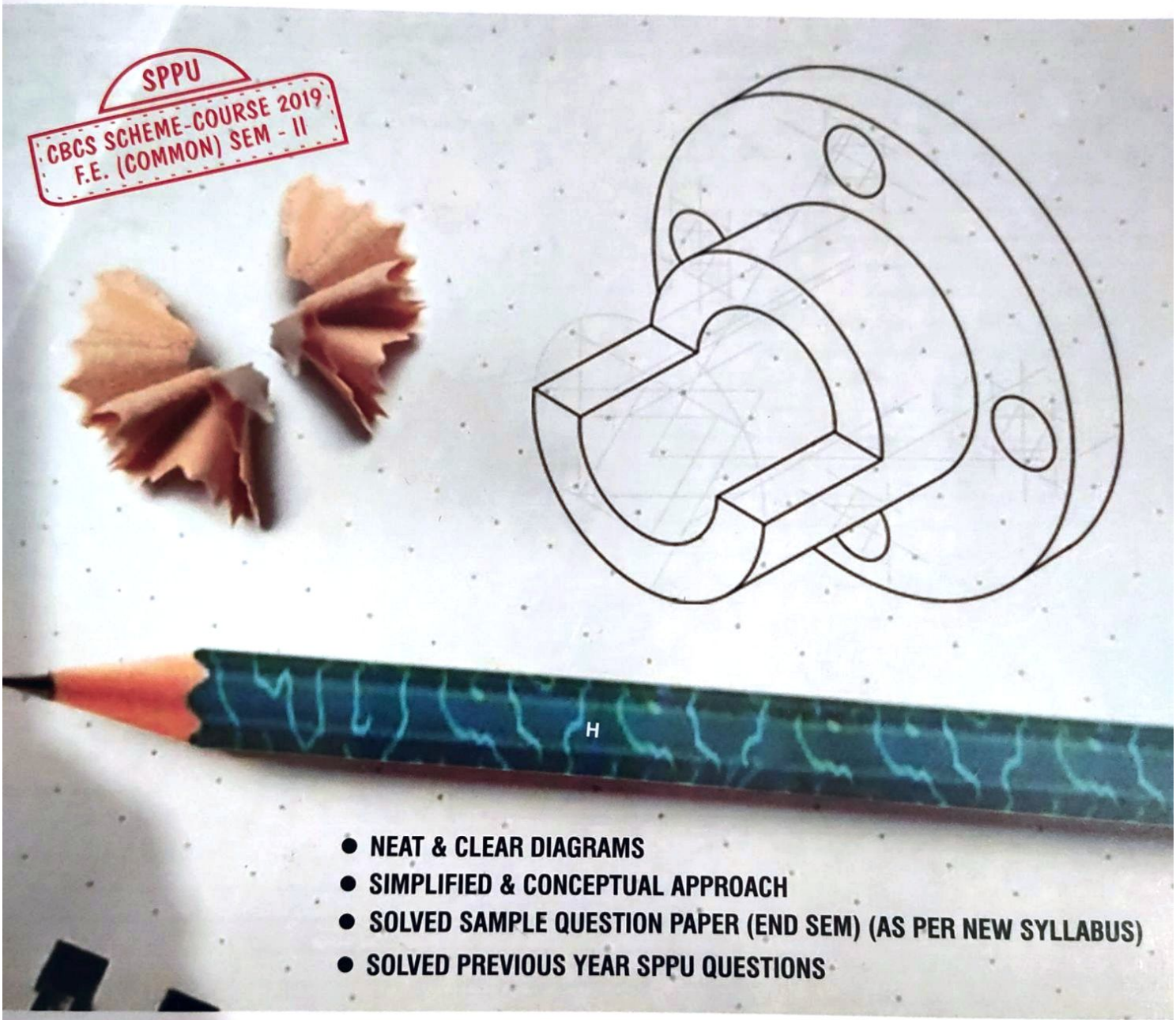
ENGINEERING GRAPHICS

SPPU
CBCS SCHEME-COURSE 2019
F.E. (COMMON) SEM - II



- NEAT & CLEAR DIAGRAMS
- SIMPLIFIED & CONCEPTUAL APPROACH
- SOLVED SAMPLE QUESTION PAPER (END SEM) (AS PER NEW SYLLABUS)
- SOLVED PREVIOUS YEAR SPPU QUESTIONS

TECHNICAL PUBLICATIONS
An Up-Thrust for Knowledge
1993

Dr. R. G. Biradar
A. M. Umbrajkaar
Manoj Y. Bhojane

SUBJECT CODE : 102012

As per Revised Syllabus of

SAVITRIBAI PHULE PUNE UNIVERSITY

F.E. (Common to All Branches) Semester - II

ENGINEERING GRAPHICS

Dr. R. G. Biradar
Ph.D (Mech)
Pimpri Chinchwad Education Trust &
Nutan Maharashtra Vidya Prasarak Mandal's
NMIET, Talegaon, Pune.

A. M. Umbrajkaar
M.E.(Mech.)
Dr. D.Y. Patil Institute of Engineering,
Management and Research, Akurdi
Pune.

Manoj Y. Bhojane
D.A.E., B.E. (Mech), M.E.(Heat Power)
Formerly Worked as Visiting Lecturer in Mechanical Engineering Department
Government College of Engineering & Research,
Awasari (kd)

TECHNICAL PUBLICATIONS
SINCE 1993
An Up-Thrust for Knowledge

SYLLABUS

Engineering Graphics [102012]

Credits	Examination Scheme :
02	End-Semester : 50 Marks
	TW : 25 Marks

Unit - I Fundamentals of Engineering Drawing [No any question in ESE]

Need of Engineering Drawing and design, Sheet layout, Line types and dimensioning and simple geometrical constructions. **(Chapter - 1)**

Unit - II Introduction to 2D and 3D Computer Aided Drafting Packages [No any question in ESE]

Evolution of CAD, Importance of CAD, Basic Commands - Edit, View, Insert, Modify, Dimensioning Commands, setting and tools etc. and its applications to construct the 2D and 3D drawings. **(Chapter - 2)**

Unit - III Engineering Curves (12 Marks)

Introduction to conic sections and its significance, various methods to construct the conic sections. Helix for cone and cylinder , rolling curves (Involutes , Cycloid) and Spiral. **(Chapter - 3)**

Unit - IV Orthographic Projection (13 Marks)

Principle of projections, Introduction to First and Third angle Projection methods, Orthographic projection of point, line, plane, solid and machine elements/parts. **(Chapter - 4)**

Unit - V Isometric Projection (13 Marks)

Introduction to isometric projection, oblique projection and perspective projection. Draw the isometric projection from the given orthographic views. **(Chapter - 5)**

Unit - VI Development of Lateral Surfaces (12 Marks)

Introduction to development of lateral surfaces and its industrial applications. Draw the development of lateral surfaces for cut section of cone, pyramid, prism etc. **(Chapter - 6)**

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UNIT - I

1 Fundamentals of Engineering Drawing

Syllabus

Need of Engineering Drawing and design, Sheet layout, Line types and dimensioning and simple geometrical constructions.

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1.1 : Introduction

An engineer must communicate all thoughts effectively to manufacturer, learner and reader. The various mode of communicating ideas are

- Any language, in oral as well as written form.
- Some of symbolic presentation
- Systematic graphic language

The systematic and scientifically developed graphic language has immerged as most effective form of engineering communication. An oral or written information may have different interepretation out of given instructions. But, scientifically developed graphic language in the form of engineering drawing has entire potential of communicating all information without any mis-interpretation. It gives write information in write form. The graphical representation of an object is called drawing. It contains necessary information like actual shape, size, manufacturing method, assembly method.

1.2 : Drawing

- The art of representation of an object by systematic lines on a paper is called drawing.

1.2.1 : Classification of Drawing

- The drawing may be classified into the following two main groups :
  1. Artistic drawing (Free hand or model drawing)
  2. Engineering drawing (Instrument drawing)

1.2.2 : Artistic Drawing

- The art of representation of an object such as painting, cinema slide, advertisement boards etc. by the artist by his imagination or by keeping the object before him is known as artistic drawing.
- The artist tries to produce the object in the shape of picture by giving various shades and colours. Dimensions and other details are not given in it, however, one can appreciate the shape and size of the object.
- The artistic drawing is commonly used by the artists for commercial purpose, i.e. in painting, advertisement board, cinema slides etc.

1.2.3 : Engineering Drawing

- The art of representation of engineering objects such as building, roads, machines, etc. on a paper is called engineering drawing.
- Engineering Drawing is always prepared by the drawing instruments according to some suitable scale giving all the information necessary for the construction of an object.
- The subject of engineering drawing can be divided from engineering point of view into the following categories :
  1. Geometrical drawing
     i) Plane geometrical drawing
     ii) Solid geometrical drawing
  2. Mechanical engineering drawing
  3. Civil engineering drawing
  4. Electrical and electronic engineering drawing etc.

1.2.4 : Geometrical Drawing

- The art of representation of geometrical objects such as rectangle, square, cube, cone, cylinder, sphere etc. on a paper is called geometric drawing.

1.2.4.1 : Plane Geometrical Drawing

- The art of representation of objects having two dimensions, i.e. length and breadth such as square,
- rectangle, triangle etc. on a paper is called plane geometrical drawing.

1.2.4.2 : Solid Geometrical Drawing×

- The art of representation of objects having three dimensions, i.e. length and breadth and thickness such as cube, prism, cylinder, sphere etc. on a paper is called solid geometrical drawing. It is also called descriptive or practical solid geometrical drawing.

1.2.5 : Mechanical Engineering Drawing or Machine Drawing

- The art of representation of mechanical engineering objects such as machines, machine parts, etc. on a paper is called mechanical engineering drawing or machine drawing.

1.2.6 : Civil Engineering Drawing

- The art of representation of civil engineering objects such as roads, building, bridges, dams, etc. on a paper is called civil engineering drawing.
- The civil engineering drawing is commonly used by civil engineers to express civil engineering works and projects for actual execution.

1.2.7 : Electrical and Electronic Engineering Drawing

- The art of representation of electrical objects such as motors, generators, poles, towers, transformers, wiring diagrams, etc. on a paper is called electrical engineering drawing or electrical drawing.

1.3 : Use of Drawing Instruments

1) Drawing Paper :

- Engineering and technical drawings are drawn on special quality drawing papers. These drawing sheets are of thicker quality and white in color. They are available in various standard sizes as shown in the table below.

Drawing Paper Size in Inches		Drawing Paper Size in mm	
Designation	**Length × Width (inches)**	**Designation**	**Length × Width (mm)**
A0	841 × 1189	E	33.11 × 46.81 (36 × 48)
A1	594 × 841	D	23.39 × 33.11 (24 × 36)
A2	420 × 594	C	16.54 × 23.39 (18 × 24)
A3	297 × 420	B	11.69 × 16.54 (12 × 18)
A4	210 × 297	A	8.27 × 11.69 (9 × 12)

Table 1.3.1

- The size of the drawing paper depends on the size of drawing board as well as the size of the object and the number of views you will be drawing. Note that sufficient space must be provided for the

title block, space for any text to be displayed such as instructions, notes, etc as well as border around the drawing.

2) Drawing Board or Table :

- Drawing board is one of the basic requirements for drawing. It provides a plain and smooth surface for drawing purposes. It is a flat rectangular wooden piece fixed to a couple of battens for support. The length of the board is more than the width. The left edge of the board is the working edge, and is provided with an ebonite edge which facilitates the smooth movement of the T - square. The ebonite edge must be absolutely straight and true.
- The paper on which the object is to be drawn is thumb-tacked to the surface of the drawing board. The drawing boards are normally made of soft wood such as pine wood) so that papers can be easily fixed to the drawing surface using thumbtacks or drawing pins.

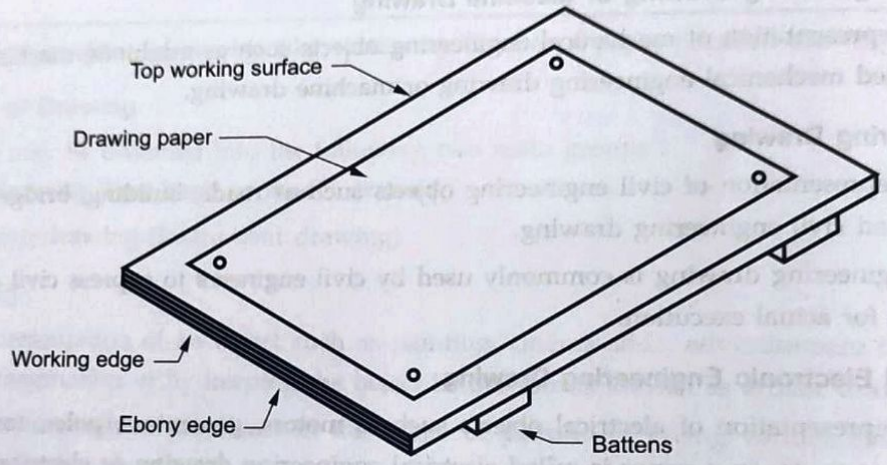


Fig. 1.3.1

- Drawing board comes in different standard sizes. Indian Standard IS 1444-1989 specifies the following standard sized drawing boards.
- Sizes of drawing boards (Ref : IS 1444 - 1989)

Drawing Board Designation	Drawing Board Size		Suitable for Drawing Paper Size
	Length (mm)	Width (mm)	
D0	1270	1270	A0
D1	920	650	A1
D2	650	470	A2
D3	500	350	A3

3) PENCILS :

- Drawings are created on papers using drawing Pencils. The appearance, quality and accuracy of the drawings depend on the type and quality of pencils used in creating them. So naturally, good quality drawing pencils are essential for creating professional drawings. Drawing pencils are available in a

variety of grades of softness and hardness suitable for various types of drawing purposes. The grade of the pencil can be identified by the letters H, B, F and HB marked on them.

- The pencils are graded from 7B which is very soft to 9H which is very hard. Extreme graded pencils are however seldom used. Grades refer to the line thickness, the sharpness and its visibility.
- Pencils marked as H are used for drawing hard lines. The H grade ranges from H to 9H in the increasing grade of hardness.
- Pencils marked with B are used for drawing soft lines. The B grade ranges from B to 7B in the increasing grade of softness.
- Pencils marked as HB and F are meant for drawing medium soft lines.
- The following table shows the grading of the drawing pencils.

Hard Grade						Medium Grade						Soft Grade					
9H	8H	7H	6H	5H	4H	3H	2H	H	F	HB	B	2B	3B	4B	5B	6B	7B

Table 1.3.2

Which grade pencil you use depends on what you are drawing. Though there are no hard and fast rules, the following lists the conventional practice.

- If you are drawing constructional lines, guide lines or faint marker lines, then 2H or 3H are preferable.
- For preliminary layout drawings you may use 3H or 4H grade pencils.
- For most drawing needs such as drawing dimension lines, leader lines, hidden lines, center lines, break lines, extension lines and similar other lines, H or 2H are preferred.
- For cross-hatching lines, H or 2H is preferred.
- For lettering purposes, H, F and HB graded pencils are preferred.
- If you are drawing borders, or Title blocks and such defining lines which are required to stand out and which are normally not required to be erased, you may use pencils of harder grade such as 4H or even harder.
- Lines drawn with heavily harder graded pencils leave smudges when erased. So avoid them in main drawings.
- The pencil lead is sharpened by sharpeners to a fine point, and frequently rubbed against sand paper surfaces to maintain its sharpness while drafting.
- Another alterative to pencils are the pencil leads. Pencil lead holders are used to hold the pencil leads firmly in place while drafting. Pencil leads also come in various grades of softness and hardness. Pencil leads are more convenient to use than pencils.
- In addition to pencils and pencil leads, micro-tip pencils are also becoming popular with drafters now-a-days since they require no sharpening.

4) Protractor :

- A protractor is used to measure and lay out angles.
- A conventional protractor is a semi-circular plastic tool. The semi-circular edge is beveled and graduated with angle markings starting with 0 degrees at one end to 180 degrees at the other end. The bottom edge of the protractor is a straight edge generally marked with a measuring scale.

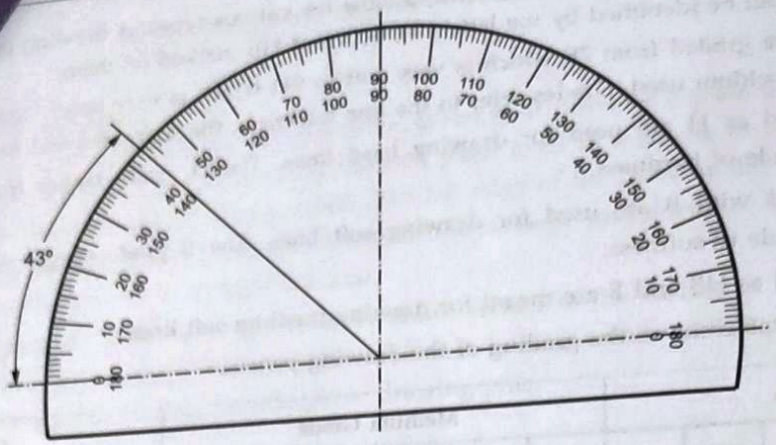


Fig. 1.3.2

- To construct an angle using the protractor :
- First mark the point on the reference line from which another line at an angle to the reference line is to be drawn.
- Align the horizontal line appearing at the bottom straight edge of the protractor with the reference line and at the same time position the center of the protractor (as marked on the scale located at the lower edge of the protractor) to coincide with the marked point from which the angled line is to be drawn.
- Read the required angle in degrees along the beveled semi-circular edge and lightly mark the point at the angle at which you want to draw the line. Normally 0 starts from both ends of the protractor and ends with 180 at the opposite ends. Center is marked as 90. This enables you to mark out angles from either side.
- Remove the protractor and using a triangle or any straight edge, join the marked point with the point on the reference line.

5) Set Square :

- The set-square is made of transparent celluloid or plastic materials, etc. The set-square made of transparent celluloid is most satisfactory as the line underneath the set-square can be seen quite easily and this often prevents another line being drawn in the wrong place.

Types of Set-squares : The sets-squares are of following two types :

1. Thirty-sixty degree (30° - 60°) set square.
2. Forty five degree (45°) set square.

- The 30° - 60° set-square has three edges, one of which forms 90° and other edges forming angles of 30° and 60° with the other sides respectively (See Fig. 1.3.3)
- The 45° set-square is similar to the 30° - 60° set-square, but its edges form an isosceles triangle in which two of the angles are of 45° each and other one's 90° (See Fig. 1.3.4).

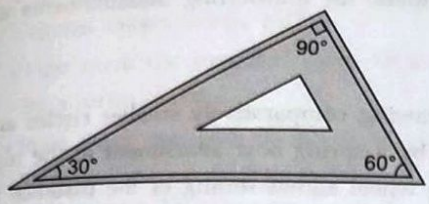


Fig. 1.3.3 30° - 60° set square

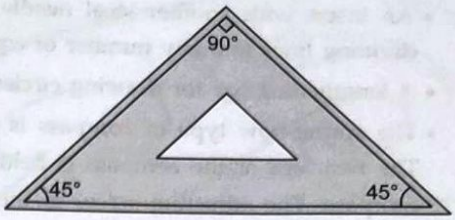


Fig. 1.3.4 45° set square

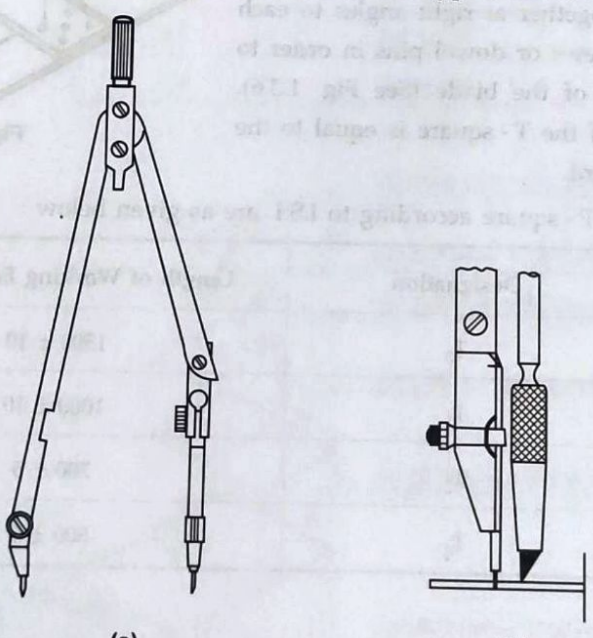
Sizes of Set-squares : The set-squares can be available in different suitable lengths, but 30°-60° set squares of 250 mm and 45° set-square of 200 mm are more suitable for general work.

Uses of Set-squares : The following are the important uses of set-squares :

1. The set-squares are used for drawing all straight lines except the horizontal lines which are usually drawn with T-square.
2. The perpendicular lines or the lines at 30°,60° and90° to the horizontal can be drawn by using the set-squares.

6) Compass :

- The compass is used for drawing circles and arcs both in pencil as well as in ink. There are two types of compasses that are used in drafting. One is the friction type and the other is the spring-bow type.



(a) (b)

Fig. 1.3.5

The friction type consists of two-legs pivoted at the top. One leg is equipped with a steel needle attached with a screw. The other leg is shorter and is provided with a socket for detachable inserts which include :

- An insert furnished with a lead for drawing circles and arcs in pencil,
- An insert with a ruling pen for ink,

- An insert with another steel needle to be used as dividers, for transferring measurements and dividing lines into any number of equal parts.
- A lengthening bar for drawing circles of larger radii.
- The spring-bow type of compass is mainly used for drawing comparatively smaller circles and The two legs of the compass is held firmly in position by a spring bow attachment at the top of compass. The adjusting screw in the form of a rotating wheel allows setting of the distance betw the compass legs. One leg is equipped with a steel needle attached with a screw. The other leg provided with a pencil lead attachment.
- To draw a circle or an arc, the taller leg of the compass is pressed and held. down firmly at center point of the circle or arc to be drawn. Then holding the pivot of the compass with the thum and the index finger of the right hand the shorter leg with an appropriate attachment is rotated draw the required drawing segment.

7) T - Square / Mini Drafter :

- T-square is made of hard quality wood such as teak or mahogany, etc.. There are two essential parts of T - square, namely the stock and the blades. The blade is fitted with an ebony or plastic piece to form working edge of T - square. The two parts being held securely together at right angles to each other by means of screws or dowel pins in order to form a straight edge of the blade (See Fig. 1.3.6). The working length of the T - square is equal to the length of drawing board.

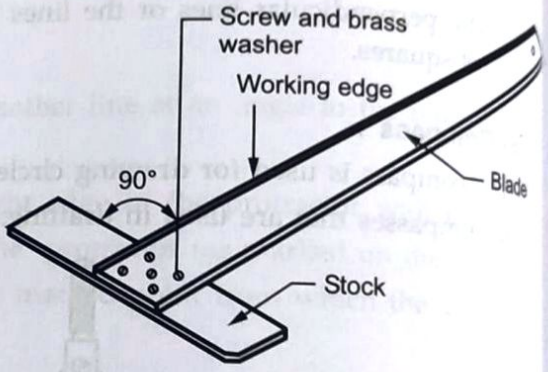


Fig. 1.3.6 T-square

- The standard sizes of T - square according to I.S.I. are as given below :

Sr.No.	Designation	Length of Working Edge in mm
1.	T_0	1500 ± 10
2.	T_1	1000 ± 10
3.	T_2	700 ± 5
4.	T_4	500 ± 5

8) French Curves :

- If the drawings for the objects you want to draw, possess straight edges and regular curves such circles or arcs, then it is easy enough to draw them using the conventional drawing aids such scales, straightedges, triangles, compasses, etc. However, in practice, the objects have irregular profi and surfaces. The drawings of such objects present some challenges. French curves are used to dr such irregular curves. French curves are mostly segments of such geometric curves such as ellips parabolas, hyperbolas and the like.

- To draw an irregular curve using French curves shown in Fig. 1.3.7.:
- First mark the irregular curve to be drawn by a series of dots.
- Start from one end of the required curve. Place and move the French curve such that a portion of the curve aligns along as many dotted points as possible.

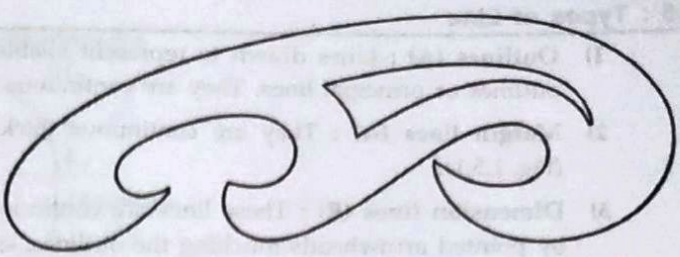


Fig. 1.3.7

- Hold down the French curve firmly and draw the curve joining the points with a pencil.
- Repeat the above process for the next set of dots.

1.4 : Drawing Sheet Layout

- As per ISO - A series following are the some standard size of the drawing sheets.

Drawing Paper Size in Inches	
Designation	**Length × Width (Inches)**
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

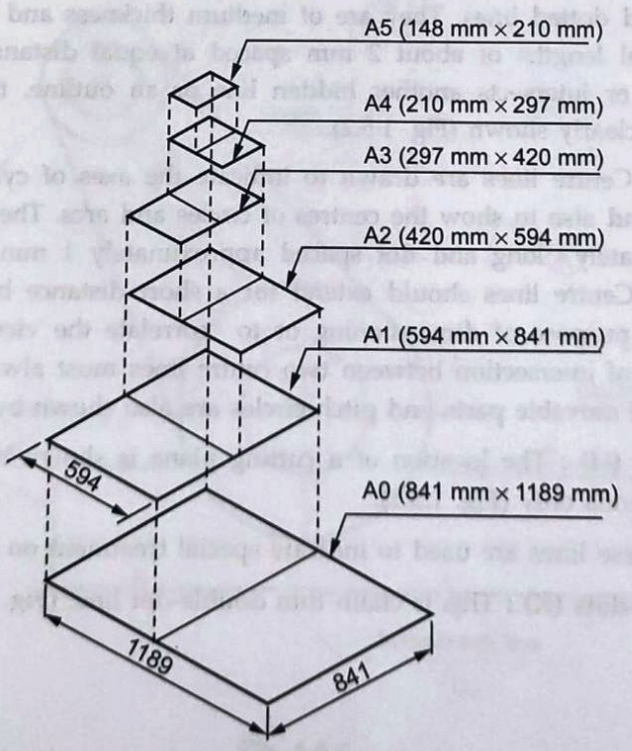


Fig. 1.4.1

1.5 : Types of Line

1) **Outlines (A) :** Lines drawn to represent visible edges and surface boundaries of objects are called outlines or principal lines. They are continuous thick or wide lines (Fig. 1.5.1)

2) **Margin lines (A) :** They are continuous thick or wide lines along which the print are trimmed (Fig. 1.5.1).

3) **Dimension lines (B) :** These lines are continuous thin lines. They are terminated at the outer ends by pointed arrowheads touching the outlines, extension lines or centre lines (Fig. 1.5.1).

4) **Extension or, projection lines (B) :** These lines also are continuous thin lines. They extend by about 3 mm beyond the dimension lines (Fig. 1.5.1).

5) **Construction lines (B) :** These lines are drawn for constructing figures. They are shown in geometrical drawings only. They are continuous thin light lines.

6) **Hatching or section lines (B) :** These lines are drawn to make the section evident. They are continuous thin lines and are drawn generally at an angle of 45° to the main outline of the section. They are uniformly spaced about 1 mm to 2 mm apart (Fig. 1.5.1).

7) **Leader or pointer lines (B) :** Leader line is drawn to connect a note with the feature to which it applies. It is a continuous thin line (Fig. 1.5.1).

8) **Border lines (B) :** Perfectly rectangular working space is determined by drawing the border lines (Fig. 1.5.1(a)). They are continuous thin lines.

9) **Short-break lines (C) :** These lines are continuous, thin and wavy. They are drawn freehand and are used to show a short break, or irregular boundaries (Fig. 1.5.2).

10) **Long-break lines (D) :** These lines are thin ruled lines with short zigzags within them. They are drawn to show long breaks (Fig. 1.5.2).

11) **Hidden or dotted lines (E or F) :** Interior or hidden edges and surfaces are shown by hidden lines. They are also called dotted lines. They are of medium thickness and made up of short dashes of approximately equal lengths of about 2 mm spaced at equal distances of about 1 mm. When a hidden line meets or intersects another hidden line or an outline, their point of intersection or meeting should be clearly shown (Fig. 1.5.2).

12) **Centre lines (G) :** Centre lines are drawn to indicate the axes of cylindrical, conical or spherical objects or details, and also to show the centres of circles and arcs. They are thin, long, chain lines composed of alternately long and dot spaced approximately 1 mm apart. The long dashes are about 9 to 12 mm. Centre lines should extend for a short distance beyond the outlines to which they refer. For the purpose of dimensioning or to correlate the views they may be extended as required The point of intersection between two centre lines must always be indicated. Locus lines, extreme positions of movable parts and pitch circles are also shown by this type of line (Fig. 1.5.1).

13) **Cutting-plane lines (H) :** The location of a cutting plane is shown by this line. It is a long, thin, chain line, thick at ends only (Fig. 1.5.1).

14) **Chain thick (J) :** These lines are used to indicate special treatment on the surface. (Fig. 1.5.2)

15) **Chain thick double-dots (K) :** This is chain thin double-dot line. (Fig. 1.5.2)

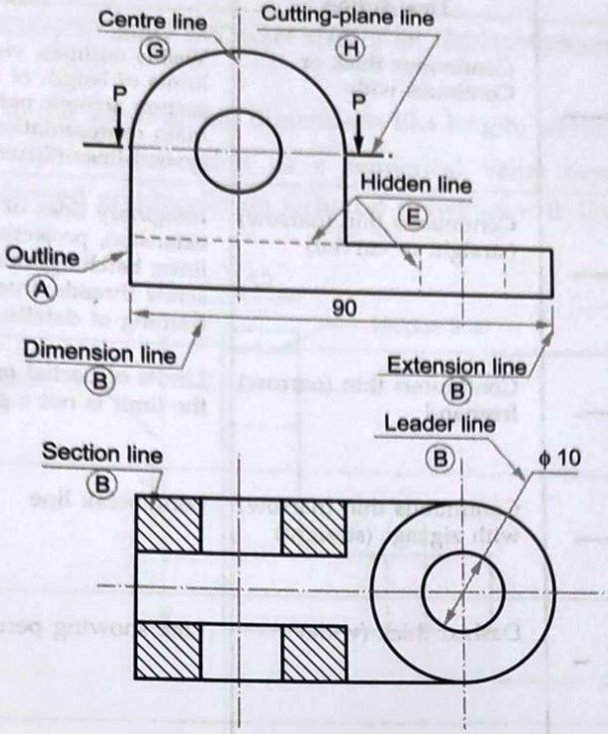


Fig. 1.5.1

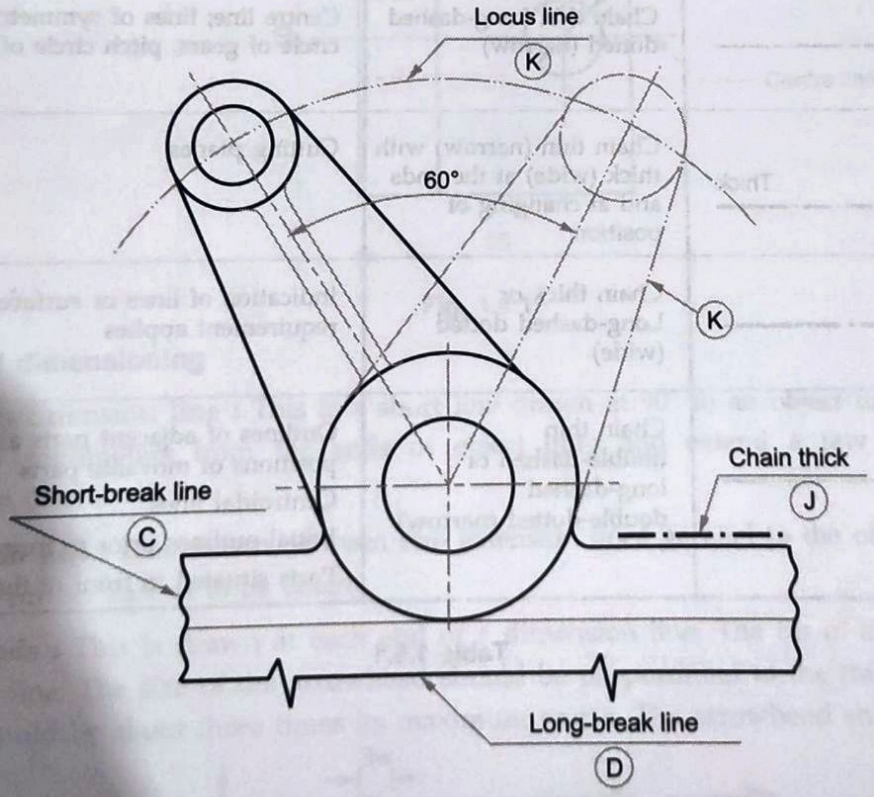


Fig. 1.5.2

Line	Description	General applications
A ———	Continuous thick or Continuos wide	Visible outlines, visible edges, crests of screw threads, limits of length of full deph thread, lines of cuts and section arrows; parting lines of moulds in views; main representations in diagrams, maps, flow charts; system lines (Structural metal engg.)
B ———	Continuous thin (narrow) (straight or curved)	Imaginary lines of intersection; grid dimension, extension, projection, short centre, leader, reference lines; hatching; outlines of revolved sections; root of screw threads; interpretation lines of tapered features; framing of details; indication of repetitive details;
C ~~~	Continuous thin (narrow) freehand	Limits of partial or interrupted view and sections, if the limit is not a chain thin line.
D —/\/\/—	Continuous thin (narrow) with zigzags (straight)	Long-break line
E — — — — —	Dashed thick (wide)	Line showing permissible of surface treatment
F - - - - - -	Dashed thin (narrow)	Hidden outlines; hidden edges
G —·—·—	Chain thin Long-dashed dotted (narrow)	Centre line; lines of symmetry; trajectories; pitch circle of gears, pitch circle of holes,
H Thick Thin Thick —·—·—	Chain thin (narrow) with thick (wide) at the ends and at changing of position	Cutting planes
J —·—·—	Chain thick or Long-dashed dotted (wide)	Indication of lines or surfaces to which a special requirement applies
K —··—··—	Chain thin double-dashed or long-dashed double-dotted (narrow)	Outlines of adjacent parts alternative and extreme positions of movable parts Centroidal lines Initial outlines prior to forming Parts situated in front of the cutting plane

Table 1.5.1

1.6 : Dimensioning

- Dimensions are necessary to show the exact size of an object. Without dimensions a drawing can not be understood.
- Dimensioning refers to the act of giving dimensions like length, width diameter, height etc.
- BIS (SP 46 : 2003) defines dimension as a numerical value expressed in appropriate units of measurement and indicated graphically on technical drawings with lines, symbols and notes.

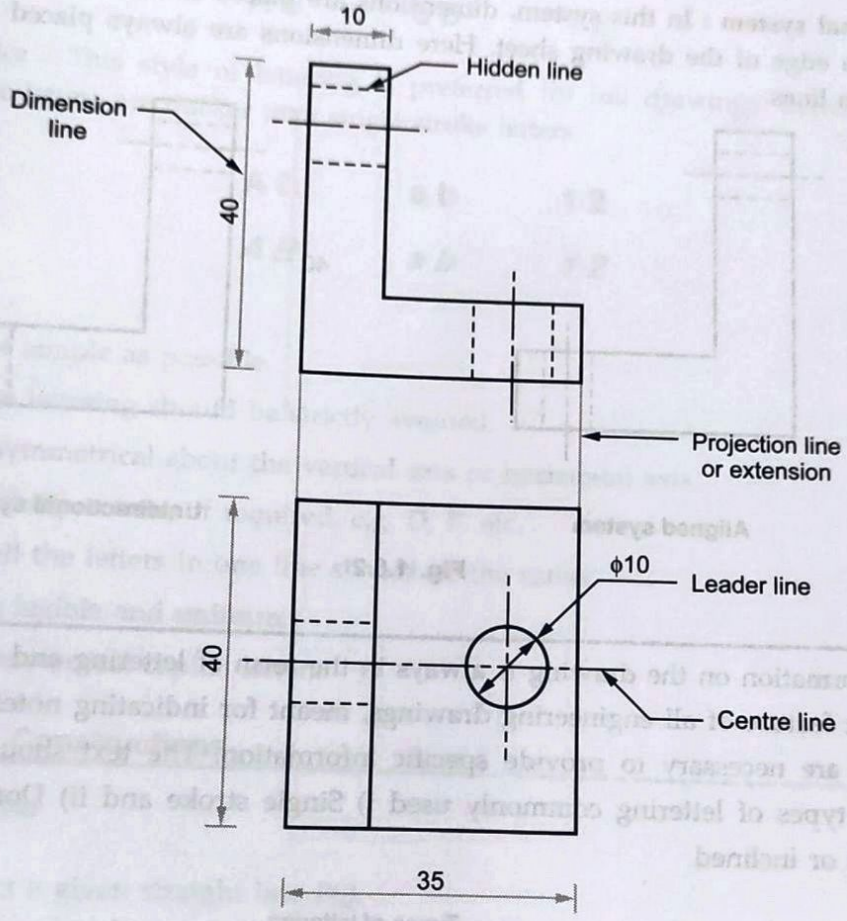


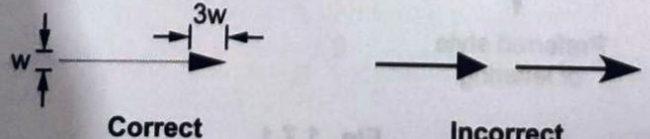
Fig. 1.6.1

Elements of dimensioning

i) **Projection/Extension line :** This is a short line drawn at 90° to an object line. It starts immediately or a few millimeters from the ends of object lines and extend a few millimeters beyond a dimension line.

ii) **Dimension line :** It is drawn between two extension lines parallel to the object line. While showing an angle, proper care is to be taken.

iii) **Arrowheads :** This is drawn at each end of a dimension line. The tip of an arrowhead touches the extension line. The size of the arrowhead should be proportional to the thickness of the outlines. Its length should be about three times its maximum width. The arrowhead should be closed and filled.

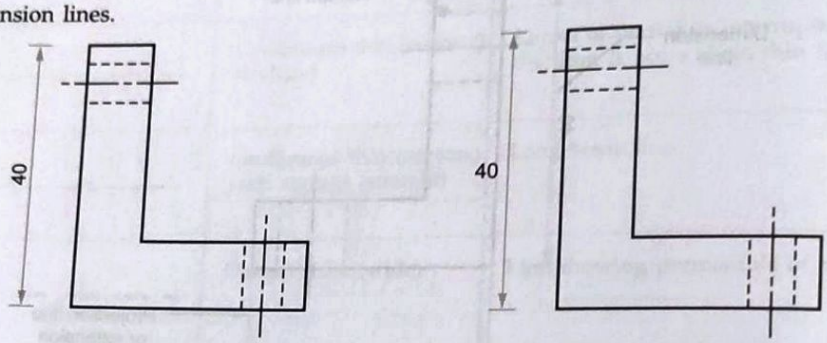


iv) **Leader line :** Leader line connects a note or a dimension, symbol with the feature to which it applies. It is a thin continuouse line inclinned to the reference line at 30° or 45° or 60°.

Systems of dimensioning

i) **Aligned system :** Here dimensions are placed at 90° to the dimension line so as to read from right hand side or bottom of the sheet. Dimensions are placed at the middle and on top of the dimension lines.

ii) **Unidirectional system :** In this system, dimensions are placed in such a way that they can be read from bottom edge of the drawing sheet. Here dimensions are always placed vertically irrespective of dimension lines.



Aligned system **Unidirectional system**

Fig. 1.6.2

1.7 : Lettering

- All written information on the drawing is always in the form of lettering and not in handwriting. This is an important feature of all engineering drawings, meant for indicating notes, dimensions etc. on the drawing Texts are necessary to provide specific information. The text should be clear and concise. There are two types of lettering commonly used i) Single stroke and ii) Double stroke. These letters may be vertical or inclined.

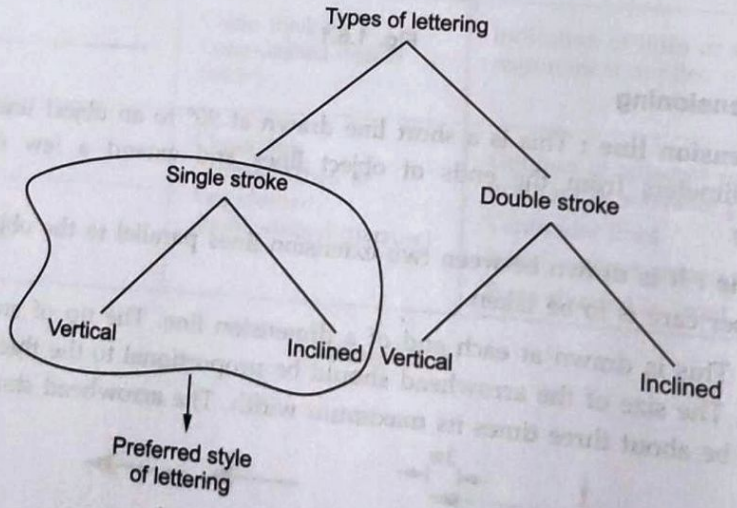


Fig. 1.7.1

i) **Single stroke :** This is the most common and preferred lettering style. Single stroke refers to the thickness obtained in one stroke of a pencil. The letters are drawn upright.

1. **Vertical :** Letters, alphabets and numerials are vertically oriented.

A B a b 1 2

2. **Inclined :** Here direction of alphabets is inclined to the horizontal at 75°. The inclinations of all the letter should be the same.

A B a b 1 2

ii) **Double stroke :** This style of lettering is preferred for ink drawings. Letters can be vertical or inclined.These letters are thicker than single stroke letters.

A B a b 1 2

A B a b 1 2

Letter ing Rules

1. Draw letters as simple as possible.
2. Artistic, cursive lettering should be strictly avoided.
3. Draws letters symmetrical about the vertical axis or horizontal axis.
4. Round off the sharp corners if required, e,g. D, P. etc.
5. The height of all the letters in one line should be the same.
6. Draw all letters legible and uniform.
7. Use single stroke vertical capital letters.

1.8 : Simple Geometrical Constructions

1. a) To bisect a line

Example : To bisect a given straight line PQ.

1. With P as centre and radius greater than half of PQ, mark two arcs, one on one each side of PQ.
2. With Q as centre and same radius, mark two arcs intersecting the previous arcs at R and S.
3. Join RS. RS is the perpendicular bisector of PQ.

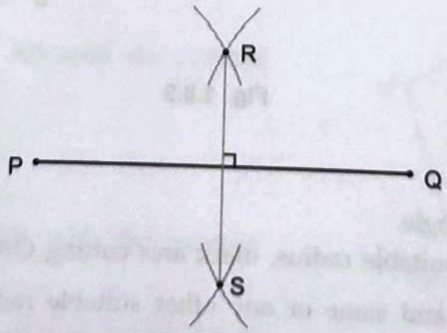


Fig. 1.8.1

b) To bisect a given arc PQ.

Example : Follow the same procedure as that of a line.

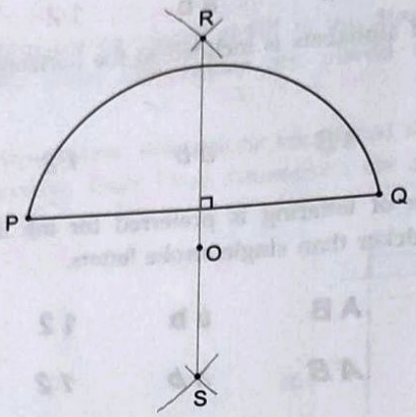


Fig. 1.8.2

2. To divide a line into any number of equal parts.

Example : Divide a straight line of 75 mm length into six equal parts.

i) Draw a line AB of 75 mm length.

ii) Draw a line AC of any length, inclined at suitable acute angle say 30° or 45° to AB.

iii) From A and along AC, mark successively 6 equal divisions of any convenient length. Name the division points as, 1, 2, 3, ...6 on AC joint 6 and B.

iv) Draw lines parallel to B6 through 1, 2, 3, 4, 5 to cut AB at 1', 2', 3', 4' and 5'. The points 1', 2', 3', etc. are division points dividing AB into six equal parts.

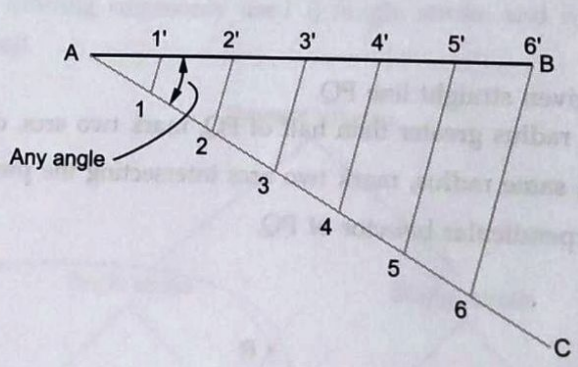


Fig. 1.8.3

3. To bisect an angle

Example : Bisect the given angle.

i) With 0 as centre and any suitable radius, mark arcs cutting OA and OB at C and D respectively.

ii) With C and D as centres and same or any other suitable radius, mark two arcs intersecting each other at E.

iii) Join OE, OE is the bisector of ∠AOB, i.e. ∠AOE = ∠EOB.

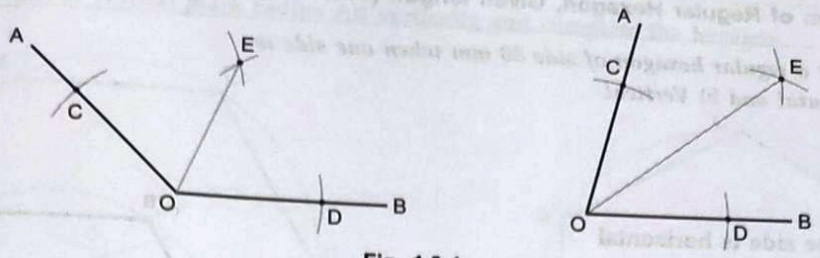


Fig. 1.8.4

Polygons

- Polygon is a plane figure bounded by more than four lines. Regular polygons include five-sided pentagon, six sided hexagon, seven sided heptagon and eight sided octagon.

Regular polygon : When all the sides of a polygon are equal, it is known as a regular polygon. Unlesses specified as irregular, polygons means regular polygon only.

- Construction of regular polygons means, Given length of side.

Method I : Using base angle of side.

Ex. 1.8.1 : ***Construct a polygon (pentagon) of 30 mm side.***

Sol. :

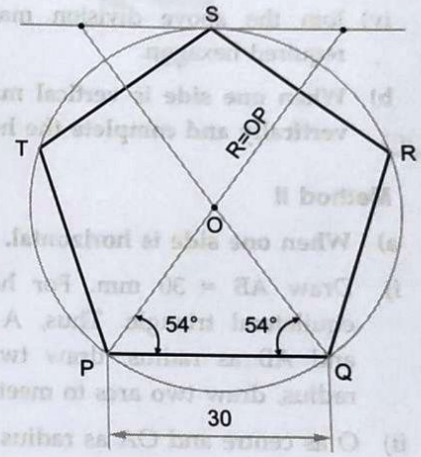
i) Draw PQ = Length of side = 30 mm.

ii) Draw on isosceles triangle OPQ with PQ as base and base angles of 54° [For the pentagon, Angle subtended at the centre of the isosceles triangle = 360°/5 = 72°, Hence, its base angle = (180° – 72°)/2 = 54°.

iii) 'O' as centre and OP as radius, draw a circle passing through P and Q.

iv) 'PQ' as radius, cut the circle successively at R, S and T.

v) Join QR, RS and TP, PQRST is the required pentagon.



Method II : Exterior angle method

Ex. 1.8.2 : ***Construct a pentagon of side 35 mm.***

Sol. :

i) Draw AB = 35 mm.

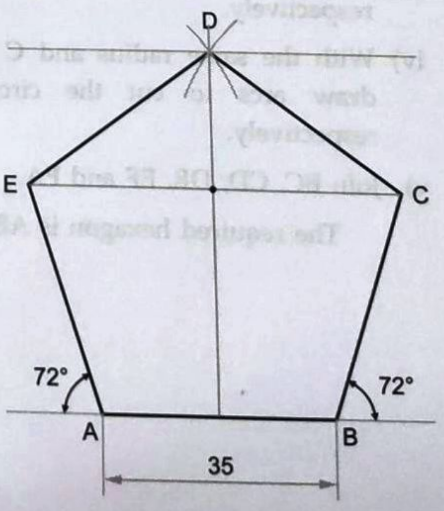
ii) Draw the second side BC = AB with the exterior angle of 72°,

$\left(\because \frac{360}{5} = 72°\right)$ similarly,

Draw the fifth side AE = AB with the exterior angle of 72°.

iii) C and E as centres, draw two arcs of radius AB to intersect each other at D.

iv) Join CD and ED. ABCDE is a required pentagon.



Construction of Regular Hexagon, Given length, (Side length)

Ex. 1.8.3 : *Construct a regular hexagon of side 30 mm when one side is a) Horizontal and b) Vertical*

Sol. :

Method I

a) When one side is horizontal

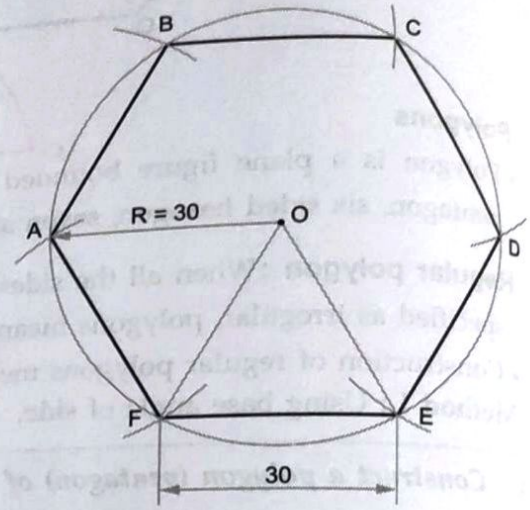
i) O as centre and the given side length 30 mm as radius, draw a circle, mark radius OA horizontally.

ii) 'A' as centre and given side length as radius, draw an arc to cut the circumference of the circle at B.

iii) Similarly, mark points C,D,E and F, Now, we get six division marks on the circumference of the circle.

iv) Join the above division marks to obtain the required hexagon.

b) When one side is vertical mark the radius OA vertically and complete the hexagon.



OFE = Equilateral triangle

(a)

Method II

a) When one side is horizontal.

i) Draw AB = 30 mm. For hexagon, Δ OAB is equilateral triangle. Thus, A and B as centres and AB as radius, draw two arcs and AB as radius, draw two arcs to meet at O.

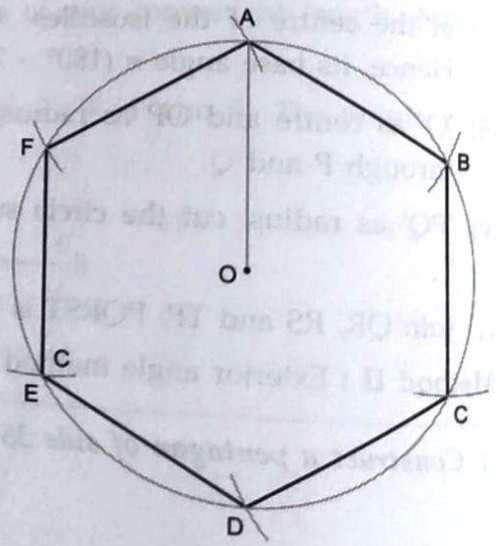
ii) O as centre and OA as radius describe a circle.

iii) With the same radius and A and B as centres, draw arcs to cut the circle at F and C respectively.

iv) With the same radius and C and F as centres, draw arcs to cut the circle at D and E respectively.

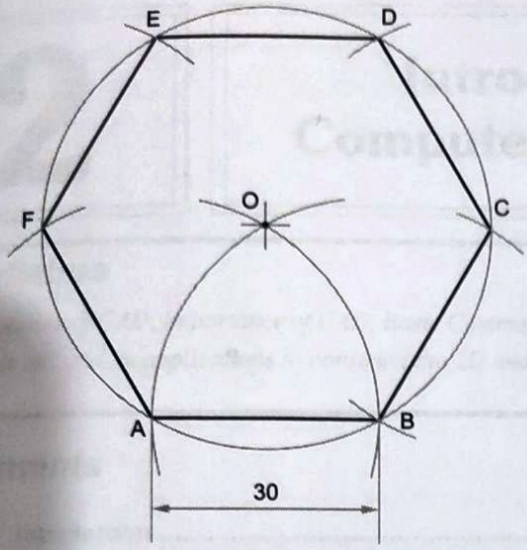
v) Join BC, CD, DE, EF and FA.

The required hexagon is ABCDEF.



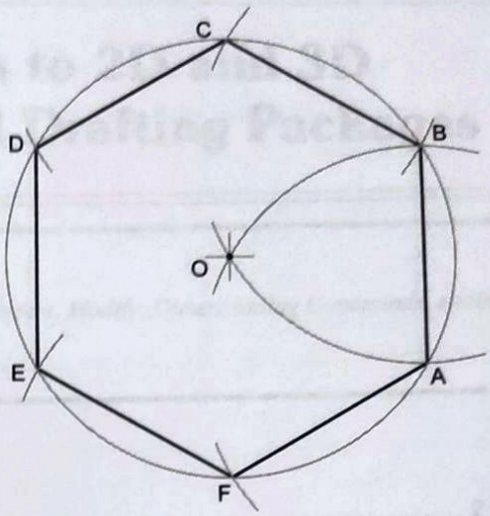
(b)

b) When one side is vertical mark radius AB vertically and complete the hexagon.



AB - Horizontal

(a)



AB - Vertical

(b)

❑❑❑

UNIT - II

2 Introduction to 2D and 3D Computer Aided Drafting Packages

Syllabus

Evolution of CAD, Importance of CAD, Basic Commands - Edit, View, Insert, Modify, Dimensioning Commands, setting and tools etc. and its applications to construct the 2D and 3D drawings

Contents

2.1 : Introduction ..... 2 - 2

2.2 : Introduction of AutoCAD ..... 2 - 2

2.3 : Advantages of AutoCAD ..... 2 - 3

2.4 : Application of AutoCAD ..... 2 - 3

2.5 : Basic Commands of AutoCAD ..... 2 - 4

2.6 : Illustartive Examples ..... 2 - 11

2.1 : Introduction

- Software communication is a pattern of code called a language. The most primitive language is called machine code, which speaks, directly to the hardware equipment in either binary (two digit) signals. The writing of software is made much less involved with the aid of high level languages which are used in most areas of CADD. Software usually consists of a number of separate application package to perform the desired function. The size of computer depends on the number and size of packages and number of workstations
- A wide range of standard software is available and generally it is not worth developing users own software. Basically a software is an interpreter which allows the user to perform specific type of application related to CAD software. There are a number of 2D drafting software packages available in the market. Auto Desk, makers of AutoCAD is a leader in the 2D engineering CADD software industry. Although this course will focus on AutoCAD, there are other CADD software, packages available.
- They include :

1. Corel Draw 2. CAD Std 3. Pro CAD+ 4. Accucadd 5. CADD5
6. CADD 2002 7. Vector Engineer 8. Dexterpen 9. Corel CAD

- All the above software are capable of creating drafting, but many of them do not have as many features as AutoCAD. The most important characteristic of CAD software is its three dimensional associative centralized and integrated data base known as 3D drafting. Such a data base is always rich in information needed in design. Various 3D modelling packages are:

1. Pro\E 2. Unigraphics 3. CATIA 4. Ideas 5. Solid Works 6. Solid edge

Application software includes drafting and dimensioning software.

- 3D geometric modelling,
- Surface modelling,
- Solid modelling,etc

2 : Introduction of AutoCAD

- Learning to use a CAD system is similar to learning a new language. It is necessary to begin with the basic alphabet and learn how to use it correctly and effectively through practice. This will require learning some new concepts and skills as well as learning a different vocabulary. All CAD systems create designs using basic geometric entities. Many of the constructions used in technical designs are based upon two-dimensional planar geometry. The method and number of operations that are required to accomplish the constructions are different from one system to another, In engineering field, Computer-Aided Drafting (CAD) or Computer-Aided Design (CAD) and Computer-Aided Engineer (CAE) have been utilized in different fields of engineering and science. Manufacturing of a product is the main activity in engineering profession. The design of a product may start with trial design in the form of sketches on the paper. As the design improves and under goes changes, the final form of design must be the scaled manufacturing drawing with finer details included. These drawings can be two-dimensional and three-dimensional.
- An engineering drawing may be prepared by means other than the use of conventional tools. Traditionally, drafting instruments have been used. The popular alternative now is to prepare the

drawing with the aid of a computer. This method is known as Computer-Aided Design or Computer Aided Drafting.

2.3 : Advantages of AutoCAD

The main advantage of CAD drawing

1. **Saves time :** When you are using the computer-aided design software, it will save your time and you can make better and more efficient designs in shorter time duration.
2. **Easy to edit :** When you are making designs, you may find the need to make alterations. When you are using computer-aided design software, it will be much easier to make any changes because you can fix the errors and modify the drawings easily.
3. **Decrease in error percentage :** As the CAD software makes use of some of the best tools, the percentage of error that occurred because of manual designing is significantly reduced.
4. **Decrease design effort :** When it comes to the amount of effort that was needed for the sake of designing the different models, it has been reduced significantly because the software automates most of the task.
5. **Code re-use :** As the entire task is carried out with the help of computer tools, it removes the problem of duplication of labor, you can copy the different parts of code and design which can then be reused multiple times over and over again.
6. **Easy to share :** The CAD tools make it easier to save the files and store it in a way that you can use it time and again and send it without any unwanted hassles too.
7. **Improved accuracy :** There is absolutely no doubt about the fact that the kind of accuracy that CAD software will offer can never be achieved by opting for manual drawings. You have tools to measure the precision, skill and accuracy level of the designs.

2.4 : Application of AutoCAD

- CAD applications in various fields of engineering are as follows :
- Mechanical : Aerospace, Design of machine elements, CNC,VMC machine tools, Robots etc.
- Automotive : Gear design, Kinematics, Hydraulics, Steering etc.
- Electrical : Panel design, Circuit layout, , Control system etc.
- Electronics : Mechatronics, Schematic diagrams of PCs, ICs etc.
- Communication : Communication network, Satellite transmitting picture etc.
- Civil and Architectural : Mapping, Building drawing, Structural design, Town planning, Interior decorations, Multi-storeyed complex etc.
- Aerospace : Design of spacecraft, Flight simulator lofting etc.
- Automated-design : Automatic dimensioning, Generation of cross-hatched area, Scaling of drawing,
- Developed section view and Enlarged view in details etc.
- Geometric modelling : Generation of points, Lines and Circles, Rotation of objects etc.

2.5 : Basic Commands of AutoCAD

- We can also select commands from the menu. The menu bar is at the top of the screen. If we move the cursor over the menu bar, different titles are highlighted. These menu hold all the commands and functions that are the heart of the AutoCAD 2007.
- These menus hold all the commands and functions that are the heart of the AutoCAD. The best example of that are shown in Fig. 2.5.1 These menus can be used by clicking on menu item and then selecting appropriate commands such as:

(i) **File** : This menu includes file new, file open, file save, print, copy, paste etc.

(ii) **Edit** : This menu provides commands from interfacing with the other windows application.

(iii) **View** : Shows the most commonly used display commands.

(iv) **Insert** : Lets you to insert various blocks

(v) **Format** : You can change fonts.

(vi) **Tool** : Various tools available which support drawing.

(vii) **Draw** : Lets you to select various draw commands.

(viii) **Dimension** : It provides dimension to the existing drawing.

(ix) **Modify** : Provision of changes in the existing drawing.

(x) **Window** : Prints the area that you select using a window.

(xi) **Help** : It has on the line help for AutoCAD. The entire manual is contained in this context sensitive windows based help system

(i) File :

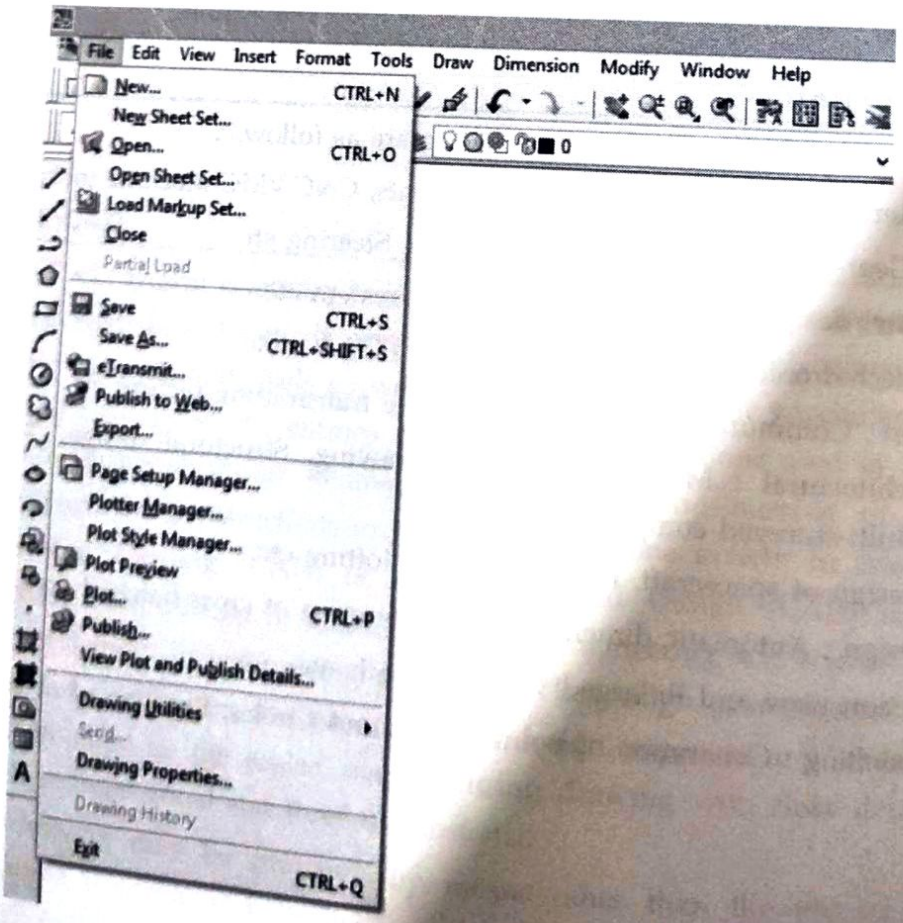
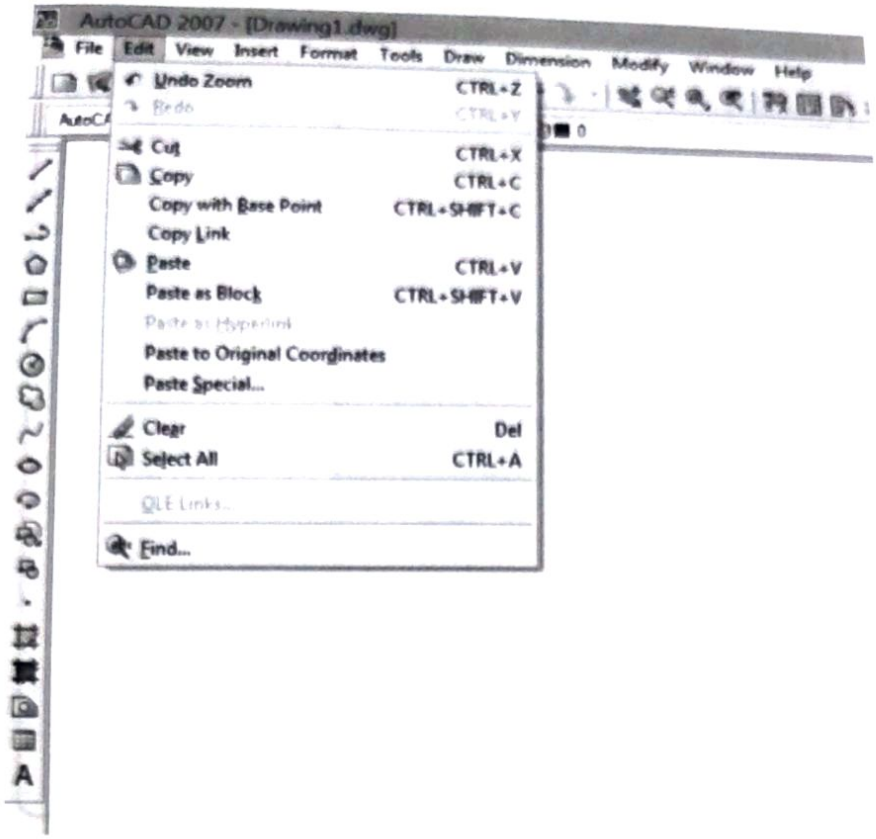
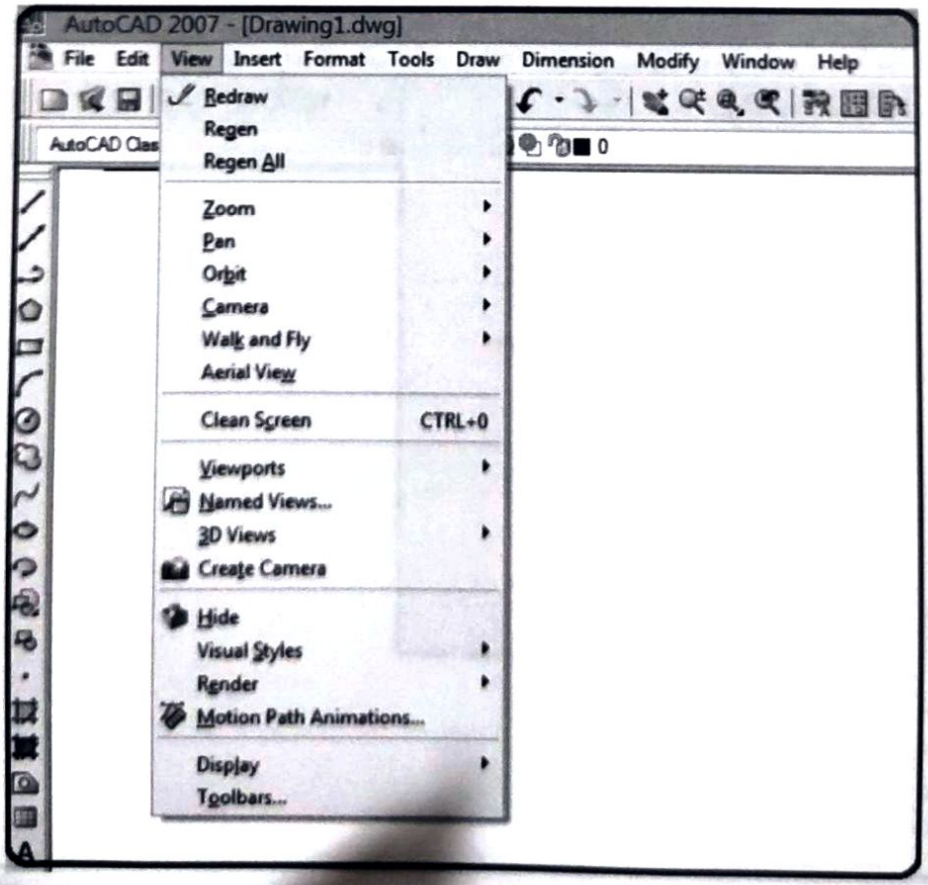


Fig. 2.5.1

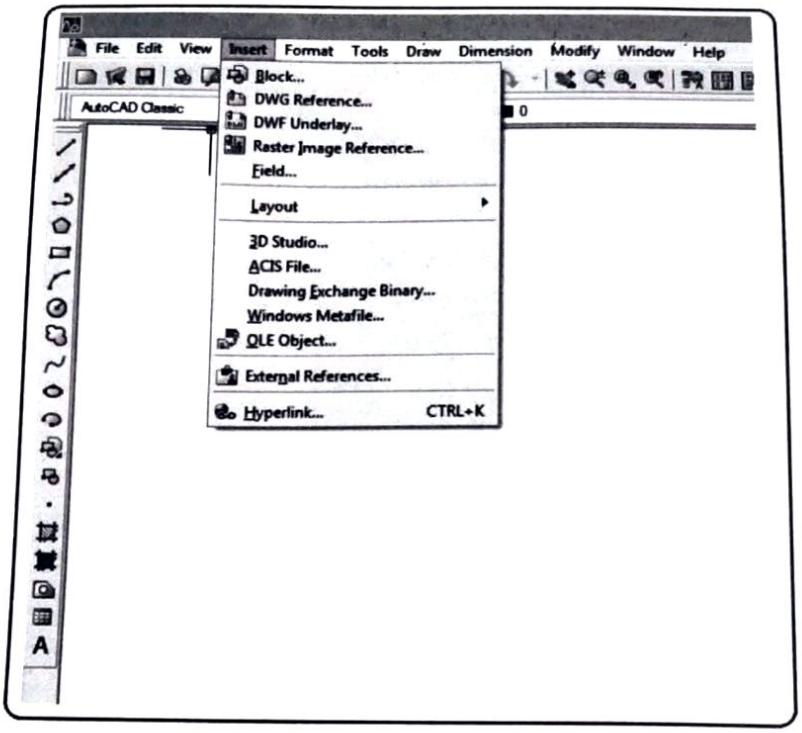
(ii) Edit :



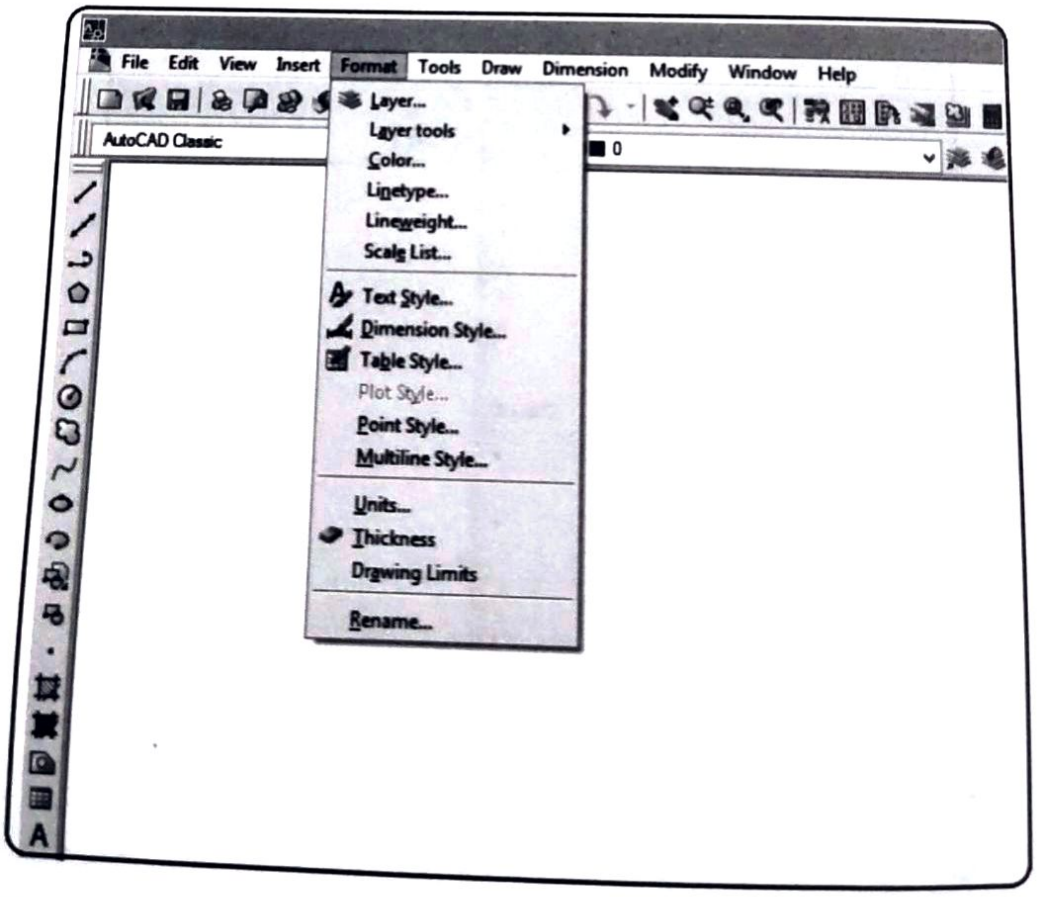
(iii) View :



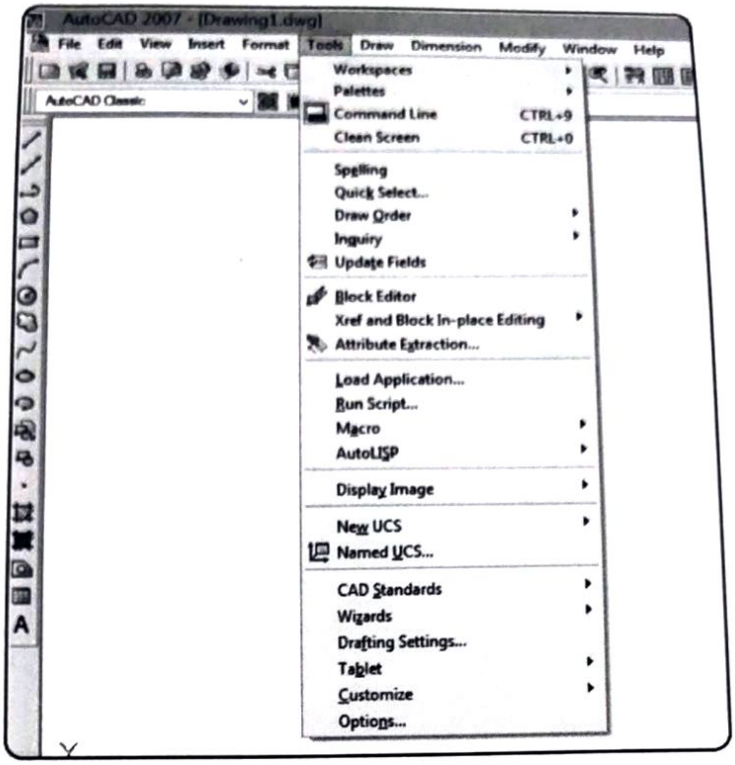
(iv) Insert :



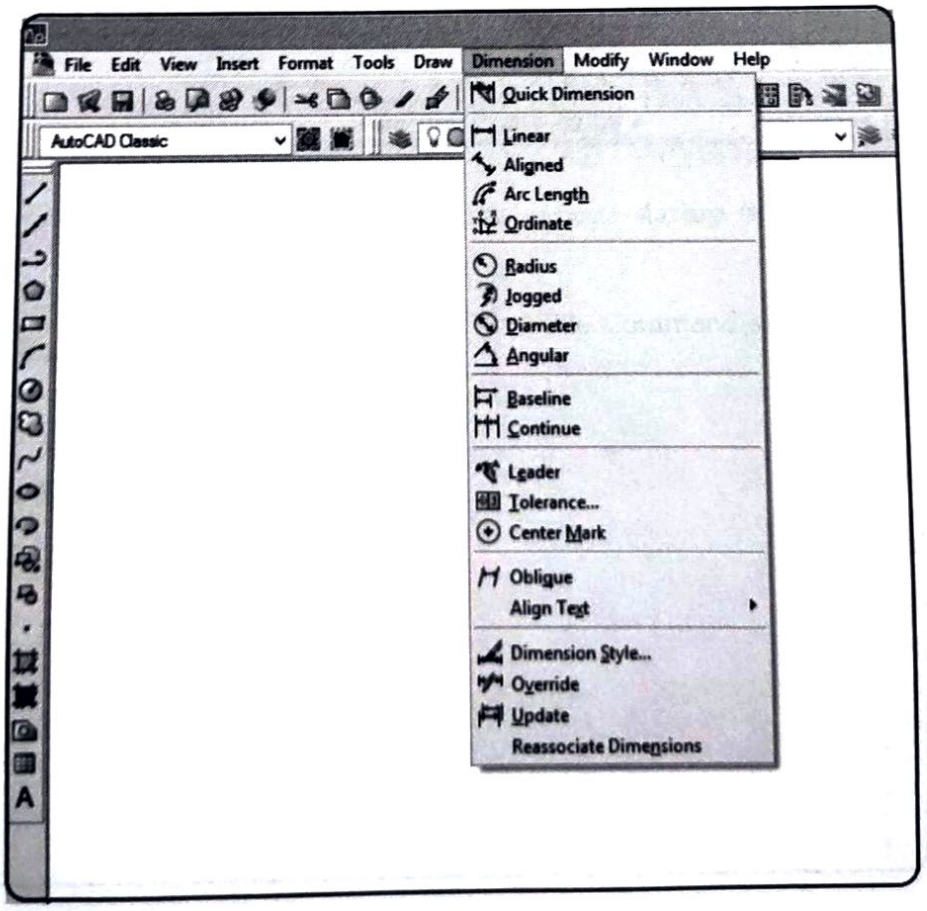
(v) Format :



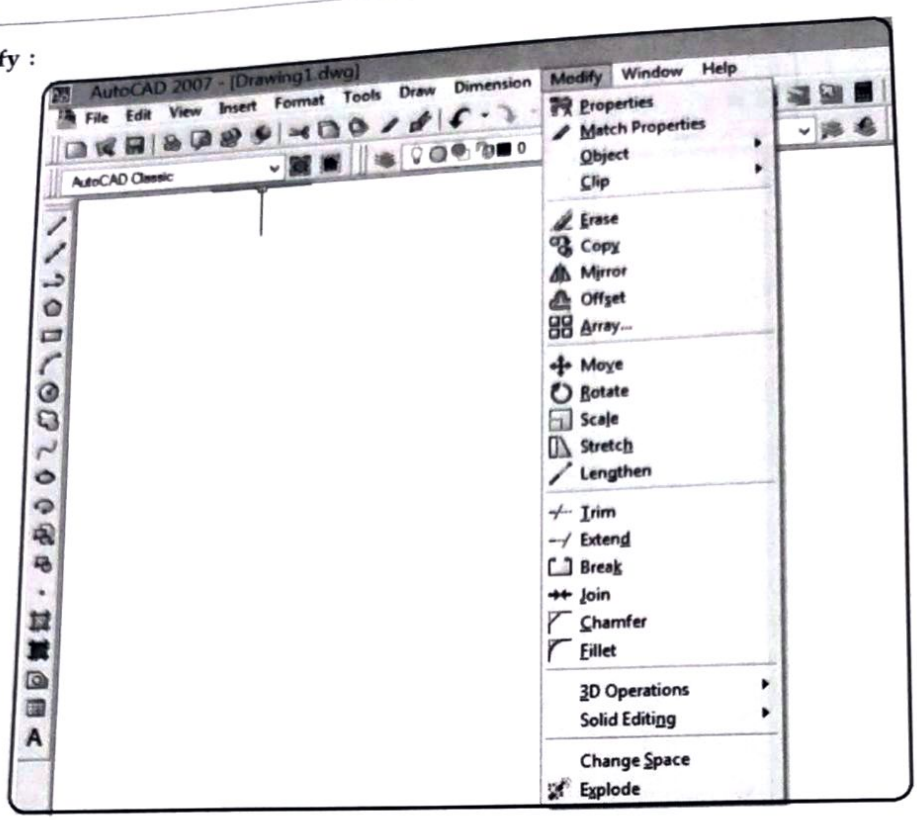
(vi) Tool :



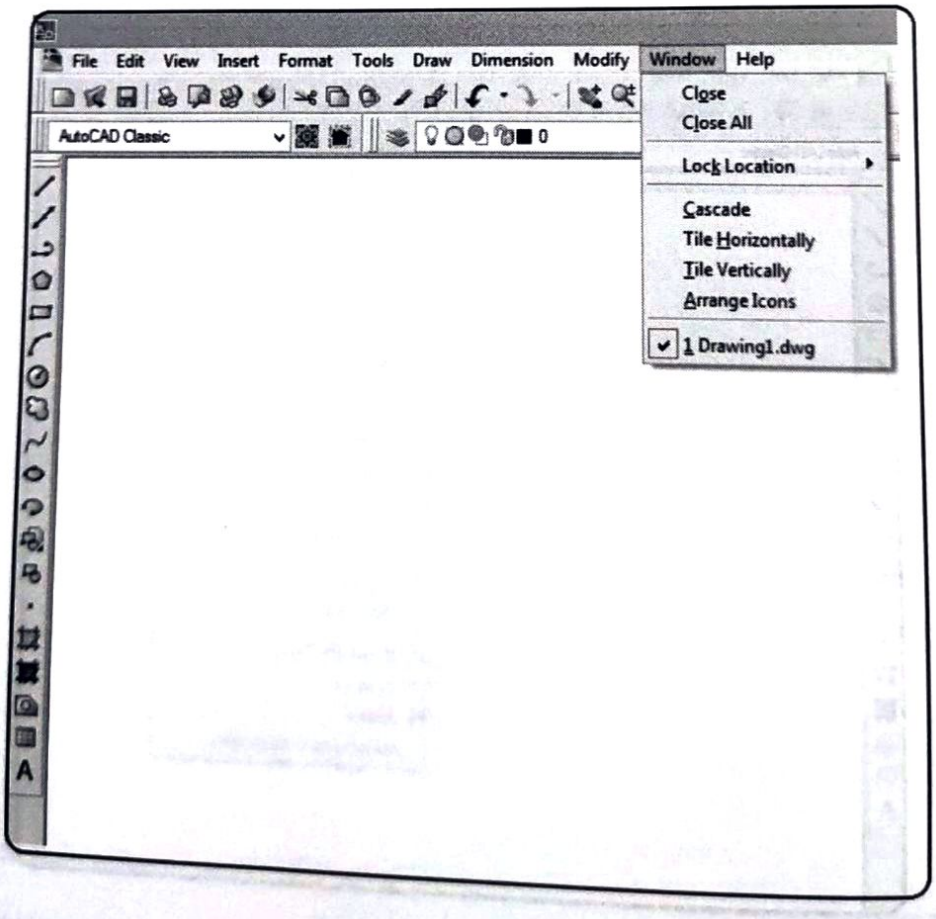
(viii) Dimension :



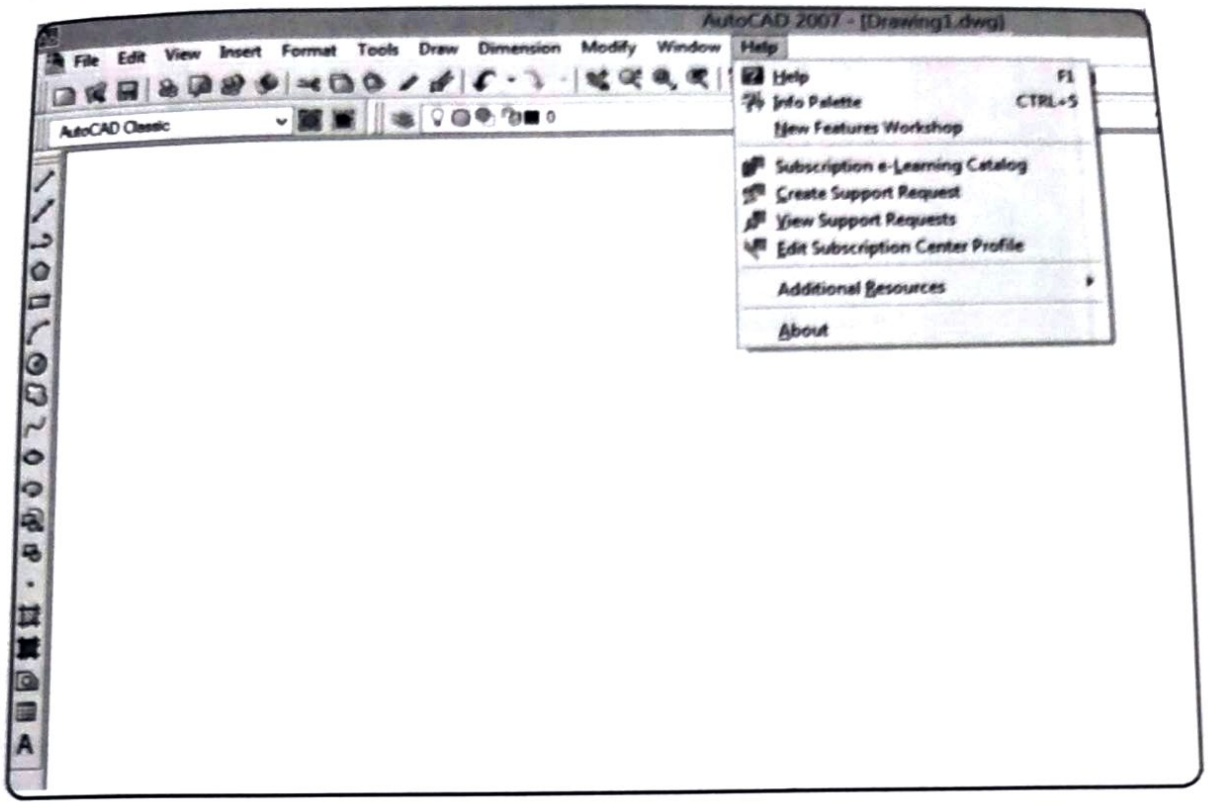
(ix) Modify :



(x) Window :



(xi) Help :

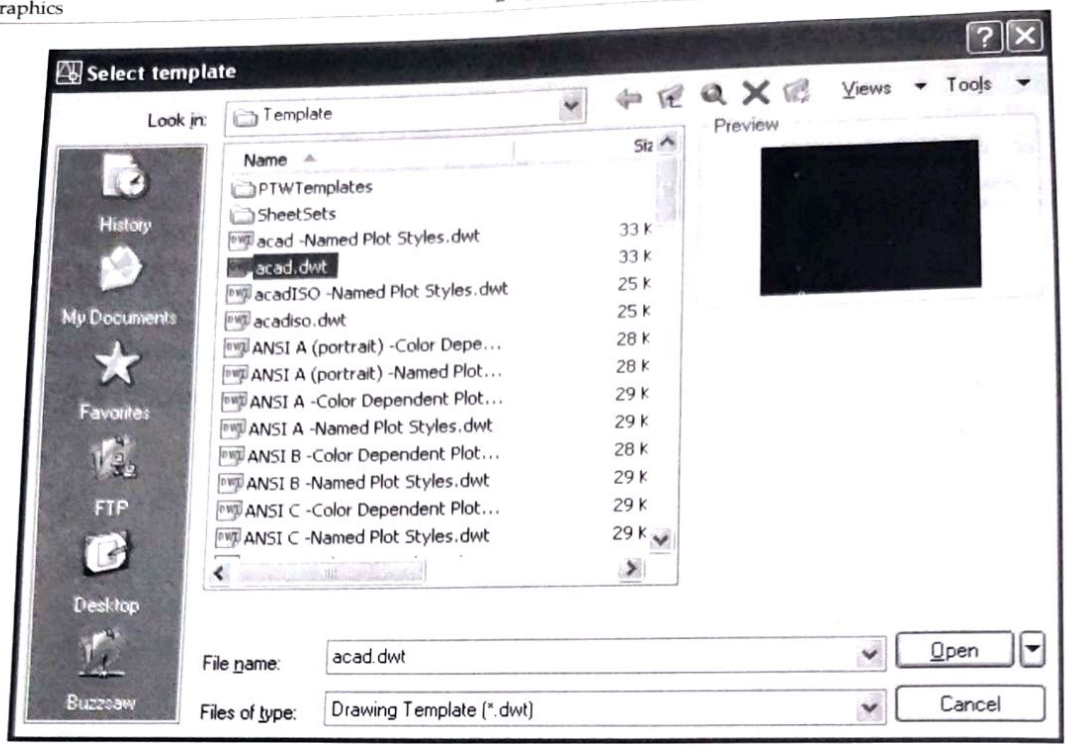


2.5.1 Dialog Boxes and Windows

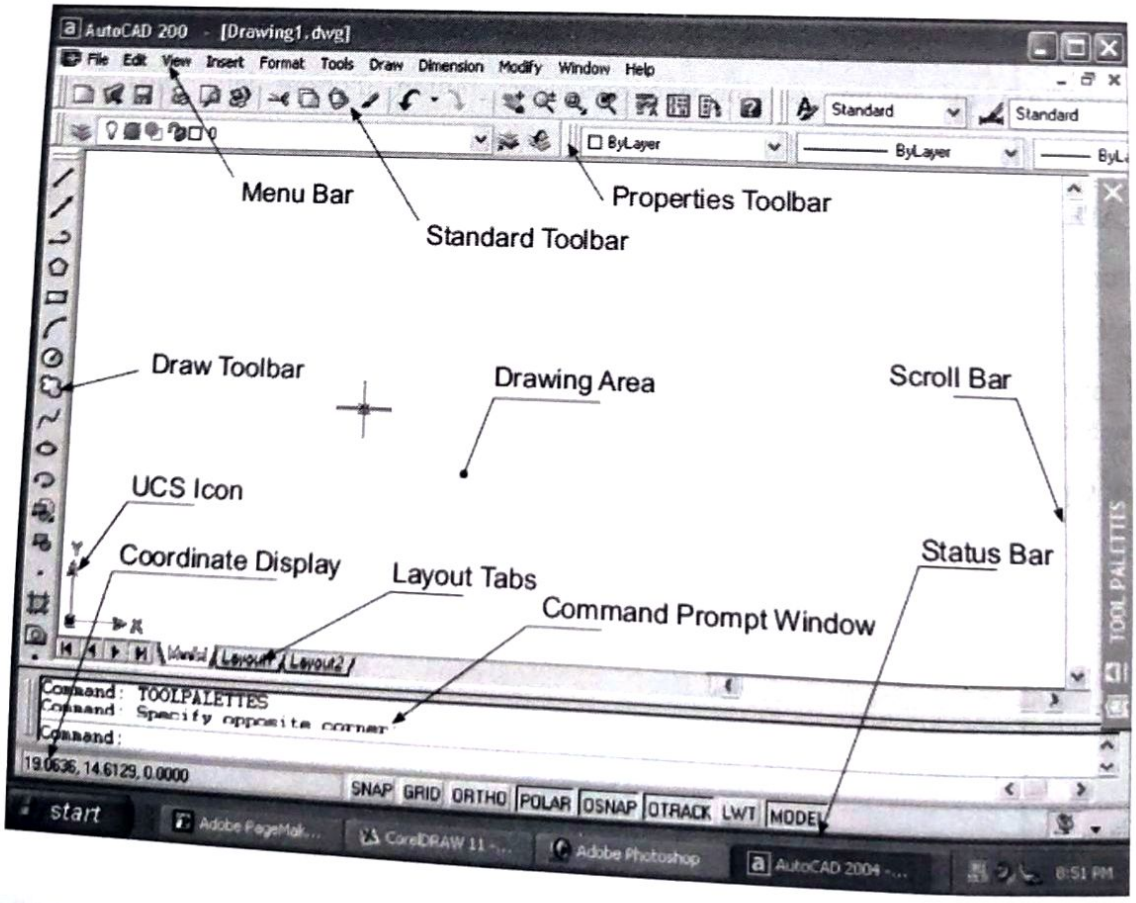
- Start AutoCAD by clicking on the Windows Start button (bottom left), then move the mouse to Programs then CAD and Modeling then "AutoCAD Architectural Desktop 2" and click on AutoCAD Architectural Desktop 2. A dialog giving various startup options will be displayed. Select the second option: "Start from Scratch" and click OK.
- Select Template Dialog-Box Appears After the New File Command(s)
- A Template is a Standard format

For Now Suggest Using the acad.dwt Template

- Click Open to Start the New Drawing

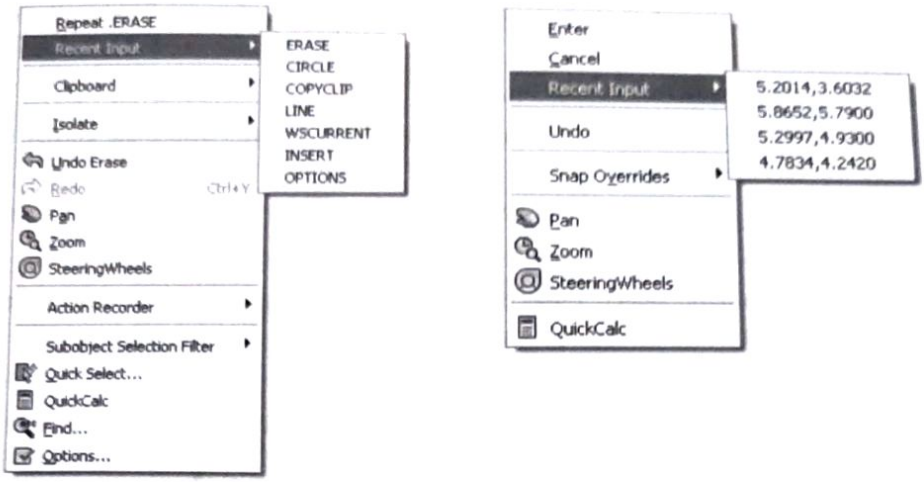


- Once you have loaded AutoCAD, move the mouse around until you see a crosshair cursor. The AutoCAD window has a number of important features.



Shortcuts Menus (Button bars)

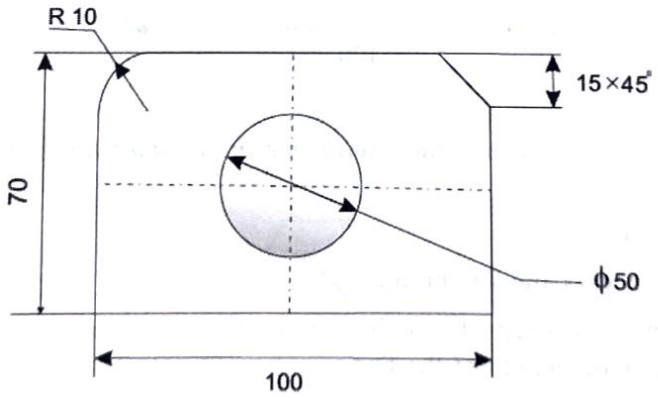
- Shortcut menus allow quick access to commands that are relevant to your current activity. You can display different shortcut menus when you right-click different areas of the screen and during a command. The shortcut menus shown in Figure appear when you right click in the drawing window and during the LINE command.



2.6 : Illustartive Examples

The following program are to be worked out using a 2D CAD (computer aided drafting) package. AUTOCAD-2007

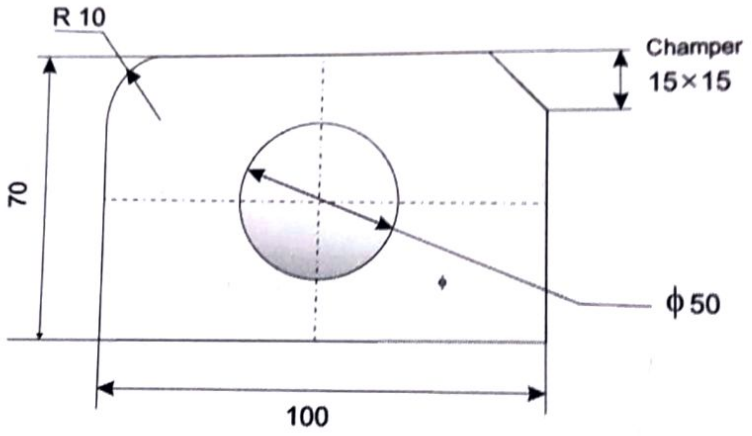
Ex. 2.6.1 : ***Draw the sketch shown in figure as per the given dimension.***



Sol. :

1. Click On the draw toolbar, click the line button.
2. Click where you want the line to begin. Enter the length of line, 100 mm and then click where you want the line to end. This defines the line's length.
3. Move the cursor line vertically upward, enter the length of line, 70 mm and angle as 900 press the enter button in keyboard or left button on mouse.

4. Repeat and continue, move the cursor line left side, enter the length of line, 100 mm and angle as 1800 click left button on mouse to get the line.
5. Finally move the cursor line downward, enter the length of the line as 70 mm and angle as -900 this forms as a rectangular shape.
6. On the draw tool bar, click the fillet button
7. Enter radius 10 press enter button in keyboard. Now click on corner of rectangle to get the radius as shown.
8. On the draw toolbar, click the chamfer button.
9. Enter angle as 450, setback A as 70 mm and setback B as 70 mm select the corner of rectangle and click inside the rectangle shape to get the chamfer as shown.
10. On the draw toolbar, click the circle by center button.
11. Select center point and radius as 50 mm to get the required geometry.
12. Select dimension command select the require line and geometric to dimension the features as shown in FIG the output is shown in figure.

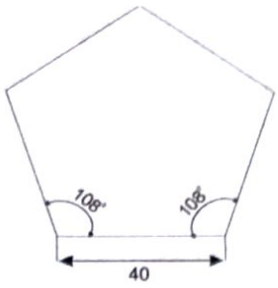


Ex. 2.6.2 : ***Construct a pentagonal of 40 mm sides with one of its sides horizontal and the corner opposite to that edge above it.***

Sol. : Fig. 2.6.2 computer output

1. On the draw toolbar, click the line button.
2. Click where the line is to begin. Enter the length of line 40 mm and angle as 00 and then click to end line. This defines the length of the line.
3. Move the cursor, line continues, now enter the length of line 40 mm and angle as 720, press enter button in keyboard or left button on mouse.
4. Move the cursor, line continues, now enter the length of line 40 mm and angle as 1440 press enter button in keyboard or left button on mouse.
5. Move the cursor, line continues, now enter the length of line 40 mm and angle as -1440 press enter button in keyboard or left button on mouse.
6. Move the cursor, line continues, now enter the length of line 40 mm and angle as -720, press enter button in keyboard or left button on mouse.

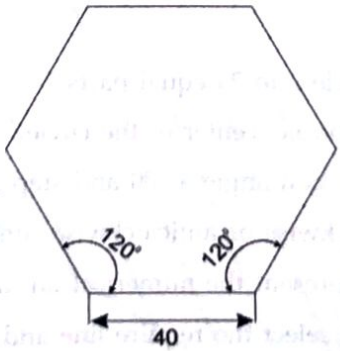
7. Select dimension command select the require line and geometry to dimension the pentagon as shown in figure.



Ex. 2.6.3 : ***Construct hexagon of 40 mm side.***

Sol. :

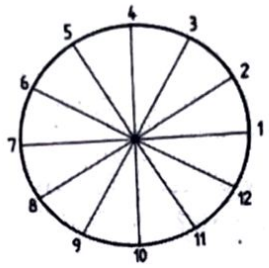
1. On the draw toolbar, click the line button.
2. Click where the line is to begin. Enter the length of line 40 mm and angle as 00 and then click to end line. This defines the length of the line.
3. Move the cursor, line continues, now enter the length of line 40 mm and angle as 600,press enter button in keyboard or left button on mouse.
4. Move the cursor, line continues, now enter the length of line 40 mm and angle as 1200 press enter button in keyboard or left button on mouse.
5. Move the cursor, line continues, now enter the length of line 40 mm and angle as 1800 press enter button in keyboard or left button on mouse.
6. Move the cursor, line continues, now enter the length of line 40 mm and angle as -1200,press enter button in keyboard or left buttwon on mouse.
7. Move the cursor, line continues, no enter the length of line 40 mm and angle as -600,press enter button in keyboard or left button on mouse.
8. Select dimension command select the require line and geometry to dimension the hexagon as shown in figure.



Ex. 2.6.4 : ***Divide a circle of 50 mm diameter into 12 equal parts.***

Sol. :

1. On the draw click the circle by center button.
2. Select center point and diameter as 50 mm or radius 25 mm to get the required circle
3. On the draw toolbar, click line button.
4. Draw line passing though the center of circle.
5. Click the rotate button.
6. Select the line to divide the circle into 12 equal parts.
7. Select the center point of rotation i.e. center of the circle.
8. Enter rotation angle as 300, position angle as 00 and step angel as 300.
9. Rotate and click the mouse clockwise or anticlockwise 5 times or until it divides into 12 parts.
10. Select text command to represent the numerical on divide parts.
11. Select dimension command select the require line and geometry to dimension the figure as in figure.



Ex. 2.6.5 : ***Divide a circle of 50 mm diameter into 24 equal parts.***

Sol. :

1. On the draw click the circle by center button.
2. Select center point and diameter as 50 mm or radius 25 mm to get the required circle.
3. On the draw toolbar, click line button.
4. Draw line passing though the center of circle.
5. Click the rotate button.
6. Select the line to divide the circle into 24 equal parts.
7. Select the center point of rotation i.e. center of the circle.
8. Enter rotation angle as 150, position angle as 00 and step angel as 150.
9. Rotate and click the mouse clockwise or anticlockwise until it divides into 24 parts.
10. Select text command to represent the numerical on divide parts.
11. Select dimension command select the require line and geometry to dimension the figure. (See figure on next page)

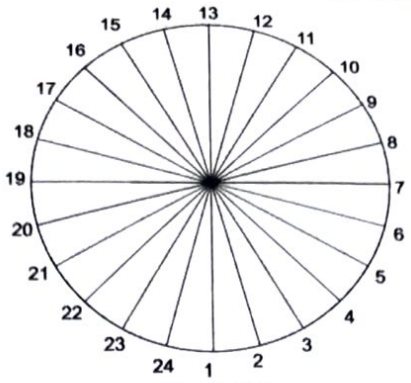
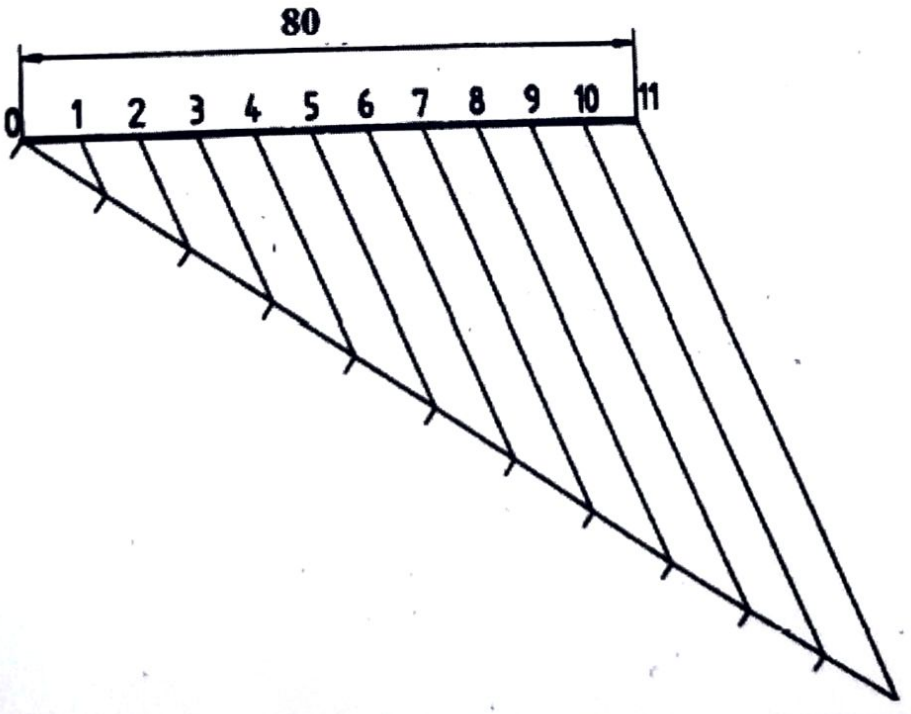


Fig. 2.6.5

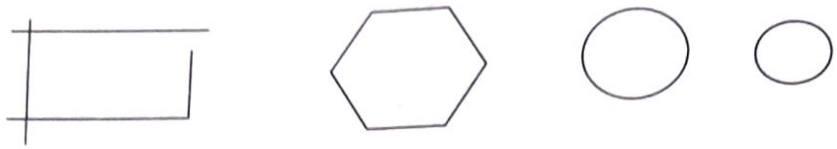
Ex. 2.6.6 : ***Divide the straight line of 80 mm into eleven equal parts.***

Sol. :

1. On the draw toolbar, click the line button.
2. Click where the line is to begin. Enter the length of line 80 mm and angle as 00 and then click to end line. This defines the length of the line.
3. Select the line button draw a line of any length at an angle les then 900.
4. Divide the angled line into 11 equal parts of any equal length by selecting an arc by center point icon.
5. Click the line button. Join last point of angled line to end point of the line.
6. Draw the parallel line to previous line draw till it gets divided in to 11 equal parts.
7. Select text command to represent the numerical on divide parts.
8. Select dimension command select the require line and geometry to dimension the figure as shown below.

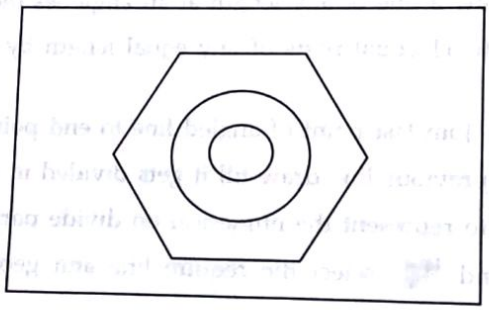


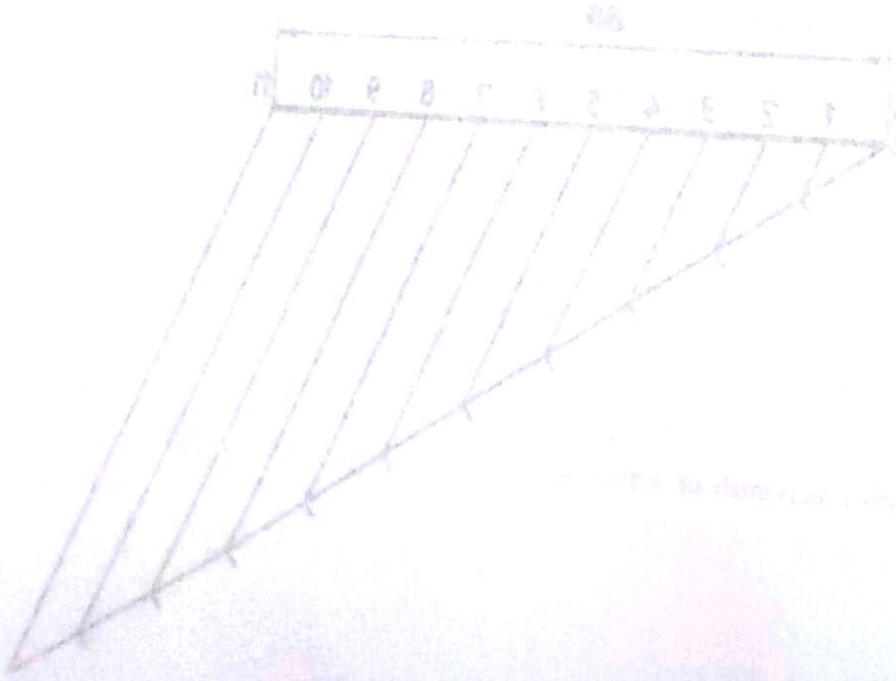
Ex..2.6.7 : ***Assemble the following geometric figure concentrically using necessary commands viz. extend, trim, copy, past etc.***



Sol. :

1. Select the trim button to remove the excess lines.
2. Select the line which has to be extended till target by select the extend button.
3. Select the move button click on the circle to select and select center point now move the cursor to the require position to click.
4. Select the concentric button, select the circle to be concentric to the circle which has already been moved.
5. Select the copy command select the hexagon and pest as shown in Figure.





UNIT - III

3 Engineering Curves

Syllabus

Introduction to conic sections and its significance, various methods to construct the conic sections. Helix for cone and cylinder , rolling curves (Involutes , Cycloid) and Spiral

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3.1 : Introduction

Engineering curves are used in designing certain objects. Designers provide specific profiles of the objects to meet their functional or asthetic or ergonomic requirements. Therefore, it is important for engineers to study various engineering curves and their applications.

A wide variety of engineering curves are used in design practice. However, this chapter deals with a few common engineering curves like conic sections, cycloids, spirals, involutes and the helixes. All these curves satisfy specific mathematical equations. The following sections explain the properties, methods of drawing and applications of common engineering curves.

3.2 : Conic Sections

Conic sections (or conics), as the name suggests, are the sections of a right circular cone obtained by cutting the cone in different ways. Depending on the position of the cutting plane relative to the axis of cone, three conic sections - ellipse, parabola and hyperbola - can be obtained, Fig. 3.2.1.

An *ellipse* is obtained when a section plane *A-A*, inclined to the axis cuts all the generators of the cone.

A *parabola* is obtained when a section plane *B-B,parallel to one of the generators cuts the cone. Obviously, the section plane will cut the base of the cone.*

A *hyperbola* is obtained when a section plane *C-C*, inclined to the axis cuts the cone on one side of the axis. A *rectangular hyperbola* is obtained when a section plane *D-D*, parallel to the axis cuts the cone.

Note : A *circle* is also a conic section. It is obtained when a cutting plane parallel to the base cuts all generators of the cone.

A conic is defined as the curve traced by point moving in a plane such that the ratio of its distances from a fixed point and a fixed. line is always constant. The fixed point is called the *focus* and the fixed line is the directrix, (Fig. 3.2.1) The ratio is called the *eccentricity* and is denoted by *e*.

Thus, *e* = (Distance of a point from focus)/(Distance of a point from directrix)

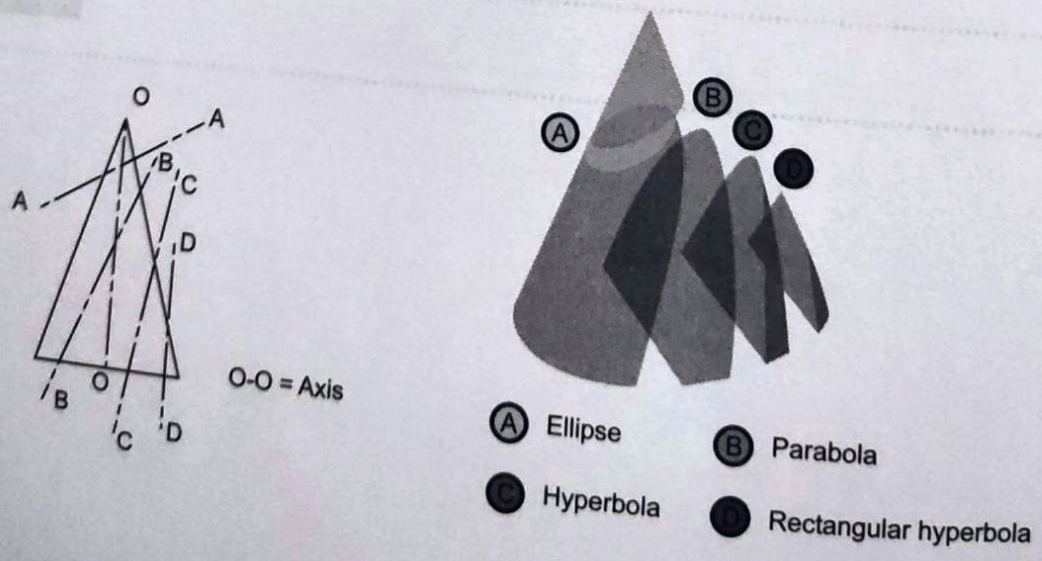


Fig. 3.2.1

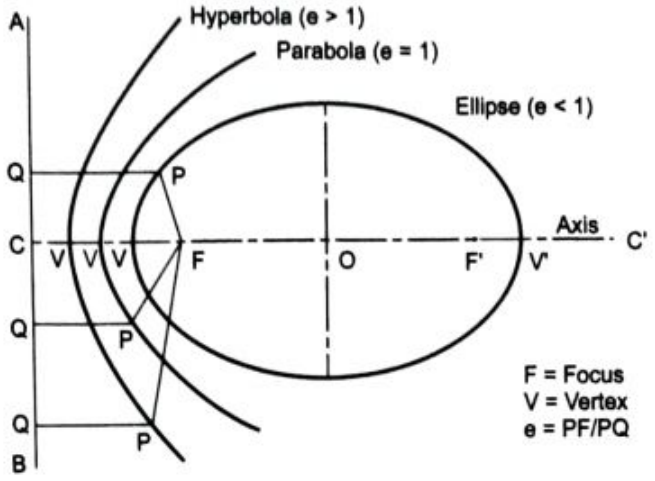


Fig. 3.2.2

For an ellipse, e is less than 1. For a parabola, it is equal to a 1 and for a hyperbola, it is greater than 1. Other important terms related to conics are as follows :

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

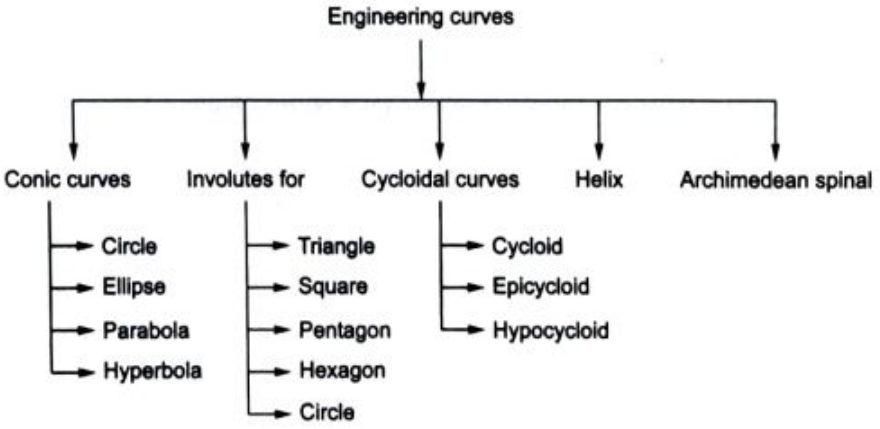
VERTEX : The point at which the curve intersects the axis is called the vertex.

REMEMBER the following

For ellipse, $e < 1$

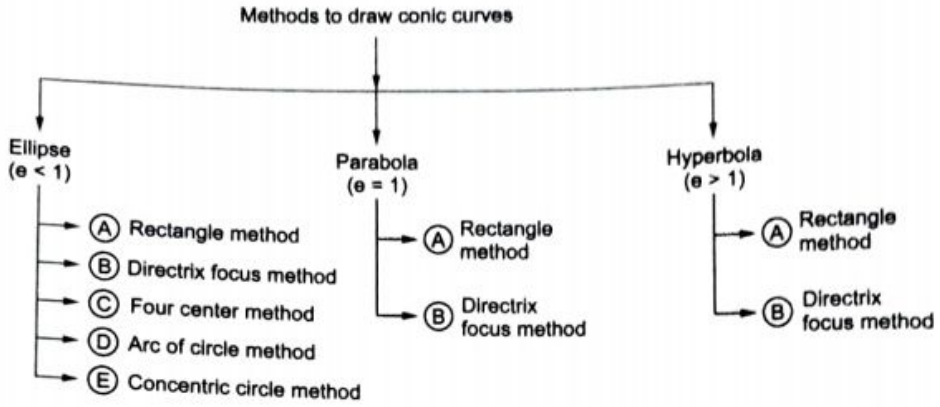
For parabola, $e = 1$

For hyperbola, $e > 1$.



3.2.1 Conic Curves

Following are the some methods to draw the conic curves.



3.3 : Ellipse

SPPU : Oct.-12,13

a) Rectangle method

Ex 3.3.1 : ***Draw an ellipse by rectangular method if the major axis and minor axis are 90 mm and 60 mm respectively.***

Sol. :

Ellipse

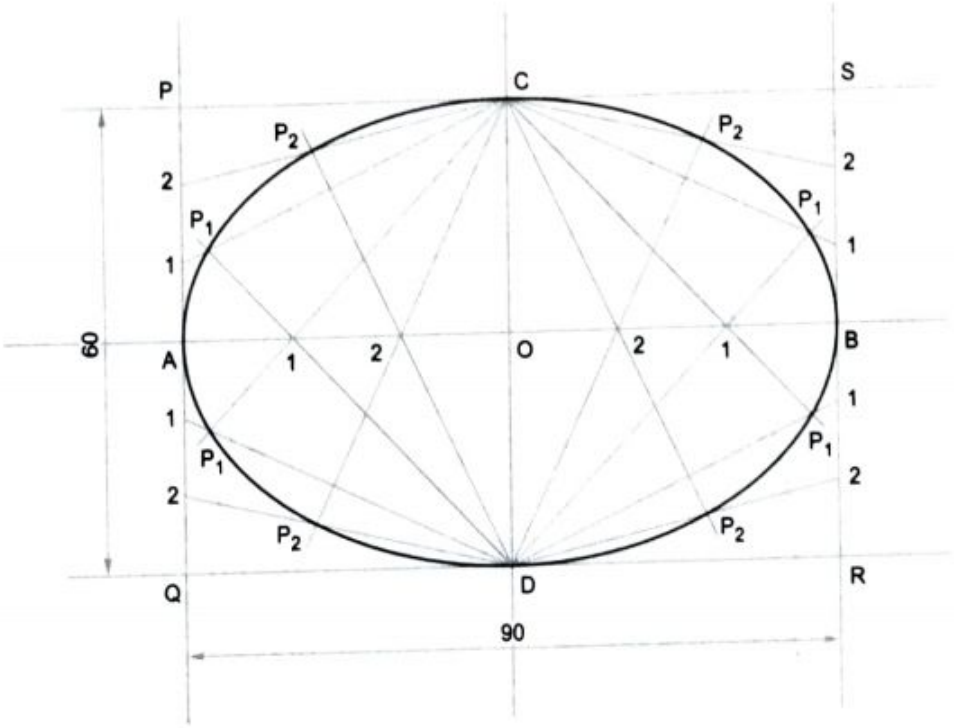
Major Axis = AB = 90 mm

Minor Axis = CD = 60 mm

Steps

1) Draw two mutually perpendicular lines which intersect at point 'O'.
2) Mark major axis (AB) = 90 mm and minor axis (CD) = 60 mm having 'O' as their midpoint.
3) Complete the rectangle PQRS [PQ = CD and PS = AB]
4) Now, divide **AP** and **AO** into equal number of divisions (3). Name these points 1, 2 from point A.
5) Join 1, 2 on AP to point C. From other end D join 1, 2 on **AO** and extend these lines.
6) Intersection of line 1C and extended D1 is point P_1. Similarly locate the point P_2.
7) Repeat the same procedure for remaining three quadrants.
8) Join all these points including end points of major and minor axis with smooth curve to get the required curve.

[To the scale]



Ex. 3.3.2 : ***Draw an ellipse by rectangular method if the major axis and minor axis are 120 mm and 80 mm respectively.***

Sol. :

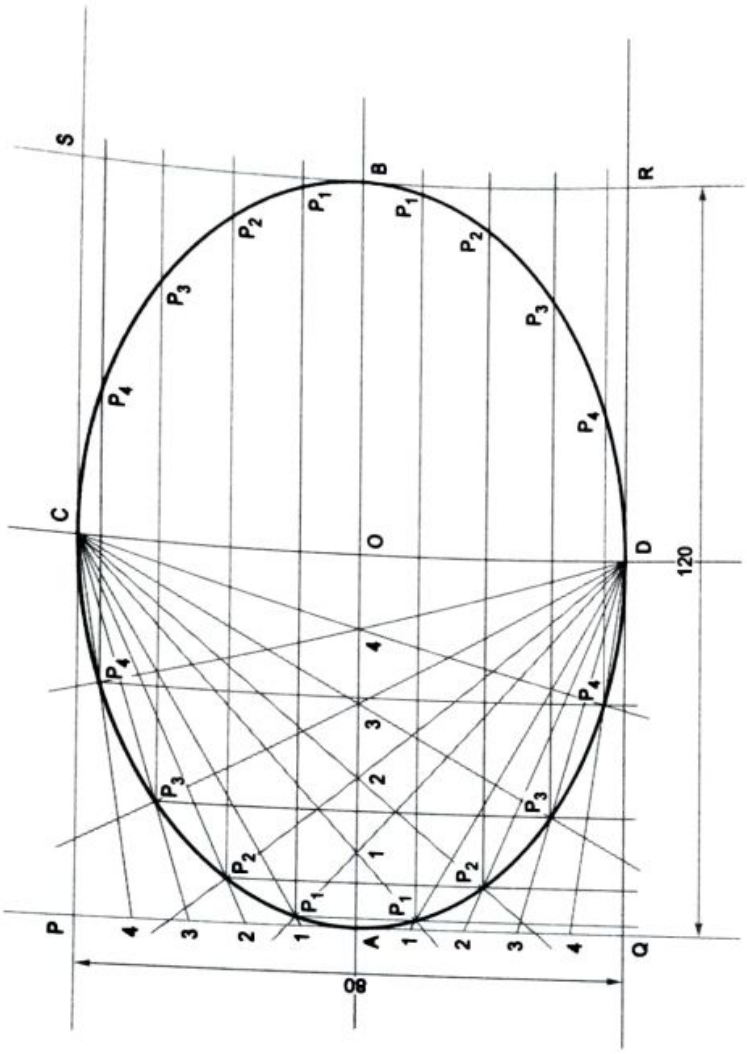
Ellipse

Major Axis = 120 mm = AB

Minor Axis = 80 mm = CD

Steps

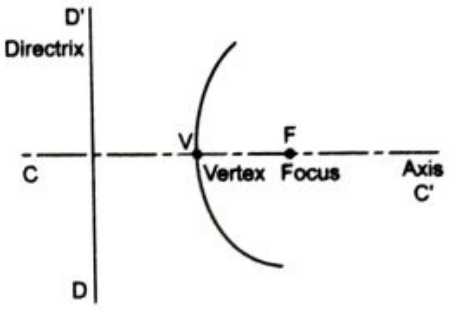
1) Draw two mutually perpendicular lines which intersect at point 'O'.
2) Mark major axis (AB) = 120 mm and minor axis (CD) = 80 mm having 'O' as their midpoint.
3) Complete the rectangle PQRS [PQ = CD and PS = AB]
4) Now, divide **AP** and **AO** into equal number of divisions (5).
5) Name these points 1, 2, 3, 4 from point A.
6) Join 1, 2, 3, 4, on AP to point C. From other end D join 1, 2, 3, 4 on **AO** and extend these line.
7) Intersection of line 1C and extended D1 is point P_1. Similarly locate the points P_2, P_3, P_4.
8) Repeat the same procedure for remaining three quadrants or use symmetry or by similar procedure.
9) Join all these points including end points of major and minor axis with smooth curve to get required curve.



b) Directrix focus method

1) **Focus (F) :** The fixed point is called the focus (F)
2) **Directrix (D) :** The fixed straight vertical line is called the directrix (DD')
3) **Axis :** The line passing through the focus and perpendicular to directrix is called an axis (CC')
4) **Vertex (V) :** The point where the ellipse, parabola and hyperbola cut the axis is called the vertex (V).
5) **Eccentricity (e) :** The ratio of the shortest distance from the focus (F) to the shortest distance from the directrix (DD') is called an eccentricity.

$$\therefore \quad \text{Eccentricity (e)} = \frac{\text{Shortest distance from the focus (F)}}{\text{Shortest distance from directrix (DD')}}$$



Note : Eccentricity for

Ellipse : (e < 1)

Parabola : e = 1

Hyperbola : (e > 1)

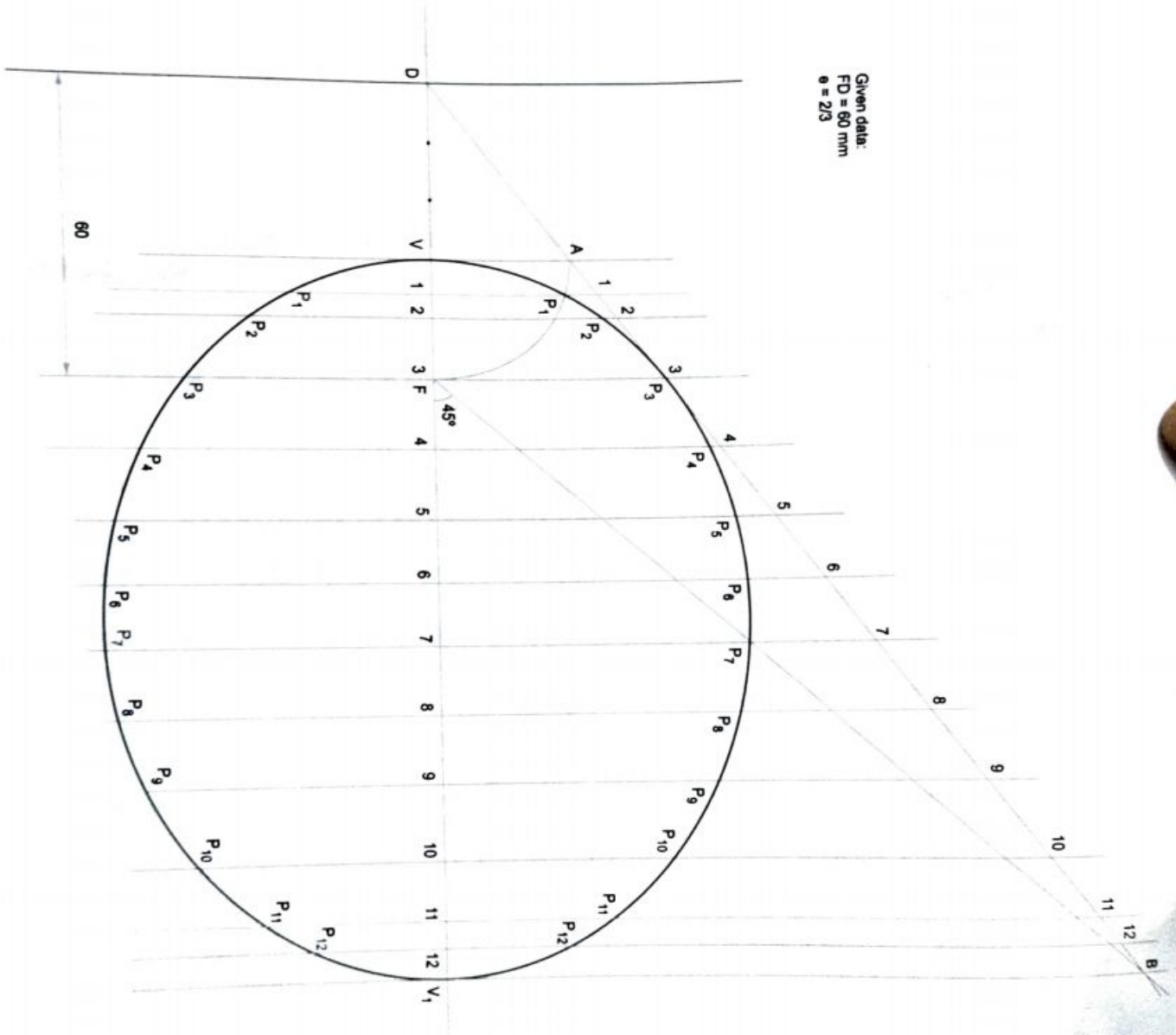
Ex. 3.3.3 : ***Draw an ellipse when the distance of focus from the directrix is equal to 60 mm and eccentricity is 2/3.***

SPPU Oct 12

Sol. : **[To the scale]**

Steps

1) Draw a vertical line as directrix. Mark a point 'D' on it and draw perpendicular line to the directrix through point D as axis line.
2) Mark point F(focus) at a distance is 60 mm from point D on axis line.
3) Divide the distance FD into 5(2+3) equal divisions. Mark vertex V after 2 divisions from the focus so that $e = \frac{VF}{VD} = \frac{2}{3}$.
4) Draw a perpendicular line to axis line through point V. Draw an arc with centre V and radius VF to intersect this perpendicular line at A.
5) Join DA and extend it. Draw an inclined line at 45° from point F which intersect the line DA at point B. Draw a vertical line through point B which intersect the axis line at point V_1 (second vertex). VV_1 is major axis of ellipse.
6) Mark points 1, 2, 3, 4, ... (approximately) on line VV_1. Through these points draw the perpendicular lines to axis which intersect the extended DA line at points 1, 2, 3, 4, ...
7) Take the distance 11 as radius and F as centre, cut arcs on perpendicular line on both sides of axis to get points P_1, P_1 as shown.
8) Similarly other points P_1, P_2, P_3, P_4, ... can be obtained. Join all points with smooth curve to obtain required curve.


Given data:
FD = 60 mm
e = 2/3
D
V
F
A
B
60
45°
1
2
3
4
5
6
7
8
9
10
11
12
V_1
P_1
P_2
P_3
P_4
P_5
P_6
P_7
P_8
P_9
P_{10}
P_{11}
P_{12}

Ex. 3.3.4 : ***Draw an ellipse when the distance of focus from the directrix is 50 mm and eccentricity is $\frac{2}{3}$.***

SPPU - Oct.-13

Sol. : [To the scale]

Steps

1) Draw a vertical line as directrix. Mark a point 'D' on it and draw perpendicular line to the directrix through point D as axis line.

2) Mark point F(focus) at a distance is 50 mm from point D on axis line.

3) Divide the distance FD into 5(2+3) equal divisions. Mark vertex V after 2 divisions from the focus so that $e = \frac{VF}{VD} = \frac{2}{3}$.

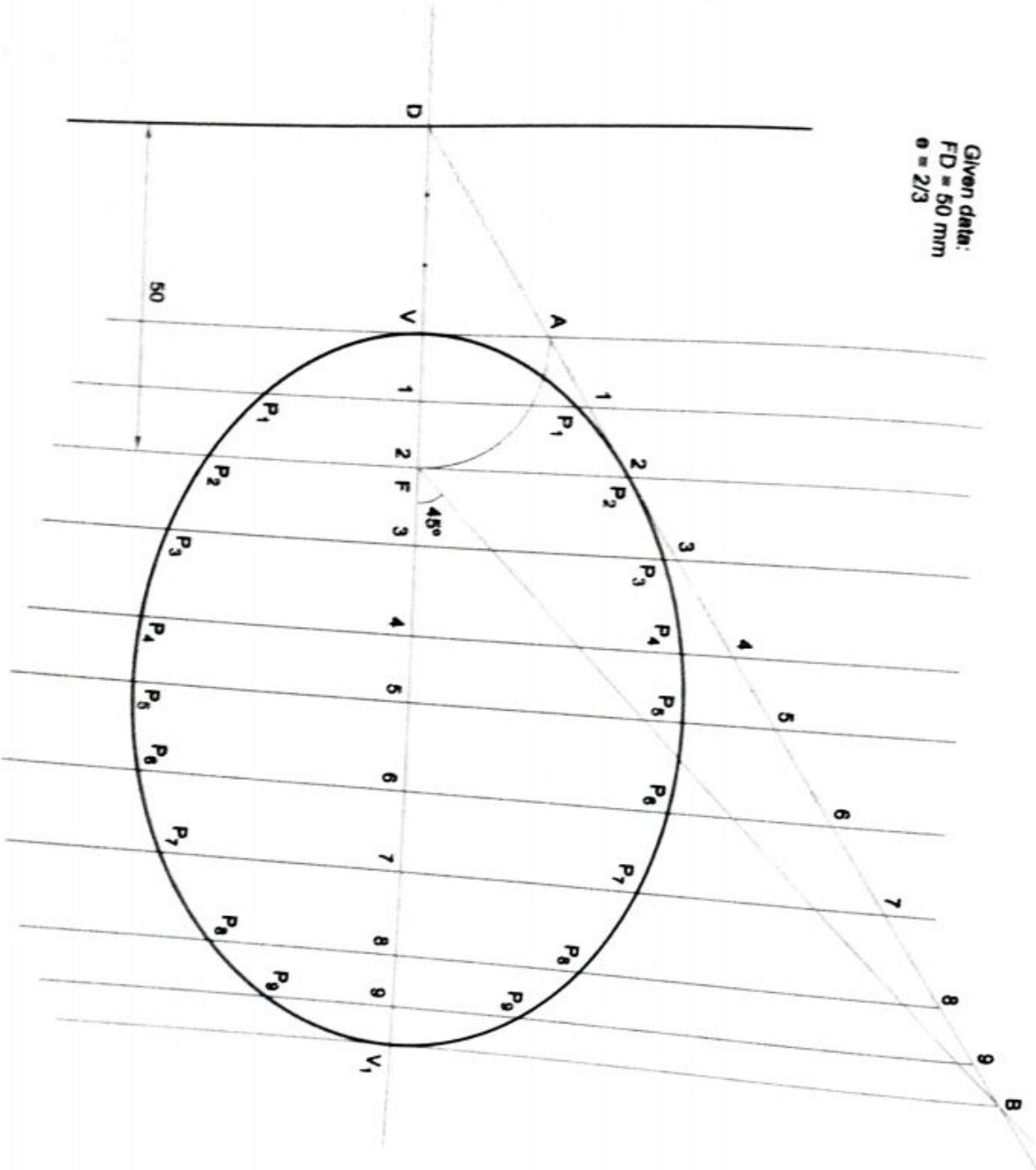
4) Draw a perpendicular line to axis line through point V. Draw an arc with centre V and radius VF to intersect this perpendicular line at A.

5) Join DA and extend it. Draw an inclined line at 45º from point F which intersect the line DA at point B. Draw a vertical line through point B which intersect the axis line at point V_1 (second vertex). VV_1 is major axis of ellipse.

6) Mark points 1, 2, 3, 4, ... (approximately) on line VV_1. Through these points draw the perpendicular lines to axis which intersect the extended DA line at points 1, 2, 3, 4, ...

7) Take the distance 11 as radius and F as centre, cut arcs on perpendicular line on both sides of axis to get points P_1, P_1 as shown.

8) Similarly other points P_2, P_3, P_4, ... can be obtained. Join all points with smooth curve to obtain required curve.


Given data:
FD = 50 mm
e = 2/3
D
50
V
A
F
45°
1
2
3
4
5
6
7
8
9
B
V_1
P_1
P_2
P_3
P_4
P_5
P_6
P_7
P_8
P_9

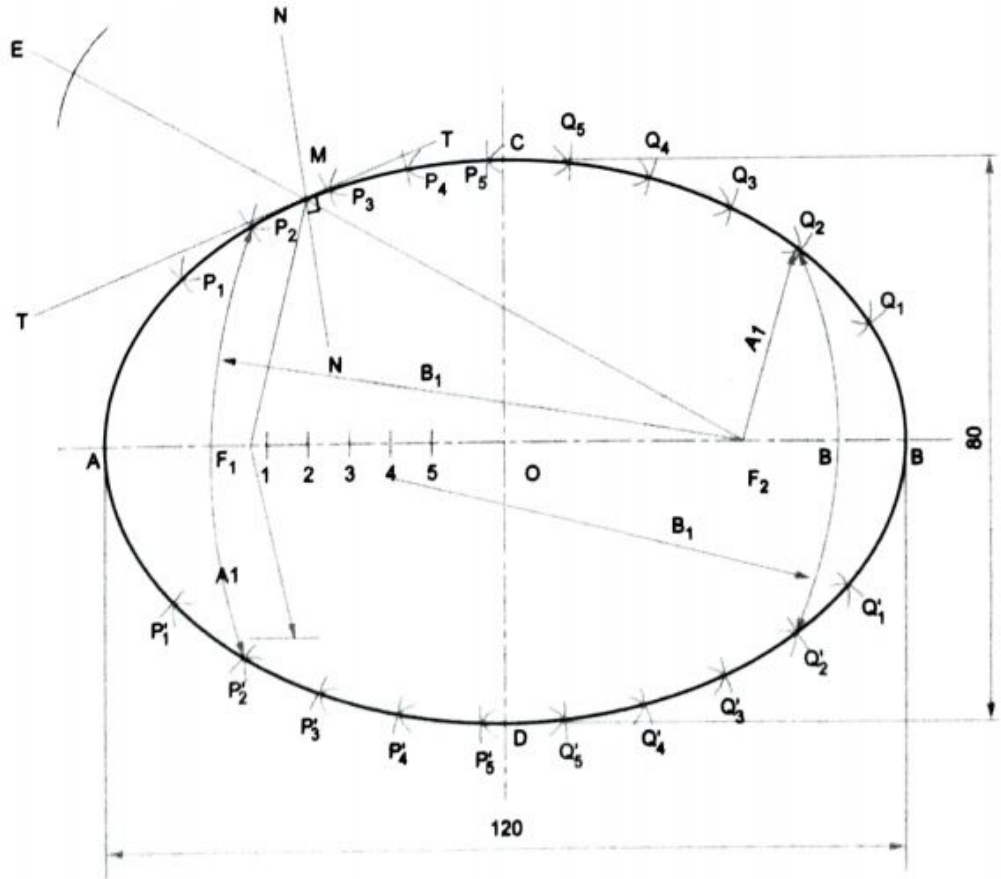
c) Arc of circle method

Ex.3.3.5 : ***To draw an ellipse by arcs of circle method with major and minor axes equal to 120 mm and 80 mm respectively. Find the foci. Also draw the tangent and normal.***

Sol. : Steps :

1) Draw the major (AB) and minor (CD) axes and locate the centre O.
2) Locate the foci F_1 and F_2 by taking a radius equal to 60 mm and cutting AB at F_1, P_1 and F_2 with C as the centre.
3) Mark a number of points 1, 2, 3, etc, between F_1 and 0, which need not be equi - distance.
4) With centres F_1 and F_2 and radii A_1 and B_1 respectively, draw arcs intersecting at the points P_1 and P'_1.
5) Again with centres F_1 and F_2 and radii Bland A_1 respectively, draw arcs intersecting at the points Q_1 and Q'_1.
6) Repeat the steps 4 and 5 with the remaining points 2, 3, 4, etc. and obtain additional points on the curve.
7) Join the points by a smooth curve, forming the required ellipse.

- **Tangent :**
  1) To mark a tangent and normal to the ellipse at any point, say M on it.
  2) Then join the focus F_1 and F_2 with M and extend F_2M to E and bisect the angle $<EMF_1$.
  3) The bisector TT represents the required tangent and a line NN drawn through M and perpendicular to TT is the normal to the ellipse.



d) Concentric circle method

Ex.3.3.6 : ***To draw an ellipse by concentric circles method with major and minor axes equal to 120 & 80 mm respectively.***

Sol. : 1) Draw the major and minor axes AB = 120 and CD = 80 and locate the centre O.

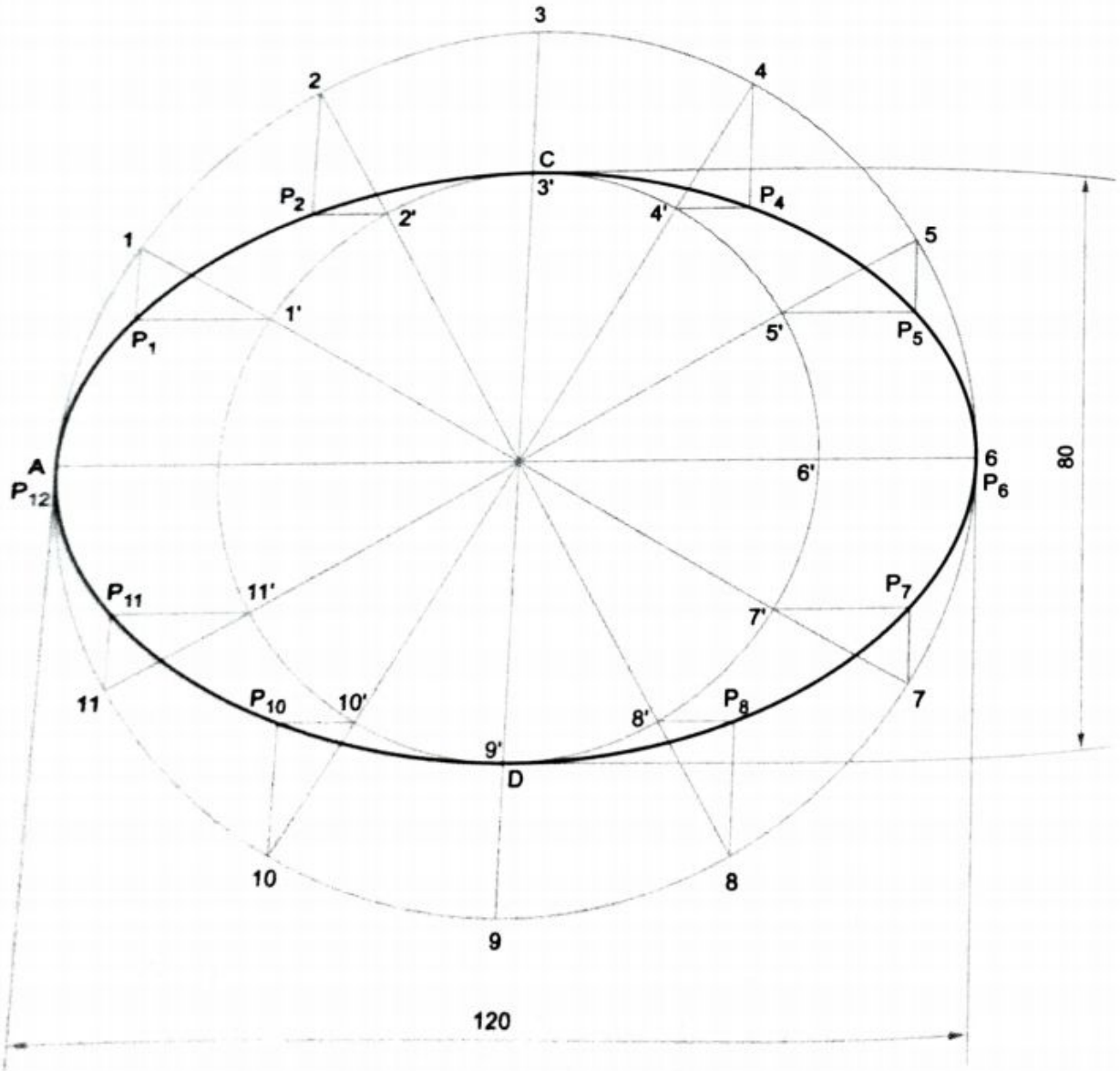
2) With centre O and major axis and minor axes as diameters, draw two concentric circles.

3) Divide both the circles into equal number of parts, say 12 and draw the radial lines.

4) Considering the radial line 0 - 1', draw a horizontal line from 1' to meet the vertical line from 1 P_1.

5) Repeat the steps 4 and obtain other points P_2, P_3, etc.

6) Join the points by a smooth curve forming the required ellipse.



3.4 : Parabola

SPPU : Oct.-12,15, June-13

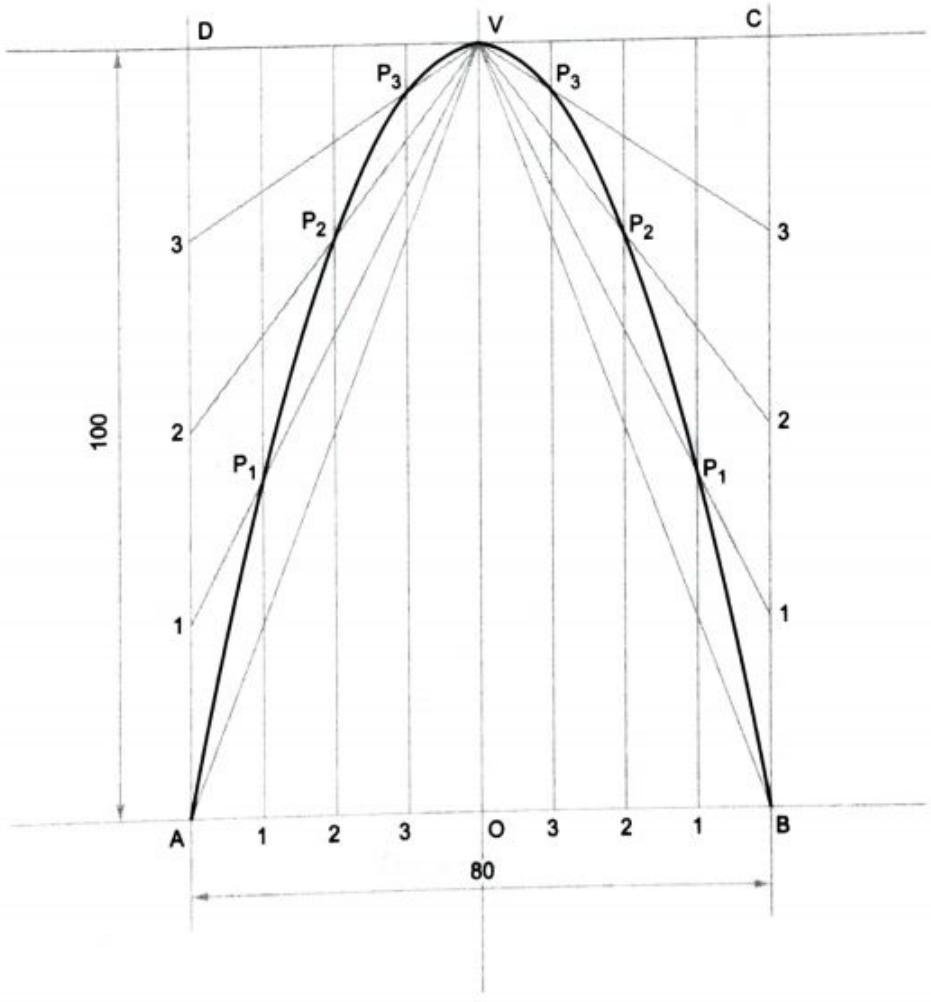
a) Rectangle method

Ex. 3.4.1 : ***Draw a parabola by rectangular method if base is 80 mm and axis height is 100 mm.***

Sol. : Base = 80 mm, Axis = 100 mm

Steps

1) Draw a line AB = 80 mm as base.
2) Draw its perpendicular bisector and mark OV (axis) on it. OV = 100 mm.
3) Complete the rectangle **ABCD** [AD = OV].
4) Now, divide **AO** and **AD** into equal number of divisions (4). Mark the points 1, 2, 3 on AO and AD starting from A.
5) Through points 1, 2, 3 on base draw the perpendicular lines. Join points 1, 2, 3 on AD to vertex V.
6) Intersection of line 1V and perpendicular line through point 1 is P_1. Similarly locate P_2, P_3.
7) Repeat the same procedure on other side of axis.
8) Draw a smooth curve passing through all these points to get required curve.



[To the scale]

Ex. 3.4.2 : ***Draw a parabola by rectangle method if base is 80 mm and axis height is 60 mm.***

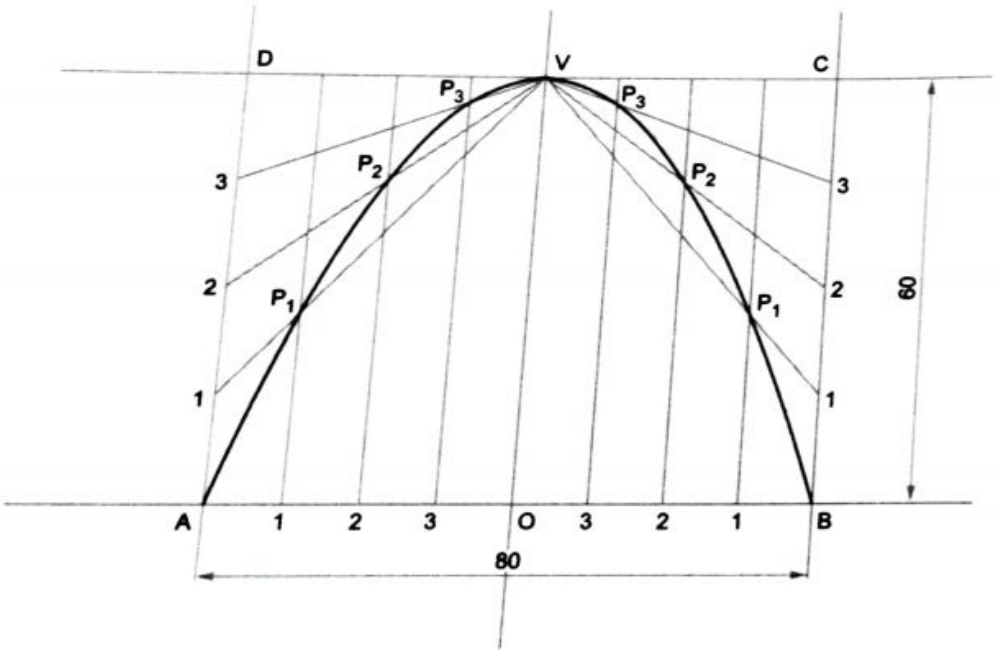
Sol. :

Base (AB) = 80 mm

Axis (OV) = 60 mm

Steps

1) Draw a line AB = 80 mm as base.
2) Draw its perpendicular bisector and mark OV (axis) on it. OV = 60 mm.
3) Complete the rectangle **ABCD** [AD = OV].
4) Now, divide **AO** and **AD** into equal number of divisions (4). Mark the points 1, 2, 3 on AO and AD starting from A.
5) Through points 1, 2, 3 on base draw the perpendicular lines. Join points 1, 2, 3 on AD to vertex V.
6) Intersection of line 1 V and perpendicular line through point 1 is P_1. Similarly locate P_2, P_3.
7) Repeat the same procedure on other side of axis.
8) Draw a smooth curve passing through all these points to get required curve.



[To the scale]

b) Directrix focus method

Ex. 3.4.3 : ***Draw a parabola by focus directrix method, if the distance of focus from the directrix is 60 mm.***

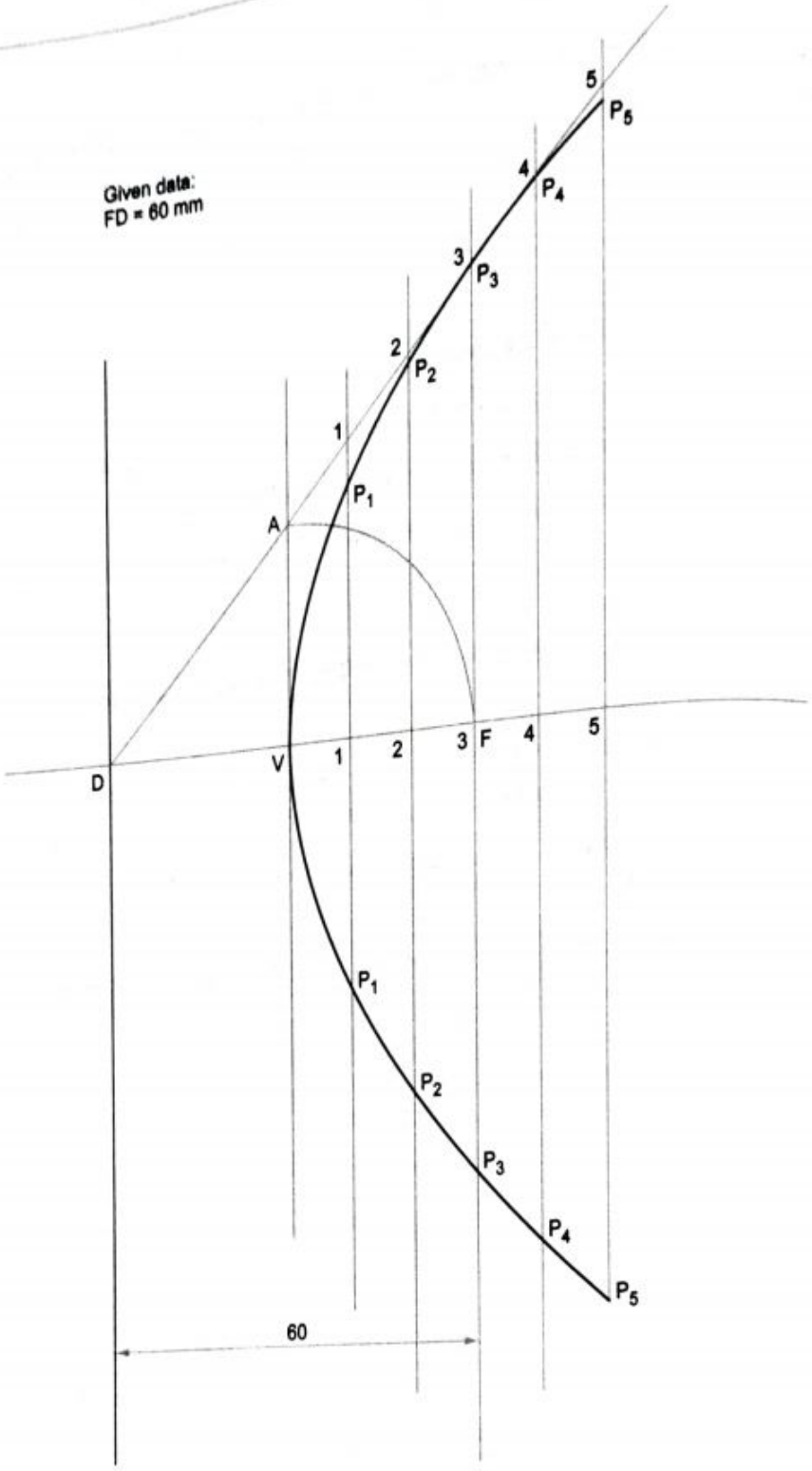
Sol. : **[To the scale]**

Parabola

Directrix Focus Method

Steps

1) Draw a vertical straight line as directrix.
2) Consider a point D on it and draw a line to directrix through point D which is axis.
3) Mark a focus point F at a distance mm from D on axis (FD = 60 mm).
4) For parabola e = $1/1$. Divide the distance FD into (1 + 1) 2 equal parts. Mark the point 'V' so that VD = VF $\left[e = \frac{VF}{VD} = 1\right]$.
5) Draw a perpendicular line from point V to axis. Take 'V' as centre and draw a arc with radius VF to intersect this line at point A.
6) Join DA and extend it. Mark points 1, 2, 3, ... etc. (approximately) on the axis. Through these points draw lines perpendicular to axis which intersects line DA at 1, 2, 3, ... etc.
7) Take the distance 11 as radius and F as centre, cut arcs on perpendicular line on both sides of axis to get point P_1, P_1 as shown.
8) Similarly other points P_2, P_3, ... can be obtained. Join all points with smoothly to get the required.


Given data:
FD = 60 mm
5
P5
4
P4
3
P3
2
P2
1
P1
A
D
V
1
2
3
F
4
5
P1
P2
P3
P4
P5
60

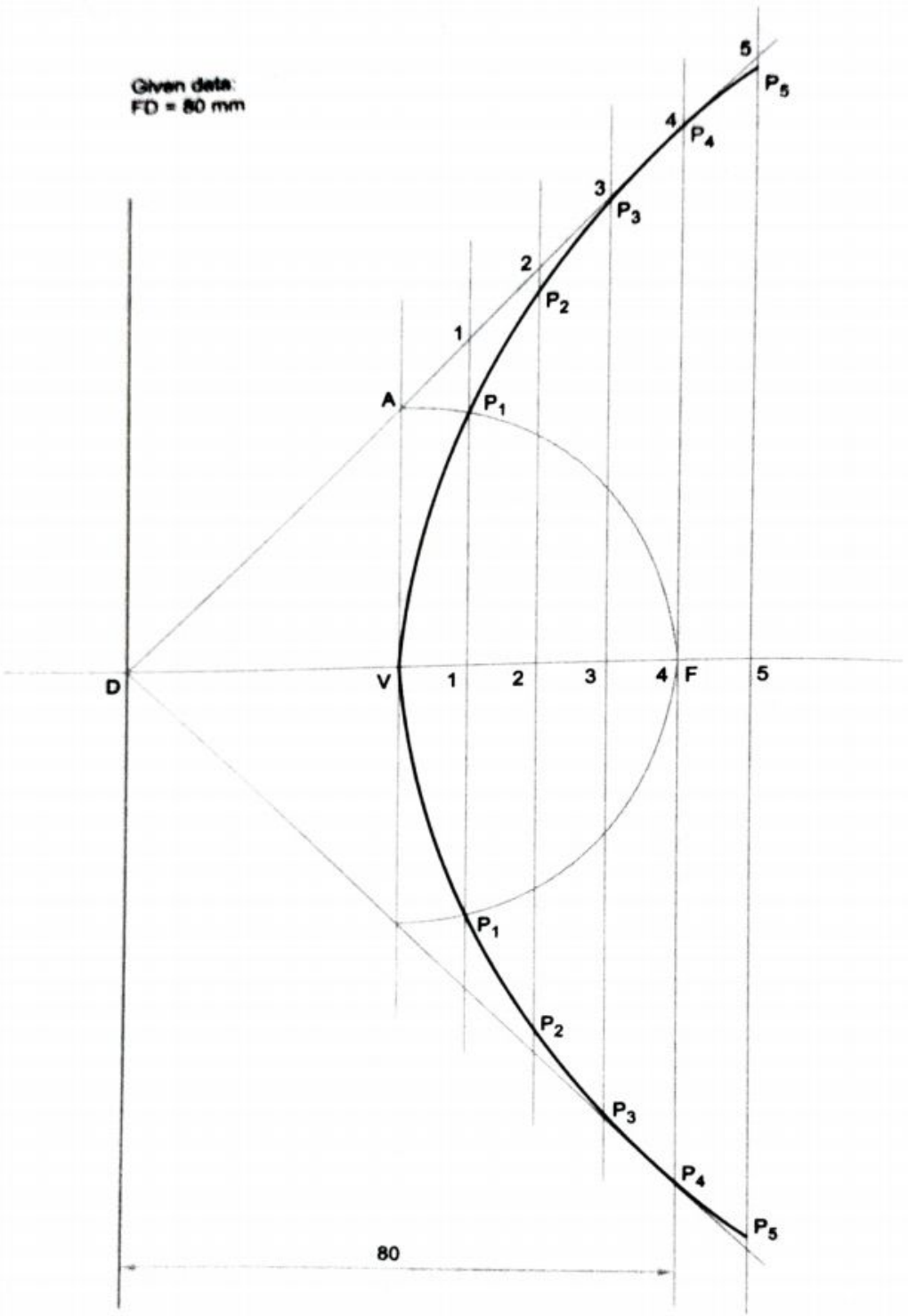
Ex. 3.4.4 : ***Draw a parabola by focus directrix method, if distance of focus from directrix is 80 mm.***

SPPU : Oct.-12,15, June-13

Sol. : **[To the scale]**

Steps

1) Draw a vertical straight line as directrix.
2) Consider a point D on it and draw a line to directrix through point D which is axis.
3) Mark a focus point F at a distance mm from D on axis (FD = 80 mm).
4) For parabola e = 1/1. Divide the distance FD into (1+1) 2 equal parts. Mark the point 'V' so that VD = VF $\left[e = \frac{VF}{VD} = 1\right]$
5) Draw a perpendicular line from point V to axis. Take 'V' as centre and draw a arc with radius VF to intersect this line at point A.
6) Join DA and extend it. Mark points 1, 2, 3, ... etc. (approximately) on the axis. Through these points draw lines perpendicular to axis which intersects line DA at 1, 2, 3, ... etc.
7) Take the distance 11 as radius and F as centre, cut arcs on perpendicular line on both sides of axis to get point P_1, P_1 as shown.
8) Similarly other points P_2, P_3, ... can be obtained. Join all points smoothly to get the required.


Given data:
FD = 80 mm
A
D
V
F
1
2
3
4
5
P_1
P_2
P_3
P_4
P_5
80

3.5 : Hyperbola

SPPU : May-14, Oct.-16

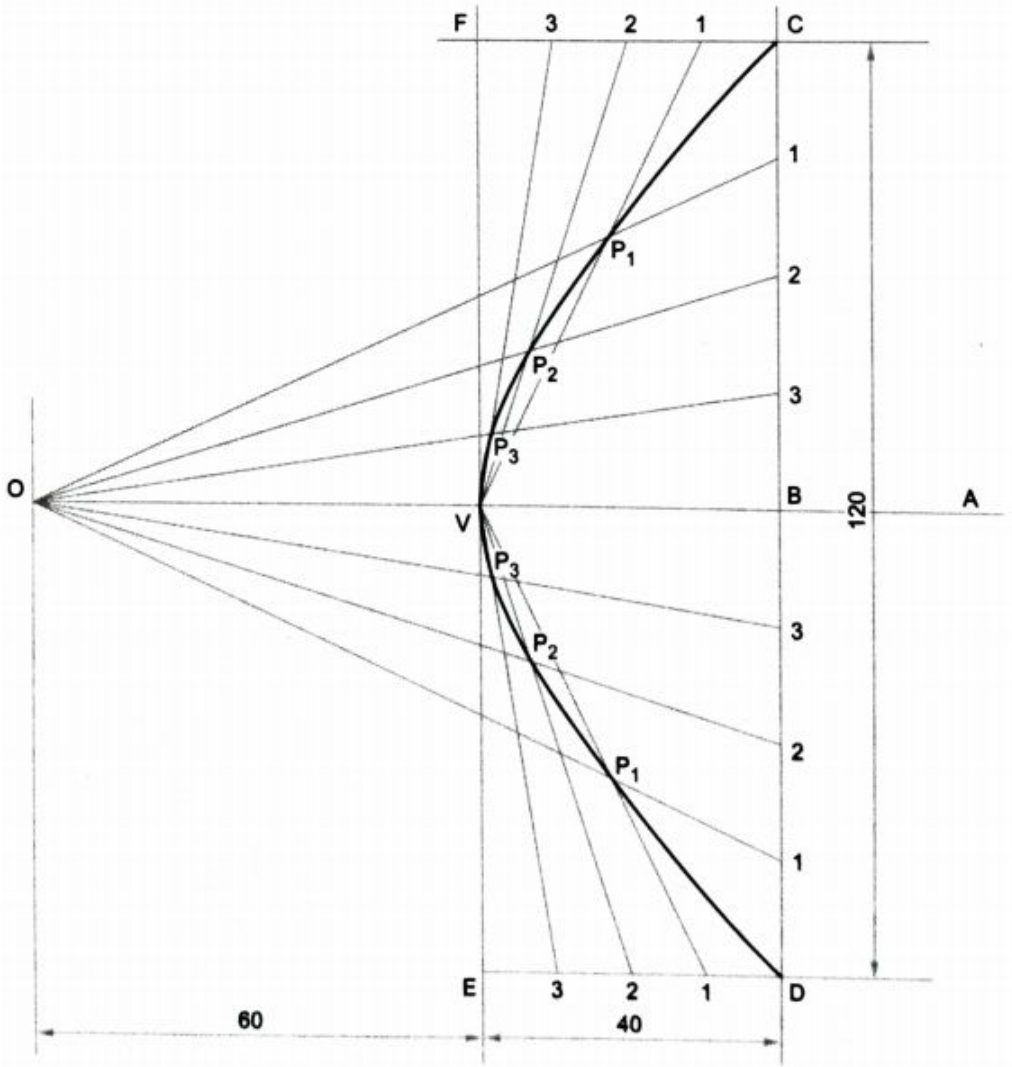
a) Rectangle method

Ex. 3.5.1 : ***Draw a hyperbola having the double ordinate of 120 mm, the absciss of 40 mm and transverse axis 120 mm.***

Sol. : **[To the scale]**

Steps

1) Draw a horizontal line OA as axis line.
2) Mark point V $\left(OV = \frac{1}{2} \times \text{ Transverse axis} \right)$ on it.
3) Mark VB = 40 mm (abscissa) on the axis.
4) Through point B draw a perpendicular line to the axis on it mark double ordinate CD = 120 mm.
5) Complete the rectangle **CDEF** [ED = VB].
6) Divide CB and CF into equal number of divisions (4). Name the points as 1, 2, 3 on CF and CB. Starting from C.
7) Join points 1, 2, 3 on CF to point V and points 1, 2, 3 on CB to point 'O'.
8) Intersection of 1 V and 10 is P_1. Similarly locate P_2, P_3.
9) Repeat the same procedure for remaining half of rectangle.
10) Join all these points with a smooth curve to get the required curve.

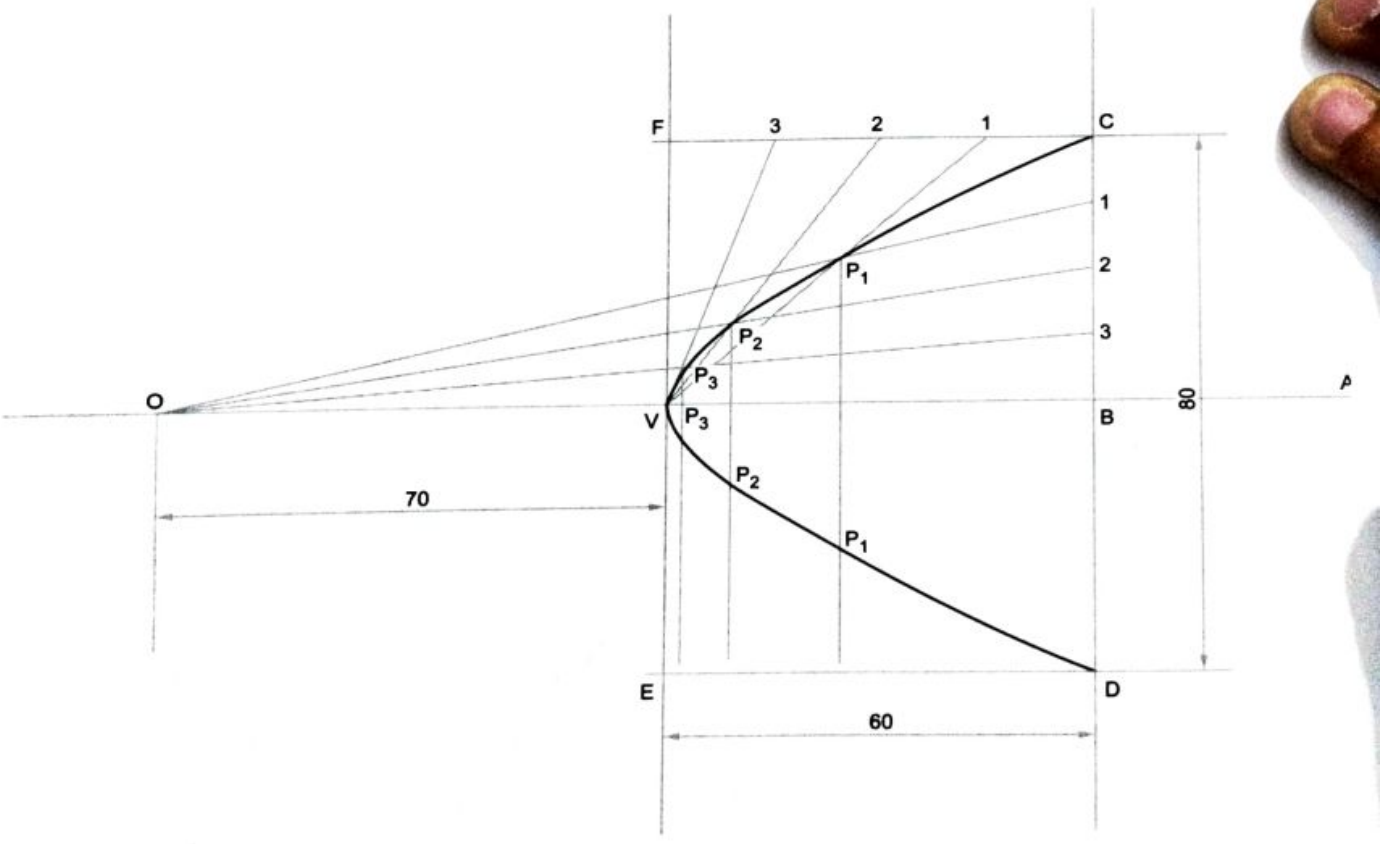


Ex. 3.5.2 : ***Draw a hyperbola the double ordinate of 80 mm, the abscissa 60 mm and transverse axis 140 mm.***

Sol. :

Steps

1) Draw a horizontal line OA as axis line.
2) Mark point $V\left(OV=\frac{1}{2}\times \text{Transverse axis}\right)$ on it.
3) Mark VB = 60 mm (abscissa) on the axis.
4) Through point B draw a perpendicular line to the axis on it mark double ordinate CD = 80 mm.
5) Complete the rectangle **CDEF** [ED = VB].
6) Divide CB and CF into equal number of divisions (4). Name the points as 1, 2, 3 on CF and CB. Starting from C.
7) Join points 1, 2, 3 on CF to point V and points 1, 2, 3 on CB to point 'O'.
8) Intersection of 1 V and 10 is P_1. Similarly locate P_2, P_3.
9) Complete Lower half by symmetry.
10) Join all these points with a smooth curve to get the required curve.



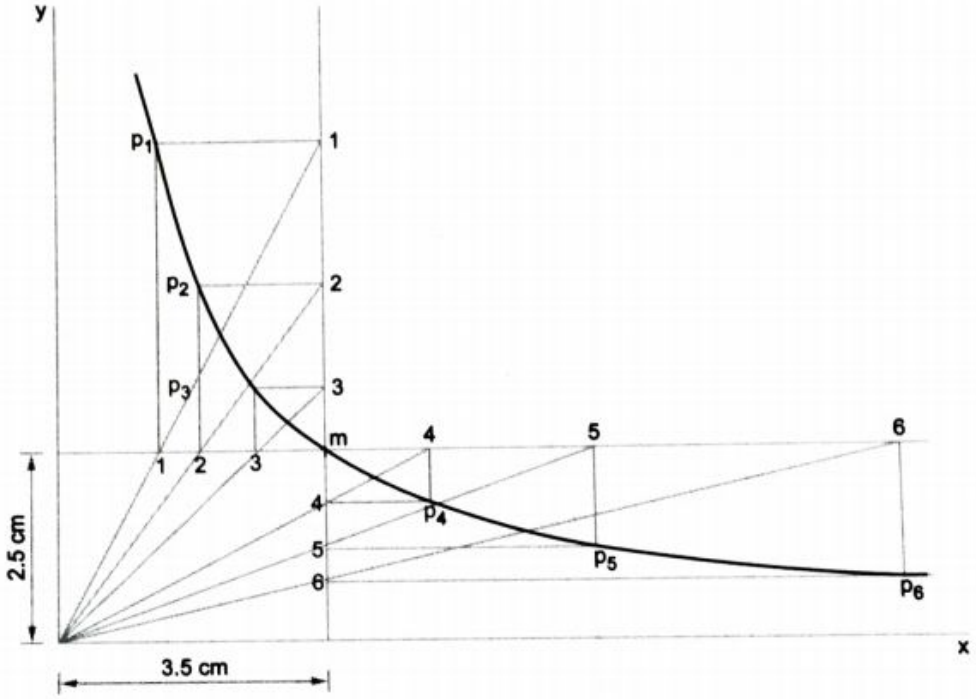
[To the scale]

Ex. 3.5.3 : ***A point 'm' is 2.5 cms from x-axis and 3.5 cms from y-axis. Draw a hyperbola passing through this point.***

Sol. : Given : Point P

2.5 cm from x - axis

3.5 cm from y - axis



b) Directrix focus method

Ex. 3.5.4 : ***Draw a hyperbola by focus directrix method, if focus is 50 mm from directrix and eccentricity is 3/2.***

SPPU Mar 14, Oct 16

Sol. : **[To the scale]**

Steps

1) Draw a vertical straight line as directrix.

2) Mark point 'D' on it and a line perpendicular to directrix through point D as axis line.

3) Mark a focus point F at a distance of 80 mm from D on axis line.

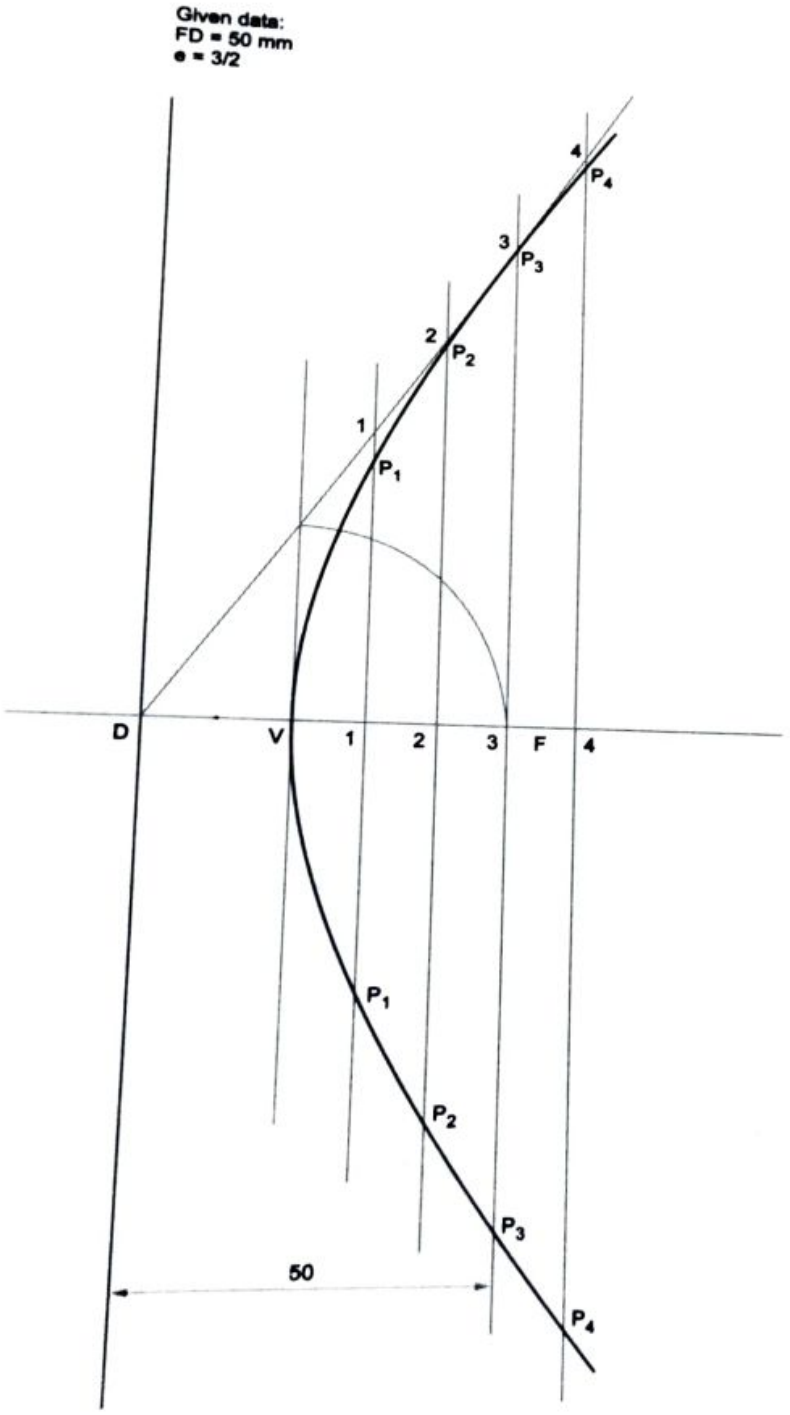
4) As e = 3/2, Divide FD into (3 + 2 = 5) 5 equal divisions. Mark V (vertex) after 3 divisions from focus $\left[\frac{VF}{VD} = \frac{3}{2}\right]$.

5) Draw a vertical line through point V. Draw an arc with centre V and radius VF to intersect this vertical line at A.

6) Join DA and extend it. Mark points 1, 2, 3, 4, ... (approximately) on axis line. Through these points draw perpendicular line to the axis line which intersect line DA at 1, 2, 3, ...

7) Take the distance 11 as radius and F centre, cut arcs on perpendicular line on both sides of axis to get points P_1, P_1 as shown.

8) Similarly other points P_2, P_3, P_4 ..... can be obtained. Join all the points with smooth curve to get required curve.

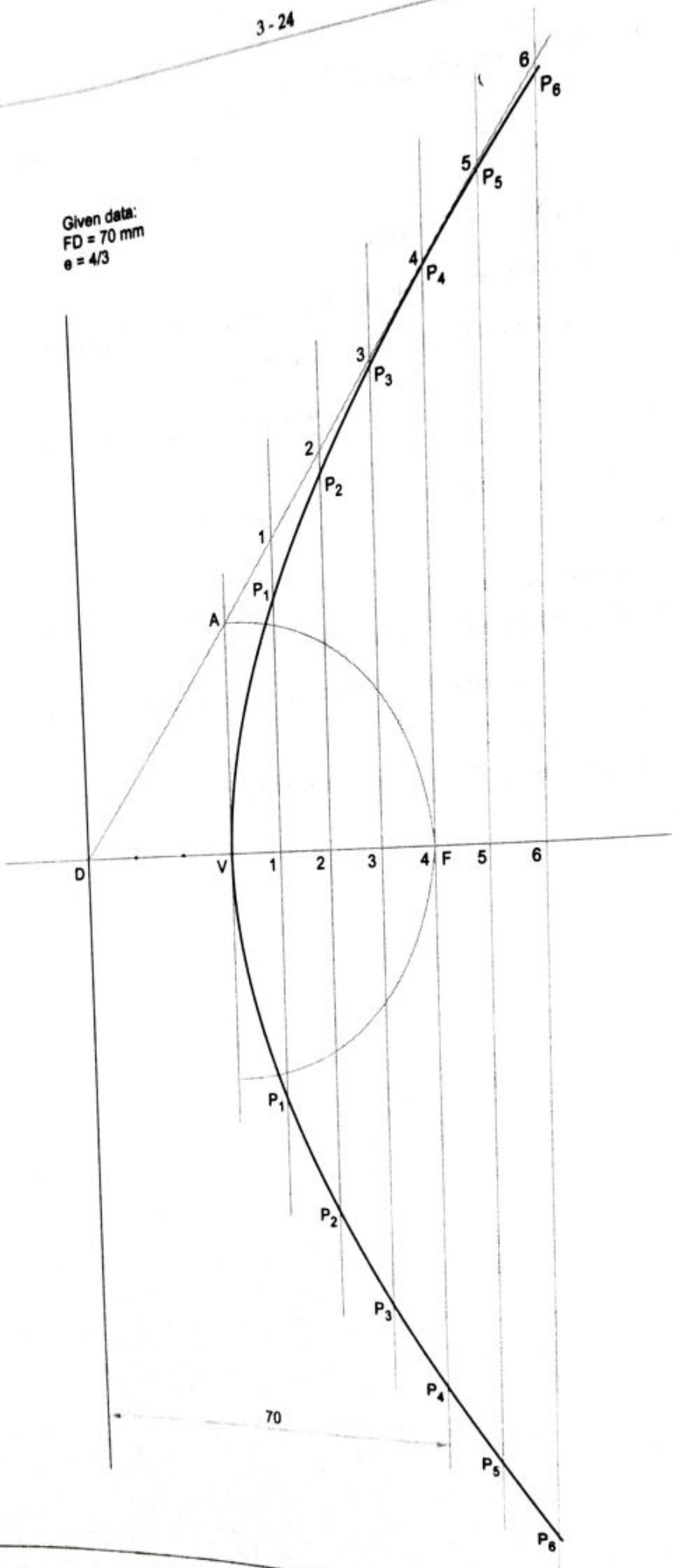


Ex. 3.5.5 : ***Draw a hyperbola by focus directrix method, if focus is 70 mm from directrix and eccentricity is 4/3.***

Sol. :

Steps

1) Draw vertical straight line as directrix.
2) Mark point 'D' on it and a line perpendicular to directrix through point D as axis line.
3) Mark the focus F at a distance as 70 mm from D on axis line.
4) As e = 4/3 , Divide FD into (4 + 3 = 7) 7 equal parts. Mark V (vertex) after 4 divisions from focus [VF/VD = 4/3].
5) Draw a vertical line through point V. Draw an arc with centre V and radius VF to intersect this vertical line at A.
6) Join DA and extend it. Mark points 1, 2, 3, 4, ... (approximately) on axis line. Through these points draw perpendicular line to the axis line which intersect line DA at 1, 2, 3, ...
7) Take the distance 11 as radius and F as centre, cut arcs on perpendicular line on both sides of axis to get points P_1, P_1 as shown.
8) Similarly other points P_2, P_3, P_4 ..... can be obtained. Join all the points with smooth curve to get required curve.


Given data:
FD = 70 mm
e = 4/3
A
D
V
F
1
2
3
4
5
6
P1
P2
P3
P4
P5
P6
70

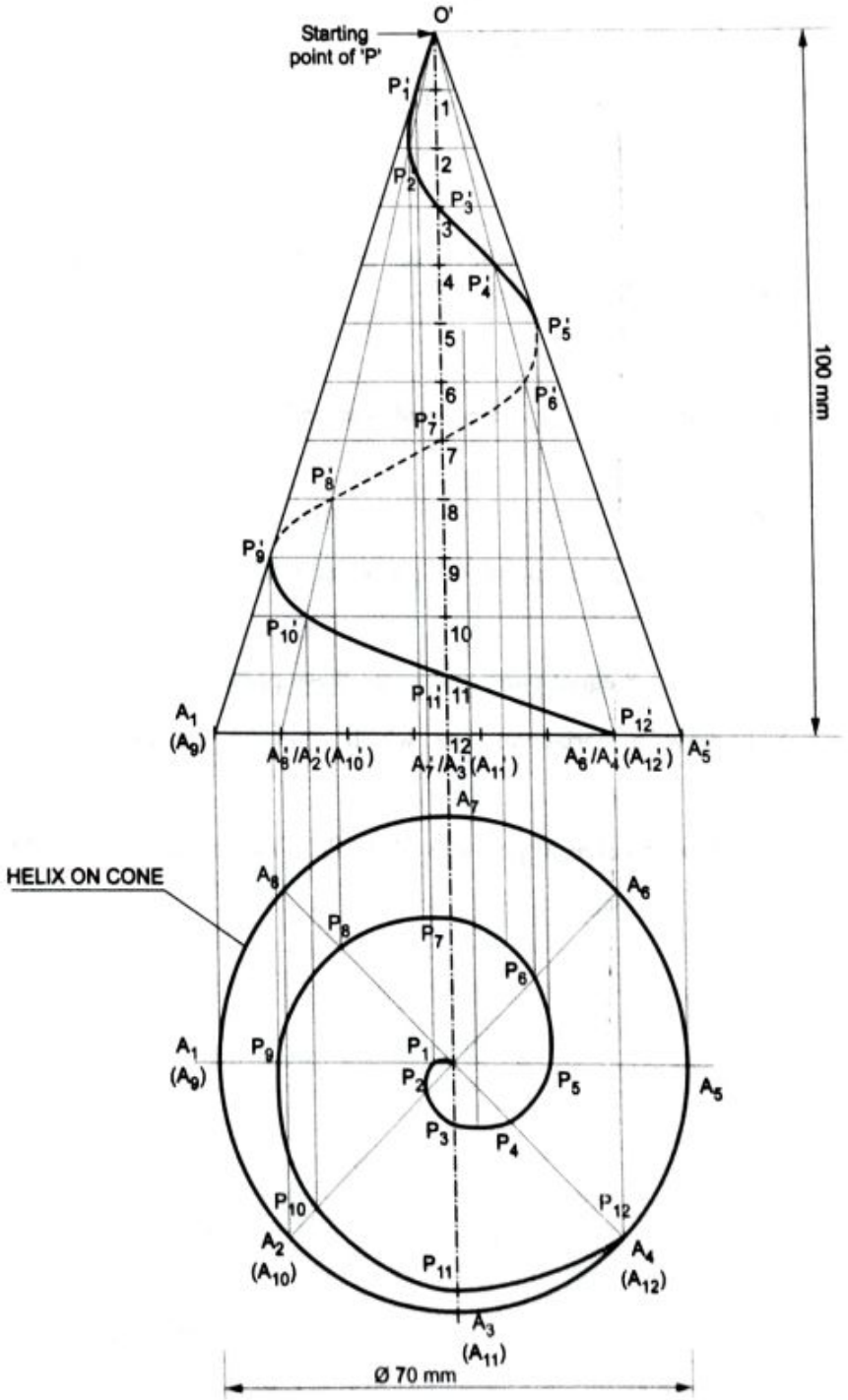
3.6 : Helix

a) Helix for cone

It is a curve generated by a point which moves around the surface of a right circular cone and at the same time advances in the direction of axis at a speed which bears a constant ratio to the speed of rotation.

Ex. 3.6.1 : ***A Point 'P' is moving around the surface of a cone of base 70 mm and height 100 mm. If the point 'P' starting from apex, reaches the periphery of cone base in one and half turns, draw the projections of the path of P. Assume axial descent of the point is uniform with its rotation.***

Sol. :



Following steps can be considered to draw helix on cone.

i) Draw plan and elevation of cone as shown in figure.

ii) Divide plan i.e. circle into 8 equal parts.

iii) Divide height of cone in 12 equal part (as it is $1\frac{1}{2}$ revolution, hence 8 + 4 + 12 parts) and name as 1, 2, 3 ..... etc.

iv) Draw all generators of cone in elevation as OA′, OA_1', OA_2',.....etc.

v) Draw lines parallel to base in elevation and mark point P_1', P_2', P_3',.....etc. on generators OA′, OA_1', OA_2',.....etc. respectively.

vi) Transfer these points as P_1', P_2', P_3',.....P_{12} in plan. Complete the curve showing path of 'P' in both plan and elevation.

b) Helix for cylinder

It is the curve generated by a point which moves around the surface of right circular cylinder and at the same time advances in the axial direction at a speed which bears a constant ratio to speed of rotation.

Ex. 3.6.2 : ***Draw a helix on a cylinder of base diameter 60 mm and axis length 60 mm.***

Sol. : Steps

1) Draw the T.V. and F.V. of cylinder as shown in figure.

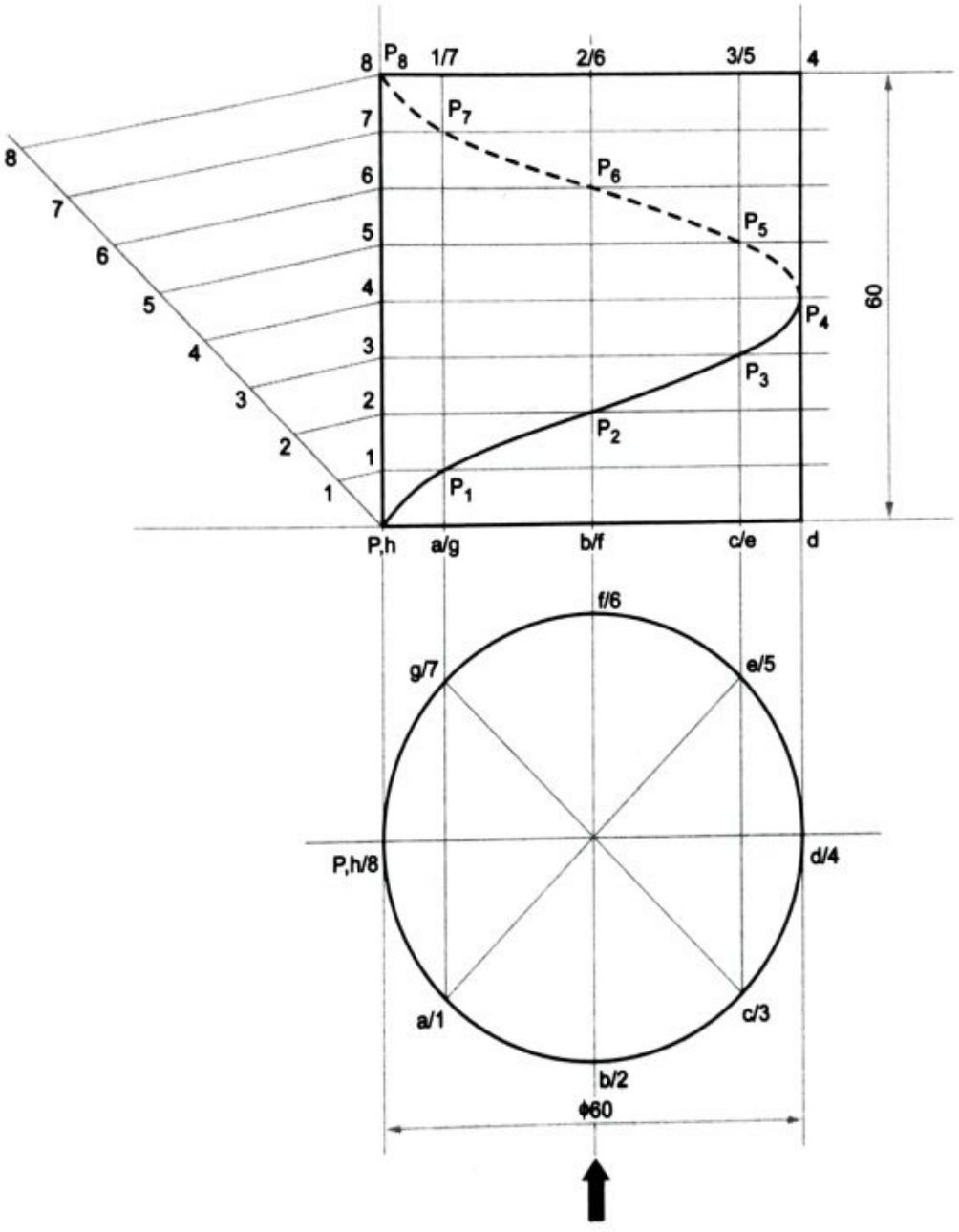
2) Divide the circle into 8 parts and name the points as a, b, c, d, e, f g, h for the base and 1, 2, 3, 4, 5, 6, 7, 8 for top face.

3) Divide h8 in the F.V. into 8 equal parts and name these point 1, 2, 3, 4, 5, 6, 7, 8.

4) Through point 1 draw a horizontal line which intersect the line a1 at P_1. Similarly locate P_1, P_2, P_3, P_4, ... P_8.

5) Join P_1 to P_8 with smooth curve to get helix. P_1 to P_4 is dark as it is visible and P_4 to P_8 is dotted curve.




8
7
6
5
4
3
2
1
P8
1/7
2/6
3/5
4
P7
P6
P5
P4
P3
P2
P1
60
P,h
a/g
b/f
c/e
d
f/6
g/7
e/5
P,h/8
d/4
a/1
c/3
b/2
ϕ60

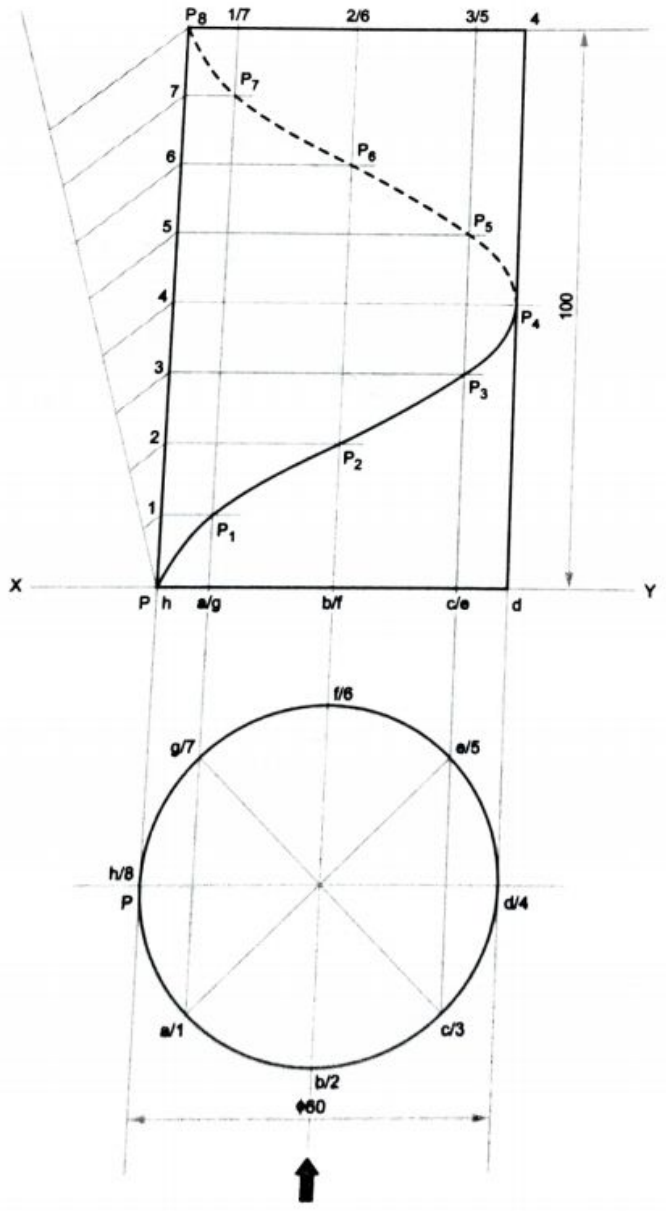
Ex. 3.6.3 : ***Draw a helix on a cylinder of base diameter 60 mm and axis length 100 mm.***

SPPU : Oct.-12, Jan-13, June-15, June-16

Sol. : **[To the scale]**

Steps

1) Draw the T.V. and F.V. of cylinder as shown in figure
2) Divide the circle into 8 parts and name the points as a, b, c, d, e, f g, h for the base and 1, 2, 3, 4, 5, 6, 7, 8 for top face.
3) Divide h8 in the F.V. into 8 equal parts and name these point 1, 2, 3, 4, 5, 6, 7, 8.
4) Through point 1 draw a horizontal line which intersect the line a1 at P_1. Similarly locate P_2, P_3, P_4, ... P_8.
5) Join P_1 to P_8 with smooth curve to get helix. P_1 to P_4 is dark as it is visible and P_4 to P_8 is dotted curve.



3.7 : Involutes

SPPU : June-14,16, May-15

The involute of a circle or polygon is a curve traced out by an end of a piece of an inelastic string wound around the circle or polygon, the string being kept tight.

It may also be defined as a curve traced out by a point on a straight line which rolls around the circle without **slipping.**

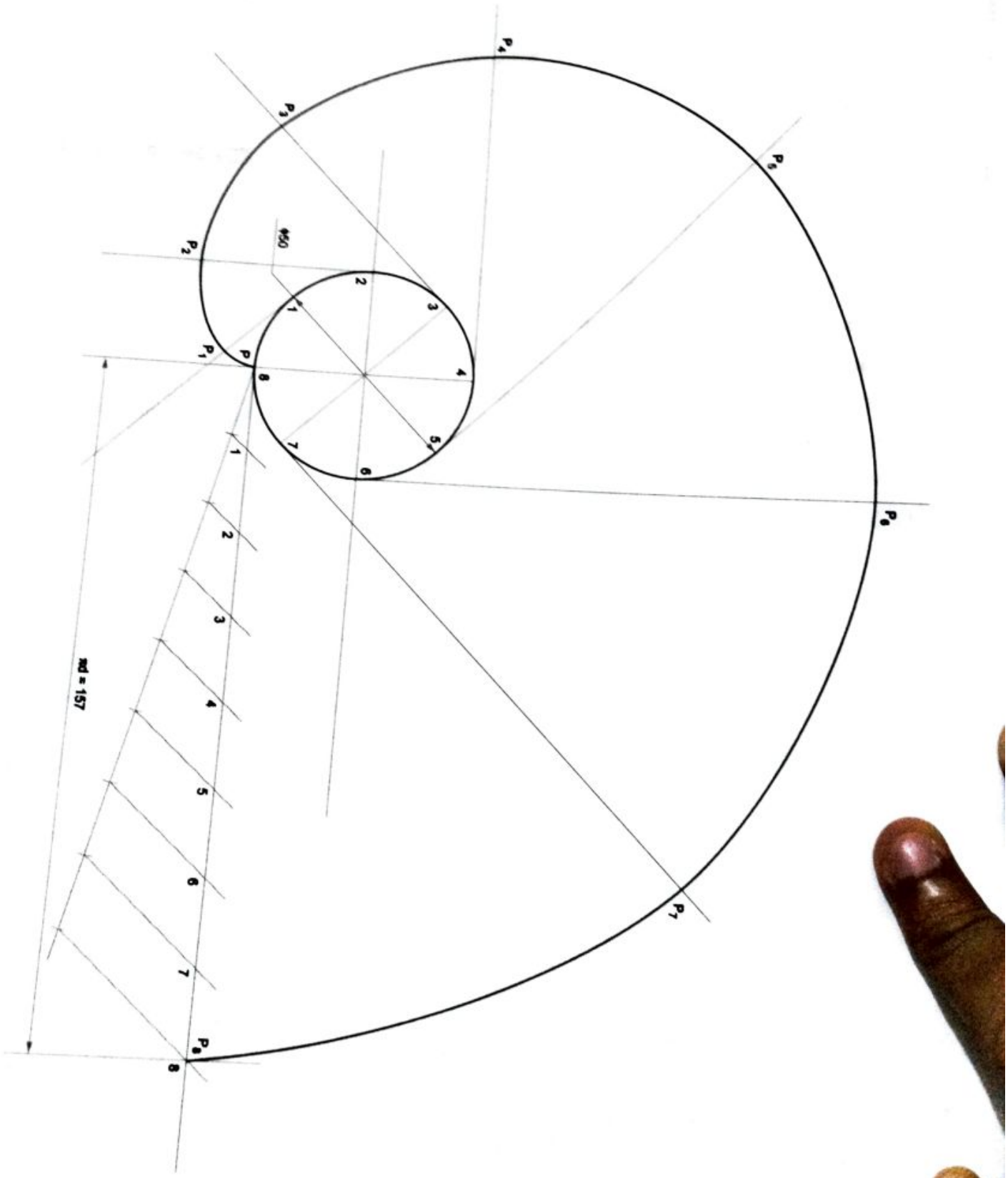
Ex. 3.7.1 : ***Draw an involute of circle of diameter 50 mm.***

SPPU : June-14, May-15

Sol. :

Steps

1) Draw a circle of diameter 40 mm and divide it into 8 equal parts and name the points as shown.
2) Through all these points draw the tangents.
3) Mark P8 = πd = 157 mm on a tangent through points 8 on a circle.
4) Divide P8 into 8 equal parts and name the points 1, 2, ... 8.
5) Now with P1 (on P8) as radius and 1 on circle as a centre cut the arc on a tangent through point 1 to get point P_1. Repeat the same procedure to get the points P_2, P_3, ... P_8.
6) Join all these points with a smooth curve to get the involute.

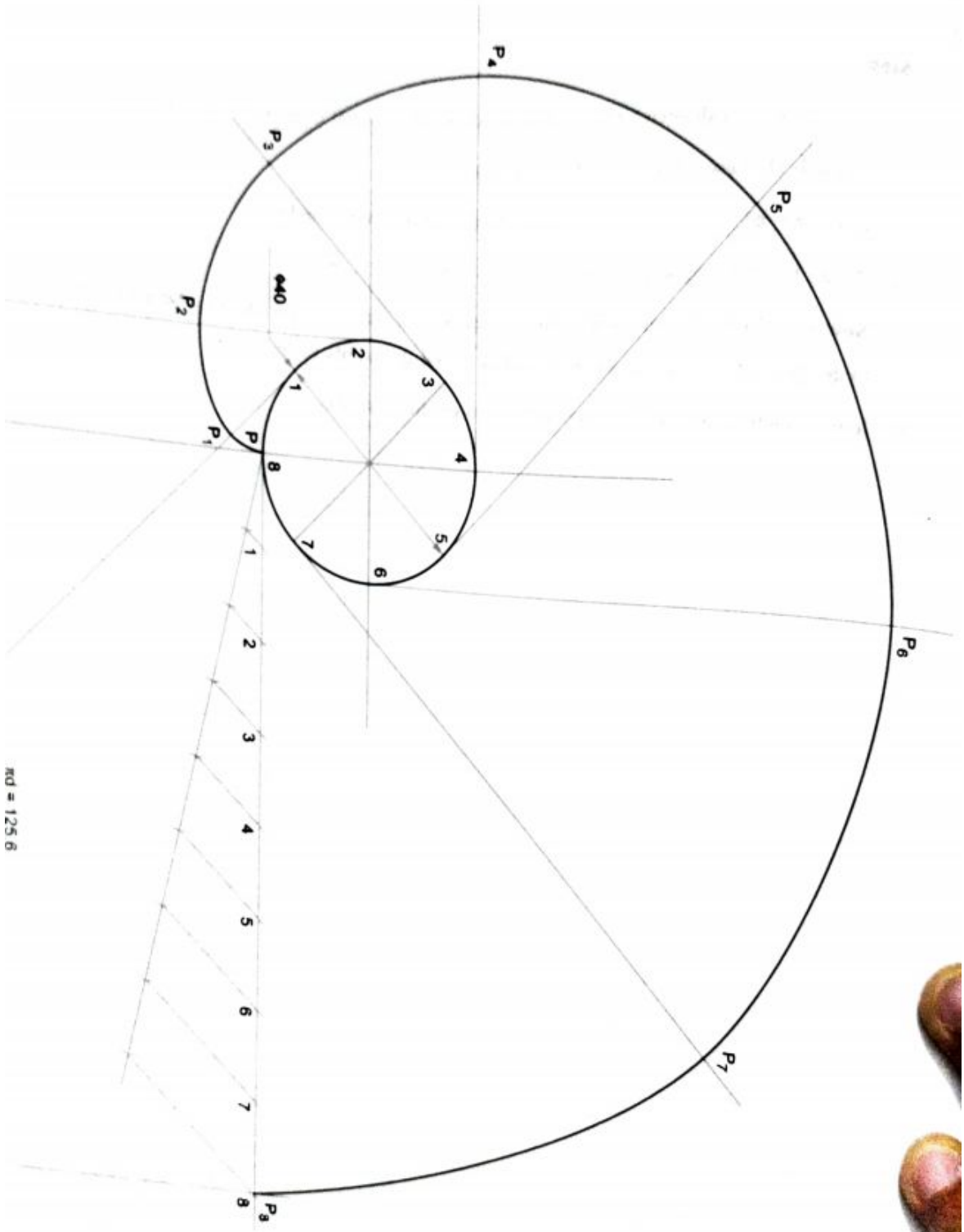

P4
P3
P5
P2
P1
P
P6
P7
P8
1
2
3
4
5
6
7
8
rad = 157

Ex. 3.7.2 : ***Draw an involute of circle of diameter 40 mm.*** SPPU June 16

ol. :

Steps

1) Draw a circle of diameter 40 mm and divide it into 8 equal parts and name the points as shown.
2) Through all these points draw the tangents.
3) Mark P8 = πd = 126.5 mm on a tangent through point 8 on a circle.
4) Divide P8 into 8 equal parts and name the points 1, 2, ... 8.
5) Now with P1 (on P8) as radius and 1 on circle as a centre cut the arc on a tangent through point 1 to get point P_1. Repeat the same procedure to get the points P_2, P_3, ... P_8.
6) Join all these points with a smooth curve to get the involute.


P4
P3
P5
P2
Ø40
P1
P
8
1
2
3
4
5
6
7
P6
P7
P8
rad = 125.6

3.8 : Cycloid

SPPU : May-13, Dec.-13,14,16

It is defined as the locus traced out by a point on the circumference of a circle when rolls along a straight line without slipping.

Rolling Circle

The circle which rolls on a fixed straight line is called rolling circle. It is also called as generating circle.

Directing Line

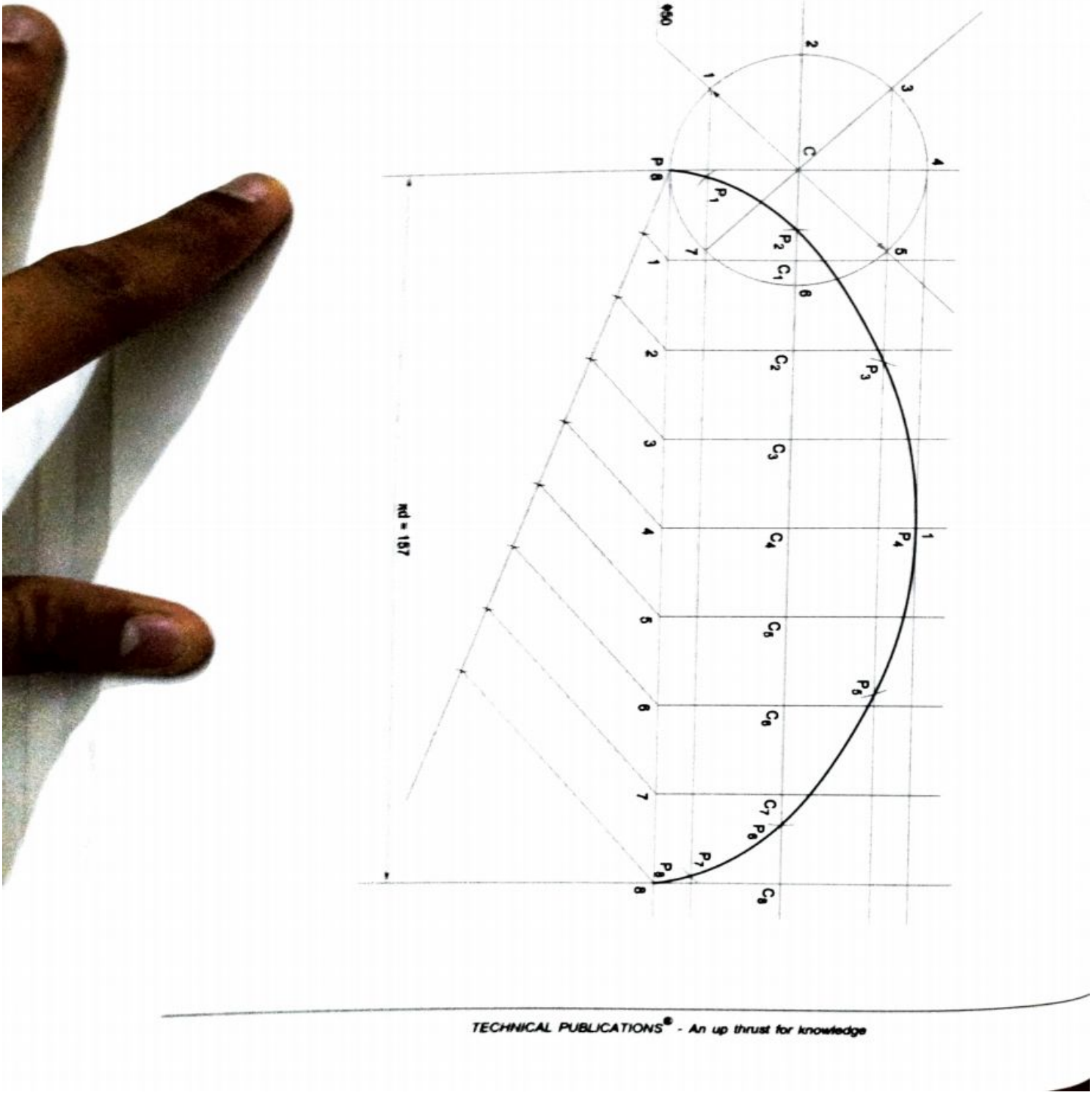
The straight line on which generating circle rolls is called directing line.

Ex. 3.8.1 : ***Draw a cycloid of rolling circle of diameter 50 mm.*** SPPU : Oct.-13

Sol. : **[To the scale]**

Steps

1) Draw a circle of (ϕ = 50 mm) and divide it into equal divisions. Name the points 1, 2, ... 8.
2) Mark lower most as point P and draw a tangent to this circle through point P. It is a directing line.
3) Mark 8(πd = 157 mm) distance on this tangent and divide it into 8 equal parts. Name the points 1, 2, ... 8 on it starting from P.
4) Draw the horizontal lines from the points on a circle and vertical lines from the points on the tangent. Mark the intersections of these lines as C_1, C_2, C_3, ... C_8.
5) Cut the arc on a horizontal line passing through point 1 with centre C_1 and radius CP (radius of circle) to get point P_1. Repeat the same procedure to get the points P_2, P_3, ... P_8.
6) Join all these points with a smooth curve to get the cycloid.


Φ50
2
1
3
C
4
P0
P1
P2
C1
7
5
6
1
C2
P3
2
C3
3
C4
P4
4
C5
P5
5
C6
6
C7
P6
P7
P8
7
C8
8
Rd = 187

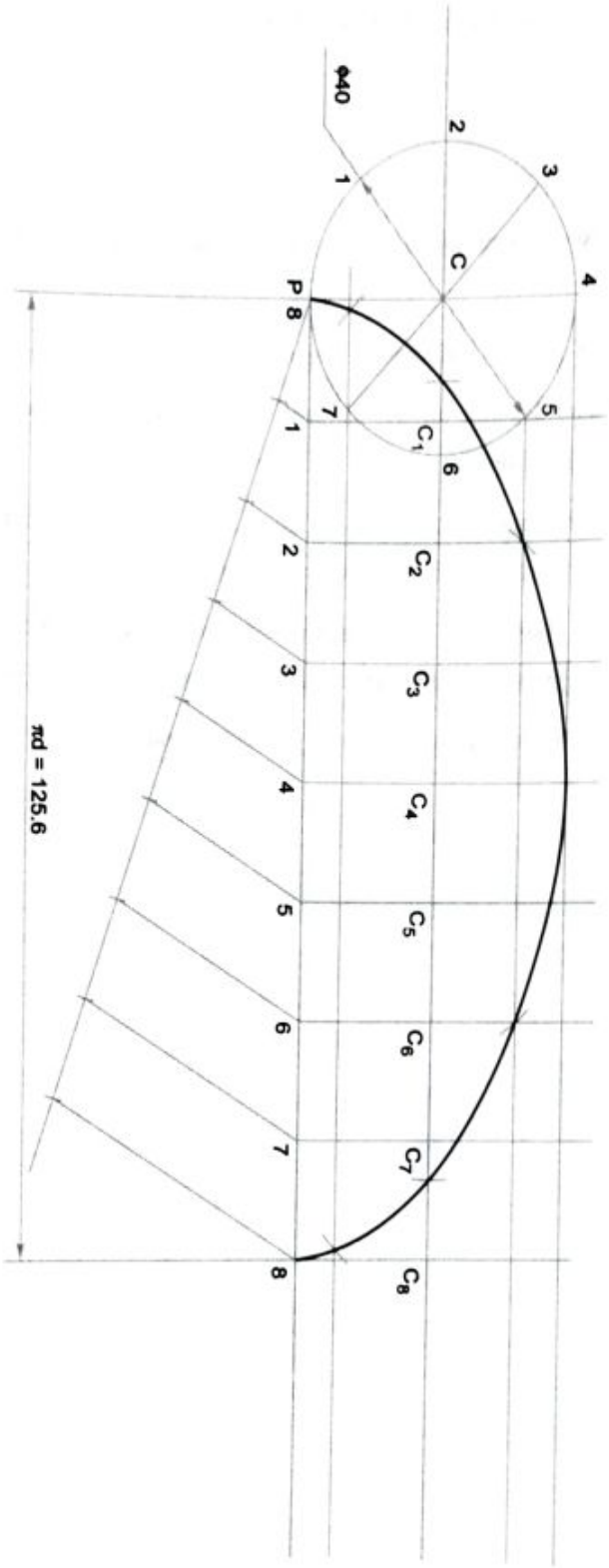
Ex. 3.8.2 : ***Draw a cycloid of rolling circle of diameter 40 mm.***

SPPU Mar 15, Oct 14, 16

Sol. : **[To the scale]**

Steps

1) Draw a circle of ($\phi = 40$ mm) and divide it into 8 equal divisions. Name the points 1, 2, ... 8 and centre as C.
2) Mark lower most as point P and draw a tangent to this circle through point P. It is a directing line.
3) Mark ($\pi d = 125.6$ mm) distance on this tangent and divide it into 8 equal parts. Name the points 1, 2, ... 8 on it starting from P.
4) Draw the horizontal lines from the points on a circle and vertical lines from the points on the tangent. Mark the intersections of these lines as C_1, C_2, C_3, ... C_8.
5) Cut the arc on a horizontal line passing through point 1 with centre C_1 and radius CP (radius of circle) to get point P_1. Repeat the same procedure to get the points P_2, P_3, ... P_8.
6) Join all these points with a smooth curve to get the cycloid.


Φ40
P
1
2
3
4
5
6
7
8
C
C1
C2
C3
C4
C5
C6
C7
C8
πd = 125.6

3.9 : Spiral

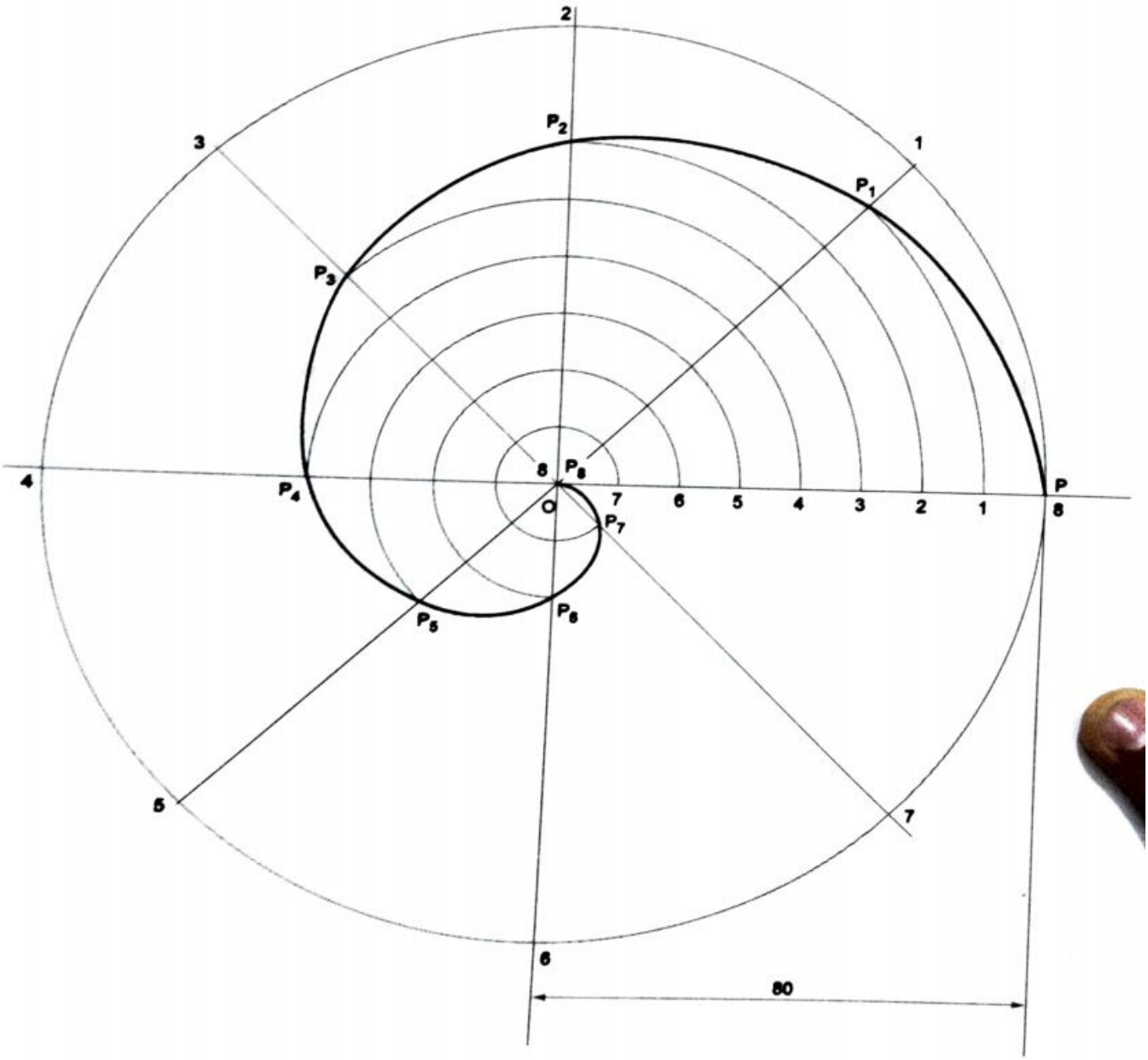
It is a curve traced out by a point which moves uniformly both about the centre and at the same time away or towards the centre.

Ex. 3.9.1 : ***Draw an archemedian spiral of radius 80 mm for one convolution.***

Sol. :

Steps

1) Draw a circle with radius 80 mm and divide it into 8 equal parts. Name points 1, 2, 3, ... 8 as shown and centre 'O'.
2) Divide **OP = 08** also into eight equal divisions and name the points on it as 1, 2, ... 8 starting from P.
3) Draw an arc with centre O and radius **01** (on OP) to intersect the radius 01 to get the point P_1.
4) Repeat the same procedure to get the points P_2, P_3, ... P_8.
5) Join all these points with a smooth curve to get archemedian spiral of one convolution.


2
3
1
P_2
P_1
P_3
4
P_4
8
P_8
O
7
6
5
4
3
2
1
P
8
P_7
P_5
P_6
5
7
6
80

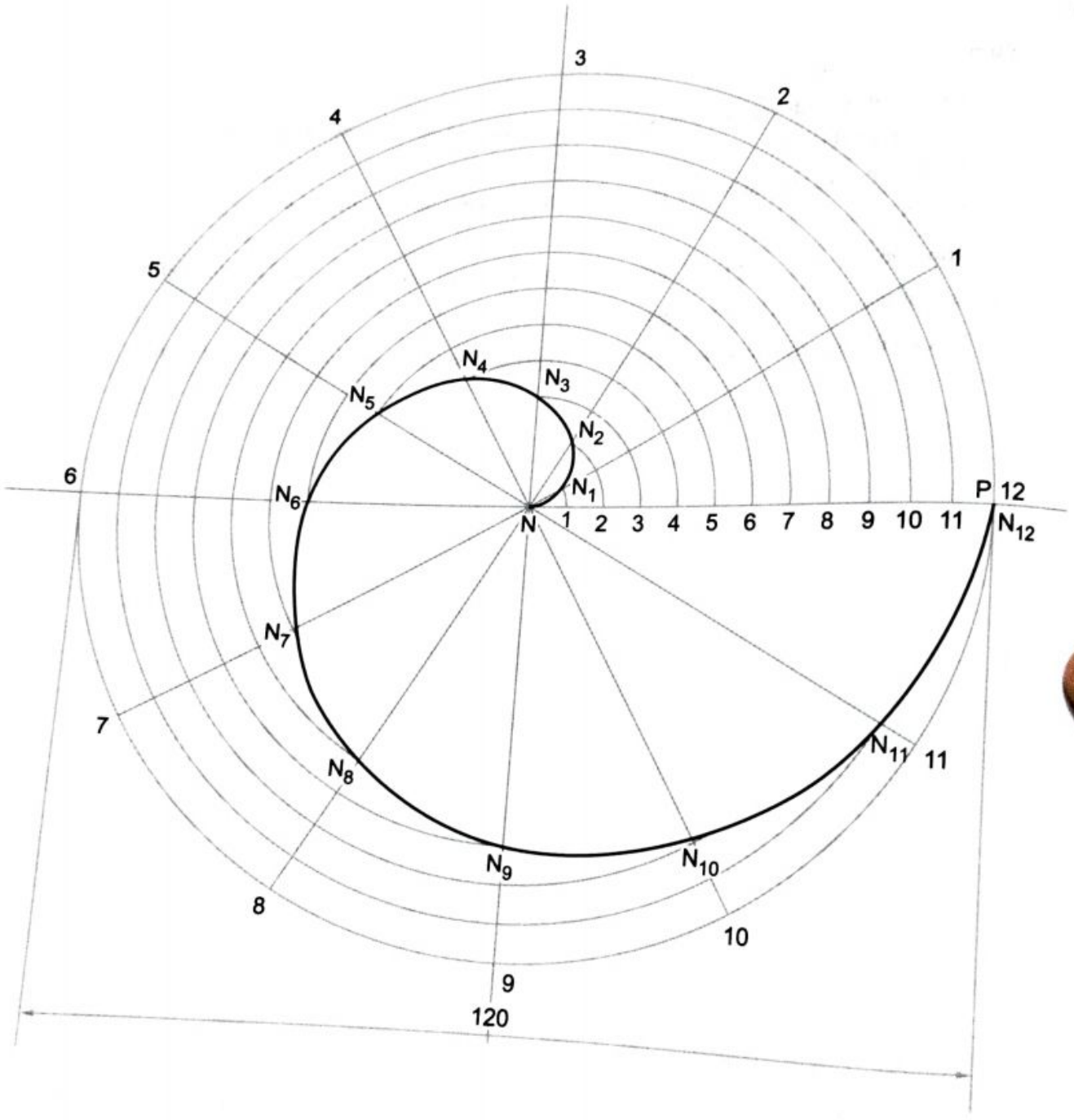
Archemedian Spiral

Ex. 3.9.2 : ***Draw an archemedian spiral of diameter 120 one convolution. Point N moves from centre to one of the end of rod.***

Sol. :

Steps

1) Draw a circle with radius 60 mm and divide it into 12 equal parts. Name points 1, 2, 3, ... 12 as shown and centre 'N'.
2) Divide **NP = 60 mm** also into 12 equal divisions and name the points on it as 1, 2, ... 12 starting from N.
3) Draw an arc with centre N and radius **N1** (on NP) to intersect the radius N1 to get the point P_1.
4) Repeat the same procedure to get the points P_2, P_3, ... P_{12}.
5) Join all these points with a smooth curve to get archemedian spiral of one convolution.


3
2
1
4
5
6
7
8
9
10
11
12
120
N
P
N1
N2
N3
N4
N5
N6
N7
N8
N9
N10
N11
N12

UNIT - IV

4 Orthographic Projections

Syllabus

Principle of projections, Introduction to First and Third angle Projection methods, Orthographic projection of point, line, plane, solid and machine elements/parts.

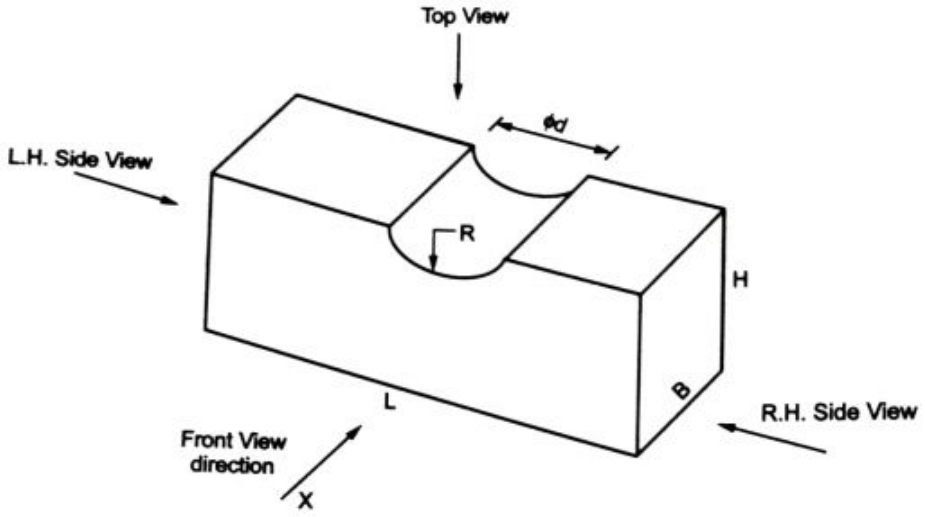
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4.1 : Introduction

Generally, length, breadth and height (L, B and H) or radius are dimensions which are mean's orthogonal or perpendicular to each other. Hence, is orthographic view any two dimension. Which are perpendicular to each other different projections (i.e. views) of solid geometry, in different directions i.e. front, top and side, are studied which shows any two dimensions (i.e. either L and b, or b and h or L and H) in a plane, is called as orthographic projection.

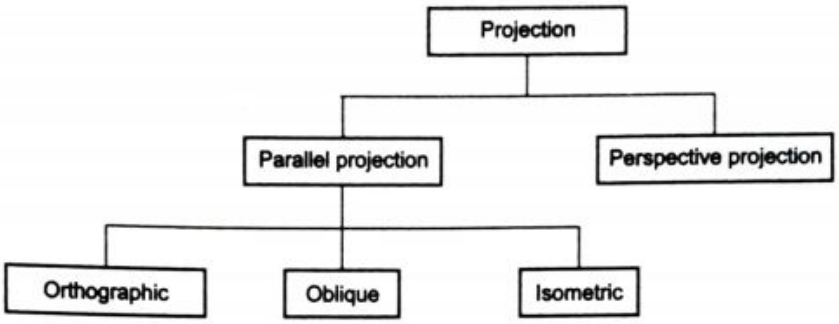
Let's discuss basically, how different dimensions can be seen in orthographic view in different direction.



View	Dimensions seen
Front View (F.V.) or (Elevation View)	L, H, R
Top View (T.V.) or Plan View	B, L, ϕd
L.H. Side View	B, H
R.H. Side View	B, H

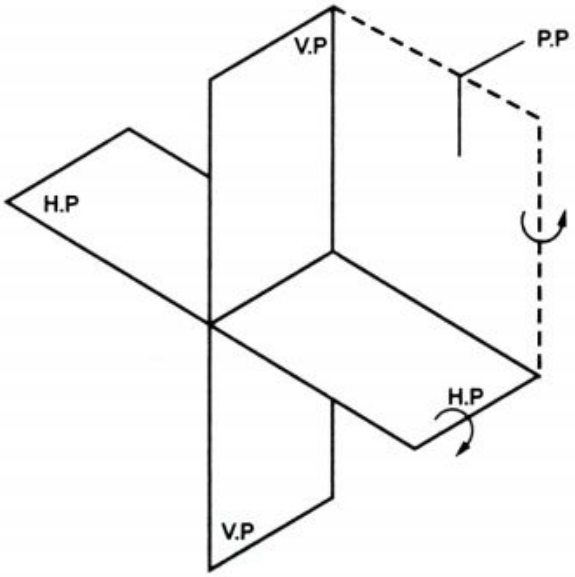
(Hidden dimensions are not considered)

The various types of projection that are used are mentioned below :



4.2 : Principal Plane and Principal Views

Following planes as shown in Fig. are used as principal plane in orthographic projection.



i) Vertical Plane (V.P.) i.e. Front Reference Plane (FRP).

ii) Horizontal Plane (H.P.) i.e. Horizontal Reference Plane (HRP)

iii) Profile Plane (P.P.) i.e. Side Reference Plane (SRP)

Vertical Plane (V.P.) is always assumed to be fixed while Horizontal Plane (H.P.) and Profile Plane (P.P.) are assumed to rotate by 90° as shown in Fig., so that different views and their projection can be studied in Single Plane.

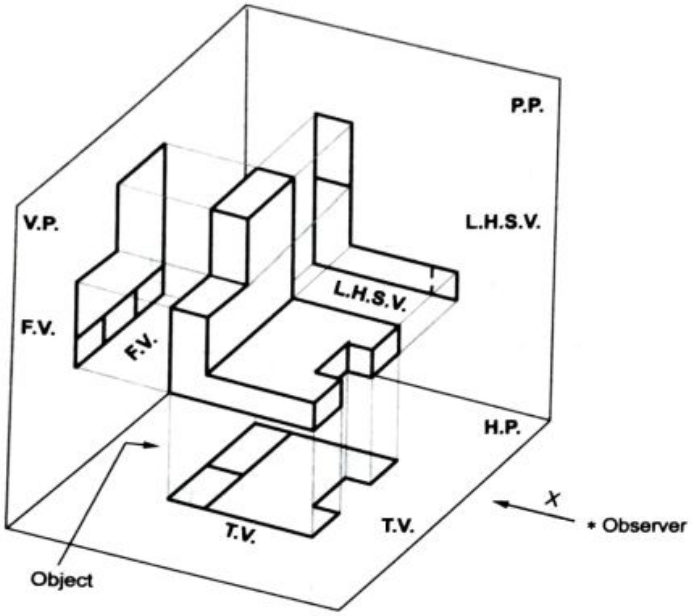
4.3 : Method of Projection

Following are two angle of projection method used in orthographic projection.

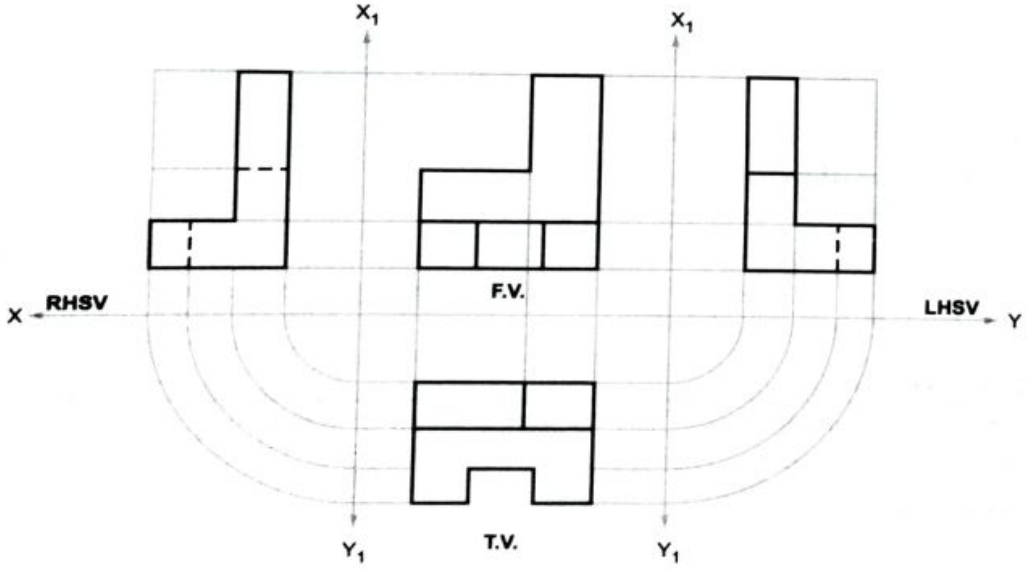
i) First angle projection method

ii) Third angle projection method

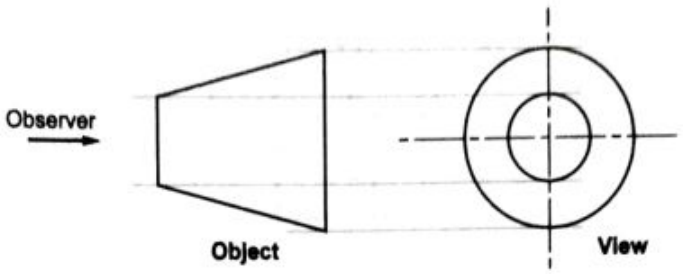
4.3.1 First Angle Projection Method



When object is placed in first quadrant and if achieved sequence is observer → object → plane i.e. object is between observer and plane, then orthographic view obtained by such method is called as first angle projection method. This as explained in Fig.( ). The solution part of orthographic projection contents always F.V. projected on V.P., T.V. projected on H.P. and side view (either LHSV or RHSV) on P.P.



4.3.1.1 Symbol i.e. Graphical Representation of Ist Angle Projection Method

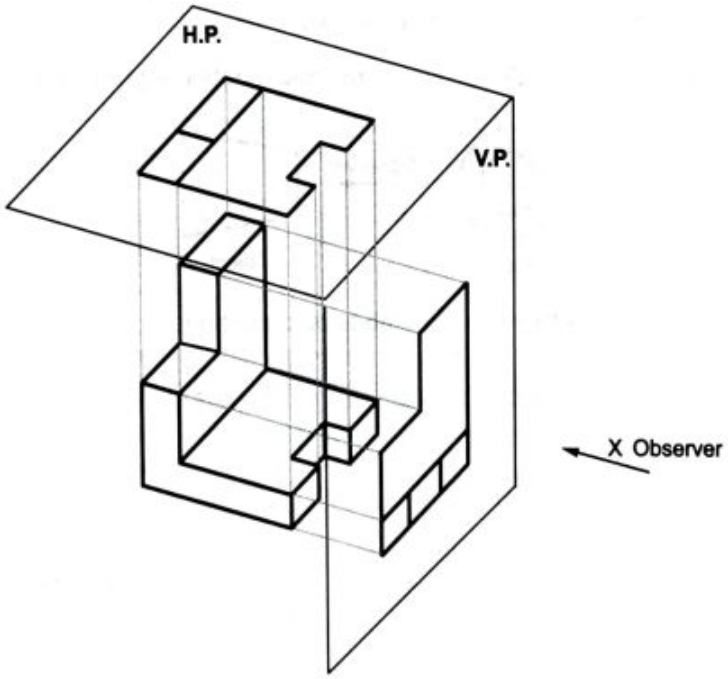


In first anlge projection method,, observer see from one side of object and project view to other side of object, satisfying condition of observer → object → view (plane).

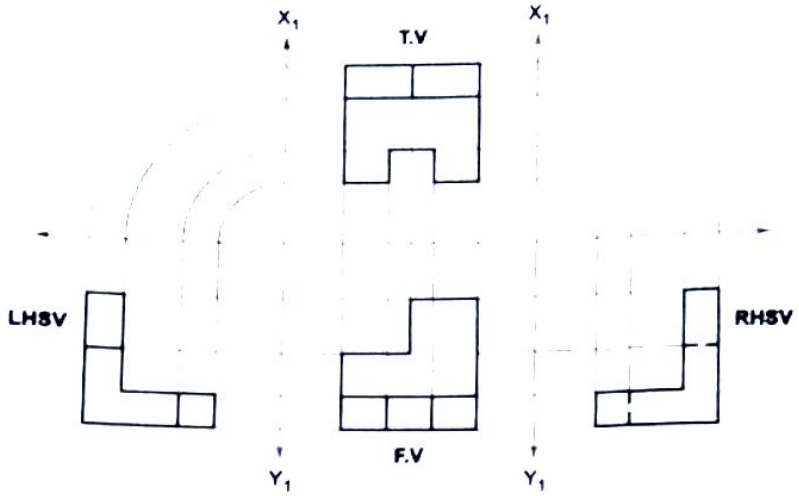
According to this condition Ist angle projection method symbol is presented as follow.

4.3.2 Third Angle Projection Method

When object is placed in third quadrant and if achieved sequence is observed → object → plane → object i.e. plane is between observed and object, then orthographic view obtained by such method is called as third angle projection method. This is as explained in Fig.



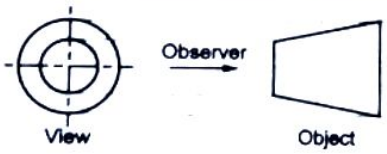
The solution of orthographic projection by third angle projection method is as given below.



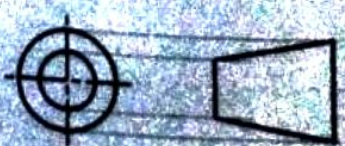
4.3.2.1 Symbol i.e. Graphical Representation of IIIrd Angle Projection Method

In third angle projection method, observer see from one side of object and project view to same side of object, satisfying condition of view ← observer → object.

According to this condition IIIrd angle projection method symbol is presented as follow :



One glance comparison between these two methods of projection are as follow :

Sr. No.	First Angle Method of Projection	Third Angle Method of Projection
i)	Object position is considered in first quadrant.	Object position is considered in third quadrant.
ii)	Object is always in between observer and plane	Plane is always in between observer and object.
iii)	F.V. is always above reference (XY) line.	T.V. is always above reference (XY) line.
iv)	Symbol 	Symbol 

Part - A : Projection of Point, Line, Plane and Solid

A) Projection of Point

4.4 : Introduction

- A point has a geometrical figure. Which has no dimensions.
- It is represented by smallest but visible dot.
- Front view of point 'A' is denoted by a' and top view denoted by a.
- Positions of point in different quadrants.

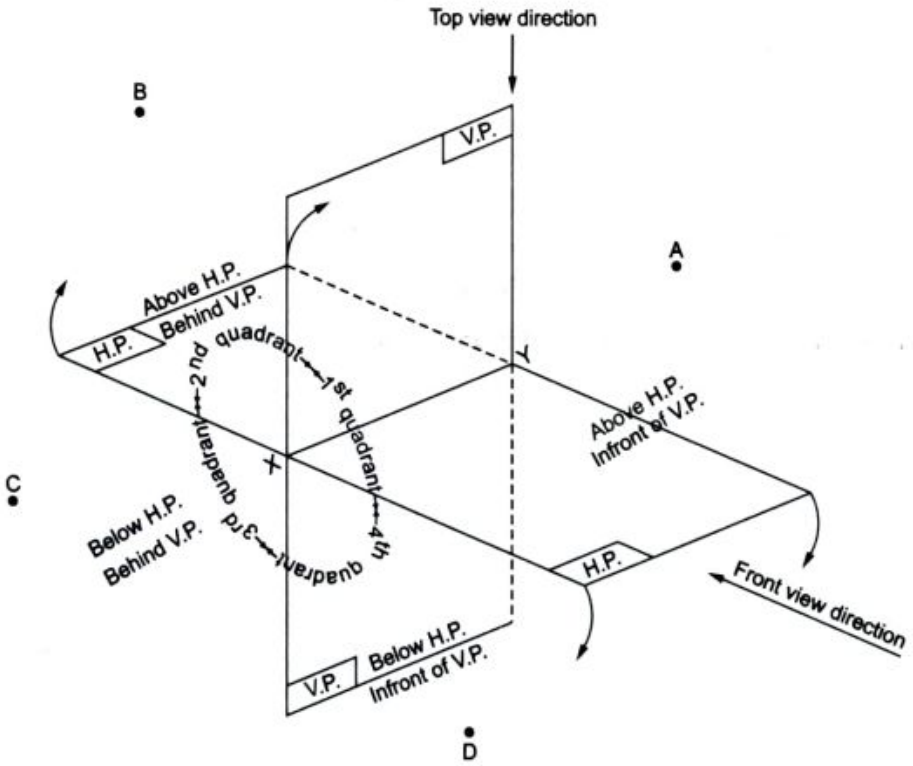


Fig. 4.4.1

1) 1st quadrant point A - Above the H.P. and in front of the V.P.
2) 2nd quadrant point B - Above the H.P. and behind the V.P.
3) 3rd quadrant point C - below the H.P. and behind the V.P.
4) 4th quadrant point D - below the H.P. and in front of the V.P.

... above the H.P. and infront of the V.P.

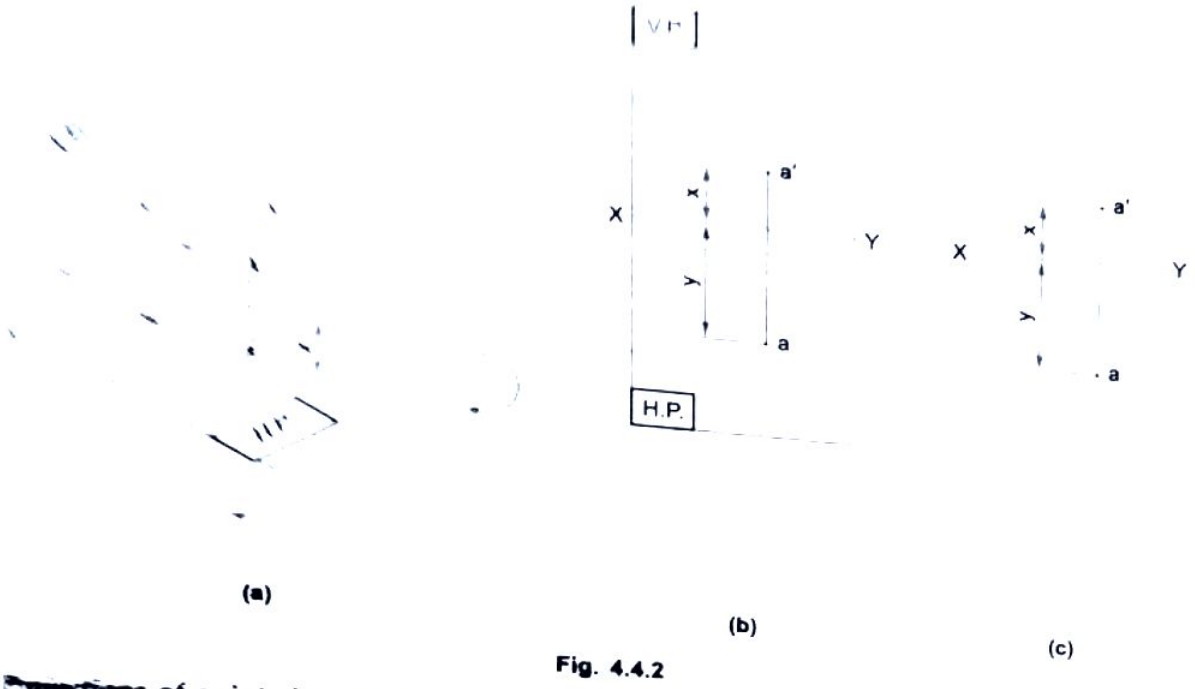


Fig. 4.4.2

2 Projections of point situated above the H.P. and in the V.P.

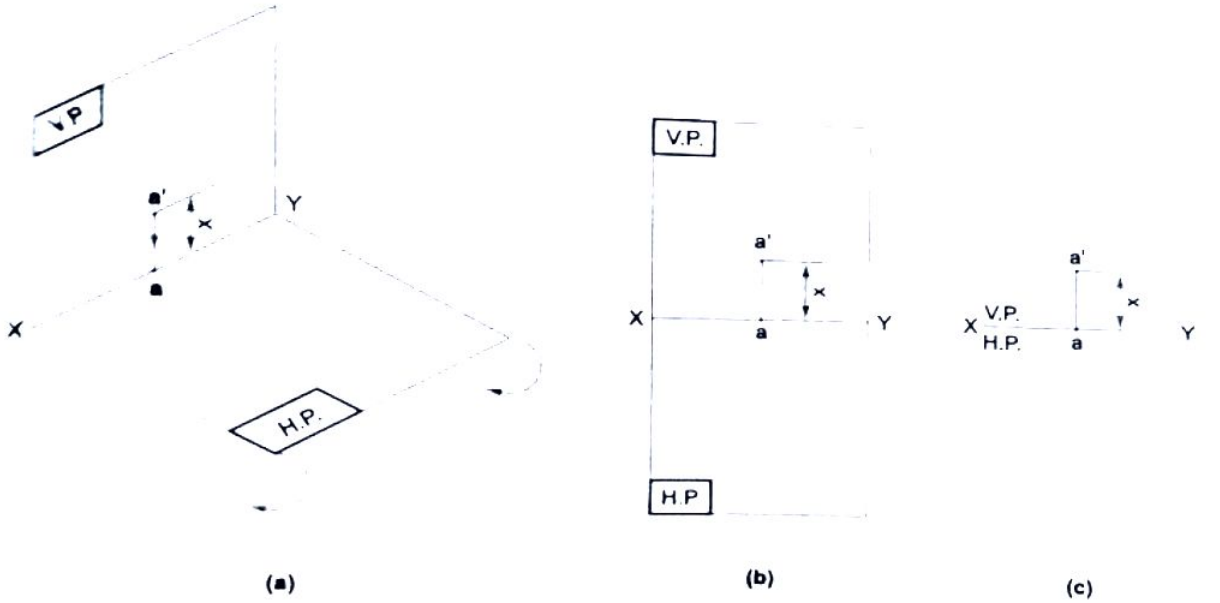
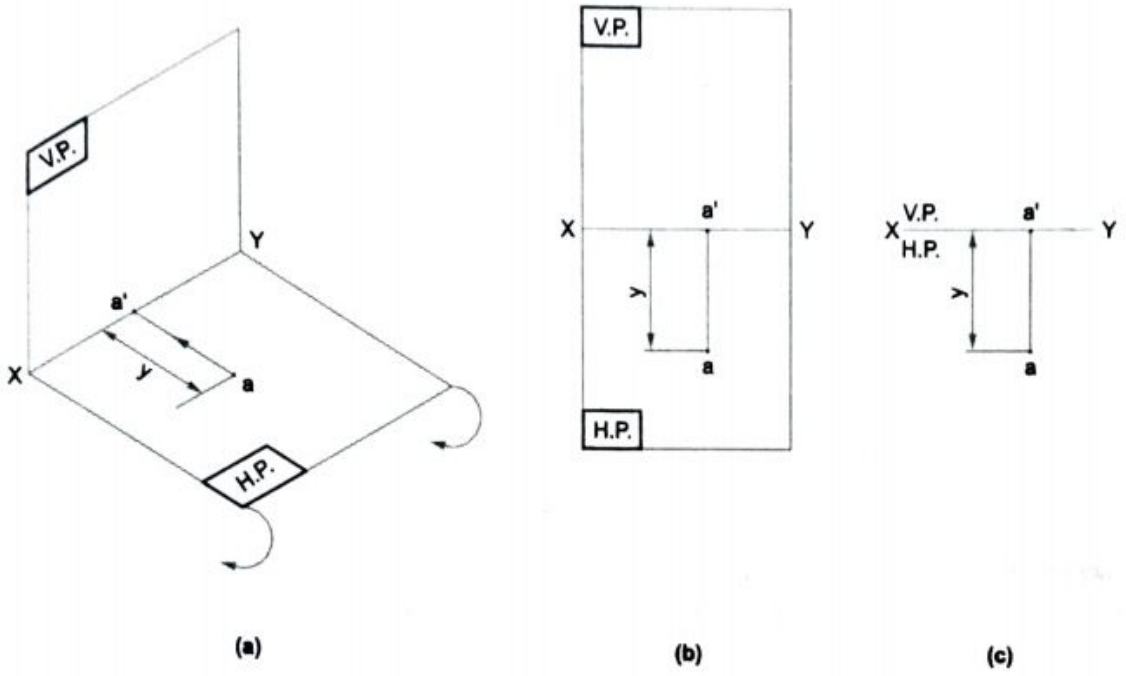


Fig. 4.4.3

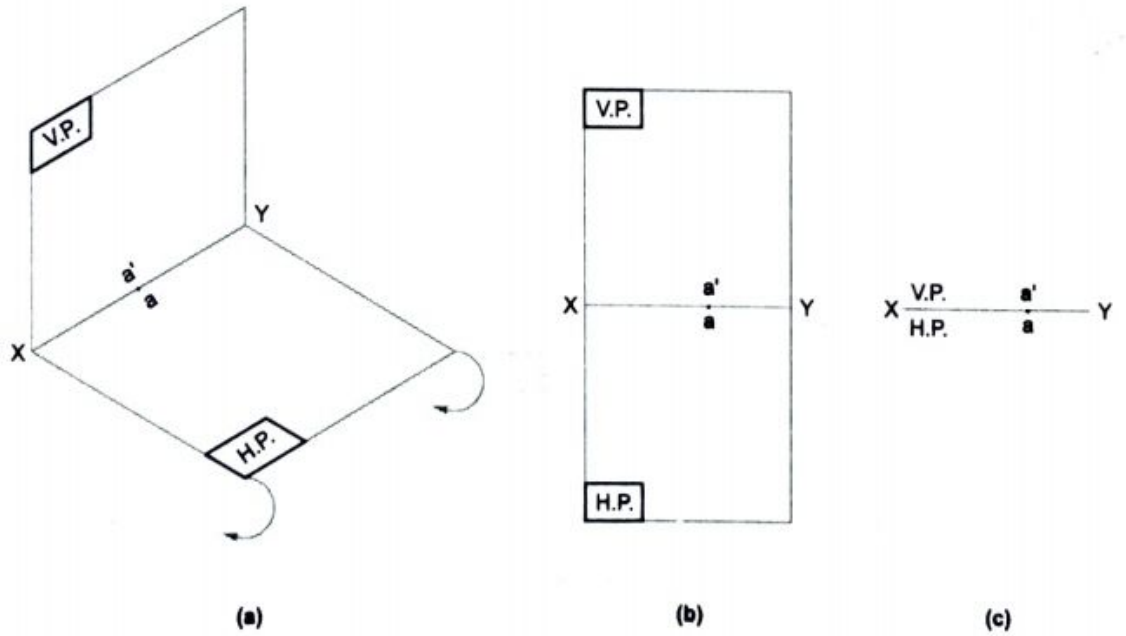
3) Projections of a point situated infront of V.P. and on the H.P.



(a) (b) (c)

Fig. 4.4.4

4) Projections of point a situated on the H.P. and in the V.P.

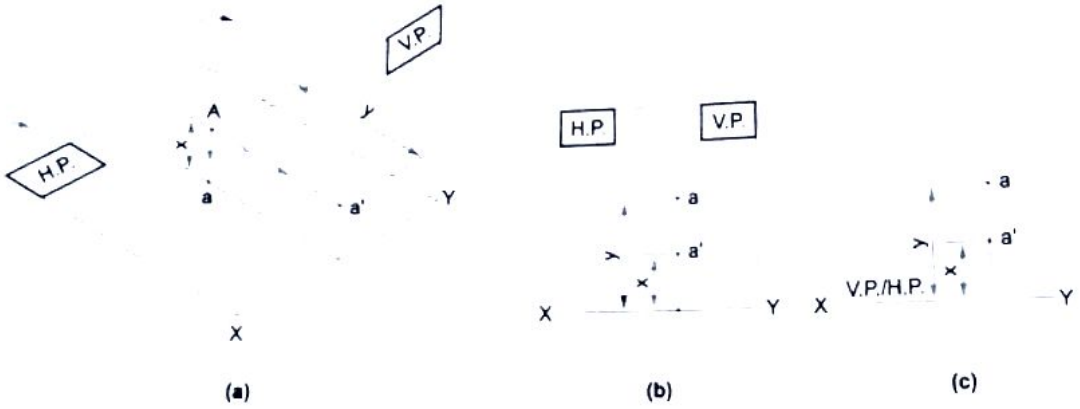


(a) (b) (c)

Fig. 4.4.5

B) When Point it is in 2nd quadrant :

- Projections of point situated above the H.P. and behind the V.P. :

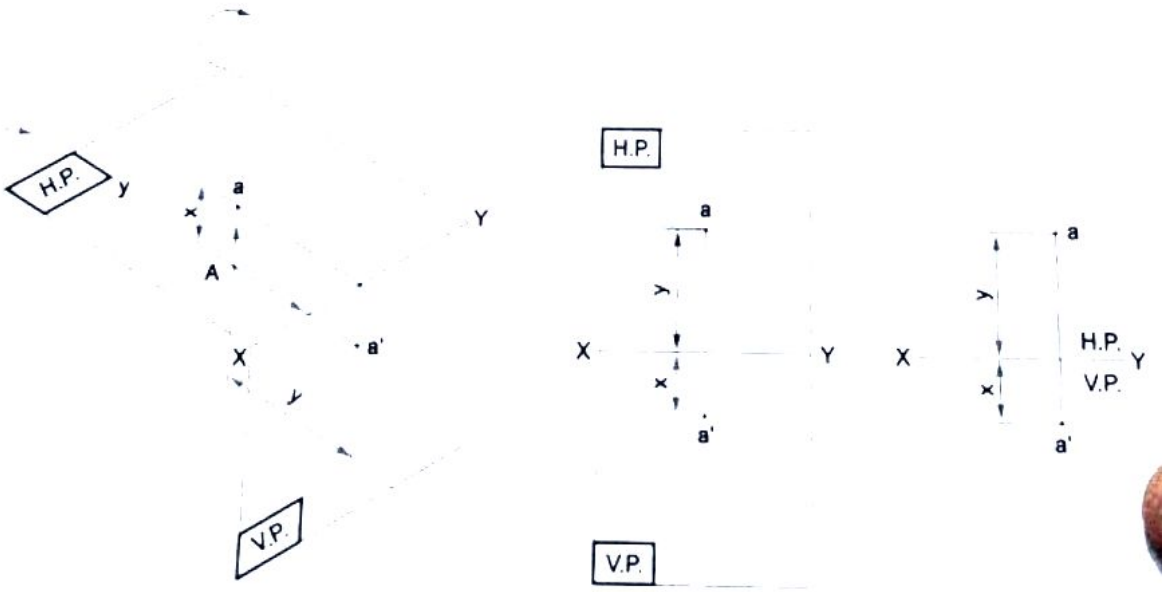


(a) (b) (c)

Fig. 4.4.6

C) When Point it is in 3rd quadrant :

- Projections of point situated below the H.P. and behind the V.P. :

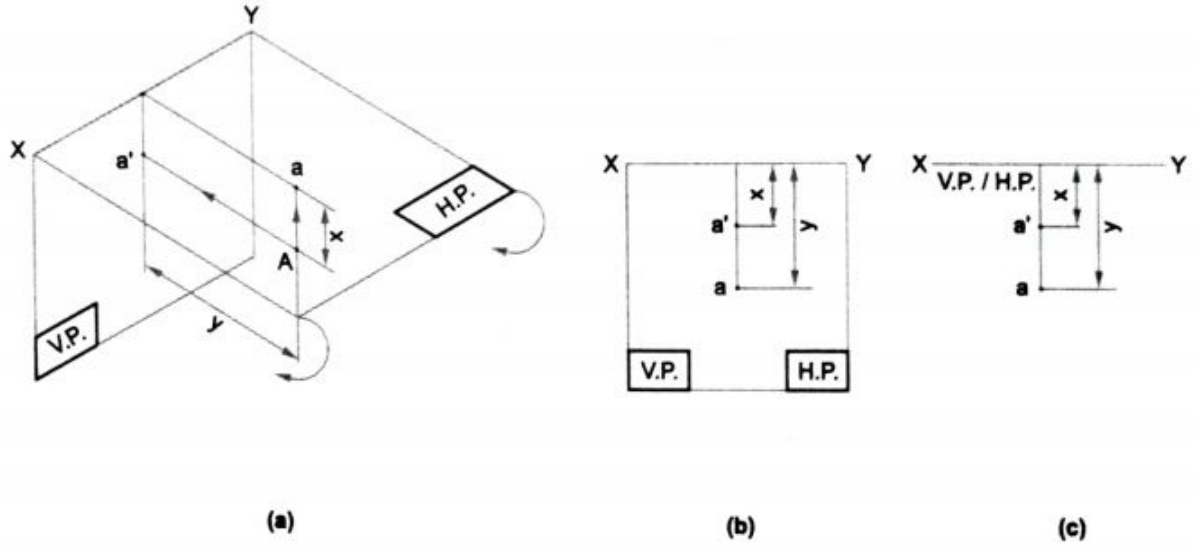


(a) (b) (c)

Fig. 4.4.7

D) When point it is in 4th quadrant :

- **Projections of point situated below the H.P. and infront of V.P. :**

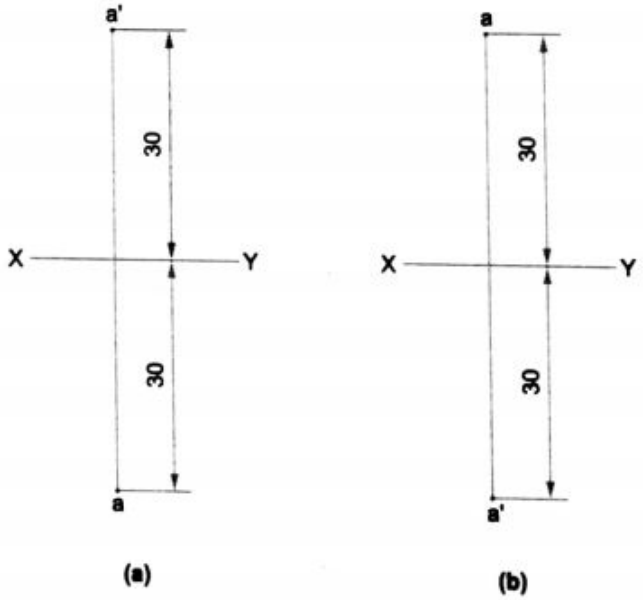


(a) (b) (c)

Fig. 4.4.8

Ex. 4.4.1 : *A point A is 30 mm from both H.P. and V.P. Draw its projections when (a) A is in 1st quadrant and (b) in 3rd quadrant.*

Sol. :



(a) (b)

Fig. 4.4.9

Ex. 4.4.2 : *Draw the projections of the following points : (i) A, 35 mm above the H.P. and 30 mm in front of the V.P. (ii) B, in both H.P. and V.P.*

Sol. :

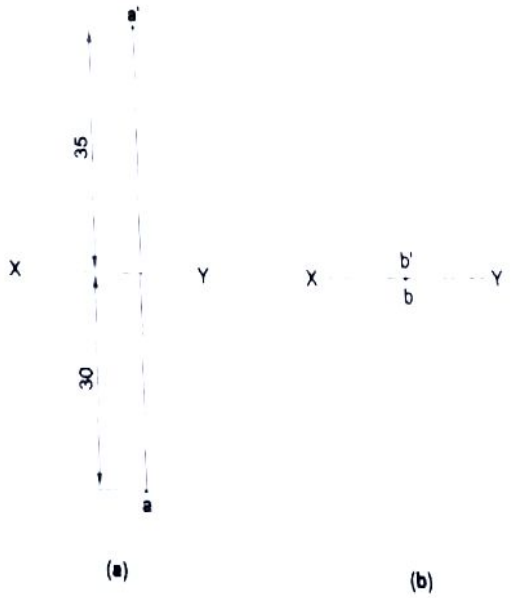


Fig. 4.4.10

Ex. 4.4.3 : *A point A is 25 mm below H.P. and 45 mm behind V.P. Draw its projections.*

Sol. :



Fig. 4.4.11

Ex. 4.4.4 : *A point A is on H.P. and 25 mm behind V.P. Draw its projections.*

Sol. :

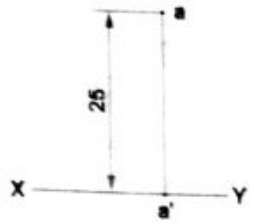


Fig. 4.4.12

Ex. 4.4.5 : *Draw the projections of a Point A when it is 10 mm infront of V.P. and 30 mm below H.P.*

Sol. :

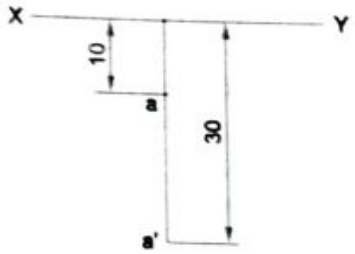


Fig. 4.4.13

Ex. 4.4.6 : *A point A is on H.P. and 25 mm infront of V.P. Draw its projections.*

Sol. :

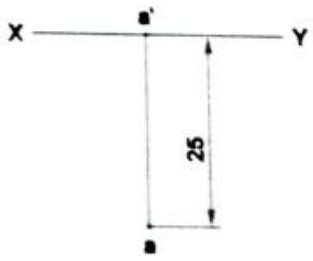


Fig. 4.4.14

B) Projection of Line

4.5 : Terms used in Projection of Lines

Intersection of two reference planes is called as reference line. It is denoted by XY

1. Front veiw of any point (A) is denoted by a′ and top view by a.
2. **Projector :** A line joining the front view and top view of a point [any two adjacent views] is called as projector. It is always perpendicular to reference line (XY).
3. **True length (TL) :** The actual length of a line is called as it's true length and denoted by TL.
4. **Plan length (PL) / Top View Length (TVL) :** The apparant length of a line seen in TV is called the plan length or top view length. It is denoted by PL or TVL. Always PL ≤ TL
5. **Elevation length (EL) / Front View Length (FVL) :** The apparant length of a line seen in FV is called the elevation length or front view length. It is denoted by EL or FVL. Always EL ≤ TL
6. **Inclination of line with HP (θ) :** It is the true angle which line makes with HP.
7. **Inclination of line with VP (ϕ) :** It is the true angle which line makes with VP.
8. **Apparant angle with the HP (α) :** It is the angle which an oblique line seems to make with HP in FV. It is the angle between FV and XY. It is denoted by α and is always greater than θ.
9. **Apparant angle with the VP (β) :** It is the angle which an oblique line seems to make with VP in TV. It is the angle between TV and XY. It is denoted by β and is always greater than ϕ
10. **Point view of the line :** When the views of two end points of a line coincides then it is seen as a point. It is called as point view of a line.

4.6 : Projections of Lines

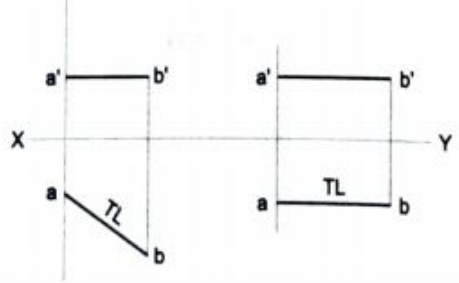
A straight line is the shortest distance between the two points. Projectios of lines are obtained by projecting its end points and joining them by straight lines.

4.6.1 Classification of Lines

1. Horizontal line
2. Frontal line
3. Profile line
4. Oblique line

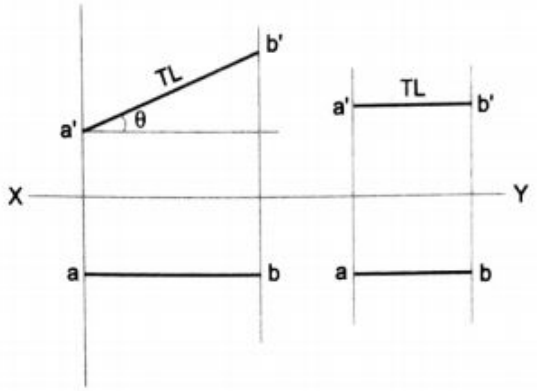
4.6.2 Horizontal Line

The line which is parallel to HRP is called as horizontal line. Its top is always true length and FV is parallel to XY



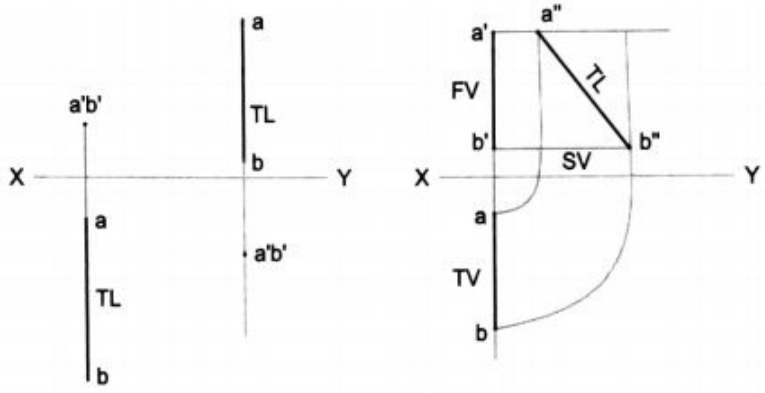
4.6.3 Frontal Line

A line parallel to frontal reference plane (VP) is called as frontal line. It's FV is always TL and TV is parallel to XY



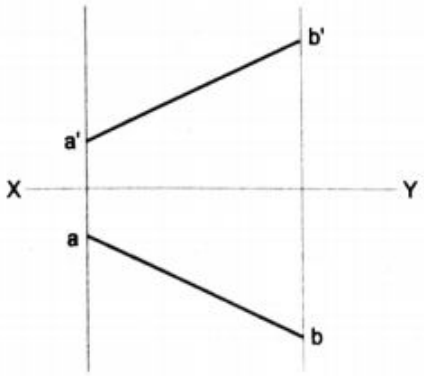
4.6.4 Profile Line

A line parallel to profile plane (The plane which is ⊥r to HP and VP) is called as profile line. It's side view is TL. It's FV and TV lies on single projector.



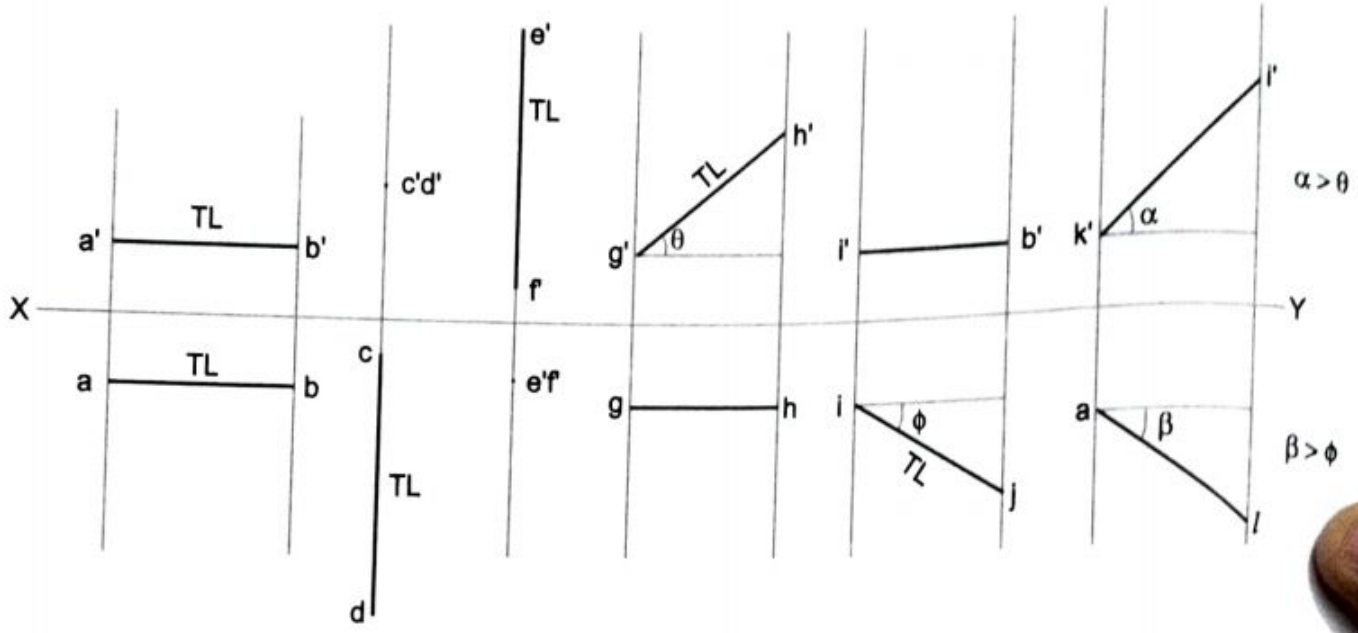
4.6.5 Oblique Line

A line which is inclined to HP (θ) and VP (ϕ) is called as oblique line. It's FV as well as TV are not in true length form. Both the views are in apparant length form.



4.7 : Various Positions of Line in First Quadrant

1. Line parallel to HP and VP (AB)
2. Line parallel to HP and ⊥r to VP (CD)
3. Line ⊥r to HP and parallel to VP (EF)
4. Line inclined to HP (θ) and parallel to VP (GH)
5. Line parallel to HP and inclined to VP (ϕ) (IJ)
6. Line inclined to HP (θ) and VP (θ) (KL)



OBSERVATIONS

1. **If one view of line is true length (TL) then it's adjacent view is either parallel to XY (reference line) or point view.**
2. **True inclination (θ or ϕ) of line is always with the true length.**
3. **If line is in apparant length form then its inclination is apparant (α or β).**
4. **Apparant length is always less than true length.**
5. **Apparant inclinations (α or β) are always greater than true inclinations (θ or ϕ).**

4.8 Traces of a Line

The point of intersection of the line or it's extension with HP or VP are called as traces of the line.

4.8.1 Horizontal Trace (HT)

The point of intersection of the line or it's extension with horizontal plane is called as horizontal trace (HT) of the line.

4.8.2 Vertical Trace (VT)

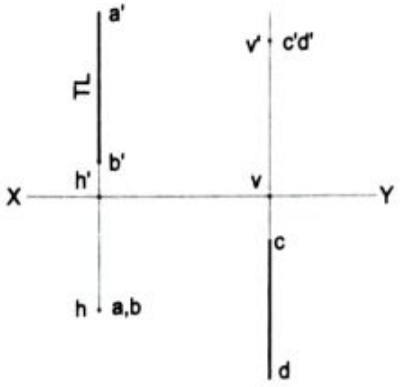
The point of intersection of the line or it's extension with vertical plane is called as vertical trace (VT) of the line.

4.8.3 Trace of the Line Parallel to HP and VP

If a line is parallel to HP and VP then it will not have trace as it never meets HP or VP.

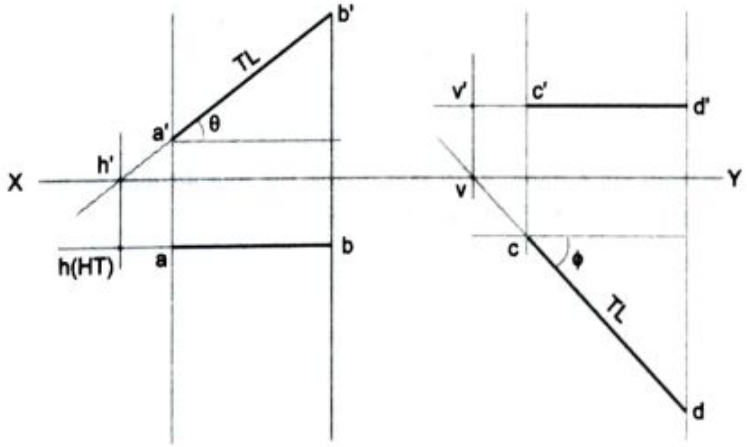
4.8.4 Trace of the Line Perpendicular to HP and VP

If a line is perpendicular to HP then it will have HT and if a line is perpendicular to VP then it will have VT. Line AB is ⊥r to HP and CD is perpendicular to VP.



4.8.5 Traces of a Line Inclined to One Reference Plane and Parallel to Other Reference Plane

If a line is inclined to the HP and parallel to VP then it will have only HT and if a line is inclined to VP and parallel to HP then it will have only VT.

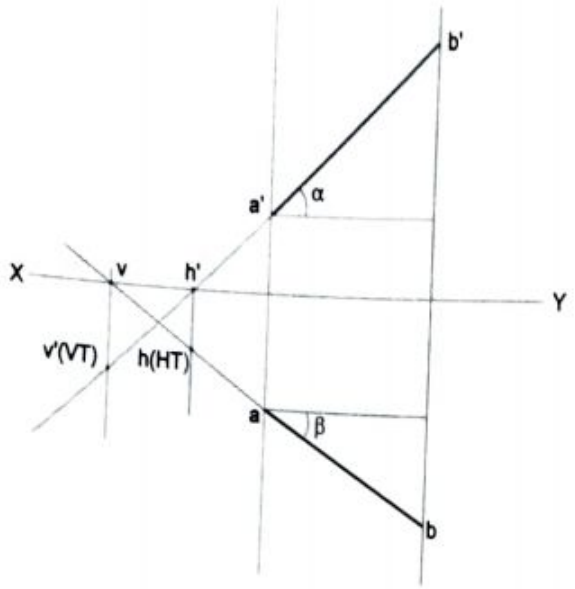


[Line inclined to HP and parallel to VP]

[Line inclined to VP and parallel to HP]

4.8.6 Traces of Line Inclined to HP and VP

If a line is inclined to HP and VP the it will have both HT and VT.



4.9 : Auxilary Planes

When normal F.V., T.V and S.V. are not sufficient to describe the objects completely then additional views are projected on the planes which are perpendicular to HP or VP. These planes are clled as auxilary planes and the views drawn on these planes are called as auxilary views.

1. Auxilary Vertical Plane (AVP) 2. Auxilary Inclined Plane (AIP)

4.9.1 AVP

The plane which is ⊥r to HP and inclined to VP is called as Auxilary Vertical Plane (AVP) and the view drawn on it is called as AFV.

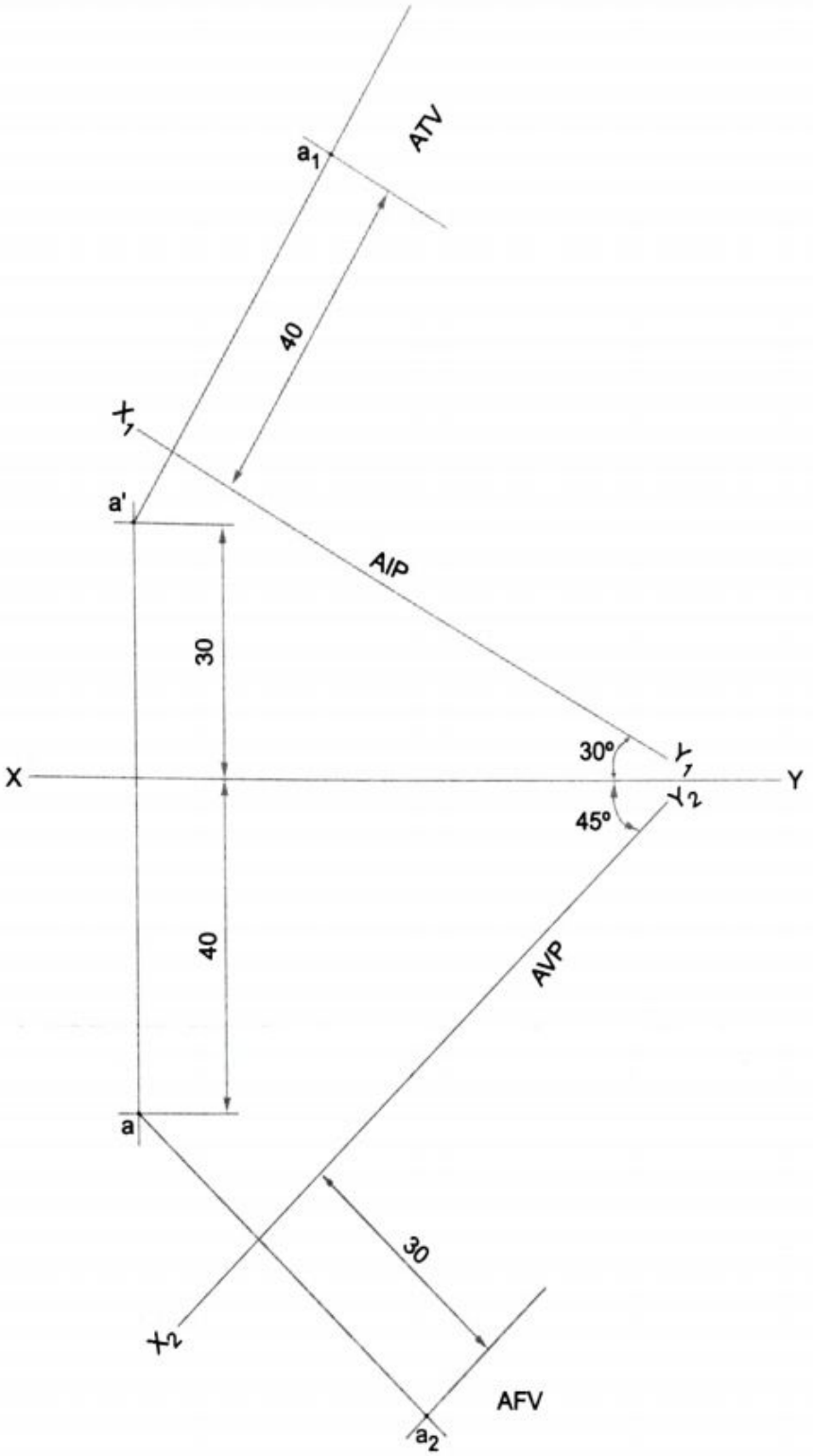
4.9.2 AIP

The plane which is ⊥r to VP and inclined to HP is called as Auxilary Inclined Plane (AIP) and view drawn on it is called as Auxilary Top View.

4.9.3

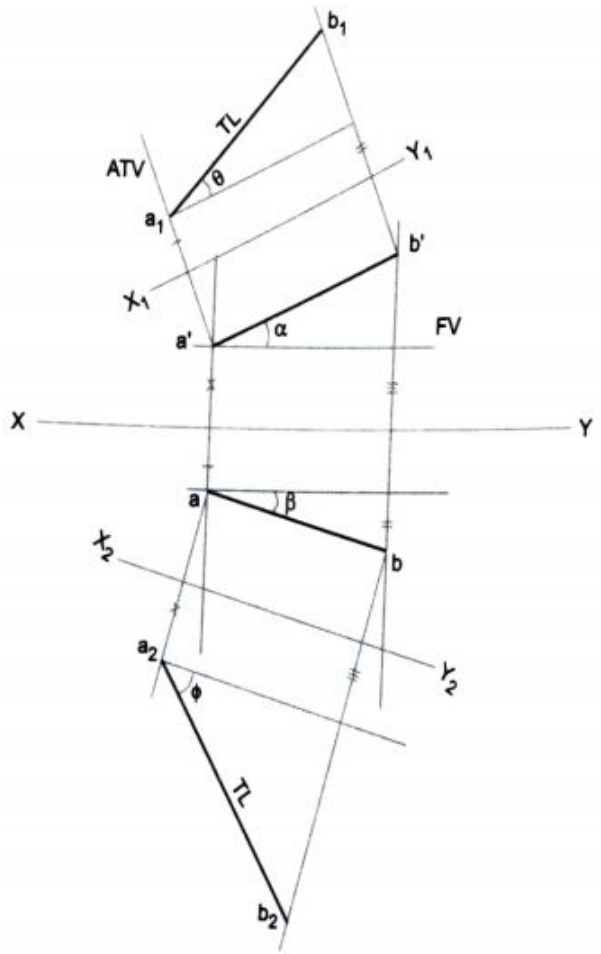
Ex. 4.9.1 : ***Draw the projections of a point A 30 mm above HP and 40 mm in front of VP. Alos draw it's AFV and ATV on the planes inclined at 30° to HP and 45° to VP.***

Sol. :



4.9.4

FV and TV of a line is as shown in fig. Find its true length and true inclinations by using auxilary plane methods.

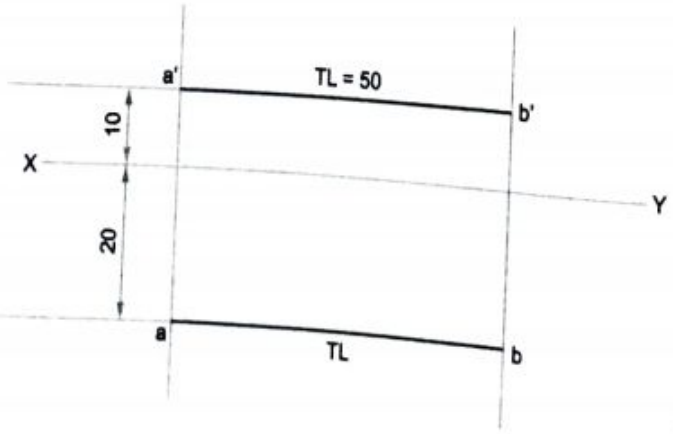


4.10 : Line Parallel to HP and VP

Ex. 4.10.1 : ***A 50 mm long line AB is parallel to HP and VP. Draw its projections if point 'A' is 10mm above HP and 20 mm infront of VP.***

Sol. :

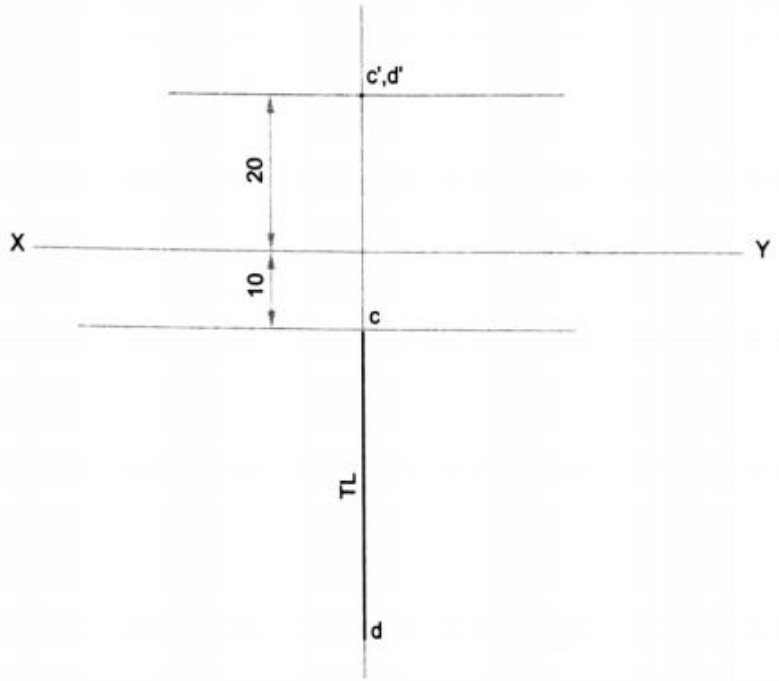
A(10↑, 20→)
TL = 50 mm



4.11 : Line Parallel to HP and ⊥r to VP

Ex. 4.11.1 : *Draw the projections of line CD which is parallel to HP and perpendicular to VP. Point 'C' is 20 mm above HP and 10 mm infront of VP. Line is 40 mm long.*

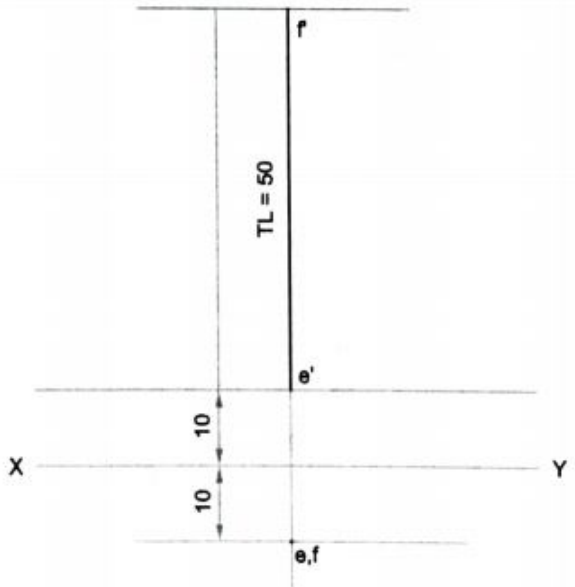
Sol. :



4.12 : Line Perpendicular to HP and Parallel to VP

Ex. 4.12.1 : *Draw the projection of 50 mm long line EF which is ⊥r to HP and parallel to VP. Point E is 10 mm away from both reference planes.*

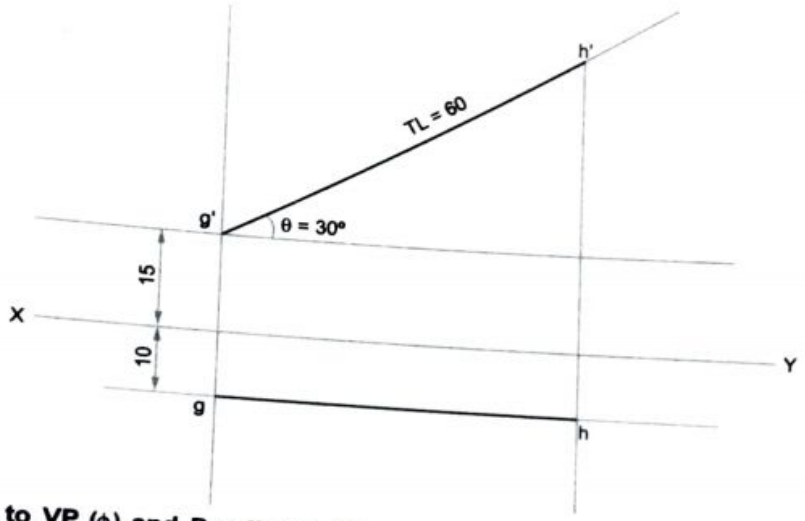
Sol. :



4.13 : Line Inclined to HP and Parallel to VP

Ex. 4.13.1 : *A line GH is inclined at an angle of 30° with HP and parallel to VP. End point G is 15 mm above HP and 10 mm infront of VP. Take true length of line 60 mm.*

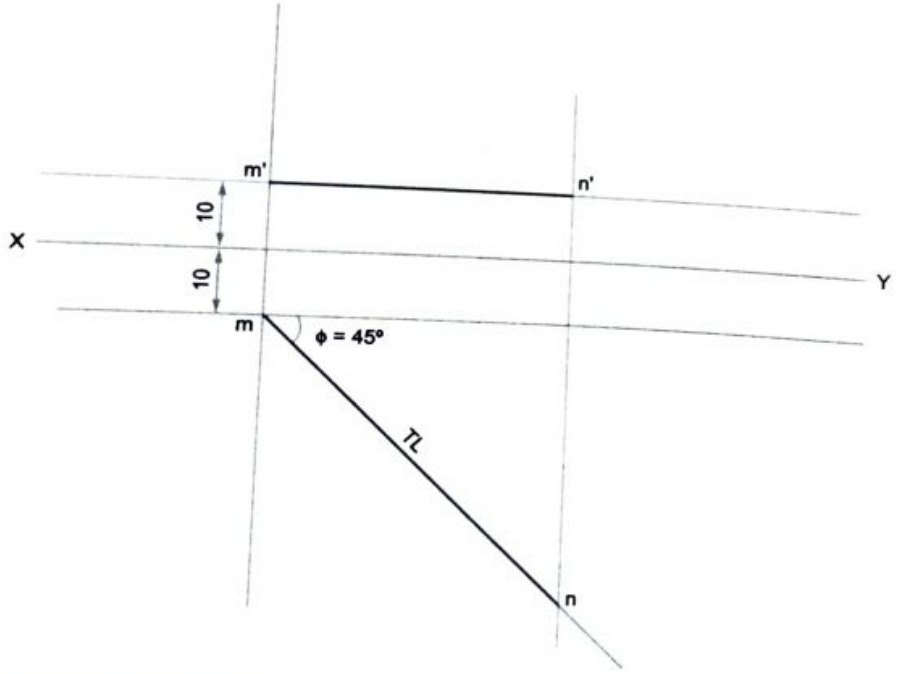
Sol. :



4.14 : Line Inclined to VP (ϕ) and Parallel to HP

Ex. 4.14.1 : *Draw the projections of line MN which is inclined to VP at angle of 45° and parallel to HP. End point 'M' is 10 mm away from HP and VP. Take TL = 60 mm.*

Sol. :



4.15 : Oblique Lines [Line Inclined to HP and VP]

Ex. 4.15.1 : ***A 90 mm long line AB is inclined to HP at 30° and 45° to VP. Draw it's projections if point A is 10 mm above HP and 20mm infront of VP.***

Sol. : Procedure :

1. Draw XY line and projector for point 'A'. Locate a′ 10 mm above XY and a 20mm below XY on projector of 'A'.
2. Consider line AB_1 as line inclined to HP only and parallel to VP. Draw its projections [FV $a'b'_1$ inclined at 30º to XY and ab_1 parallel to XY].
3. ab_1 is called as PL (plan length or Top view length).
4. Now consider another line AB_2 which inclined to VP only and || to HP. Draw its projections [T.V. is inclined at 45º to HP and $a'b'_2$ (F.V.) is parallel to XY.]
5. $a'b'_2$ is called as EL (Elevation length or front view length)
6. As a′ is fixed, T.L. = $a'b'_1$ = 90 is fixed and its inclination θ = 30º is fixed hence draw the locus line parallel to XY through b'_1 on which 'b′' will be fixed.
7. Similarly in T.V. 'a' is fixed TL = ab_2 = 90 is fixed and it's inclination ϕ = 45º is fixed hence draw the locus line parallel to XY through b_2 on which 'b' will be fixed.
8. EL = $a'b'_2$ and PL = ab_1 are parallel to XY and lengths are fixed. Now rotate $a'b'_2$ and ab_1 in FV and TV we will get b′ and b on at the intersection on locus line.
9. Now join a′ b′ and ab which are FV and TV respectively.
10. Draw the projector through 'b′' if it passes through 'b' then solution is right.
11. For locating the traces extend a′ b′(FV) and ab (TV). Intersection of extension line of a′b′ and XY is point 'h' front view of horizontal trace. Draw the projector thorugh point h′. Intersection of ab (TV) and this projector is h (H.T.) top view of horizontal trace.
12. Intersection of extension of ab (TV) and XY is point 'V' top view of vertical trace. Draw the projector through point 'V' and its intersection with extension line of a′ b′ is 'v^' (VT) front view of vertical trace.

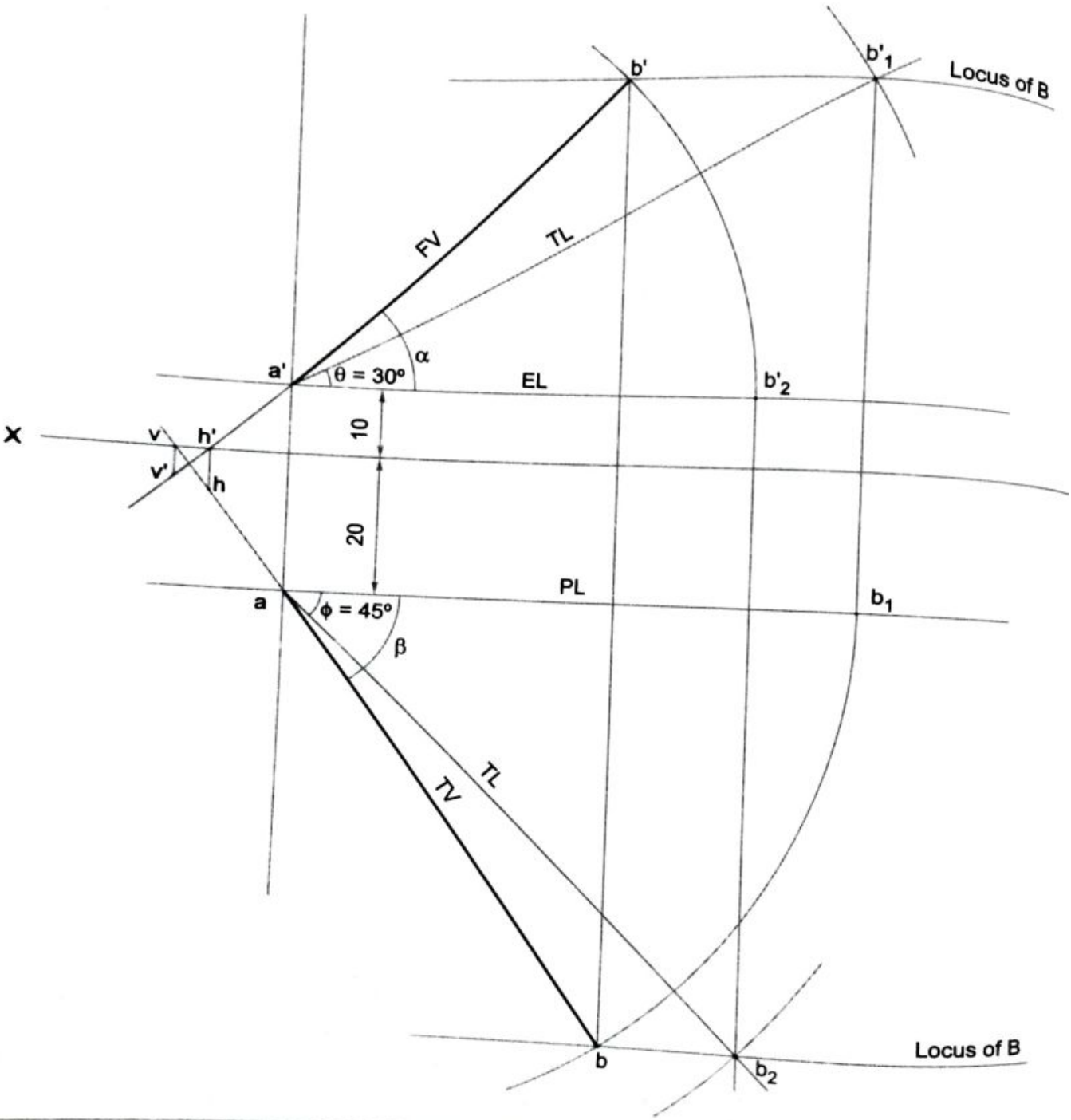
Given Data :

A (10 mm ↑, 20 mm →)

θ = 30°

ϕ = 45°

TL = 90 mm



Important things useful to solve any problem

1. $a'b'_1$ – TL – θ

   $a'b'_2$ – EL – || to XY

   $a'b'$ – FV – α

   X ——————————————— Y

   ab_2 – TL – ϕ

   ab_1 – PL – || to XY

   ab – TV – β

2. b', b'_1 are on locus line in FV

   b, b_2, are on locus line in TV

3. h' – FV(a' b') – v' are always colinear

   v – TV (ab) – h are always colinear

Ex. 4.15.2 : ***Elevation of 100 mm long line AB is 80 mm. Line is inclined at an angle is 45° to the HP. End point 'A' is 20 mm away from HP and VP. Draw it's projections, find it's inclination with VP.***

Sol. : Procedure :

1. Draw the reference line XY and projector for point A. Mark a′ and a 20mm above and below XY line.
2. Draw a line inclined at angle of 45° through point 'a'' in F.V. Mark the point b'_1 on this line at a distance of 100 mm from a′. Draw the locus of 'B' in FV through point b'_1.
3. Draw EL (ab'_2) = 80 mm parallel to XY. Draw an arc. With centre a′ and radius ab'_2 to intersect the locus of 'B' at point b′. Join a′ b′ which is elevation of AB.
4. Draw the projectors through points b′, b'_1 and b'_2. Draw a horizontal line through point 'a' in the top view to intersect the projector through b'_1 at b_1. ab_1 is the PL.
5. Draw an arc with centre a and radius ab_1 to intersect the projector of b′ at 'b'. Join ab which is plan of line AB. Draw the locus line of 'B' through 'b' in TV.
6. Mark the intersection of locus line of 'B' and projector of b'_2 as b_2 in the TV. ab_2 is the TL in the TV and measure it's inclination (ϕ) with XY.

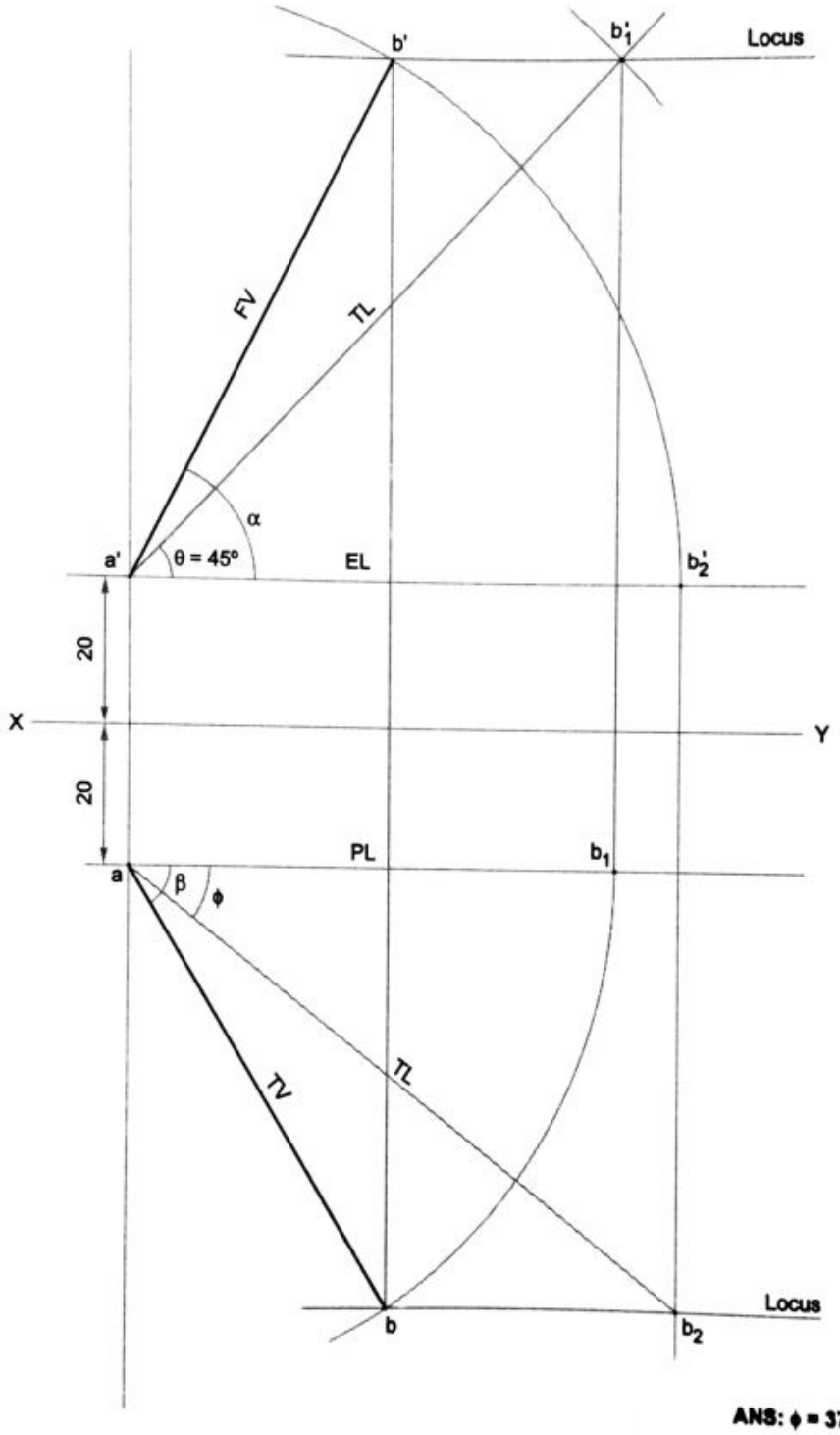
Given :

TL = 100 mm

EL = 80 mm

θ = 45°

A (20 mm ↑, 20 mm →)



ANS: ϕ = 37°

Ex. 4.15.3 : ***Draw the projections of 80mm long line AB which measures 50 mm in it's plan and inclined at 30° to VP. The point A is 10 mm above HP and 20 mm infront of VP. Locate it's traces. Find it's inclination with HP.***

Sol. :

Procedure :

1. Draw the reference line XY and projector for point A. Mark a′ 10 mm above XY and a 20mm below XY on the projector.
2. Draw a line inclined at angle of 30° with XY through point a. Cut an arc with centre as 'a' and radius equal to TL = 80 mm and mark point 'b_2'. Draw the locus of 'B' in top view through point b_2.
3. Draw PL (ab_1) parallel to XY. Draw an arc with centre a and radius ab_1 to intersect the locus at point 'b'. Join ab which is plan of line AB
4. Draw the projectors through point b and b_2. Draw a horizontal through a′ which will intersect the projector through b_2 at b'_2 to get EL($a'b'_2$).
5. Draw an arc with centre 'a' and radius $a'b'_2$ to intersect the projector through b at b′. Join $a'b'_1$ which is elevation of the line. Draw the locus line through b′ in FV.
6. Draw the projector through b_1 to intersect the locus of 'B' in FV at point b'_1. $a'b'_1$ is the must be TL = 80 and it's inclination with XY is θ.



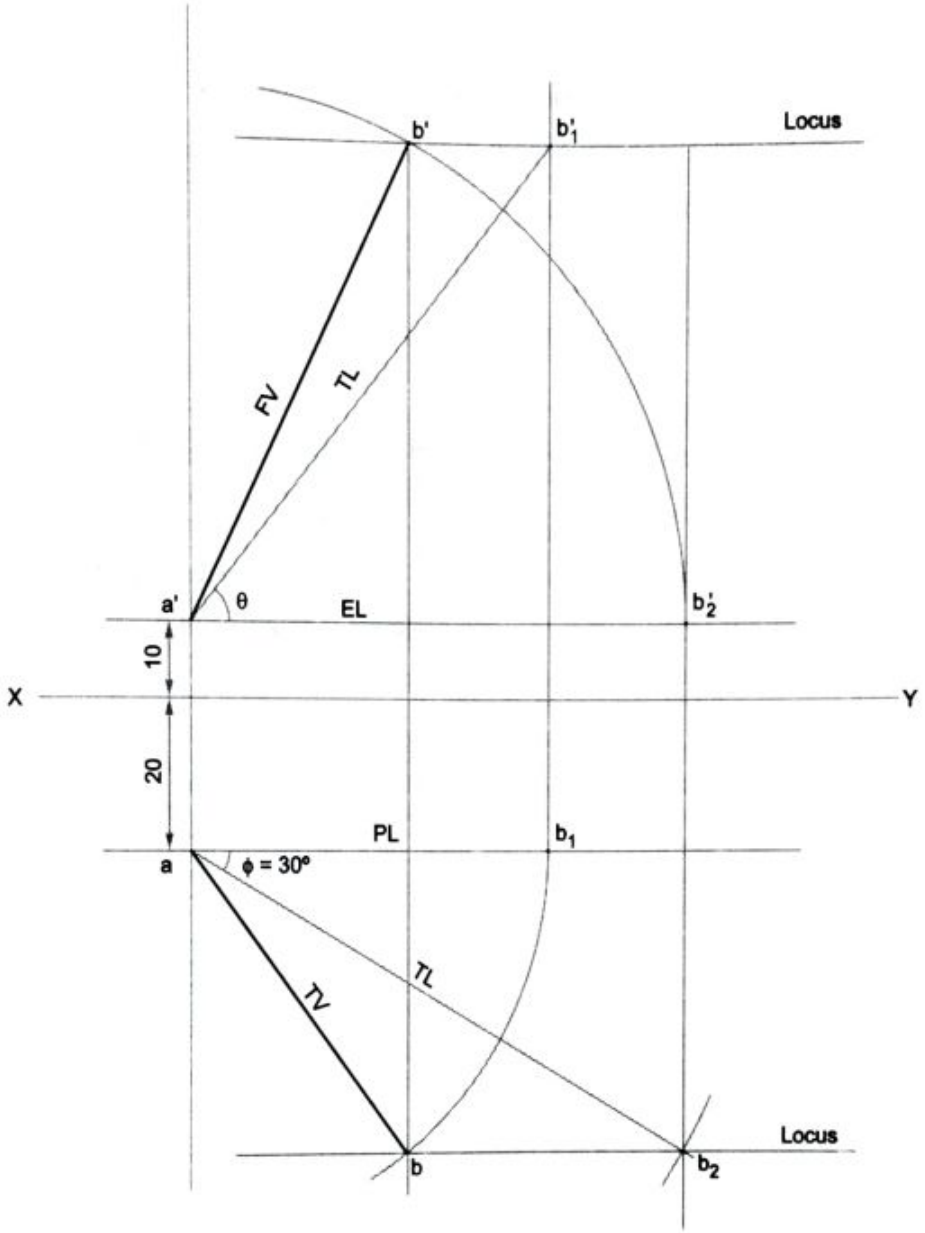
Given :

A (10 mm ↑, 20 mm →)

ϕ = 30°,

PL = 50 mm

TL = 80 mm



ANS. : θ = 51°

Ex. 4.15.4 : *Draw the projections of the 85 mm long line AB. It's plan measures 60 mm and elevation measures 70 mm. Find it's inclinations with reference planes. Also locate the traces. If end point A is on HP and 20 mm infront of VP.*

Sol. : **Steps :**

1. Draw the reference line XY and projector of point A and locate a' on XY and projector of point A and loacate a' on XY and a 20mm below XY.
2. Mark ab_1 (PL) = 60 mm and $a'b_2'$ (EL) = 70mm parallel to XY and on XY respectively. Draw the projectors through points b_2' and b_1.
3. Draw the arcs with centres a', a and radius = 80mm to intersects the projectors of b_1 and b_2' at points b_1' and b_2 in FV and TV.
4. Join $a'b_1'$ and ab_2 which are TL in FV and TV. Measure their inclinations (θ and ϕ).
5. Draw the locus lines through b_1' and b_2.
6. Draw an arc with centre a' and radius $a'b_2'$ to intersect the locus line at b'. Join $a'b'$ which is elevation of the line.
7. Draw the projector through point b' which intersect the locus line in TV at b.
8. Join ab which is the TV of a line.
9. For locating the traces extend $a'b'$(FV) and ab (TV). Intersection of extension line of $a'b'$ and XY is point 'h' front view of horizontal trace. Draw the projector thorugh point h'. Intersection of ab (TV) and this projector is h (H.T.) top view of horizontal trace.
10. Intersection of extension of ab (TV) and XY is point 'V' top view of vertical trace. Draw the projector through point 'V' and its intersection with extension line of $a'b'$ is 'v' (VT) front view of vertical trace.

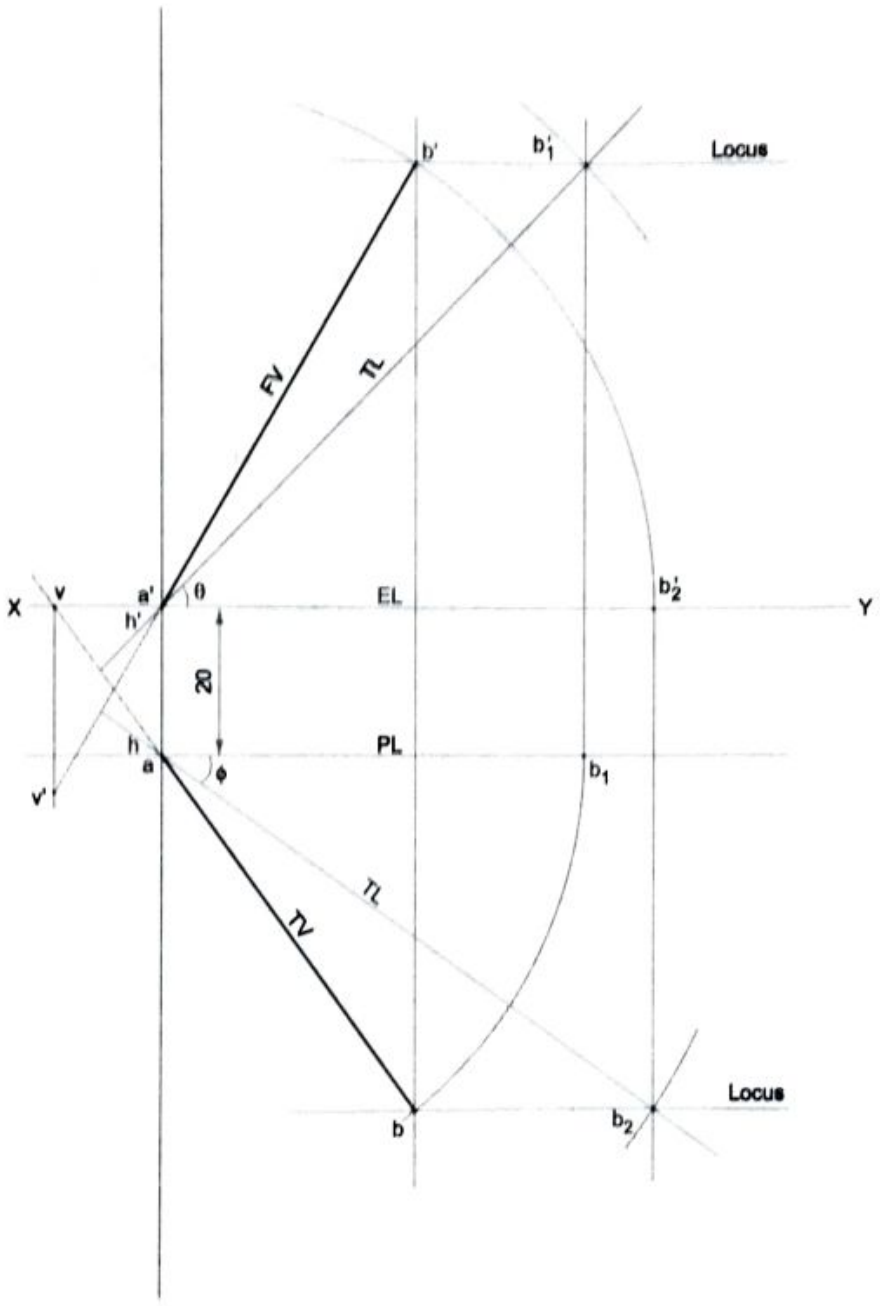
Given :

TL = 85 mm

PL = 60 mm

EL = 70 mm

A (0, 20 mm →)



ANS. : θ = 45°
ϕ = 34°

Ex. 4.15.5 : ***Line AB of length 75 mm has its point A 25 mm above HP and 15 mm infront of VP. It is inclined at 35° to VP. Its PL is 50 mm. Draw its projections. Find indination with HP and also locate the traces***

Sol. :

Procedure

1. Draw reference line XY and projector for point A. Mark a′ 25mm above XY and a 15 mm below XY.
2. Draw a line inclineal at 35° through point a and mark a point b_2 at a distance of 75 mm on this line. Draw the locus line through point b_2.
3. Draw ab_1 (PL) = 50mm parallel to XY. Draw an arc with centre a and radius ab_1 to intersect locus line at b. Join ab which is plan of line.
4. Draw the projectors through points b, b_2 and b_1.
5. Draw a horizontal line through point a′ to intersect the projector through point b_2 at b_2'. $a'b_2'$ is EL. Draw an arc with centre a′ and radius $a'b_2'$ to intersect the projector through point b at b′. Join a′b′ which is elevation of the line.
6. Draw the locus line through point b′. Intersection of this locus line and projector through point b_1 is b_1'. Join $a'b_1'$ which is TL in the FV and measure its inclination.
7. For locating the traces extend a′b′(FV) and ab (TV). Intersection of extension line of a′b′ and XY is point 'h' front view of horizontal trace. Draw the projector thorugh point h′. Intersection of ab (TV) and this projector is h (H.T.) top view of horizontal trace.
8. Intersection of extension of ab (TV) and XY is point 'V' top view of vertical trace. Draw the projector through point 'V' and its intersection with extension line of a′b′ is 'v′ (VT) front view of vertical trace.

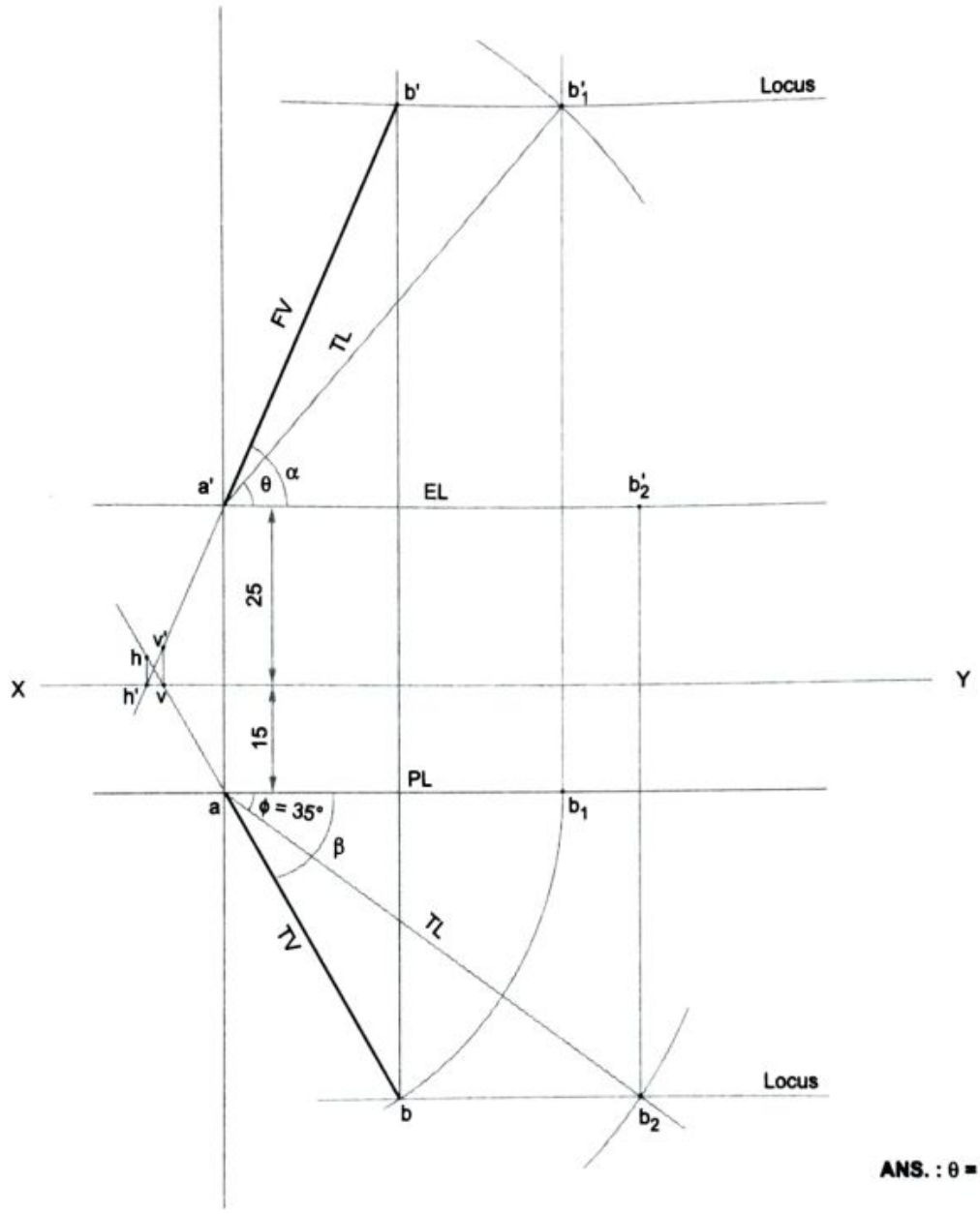
Given :

TL = 75 mm

A (25↑, 15 →)

ϕ = 35°

PL = 50 mm



ANS. : θ = 48°

Ex. 4.15.6 : ***The point A of a line AB is 15 mm above HP and in VP. The line is inclined to HP and VP at 40° and 35° resp. Draw projections of line if its plan measures 65 mm. Find TL and locate the traces.***

Sol. :

Steps

1. Draw the reference line XY and draw the projector for point A.
2. Mark a′ 15mm above XY and a on XY line.
3. Draw the lines inclined at 40° and 35° through points a′ and a respectively in FV and TV.
4. Mark PL (ab_1) = 65 on XY line. Draw the projector through point b_1. Intersection of this projector and line inclined at 40° in the FV is point b_1'.
5. $a'b_1'$ is the TL in FV and measure its length. Draw the locus line through point b_1'.
6. Now mark point b_2 on inclined in the TV a distance of (TL = 80 mm). Draw the locus line through point b_2.
7. Draw an arc with centre a and radius ab_1 to intersect the locus line at point 'b'. Join ab which is plan of the line.
8. Draw projector point b which intersect the locus line in front view at b′. Join a′b′ which is elevation of the line.
9. For locating the traces extend a′b′(FV) and ab (TV). Intersection of extension line of a′b′ and XY is point 'h' front view of horizontal trace. Draw the projector thorugh point h′. Intersection of ab (TV) and this projector is h (H.T.) top view of horizontal trace.
10. Intersection of extension of ab (TV) and XY is point 'V' top view of vertical trace. Draw the projector through point 'V' and its intersection with extension line of a′b′ is 'v^ (VT) front view of vertical trace.

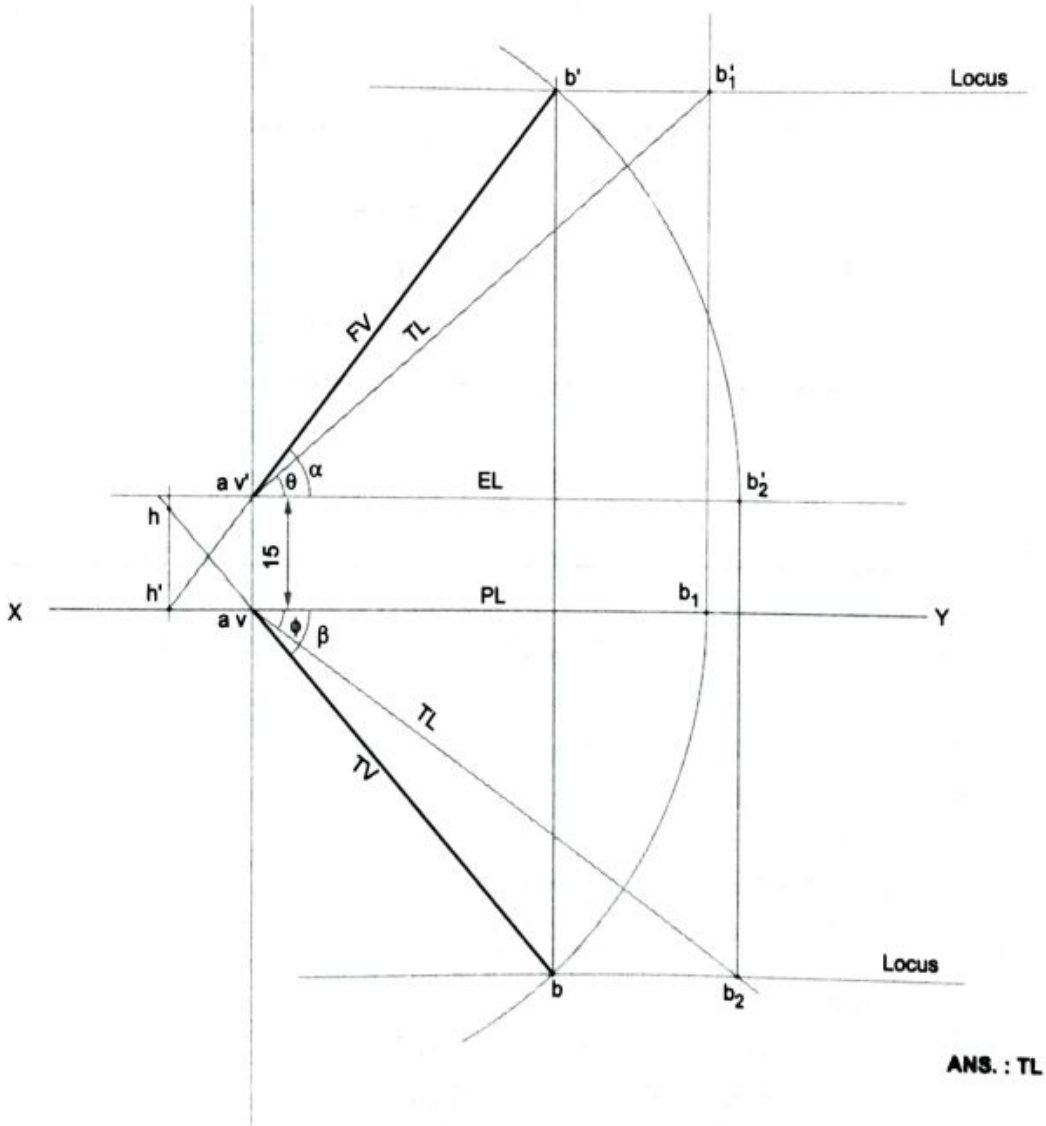
Given :

A(15 ↑, 0 →)

θ = 40°,

ϕ = 35°

PL = 65 mm



ANS. : TL = 85 mm

C) Projection of Plane

- A plane is a two dimensional object having length and breadth only.
- The thickness of the plane is negligible. e.g. A thin sheet or paper.
- Various shapes of plane figures are considered such as square, rectangle, circle, pentagon, hexagon, triangle etc.

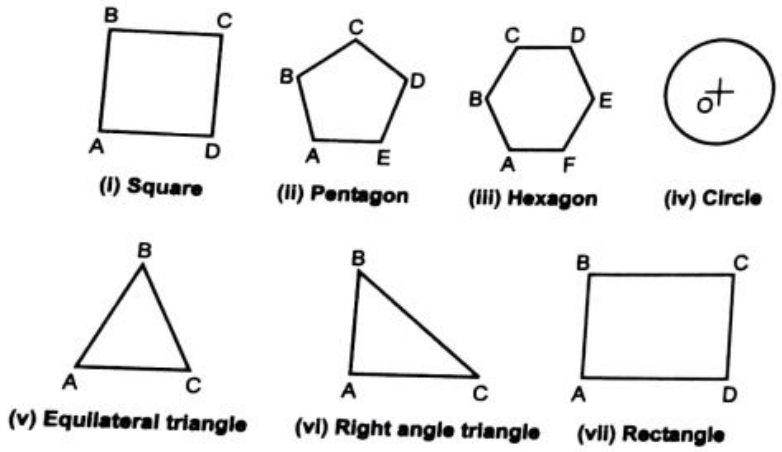


Fig. 4.15.1

4.16 : Types of Planes

A) Perpendicular Planes :

The planes which are perpendicular to one or both the principal planes (i.e. V.P. and H.P.) are called perpendicular planes.

1) Plane perpendicular to H.P. and parallel to V.P.
2) Plane perpendicular to V.P. and parallel to H.P.
3) Plane perpendicular to H.P. and VP.
4) Plane perpendicular to V.P and inclined to H.P. ($\theta°$).
5) Plane perpendicular to H.P. and inclined to V.P. ($\phi°$).

Note :

$\theta°$: Inclination made by the plane with H.P.

$\phi°$: Inclination made by the plane with V.P.

B) Oblique Plane :

The planes which are inclined to both the principal planes or reference planes (i.e. H.P. and V.P.) are called as oblique plane.

Traces of the planes :

The traces of a plane is the line of intersection or meeting of the plane surface with the reference plane, (i.e. H.P. and V.P.) are called as **Traces of the planes**.

Types of traces :

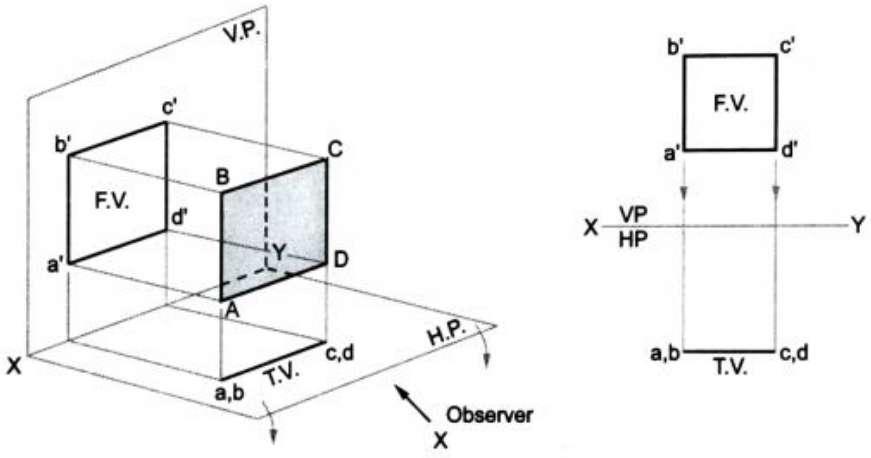
1) Horizontal Traces (H.T.) 2) Vertical Traces (V.T.)

1) Horizontal Traces (H.T.) : The intersection of a plane with H.P. is called the Horizontal Traces (H.T.).

2) Vertical Traces (V.T.) : The intersection of a plane with V.P. is called the Vertical Traces (V.T.)

1. Plane perpendicular to the H.P. and parallel to the V.P.

If plane is parallel to the V.P. then its front view appears true Fig. shape and then the top view appears a line.

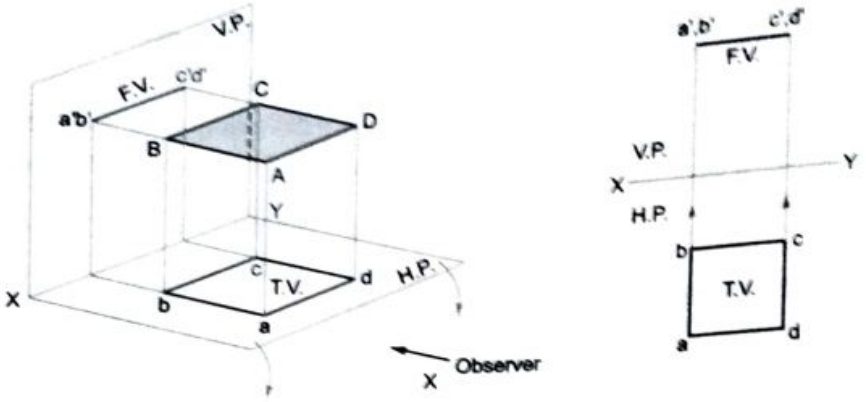


(a) Pictorial view **(b) Orthographic view**

Fig. 4.16.1

2. Plane perpendicular to V.P. and parallel to the H.P.

Its plane is parallel to the H.P. then its top view appears true shape and front view appears a line.

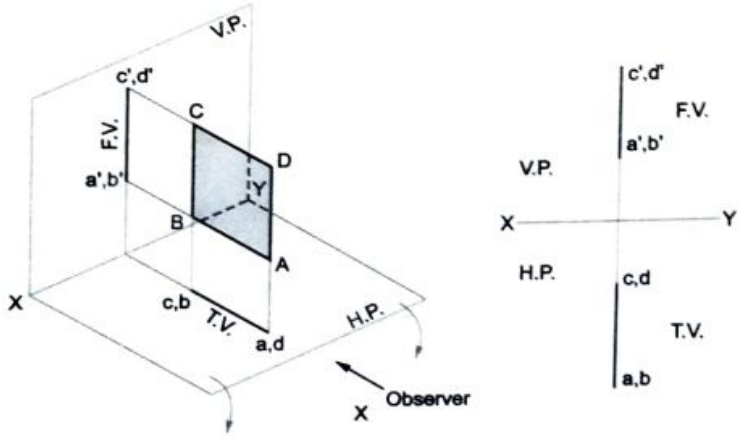


(a) Pictorial view (b) Orthographic view

Fig. 4.16.2

3. Plane perpendicular to both the H.P. and the V.P.

If plane is parallel to the P.P. and perpendicular to the H.P. and V.P. Then its F.V. and T.V. appears a line.



(a) Pictorial view (b) Orthograhic view

Fig. 4.16.3

4. Plane perpendicular to the V.P. and inclined to the H.P.

- If plane is inclined with H.P. then its front view appears a True line and angle with H.P. = θ°.
- Then its T.V. appears plan view (less than True Shape).

Note : Angle with H.P. = θ° – Above the XY line.

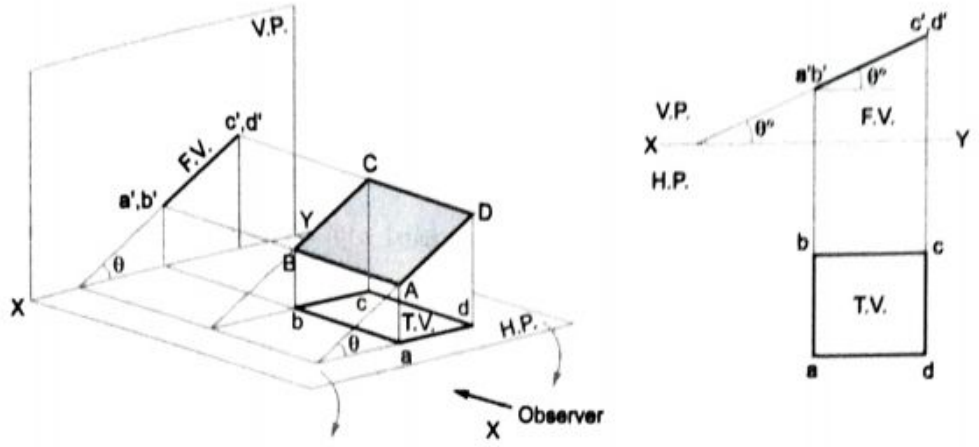


Fig. 4.16.4

5. Plane perpendicular to the H.P. and inclined to the V.P.

- If plane is inclined with V.P. then its T.V. a True line and angle with V.P. - ϕ° - ↓.

Then its Front View apears elevation view (less than true shape).

Note : Angle with V.P. - ϕ° - below the XY line.

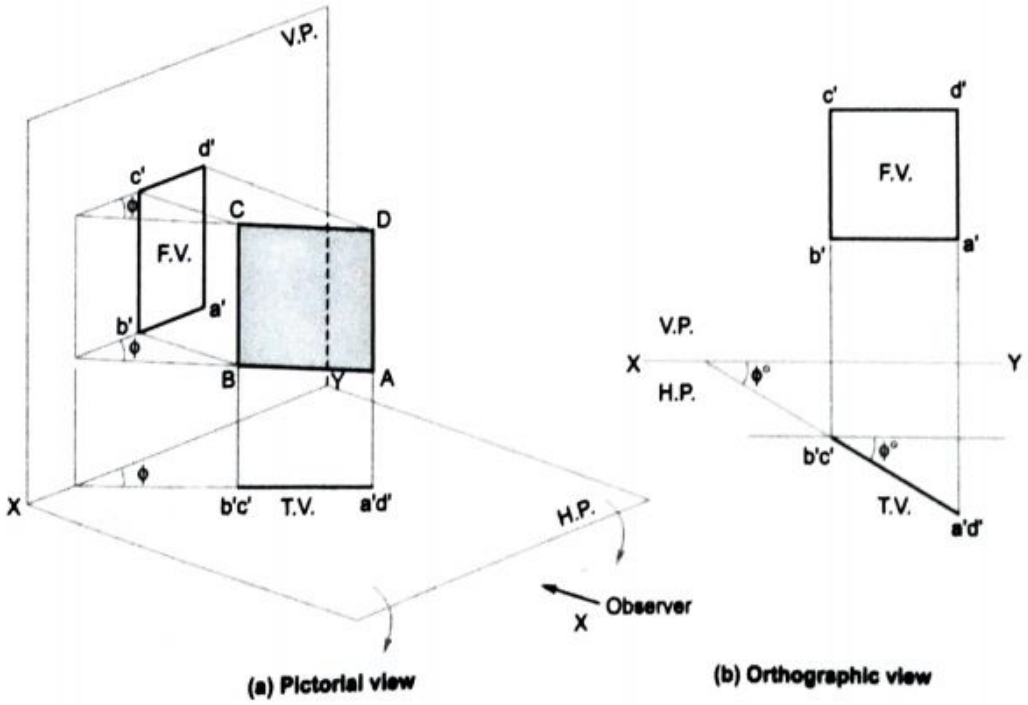
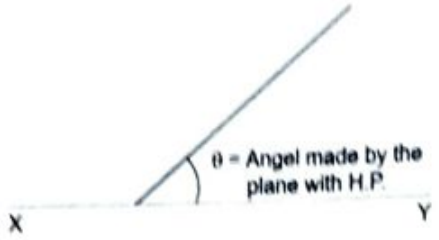


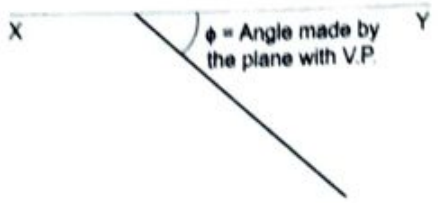
Fig. 4.16.5

Important Note :

1) If plane is incline with H.P. i.e. angle with H.P. denoted with the help of θ° and it is always above the XY line.



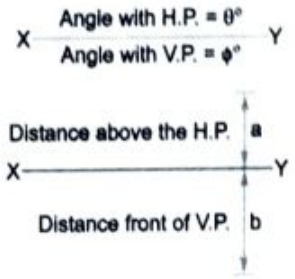
2) If plane in incline with V.P. i.e. angle with V.P. denoted with the help of ϕ° and it is always below the XY line.



3) If plane rest on side/edge or corner mark it in stage - I at left side.

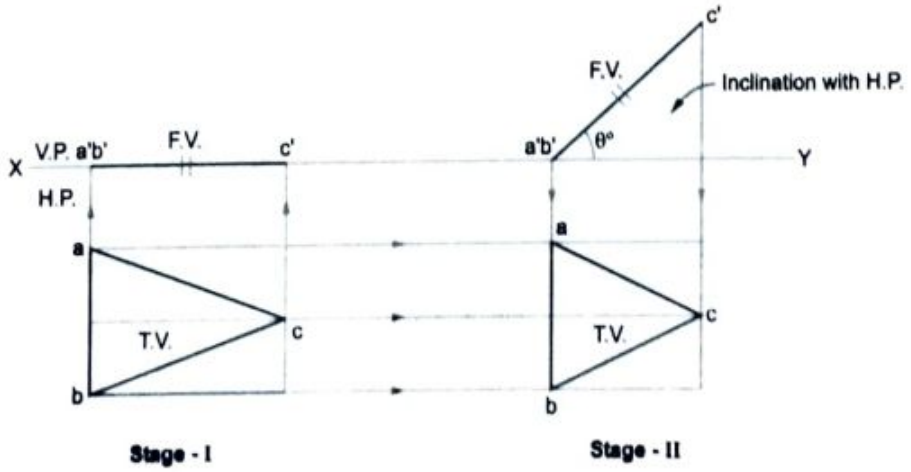
4) If plane is incline with H.P. then in stage - I consider completely plane kept on HP i.e. below the XY line. Draw true shape of the plane (T.V.) and on XY line F.V. will a straight line.

5) If plane is incline with V.P. then in stage - I consider completely plane kept in V.P. i.e. above the XY line. Draw true shape of the plane (F.V.) and on XY line T.V. will a straight line.

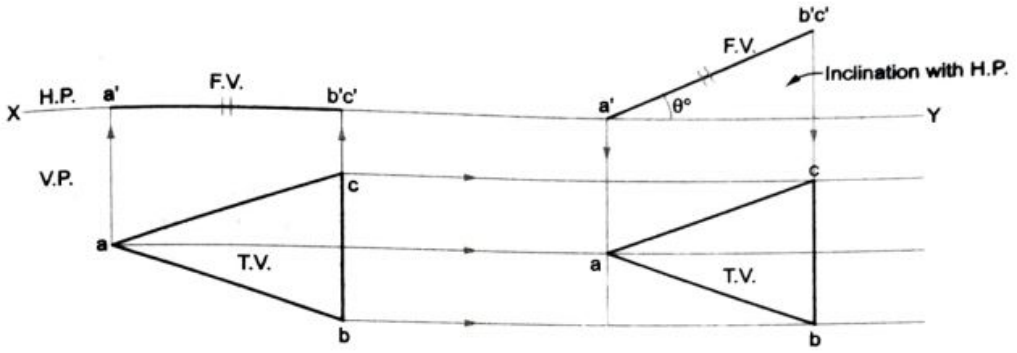


A) Plane Rest on H.P.

1) Plane Rest on Side :



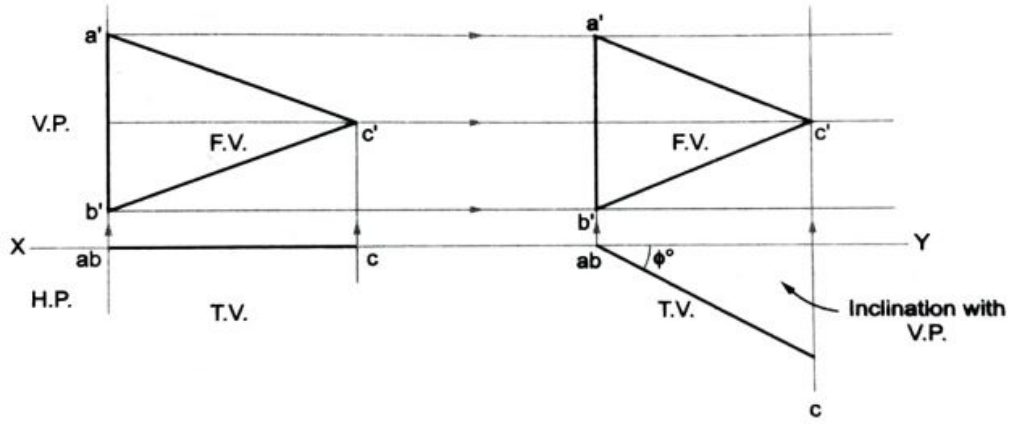
2) Plane Rest on Corner :



Stage - I **Stage - II**

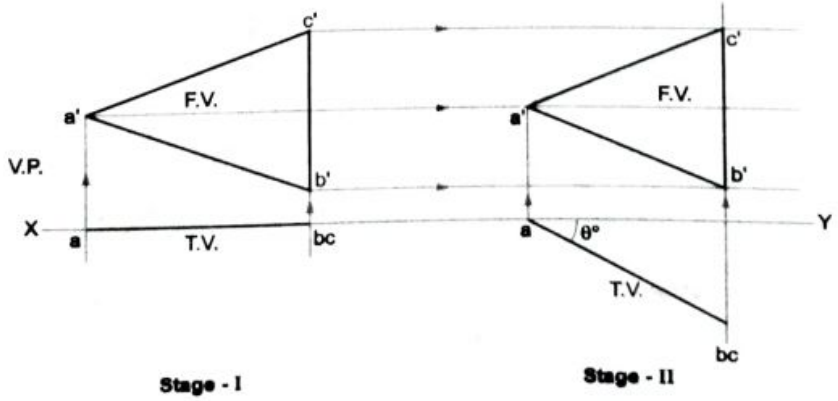
B) Plane Rest on V.P.

1) Plane rest on side :



Stage - I **Stage - II**

2) Plane Rest on corner :



Stage - I **Stage - II**

Note :

1) The notations in F.V. mark - a′, b′, c′, d′, e′, f′..... and 1′, 2′, 3′, 4′..... .

2) The notations in T.V. marks - a, b, c, d ..... and 1, 2, 3, 4, ...

3) The notations in side view marks - a″, b″, c″..... and 1″, 2″, 3″, 4″..... .

Ex. 4.16.1 : ***A regular hexagonal plate, 30 mm side, is resting on H.P on one of its edges/sides. The surface of the plate is inclined at 45° to HP and is perpendicular to V.P. Draw the projections of plate. (Use first angle method of projection).***

Sol. :

Given : Plane - Hexagonal

Side - 30 mm

Rest on - H.P. ↓

Incline with H.P. = θ° = 45° ↑

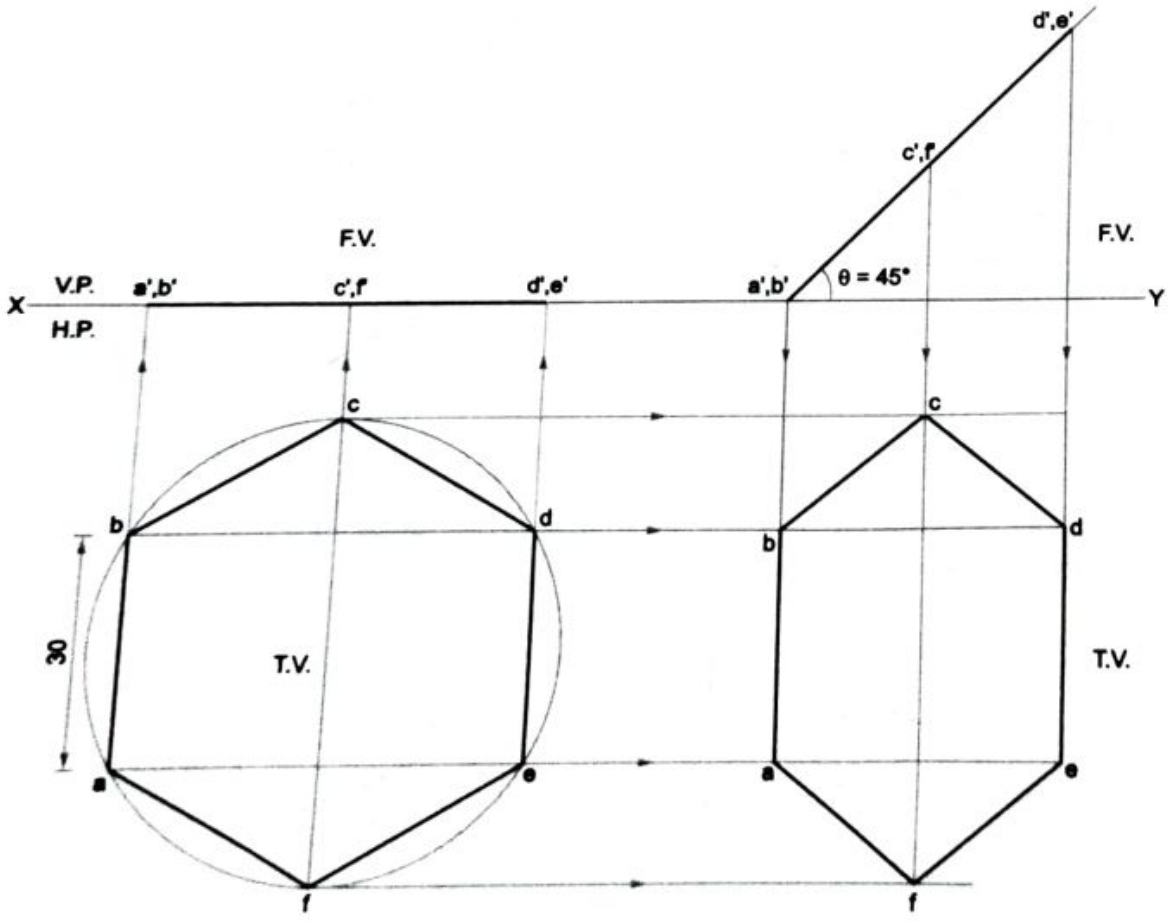


Fig. 4.16.6

Ex. 4.16.2 : ***A circular plate of negligible thickness and 50 mm diameter appears as an ellipse in the top view, having its major axis 50 mm long and minor axis 30 mm long. Draw it projections when the major axis of the ellipse is perpendicular to V.P. Also determine its inclination with H.P.***

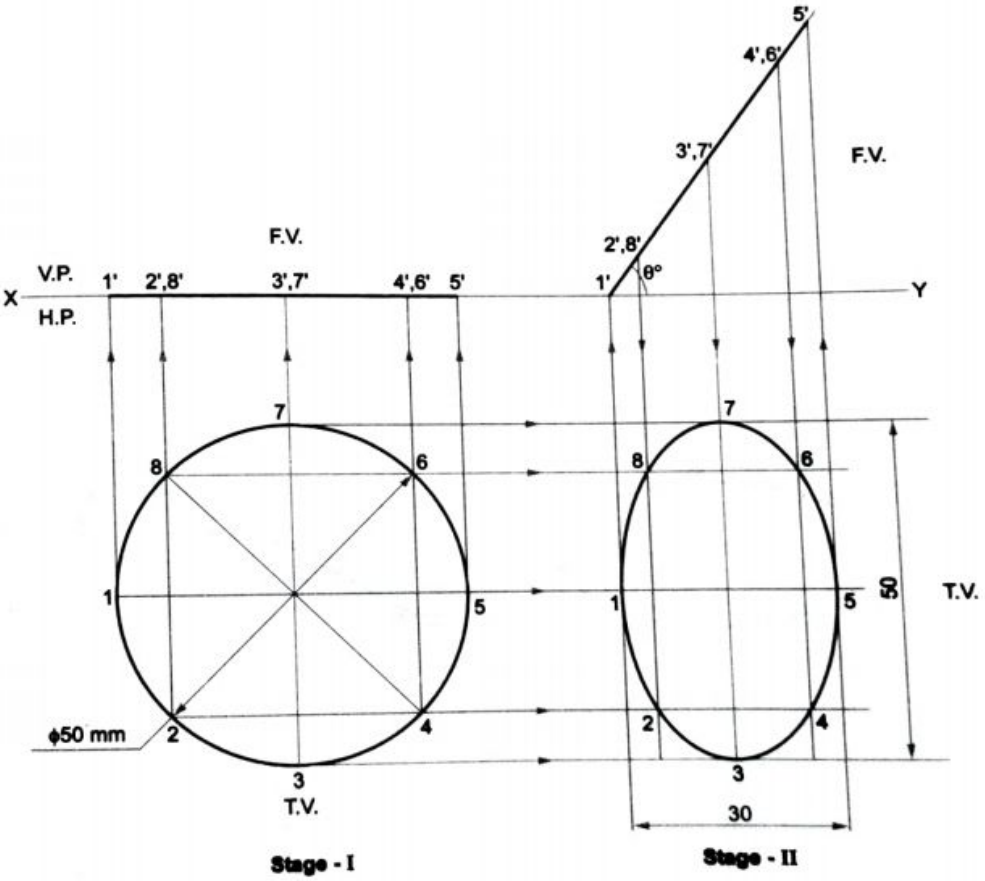
Sol. :

Given : **Plane - Circular**

Diameter - 50 mm

In T.V. appears ellipse-minor axis - 30 mm

Find inclination made by the plane with H.P. = ?



Ans.: Angle made by the plane with H.P.
θ_{plane} = 54°

Fig. 4.16.7

Ex. 4.16.3 : ***A circular plate of diameter 45 mm has its one point on circumference resting on H.P. It is inclined at 60° to V.P and perpendicular to H.P. It's centre is 40 mm in front of V.P. Draw three views. Neglect the thickness of the plate.***

Sol. : **Given :** Plane - Circular

Diameter - 45 mm

Rest in V.P. ↑

Centre - 40 mm front of V.P ↓

Inclined with V.P $\phi° - 60°$ ↓

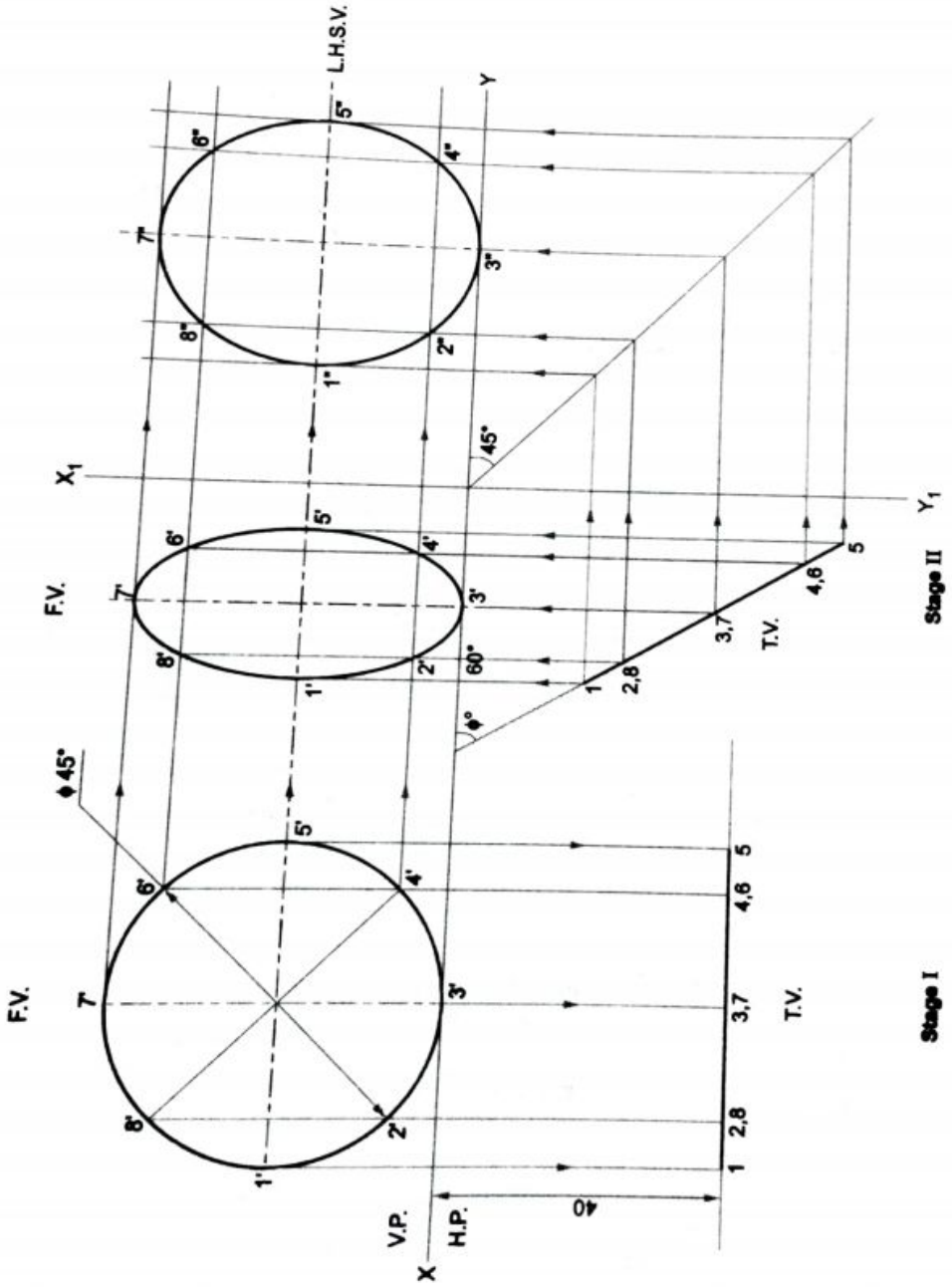


Fig. 4.16.8

Ex. 4.16.4 : ***An isosceles triangle of base 30 mm and altitude 50 mm is having its base on H.P. Plane is perpendicular to V.P. and is inclined to H.P. in such a way that top view appears to be an equilateral triangle. Draw three views of the plane and find inclination of the plane with H.P.***

Sol. : Given : Plane - Isosceles triangle

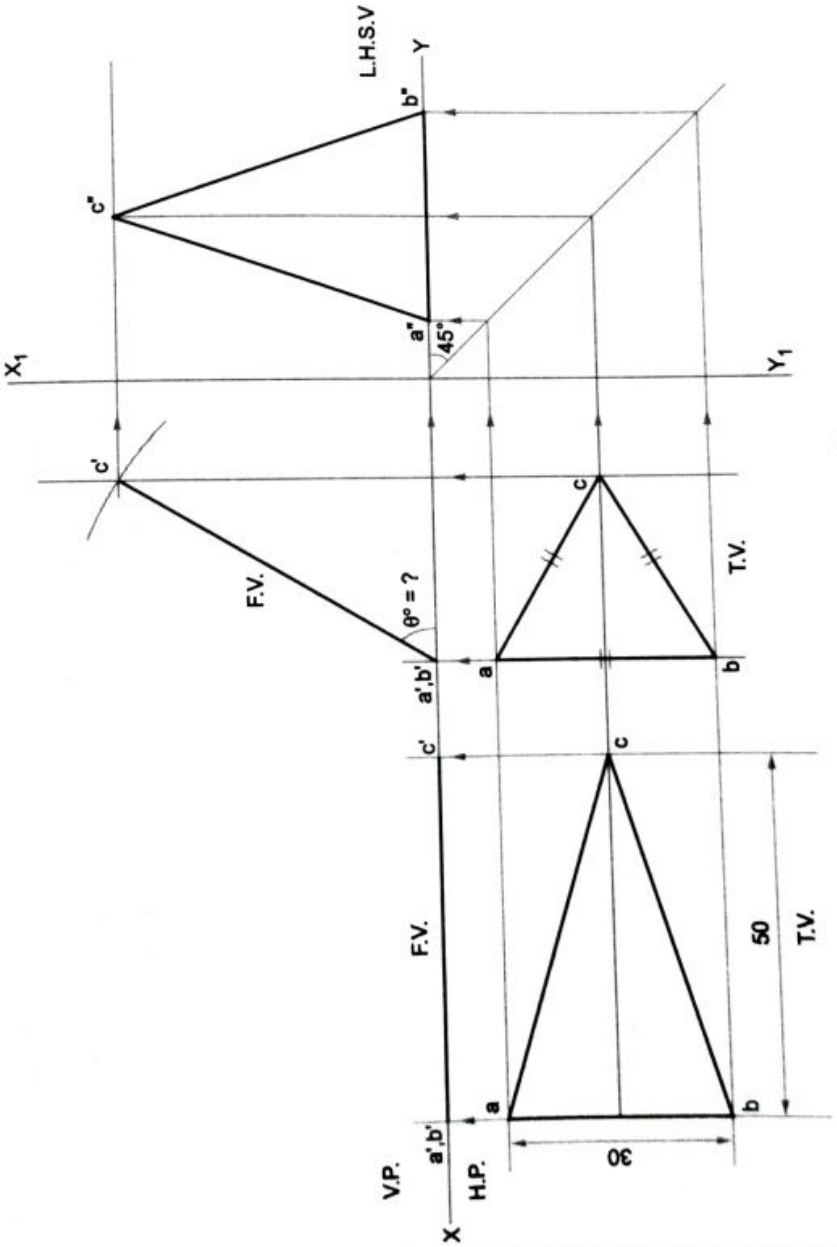
Side - 30 mm

Altitude - 50 mm

Rest on H.P. ↓

T.V. appears equilateral triangle

Find θ° = ? ↑ Fi



Ans.: Angle made by the plane with H.P. $\theta_{plane} = 59°$

Fig. 4.16.9

Ex. 4.16.5 : ***A rectangular lamina ABCD of smaller side AB = 30 and longer side BC = 50 mm resting on the V. on its smaller side AB lamina is inclined to V.P. in such a way that its front appears to be a square side AB perpendicular to H.P. Draw three views of lamina and find its inclination with V.P.***

Sol. : **Given :** Plane - Rectangle

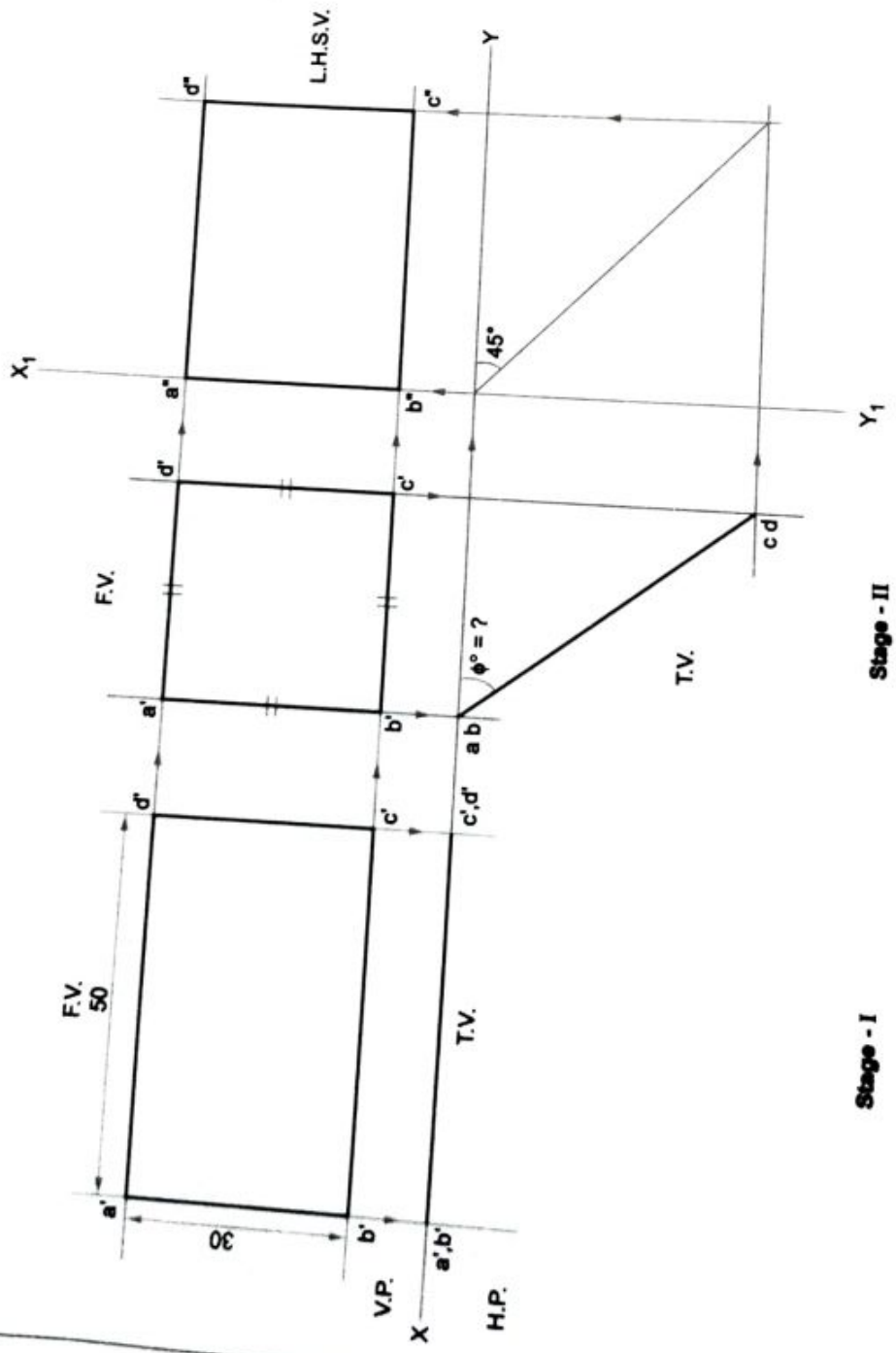
Small side - 30 mm

Longer side - 50 mm

Rest in V.P. ↑

F.V. appears square of side - 30 mm

Find $\phi° = \downarrow$



Ans.: Inclination made by the plane with V.P. = ϕ_{plane} = 53°

Fig. 4.16.10

Ex. 4.16.6 : ***A square plate of side 60 mm is resting on HP on one of its corner. Plate is inclined to HP such that the plan of it is rhombus with a diagonal of 30 mm. Determine the inclination with HP. The plan of diagonal makes an angle of 45° VP.***

Sol.: Given : Square plate

Side = 60 mm , $\phi = 45°$

$\theta° = 60°$

∴

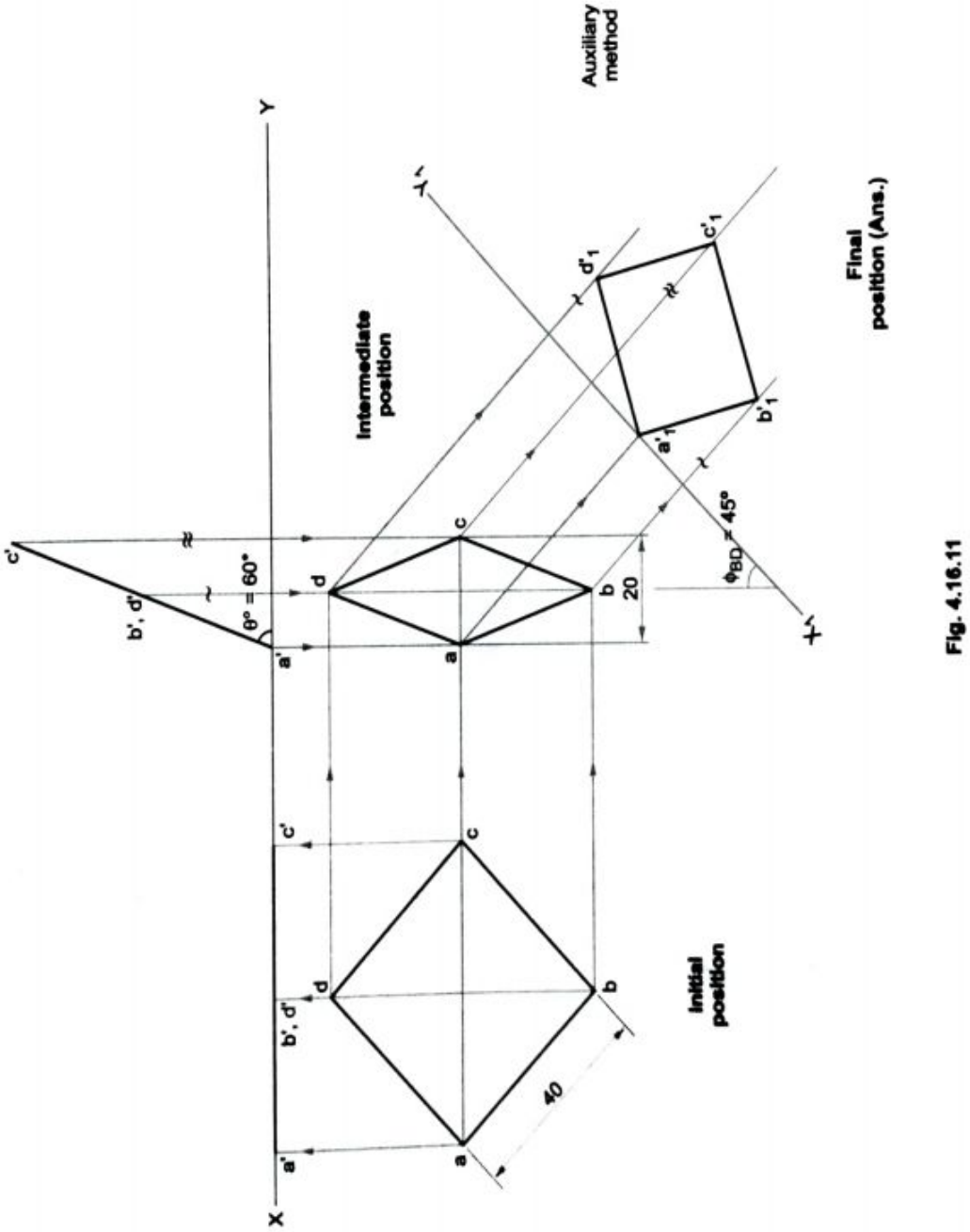


Fig. 4.16.11

Ex. 4.16.7 : ***A regular pentagonal plate PQRST of 30 mm sides, has its corner P on the V.P. the plate is inclined at 30° to the V.P. such that the side RS parallel to the both the reference planes. Draw the projections of the plate.***

Sol.: **Given :** Pentagonal plate – Side = 30 mm

$\phi° = 30°$

rs is parallel to HP and V.P.

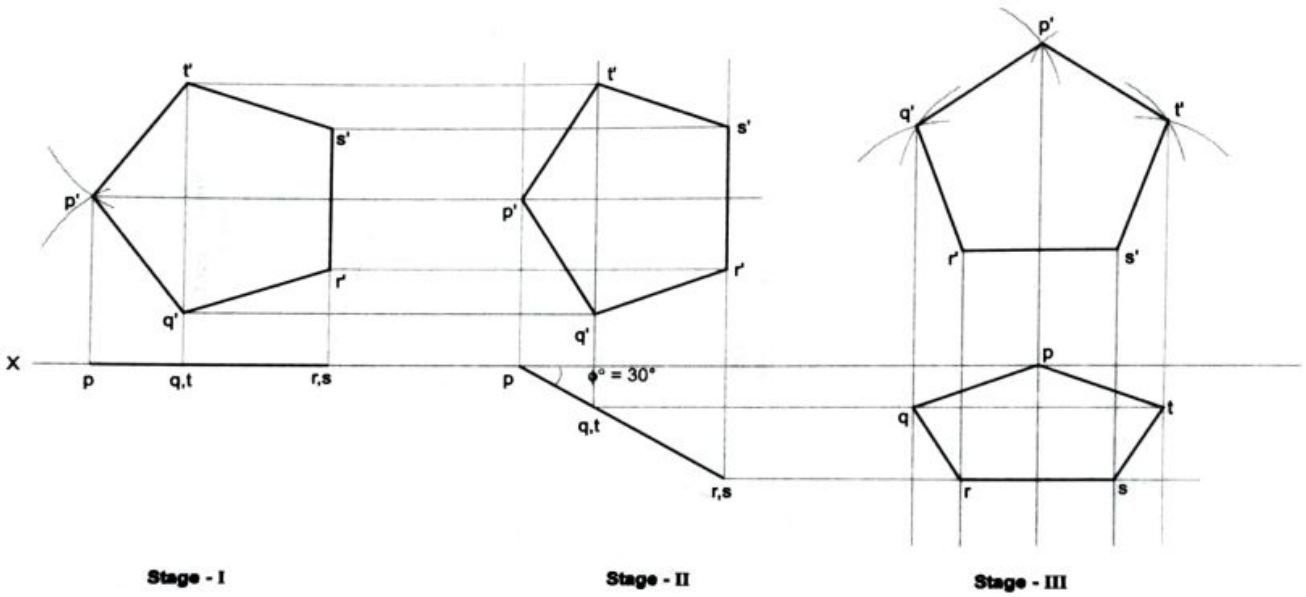


Fig. 4.16.12

Ex. 4.16.8 : ***A regular hexagonal plate of 30 mm side is resting on one of it's edges on V.P. such that the surface is inclined at 45° to V.P. and the edge on which it is resting is inclined at 30° to H.P. Draw the projections of the hexagonal surface.***

Sol. : **Given :** Hexagonal plate

Side = 30 mm

ϕ = 45°

θ_{ab} = 30°

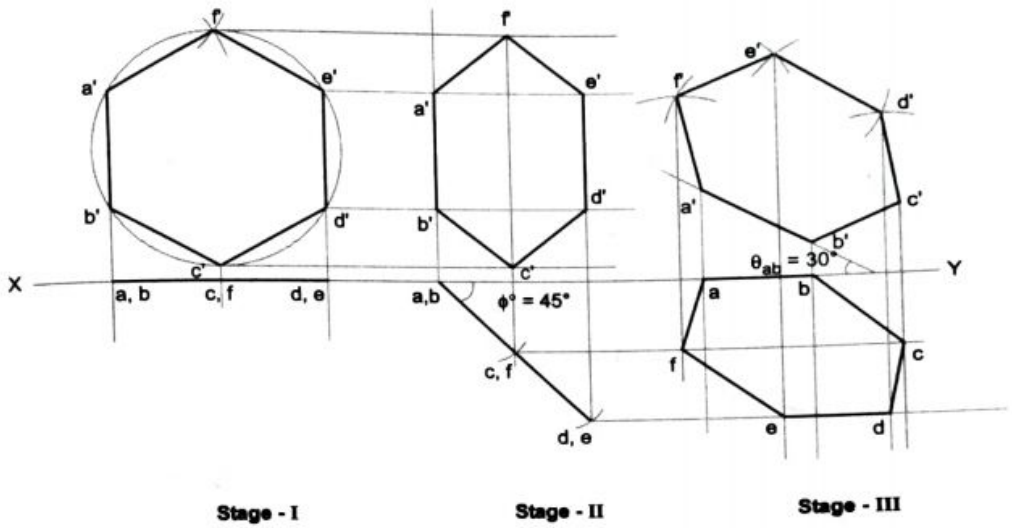


Fig. 4.16.13

Ex.4.16.9 : ***A pentagon plate, side 40 mm is resting on H.P. on one of its corners. The plate is inclined to H.P by 45° and perpendicular to V.P. Draw the projections.***

Sol. : Given : Pentagonal plate

Side = 40 mm

θ = 45°

Refer Fig. 4.16.14 on next page

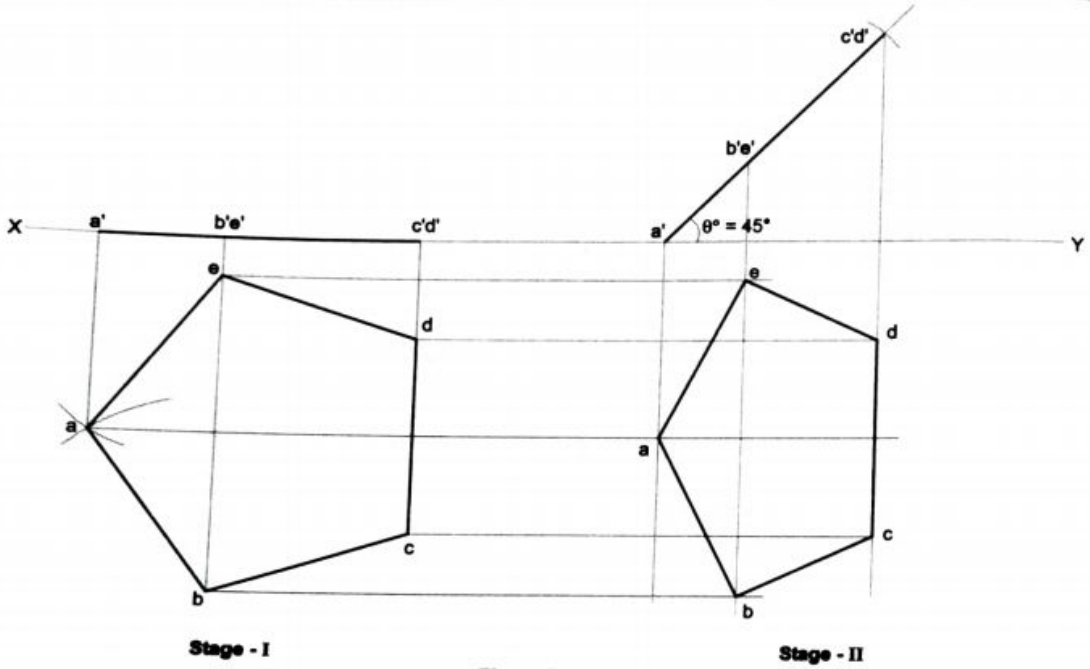


Fig. 4.16.14

Ex. 4.16.10 : ***A hexagonal plate is resting on one of its side on H.P. The side on which it rests makes an angle of 45° with V.P. and the plate makes an angle of 45° with H.P. Draw the projections of the plate.***

Sol. : **Given :** Hexagonal plate

Consider side = 30 mm, $\theta° = 45°$, $\phi = 45°$

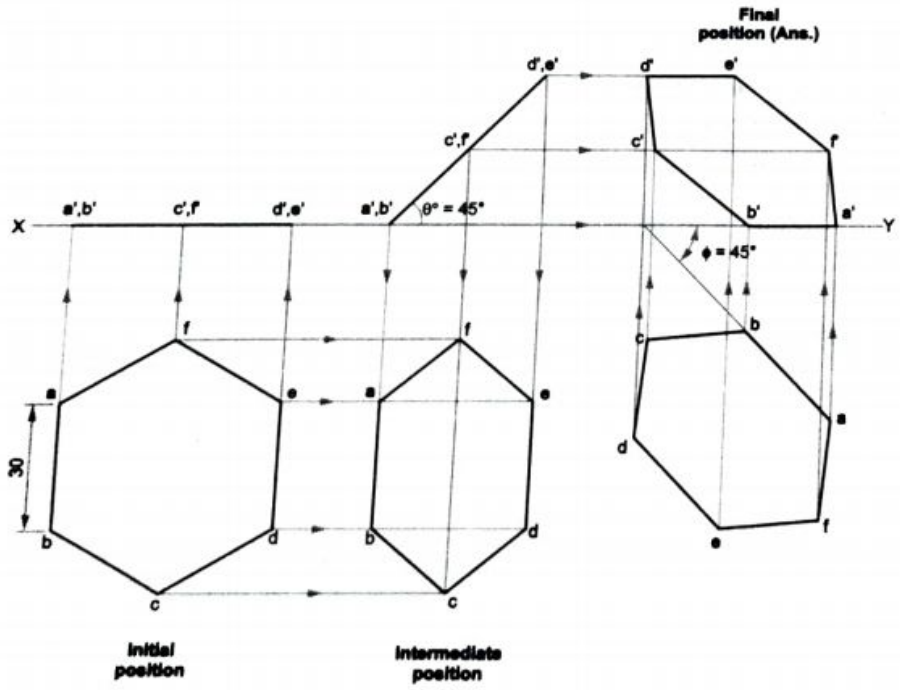


Fig. 4.16.15

Ex. 4.16.11 : ***A regular pentagonal plate is resting in V.P. on one of its sides with surface making an angle 45° with V.P. The side on which it rests on V.P. makes 60° with H.P. Draw the projections of pentagonal plate having the side 30 mm.***

Sol. : **Given :**

Pentagonal plate

Side = 30 mm

$\phi° = 45°$

$\theta° = 60°$

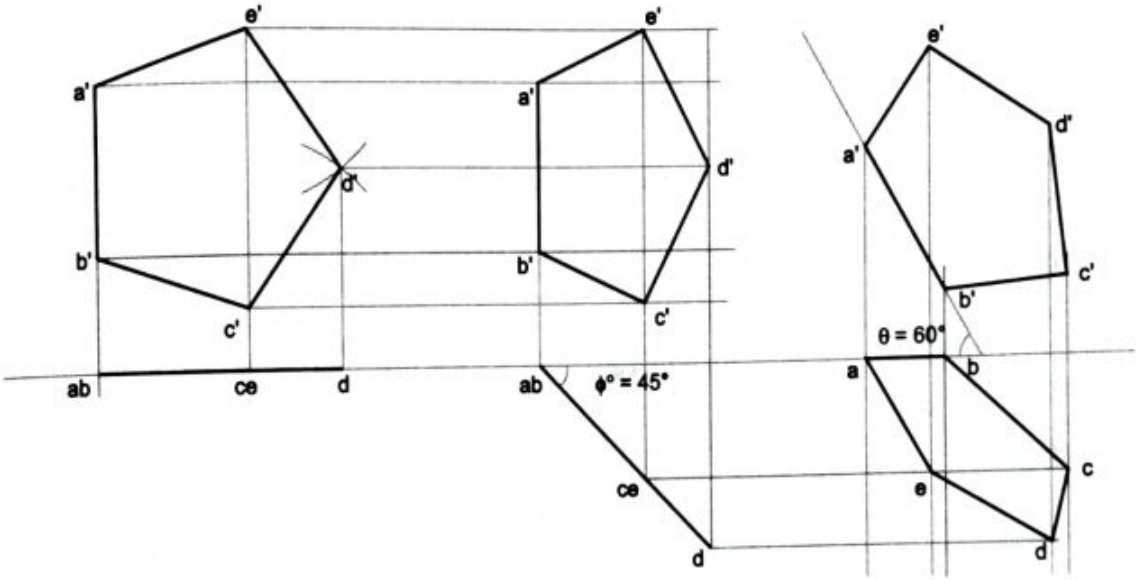


Fig. 4.16.16

D) Projection of Solid

4.17 : Introduction

Any entity or object which is expressed with three dimension viz length, breadth and height can be considered as solid.

Solids are classified into two groups :

i) Polyhedrons ii) Solids of revolution

4.18 : Polyhedron

When a solid is bounded by plane surfaces, it is called as a polyhedron. The plane surfaces are termed as the faces of solid and lines of intersection of faces of solid are termed as edges. The point at which any three faces meet is termed as the corner. Based upon above points polyhedron can be broadly classified as -

i) Prism ii) Pyramid

4.18.1 Prism

It is polyhedron, which is bounded by the rectangular faces having its end base and top face equal, similar and parallel to each other.

Other type of polyhedron prism are -

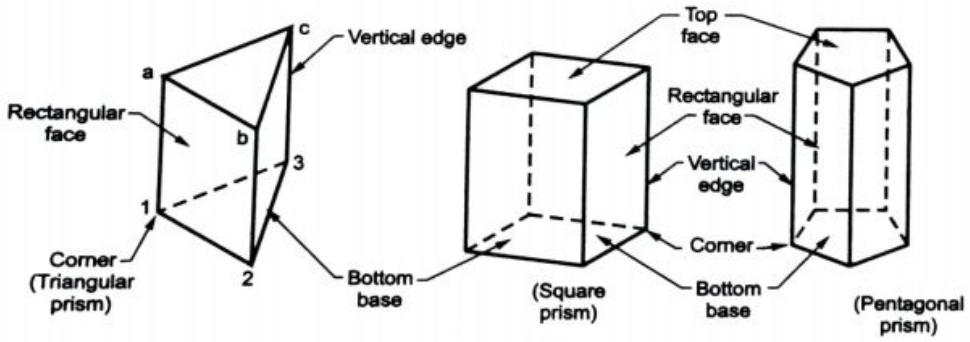


Fig. 4.18.1

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

ii) **Hexahedron or Cube :** It has six equal faces, each a square.

iii) **Octahedron :** It has eight equal faces, each an equilateral triangle.

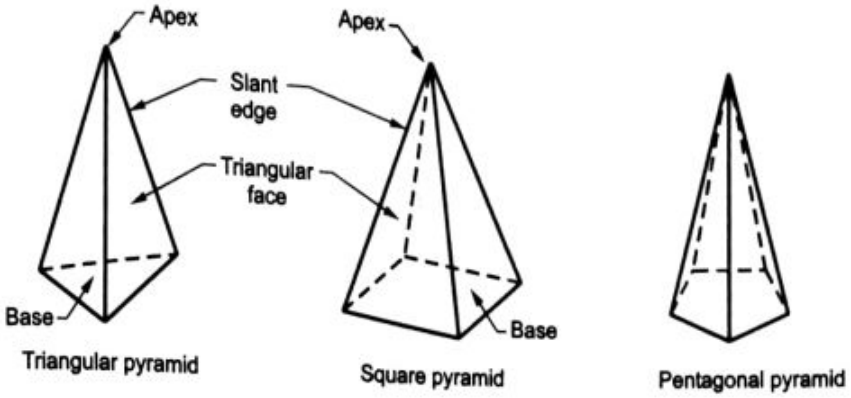
iv) **Dodecahedron :** It has twelve equal faces, each a regular pentagon.

v) **Icosahedron :** It has twenty equal faces, each an equilateral triangle.

4.18.2 Pyramid

It is a polyhedron having one base and a number of isosceles triangular faces (i.e. equal to number of side of base meeting at a point, called vertex or apex.

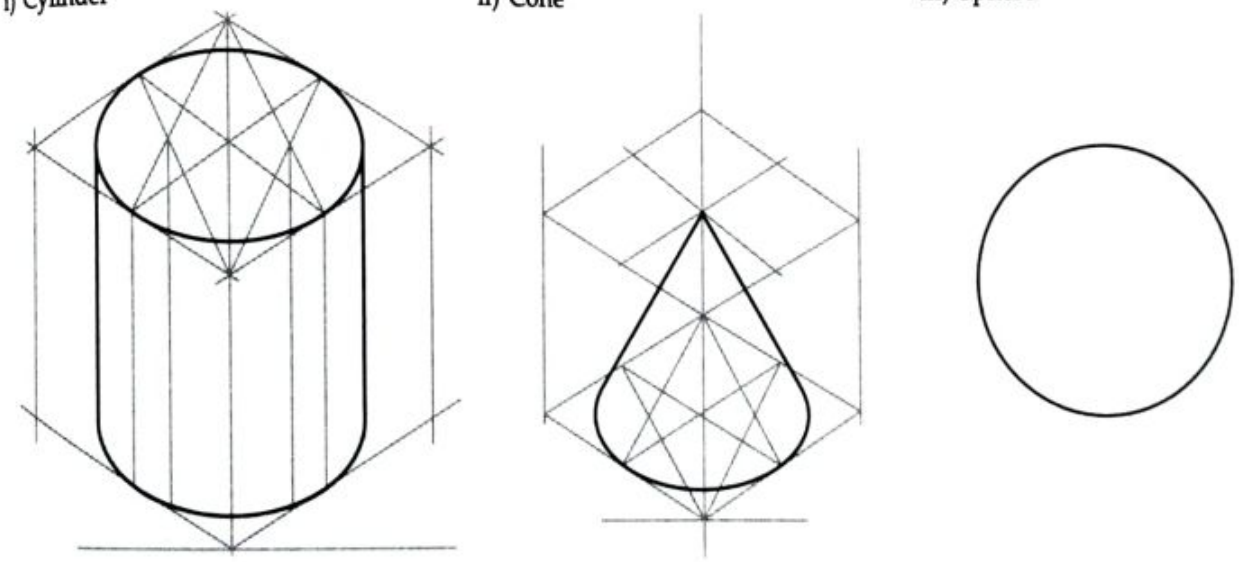
A pyramid or prism is said to be right regular, when axis is perpendicular to base.



4.19 : Solids of Revolution

Solids of revolution are obtained or generated by rotating a plane figure about one of its edges. The various types of solids of revolution are -

i) Cylinder ii) Cone iii) Sphere



4.20 : General Guidelines to Remember

1) Always start with true shape of solid base as first view in first stage (I stage).

i) If it is rest on H.P. on its base, true shape of base will appear in T.V. in I stage.

ii) If it is rest on V..P. on its base, true shape of base will appear in F.V. in I stage.

2) **If condition (about inclination) is given with two planes (H.P. and V.P.), then first condition shall be considered with plane on which it is resting or assumed to be resting in first stage.**

3) **General interpretation of three stage :**

i) **I stage :** It is mainly observed with true shape and true dimensions (i.e. base side, vertical edge, axis length) in T.V. and F.V. or vice-versa.

ii) **II stage :** In this stage condition with plane on which it is resting or assumed to be resting should be considered.

If resting on H.P. in **first stage**, then inclination with H.P. should be considered in stage II.

If resting on V.P. in **first stage**, then inclination with V.P. should be considered in stage II.

iii) **III stage** : In this stage last or remaining condition with plane shall be finished.

4) **Any two dark lines should not cross each other.**

4.21 : Guidelines / Tips for Visibility and Non-visibility

1) The outlines i.e. boundary of any view or projection is always visible.
2) All **lines** or part of curve passing from farthest point to the observer are always invisible.(Except boundary lines or surfaces) [Point closer to plane.]
3) All lines or part of curves passing from nearest point to observer **OR** away from plane, are always visible.
4) No dotted line or surface should appear out of boundary of an object.
5) i) In stage I, true shape of prism will be followed by rectangular faces or rectangle.
   ii) In stage I true shape of pyramid will be followed by triangle or triangular faces.

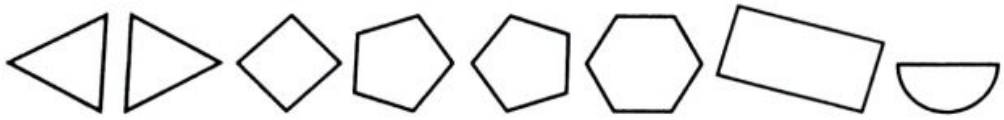
4.22 : Position of T.S. of Base

We are going to deal with the object resting on HP in this topic. Hence we will always start the solution with T.V. of object having T.S. of base means solid resting on its base of HP.

Always we may face the problem of orientation of its base in T.S. then make use of following hints.

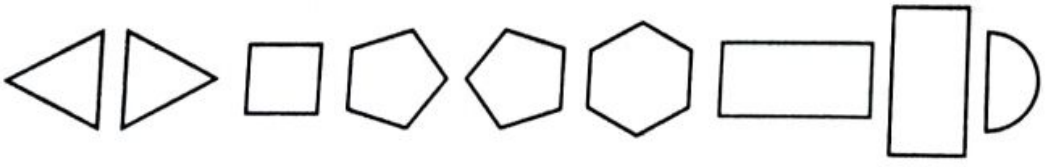
Hint I

It in the statement of the problem condition of corner of base, longer edge (prims), slan edge (pyramid) then keep one corner on L.H.S. or R.H.S.



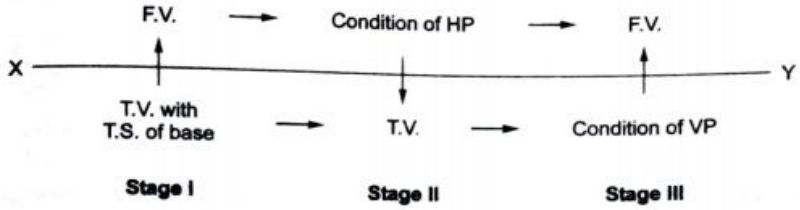
Hint II

It in the statement of the problem condition of edge of base / traingular face / rectangulare face (prism) then keep one edge perpendicular to XY line either on LHS or RHS.

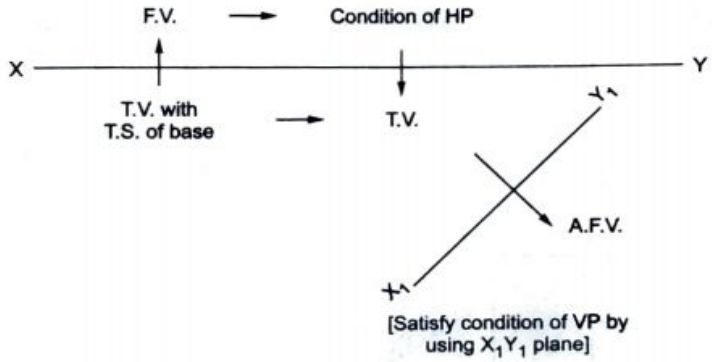


Fore cone and cylinder there will not be such problem as their top view is a circle.

4.23 : General Flow of the Solution



In this method in the third stage in T.V. redrawing of T.V. in stage II is laborious hence following method of solution is recommended.



Hint

It T.V/plan of axis /side /edge is mentioned in the inclination with VP then donot find apparant inclination (β). Actually given angle itself is β.

Ex. 4.23.1 : ***A square prism with side of base 45 mm and axis height 70 mm is resting on the H.P., on one of its base corner such that its axis is inclined at 30° to H.P. and parallel to the V.P. Draw its projections.***

Sol. : Given :

i) Resting on H.P.

ii) Axis inclined at 30° to H.P. i.e. $\theta = 30°$

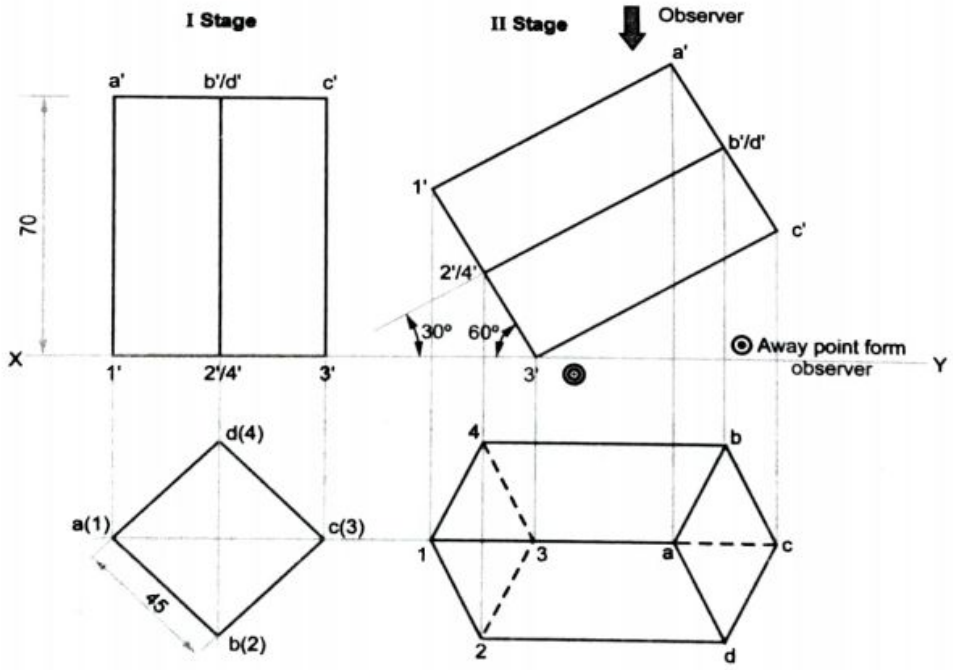
Step to follow :-

STAGE I

1) It is given that the axis of a solid is inclined to the H.P. and one of its base corner is in the H.P. therefore **Assume that the complete base of a solid to be resting in H.P. for stage I.**
2) Draw true shape of base in T.V., taking corner to right side, as it is resting on one of base corner.
3) Project F.V. with the given axis length.

STAGE II

4) Axis of solid is normal to base of solid. Therefore, for making axis inclined by 30°, make base of solid inclined by 60°. Take base (1', 2'/4', 3') inclined at 60° and redraw F.V. of solid.
5) Project the points from the F.V. vertically down and project the points from T.V. of first stage horizontally right to get corresponding point of the T.V. as a final projection.
6) To make a decision about continuous line and hidden line while joining the sequential point, see position of observer ( ). Most away point from observer is 3'. Lines passing from point 3' are 3-2, 3-4, 3-c. All these lines will be joined as dotted lines. Join remaining lines as continuous line.
7) If any dotted line appears as boundary line, will become continuous line.



Ex. 4.23.2 : ***A square pyramid, side of base 40 mm and axis length 65 mm has one of the side of a base in the H.P. Draw projection of pyramid if the base is inclined at 40° to the H.P. and axis is parallel to V.P.***

Sol. : Given

i) Resting on base edge on H.P.

ii) Base is inclined to H.P., $\theta = 40°$

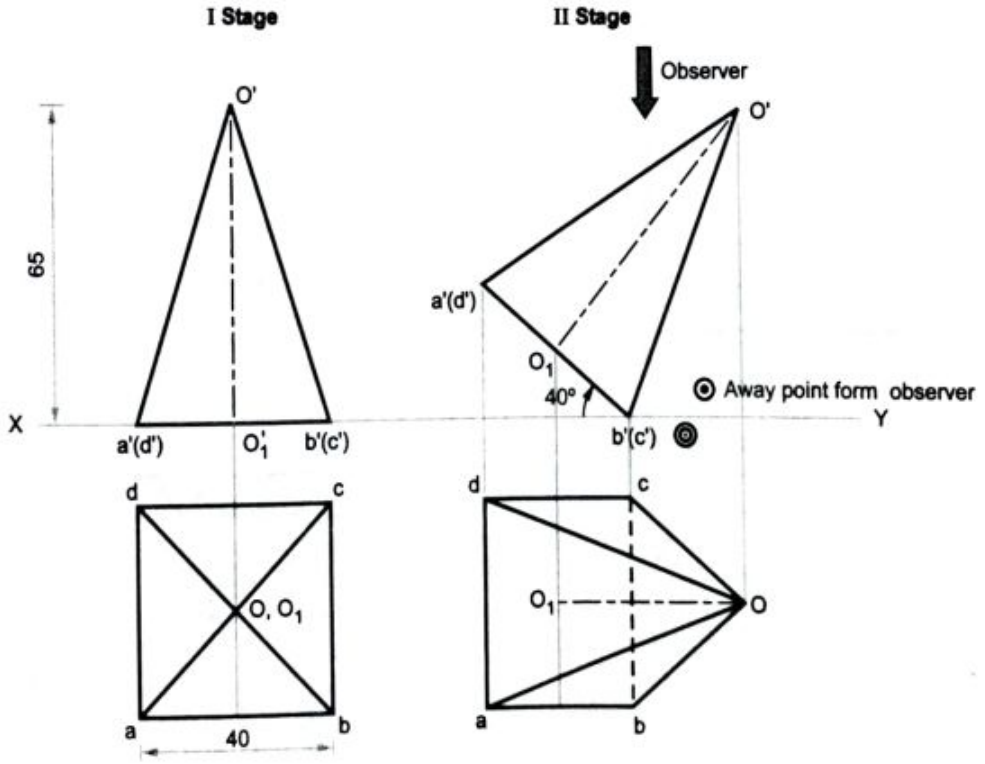
Step to follow :-

STAGE I

1) It is given that, base of solid is inclined to H.P. Therefore, assume that complete base of solid to be resting in H.P.
2) Draw true shape of base of pyramid in T.V., so that one of base edge appear on right hand side.
3) Project F.V. in stage I, with given length of axis.

STAGE II

4) Make base of pyramid inclined at an angle 40° with H.P., as shown and redraw F.V.
5) Project the points from the F.V. vertically down and project the points from T.V. (Stage I) horizontally right to get corresponding point of T.V. (Stage II) as a final projection.
6) To decide about hidden and continuous line, most away point from observer [i.e. b'(c')] is considered. Line passing from point [b'(c')] are b-c, b-o, c-d, c-o. The lines b-a, b-o, c-d, c-o are boundary lines or outlines which cannot be dotted. Hence, only line b-c will be dotted line. Rest of all lines are continuous lines.



Ex. 4.23.3 : ***A right circular cylinder of base diameter 40 mm, axis length 65 mm has a point of base circle on the H.P. and parallel to V.P. Draw its projection.***

Sol. : Step to follow :-

STAGE I

1) It is given that , the axis of cylinder is inclined to H.P. and has a point of base circle on H.P. Therefore, assume that complete base of a solid to be resting in H.P., for stage I, initially.

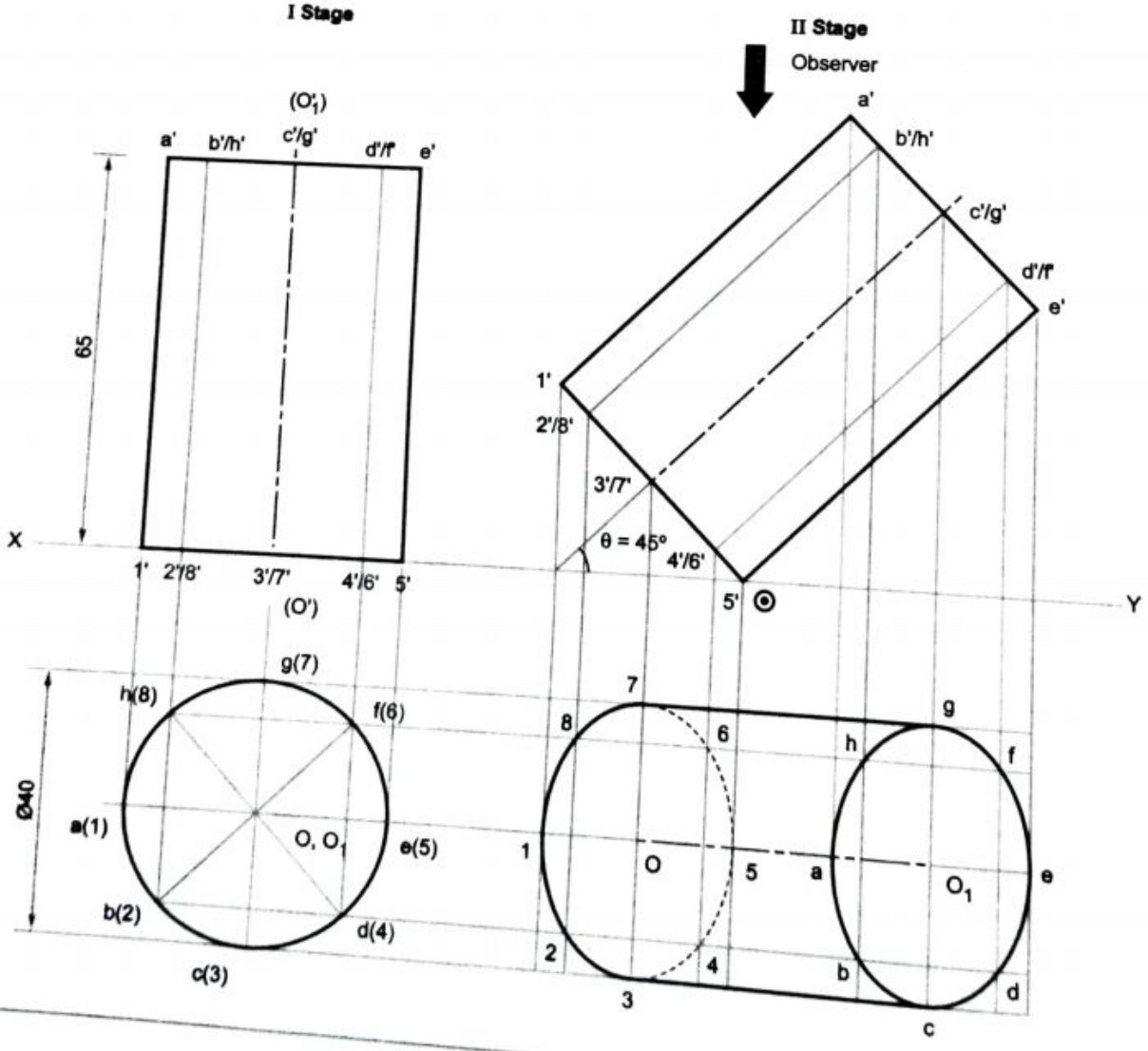
2) Draw true shape of base in T.V., i.e. circle and project its F.V. as a rectangle with given height.

STAGE II

3) Redraw the F.V. as per given inclination of an axis i.e. $\theta = 45°$. As axis is perpendicular to base, make base inclined at 45° with H.P. (xy) to get axis inclination as 45°.

4) Project the points from the F.V. vertically down and project the points from T.V. (Stage I). Horizontally right to get corresponding point of T.V. as final projection (Stage II).

5) To decide about dotted line, refer most away i.e. farthest point (5') from observer. Line passing from this point upto centre line i.e. 5-6-7 and 5-4-3 is dotted line.



Ex. 4.23.4 : ***A pentagonal pyramid of base side 40 mm and axis length 60 mm is resting on H.P., on one of its corner, with the axis parallel to V.P. and base making an angle of 40° to H.P. Draw it's projection showing final position.***

Sol. :

i) Resting on base corner on H.P.

ii) Base making an angle of 40° to H.P. i.e. $\theta = 40°$.

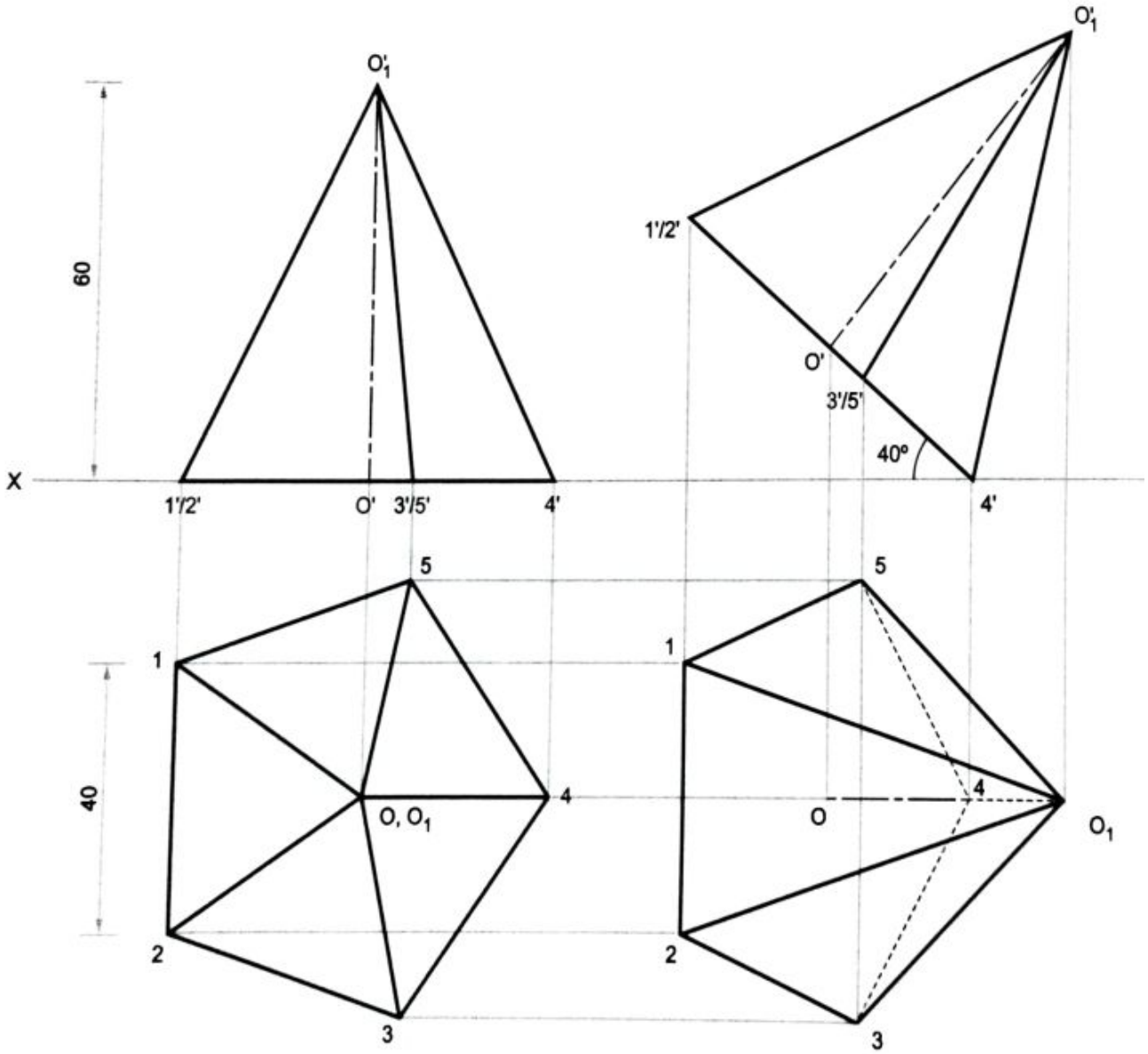
Step to follow :-

STAGE I

1) It is given that, base of pentagonal pyramid is making an angle with H.P., initially.
2) Draw true shape of base of pyramid in T.V. so that either base edge or corner appear on right hand side.
3) Project F.V. in stage I, with given length of axis.

STAGE II

4) Base of pyramid appears as line 1'/2' - 3'/5' - 4' in F.V. To obtain base inclination, make this line inclined by 40° with H.P. i.e. with XY line in F.V. and redraw F.V. as shown in figure.
5) Projects the points from F.V. vertically down and points from T.V. (Stage I) horizontally right to get corresponding point of T.V. (Stage II) as final projection.
6) To decide about hidden line refer point [4'] which is most away from observer or nearer to plane. All lines passing from this point as 4-5, 4-3 and 4-0 are dotted lines.


O'1
60
X
1'/2'
O'
3'/5'
4'
O'1
1'/2'
O'
3'/5'
40°
4'
5
1
4
O, O1
2
3
40
5
1
4
O
O1
2
3

Ex. 4.23.5 : ***A hexagonal pyramid of base side 30 mm and slant length 70 mm is resting on one of its base edge on H.P. Its axis is inclined to H.P. such that apex is 50 mm above V.P. Draw its projection and determine inclination of axis with H.P.***

Sol. :

i) Resting on base edge, on H.P.

ii) Apex is 50 mm above H.P.

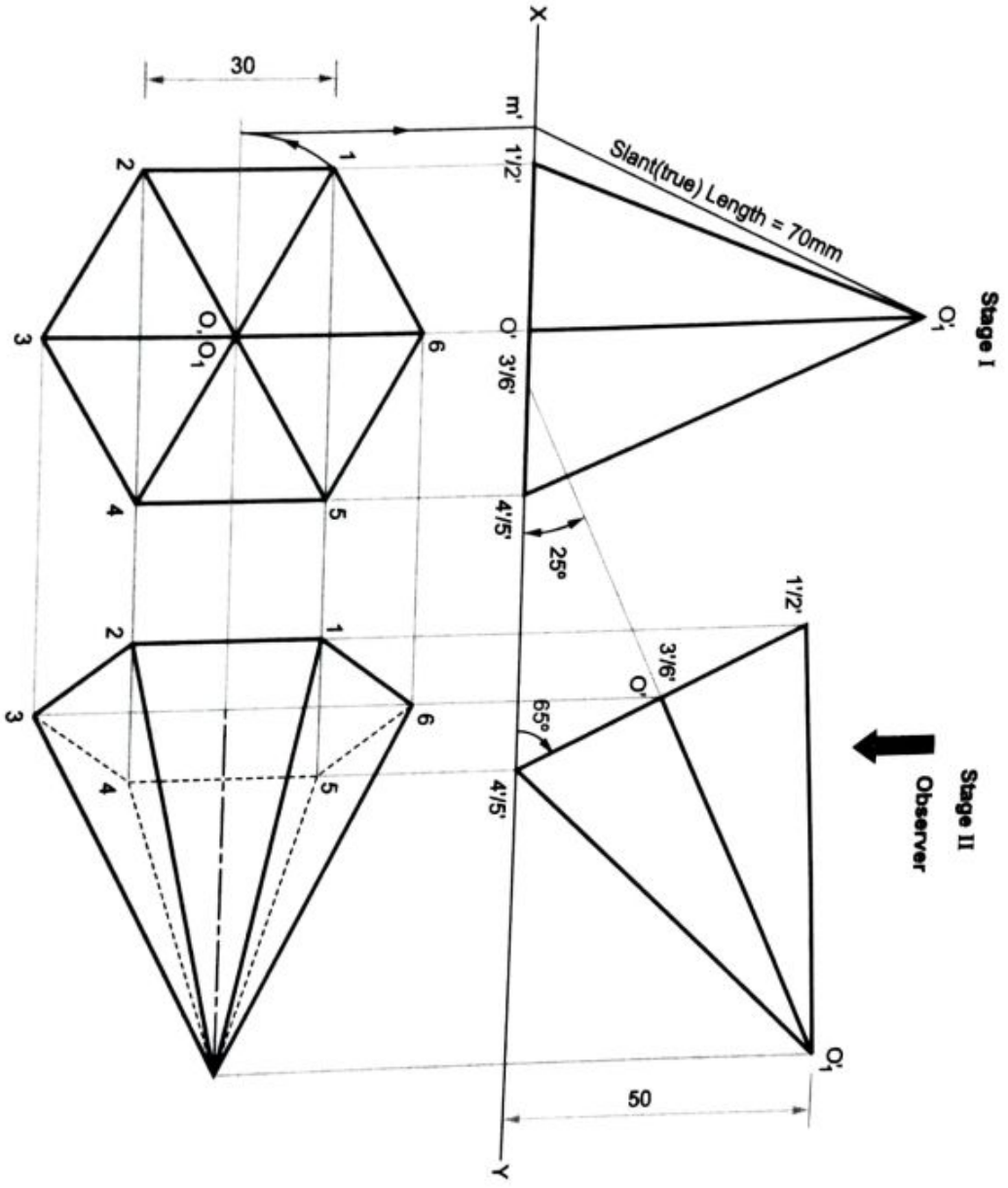
Step to follow :-

STAGE I

1) It is given that, apes should be 50 mm above H.P. its to achive this condition, it is required to tilt solid on one of its base edge. In this case, base will make 'θ' angle &unknown) with H.P. Hence, assuming base is resting on H.P. initially.
2) Draw true shape of base of pyramid in T.V., so that one of base edge appear to right hard side, as shown in stage I.
3) As slant length of solid is given it is true length. To mark given true length its corresponding other view should be parallel to one of plane i.e. XY line. therefore, take 'O' as centre and radius equal to 'O1' make 'O1' line horizontal i.e. parallel to XY. Line as line 'OM' shown in T.V. Now, project point m' in F.V. Take given slant length ($m'o'_1$ = 70 mm) in compass and m's as centre of it along axis, as point o'_1. This gives you apex point of pyramid. Project F.V. in stage I.

STAGE II

4) As apex is 50 mm above H.P., draw a trace line at 50 mm from XY line in F.V., as shown in stage II.
5) Take 4'5' as any point on XY line and cut distance equal to '4'5'o'_1' on trace, so point o'_1 will appear on trace line with respect to 4'5' point on xy line. Redraw F.V. with this side, as shown in stage-II.
6) Projects the points from V.V. vertically downward and points from T.V. (stage I) horizontally right to get corresponding point of intersection for T.V. (stage II), as find projection.
7) Before completion of T.V. in stage II, decide about hidden line. Refer point (4'/5') which is most any point from observer. All lines passing from this point as, 4-5, 5-6, 4-3, 5-0 and 4-0 are hidden or dotted lines. Rest of all line will be continuous line to complete T.V. in stage II, as find view.


X
Y
30
m'
1'/2'
3'/6'
4'/5'
O'
Slant(true) Length = 70mm
O'1
Stage I
25°
1'/2'
3'/6'
O'
65°
4'/5'
O'1
Stage II
Observer
50
1
2
3
4
5
6
O,O1

Ex. 4.23.6 : ***A tetrahedron of 40 mm long edges is resting on H.P., such that base edge is parallel to V.P. Draw projection of solid, if axis of solid is 30° to H.P.***

Sol. :

i) Resting on H.P., base edge parallel to V.P.

ii) Axis is inclined to H.P. by 30º.

iii) Tetrahedron is solid, which has all faces as equilateral triangle.

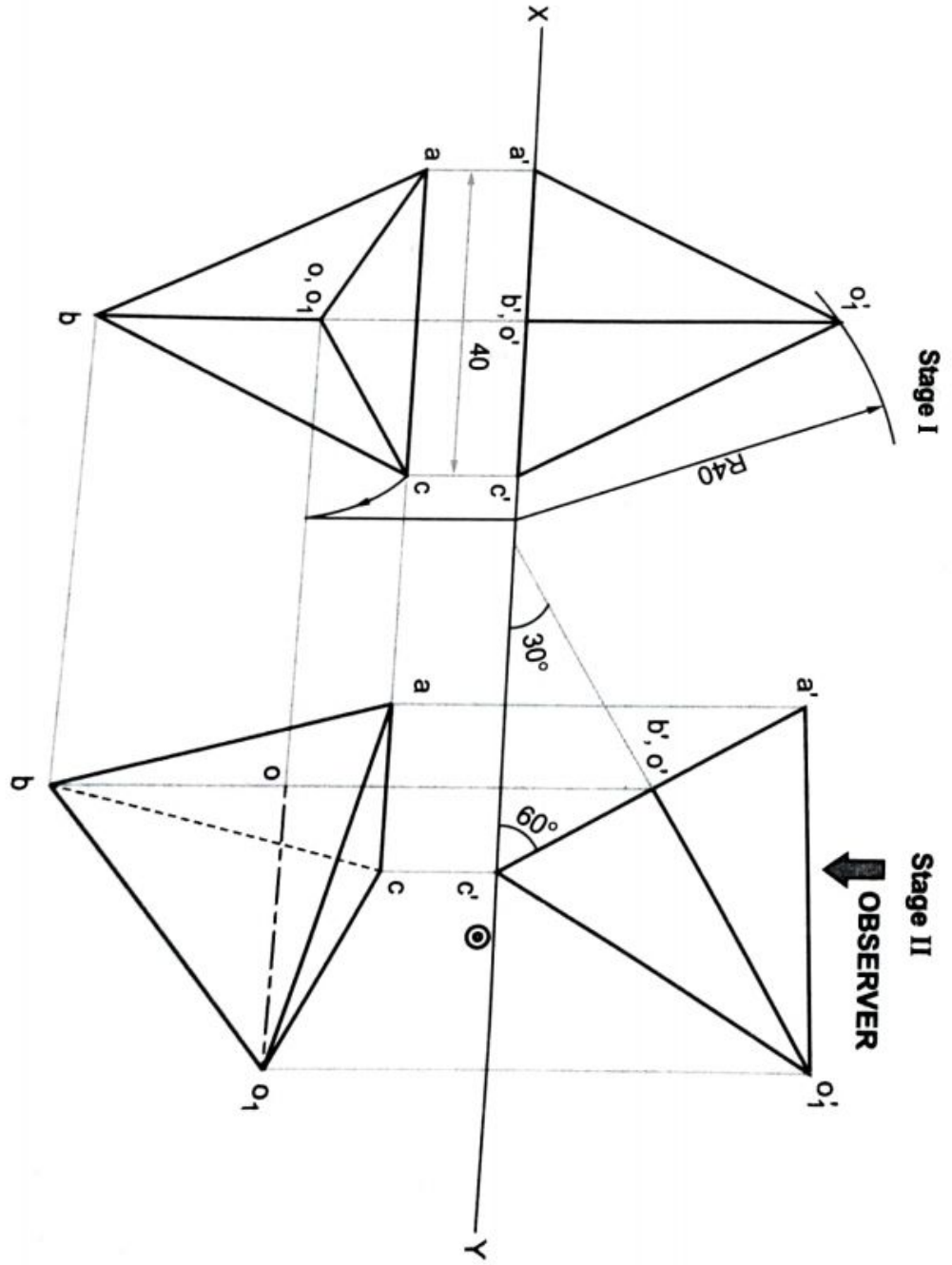
Step to follow :-

STAGE I

1) It is given that axis is inclined to H.P. Therefore assume that complete base of tetrahedron solid to be resting on H.P., initially for stage I.
2) Draw true shape of base as equilateral triangle of 40 mm side so that one of base edge is parallel to V.P. i.e. parallel to XY line, as shown in stage I.
3) Make OC parallel to XY line as oc_1. If line is parallel in one view, corresponding view will show true length. Project point c'_1 in F.V. Take radius equal to 40 mm (side of tetrahedron) and cut along axis of solid, to get height of solid.
4) Project F.V. in stage I, with obtained height of solid.

STAGE II

5) As axis of solid is always normal to base, hence to get required inclination of axis as $\theta = 30^\circ$ with H.P, make base inclined at $(90 - \theta)$. i.e. at 60°. Base of solid appears as line a'–b'–c' in F.V. make this line inclined by $(90 - \theta)$. i.e. at 60° and redraw F.V. in stage II.
6) Project points from F.V., vertically downward and points from T.V. (stage I), horizontally right to get corresponding point of T.V. (stage II), as final projection.
7) to decide about hidden line, refer most away point from observer (i.e. point c').


X
Y
a
a'
b
o, o1
b', o'
o1'
40
c
c'
R40
Stage I
30°
a
a'
b
o
b', o'
60°
c
c'
Stage II
OBSERVER
o1
o1'

Ex. 4.23.7(a) : ***A square prism, side of base 30 mm and axis 55 mm has one of the side of base in the H.P. which makes an angle 30° with V.P. and axis inclined at an angle 45° with the H.P. Draw its projection.***

Sol. : Given :

i) Resting on H.P. on side of base

ii) Axis is inclined with H.P., $\theta = 45°$

iii) Base side inclined with V.P. $\phi = 30°$

Step to follow :- [Change of position Method]

STAGE I

1) It is given that, one of side of base is in H.P, assurance that the complete base of solid be in the H.P, such that side of base appear to R.H. side and perpendicular to XY line.

2) Draw the shape of base in T.V. and project its F.V. with the given axis length.

STAGE II

3) As base is assured to be in H.P (Stage I), it is necessary to consider solid inclination with H.P. in stage II. As axis is normal to base, mark base of solid $(90 - \theta_e)$ to get required axis inclination with H.P. and with angle of redraw F.V. in stage II, as shown in figure.

4) Project the points from the F.V. vertically downward and project points from the T.V of stage I horizontally towards right to get corresponding points of T.V of stage II.

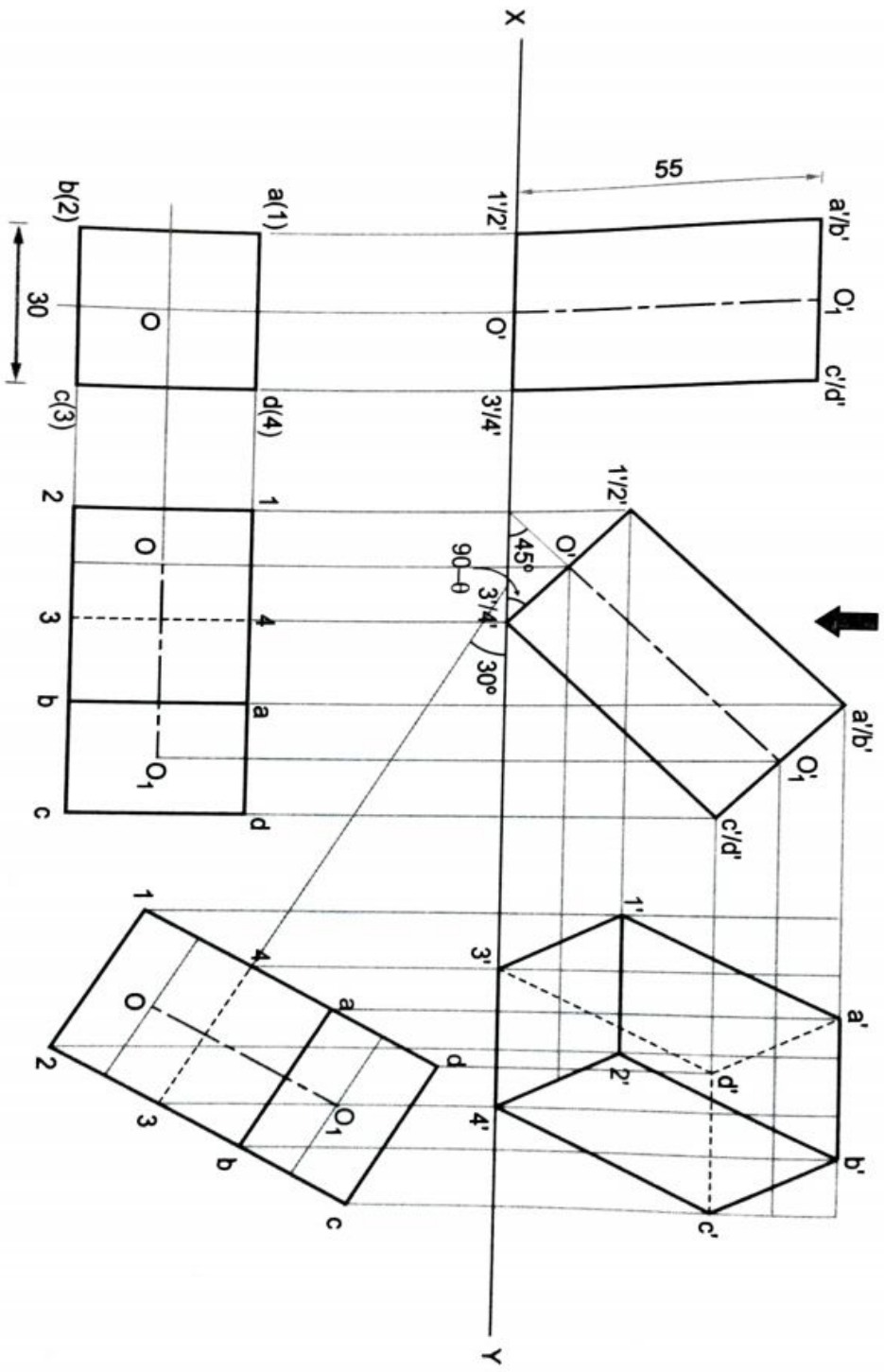
5) Joint the point in proper sequence with reference to most away point from observer with all carve of hidden and continuous line.

STAGE III

6) Redraw the T.V of stage II such that the side of base (3-4), marking an angle $\phi = 30°$, with XY line. This is an inclination of base with V.P.

7) Project the points from the T.V vertically up and project the points from F.V of stage II, horizontally towards the right to get corresponding points of F.V. of stage III.

8) To decide about hidden line and continuous line, refer most away point from direction of observer. (i.e point d)


X
Y
55
30
a'/b'
c'/d'
1'/2'
3'/4'
O'
O_1'
a(1)
b(2)
c(3)
d(4)
O
O_1
45°
90−θ
θ
30°
a
b
c
d
1
2
3
4
a'
b'
c'
d'
1'
2'
3'
4'

Ex. 4.23.7(b) : ***A square prism, side of base 30 mm and axis 55 mm has one of the side of base in the H.P. which makes an angle 30° with V.P. and axis inclined at an angle 45° with the H.P. Draw its projection.***

Sol. : [Combination of change of position and Auxilary Plane Method]

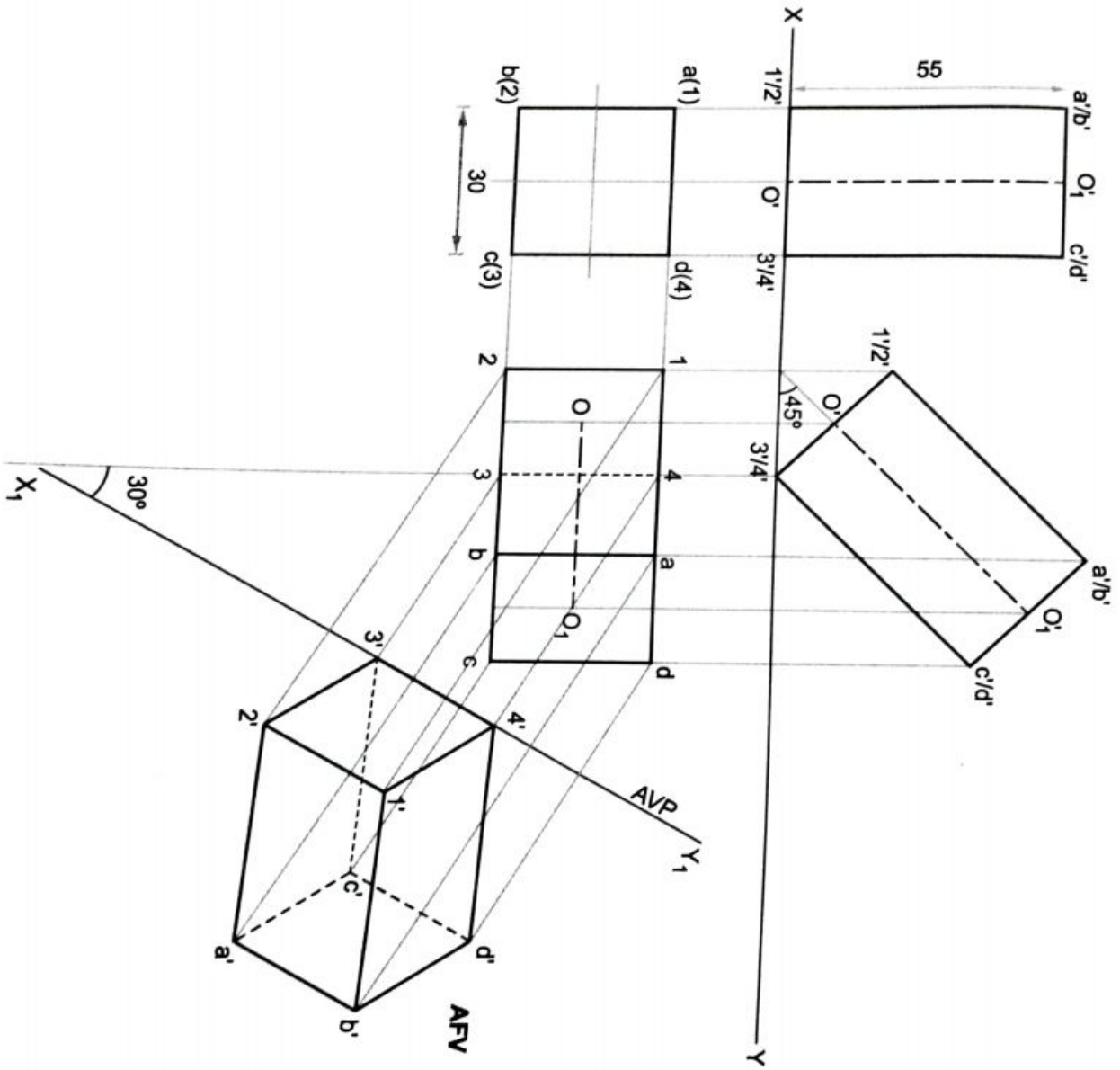
Draw first two stage (I and II) projection of solid as explained in steps for problem 7(a).

STAGE III

6) Since the base edge 3-4 has to be inclined at $\phi=30°$ to V.P. Draw now reference line x_1y_1 in top view inclined at 30° to edge 3-4 at any convenient distance from it, as shown in figure.

7) Draw the projectors through all the corners in the top view, perpendicular to X_1Y_1 line. Auxiliary Plane shown in top view is AVP, it represents AFV (Auxiliary Front View). Hence on these projectors, distances of all points of F.V. from XY line will be transferred to X_1Y_1 line. It is shown with simillar distance symbol (~, ≈, –).

8) In the given direction of observer ( ) for stage III, decide most away point from observer It is point 'C' (stage II, TV) shown with mark. Line joining to this corner will be dotted lines and other corner point joined with continuous line.


X
Y
55
a'/b'
O'1
c'/d'
1'/2'
O'
3'/4'
b(2)
a(1)
c(3)
d(4)
30
2
1
3
4
b
a
c
d
O
O1
X1
30°
45°
AVP
Y1
AFV
1'
2'
3'
4'
a'
b'
c'
d'

Ex. 4.23.8 : ***A square pyramid side of base 40 mm, axis length 60 mm has one of the side of base in the H.P. The axis of a solid is inclined to H.P. and V.P. at on angle 30° and 45° respectively. Draw its projection.***

Sol. : Given

i) Resting on H.P. on base side,

ii) Axis inclined to H.P., $\theta = 30°$.

iii) Axis inclined to V.P., $\phi = 45°$

Step to follow :-

STAGE I

1) It is given that, one of side of base is in H.P., assume that the complete base of solid be is the H.P. such that side of base appear to R.H. side and perpendicular to XY line.

2) Draw true shape of base in T.V. and project in F.V., with given axis length.

STAGE II

3) As base is assumed to be in H.P. (stage I), it is considered for condition of inclination with H.P. in stage II. As axis of solid is normal to base, take base of solid (Line view a'b' - c'd') to an angle $(90-\theta)$ to get required axis inclination with H.P. ($\theta = 30°$). Redraw F.V. in stage II, as shown in figure.

4) Project the points from the F.V. vertically downward and project points from the T.V. of stage I, horizontally right to get corresponding points of T.V.

5) Join te point in proper sequence with reference to most away point from observer with all care of hidden and continuous line.

STAGE III

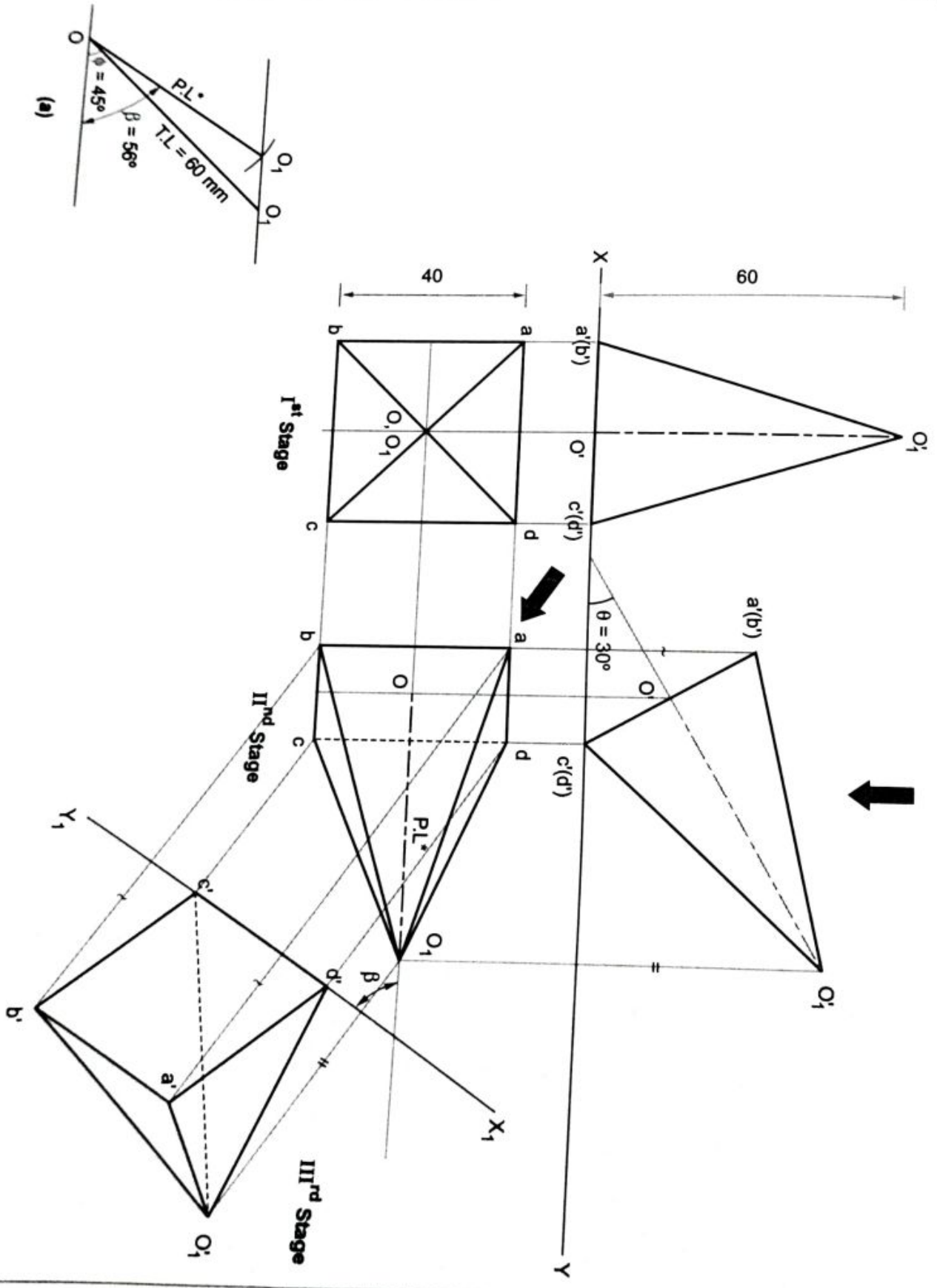
6) As length of axis in stage II (T.V.), is not true length, hence for apparent length, apparent angle will be obtained as shown in figure.

   Draw a line inclined at an angle $\phi = 45°$ and cut on it the T.L. of the axis. Draw locus line from other end. Taking P.L. of axis from stage II and keeping one end point as centre, cut an arc on the locus line. This gives appear apparent angle β with XY line.

7) Draw new reference line x_1y_1 as AVP, inclined at β angle with extended projection of axis $o-o_1$, at any convenient distance.

8) Draw projectors through all the corners of T.V., stage II, perpendicular to X_1Y_1 line. On these projector lines measure the distance of each corner in auxiliary front view from x_1y_1 line equal to the distances of each corresponding corner in second view from XY line, as shown with equality symbol (~, =) and complete AFV (auxiliary front view).

9) Take decision about hidden and continuous line w.r.t. most any point from observer.


(a)
O
φ = 45°
β = 56°
P.L.*
T.L = 60 mm
O1
O1
X
Y
40
60
a'(b')
O'
c'(d')
O1
I st Stage
O, O1
a
b
c
d
θ = 30°
II nd Stage
P.L.*
Y1
X1
III rd Stage
a'
b'
c'
d'
β
O1
O1

Ex. 4.23.9 : ***A pentagonal prism having an edge of base 25 mm, axis height 55 mm has one of its corner in the H.P. The axis is inclined at 30° to the H.P. and T.V. of an axis is inclined at 45° to the V.P. Draw the projections.***

Sol. : Given points :

i) Resting on base corner on H.P.

ii) Axis inclined to H.P., $\theta = 30°$.

iii) T.V. of an axis inclined to V.P., $\beta = 45°$

Step to follow :-

STAGE I

1) As one of corner of base is in H.P., assume that complete base of solid be in the H.P. such that corner of base appears to R-H and one of base edge perpendicular to XY line.

2) Draw true shape of base in T.V. and project its F.V. with given axis length.

STAGE II

3) As base is assumed to be in H.P. condition of axis inclination with with H.P. shall be taken, in stage II. Axis of prism is inclined at $\theta = 30°$ to H.P. To get this inclination make base of prism (Line view 1'/2' - 3'/5'-4') inclined at angle $(90 - \theta)$ and redraw F.V. of prism in stage II.

4) Project the points from F.V. vertically downward and points from T.V. (stage I), horizontally right to get corresponding points of T.V. stage II.

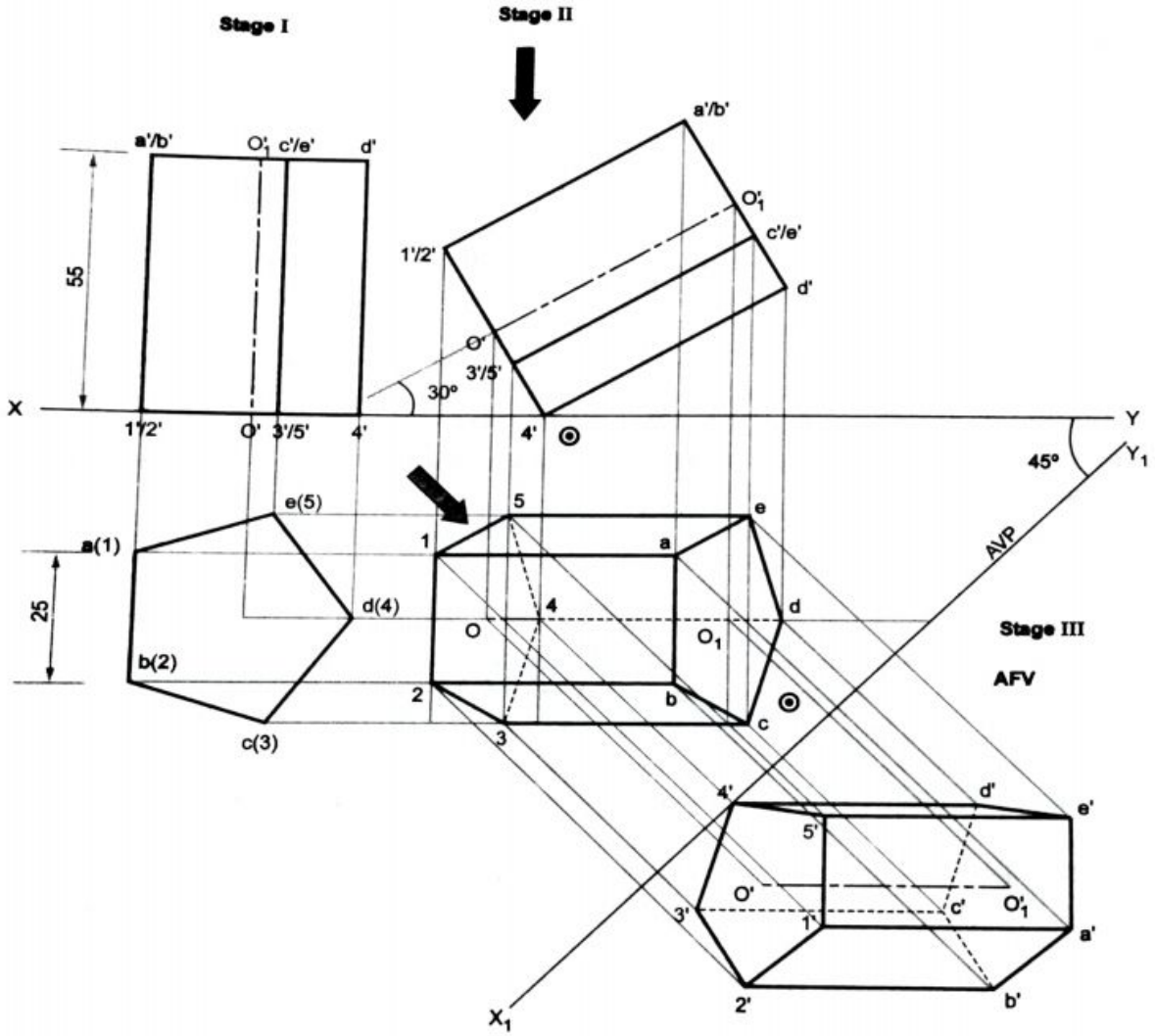
5) Joint all point with proper sequence with reference to most away point [ ] from observer with all care of hidden and continuous line.

STAGE III

6) Inclination of T.V. of axis i.e. $\beta = 45°$ with V.P. is given. Draw new reference line X_1Y_1, with extension or projection line of axis $o\,o_1$, at an angle $\beta = 45°$, at any convenient distance.

7) Draw projectors through all the corners of T.V. (stage II), perpendicular to X_1Y_1 line. On these projector lines measure distance of each corner in auxiliary front view from X_1Y_1 line equal to distance of each corresponding corner in stage II, from XY line as shown in figure and complete AFV.

8) Take decision about hidden and continuous line w.r.t. most away point [ ] from observer.


Stage I
Stage II
Stage III
a'/b'
O'1
c'/e'
d'
55
1'/2'
O'
3'/5'
4'
30°
X
Y
45°
Y1
AVP
AFV
e(5)
a(1)
d(4)
b(2)
c(3)
25
1
2
3
4
5
a
b
c
d
e
O
O1
X1
5'
1'
2'
3'

Part - B : Orthographic Projections of Machine Elements / Parts

A) Orthographic Projections

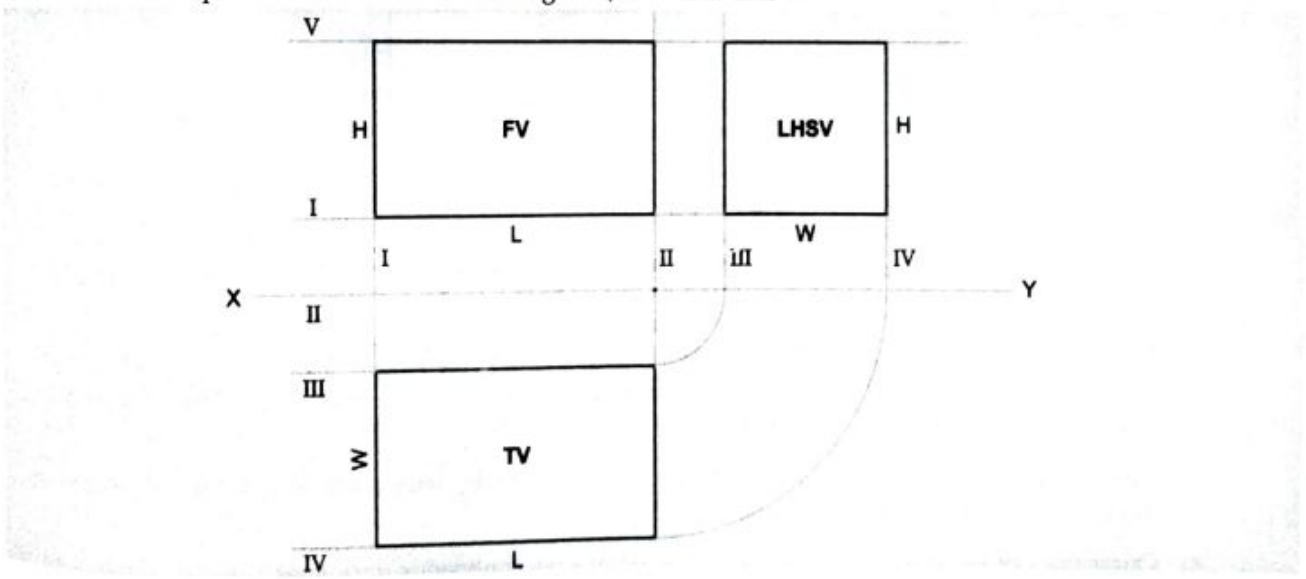
4.24 : General Guidelines for Drawing Orthographic View

Nov.-14,16, 08,09,10,11,12,13,May-13,14,15, 16, Marks 20

While drawing orthographic views it is always observed that students draw FV and TV nicely but after the completion of these two views they don't find enough space to draw the LHSV or RHSV. Sometimes many students draw reference line (XY) centrally and if height of the object or width of the object is comparatively more then it is not possible to accomodate the views within the page.

To take care of such practical problems following method is suggested in this book.

1) Read the object carefully and get the overall length, width and height of the object.
2) See carefully which side (LHSV or RHSV) has to be drawn.
3) If LHSV is required to draw then,
   i) First draw the horizontal line at a distance which is more than height from top edge so that FV will not cross the page.
   ii) Draw the second horizontal line as a reference line at a gap of minimum 15 mm so that we can give dimensions properly.
   iii) Draw third horizontal line below **reference line** at a gap of 15 to 25 mm depending the object dimensions.
   iv) Write **X** on left hand side of reference line and by leaving some gap (10 mm to 20 mm from X) draw a vertical line.
   v) Draw second vertical line at a distance of L (overall length of object) from first vertical line. Mark the intersection point of this second vertical line and reference line (XY) as **centre** for rotation.
   vi) Draw a fourth horizontal line at a distance of W(overall width) from third horizontal **line.** Thus we get the block for drawing TV of dimensions LXW.
   vii) Now by using centre for rotation and drawing the arcs (quarter circular only) transfer the width from TV to **LHSV** as shown then draw the two vertical lines (III, IV) for the block of **LHSV.**
   viii) Draw a horizontal line at a distance of H(overall height) from first horizontal **line** to get the complete three blocks for drawing F.V., T.V. and LHSV.



4) If R.H.S.V. is required to draw then,

i) First draw the horizontal line at a distance which is more than height from top edge so that FV will not cross the page.

ii) Draw the second horizontal line as a reference line at a gap of minimum 15 mm so that dimensions can be given properly.

iii) Draw the third horizontal line below reference line at a gap of 15 to 25 mm depending on the object dimensions.

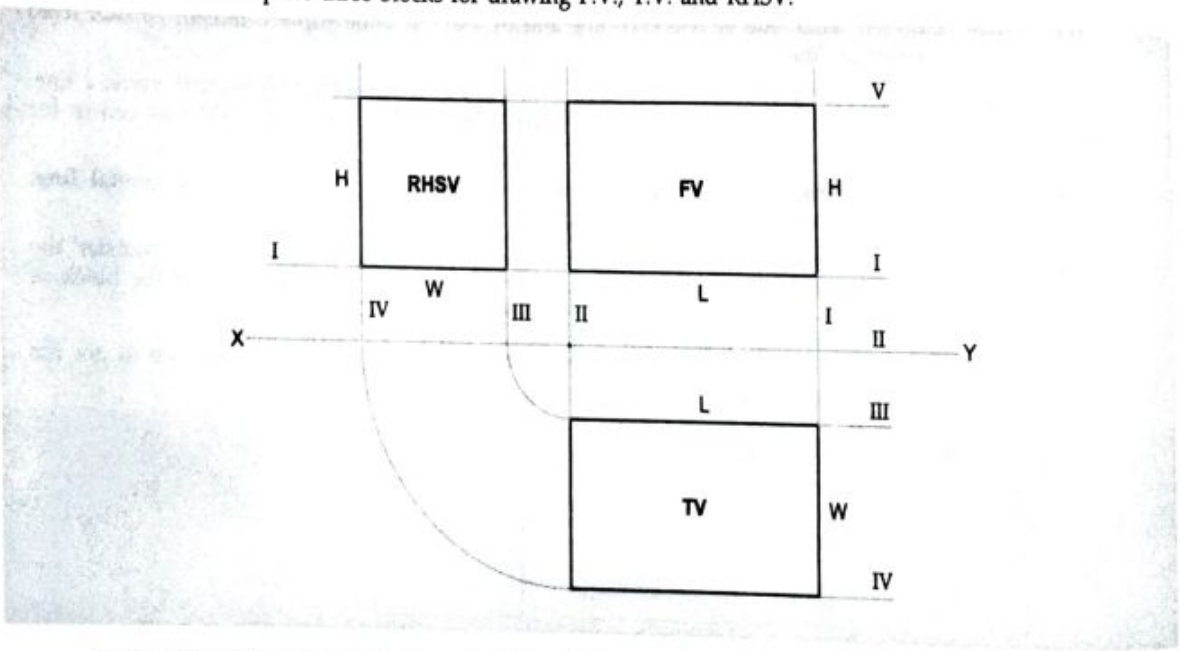
iv) Write Y on right hand side of reference line and by leaving some gap (10 mm to 20 mm from Y) draw a vertical line.

v) Draw a second vertical line at a distaqnce of L(overall length of object) from first vertical line. Mark the intersection point of this second vertical line and reference line (XY) as centre for rotation.

vi) Draw a fourth horizontal line at a distance of W(overall width) from third horizontal line. Thus we get the block for drawing TV of dimensions **LXW.**

vii) Now by using centre for rotation and drawing the arcs (quarter circular only) transfer the width from TV to RHSV as shown. Then draw the vertical lines (III and IV) for the block of RHSV.

viii) Draw a vth horizontal line at a distance of H(overall height) from first horizontal line to get the complete three blocks for drawing F.V., T.V. and RHSV.



5) If object is not symmetric then first draw **FV**, then complete TV and SV by taking the projections from F.V.

6) If object is symmetric then first mark line of symmetry (centre line) in the blocks of FV, TV and SV. For cylindrical parts of the object, circular holes mark the centre lines. First draw circles, semi-circles or quarter circles in all blocks.

7) Initially complete the view in which more number of circle, semi circle or quarter circles are seen. Then complete the remaining two views.

8) Outer lines of the objects in all three views are always contineous dark lines.

9) Two contineous dark lines never intersect each other.

10) Dotted line and contineous line can intersect.

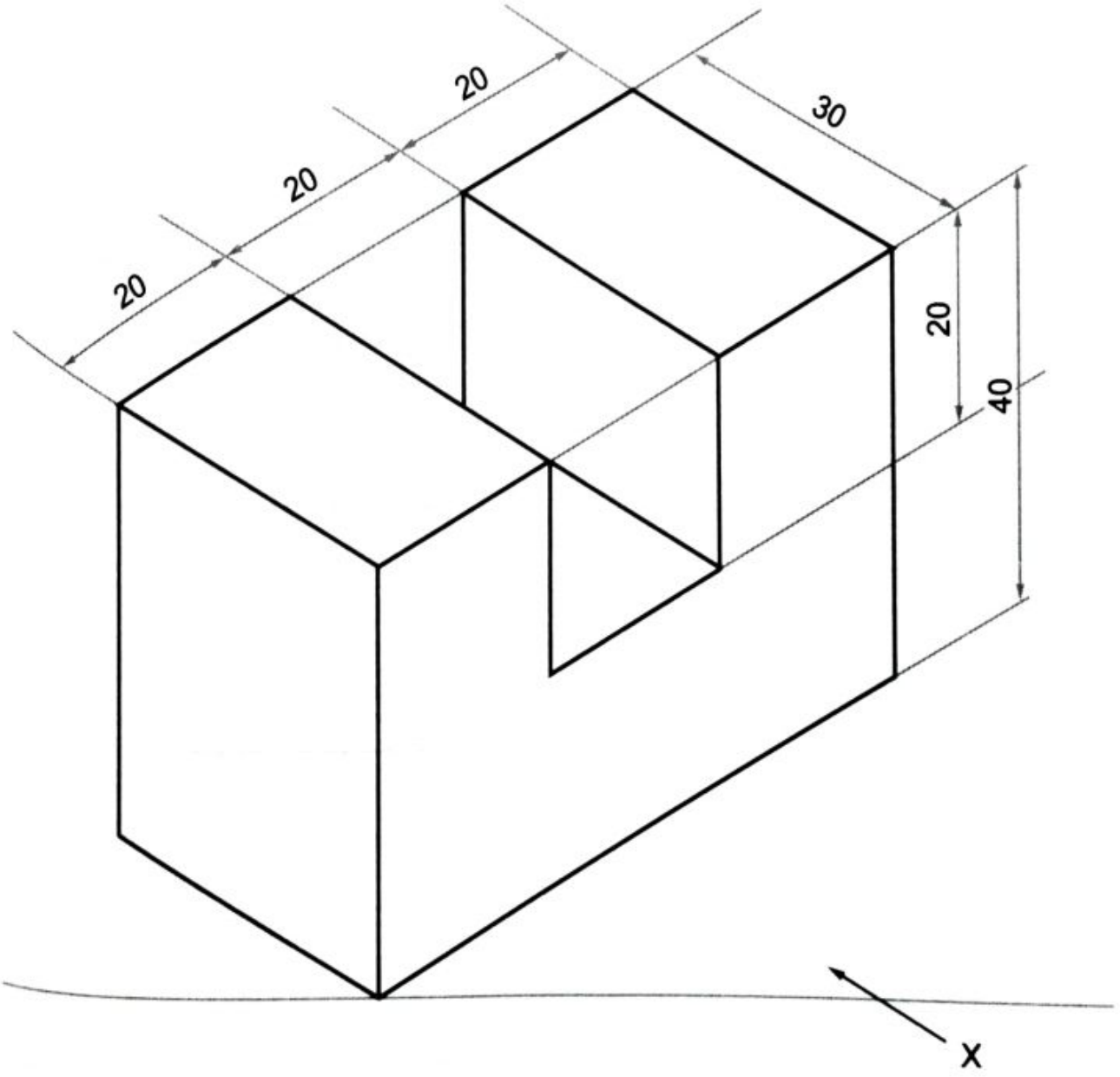
11) Give the dimensions for all the parts carefully. Avoid over dimensioning.

12) For drawing sectional view, show the cutting plane line by making the ends dark of a centre line (axisw of symmetry). In the next view show the hatching line for the new cut surfaces which is the sectional view.

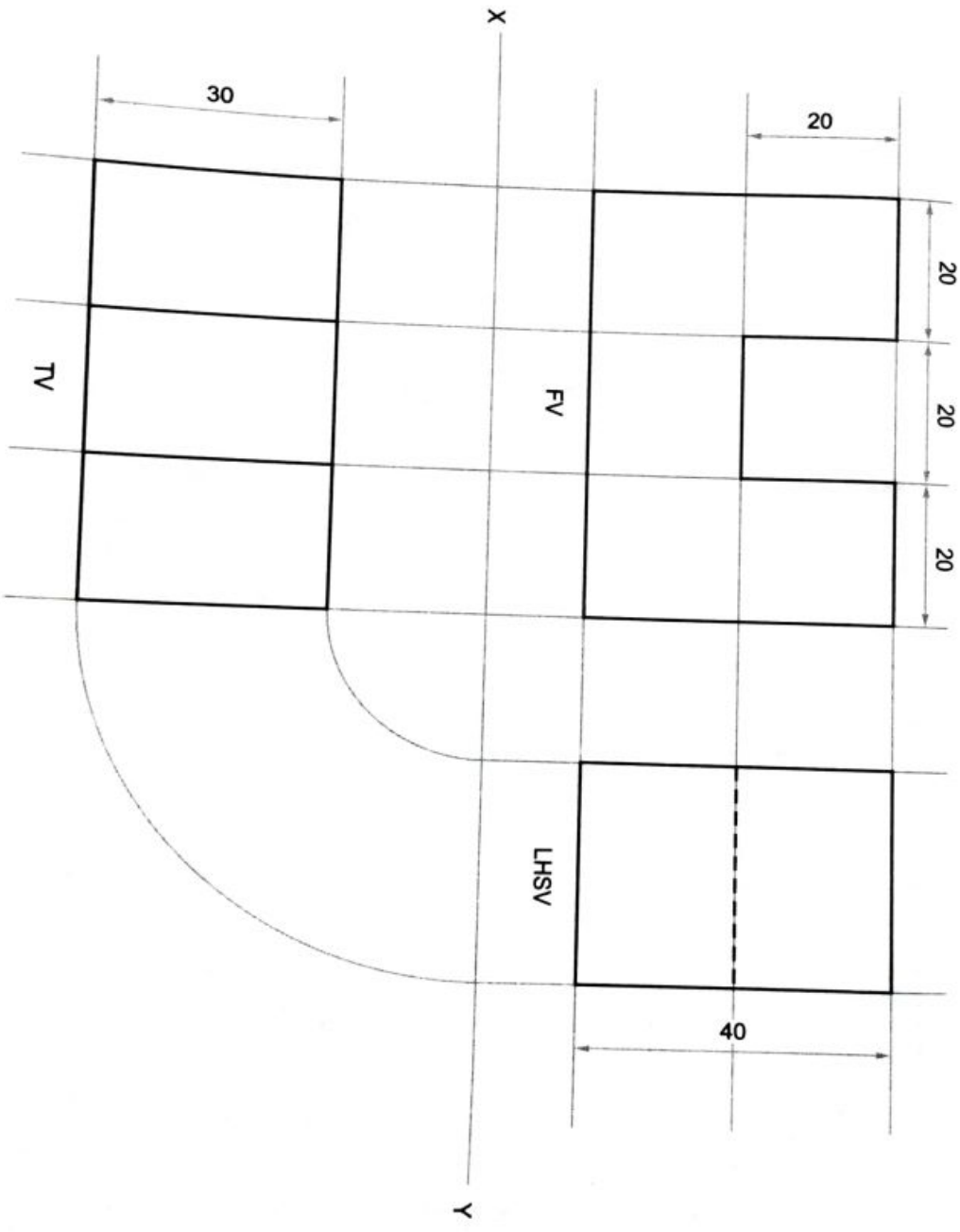
13) No need to show dotted lines in sectional views.

14) When dimensions are very large or small then use appropriate scale and draw the views.

Ex. 4.24.1 : ***The figure shows pictorial view of an object. Using first angle method of projection draw. a) FV in the direction of X. b) Left hand side view c) Top view***

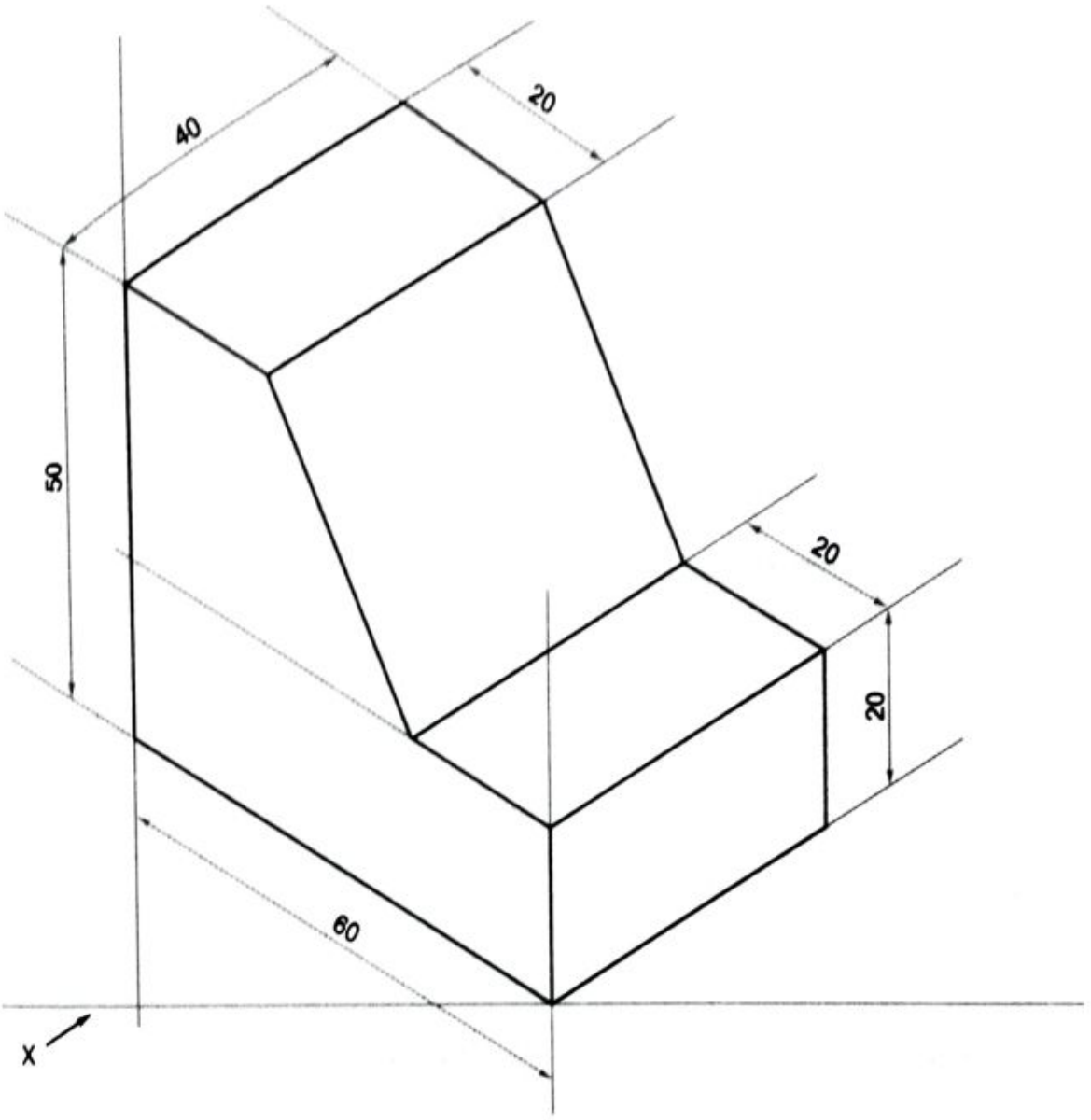


Sol. :

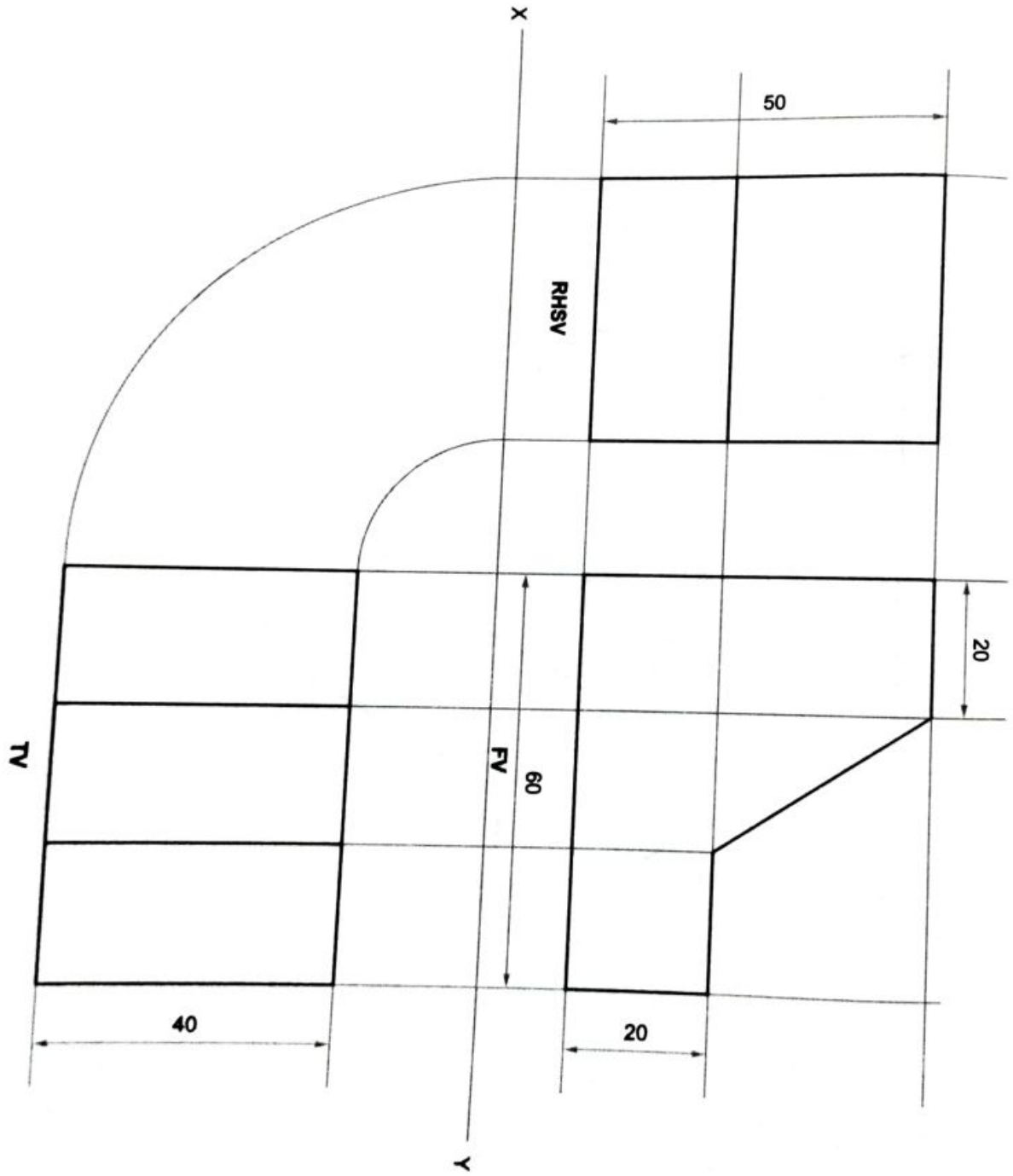


Ex. 4.24.2 : The figure shows pictorial view of an object. Using first angle method of projection draw. a) FV in the direction of X. b) Right hand side view c) Top view

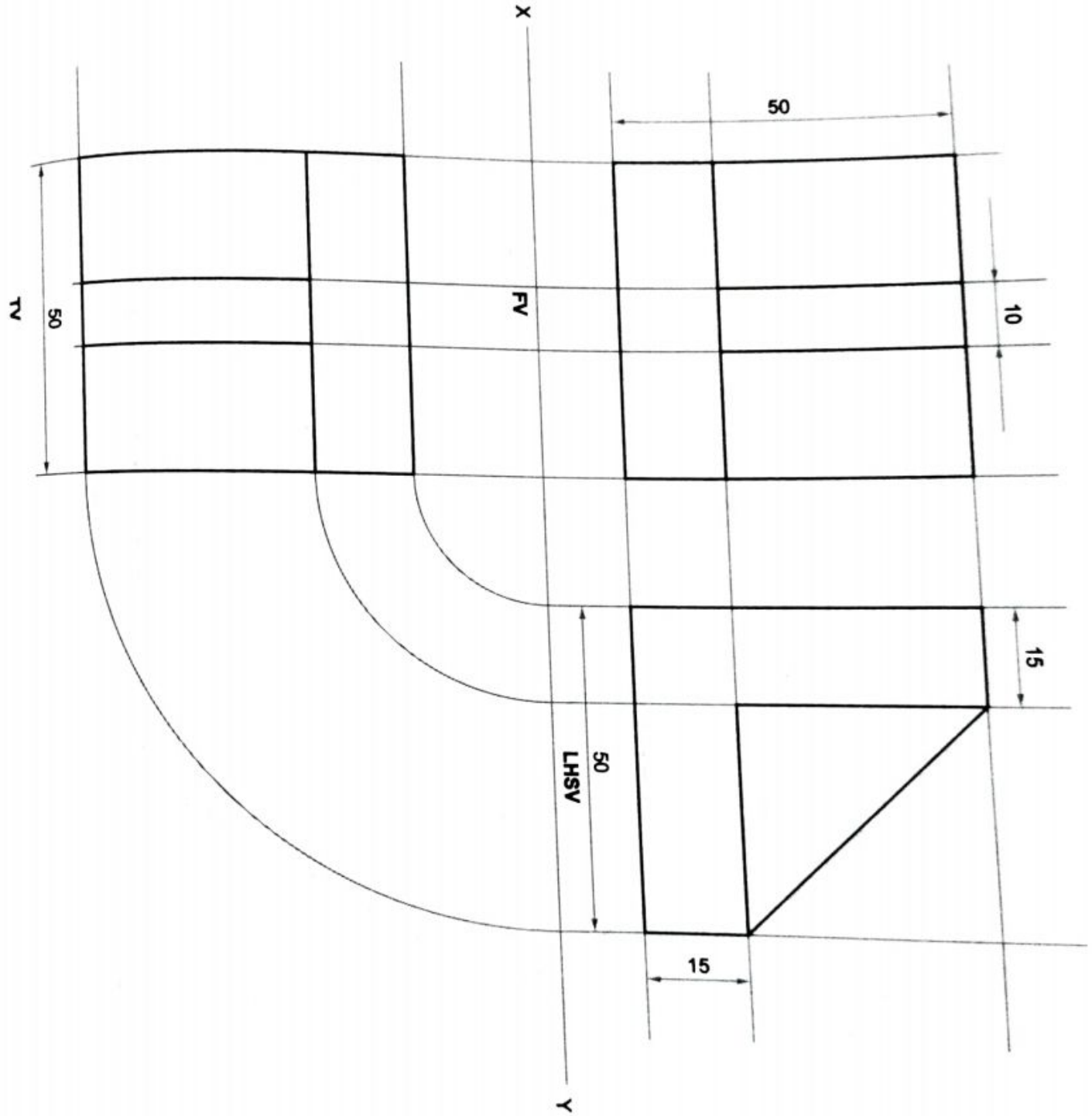
Sol. :



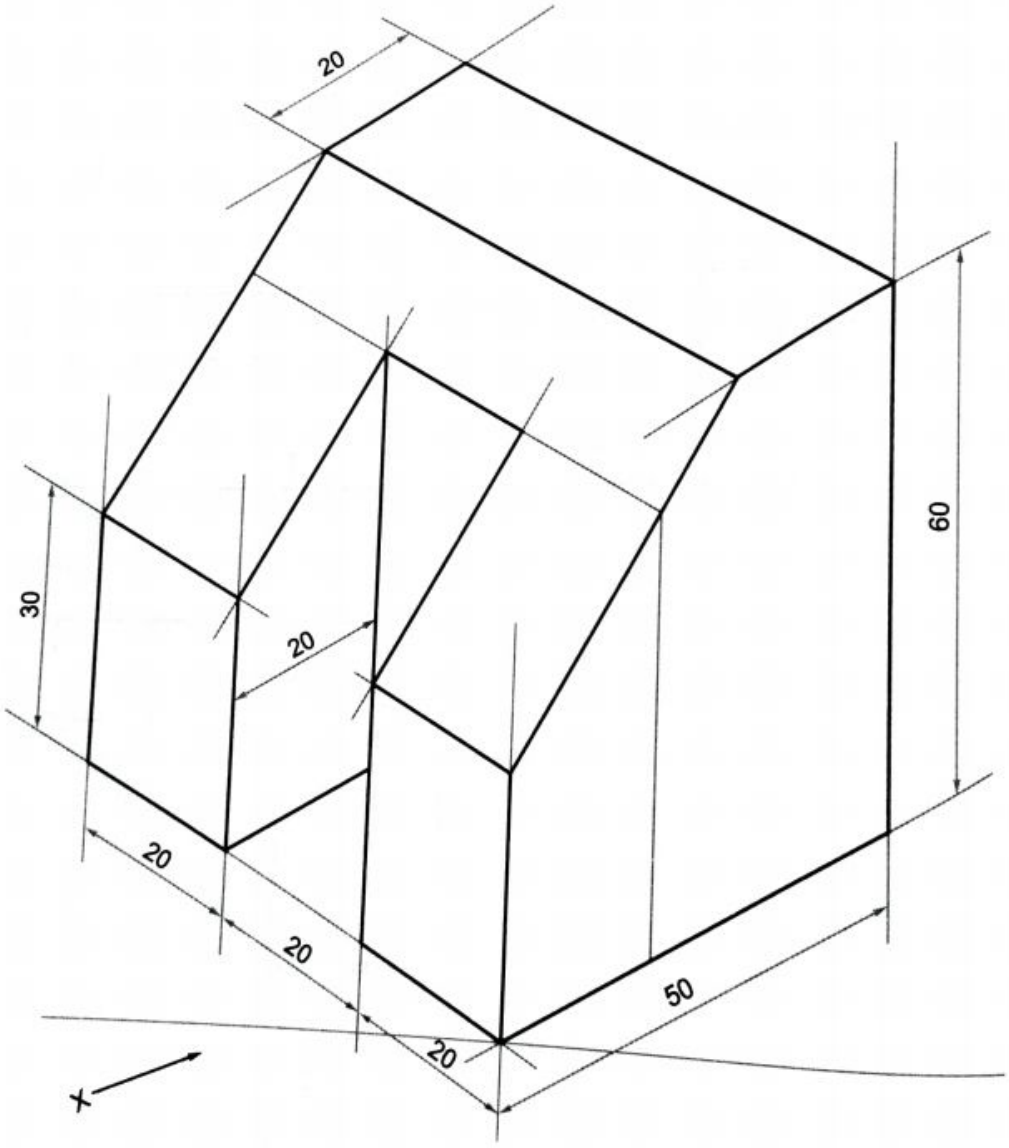
Ex. 4.24.3 : ***The figure shows pictorial view of an object. Using first angle method of projection draw, a) FV in the direction of X. b) Left hand side view c) Top view***



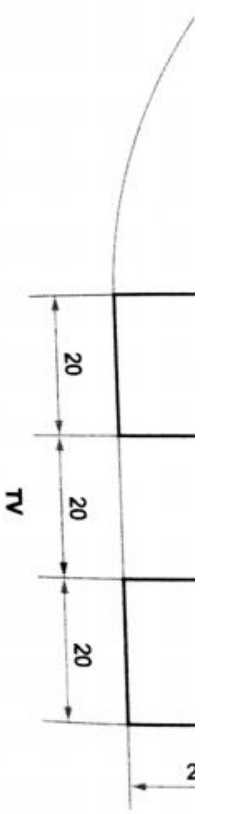
Sol. :



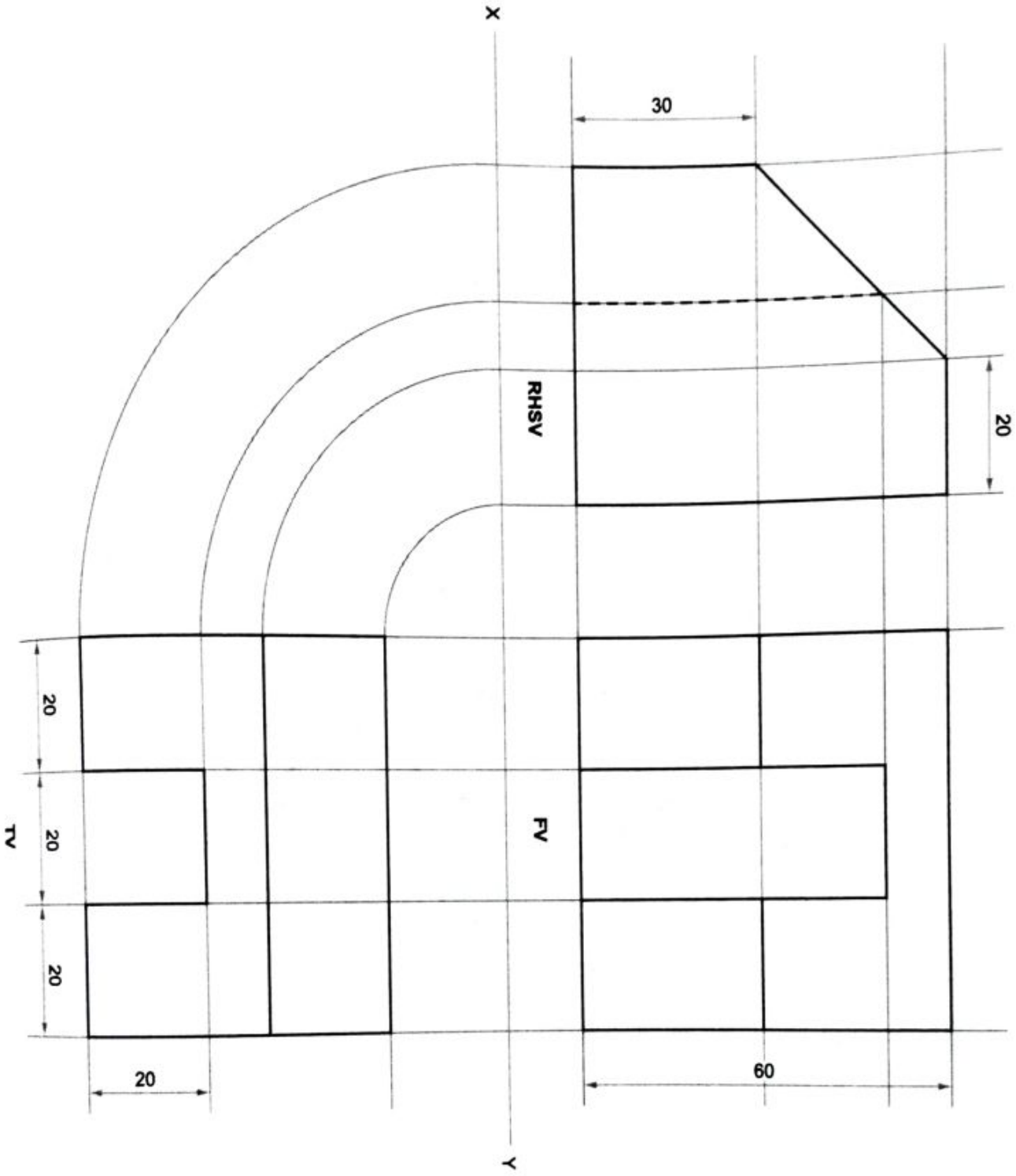
Ex. 4.24.4 : *The figure shows pictorial view of an object. Using first angle method of projection draw.*
a) FV in the direction of X. b) Right hand side view c) Top view



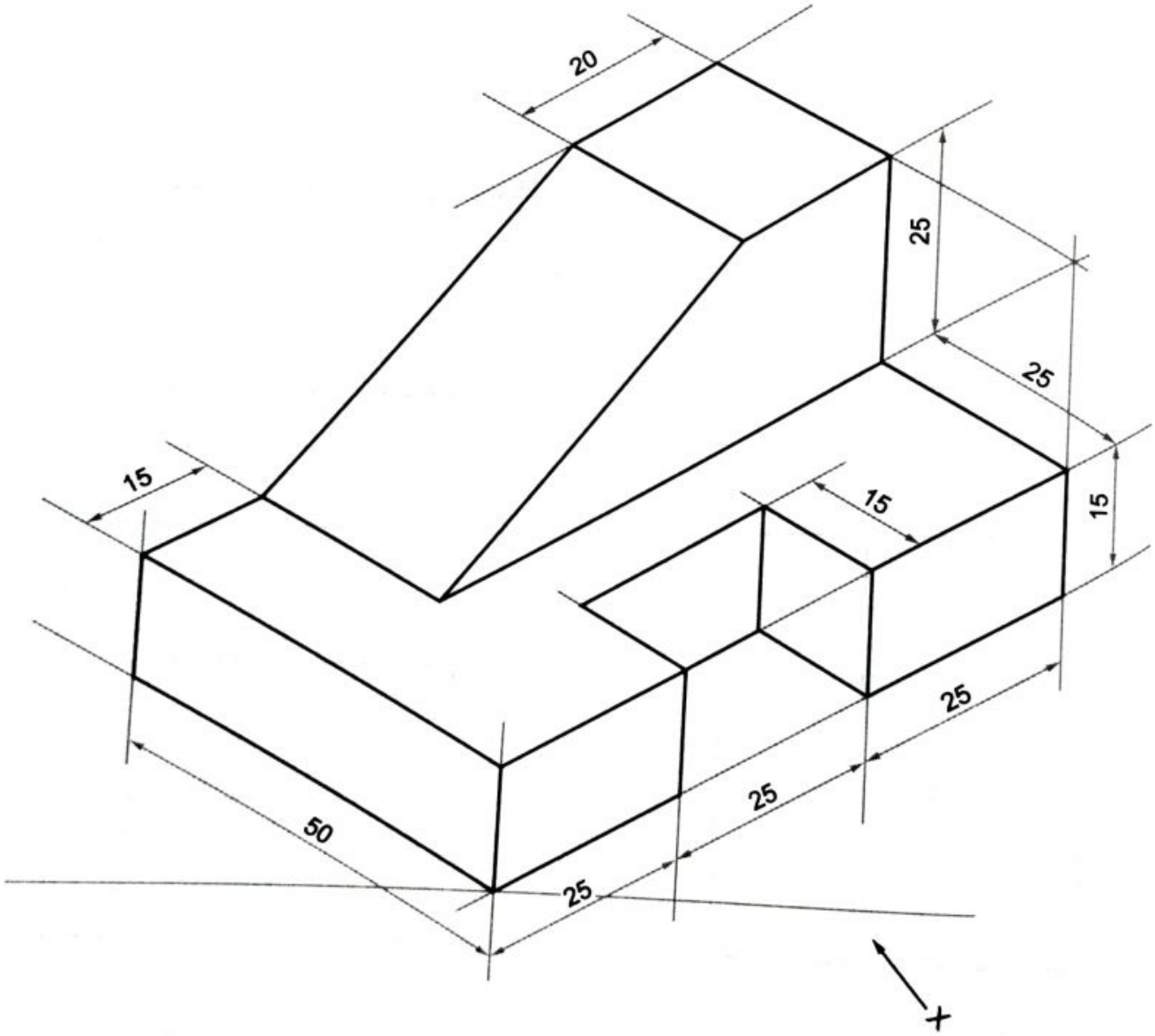
Sol. :



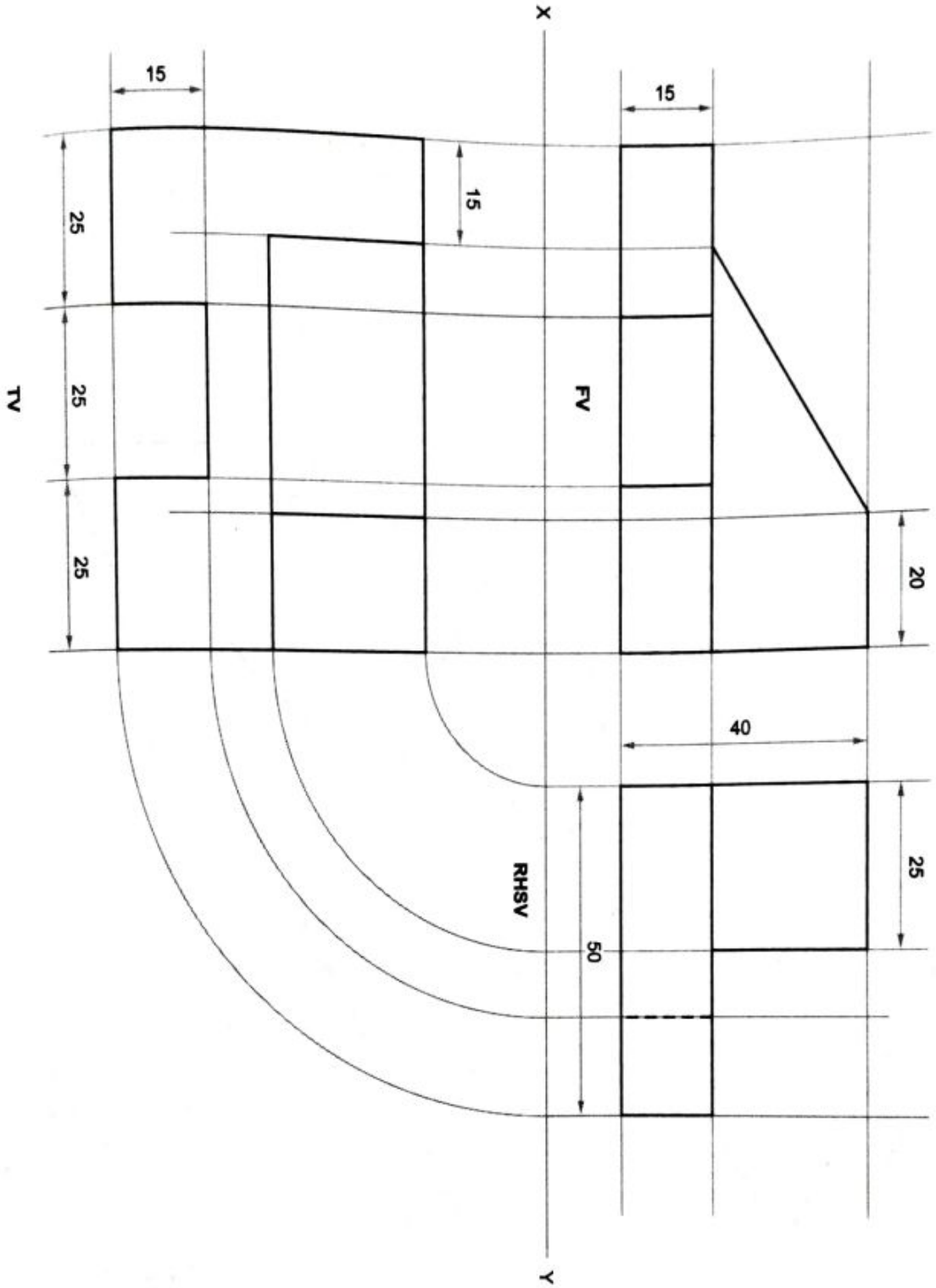
Sol :



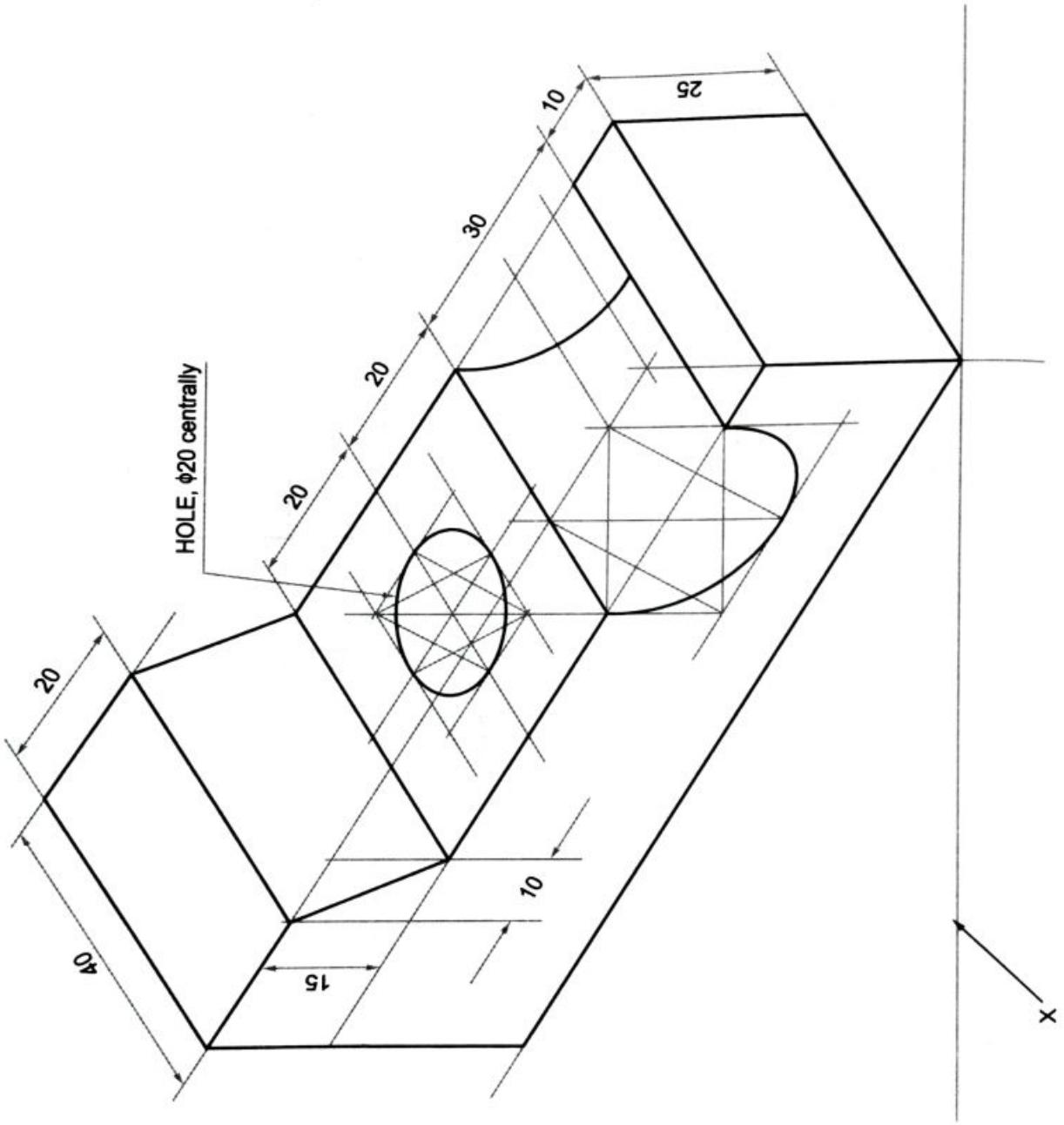
Ex. 4.24.5 : ***The figure shows pictorial view of an object. Using first angle method of projection draw. a) FV in the direction of X. b) Left hand side view c) Top view***



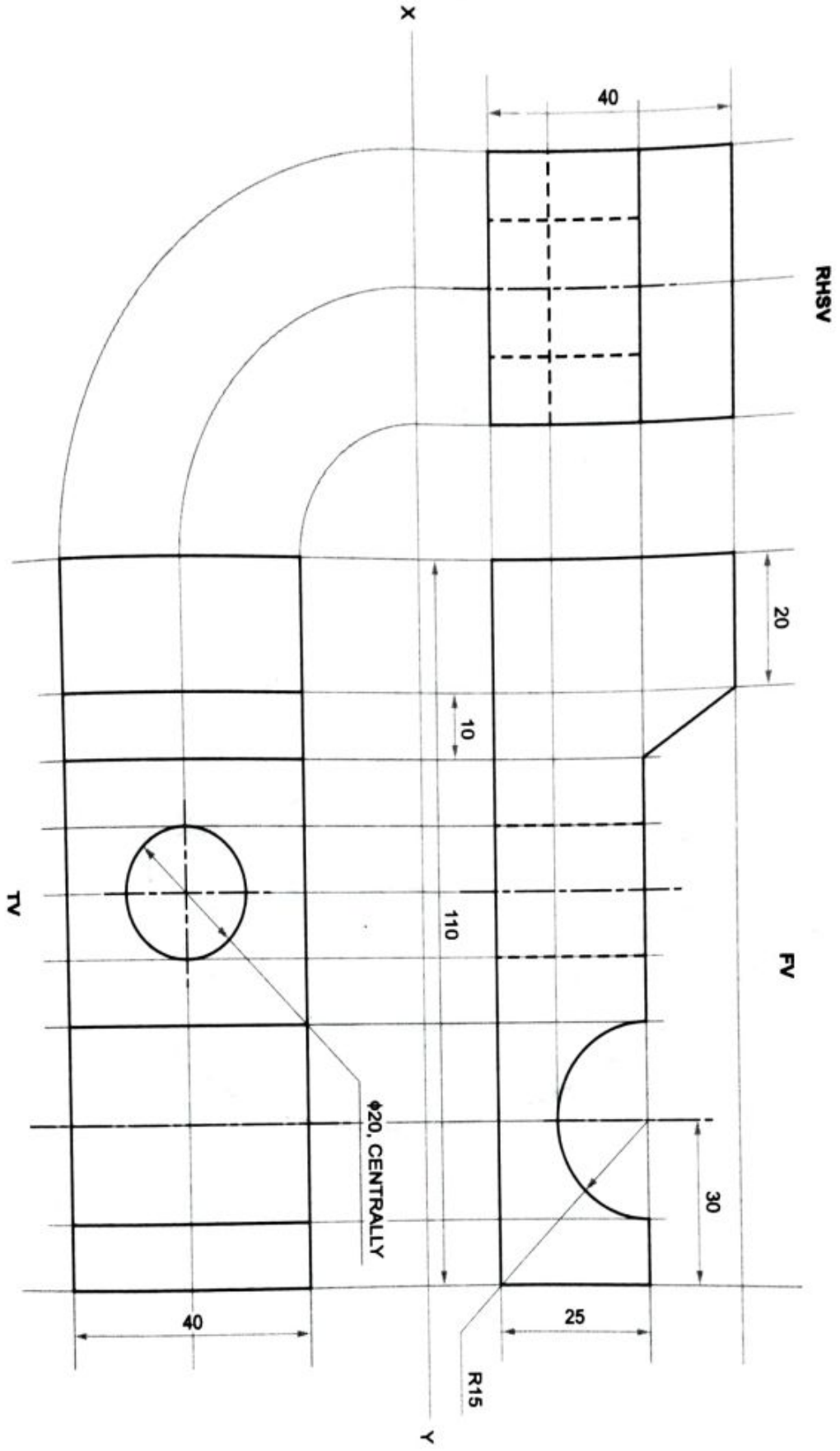
Sol. :



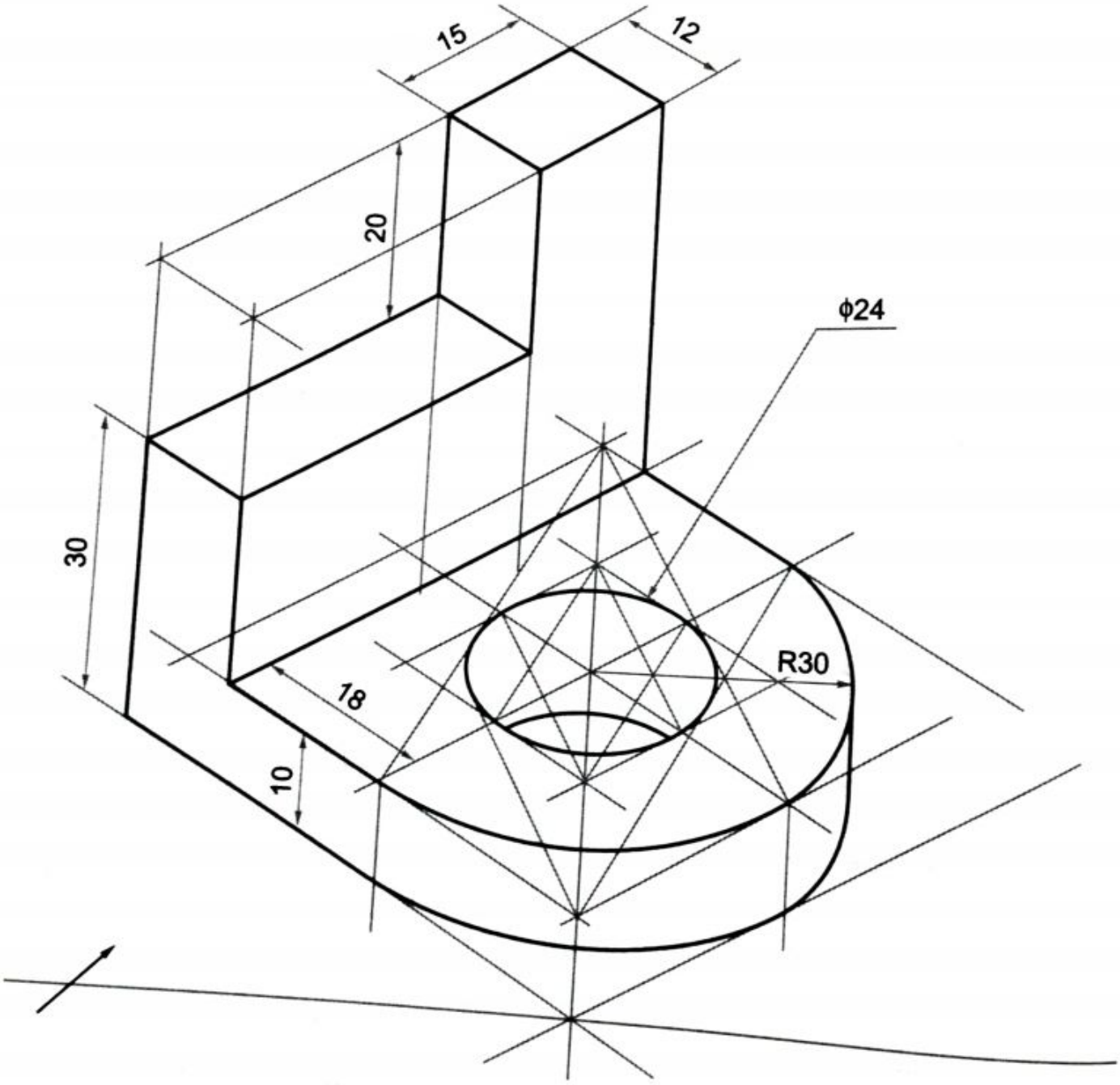
Ex. 4.24.6 : ***The figure shows pictorial view of an object. Using first angle method of projection draw. a) FV in the direction of X. b) Right hand side view c) Top view***



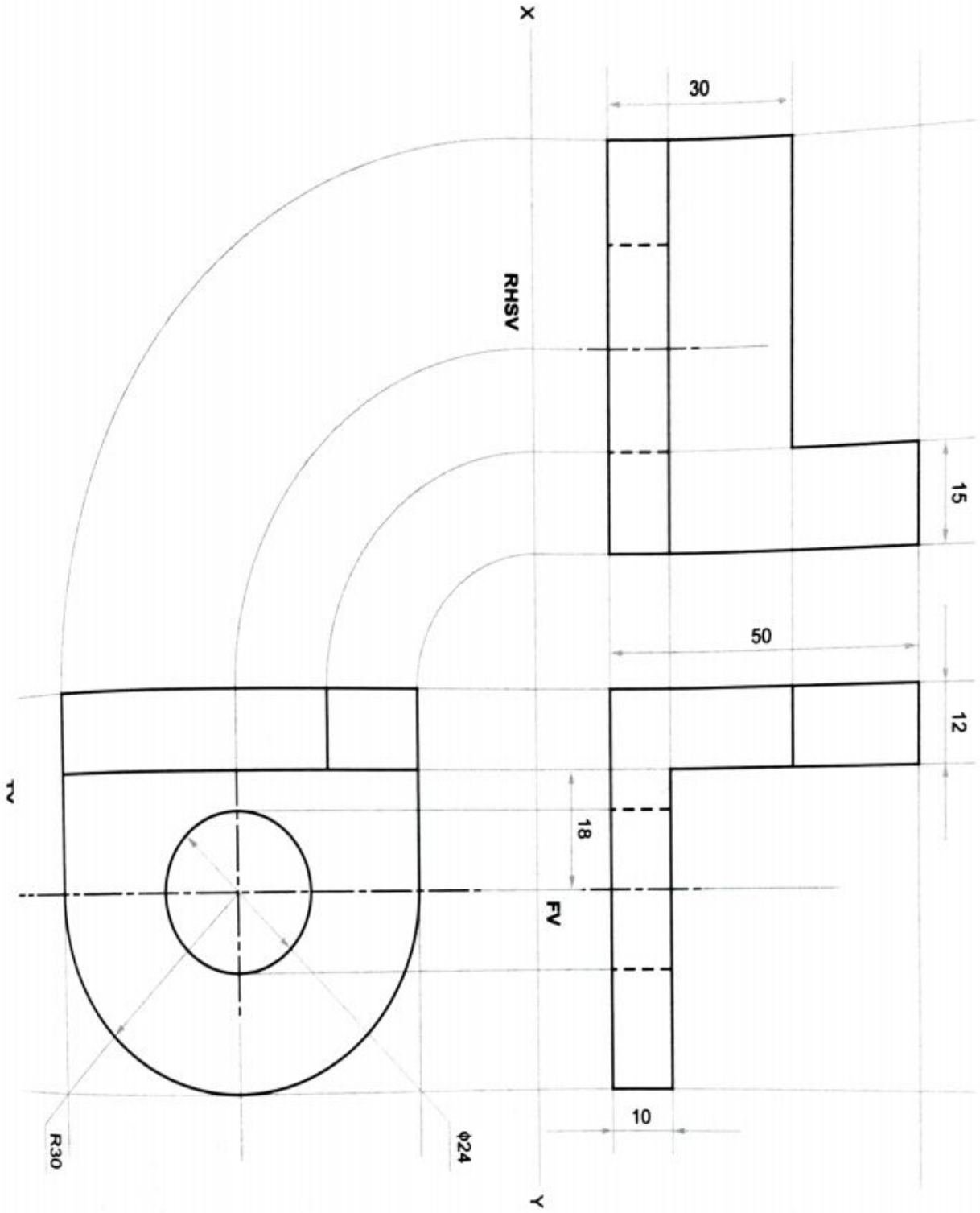
Sol. :



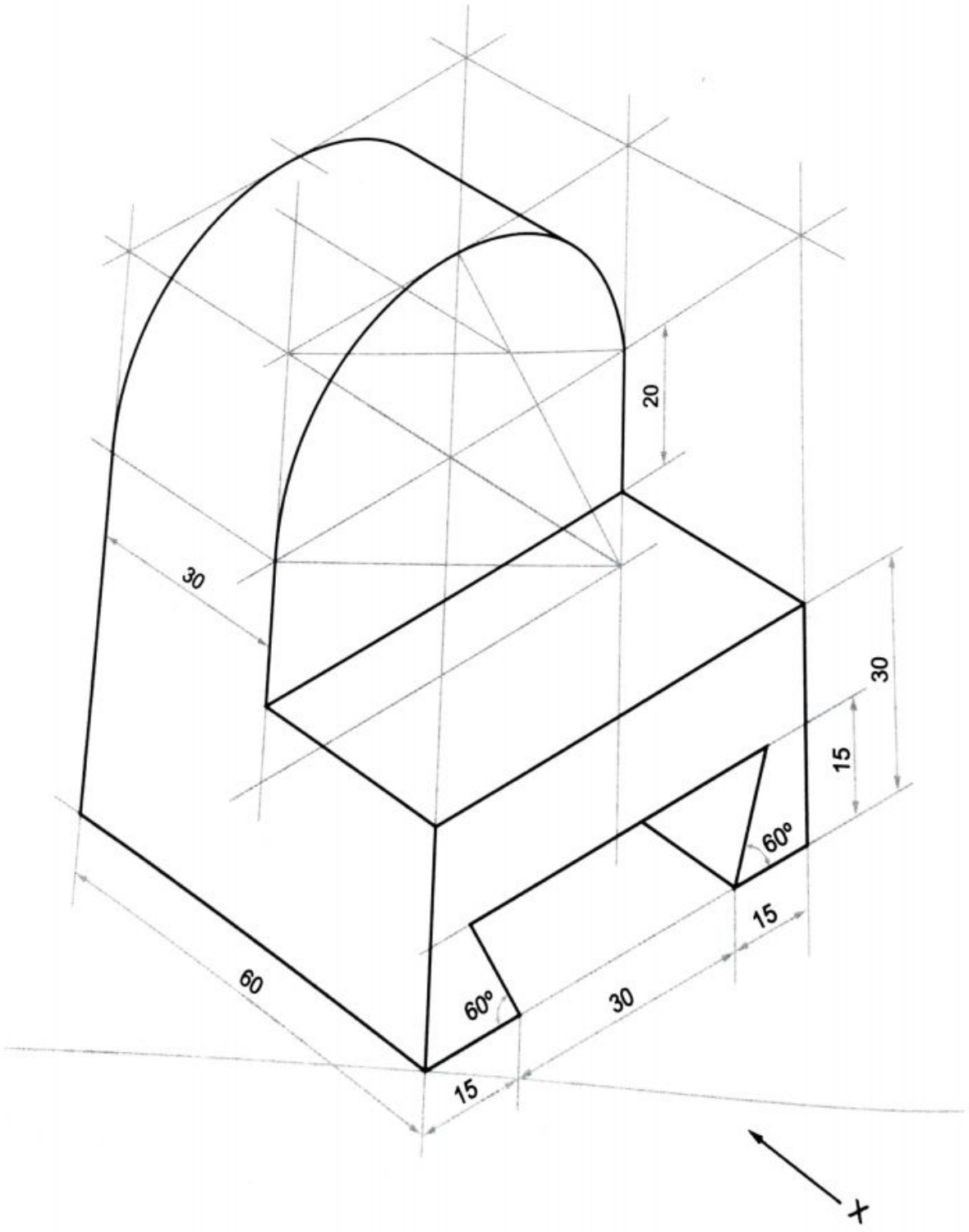
Ex. 4.24.7 : ***The pictorial view of an objection is shown in figure.***
a) FV of X. b) TV c) RHSV



...ale : [To the scale]

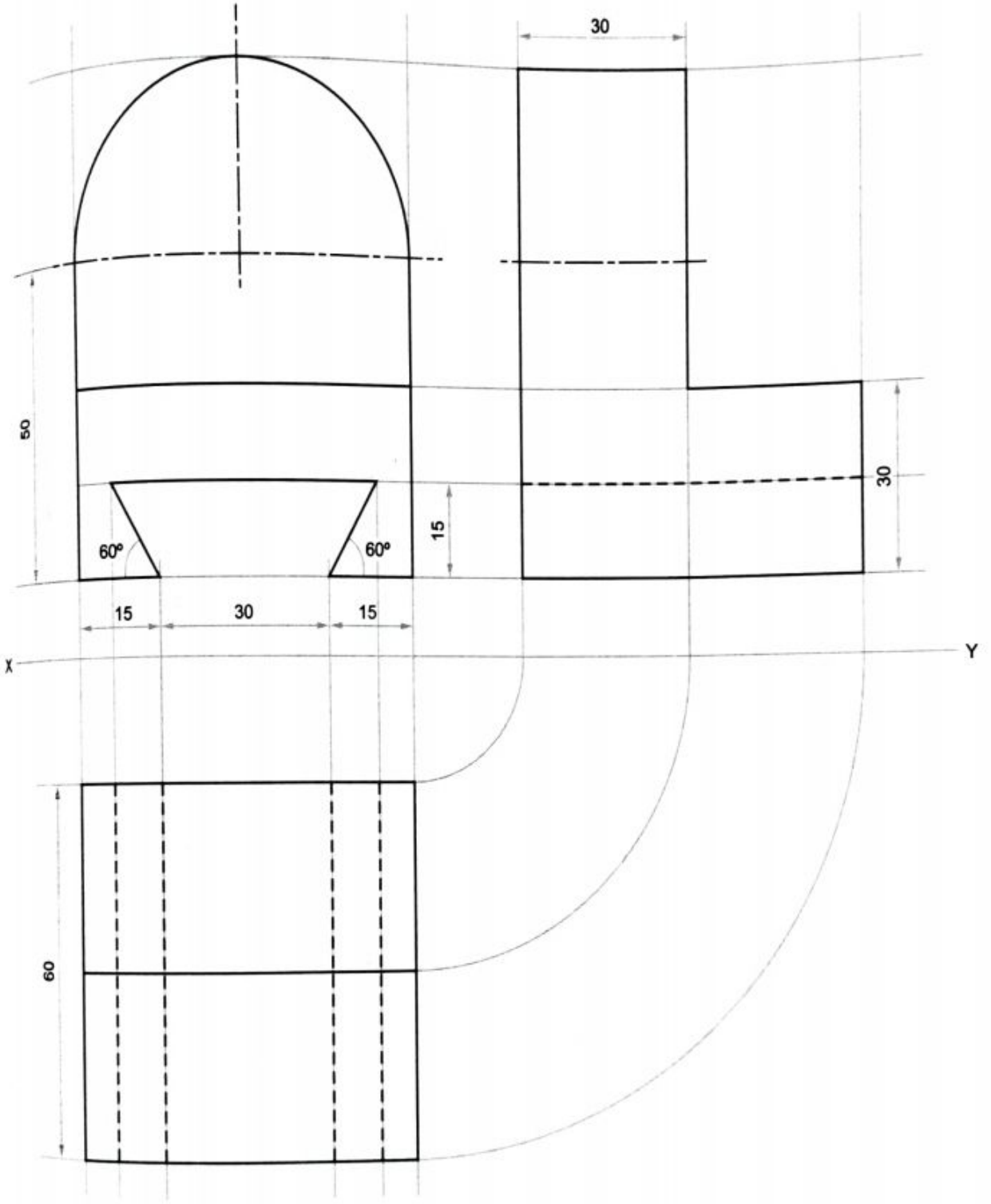


Ex. 4.24.8 : *The figure shows pictorial view of an object. Using first angle method*
a) FV b) Left hand side view c) Top view

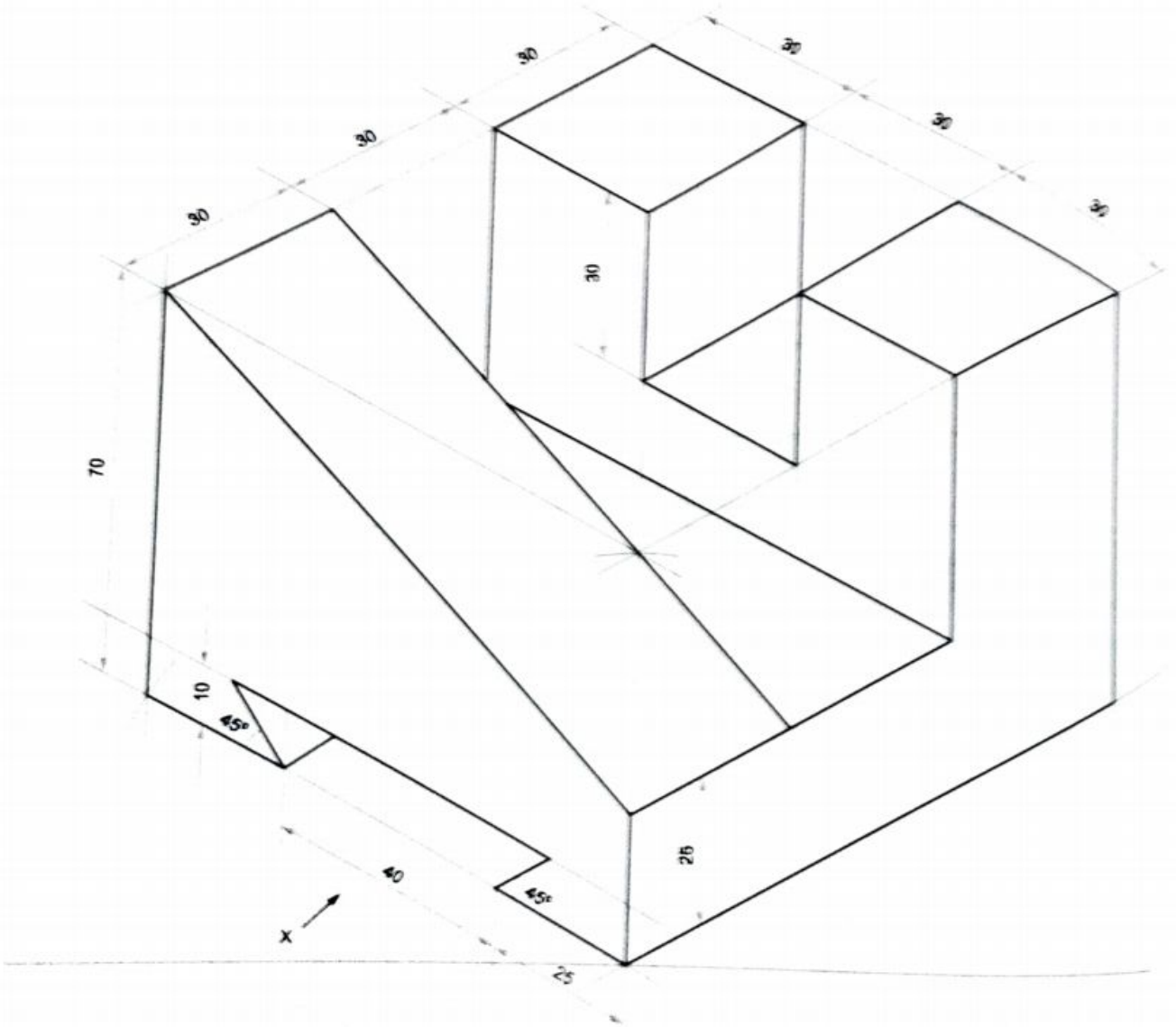




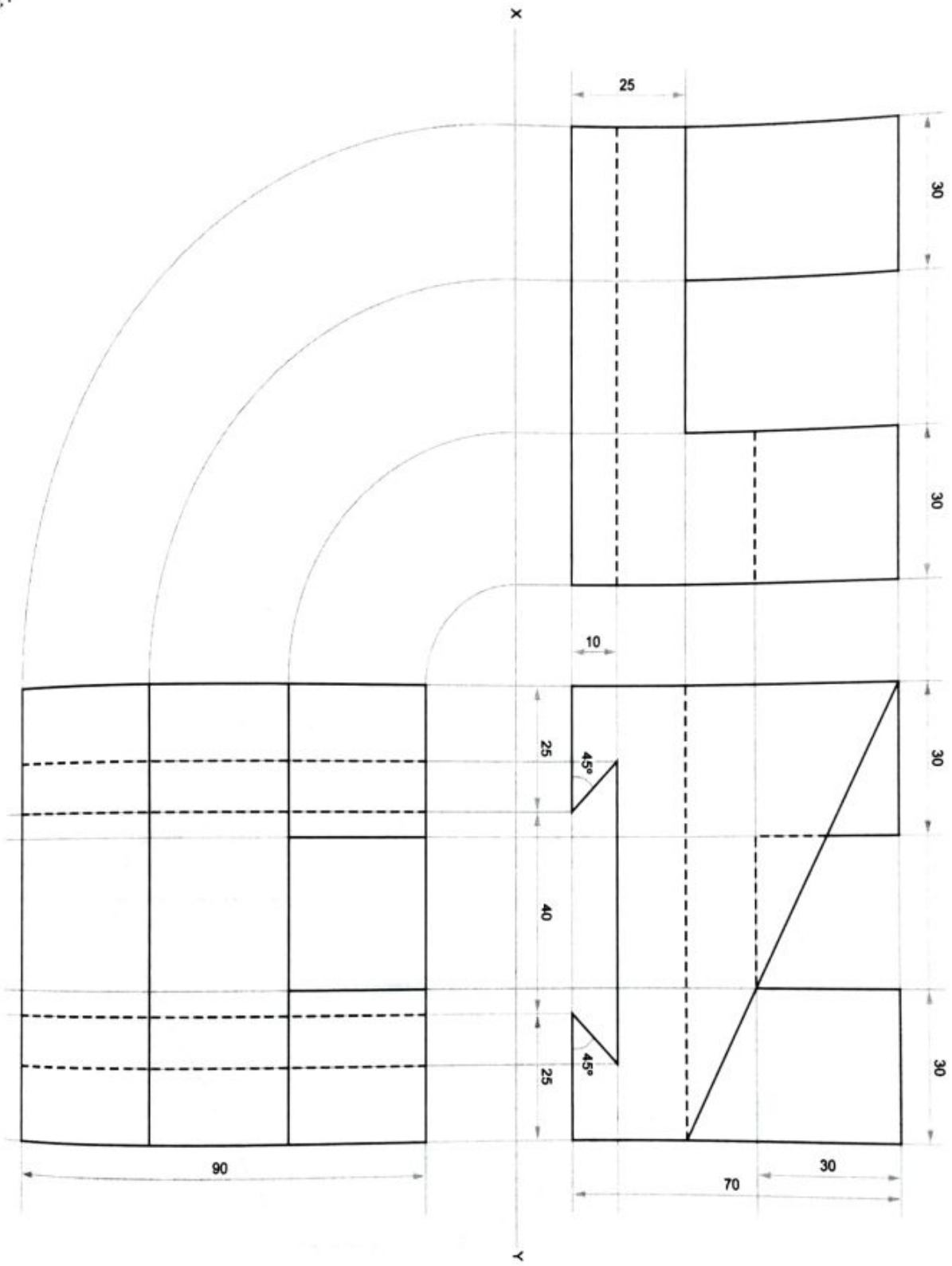
Sol. :



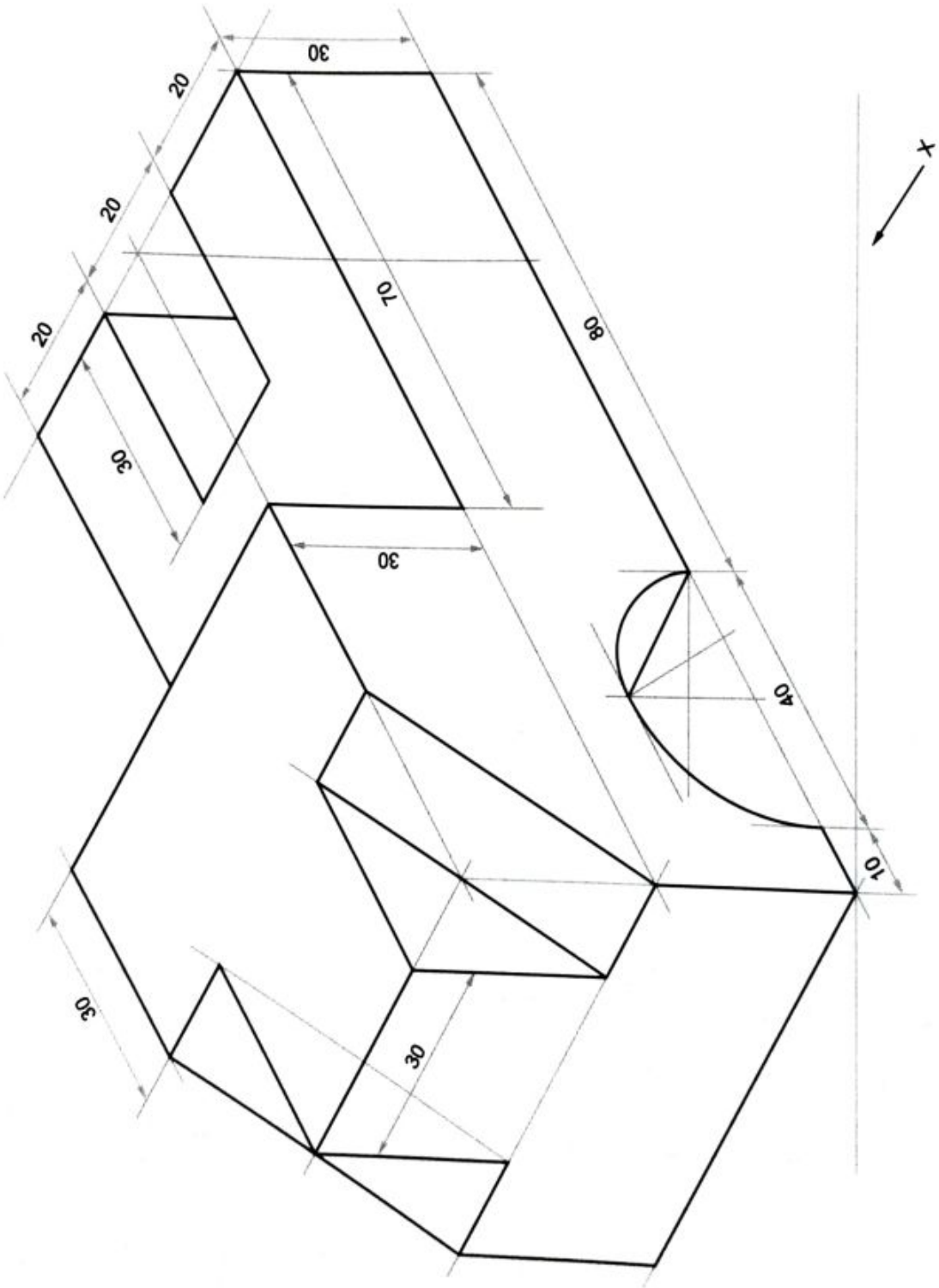
Ex. 4.24.9 : *The figure shows pictorial view of an object. Using first angle method of projection draw.*
a) FV b) Right hand side view c) Top view



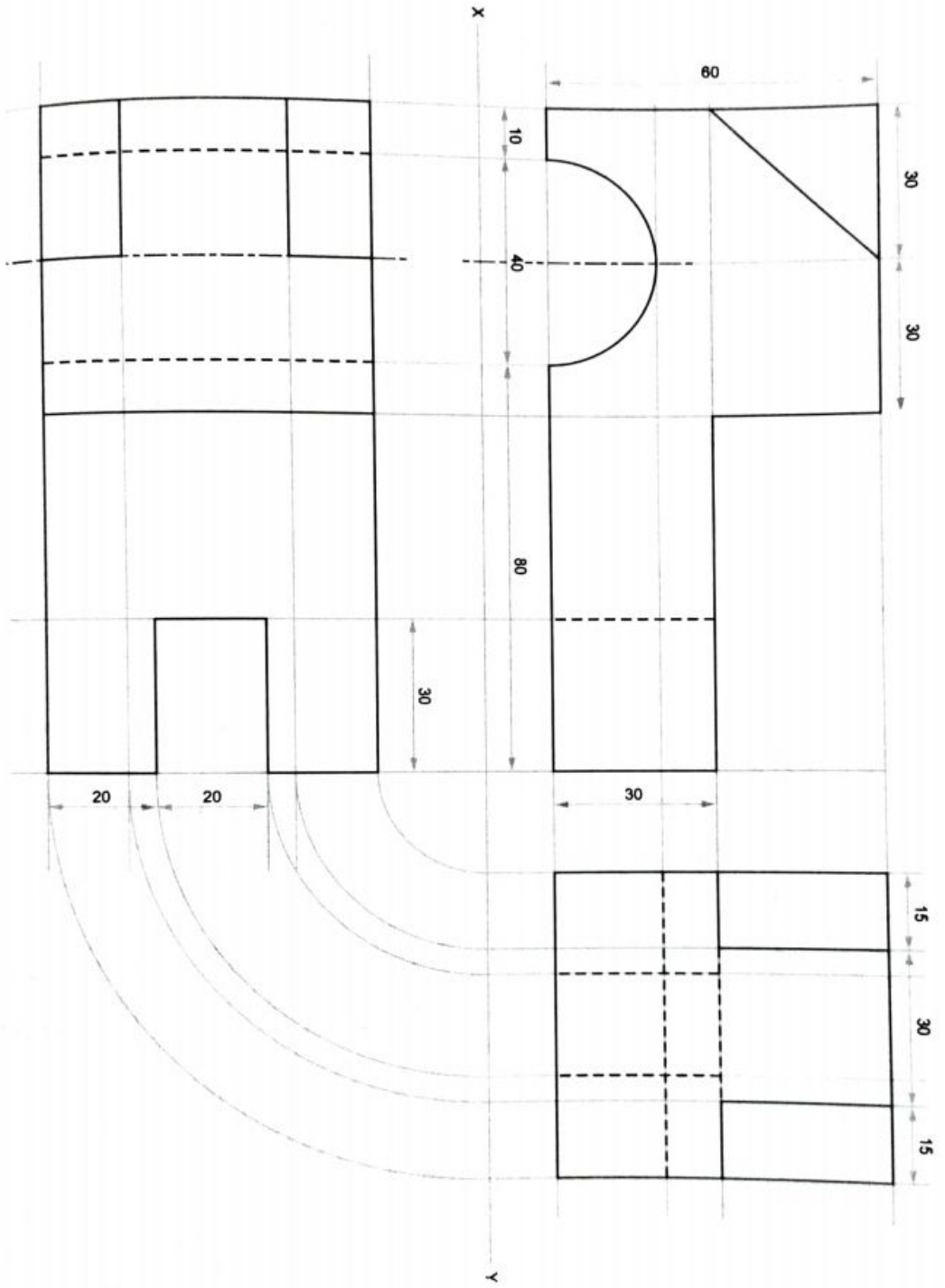
Sol. :



Ex. 4.2410 : ***The figure shows pictorial view of an object. Using first angle method of projection draw.***
a) FV b) Left hand side view c) Top view



Sol. :



B) Sectional Orthographic Projections

4.25 : Sectional Views

In general, orthographic projection gives F.V., T.V. and S.V. which includes unseen (internal detail) parts in the form of hidden lines. Sometimes, it is essential to know internal parts details clearly which are unseen in normal views.

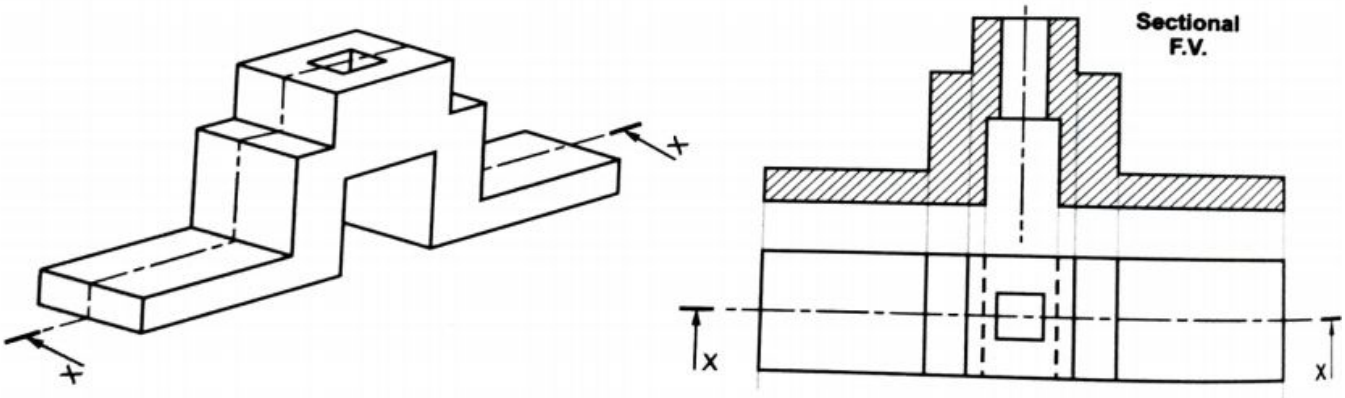
Hences an imaginary cutting plane or section plane is assumed to virtually remove half or cut section part of object to get clear visibility of internal details.

Sectional view changes are applicable to any one view i.e. F.V. or T.V. or S.V. and remaining two views remain unchanged as earlier. The portion cut by section plane (necessarily solid portion) is indicated by drawing hatched lines in it. Hatched lines are approximately drawn equi-spaced and at 45° to any border line of an object. Section lines are not shown in thin section resulted after cutting plane.

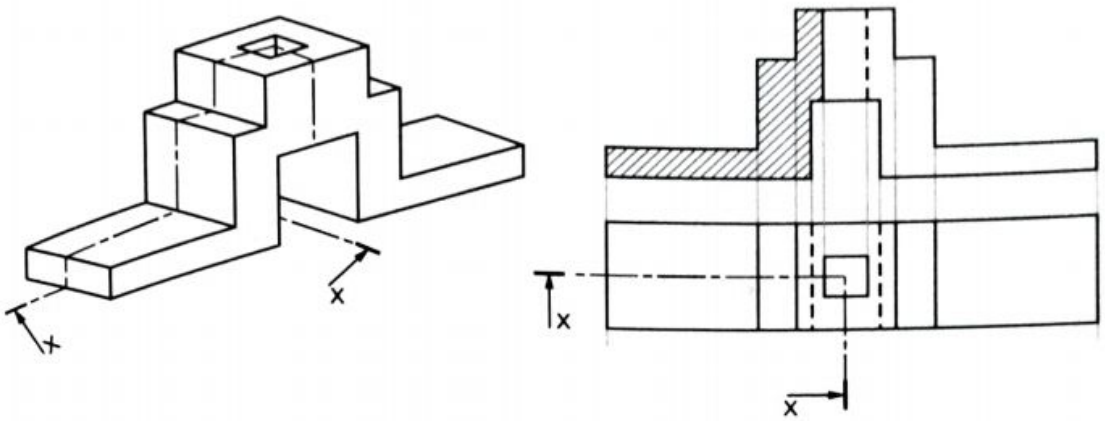
4.25.1 Types of Sectional Planes

4.25.1.1 Full Sectional View Plane

Example :



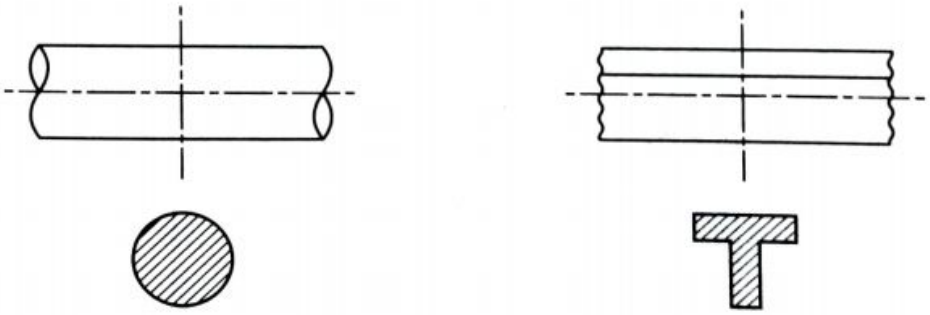
4.25.1.2 Half Sectional View Plane



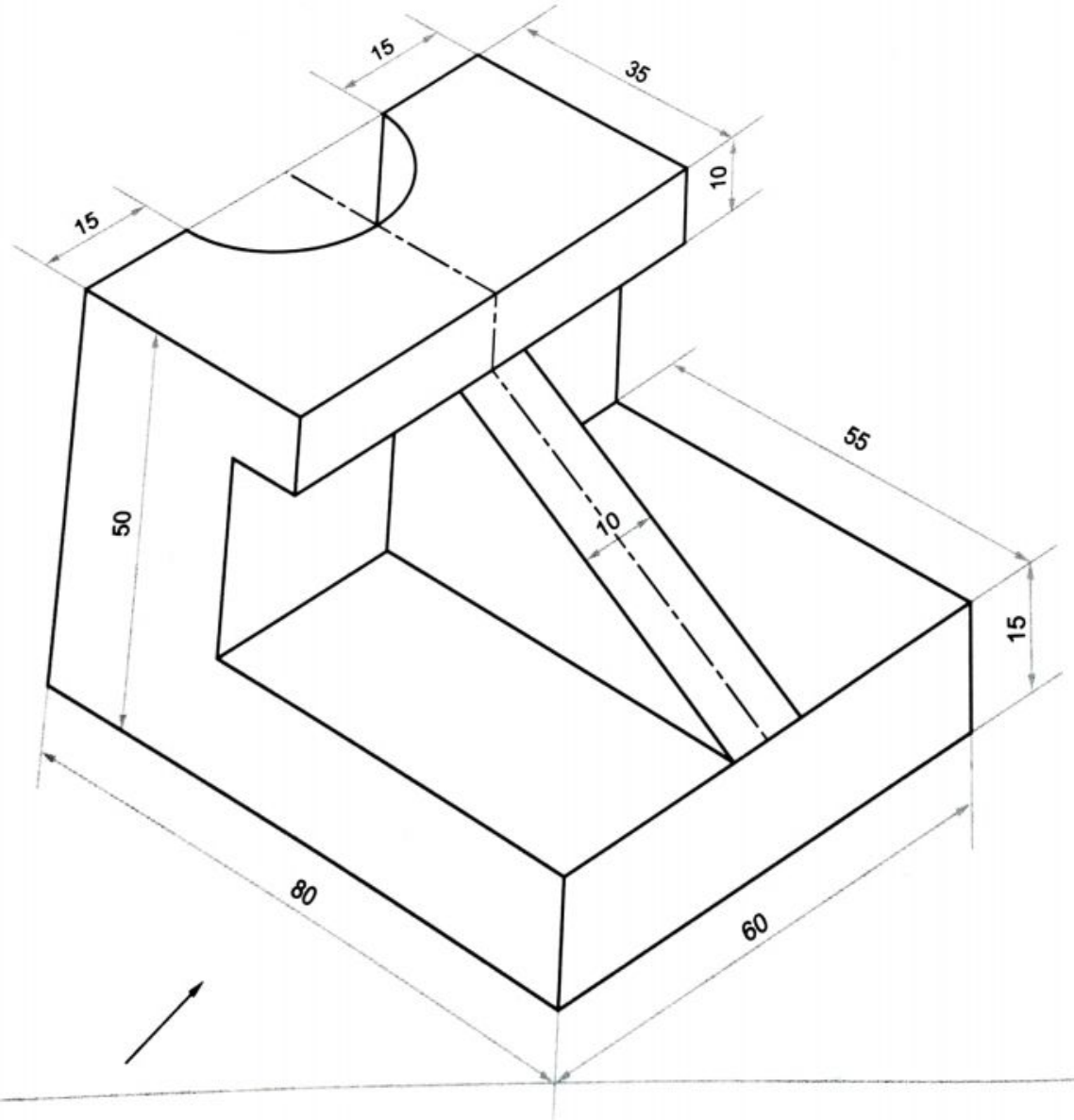
4.25.2 Revolved Section



4.25.3 Removed Section

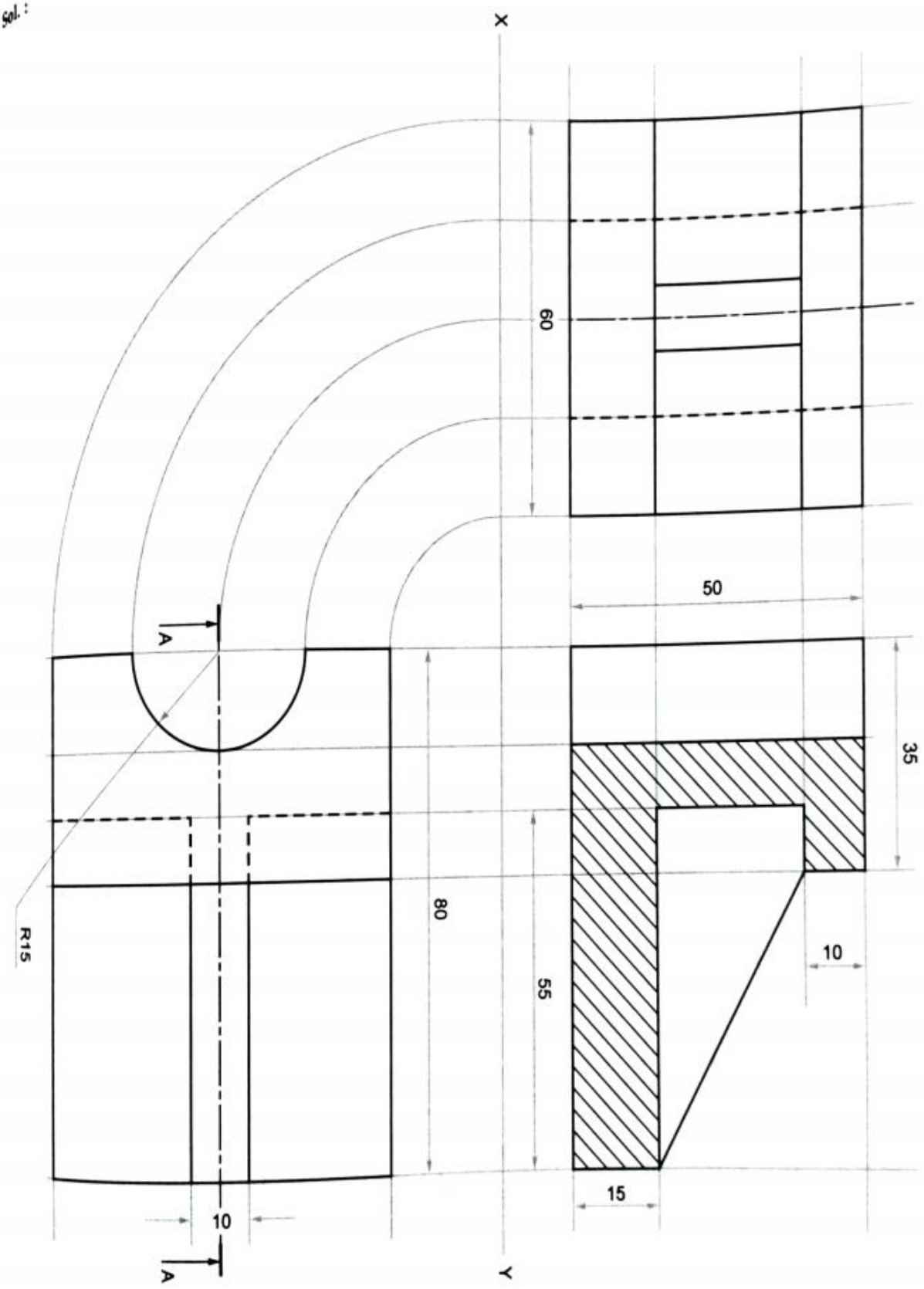


ii) Right hand side view iii) Top view iv) Dimensions



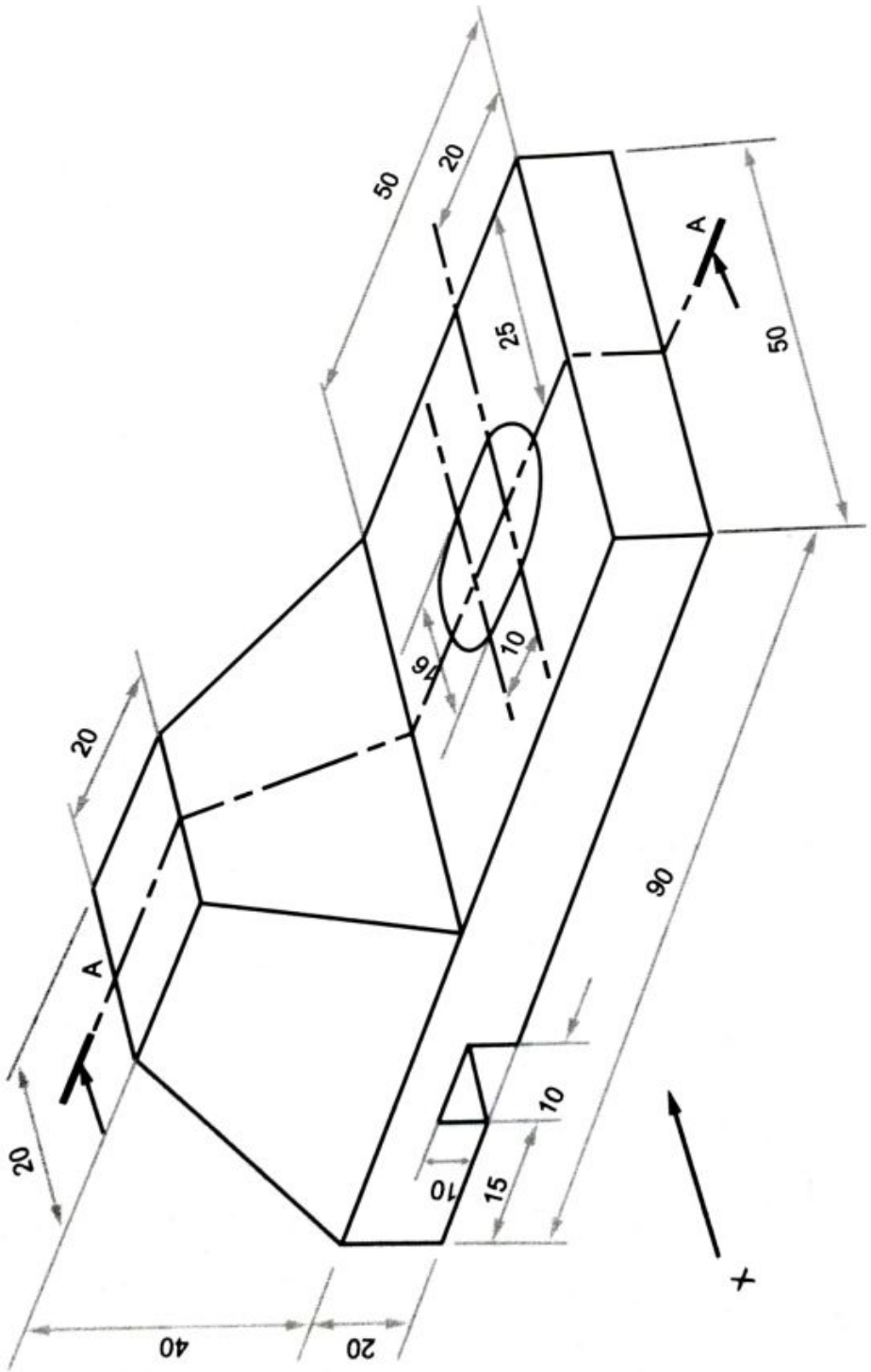
R15

Sol. :



Ex. 4.25.2 : ***Figure shows a pictorial view of an object. By using first angle method of projection draw.***
i) Sectional front view, along symmetry of object
ii) Right hand side view iii) Top view iv) Dimensions

SPPU : Nov.-1



Sol. :

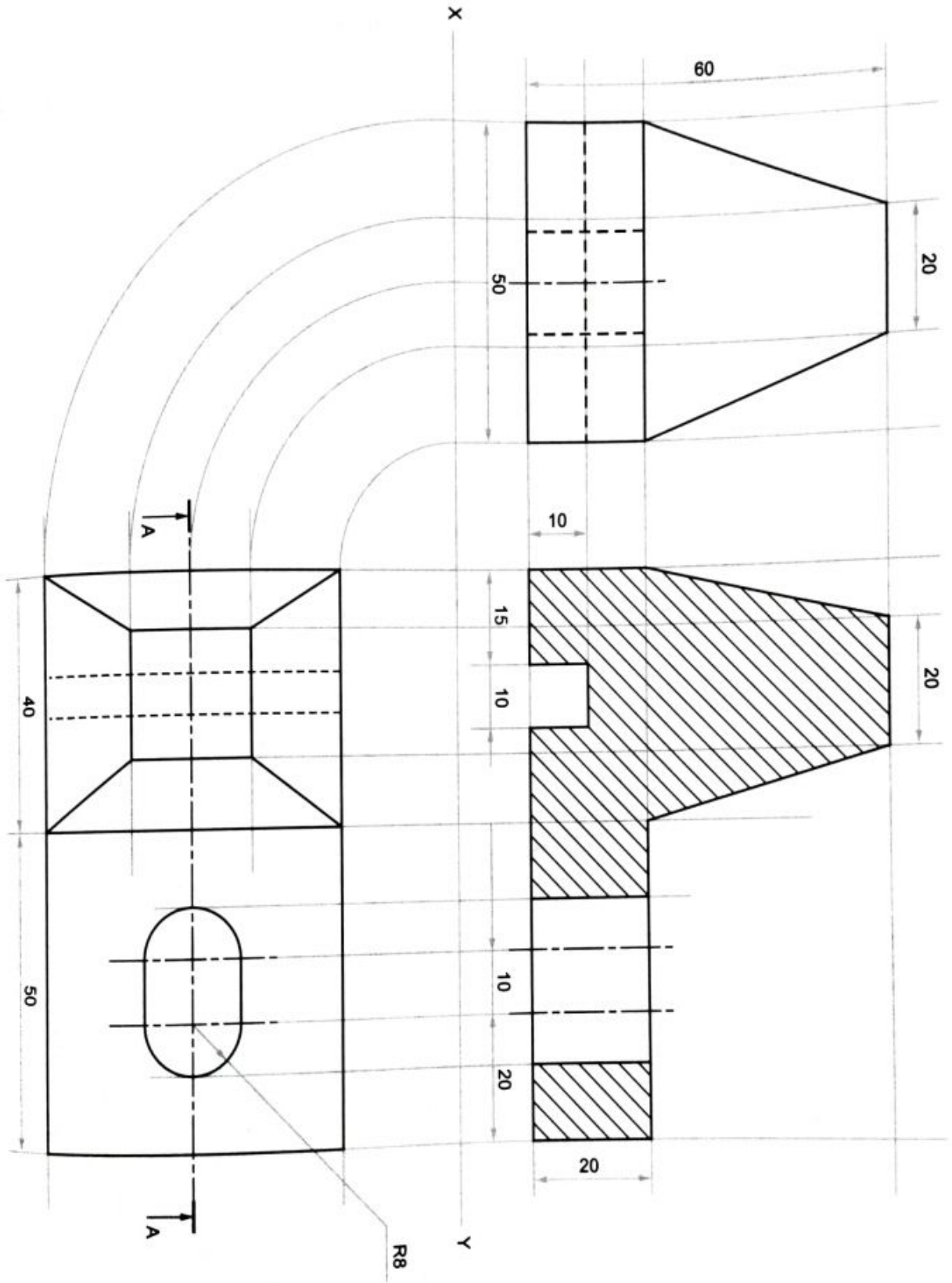
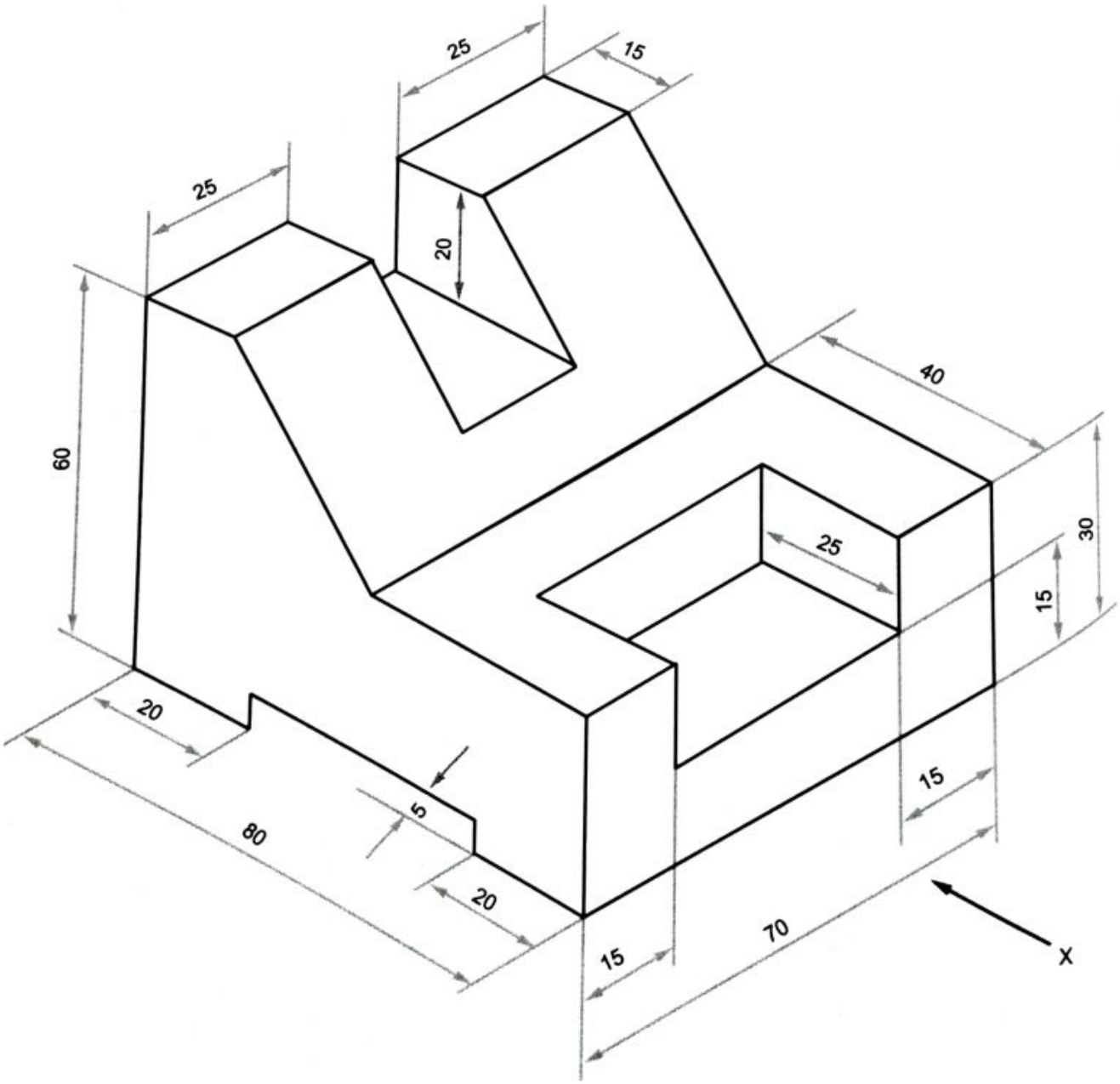


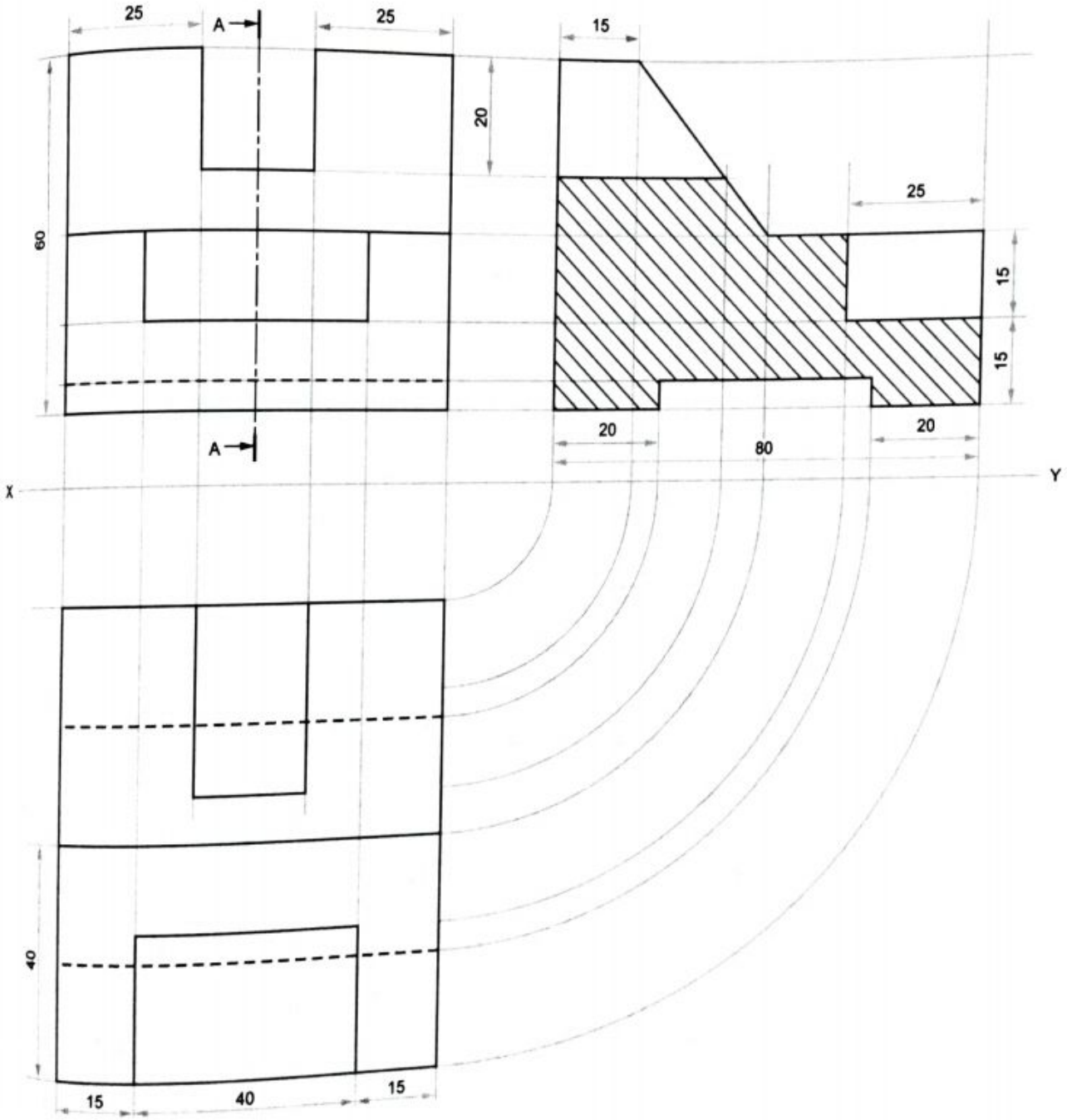
Fig 22

Ex. 4.25.3 : ***Figure shows a pictorial view of an object. By using first angle method of projection draw.***
i) Front view ii) Sectional left hand side view along symmetry of object
iii) Top view
Give all required dimensions.

SPPU : Dec.-13

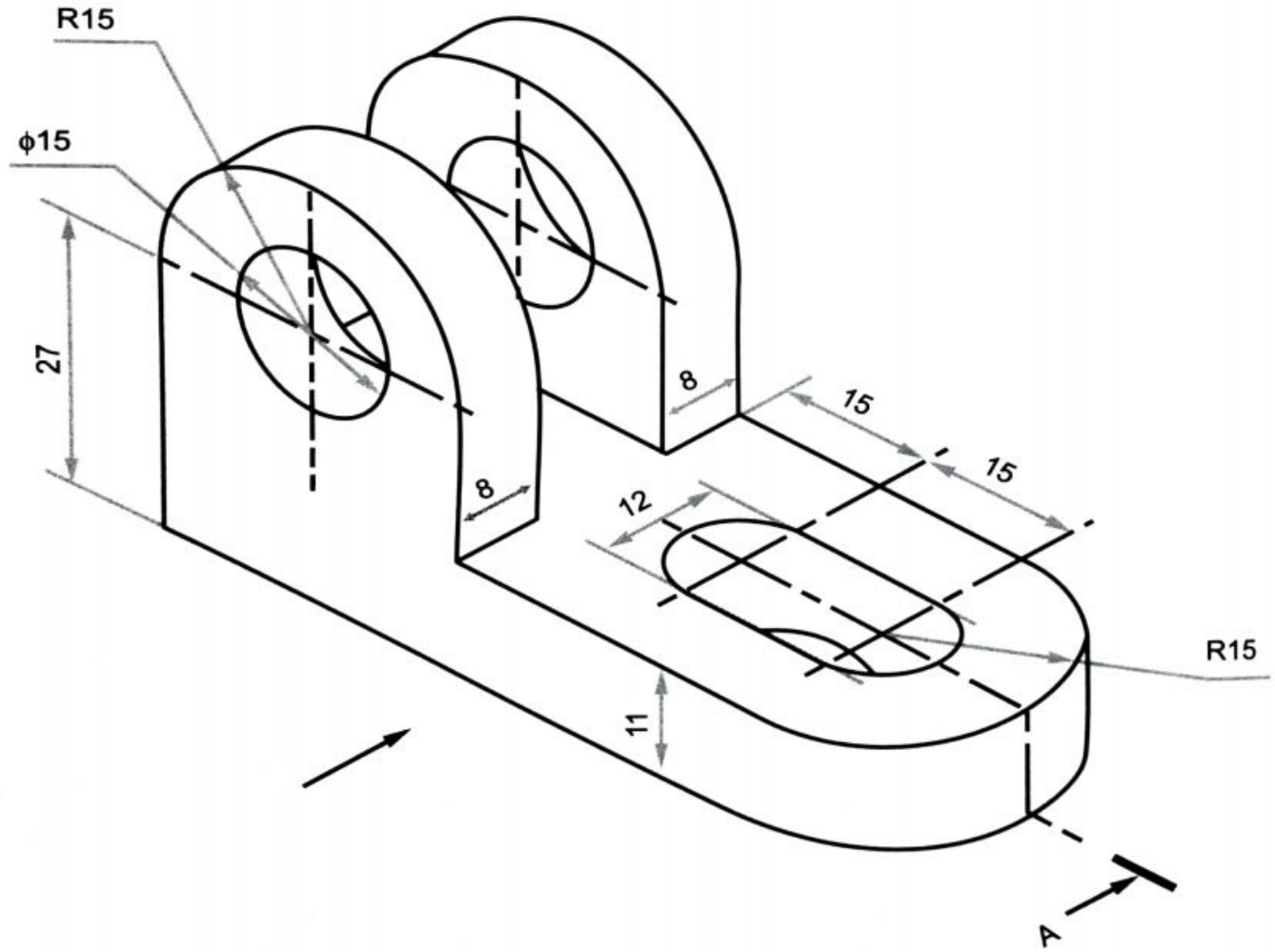


Sol. :

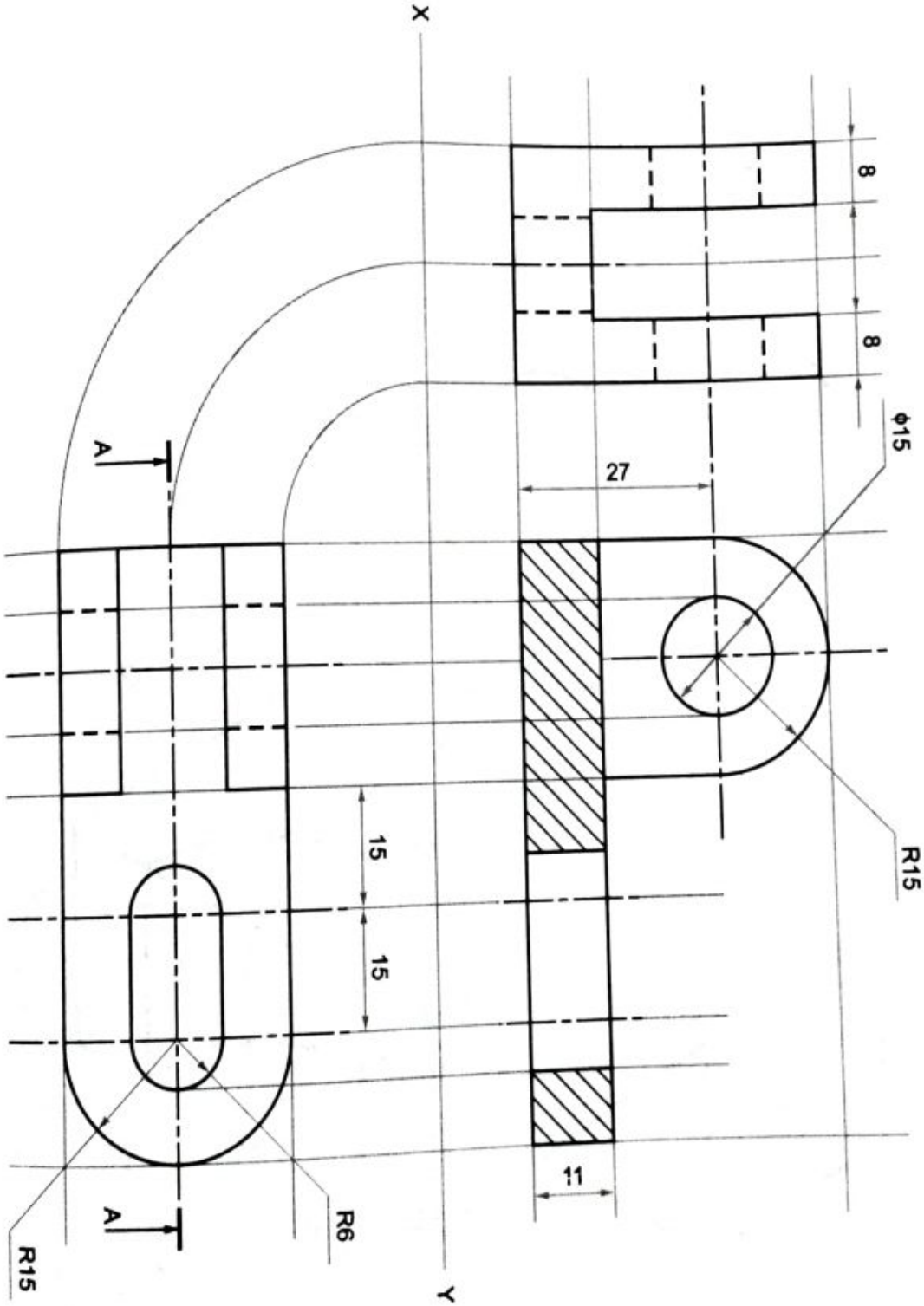


Ex. 4.25.4 : *The following figure shows a cast iron bracket. By using first angle projection method. Draw :*
i) Sectional left hand side view along symmetry of object ii) Top view
iii) RHSV
Give all the dimensions

SPPU : May-15

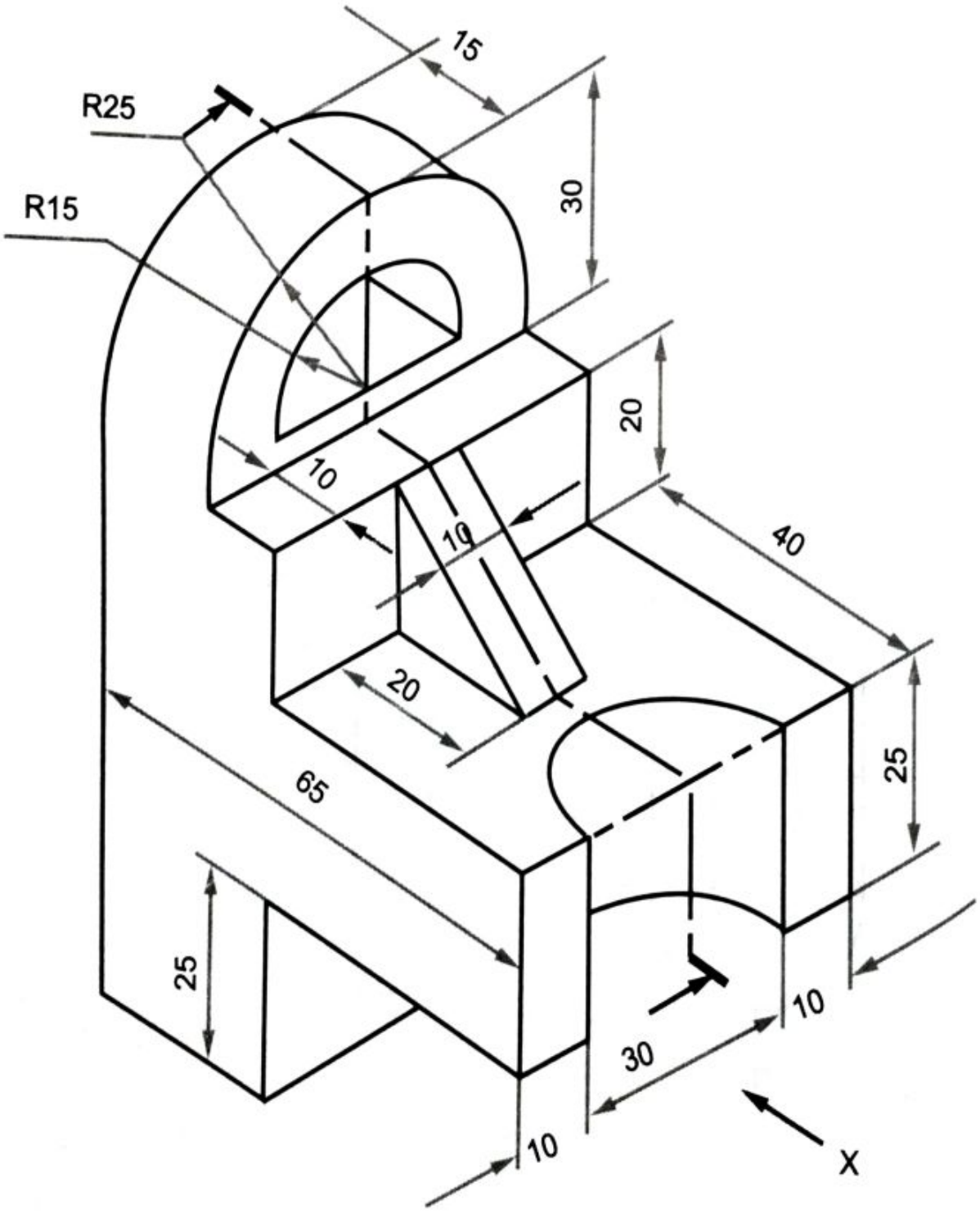


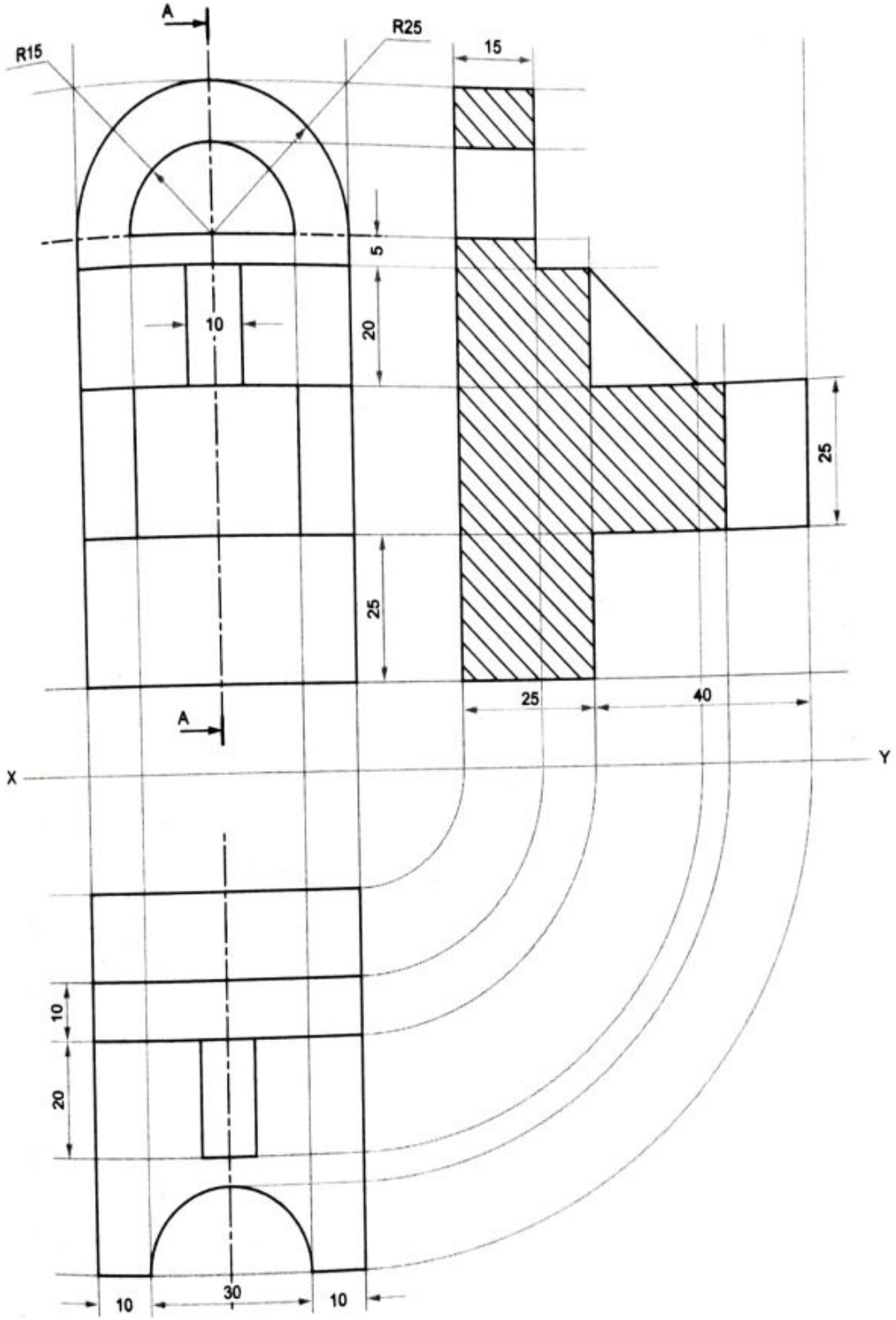
Sol. :



Ex. 4.25.5 : *Figure shows a pictorial view of an object. By using first angle method of projection draw.*
i) Sectional left hand side view along symmetry of object
ii) Front view iii) Top view iv) Dimensions

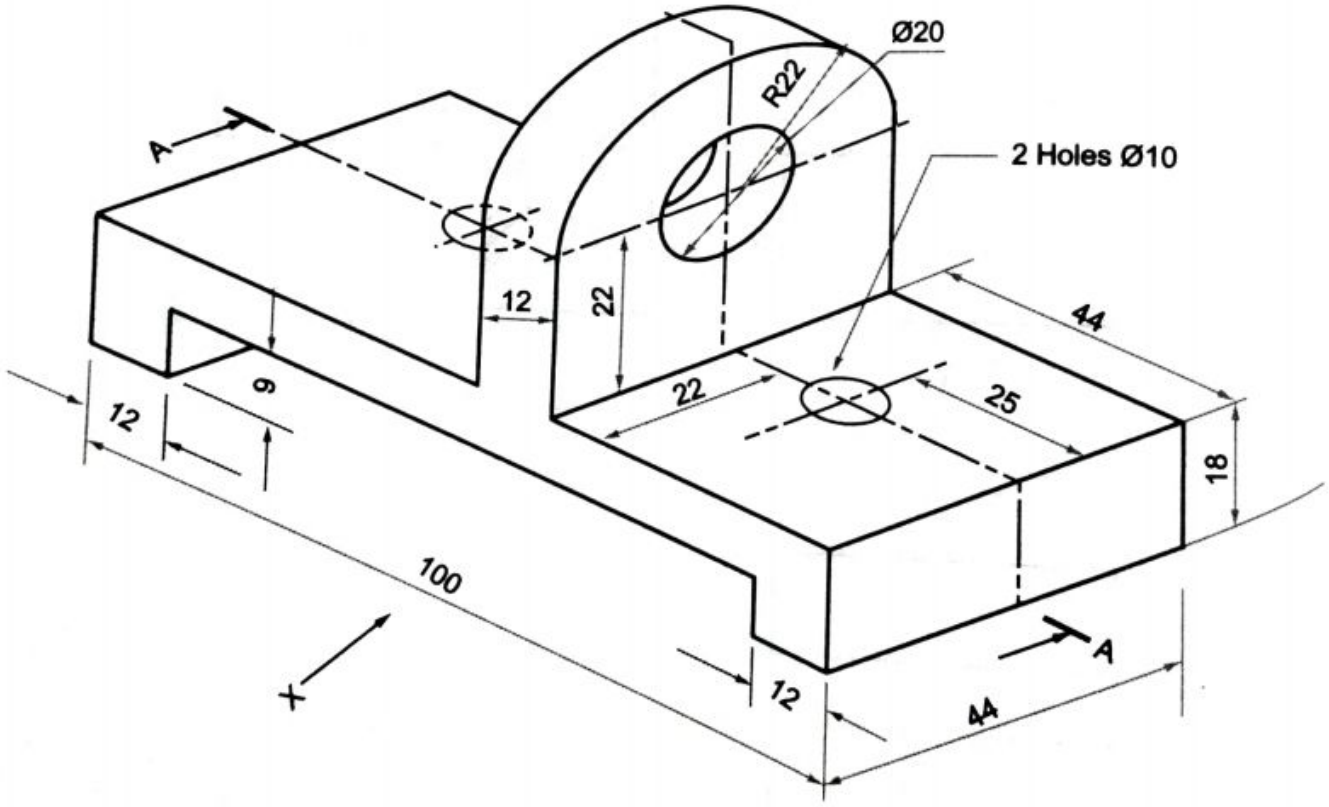
SPPU : Dec



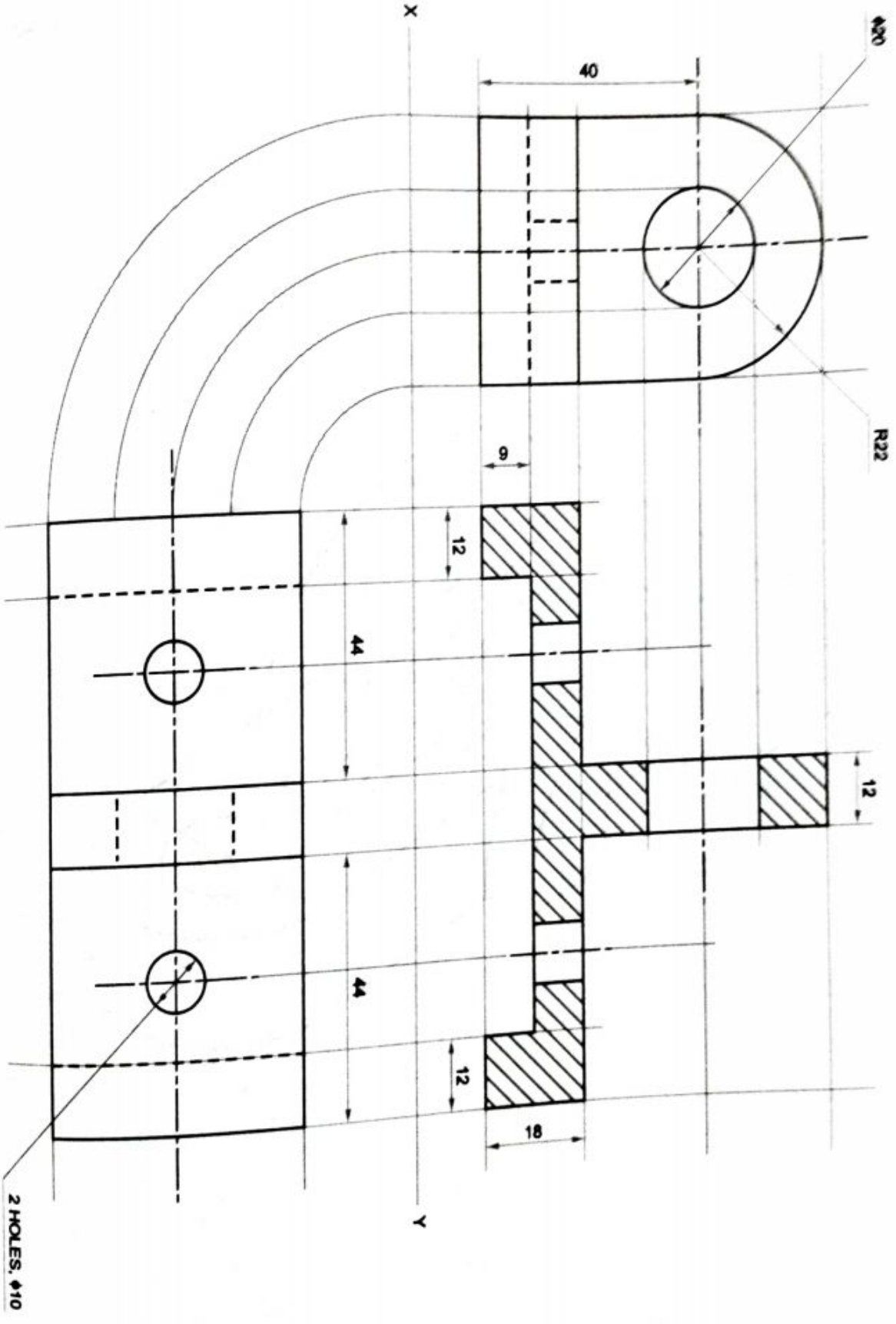

A
R15
R25
15
5
10
20
25
25
40
A
X
Y
10
20
10
30
10

Ex. 4.25.6 : *Figure shows a pictorial view of an object. By using first angle method draw.*
i) Sectional front view, along sectional plane A-A
ii) Right hand side view
iii) Top view *iv) Dimensions*

SPPU Mar. 13

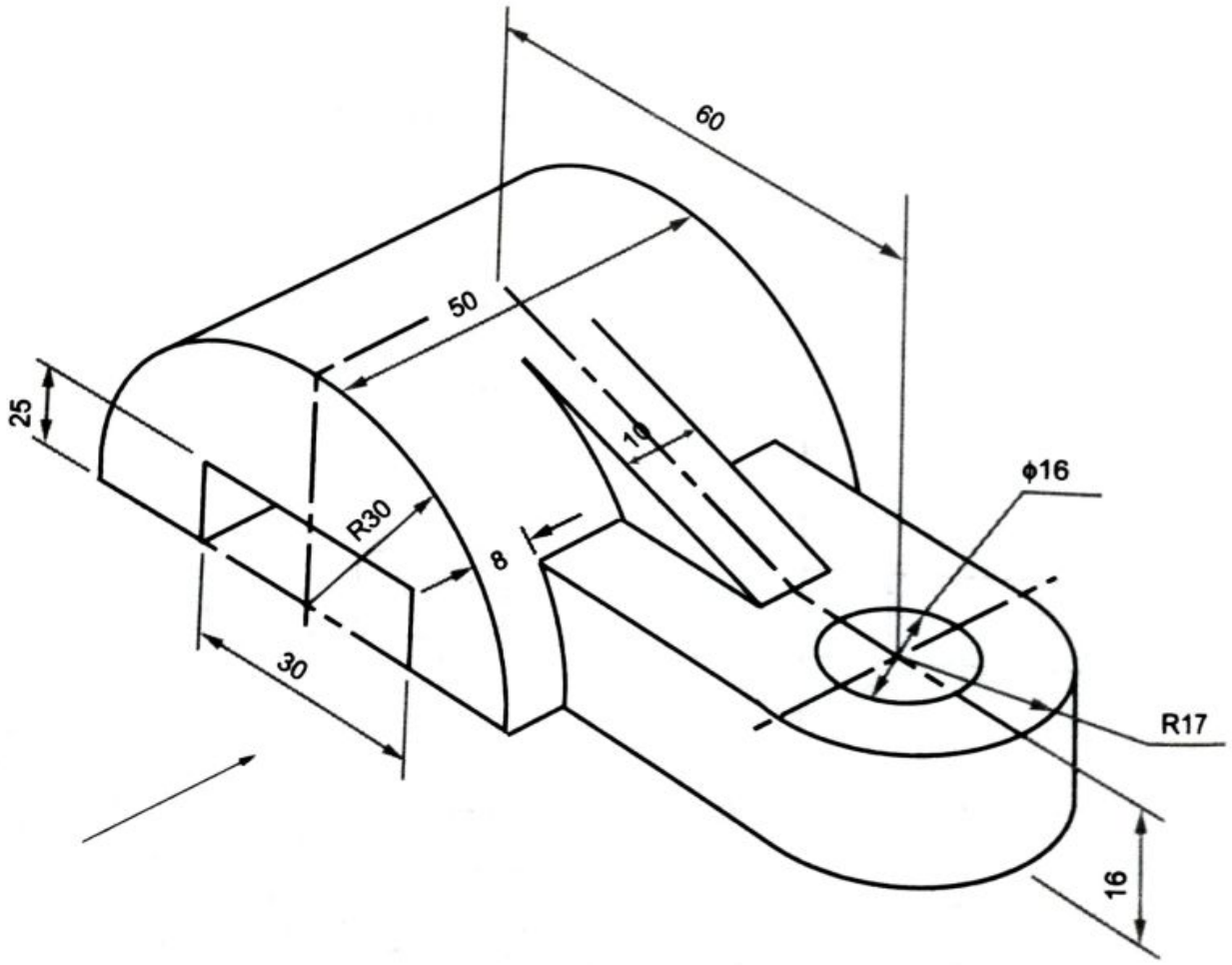


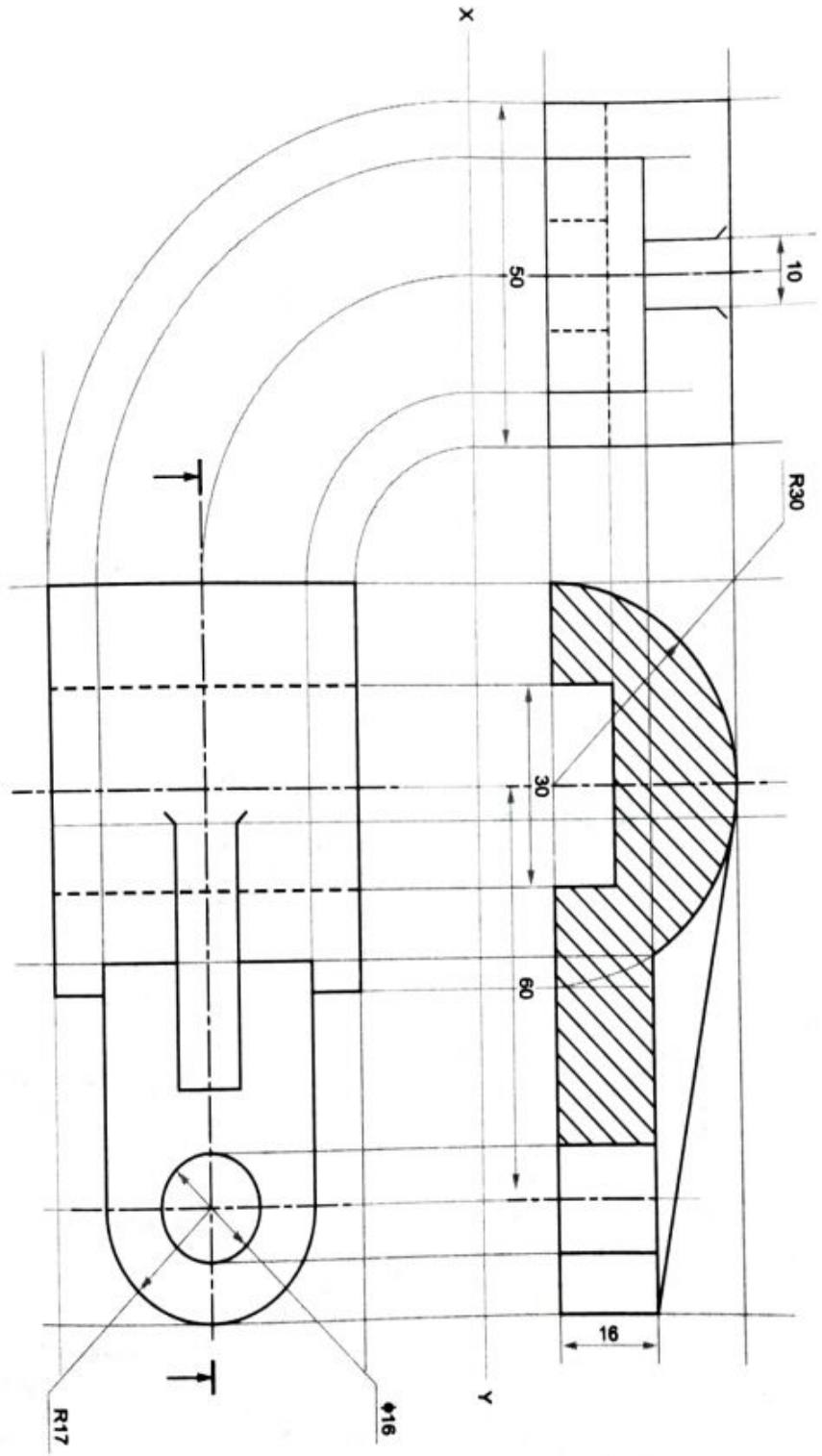
Sol. :



Ex. 4.25.7 : ***Figure shows a casr iron bracket. By using first angle method projections, draw; i) Sectional front view ii) Right hand side view iii) Top view***

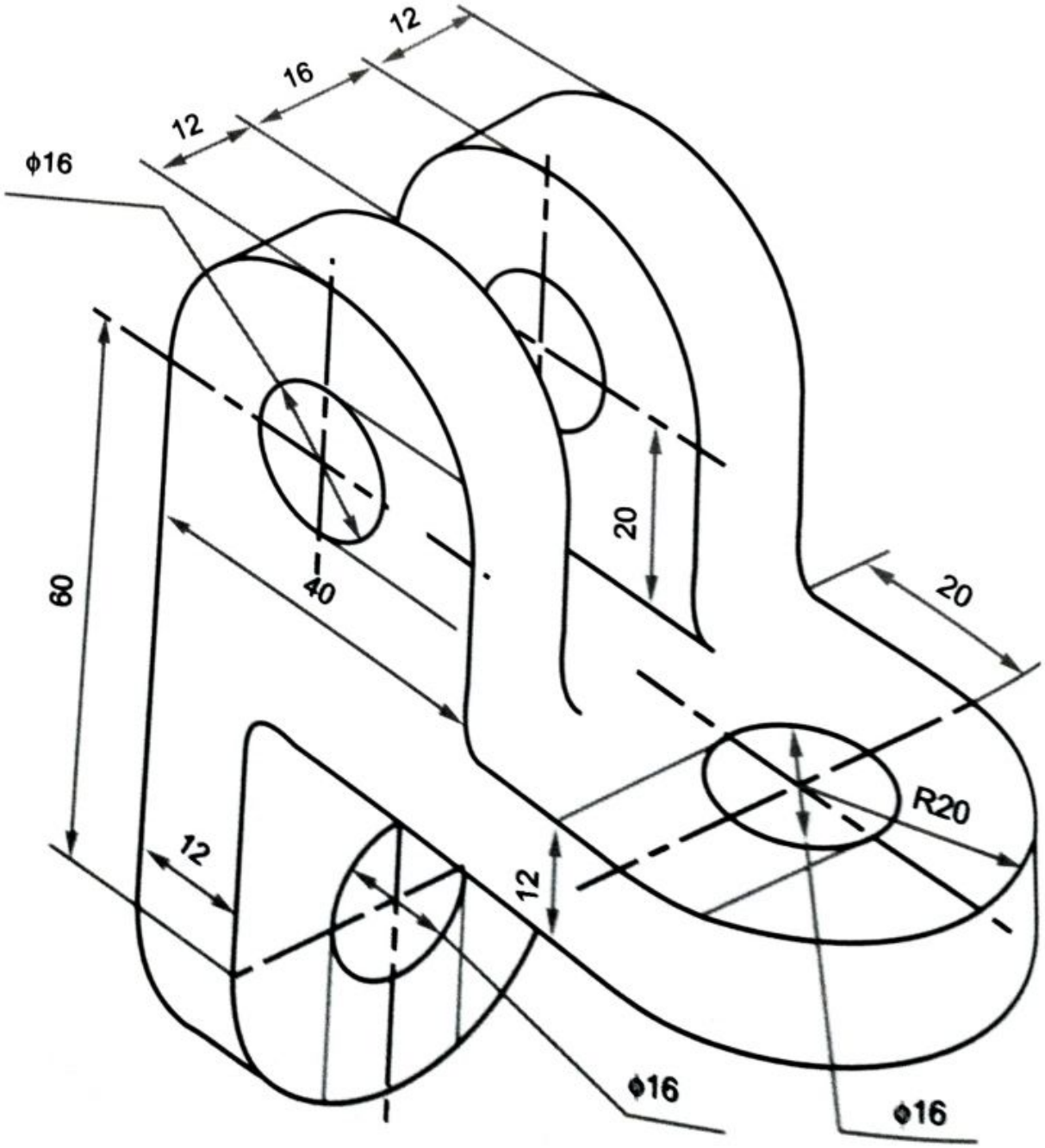
SPPU May-1



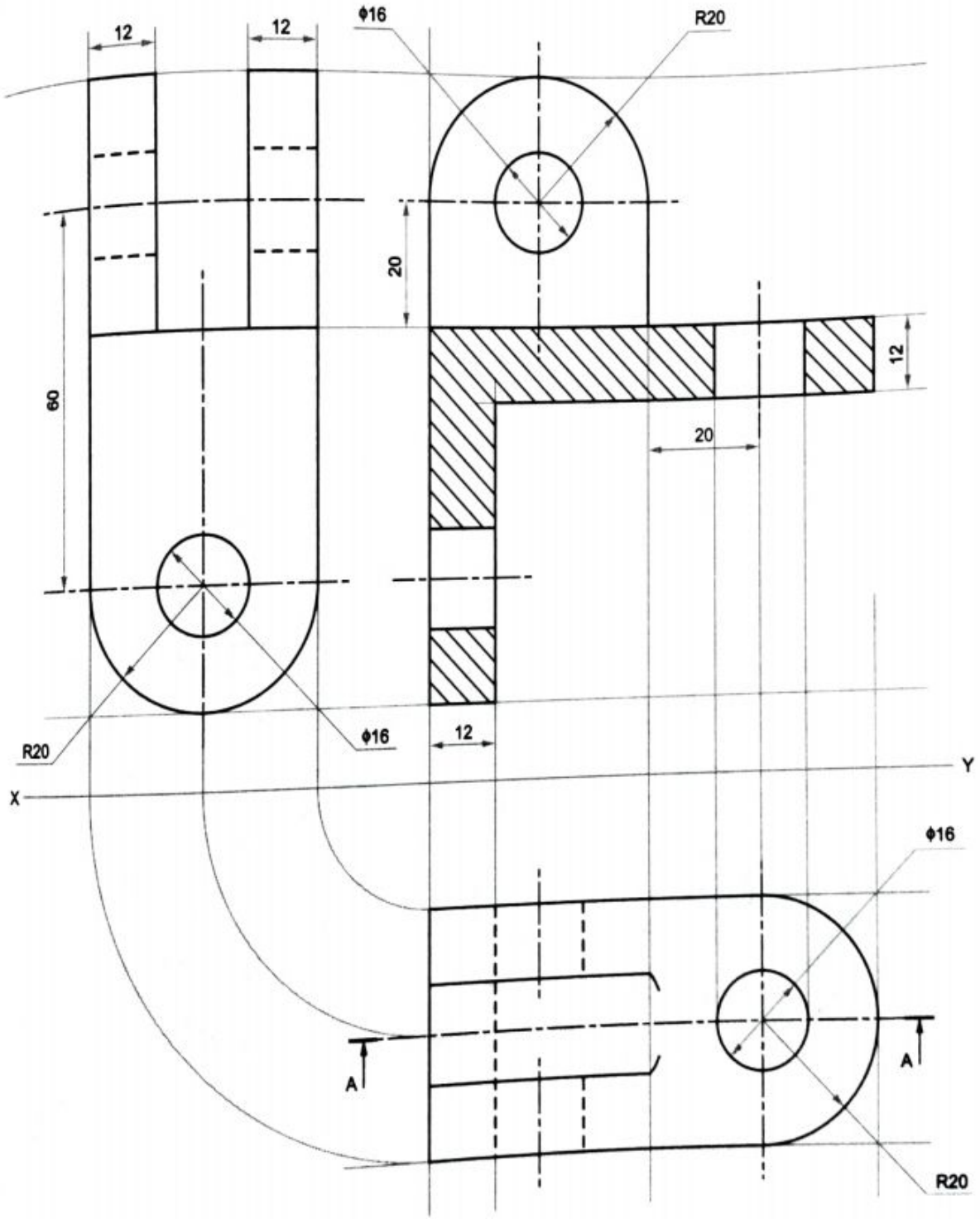

X
50
10
R30
30
60
16
Y
R17
ϕ16

Ex. 4.25.8 : *Figure shows a pictorial view of an object. By using first angle method projections, draw;*
i) Sectional front view, along symmetry of the object
ii) Right hand side view iii) Top view iv) Dimensions

SPPU Mar.

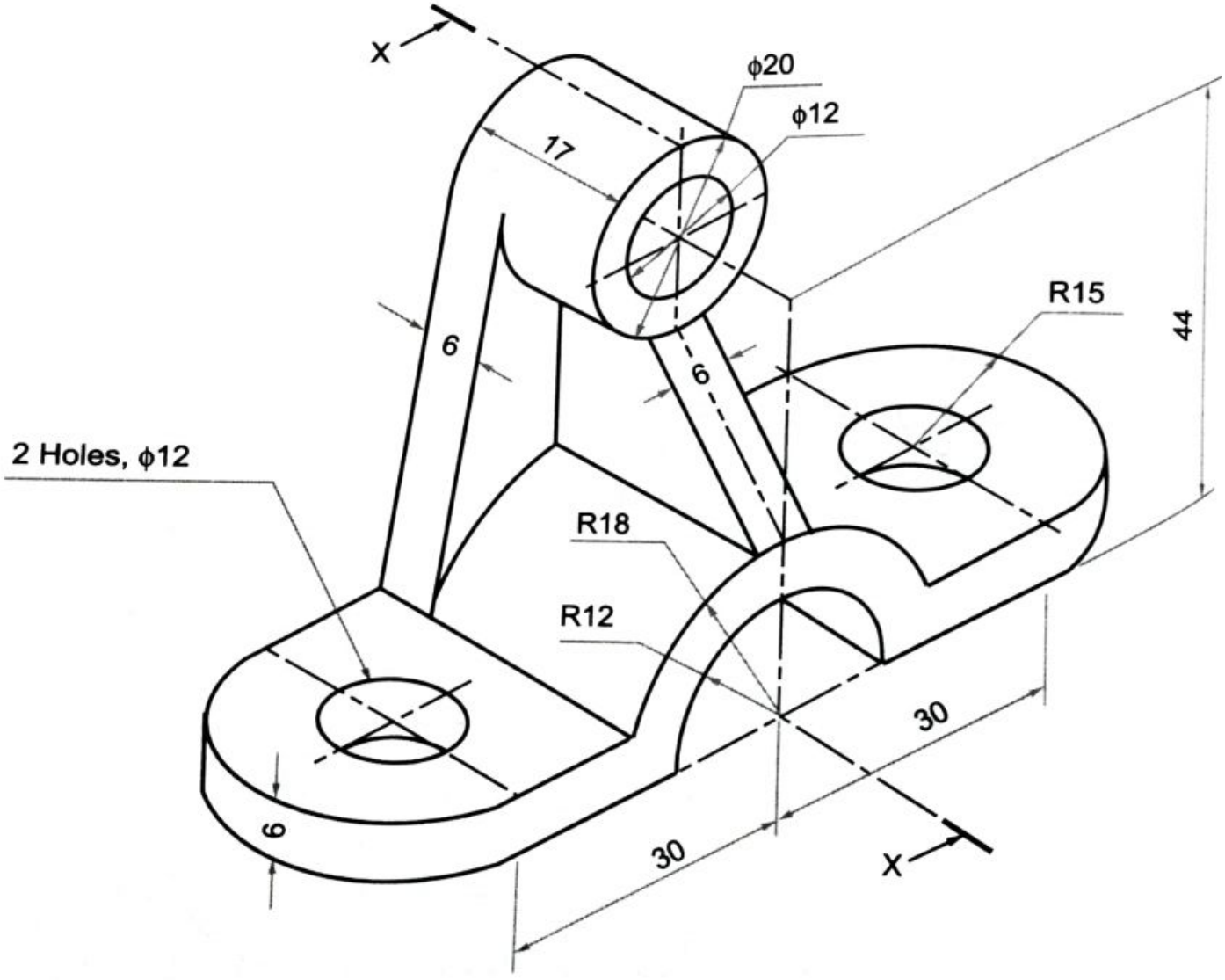


Sol. :

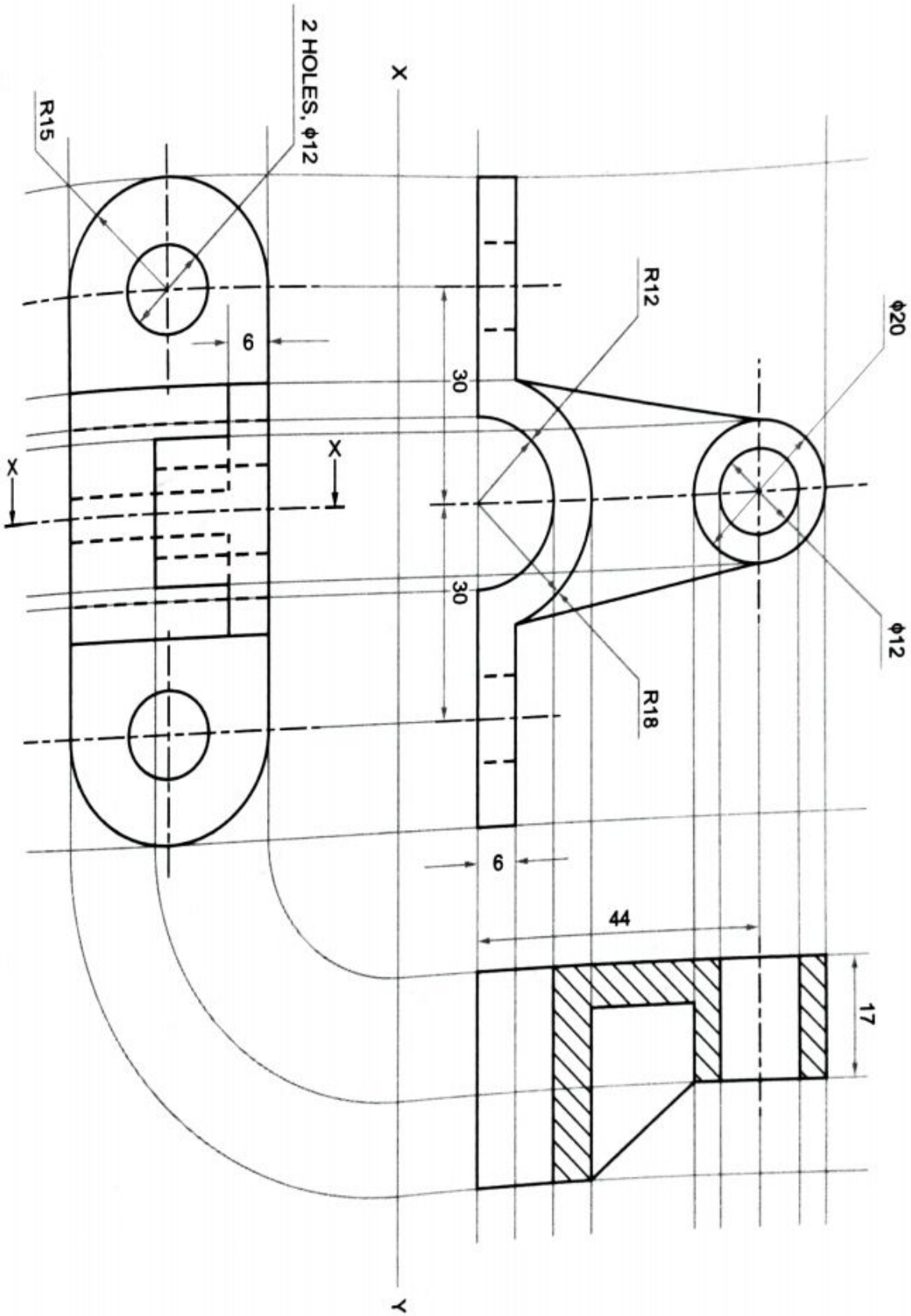


Ex. 4.25.9 : *The following figure shows a cast iron bracket. By using first angle projection method draw :*
i) Front view iii) Top view
iii) Sectional LHSV along plane X-X.

SPPU : May-15

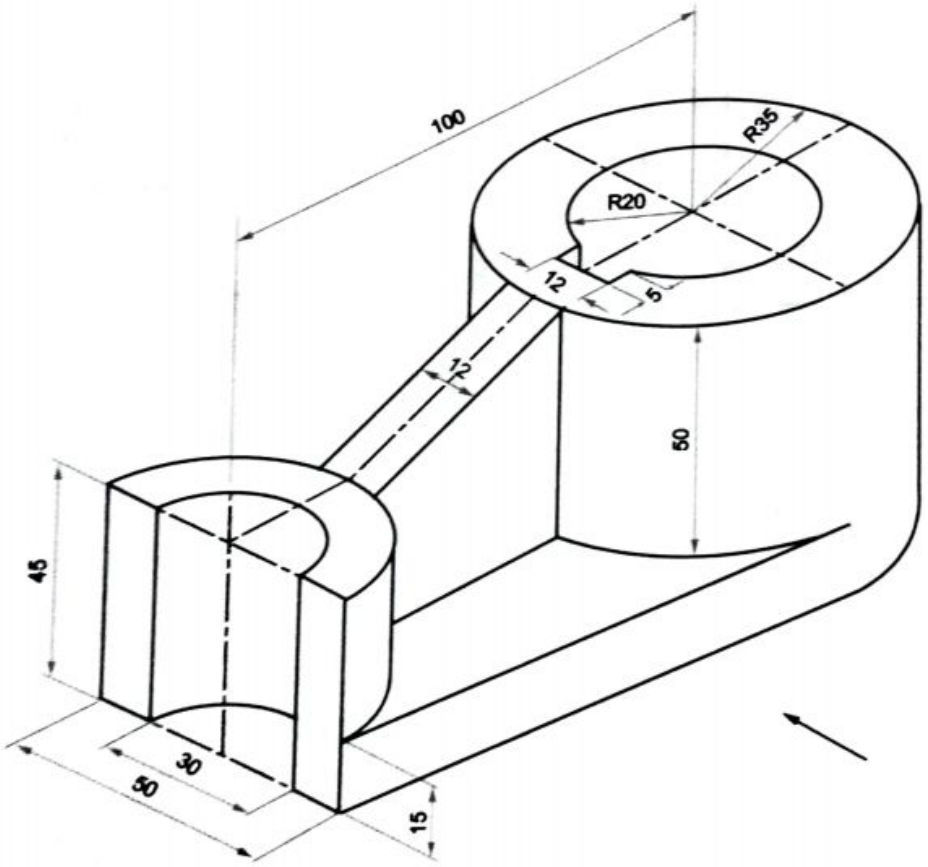


Sol. :

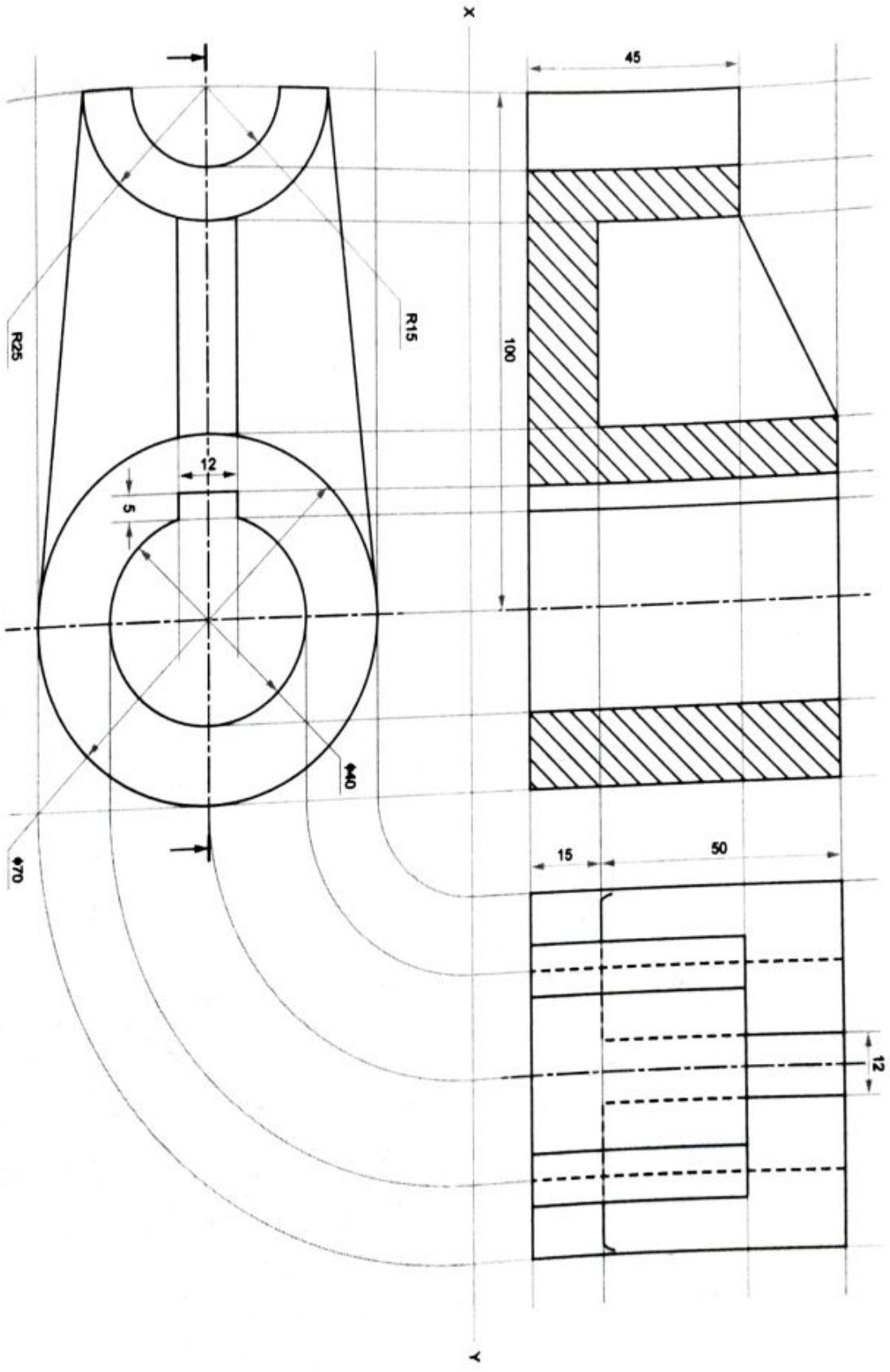


Ex. 4.25.10 : *Figure shows a pictorial view of an object. By using first angle method of projections, draw;*
i) Sectional front view, along symmetry of the object
ii) Left hand side view iii) Top view
Give all required dimensions.

SPPU : Dec.-13, Marks 13



Sol. :



Ex. 4.25.11 : *For the object shown in figure draw the following views, using first angle method of projection :*

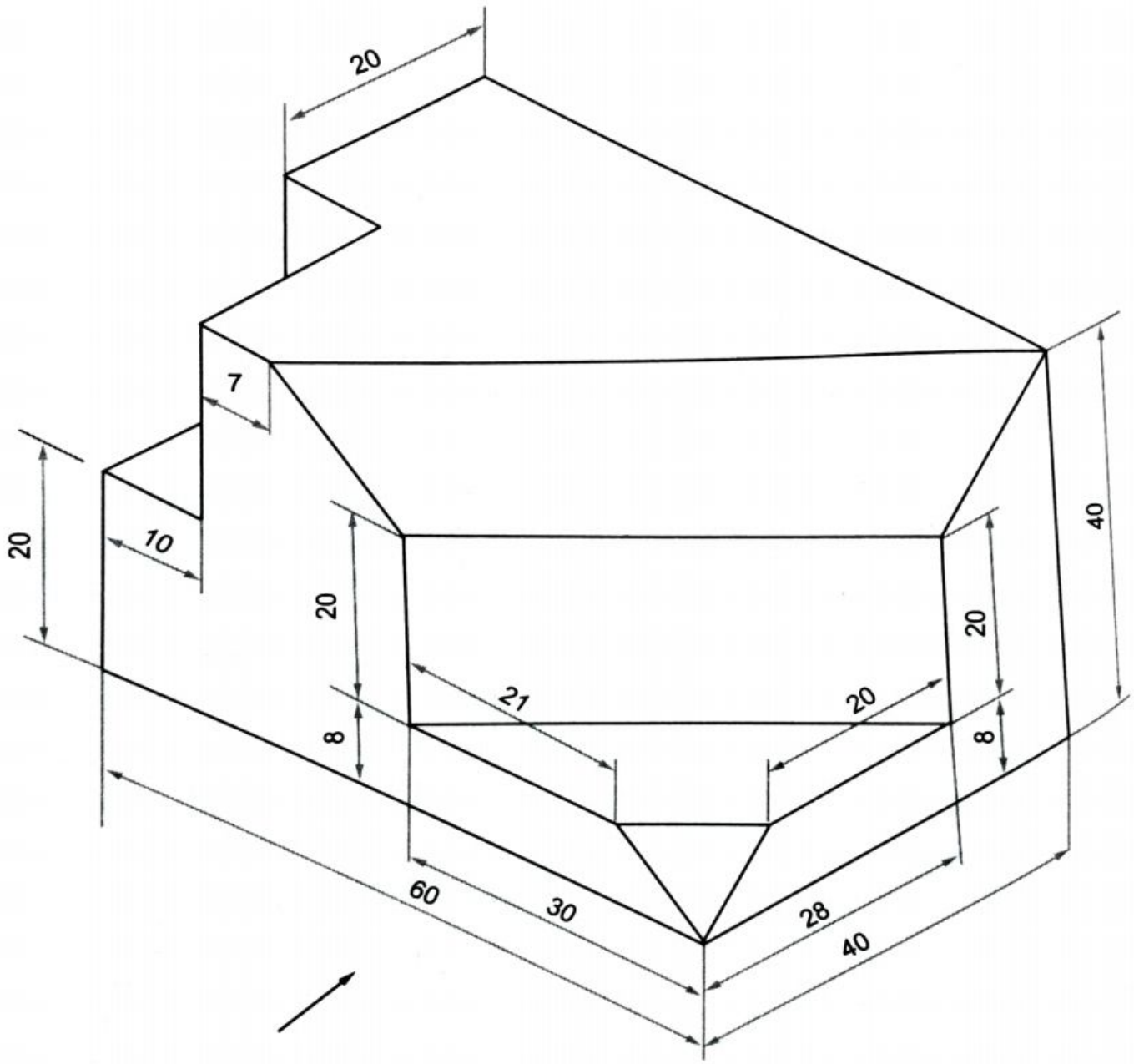
a) Elevation in the direction of arrow

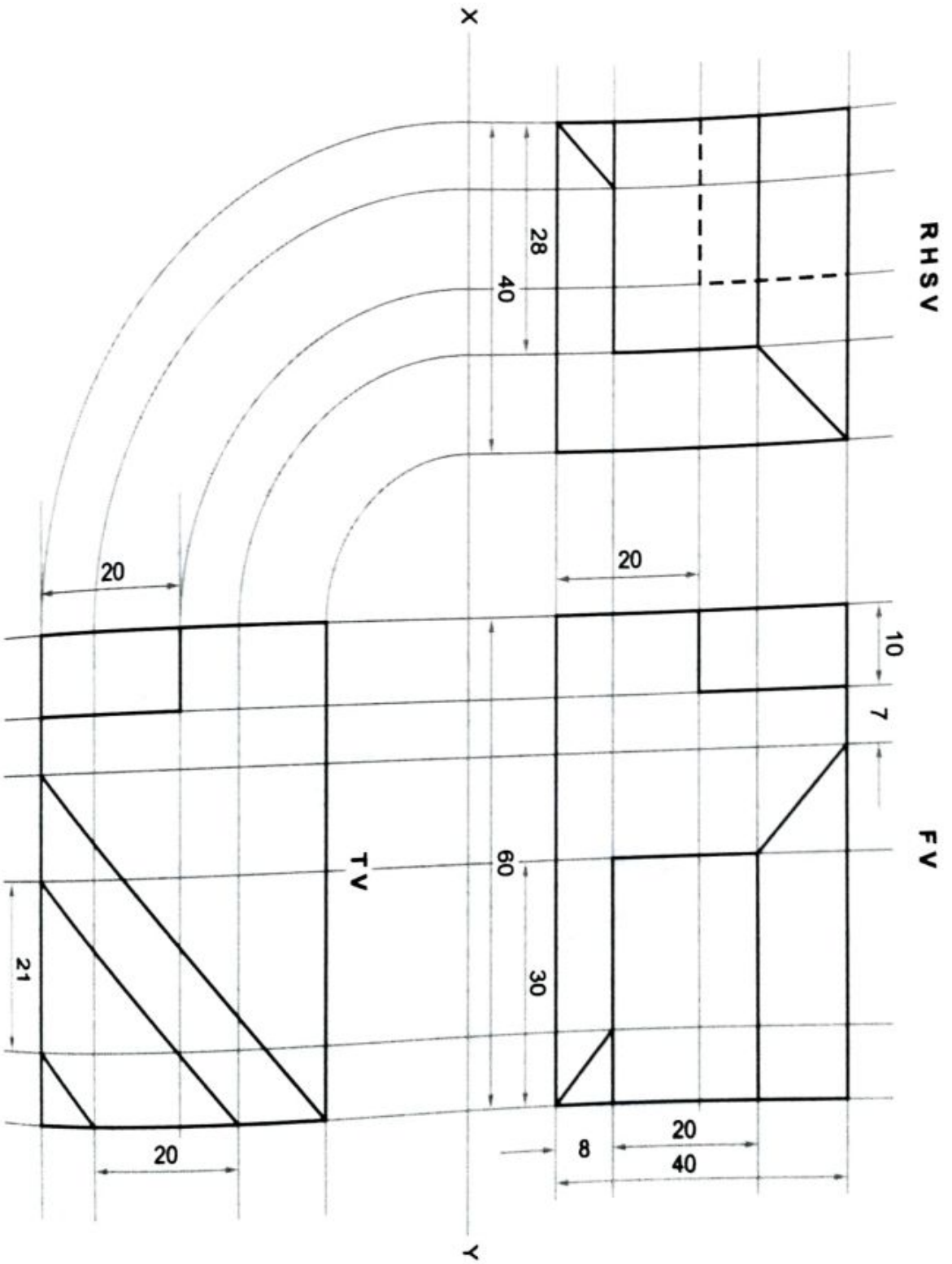
b) Plan

c) End view from right hand side

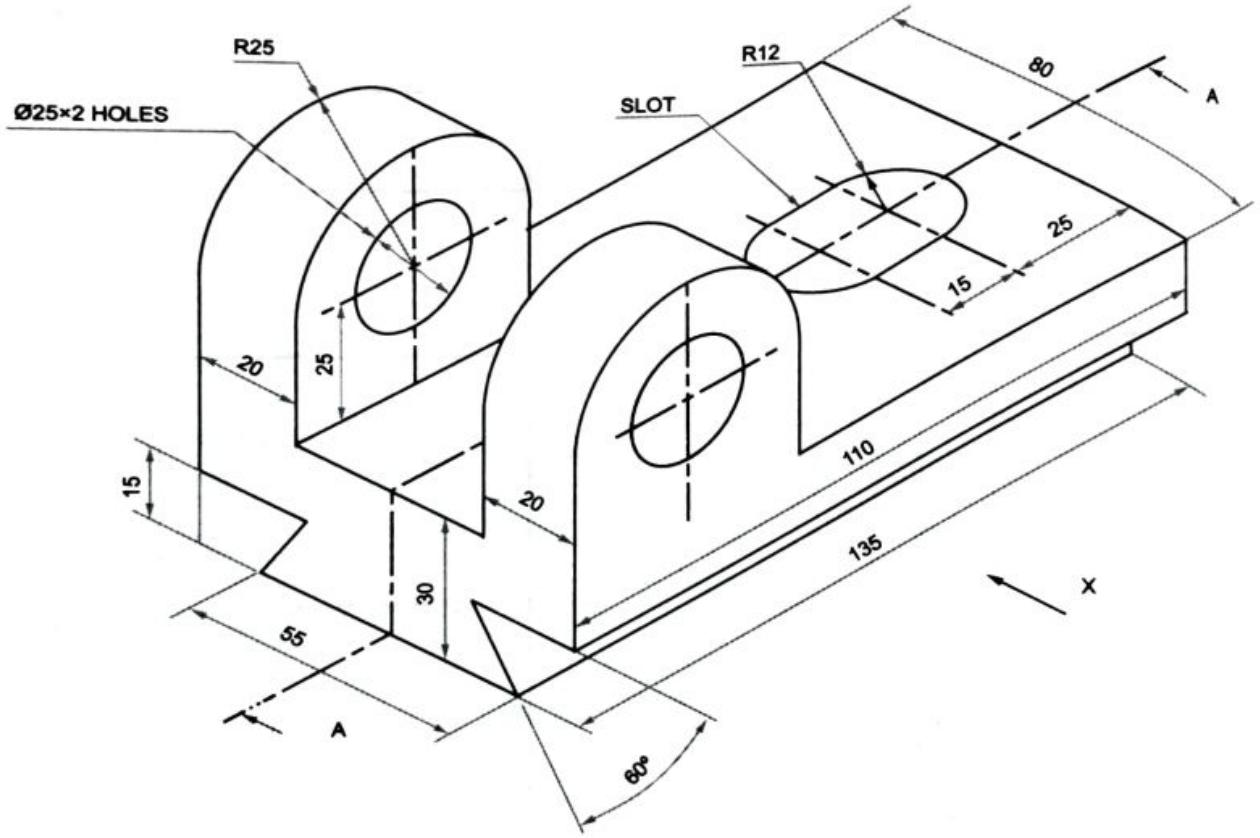
d) Give all dimensions.

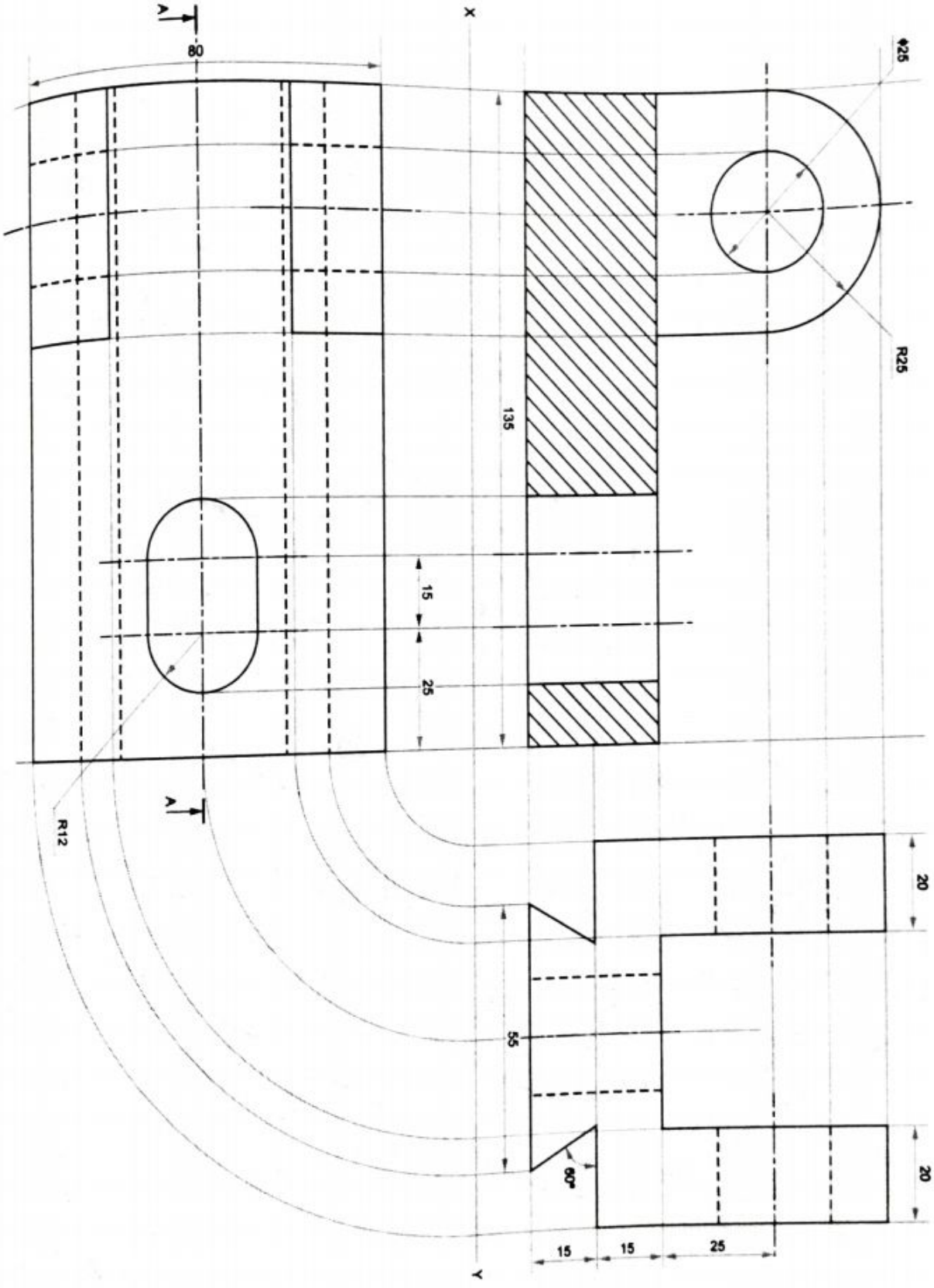
SPPU : Dec.-10, Marks 20



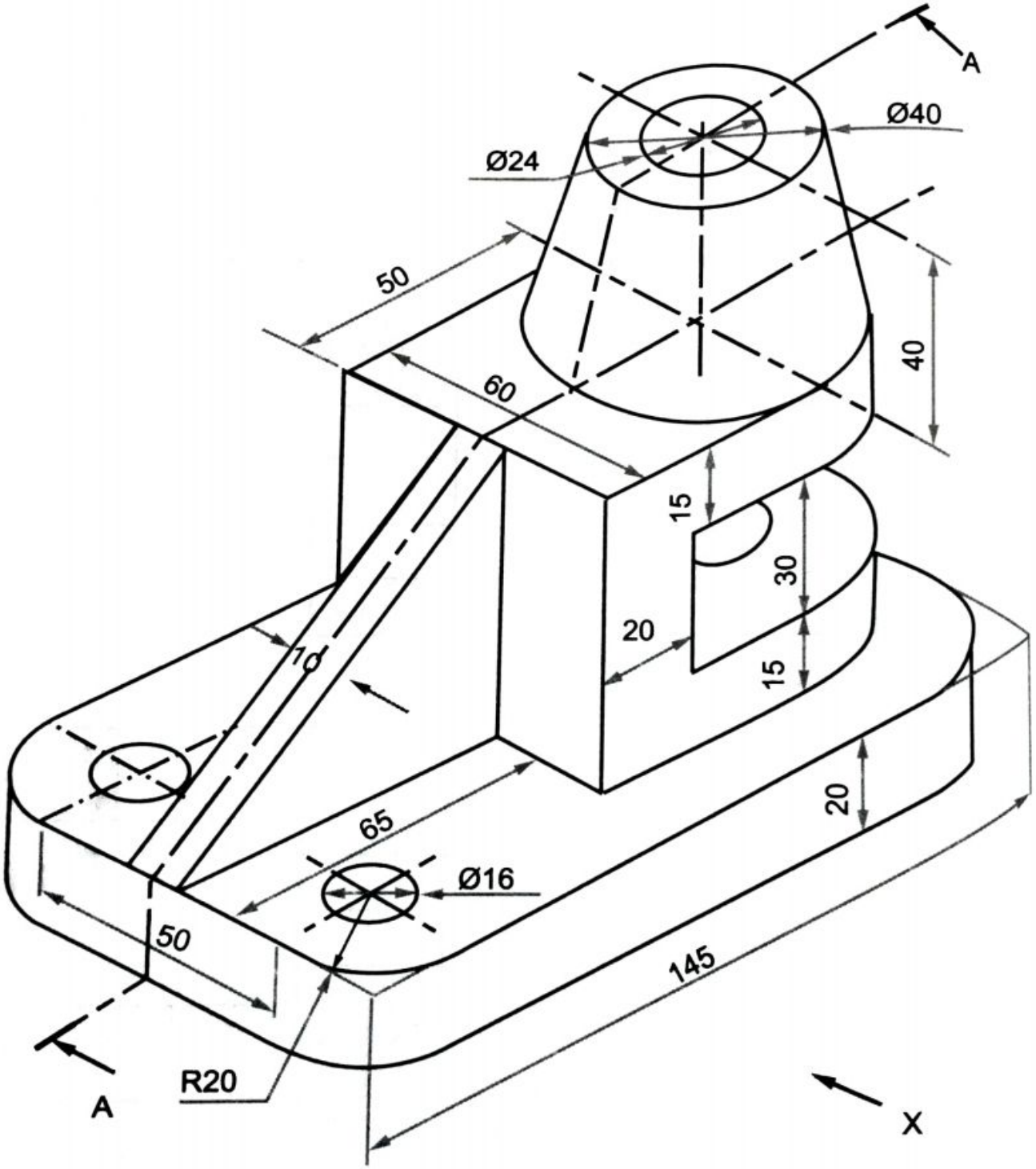

X
Y
RHSV
FV
TV
28
40
20
20
10
7
60
30
21
20
8
20
40

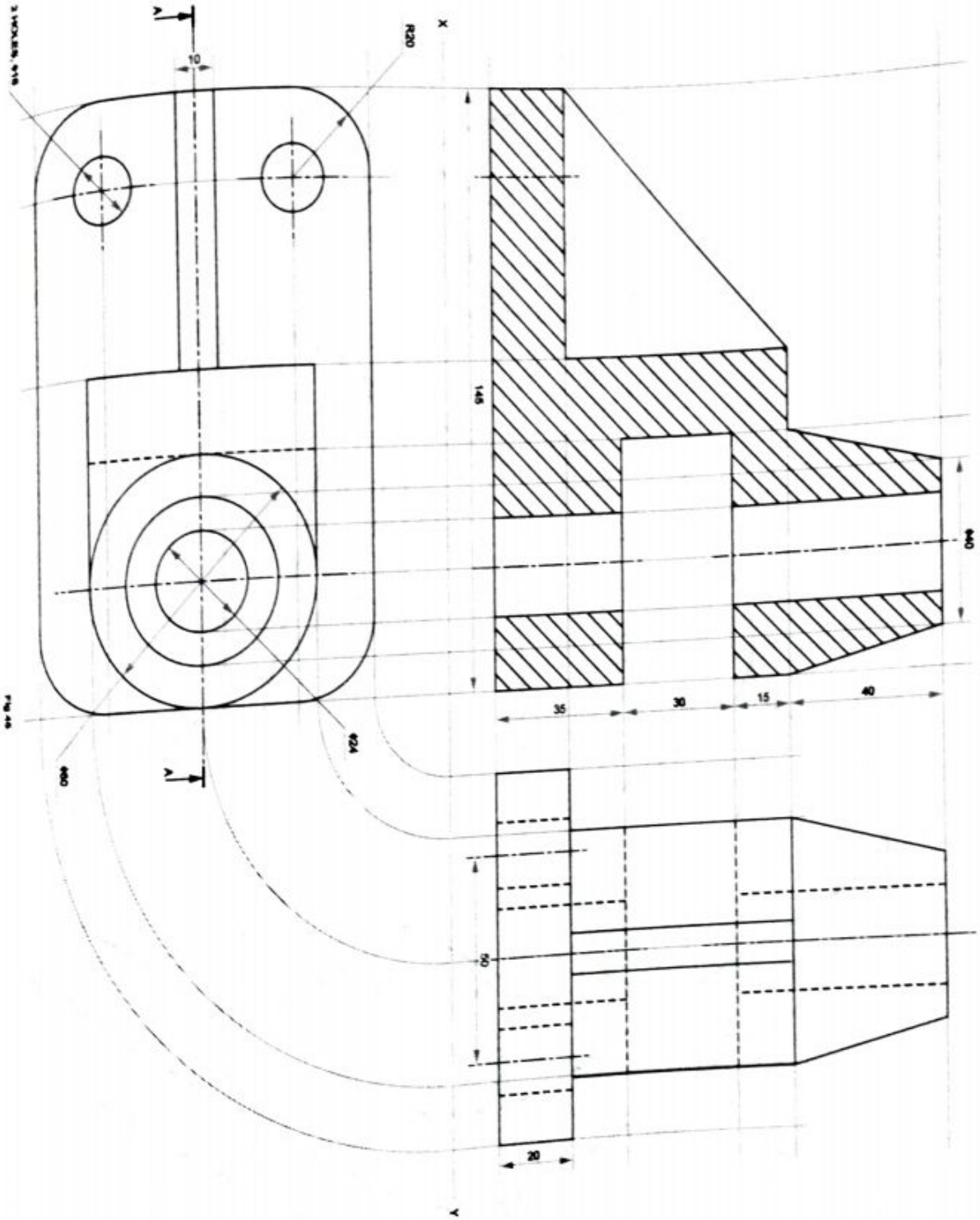
Ex. 4.25.12 : *A figure shows a pictorial view of a C.I. DOVE TAIL BRACKET. Draw to scale full size, the following views by using first angle method of projection. (a) Full sectional elevation, along cutting plane A-A (b) Sectional Plan and (c) Right Hand End view.*



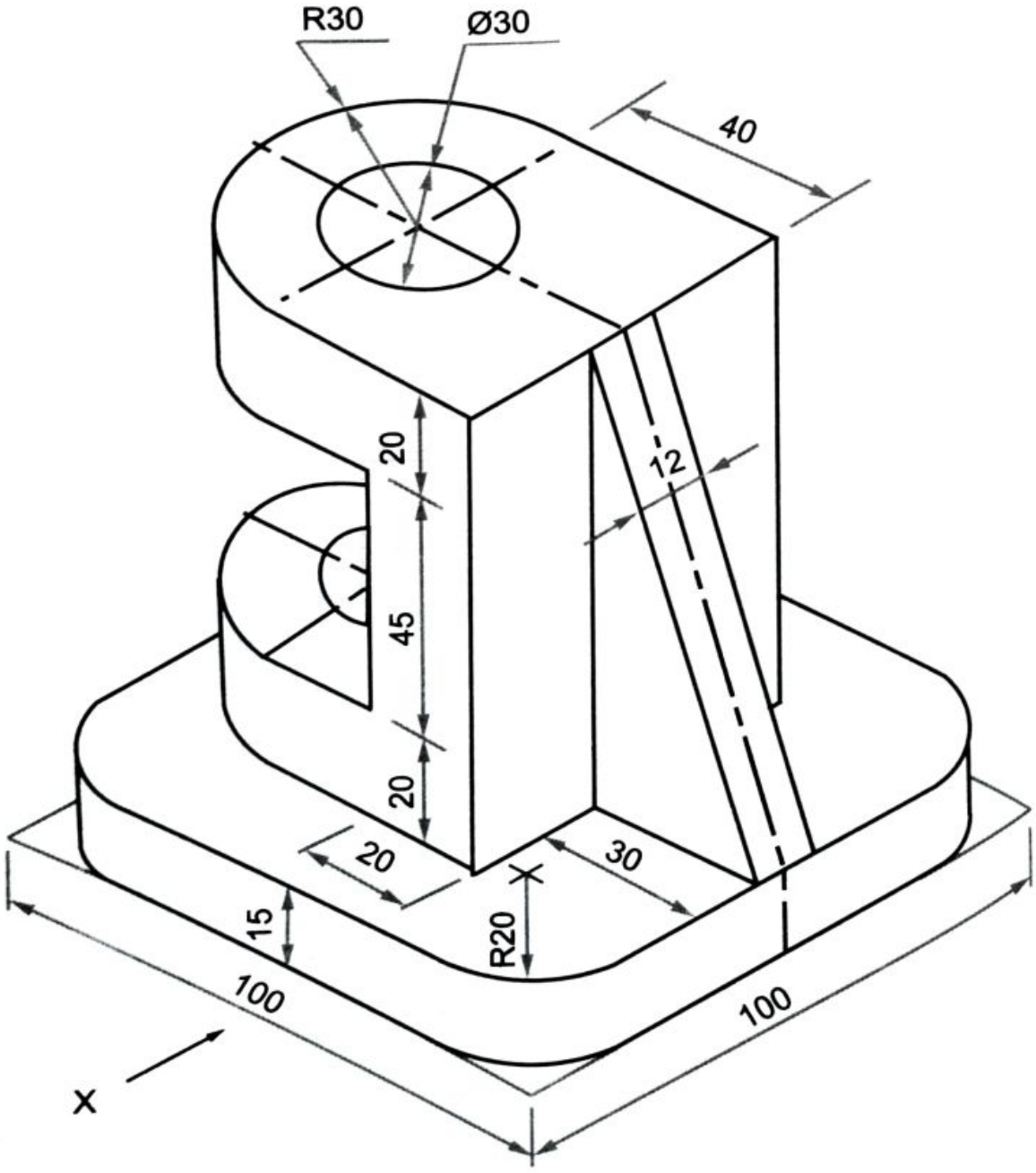

A
80
X
Φ25
R25
135
15
25
A
R12
20
55
60°
20
15
15
25
Y

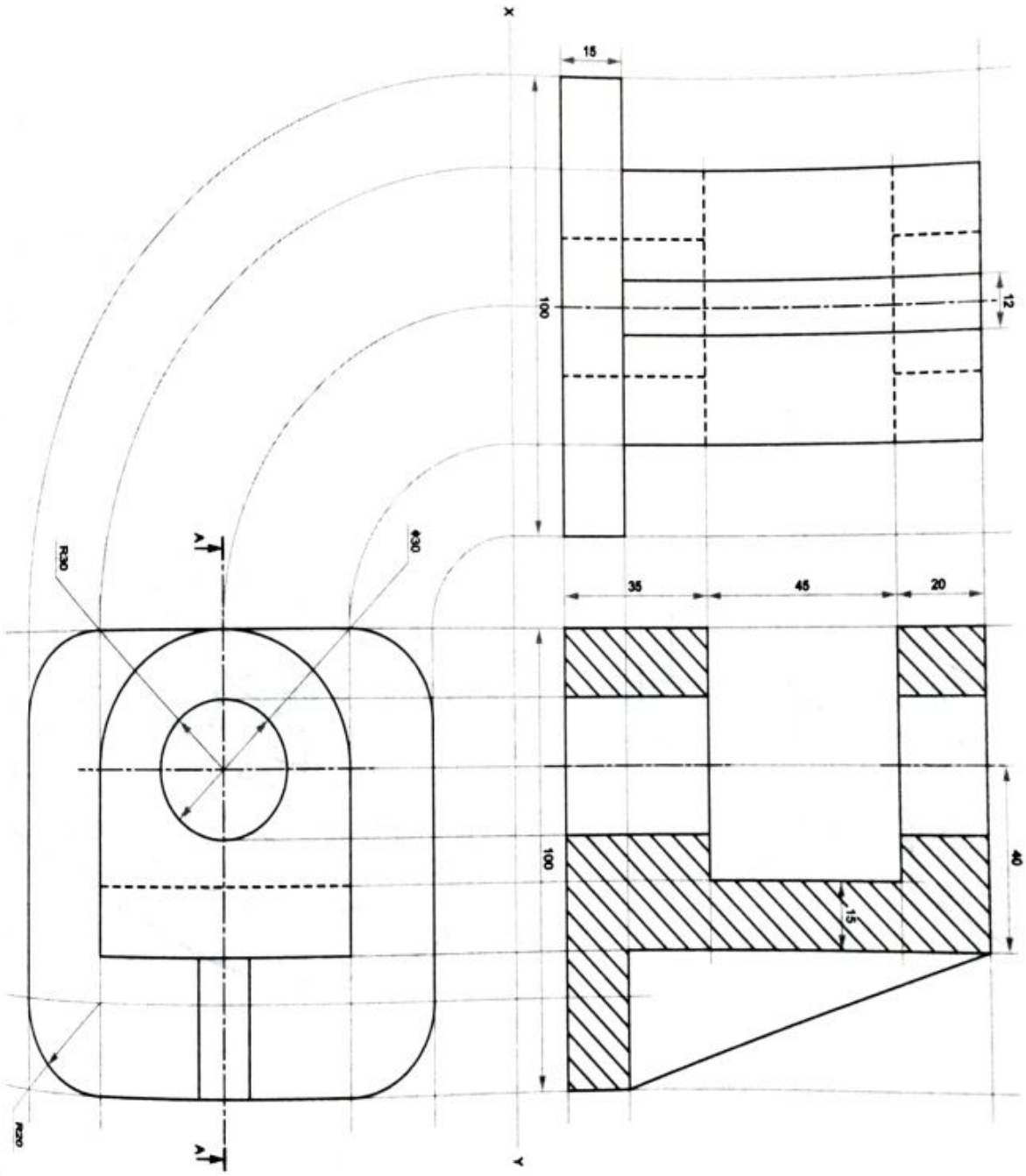
Ex. 4.25.13 : *The figure shows pictorial view of an object, using first angle method of projection, draw.*
(a) Sectional Elevation Along Section A-A (b) Plan. (c) End view from left side.
(d) Show 10 to 12 important dimensions.



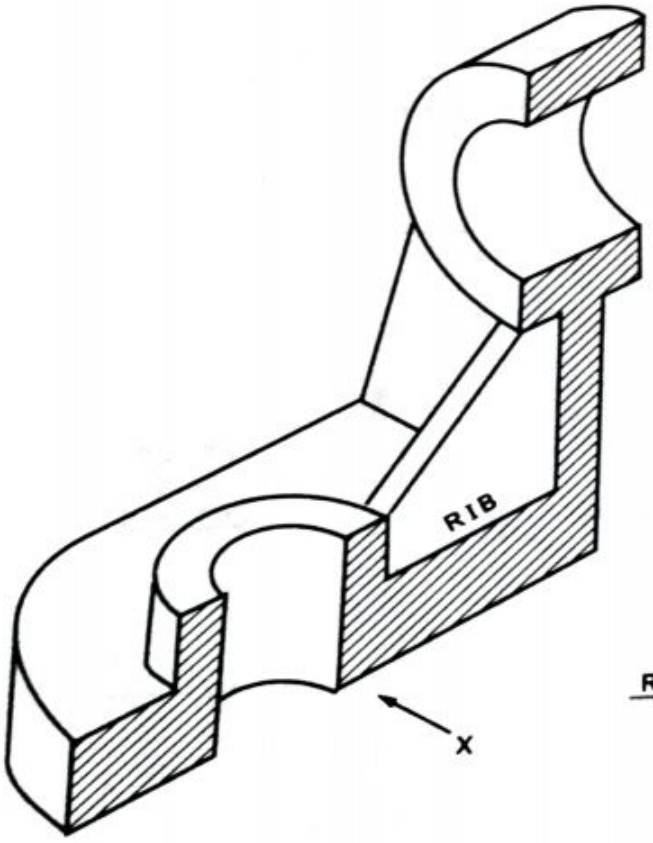

10
R20
Ø24
Ø40
145
40
35
30
15
40
20

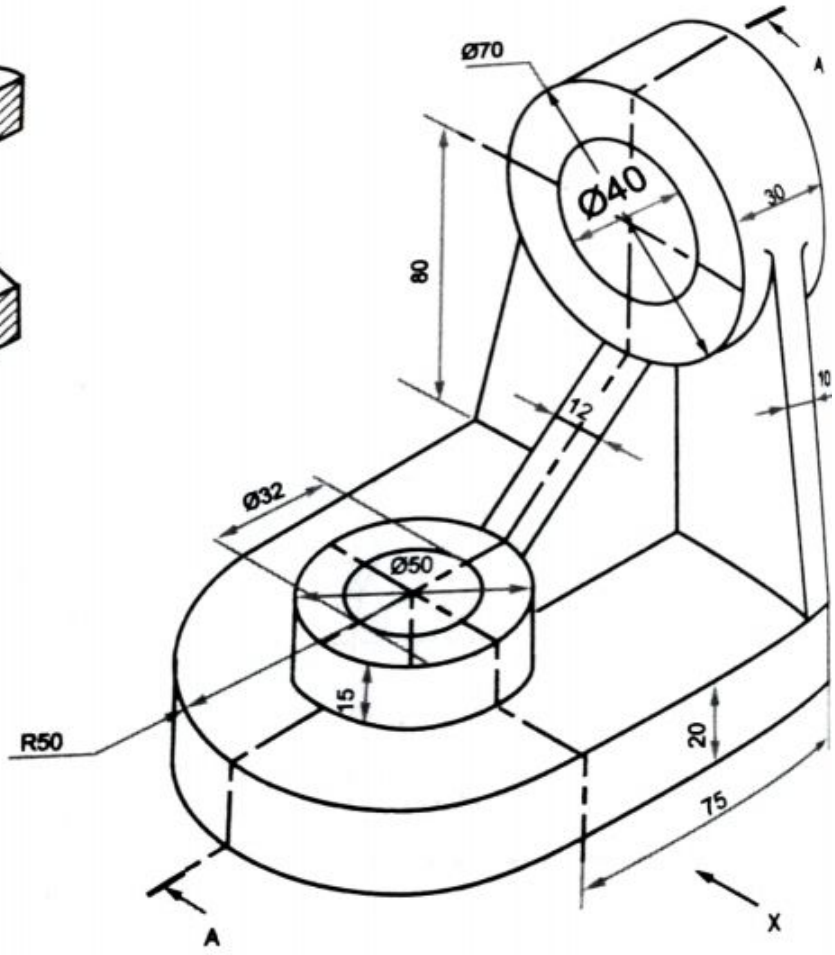
Ex. 4.25.14 *The figure shows pictorial view of an object, draw the following views using first angle method of projection. (a) Plan (b) Sectional elevation (c) Right hand side view.*



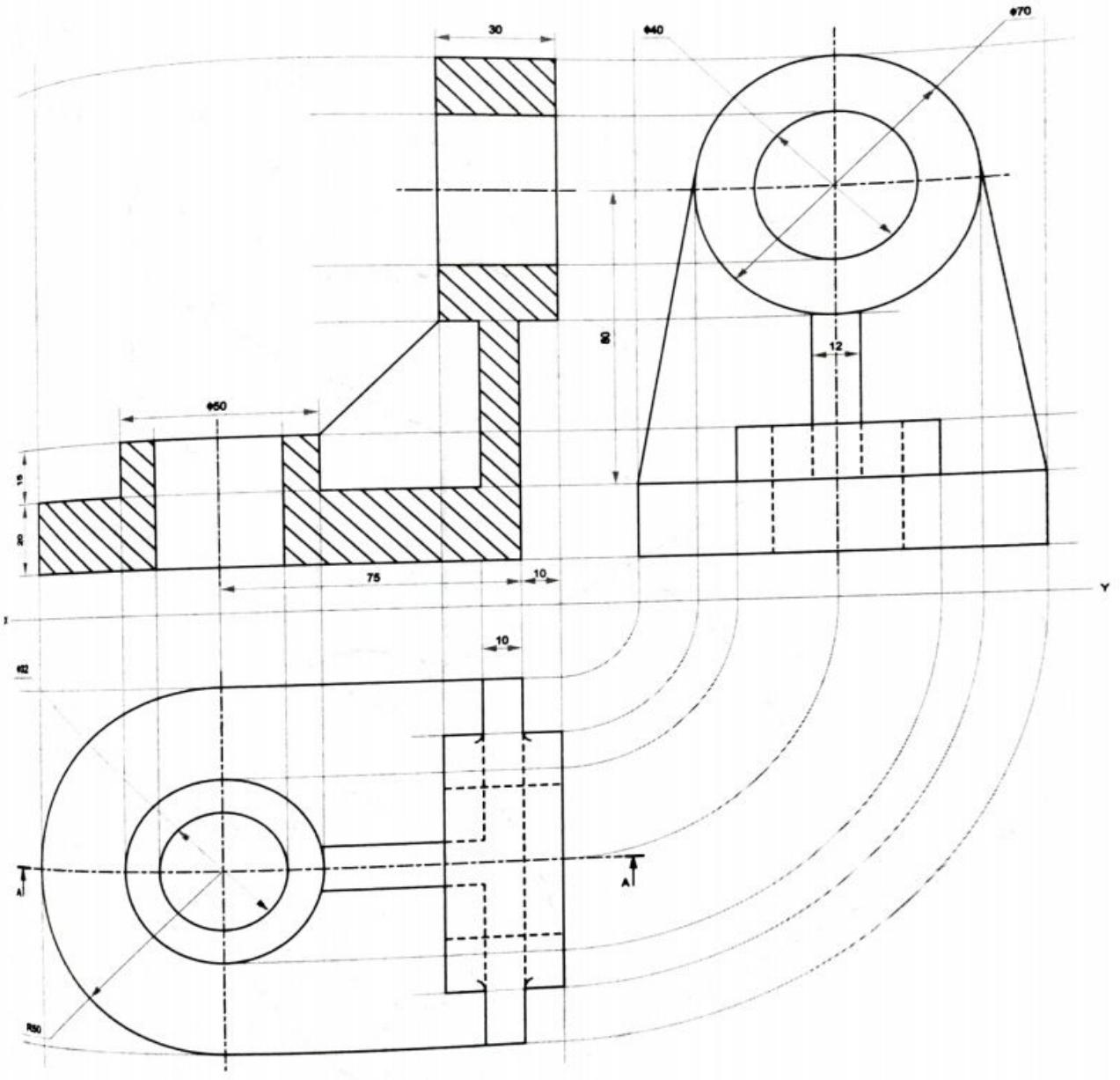

15
100
12
R30
Ø30
35
45
20
100
40
15
R30

Ex. 4.25.15 : *The figure shows pictorial view of an object. Using first angle method of projections draw.*
(a) Sectional front view, section along A-A. (b) Top view.
(c) Side view from left side. (d) Give dimensions.



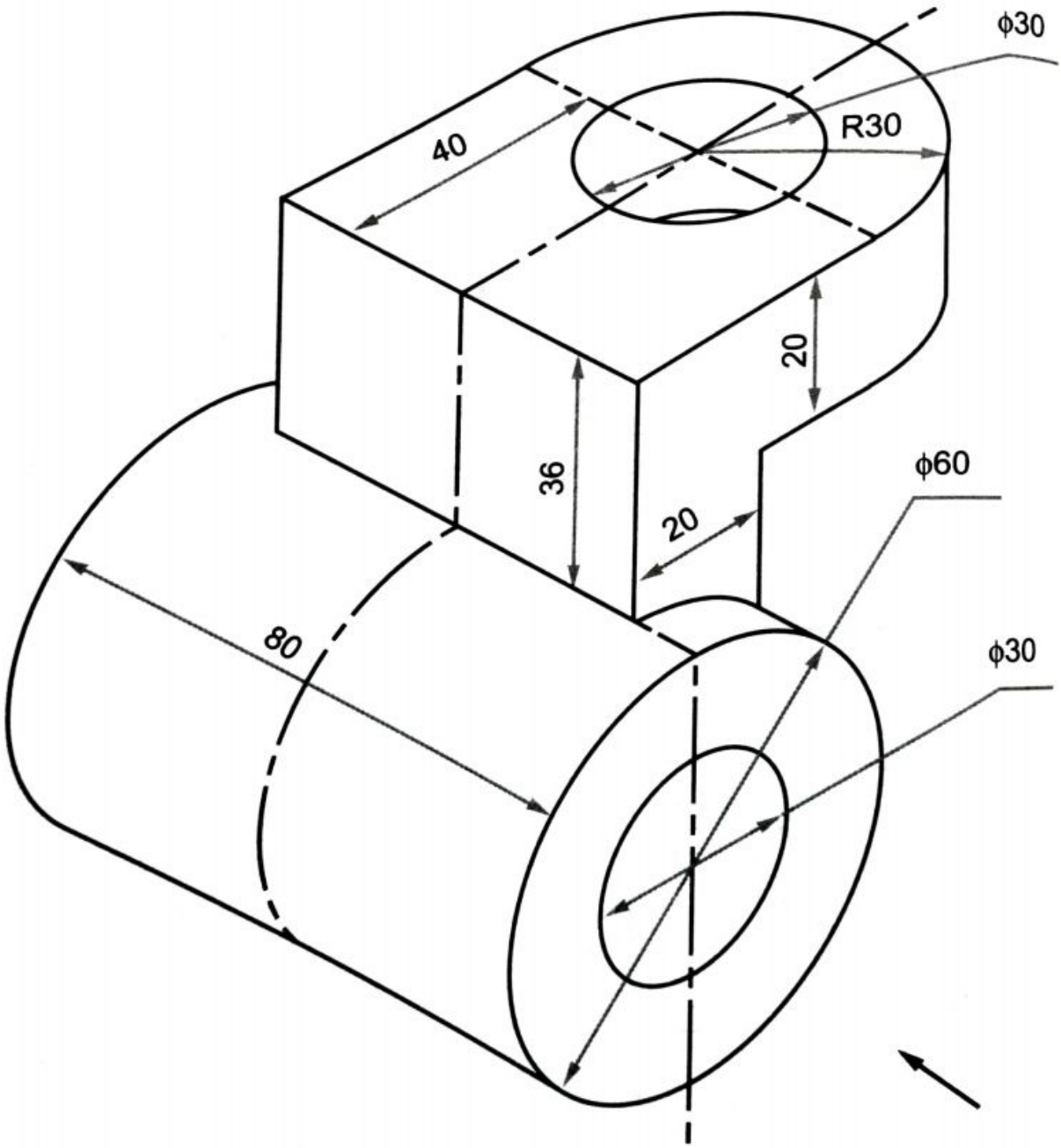


Sol :

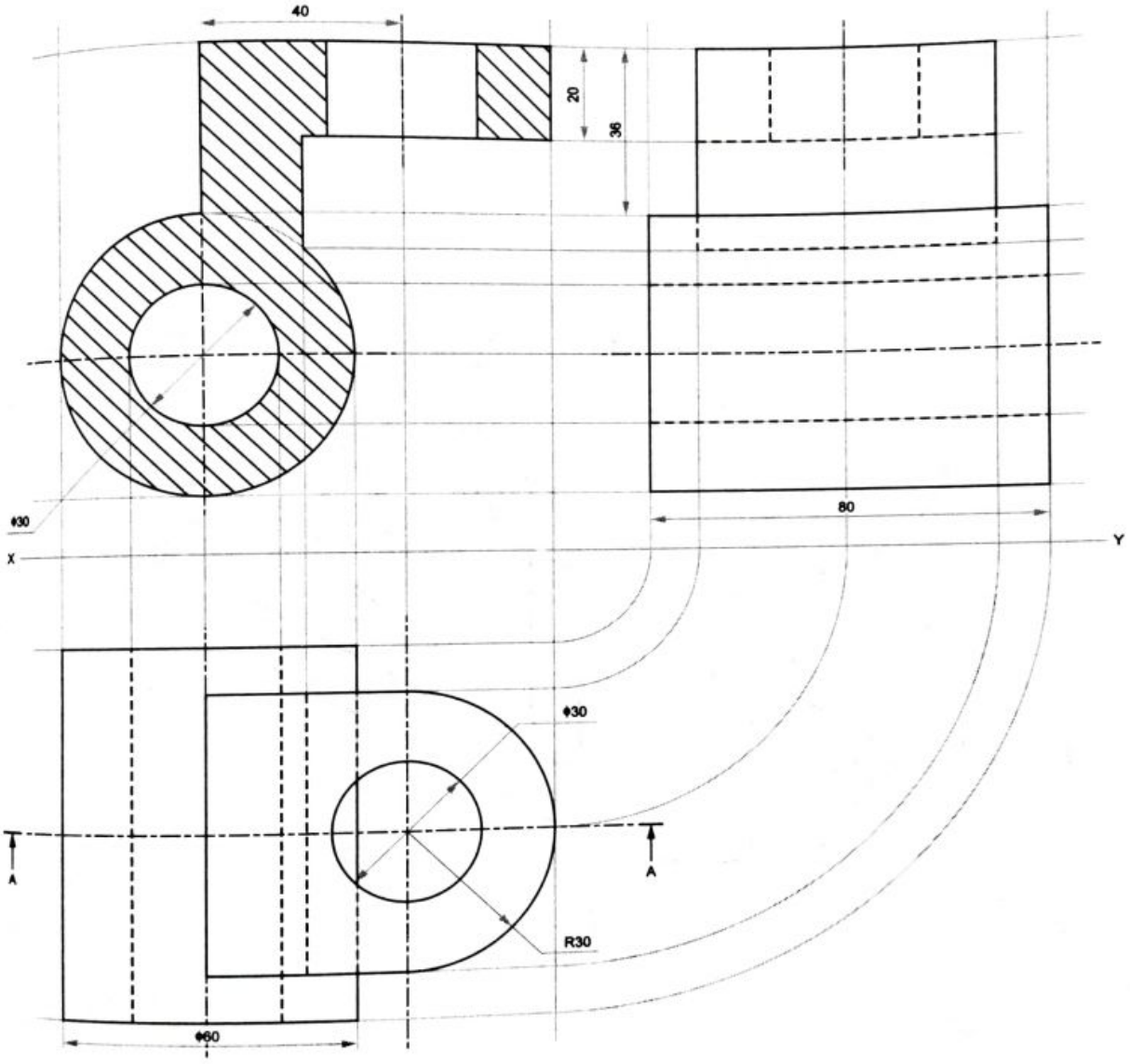


Ex. 4.25.16 : *Figure shows a pictorial view of an object. By using first angle method of projection, draw;*
i) Sectional front view, along symmetry of object
ii) Left hand side view
iii) Top view
iv) Dimensions

SPPU : Nov.

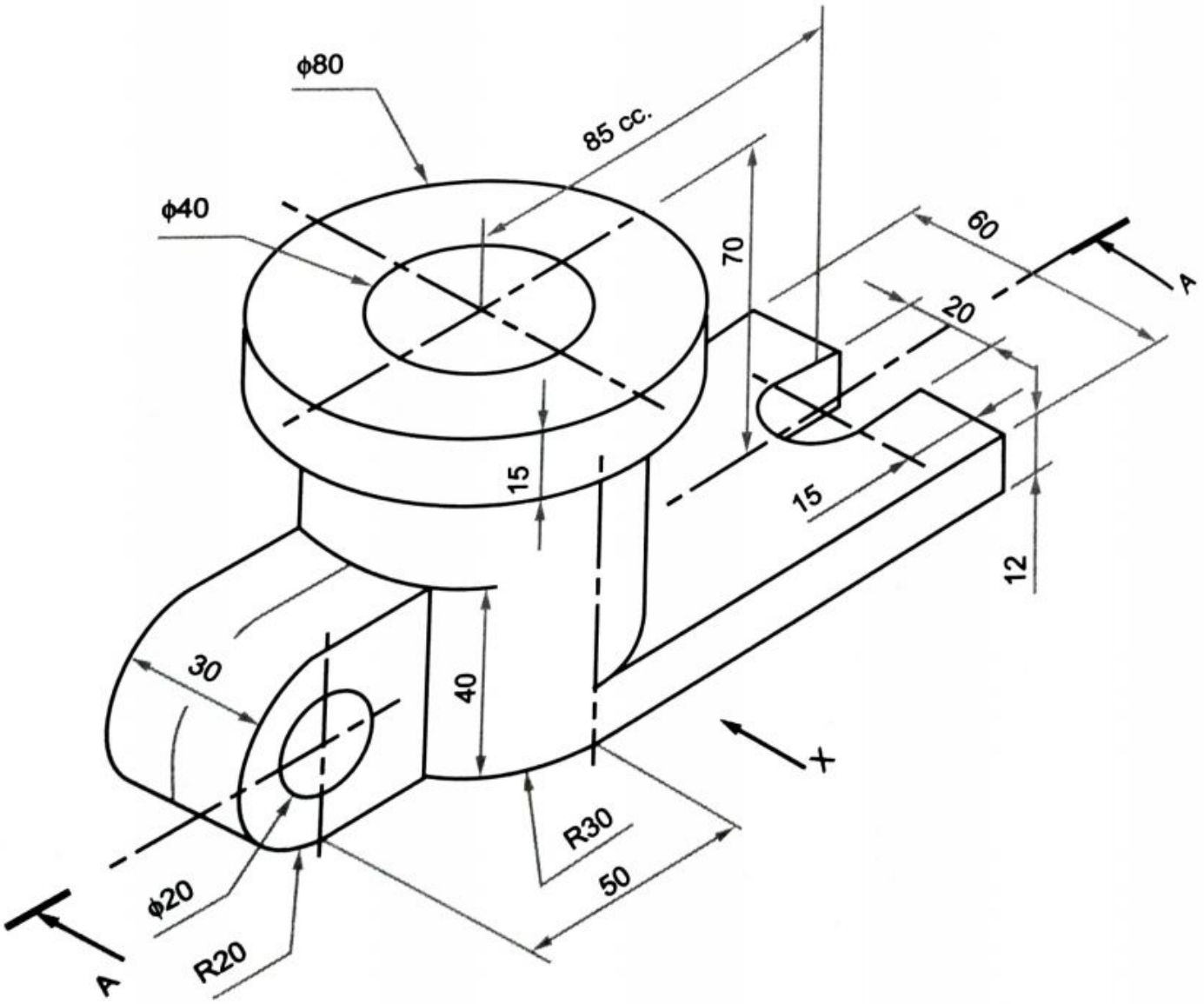


Sol. :

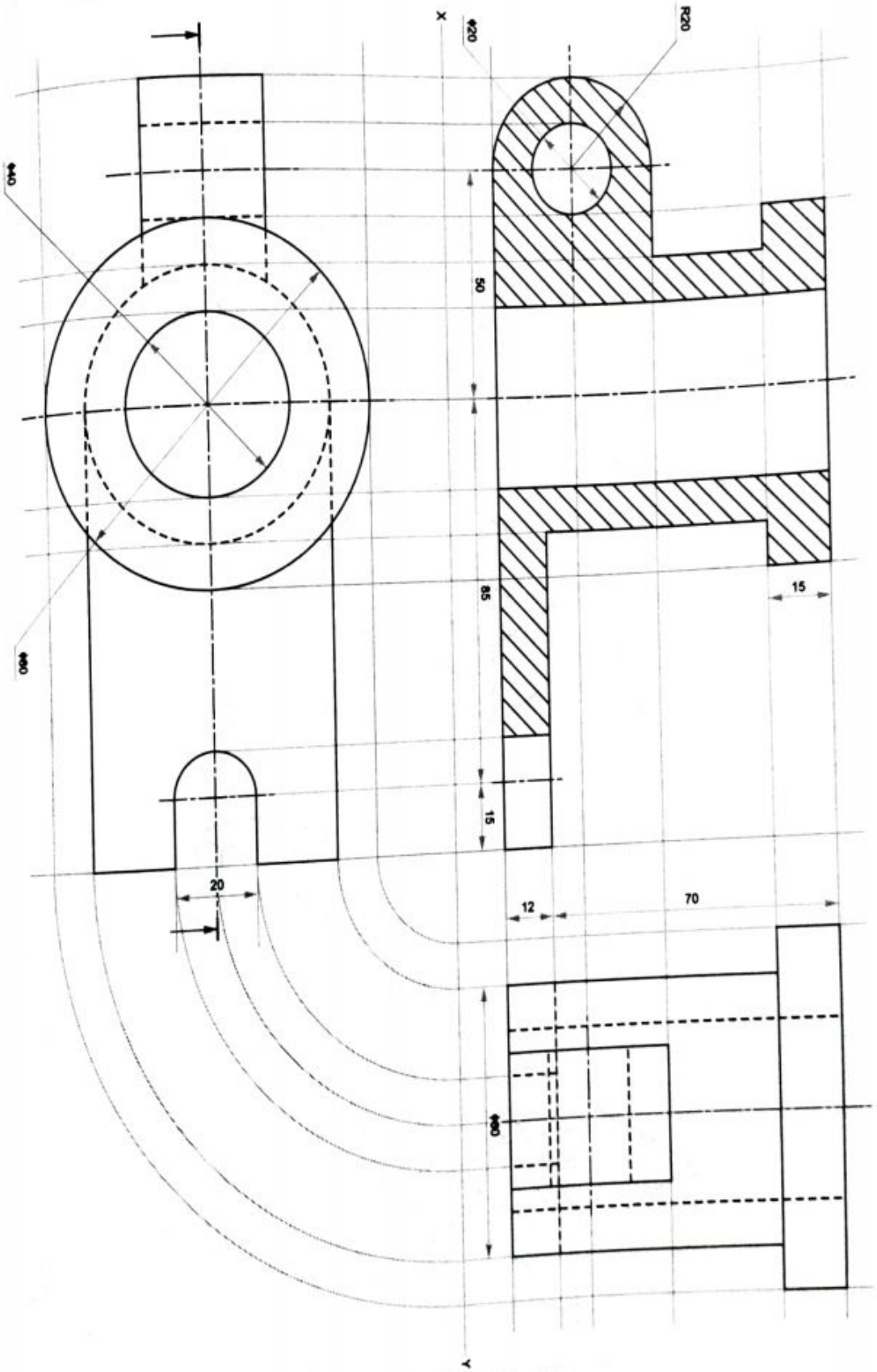


Ex. 4.25.17 : ***Figure shows a pictorial view of an object. By using first angle method of projection, draw;***
i) Sectional front view, along sectional plane A-A
ii) Left hand side view
iii) Top view
iv) Dimensions

SPPU : Dec. 12

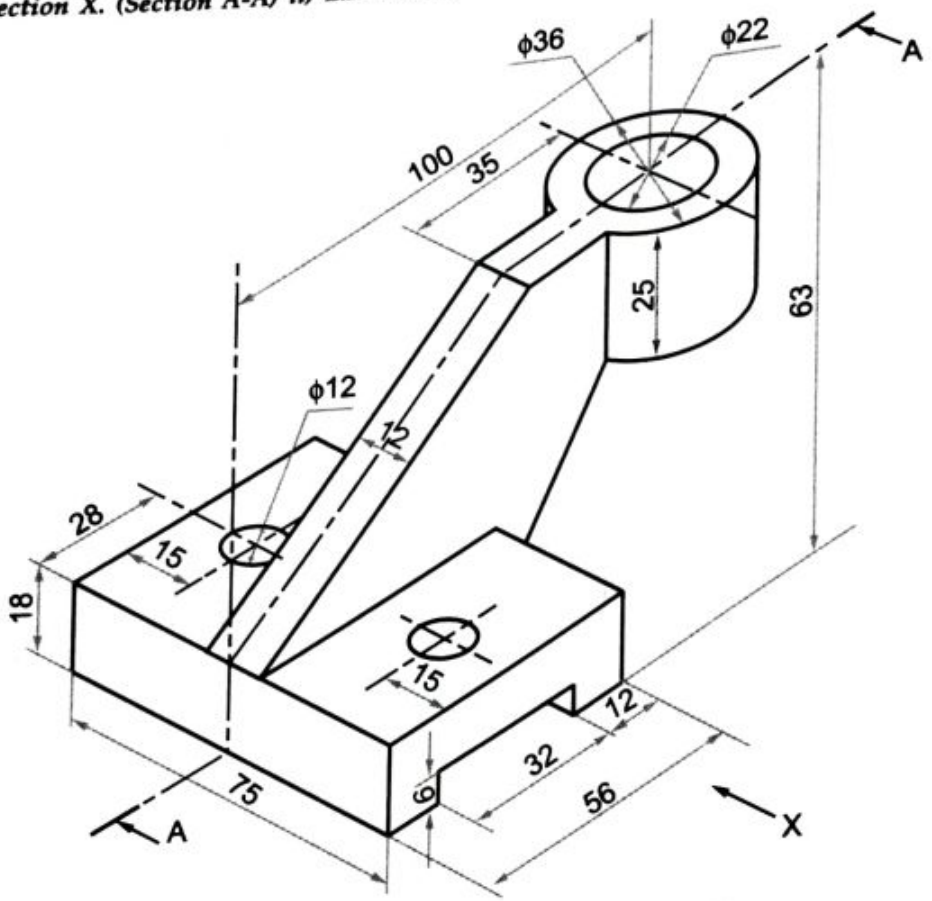


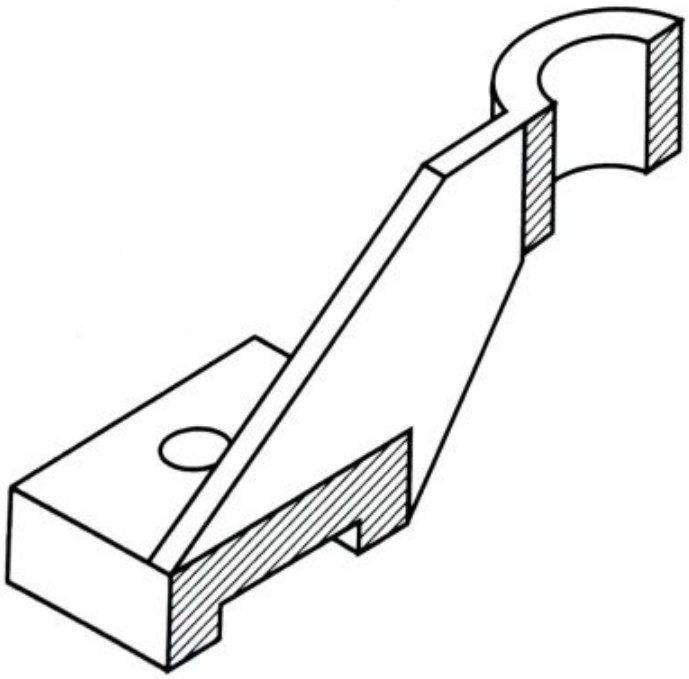
Sol. :



Ex. 4.25.18 : ***Figure shows isometric view of a machine component. Draw following views i) Sectional F.V. looking in the direction X. (Section A-A) ii) L.H.S.V. iii) T.V.***

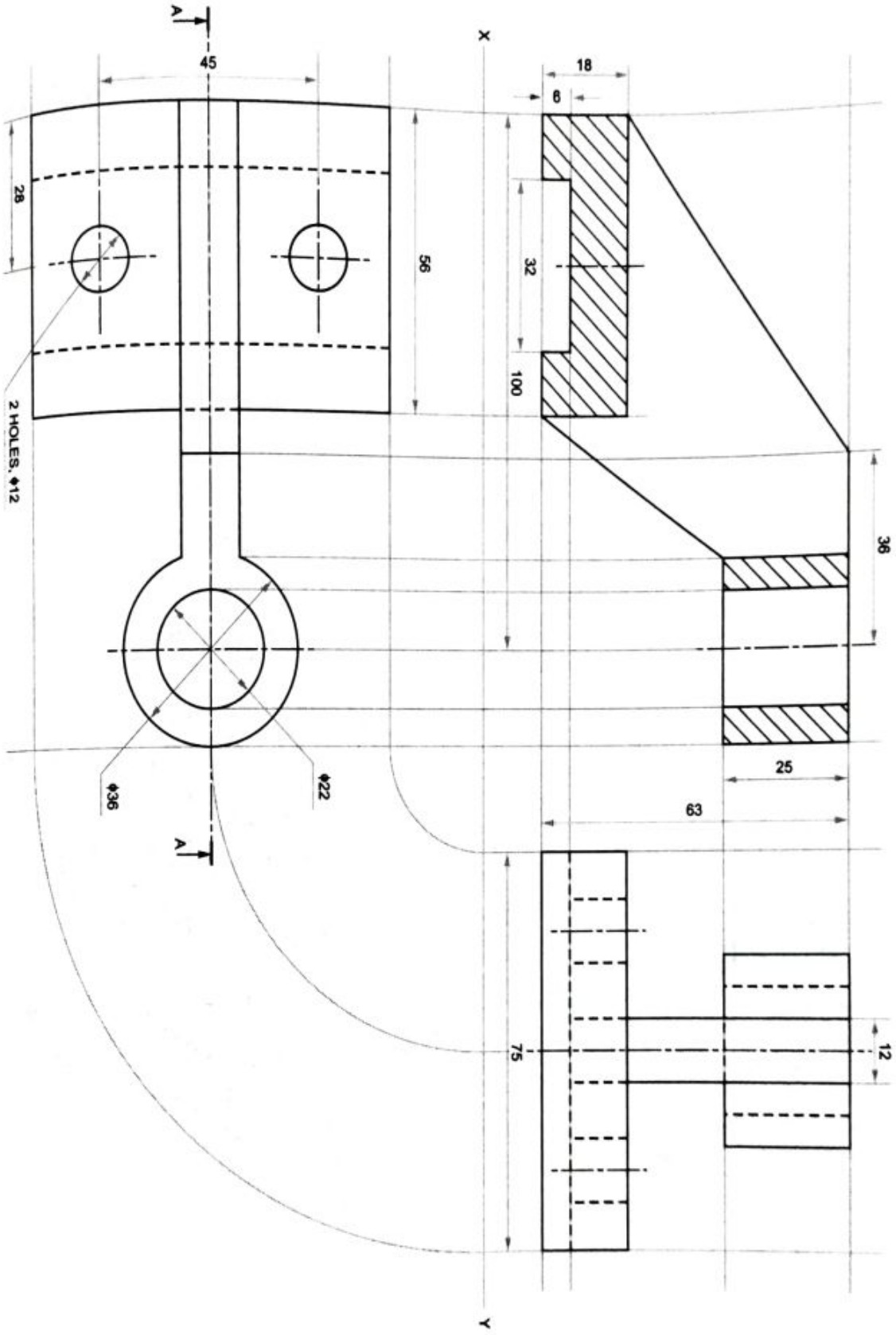
SPPU : May-10, Marks 20, Nov.-16, Marks 13





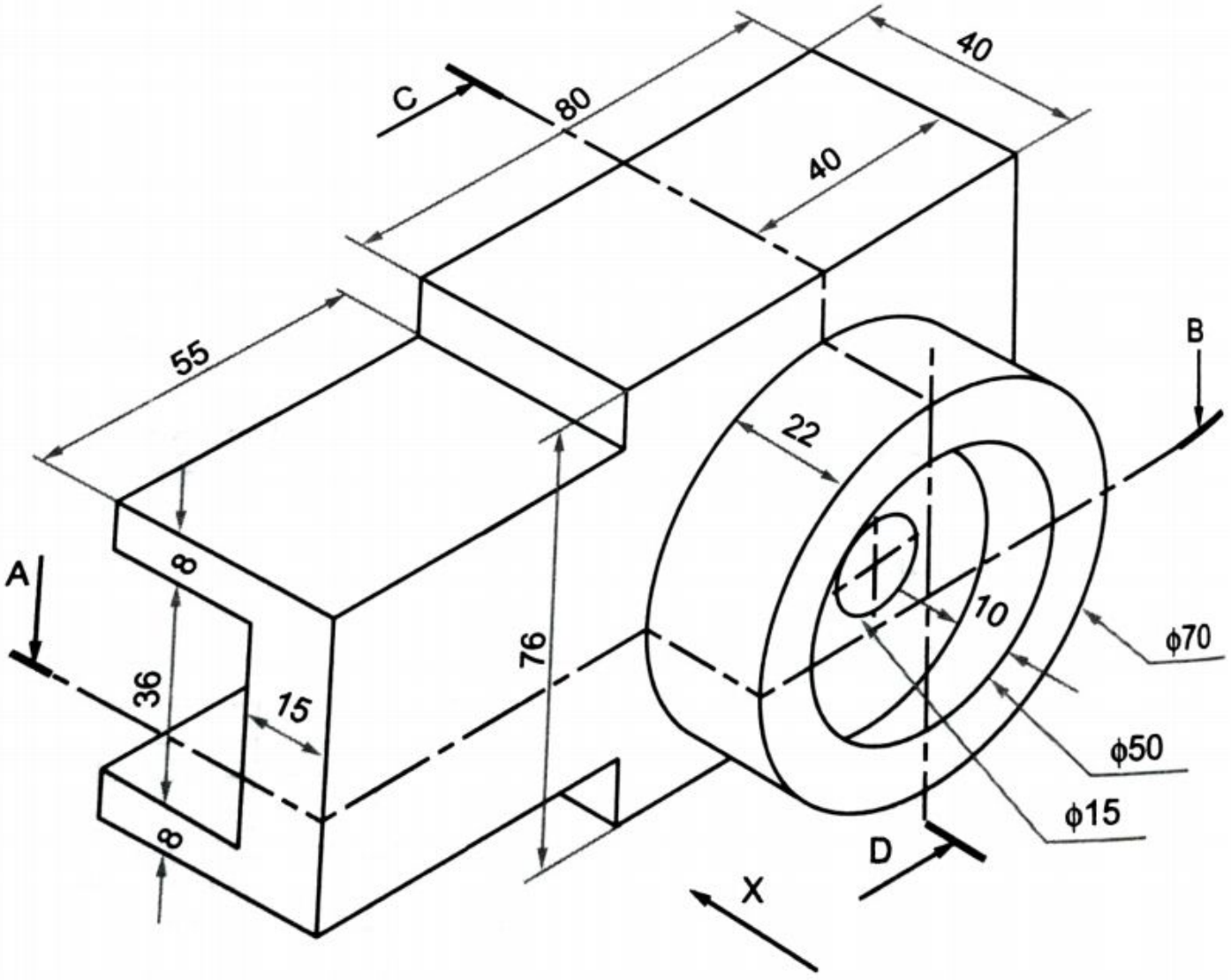
SECTIONAL ISOMETRIC VIEW

Sol. :

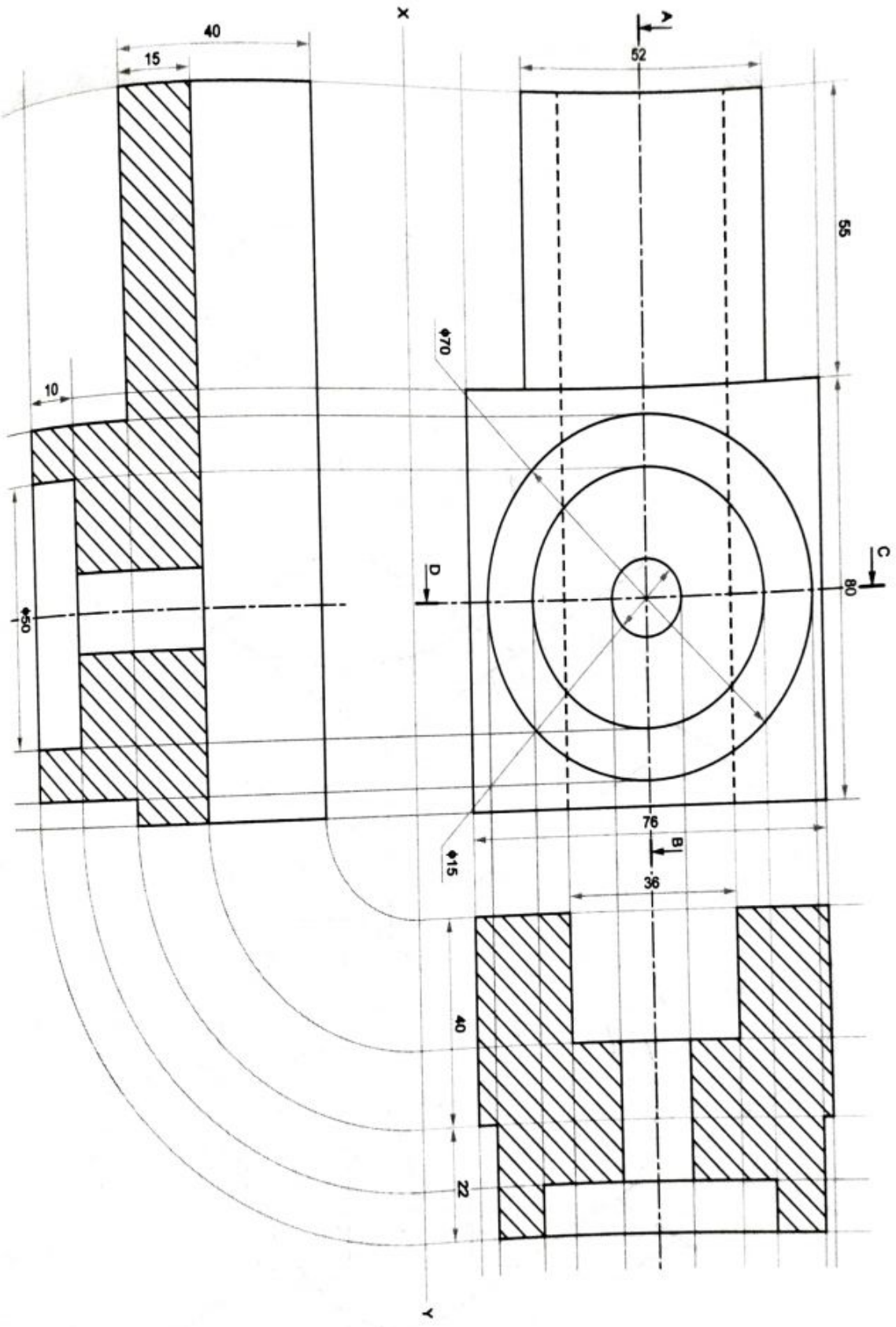


Ex. 4.25.19 : ***For the casting shown in figure draw to full size following views :***
i) Elevation in the direction of arrow 'X'
ii) Section plan section along A-B
iii) Sectional end view section along C-D
iv) Give all dimensions

SPPU - Dec.-08, Marks 20



Sol :



Ex. 4.25.20 : *For the supporting block, shown in figure draw to full size the following views :*

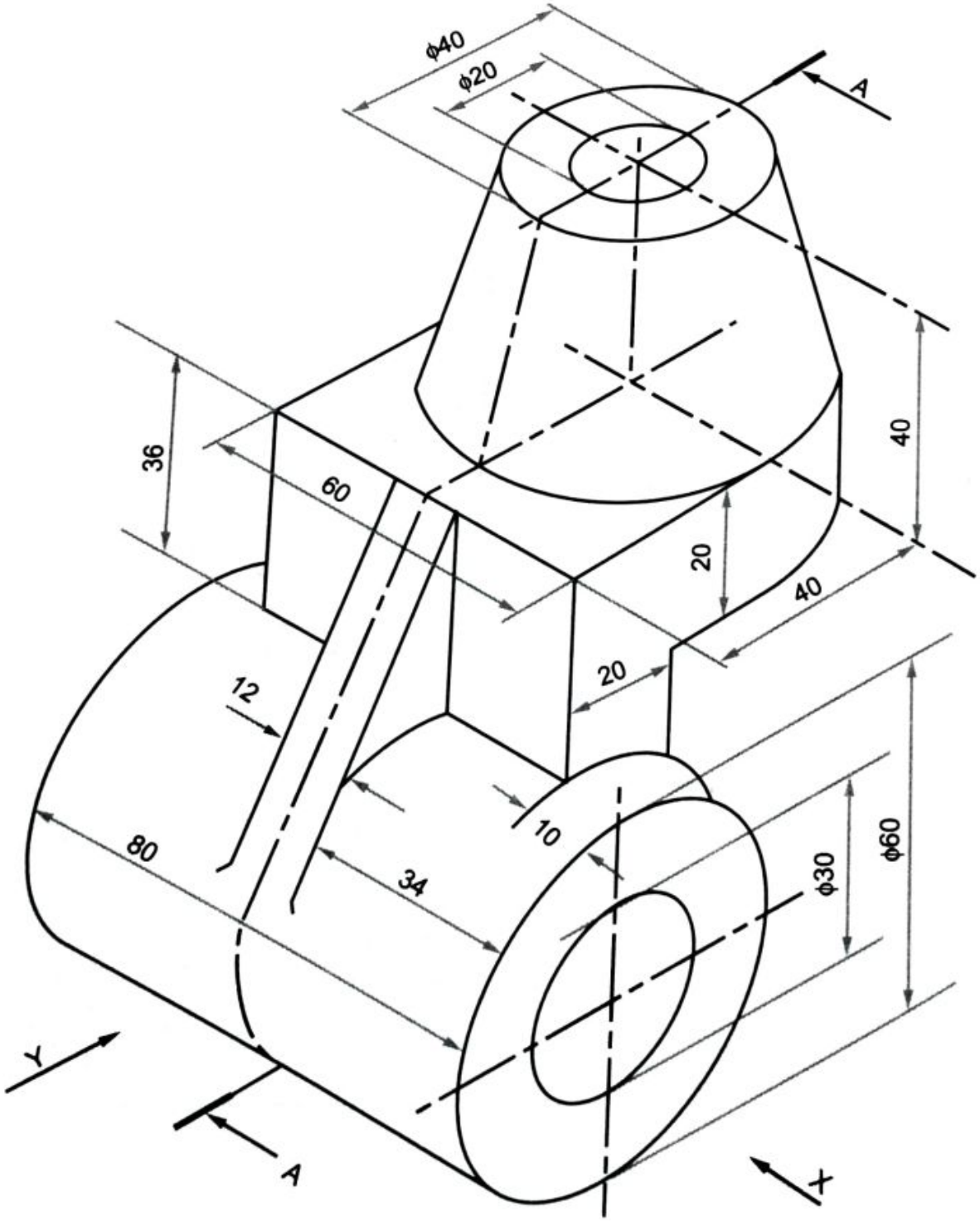
a) Sectional elevation along the direction of arrow X and section along A-A.

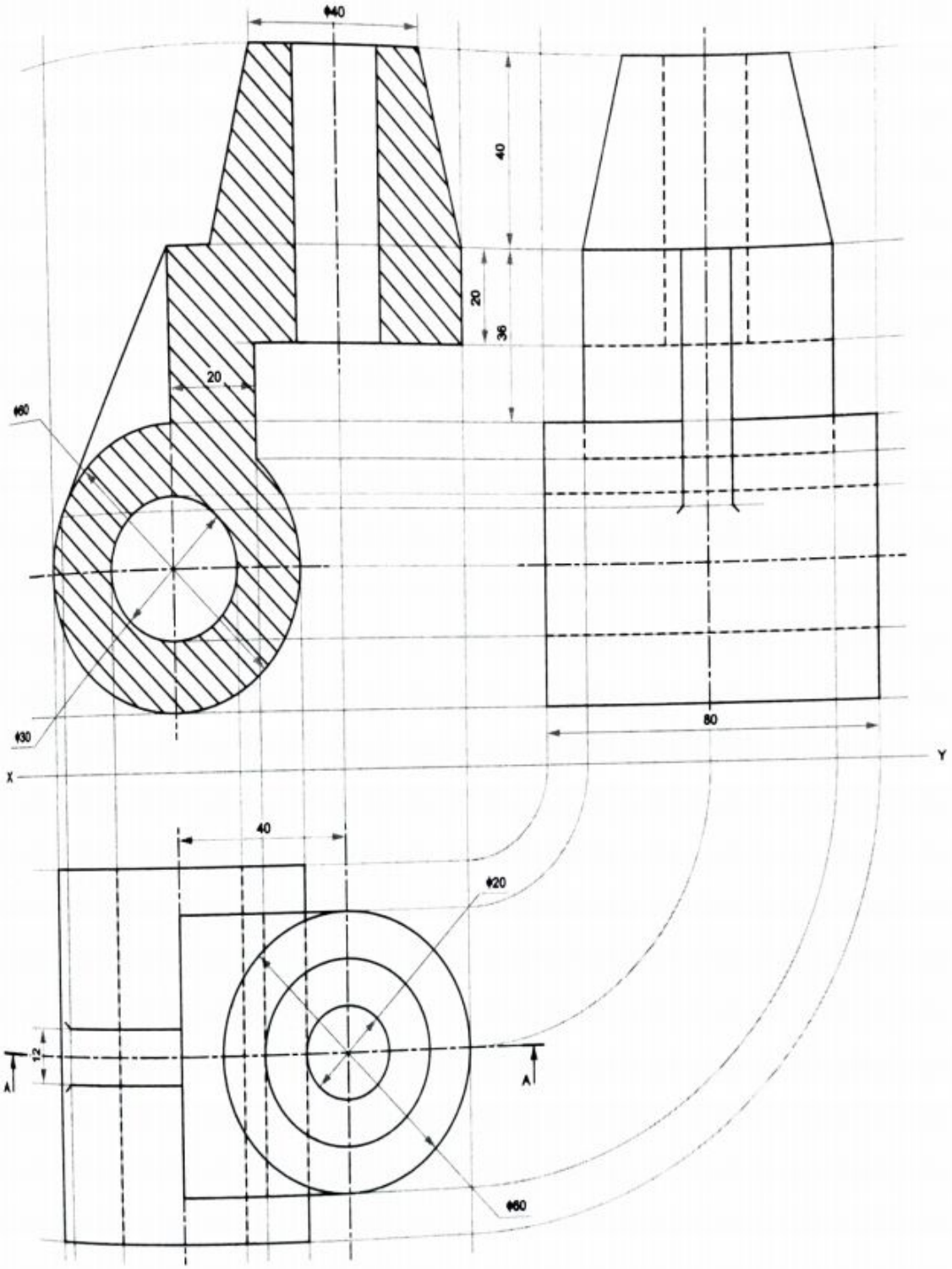
b) Plan

c) End view along the direction of arrow Y.

d) Give all dimensions

SPPU : Dec.-08, Marks 20




ϕ40
40
20
36
20
ϕ60
ϕ30
80
X
Y
40
ϕ20
12
A
A
ϕ60

Ex. 4.25.21 : *For the object shown in figure, draw the following views, using first angle projection method.*

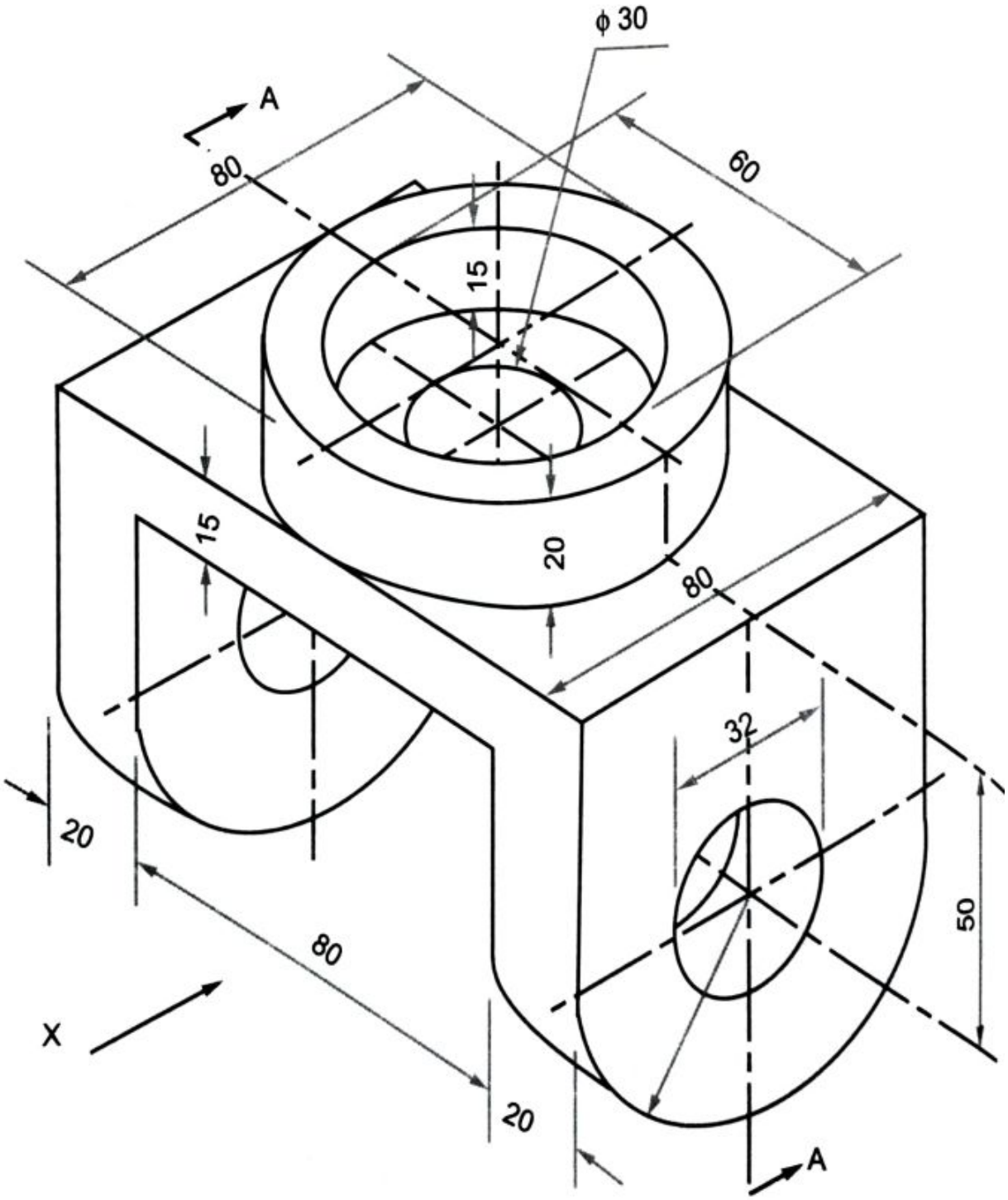
a) Sectional front view in the direction of arrow X. (Section along A-A)

b) Top view

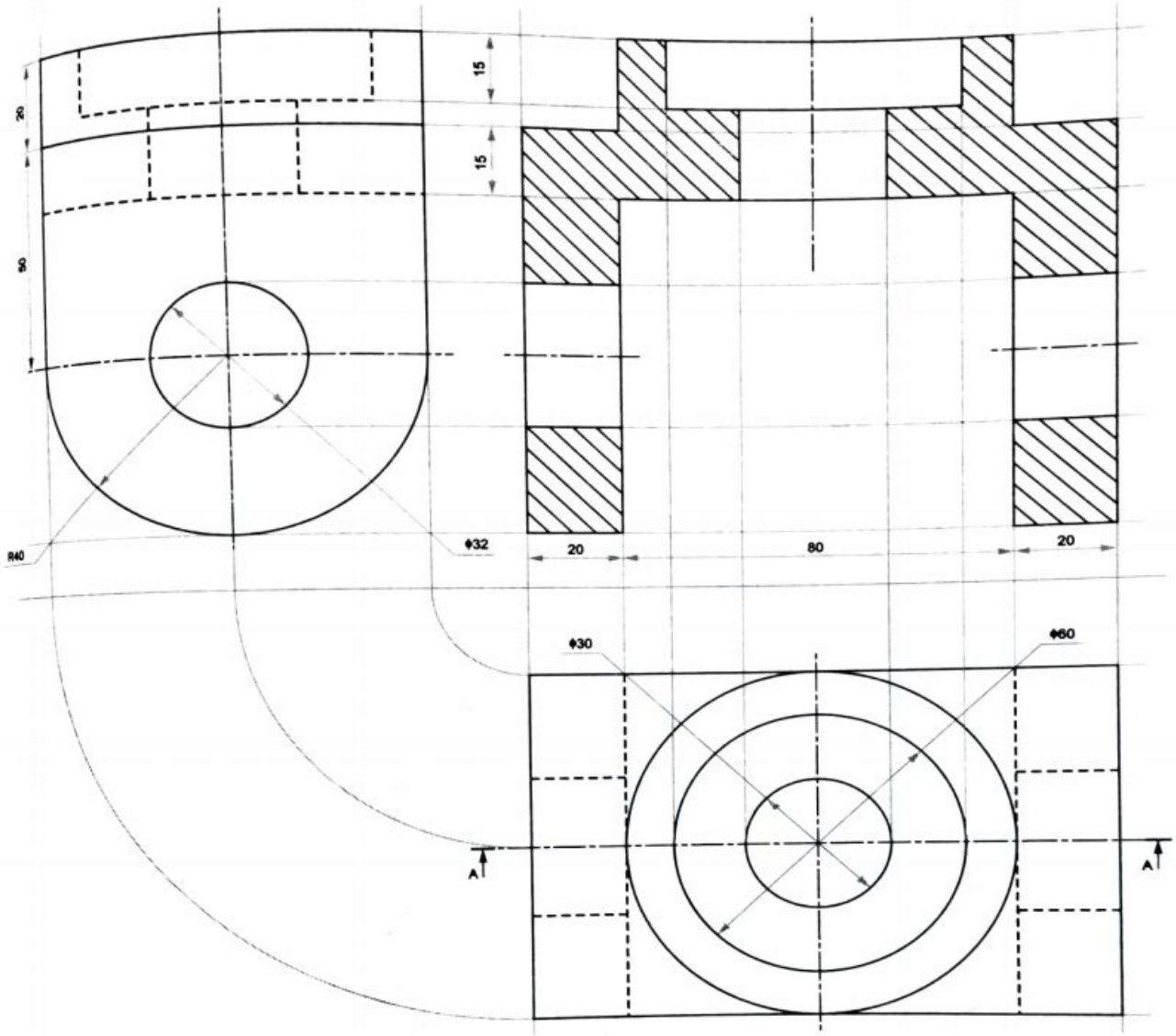
c) Right hand side view

Give all dimensions

SPPU : Dec.-11, Marks



Sol. :



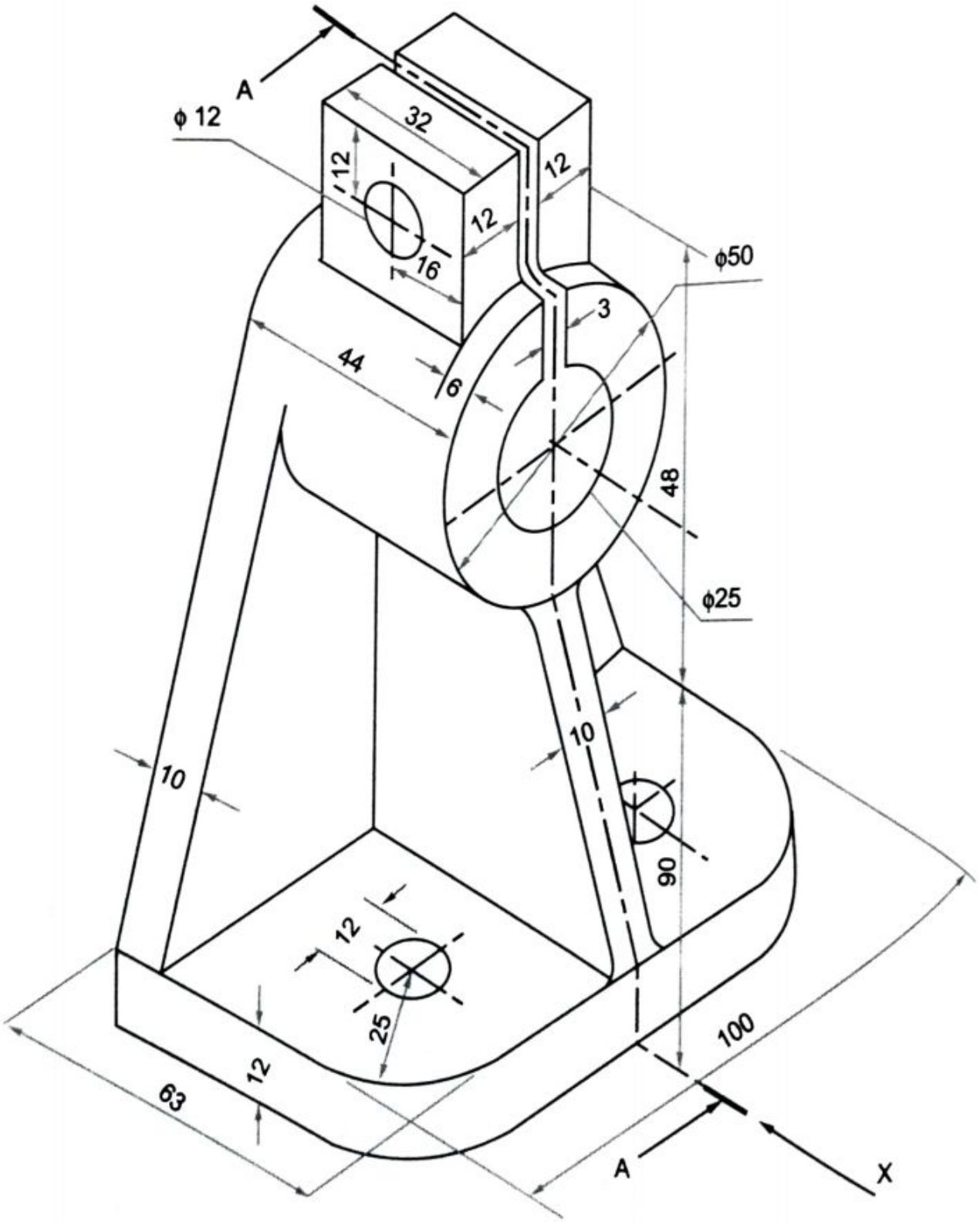
Ex. 4.25.22 : *For the object shown in figure, draw the following views, using first angle projection method.*

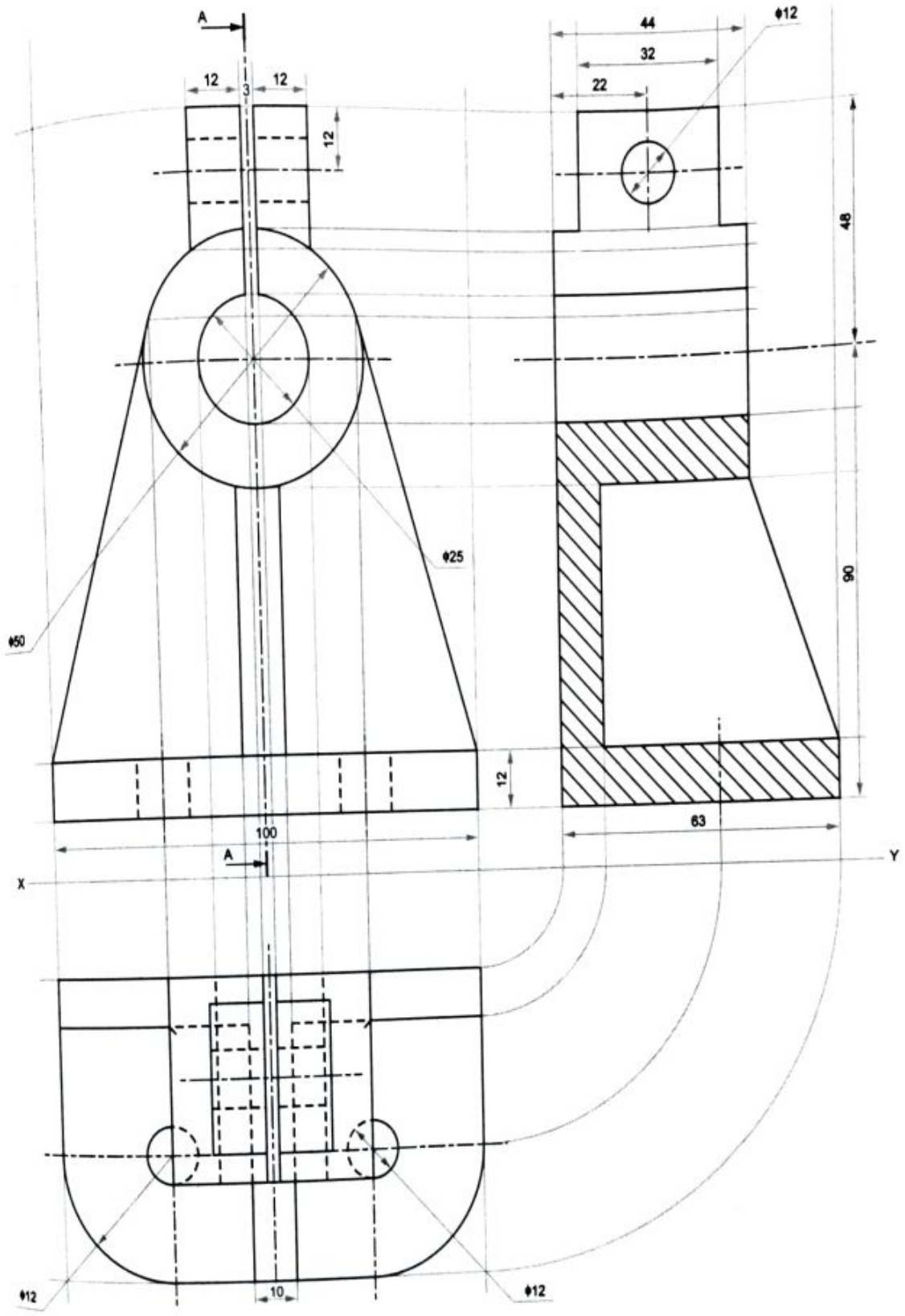
a) Front view in the direction of arrow X.

b) Top View

c) Sectional left hand side view

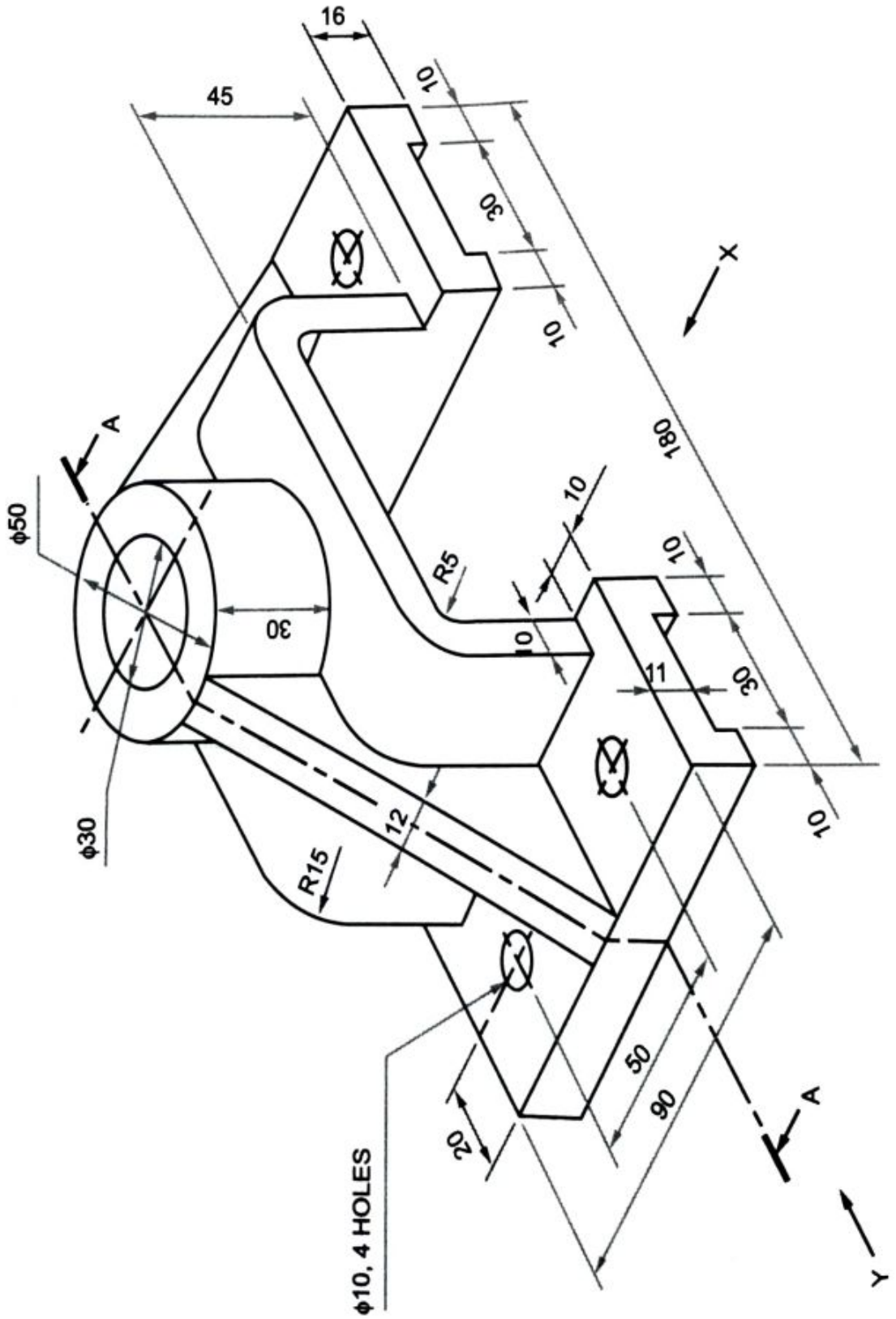
SPPU : Dec.-11, Marks 2

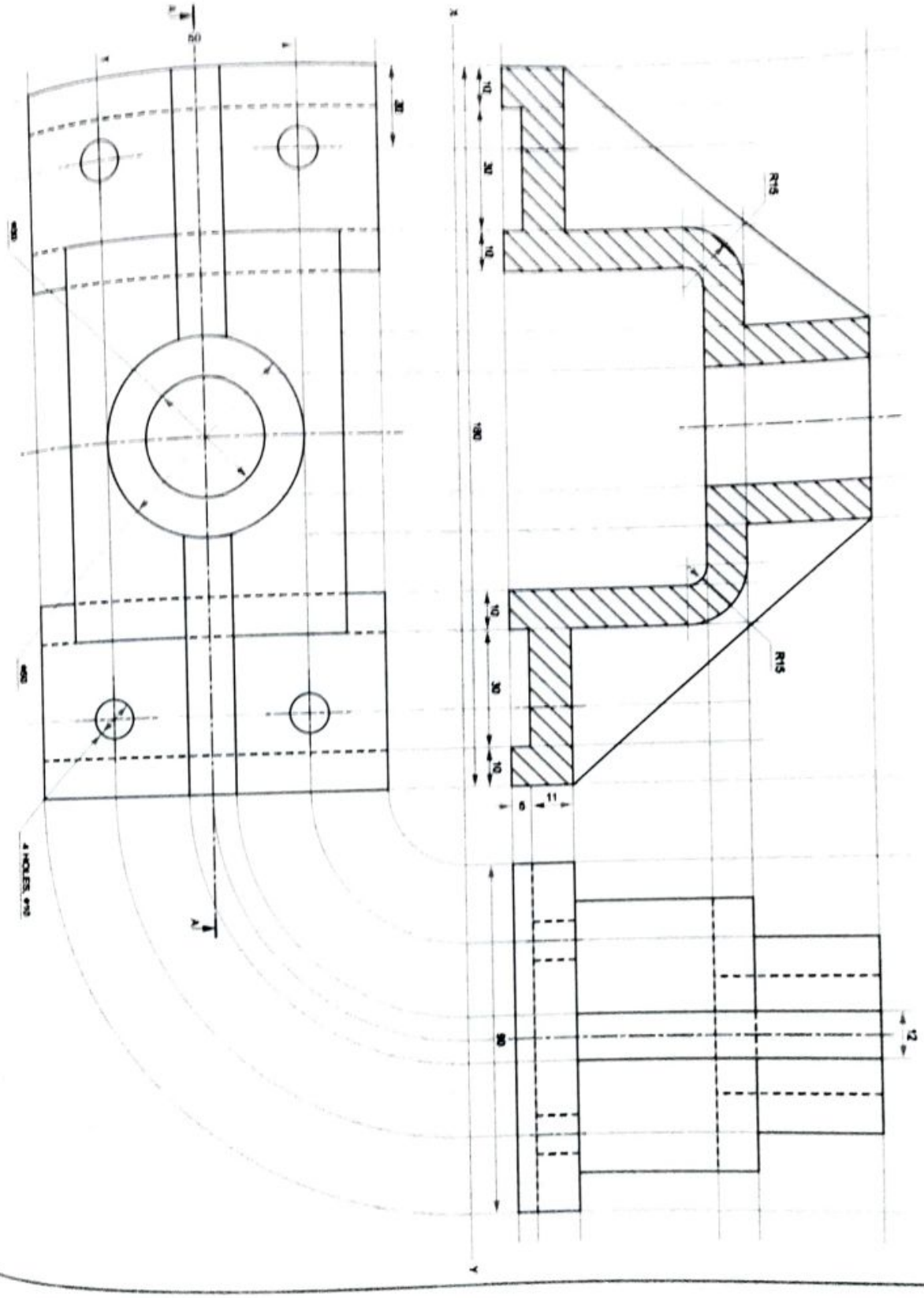



A
12
3
12
12
44
32
22
ϕ12
48
ϕ25
ϕ50
90
12
100
63
A
X
Y
ϕ12
10
ϕ12

Ex. 4.25.23 : *Figure shows isometric view of a machine component. Draw following views :*
i) Sectional front view looking in the direction

SPPU : Dec.-11, Marks 20, May-16, Marks 13




R15
R15
4 HOLES Ø9

Ex. 4.25.24 : *For the object shown in figure, draw the following views, using first angle method of projection.*

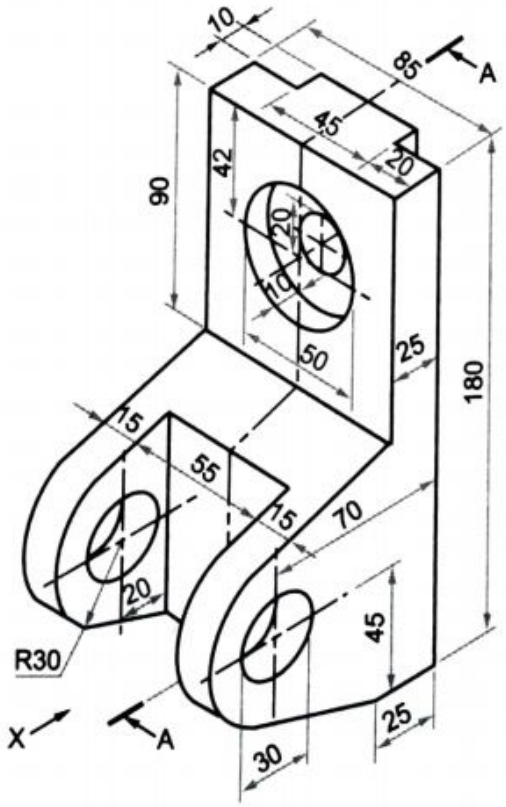
a) Elevation looking in the direction of arrow 'X'.

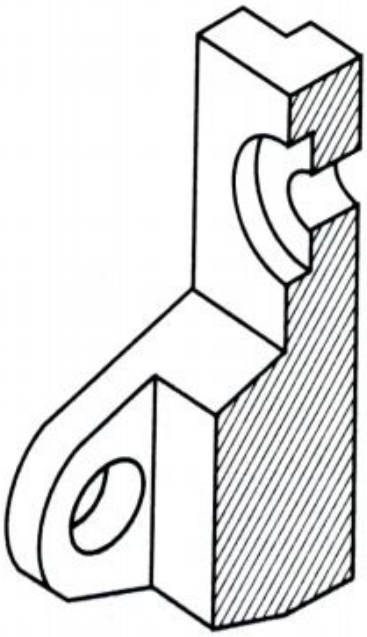
b) Plan

c) Sectional end view from the right hand side. (Section along A-A)

d) Give all dimensions

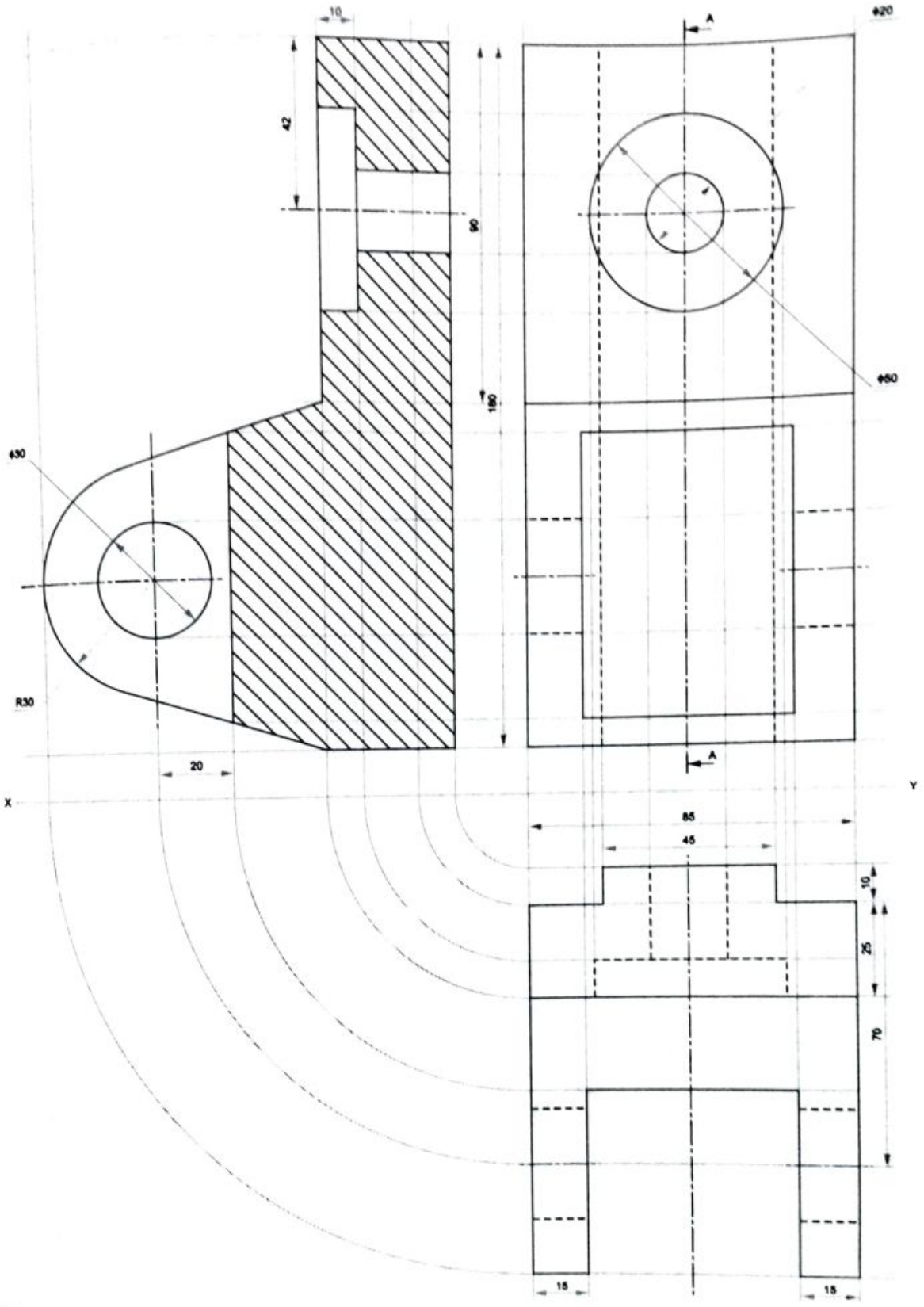
SPPU : Dec.-09, Marks 4





SECTIONAL ISOMETRIC VIEW

Sol. :



Ex. 4.25.25 : *For the object shown in figure draw the following views, using first angle method of projection :*

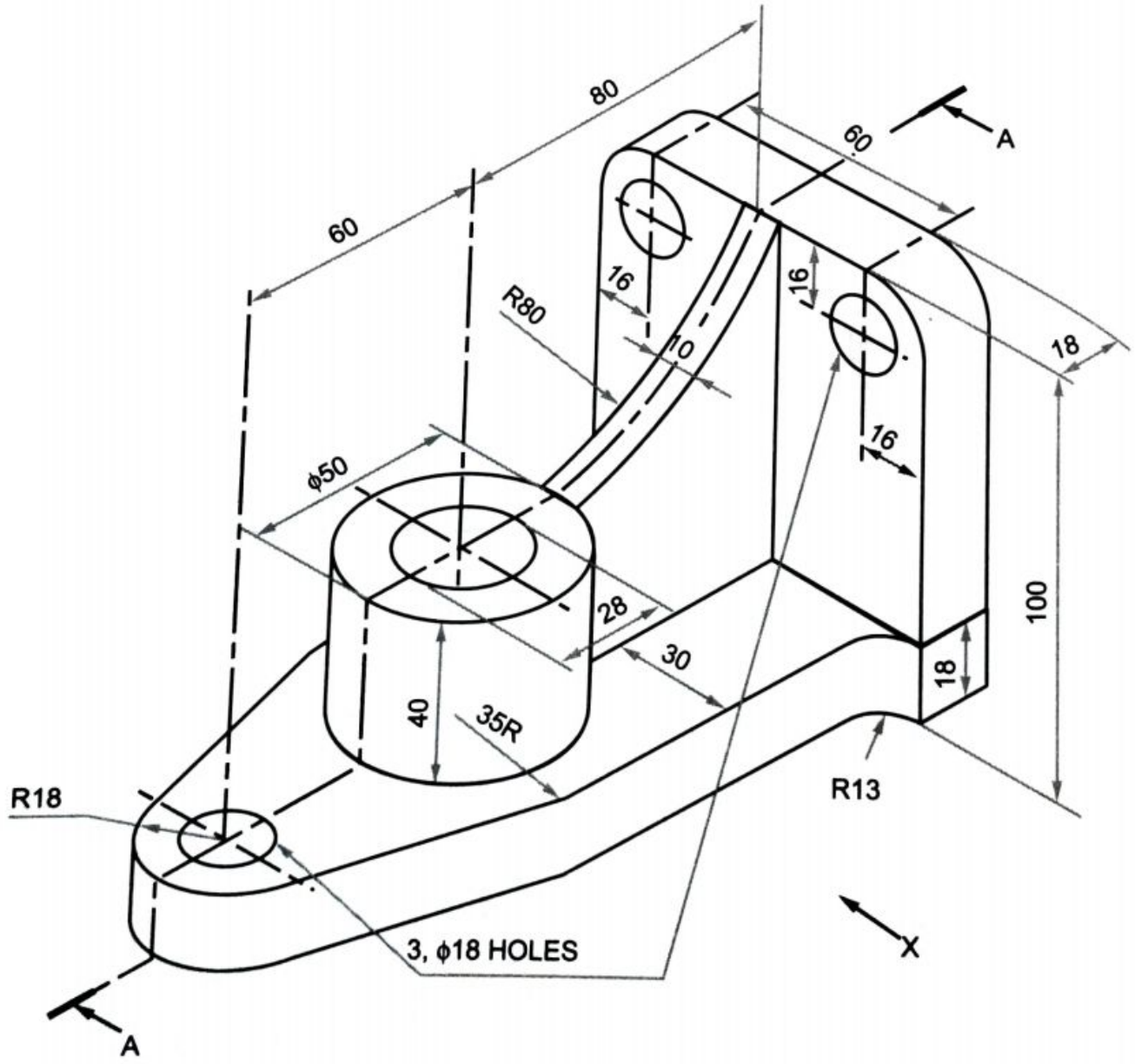
a) Sectional elevation in the direction of arrow X. (Section along A-A)

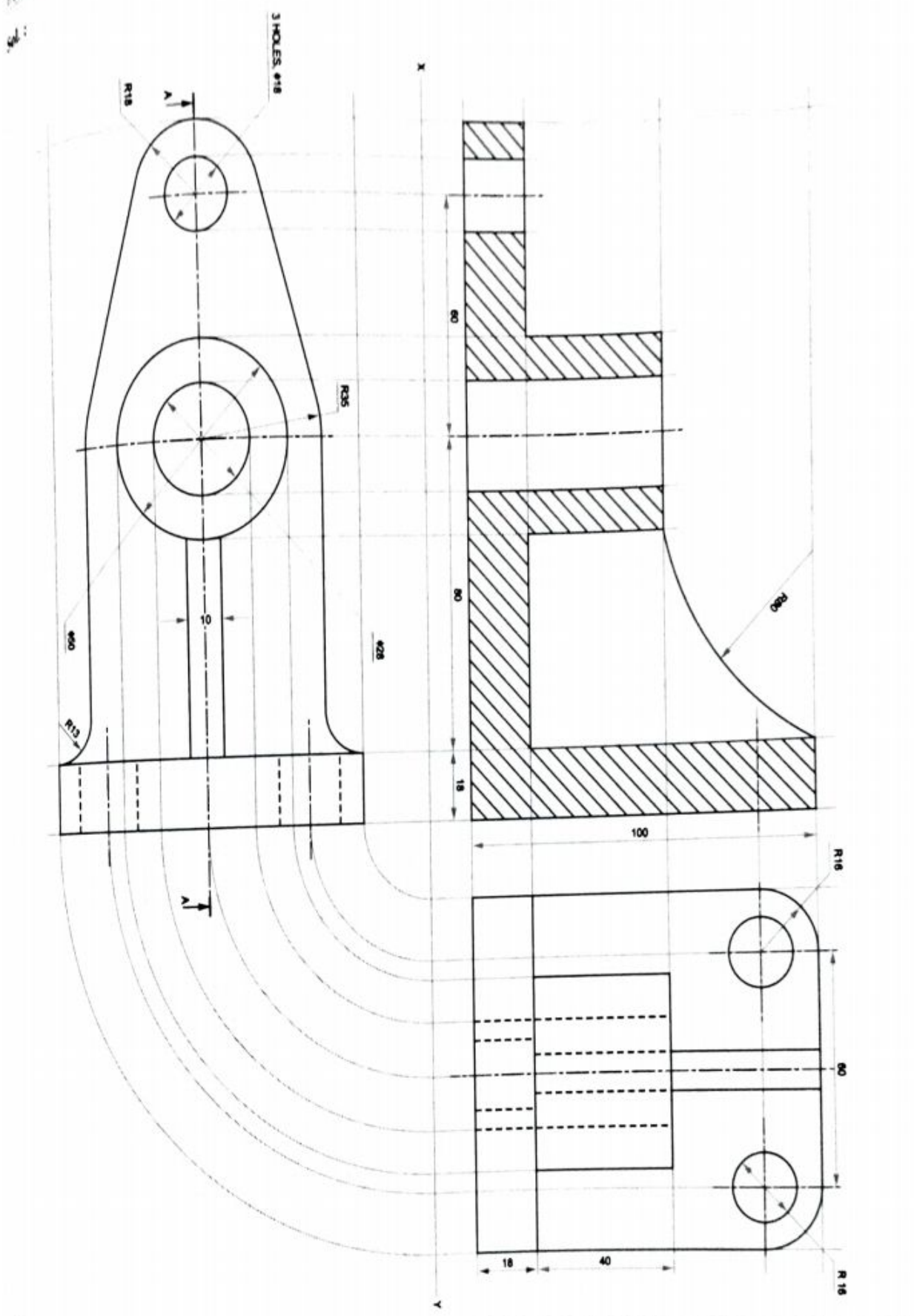
b) Plan

c) End view from left hand side

d) Give all dimensions

SPPU : Dec.-09, Marks 20




3 HOLES, ø18
R18
A
R35
ø50
ø28
10
R13
A
X
Y
60
60
18
100
R80
R16
60
18
40
R 16

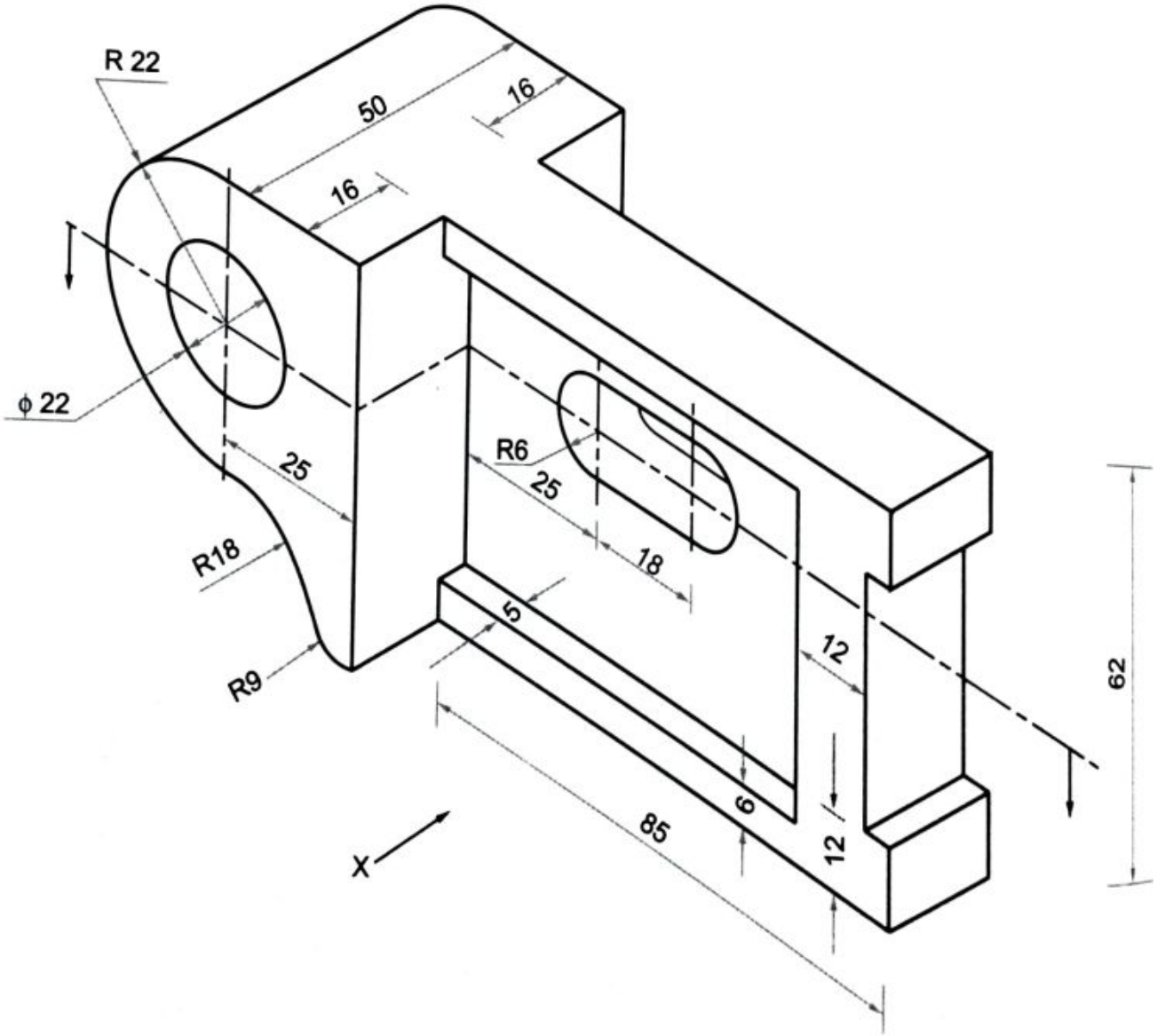
Ex. 4.25.26 : *For the given pictorial view*

i) Fron view

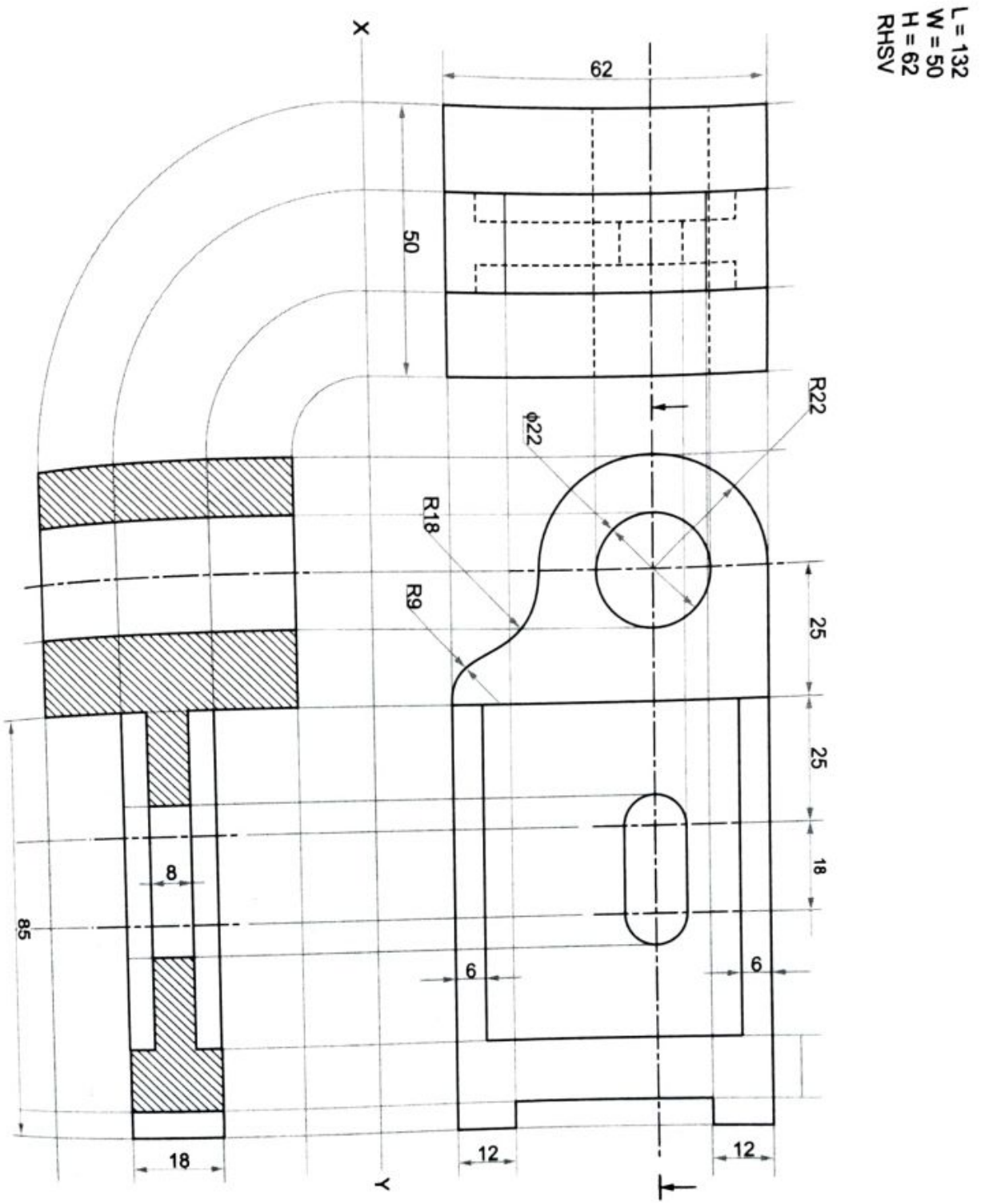
ii) Sectiobnal top view

ii) R.H.S. view

iv) Insert all major dimensions



Sol. :



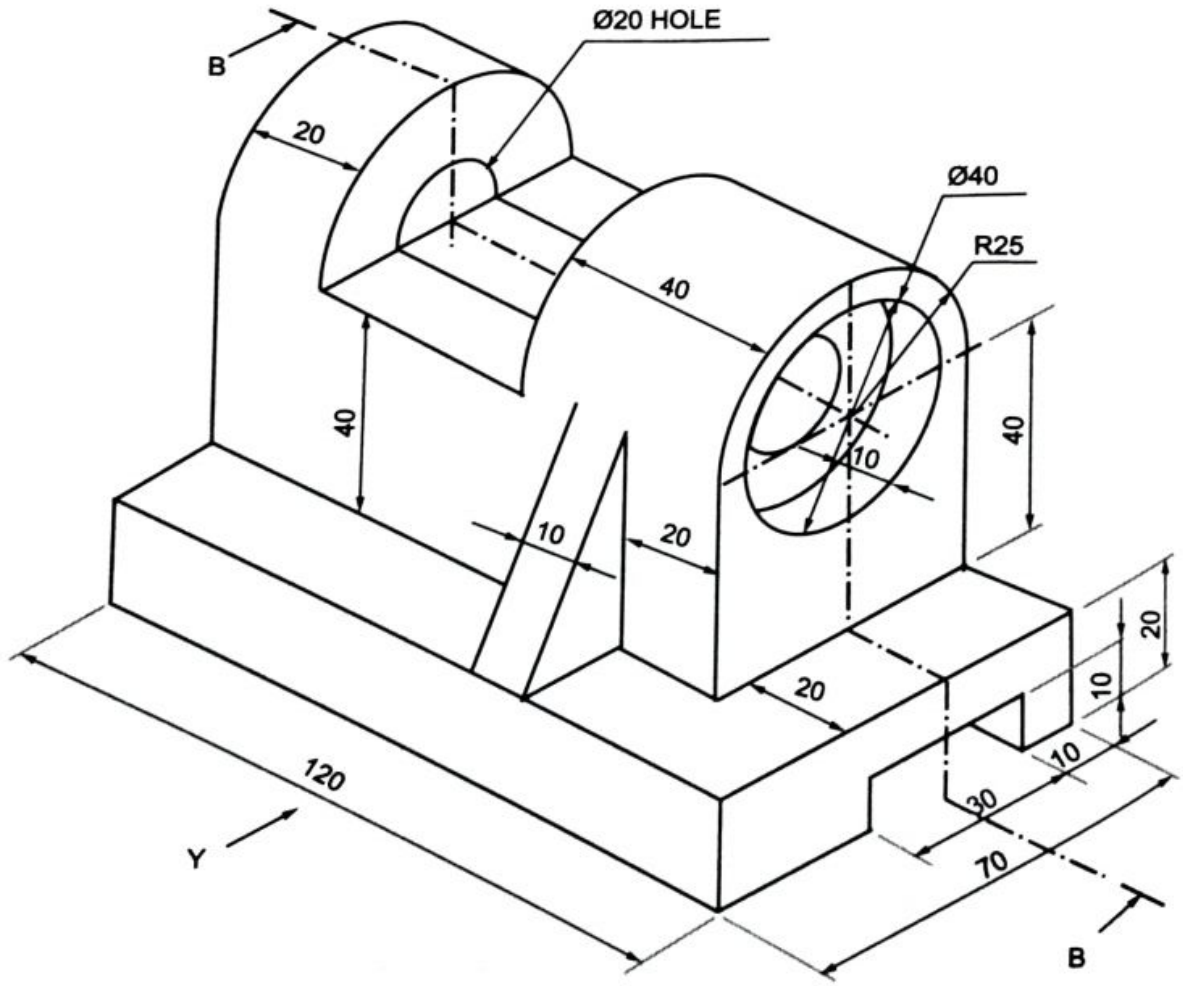
Ex. 4.25.27 : ***For the given pictorial view, draw :***

a) Sectional F.V. (Section B-B)

b) T.V.

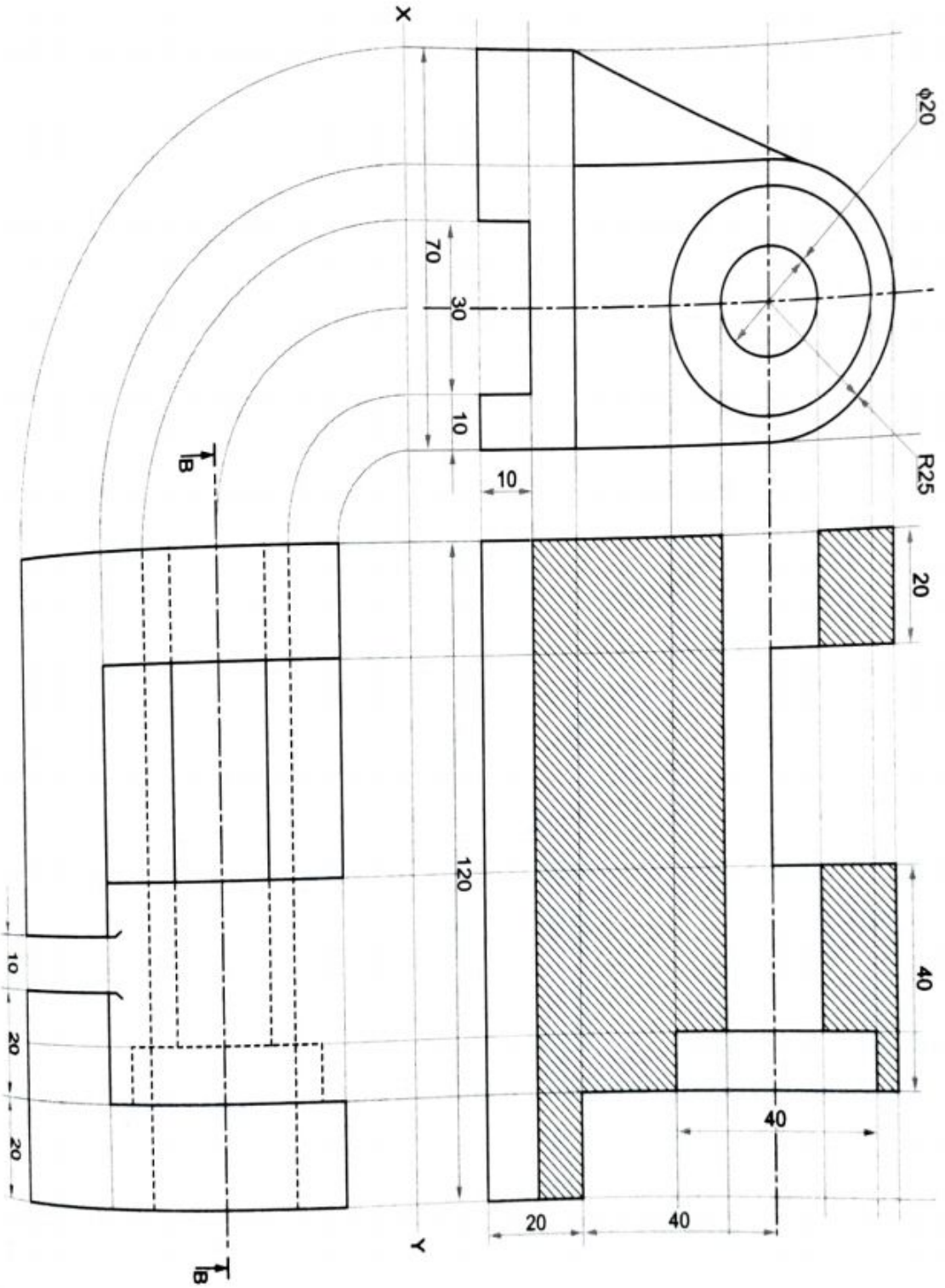
c) RHSV

Insert at least 10 major dimensions.

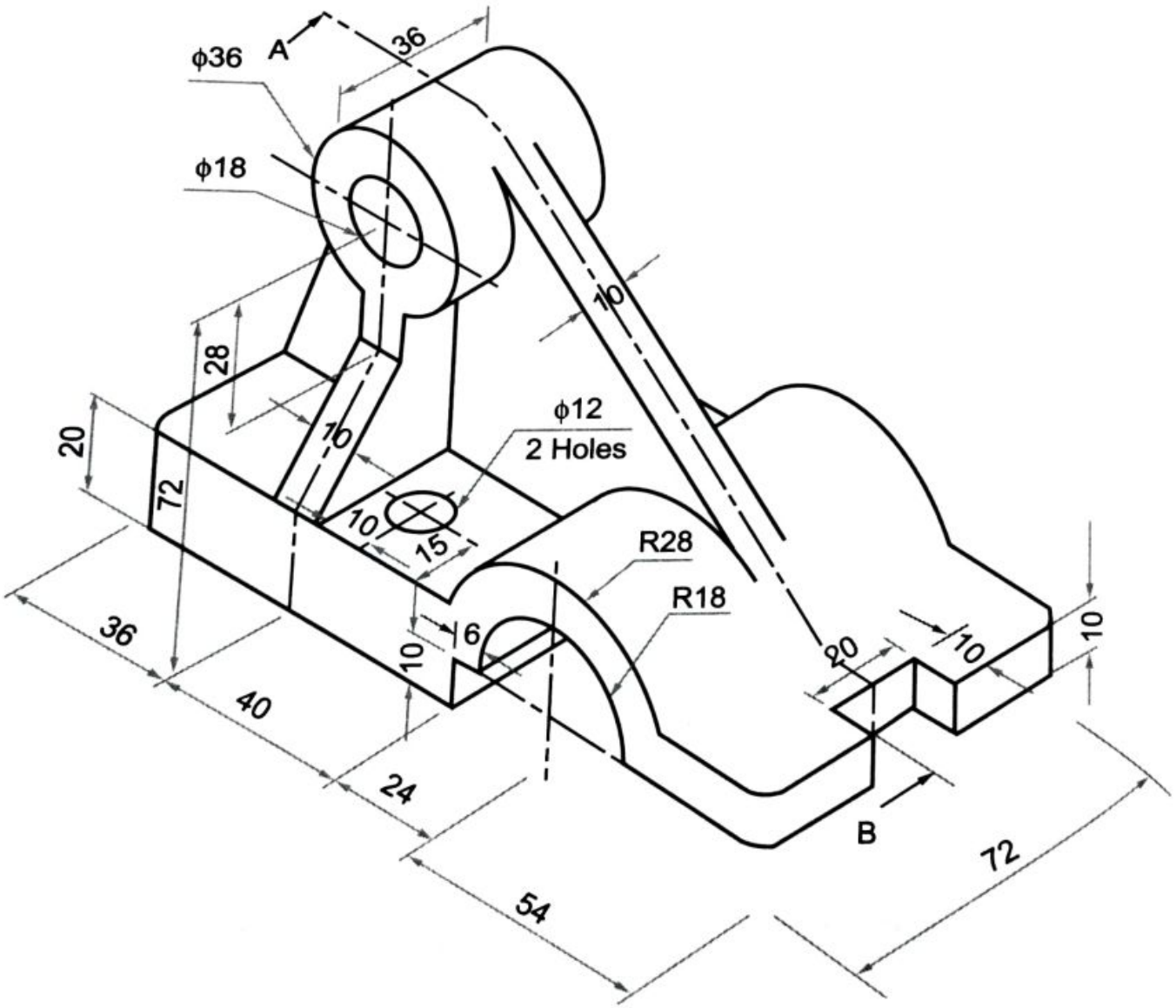


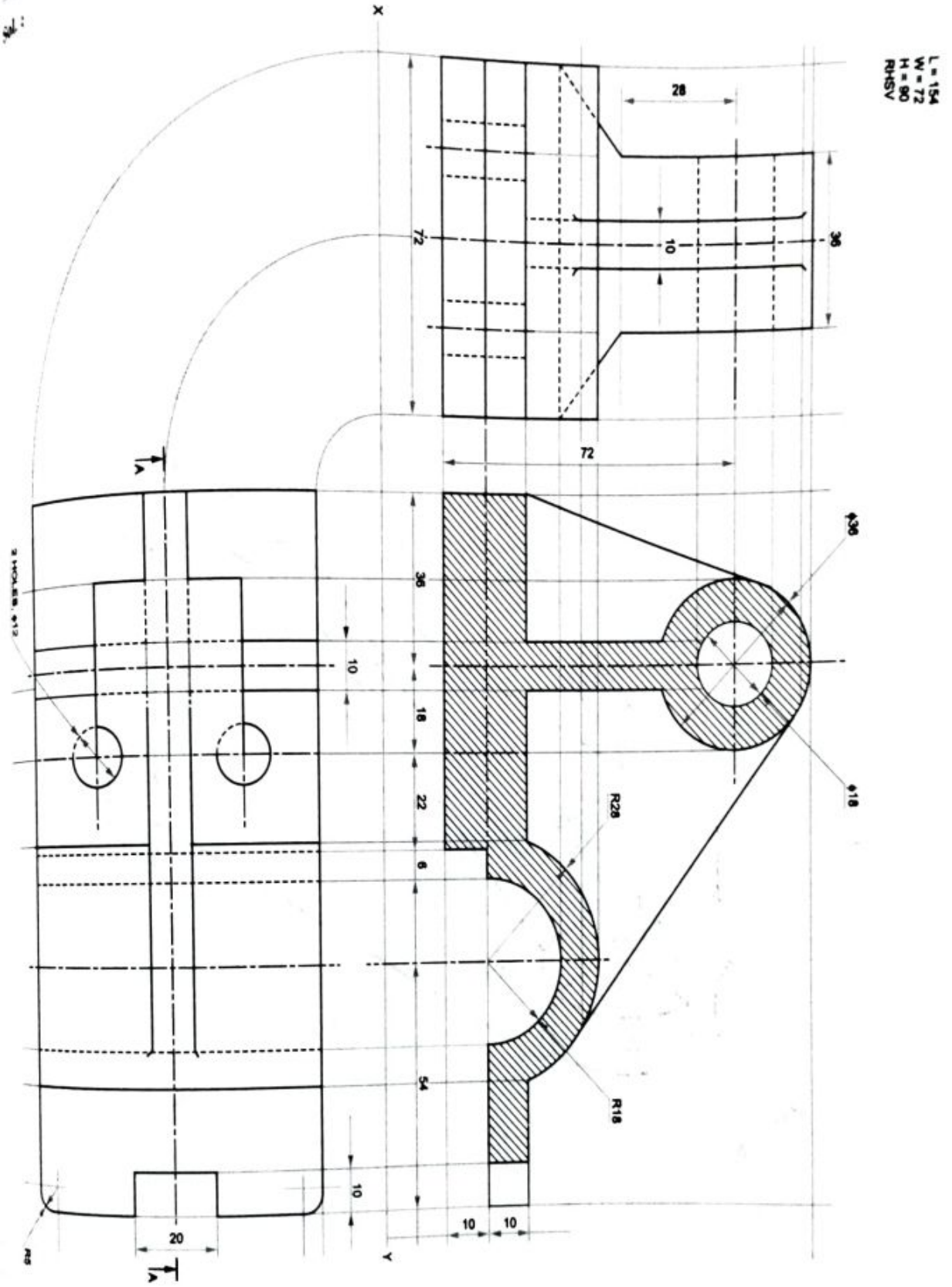
Sol. :

L = 120
W = 70
H = 85
RHSV



Ex. 4.25.28 : ***Figure given below shows the pictorial view of an object. Draw to full scale the following views.***
i) Sectional front view(section AB)
ii) Top view
iii) Right hand side view
Insert 10 major dimensions



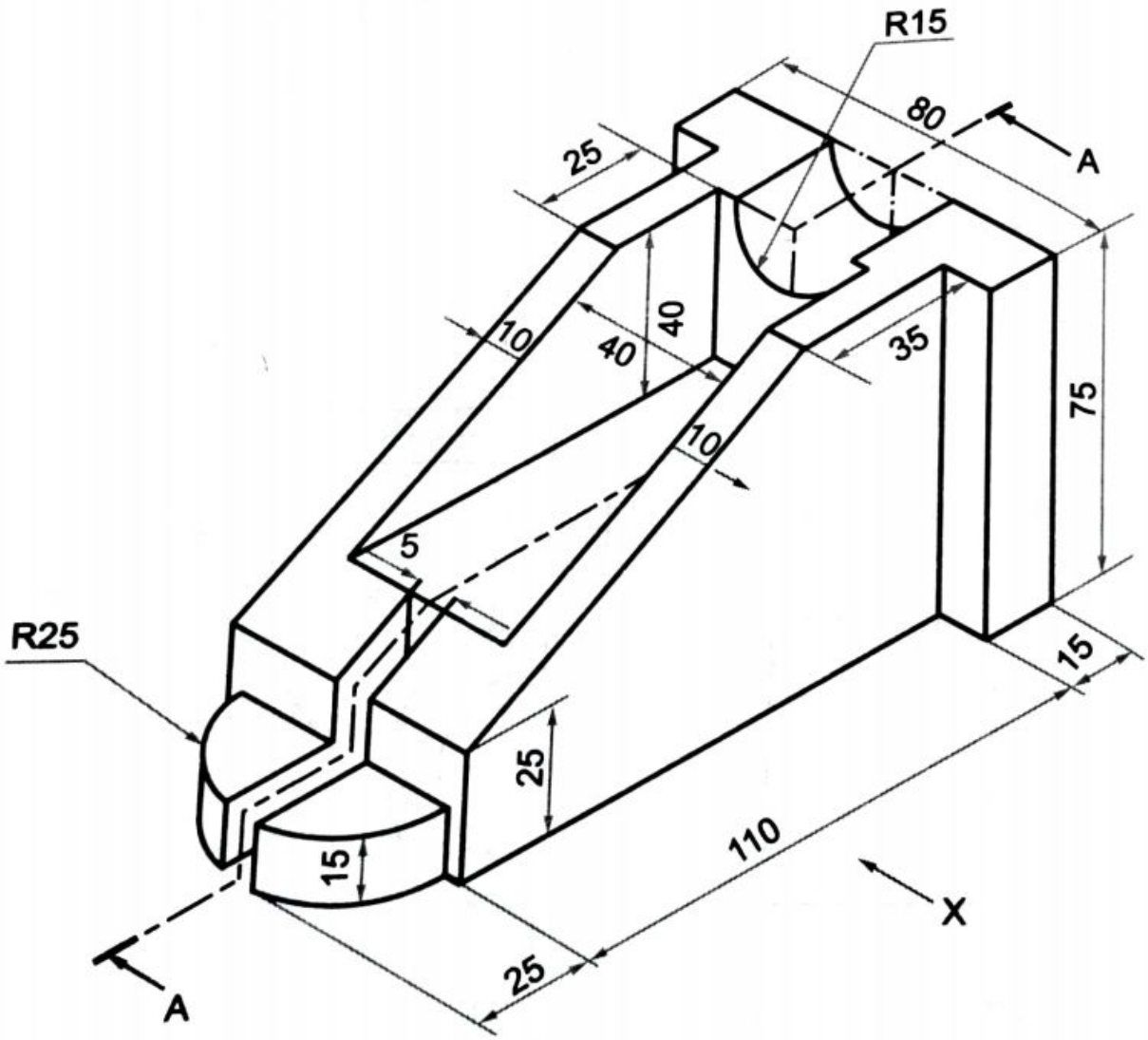

L = 154
W = 72
H = 90
RHSV
X
Y
28
72
36
10
72
A
A
36
18
22
6
54
10
10
10
10
20
2 HOLES, ϕ12
ϕ36
ϕ18
R28
R18
R5

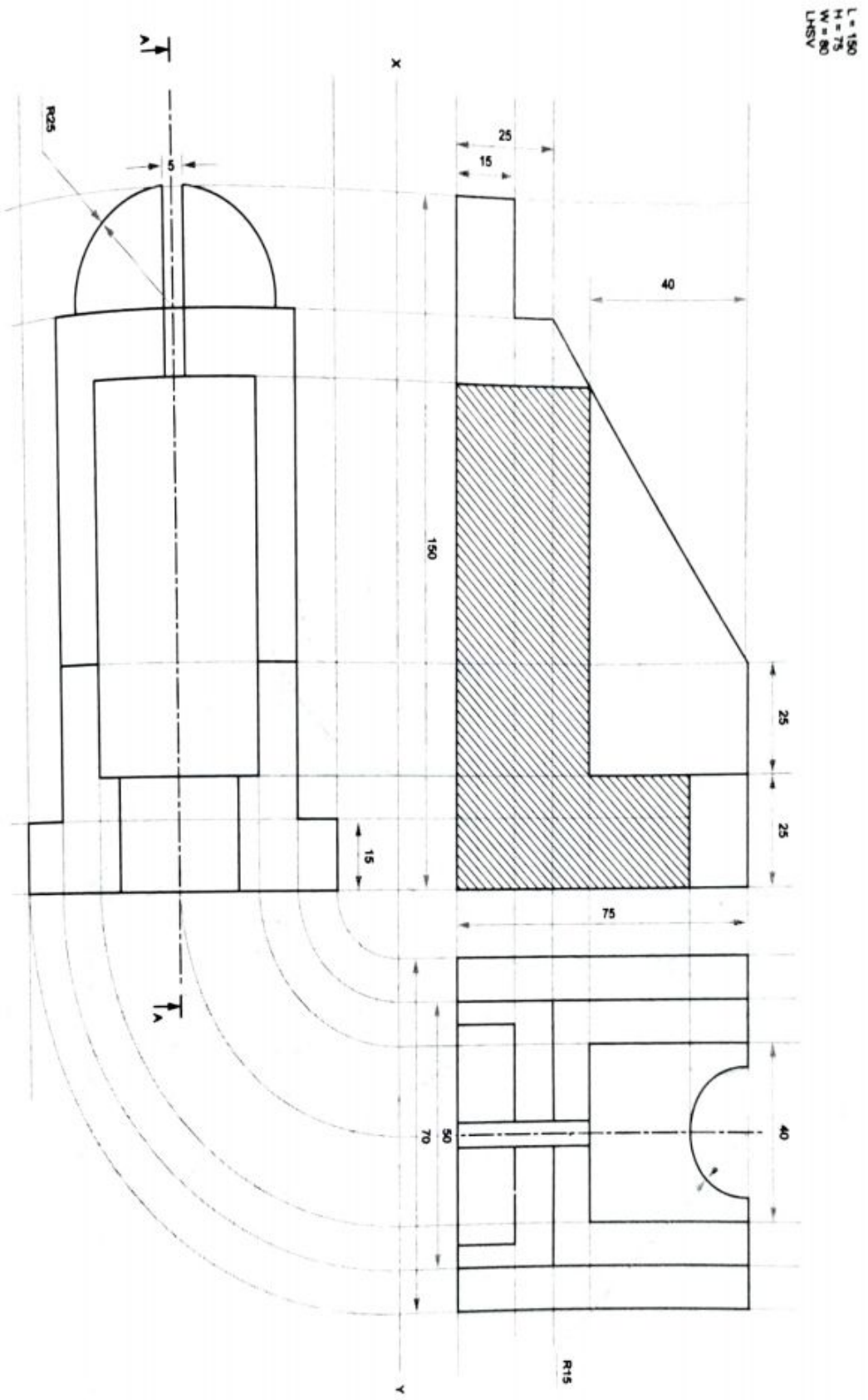
Ex. 4.25.29 : ***Figure given below shows the pictorial view of an object. Draw to full scale the following views.***

i) Sectional front view

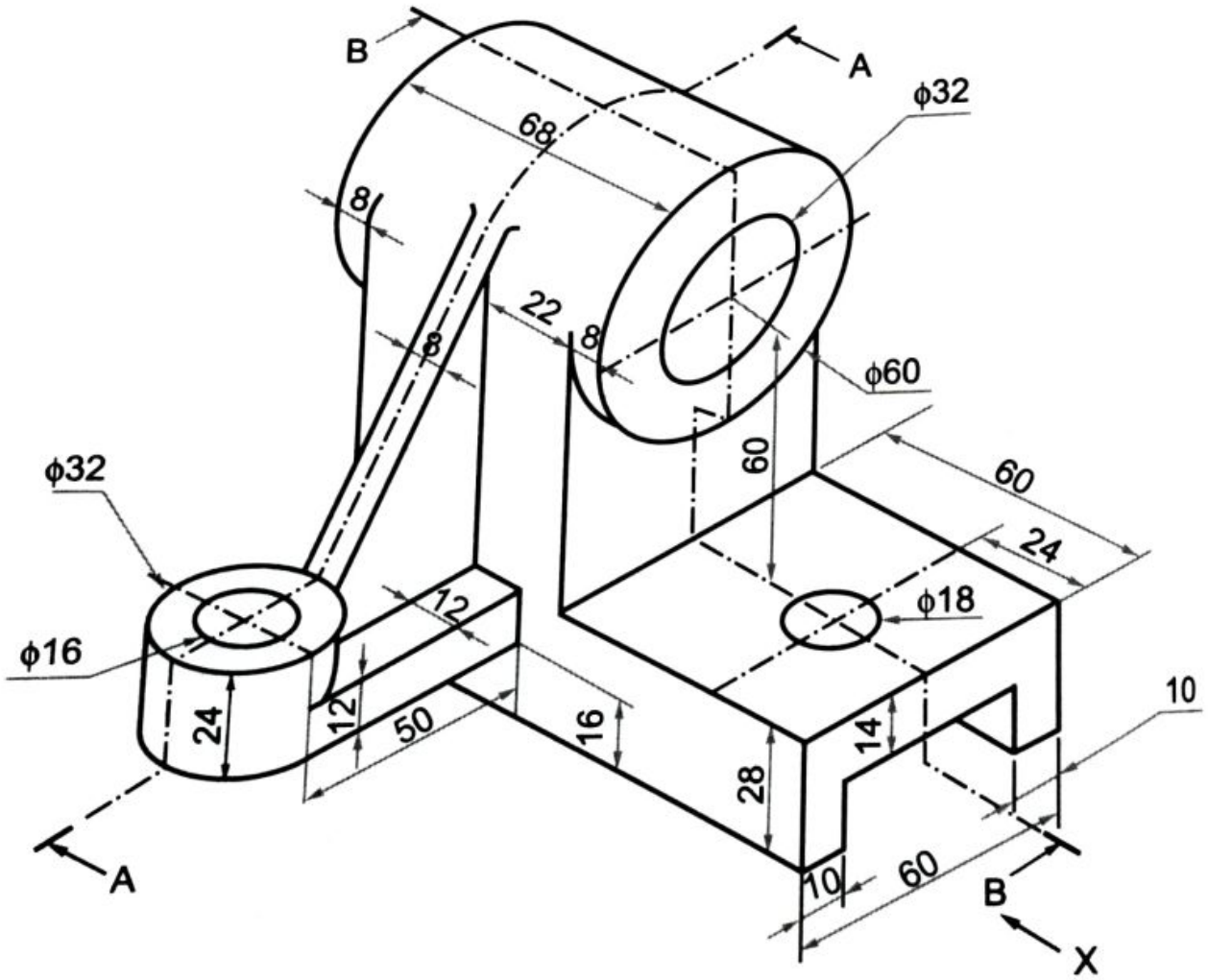
ii) Top view

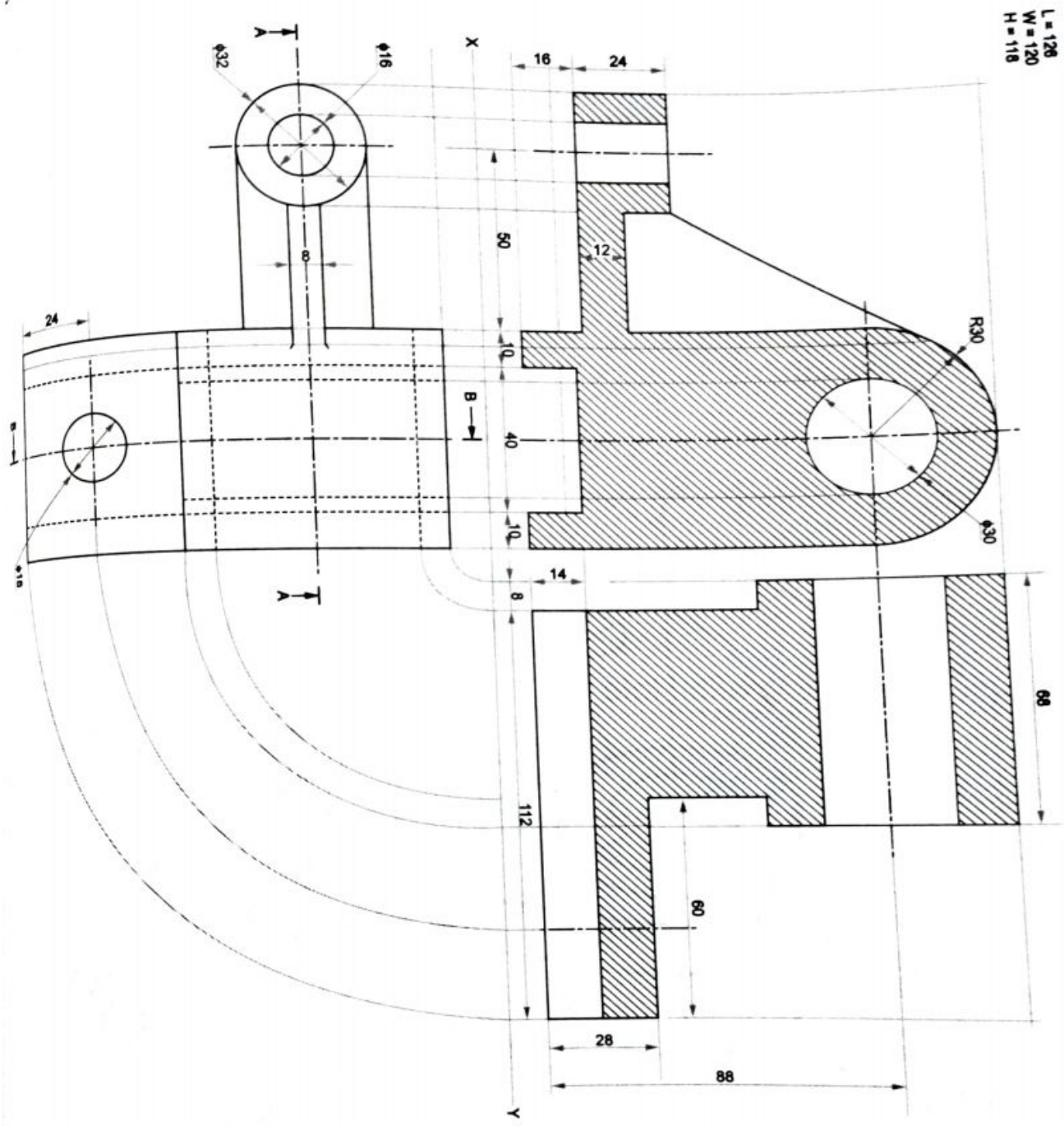
iii) Left hand side view, Insert 10 major dimensions



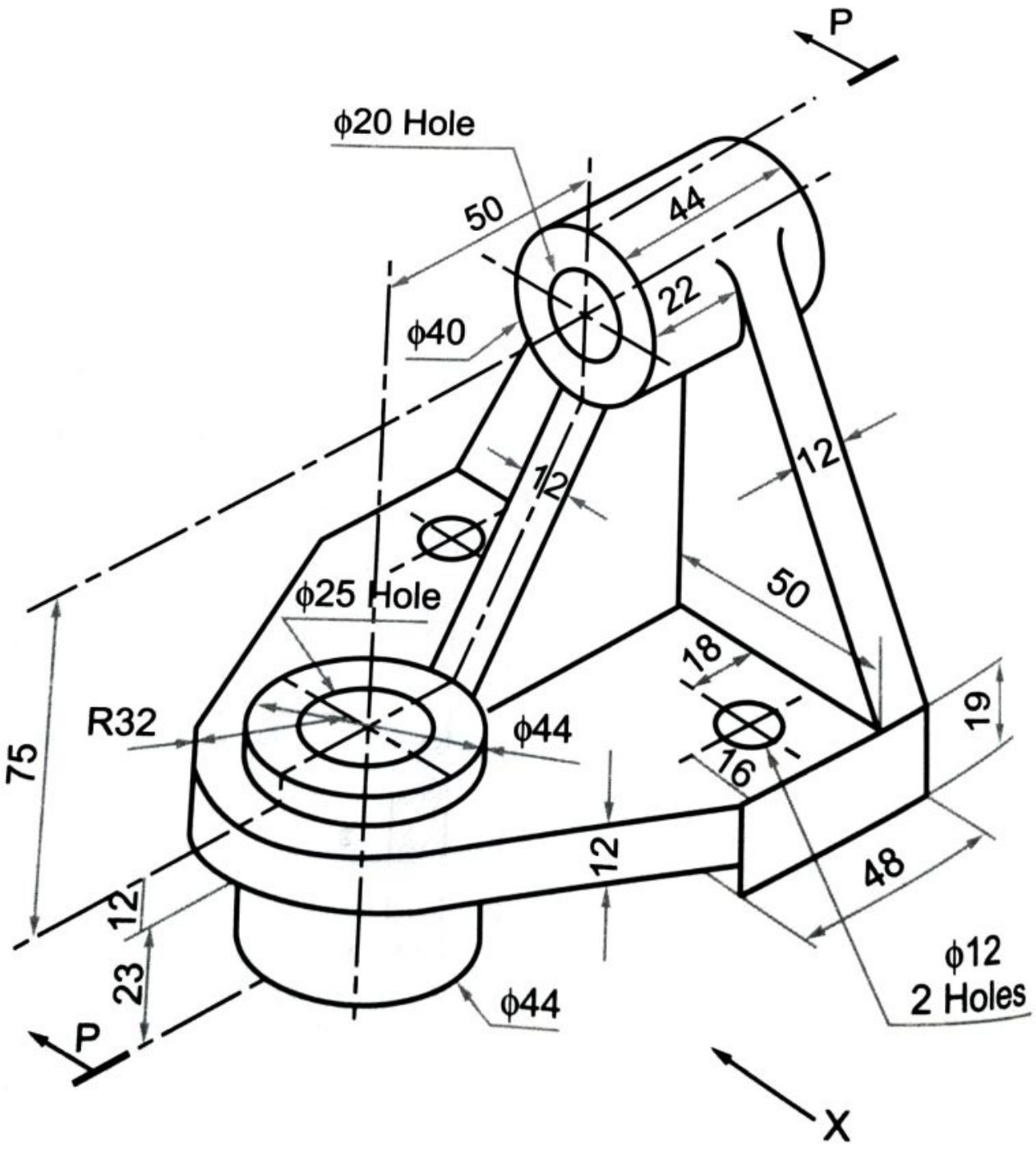

L = 150
W = 75
H = 80
LHSV
A
A
X
Y
R25
5
25
15
40
150
25
25
15
75
70
50
40
R15

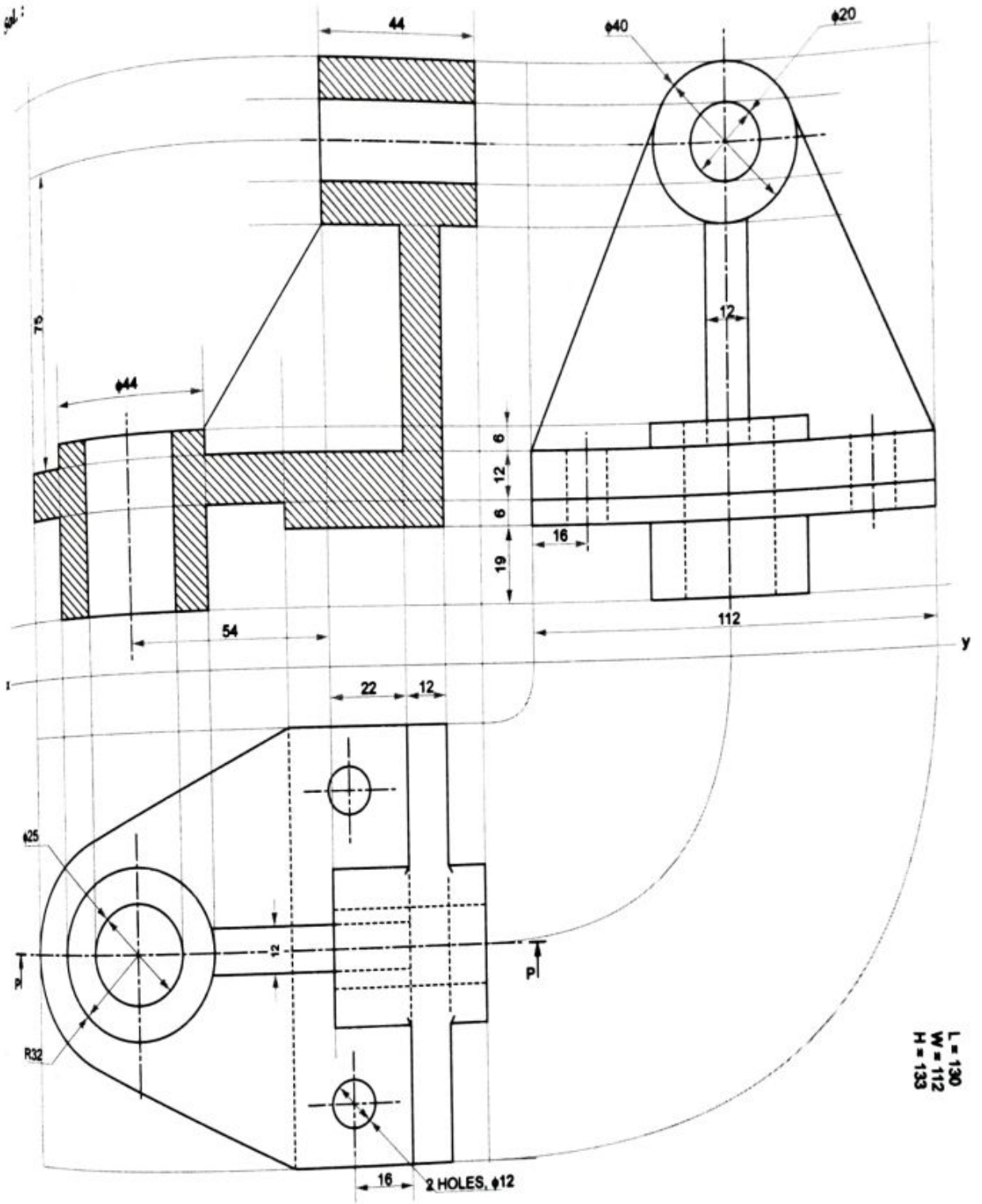
Ex. 4.25.30 : *Figure shows pictorial view of an object. Draw*
i) Sectional front view along A-A
ii) Sectional left hand side view along B-B.
iii) Top view
Dimenson the views (any four)




L = 126
W = 120
H = 118
A
A
B
B
X
Y
ϕ32
ϕ16
ϕ10
16
24
50
12
8
24
10
40
10
R30
ϕ30
14
8
66
112
60
28
88

Ex. 4.25.31 : *Figure shows the pictorial view of an object. Draw the following views to full scale.*
i) Sectional front view along section PP
ii) Left hand side view
iii) Top view
Insert at least 10 major dimensions




44
ϕ40
ϕ20
75
ϕ44
12
6
12
6
19
16
54
112
y
22
12
ϕ25
12
30
P
R32
16
2 HOLES, ϕ12
L = 130
W = 112
H = 133