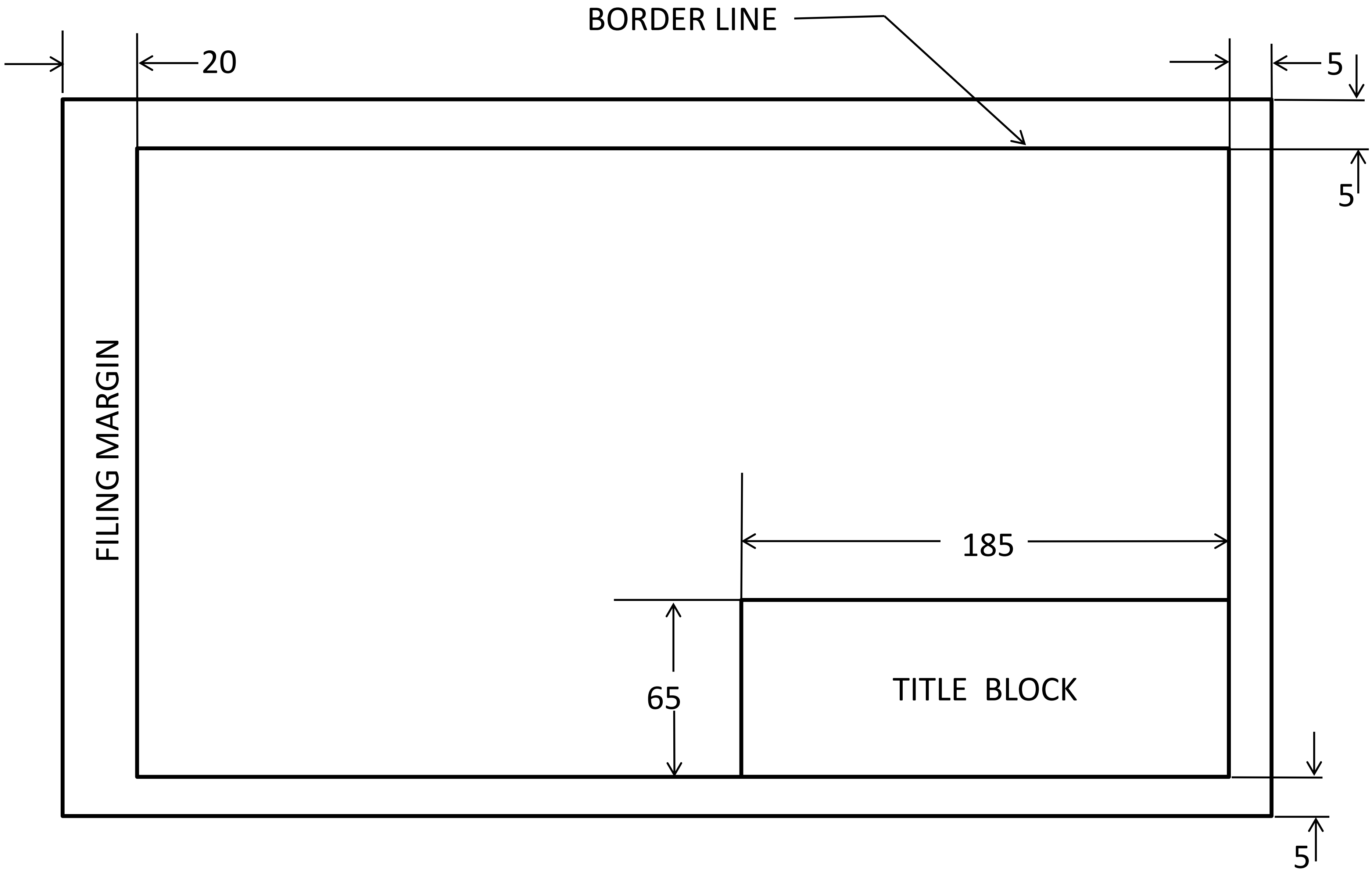
Standards

1. **I.S.O**- International Organization for Standardization

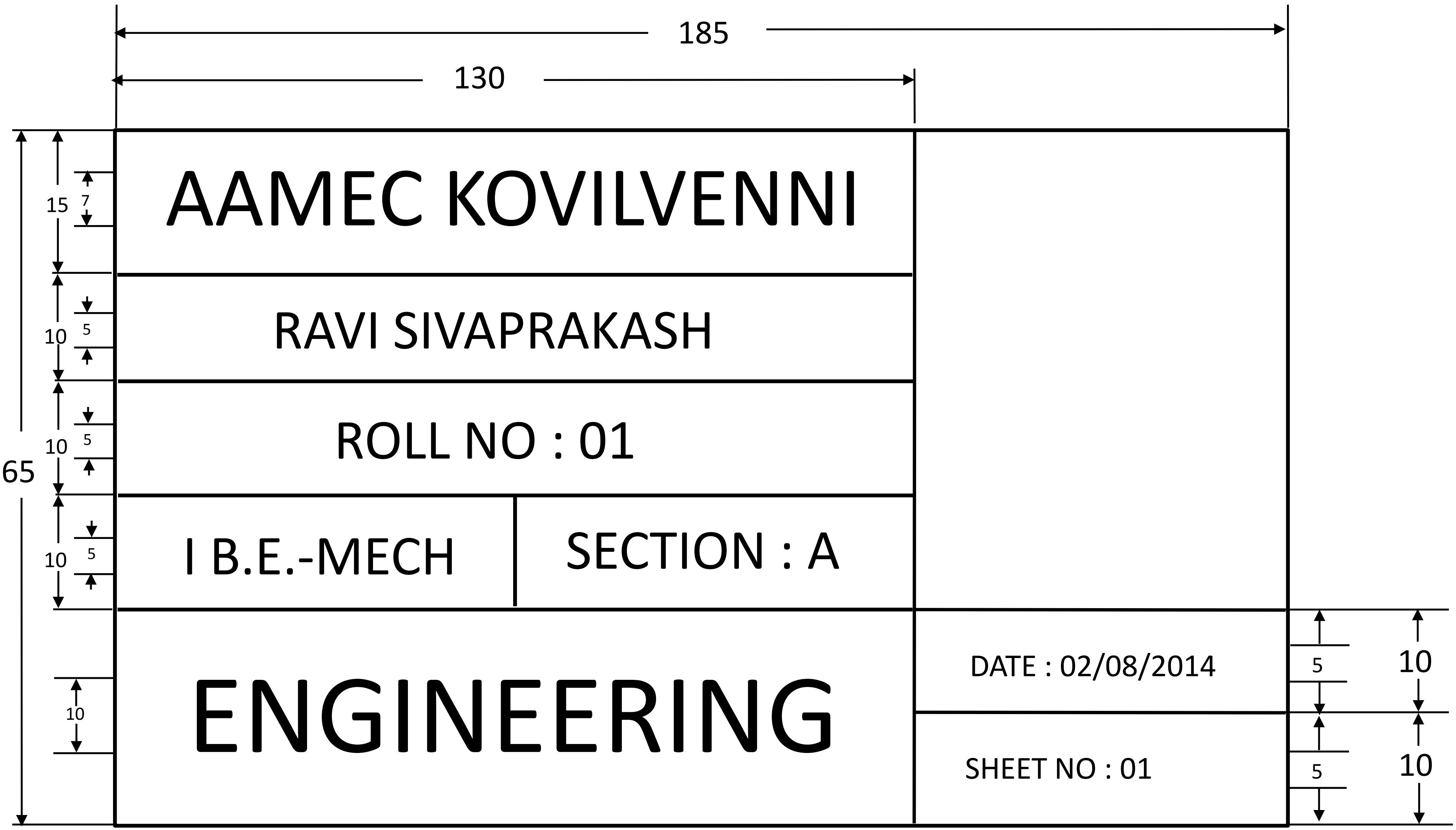
2. **I.S.I**-Indian Standards Institution

3. **B.I.S** -Bureau Of Indian Standards

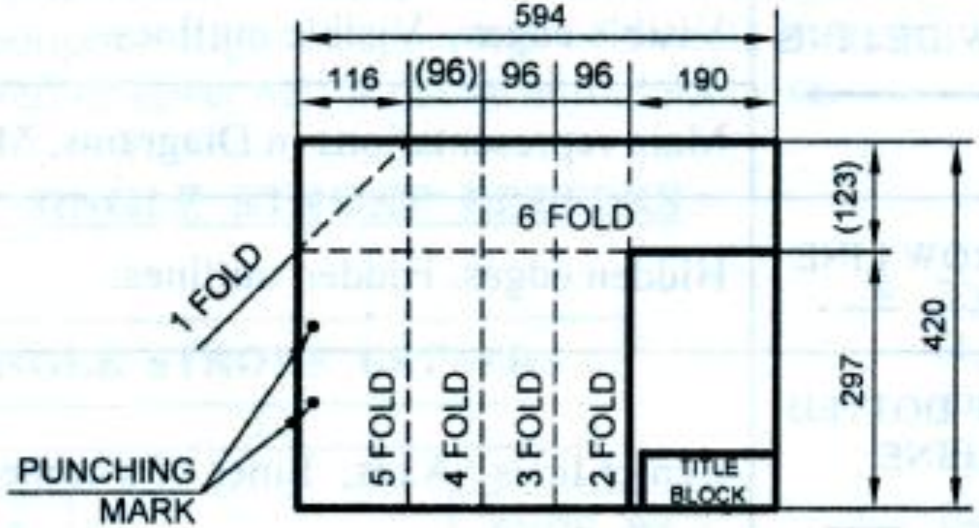
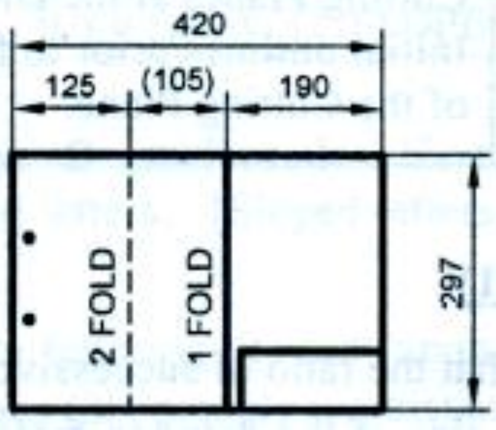
Sheet Layout



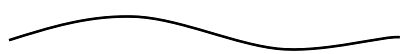
Title Block


185
130
AAMEC KOVILVENNI
RAVI SIVAPRAKASH
ROLL NO : 01
I B.E.-MECH
SECTION : A
ENGINEERING
DATE : 02/08/2014
SHEET NO : 01
65
15
7
10
5
10
5
10
5
10
5
10
5
10

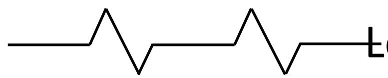
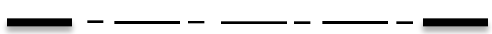
Folding of Drawing Sheets

SHEET SIZE	FOLDING DIAGRAM	LENGTHWISE FOLDING
A2 420 x 594		
A3 297 x 420		

Types of Lines

Type of line	Illustration	Application	Pencil Grade
Continuous thick		Visible outlines.	H
Continuous thin		Dimension lines, leader lines, extension lines, Construction lines & Hatching lines.	2H
Continuous thin wavy (drawn free hand)		Irregular boundary lines, short break lines.	2H

Types of Lines

Type of line	Illustration	Application	Pencil Grade
Continuous thin with zigzag		Long break lines.	2H
Short dashes	----------------------------	Invisible edges.	H
Long chain thin	—— – —— – —— – —— – ——	Centre lines, locus lines.	H
Long chain thick at ends and thin elsewhere		Cutting plane lines.	2H & H

Types of lettering

i. Vertical Letters
   a) CAPITAL (UPPER CASE) LETTERS.
   b) Small (lower case) letters.

ii. Inclined Letters (inclined at 75° to the horizontal)
   a) CAPITAL (UPPER CASE) LETTERS.
   b) Small (lower case) letters.

Lettering Standards

1. Standard heights for lettering are **3.5, 5, 7 & 10 mm.**

2. Ratio of height to width, for most of the letters is approximately **5:3**.

3. However for M and W, the ratio is approximately**5:4**

Lettering Standards

Different sizes of letters are used for different purposes:

1. Main title - 7 (or) 10 mm

2. Sub-titles - 5 (or) 7 mm

3. Dimensions, notes etc. - 3.5 (or) 5 mm.

Single Stroke Letters

ABCDEFGHIJKLMNOPQ

RSTUVWXYZ

abcdefghijklmnopqr

stuvwxyz

0123456789

Gothic Letters (thick letters)

10 mm

ABCDEFGHIJKLMN

OPQRSTUVWXYZ

abcdefghijklmn

opqrstuvwxyz

0123456789

VERTICAL (CAPITAL & LOWER CASE) LETTERS AND NUMERALS

Lettering Standards

NOTE:

1. Vertical letters are preferable.

2. Guide lines -2H pencil
   lettering -HB pencil

Lettering Standards

NOTE:

3. Spacing between two letters 1/5th of the height of the letters.

4. Space between two words 3/5th of the height of the letters.

Exercise :

Write free-hand, In single stroke vertical (CAPITAL& lower case) letters, the following:

1. Alphabets and Numerals (Heights 5, 7 & 10 mm).

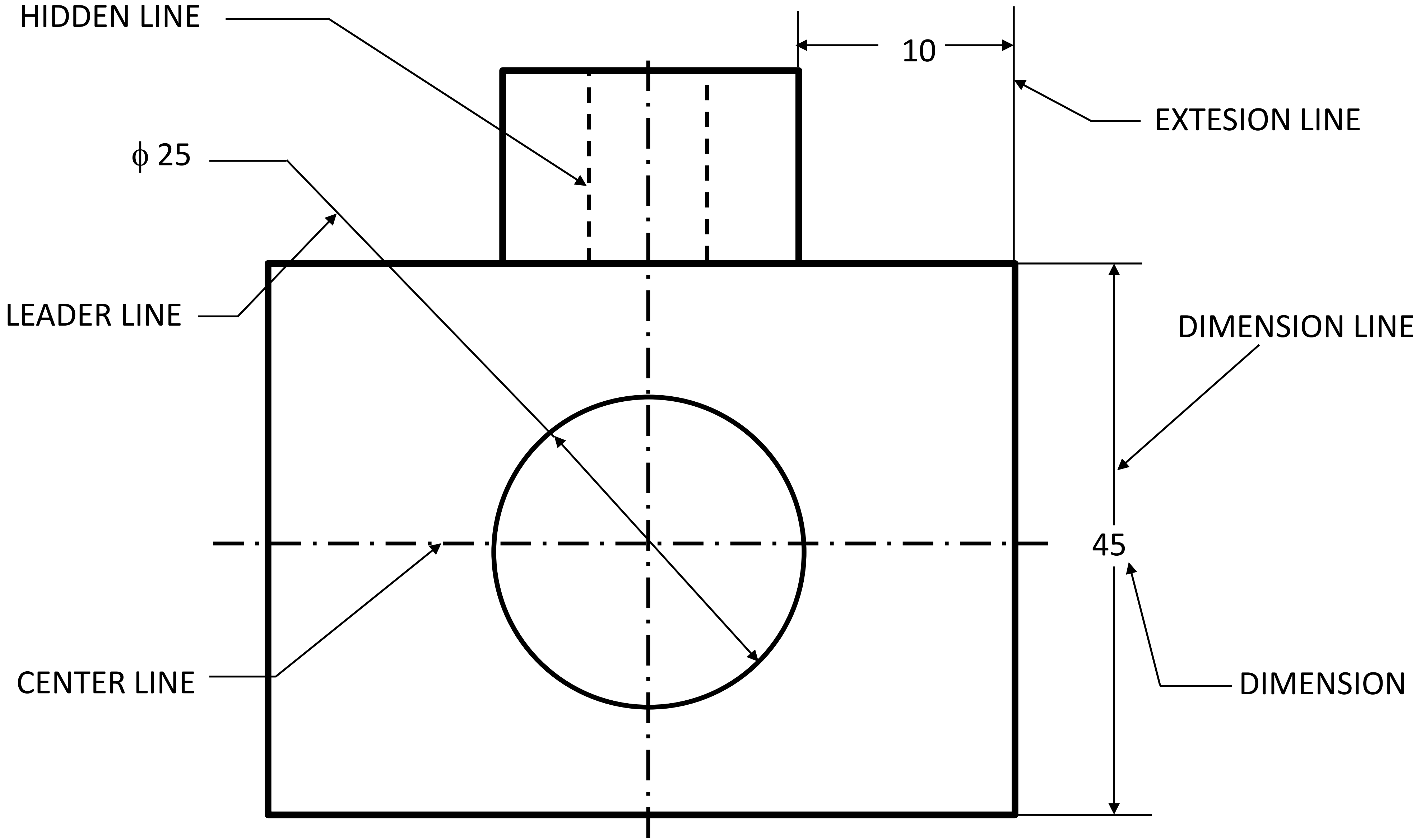
2. "DRAWING IS THE LANGUAGE OF ENGINEERS" (Heights 5 & 7 mm).

Dimensioning

1. An Engineering drawing should contain the details regarding the sizes, besides giving the shape of an object.

2. The expression of details in terms of numerical values regarding distances between surfaces etc., on a drawing by the use of lines, symbols and units is known as **dimensioning.**

Anatomy of a dimension



General Principles

1. All dimensions should be detailed on a drawing.

2. No single dimension should be repeated except where unavoidable.

3. Mark the dimensions outside the drawing as far as possible.

General Principles

4. Avoid dimensioning to hidden lines wherever possible.

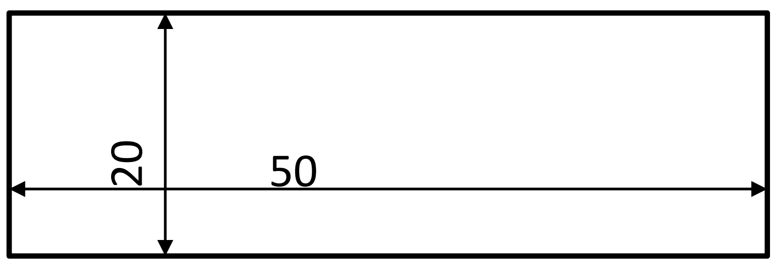
5. The longer dimensions should be placed outside all intermediate dimensions, so that dimension lines will not cross extension lines.

Illustration of principles of dimensioning

1. Place the dimensions outside the views.

Note:

Dimensions of diameter, circle and radius may be shown inside.



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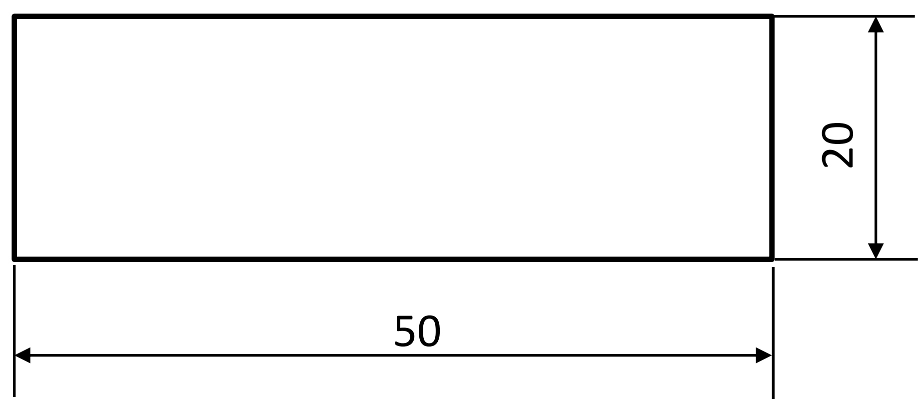
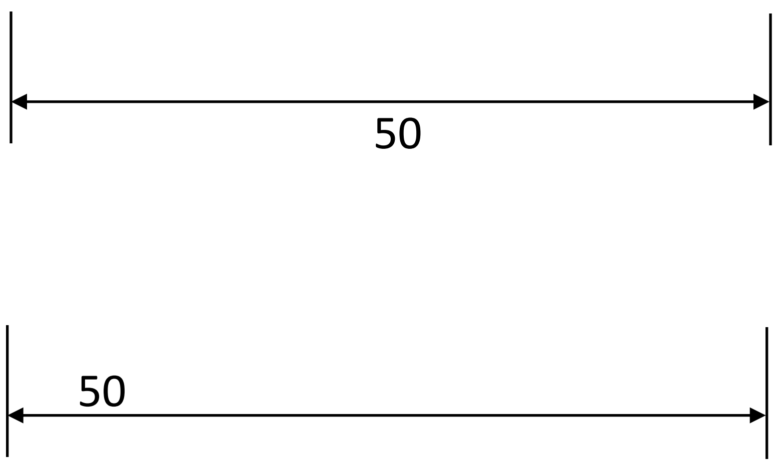


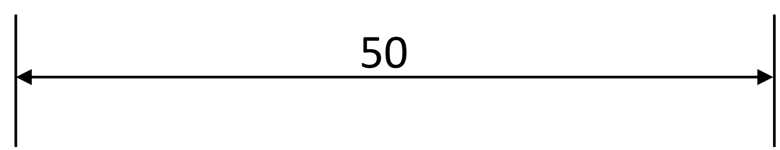
Correct

Illustration of principles of dimensioning

2. Place the dimension value above the horizontal line near the middle.



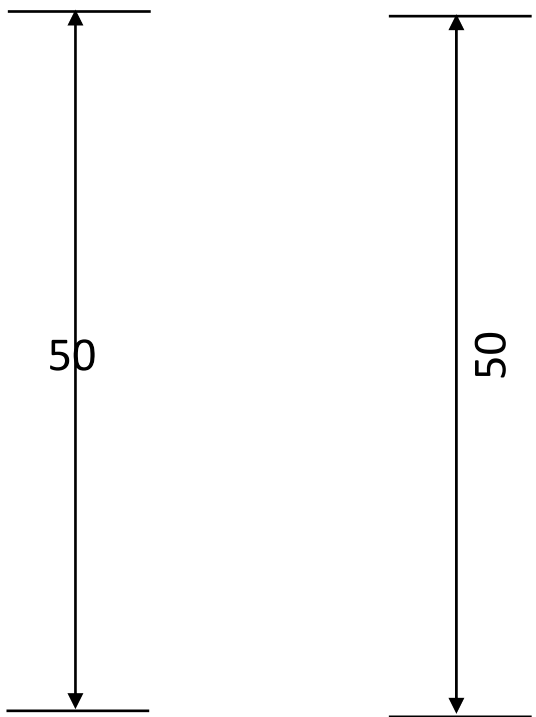
Not Correct



Correct

Illustration of principles of dimensioning

3. Dimensioning a vertical line.



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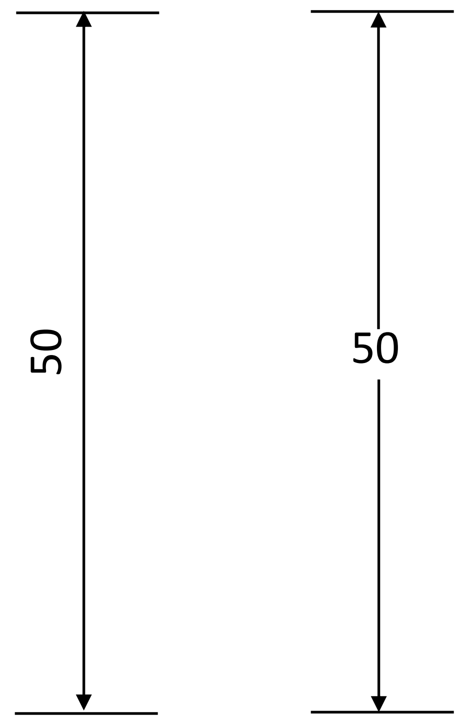
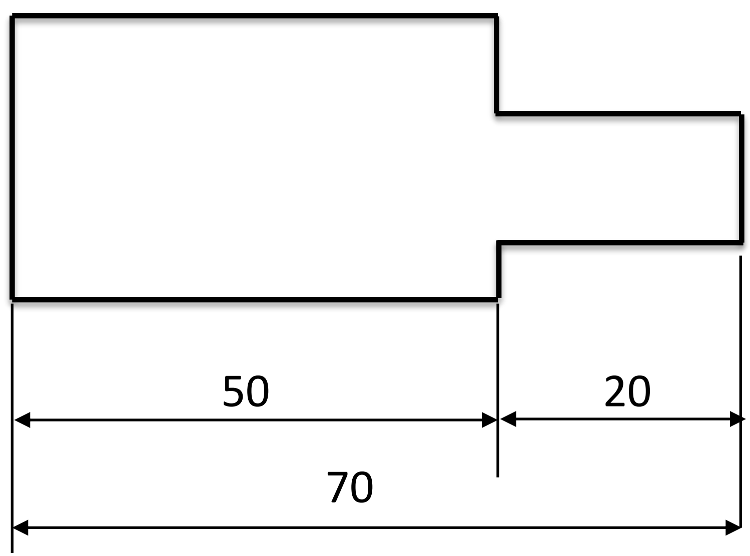


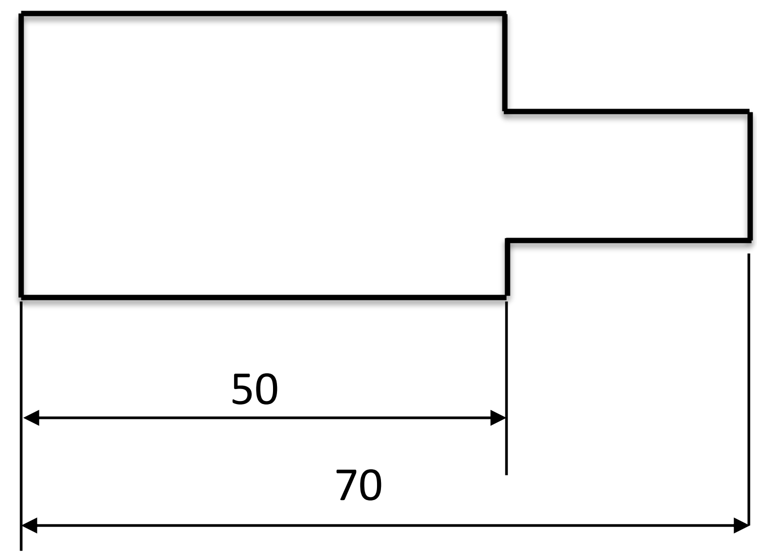
Correct

Illustration of principles of dimensioning

4. When on overall dimension is shown, one of the intermediate dimensions should not be given.



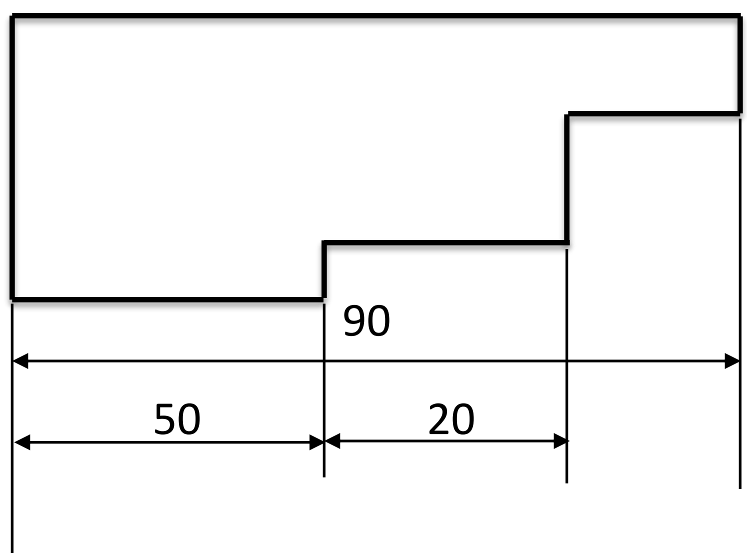
Not Correct



Correct

Illustration of principles of dimensioning

5. Overall dimensions should be placed outside intermediate dimensions.



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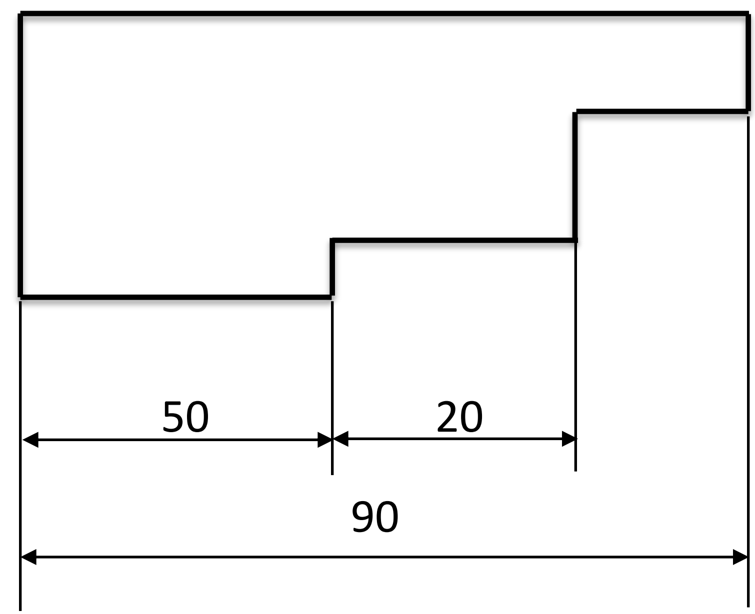
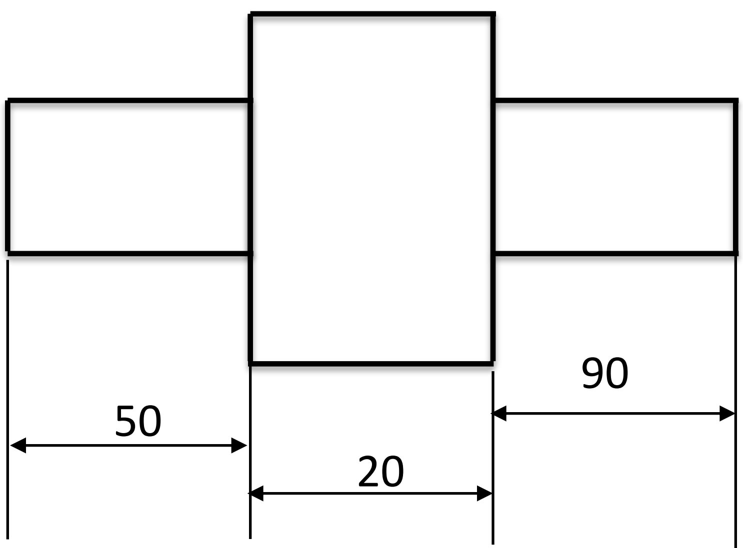


Correct

Illustration of principles of dimensioning

6. Arrange a chain of dimensions in a continuous line.



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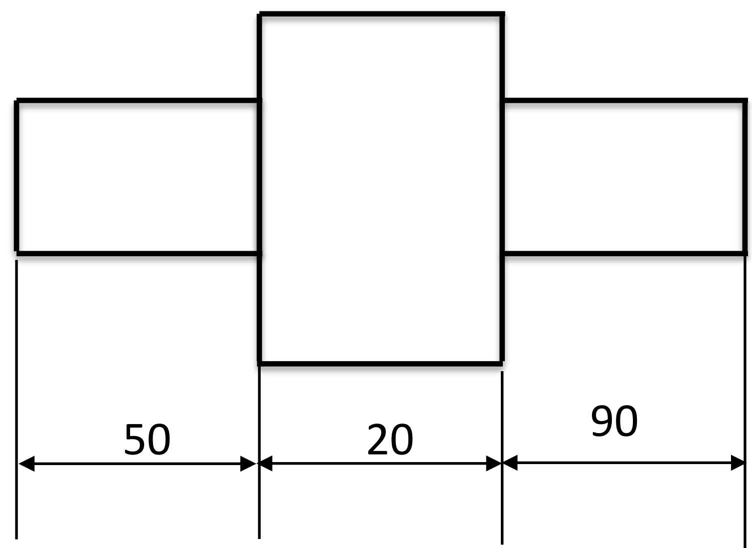
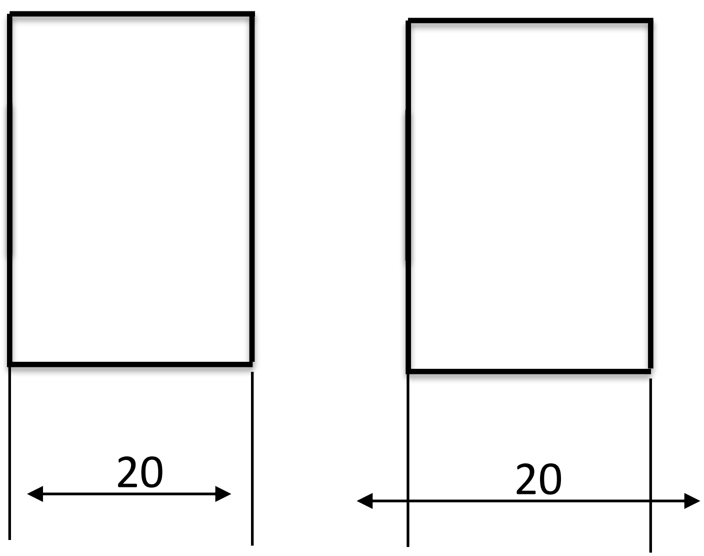


Correct

Illustration of principles of dimensioning

7. Arrowheads should touch the projection lines.



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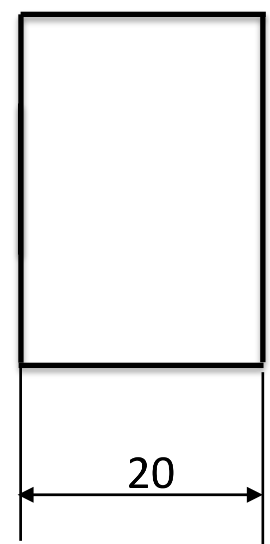
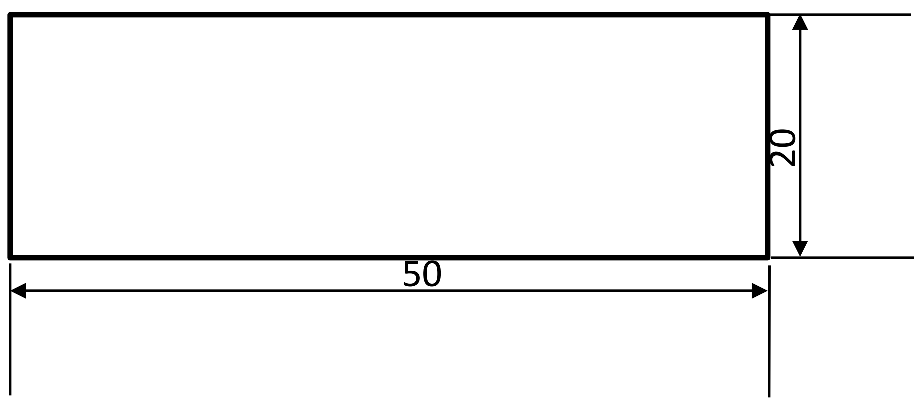


Correct

Illustration of principles of dimensioning

8. Dimension lines should be placed at least 6 to 10 mm away from the outlines.



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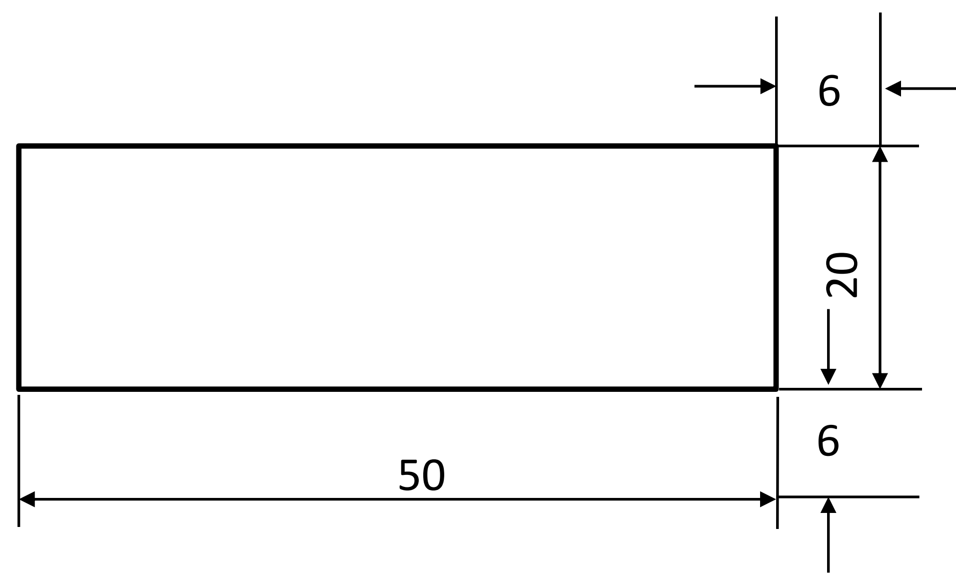
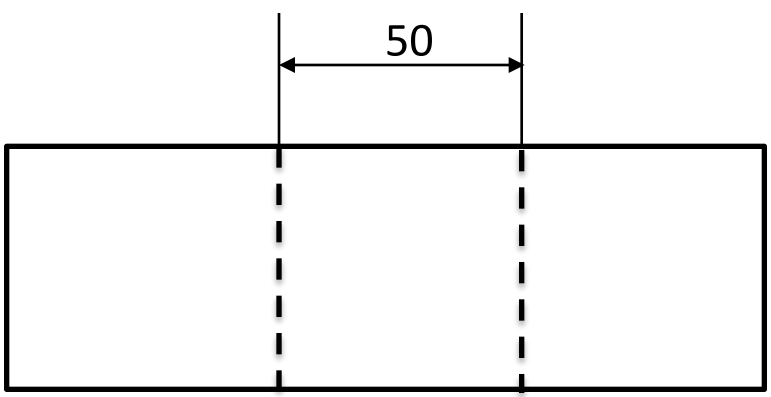


Correct

Illustration of principles of dimensioning

9. Dimensions are to be given to visible lines and not to hidden lines.



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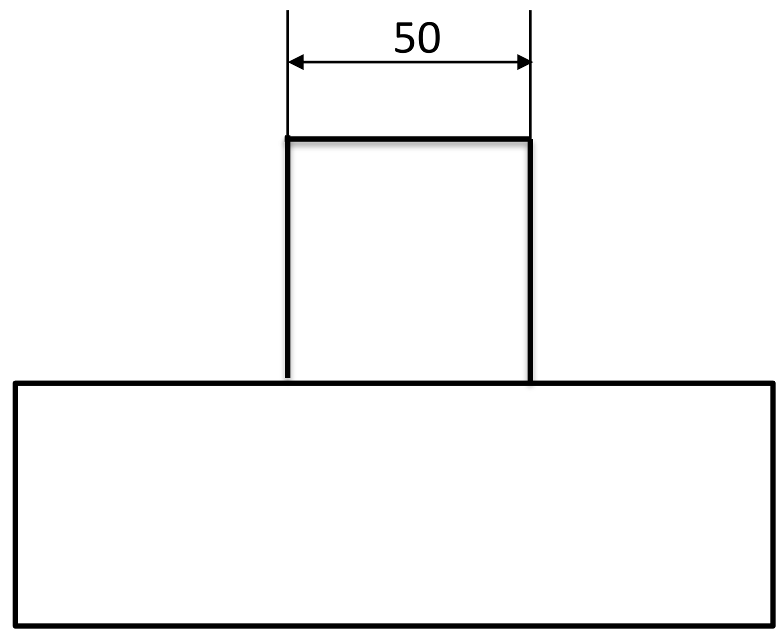
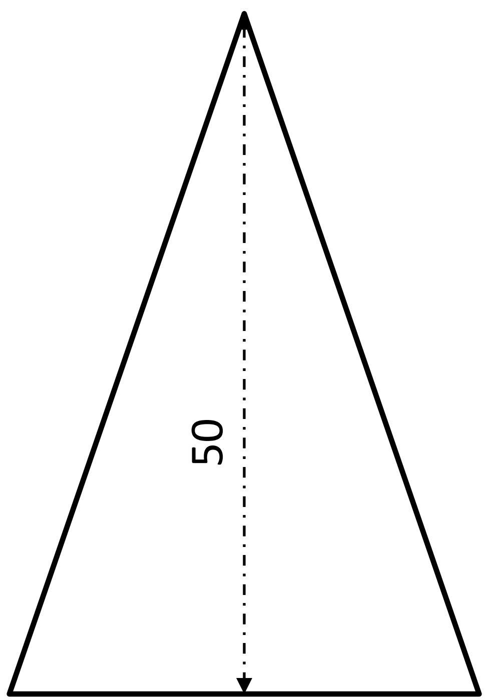


Correct

Illustration of principles of dimensioning

10. Centre line should not be used as a dimension line.



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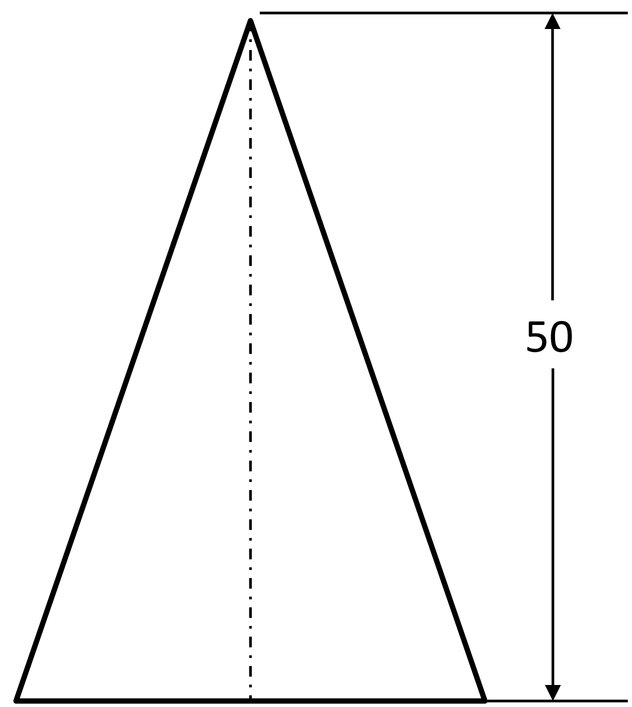
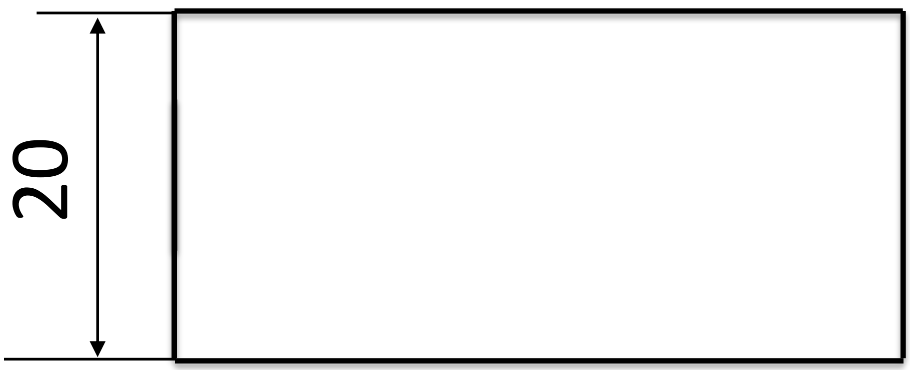


Correct

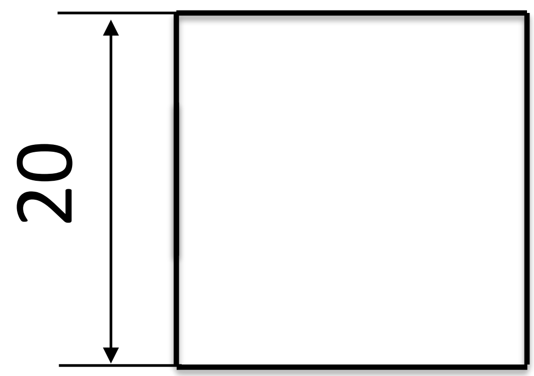
Illustration of principles of dimensioning

11. Do not repeat the same dimension in different views.



FRONT VIEW

Not Correct

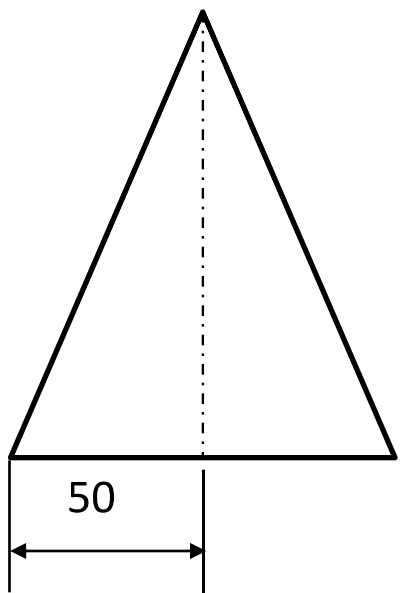


L.S. VIEW

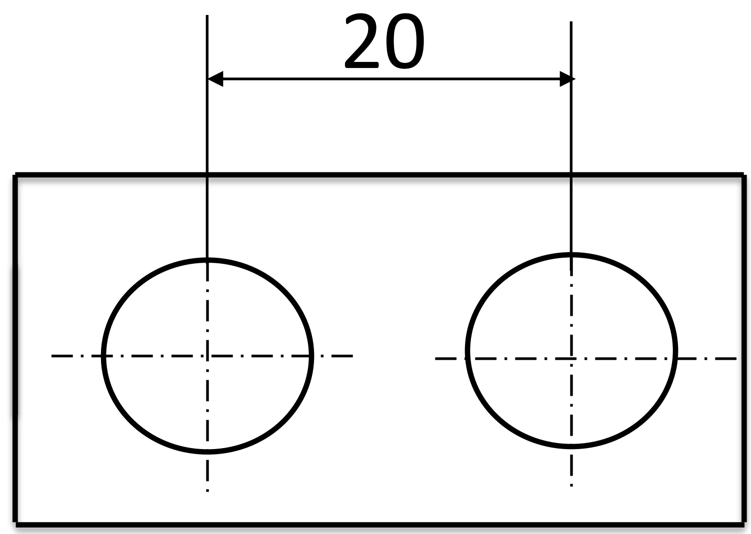
Correct

Illustration of principles of dimensioning

12. Dimensioning from a centre line should be avoided except when centre line passes through the centre of a hole or a cylinder part.



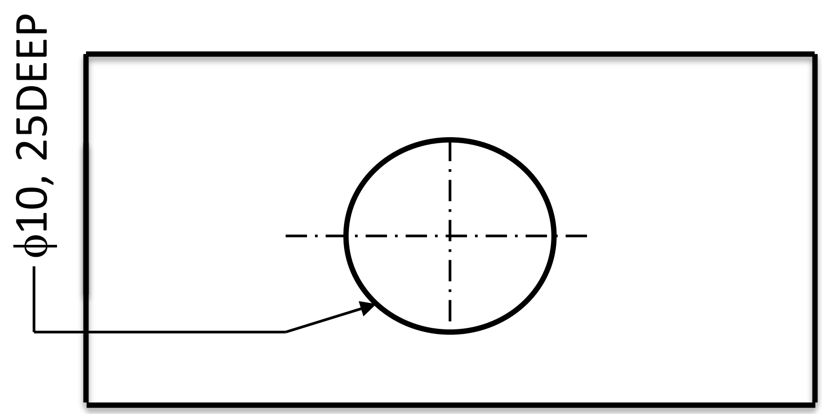
Not Correct



Correct

Illustration of principles of dimensioning

13. Indicate the depth of the hole as notes written horizontally.



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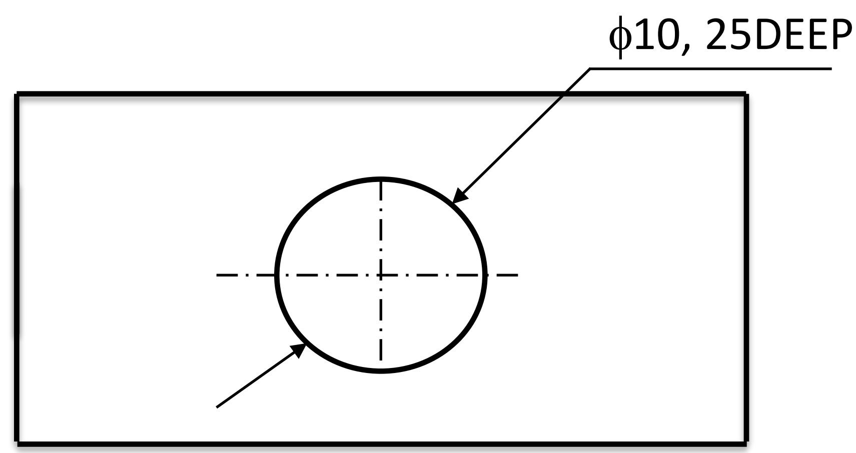
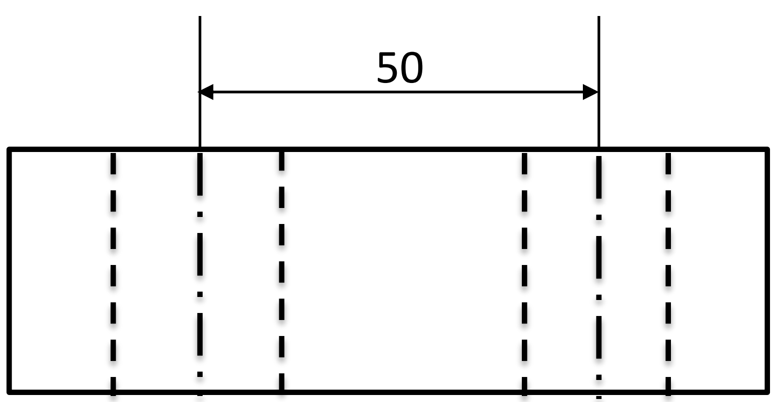


Correct

Illustration of principles of dimensioning

14. Locate holes in the proper view.



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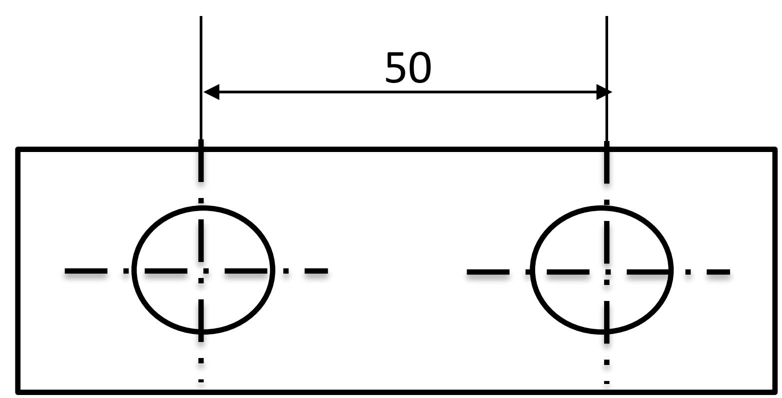
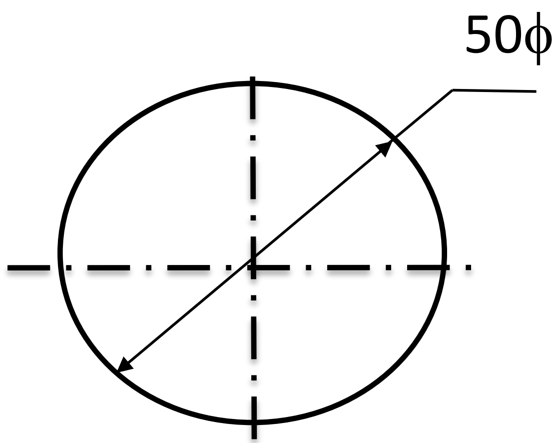


Correct

Illustration of principles of dimensioning

15. Diameter and radius symbols should be placed before the values.



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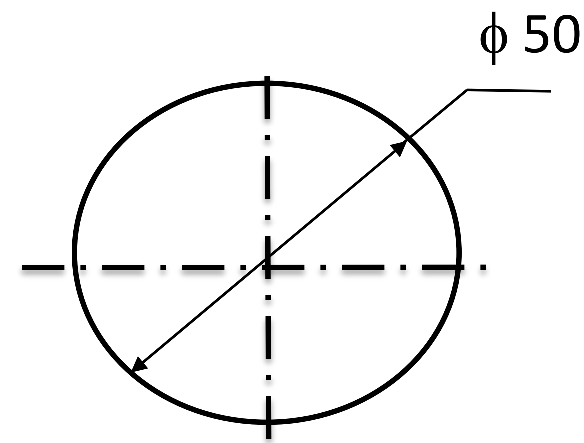
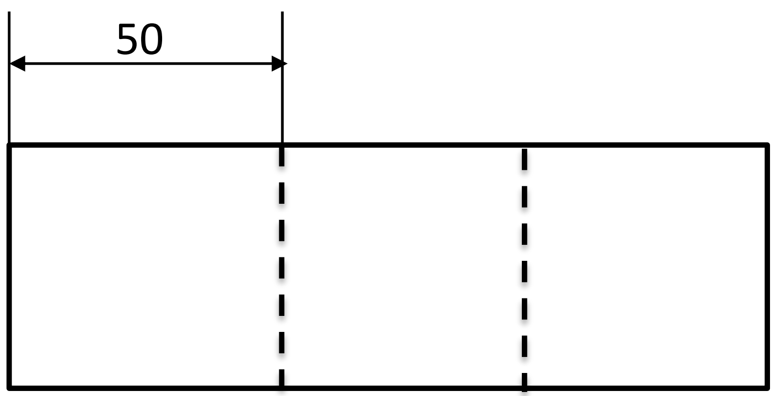


Correct

Illustration of principles of dimensioning

16. Dimensions are to be given from visible lines and not from hidden lines.



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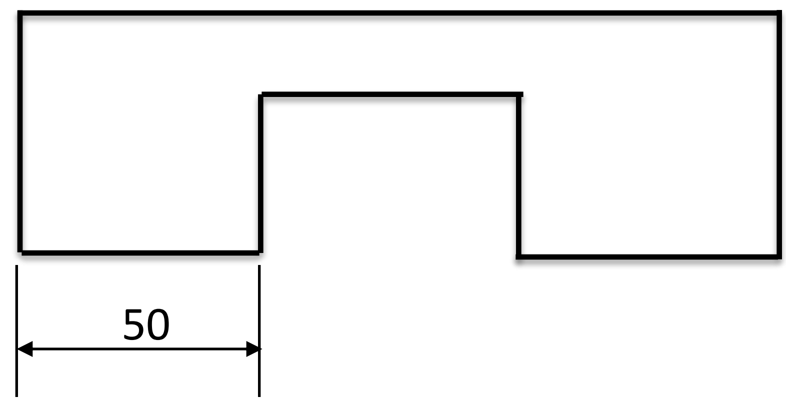


Correct

Methods of Dimensioning

1. Unidirectional System (preferable)

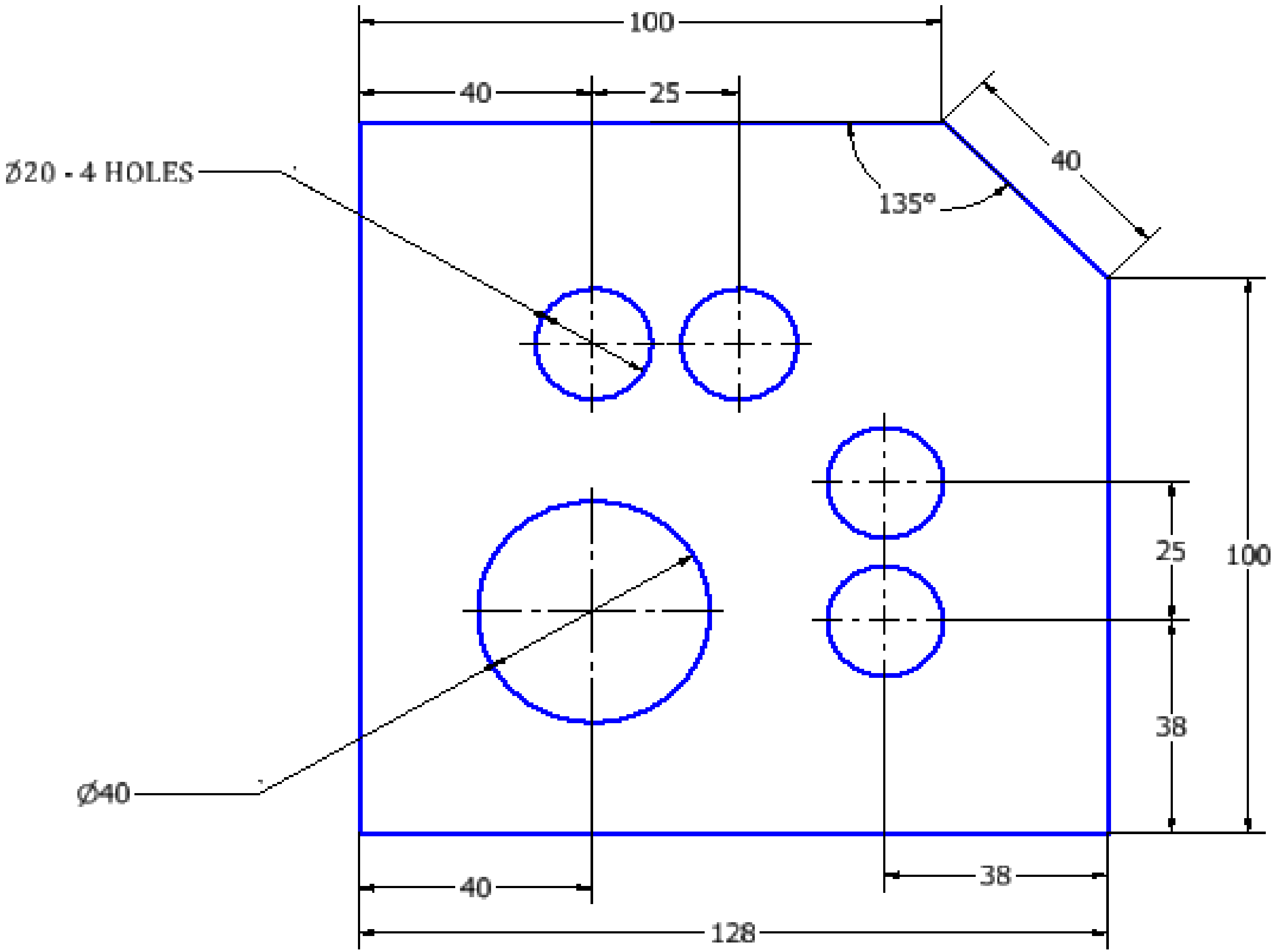
2. Aligned System

Unidirectional System

1. In this method dimensions shall be horizontally so that they can be read from the bottom of the sheet.

2. Here the **dimension lines may be interrupted near the middle** for the insertion of dimensions.

UNIDIRECTIONAL METHOD OF DIMENSIONING

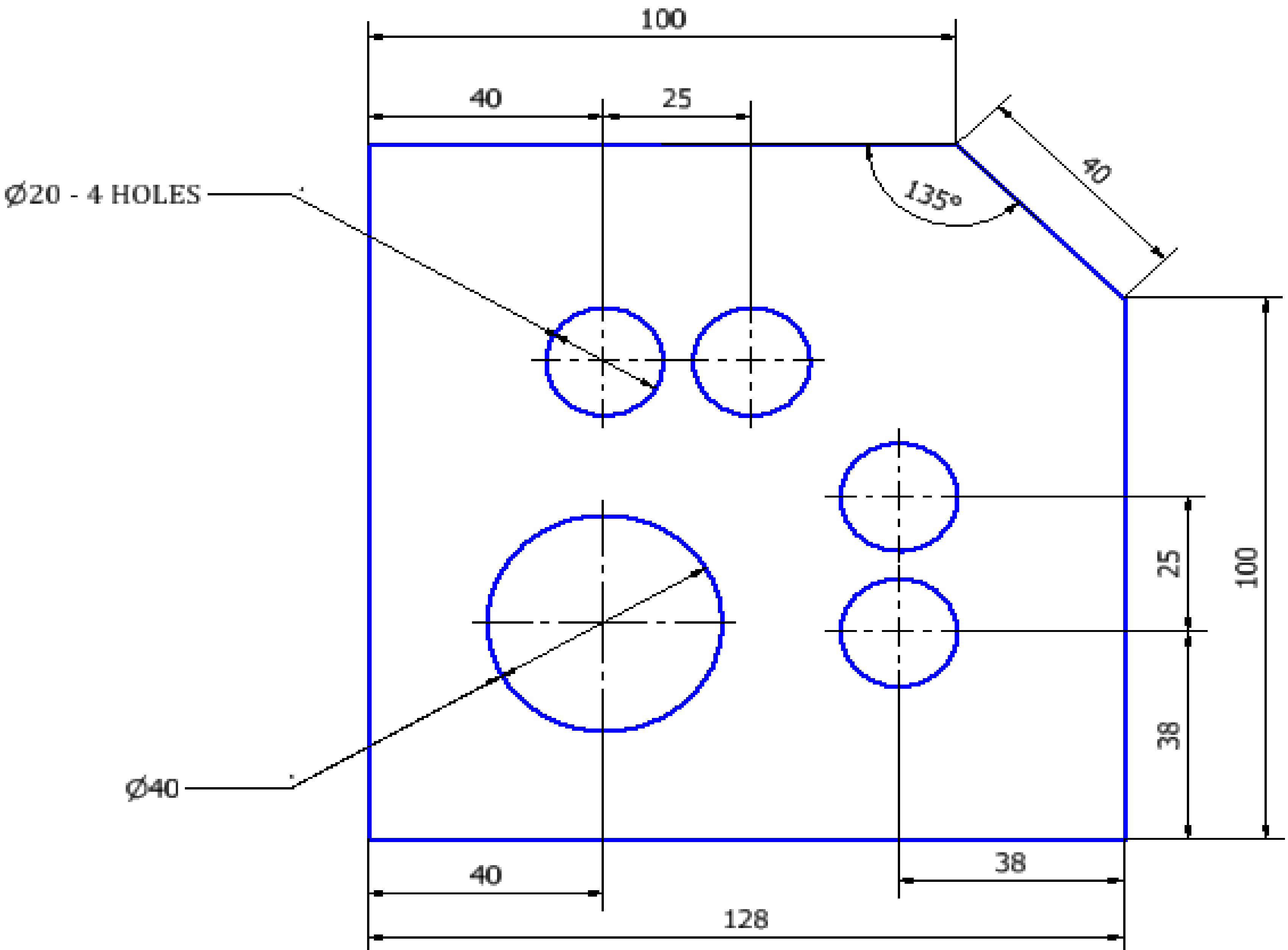


Aligned System

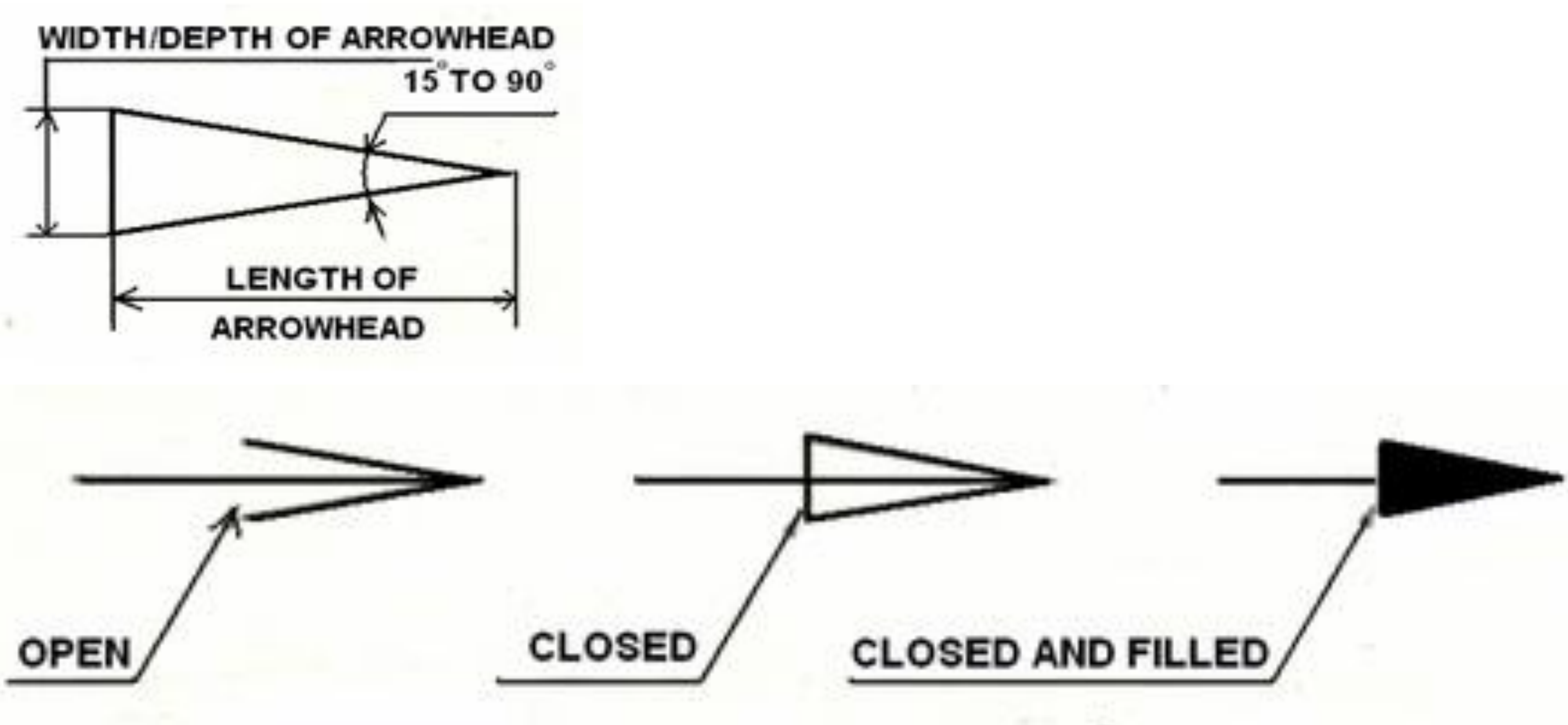
1. In aligned system, dimensions shall be placed **parallel to (i.e., aligned with) and above the dimension lines**, preferably in the middle and not by interrupting the dimension lines.

2. Here the dimensions can be read from the bottom or from the right side of the drawing.

ALIGNED METHOD OF DIMENSIONING



Arrow heads


WIDTH/DEPTH OF ARROWHEAD
15° TO 90°
LENGTH OF
ARROWHEAD
OPEN
CLOSED
CLOSED AND FILLED

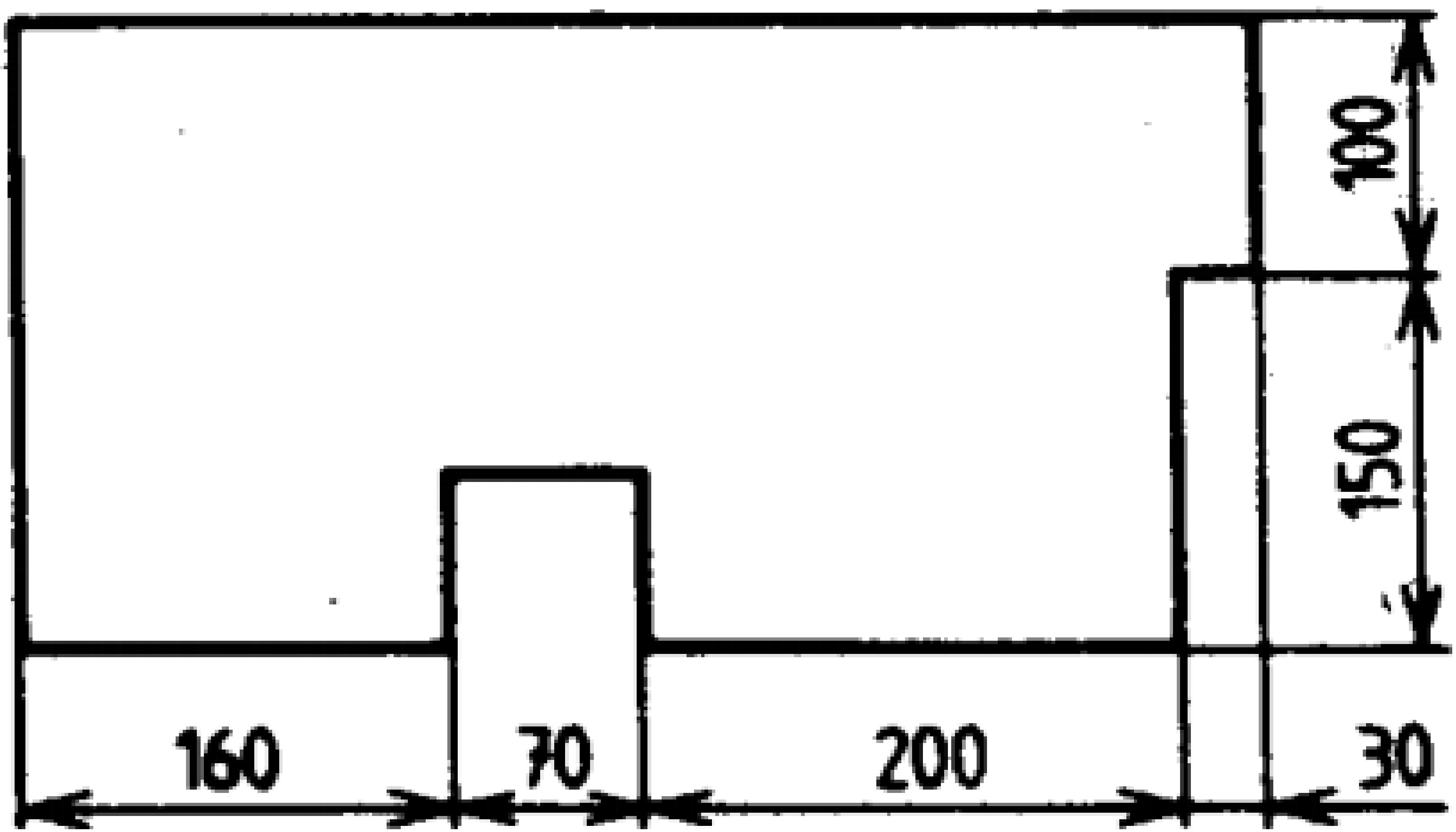
Arrangement of dimensions

1. Chain dimensioning

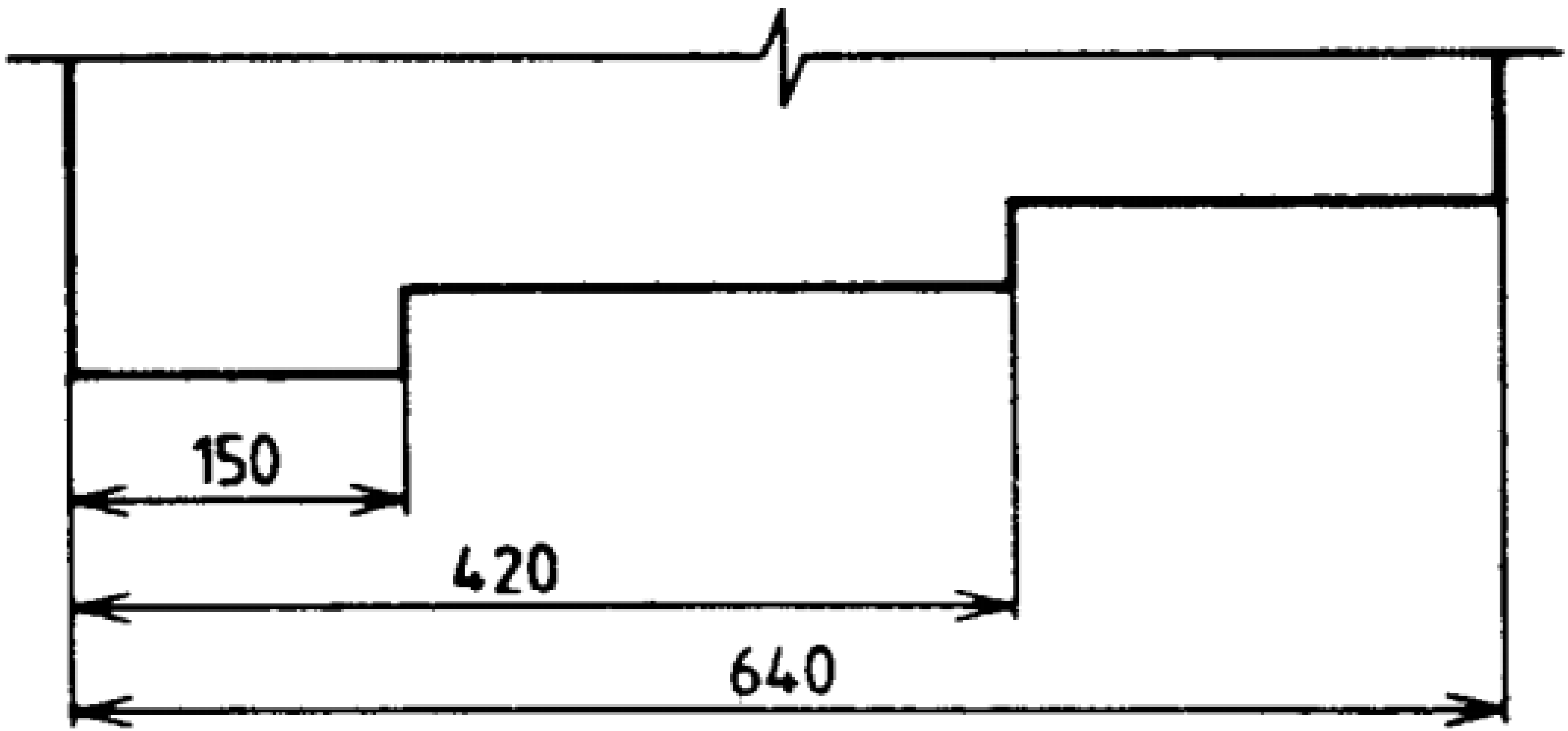
2. Parallel dimensioning

3. Superimposed running dimensioning

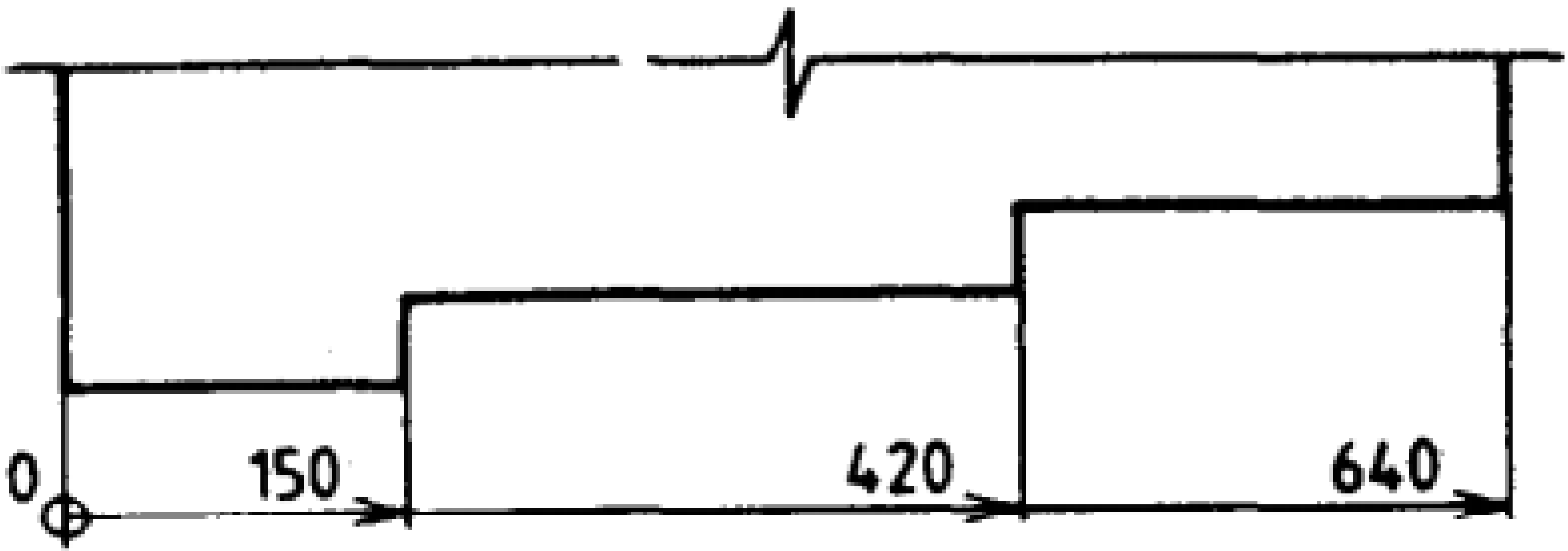
Chain dimensioning

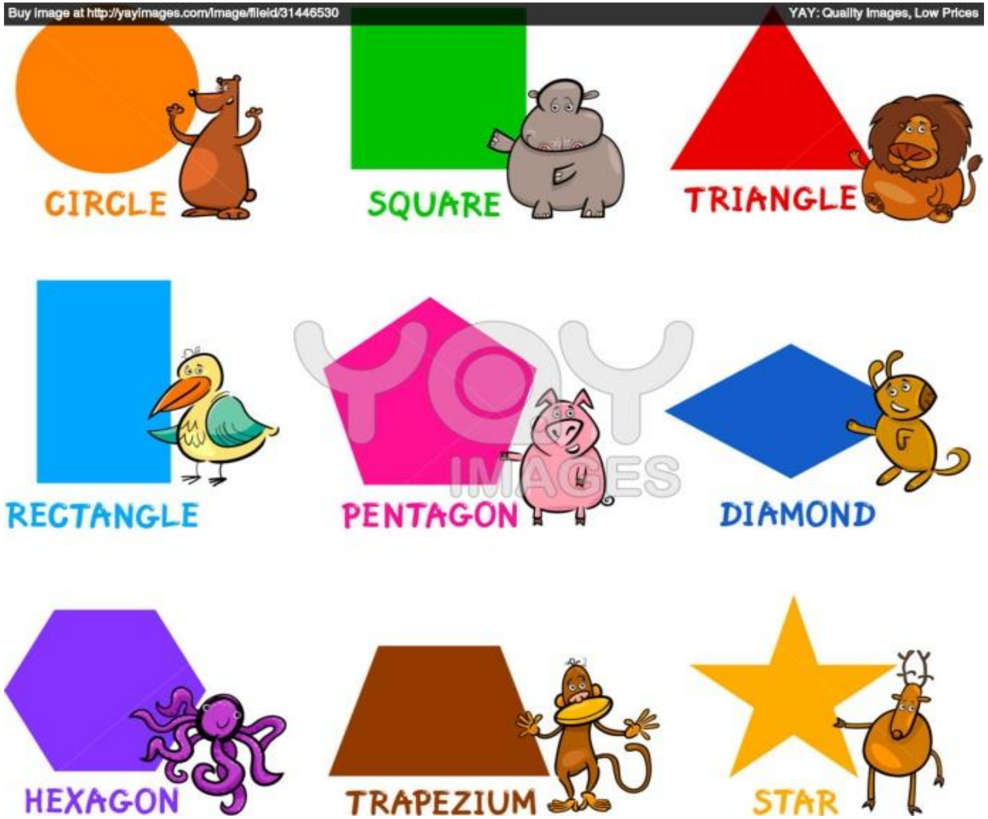


Parallel dimensioning



Superimposed running dimensioning





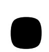
GEOMETRICAL CONSTRUCITON

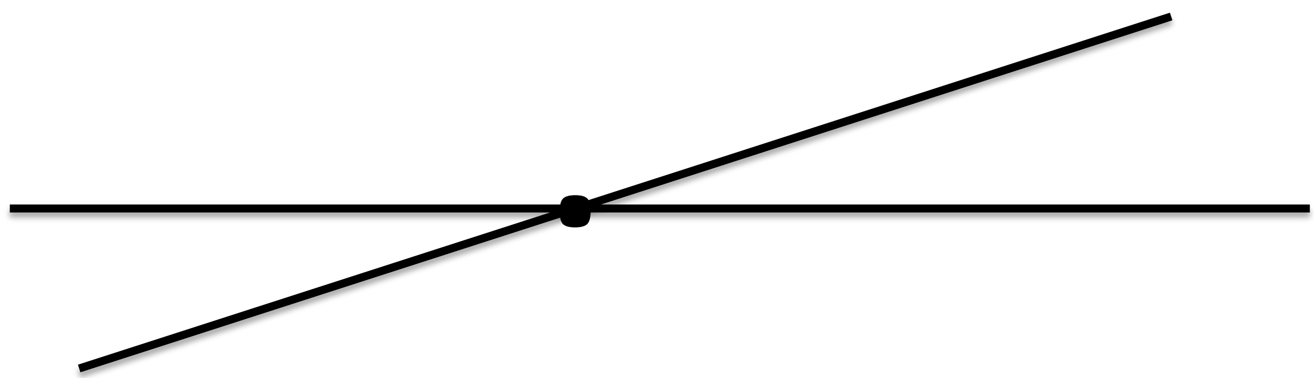
Geometrical Construction

1. Geometrical construction of lines, arcs, circles, polygons and drawing tangents and normal form the basics of Engineering drawing.

Points

1. A point represents a location in space or on a drawing, and has no width, height and depth.
2. A point is represented by the intersection of two lines.





Lines

1. A straight line is the shortest distance between two points and is commonly referred as “Line”.

2. It as length and no width.

Angles

1. An Angle is formed between two intersecting lines.

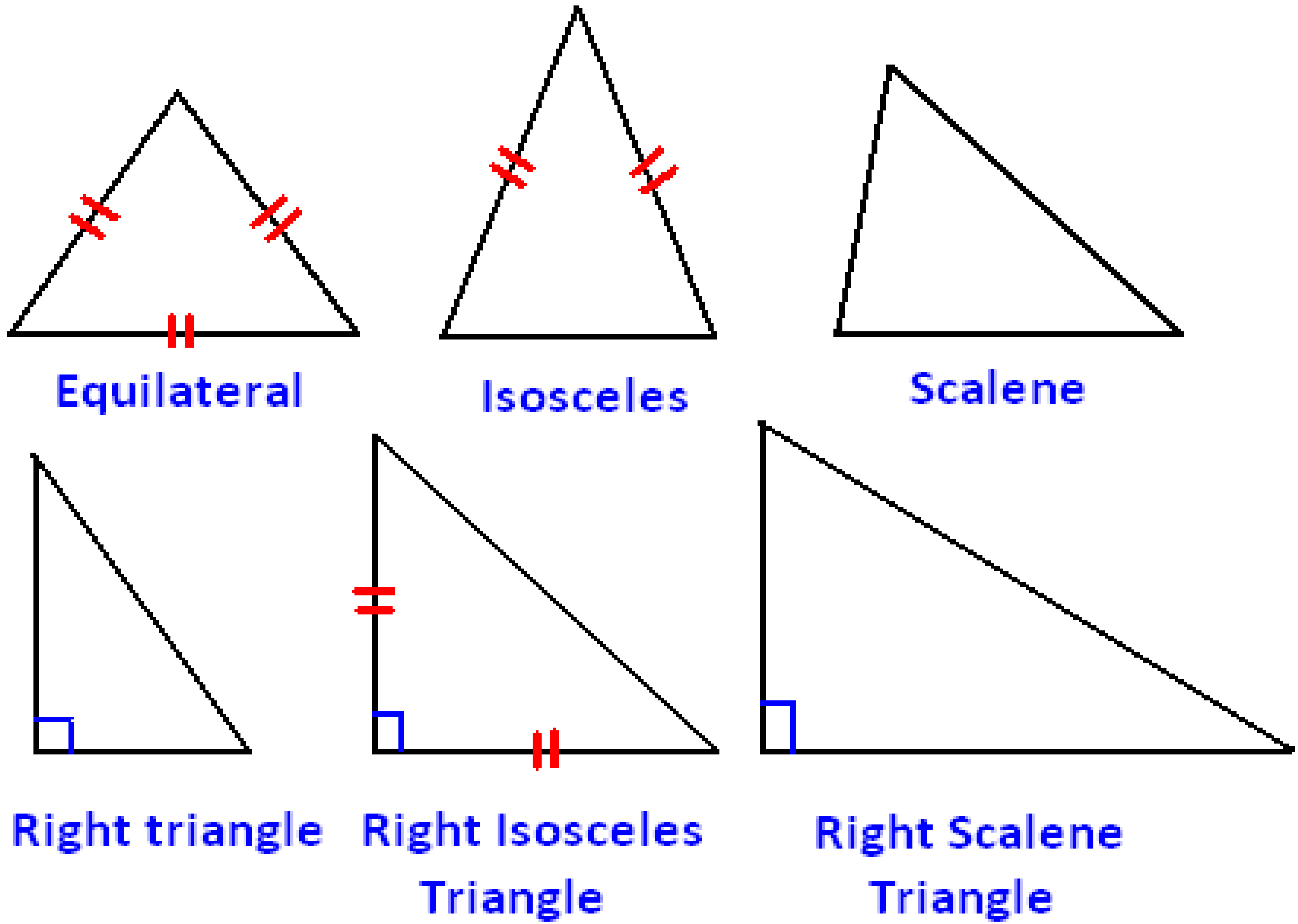
2. A common symbol for angle is $\angle$

Triangles

1. A Triangle is a plane figure bounded by three lines, and the sum of the interior angle is always 180°.

2. A right angle triangle has one 90°angle.

Triangles

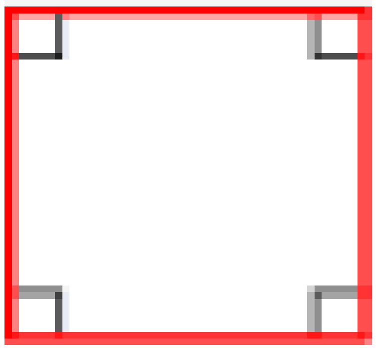

Equilateral
Isosceles
Scalene
Right triangle
Right Isosceles Triangle
Right Scalene Triangle

Quadrilaterals

1. A Quadrilateral is a plane figure bounded by four lines.

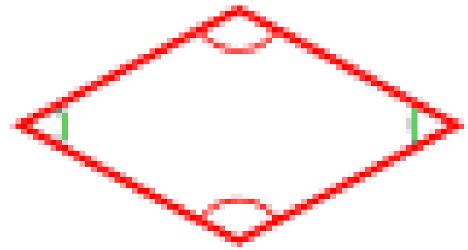
2. In this quadrilaterals if the opposite sides are parallel, the quadrilateral is called parallelogram.

Quadrilaterals

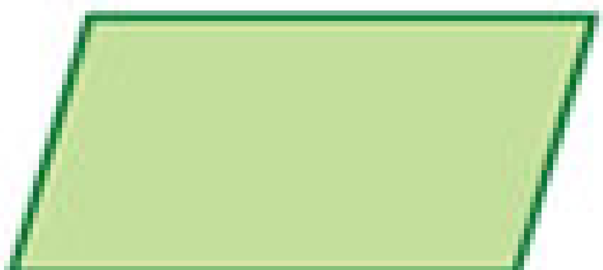


Square

Rectangle

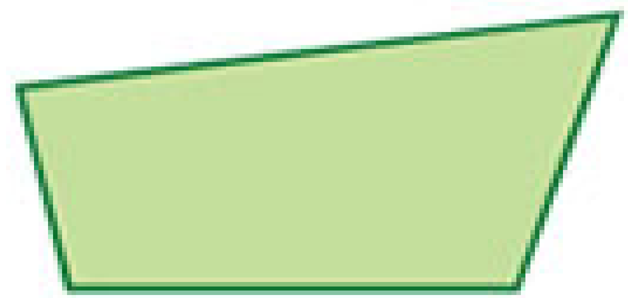


Rhombus



rhomboid

trapezoid



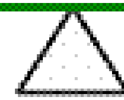
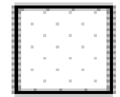
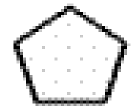
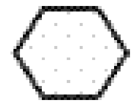
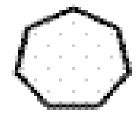
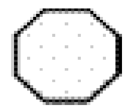
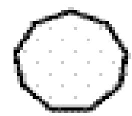
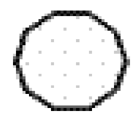
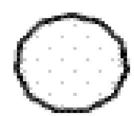
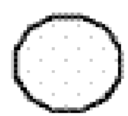
trapezium

Polygons

1. A Polygon is plane figure bounded by number of straight lines.

2. If the polygon has equal angles and equal sides and if it can be inscribed in or circumscribed around a circle, it is called as Regular polygon.

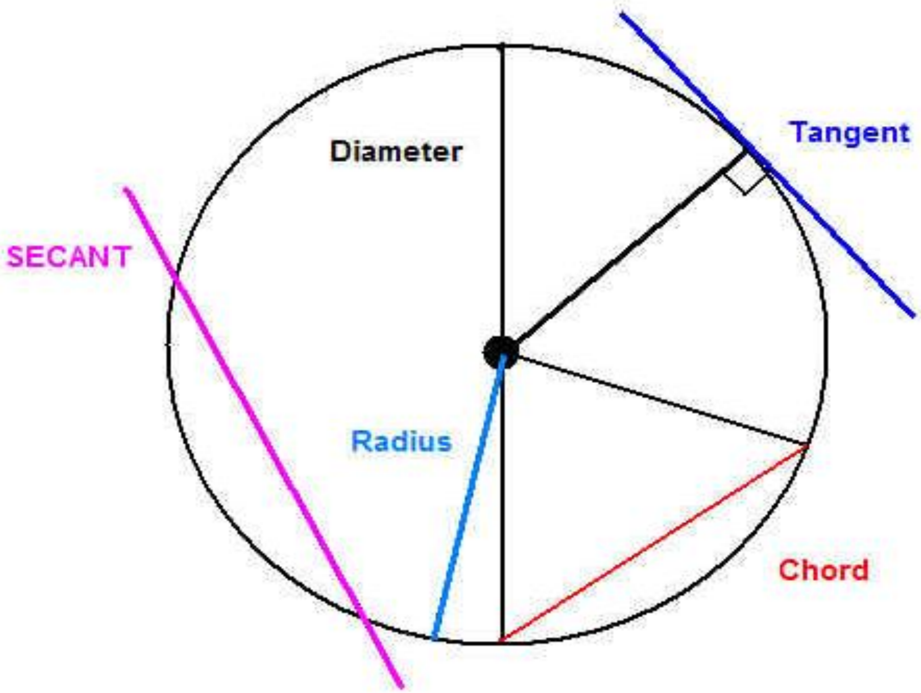
Types of Regular polygons

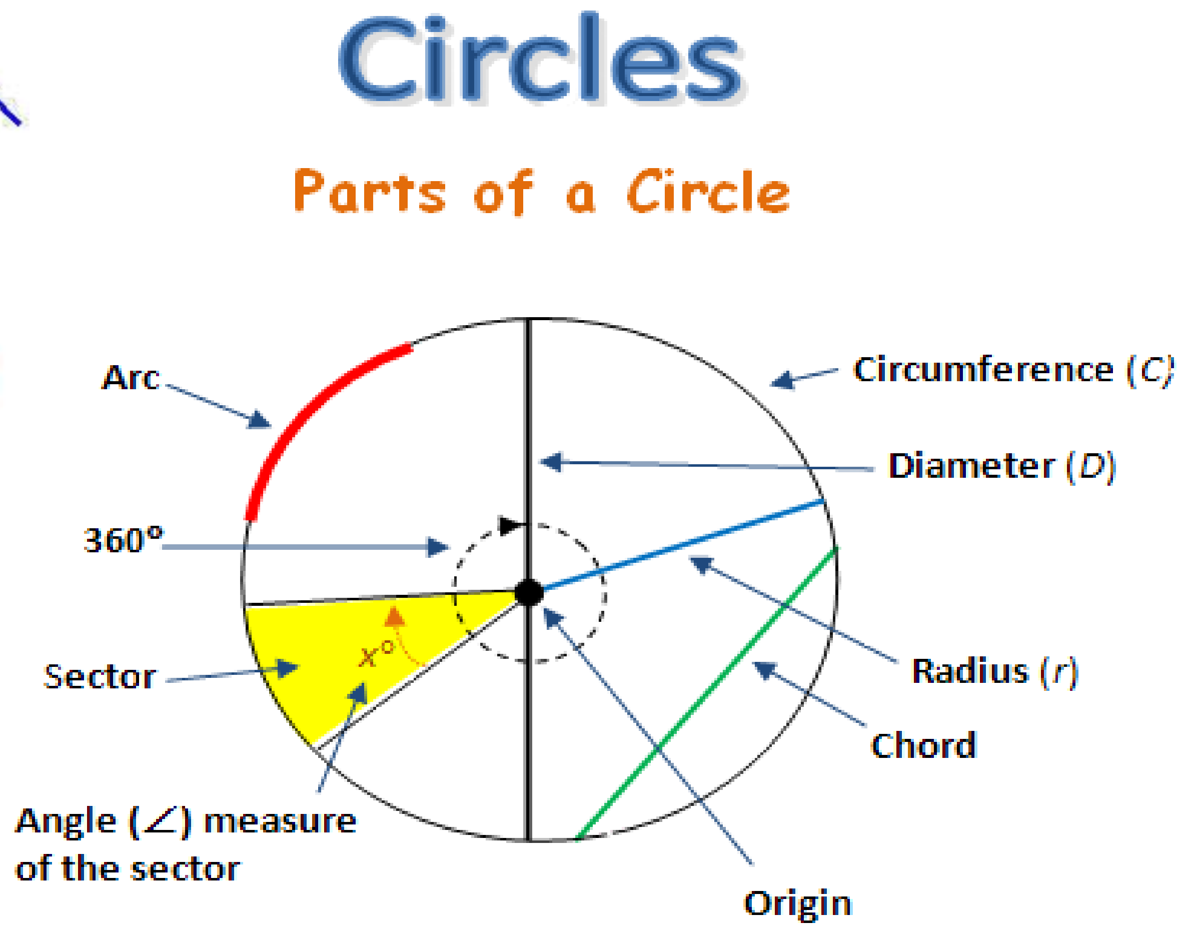
Types	Sides	Shapes
Triangle	3	
Square	4	
Pentagon	5	
Hexagon	6	
Heptagon	7	
Octagon	8	
Nonagon	9	
Decagon	10	
Hendecagon	11	
Dodecagon	12	

Circles and Arcs

1. A Circle is a closed curve and all points of which are at the same distance from a point called the center.
2. Circumference refers to the distance around the circle.
3. If number of circles of circles have a same center, they are called as Concentric circles.

Circles and Arcs

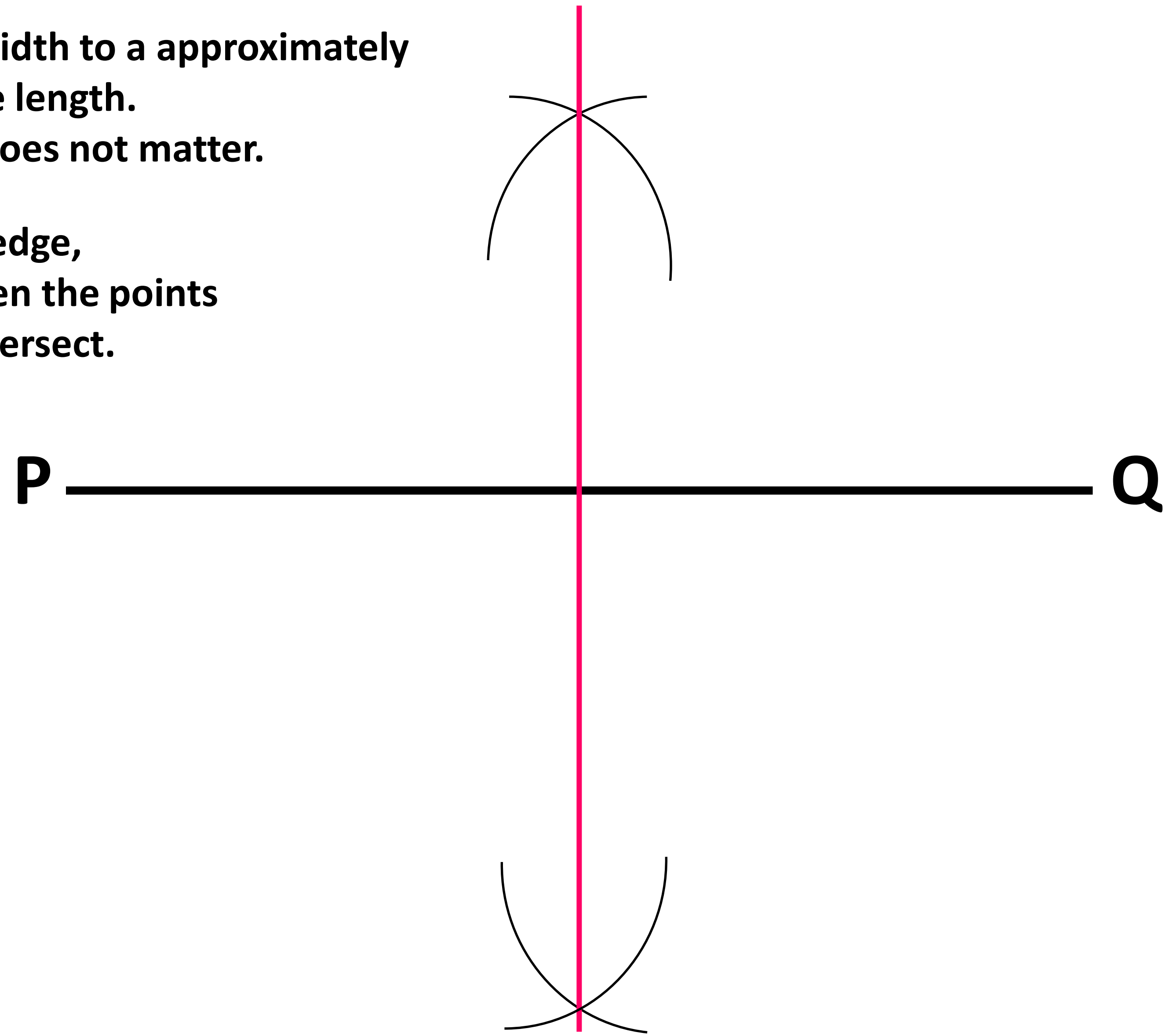




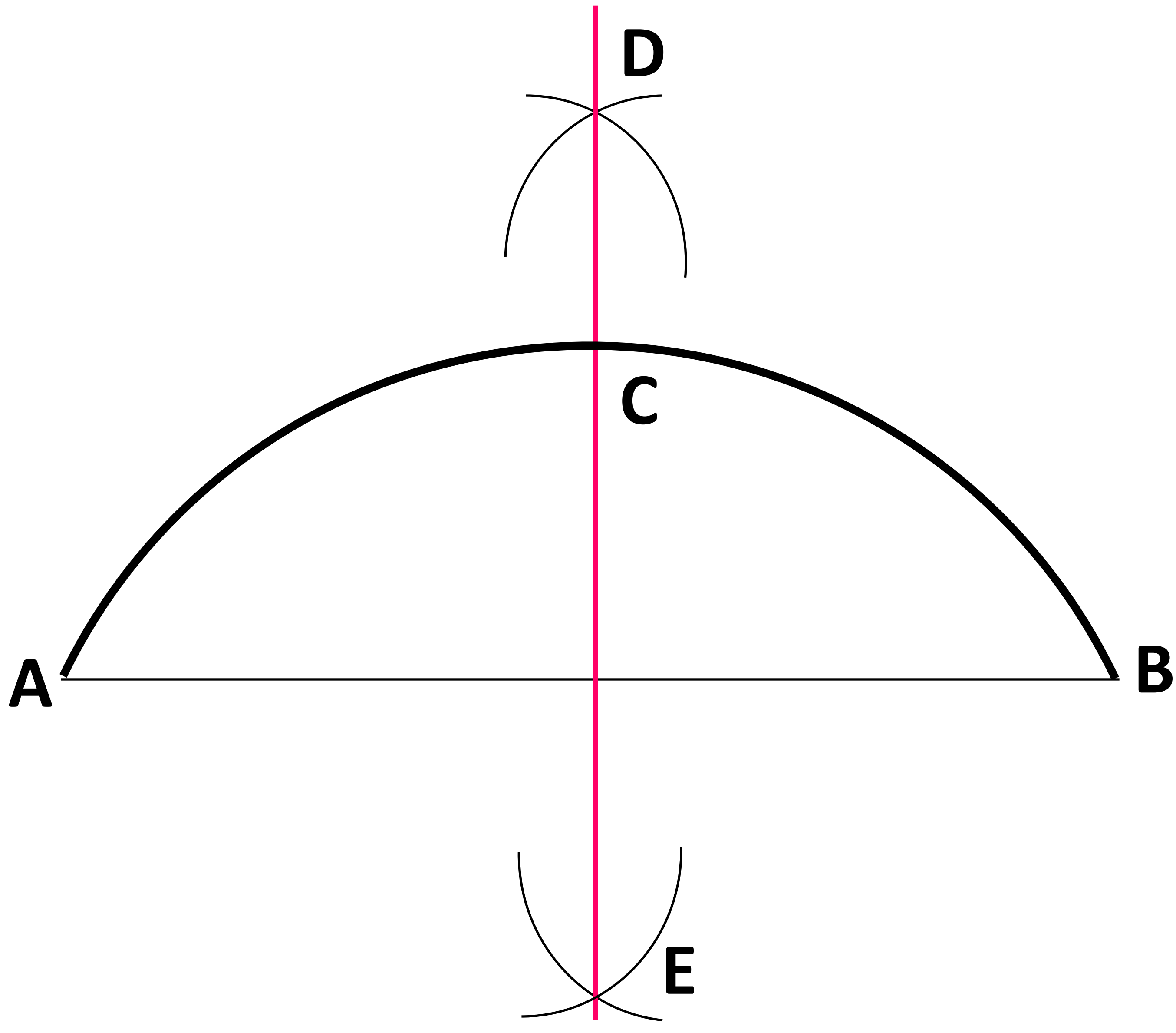
Bisect a line

1.Set a Compass width to a approximately two thirds the line length.
The actual width does not matter.

2.Using a straight edge, draw a line between the points where the arcs intersect.



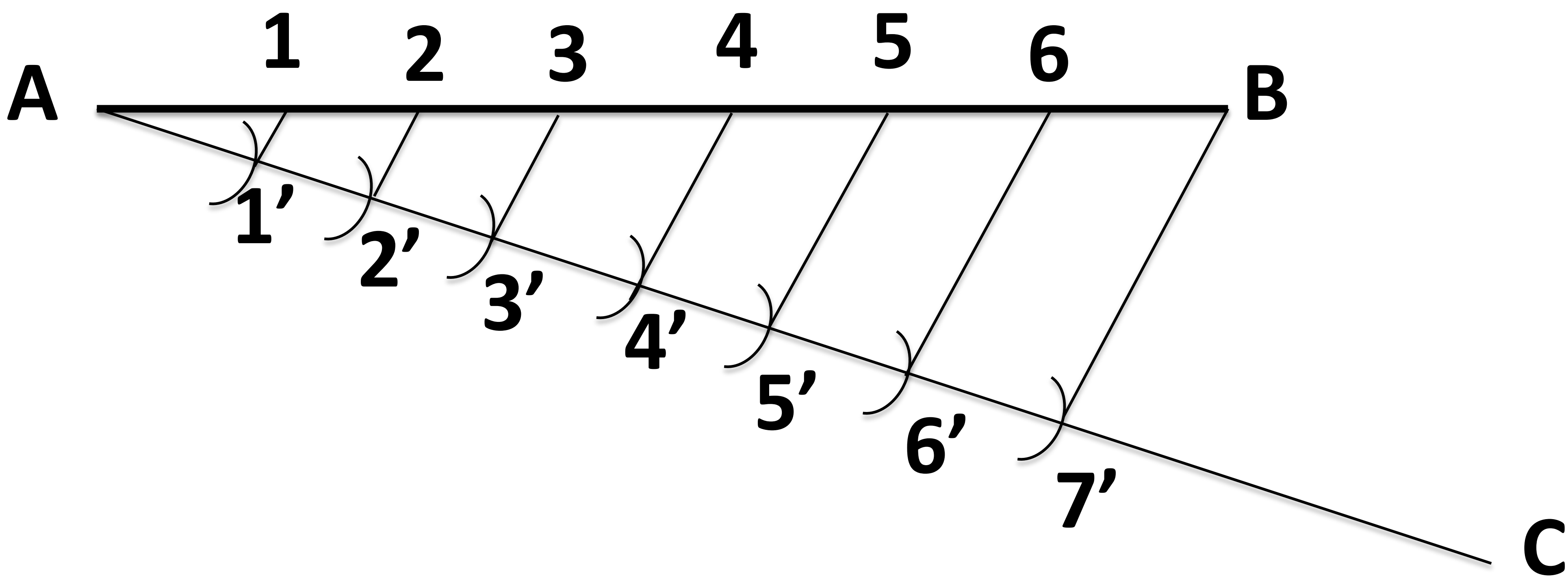
To Bisect a Circular Arc



Divide a Line into number of equal parts

1. Draw a straight line AB.
2. Draw a line AC at any convenient acute angle with AB.
3. Set the divider to a convenient length and mark off seven spaces on AC. Let the points obtained be l’,2’,3’,4’,5’,6’,and7’.
4. Join 7’to the point B.
5. Draw lines through points 1’, 2’, 3’. 4’, 5’ and 6’ parallel to 7’B to meet AB at points 1, 2, 3, 4, 5and 6 respectively. These points divide AB in equal length.

Divide a Line into number of equal parts

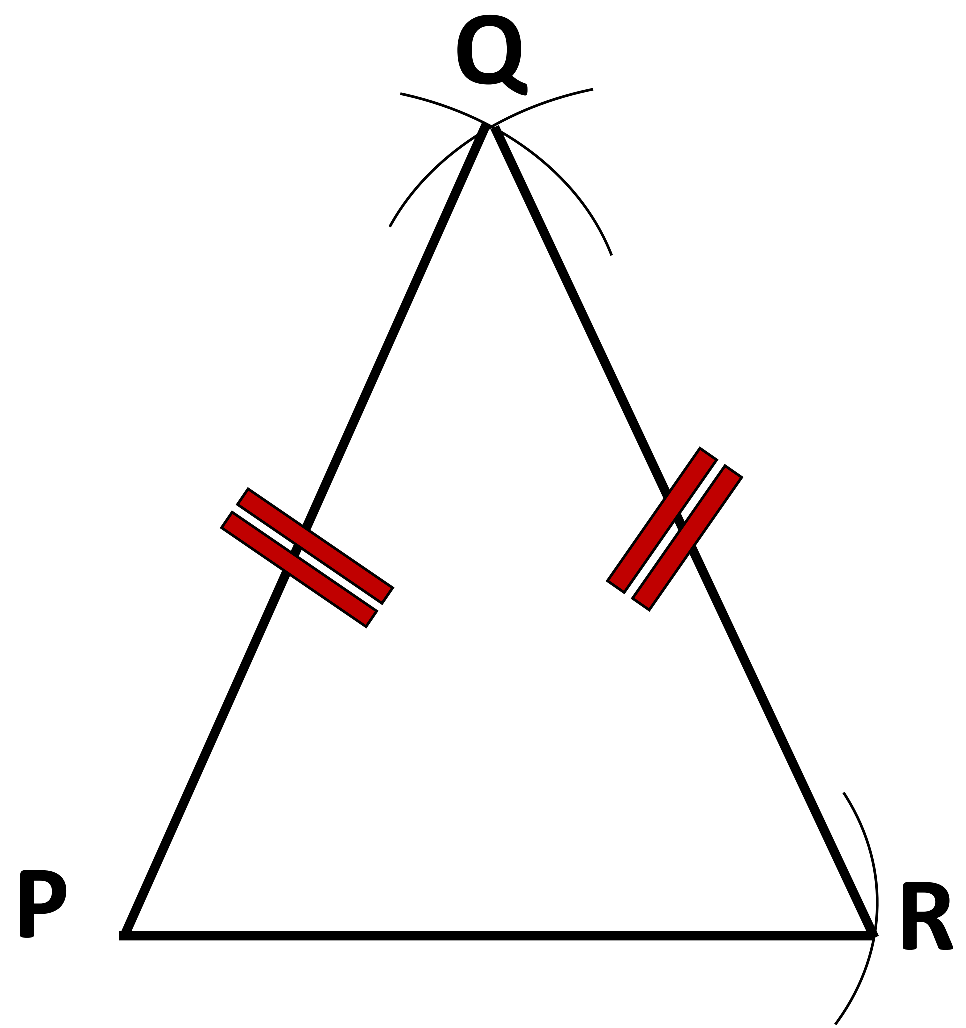


***An acute angle is less than 90°**

To Construct an Isosceles Triangle

1. Mark a point P that will become one vertex of the triangle.
2. Mark a point R on arc. PR will be the base of the triangle.
3. Draw the base PR of the triangle.
4. With Points P and R as centres and radius R, equal to the length of the sides, draw intersecting arcs to locate the vertex (top point) of the triangle.
5. PQR is an isosceles triangle with the desired dimensions.

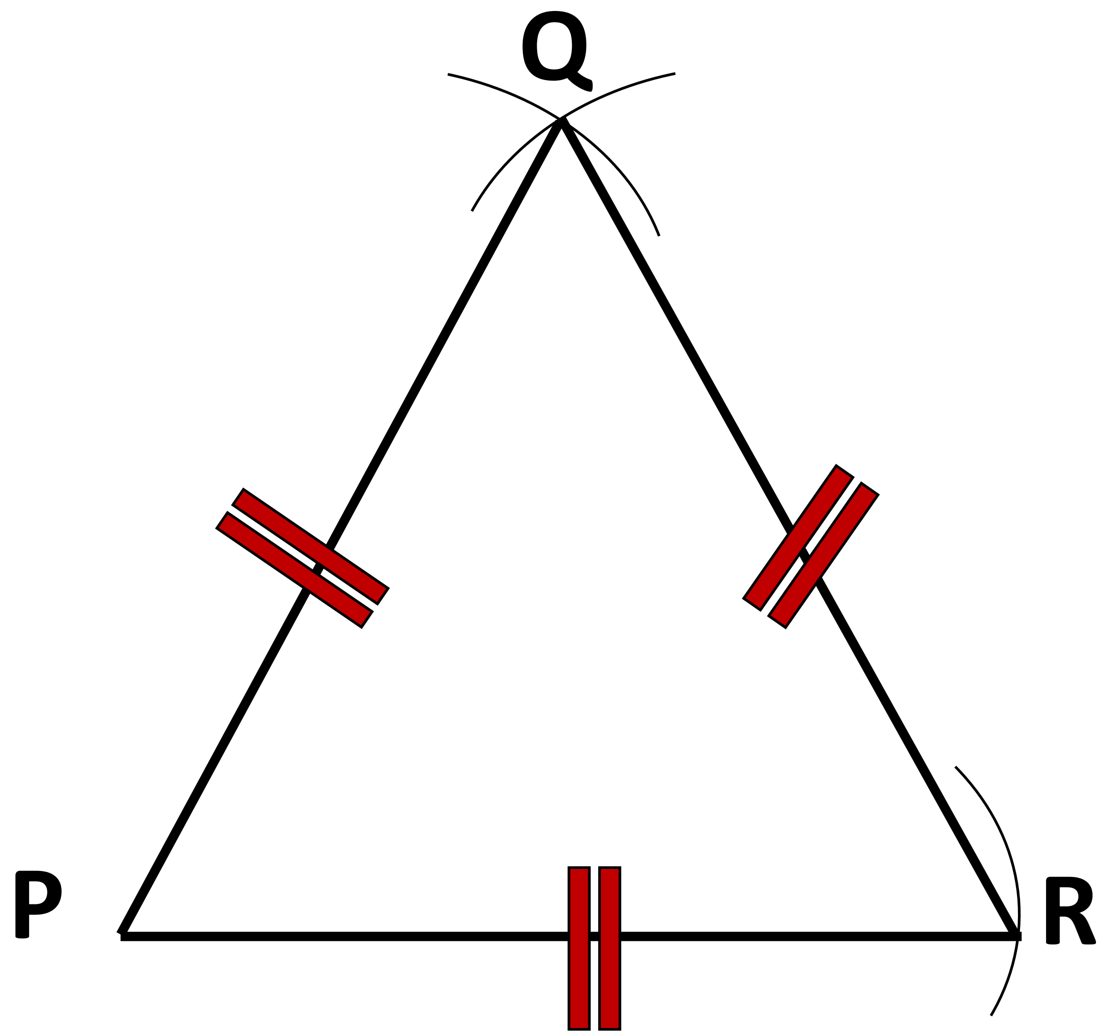
To Construct an Isosceles Triangle



To Construct an Equilateral Triangle

1. Mark a point P that will become one vertex of the triangle.
2. Mark a point Q on either arc to be the next vertex.
3. Without changing the width, move to Q and draw an arc across the other, creating R
4. Draw three lines linking P, Q and R

To Construct an Equilateral Triangle



Construct a regular pentagon

First Method

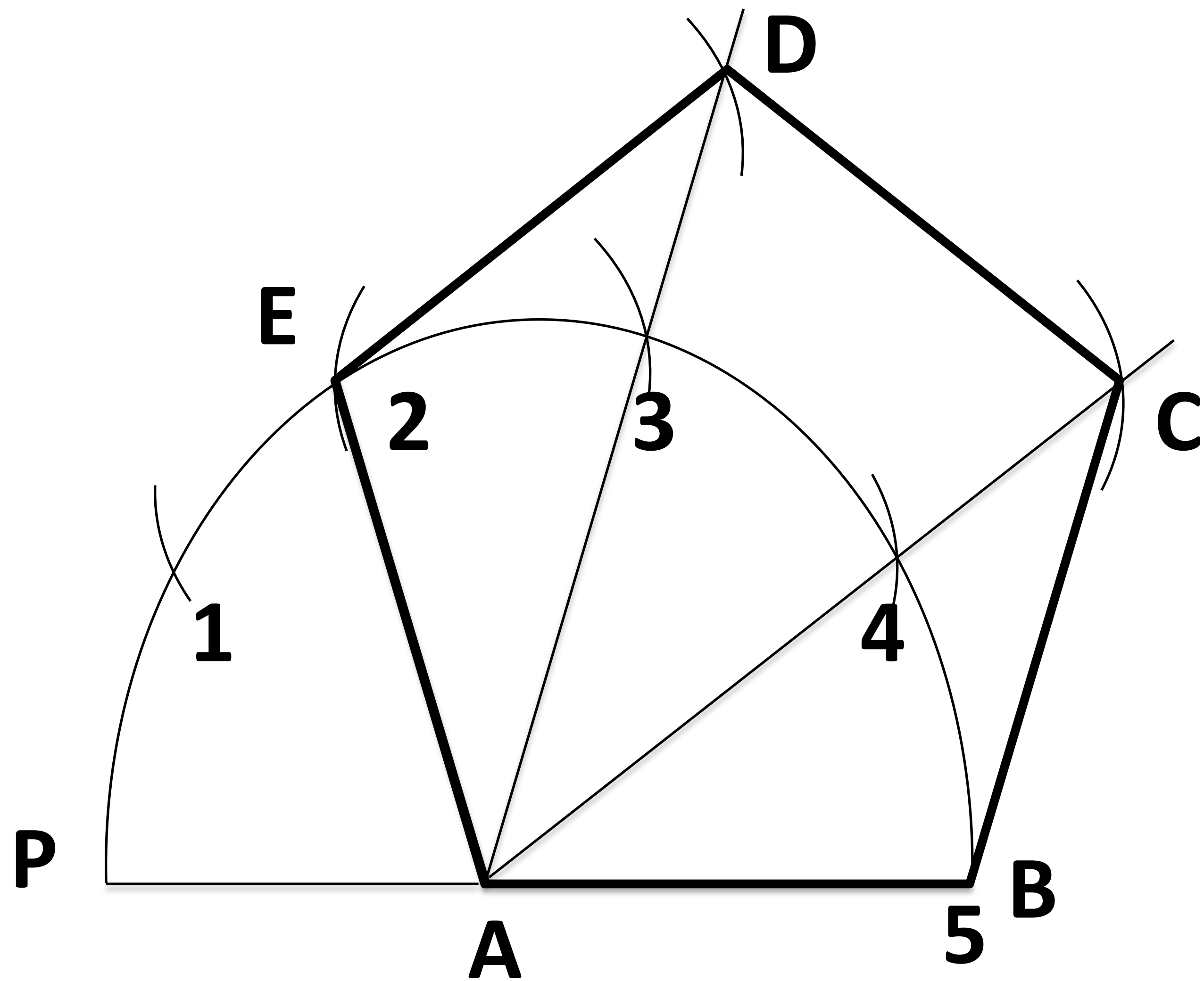
1. Draw a line AB equal to the given length of a side.
2. Draw a line AB equal to the given length of a side. Extend the side BA and mark P such that AP=AB
3. Divide the semi-circle into 5 equal parts (for pentagon) by trial and error method and name the points as 1,2,3,4 and 5 starting form P.

Construct a regular pentagon

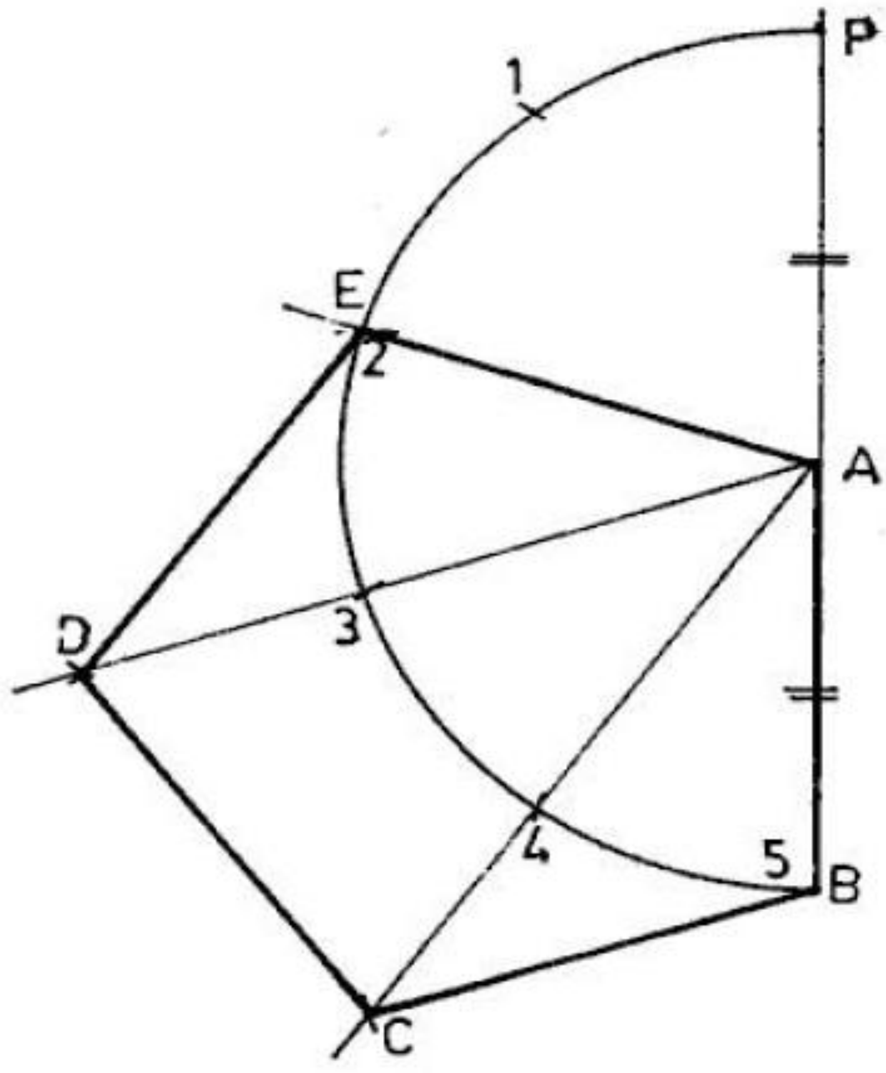
First Method

5. Join A2. Now A2 = AB = AE.
6. Join A3 and A4 and extend them.
7. With AB as radius and B as centre, draw an arc to cut the extension of A4 at C.
8. With E as centre and same radius draw an arc to intersect the extension of A3 at D.
9. Join BC, CD and DE. ABCDE is the required pentagon.

Construct a regular pentagon



Pentagon (vertical)



Construct a regular pentagon

Second Method

1. Draw AB equal to one side of the pentagon.
2. Draw AB equal to one side of the pentagon. Extend the side AB and mark P such that AB = BP.
3. With B as centre and BA as radius draw a semi-circle.
4. Divide the semi-circle into 5 equal parts (for pentagon) by trial and error method and name the points as 1,2,3,4 and 5 starting from P.

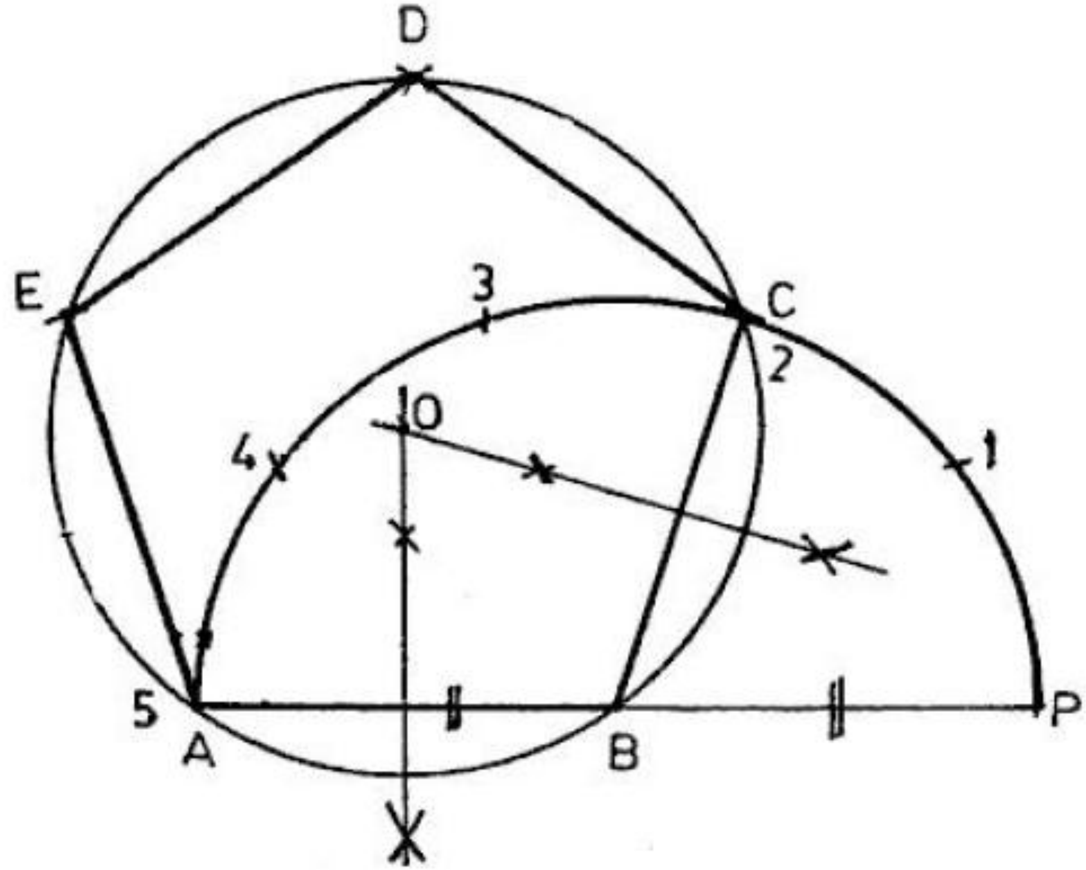
Construct a regular pentagon

Second Method

5. Join B2. Now AB = B2 = BC
6. Draw the perpendicular bisectors of AB and BC to intersect at O.
7. With O as centre and OA = OB = OC as radius draw a circle.
8. With A and C as Centre's and AB as radius, draw arcs to cut the circle at E and D respectively.
9. Join CD, DE and EA. ABCDE is the required pentagon.

Construct a regular pentagon

Second Method



Problem

Problem 1 :

Construct a regular pentagon of 40mm side with side (i) horizontal and (ii) vertical.

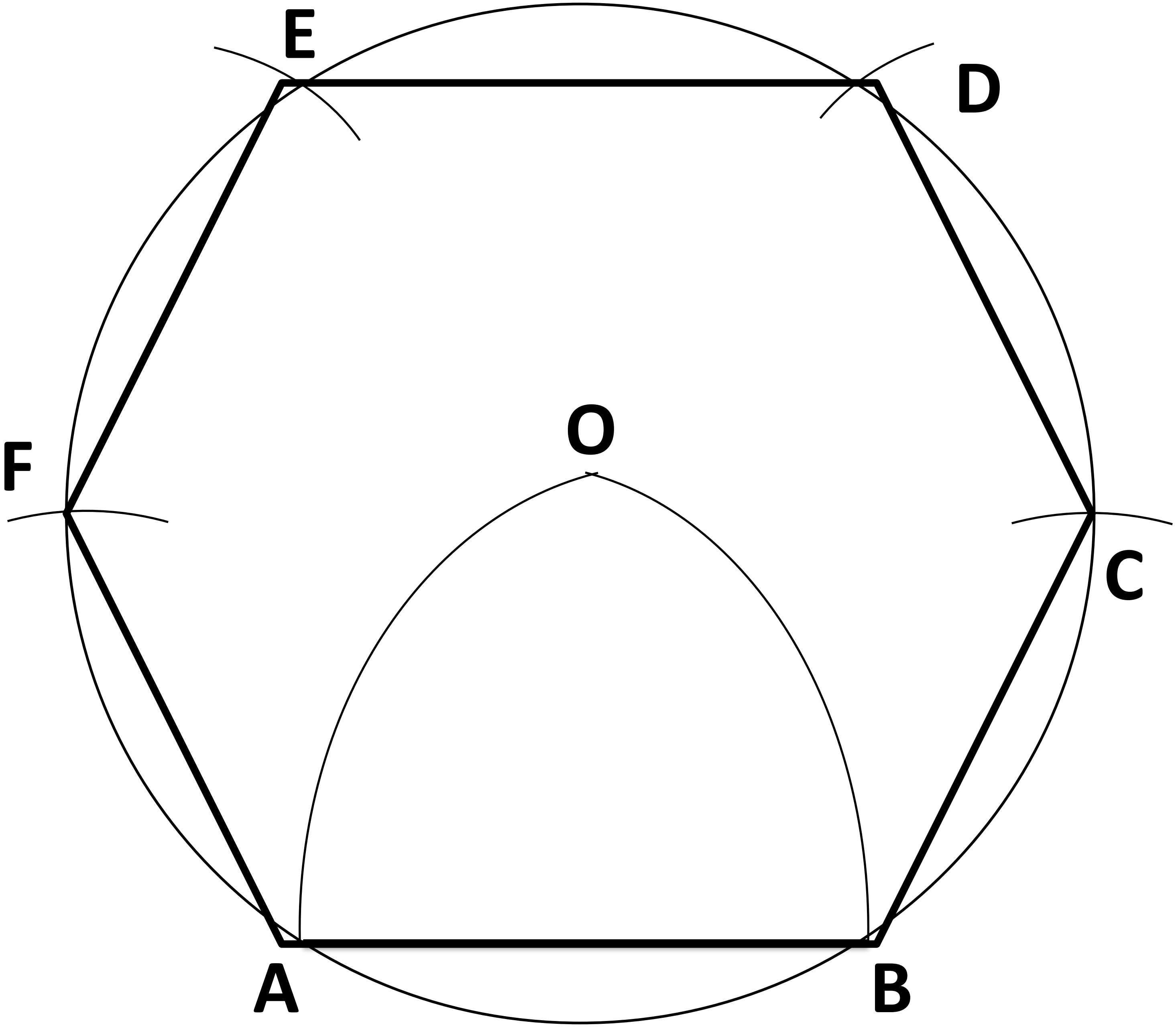
Construct a regular hexagon

1. Let AB be the given side.
2. With A and B centres and AB as radius, draw two arcs to intersect at O.
3. With O as centre and AB as radius describe a circle.
4. With the same radius and A and B as centres, draw arcs to cut the circumference of the circle at F and C respectively.

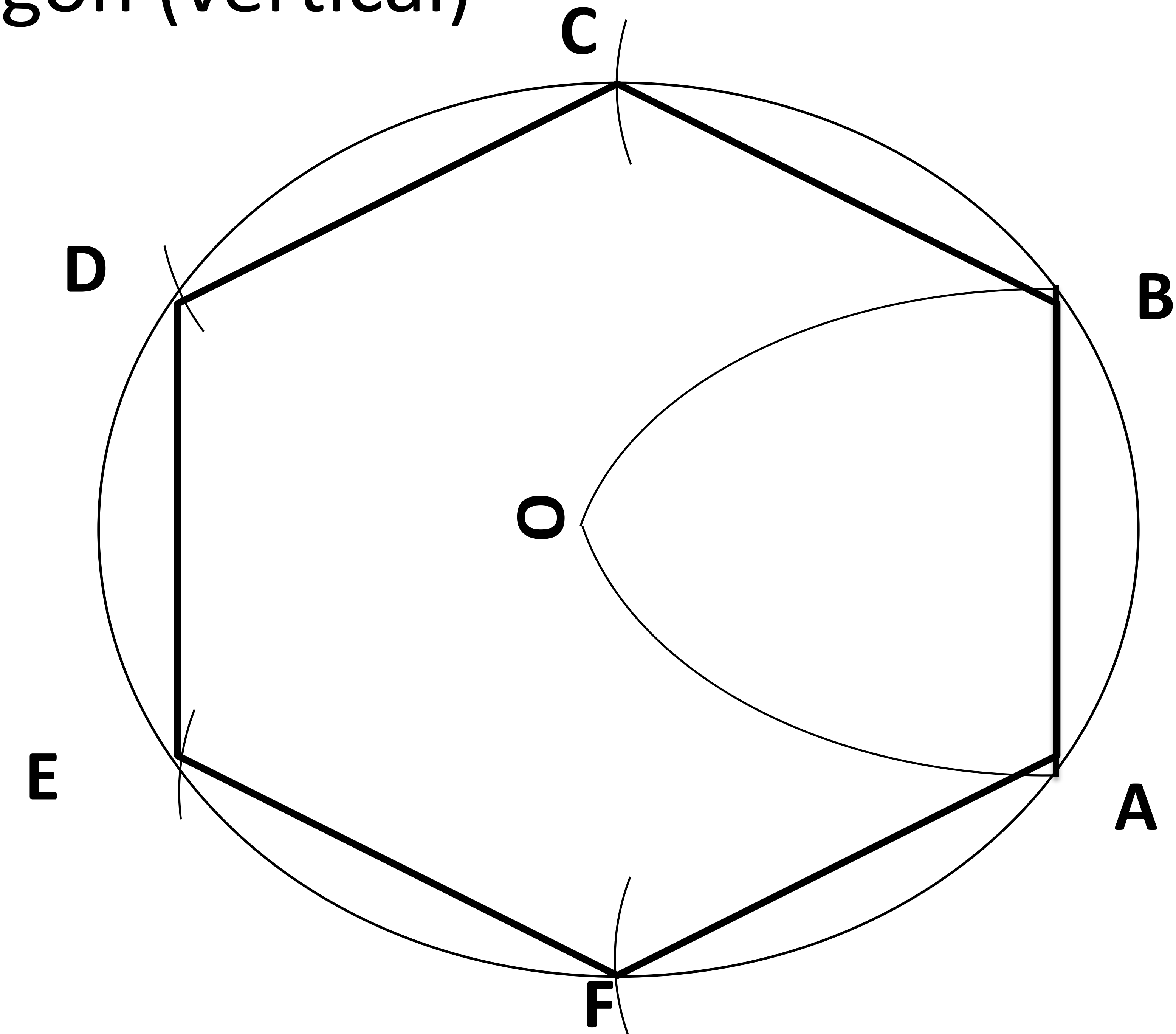
Construct a regular hexagon

5. With the same radius and C and F as centres, draw arcs to cut the circle at D and E respectively. Join BC, CD, DE, EF and FA. ABCDEF is the required hexagon.

Hexagon (horizontal)



Hexagon (vertical)



Problem

1. Construct a regular hexagon of side 35mm when one side is

   (i) horizontal and

   (ii) vertical.

CONIC SECTIONS

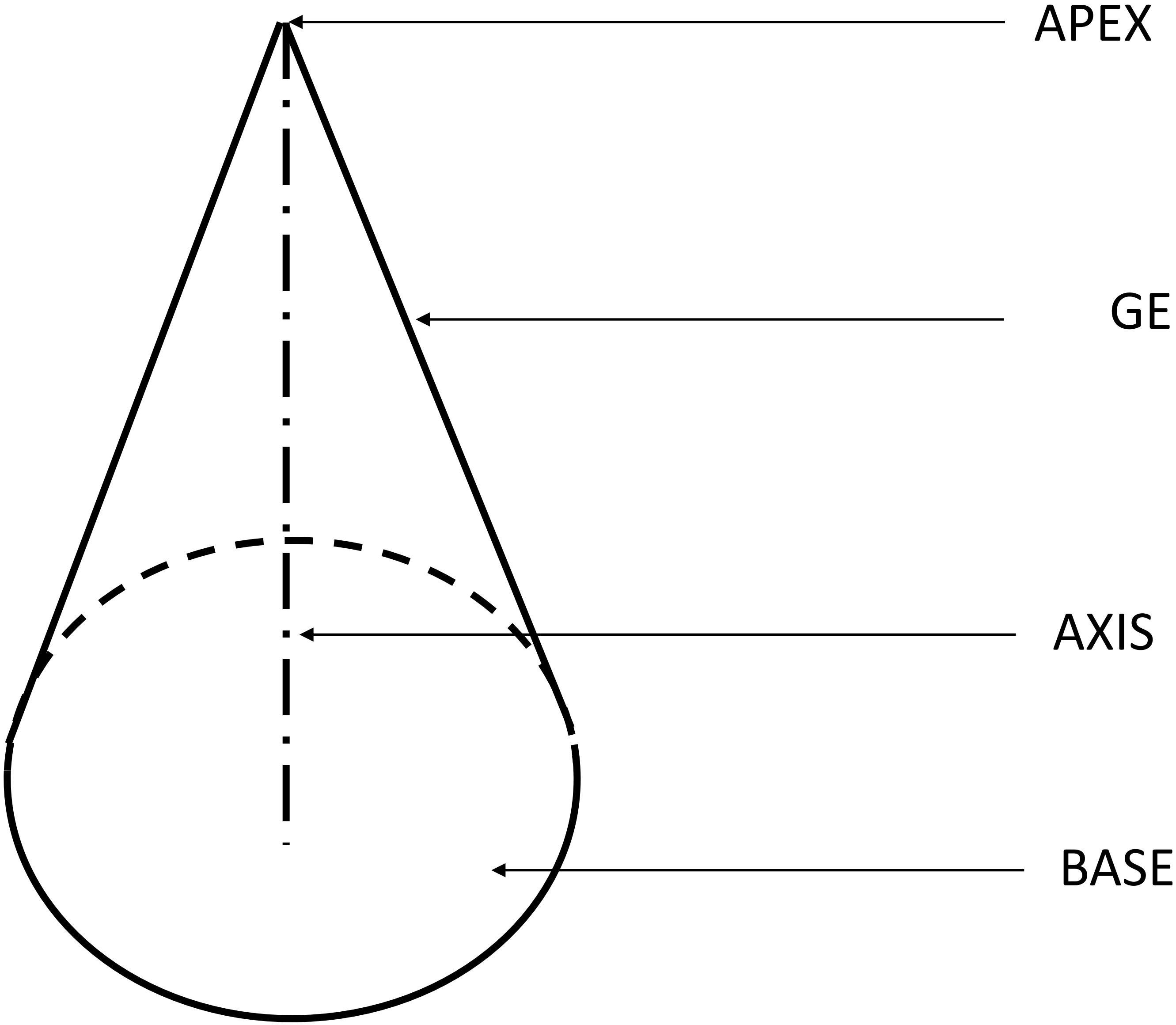
CONIC SECTIONS

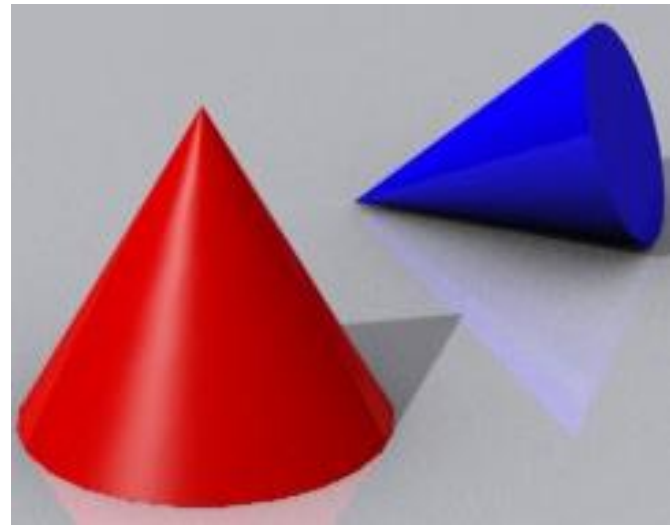
1. The sections obtained by the intersection of a right circular cone by cutting plane in different positions relative to the axis of the cone are called Conics or Conic Sections.

Circular Cone

1. A right circular cone is a cone having its axis perpendicular to its base.
2. The Top point of the cone is called APEX.
3. The imaginary line joining the apex and the centre of the base is called AXIS.
4. The Lines joining the apex to the circumference of the base circle is called GENERATORS.

Right Circular Cone





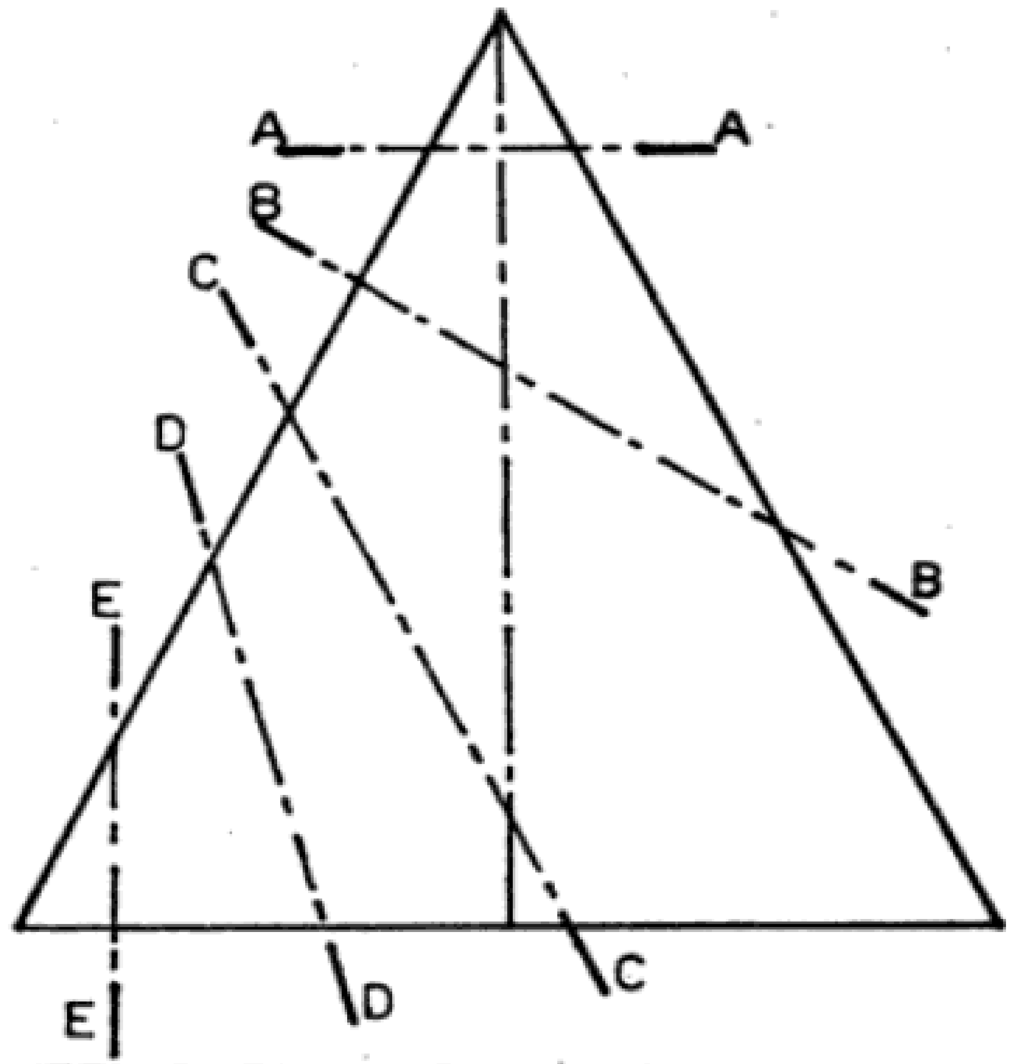
Definitions

1. The conic sections can be defined in TWO WAYS :
   a) By Cutting a right circular cone with a sectional plane.
   b) Mathematically, i.e., with respect to the loci of a point moving in a plane.

Cutting Planes

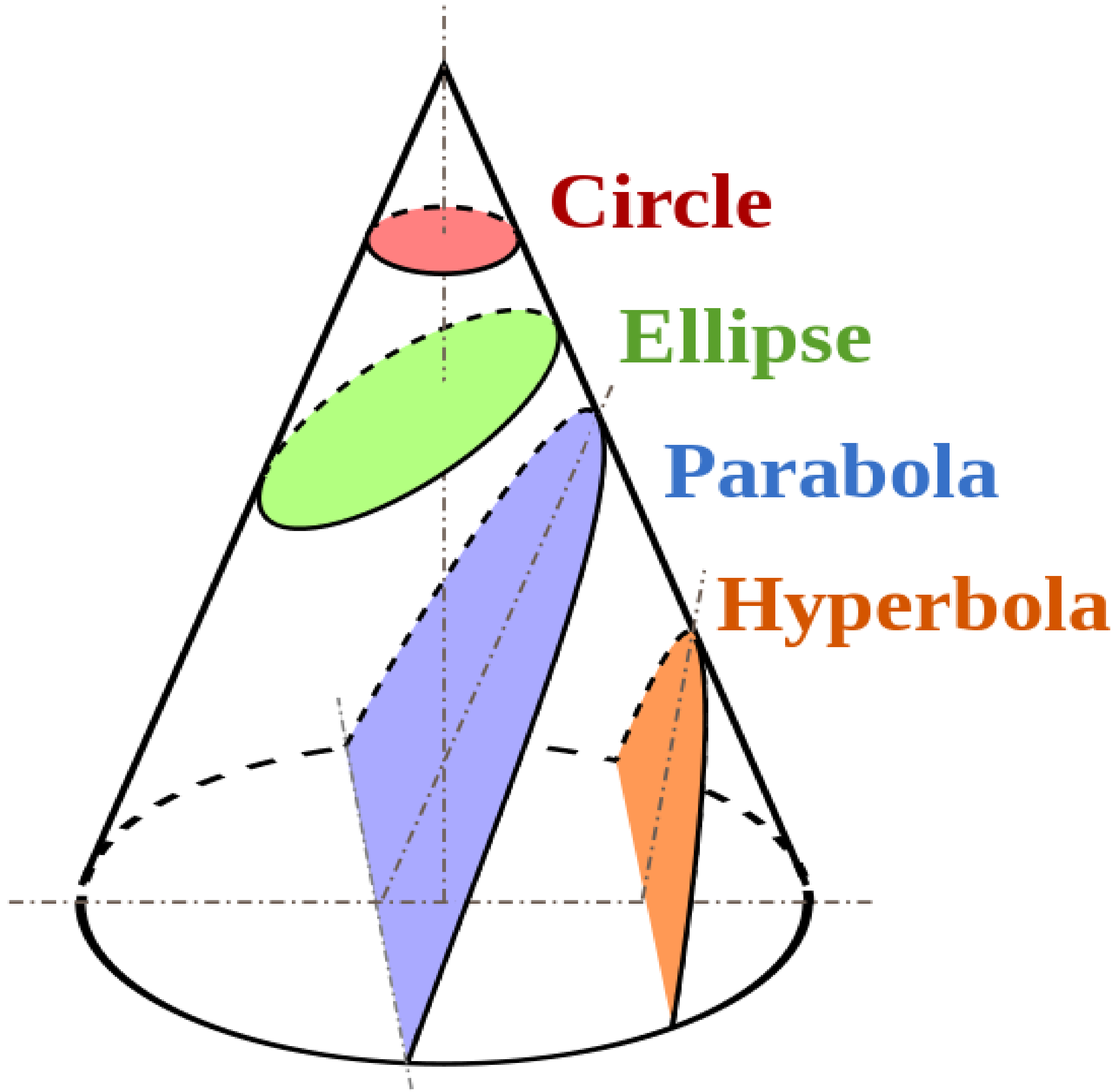
AA	GIVES	CIRCLE
BB	,,	ELLIPSE
CC	,,	PARABOLA
DD	,,	HYPERBOLA
EE	,,	RECTANGULAR-HYPERBOLA

FIG.6.1



(b) CUTTING PLANES AA, BB, -----

Cutting Planes



Definition of Conic sections by Cutting a right circular cone with a sectional plane

1. Circle

When the cutting plane AA is perpendicular to the axis and cuts all the generators, the section obtained is a circle.

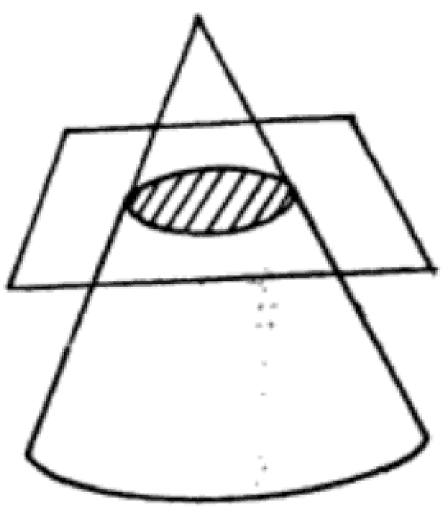


FIG.6.2(a)

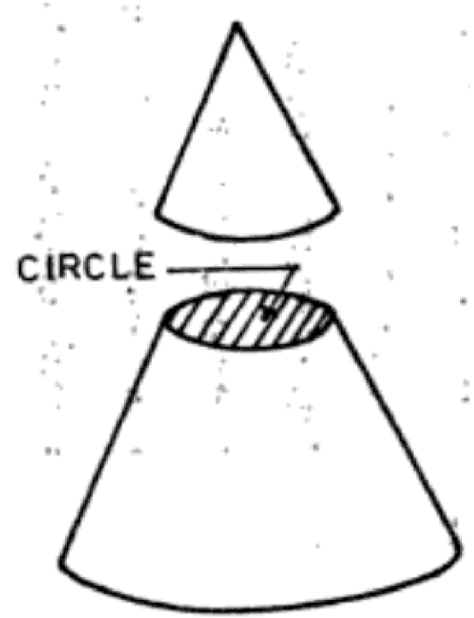
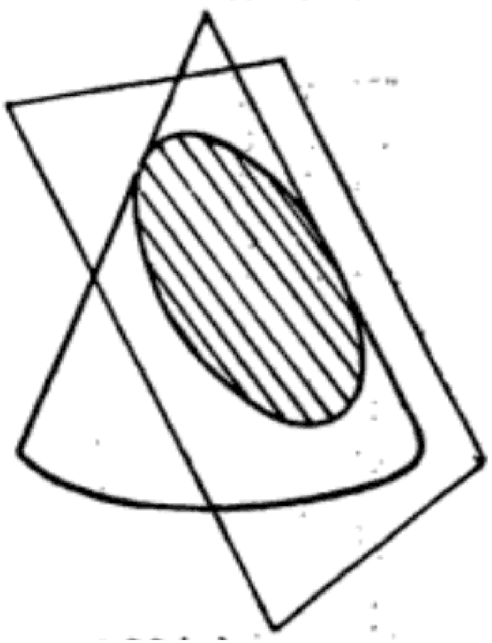


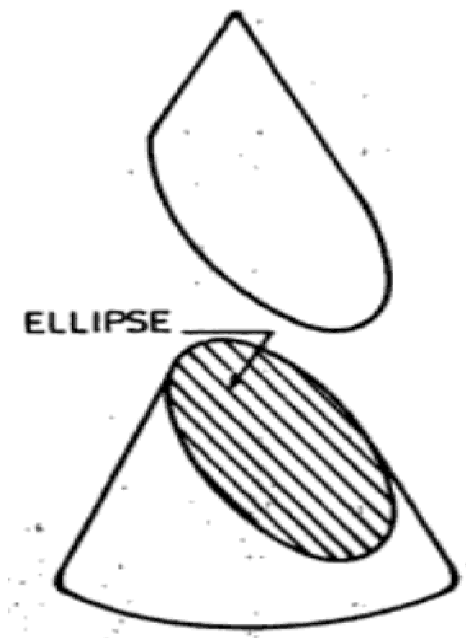
FIG.6.2(b)

Definition of Conic sections by Cutting a right circular cone with a sectional plane

2. Ellipse

When the cutting plane BB is inclined to the axis of the cone and cuts all the generators on one side of the apex, the section obtained is an ellipse.

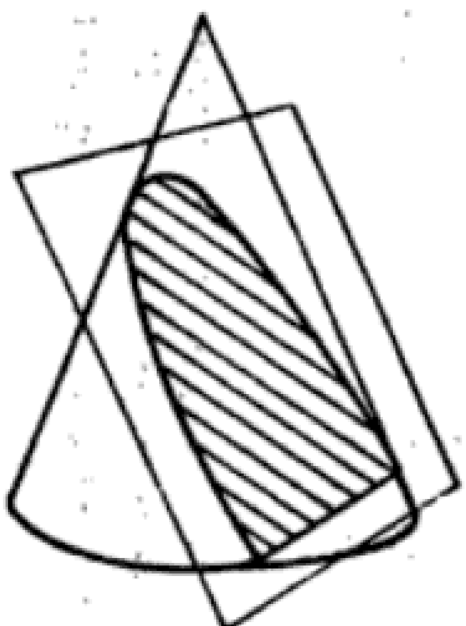


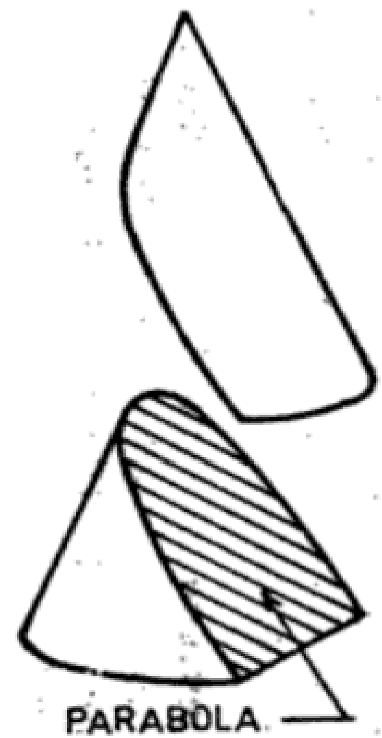


Definition of Conic sections by Cutting a right circular cone with a sectional plane

3. Parabola

When the cutting plane CC is inclined to the axis of the cone and parallel to one of the generators , the section obtained is a parabola.

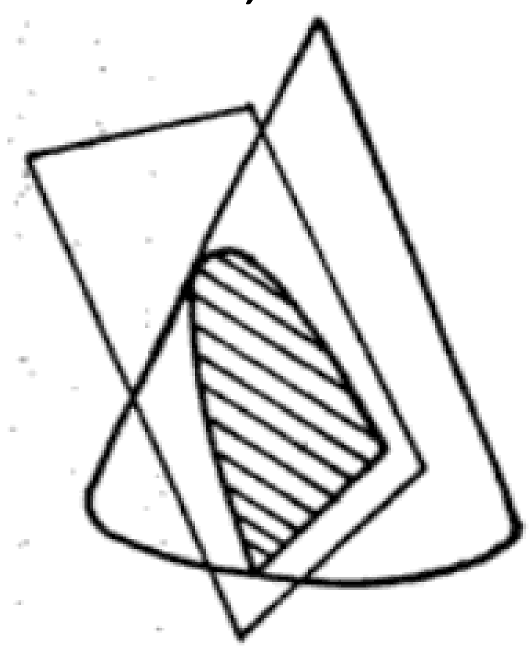


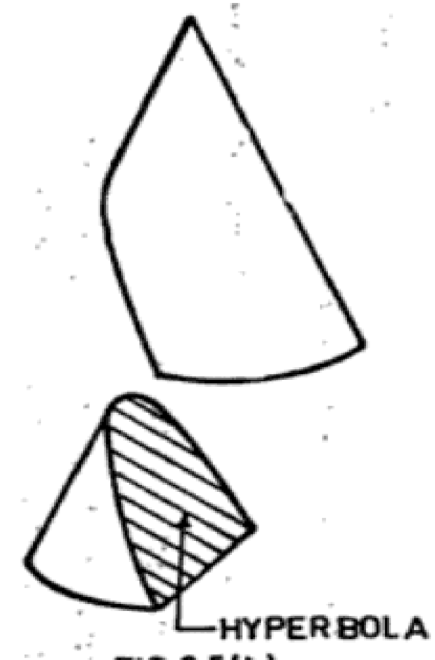


Definition of Conic sections by Cutting a right circular cone with a sectional plane

4. Hyperbola

When the cutting plane DD makes a smaller angle with the axis than that of the angle made by the generator of the cone, the section obtained is a hyperbola.

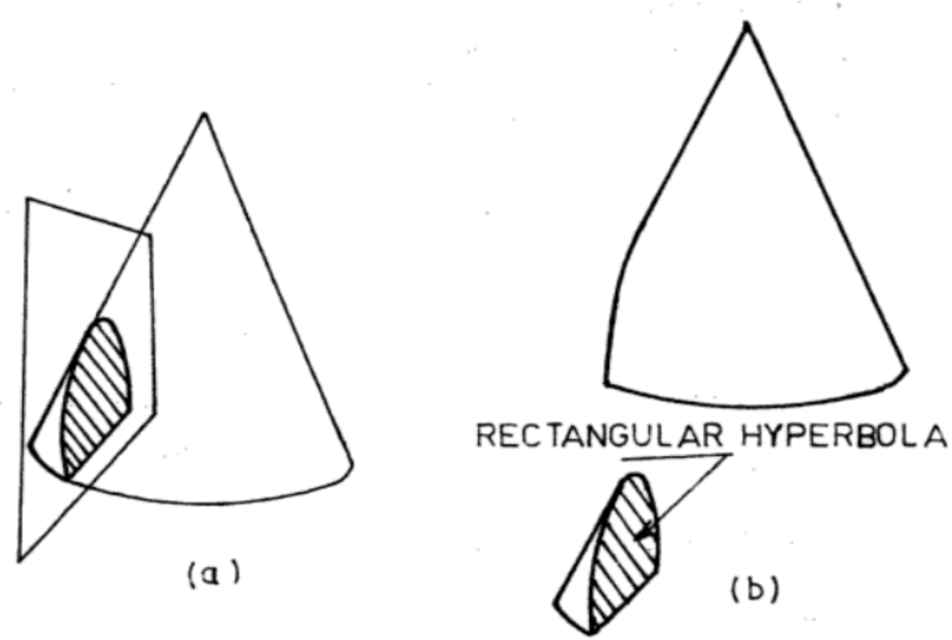




Definition of Conic sections by Cutting a right circular cone with a sectional plane

5. Rectangular Hyperbola or Equilateral Hyperbola

When the cutting plane EE is parallel to the axis of the cone, the section obtained is a RECTANGULAR or EQUILATERAL HYPERBOLA.



Conic sections Defined Mathematically-Conic Terminology

1. 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 fixed point to a fixed straight line is always a constant. This ratio is called eccentricity.

Conic sections Defined Mathematically

2. Ellipse

   Ellipse is the locus of a point moving in a plane in such a way that the ratio of its distance from a point (F) to the fixed straight line (DD) is a constant and is always less than 1.

Conic sections Defined Mathematically

3. Parabola

   Parabola is the locus of a point moving in a plane in such a way that the ratio of its distance from a point (F) to the fixed straight line (DD) is a constant and is always equal to 1.

Conic sections Defined Mathematically

4. Hyperbola

   Hyperbola is the locus of a point moving in a plane in such a way that the ratio of its distance from a point (F) to the fixed straight line (DD) is a constant and is greater than 1.

5. Focus

   The fixed point is called the focus (F).

6. Directrix

   The fixed line is called the directrix (DD).

Conic sections Defined Mathematically

7. Eccentricity (e)

It is the ratio =

$$\frac{\text{distance of the moving point from the focus}}{\text{Distance of the moving point from the directrix}}$$

Conic sections Defined Mathematically

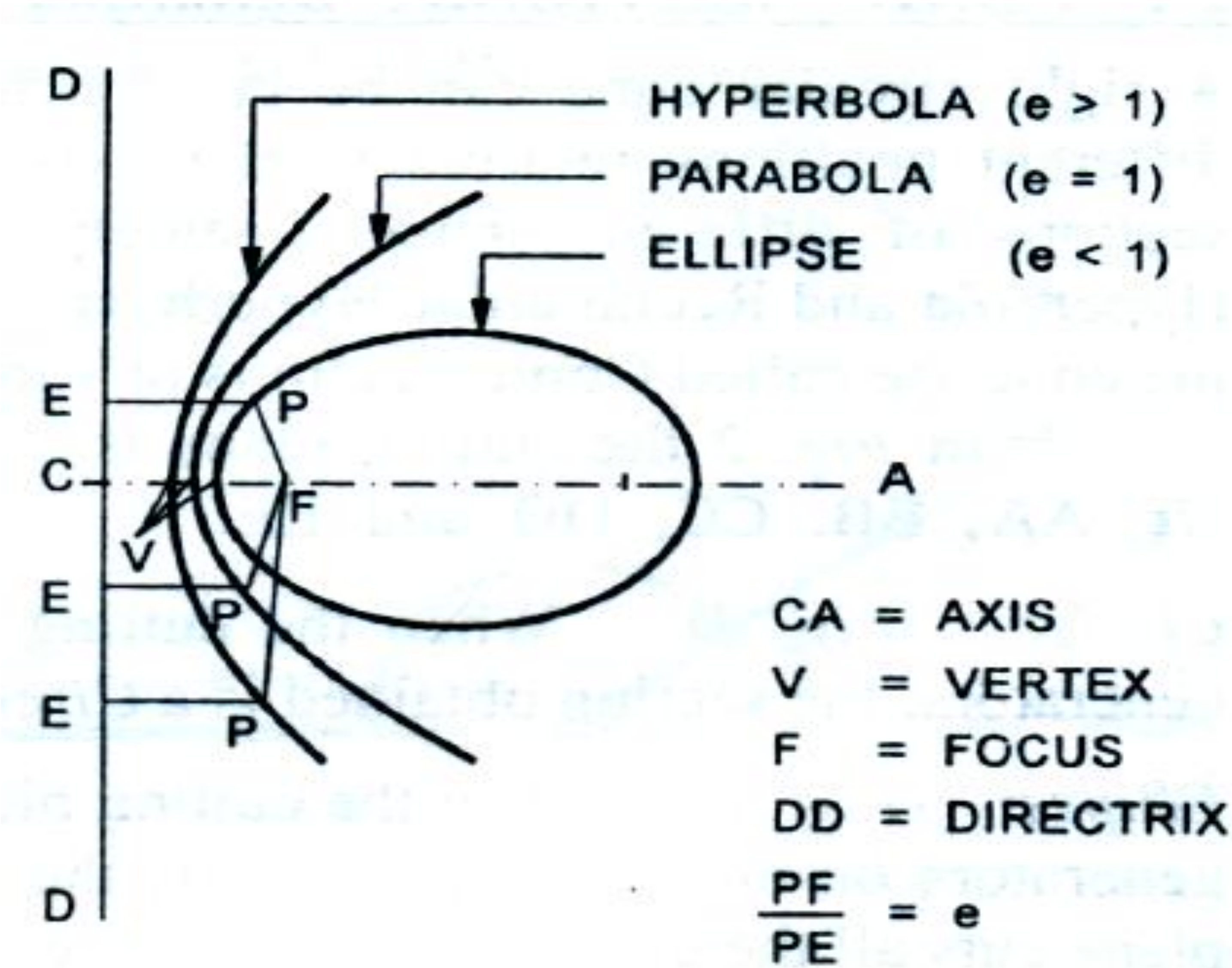
8. Axis (CA)

   The line passing through the focus and perpendicular to the directrix is called axis.

9. Vertex (V)

   It is a point at which the conic cuts its axis.

Conic sections Defined Mathematically



Ellipse

Methods of Construction

1. Eccentricity method

2. Pin and String method

3. Trammel method

4. Intersecting arc or Arc of Circles or Foci method

Ellipse

Methods of Construction

5. Concentric Circles method

6. Rectangle or Oblong method

7. Parallelogram method

8. Circle method (using conjugate diameters)

9. Four centers (approximate) method

Problem 1

a)Construct an ellipse when the distance between the focus and the directrix is 50mm and the eccentricity is 2/3.

(b) Draw the tangent and normal at any point P on the curve using directrix.

Solution

1. Draw a vertical line DD’ to represent the directrix. At any point A on it draw a line perpendicular to the directrix to represent the axis.

2. The distance between the focus and the directrix is 50 mm. So mark F1, the focus such AF1 = 50 mm.

3. Eccentricity = 2/3 i.e., 2 + 3 = 5. Divide AF1 into 5 equal parts using geometrical construction and locate the vertex V1 on the third division from A. Now V1F1/V1A = 2/3.

Solution

4. Draw a perpendicular line at V1. Now draw 45° inclined line at F1 to cut the perpendicular line drawn at V1. Mark the cutting point as S. Or V1 as centre and V1F1 as radius cut the perpendicular line at S.

5. Join A and S and extend the line to Y.

   From F1 draw a 45° line to intersect the line AY at T. From T erect vertical to intersect AA' at V2, the another vertex. V1V2 = Major axis.

Solution

6. Along the major axis, mark points 1, 2... 10 at approximately equal intervals. Through these points erect verticals to intersect the line AY (produced if necessary) at 1', 2',...10'.

7. With 11' as radius and F1 as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 1 at P1 and Q1.

8. With 22' as radius and F1 as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 2 at P2 and Q2.

Solution

9. Repeat the above the obtain P3 and Q3…P10 and Q10 corresponding to 2,3, ... 10 respectively and draw a smooth ellipse passing through V1, P1.... P10, V2, Q10,… Q1,…V1…

10. To mark another focus F2 : Mark F2 on the axis such that V2F2 = V1F1.

11. To mark another Directrix D1D1’ : Mark A' along the axis such that A'V2 = AV1. Through A' draw a vertical line D1D1’.

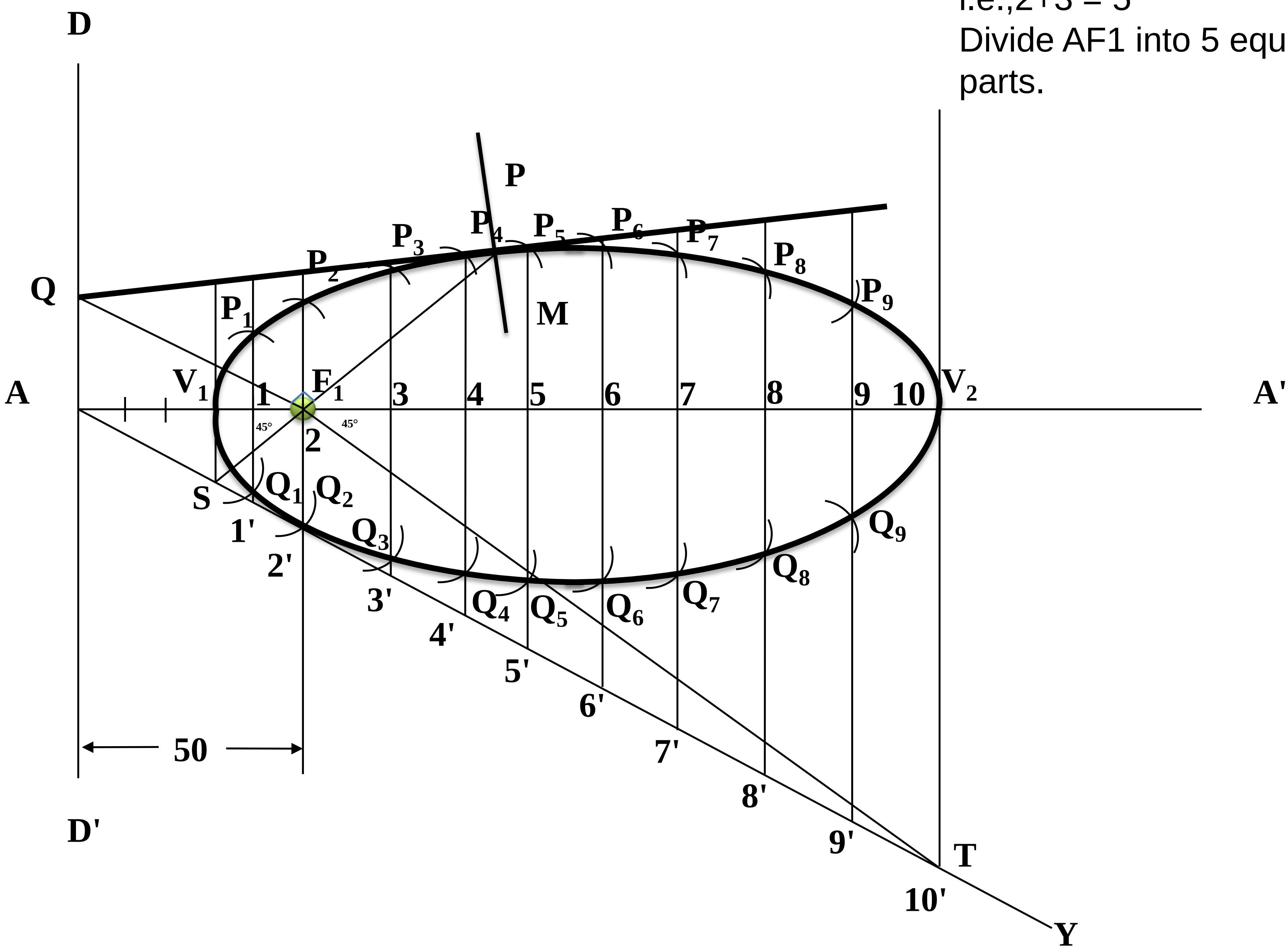
Solution

Draw the tangent and normal at any point P on the curve using directrix.

12. Mark a point P and join PF1.

13. At F1 draw a line perpendicular to PF1 to cut DD’ at Q. Join QP and extend it. QP is the tangent at P.
14. Through P, draw a line NM perpendicular to QP. NM is the normal to the ellipse at P.

Eccentricity = 2/3
i.e.,2+3 = 5
Divide AF1 into 5 equal parts.



Engineering Applications

The shape of an ellipse is used for making

1. Concrete arches
2. Stone bridges
3. Glands
4. Stuffing boxes
5. Reflectors used in automobiles etc.

Exercise

Problem 2:

a) Construct an ellipse when the distance between the focus and the directrix is 60mm and the eccentricity is 3/4.

(b) Draw the tangent and normal at any point P on the curve using directrix.

Exercise

Problem 3:

a) Construct an ellipse given the distance of the focus from the directrix as 60 mm and eccentricity as 2/3.

(b) Draw the tangent and a normal to the curve at a point on it 20 mm above the major axis.

Exercise

Problem 4:

a) Construct an ellipse when the distance of the focus from the directrix is equal to 5 cm and the eccentricity is 3/4.

(b) Draw the tangent and normal at any point P on the curve using directrix.

Exercise

Problem 5:

a) Draw the locus of a point P moving so that the ratio of its distance from a fixed point F to its distance from a fixed straight line DD’ is (i) 3/4

(ii) 1 and (iii) 4/3.

(b) Point F is at a distance of 35 mm form DD’. Draw a tangent and a normal to each curve at any point on it.

Construct a Parabola

Problem 6 :

Construct a parabola when the distance between focus and the directrix is 50mm. Draw tangent and normal at any point P on the curve.

Construct a Parabola

1. 1. Draw a vertical line DD’ to represent the directrix. At any point A on it draw a line perpendicular to the directrix to represent the axis.
2. The distance between the focus and the directrix is 50 mm. So mark F the focus such AF = 50 mm.
3. For parabola the eccentricity is always equal to 1. So mark the mid-point of AF as V (vertex) Now VF/VA = 1.
4. Draw a perpendicular line at V. Now draw 45° inclined line at F to cut the perpendicular line drawn at V. Mark the cutting point as S. Or V as centre and VF as radius cut the perpendicular line at S.

Construct a Parabola

5. Join A and S and extend the line to Y.
6. Along the axis AA’ mark points 1, 2...5 at approximately equal intervals. Through these points erect verticals to intersect the line AY (produced if necessary) at 1', 2',...5'.
7. With 11' as radius and F as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 1 at P1 and Q1.
8. With 22' as radius and F as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 2 at P2 and Q2.

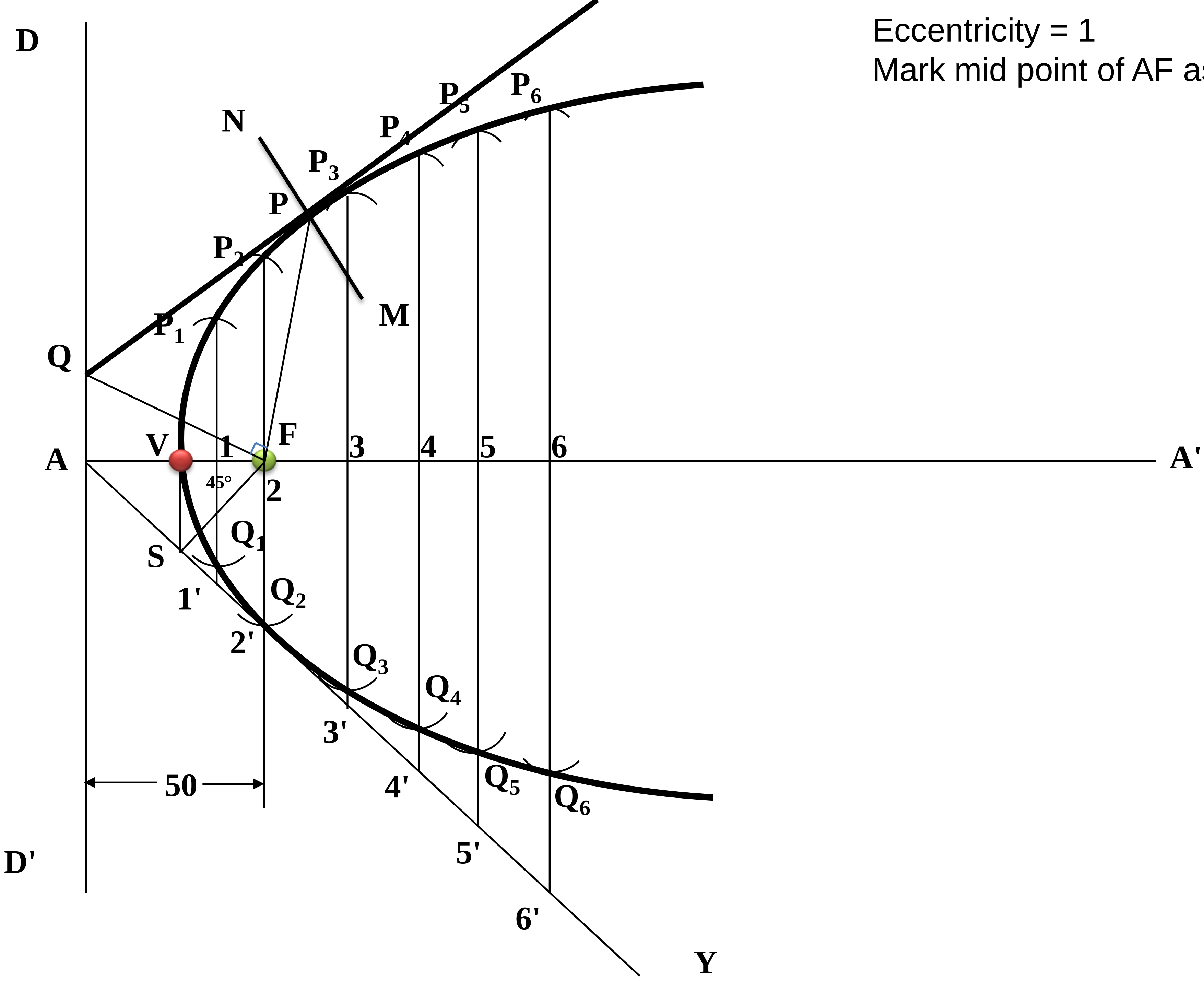
Construct a Parabola

9. Repeat the above the obtain P3 and Q3…P5 and Q5 corresponding to 2,3, … 5 respectively and draw a smooth parabola passing through P5,… P1, V,Q1,Q5.

Draw the tangent and normal at any point P on the curve using directrix.

10. Mark the given point P and join PF.
11. At F draw a line perpendicular to PF to cut DD’ at Q. Join QP and extend it. QP is the tangent at P.
12. Through P, draw a line NM perpendicular to QP. NM is the normal to the parabola at P.

Eccentricity = 1
Mark mid point of AF as V.



Exercise

Problem 7:

Draw a **parabola** given the distance of the focus from the directrix as 60 mm. Draw tangent and normal at any point P on the curve.

Exercise

Problem 8:

Draw the **parabola** whose focus is at a distance of 40 mm from the directrix. Draw a tangent and a normal at any point on it.

Exercise

Problem 9 :

Draw a **parabola** when the distance of focus from the directrix is equal to 65 mm. Draw a tangent and a normal at any point on it.

Exercise

Problem 10:

A fixed point is 55 mm from a fixed straight line. Draw the locus of a point moving in such a way that its distance from the fixed straight line is equal to its distance from the fixed point. Name the curve. Draw a tangent and a normal at any point on it.

Engineering Applications

Parabola is used for

1. Suspension bridges
2. Arches
3. Sound and Light reflectors for parallel beams such as search lights, machine tool structures etc.

Construct a Hyperbola

Problem 11 :

Construct a **hyperbola** when the distance between the focus and the directrix is 40 mm and the eccentricity is 4/3. Draw a tangent and normal at any point on the hyperbola.

Construct a Hyperbola

1. Draw a vertical line DD’ to represent the directrix. At any point A on it draw a line perpendicular to the directrix to represent the axis.
2. The distance between the focus and the directrix is 40 mm. So mark F the focus such that AF = 40 mm.
3. Eccentricity = 4/3 i.e., 4 + 3 = 7. Divide AF into 7 equal parts using geometrical construction and locate the vertex V on the third division from A. Now VF/VA = 4/3.

Construct a Hyperbola

4. Draw a perpendicular line at V. Now draw 45° inclined line at F to cut the perpendicular line drawn at V. Mark the cutting point as S. Or V as centre and VF as radius cut the perpendicular line at S.
5. Join A and S and extend the line to Y.
6. Along the axis AA’ mark points 1, 2... 5 at approximately equal intervals. Through these points erect verticals to intersect the line AY (produced if necessary) at 1', 2',...5‘.

Construct a Hyperbola

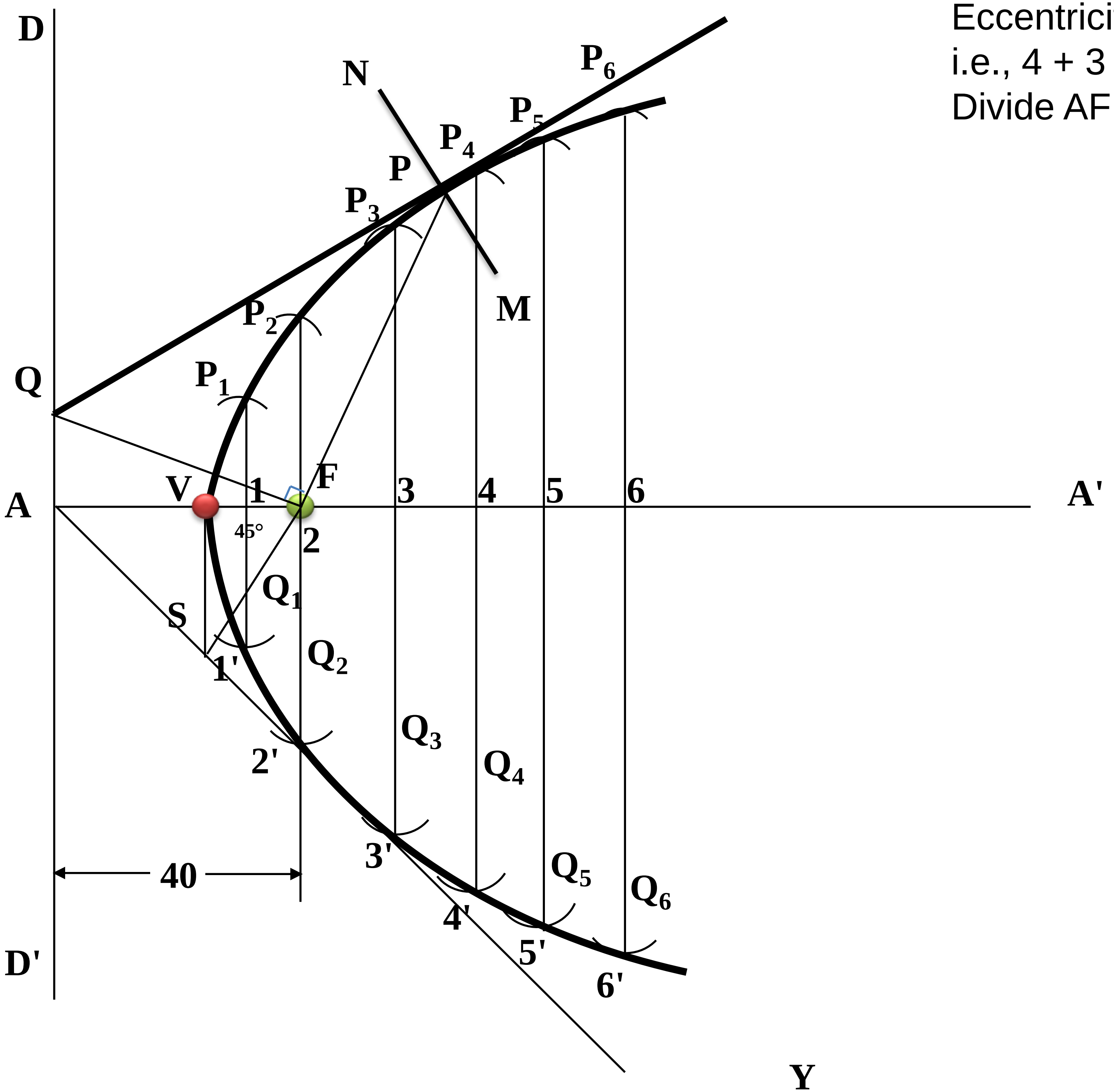
7. With 11' as radius and F as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 1 at P1 and Q1.
8. With 22' as radius and F as centre draw two arcs on either side of the axis to intersect the vertical line drawn through 2 at P2 and Q2.
9. Repeat the above the obtain P3 and Q3…P5 and Q5 corresponding to 3.. 5 respectively and draw a smooth hyperbola passing through P5, P4.... P1 V, Q1,… Q5.

Construct a Hyperbola

Draw the tangent and normal at any point P on the curve using directrix.

10. Mark a point P and join PF1.
11. At F1 draw a line perpendicular to PF1 to cut DD’ at Q. Join QP and extend it. QP is the tangent at P.
12. Through P, draw a line NM perpendicular to QP. NM is the normal to the hyperbola at P.

Eccentricity = 4/3
i.e., 4 + 3 = 7
Divide AF into 7 equal parts.



Engineering Applications

Hyperbola is used in

1. Design of Channels etc.
2. The expansion curve (p-v diagram) of a gas or steam is represented by a Rectangular Hyperbola.

Exercise

Problem 12:

Draw a **hyperbola** when the distance between its focus and directrix is 50 mm and eccentricity is 3/2. Also draw the tangent and normal at a point 25 mm from the directrix.

Exercise

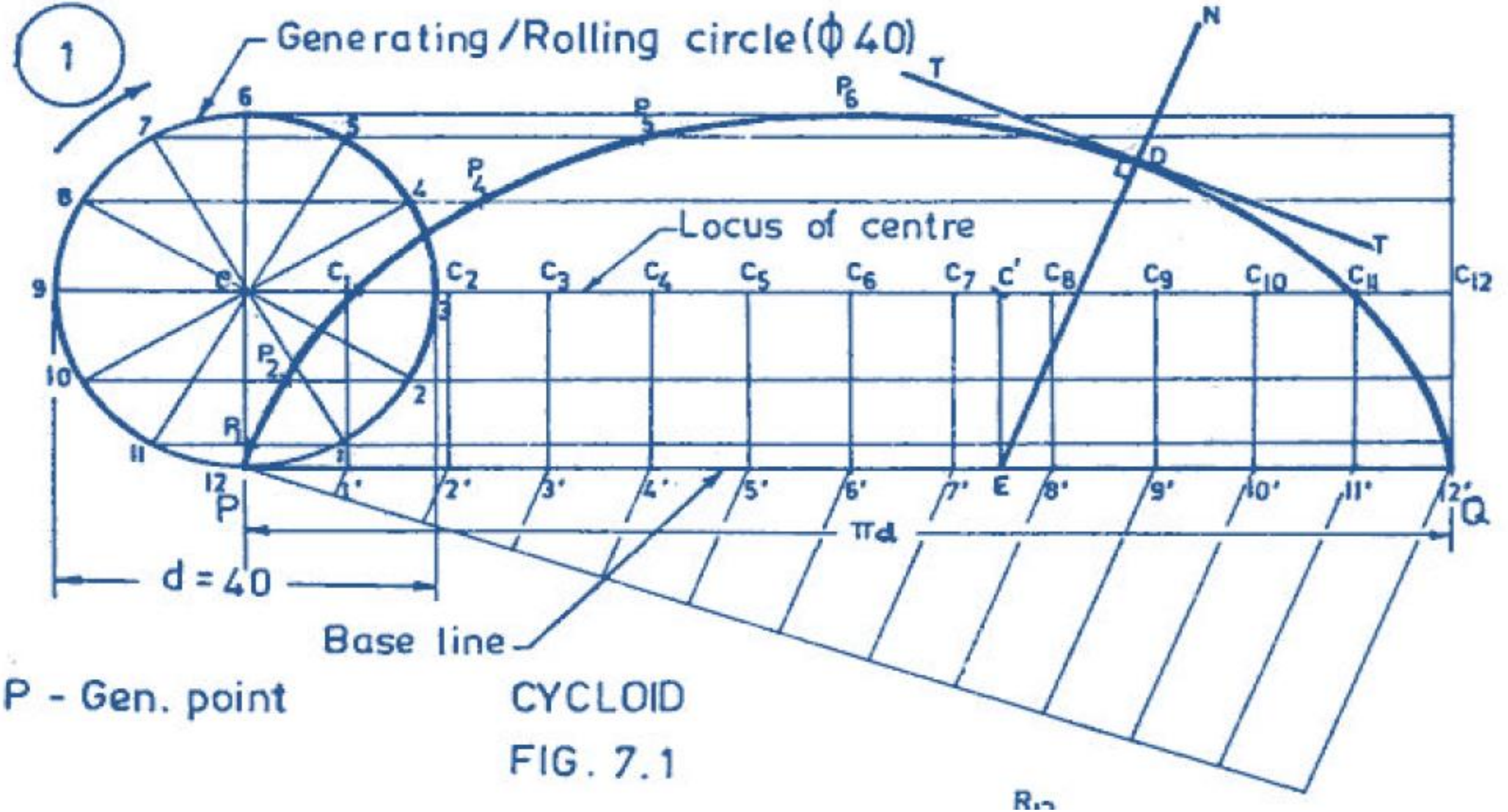
Problem 13:

Draw a **hyperbola** when the distance between its focus and directrix is 50 mm and eccentricity is 5/3. Also draw the tangent and normal at any point on the hyperbola.

Exercise

Problem 14:

Draw a **hyperbola** given the distance of the focus from the directrix as 55 mm an eccentricity as 1.5.

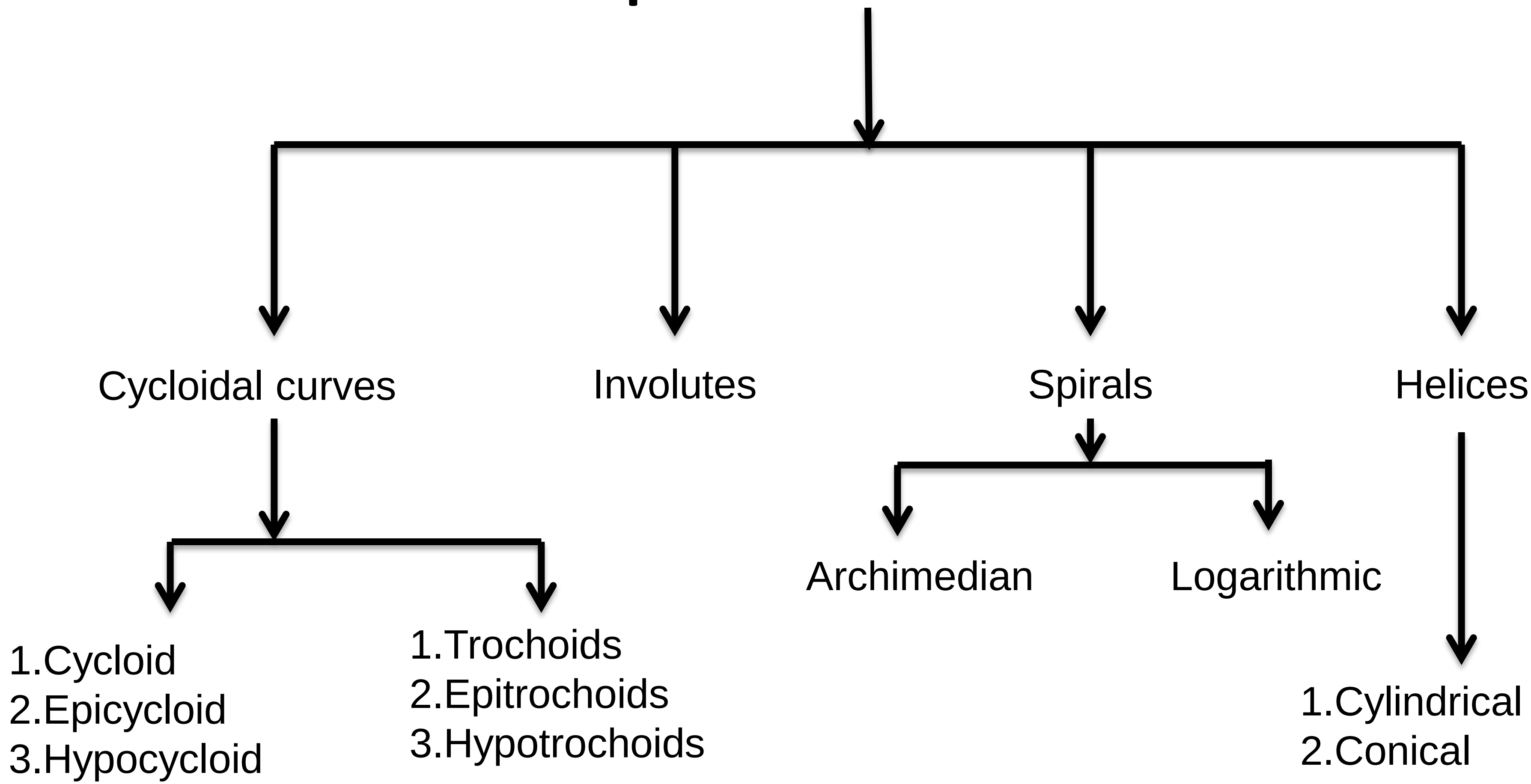


CYCLOID

FIG. 7.1

Construction of Cycloid

Special Curves



Cycloid

1. A cycloid is a curve generated by a point on the circumferences of a circle as the circle rolls along a straight line.

2. The rolling circle is called the generating circle and the line along which is rolls is called the directing line or base line.

Cycloid

NOTE :

1. When a circle makes one revolution on the base line it would have moved through a distance = circumference of the rolling circle.

2. This circumference should be obtained by geometrical construction.

Problem 1

A coin of 40 mm diameter rolls over a horizontal table without slipping.

A point on the circumference of the coin is in contact with the table surface in the beginning and after one complete revolution.

Draw the cycloidal path traced by the point. Draw a tangent and normal at any point on the curve.

Solution

1. Draw the rolling circle of diameter 40mm.
2. Draw the base line PQ equal to the circumference of the rolling circle at P.
3. Divide the rolling circle into 12 equal parts as 1,2,3 etc.
4. Draw horizontal lines through 1,2,3 etc.
5. Divide the base line PQ into the same number of equal parts (12) at 1’, 2’, 3’…etc.

Solution

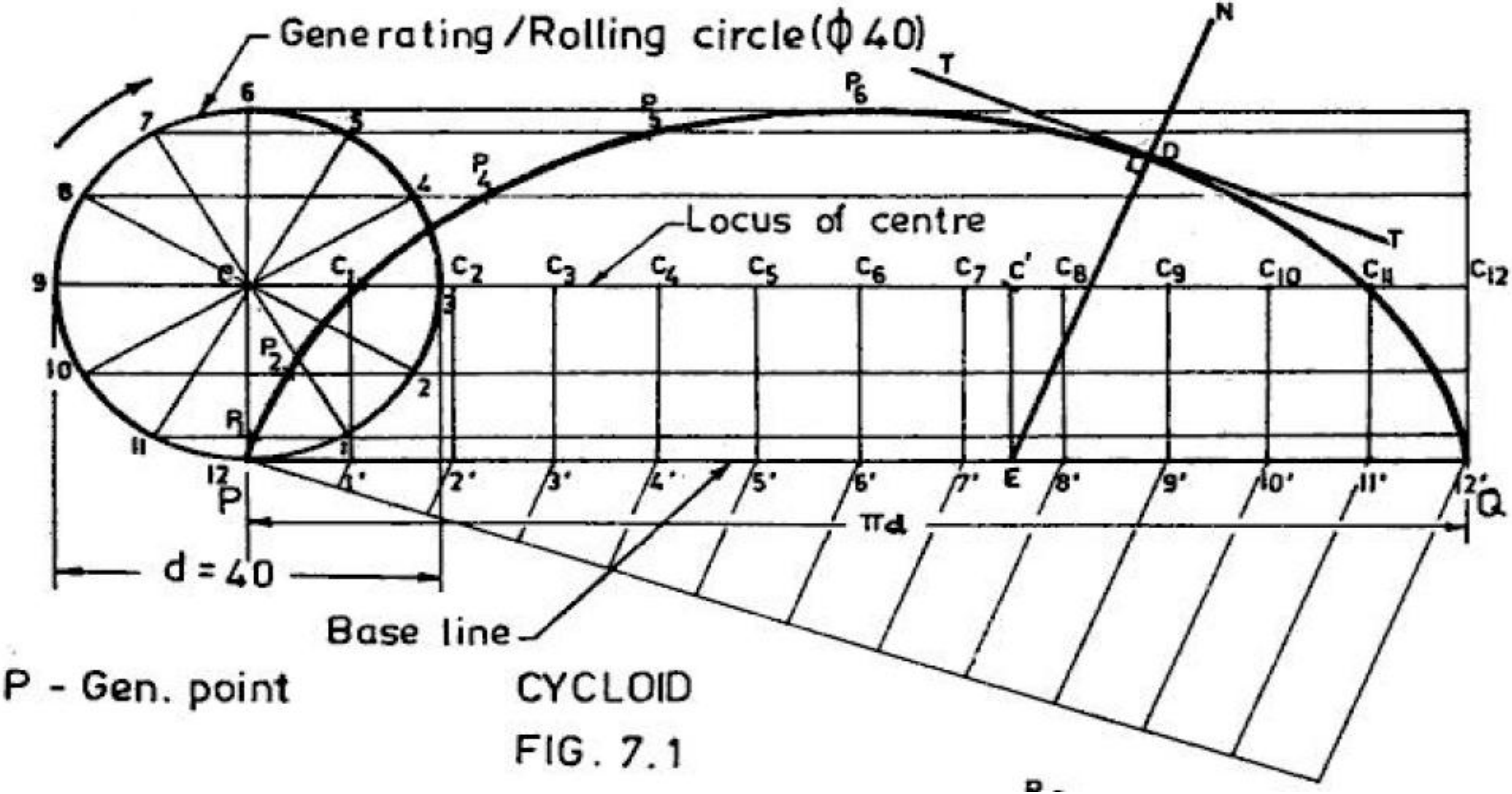
6. Draw lines perpendicular to PQ at 1', 2', 3' etc to intersect the horizontal line drawn through C (called the locus of centre) at C_1, C_2 ....etc.
7. With C_1, C_2 etc as centres and radius equal to radius of rolling circle (20mm) draw arcs to cut the horizontal lines through 1, 2, ...etc.at P_1, P_2....etc.
8. Draw a smooth curve (cycloid) through P, P_1, P_2...etc.

Solution

To draw normal and tangent at a given point D

9. With D as centre and radius equal to radius of the rolling circle, cut the line of locus of centre at C'.
10. From C' draw a perpendicular line to PQ to get the point E on the base line. Connect DE, the normal.
11. At D, draw a line perpendicular to DE and get the required tangent TT.

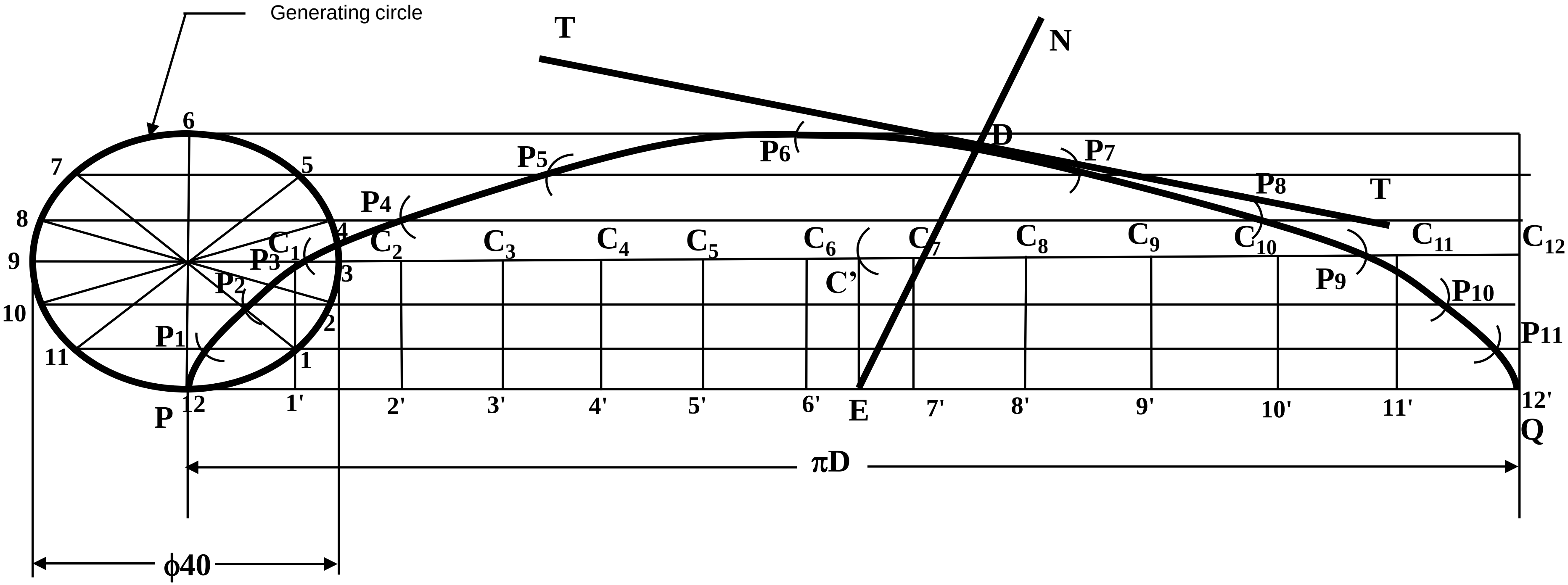
Problem 1



CYCLOID

FIG. 7.1

Problem 1



Take C_1, C_2, C_3… C_{12} as centres and radius equal to radius of generating circle (20 mm).

Applications

1. Cycloid is used in the design of gear tooth system.
2. It has application in conveyor for mould boxes in foundry shops and
3. some other applications in mechanical engineering.

Exercise

Problem 2 :

Draw a cycloid formed by a rolling circle 50 mm in diameter. Use 12 divisions. Draw a tangent and a normal at a point on the curve 30mm above the directing line.

Exercise

Problem 3 :

A circle of 40 mm diameter rolls on a straight line without slipping.

In the initial position the diameter PQ of the circle is parallel to the line on which it rolls.

Draw the locus of the points P and Q for one complete revolution of the circle.

Exercise

Problem 4 :

A circle of 40 mm diameter rolls on a horizontal line.

Draw the curve traced out by a point R on the circumference for one half revolution of the circle.

For the remaining half revolution the circle rolls on the vertical line.

The point R is vertically above the centre of the circle in the starting position.

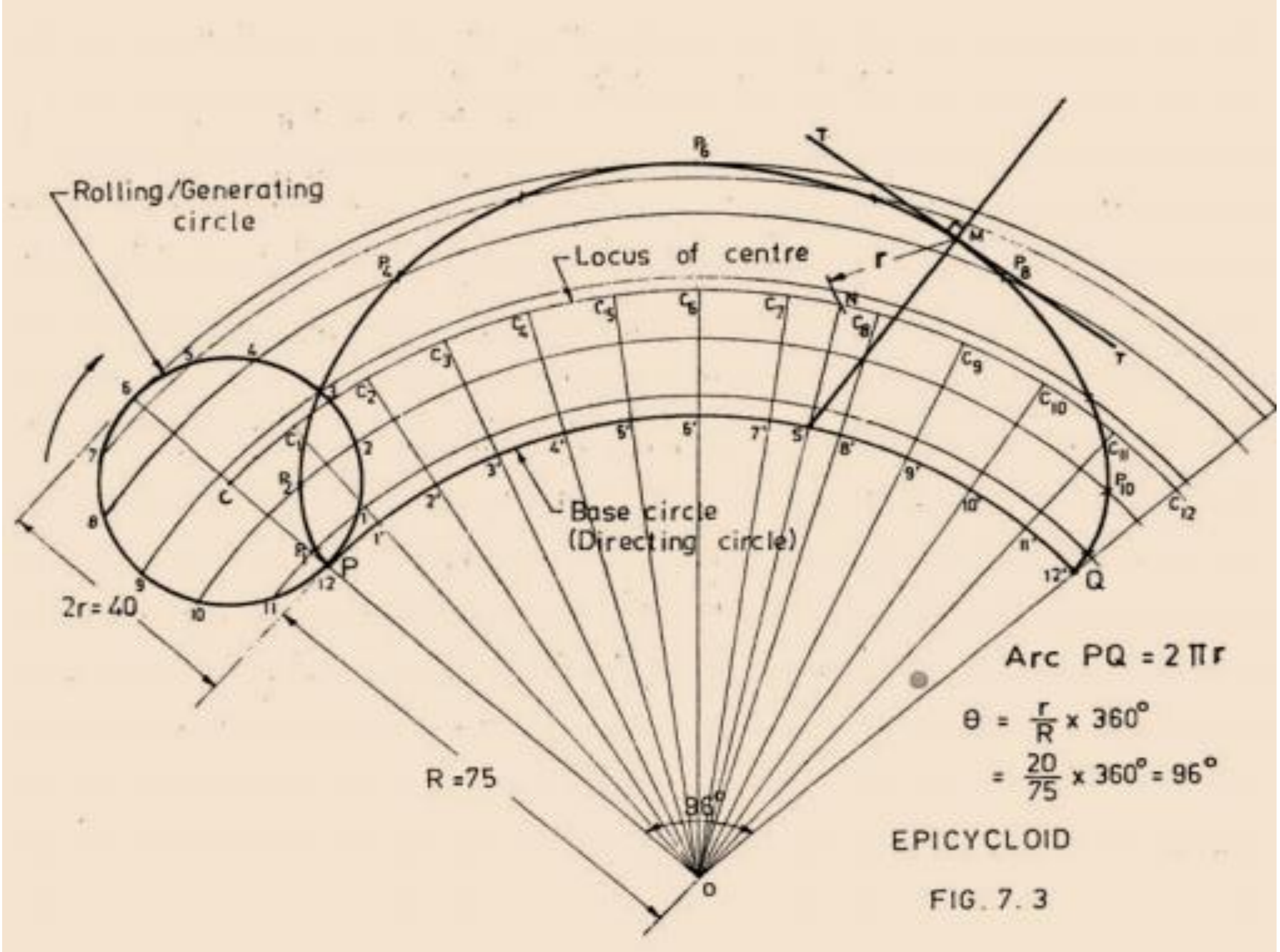
Exercise

Problem 5 :

A circle of 40 mm diameter rolls on a Straight line without slipping.

Draw the curve traced out by a point P on the circumference for 1.5 revolution of the circle.

Name the curve.Draw the tangent and normal at a point on it 35mm from the line.



Construction of Epicycloid

Epicycloid

1. Epicycloid is a curve traced by a point on the circumference of a circle which rolls without slipping on the outside of another circle.

Problem 6

Draw an epicycloid of rolling circle 40 mm (2r), which rolls outside another circle (base circle) of 150 mm diameter (2R) for one revolution. Draw a tangent and normal at any point on the curve.

Solution

1. In one revolution of the generating circle, the generating point P will move to a point Q, so that the arc PQ is equal to the circumference of the generating circle. θ is the angle subtended by the arc PQ at the centre O.

To calculate θ :

$$= \frac{\text{Arc PQ}}{\text{Circumference of directing circle}} = \frac{r}{R}$$

$$\theta = \frac{r}{R} = \frac{20}{75} \times 360 = 96°$$

Solution

2. Taking any point O as centre and radius (R) 75 mm, draw an arc PQ which subtends an angle $\theta = 96°$ at O.
3. Let P be the generating point. On OP produced, mark PC = r = 20 mm = radius of the rolling circle. Taking centre C and radius r (20 mm) draw the rolling circle.
4. Divide the rolling circle into 12 equal parts and name them as 1, 2, .3 etc in the CCW direction, since the rolling circle is assumed to roll clockwise.
5. O as centre, draw concentric arcs passing through 1, 2, 3, . . . etc.

Solution

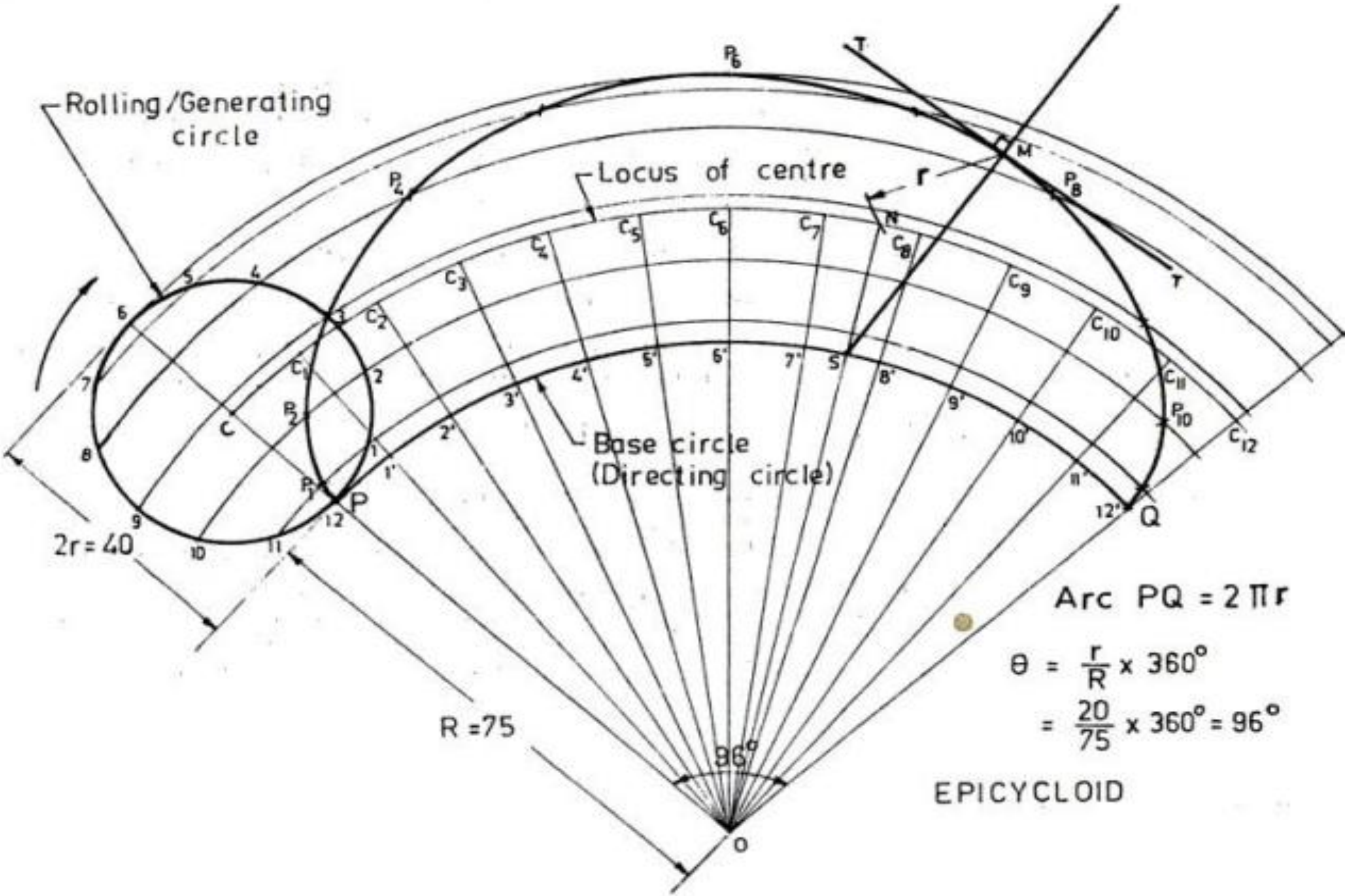
6. O as centre and OC as radius drew an arc to represent the locus of centre.
7. Divide the arc PQ into same number of equal parts (12) and name them as 1’, 2’, . . . etc.
8. Join 01’, 02’ . . . etc. and produce them to cut the locus of centre at C1,C2. . etc.
9. Taking C1 as centre and radius equal to r, draw an arc cutting the arc through 1 at P1. ‘Similarly obtain the other points and draw a smooth curve through them.

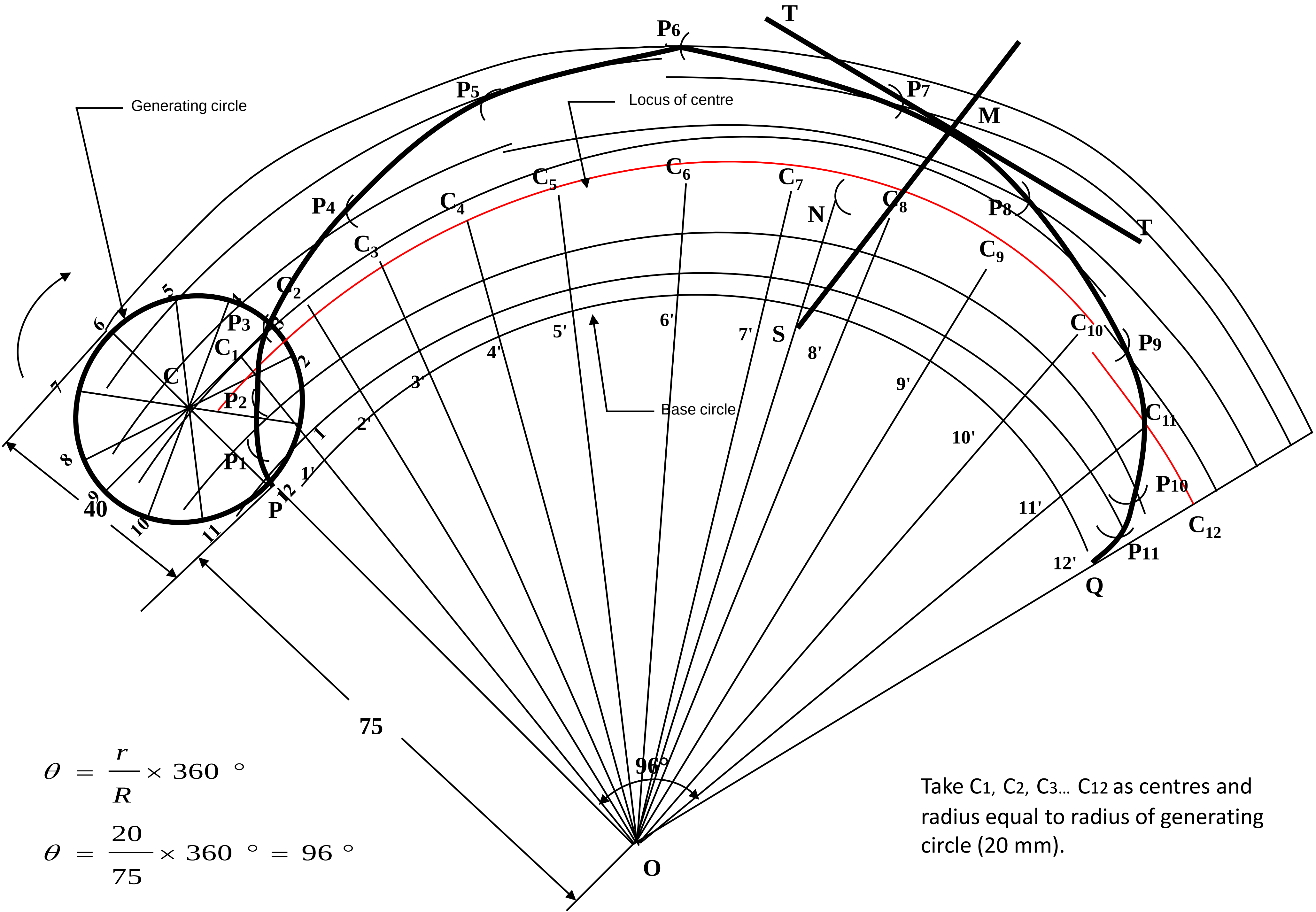
Solution

To draw a tangent and normal at a given point M:

10. M as centre, end radius r = CP cut the locus of centre at the point N.
11. Join NO which intersects the base circle arc PQ at S.
12. Join MS, the normal and draw the tangent perpendicular to it.

Solution

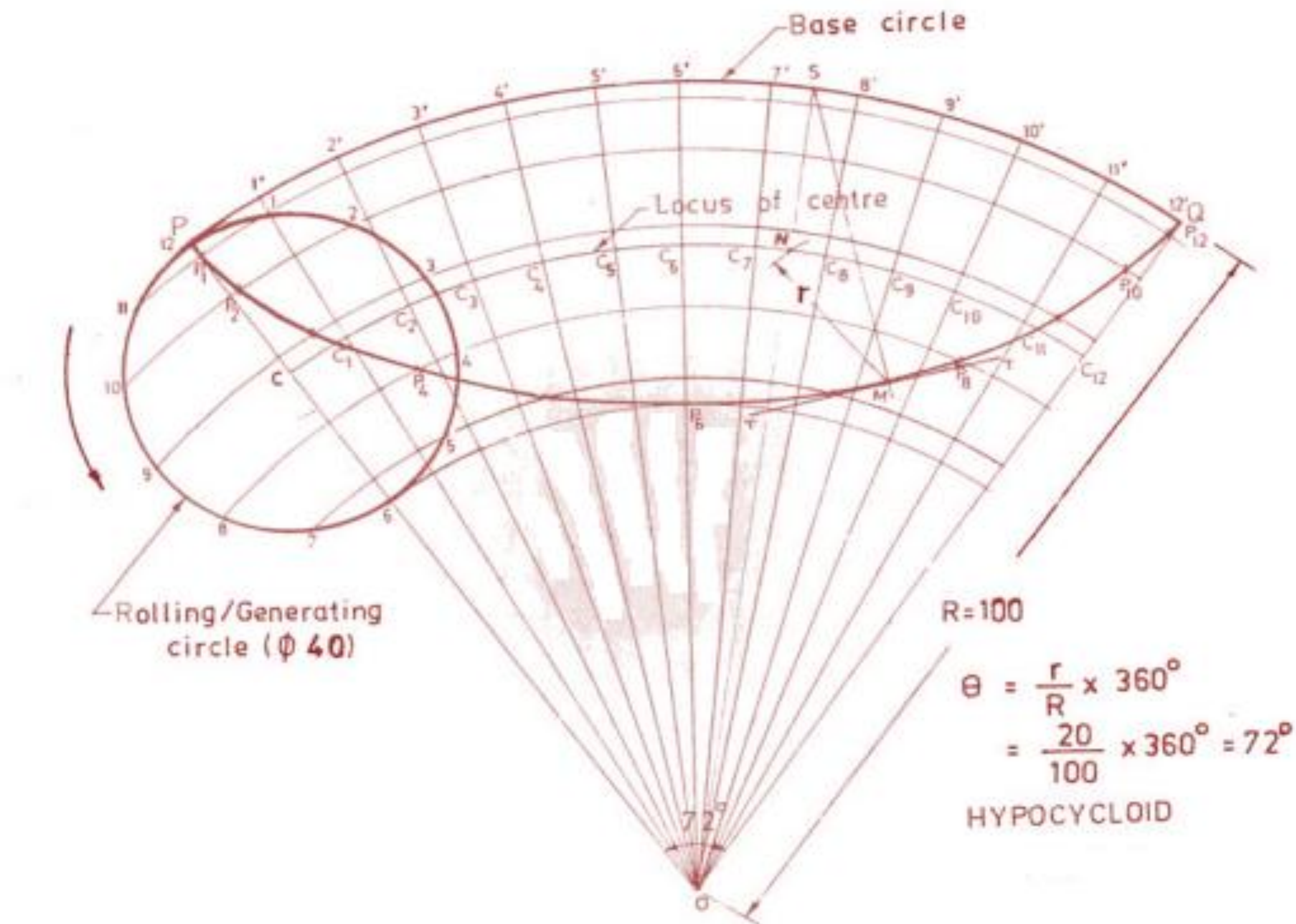

Rolling/Generating circle
Locus of centre
Base circle (Directing circle)
2r = 40
R = 75
96°
P
Q
O
C
M
N
r
T
Arc PQ = 2πr
θ = r/R x 360°
= 20/75 x 360° = 96°
EPICYCLOID



$$\theta = \frac{r}{R} \times 360^\circ$$

$$\theta = \frac{20}{75} \times 360^\circ = 96^\circ$$

Take C1, C2, C3… C12 as centres and radius equal to radius of generating circle (20 mm).



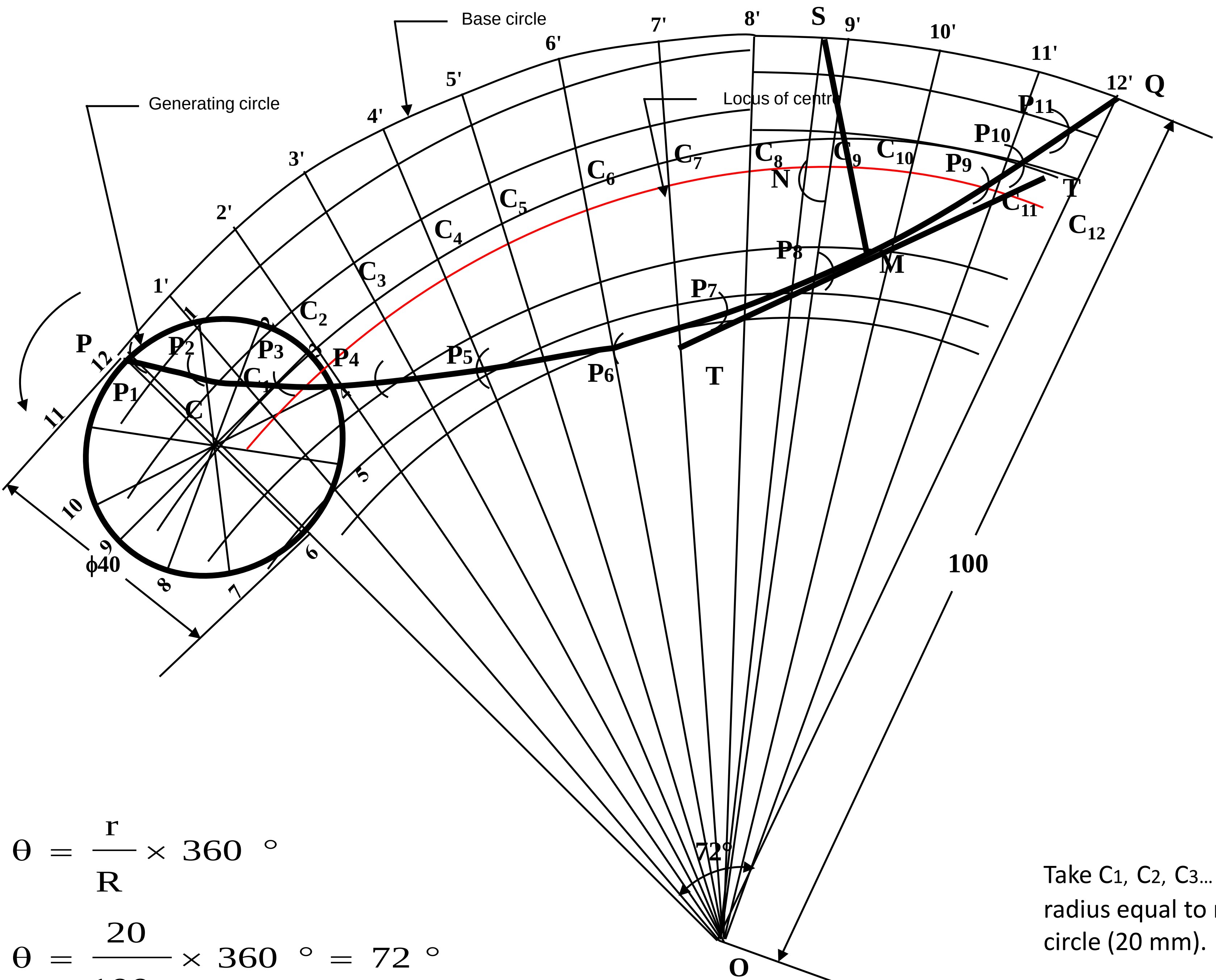
Construction of Hypocycloid

Hypocycloid

Hypocycloid is a curve traced by a point on the circumference of a circle which rolls without slipping on the inside of another circle.

Problem 7

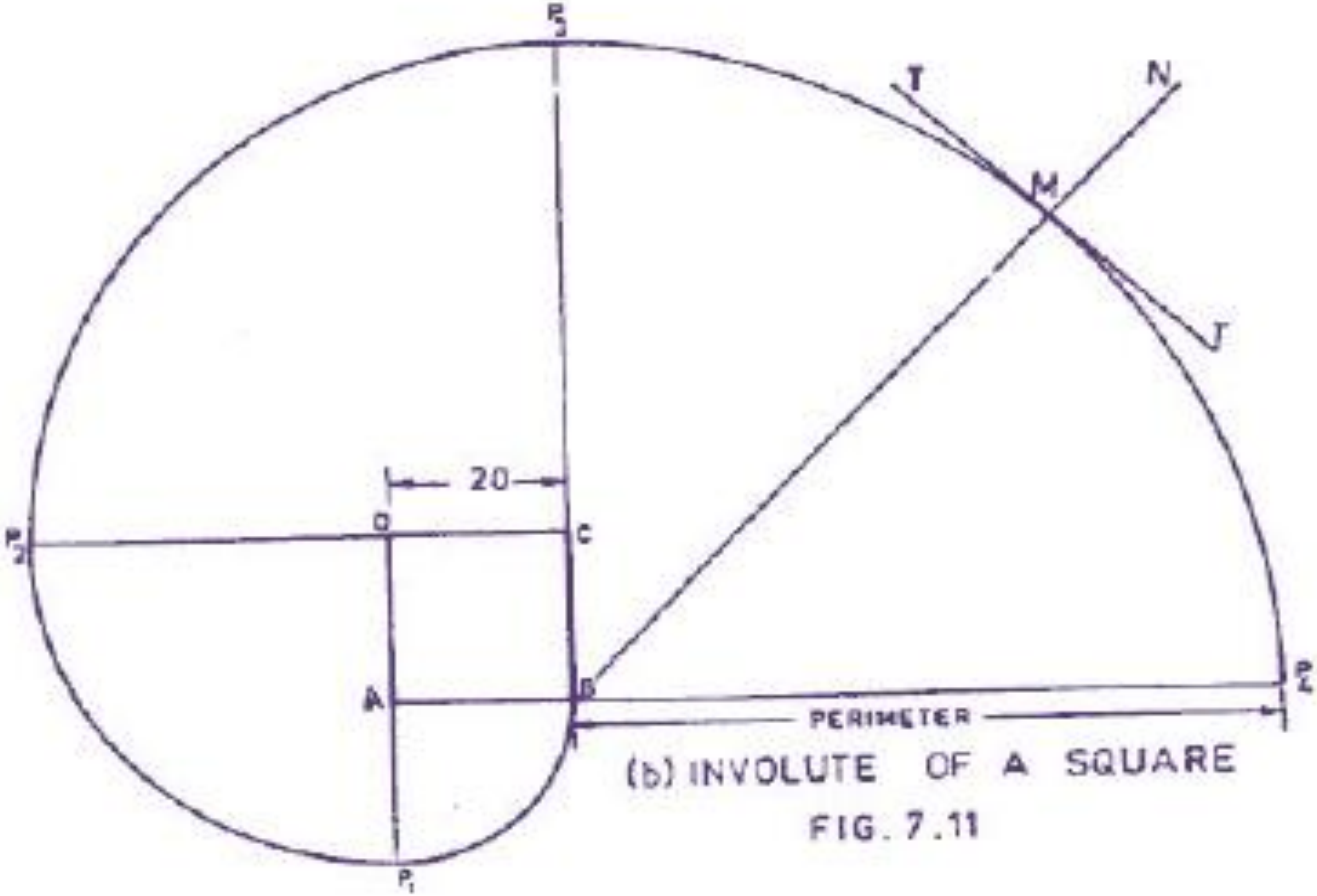
Draw a hypocycloid of a circle of 40 mm diameter which rolls inside another circle of 200 mm diameter for one revolution. Draw a tangent and normal at any point on it.



$$\theta = \frac{r}{R} \times 360^\circ$$

$$\theta = \frac{20}{100} \times 360^\circ = 72^\circ$$

Take C1, C2, C3… C12 as centres and radius equal to radius of generating circle (20 mm).



(b) INVOLUTE OF A SQUARE

FIG. 7.11

Construction of Involutes

Involutes

1. An involutes is a curve traced by a point on a string as it unwinds from around a circle or a polygon.

Problem 8

Draw the involute of a square of side 20mm.

Solution 8

1. Draw the square ABCD of side 20mm.

2. With A as centre and AB as radius, draw an arc to cut DA produced at P_1.

3. D as centre and DP_1 as radius draw an arc to cut CD produced at P_2.

Solution 8

4. C as centre and CP_2 as radius draw an arc to cut BC produced at P_3.

5. Similarly, B as centre and BP_3 as radius draw an arc to cut AB produced at P_4.

Solution 8

NOTE :

BP$_4$ is equal to the perimeter of the square. The curved obtained is the required involute of the square.

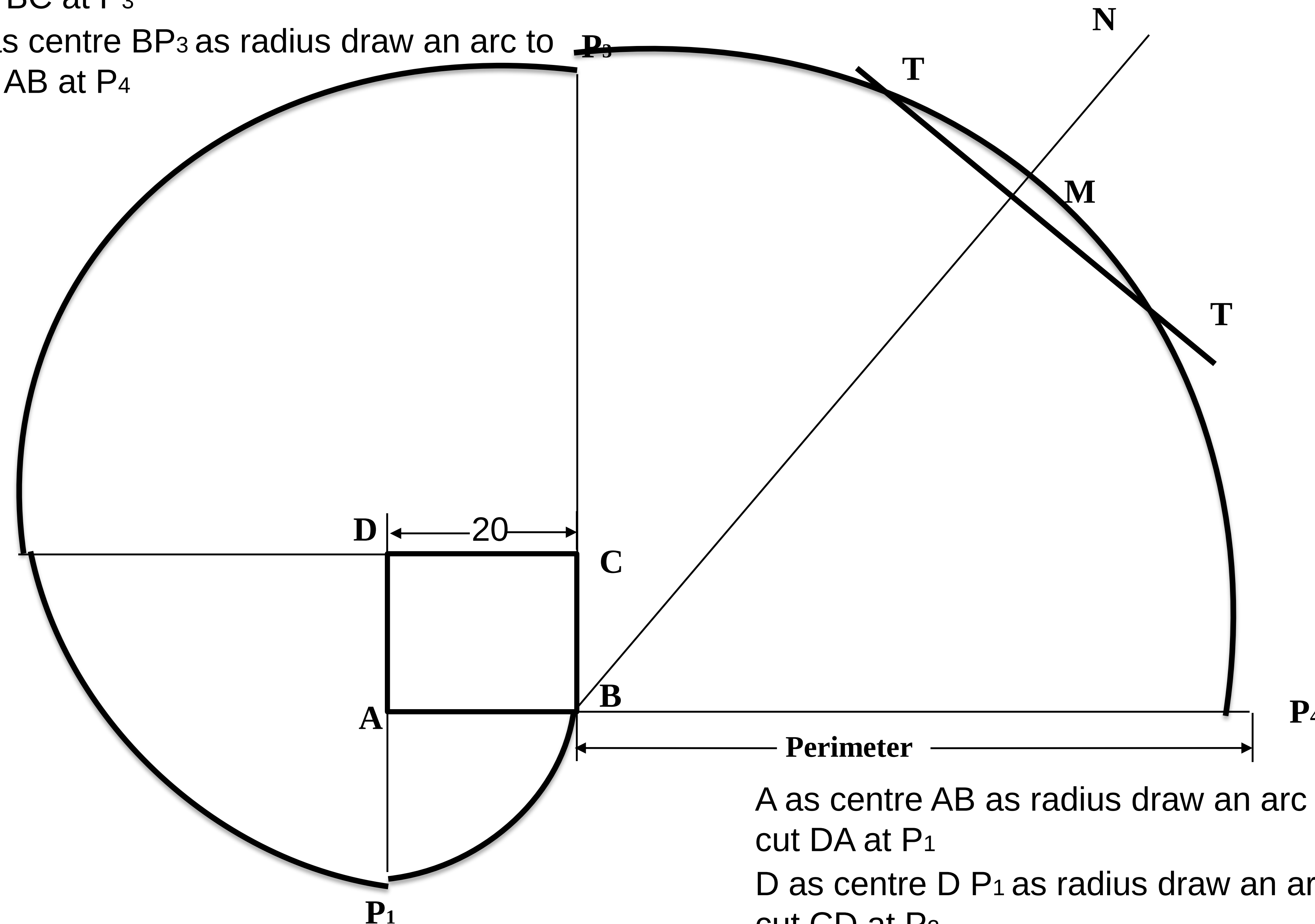
Solution 8

To draw a normal and tangent at a given point M.

1. The given point M lies in the arc P3 P4.
2. The centre of the arc P3 P4 is point B.
3. Join B and M and extend it which is the required normal.
4. At M draw perpendicular to the normal to obtain tangent TT.

C as centre C P_2 as radius draw an arc to cut BC at P_3

B as centre BP_3 as radius draw an arc to cut AB at P_4



A as centre AB as radius draw an arc to cut DA at P_1

D as centre D P_1 as radius draw an arc to cut CD at P_2

Problem 9

A coir is unwound from a drum of 30 mm diameter. Draw the locus of the free end of the coir for unwinding through an angle of 360°. Draw also a normal and tangent at any point on the curve.

Solution 9

1. Draw the given circle of 30 mm diameter (D).
2. Divide the circle into 12 equal parts as 1, 2, 3 . . . 12. Let P be the starting point i.e. one end of the thread.
3. Draw a line PQ tangential to the circle at P and equal to πD.
4. Divide PQ into 12 equal parts as 1', 2', . . .12'.
5. Draw tangents at points 1, 2, 3 . . . etc. and mark P1 , P2 ,...P12 such that 1P1 = Pl'; 2P2 = P2'; 3P3 = P3' etc.

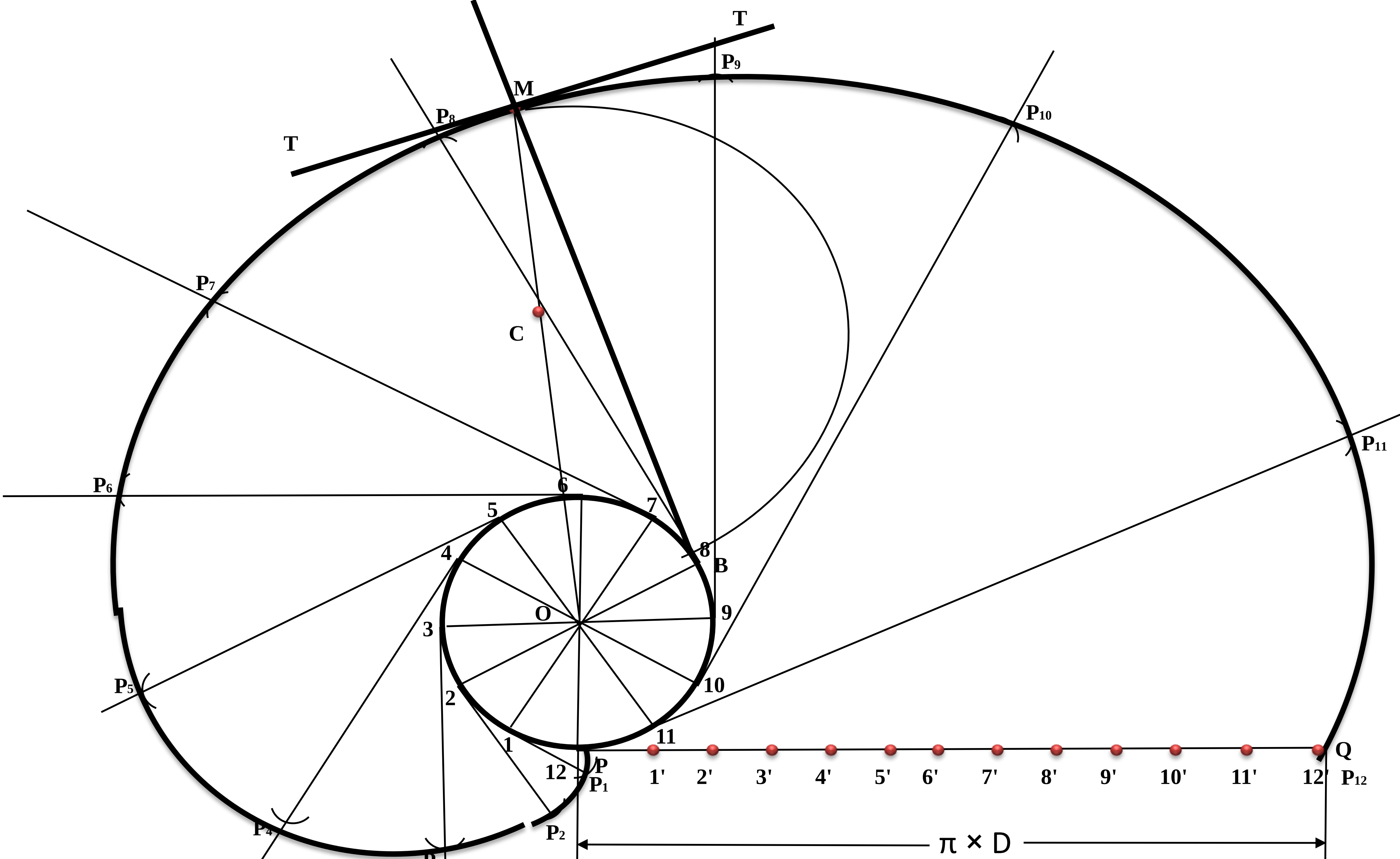
Solution 9

6. Draw a smooth curve through P, P1, P2 . . . P12 (involute of the given circle).

Solution 9

Tangent and normal to the involute of the circle at a given point M:

1. Draw a line joining M and the centre of the circle O.
2. Mark the mid-point C on OM.
3. With C as centre and MC as radius describe e semi-circle to cut the given circle at B.
4. Join MB, which is the required normal.
5. At M, draw a line perpendicular to MB, to get the required tangent TT.



C as centre MC as radius, semi-circle cut the given circle at B

Mark P_1 such that $1P_1 = P1'$

Mark P_2 such that $2P_2 = P2'$

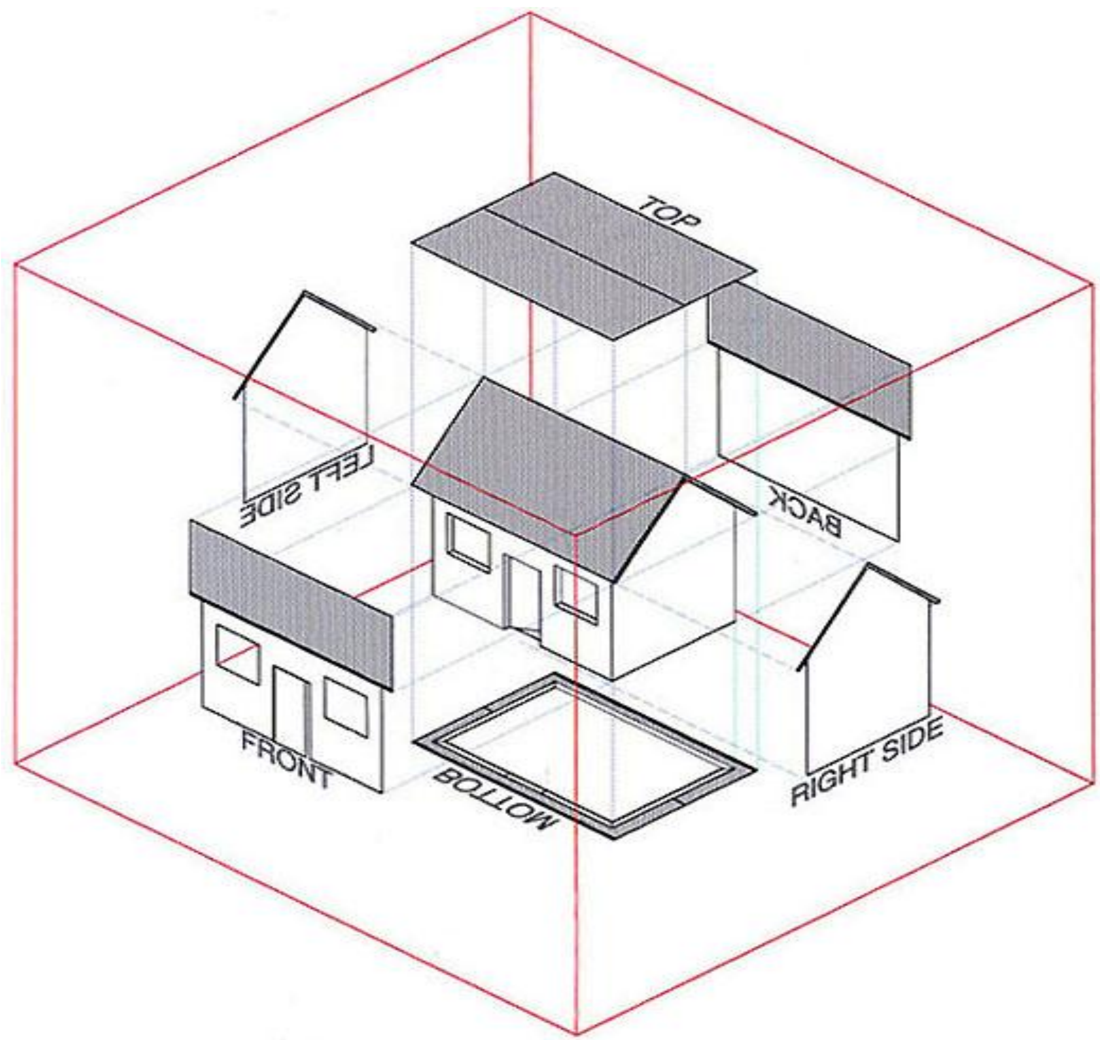
Problem 10

Draw the involute of a circle of diameter 40 mm. Draw also a normal and tangent at any point on the curve.

Problem 11

Draw one turn of the involute of a circle 50 mm in diameter. Draw a tangent and normal to the curve at a point 80 mm from the centre of the circle.

ORTHOGRAPHIC PROJECTION



ORTHOGRAPHIC PROJECTION

PROJECTION

1. The figure or view formed by joining, in correct sequence, the points at which these lines meet the plane is called the projection of the object. (It is obvious that the outlines of the shadow are the projections of an object).

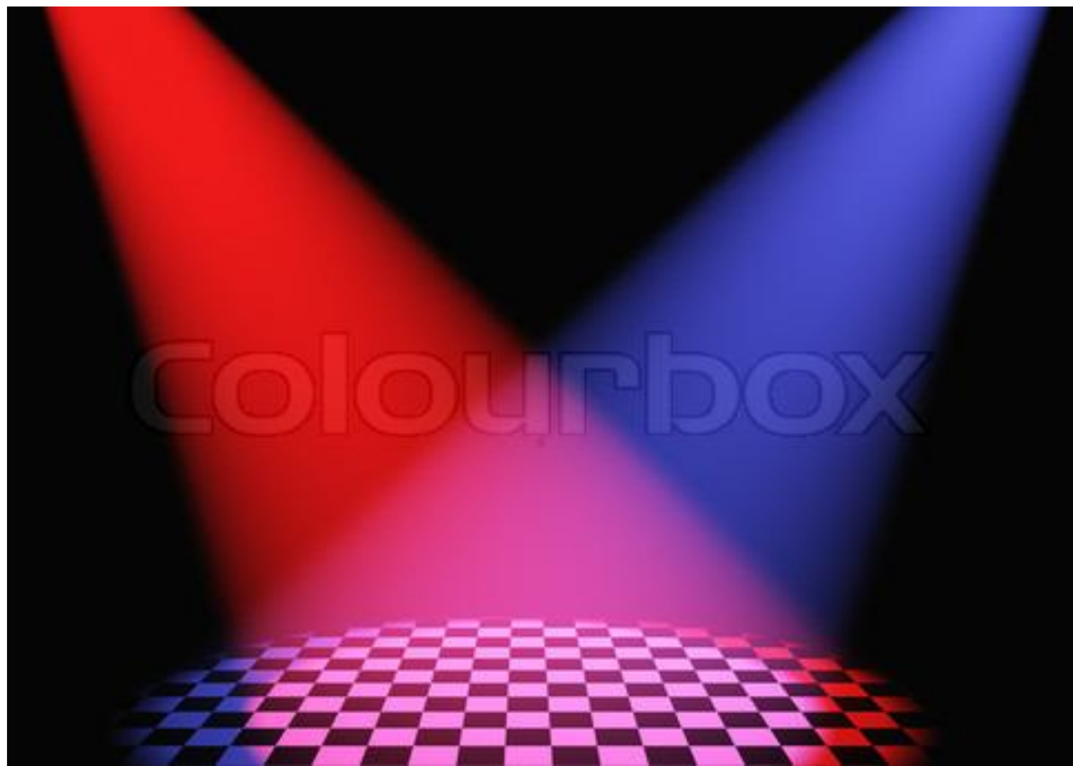
ORTHOGRAPHIC PROJECTION

PROJECTION

ORTHOGRAPHIC PROJECTION

PROJECTORS

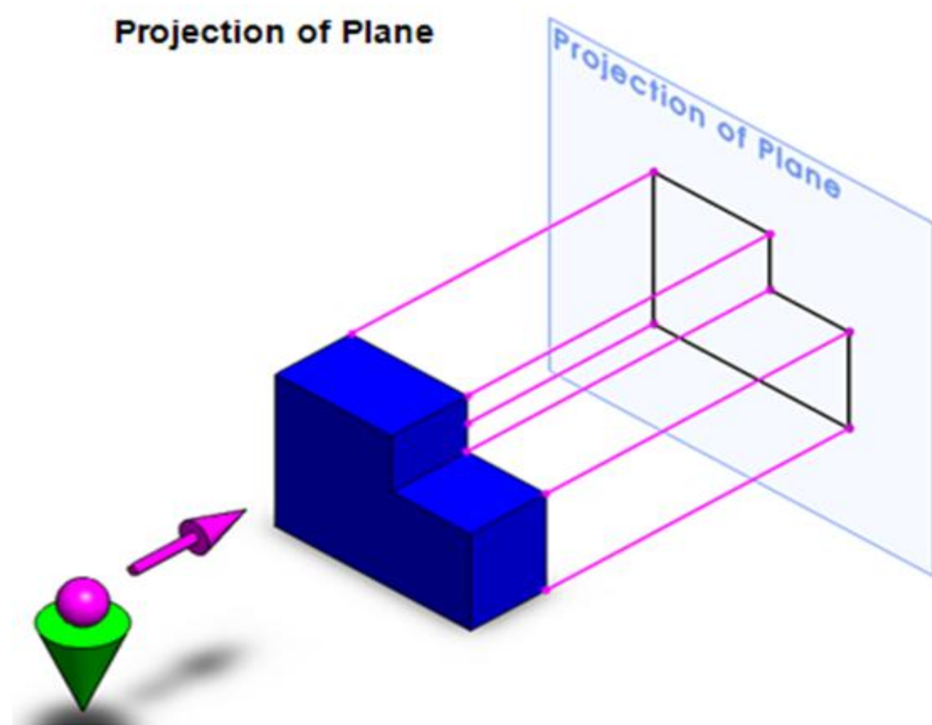
1. The lines or rays drawn from the object to the plane are called projectors.



ORTHOGRAPHIC PROJECTION

PLANE OF PROJECTION

1. The transparent plane on which the projections are drawn is known as plane of projection.



ORTHOGRAPHIC PROJECTION

TYPES OF PROJECTION

1. Pictorial Projections
   a) Perspective Projection
   b) Isometric Projection
   c) Oblique Projection

2. Orthographic Projection

ORTHOGRAPHIC PROJECTION

1. PICTORIAL PROJECTIONS

The projections in which the description of the object is completely understood in one view is know as Pictorial Projection.

PICTORIAL PROJECTIONS

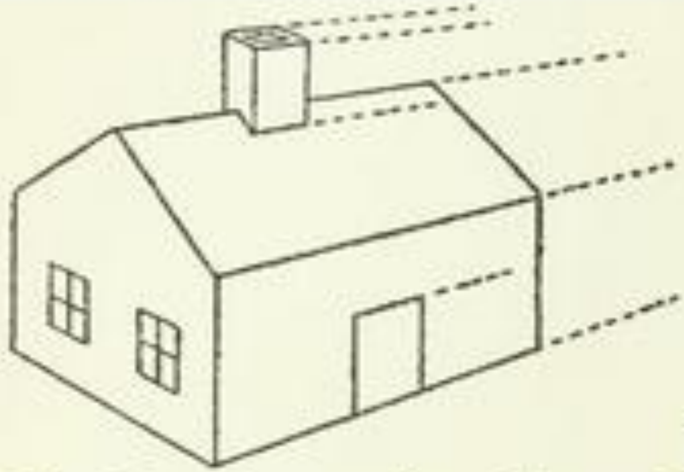


Fig. 77. Perspective View of Cabin.

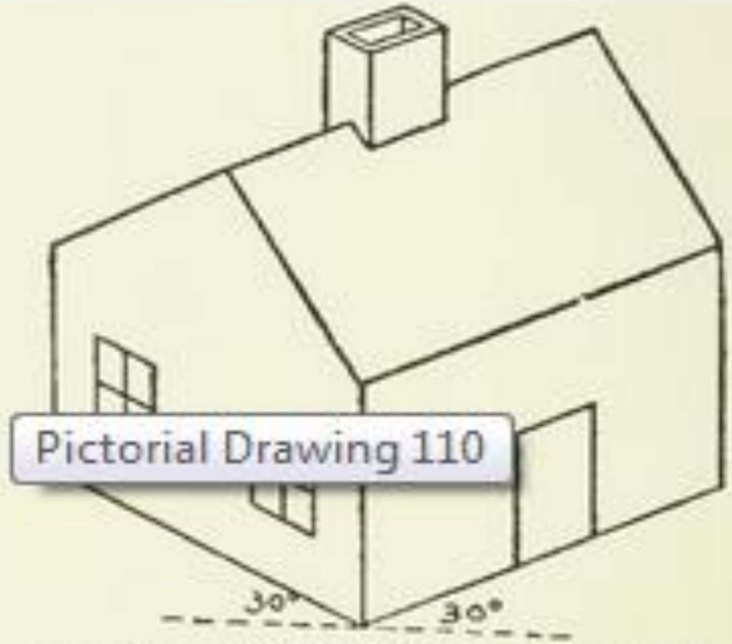


Fig. 78. Isometric Drawing of Cabin.

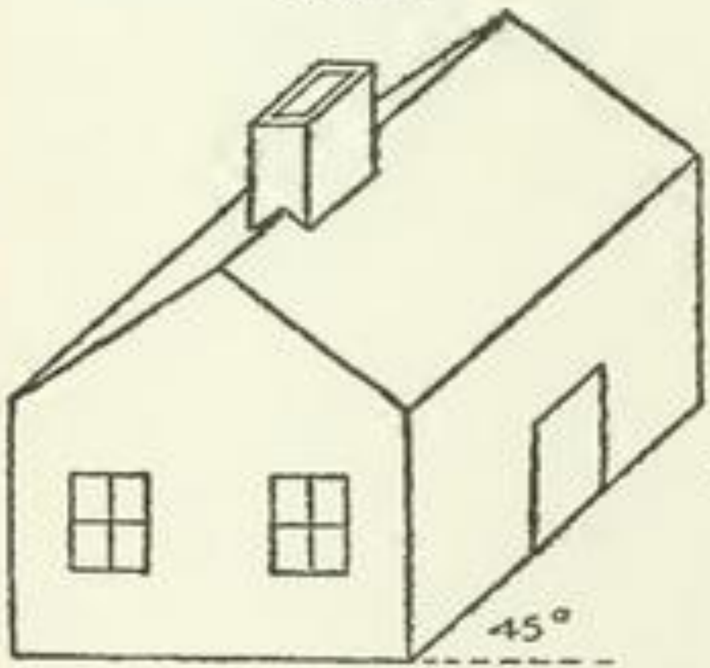


Fig. 79. Oblique Projection of Cabin.

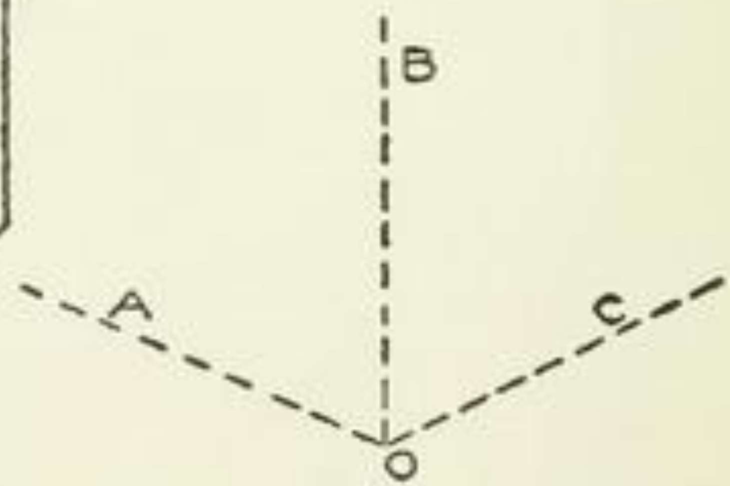


Fig. 80. Isometric Axes.

ORTHOGRAPHIC PROJECTION

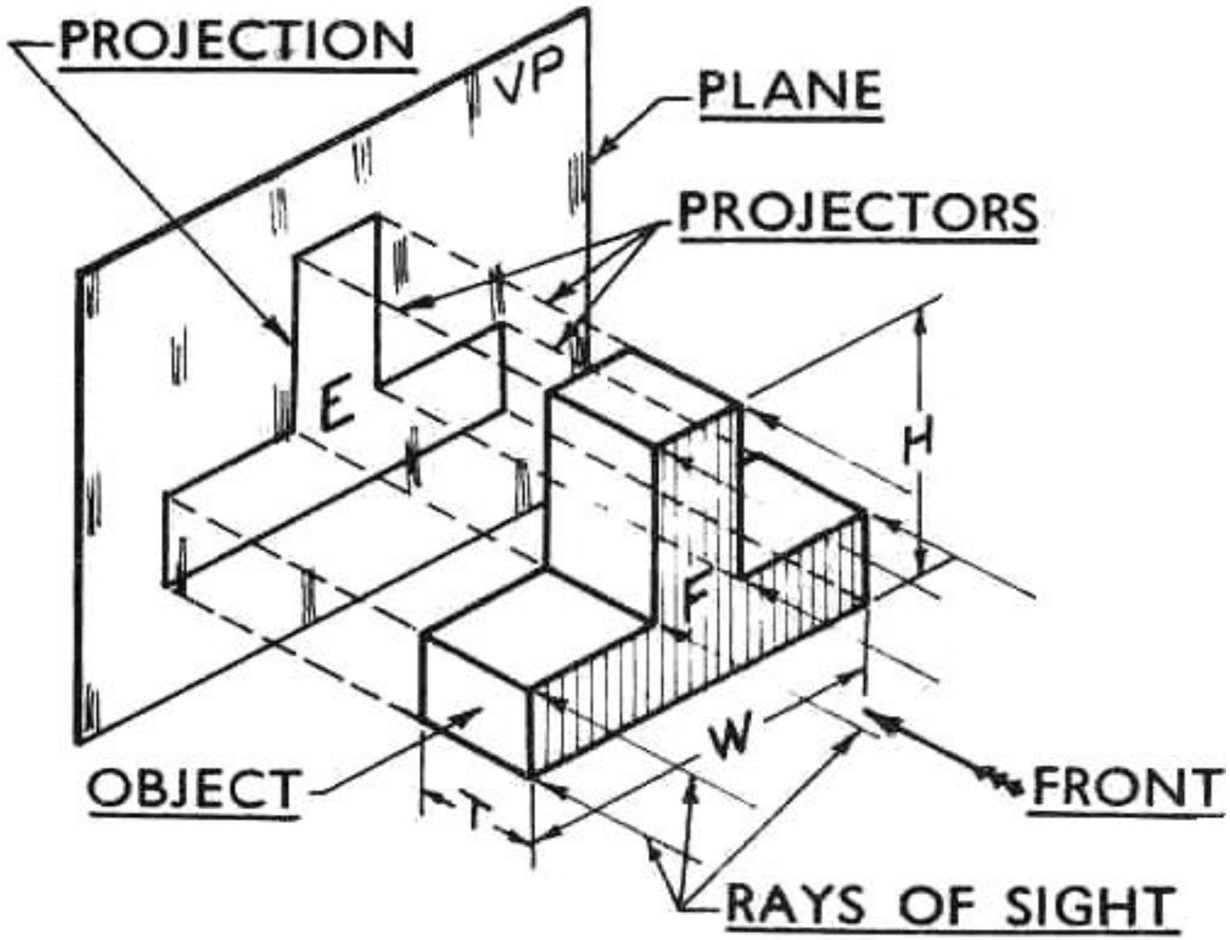
2. ORTHOGRAPHIC PROJECTIONS

‘ORTHO’ means ‘right-angle’ and ORTHO-GRAPHIC means right-angled drawing.

When the projectors are perpendicular to the plane on which the projection is obtained it is known as Orthographic Projection.

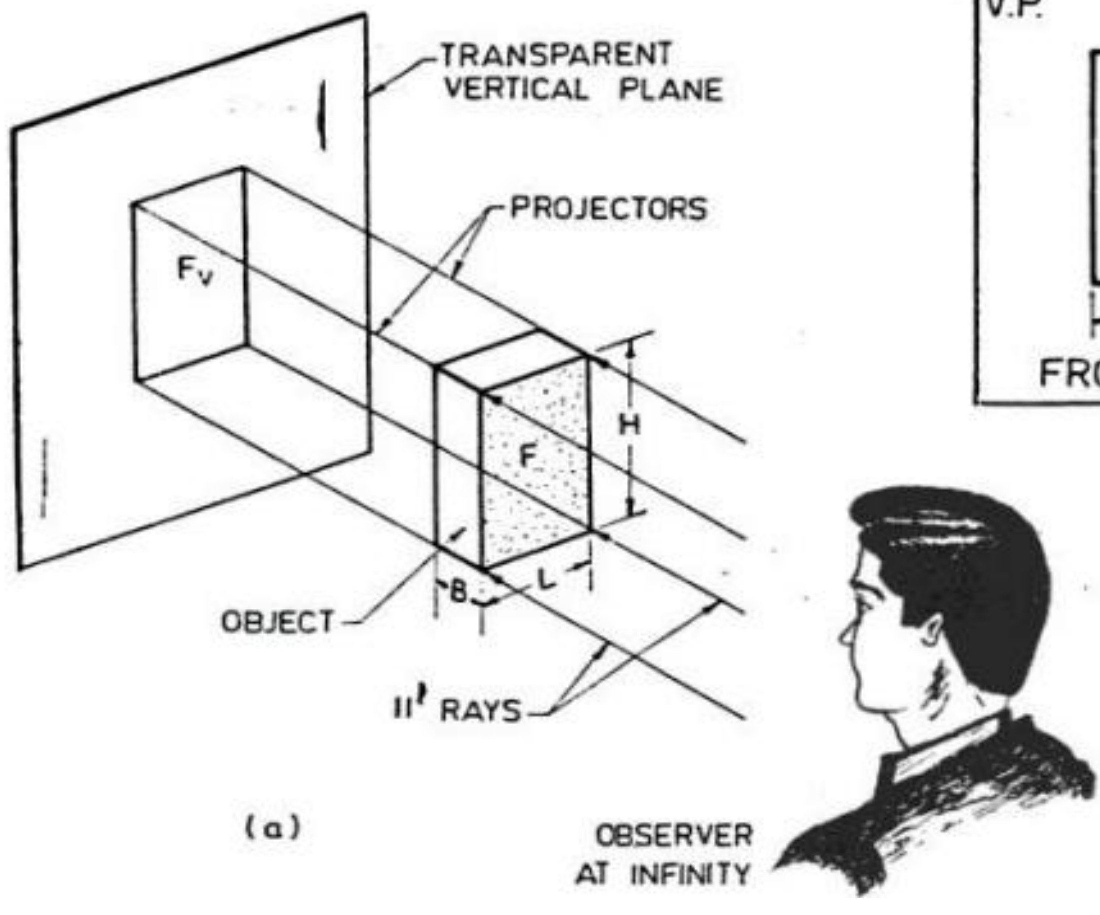
ORTHOGRAPHIC PROJECTION

2. ORTHOGRAPHIC PROJECTIONS

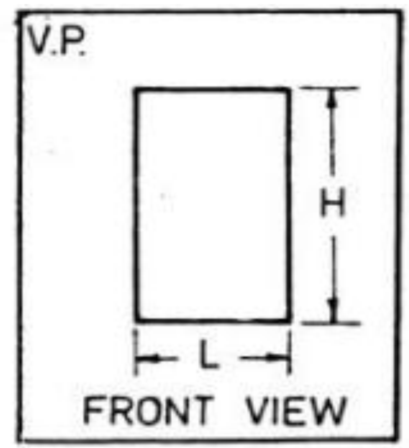


ORTHOGRAPHIC PROJECTION

2. ORTHOGRAPHIC PROJECTIONS



(a)

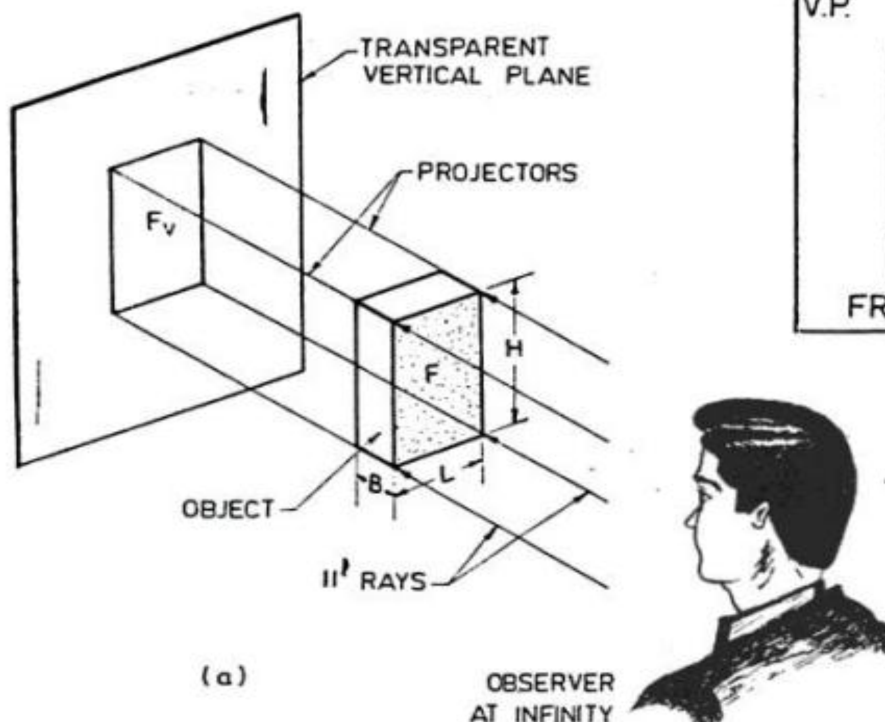


(b)

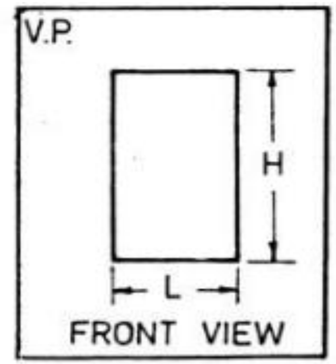
ORTHOGRAPHIC PROJECTION

Vertical Plane

Extend the rays or projectors further to meet a vertical (Transparent) plane (V.P) located behind the object.



(a)

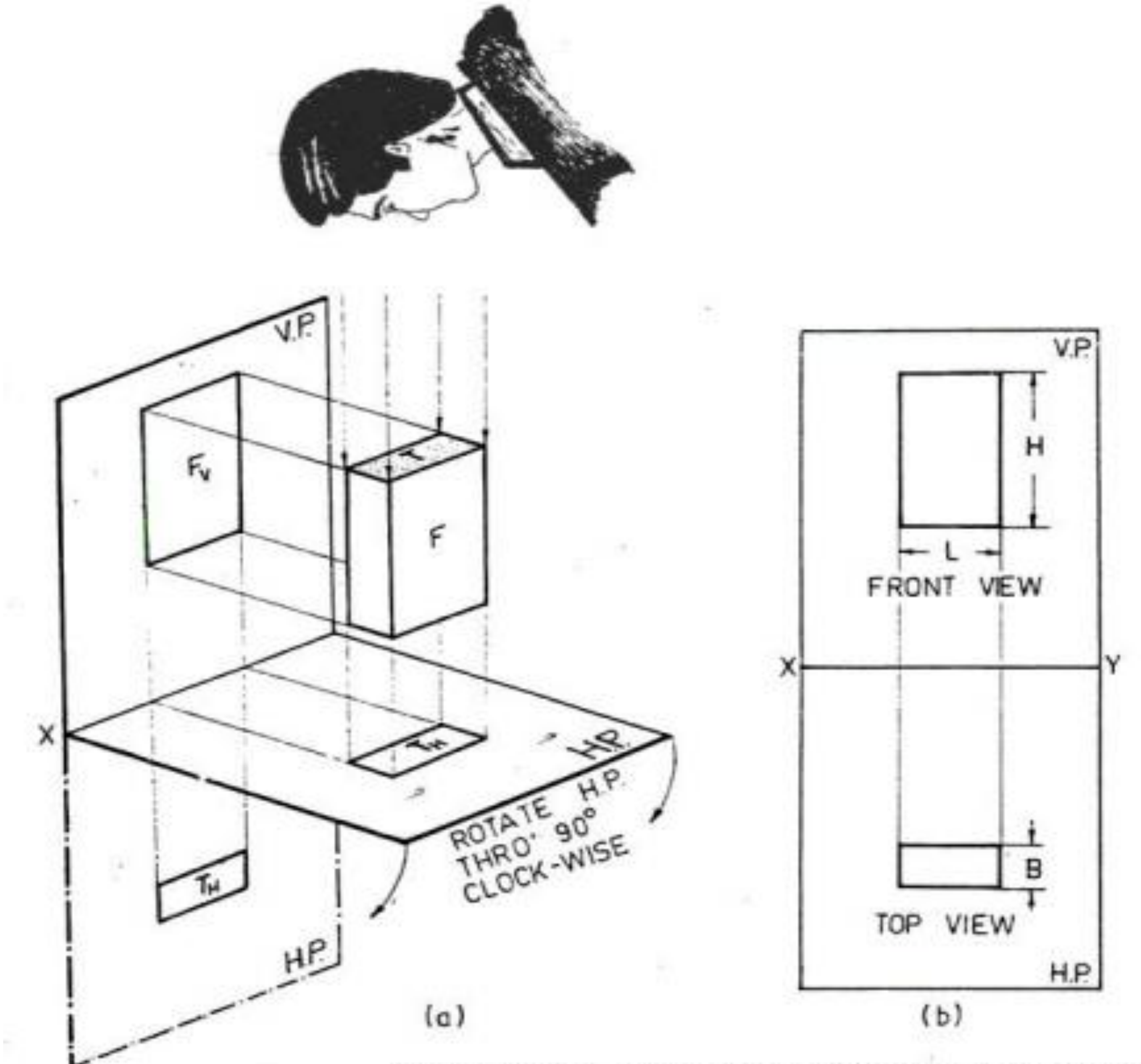


(b)

ORTHOGRAPHIC PROJECTION

Horizontal Plane

As front view alone is insufficient for the complete description of the object, let us assume another plane, called Horizontal plane (H.P.) hinged perpendicular to V.P.



ORTHOGRAPHIC PROJECTIONS (FRONT & TOP VIEWS)

ORTHOGRAPHIC PROJECTION

XY Line

The line of intersection of V.P. and H.P. is called the Reference Line and denoted as XY.

ORTHOGRAPHIC PROJECTION

TERMINOLOGY

1. V.P. and H.P. are called as principle planes of projection or reference planes.
2. They are always transparent and at right-angles to each other.
3. The projection on V.P. is Front view
4. The projection on H.P. is Top view

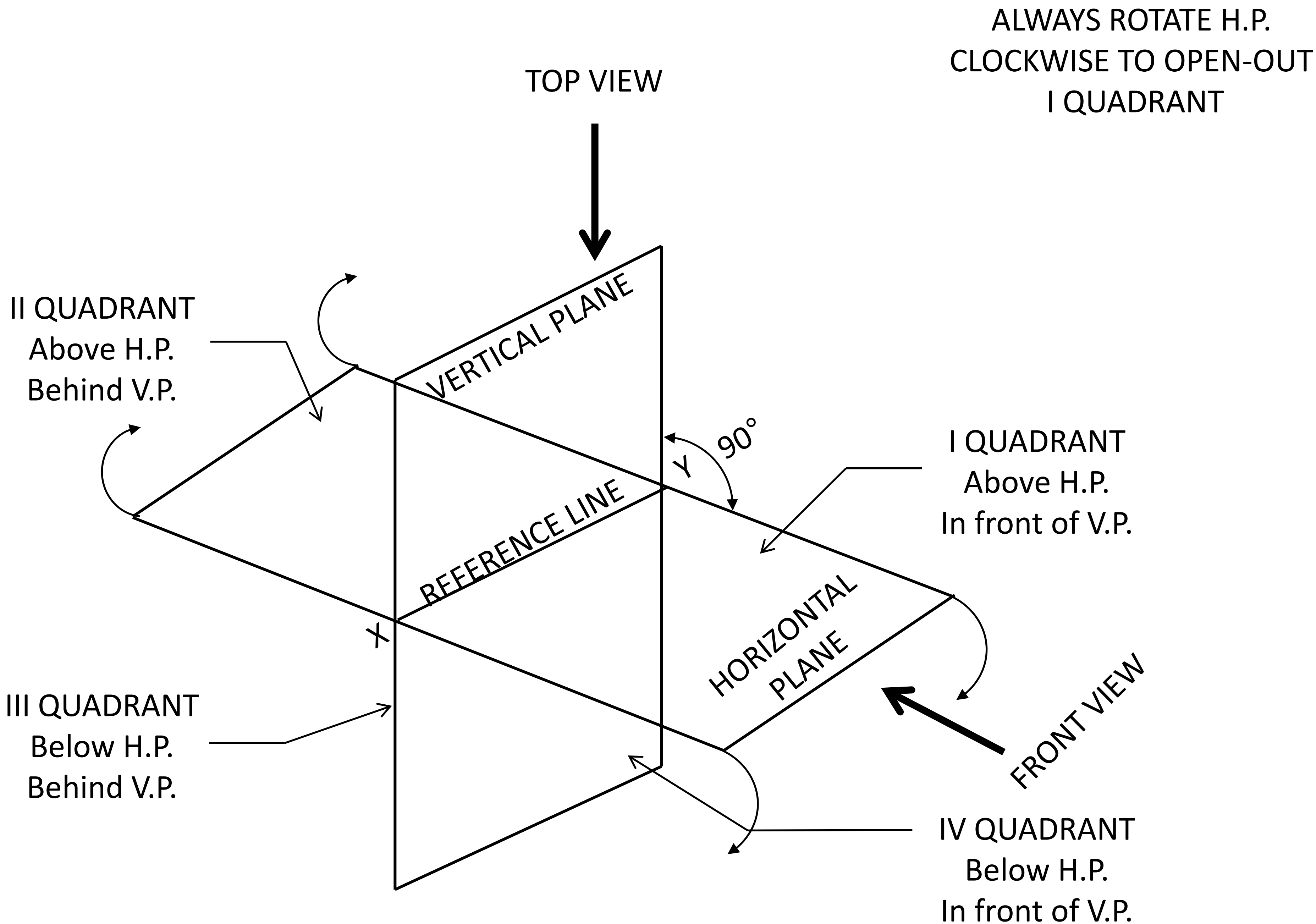
ORTHOGRAPHIC PROJECTION

FOUR QUADRANTS

When the planes of projections are extended beyond their line of intersection, they form Four Quadrants or Dihedral Angles.

POSITION OF THE OBSERVER

The observer will always be in the right side of the four quadrants.


ALWAYS ROTATE H.P.
CLOCKWISE TO OPEN-OUT
I QUADRANT
TOP VIEW
II QUADRANT
Above H.P.
Behind V.P.
VERTICAL PLANE
90°
Y
I QUADRANT
Above H.P.
In front of V.P.
REFERENCE LINE
X
HORIZONTAL
PLANE
III QUADRANT
Below H.P.
Behind V.P.
FRONT VIEW
IV QUADRANT
Below H.P.
In front of V.P.

ORTHOGRAPHIC PROJECTION

FIRST ANGLE PROJECTION

when the object is situated in first quadrant, that is in front of V.P. and above H.P. the projection obtained on these planes is called First Angle Projection.

ORTHOGRAPHIC PROJECTION

FIRST ANGLE PROJECTION

1. The object lies in between the observer and the plane of projection.

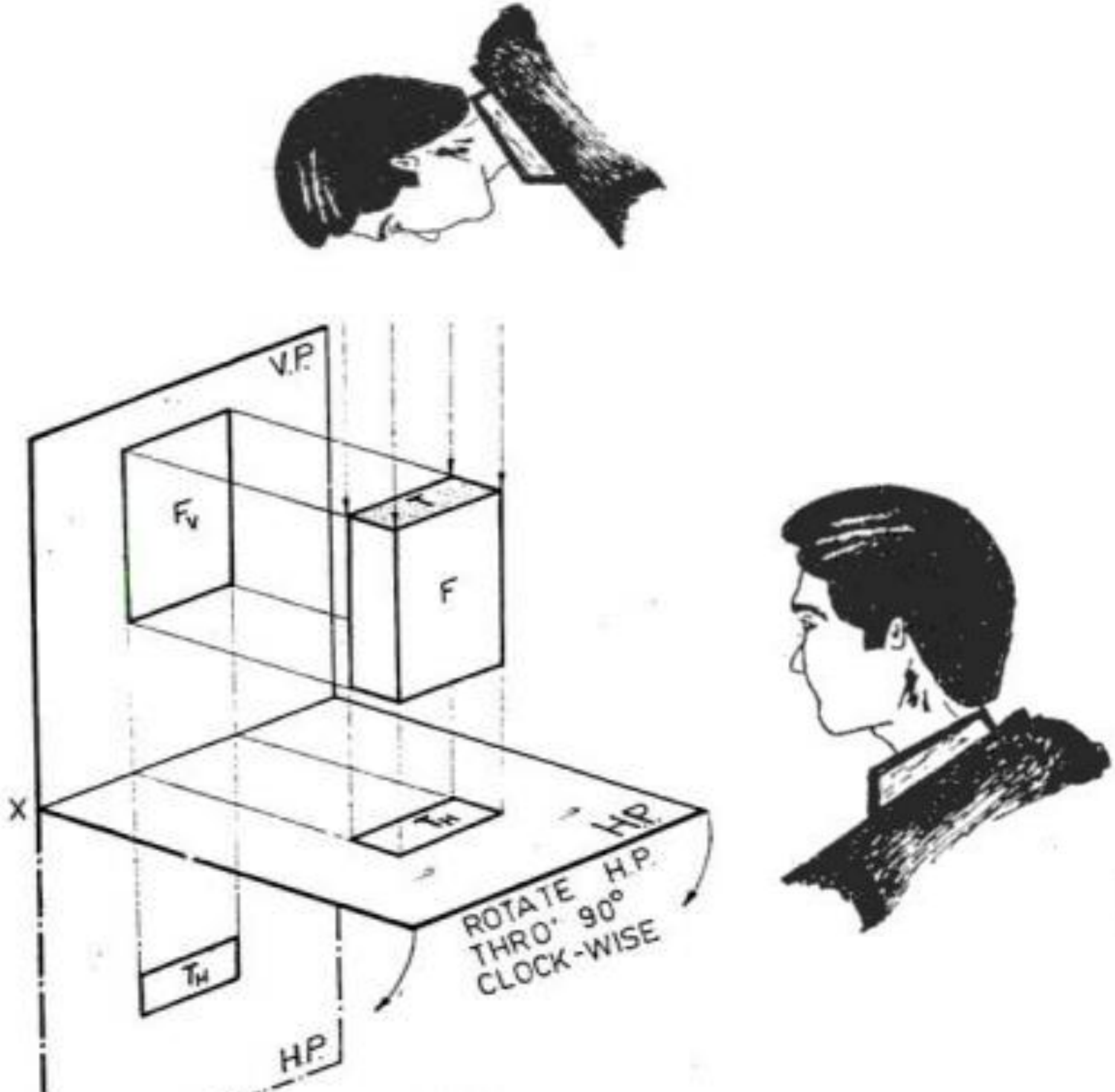
2. The front view is drawn above the XY line and the. top view below XY. (Here, above XY line represents V.P. and below XY line represents H.P.).

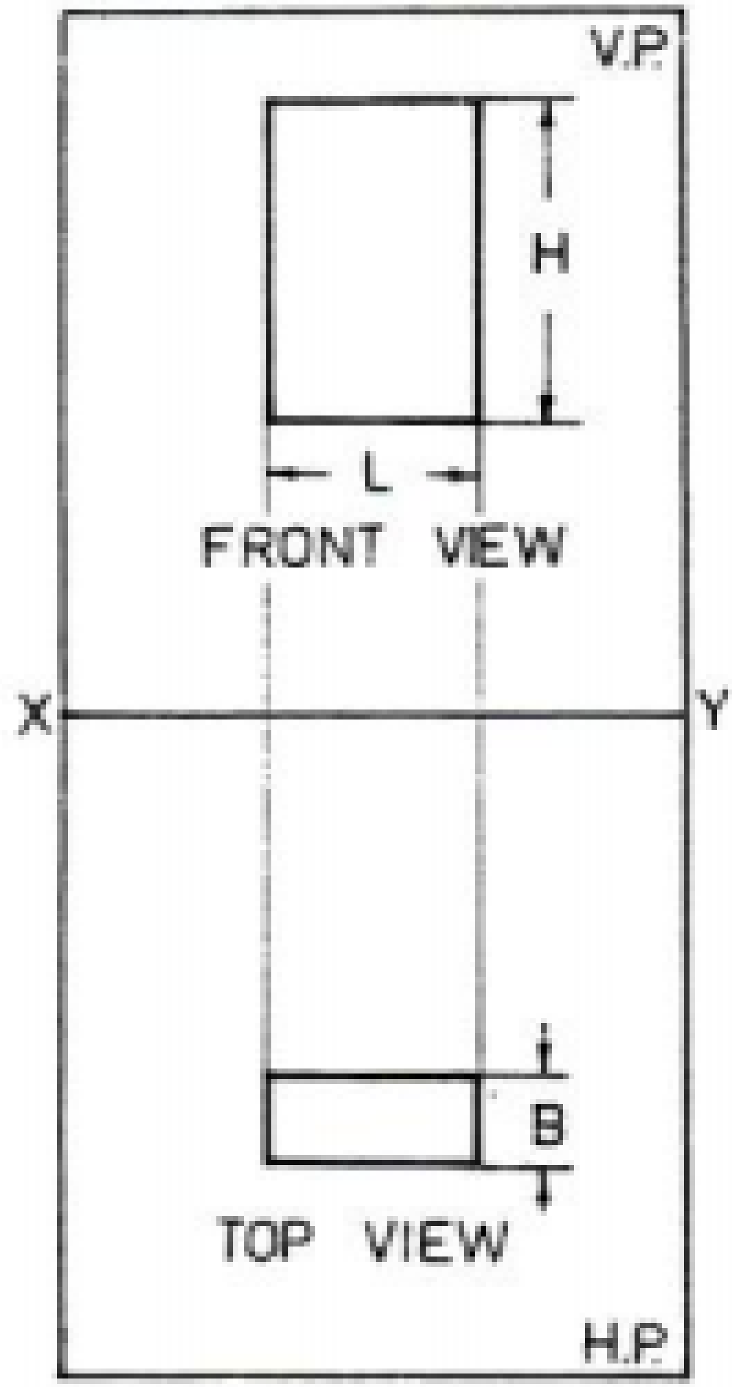
ORTHOGRAPHIC PROJECTION

FIRST ANGLE PROJECTION

3. In the front view, H.P. coincides with XY line and in top view V.P. coincides with XY line.

4. Front View shows the length (L) and height (H) of an object. Top View shows the length (L) and breadth (B) or width (W) or thickness (T) of it.





(a)

ORTHOGRAPHIC PRO.

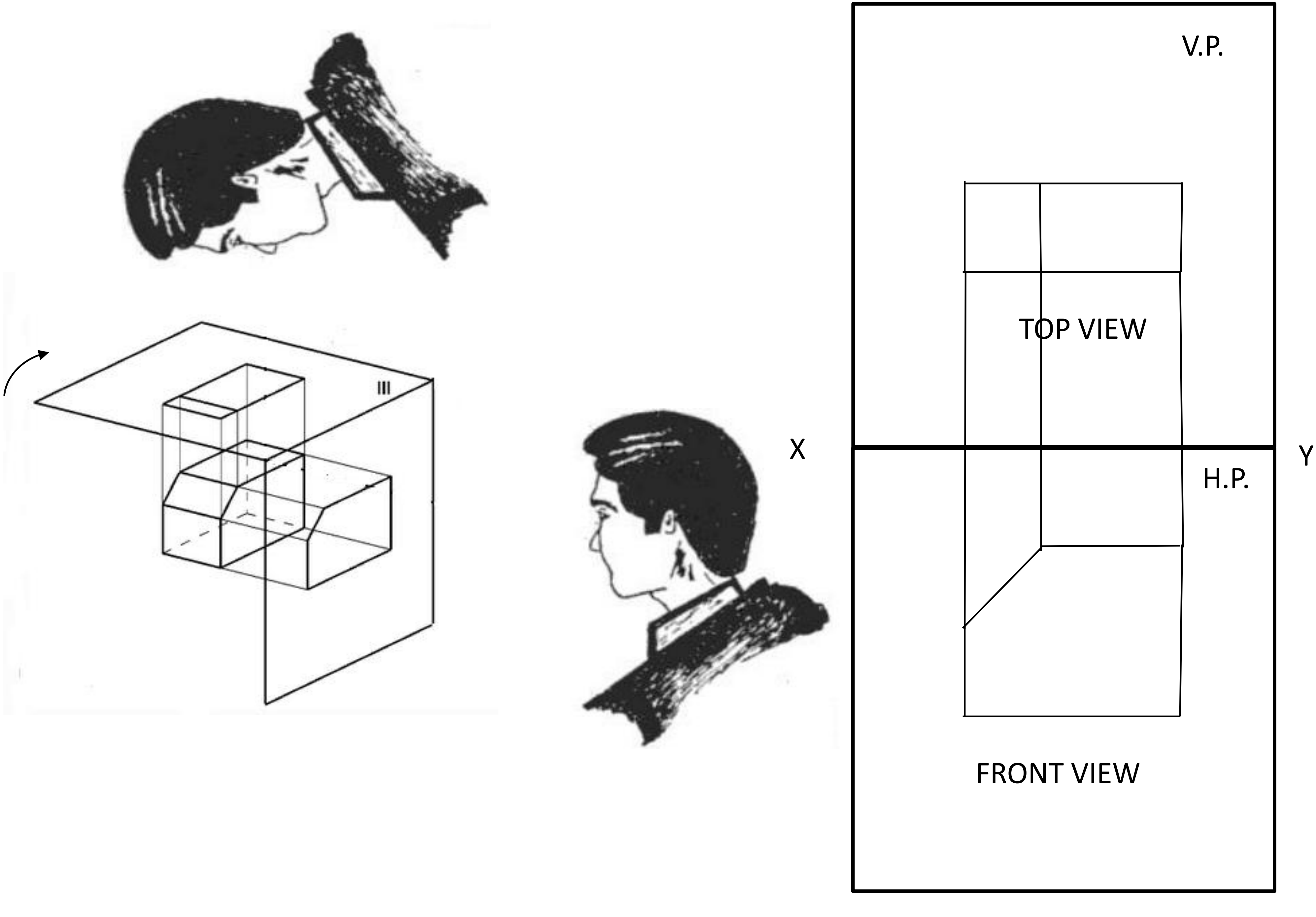
ORTHOGRAPHIC PROJECTION

THIRD ANGLE PROJECTION

In this the object is situated in Third Quadrant. The planes of projection lie between the object and the observer.

The front view comes below the XY line and the top view above it.

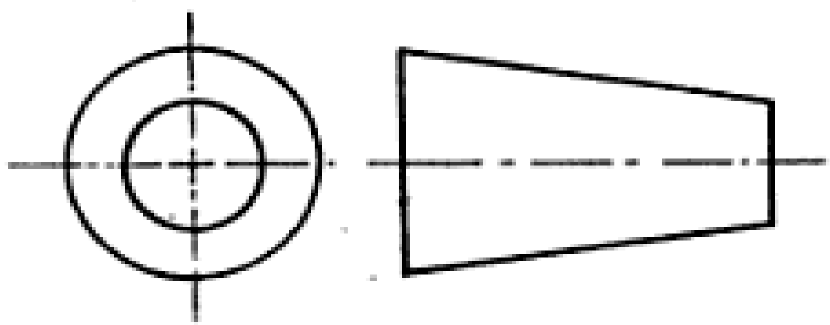
The top view above the XY line.


III
V.P.
TOP VIEW
X
Y
H.P.
FRONT VIEW

ORTHOGRAPHIC PROJECTION

First Angle Projection

1. Object lies between observer and the planes of projection.
2. Front View comes above top view.
3. Object is situated on or above the H.P.
4. Symbol:

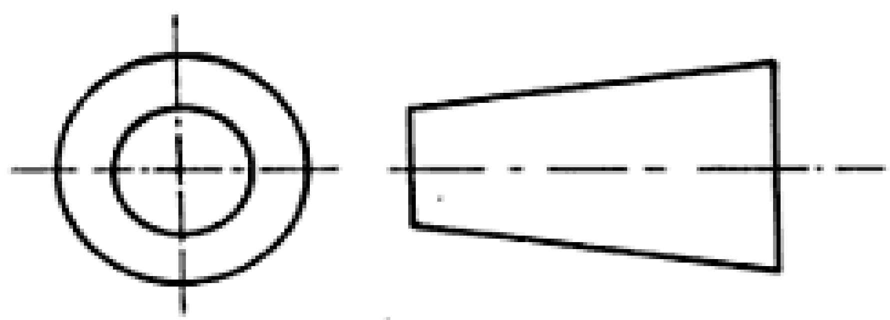


Third Angle Projection

(See fig.9.6) Planes of projection lie between the object and observer.

Top View comes above front view.

Object is situated on or above the ground.



ORTHOGRAPHIC PROJECTION

AUXILIARY VERTICAL PLANE (A.V.P.)

1. Auxiliary vertical plane is perpendicular to both V.P. and H.P.

2. Front view is drawn by projecting the object on the V.P.

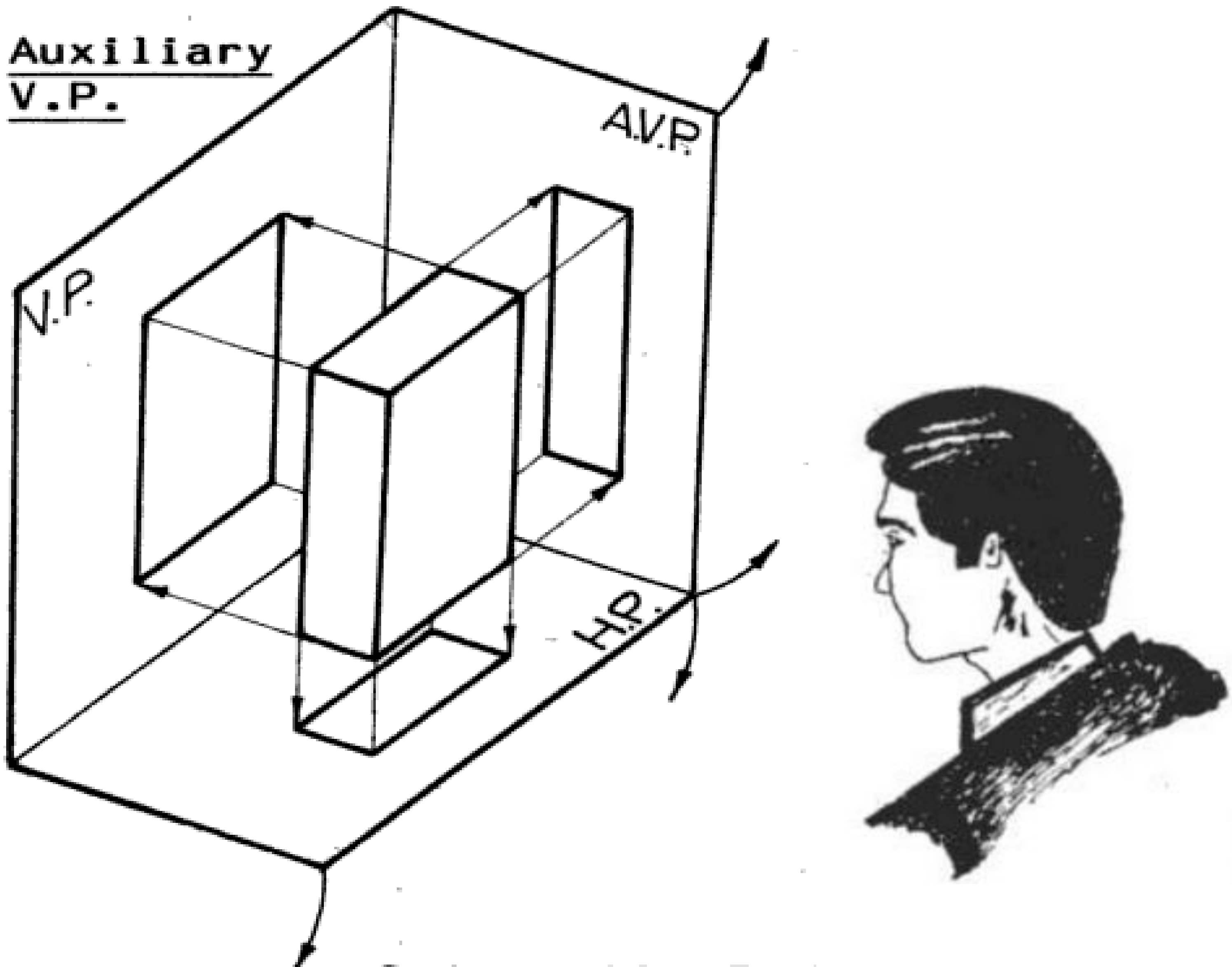
ORTHOGRAPHIC PROJECTION

AUXILIARY VERTICAL PLANE (A.V.P.)

3. Top view is drawn by projecting the object on the H.P.

4. The projection on the A.V.P. as seen from left of the object and drawn on the right of the front view, is called Left side view.

AUXILIARY VERTICAL PLANE (A.V.P.)



ORTHOGRAPHIC PROJECTION

How to draw the Side View?

1. Rotate the A.V.P. In the direction of the arrow shown, so as to make it to coincide with the V.P.

2. Looking the object from the left, the left side view is obtained and drawn on the right side of the front view.

AUXILIARY VERTICAL PLANE (A.V.P.)

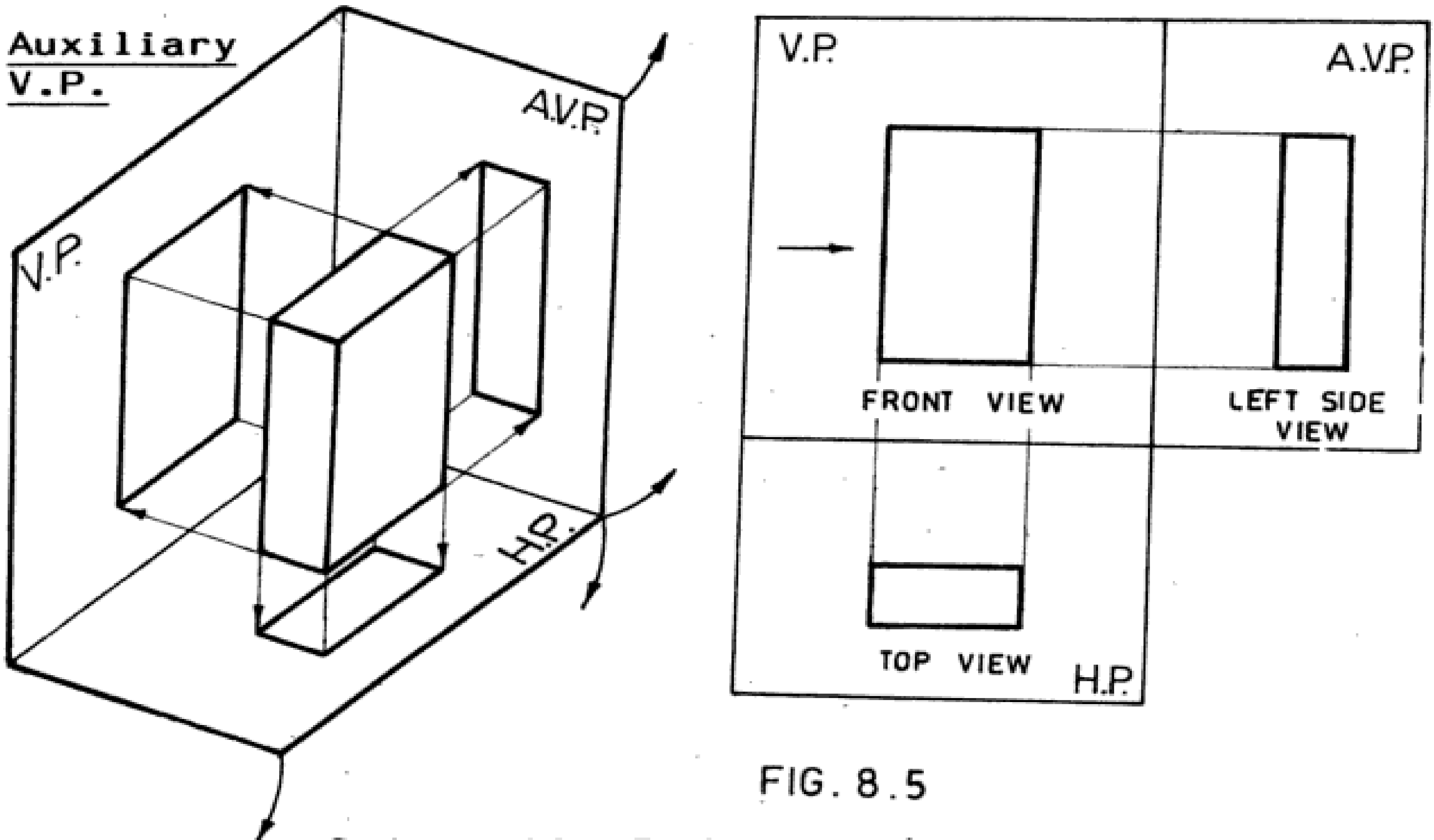


FIG. 8.5

Orthographic Projections (Front, Top and Left side views)

ORTHOGRAPHIC PROJECTION

RULE: In First Angle Projection

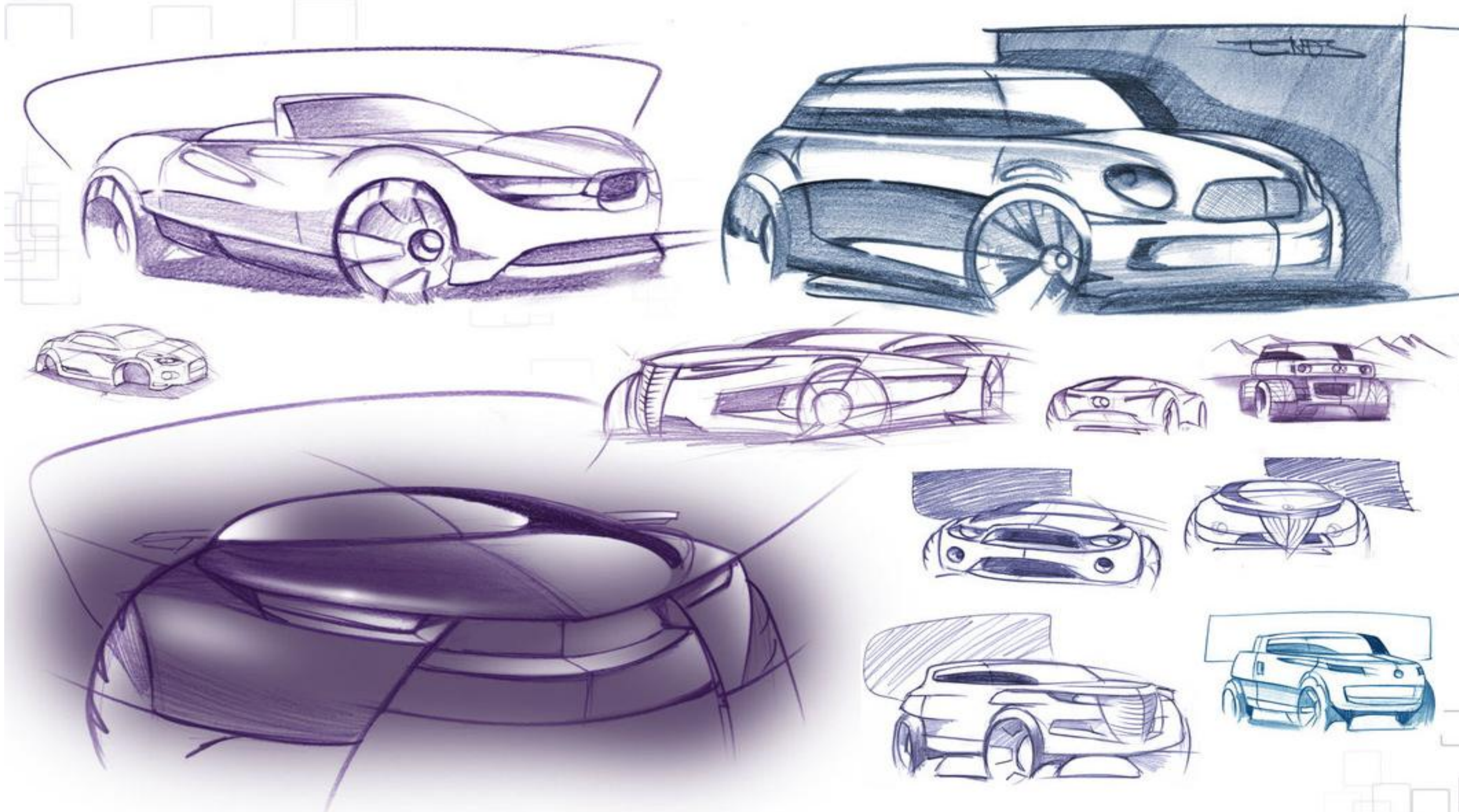
1. A.V.P. is positioned on the right side of the V.P. to obtain the left side view.

2. A.V.P. is positioned on the left side of the V.P. to obtain the right side view.

ORTHOGRAPHIC PROJECTION

RULE: In Third Angle Projection

1. (In Third Angle Projection, A.V.P. is positioned on the right side of the V.P. to obtain the right side view and vice-versa.)



FREEHAND SKETCHING

Freehand Sketching

1. A freehand sketch is a drawing made without the use of drawing instruments.

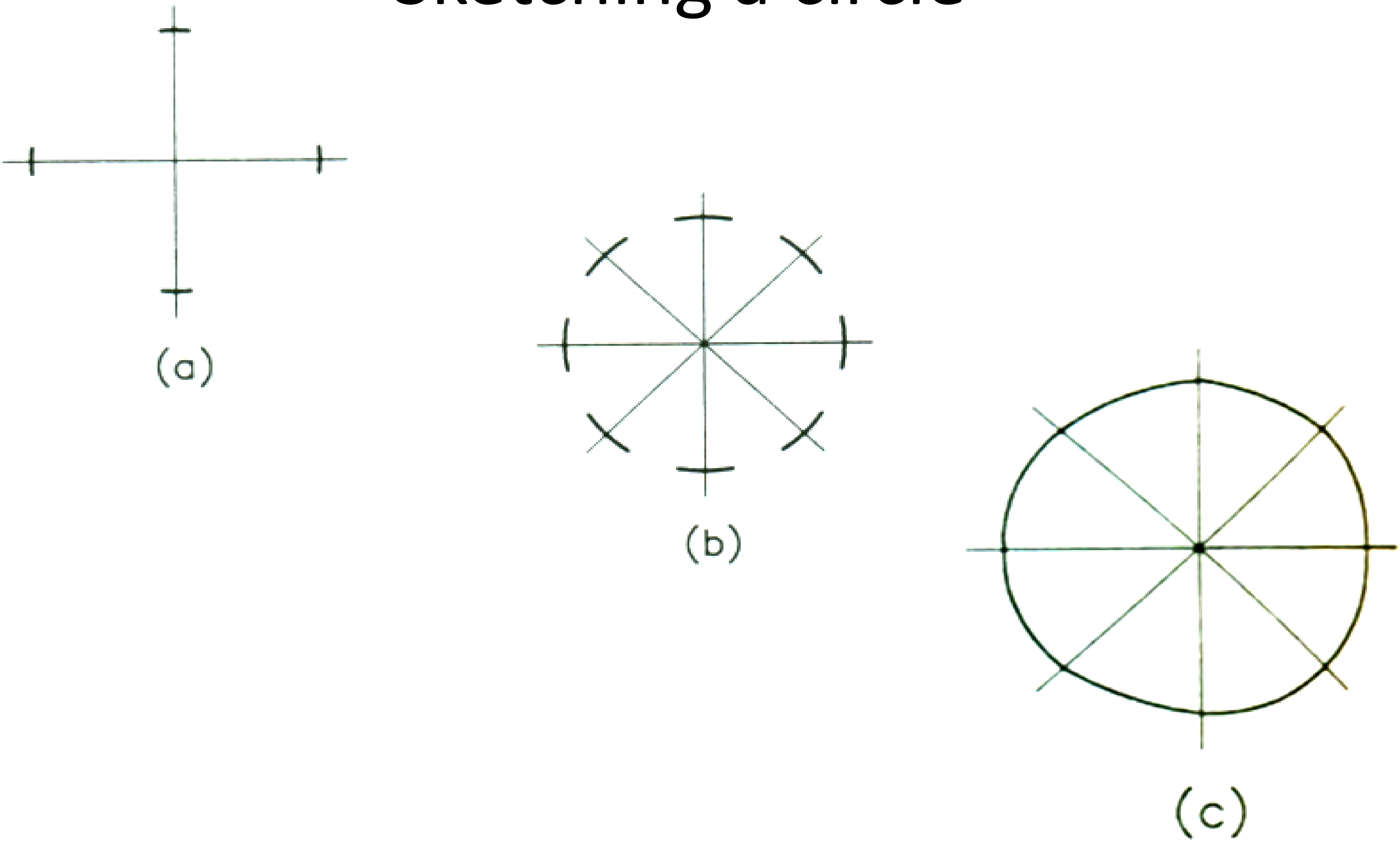
2. It is not drawn to scale, but should be in good proportion as accurately as possible by eye judgment.

Freehand Sketching

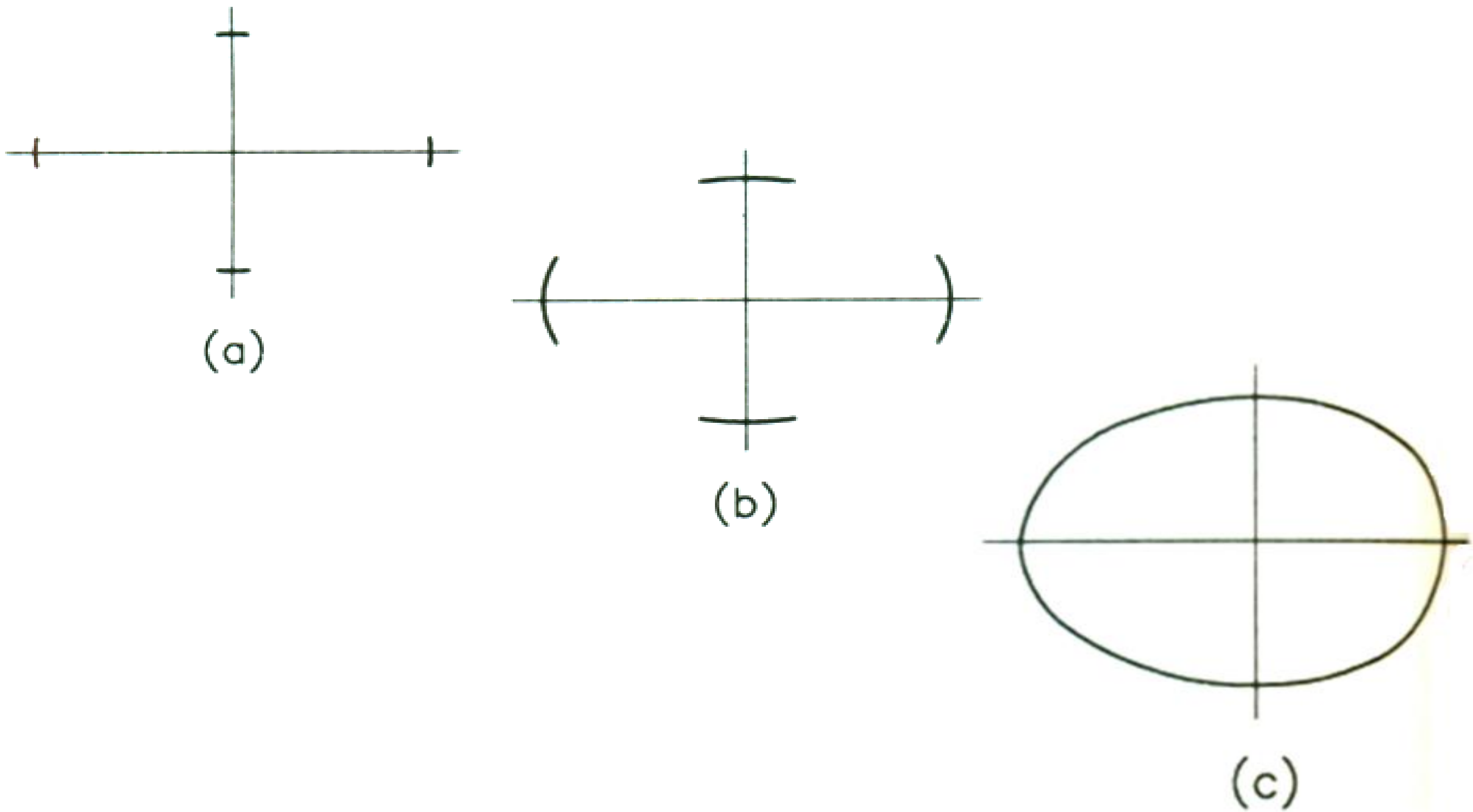
3. A freehand sketch should contain all the necessary details such as dimensions and actual shape.

4. HB pencil preferable.

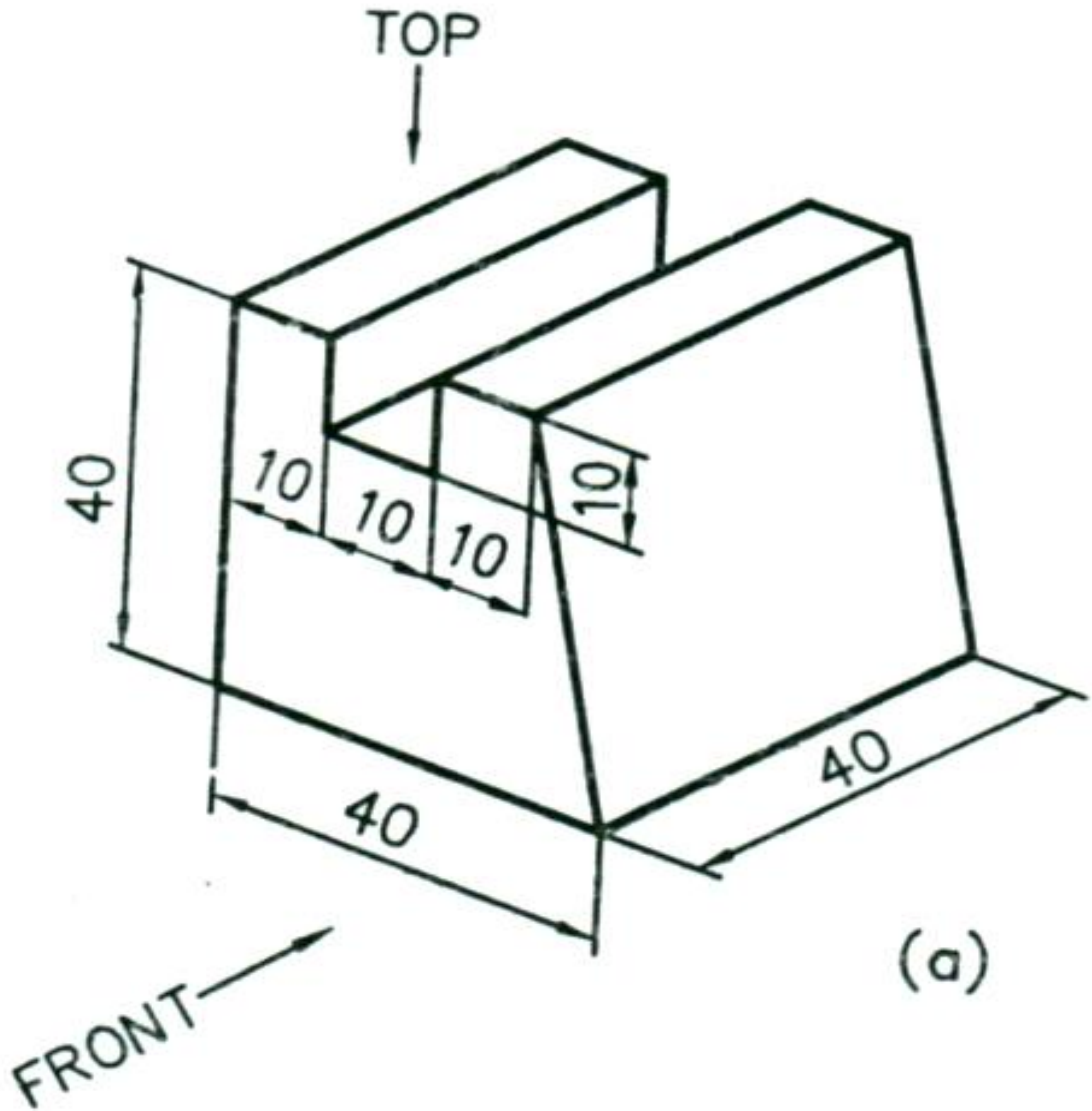
Sketching a circle



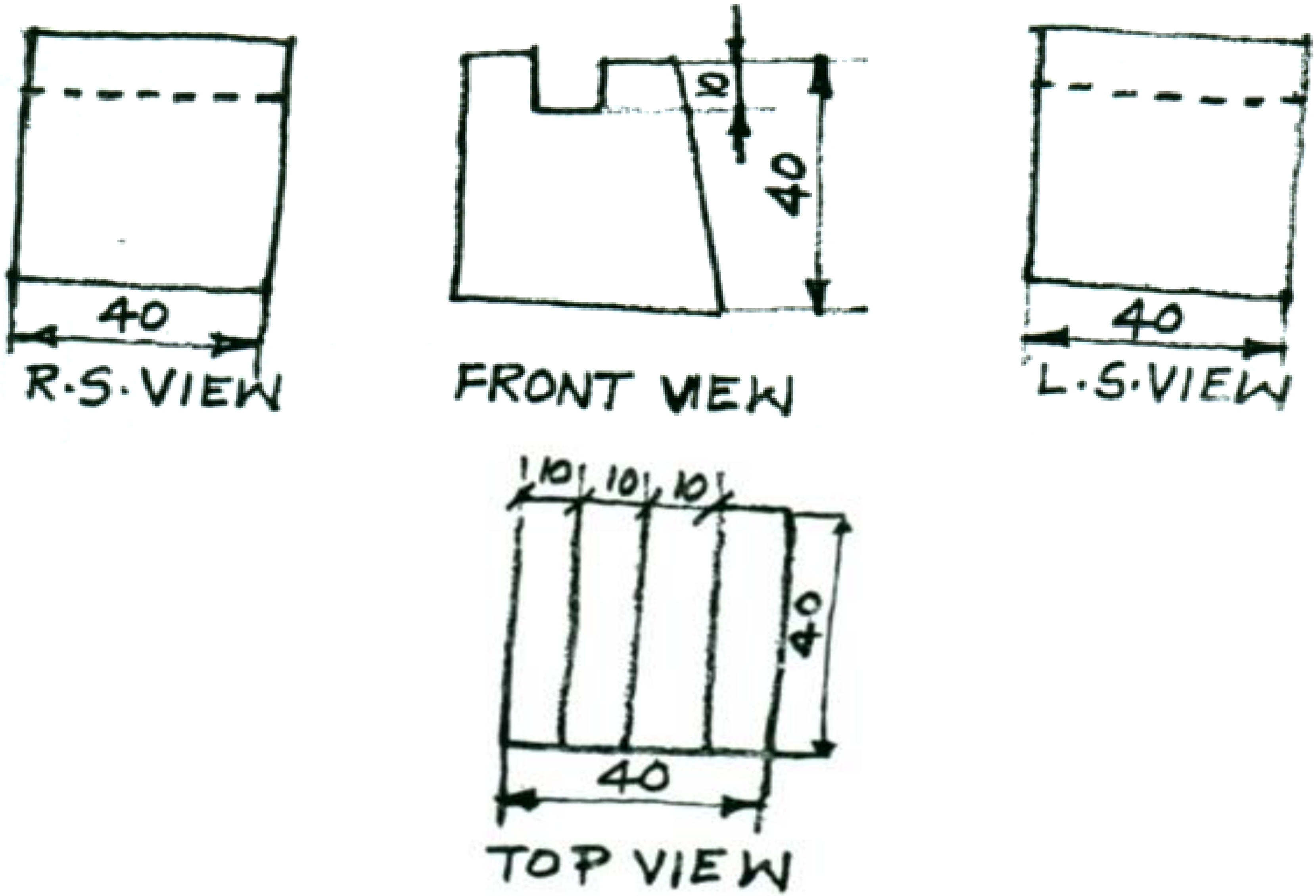
Sketching an ellipse



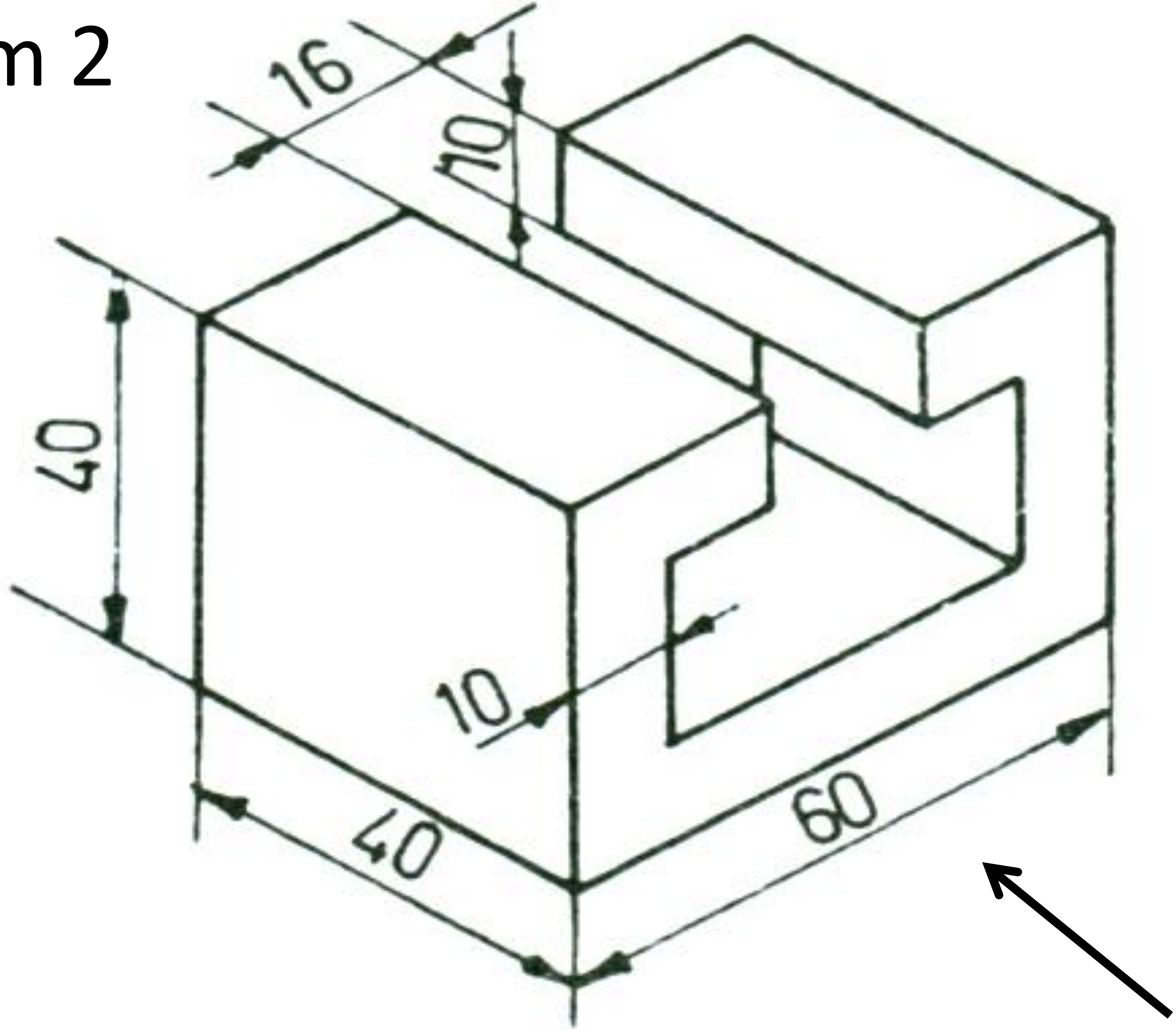
Problem 1



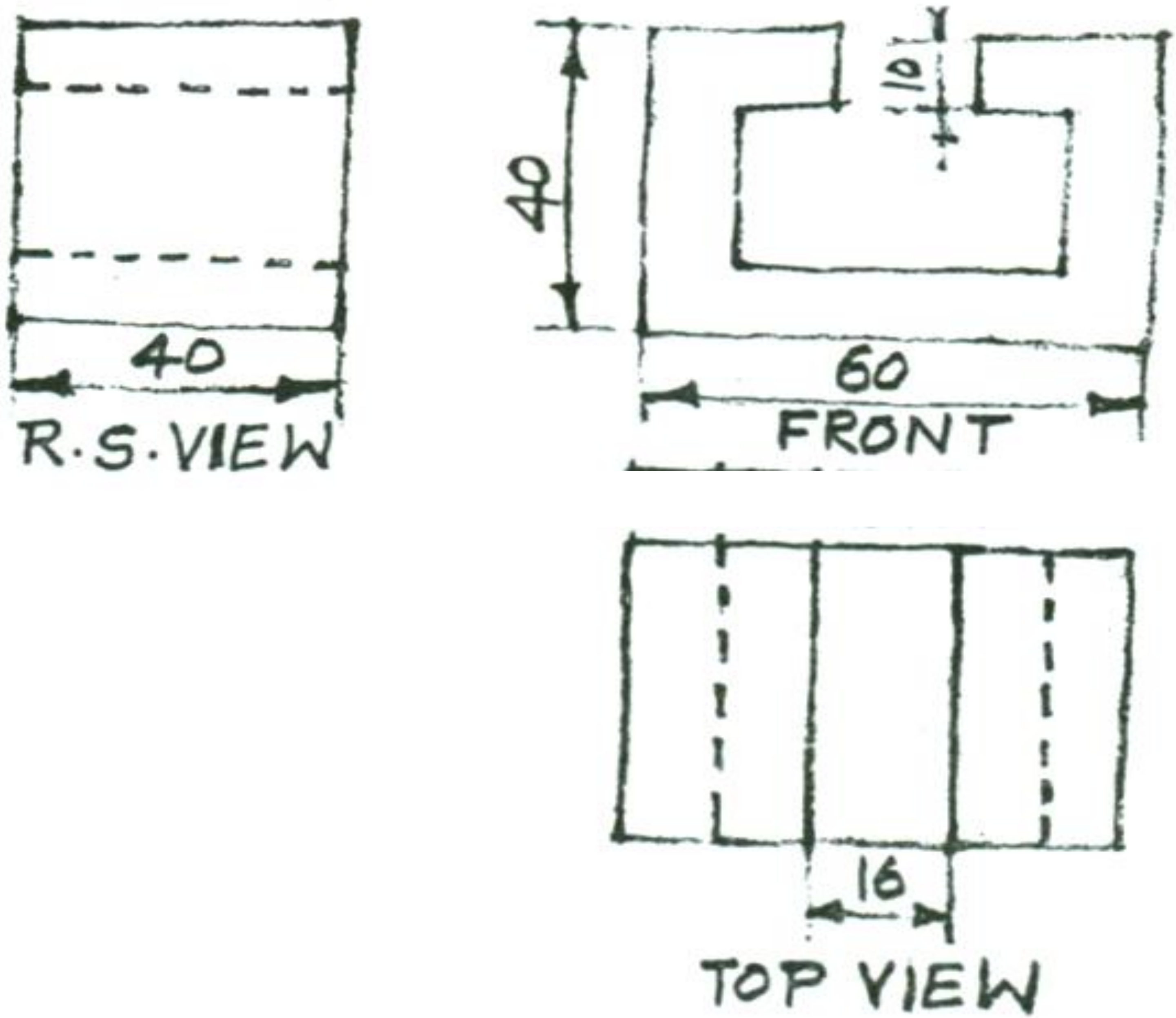
Problem 1



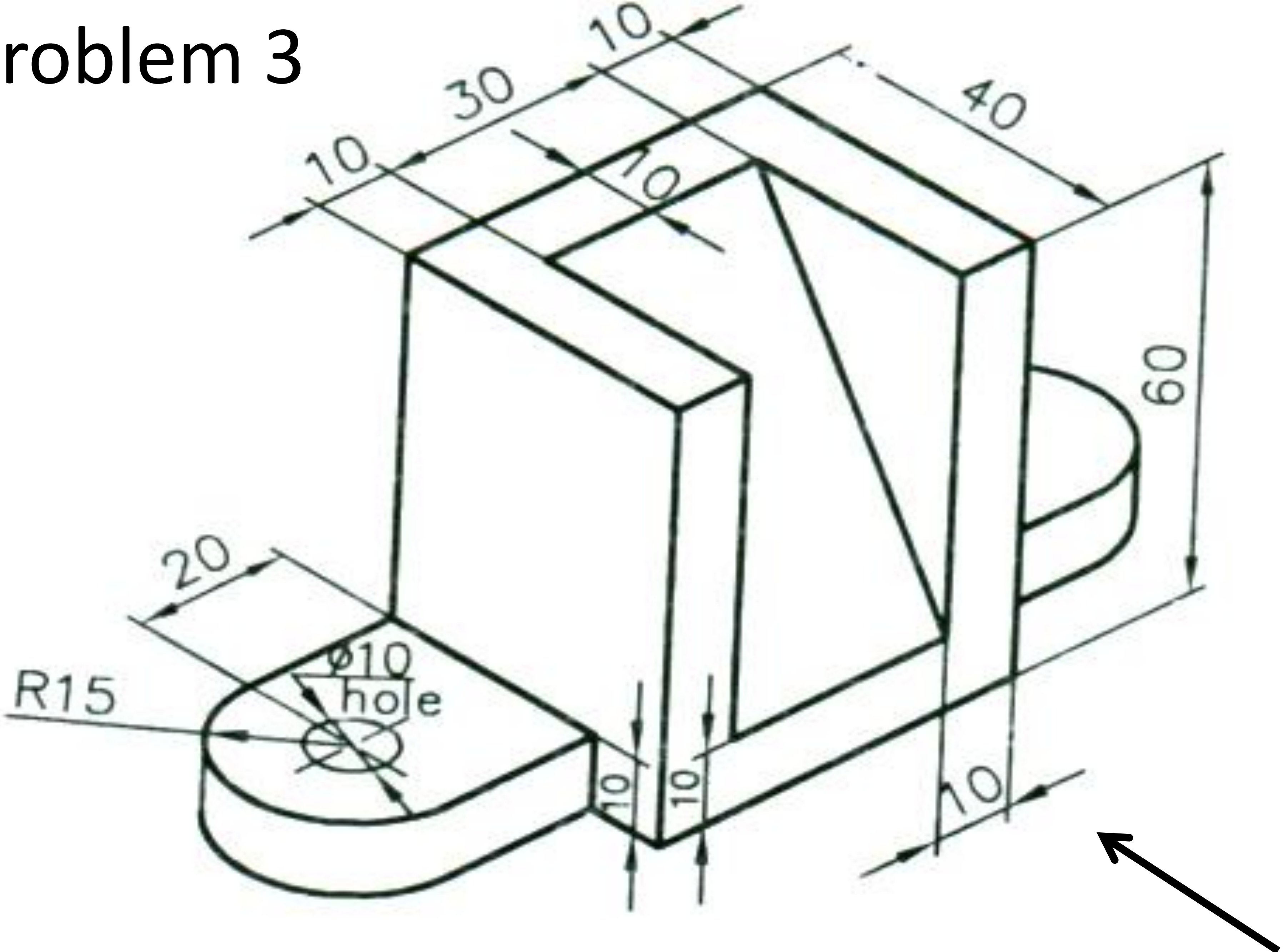
Problem 2



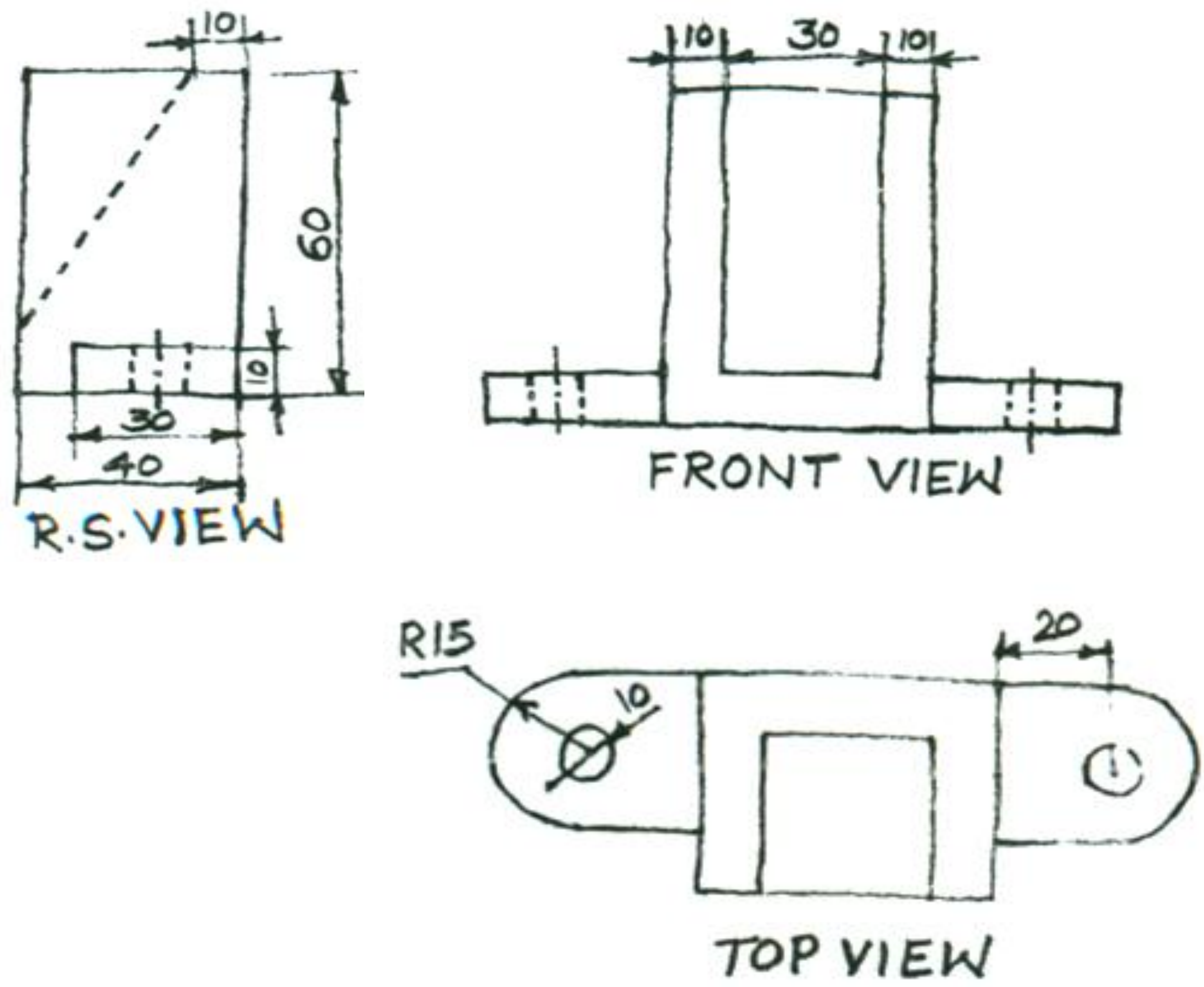
Problem 2



Problem 3



Problem 3



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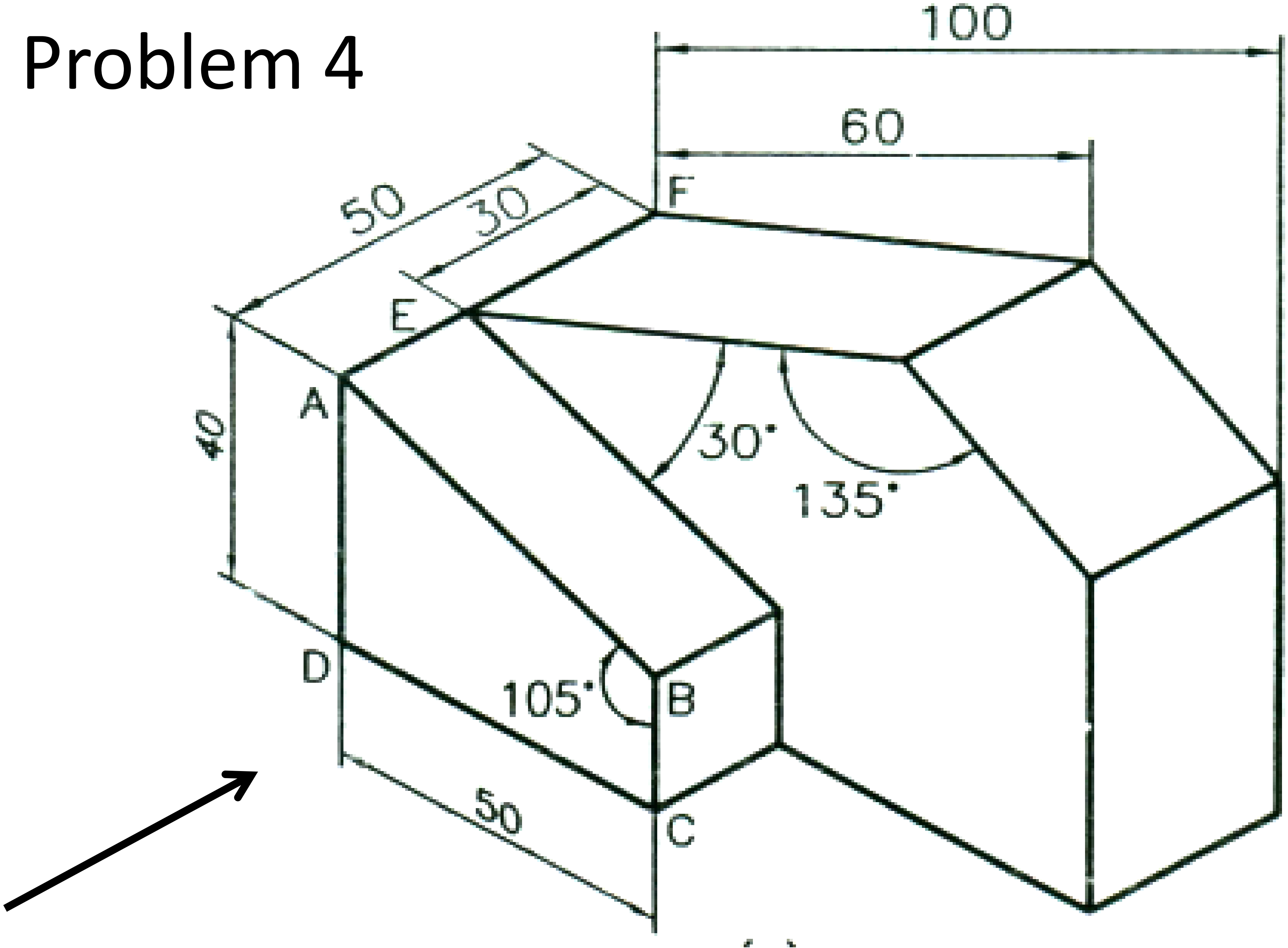

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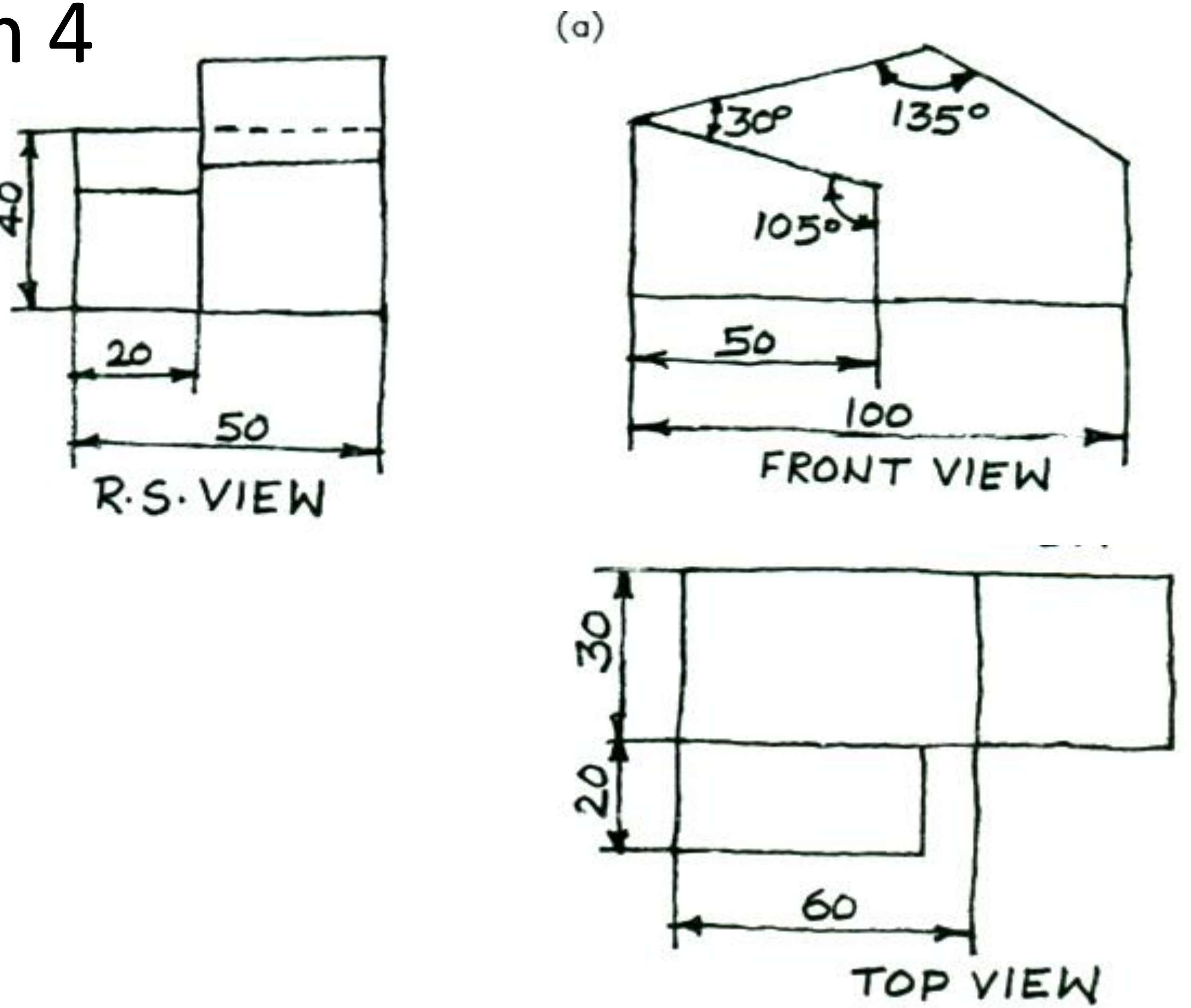
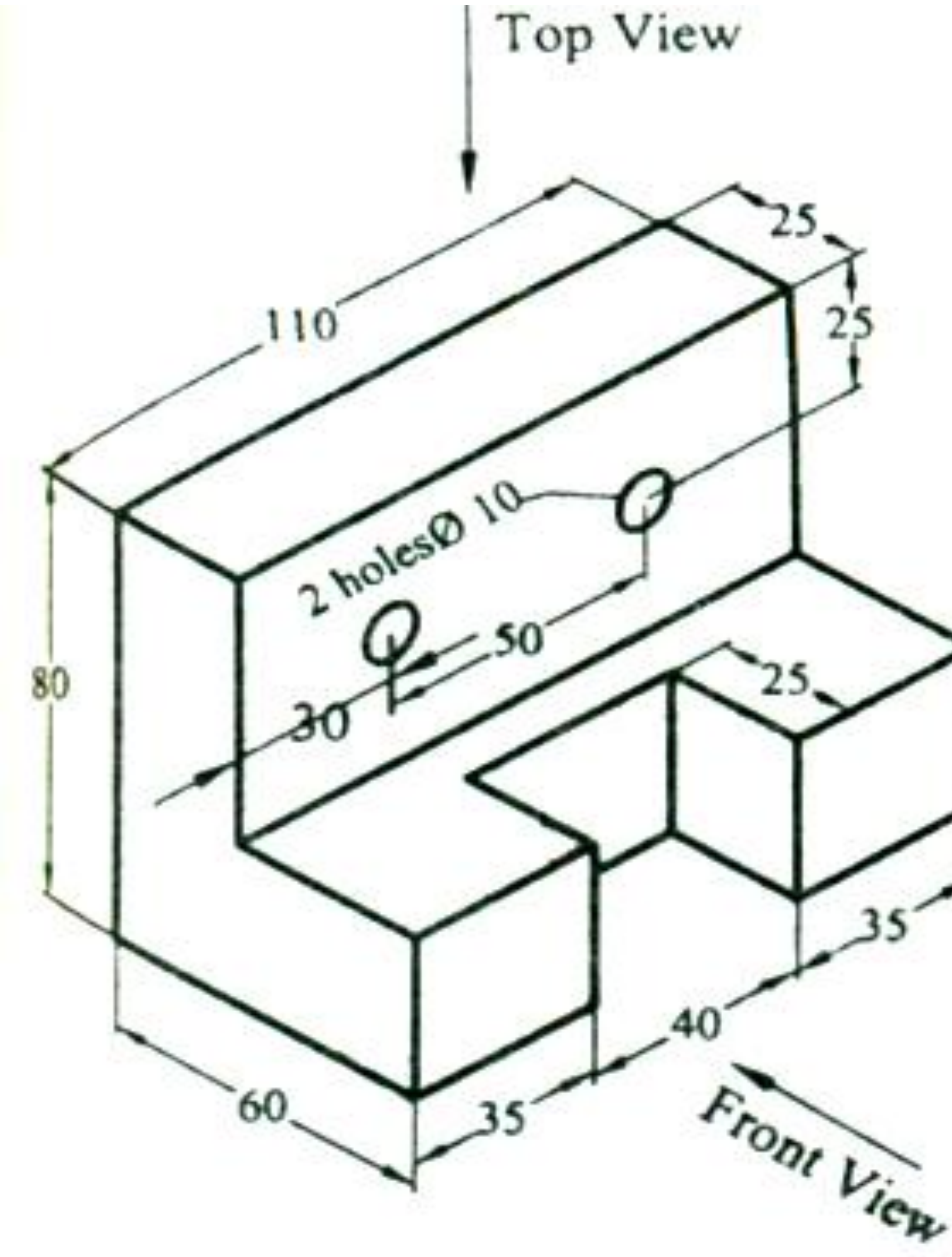
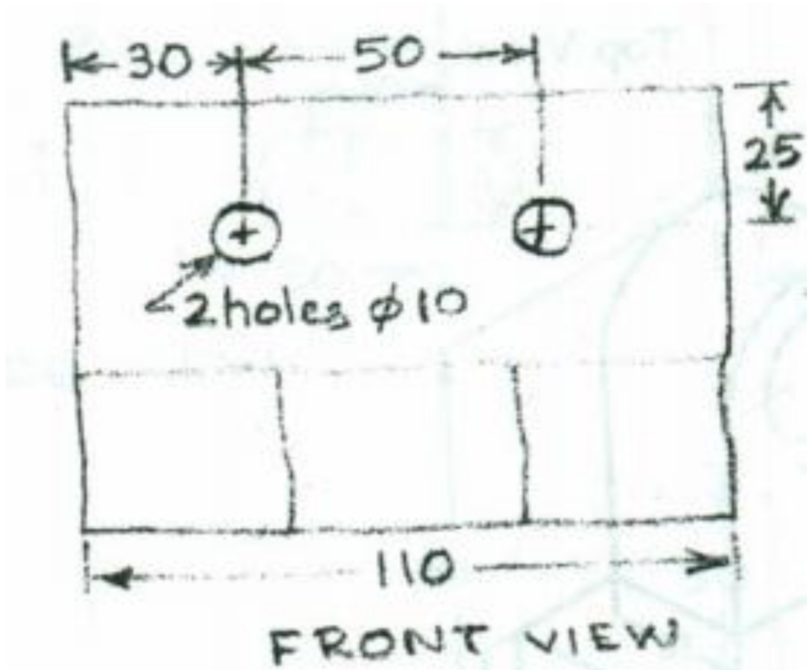


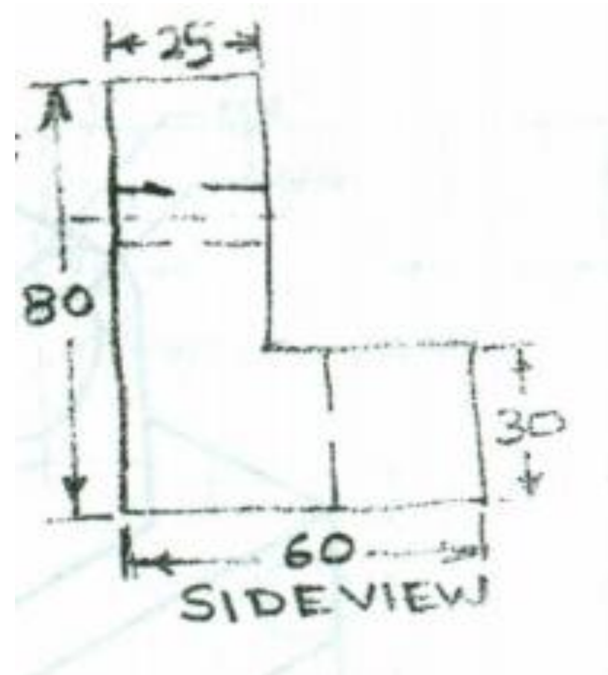
Problem 5



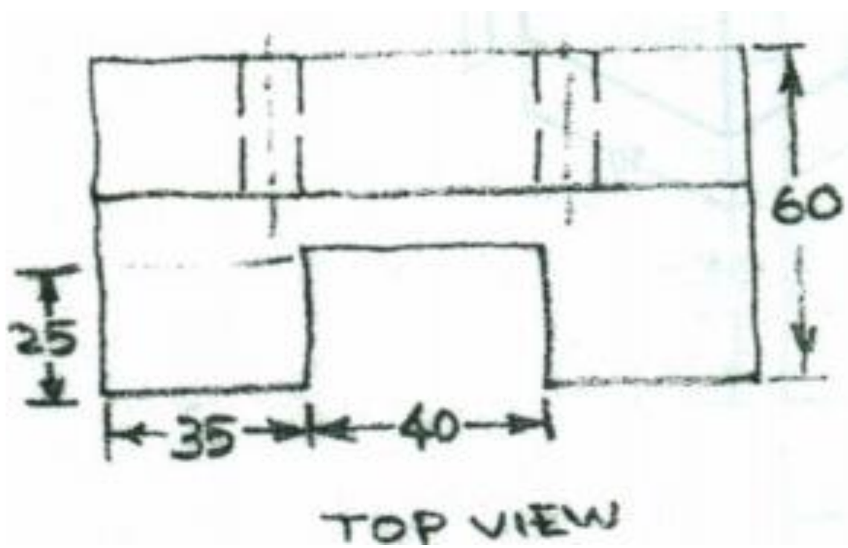
Problem 5



30
50
25
2 holes ϕ10
110
FRONT VIEW

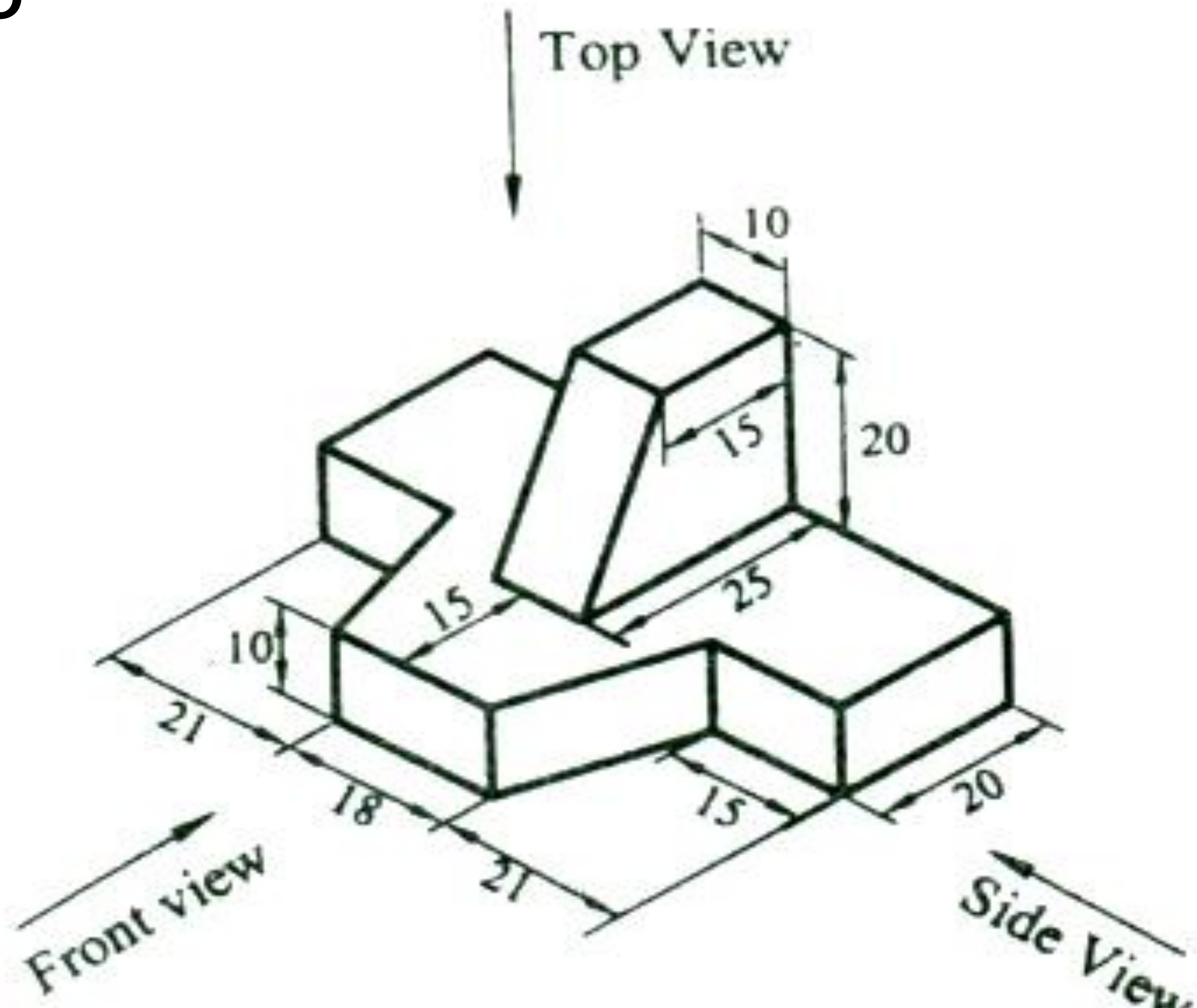


25
80
30
60
SIDEVIEW

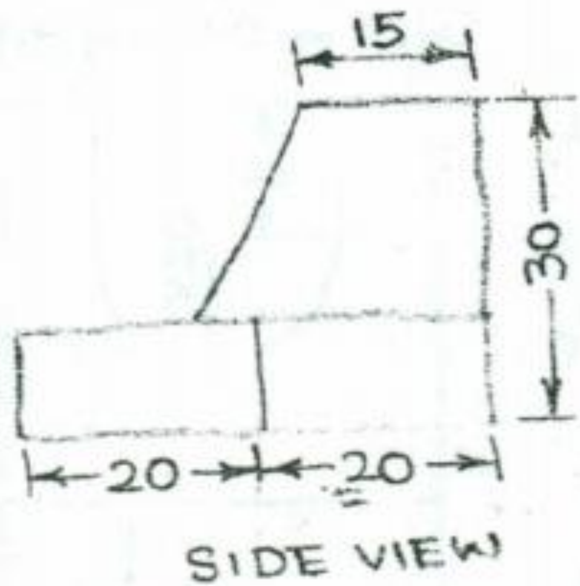


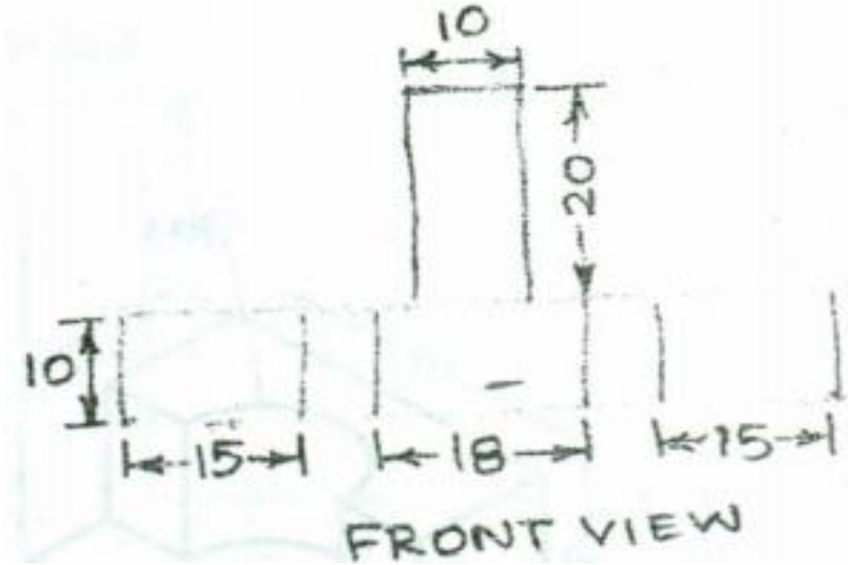
60
25
35
40
TOP VIEW

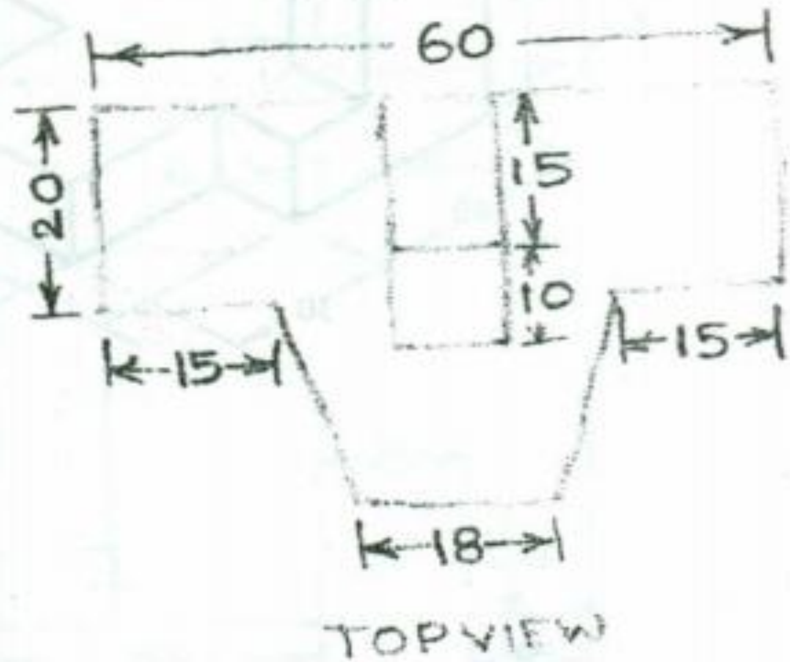
Problem 6



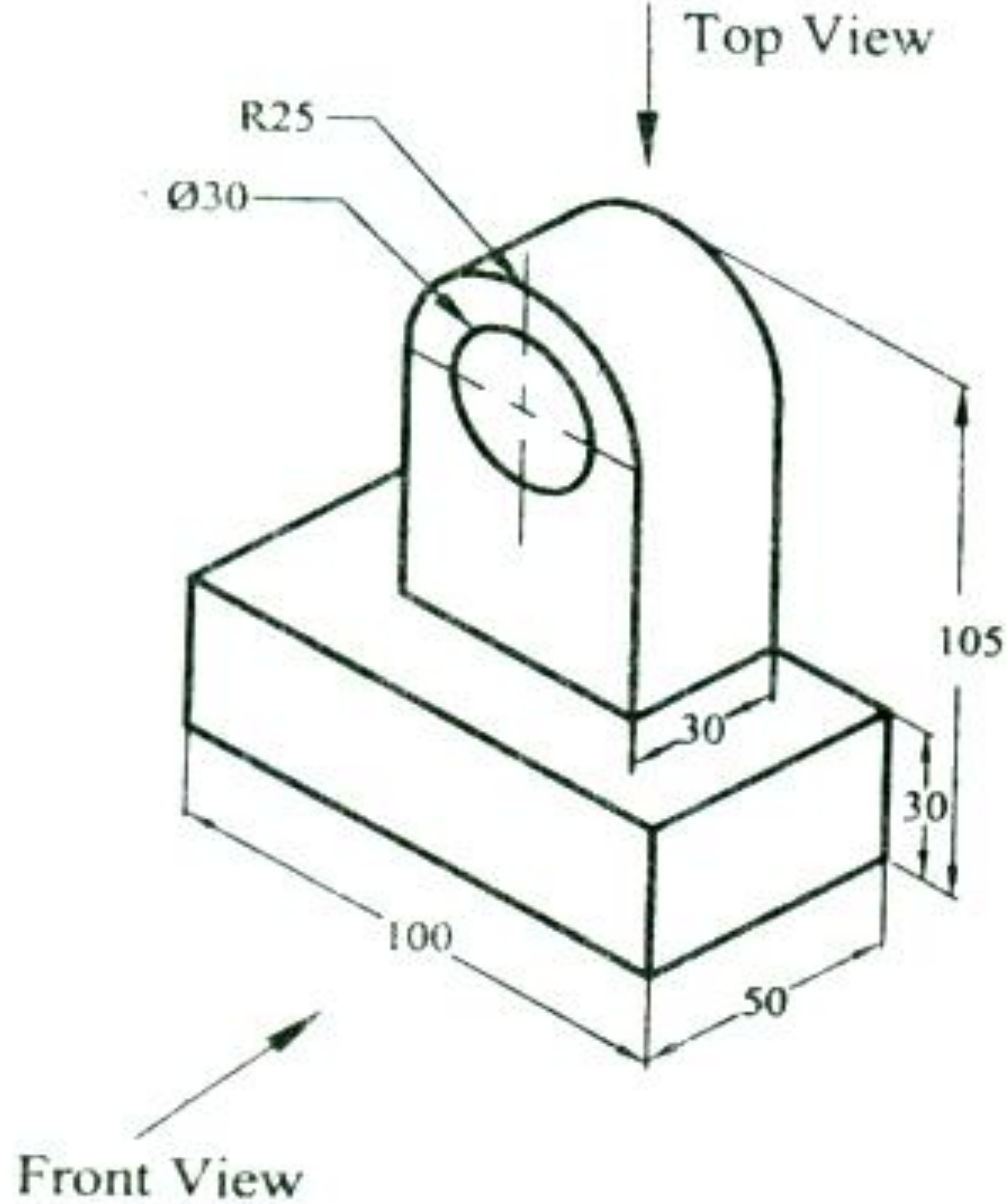
Problem 6


15
30
20
20
SIDE VIEW

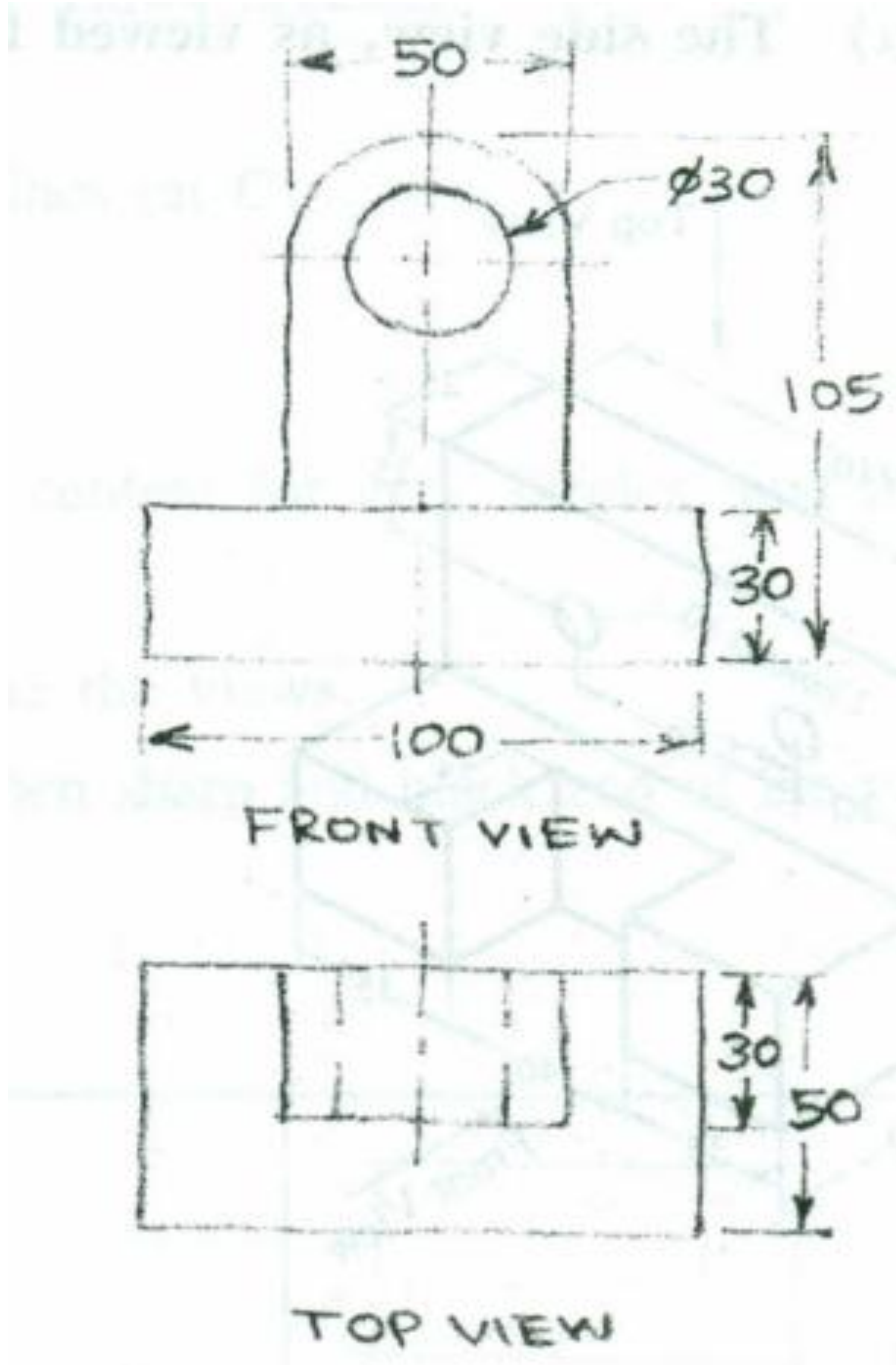

10
20
10
15
18
15
FRONT VIEW


60
20
15
10
15
15
18
TOP VIEW

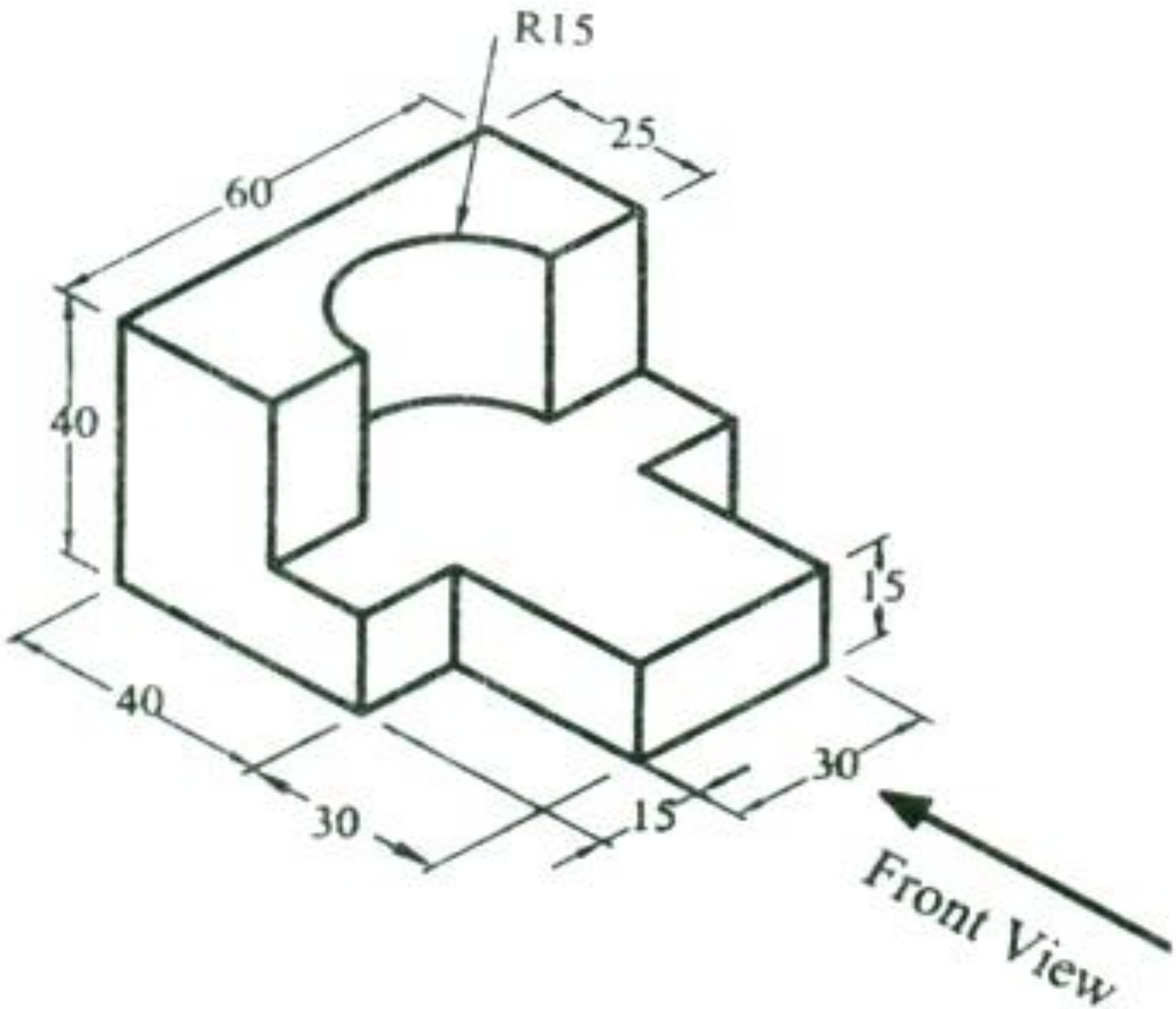
Problem 7



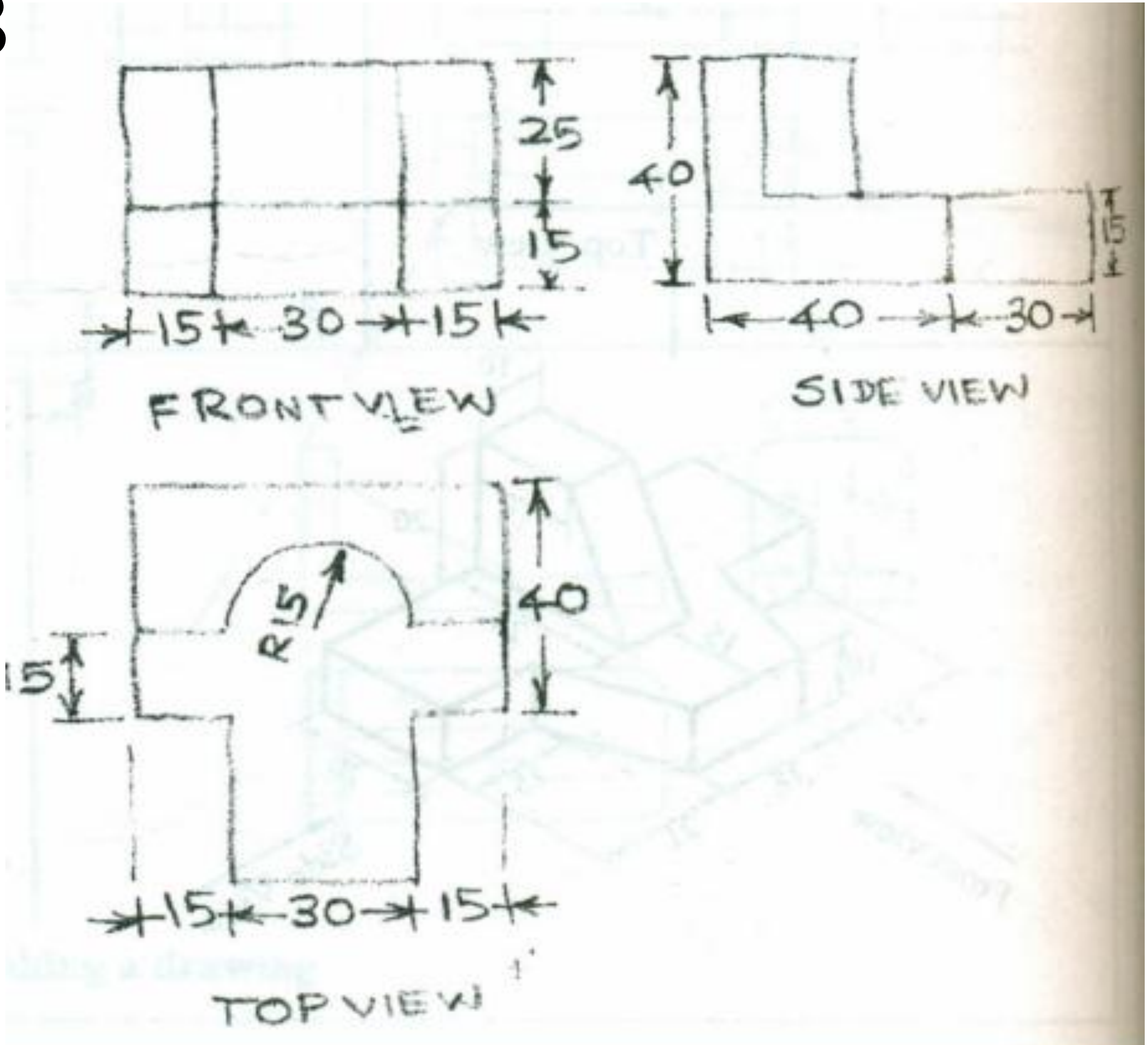
Problem 7



Problem 8

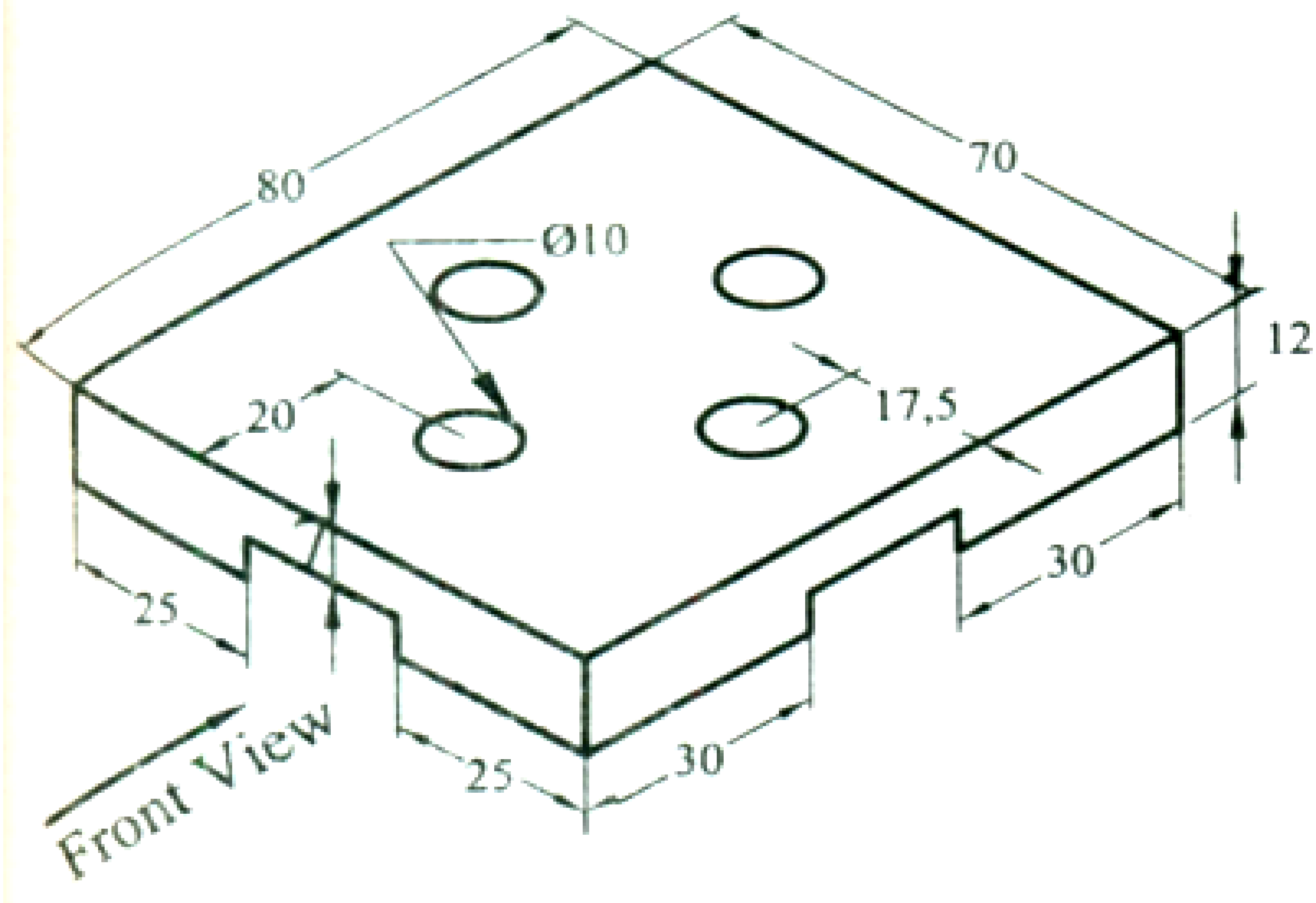


Problem 8

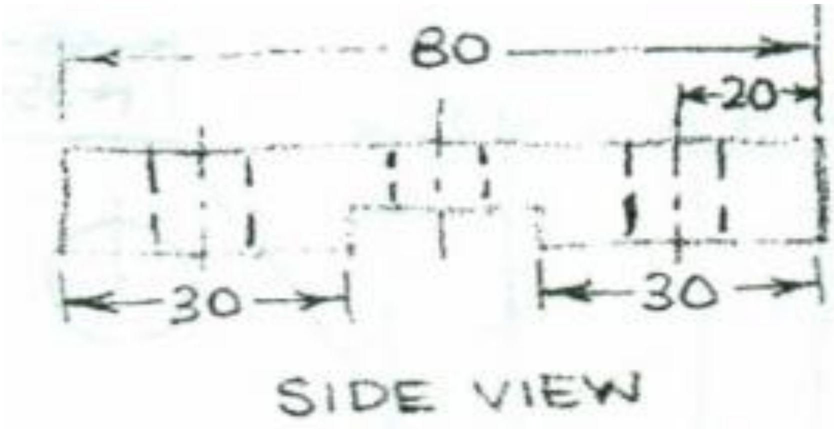


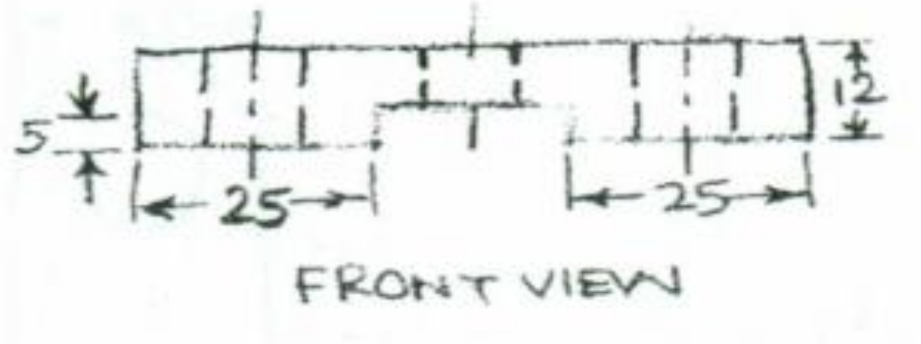
25
15
15
30
15
FRONT VIEW
40
15
40
30
SIDE VIEW
R15
40
15
15
30
15
TOP VIEW

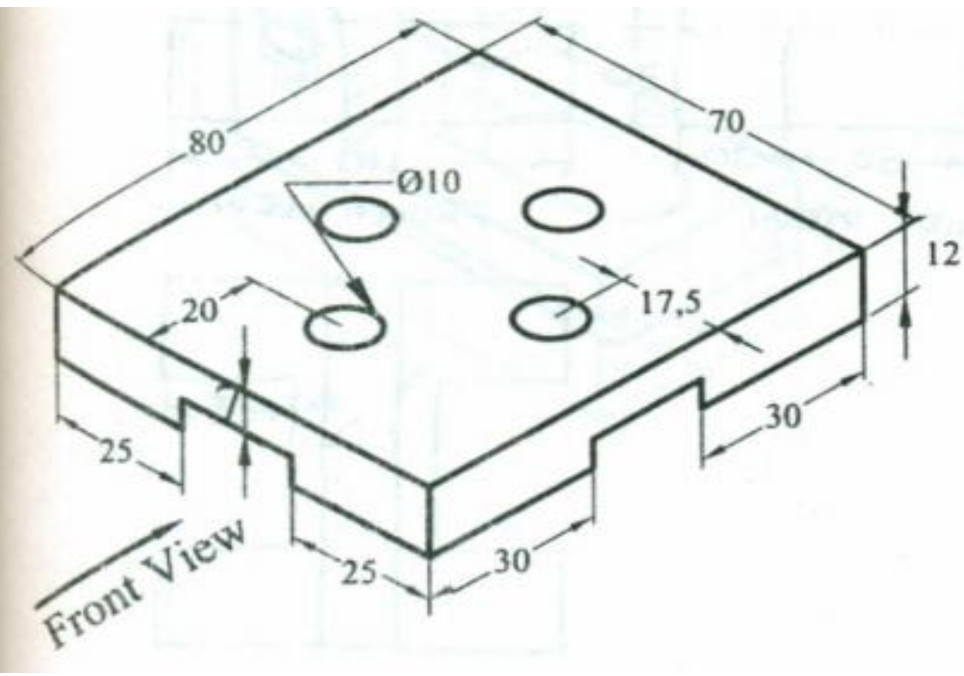
Problem 9

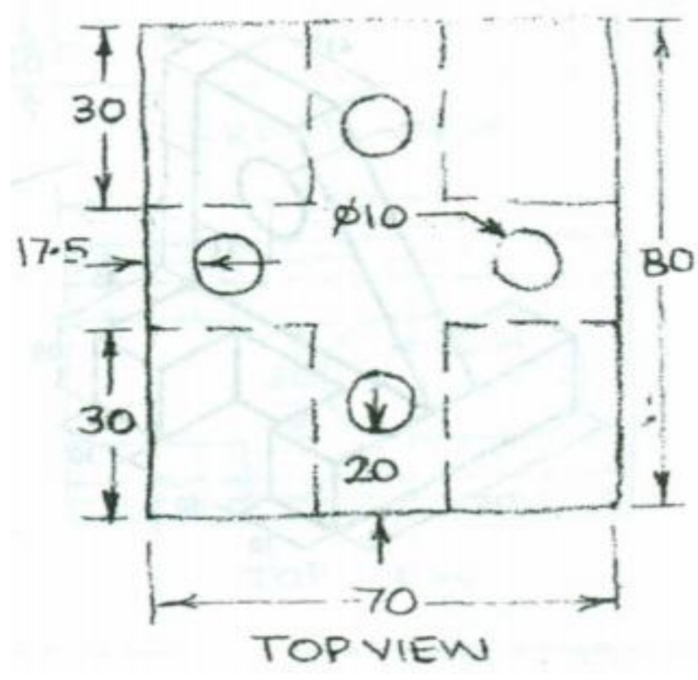


Problem 9

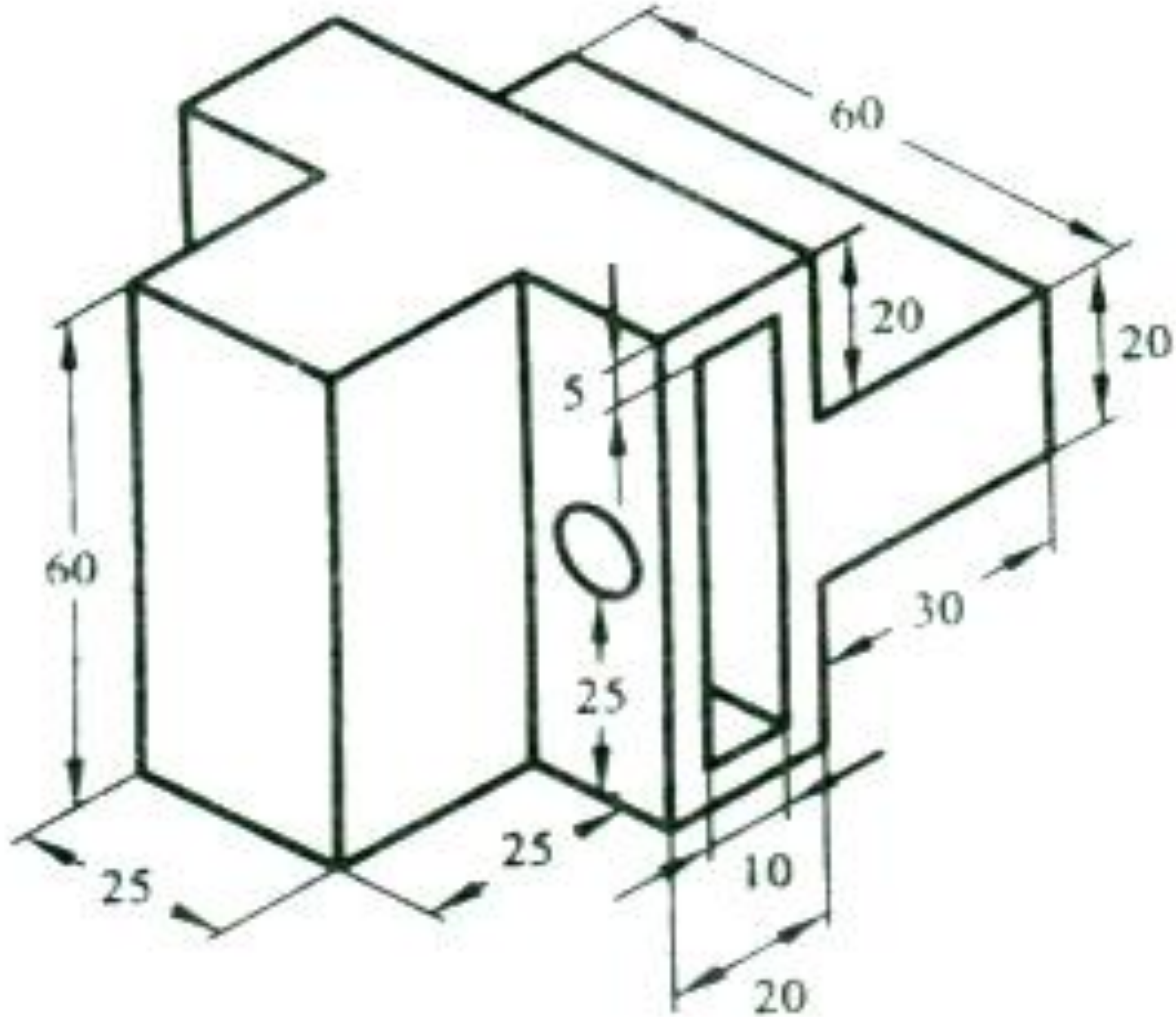

80
20
12
30
30
SIDE VIEW


5
25
25
12
FRONT VIEW

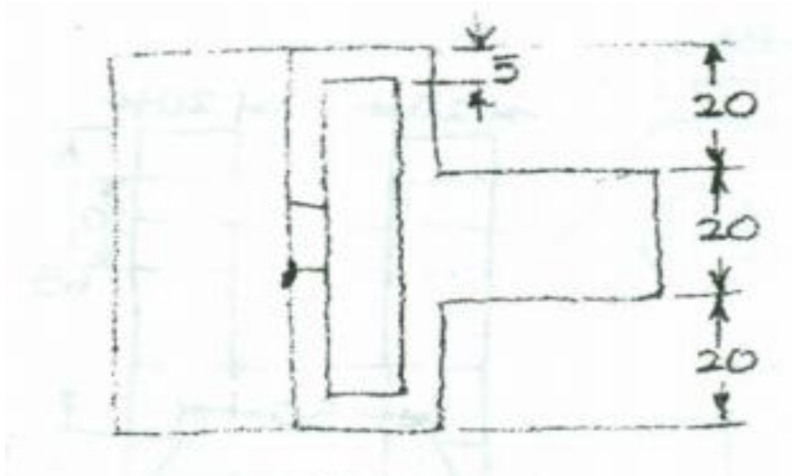

80
70
Ø10
12
20
17,5
30
25
25
30
Front View


30
17·5
ø10
80
30
20
70
TOP VIEW

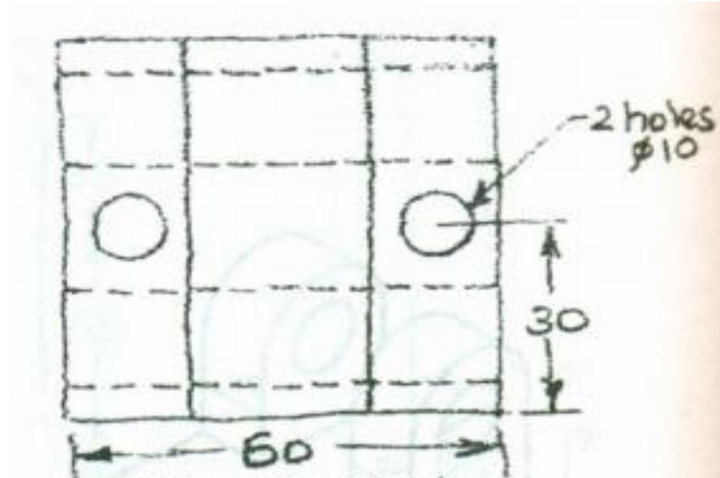
Problem 10



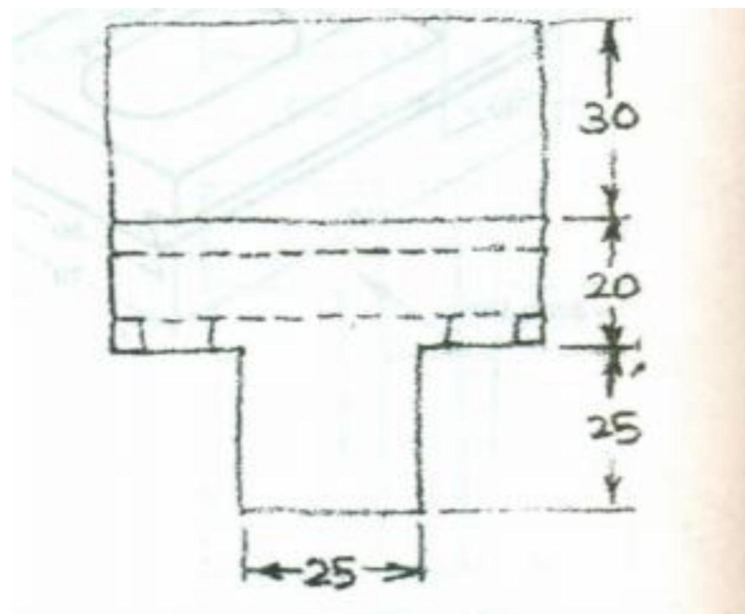
Problem 10



SIDE VIEW

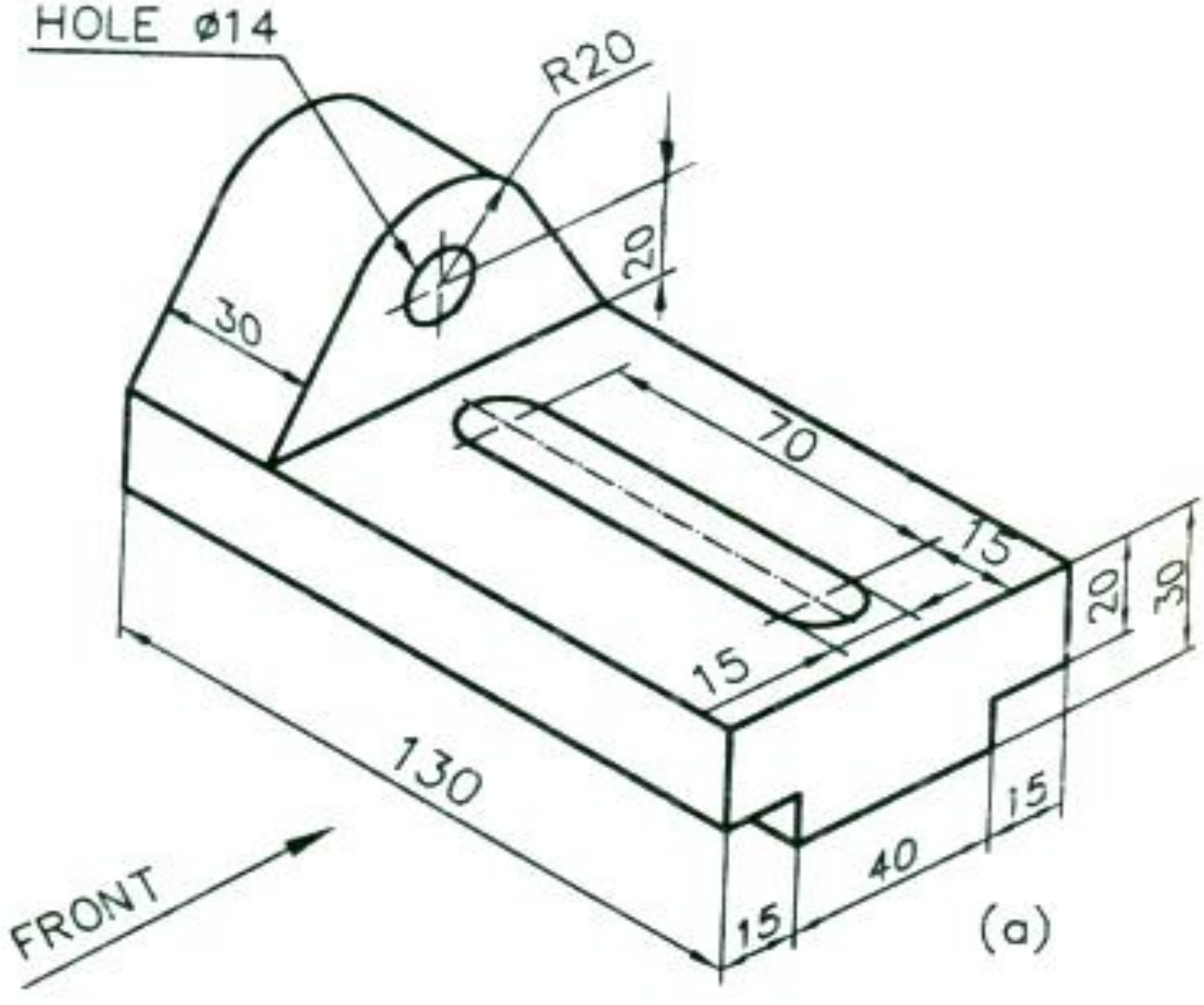


FRONT VIEW

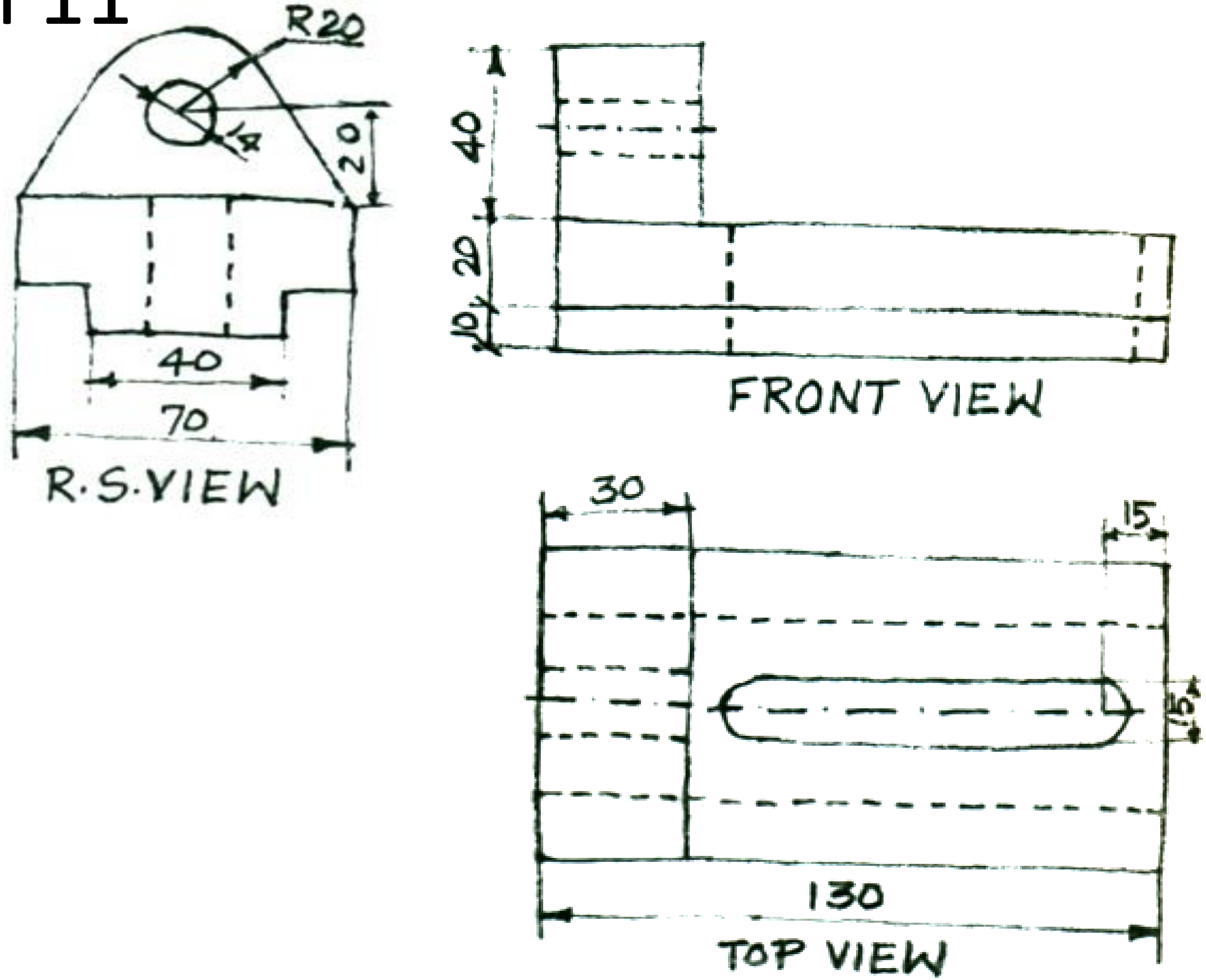


TOP VIEW

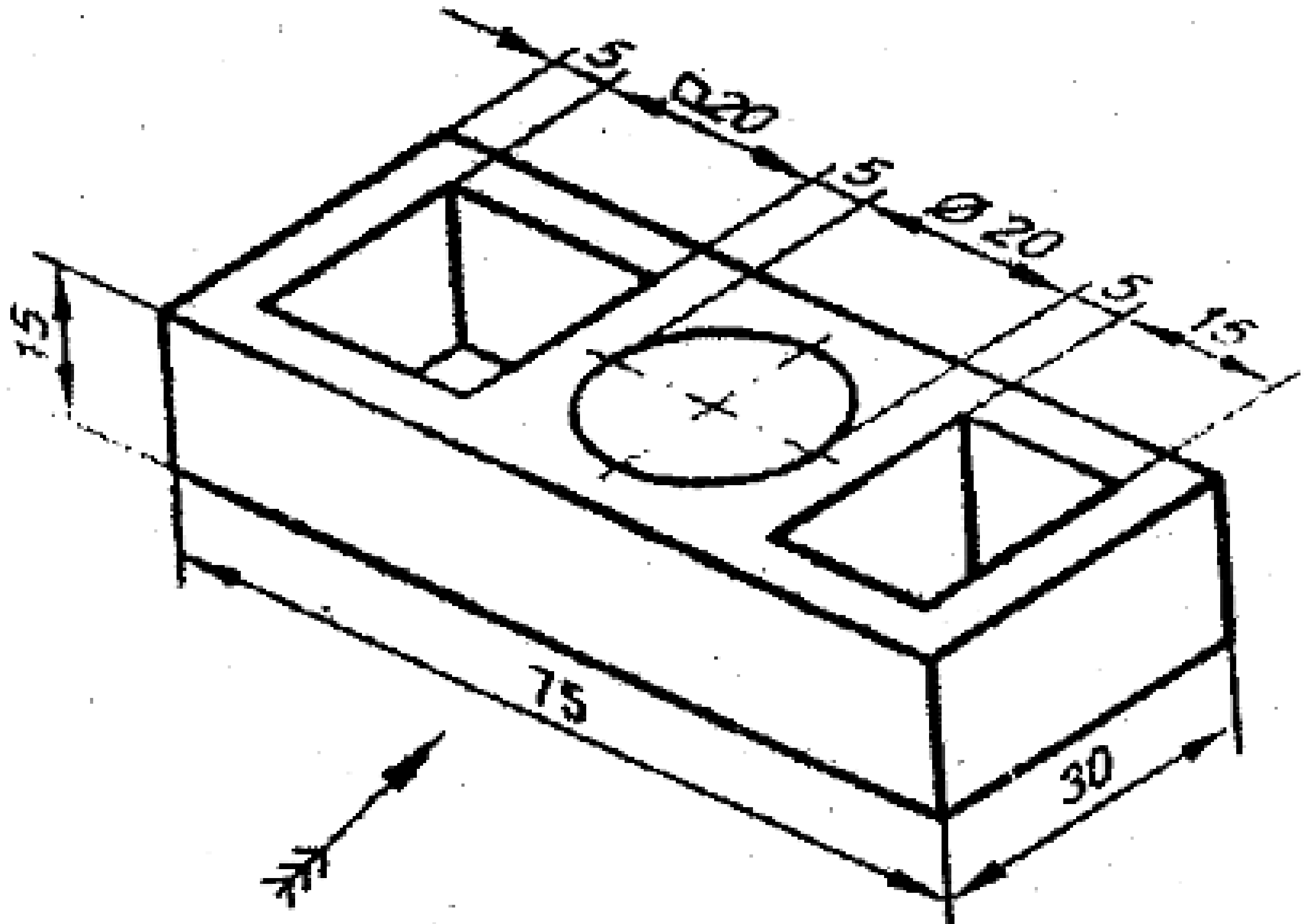
Problem 11



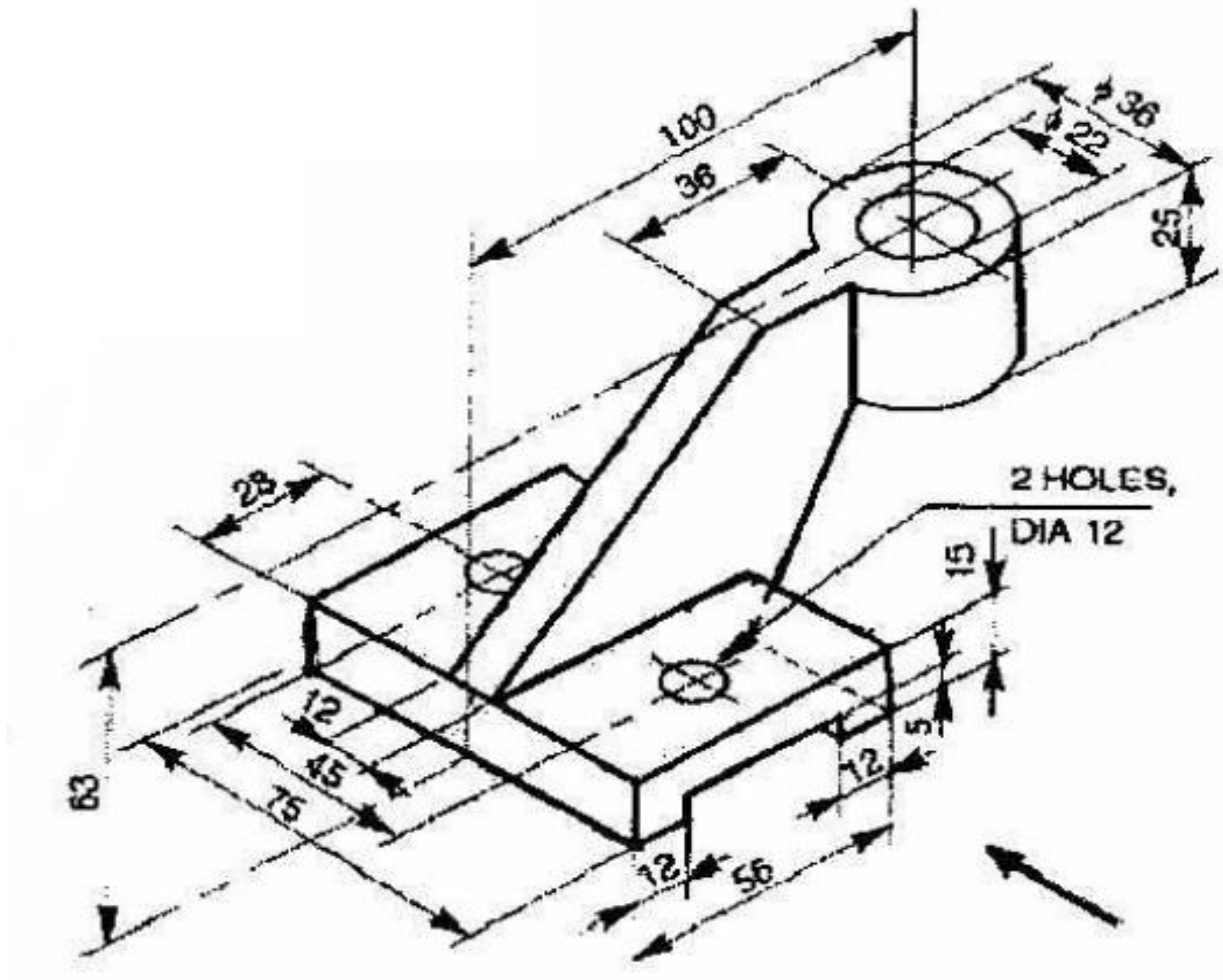
Problem 11



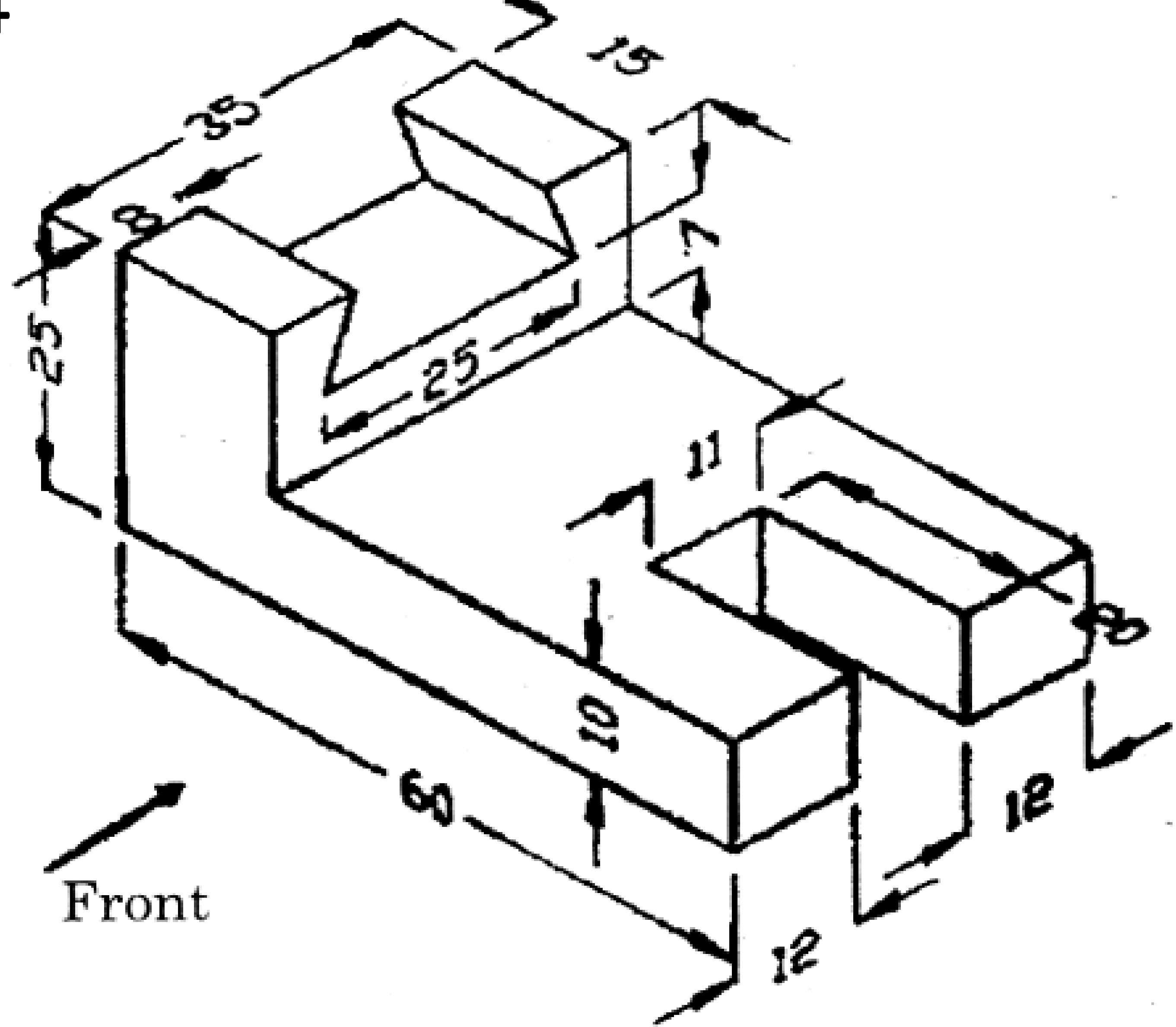
Problem 12



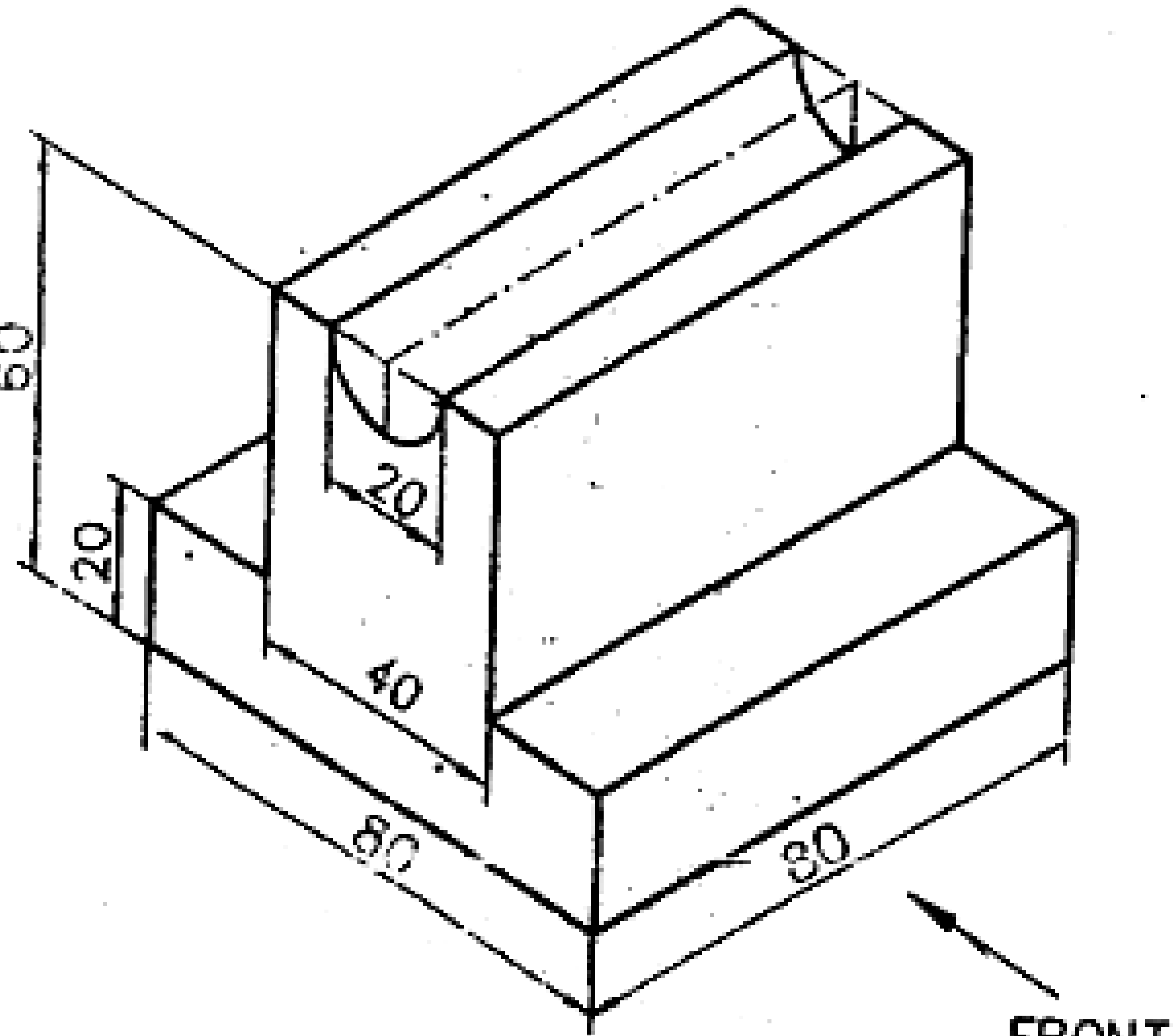
Problem 13



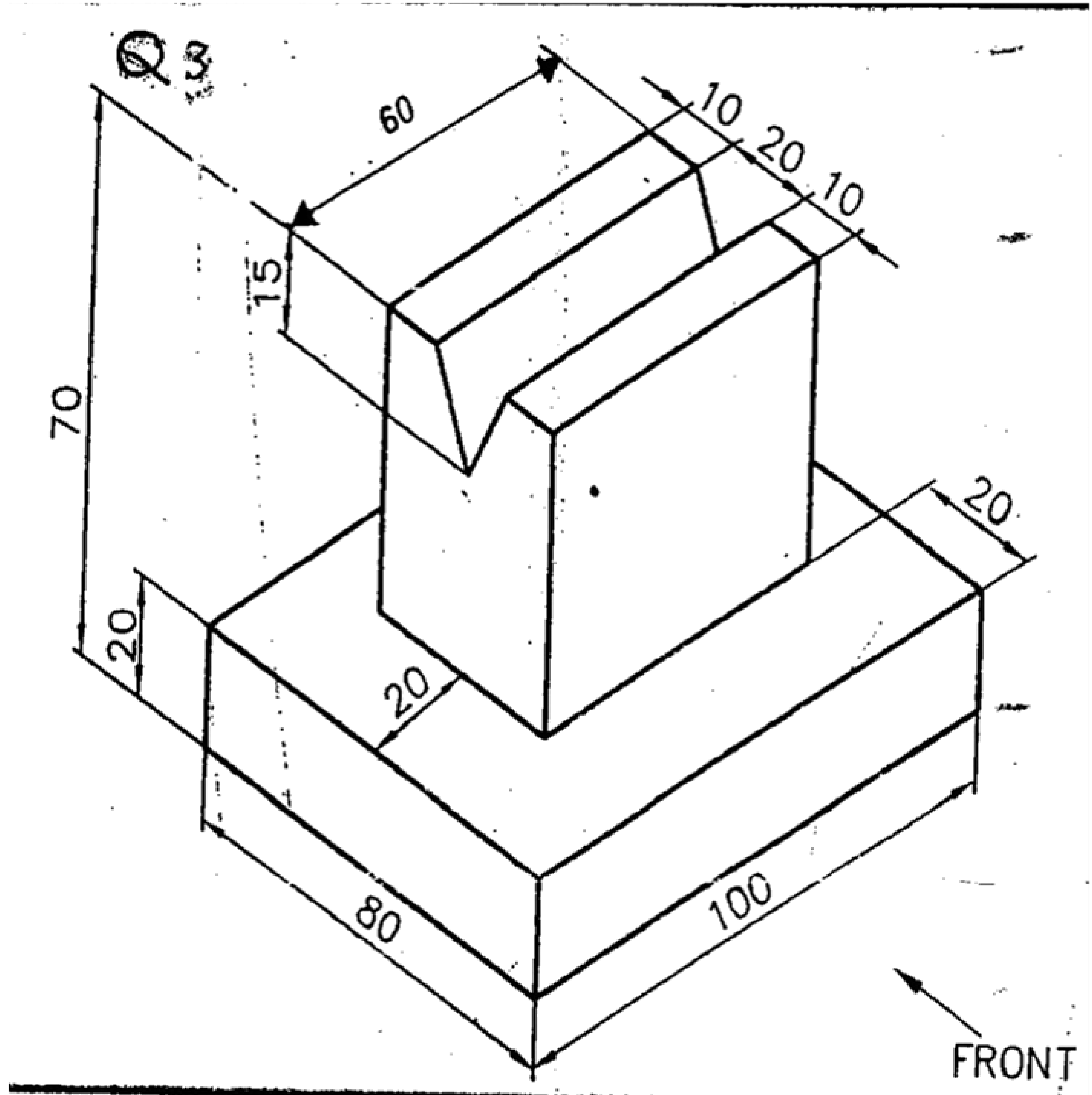
Problem 14



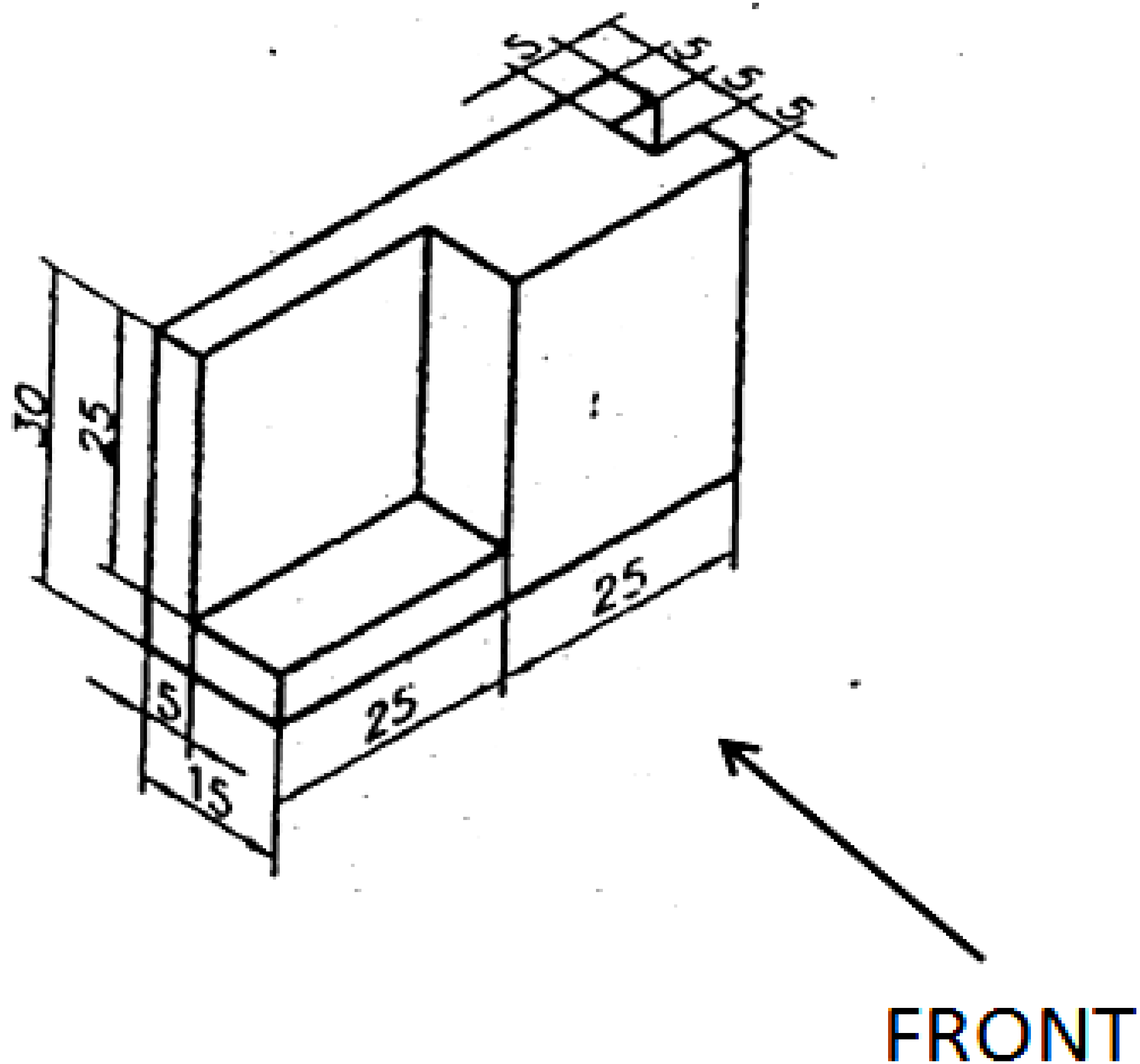
Problem 15



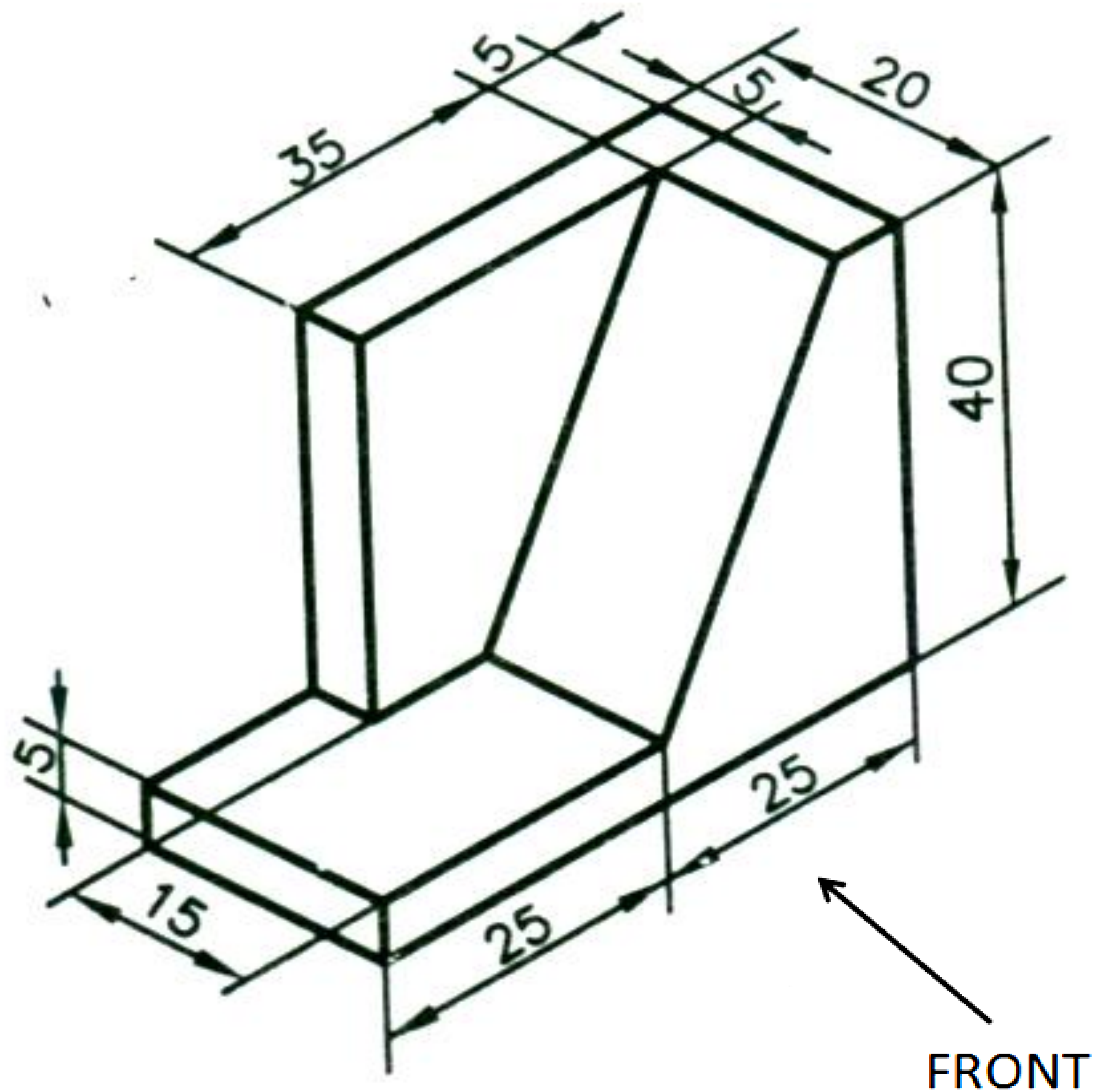
Problem 16



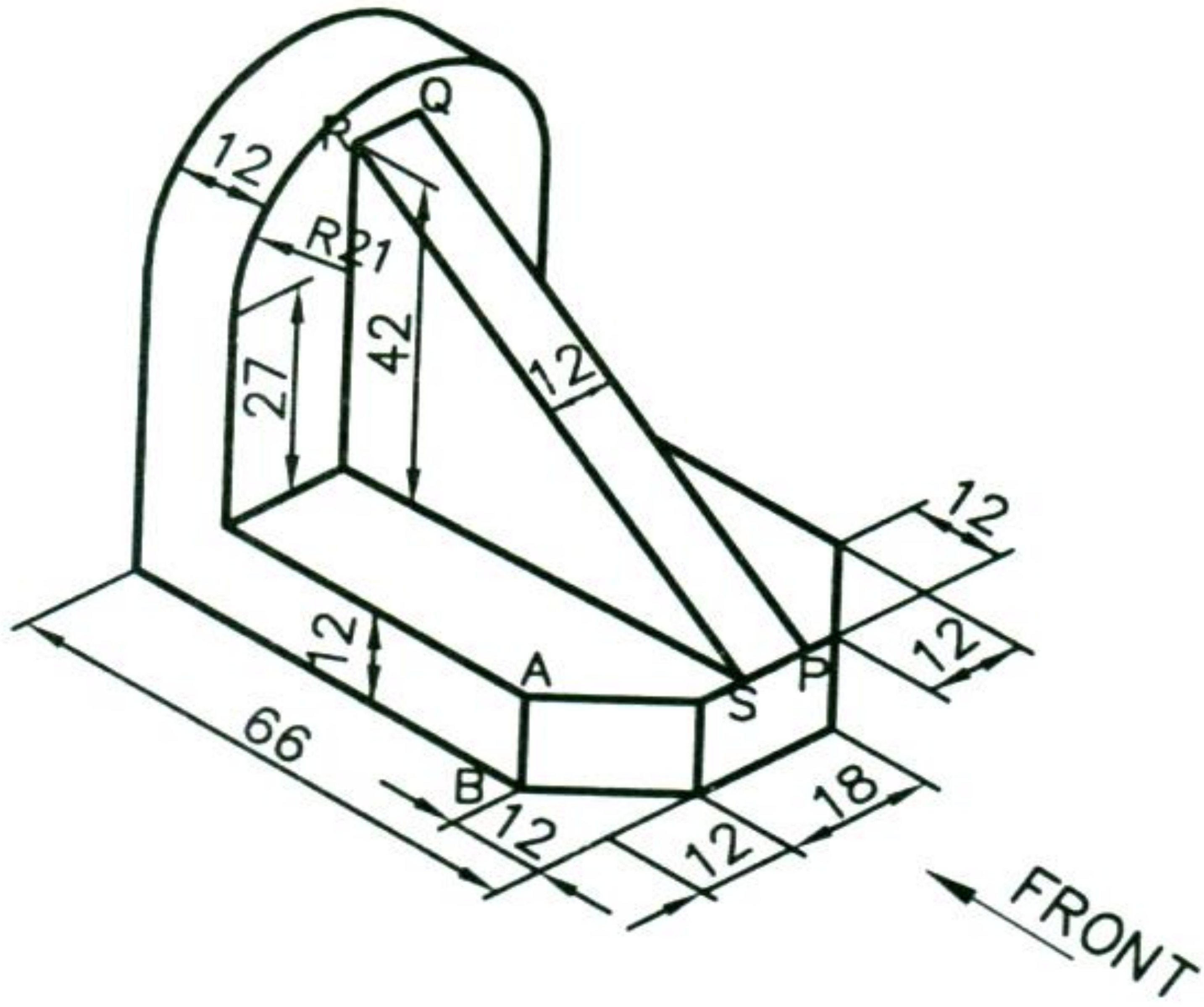
Problem 17



Problem 18



Problem 19



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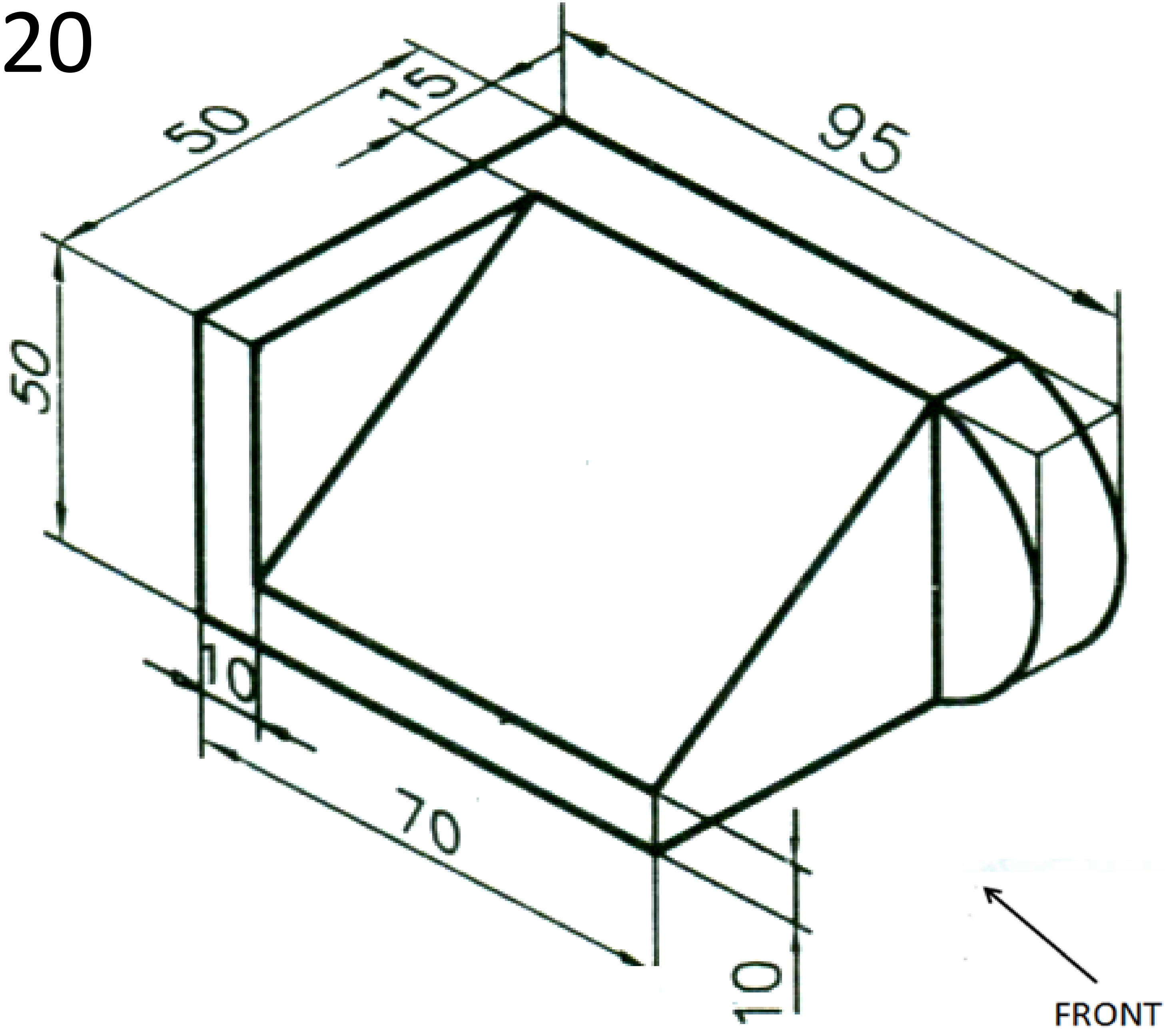
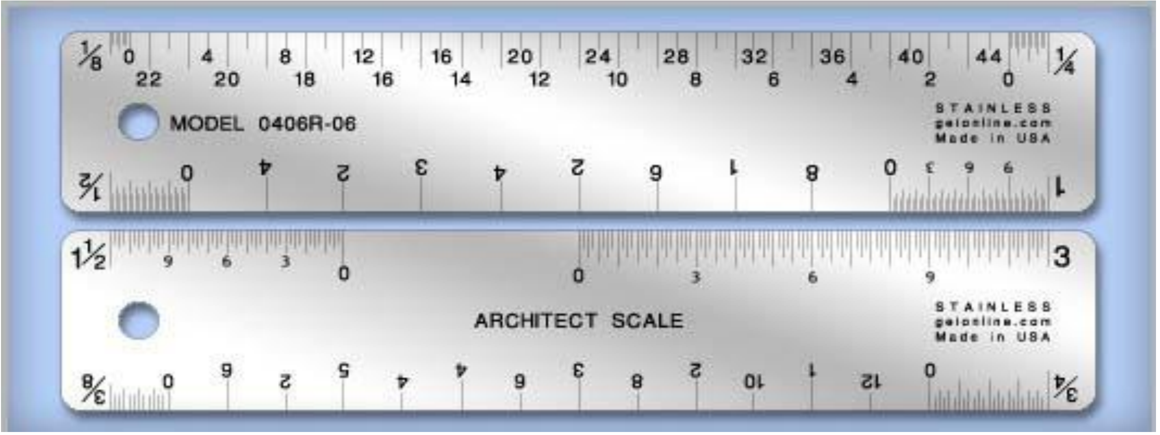
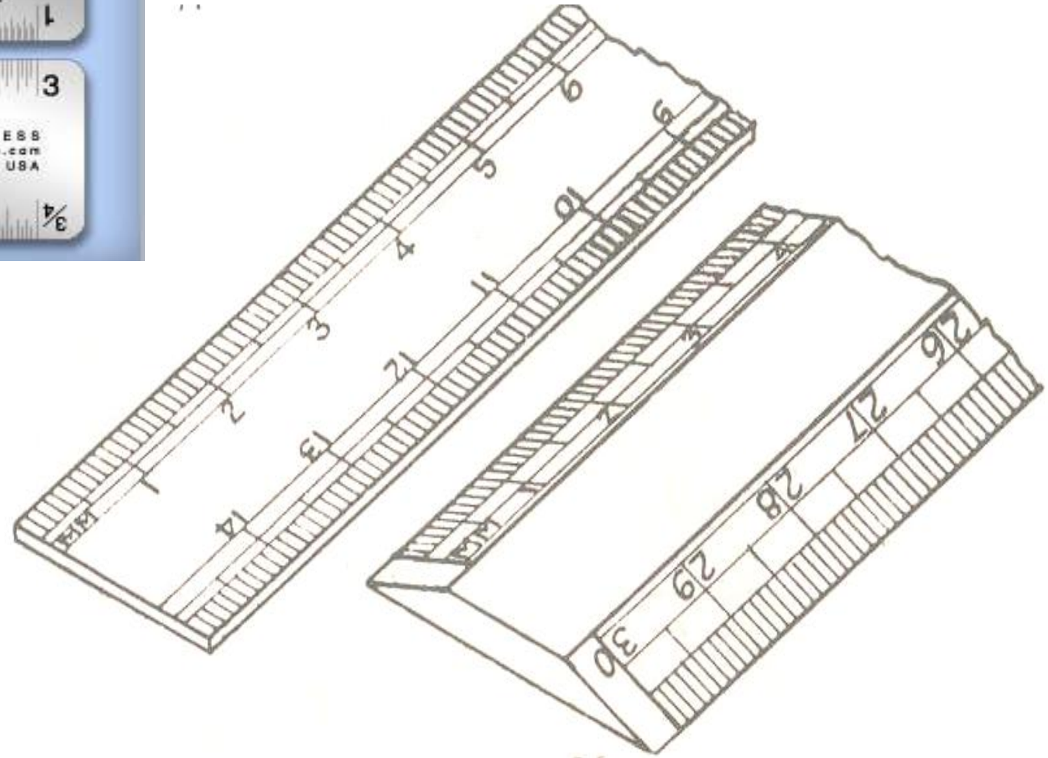






Construction of Scales

Scales

1. It is not always possible or convenient to draw drawings of an object to its actual size.

2. Drawings of very big objects like buildings, machines etc. cannot be prepared in full size.

3. Drawings of very small objects like precision instruments, namely watches, electronic devices etc.

Full size scale

1. If we show the actual length of an object on a drawing, then the scale used is called full size scale.

Reducing scale

1. If we reduce the actual length of an object so as to accommodate that object on drawing, then the scale used is called reducing scale.
2. Example :

a) large machine parts
b) Buildings
c) Bridges
d) Survey maps
e) Architectural drawings etc.

Increasing or Enlarging scale

1. Drawings of small machine parts, mechanical instruments, watches, etc. are made larger than their real size. These are said to be drawn in an increasing or enlarging scale.

NOTE :

The scale of a drawing is always indicated on the drawing sheet at a suitable place either below the drawing or near the title thus **“scale 1 : 2”**.

Representative Fraction (R.F)

1. The ratio of the drawing size of an object to its actual size is called the Representative Fraction, usually referred to as R.F.

$$R.F = \frac{\text{Drawing size of an object}}{\text{Its actual size}} \quad \text{(in same units)}$$

Reducing scale R.F

1. For reducing scale, the drawings will have R.F values of less than unity. For example 1 cm on drawing represents 1 m length.

$$R.F = \frac{1\ \text{cm}}{1 \times 100\ \text{cm}} = \frac{1}{100} < 1$$

(in same units)

Increasing or Enlarging scale R.F

1. For drawings using increasing or enlarging the R.F values will be greater than unity. For example, when 1 mm length of an object is shown by a length of 1 cm.

$$R.F = \frac{1 \times 10 \text{ mm}}{1 \text{ mm}} = \frac{10}{1} = 10 > 1$$

(in same units)

Metric Measurements

1. 10 decimeters (dm) = 1 meter (m)
2. 10 meters (m) = 1 decameter (dam)
3. 10 decameters (dam) = 1 hectometer (hm)
4. 10 hectometer (hm) = 1 kilometer (km)

Types of Scales

1. Simple or Plain scales

2. Diagonal scales

3. Vernier scales

Simple or Plain scales

1. A plain scale is simply a line which is divided into a suitable number of equal parts, the first of which is further sub-divided into small parts.
2. It is used to represent either two units or a unit and its fraction such as km an hm, m and dm, etc.

Simple or Plain scales

NOTE :

1. Before constructing a scale, it is necessary to know: (a) Its R.F.,

   (b) Maximum length to be measured and

   (c) Divisions it has to show.

2. If the length of scale and distance to be marked are not given in the problem, then assume the scale length = 15 cm.

Problem 1

Construct a **plain scale** to show meters when 1 centimeter represents 4 meters and long enough to measure upto 50 meters. Find the R.F. and mark on it a distance of 36 meters.

Problem 1

1. R.F. $= \frac{\text{Drawing size}}{\text{Actual size}} (\text{in same units}) = \frac{1\text{cm}}{4 \times 100\text{cm}} = \frac{1}{400}$
2. Length of scale = R.F. x maximum length to be measured.

Maximum length to be measured = 50 m (given)

length of scale = $\frac{1}{400} \times 50\text{ m} = \frac{1}{400} \times 50\text{ m} \times 100\ cm$

3. Draw a horizontal line of length 12.5 cm (L)
4. Draw a rectangle of size 12.5cm x 0.5cm on the horizontal line drawn above.

NOTE: Width of the scale is usually taken as 5 mm

Problem 1

5. Total length to be measured is 50m. Therefore divide the rectangle into 5 equal divisions, each division representing 10m.

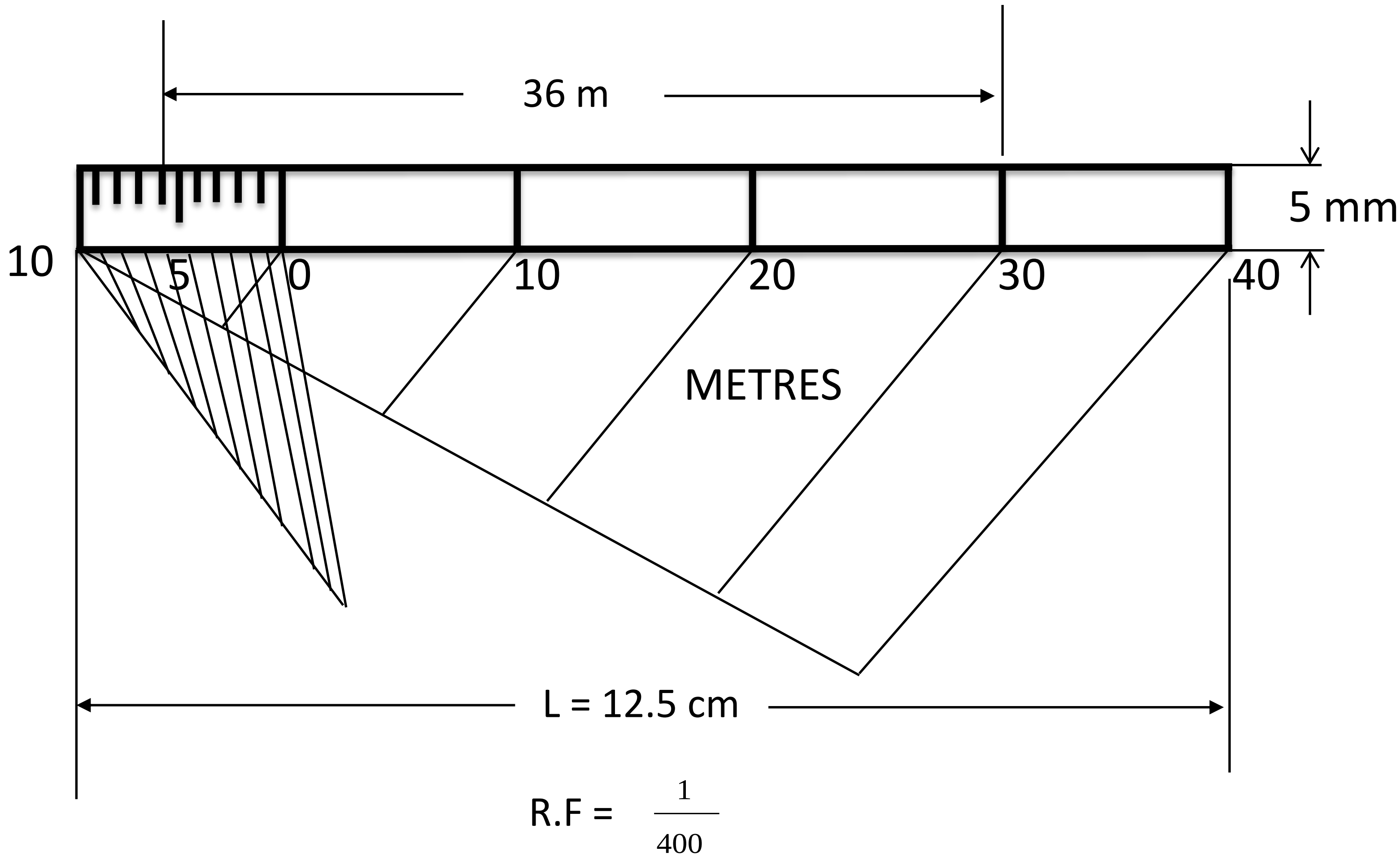
NOTE: 1. For dividing the length L into n number of equal parts, use geometrical construction.

2. Use 2H pencil for the construction lines.

6. Mark 0 (zero) at the end of the first main division.

Problem 1

7. From 0, number 10,20,30 and 40 at the end of subsequent main divisions towards right.
8. Then sub-divide the first main division into 10 sub-divisions to represent meters.
9. Number the sub-divisions. i.e. meters to the left of 0.
10. Write the names of main units and sub-units below the scale. Also mention the R.F.
11. Indicate on the scale a distance of 36 meters (3 main divisions to the right side of 0 + 6 sub-divisions to the left of 0.


36 m
5 mm
10
5
0
10
20
30
40
METRES
L = 12.5 cm
R.F = 1/400

DIAGONAL SCALE

1. Plain scales are used to read lengths in two units or to read to first decimal accuracy.

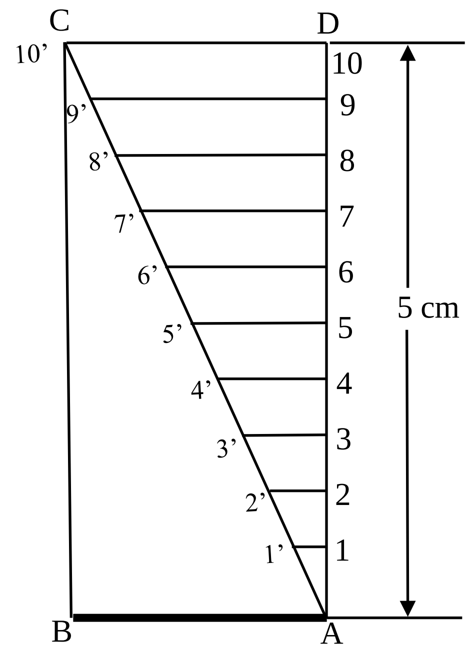
2. Diagonal scales are used either to measure very minute distances such as 0.1 mm etc., or to measure in three units such as dm, cm and mm.

DIAGONAL SCALE

Divide AD into ten equal divisions of any convenient length (5 cm)

$$\frac{88'}{DC} = \frac{A8}{AD}; \text{ But } A8 = \frac{8}{10} AD$$

$$\frac{88'}{DC} = \frac{8}{10} \text{ i.e. } 88' = \frac{8}{10} DC = 0.8\,DC = 0.8\,AB$$



11’ equal to 0.1 AB

22’ equal to 0.2 AB

.

.

.

99’ equal to 0.9 AB

Problem 2

The distance between two stations by road is 200 km and it is represented on a certain map by a 5 cm long line. Find the R.F. and construct a diagonal scale showing a single kilometer and long enough to measure up to 600 km. Show a distance of 467 km on this scale.

Problem 2

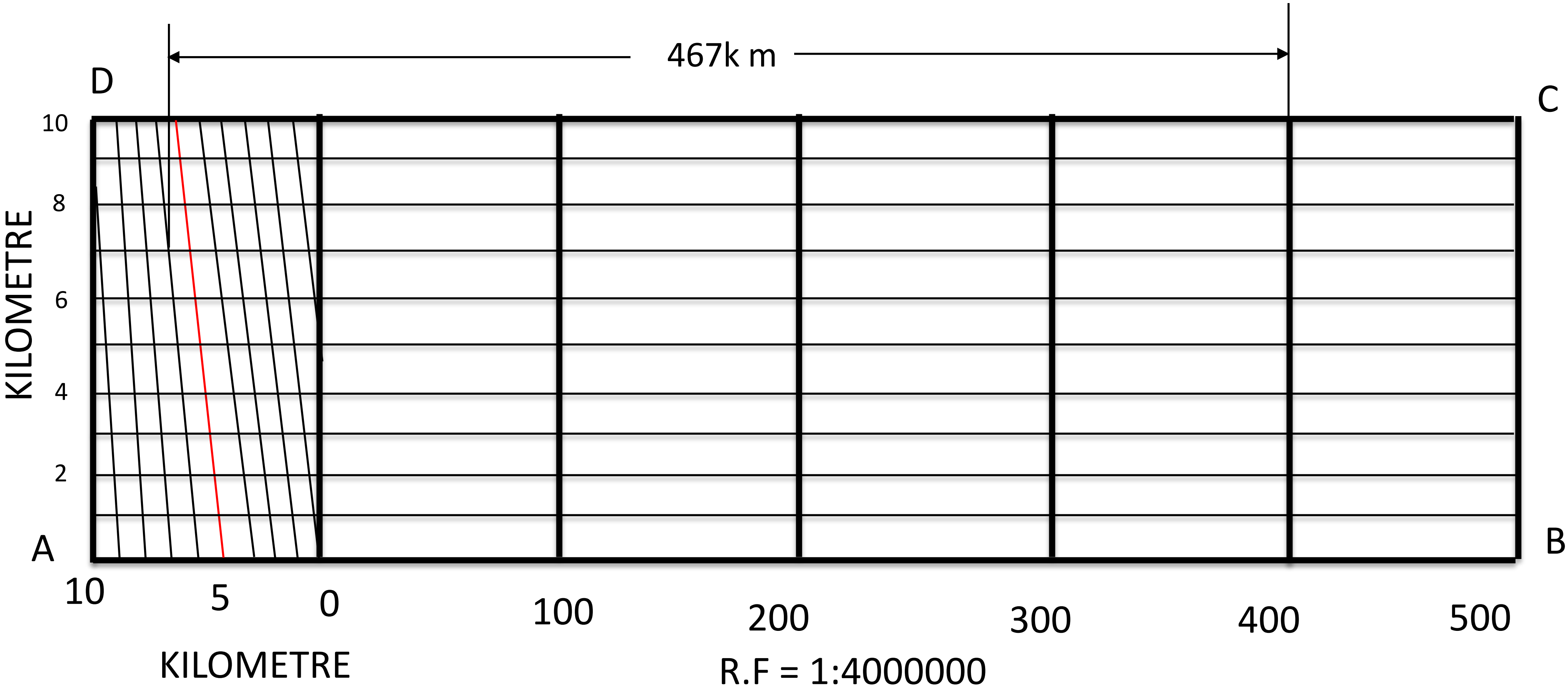
1. Determine $\text{R.F} = \dfrac{5\,cm}{200\ \ km} = \dfrac{5\,cm}{200\ \times 10^{5}\ cm} = \dfrac{1}{4 \times 10^{6}}$
2. Calculate length of scale

$$\text{L}_{s} = \text{R.F} \times \text{maximum} \quad \text{length} = \frac{1}{4 \times 10^{6}} \times 60 \times 10^{5}\ \text{cm} = 15\ \text{cm}$$

3. Draw a rectangle ABCD of length 15 cm and width between 40 to 50 mm.
4. Divide AB into 6 equal parts so that each part may represent 100 km.
5. Divide A0 into 10 equal divisions, each representing 10 km. Erect diagonal lines through them.

Problem 2

6. Divide AD into 10 equal divisions and draw horizontal lines through each of them meeting at BC.
7. Write the main unit, second unit, third unit and R.F.
8. Mark a distance of 467 km on the scale.



R.F = 1:4000000

$$R.F = \frac{5\,cm}{200\ km} = \frac{5\,cm}{200 \times 10^{5}\ cm} = \frac{1}{4 \times 10^{6}}$$

$$L_s = R.F \times \text{maximum length} = \frac{1}{4 \times 10^{6}} \times 60 \times 10^{5}\ \text{cm} = 15\ \text{cm}$$

Problem 3

Construct a **diagonal scale** of R.F. = 1:3200000 to show kilometers and long enough to measure upto 400 km. show distances of 257 km and 333 km on your scale.

VERNIER SCALE

1. Vernier Scale is a short scale used when a diagonal scale is inconvenient to use due to lack of space.
2. It consists of two parts, i.e., *Main Scale (which is a Plane Scale fully divided into minor* divisions) and a *Vernier Scale.*
3. *Vernier scale slides on the side of the main scale and both of* them are used to measure small divisions up to 3 divisions like diagonal scales.

VERNIER SCALE

1. Least Count: It is the smallest distance that is measured accurately by the vernies'Scale.

2. It is the difference between a main scale division (m.s.d.) and a vernier scale division (v.s.d.).

Problem 4

Construct a **Vernier scale** to read meters, decimeters and centimeters and long enough to measure up to 4 m. R.F. of the scale is 1/20. Mark on your scale a distance of 2.28 m.

Problem 4

1. Least Count = Smallest distance to be measured = 1 cm (given) = 0.01 m
2. L = R.F. x Maximum distance to be measured = (1/20) x 4 m = 20 cm
3. Main Scale: Draw a line of 20 cm length. Complete the rectangle of 20 cm x 0.5 cm.

Divide it into 4 equal parts each representing 1 meter.

Sub-divide each part into 10 main scale divisions. Hence 1 m.s.d. = 1m/10 *= 0.1 m = 1 dm.*

Problem 4

4. Backward Vernier: Take 11 divisions on main scale. Divide it into 10 equal parts on vernier scale. So

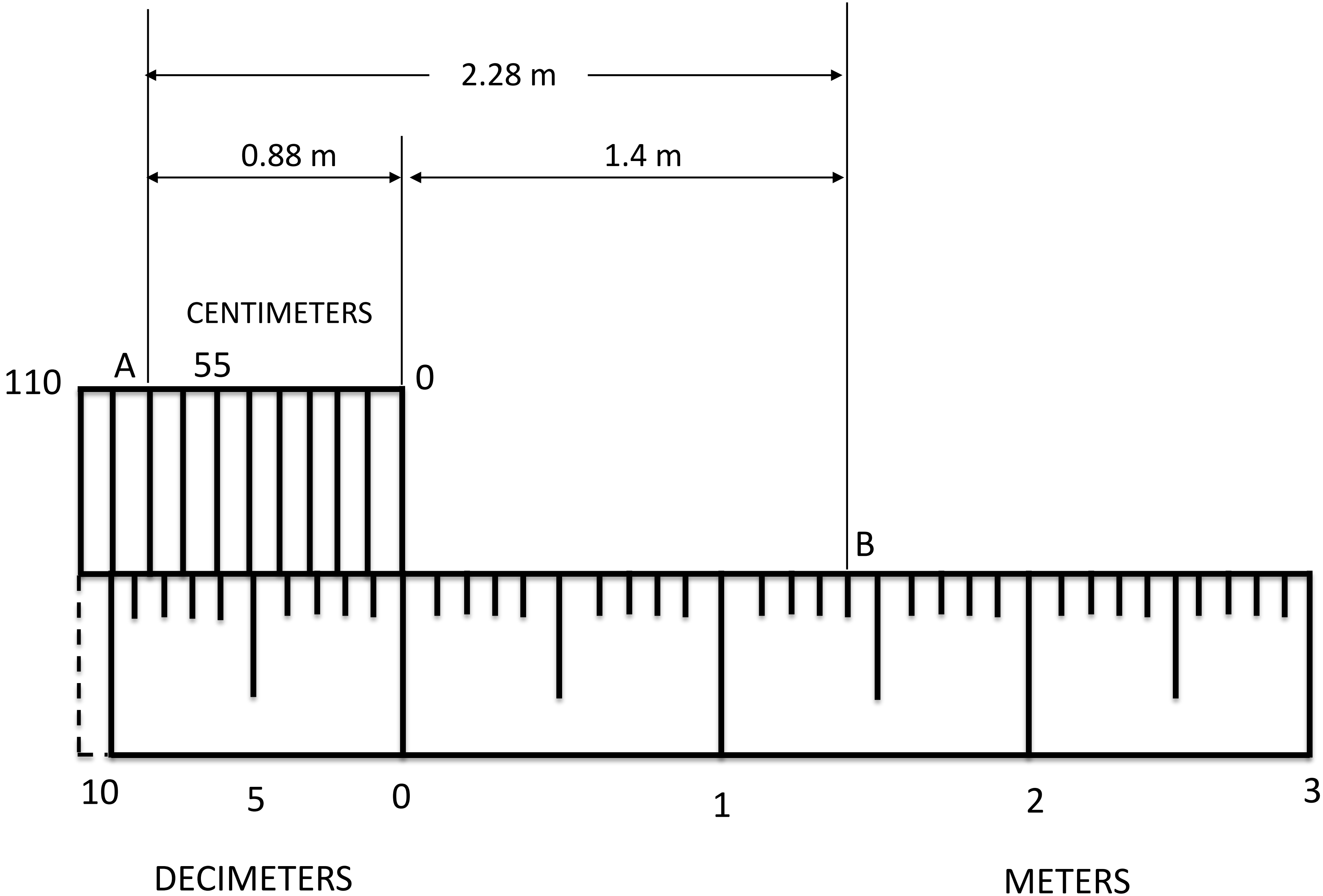
1 v.s.d. = 11 m.s.d./10= 11 x 1 dm/ 10= 0.11 m = 1.1 dm = 11 cm.

Mark 0, 55, 110 towards left from 0 on the vernier scale. The units of main divisions is METERS, sub-divisions is DECIMETERS and vernier divisions is CENTIMETERS

Problem 4

5. AB = (v.s.d x 8) + (m.s.d x 14)

   = (0.11m x 8) + (0.1m x 14) = (0.88+1.4)m



AB = (v.s.d x 8)+(m.s.d x 14)

= (0.11m x 8)+(0.1m x 14)=(0.88+1.4)m