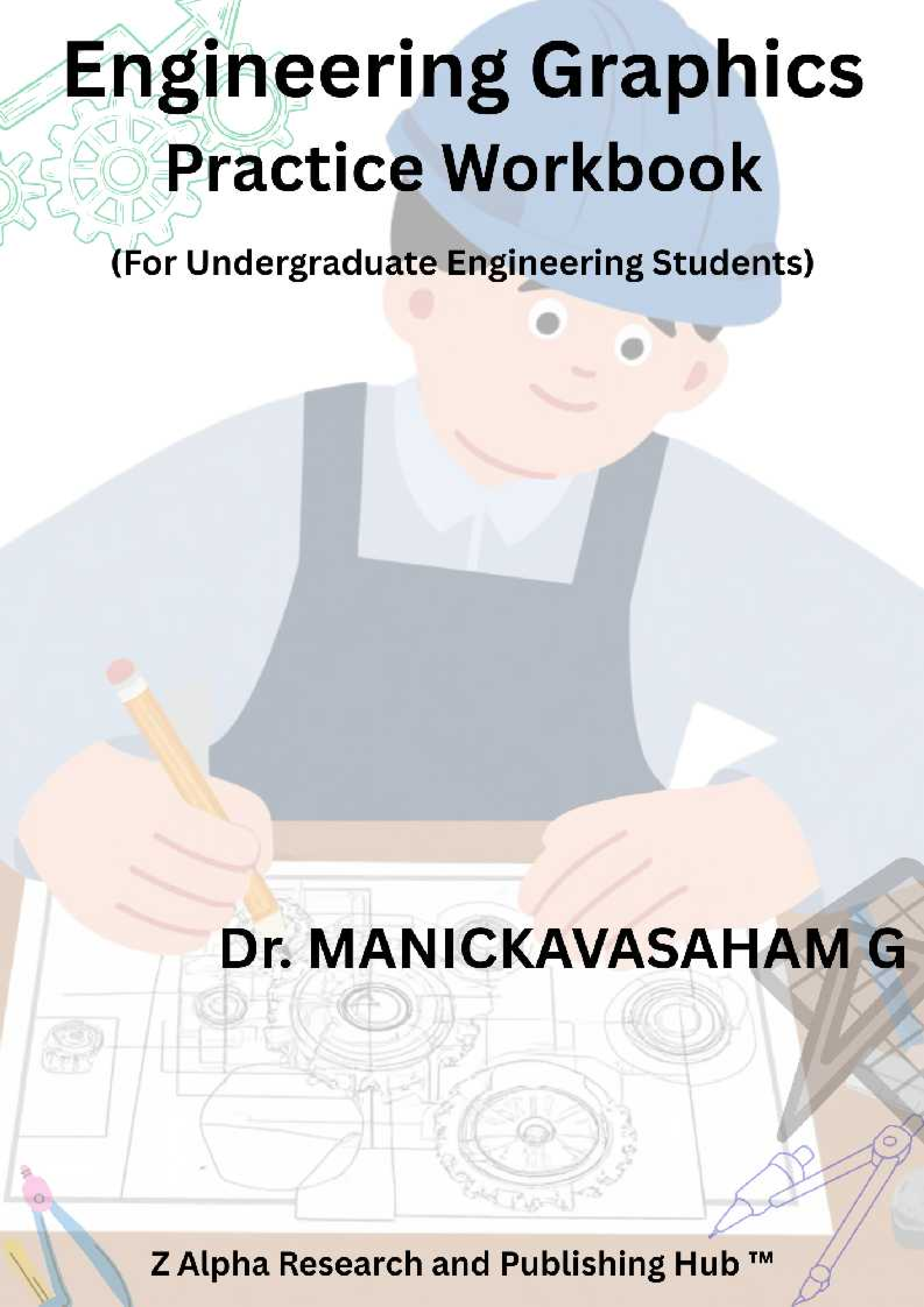

Engineering Graphics Practice Workbook

(For Undergraduate Engineering Students)

Dr. MANICKAVASAHAM G

Z Alpha Research and Publishing Hub ™

Engineering Graphics Practice Workbook

First Edition
(For Undergraduate Engineering Students)

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Preface

Engineering Graphics is a fundamental subject that forms the backbone of all engineering disciplines. It develops the ability to visualize three-dimensional objects and represent them accurately on a two-dimensional plane using standardized drawing conventions. Mastery of this subject is essential for understanding design, manufacturing, and fabrication processes in engineering practice.

This book, Engineering Graphics Practice Workbook, has been carefully prepared to serve as a practice-oriented companion for undergraduate engineering students. The primary objective of this workbook is to provide clear, systematic, and sufficient drawing practice to help students gain confidence and proficiency in engineering drawing.

The contents of this book cover the core topics prescribed in most university syllabi, with special emphasis on:

- ❖ Projection of plane surfaces (polygonal and circular laminae) inclined to both principal planes.
- ❖ Projection of solids such as prisms, pyramids, cylinders, and cones using the rotating object method,
- ❖ Projection of sectioned solids, and development of lateral surfaces of simple and sectioned solids.

Each exercise in this workbook is presented in a student-friendly format, where the question is followed by a neatly drawn, manually prepared scanned drawing. This approach allows students to refer to the correct construction while practicing the drawing independently in the classroom or at home. All drawings are prepared in first-angle projection and follow standard BIS/engineering drawing conventions.

This workbook is intended not only for students but also for faculty members as a ready reference for classroom instruction and assignments. It is hoped that this book will bridge the gap between theoretical understanding and practical drawing skills, and serve as a useful learning resource in the study of Engineering Graphics.

Dr. MANICKAVASAHAM G

Acknowledgement

The successful completion of this book would not have been possible without the guidance, encouragement, and support of many individuals.

First and foremost, I express my sincere gratitude to all my teachers and mentors, whose knowledge, guidance, and dedication to the subject of Engineering Graphics inspired me to prepare this workbook. Their teachings have laid the foundation for my understanding and approach to the subject.

I am also thankful to my students, whose learning needs and classroom interactions motivated me to design this book in a practice-oriented and student-friendly manner. Their questions and challenges helped shape the structure and presentation of the exercises.

Finally, I express my deep gratitude to my family and well-wishers for their constant support, patience, and encouragement throughout this endeavor.

I sincerely hope that this workbook will be beneficial to students and educators alike and contribute meaningfully to the teaching and learning of Engineering Graphics.

Dr. MANICKAVASAHAM G

Contents

Abbreviations, Symbols and Notations

Abbreviations

km – Kilometre

m – Metre

cm – Centimetre

mm – Millimetre

L – Length, mm

B – Breadth, mm

H – Height, mm

C.L./CL – Centre line

V.P./VP – Vertical plane

H.P./ HP – Horizontal plane

XY – Reference line

F.V./FV – Front view

T.V./TV – Top view

R.S.V./RSV – Right side view

L.S.V./LSV – Left side view

R.P.P./RPP – Right profile plane

L.P.P./LPP – Left profile plane

A.V.P./AVP – Auxiliary vertical plane

A.I.P./AIP – Auxiliary inclined plane

T.L./TL – True length

H.T./HT – Horizontal trace

V.T./VT – Vertical trace

D – Diameter

I.D./ID – Inner diameter

O.D./OD – Outside diameter

Symbols

□ – Side of square

R – Radius of circle/arc

ϕ - Diameter of circle

θ – True inclination with H.P.

ϕ - True inclination with V.P.

α – Apparent inclination with H.P.

β – Apparent inclination with V.P.

Notations

A, B, C – Names of the points

a, b, c – Top views of A, B, C

a', b', c' – Front views of A, B, C

a'', b'', c'' – Side views of A, B, C

O – Centre point

Chapter I

Projection of Planes

In engineering graphics, planes (also referred to as laminae, sheet surfaces, or flat solids) are thin, flat objects having negligible thickness and well-defined boundaries. The boundary of a plane may be polygonal-such as a triangle, square, rectangle, pentagon, or hexagon-or curvilinear, such as a circular plane.

These surfaces are fundamental elements in projection studies, as they form the basis for understanding the orientation and visibility of complex solids.

1.1 Concept of Projection

When a plane is placed in space, its orientation with respect to the Principal Planes of Projection-the Horizontal Plane (HP) and the Vertical Plane (VP)-determines the appearance of its top view and front view. The projection of a plane helps to visualize its true shape and inclined position on a two-dimensional drawing sheet.

1.2 Orientation of Planes

A plane may have different orientations:

- ❖ Plane parallel to one reference plane and perpendicular to the other - True shape appears on the plane to which it is parallel.
- ❖ Plane perpendicular to both HP and VP - Appears as a line in both views.
- ❖ Plane inclined to one reference plane and perpendicular to the other - True shape obtained by rotation.
- ❖ Plane inclined to both HP and VP - Most general and complex condition, studied using the rotating object method.

1.3 Rotating Object Method

In this method, the object (plane) is imagined to be rotated in space to attain the required inclinations with the principal planes, while the reference line (XY line) remains fixed. The steps generally followed are:

1. **Plane surface is inclined to HP and its edge or corner inclined to VP**
   - ❖ Simple Position – The plane surface is assumed to be parallel to the HP. The true shape of the plane is drawn in this position (i.e. Top View (TV))
   - ❖ First Rotation – The plane is inclined to HP by a specified angle; its new projections are obtained.
   - ❖ Second Rotation – The plane is then inclined to VP by another given angle, and the final projections are drawn.
2. **Plane surface is inclined to VP and its edge or corner inclined to HP**
   - ❖ Simple Position – The plane surface is assumed to be parallel to the VP. The true shape of the plane is drawn in this position (i.e. Front View (FV))
   - ❖ First Rotation – The plane is inclined to VP by a specified angle; its new projections are obtained.
   - ❖ Second Rotation – The plane is then inclined to HP by another given angle, and the final projections are drawn.

This systematic rotation reveals the apparent shape of the plane in both top and front views according to the first angle projection method, which is standard in Indian engineering drawing practices (IS 10711:2001).

1.4 Types of Planes Considered

In this exercise, the following planes (laminae/sheets) are used for projection practice:

- ❖ Rectangular Plane (Rectangular Lamina)
- ❖ Square Plane (Square Lamina)
- ❖ Pentagonal Plane (Pentagonal Lamina)
- ❖ Hexagonal Plane (Hexagonal Lamina)
- ❖ Triangular Plane (Triangular Lamina)
- ❖ Circular Plane (Circular Sheet or Disk)

Each plane is assumed to be uniform and thin, representing a two-dimensional surface of a solid body. Figure 1 shows the terminologies used for plane surfaces.

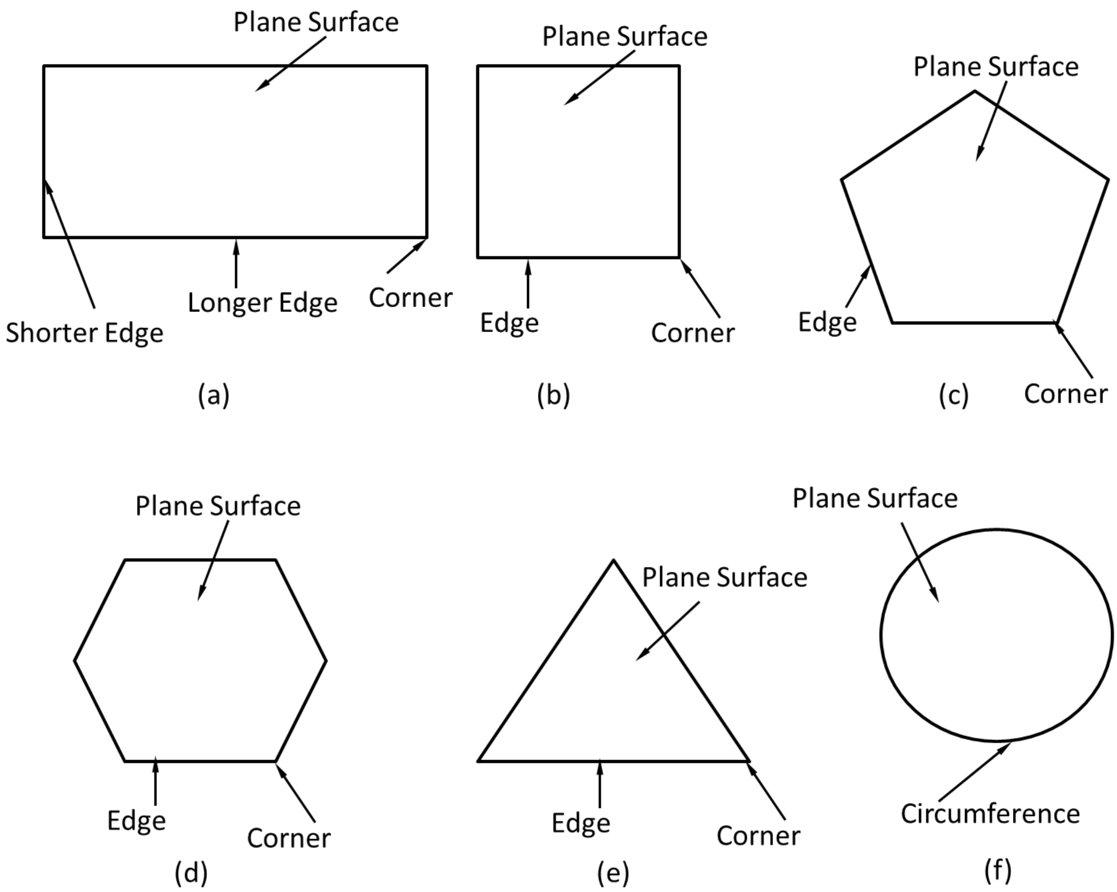


Figure 1 a) Rectangular plane, b) Square plane, c) Pentagonal plane, d) Hexagonal plane, e) Triangular plane, and f) Circular plane.

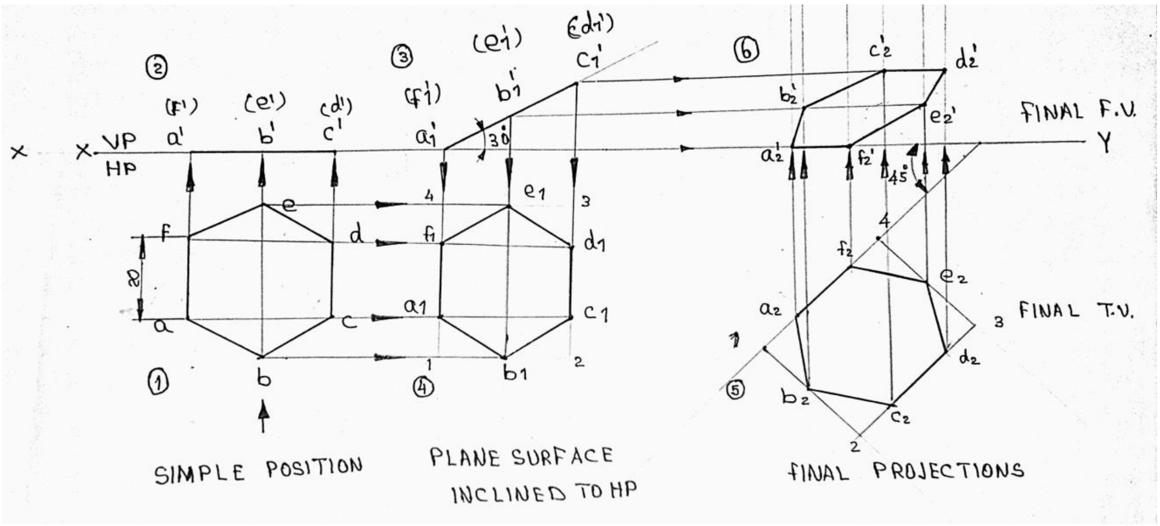
1.5 Purpose of Study

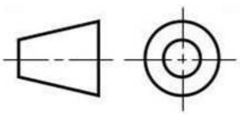
The objective of this exercise is to:

- ❖ Understand the principles of projecting plane surfaces inclined to both HP and VP.
- ❖ Develop proficiency in applying the rotating object method using the first angle projection system.
- ❖ Accurately interpret and construct the true and apparent shapes of polygonal and circular planes.

Projection of Planes (Polygonal and Circular Surfaces) Inclined to Both the Principal Planes – Using Rotating Object Method, First Angle Projection

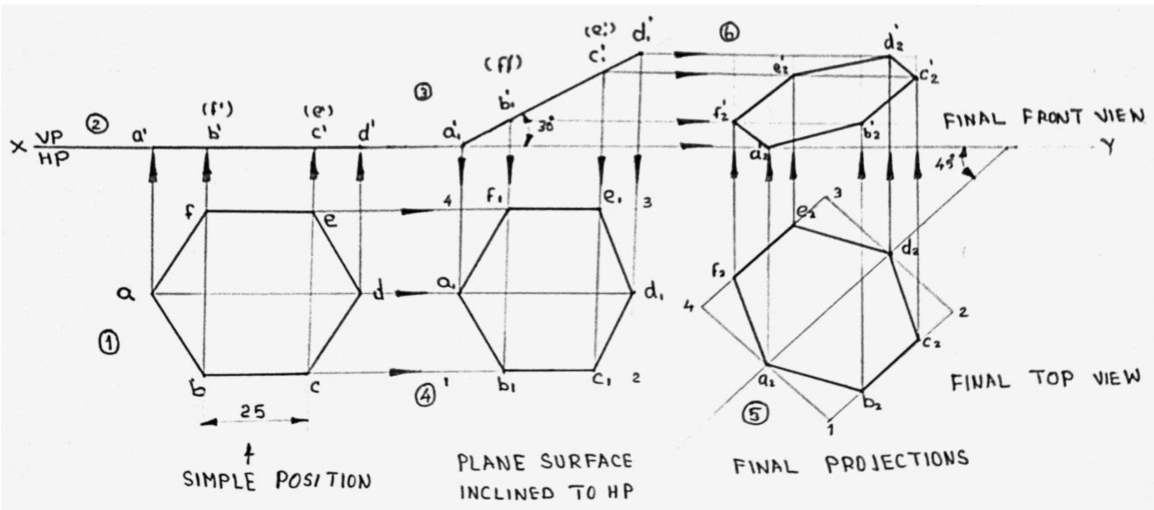
1. A hexagonal plate of side 20 mm rests on HP on one of its sides, which is inclined at 45° to VP. The surface of the plate makes an angle of 30° with HP. Draw the front and top views of the plate.

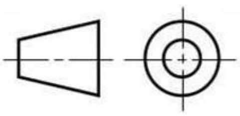




SCALE 1:1 ALL DIMENSIONS ARE IN mm

2. Draw the projections of a hexagonal plate of side 25 mm resting on a corner on HP, with its surface inclined at 30° to the ground. The resting corner is further inclined at 45° to VP.





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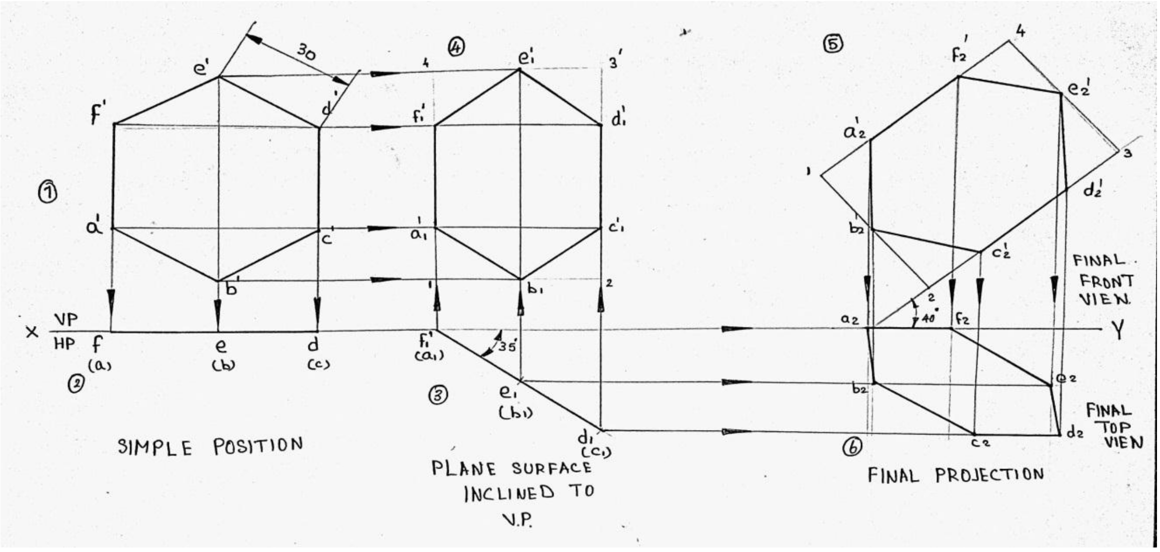
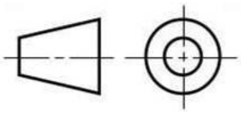
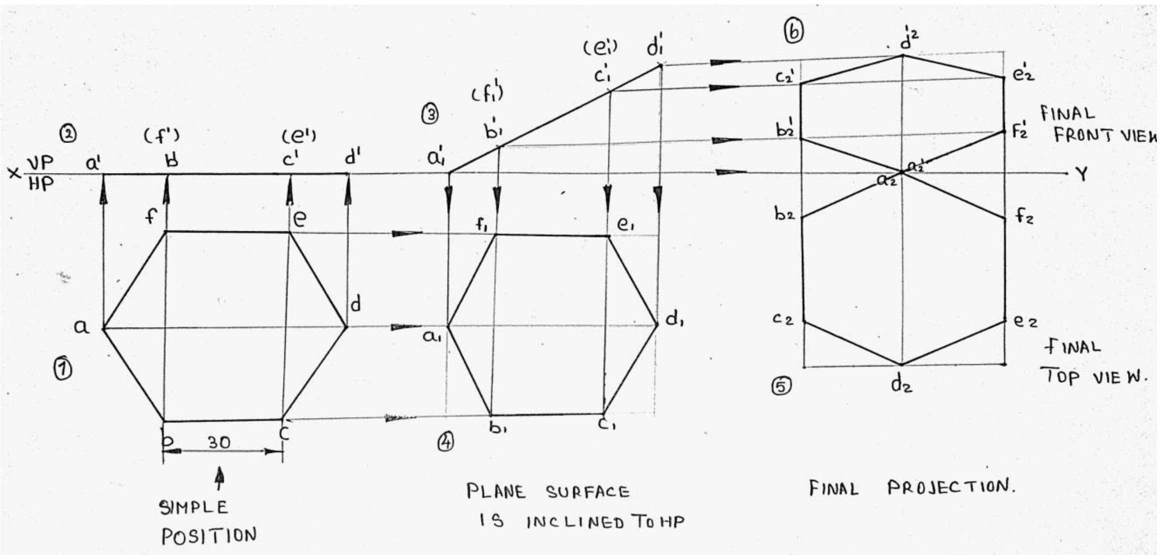
3. A hexagonal lamina of side 30 mm is resting in VP on one of its sides and is inclined at 40° to HP. Its surface is inclined at 35° to VP. Draw the projections.

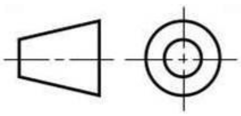




SCALE 1:1 ALL DIMENSIONS ARE IN mm

4. A hexagonal lamina of side 30 mm is resting on HP such that one of its corners touches both HP and VP. Draw the projections when its surface makes an angle of 30° with HP and 60° with VP.





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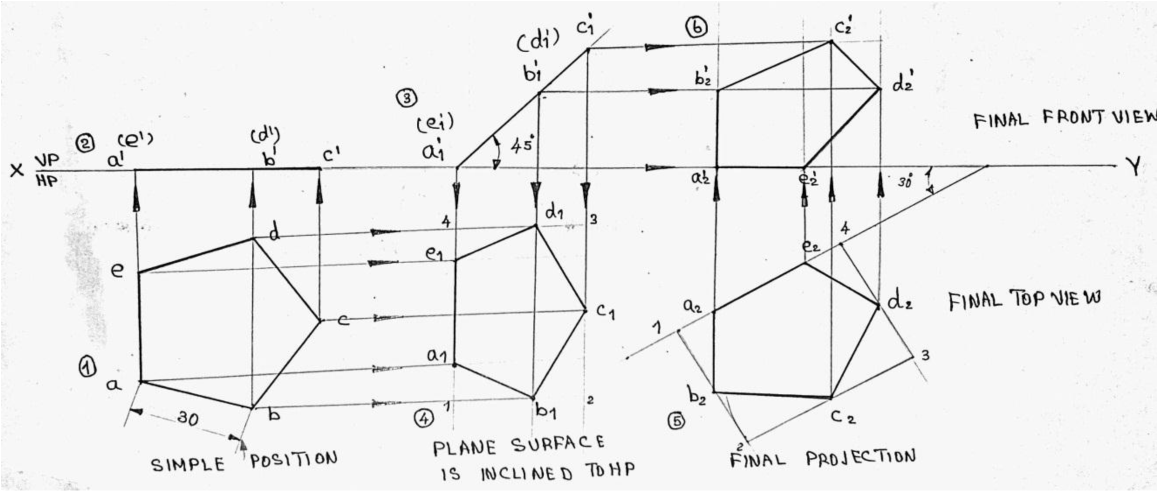
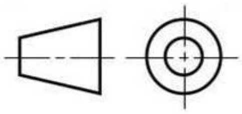
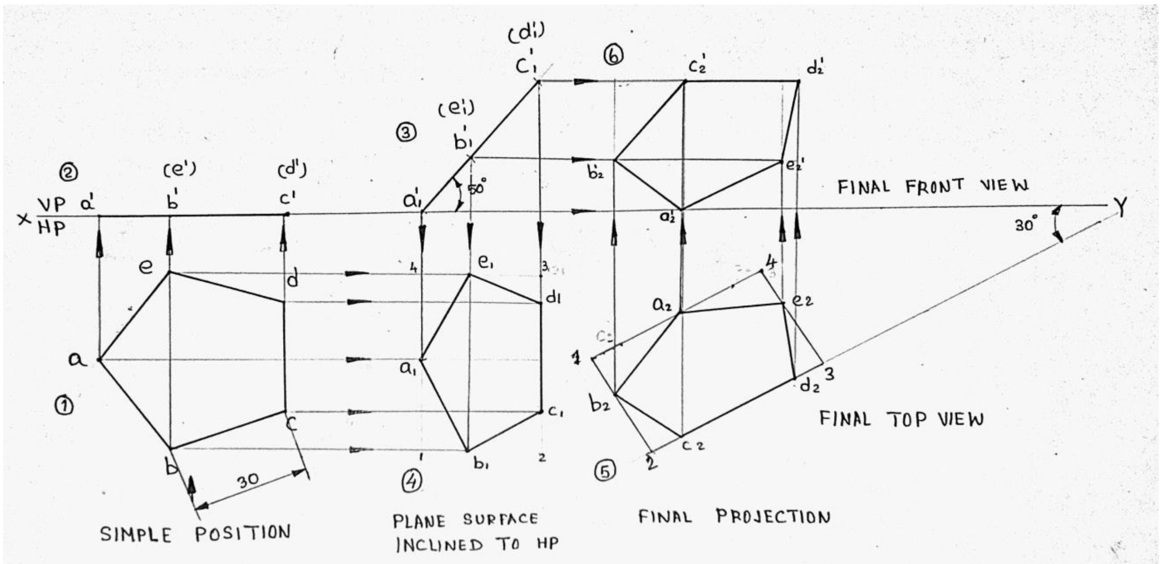
5. A regular pentagon of side 30 mm rests on one of its edges on HP, which is inclined at 30° to VP. Its surface is inclined at 45° to HP. Draw its projections.

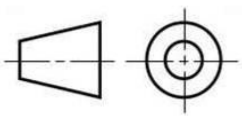




SCALE 1:1 ALL DIMENSIONS ARE IN mm

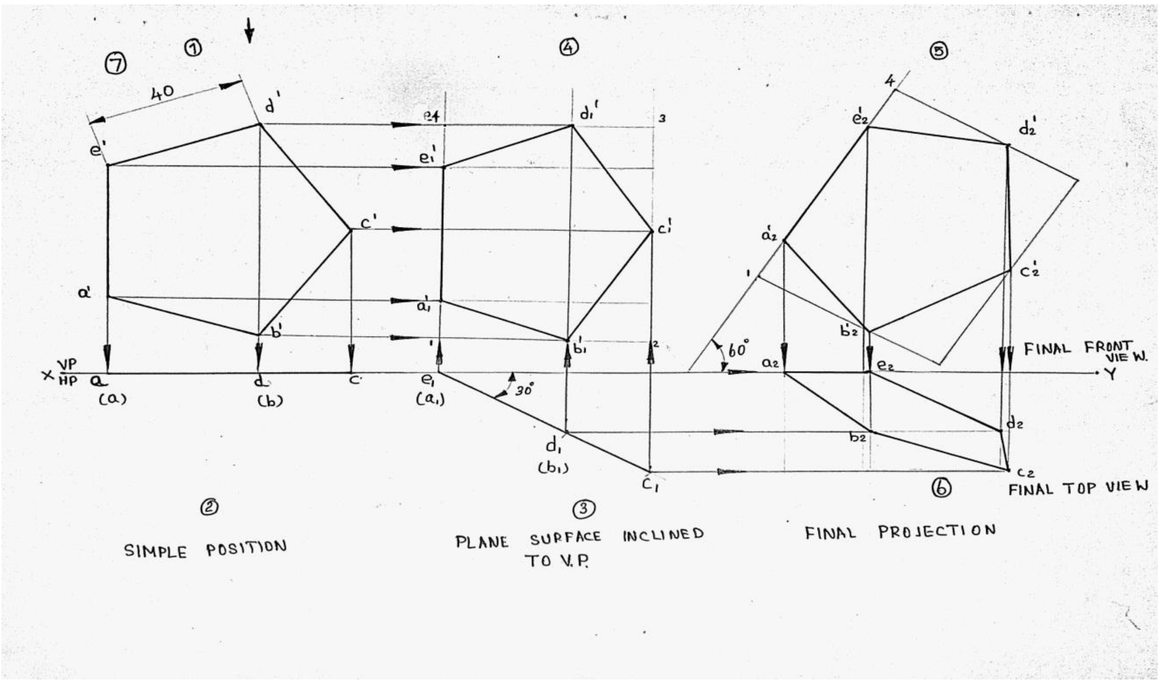
6. A pentagonal lamina of side 30 mm rests on the ground on one of its corners. The side opposite to the resting corner is inclined at 30° to VP. The surface of the lamina is inclined at 50° to HP. Draw the projections of the lamina.

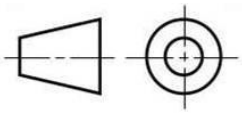




SCALE 1:1 ALL DIMENSIONS ARE IN mm

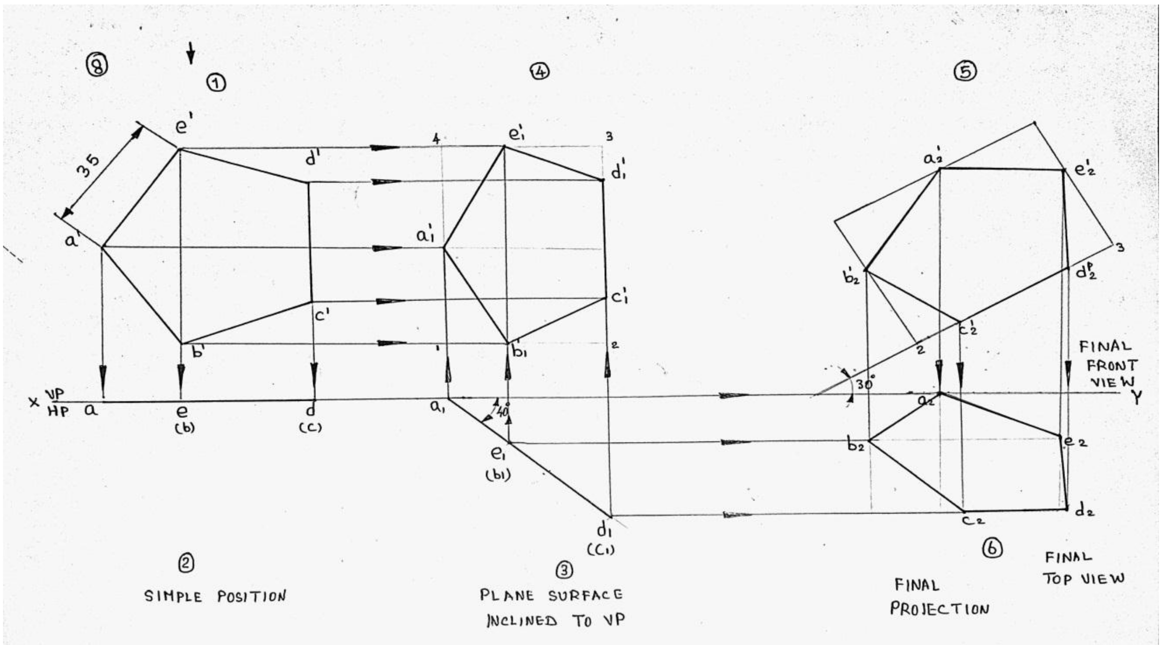
7. Draw the projections of a regular pentagon of side 40 mm, having its surface inclined at 30° to VP, and the side on which it rests on VP making an angle of 60° with HP.

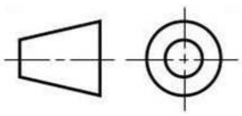




SCALE 1:1 ALL DIMENSIONS ARE IN mm

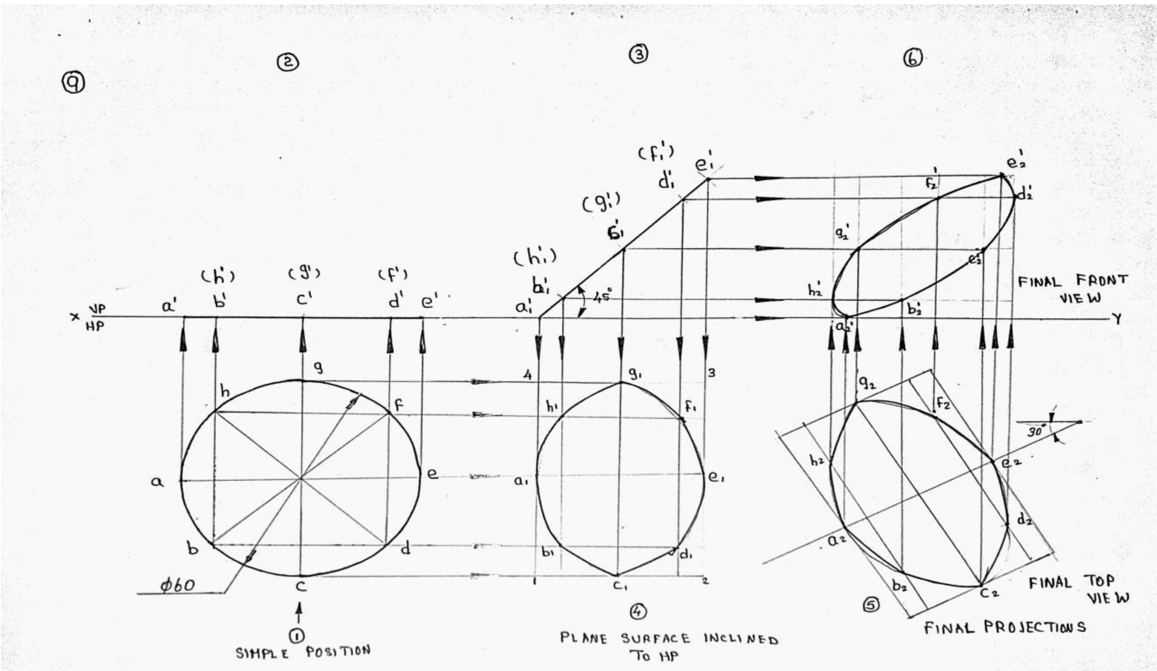
8. A pentagon of side 35 mm rests on one of its corners on VP. The edge opposite to that corner makes an angle of 30° with HP. The surface of the pentagon is inclined at 40° to VP. Draw the projections.

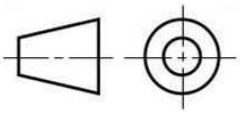




SCALE 1:1 ALL DIMENSIONS ARE IN mm

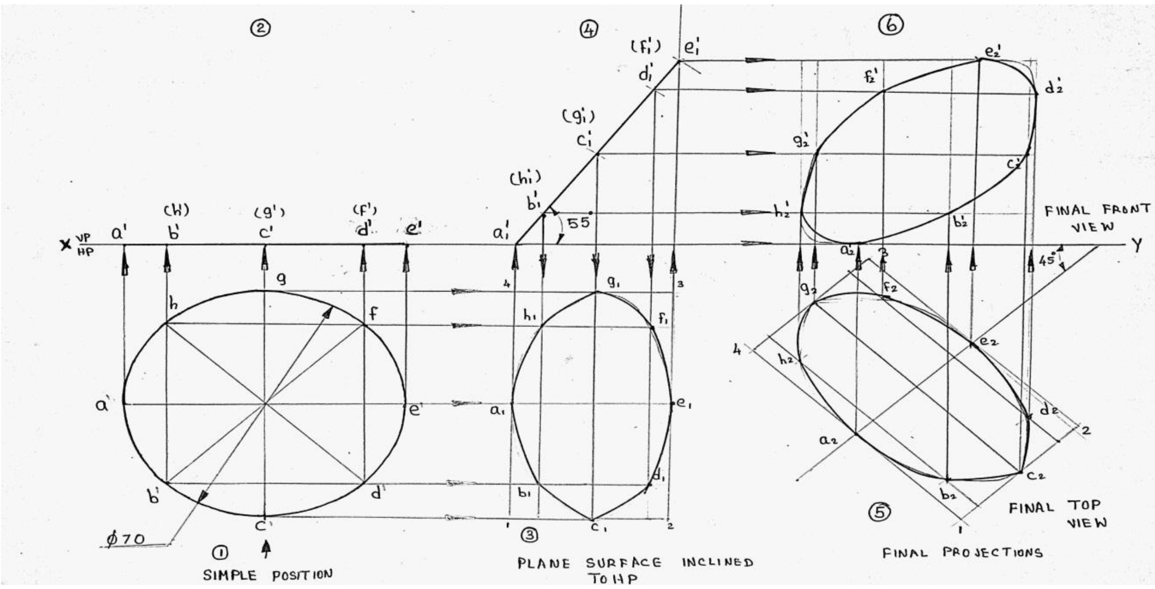
9. Draw the projections of a circular lamina of diameter 60 mm resting on the ground at a point on its circumference, with its plane inclined at 45° to HP and the plan of the diameter making an angle of 30° with VP.

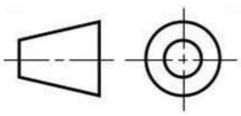




SCALE 1:1 ALL DIMENSIONS ARE IN mm

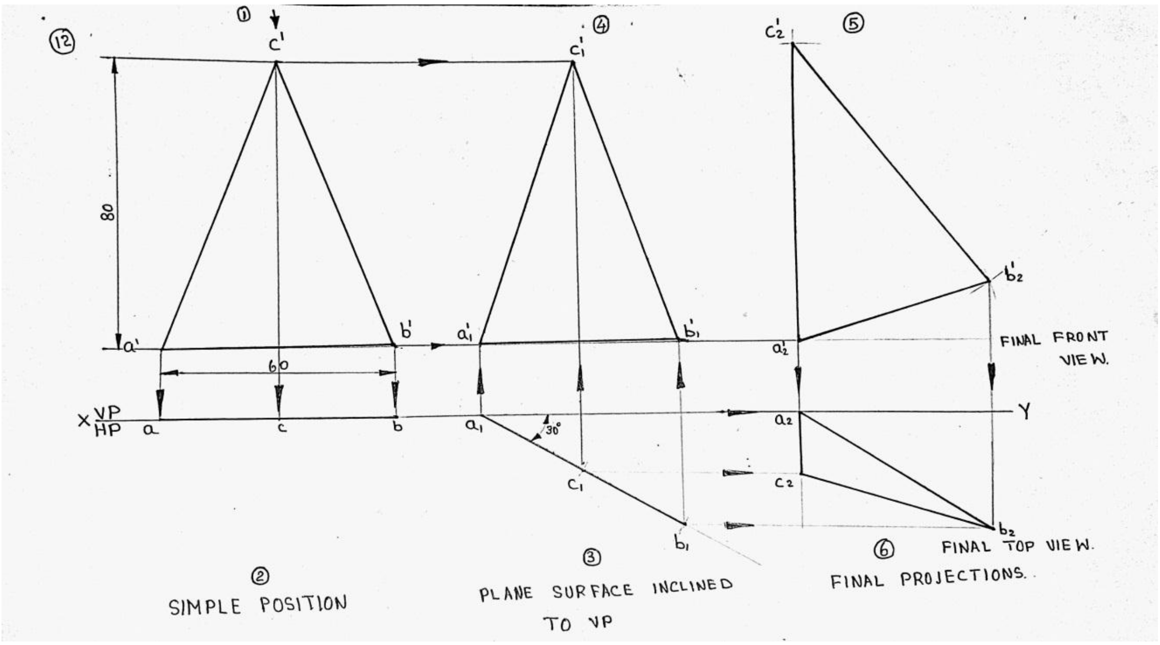
10. Draw the projections of a circle of diameter 70 mm resting on HP at a point A on its circumference. The plane is inclined to HP such that the top view is an ellipse of minor axis 40 mm. The top view of the diameter through point A makes an angle of 45° with VP. Determine the inclination of the plane with HP.

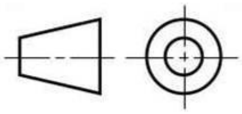




SCALE 1:1 ALL DIMENSIONS ARE IN mm

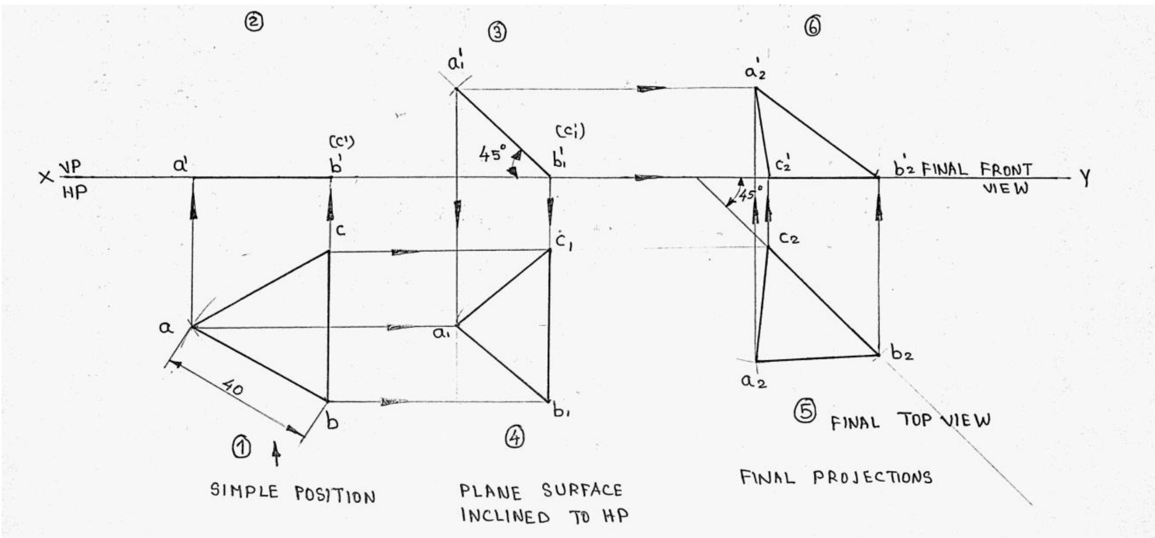
11. An isosceles triangular plate ABC has its base edge AB, 60 mm long, resting on the ground and inclined at 30° to VP. The altitude of the plate is 80 mm. The plate is placed such that the edge AC lies in a plane perpendicular to both HP and VP. Draw the projections of the plate and determine the angles of inclination of the plate with HP and VP.

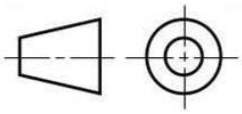




SCALE 1:1 ALL DIMENSIONS ARE IN mm

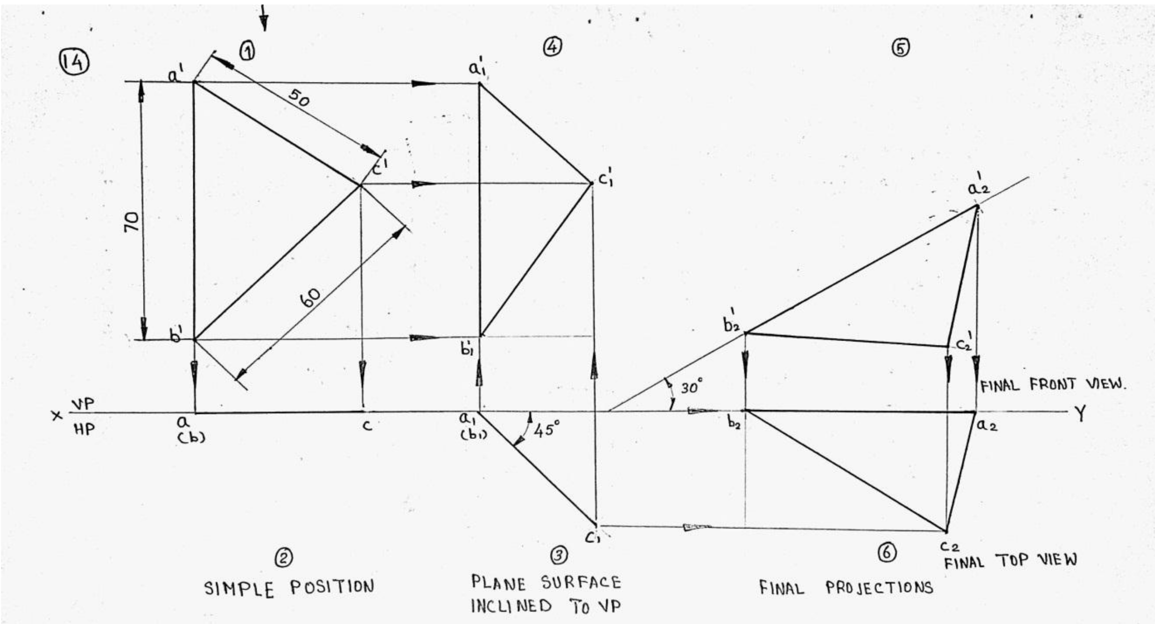
12. An equilateral triangular lamina of side 40 mm is placed with one of its sides on HP, such that the surface of the lamina is inclined at 45° to HP. The resting edge is inclined at 45° to VP. Draw the projections.

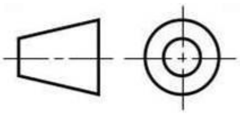




SCALE 1:1 ALL DIMENSIONS ARE IN mm

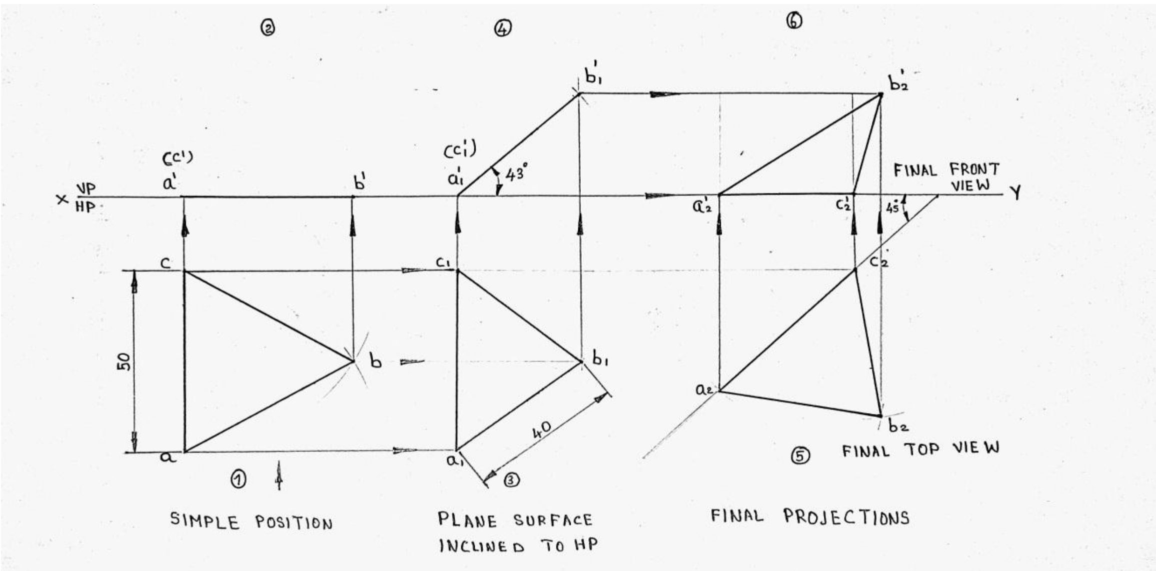
13. Draw the projections of a triangle ABC with sides AB = 70 mm, BC = 60 mm, and AC = 50 mm. The triangle is inclined at 45° to VP, and side AB lies in VP and is inclined at 30° to HP.

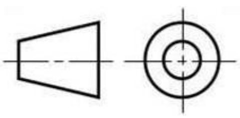




SCALE 1:1 ALL DIMENSIONS ARE IN mm

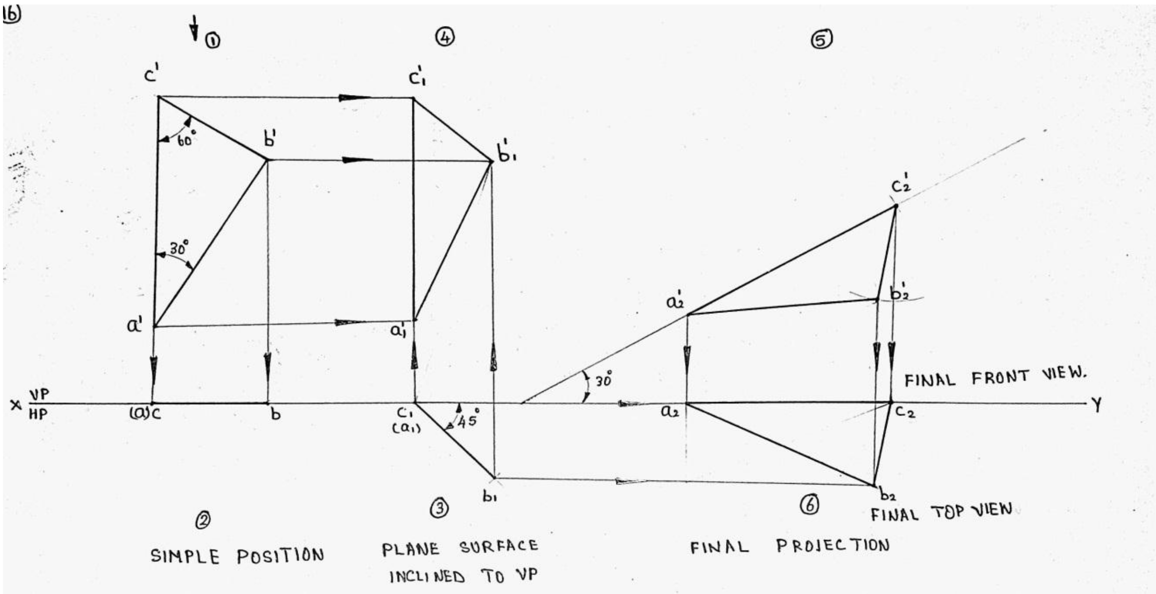
14. An equilateral triangle ABC of side 50 mm rests on the ground on edge AB, which is inclined at 45° to VP. The other edges BC and AC appear as 40 mm each in the top view. Draw the projections and determine the inclination of the triangle with HP.

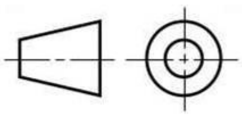




SCALE 1:1 ALL DIMENSIONS ARE IN mm

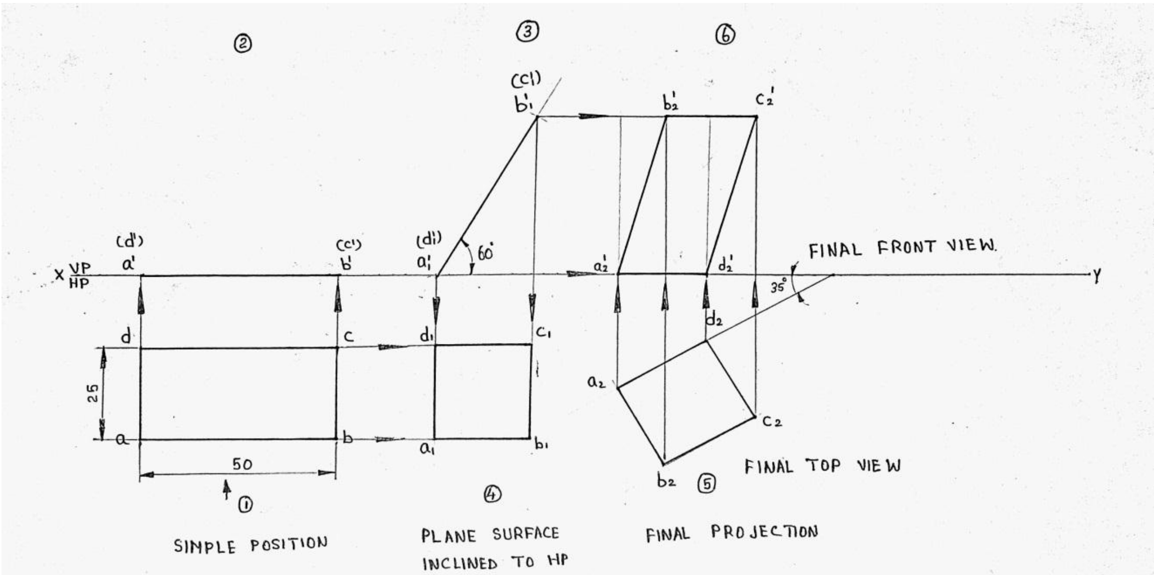
15. A thin 30°–60° set square has its longest edge in VP and inclined at 30° to HP. Its surface makes an angle of 45° with VP. Draw its projections.

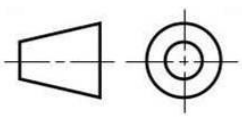




SCALE 1:1 ALL DIMENSIONS ARE IN mm

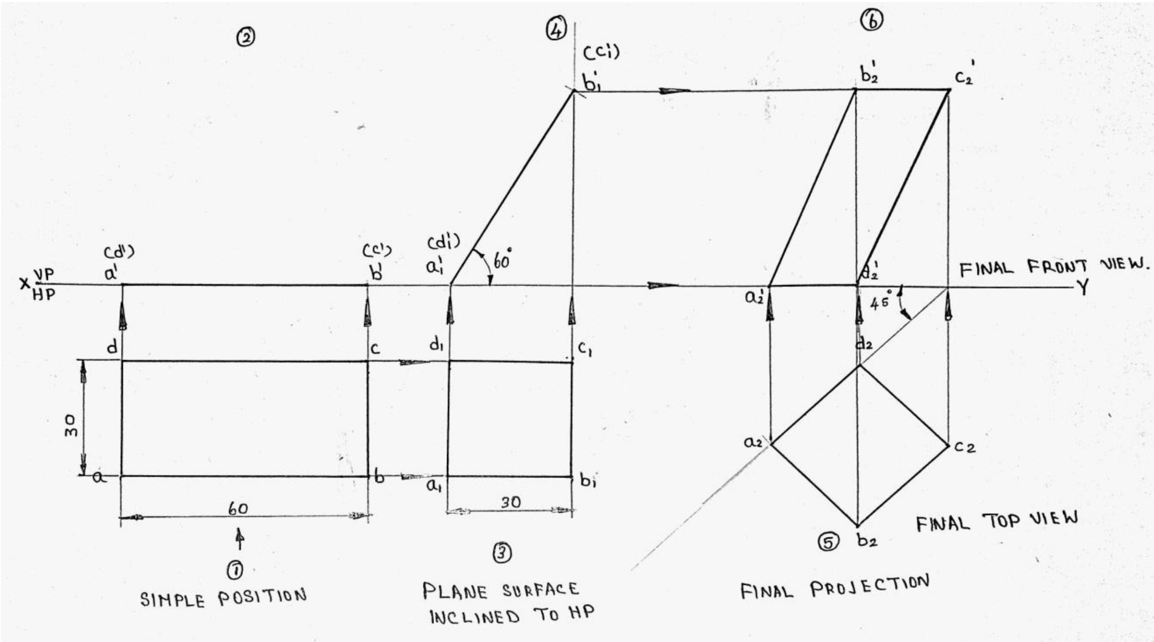
16. A rectangular plate of size 50 × 25 mm rests on its shorter side on HP and is inclined at 30° to VP. Its surface is inclined at 60° to HP. Draw its projections.

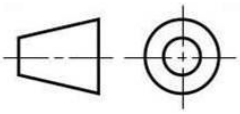




SCALE 1:1 ALL DIMENSIONS ARE IN mm

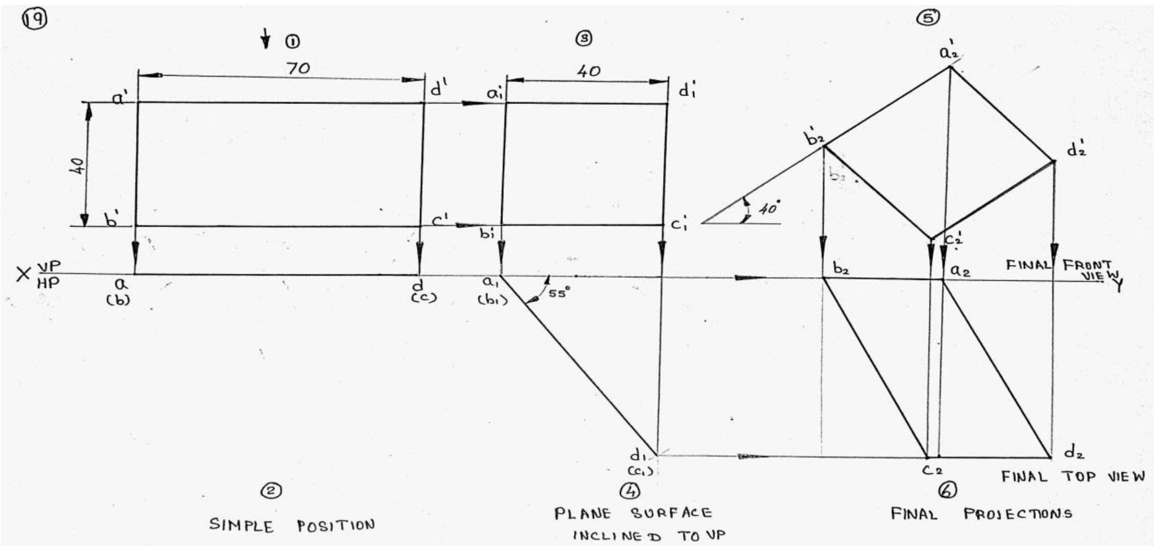
17. A rectangular lamina of size 60 × 30 mm appears as a square in the top view when it rests on one of its edges on HP and is perpendicular to VP. Draw the projections of the lamina and determine the true inclination of its surface with HP. Also, draw the front view of the lamina when the edge about which it is tilted is inclined at 45° to VP.

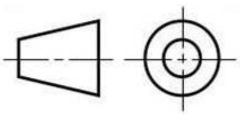




SCALE 1:1 ALL DIMENSIONS ARE IN mm

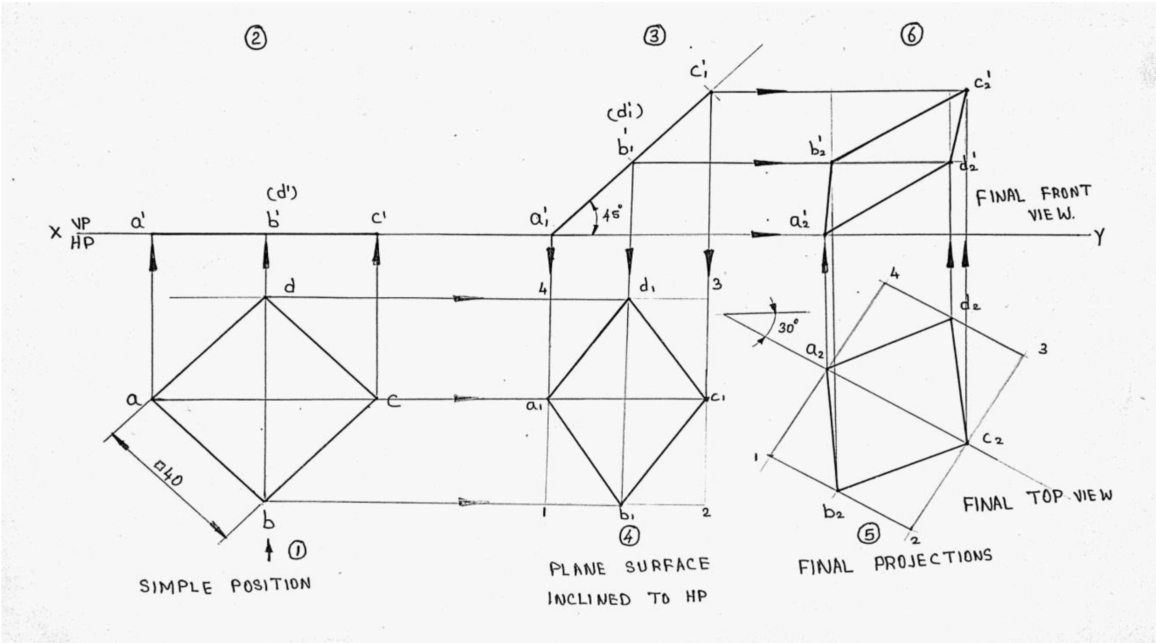
18. A rectangular plate of size 70 × 40 mm has one of its shorter edges in VP and inclined at 40° to HP. Draw its top view if its front view is a square of side 40 mm.

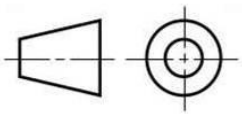




SCALE 1:1 ALL DIMENSIONS ARE IN mm

19. A square lamina PQRS of side 40 mm rests on the ground at its corner P such that the diagonal PR is inclined at 45° to HP and appears inclined at 30° to VP. Draw its projections.





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Chapter II

Projection of Solids

In engineering graphics, the accurate representation of three-dimensional objects on a two-dimensional plane is essential for visualization, analysis, and manufacturing. After understanding the projection of plane surfaces, the study naturally extends to the projection of solids, which form the fundamental components of engineering structures and mechanical parts.

A solid is defined as an object having three dimensions, namely length, breadth, and height. It is bounded by plane faces, curved surfaces, or a combination of both. Unlike plane surfaces (laminae or sheets), solids possess volume and thickness, making their projection more complex and significant in engineering drawing.

2.1 Concept of Projection of Solids

The projection of solids involves representing a three-dimensional solid by its front view, top view, and sometimes side view, when the solid is placed in different positions with respect to the Horizontal Plane (HP) and the Vertical Plane (VP). The appearance of these views depends on the orientation of the solid, such as whether its axis or faces are parallel, perpendicular, or inclined to the reference planes.

The principles used in the projection of planes—such as the concept of true shape, apparent shape, and rotation method—are extended and applied in the projection of solids.

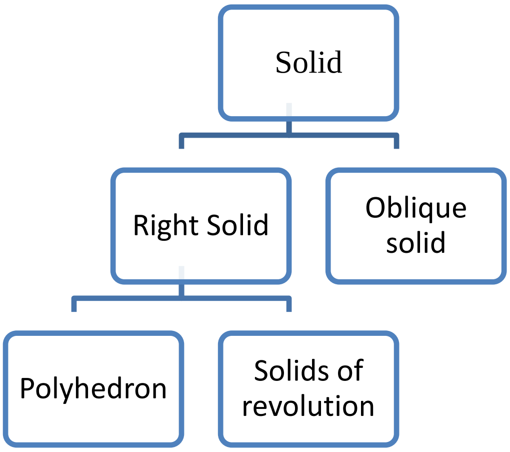
2.2 Purpose of Studying Projection of Solids

The study of projection of solids aims to:

- ❖ Develop the ability to visualize three-dimensional objects from two-dimensional drawings.
- ❖ Understand the relationship between the views of solids and their orientations.
- ❖ Apply projection principles to practical engineering problems.

- Serve as a foundation for advanced topics such as sections of solids, development of surfaces, and machine drawing.

2.3 Classifications of Solids



- If the axis of a solid is perpendicular to its base, it is called a right solid; otherwise, it is called an oblique solid.
- A solid bounded by plane surfaces, that is, surfaces formed by straight lines called edges, is known as a polyhedron.
- A solid formed by revolving a plane figure about an edge or axis that remains fixed is known as a solid of revolution.

Polyhedron:

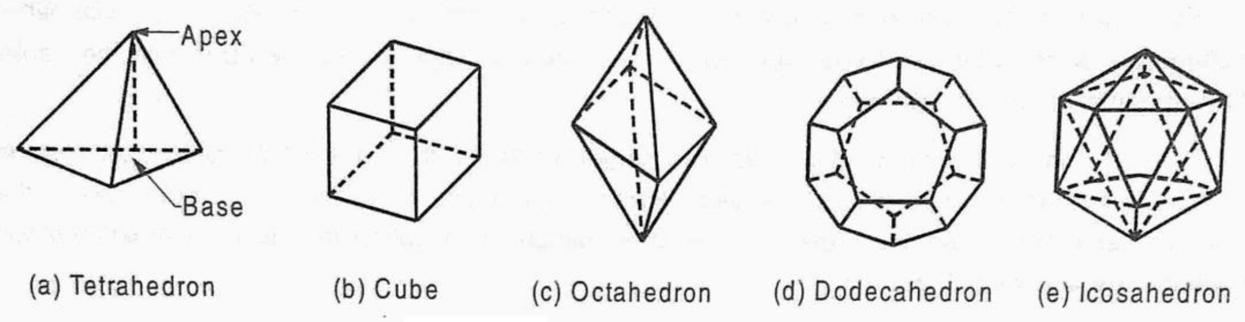
- Regular polyhedron
- Prism
- Pyramid

Solids of revolution:

- Cylinder
- Cone
- Sphere

Regular Polyhedron	Prism	Pyramid
Tetrahedron	Triangular	Triangular
Cube	Square	Square
Octahedron	Rectangle	Rectangle
Dodecahedron	Pentagonal	Pentagonal
Icosahedron	Hexagonal	Hexagonal

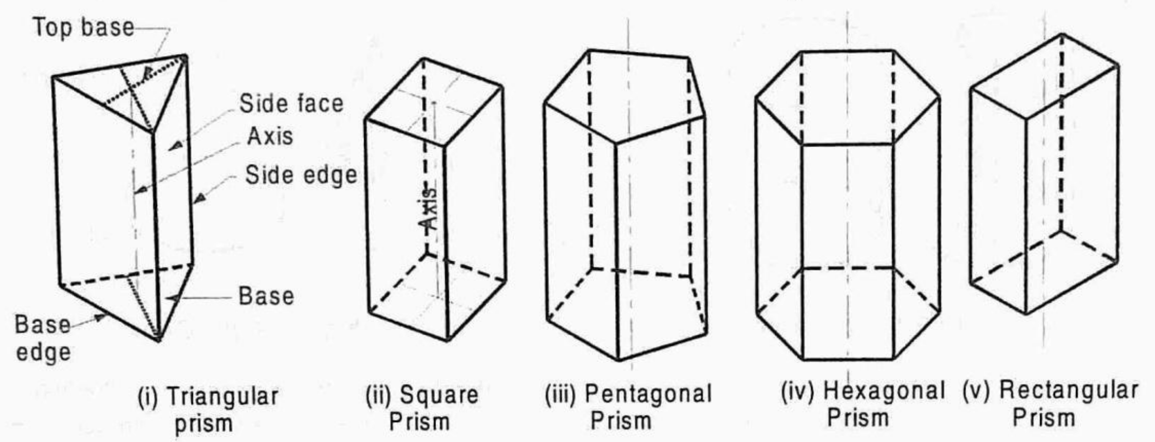
2.4 Regular polyhedron:



Types of Polyhedron

- **Tetrahedron:** Is a polyhedron having four equal equilateral triangular faces.
- **Cube:** Is a polyhedron having six equal square faces.
- **Octahedron:** Is a polyhedron having eight equilateral triangular faces.
- **Dodecahedron:** Is a polyhedron having twelve equal pentagonal faces.
- **Icosahedron:** Is a polyhedron having twenty equal equilateral triangular aces.

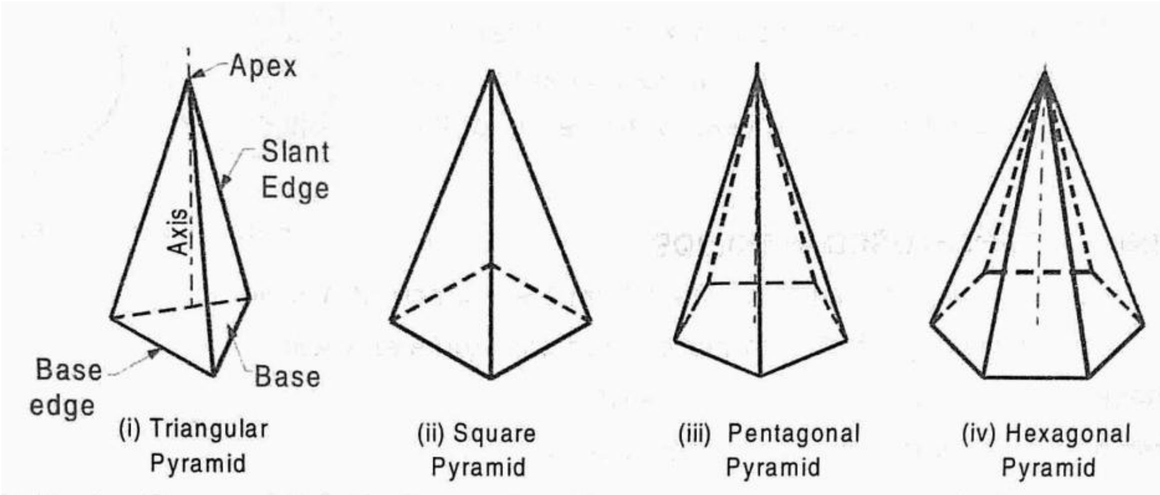
2.5 Prism



Types of Prisms

A prism is a polyhedron having two equal and similar regular polygonal faces, called its ends, which are parallel to each other and joined by rectangular lateral faces. The imaginary line joining the centres of the two end faces is called the axis of the prism.

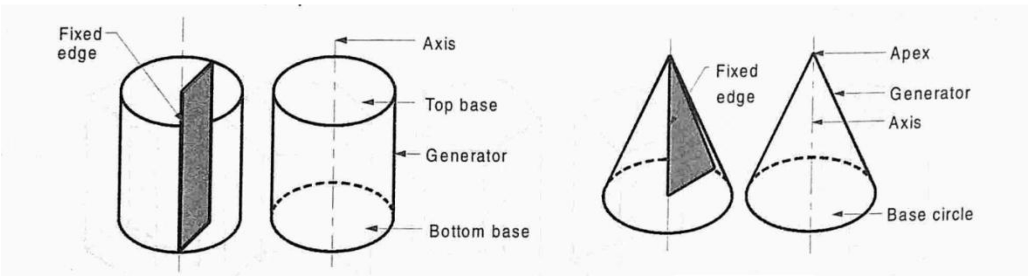
2.6 Pyramid



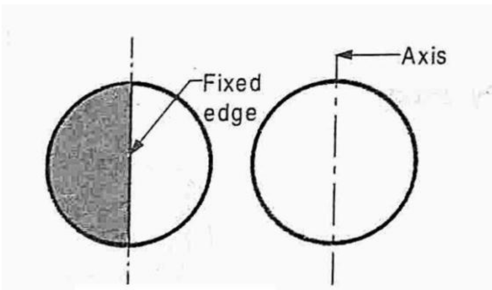
Types of Pyramids

A pyramid is a polyhedron having a plane figure as its base and a number of triangular faces meeting at a point called the vertex or apex. The imaginary line joining the apex with the centre of the base is known as the axis of the pyramid. In a right pyramid, all the lateral faces are isosceles triangles.

2.7 Solids of Revolution



Cylinder Cone

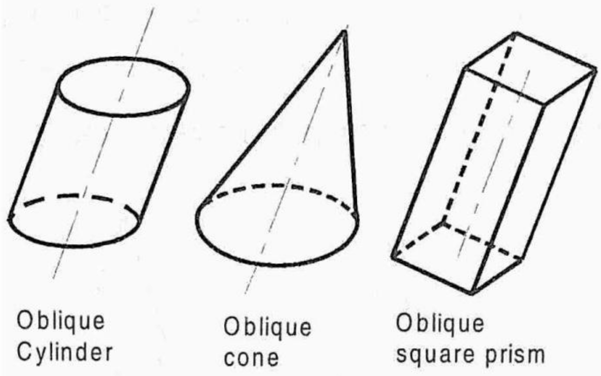


Sphere

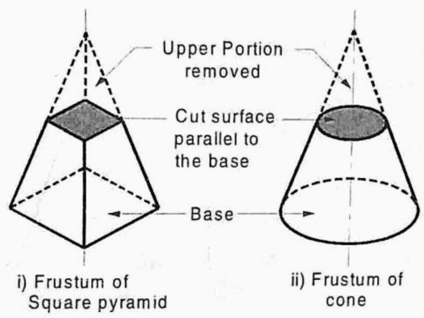
- **Cylinder:** A cylinder is a solid generated by the revolution of a rectangle about one of its sides, which remains fixed. It has two equal and parallel circular faces, namely the top face and the bottom face, and a curved lateral surface.
- **Cone:** A cone is a solid obtained by revolving a right-angled triangle about one of its perpendicular sides, which remains fixed. It has a circular base and a curved lateral surface meeting at a point called the apex.
- **Sphere:** A sphere is a solid obtained by revolving a semicircle about its diameter, which remains fixed. Every point on the surface of a sphere is at an equal distance from its centre.

2.8 Technical Terms Used in Solids

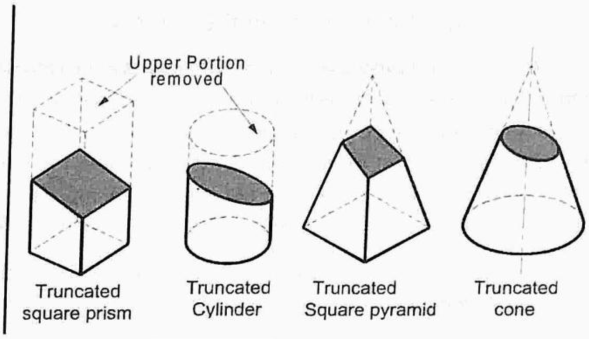
1. **Face:** A plane surface that forms part of the boundary of a solid.
2. **Edge:** The line of intersection along which two plane faces or surfaces meet.
3. **Top Face:** The upper plane surface of a solid.
4. **Bottom Face:** The lower plane surface of a solid.
5. **Axis of a Prism:** An imaginary line joining the centres of the top face and the bottom face of the prism.
6. **Axis of a Pyramid:** An imaginary line joining the apex and the centre of the base of the pyramid.
7. **Right Solid:** A solid in which the axis is perpendicular to its base.
8. **Oblique Solid:** A solid in which the axis is inclined to its base.
9. **Apex of a Pyramid:** The point at which all the equal isosceles triangular faces meet.
10. **Slant Edge:** The line joining the apex of a pyramid to a corner of its base.
11. **Generator:** A straight line drawn from the apex to the circumference of the base circle of a cone. The length of the generator is called the slant height of the cone.
12. **Frustum:** When a solid is cut by a section plane parallel to its base, and the upper portion is removed, the remaining part is called the frustum of the solid.
13. **Truncated Solid:** When a solid is cut by a section plane inclined to its base, and the upper portion is removed, the remaining part is called a truncated solid.



Oblique solids



Frustum of solids

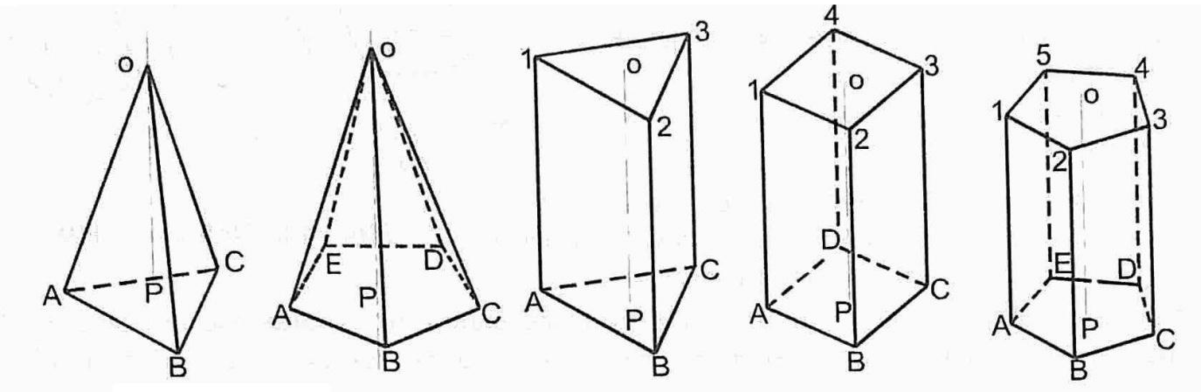


Truncated solids

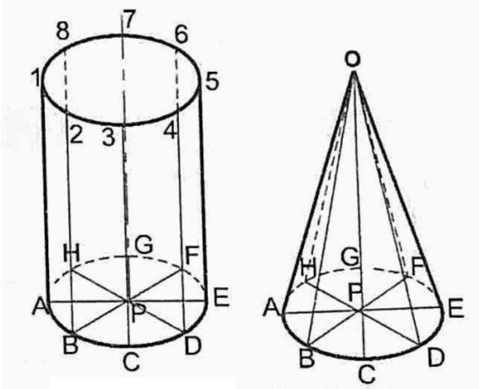
2.9 Rules and Conventions

- ❖ To completely describe a solid, a minimum of two orthographic views is required. For complicated solids, three or more views may be necessary. Additional views are obtained by projecting the solid onto auxiliary planes.
- ❖ If the distance of the solid from HP and VP is not specified in the problem, any convenient distance may be assumed.
- ❖ Continuous thick lines are used to represent the visible outlines and edges of solids.
- ❖ Dashed thick lines are used to represent hidden outlines or edges.
- ❖ Chain thin lines are used to represent the axis, lines of symmetry, and trajectories.
- ❖ Continuous thin lines are used for dimension lines, construction lines, leader lines, and other auxiliary lines.

2.10 Naming the Corners of the Solids



Naming the corners



Naming the Generators

2.11 Position of a Solid

The position of a solid is described by referring to the orientation of its axis with respect to the reference planes. In some problems, the position of a solid may also be specified based on the manner in which it rests.

A solid may be positioned in the following ways:

❖ **Based on the Manner of Resting**

i) The solid resting on its base.

ii) The solid resting on one of its faces, edges of faces, edges of the base, generators, or slant edges.

iii) The solid freely suspended from one of its corners or edges.

❖ **Simple Positions of a Solid**

i) Axis perpendicular to HP and parallel to VP.

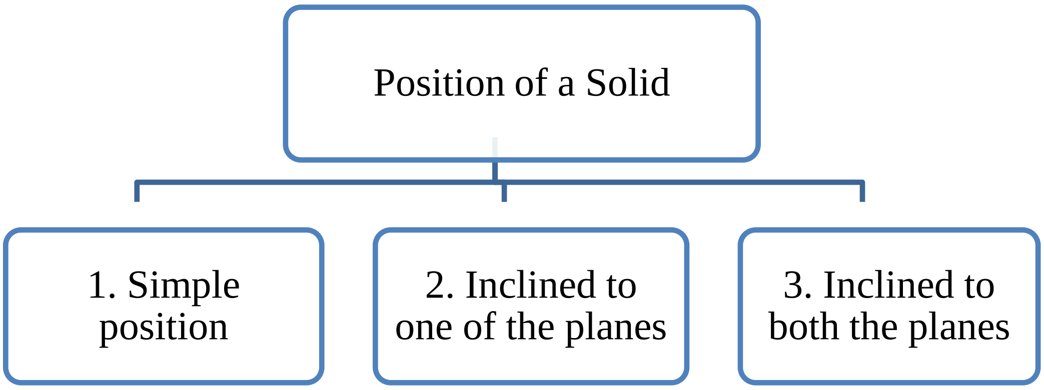
ii) Axis perpendicular to VP and parallel to HP.

iii) Axis parallel to both HP and VP (i.e., perpendicular to the Profile Plane (PP)).

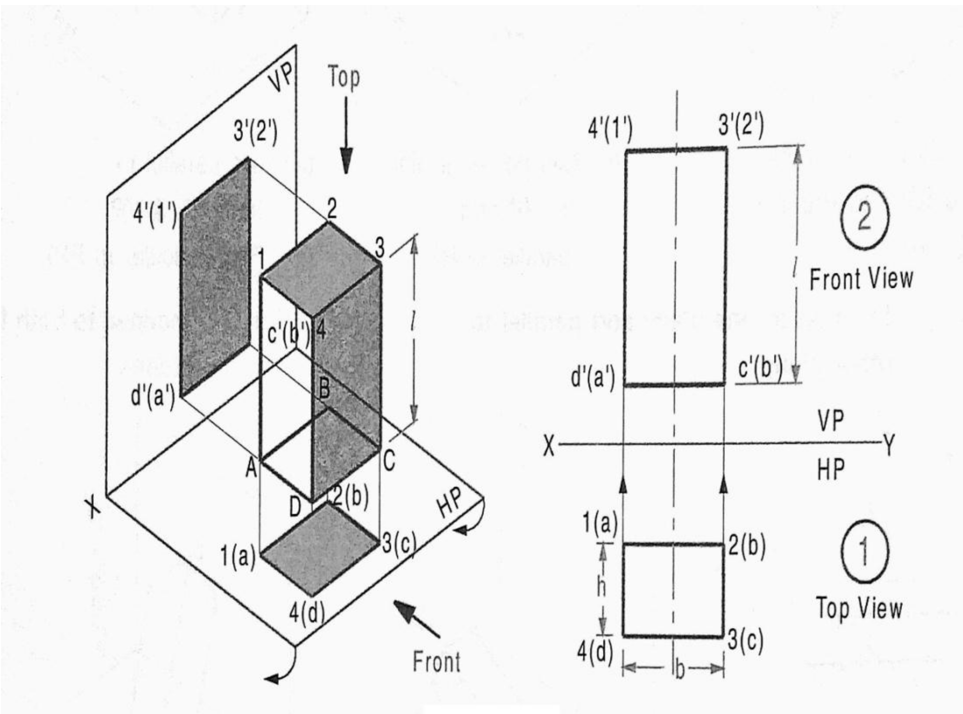
❖ **Positions Inclined to One of the Reference Planes**

i) Axis inclined to HP and parallel to VP.

ii) Axis inclined to VP and parallel to HP.



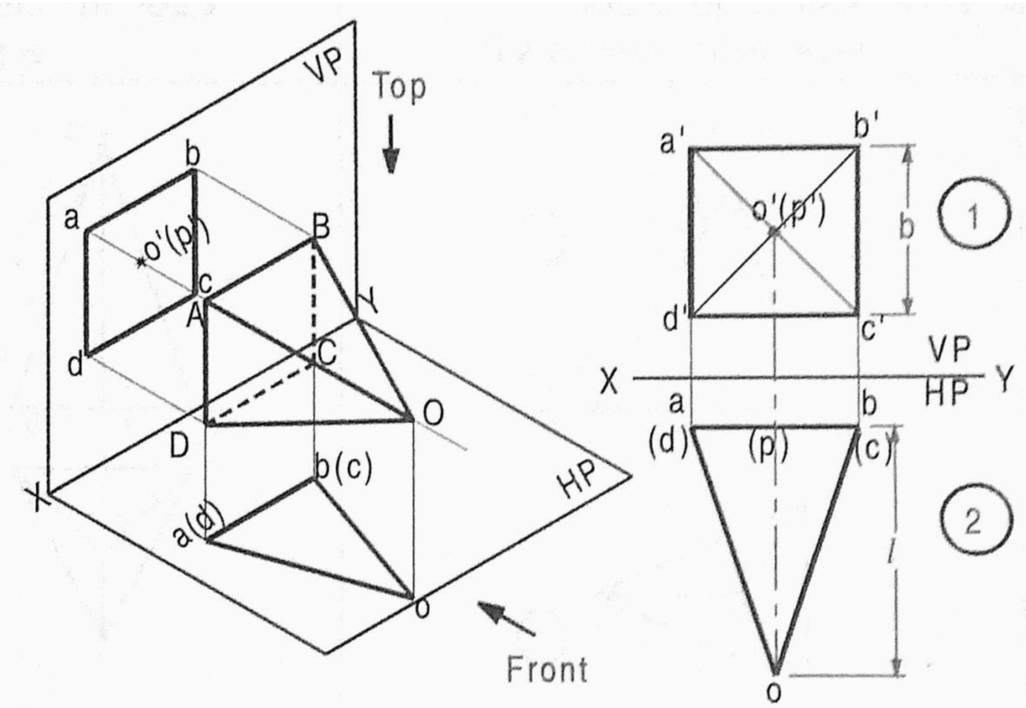
2.12 Axis Perpendicular to HP and Parallel to VP



i) Pictorial view ii) Projection

Since the base is parallel to HP, its true shape is seen in the top view. Therefore, draw the top view first, and then draw the front view by projecting the top view above the XY line using vertical projectors.

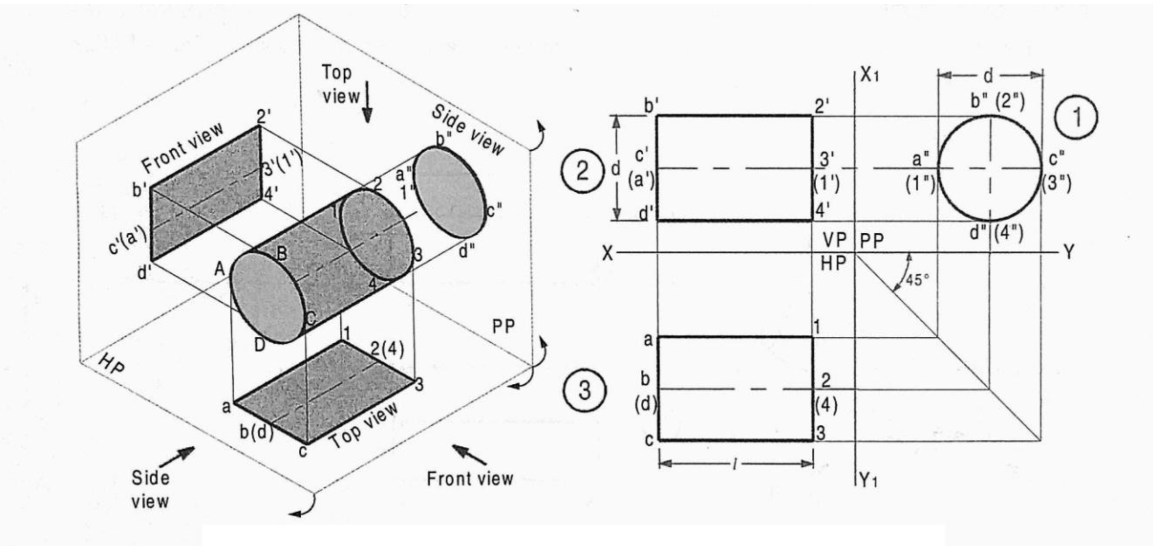
2.13 Axis perpendicular to VP and parallel to HP



(i) Pictorial view (ii) Projections

Since the base of the pyramid is parallel to VP, the true shape of the base is observed in the front view. Hence, draw the front view first, and then project it to obtain the top view.

2.14 Axis parallel to Both HP and VP

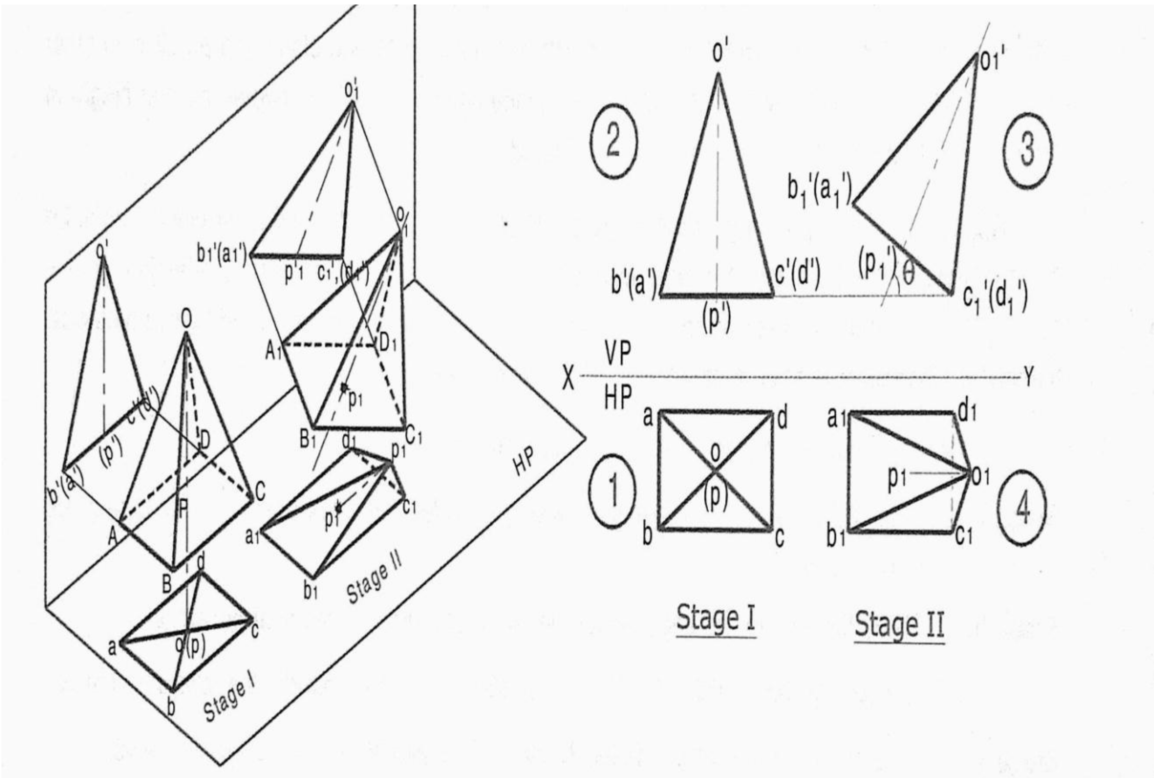


Since the axis is perpendicular to the Profile Plane (PP), the true shape and size of the solid are seen in the side view. Hence, the side view is drawn first.

From the side view, draw horizontal projectors through the points on the circumference of the circle to obtain the front view.

For drawing the top view, draw a mitre line at an angle of 45°. Draw vertical projectors from the side view to intersect the mitre line, and then draw horizontal projectors through the points of intersection on the mitre line. Finally, draw vertical projectors from the front view and complete the top view.

2.15 Axis inclined to HP and parallel to VP (by using change of position method)



Stage I

Assume that the axis is perpendicular to HP and parallel to VP, and draw the corresponding views.

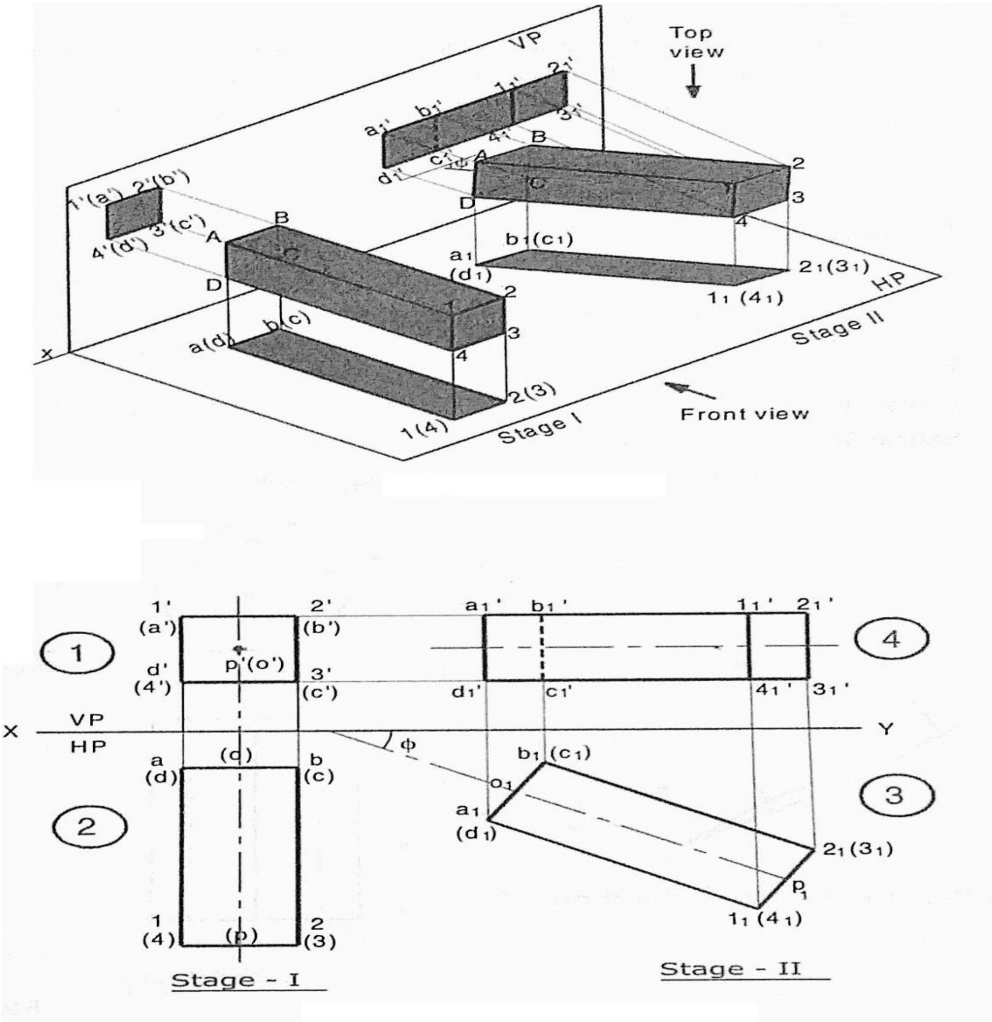
Stage II

Tilt the axis so that it is inclined to HP while remaining parallel to VP, and draw the final projections.

Note

Stage I is known as the simple position, and Stage II is known as the tilted position or final projection.

2.16 Axis inclined to VP and parallel to HP (by using change of position method)



Stage I

Assume that the axis is perpendicular to VP and parallel to HP, and draw the corresponding views.

Stage II

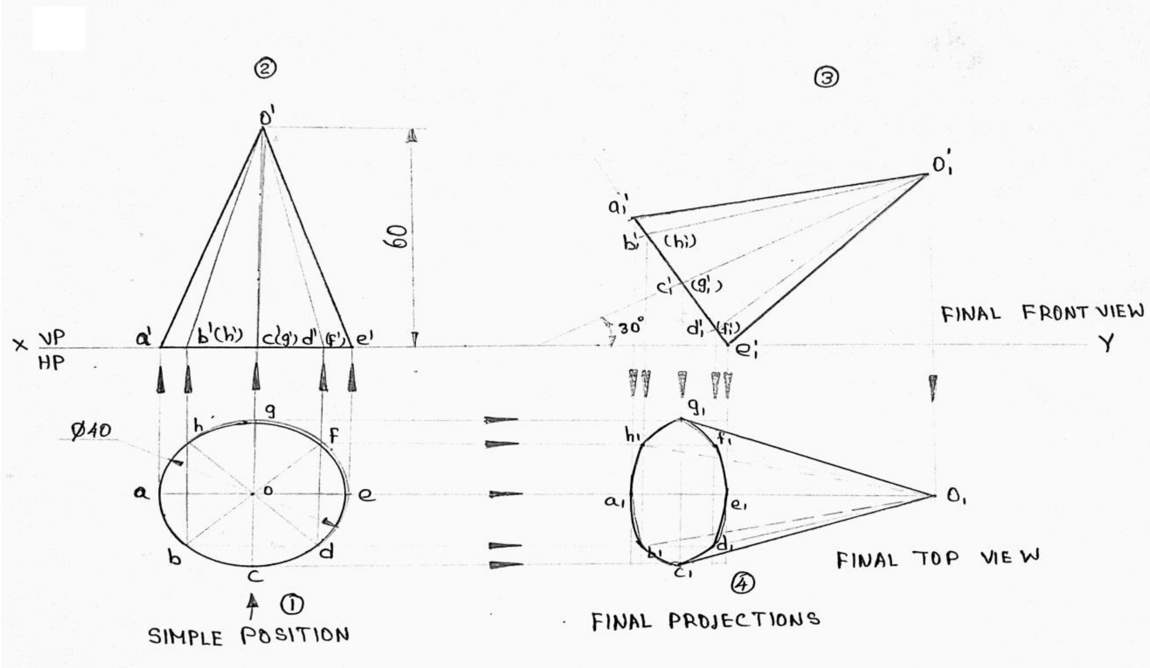
Tilt the axis so that it is inclined to VP while remaining parallel to HP, and draw the final projections.

Note

Stage I is known as the simple position, and Stage II is known as the tilted position or final projection.

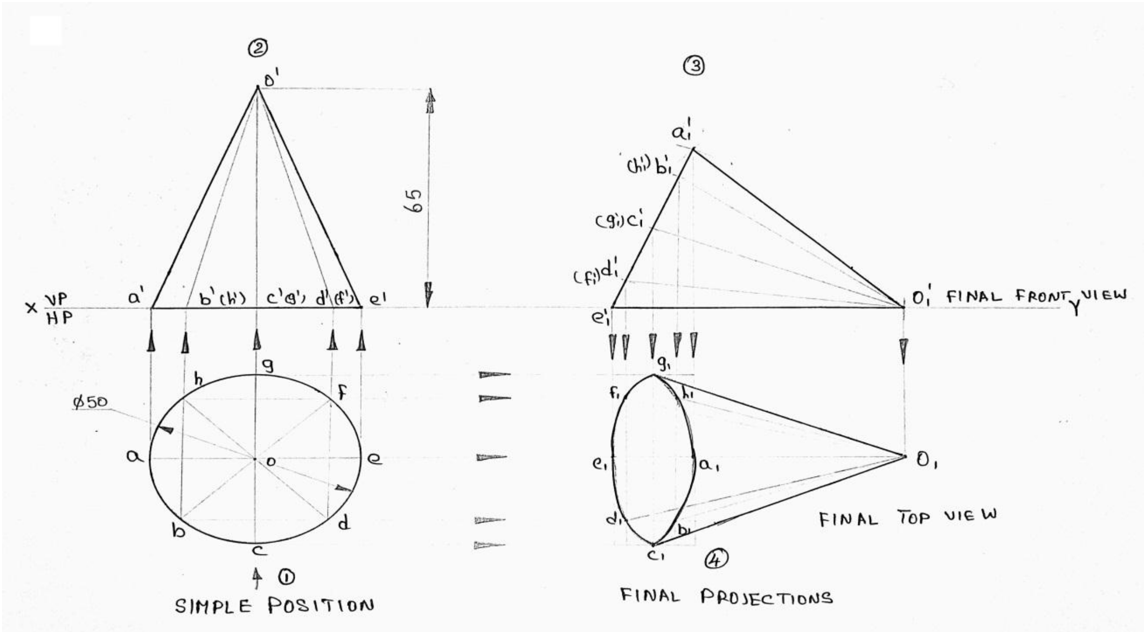
Projection of Simple Solids Inclined to One Principal Plane by the Rotating Object Method (First Angle Projection)

1. A cone of base diameter 40 mm and height 60 mm rests on HP on a point of its base, with its axis inclined at 30° to HP and parallel to VP. Draw its projections.



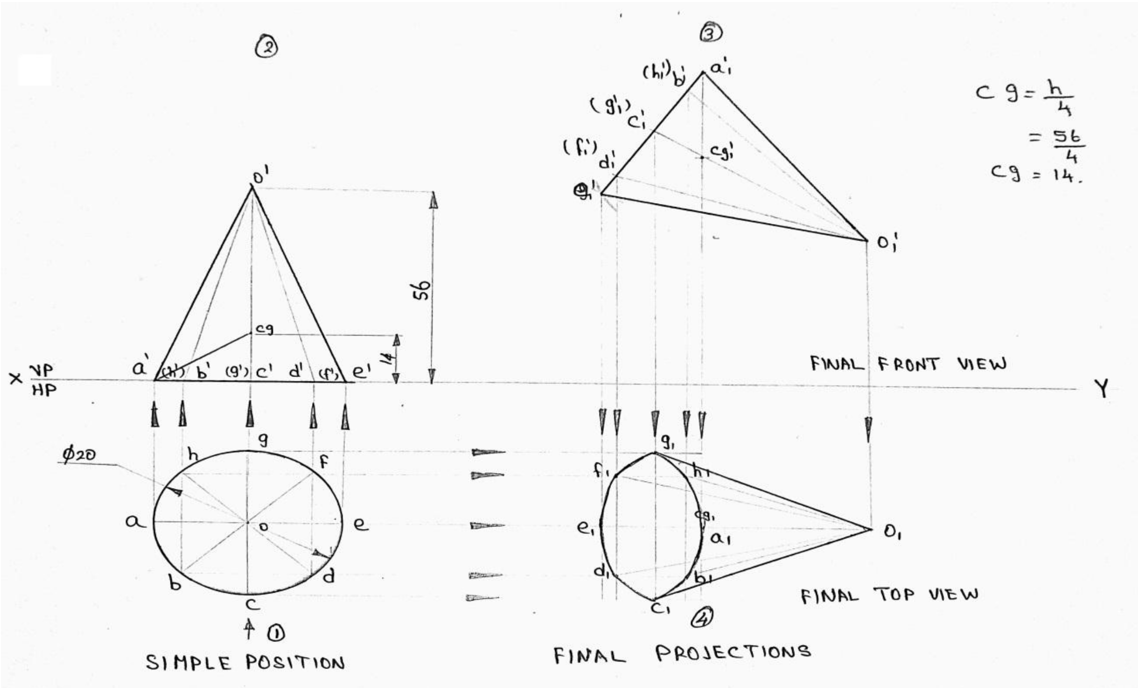
SCALE 1:1 ALL DIMENSIONS ARE IN mm

2. A cone of base diameter 50 mm and axis length 65 mm rests on one of its generators on HP, with its axis parallel to VP. Draw its projections.



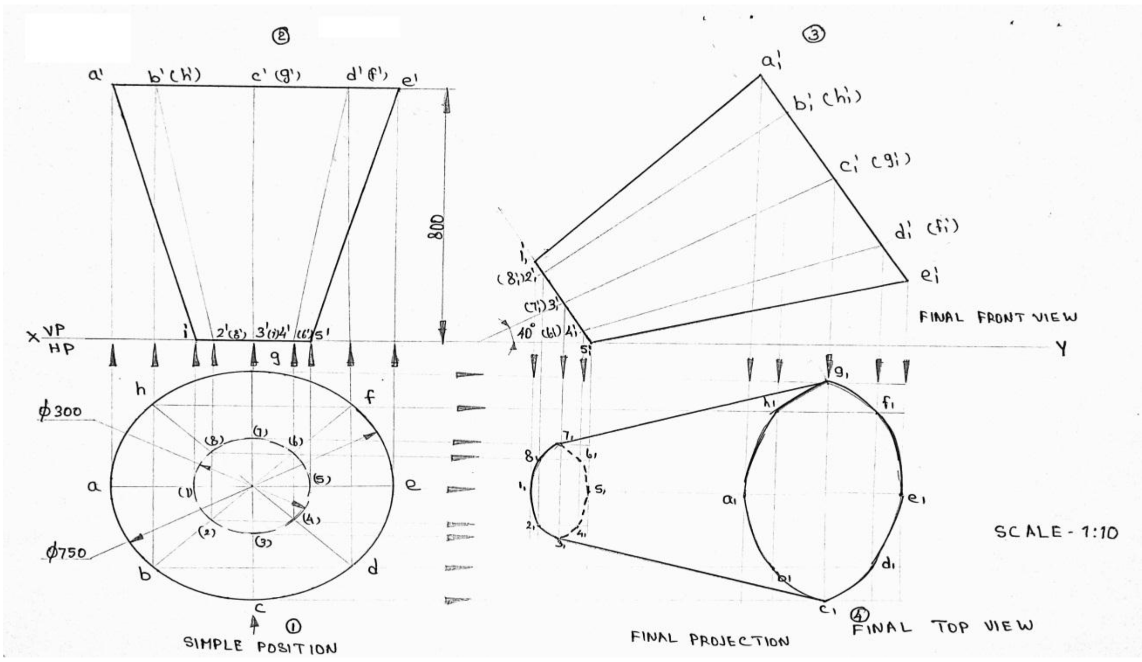
SCALE 1:1 ALL DIMENSIONS ARE IN mm

3. A cone of base diameter 40 mm and height 56 mm is freely suspended from one of its base points such that its axis is parallel to VP. Draw its projections.



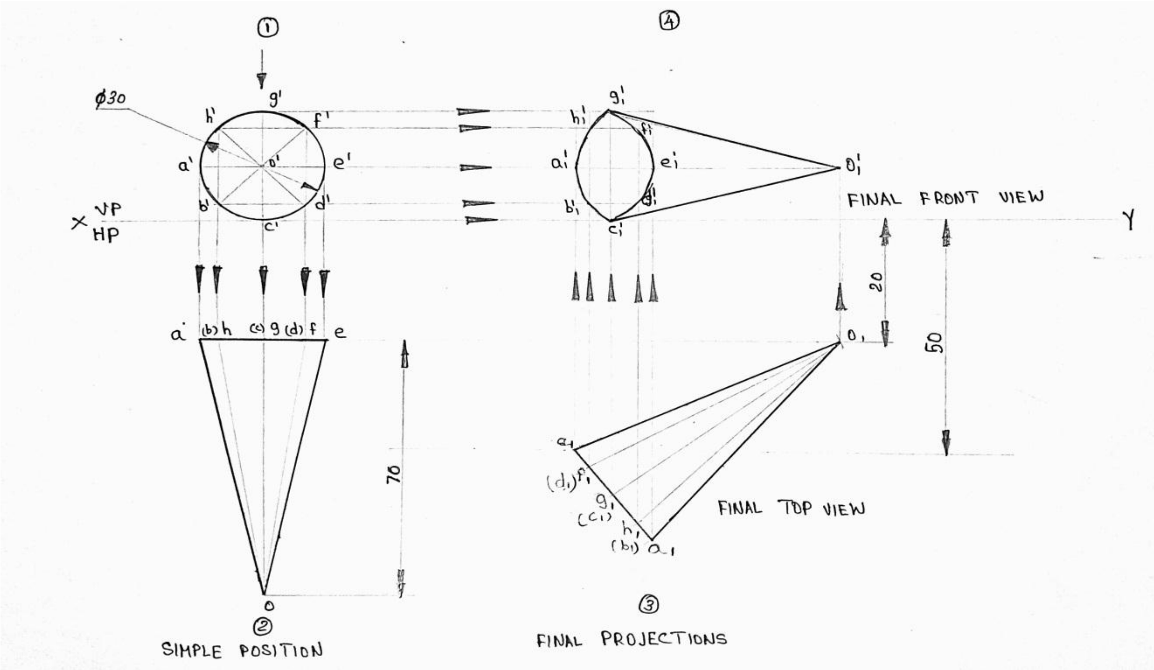
SCALE 1:1 ALL DIMENSIONS ARE IN mm

4. A bucket in the form of a frustum of a cone has bottom and top diameters of 300 mm and 750 mm respectively, and a height of 800 mm. The bucket is filled with water and then tilted through 40°. Draw the projections showing the water surface in both views. The axis of the bucket is parallel to VP.



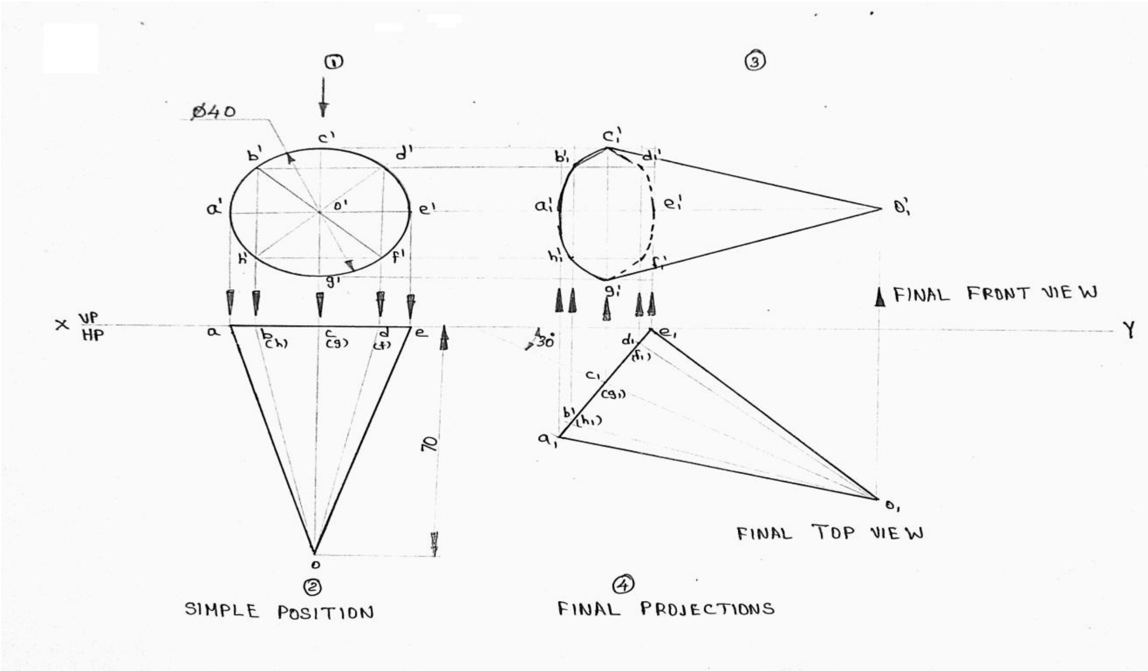
SCALE 1:10 ALL DIMENSIONS ARE IN mm

5. A cone of base diameter 30 mm and height 70 mm rests on the ground on one point of its base circle such that the apex is 20 mm in front of VP and the nearest base circle point is 50 mm in front of VP. The base is perpendicular to HP. Draw its projections.



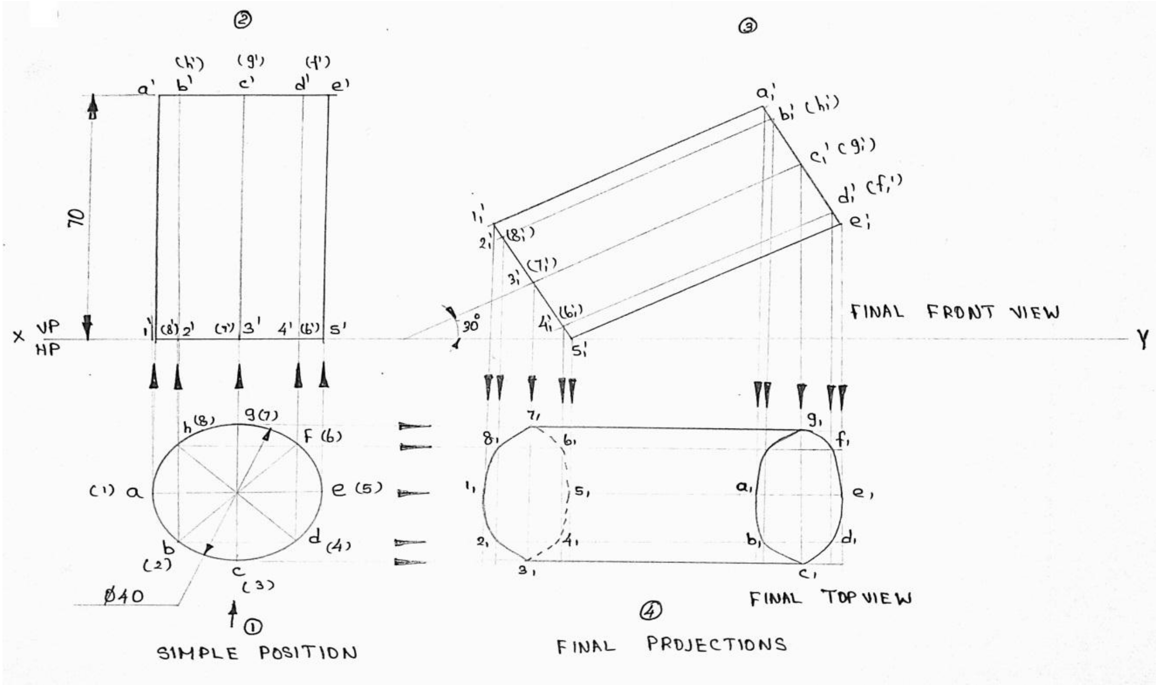
SCALE 1:1 ALL DIMENSIONS ARE IN mm

6. A cone of base diameter 40 mm and axis length 70 mm touches VP at a point on its base circle. Its axis is inclined at 30° to VP and parallel to HP. Draw its projections.



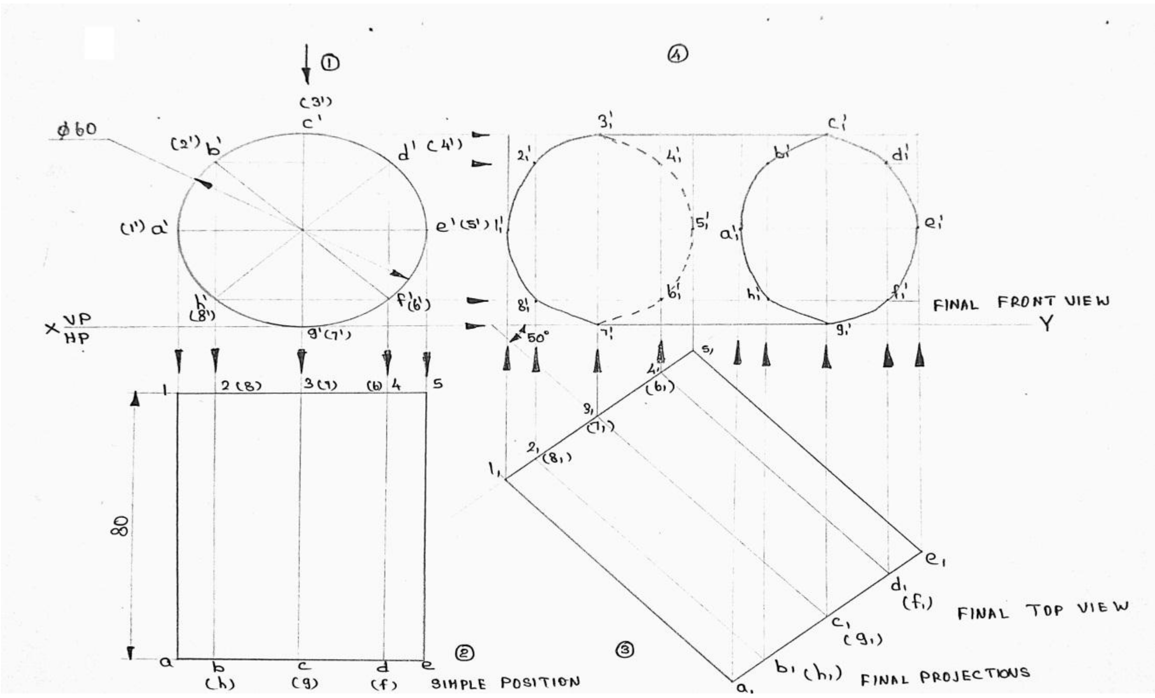
SCALE 1:1 ALL DIMENSIONS ARE IN mm

7. Draw the projections of a cylinder of diameter 40 mm and axis length 70 mm resting on HP on one of its base points. The axis is parallel to VP and inclined at 30° to HP.



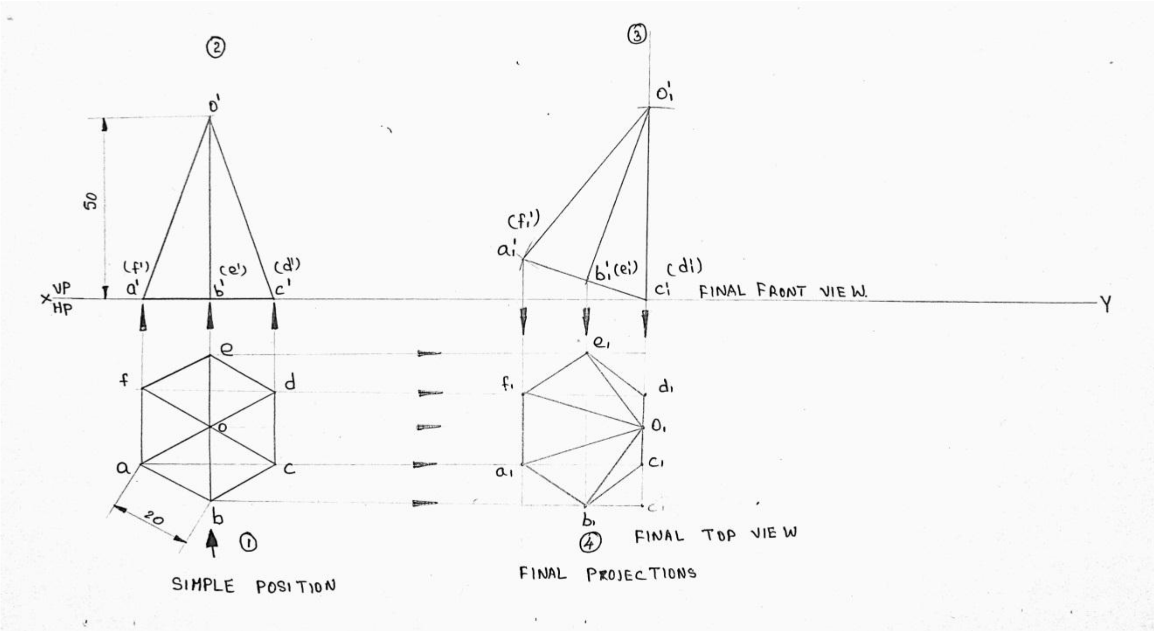
SCALE 1:1 ALL DIMENSIONS ARE IN mm

8. A cylinder of base diameter 60 mm and height 80 mm rests on HP on one of its generators, with its axis inclined at 50° to VP. Draw its projections.



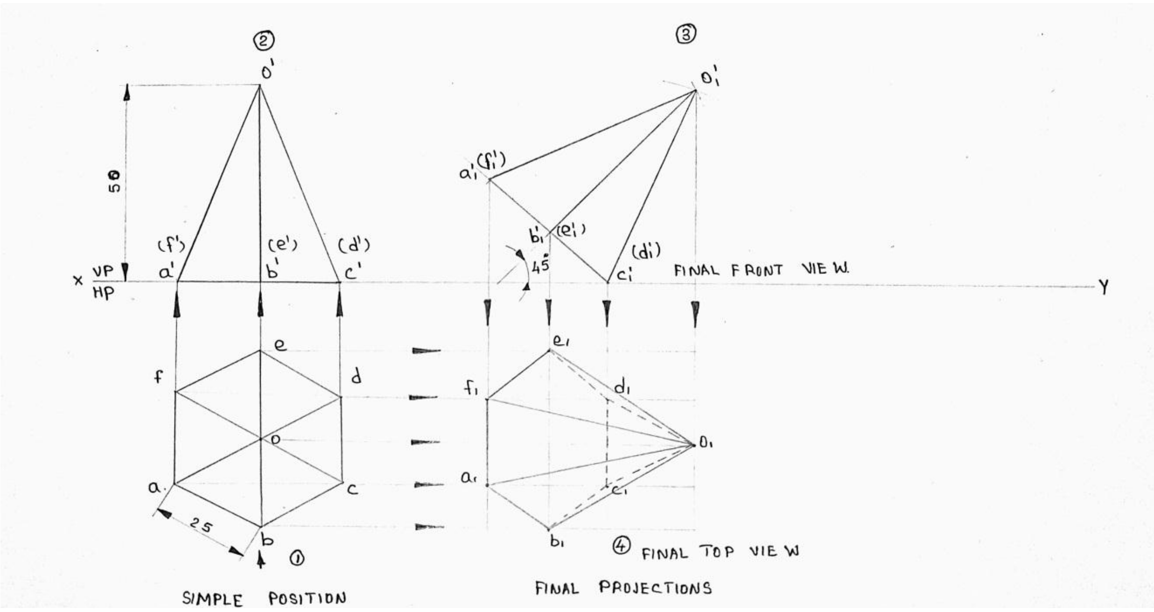
SCALE 1:1 ALL DIMENSIONS ARE IN mm

9. A hexagonal pyramid of base edge 20 mm and altitude 50 mm rests on one of its base edges on HP such that the slant face containing the resting edge is perpendicular to HP. Draw its projections.



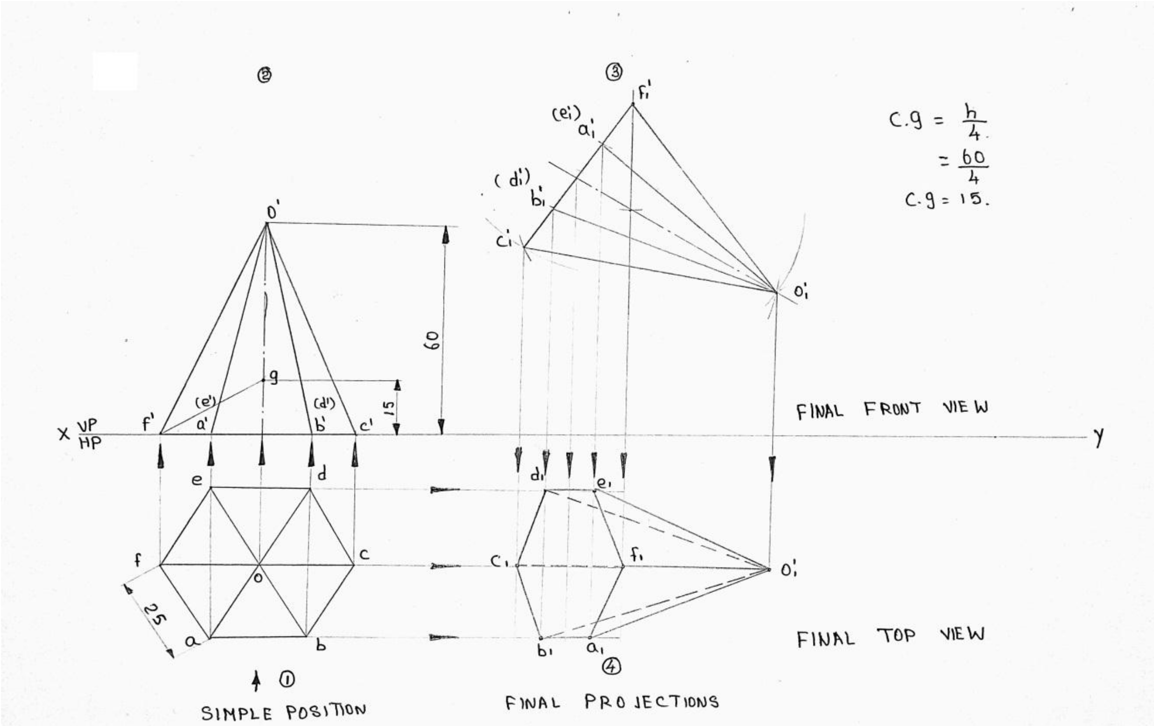
SCALE 1:1 ALL DIMENSIONS ARE IN mm

10. A right regular hexagonal pyramid of base edge 25 mm and height 50 mm rests on one of its base edges on HP, with its axis parallel to VP. Draw its projections when its base makes an angle of 45° with HP.



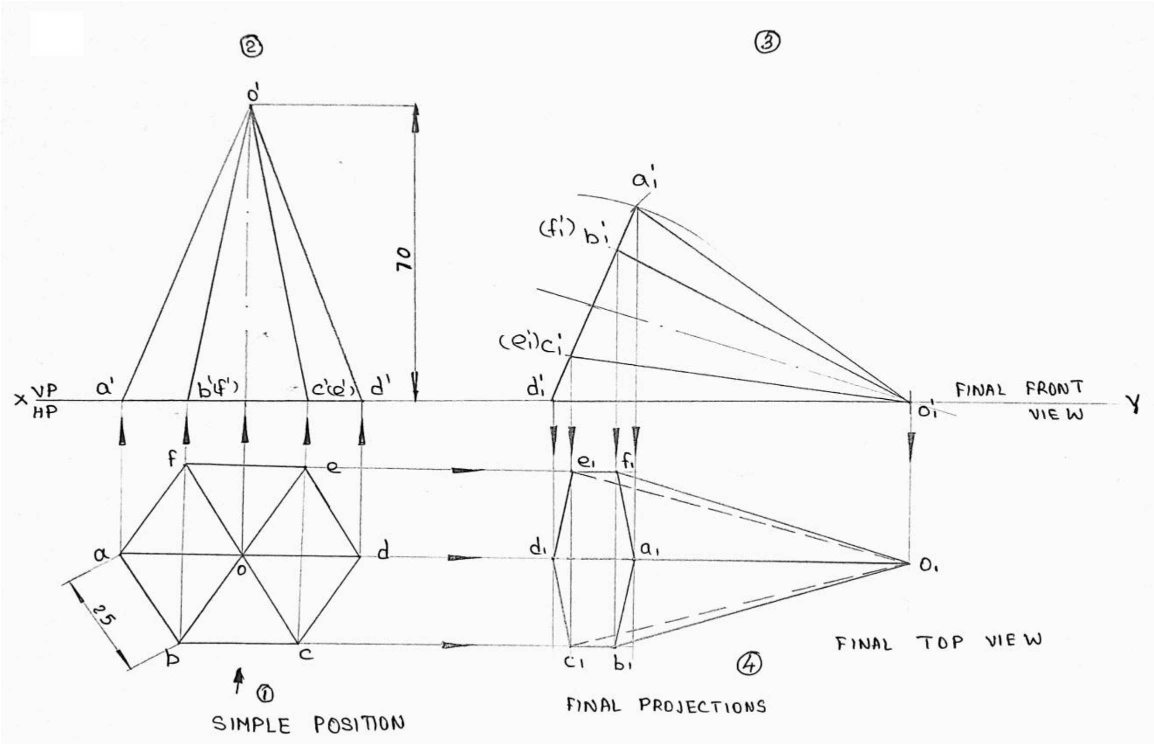
SCALE 1:1 ALL DIMENSIONS ARE IN mm

11. A hexagonal pyramid of base edge 25 mm and axis length 60 mm is freely suspended from a corner of its base such that the axis is parallel to VP. Draw its projections.



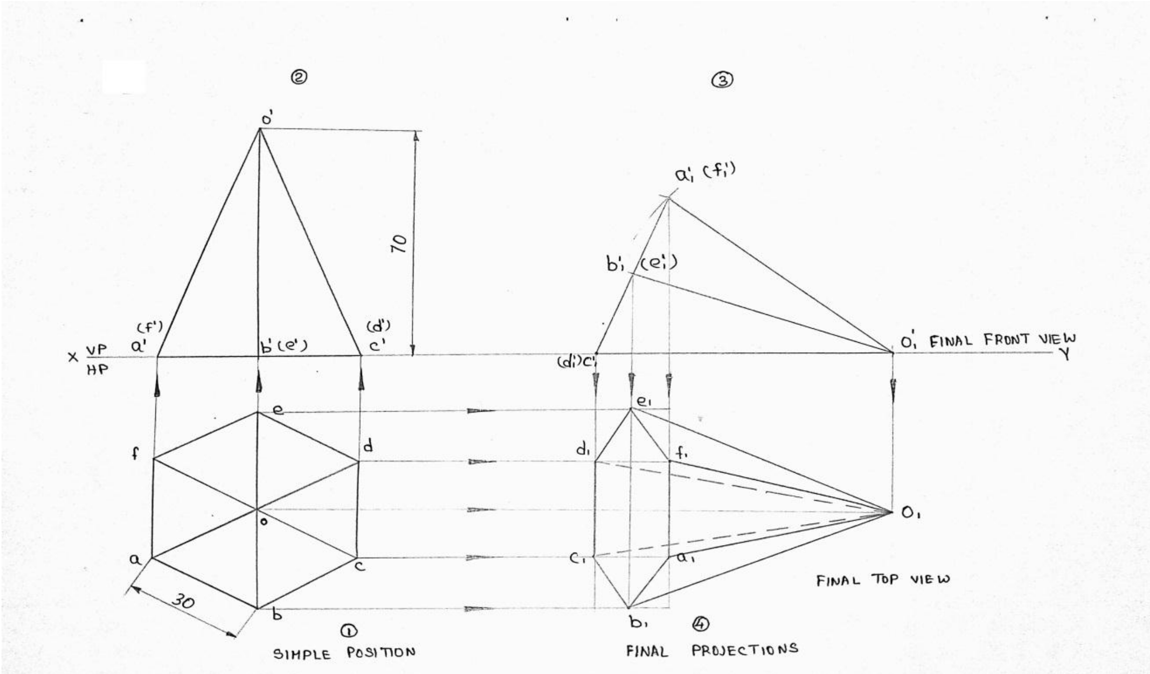
SCALE 1:1 ALL DIMENSIONS ARE IN mm

12. A hexagonal pyramid of base edge 25 mm and height 70 mm rests on one of its slant edges on HP. Its axis is parallel to VP. Draw its projections.



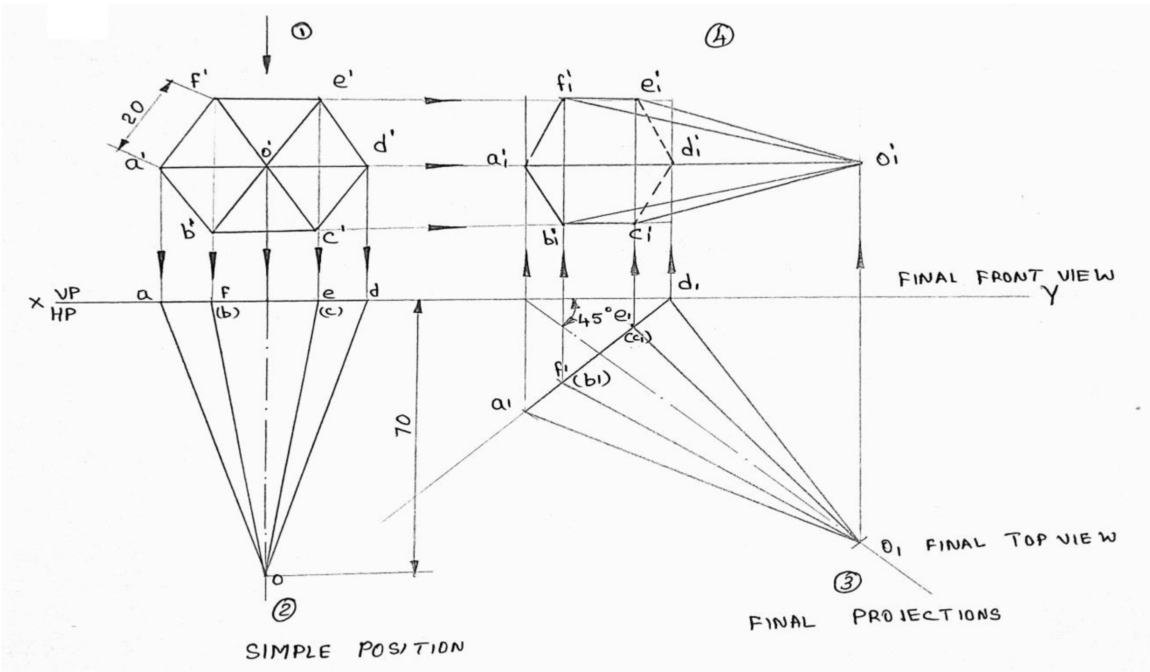
SCALE 1:1 ALL DIMENSIONS ARE IN mm

13. A hexagonal pyramid of base edge 30 mm and axis length 70 mm lies on HP on one of its triangular faces, with its axis parallel to VP. Draw the front and top views.



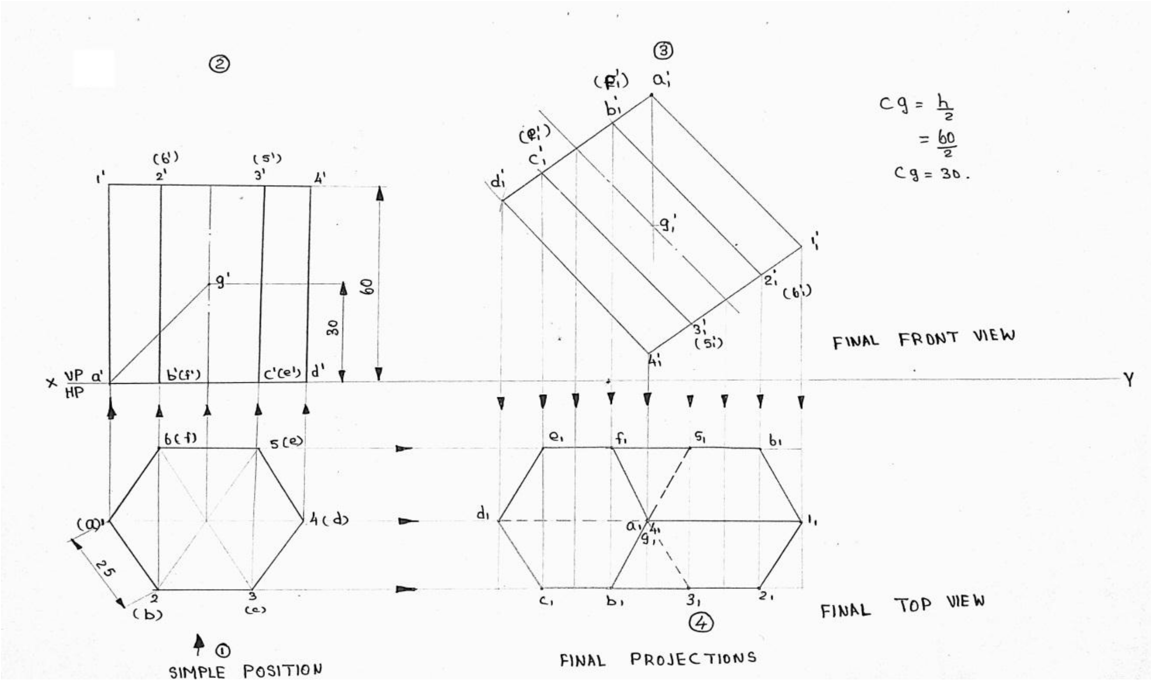
SCALE 1:1 ALL DIMENSIONS ARE IN mm

14. A hexagonal pyramid of base edge 20 mm and axis height 70 mm has one corner of its base in VP. Its axis is inclined at 45° to VP and parallel to HP. Draw its front and top views.



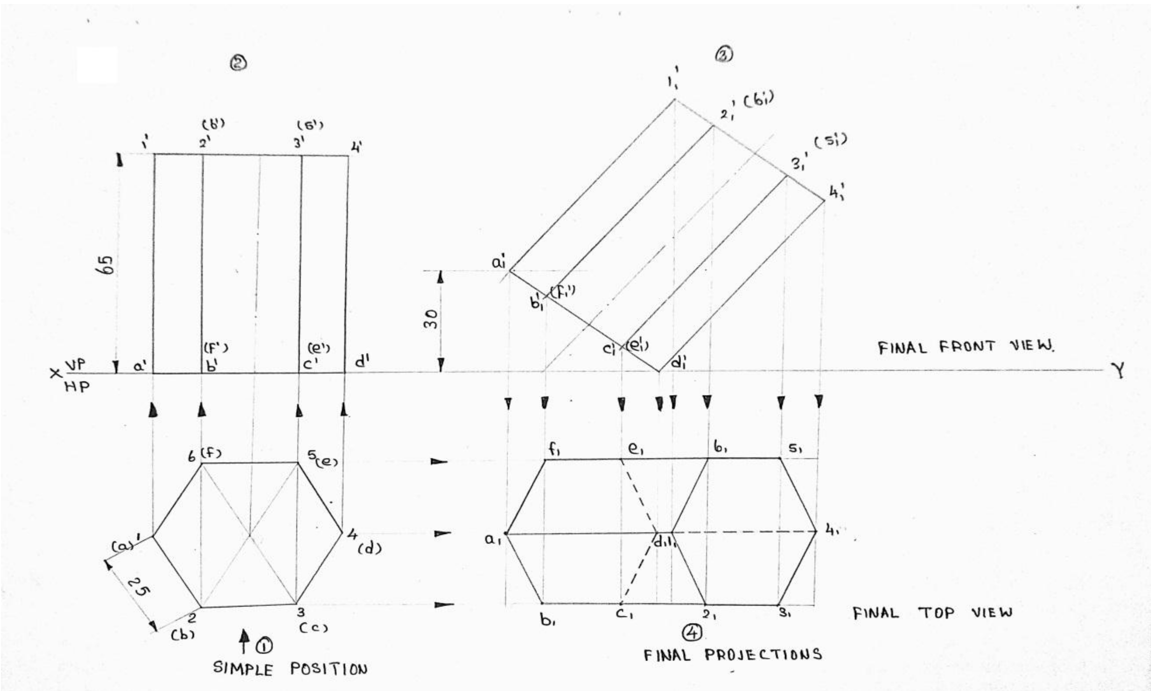
SCALE 1:1 ALL DIMENSIONS ARE IN mm

15. A hexagonal prism of base edge 25 mm and axis length 60 mm is freely suspended from a corner of its base. Draw its projections using the change of position method.



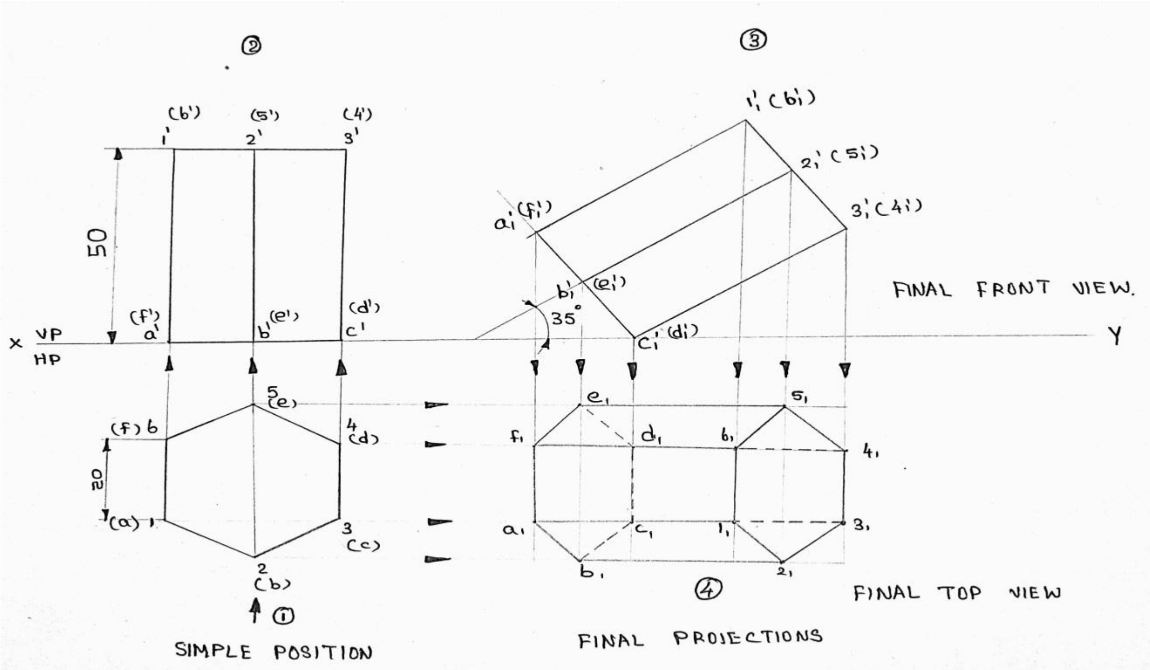
SCALE 1:1 ALL DIMENSIONS ARE IN mm

16. Draw the projections of a hexagonal prism whose rectangular face measures 25 mm × 65 mm, resting on HP on one of its base corners such that the opposite corner is 30 mm above HP. The axis is parallel to VP.



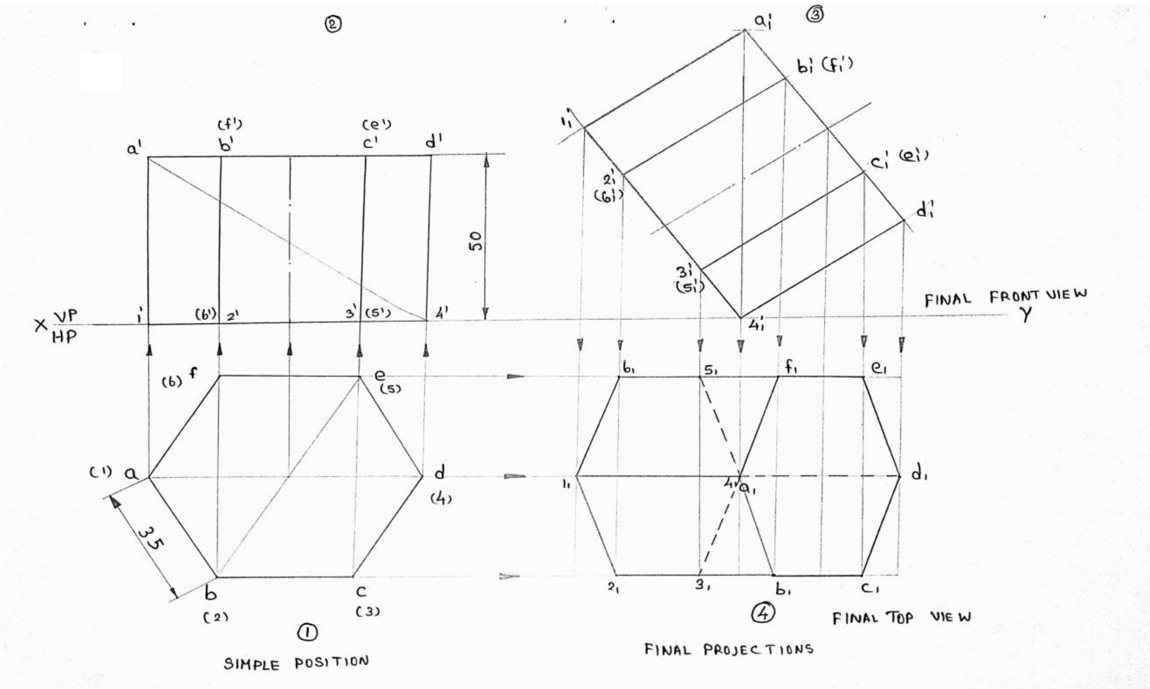
SCALE 1:1 ALL DIMENSIONS ARE IN mm

17. Draw the projections of a hexagonal prism of base edge 20 mm and axis length 50 mm resting on HP on one of its base edges, with its axis inclined at 35° to HP and parallel to VP.



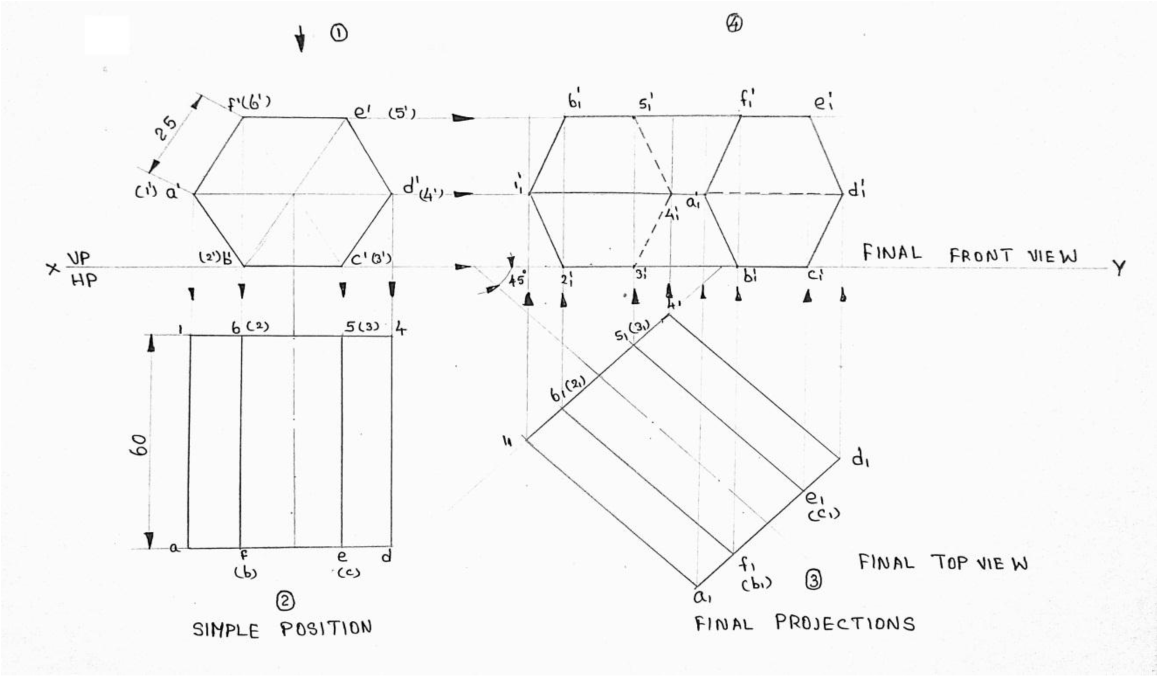
SCALE 1:1 ALL DIMENSIONS ARE IN mm

18. A hexagonal prism of base edge 35 mm and axis length 50 mm rests on HP on one of its base corners, with the solid diagonal through that corner perpendicular to HP. Draw the plan and elevation.



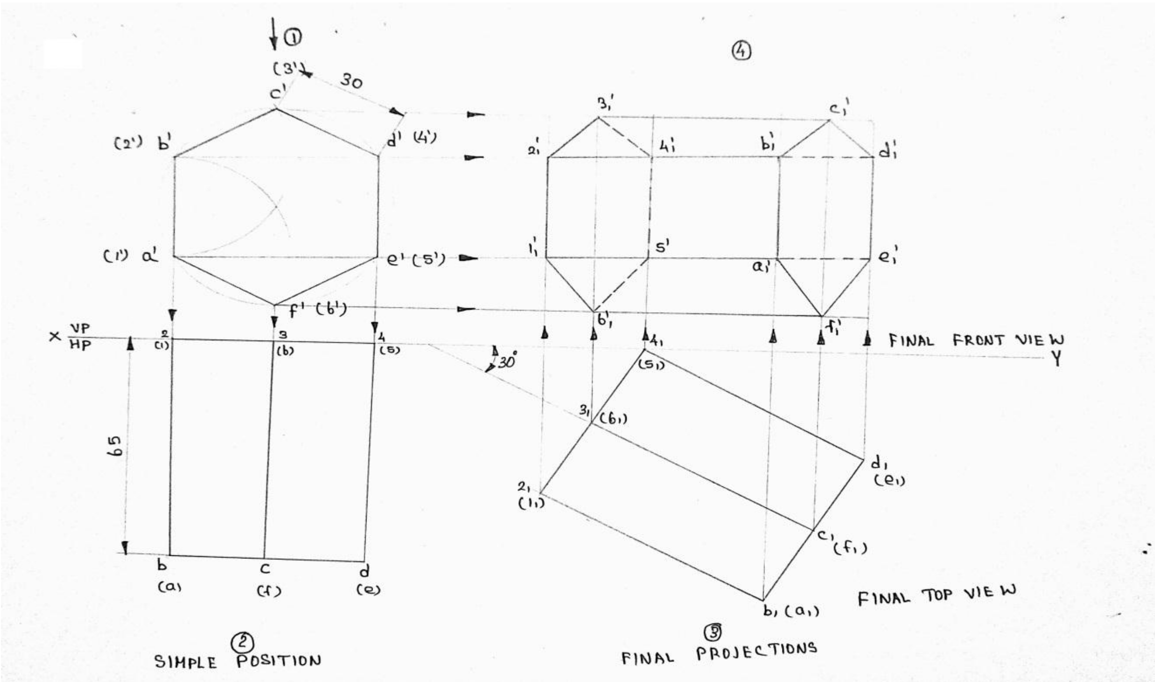
SCALE 1:1 ALL DIMENSIONS ARE IN mm

19. A hexagonal prism of base edge 25 mm and axis length 60 mm lies on HP on one of its rectangular faces, with its axis inclined at 45° to VP. Draw its projections.



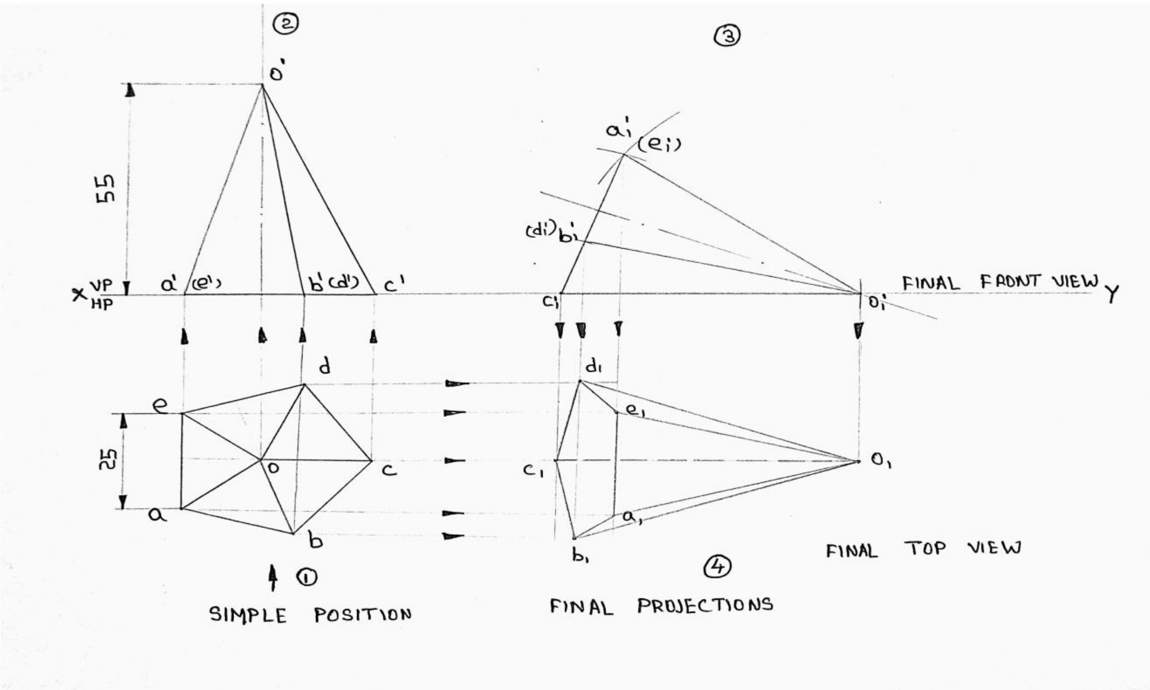
SCALE 1:1 ALL DIMENSIONS ARE IN mm

20. A hexagonal prism with base edge 30 mm and axis length 65 mm has one base edge in VP, with its axis inclined at 30° to VP and parallel to HP. Draw its projections.



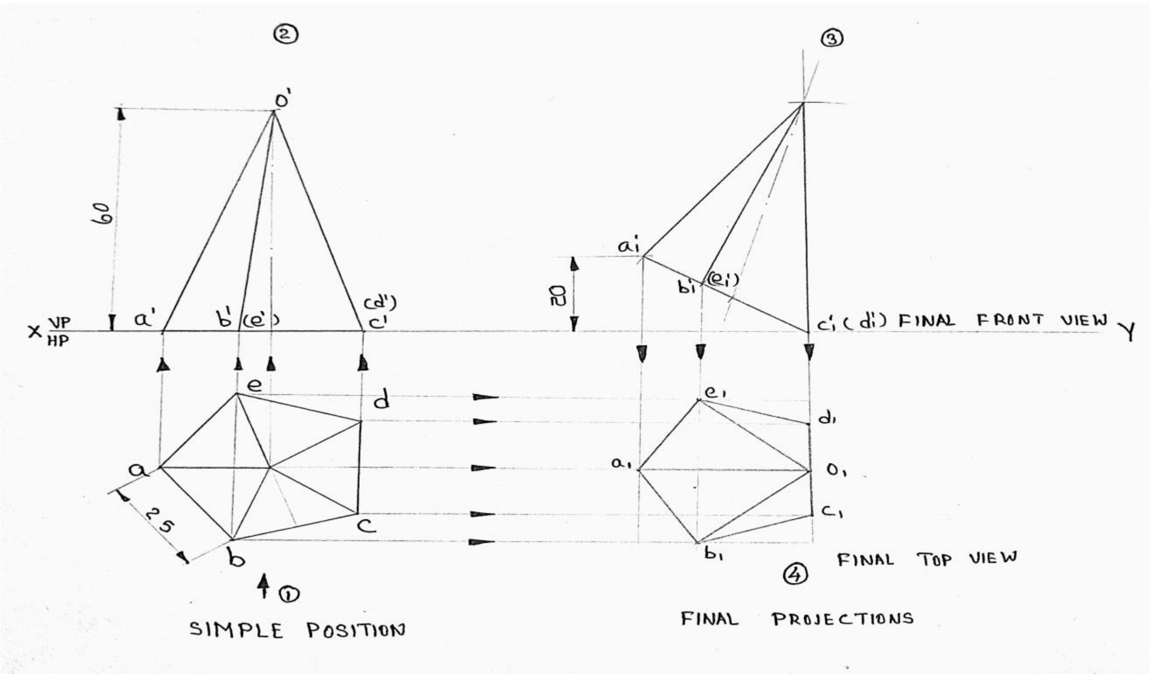
SCALE 1:1 ALL DIMENSIONS ARE IN mm

21. A pentagonal pyramid of base edge 25 mm and axis length 55 mm lies on HP on one of its slant edges, with its axis parallel to VP. Draw its projections.



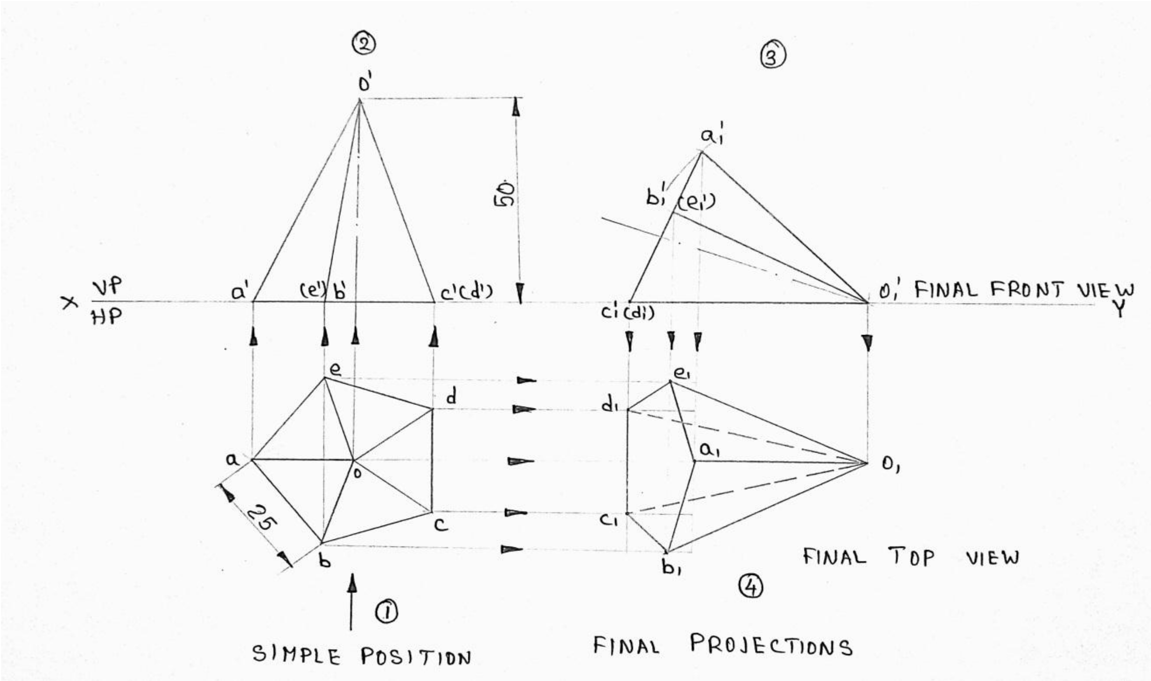
SCALE 1:1 ALL DIMENSIONS ARE IN mm

22. A right pentagonal pyramid of base edge 35 mm and altitude 60 mm rests on HP on one of its base edges. The base is lifted until the highest corner is 20 mm above HP. Draw its projections when the resting edge is perpendicular to VP.



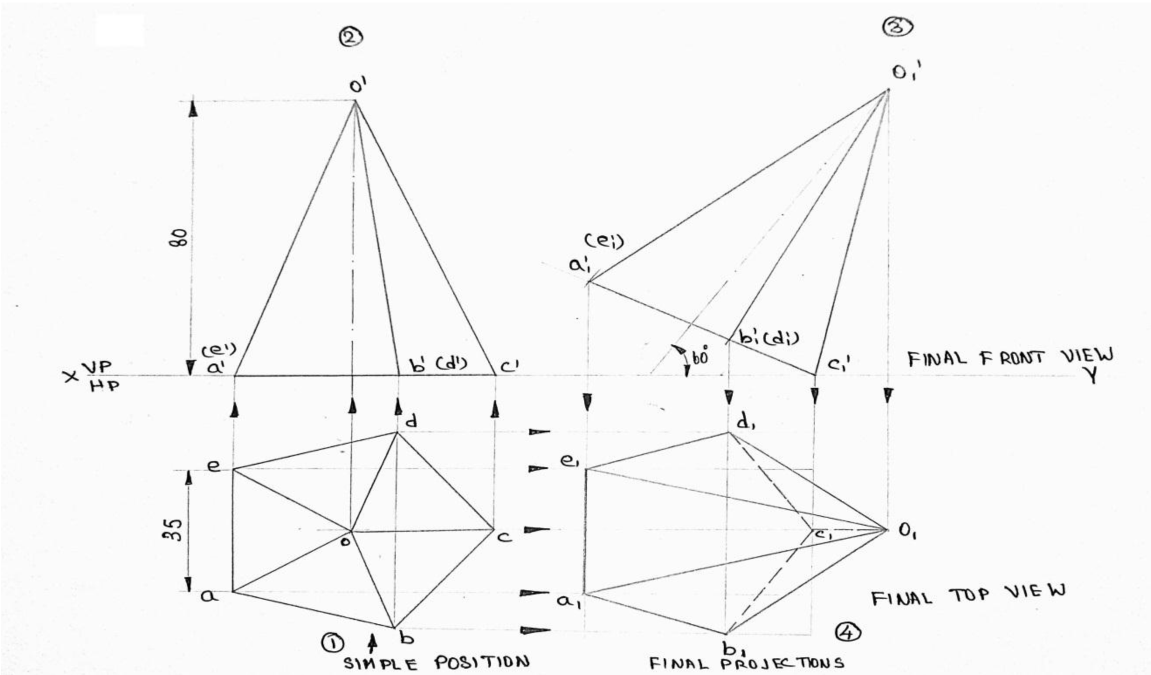
SCALE 1:1 ALL DIMENSIONS ARE IN mm

23. A pentagonal pyramid of base edge 25 mm and height 50 mm rests on HP on one of its triangular faces, with its axis parallel to VP. Draw its projections.



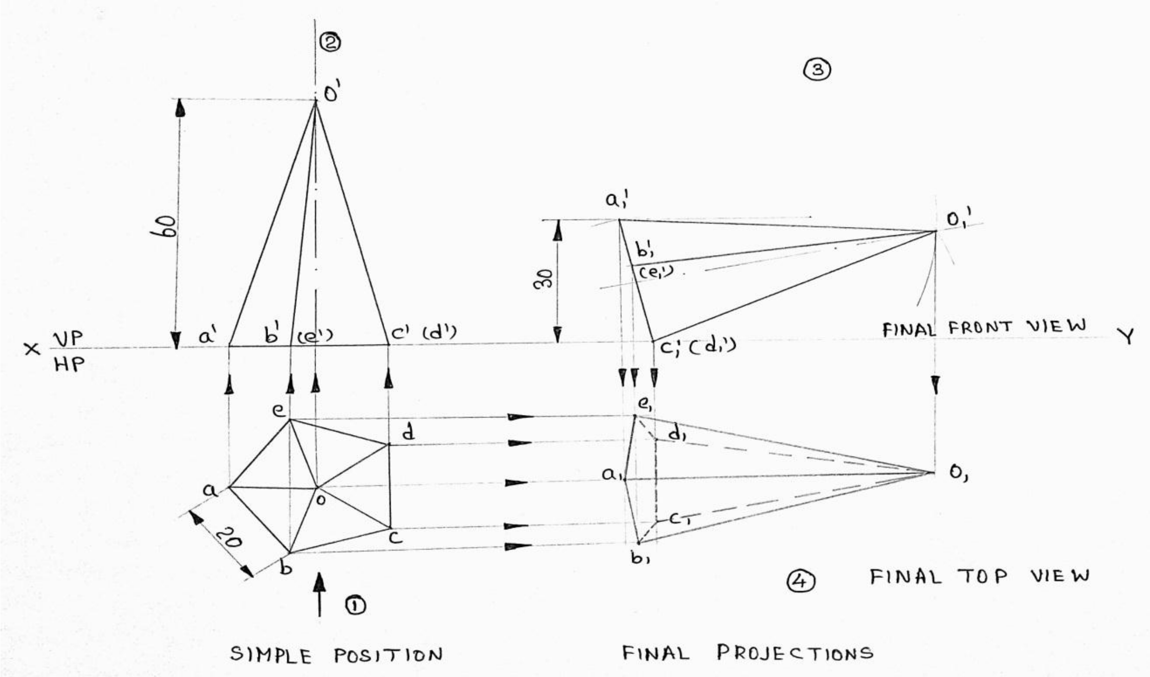
SCALE 1:1 ALL DIMENSIONS ARE IN mm

24. A pentagonal pyramid of base edge 35 mm and height 80 mm rests on HP on one of its base corners. Its axis is inclined at 60° to HP and parallel to VP. Draw its projections.



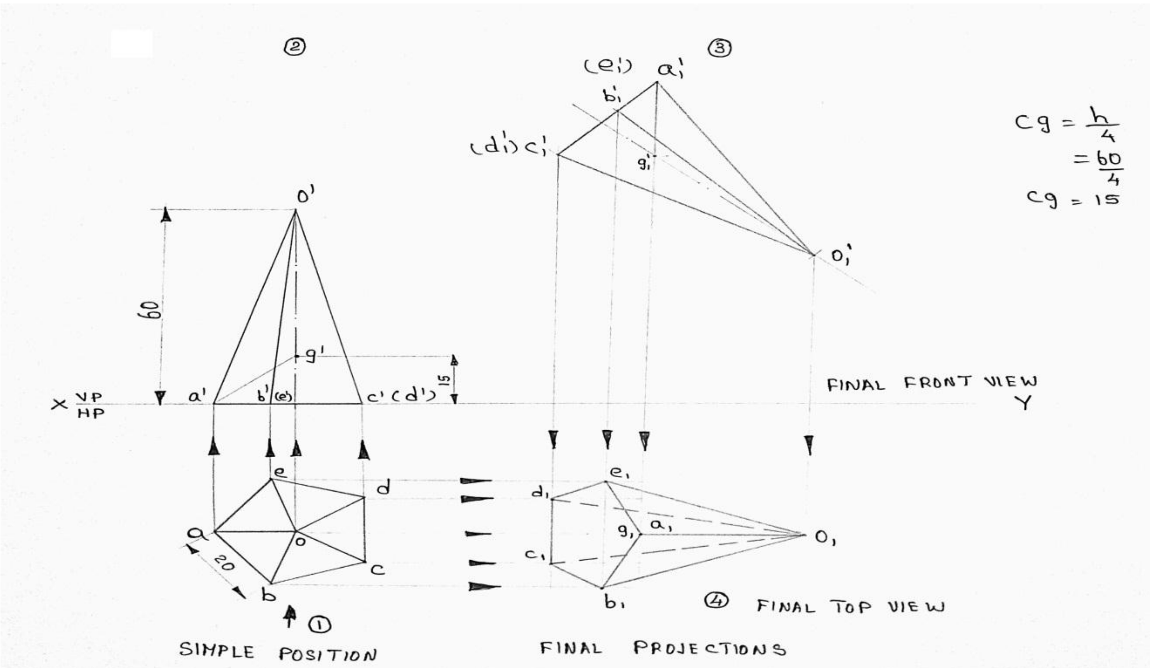
SCALE 1:1 ALL DIMENSIONS ARE IN mm

25. A right pentagonal pyramid of base edge 20 mm and altitude 60 mm rests on HP on one of its base edges. The base is lifted until the highest corner is 30 mm above HP. Draw the elevation when the resting edge is perpendicular to VP.



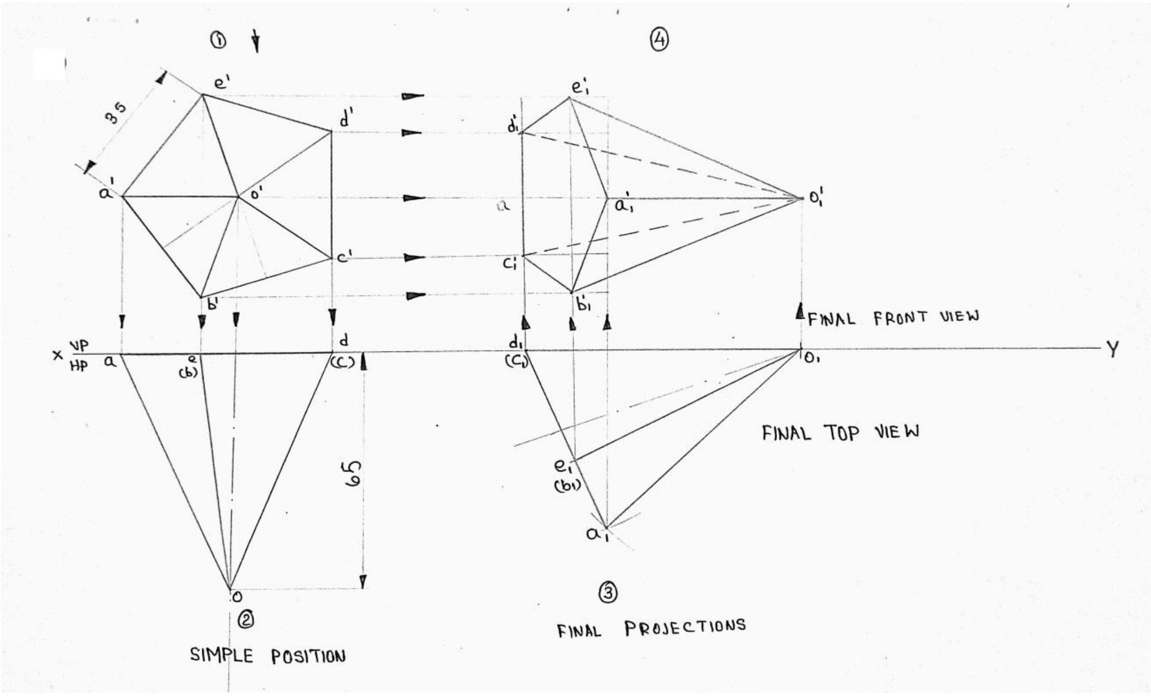
SCALE 1:1 ALL DIMENSIONS ARE IN mm

26. A pentagonal pyramid of base edge 20 mm and axis length 60 mm is freely suspended from one of its base corners, with its axis parallel to VP. Draw its front and top views.



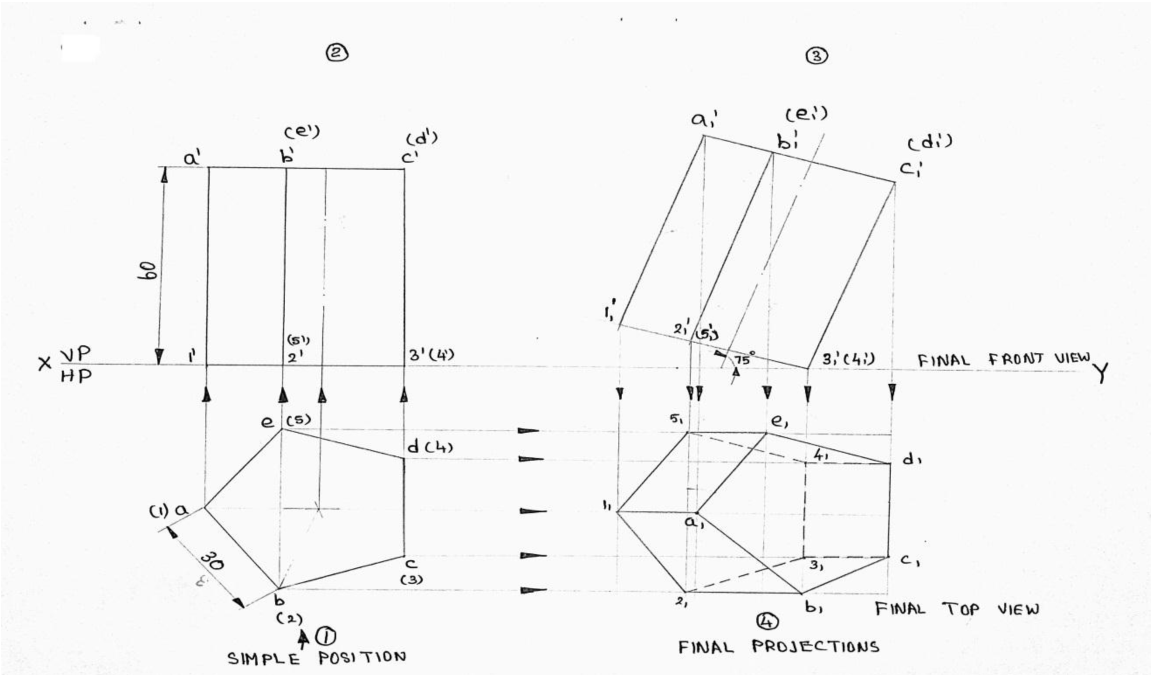
SCALE 1:1 ALL DIMENSIONS ARE IN mm

27. A pentagonal pyramid of base edge 35 mm and axis length 65 mm rests on VP on one of its triangular faces, with its axis parallel to HP. Draw its projections.



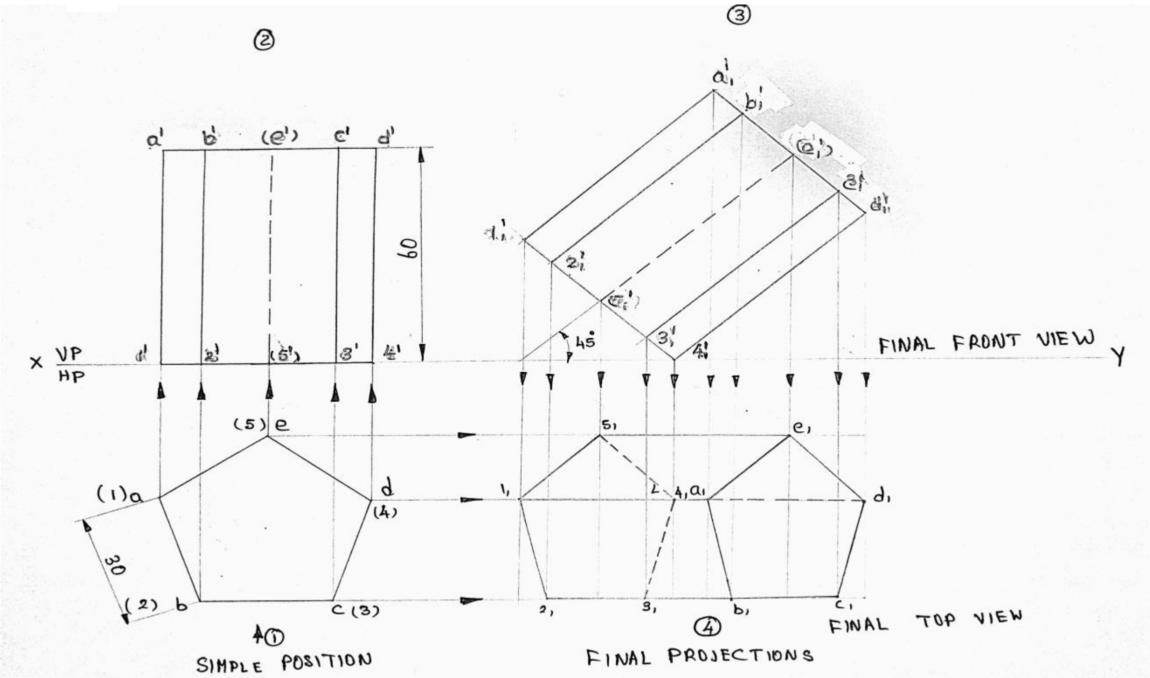
SCALE 1:1 ALL DIMENSIONS ARE IN mm

28. Draw the projections of a pentagonal prism of base edge 30 mm and axis length 60 mm, with its axis inclined at 75° to HP and parallel to VP, and with one base edge on HP.



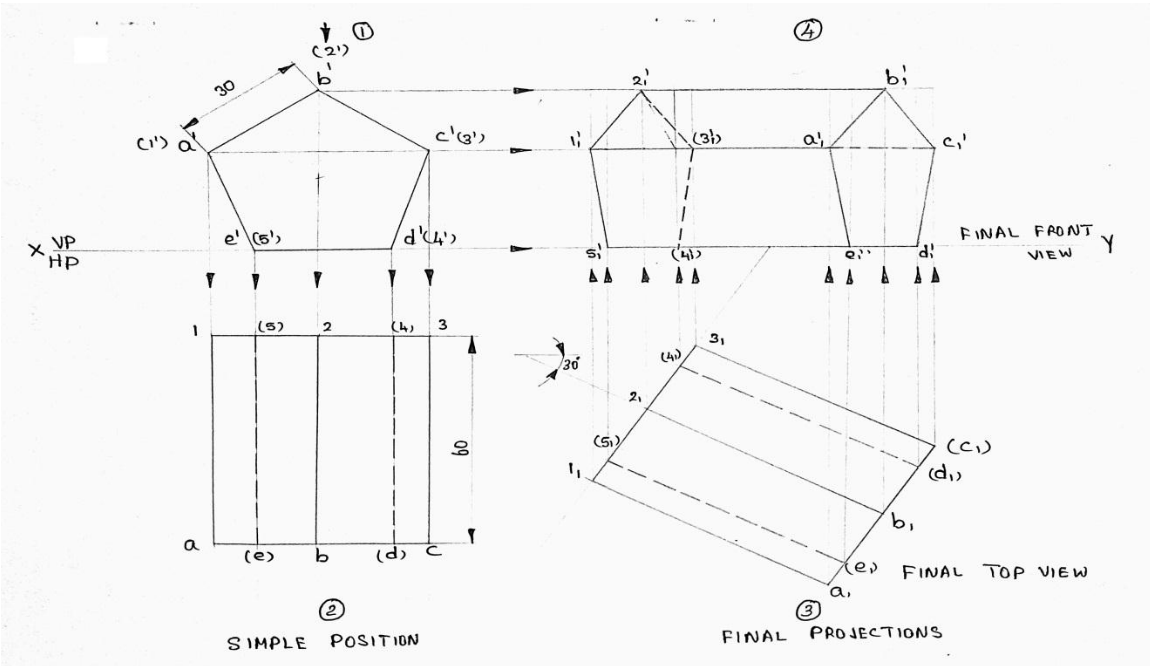
SCALE 1:1 ALL DIMENSIONS ARE IN mm

29. A pentagonal prism of base edge 30 mm and axis length 60 mm rests on HP on one of its base corners, with the base edges containing that corner equally inclined to VP. The axis is inclined at 45° to HP and parallel to VP. Draw its projections using the change of position method.



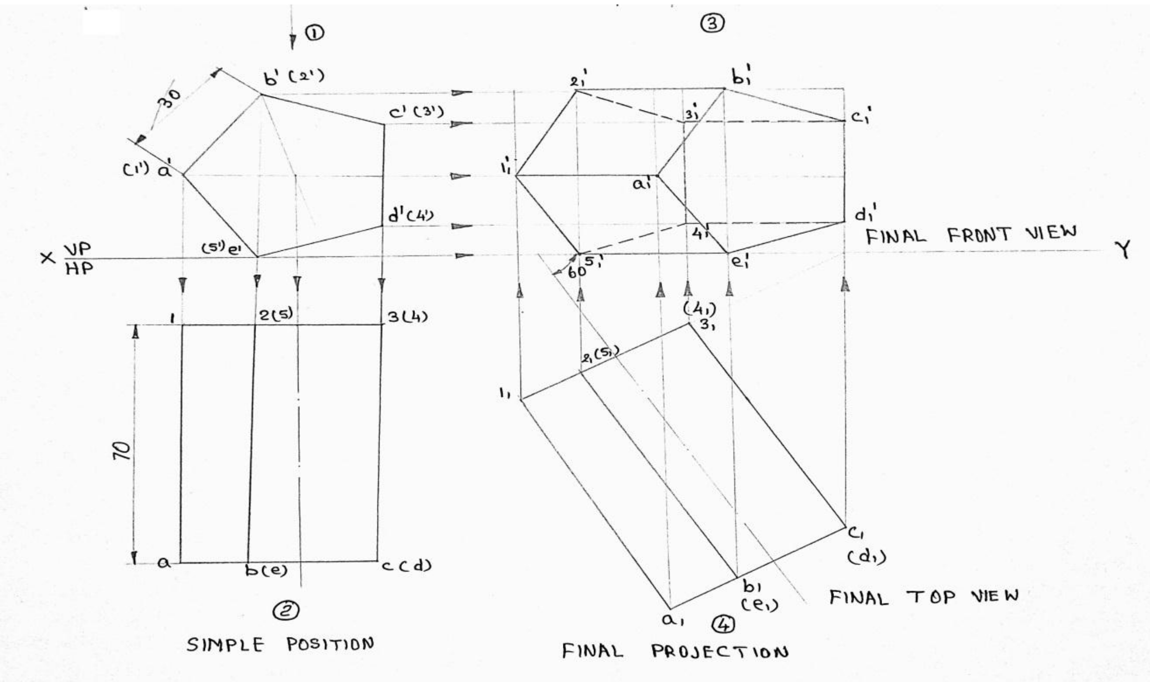
SCALE 1:1 ALL DIMENSIONS ARE IN mm

30. A pentagonal prism of base edge 30 mm and axis length 60 mm lies on HP on one of its rectangular faces. Draw the front and top views when its axis is inclined at 30° to VP.



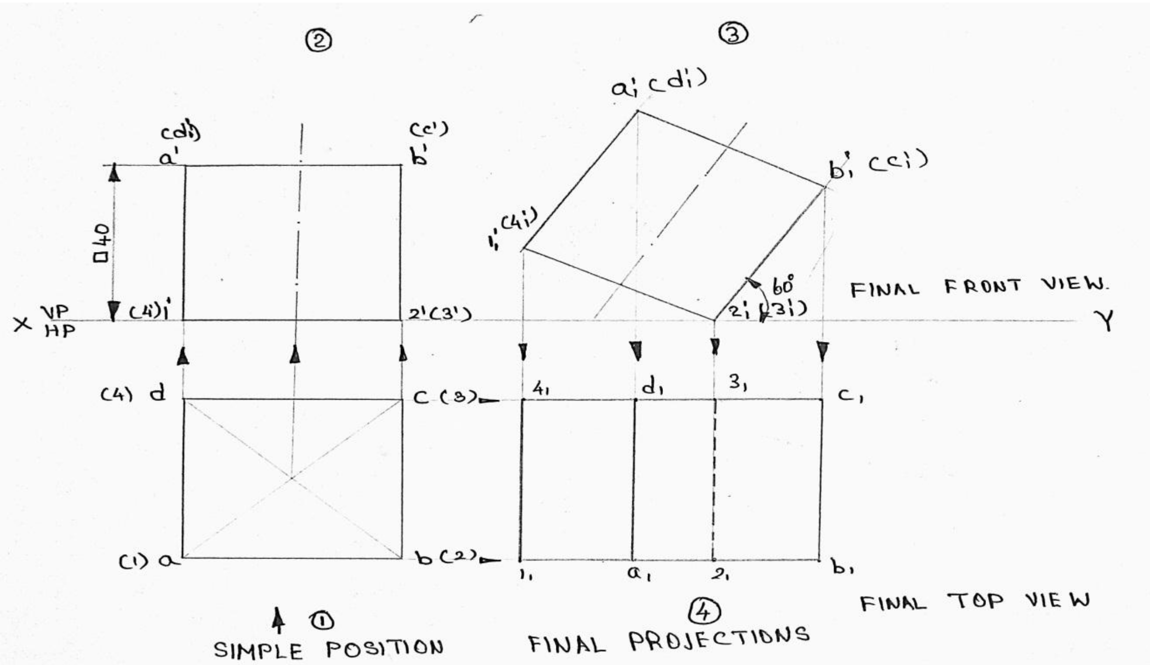
SCALE 1:1 ALL DIMENSIONS ARE IN mm

31. Draw the projections of a pentagonal prism of base edge 30 mm and axis length 70 mm lying on HP on one of its longer edges, with one rectangular face perpendicular to HP and the axis inclined at 60° to VP.



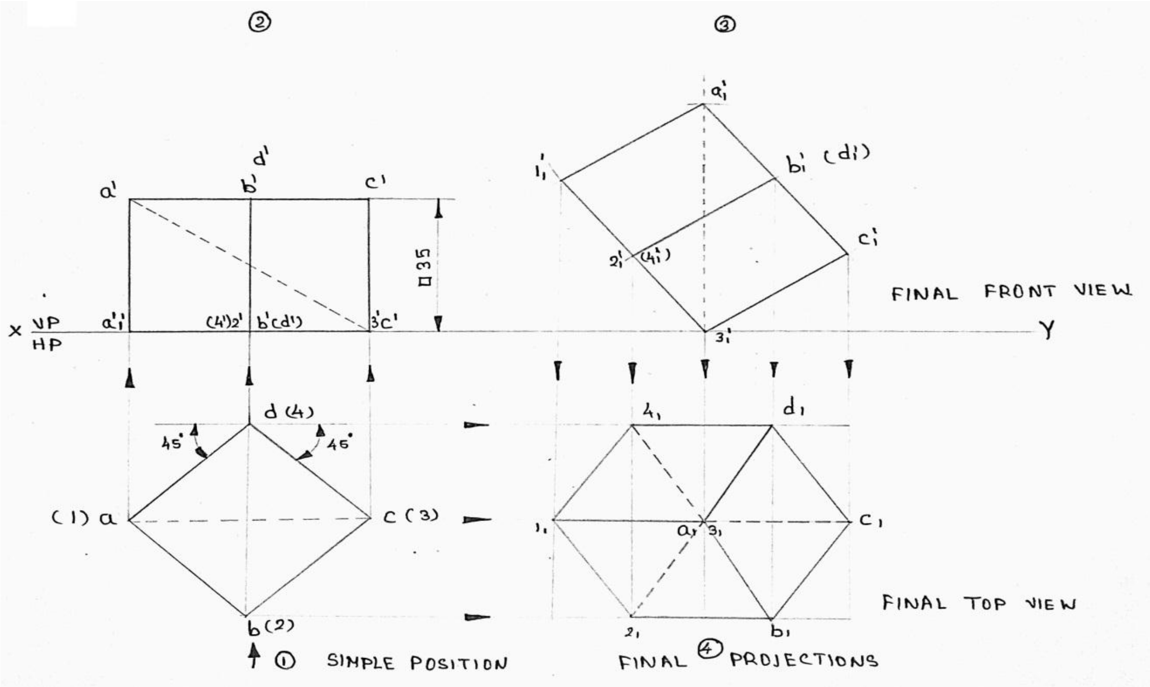
SCALE 1:1 ALL DIMENSIONS ARE IN mm

32. A cube of edge 40 mm is placed with one face parallel to VP and 20 mm away from it. One edge rests on HP and is perpendicular to VP. One face is inclined at 60° to HP. Draw its projections.



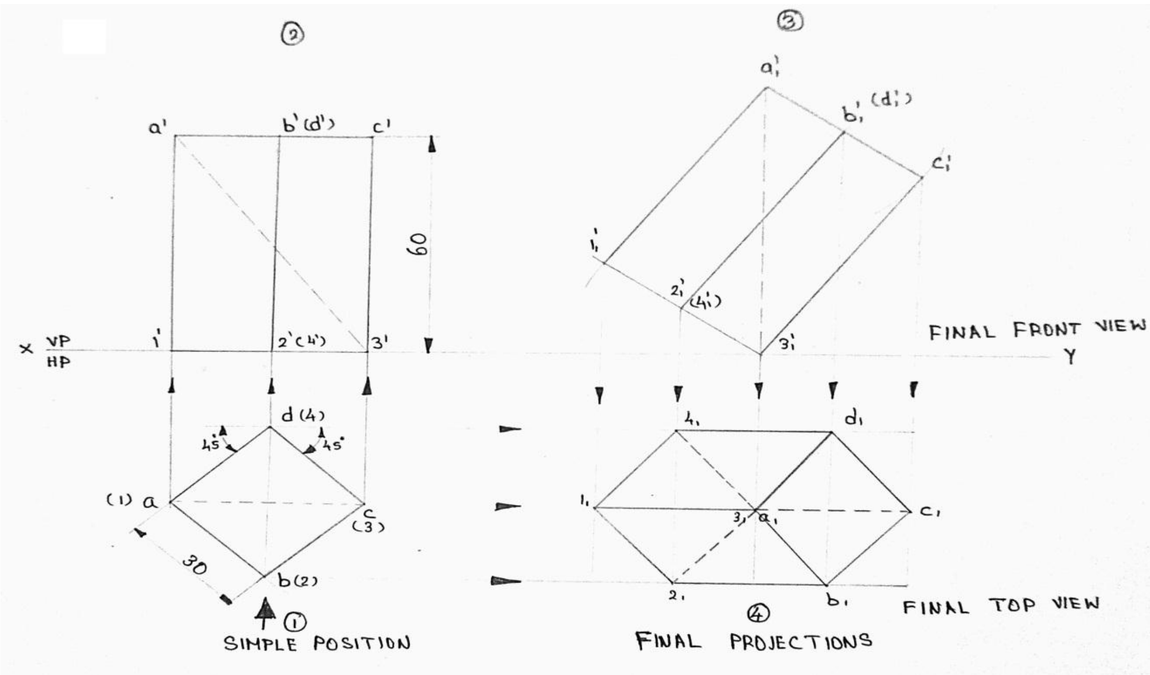
SCALE 1:1 ALL DIMENSIONS ARE IN mm

33. A cube of edge 35 mm rests on HP on one of its corners, with a solid diagonal perpendicular to HP. Draw its projections.



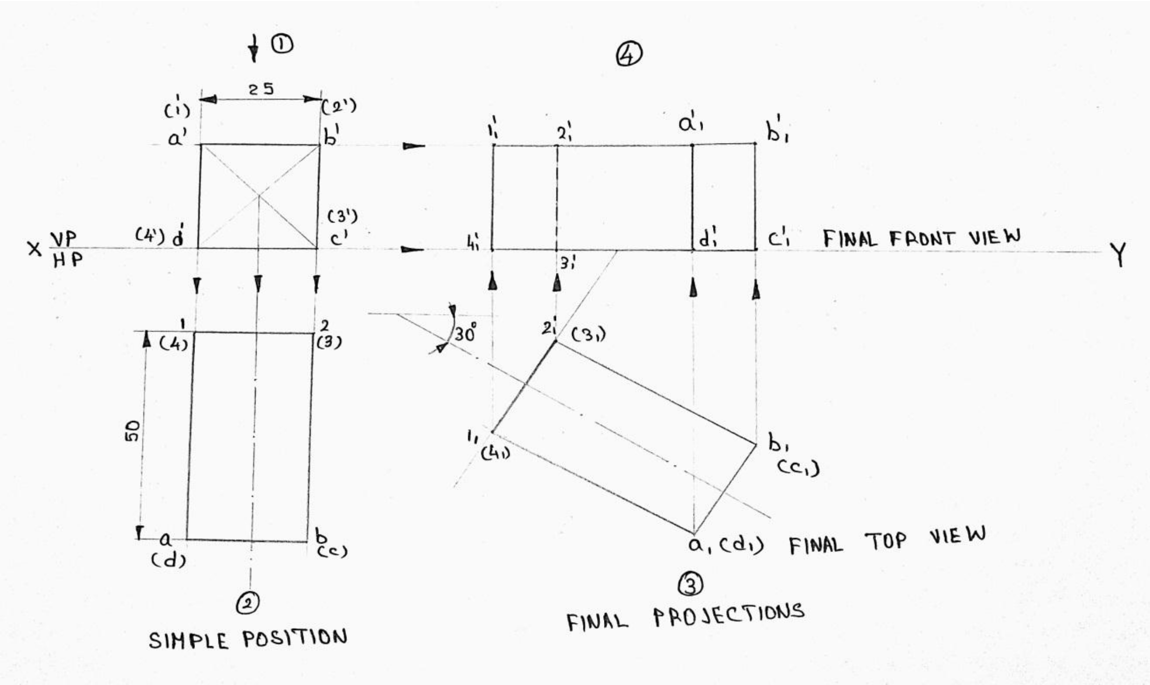
SCALE 1:1 ALL DIMENSIONS ARE IN mm

34. Draw the projections of a square prism of base side 30 mm and axis length 60 mm, with a solid diagonal vertical.



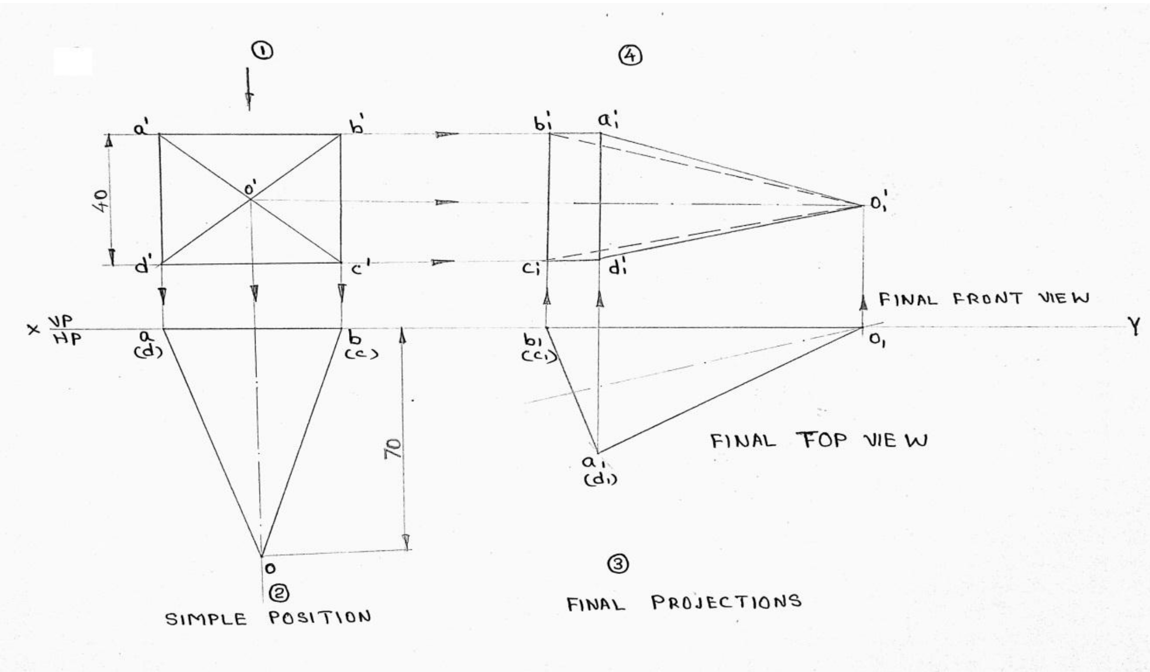
SCALE 1:1 ALL DIMENSIONS ARE IN mm

35. Draw the projections of a square prism of base side 25 mm and axis length 50 mm resting on HP on one of its rectangular faces, with its axis inclined at 30° to VP.



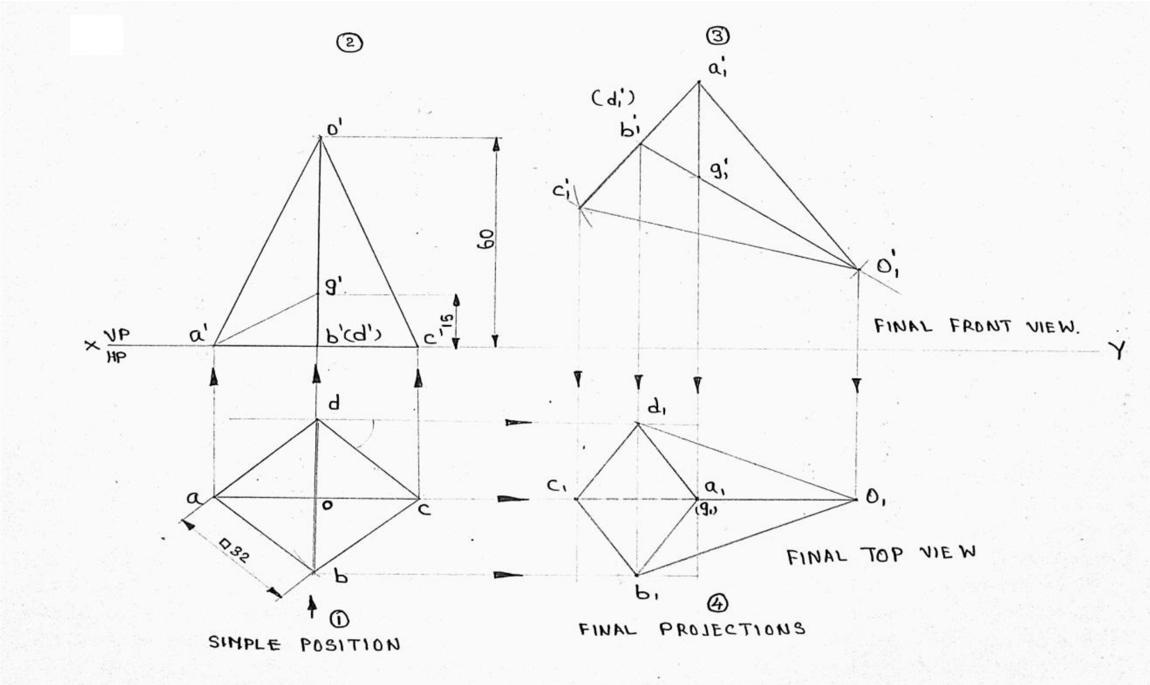
SCALE 1:1 ALL DIMENSIONS ARE IN mm

36. A square pyramid of base side 40 mm and axis length 70 mm has one of its triangular faces on VP, with the base edge contained in that face perpendicular to HP. Draw its projections.



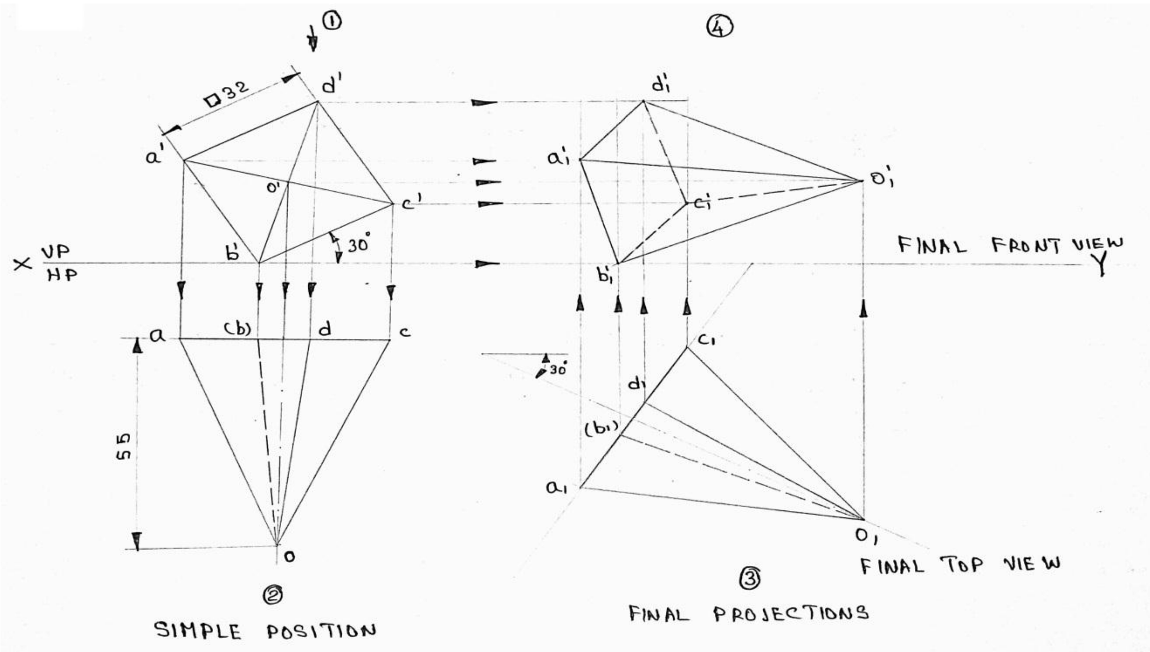
SCALE 1:1 ALL DIMENSIONS ARE IN mm

37. A square pyramid of base side 32 mm and axis length 60 mm is freely suspended from one of its base corners, with its axis parallel to VP. Draw its projections.



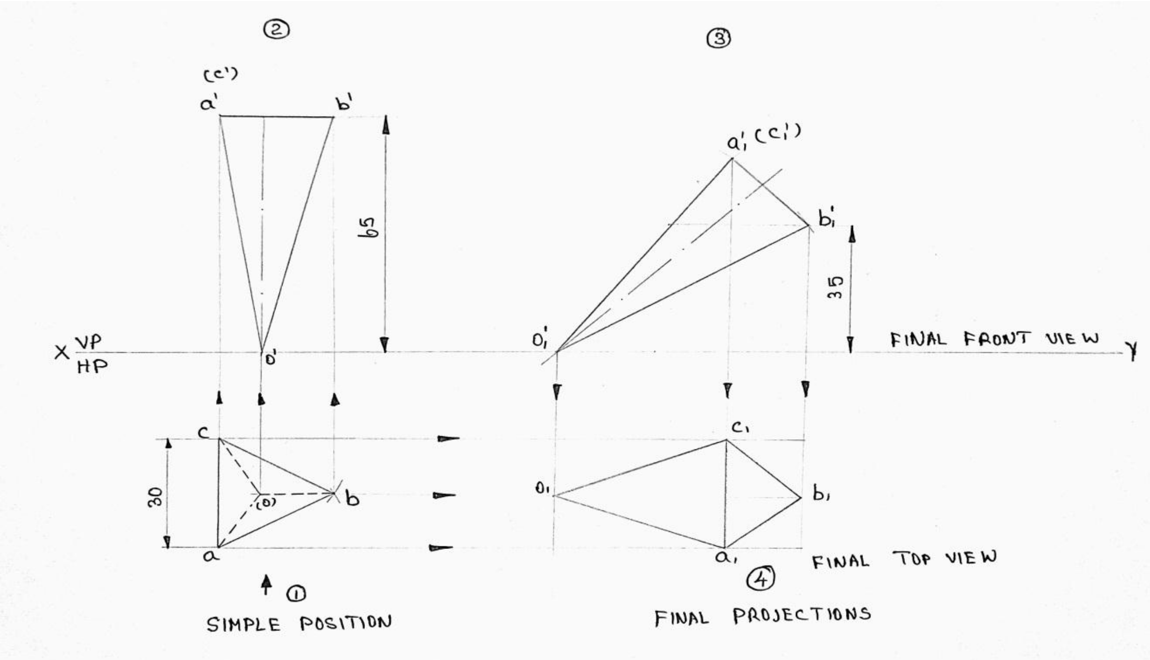
SCALE 1:1 ALL DIMENSIONS ARE IN mm

38. Draw the projections of a square pyramid of base side 32 mm and axis length 55 mm resting on HP on one of its base corners, with the base edge containing that corner making an angle of 30° with HP. The axis is inclined at 30° to VP and parallel to HP. The vertex is away from VP.



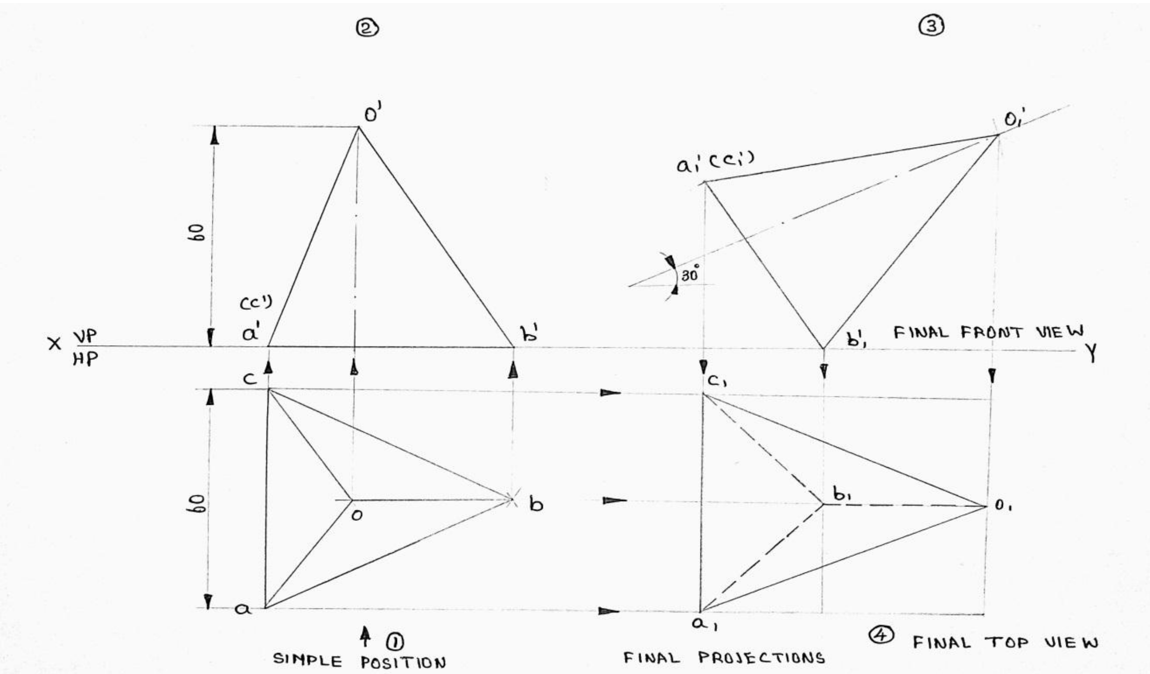
SCALE 1:1 ALL DIMENSIONS ARE IN mm

39. A triangular pyramid of base side 30 mm and axis height 65 mm rests on HP on its apex, with the nearest base corner 35 mm above HP. The axis is parallel to VP. Draw its projections.



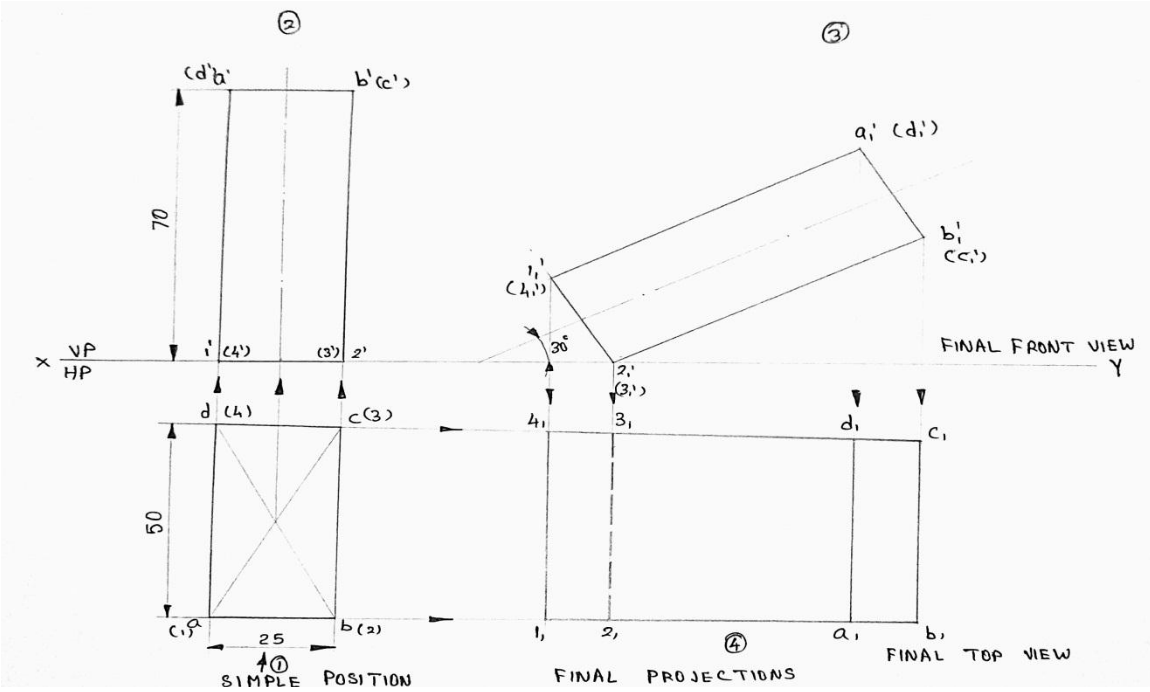
SCALE 1:1 ALL DIMENSIONS ARE IN mm

40. An equilateral triangle of side 60 mm represents the front view of a cone standing on its base. The cone is tilted until its axis makes an angle of 30° with HP, and the top view of the axis is parallel to VP. Draw its projections.



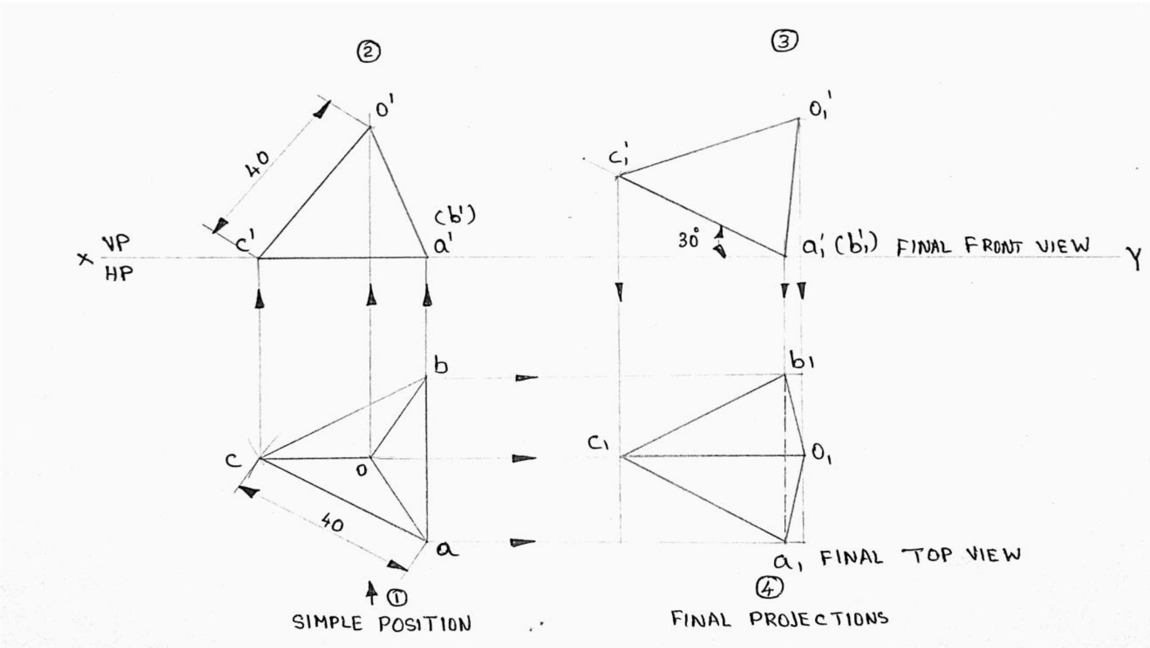
SCALE 1:1 ALL DIMENSIONS ARE IN mm

41. A rectangular prism with base 50 mm × 25 mm and axis length 70 mm rests on HP on one of its longer base edges. Its axis is inclined at 30° to HP and parallel to VP. Draw its projections.



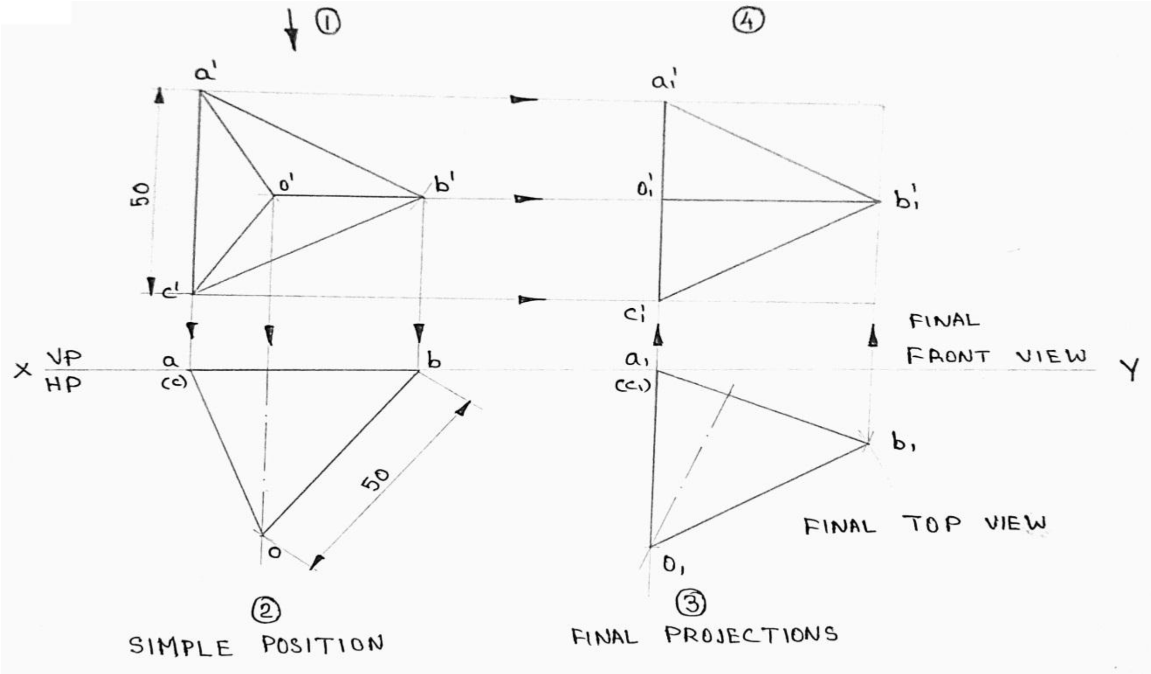
SCALE 1:1 ALL DIMENSIONS ARE IN mm

42. A tetrahedron of side 40 mm rests on HP on one of its edges, which is perpendicular to VP. The triangular face containing that edge is inclined at 30° to HP. Draw its projections.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

43. A tetrahedron of side 50 mm rests on VP on one of its edges, with the face containing that edge perpendicular to both HP and VP. Draw its projections.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

Chapter III

Projection of Sectioned Solids

In engineering graphics, orthographic projection is used to represent the shape, size, and position of an object accurately on a two-dimensional plane. However, in many cases, orthographic views contain a large number of dotted (hidden) lines, which represent edges and surfaces that are not directly visible to the observer. The presence of too many hidden details often makes the drawing confusing and difficult to interpret.

To overcome this difficulty and to clearly reveal the internal details of an object, the method of sectioning is employed. In this method, the object is imagined to be cut by an imaginary cutting plane, known as a section plane. The portion of the object lying between the observer and the cutting plane is removed, allowing the internal features to be clearly seen.

3.1 Concept of Projection of Sectioned Solids

The projection of sectioned solids involves drawing the orthographic views of a solid after it has been sectioned by an imaginary plane. The true shape of the section formed by the cutting plane is then projected onto the reference planes. The cut surface is represented by section lines (hatching) drawn at uniform spacing and inclination, in accordance with standard engineering drawing conventions.

Sectioning eliminates the need for hidden lines in the sectioned view and provides a clear and simplified representation of the object's interior. This method is widely used for solids such as prisms, pyramids, cylinders, cones, and truncated solids, where internal geometry must be clearly understood.

3.2 Purpose of Studying Sectioned Solids

The study of projection of sectioned solids helps to:

- Understand the internal construction of solids
- Reduce confusion caused by excessive hidden lines
- Accurately represent true shapes of sections
- Develop skills required for machine drawing and production drawings

3.3 Section Plane

The imaginary plane which is used to cut a solid is called the section plane or cutting plane.

3.4 Section

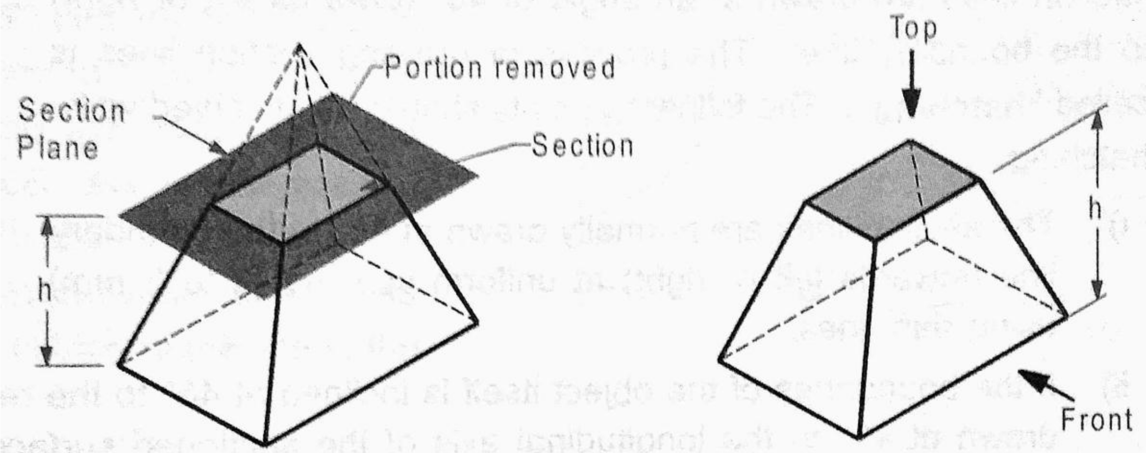
The surface of the object exposed when a solid is cut by a section plane is called the section.

3.5 Sectional View

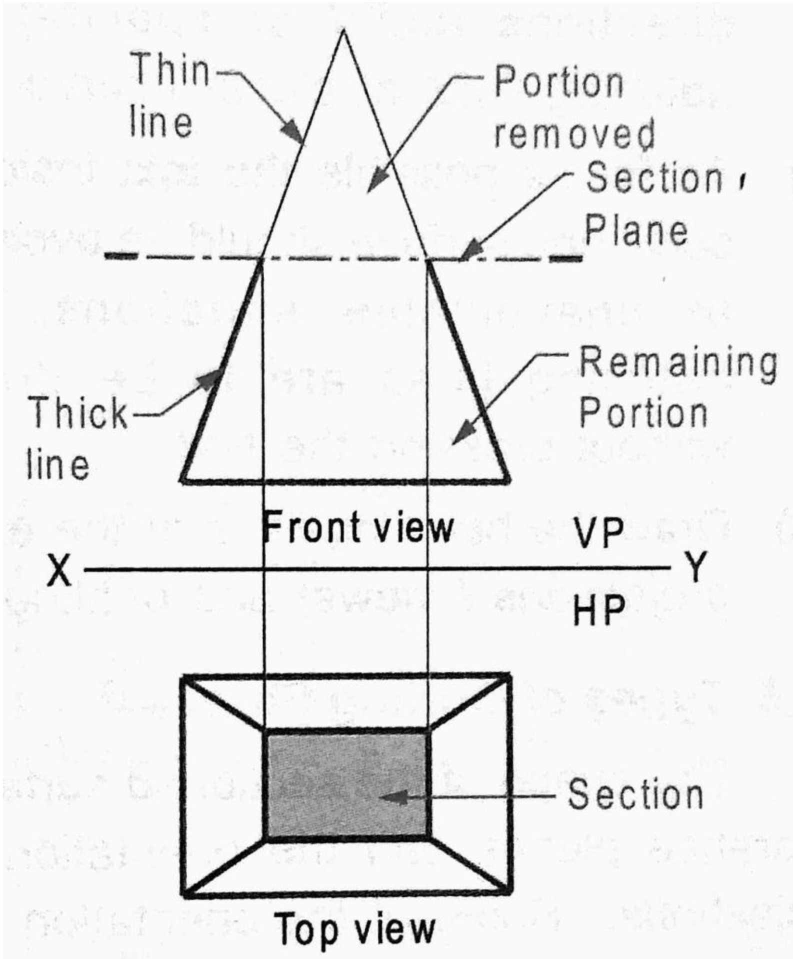
After cutting a solid by an imaginary section plane and removing the portion of the solid lying between the observer and the cutting plane, the projections of the remaining portion are drawn.

These projections, showing both the cut surface and the visible remaining portion of the solid on the reference planes, are known as sectional views.

The pictorial view of a rectangular pyramid cut by a section plane and its corresponding projections of the remaining portion together with the section are called sectional views.

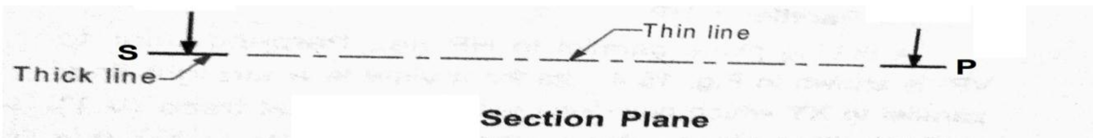


(i) Pyramid while cutting by section plane (ii) Pyramid after cutting by section plane



3.6 Representation of the Cutting Plane

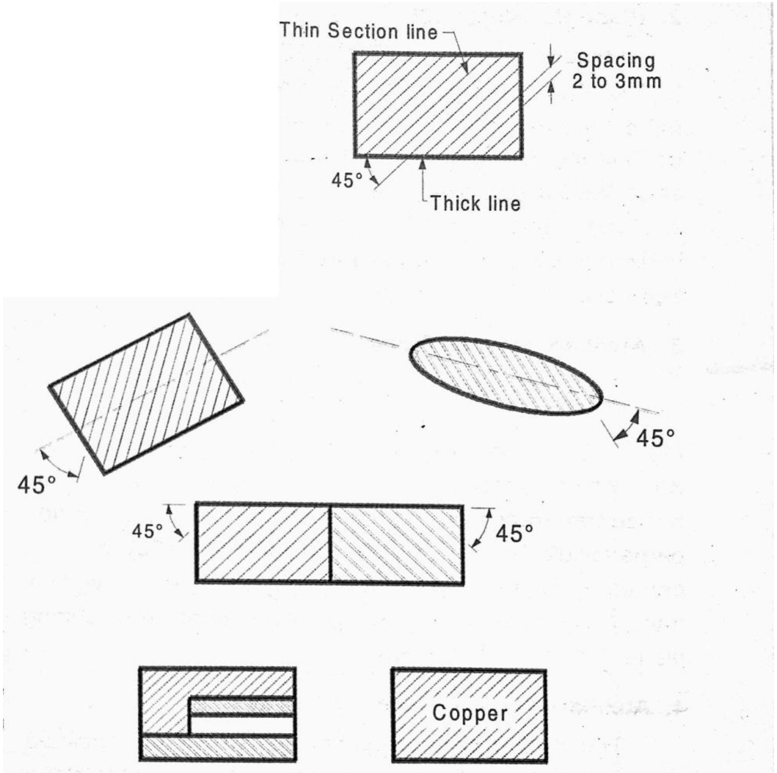
- A cutting plane is represented by its trace drawn using thin chain lines, thickened at both ends.
- The direction of viewing is shown by arrows.
- The arrows are designated by uppercase letters (e.g., S–P).



3.7 Representation of the Section (Hatching)

- The section is indicated by a closed boundary drawn with a thick continuous line.
- The cut surface is filled with section lines (hatching) drawn using thin continuous lines.
- Section lines are usually drawn at an angle of 45° to the boundary.

- ❖ Spacing of section lines is 2–3 mm, depending on the size of the drawing.
- ❖ The process of drawing section lines is called hatching.

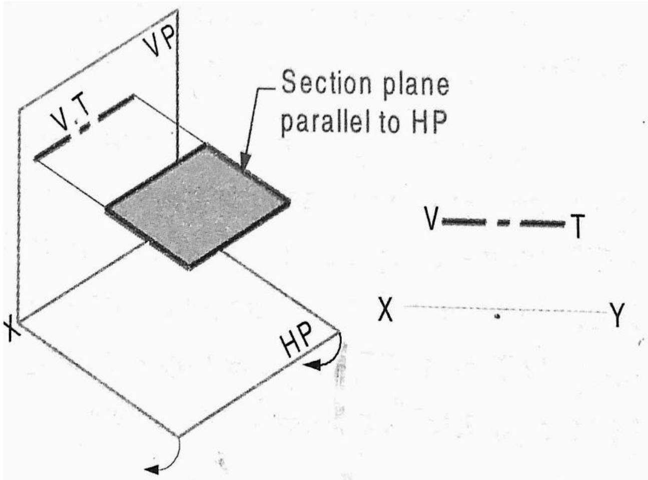


Rules for Hatching

- ❖ Section lines are drawn at 45°, uniformly spaced (2–3 mm) using thin lines.
- ❖ If the boundary itself is inclined at 45°, hatching lines are drawn at 45° to the longitudinal axis of the sectioned surface.
- ❖ Adjacent components in a sectional view must be hatched in opposite directions.
- ❖ Different materials or components are differentiated by varying hatching directions or spacing.
- ❖ Text inside a sectioned area should be avoided; if unavoidable, hatching lines must not cross the text.
- ❖ Hatching is done after completing the entire drawing.

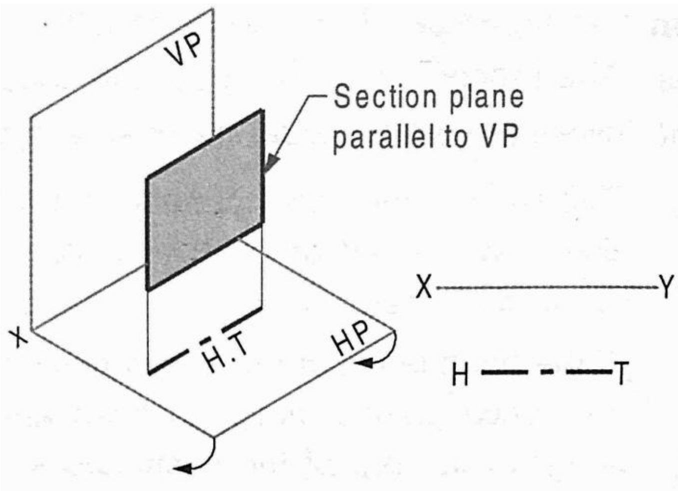
3.8 Types of Cutting Planes

Plane Parallel to HP



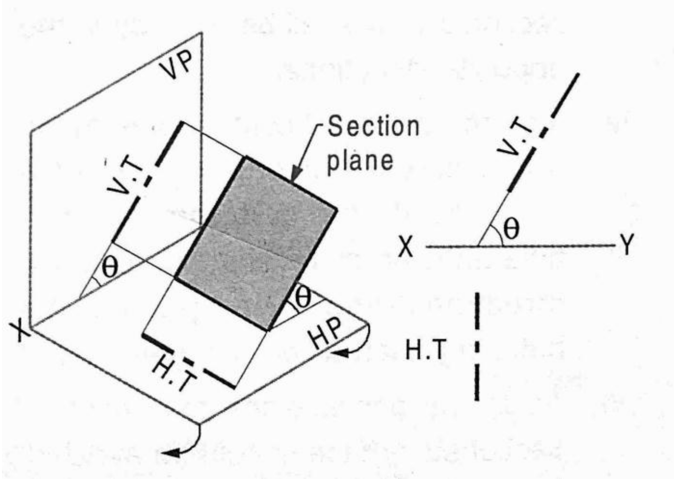
- ❖ Front view appears as a straight line parallel to XY.
- ❖ This line coincides with the Vertical Trace (V.T).
- ❖ No Horizontal Trace (H.T) exists.
- ❖ The V.T in front view is used as the cutting plane line.

Plane Parallel to VP



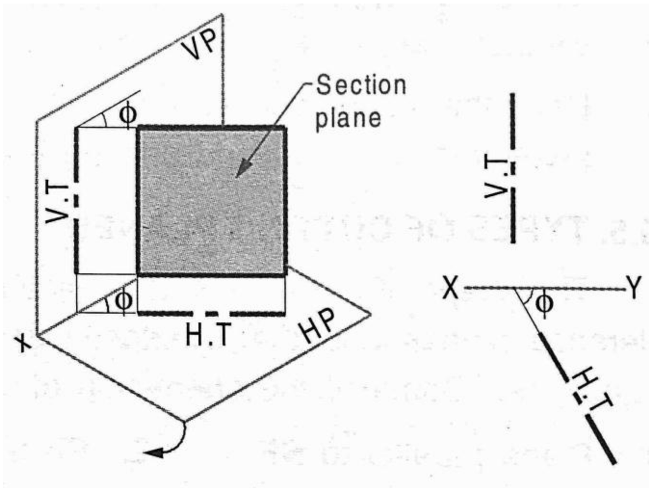
- ❖ Top view appears as a straight line parallel to XY.
- ❖ This line coincides with the Horizontal Trace (H.T).
- ❖ No Vertical Trace (V.T) exists.
- ❖ The H.T in top view is used as the cutting plane line.

Auxiliary Inclined Plane



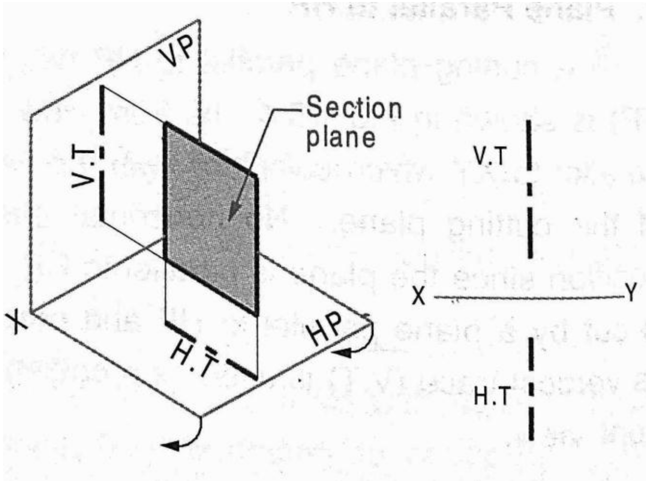
- Front view is a straight line inclined at angle θ to XY, coinciding with the V.T.
- Horizontal Trace is perpendicular to XY.
- Used when the plane is perpendicular to VP and inclined to HP.

Auxiliary Vertical Plane



- Top view is a straight line inclined at angle ϕ to XY, coinciding with the H.T.
- Vertical Trace is perpendicular to XY.
- Used when the plane is perpendicular to HP and inclined to VP.

Profile Plane



- ❖ Both top view and front view appear as straight lines.
- ❖ These coincide with H.T and V.T respectively.
- ❖ Both traces are used as cutting plane lines.

3.9 Procedure for Drawing Sectional Views

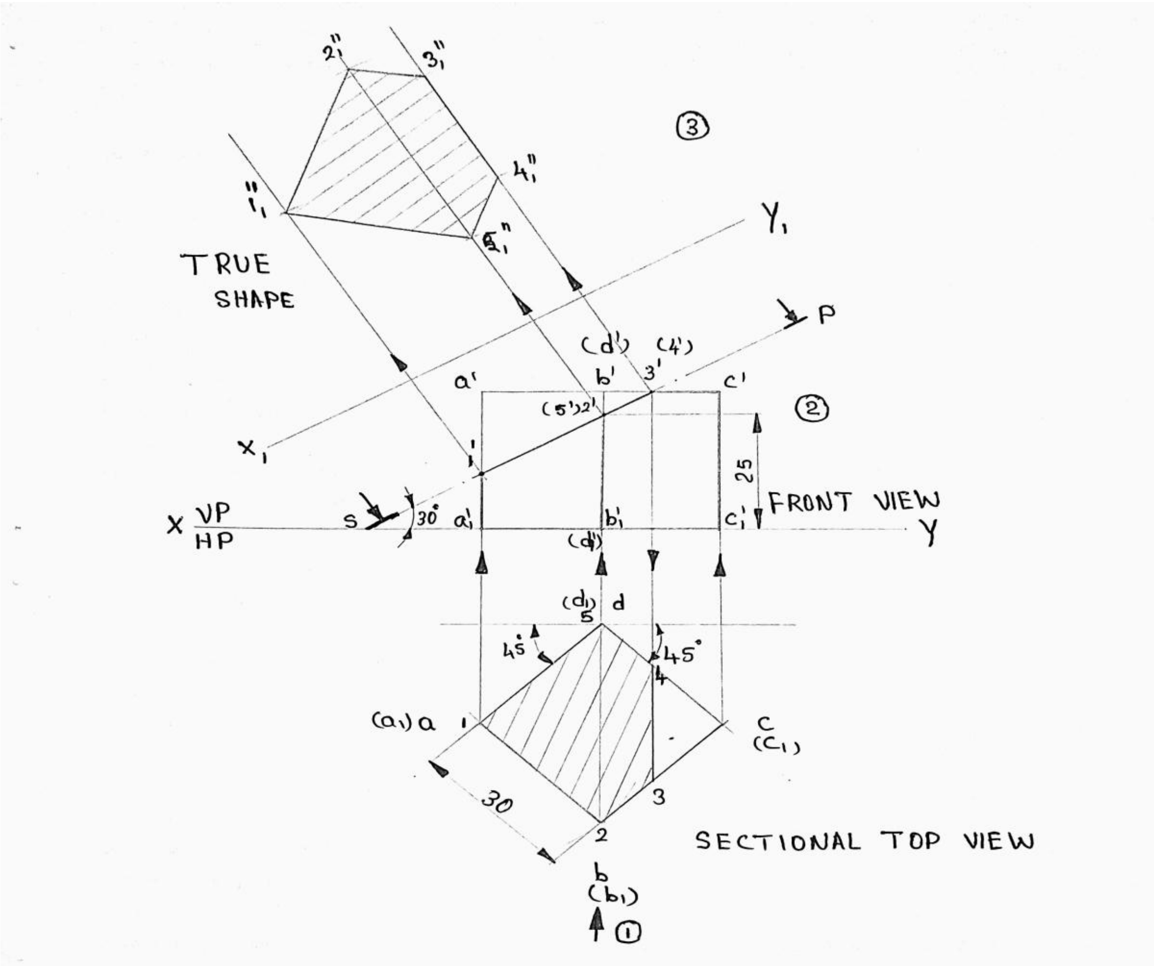
- ❖ Draw the projections of the full solid in the given position using thin lines.
- ❖ Mark the given section plane (trace) in the appropriate view.
- ❖ Project points of intersection of the section plane with the solid boundaries to the other view.
- ❖ Assume the portion between the observer and cutting plane is removed.
- ❖ Draw the boundary of the sectioned surface and remaining visible edges using thick lines.
- ❖ Complete the other view using correct line conventions.
- ❖ Add dimensions and details.
- ❖ Hatch the sectioned surface.

3.10 True Shape and Apparent Shape of Section

- ❖ When a sectioned surface is projected onto a plane parallel to the cutting plane, the shape obtained is the true shape of section.
- ❖ When the cutting plane is inclined to the plane of projection, the shape obtained is not exact and is called the apparent shape of section.

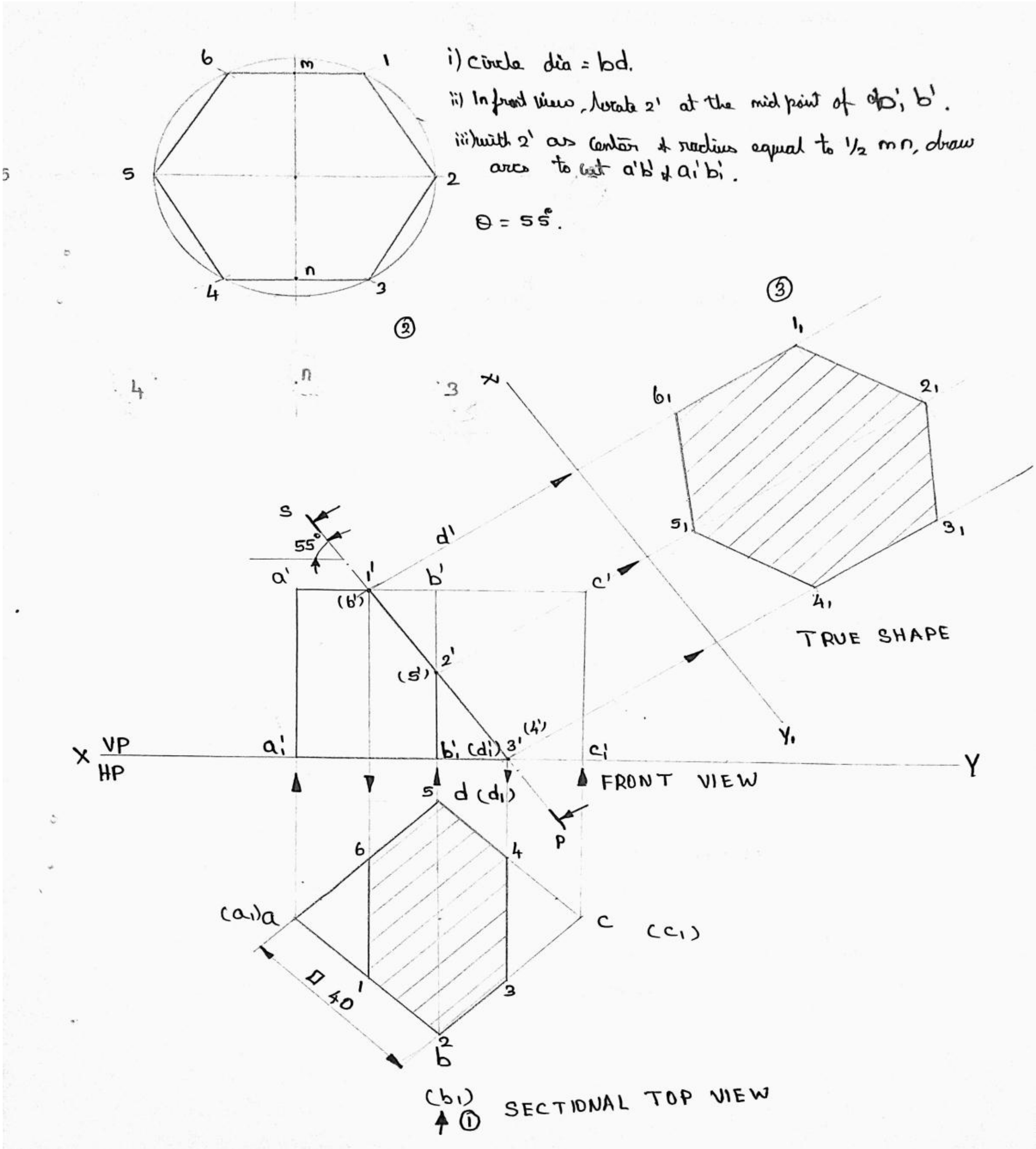
Sectioning of simple solids in simple vertical position, when the cutting plane is inclined to one of the principal planes and perpendicular to the other, and obtaining the true shape of the section using first-angle projection.

1. A cube of side 30 mm rests on the HP on one of its ends with the vertical faces equally inclined to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, meeting the axis at 25 mm above the base. Draw its front view, sectional top view, and the true shape of the section.



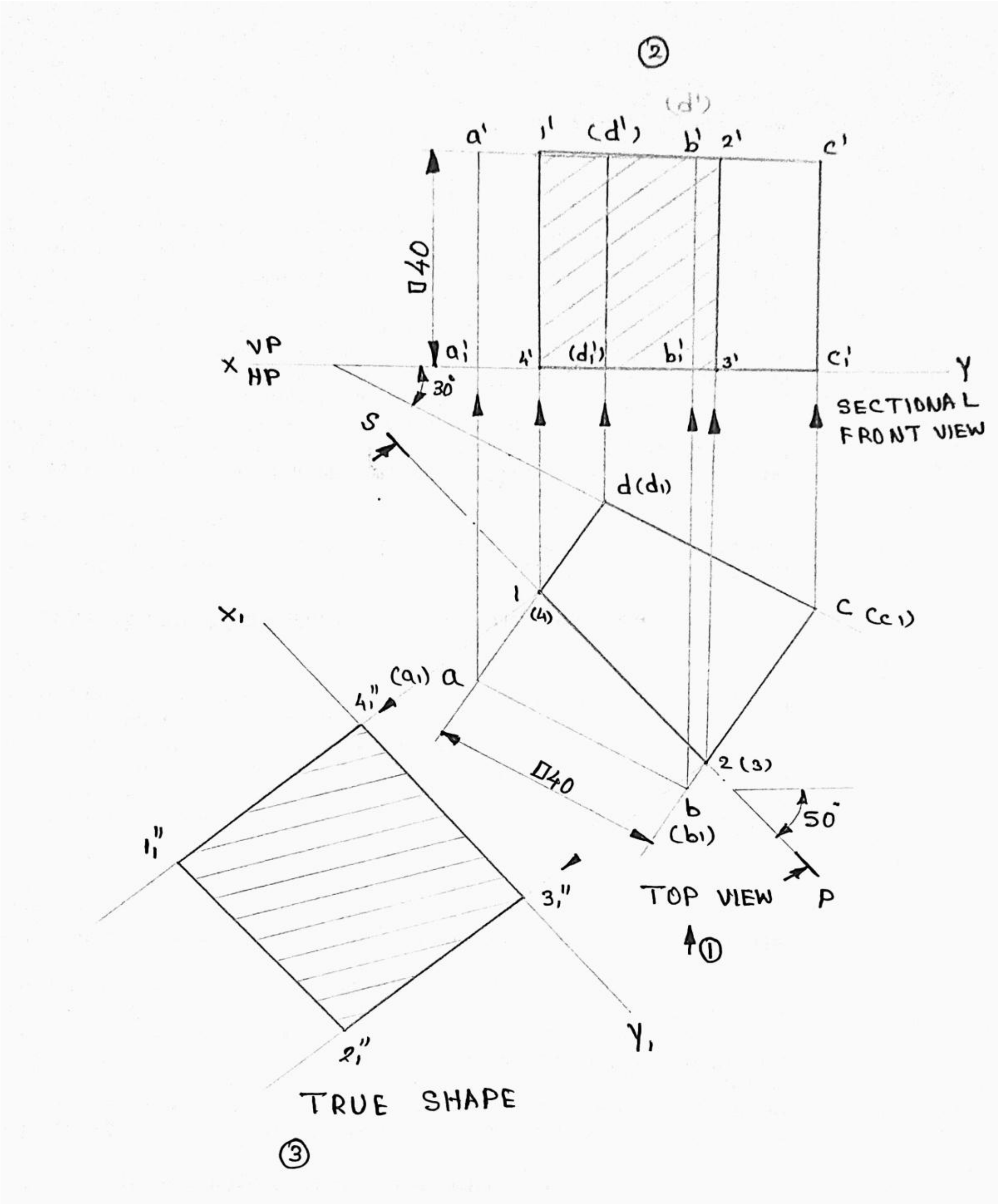
SCALE 1:1 ALL DIMENSIONS ARE IN mm

2. A cube of side 40 mm is cut by a plane such that the true shape of the section is a regular hexagon. Draw the front view and top view of the cube and determine the inclination of the cutting plane with the HP.



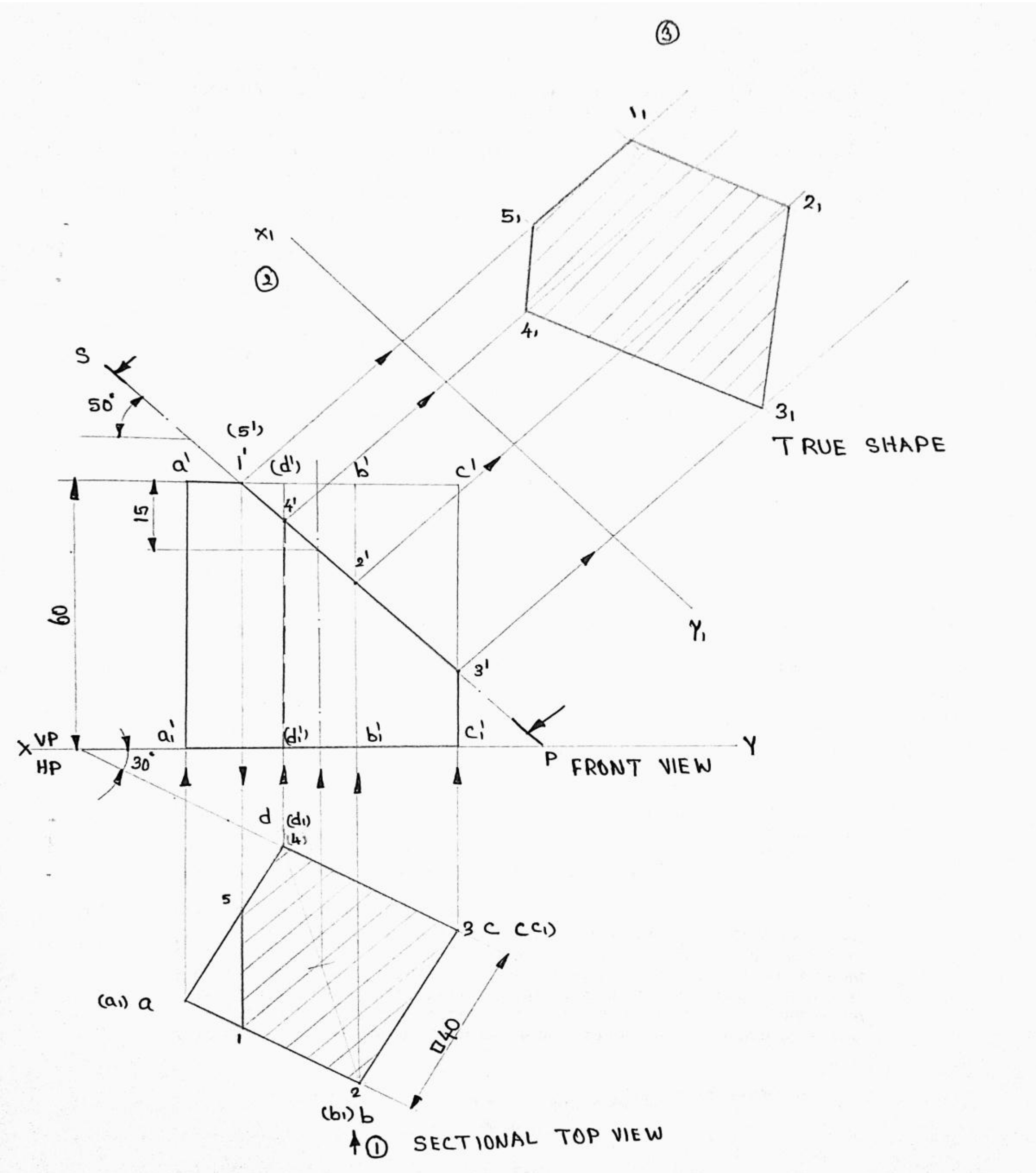
SCALE 1:1 ALL DIMENSIONS ARE IN mm

3. A cube of side 40 mm rests on its base on the HP with one edge inclined at 30° to the VP. It is cut by a section plane perpendicular to the HP and inclined at 50° to the VP, passing through the midpoint of the left edge of the top face, which is inclined at 60° to the VP.



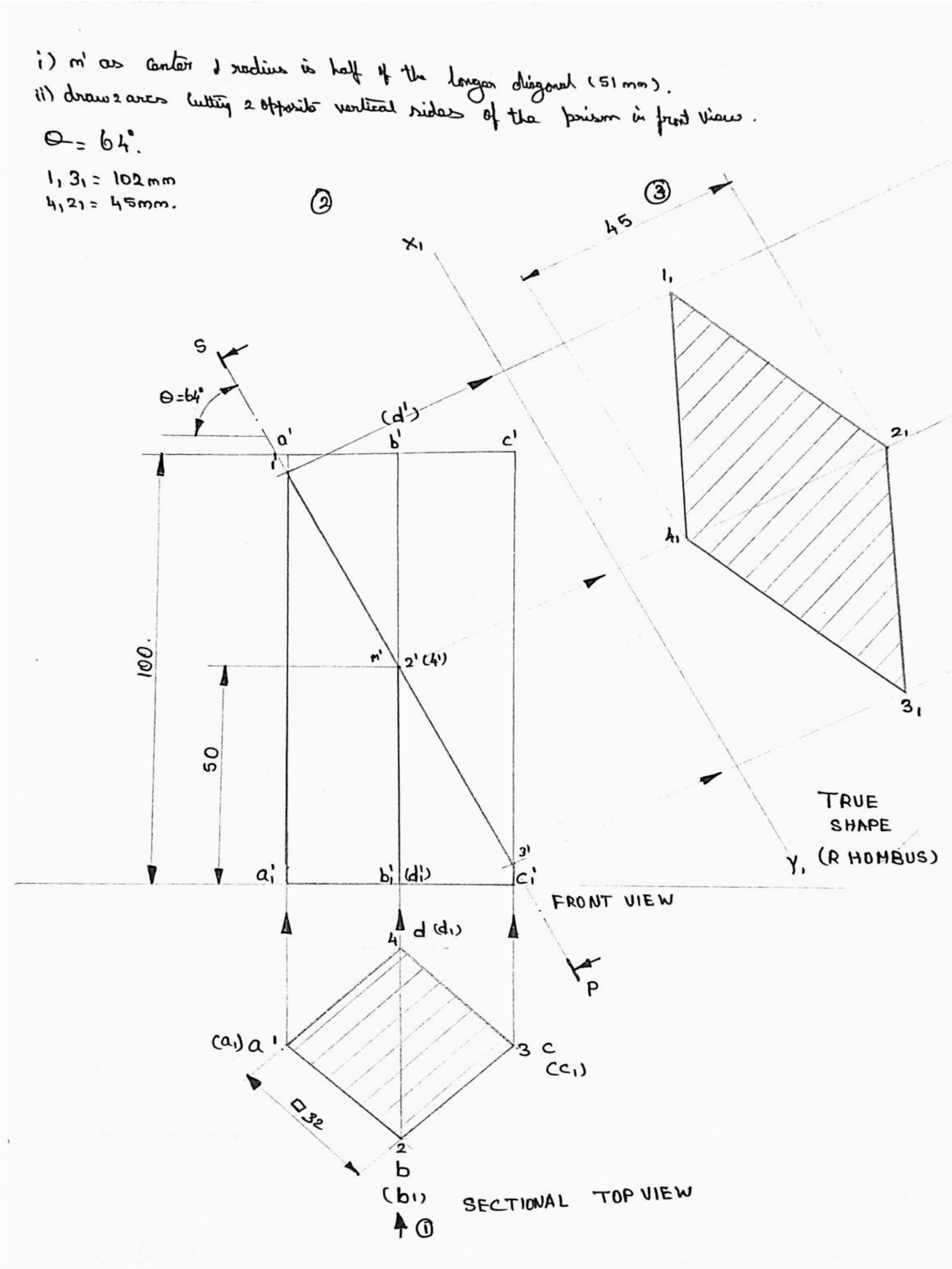
SCALE 1:1 ALL DIMENSIONS ARE IN mm

4. A square prism with a base of 40 mm side and an axis length of 60 mm rests on its base on the HP such that one of its vertical faces is inclined at 30° to the VP. A section plane perpendicular to the VP and inclined at 45° to the HP, passing through the axis at a point 15 mm from the top, cuts the prism. Draw its front view, sectional top view, and the true shape of the section.



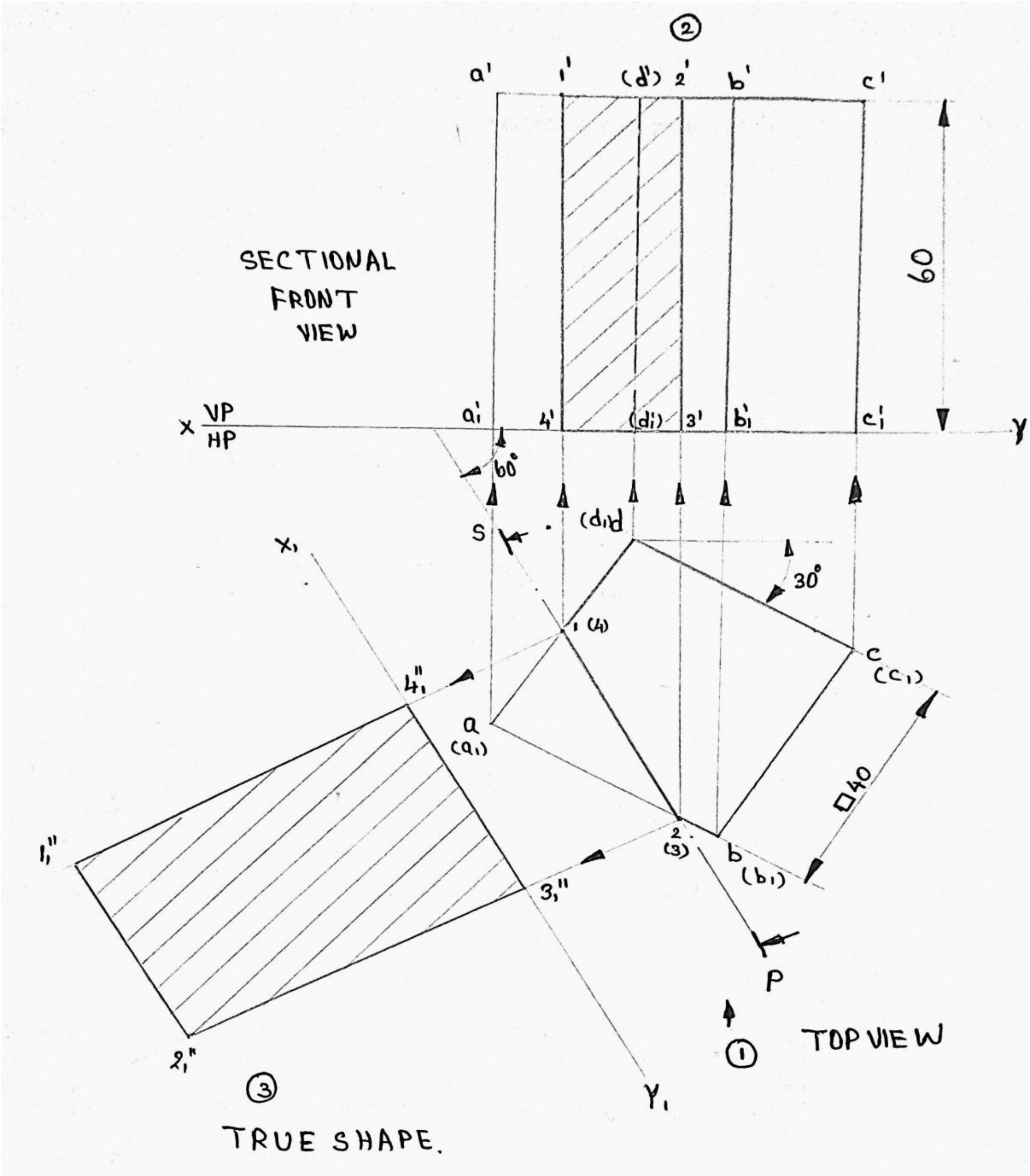
SCALE 1:1 ALL DIMENSIONS ARE IN mm

5. A square prism of base side 32 mm and height 100 mm rests on its base on the HP with the base edges equally inclined to the VP. It is cut by a section plane passing through the midpoint of the axis such that the true shape of the section is a rhombus with diagonals 102 mm and 45 mm. Determine the inclination of the section plane with the HP.



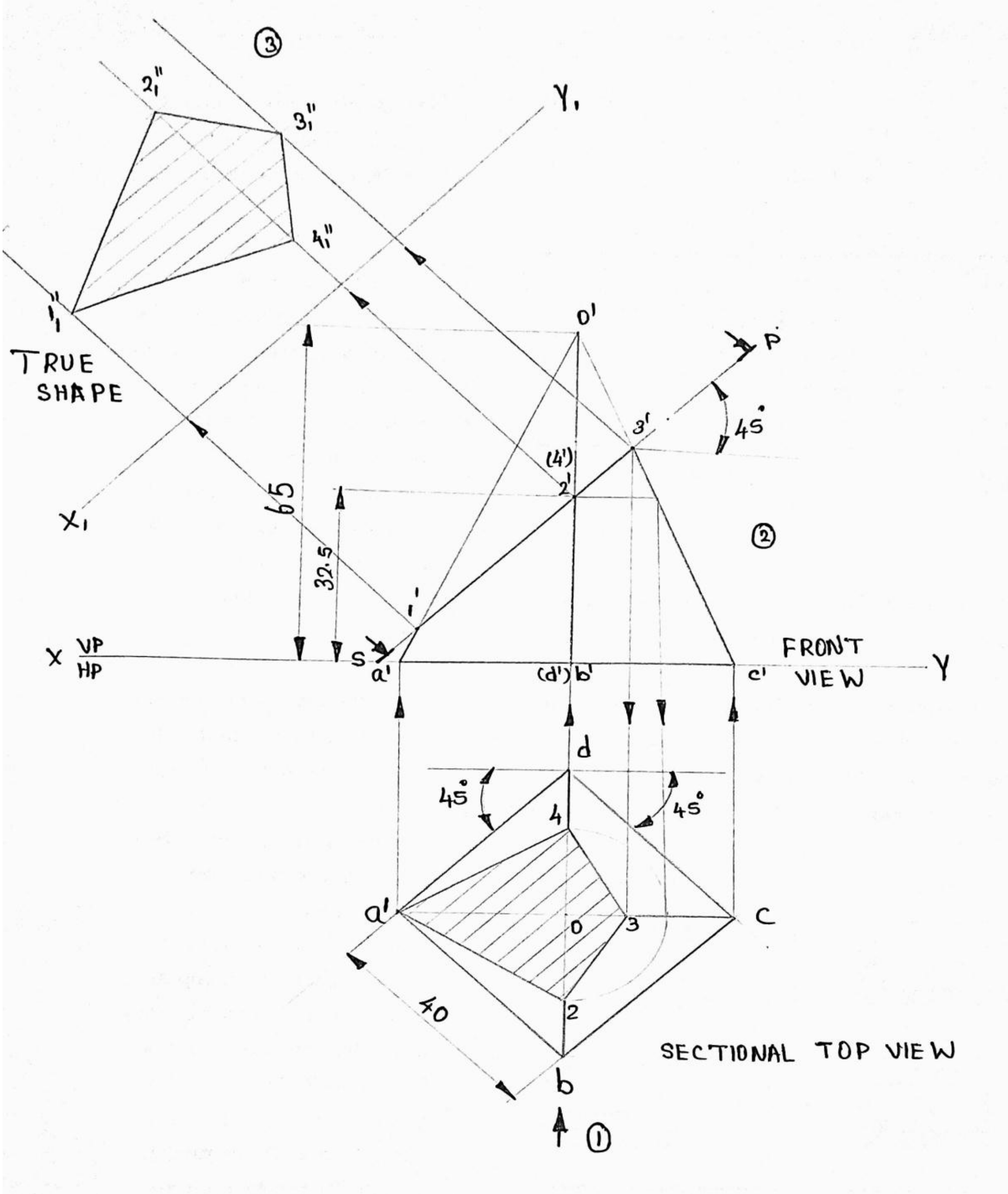
SCALE 1:1 ALL DIMENSIONS ARE IN mm

6. A square prism of base side 40 mm and axis length 60 mm rests on its base on the HP such that one of its rectangular faces is inclined at 30° to the VP. A section plane perpendicular to the HP and inclined at 60° to the VP cuts the prism so that the rectangular face making 60° with the VP is cut into two equal halves. Draw the top view, sectional front view, and the true shape of the section.



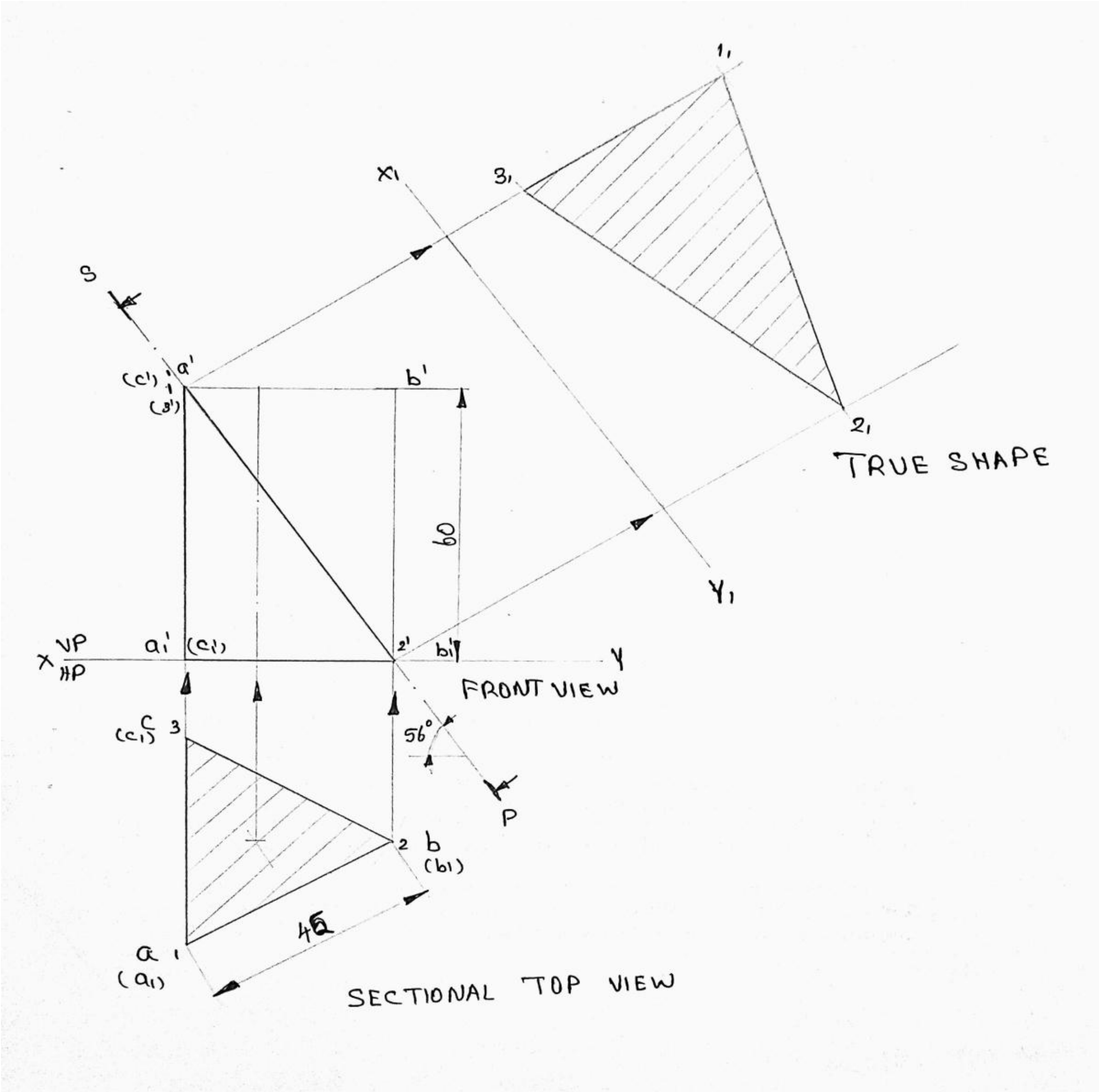
SCALE 1:1 ALL DIMENSIONS ARE IN mm

7. A square pyramid with base side 40 mm and axis length 65 mm rests on its base on the HP with all base edges equally inclined to the VP. It is cut by a section plane perpendicular to the VP and inclined at 45° to the HP, bisecting the axis. Draw the sectional top view and the true shape of the section.



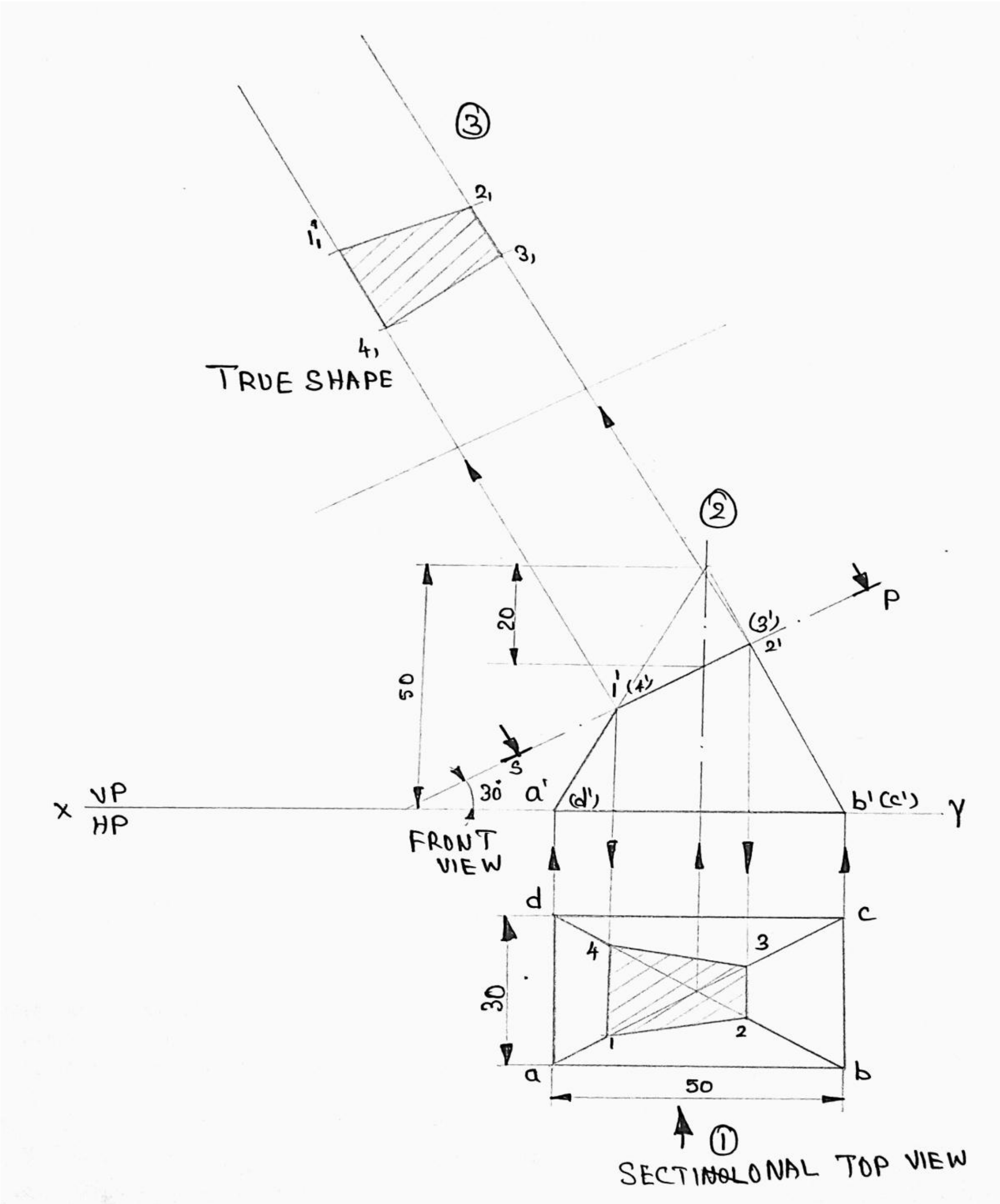
SCALE 1:1 ALL DIMENSIONS ARE IN mm

8. A triangular prism with a base side of 45 mm and height 60 mm rests on its base on the HP with one rectangular face perpendicular to the VP. It is cut by an auxiliary inclined plane such that the true shape of the section is an isosceles triangle of maximum size.



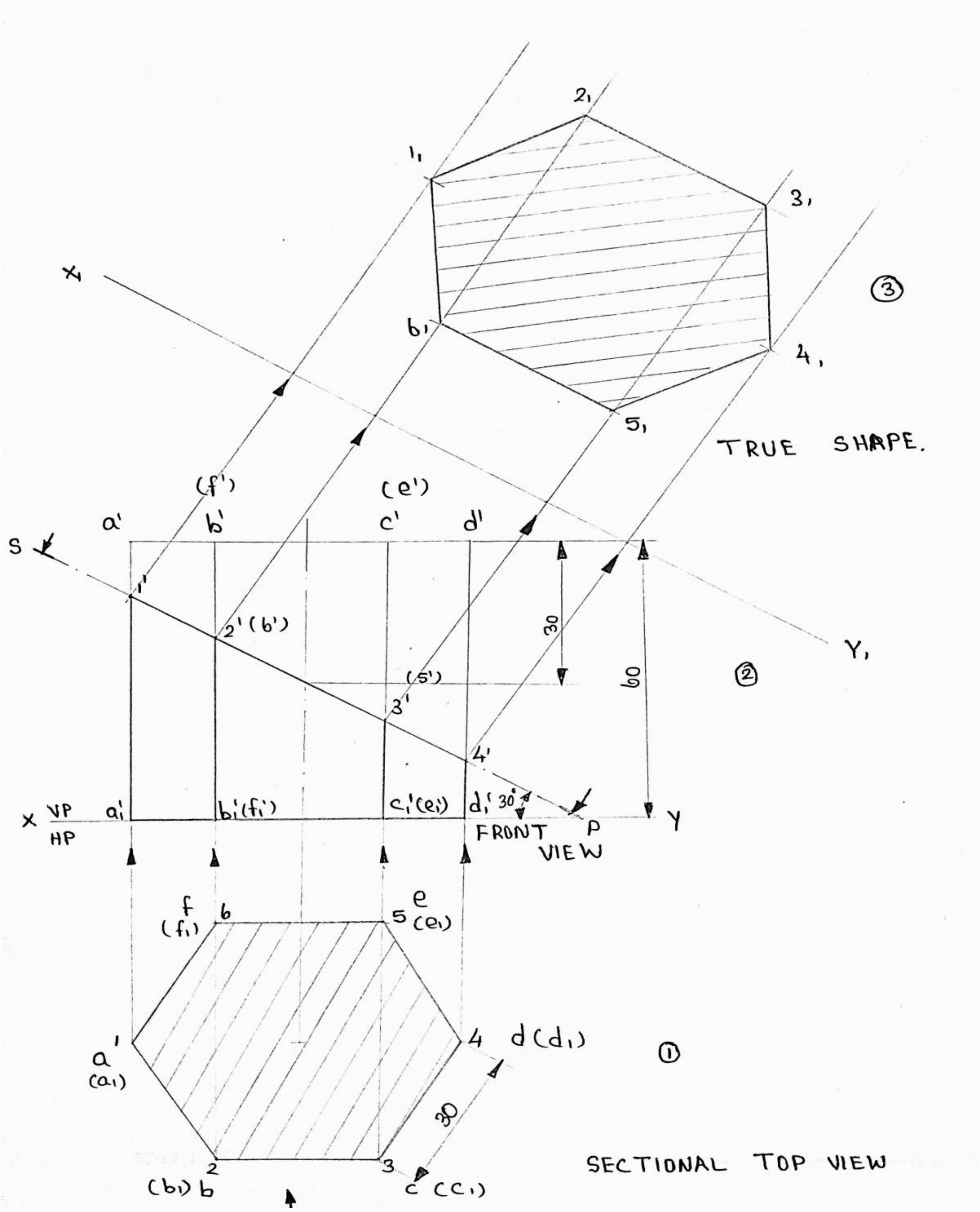
SCALE 1:1 ALL DIMENSIONS ARE IN mm

9. A rectangular pyramid with a base of 30 mm × 50 mm and axis length 50 mm rests on its base on the HP with the longer base edge parallel to the VP. It is cut by a section plane perpendicular to the VP and inclined at 30° to the HP, passing through a point on the axis 20 mm from the apex. Draw the front view, sectional top view, and the true shape of the section.



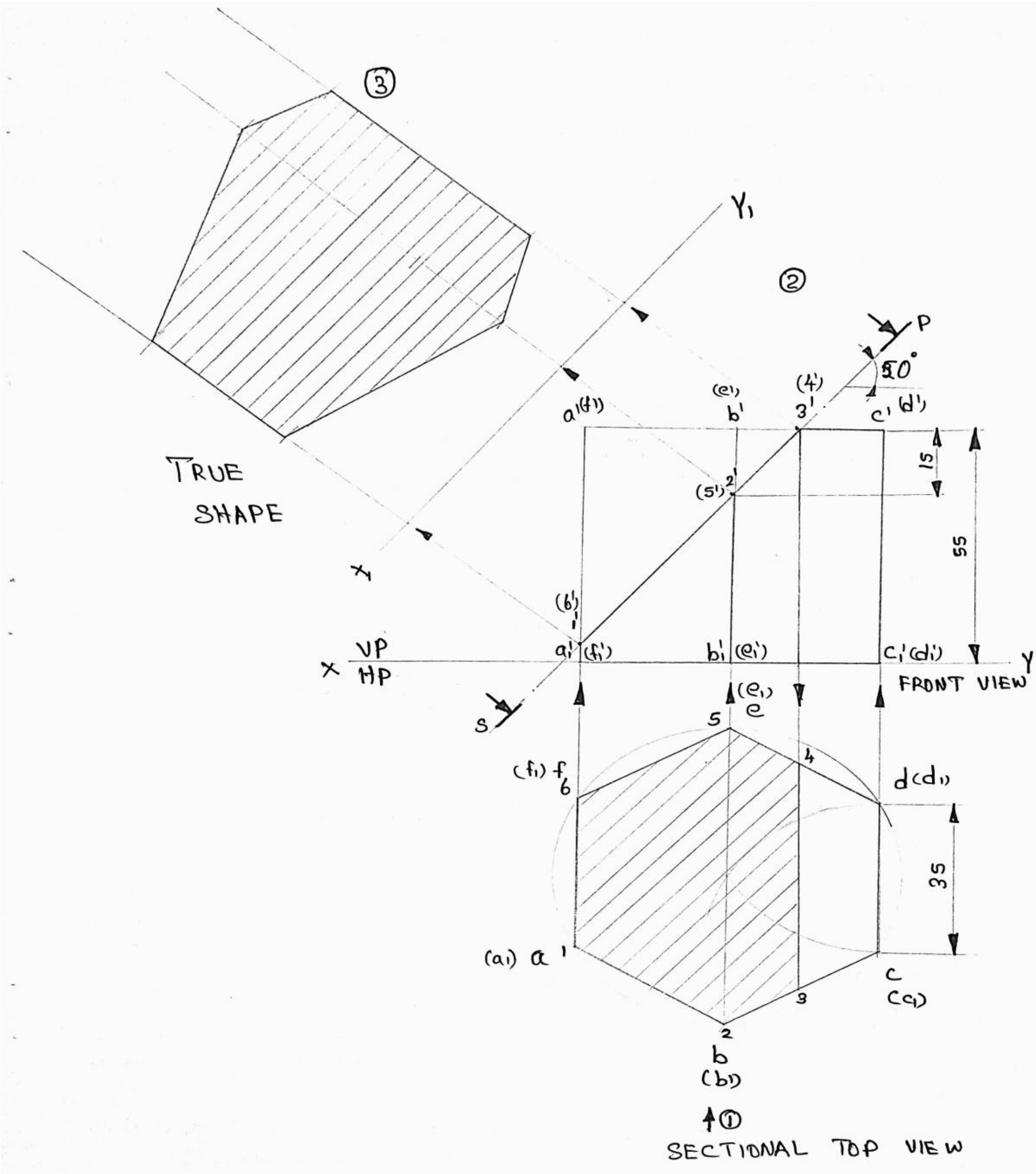
SCALE 1:1 ALL DIMENSIONS ARE IN mm

10. A hexagonal prism with base side 30 mm and axis length 60 mm rests on one of its ends on the HP with two base edges parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, meeting the axis at 30 mm from the top. Draw the front view, sectional top view, and the true shape of the section.



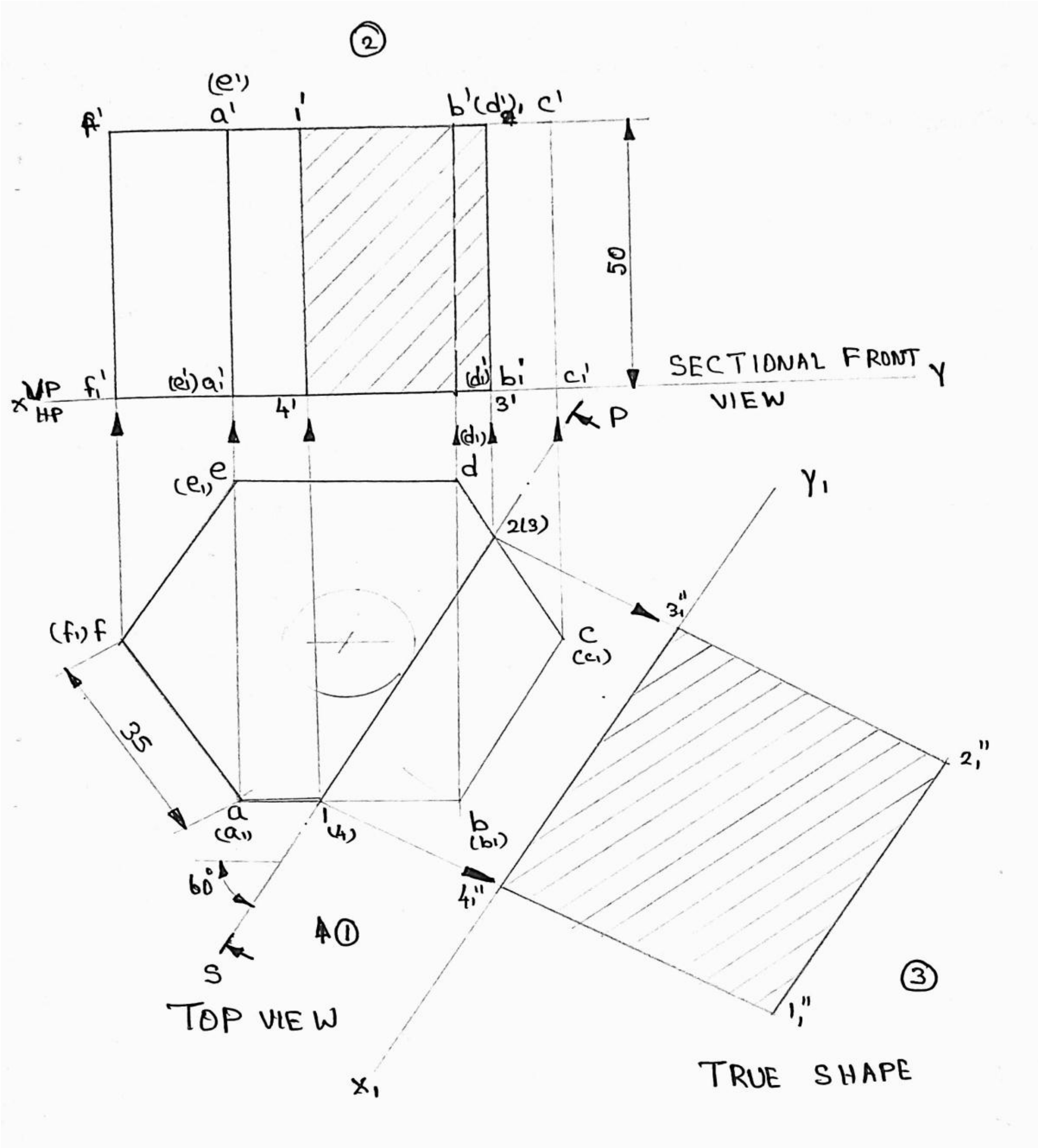
SCALE 1:1 ALL DIMENSIONS ARE IN mm

11. A hexagonal prism with base side 35 mm and axis length 55 mm rests on its base on the HP such that two vertical faces are perpendicular to the VP. It is cut by a plane perpendicular to the VP and inclined at 50° to the HP, passing through a point on the axis 15 mm from the top. Draw the front view, sectional top view, and the true shape of the section.



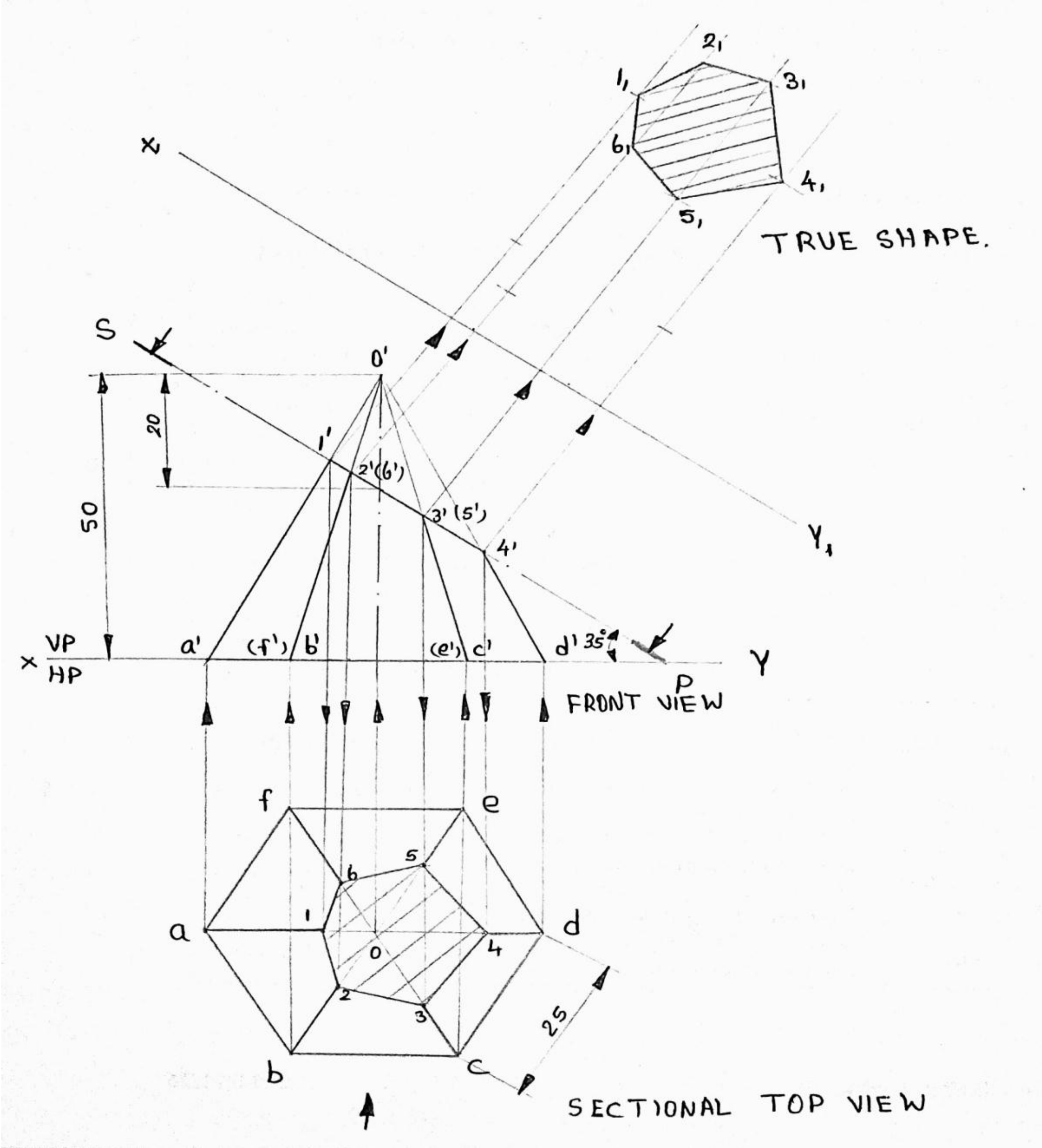
SCALE 1:1 ALL DIMENSIONS ARE IN mm

12. A hexagonal prism of base side 25 mm and height 50 mm rests on the HP on one of its ends with two rectangular faces parallel to the VP. It is cut by a plane perpendicular to the HP and inclined at 60° to the VP, at a distance of 10 mm from the axis. Draw the top view, sectional front view, and the true shape of the section.



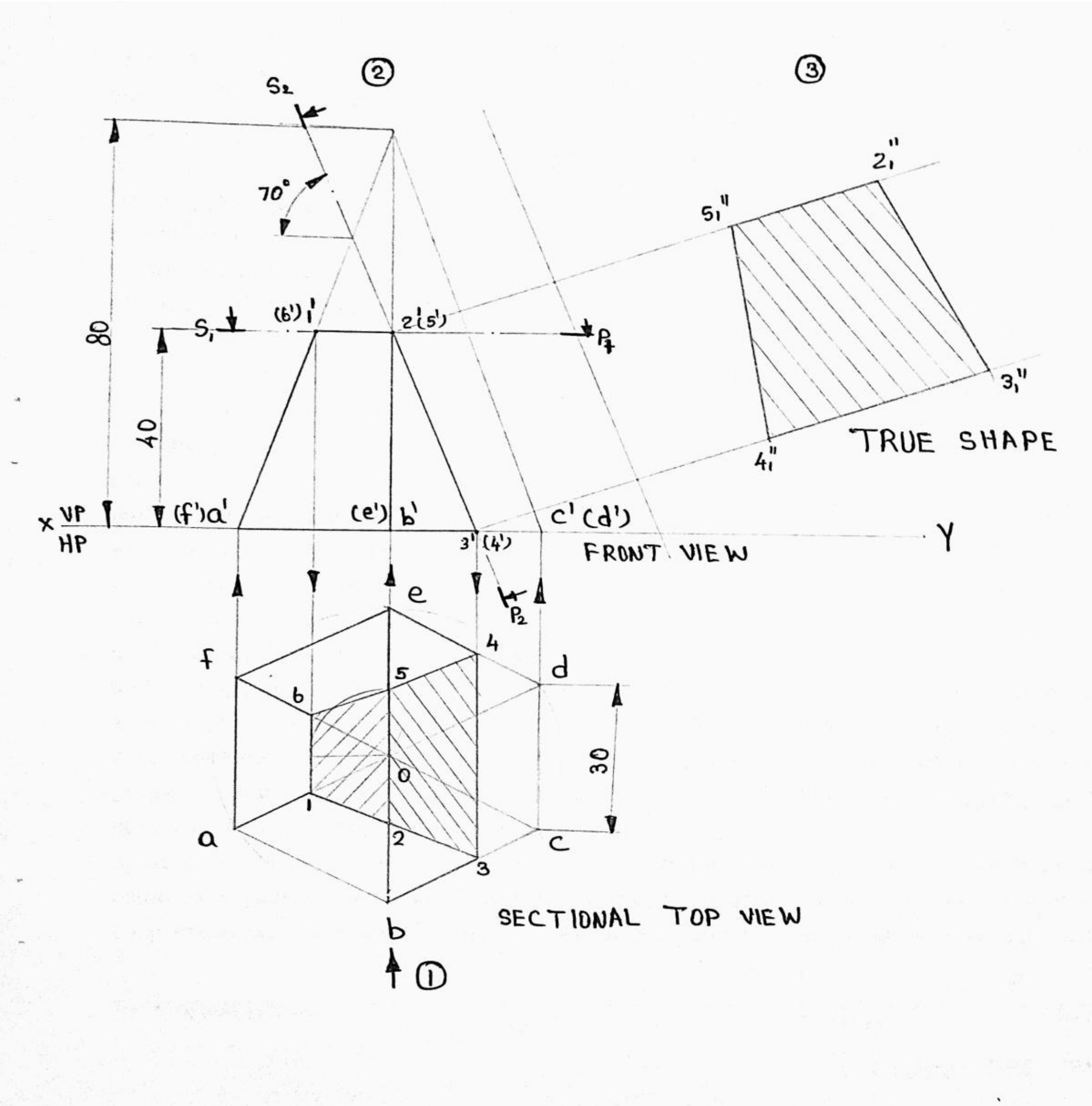
SCALE 1:1 ALL DIMENSIONS ARE IN mm

13. A hexagonal pyramid with base side 25 mm and axis length 50 mm rests on its base on the HP with one base edge parallel to the VP. It is cut by a section plane perpendicular to the VP and inclined at 30° to the HP, passing through a point on the axis 20 mm below the apex. Draw its projections.



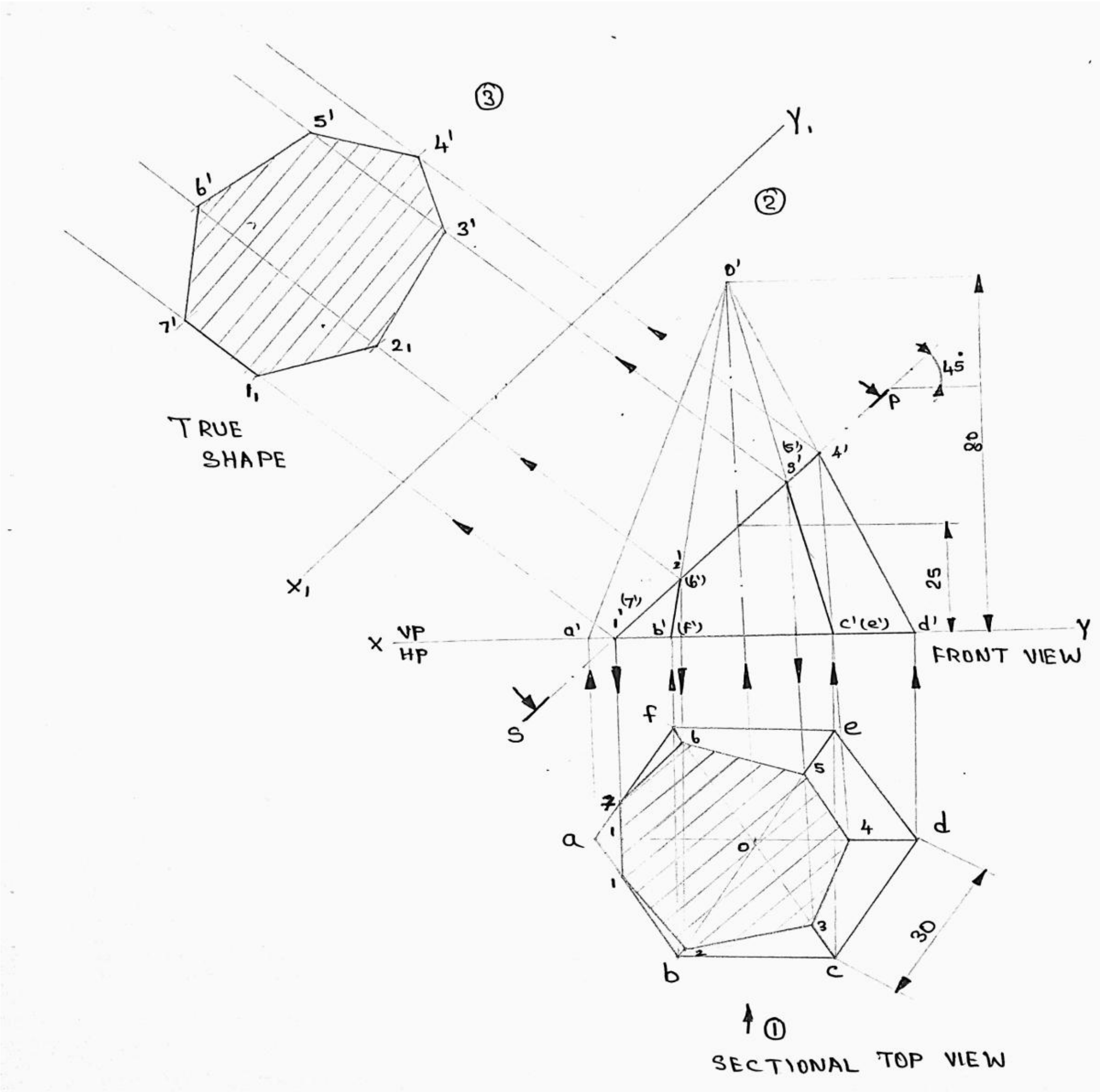
SCALE 1:1 ALL DIMENSIONS ARE IN mm

14. A right regular hexagonal pyramid with base side 30 mm and height 80 mm rests on its base on the HP with two adjacent lateral faces equally inclined to the VP. It is cut by a horizontal section plane and an inclined section plane. Both section planes meet at the midpoint of the axis in the front view. The inclined section plane makes 70° with the HP and is perpendicular to the VP. Draw the projections indicating the cut surfaces and the true shape of the section corresponding to the inclined plane.



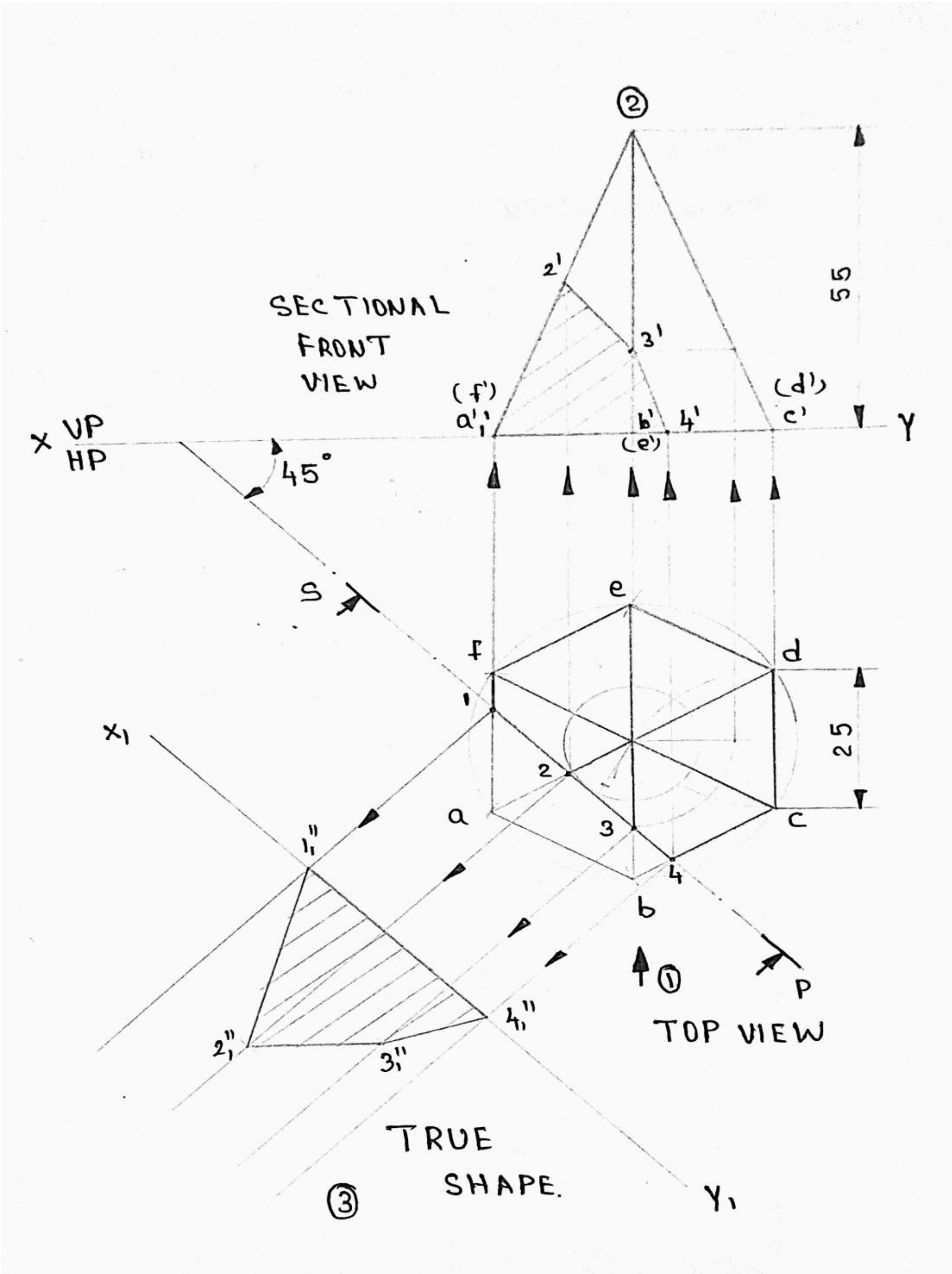
SCALE 1:1 ALL DIMENSIONS ARE IN mm

15. A hexagonal pyramid with base side 30 mm and axis length 80 mm rests on its base on the HP such that two base edges are parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 45° to the HP, meeting the axis at 25 mm from the base. Draw the sectional top view and determine the true shape of the section.



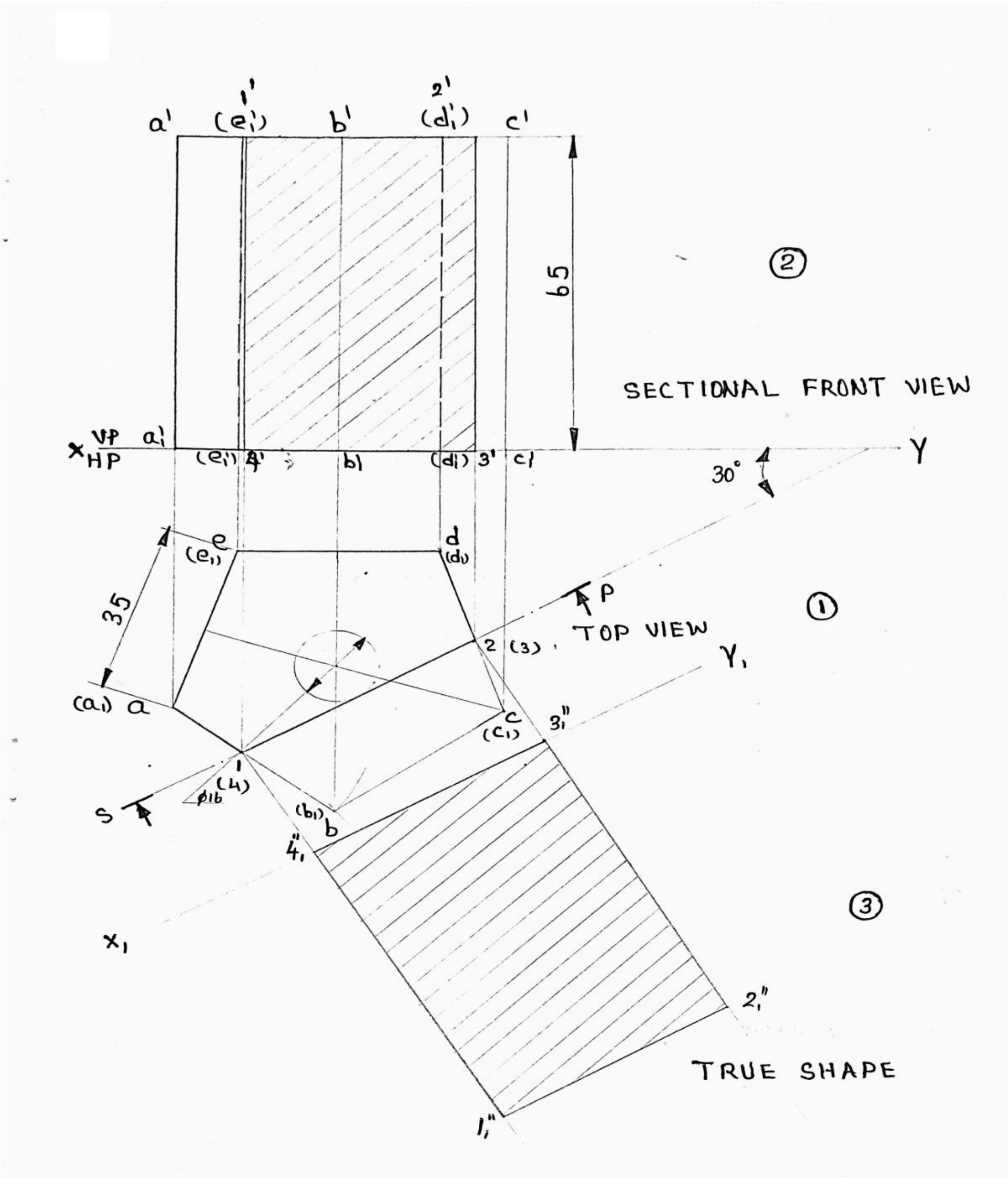
SCALE 1:1 ALL DIMENSIONS ARE IN mm

16. A hexagonal pyramid with base side 25 mm and axis length 55 mm rests on its base on the HP such that one base edge is perpendicular to the VP. It is cut by a plane perpendicular to the HP and inclined at 45° to the VP, passing through the pyramid at a distance of 10 mm from the axis. Draw the top view, sectional front view, and the true shape of the section.



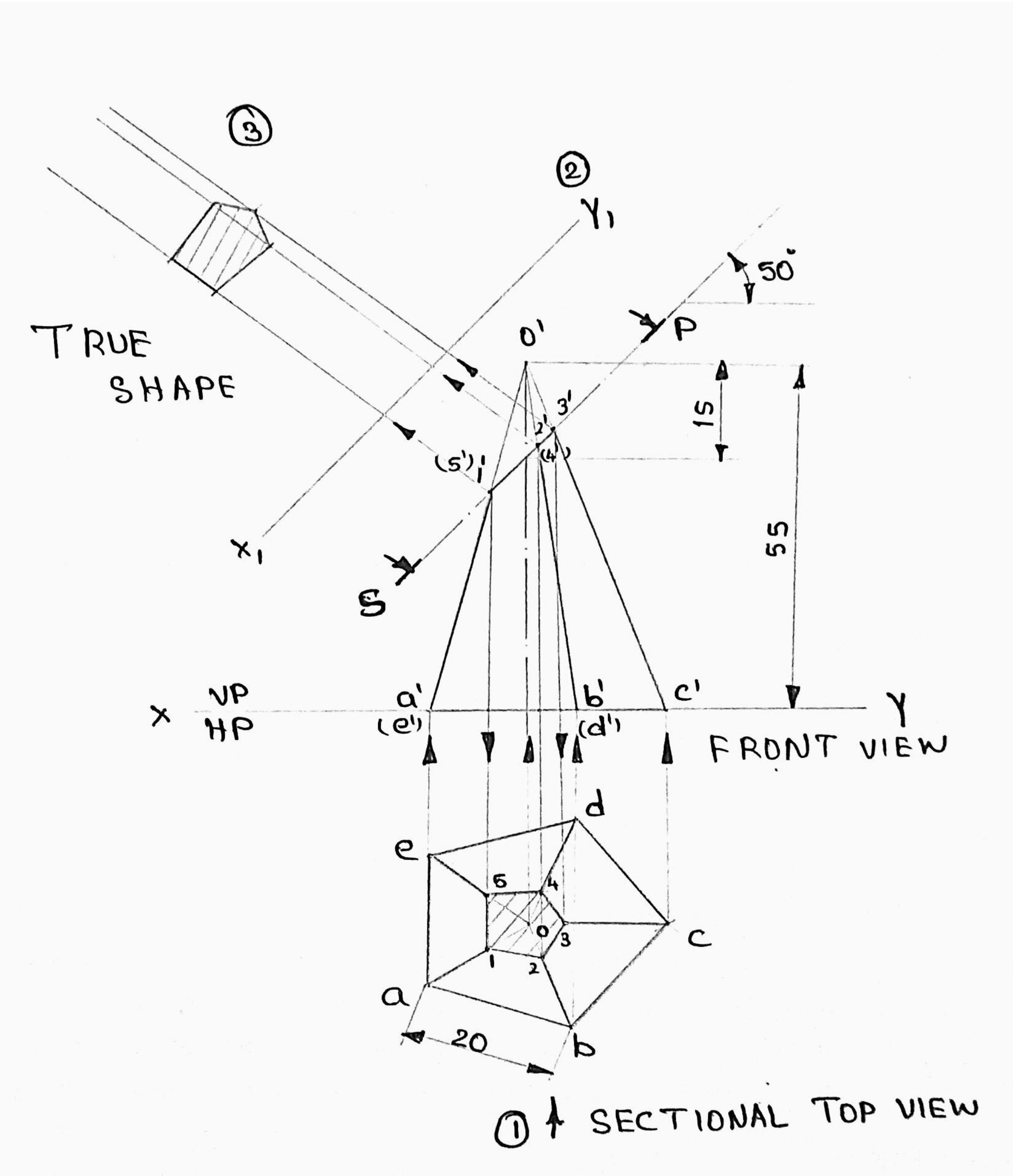
SCALE 1:1 ALL DIMENSIONS ARE IN mm

17. A pentagonal prism with base edge 35 mm and axis length 65 mm rests on the HP with one base edge parallel to the VP. It is cut by a plane perpendicular to the HP and inclined at 30° to the VP, passing through a point 8 mm from the axis. Draw the sectional elevation and the true shape of the section.



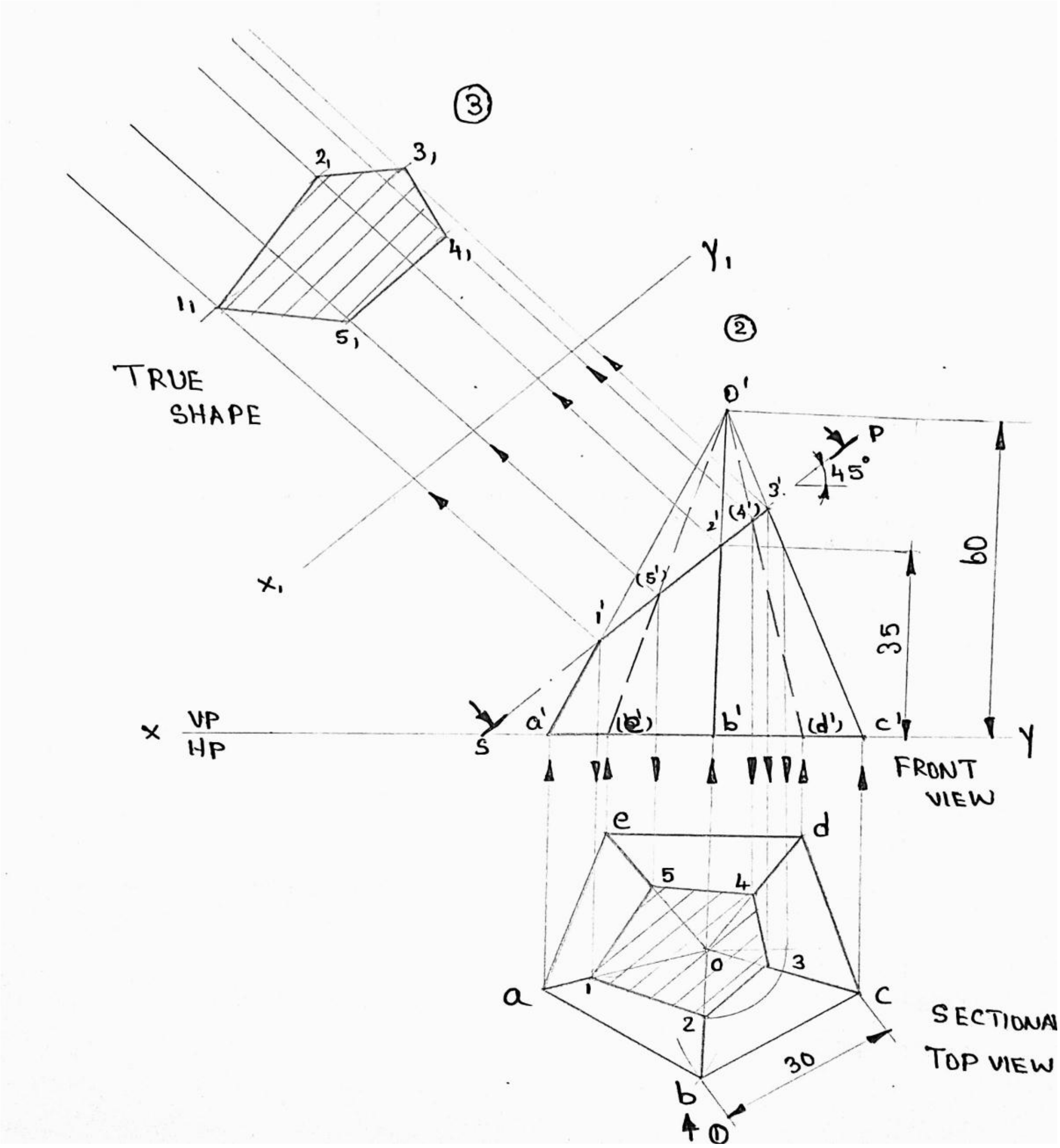
SCALE 1:1 ALL DIMENSIONS ARE IN mm

18. A pentagonal pyramid with base side 20 mm and altitude 55 mm rests on its base on the HP with one base edge perpendicular to the VP. It is cut by a plane inclined at 50° to the base, meeting the axis at 15 mm below the apex. Draw the front view, sectional top view, and the true shape of the section.



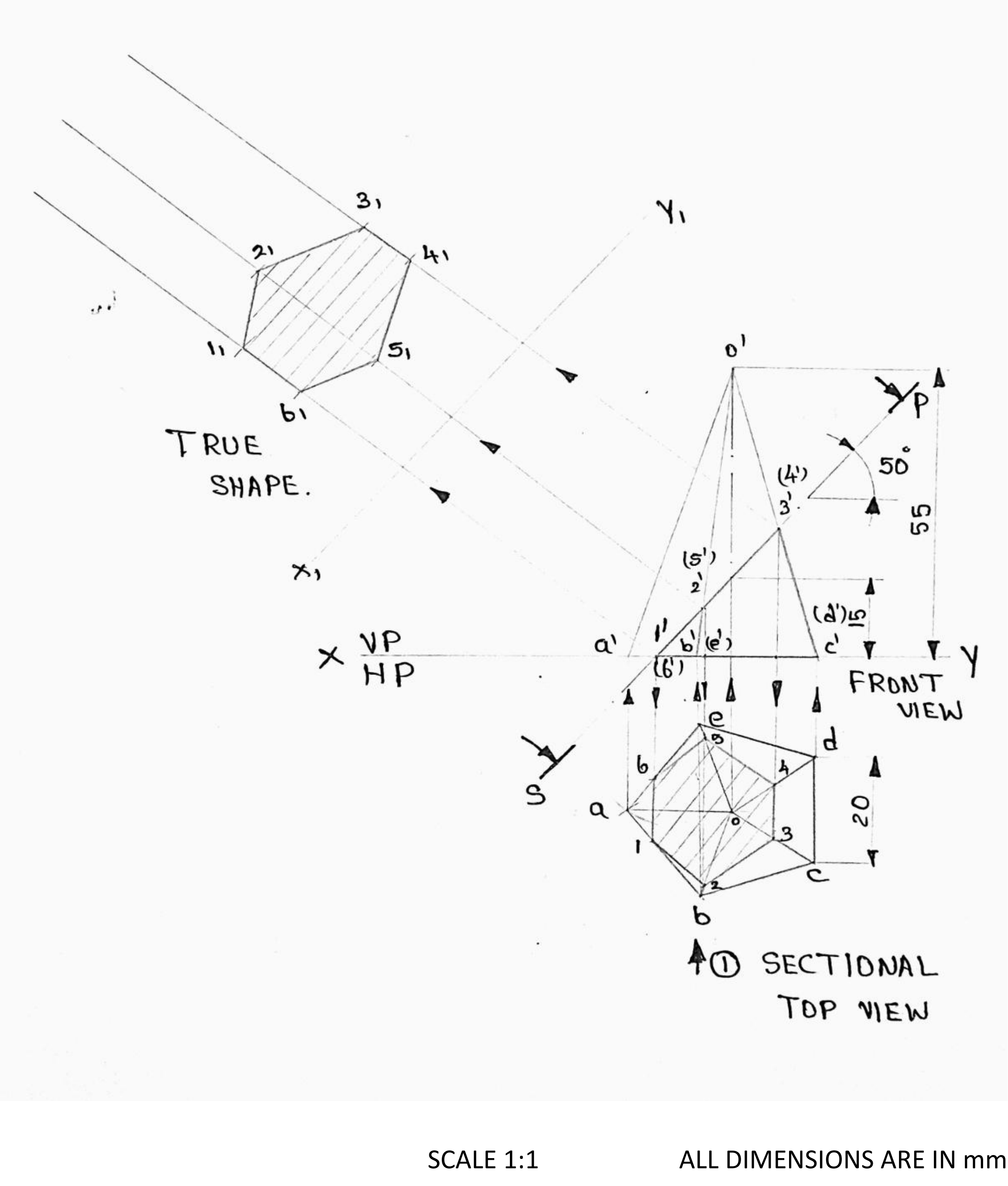
SCALE 1:1 ALL DIMENSIONS ARE IN mm

19. A pentagonal pyramid with base side 30 mm and axis length 60 mm rests on its base on the HP with one base edge parallel to the VP. A section plane perpendicular to the VP and inclined at 45° to the HP passes through the axis at a point 35 mm above the base. Draw the sectional top view and the true shape of the section.



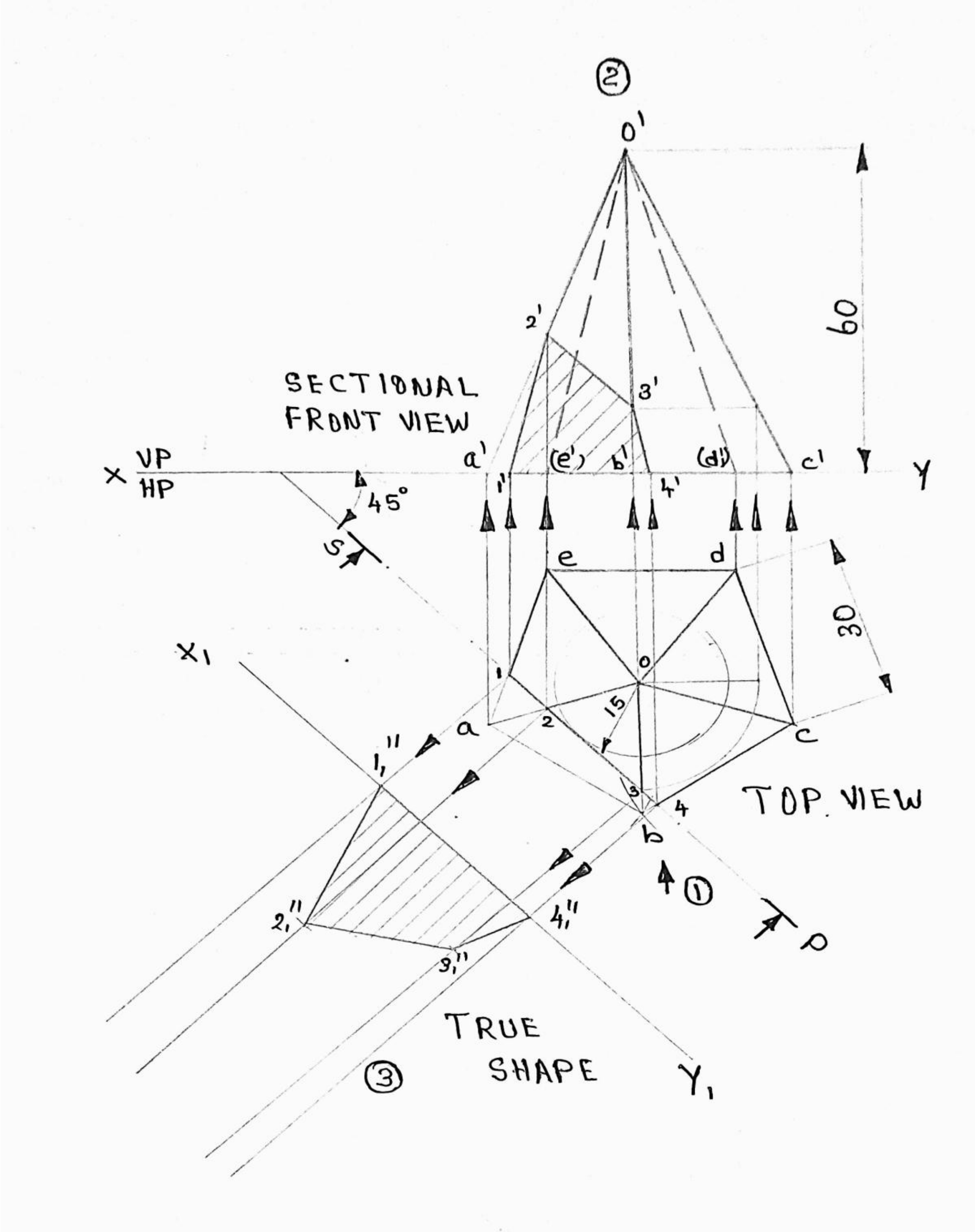
SCALE 1:1 ALL DIMENSIONS ARE IN mm

20. A pentagonal pyramid with base side 20 mm and altitude 55 mm rests on its base on the HP with one base edge perpendicular to the VP. It is cut by a plane inclined at 50° to the base, meeting the axis at 15 mm above the base. Draw the front view, sectional top view, and the true shape of the section.



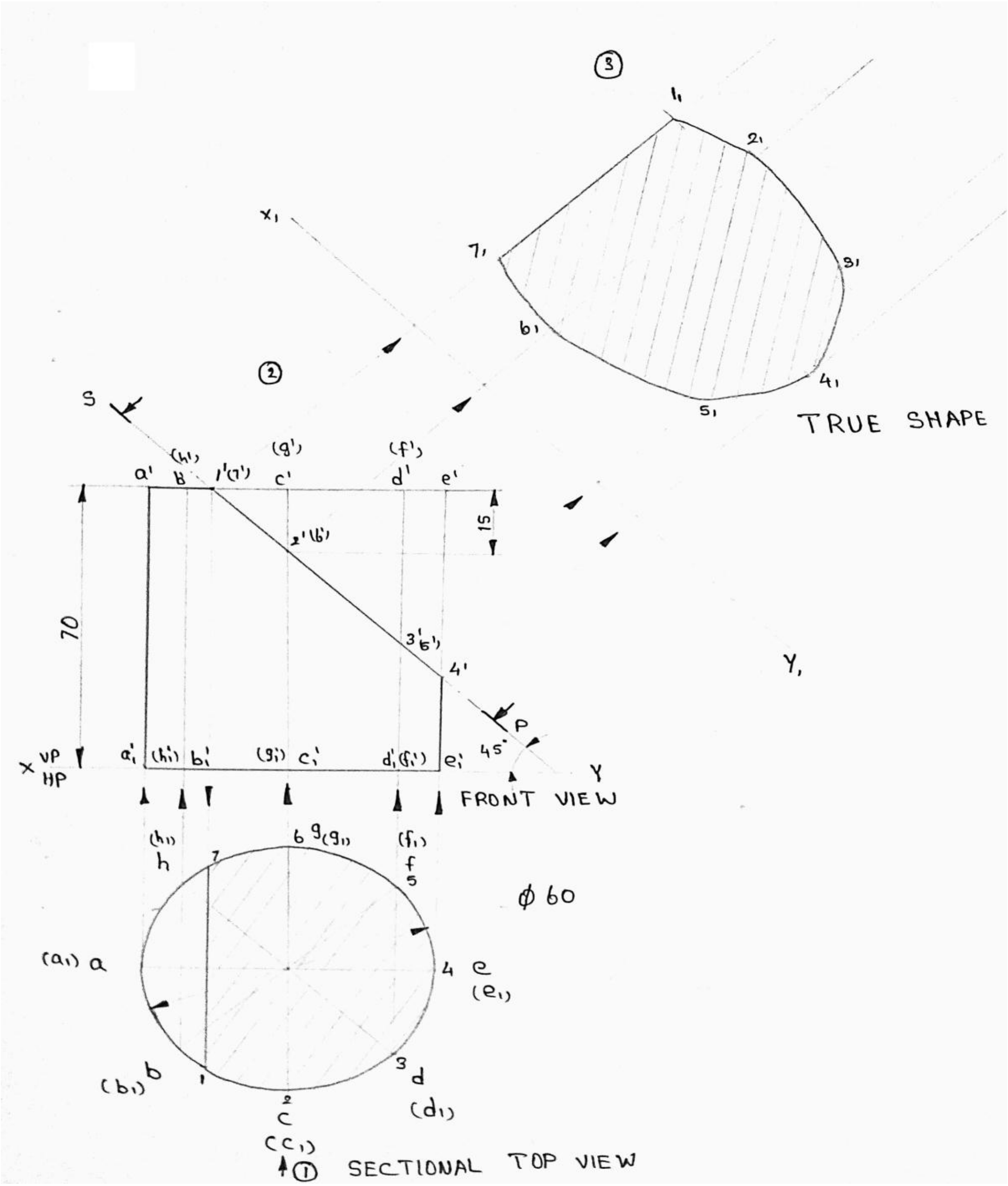
SCALE 1:1 ALL DIMENSIONS ARE IN mm

21. A pentagonal pyramid with base side 30 mm and axis length 60 mm rests on its base on the HP with one base edge parallel to the VP. It is cut by a plane perpendicular to the HP and inclined at 45° to the VP, at a distance of 12 mm from the axis. Draw the top view, sectional front view, and the true shape of the section.



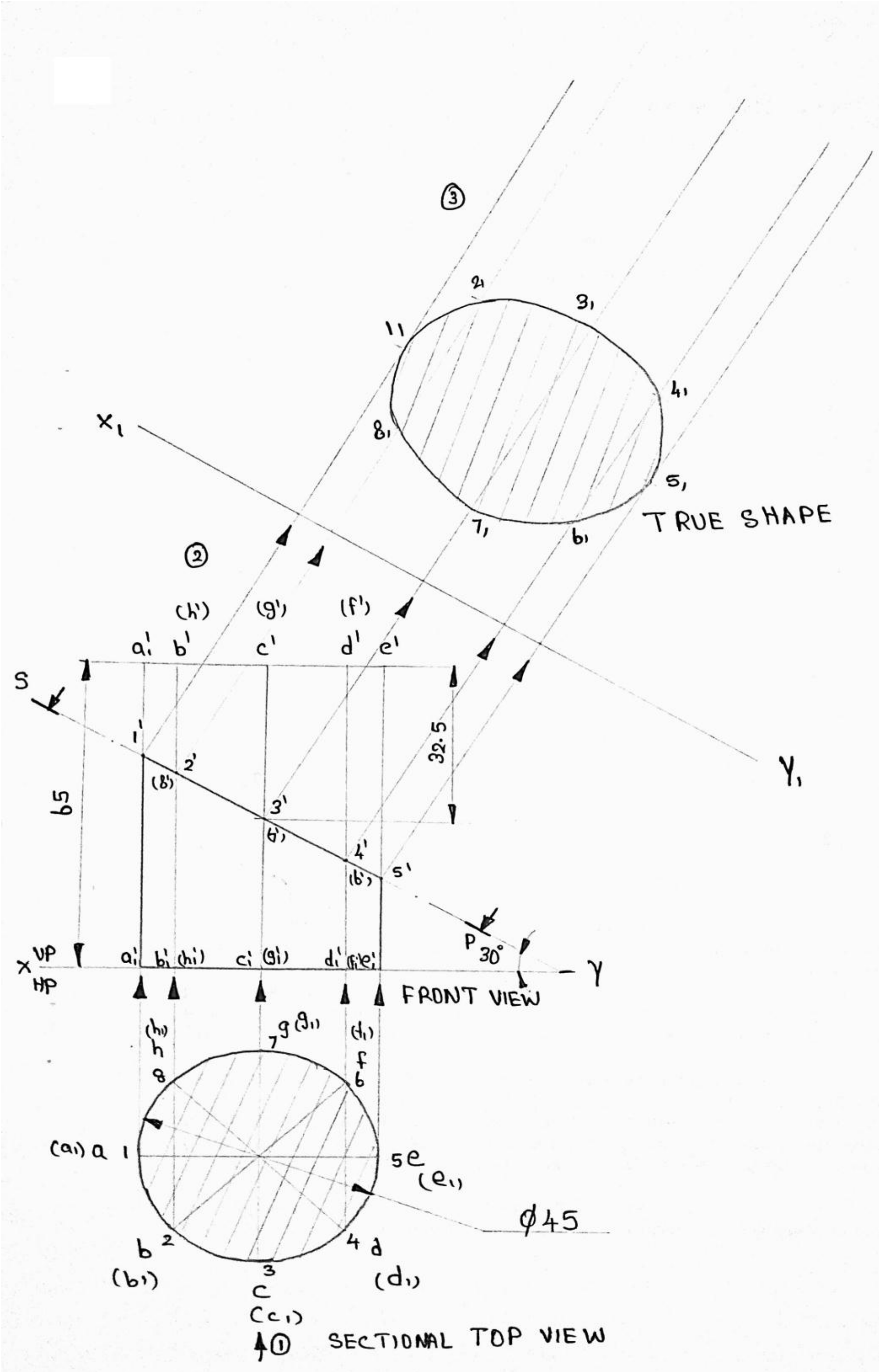
SCALE 1:1 ALL DIMENSIONS ARE IN mm

22. A cylinder of diameter 60 mm and axis length 70 mm rests on its base on the HP. It is cut by a plane perpendicular to the VP and inclined at 45° to the HP, meeting the axis at 15 mm from the top. Draw the sectional plan and the true shape of the section.



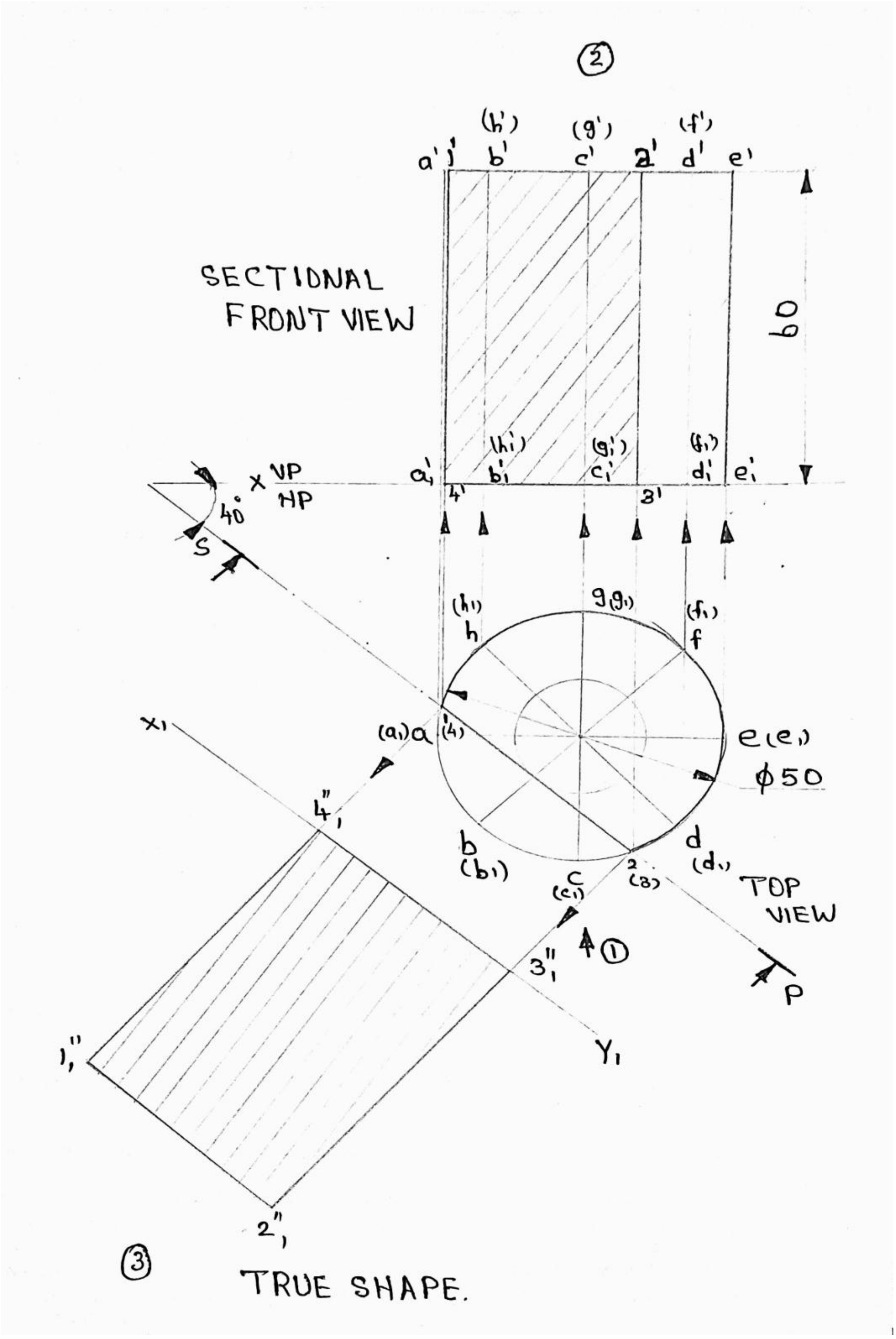
SCALE 1:1 ALL DIMENSIONS ARE IN mm

23. A cylinder of diameter 45 mm and height 65 mm rests on its base on the HP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, bisecting the axis. Draw the front view, sectional top view, and the true shape of the section.



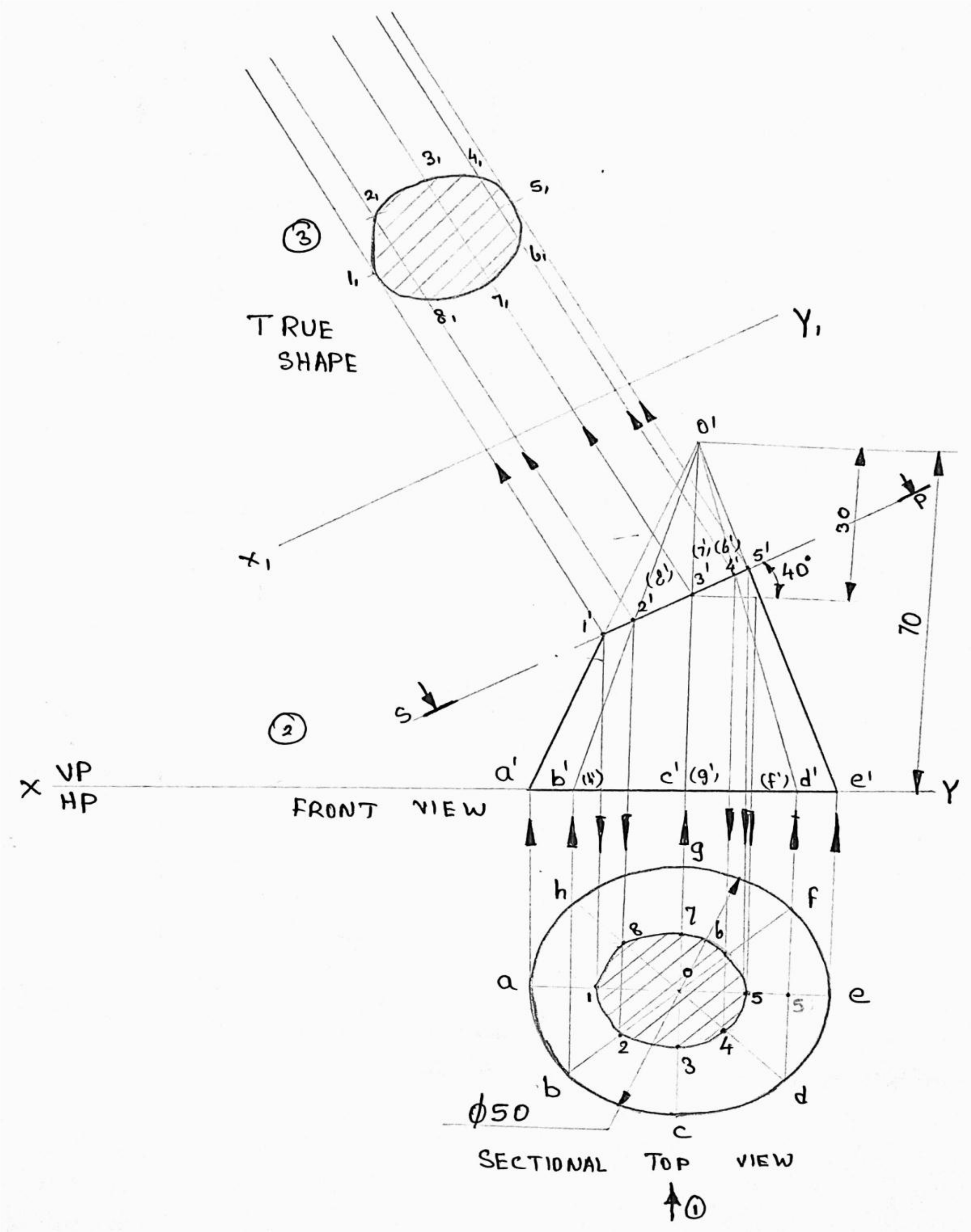
SCALE 1:1 ALL DIMENSIONS ARE IN mm

24. A cylinder of diameter 50 mm and axis length 60 mm rests vertically on the HP. It is cut by a plane perpendicular to the HP and inclined at 40° to the VP, at a distance of 12 mm from the axis. Draw the sectional front view and the true shape of the section.



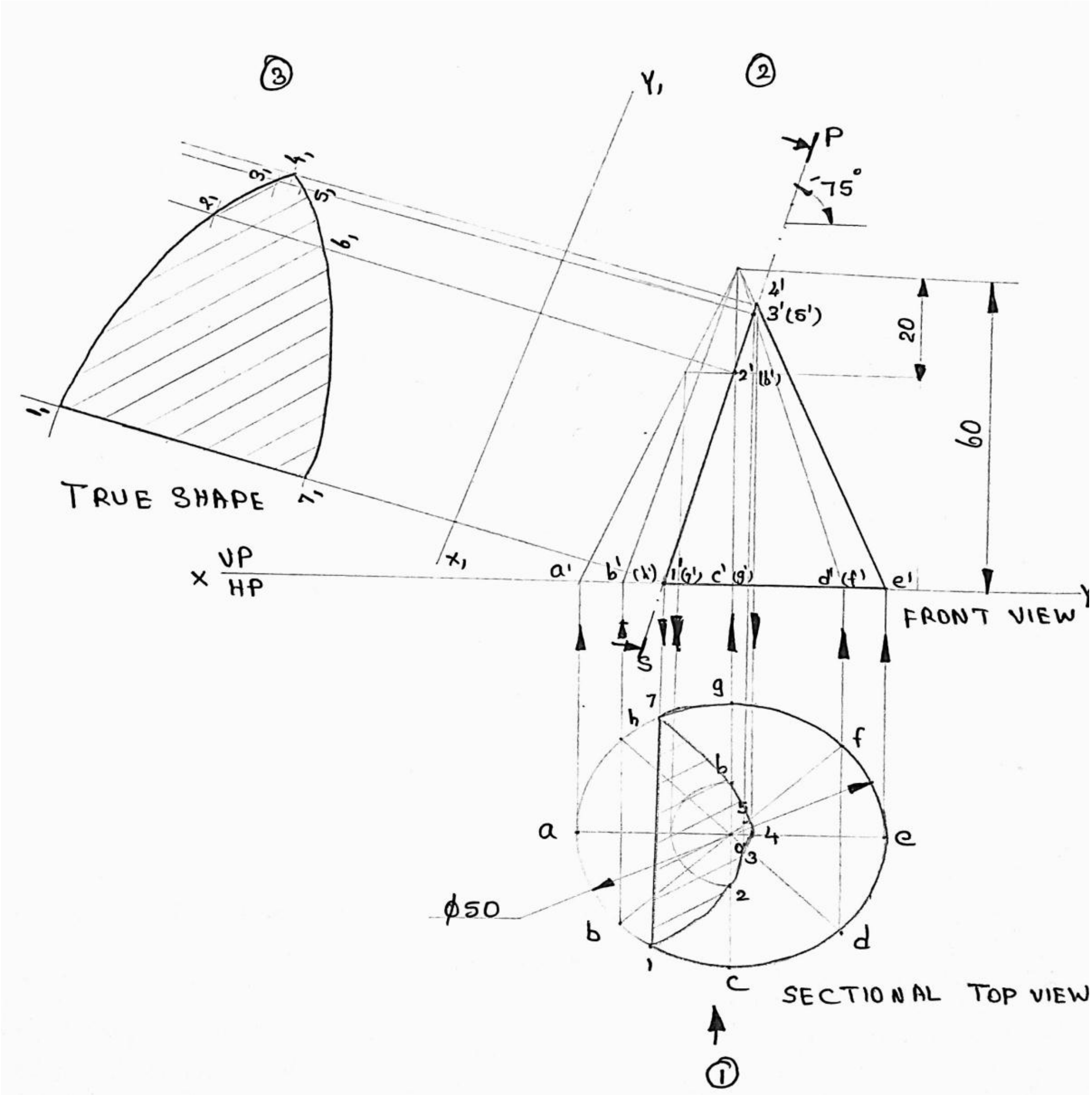
SCALE 1:1 ALL DIMENSIONS ARE IN mm

25. A cone of base diameter 50 mm and height 70 mm rests on its base on the HP. It is cut by a plane perpendicular to the VP and inclined at 40° to the HP, meeting the axis at 30 mm from the apex. Draw the sectional top view.



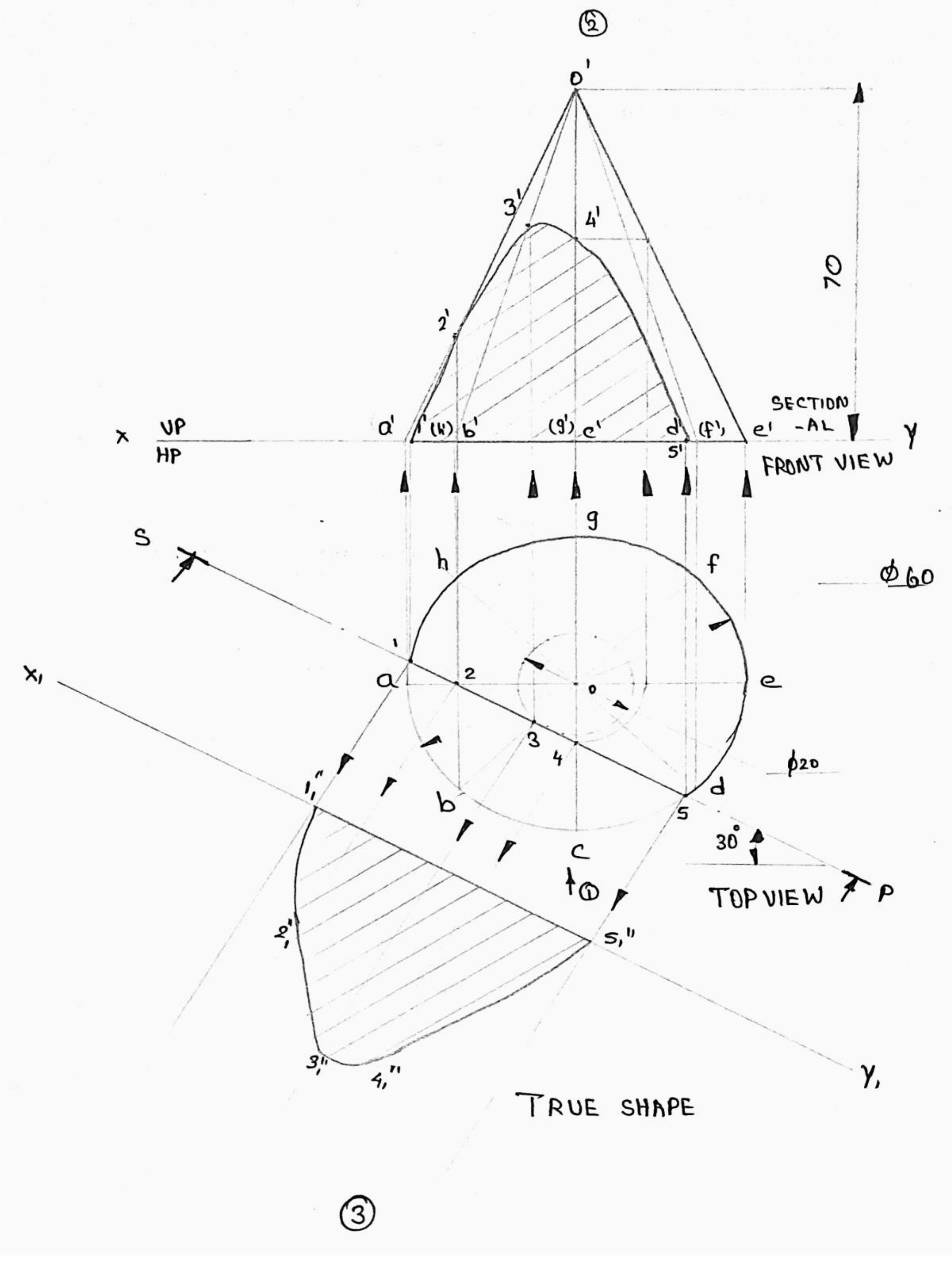
SCALE 1:1 ALL DIMENSIONS ARE IN mm

26. A cone of base diameter 50 mm and axis length 60 mm rests on its base on the HP. It is cut by a plane perpendicular to the VP and inclined at 75° to the HP, passing through a point 20 mm below the apex. Draw the front view, sectional top view, and the true shape of the section.



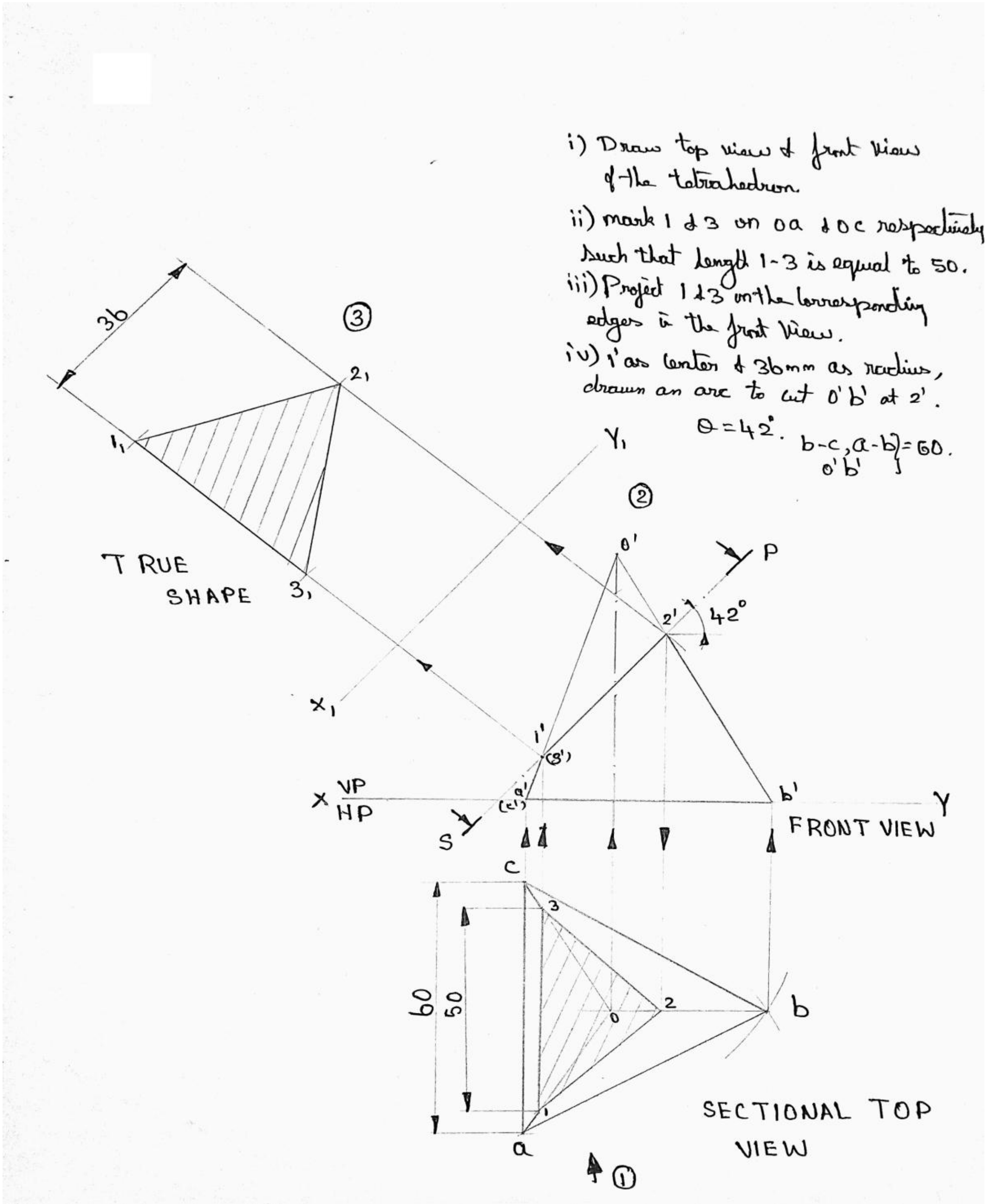
SCALE 1:1 ALL DIMENSIONS ARE IN mm

27. A cone of base diameter 60 mm and height 70 mm rests on its base on the HP. It is cut by a plane perpendicular to the HP and inclined at 30° to the VP, passing through a point 10 mm in front of the axis. Draw the sectional front view and the true shape of the section.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

28. A tetrahedron with edges of 60 mm rests on one of its faces on the HP, with one edge perpendicular to the VP. It is cut by a plane perpendicular to the VP such that the true shape of the section is an isosceles triangle with base 50 mm and altitude 36 mm. Draw the front view, sectional top view, the true shape of the section, and determine the inclination of the section plane.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

Chapter IV

Development of Surfaces

A solid object is formed by joining a number of plane figures in a proper sequence. Conversely, by unfolding a solid object, the plane surfaces used to form that solid can be obtained. In other words, by folding a plane area in a suitable manner, a solid figure is produced, and by unfolding the solid figure, the original plane area is revealed.

This process of unfolding or laying out the surfaces of a solid on a plane without distortion is known as the development of surfaces of the given solid.

The development of surfaces plays an important role in engineering graphics, as it provides the true shape and size of each surface of a solid when laid flat. It helps in visualizing how a three-dimensional object is constructed from flat surfaces and how those surfaces are arranged and joined.

4.1 Concept of Development of Surfaces

The concept of development of surfaces is based on the principle that any solid object made of thin material can be formed by folding a flat surface in a proper sequence. Conversely, by unfolding a solid object, the exact shape and size of the flat surfaces used to form that solid can be obtained.

In engineering practice, several components such as funnels, trays, boxes, chimneys, drums, storage tanks, and air-conditioning ducts are fabricated from metal sheets. These objects are manufactured by cutting metal sheets into appropriate shapes and sizes and then joining them by welding, riveting, or soldering.

To carry out this fabrication accurately and economically, it is essential to know the exact layout of the flat sheet before bending or forming. Development of surfaces provides this information and helps in:

- ❖ Accurate fabrication,
- ❖ Reduction of material wastage,

- Proper planning of cutting and bending operations.

Thus, the development of surfaces forms a vital link between engineering drawing and manufacturing practice.

4.2 Methods of Development of Surfaces

Depending on the nature of the solid and its surfaces, the following methods are commonly used for development:

i. Parallel Line Method

- This method is used when the surfaces of a solid are generated by a line that moves parallel to the axis of the solid.
- It is commonly used for the development of prisms and cylinders.

ii. Radial Line Method

- This method is adopted when the surfaces of a solid are generated by a line, one end of which remains fixed while the other end traces a path.
- It is used for the development of pyramids and cones.

iii. Triangulation Method

- This method is suitable when the surfaces of a solid can be imagined as being composed of a number of triangular elements.
- It is generally used for the development of transition pieces and oblique solids.

iv. Approximate Method

- This method is adopted when the surfaces of solids are bounded by double-curved surfaces.
- The development of a sphere is carried out using this approximate method.

4.3 Procedures for Development Methods

i. Parallel Line Method

This method is suitable for solids having a uniform cross-section throughout their length, such as prisms and cylinders.

Procedure:

- Draw the top view and front view of the solid.
- Determine the development length, which is equal to the perimeter of the base, and mark it adjacent to the front view.
- Using the height from the front view and the development length obtained, complete the outer boundary of the layout.
- Measure the distances between the lateral edges from the true size view (top view) and mark them on the stretch-out line, naming the corners accordingly.
- Draw the folding lines perpendicular to the stretch-out line using thin lines.
- In the case of a cylinder, the stretch-out length of the curved surface is equal to the circumference of the base circle, which is divided into equal parts.
- If the solid is cut by a plane, mark the cutting plane in the front view and project the points of intersection onto the developed surface.

ii. Radial Line Method

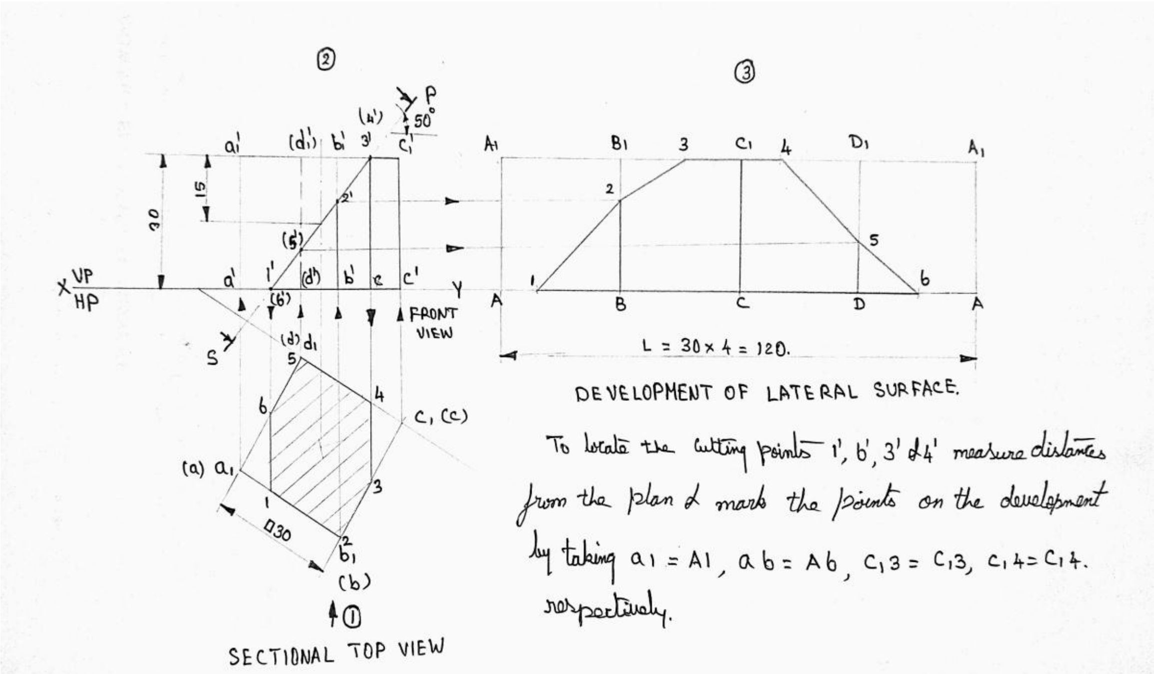
This method is suitable for solids having a uniformly varying cross-section, such as pyramids and cones.

Procedure:

- Draw the top view and front view of the solid.
- Draw one of the slant edges as a vertical line and construct the true shape of the slant surface (triangular face) by joining it to the apex.
- Draw the outer boundary lines using thick lines and the folding lines using thin lines.
- For a cone, divide the circumference of the base circle into equal parts and draw the development as a sector by determining the angle subtended at the center using the true length of the generator.
- If the solid is cut by a plane, mark the cutting plane in the front view, locate the points of intersection (P, Q, R, etc.), and project these points onto the developed surface.

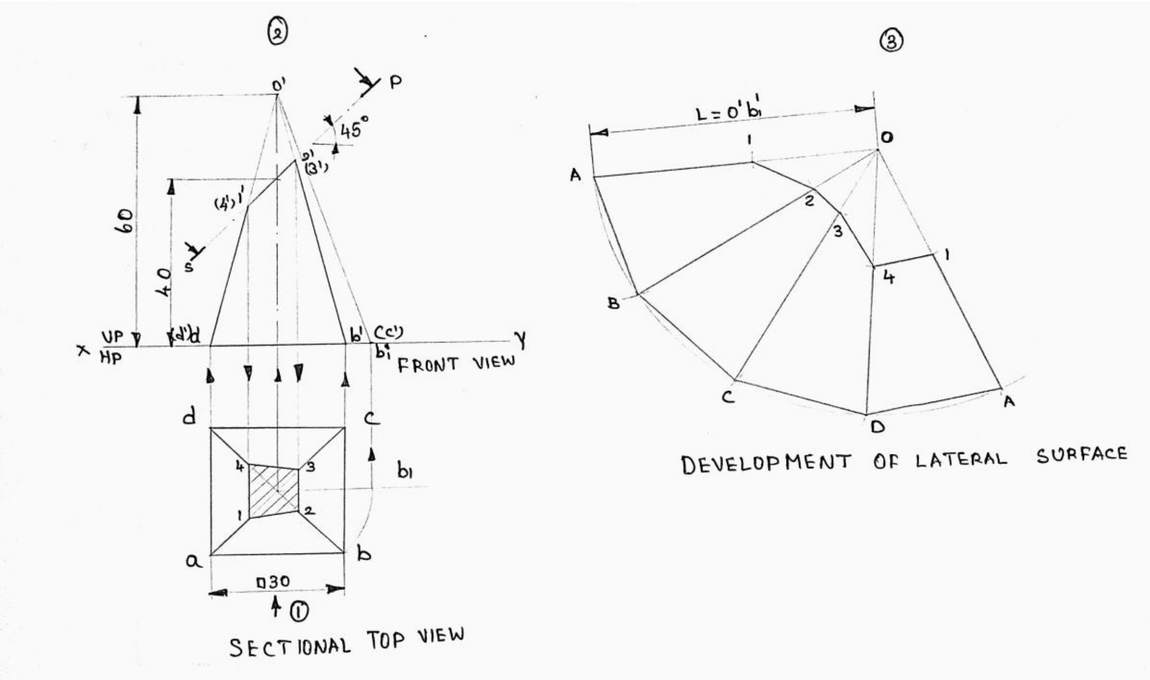
Development of Lateral Surfaces of Simple and Sectioned Solids (Prisms and Pyramids using Parallel Line Method and Radial Line Method – First Angle Projection)

1. A cube of side 30 mm rests on its base on the HP with one vertical face inclined at 30° to the VP. It is cut by a plane perpendicular to the VP and inclined at 50° to the HP. The cutting plane bisects the axis of the cube. Draw the development of the surfaces of the right portion of the cut cube.



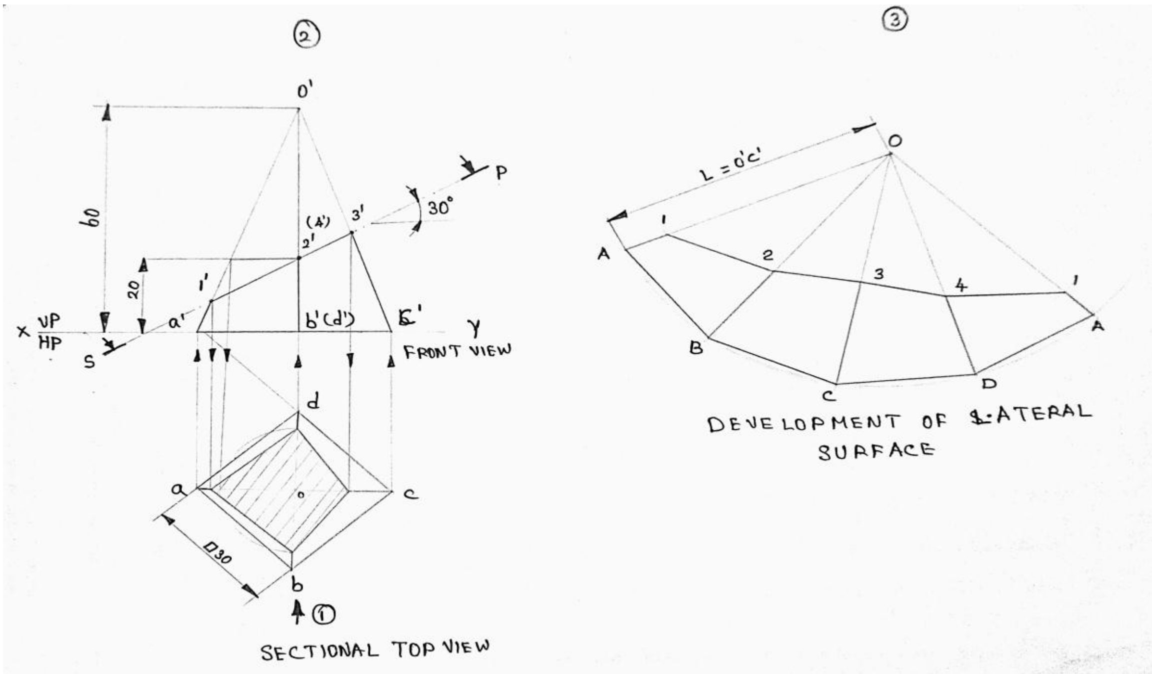
SCALE 1:1 ALL DIMENSIONS ARE IN mm

2. A square pyramid with base side 30 mm and altitude 60 mm rests on its base on the HP with two of its base edges parallel to the VP. It is cut by a plane inclined at 45° to the axis and intersecting it at a point 40 mm from the base. Draw the development of the pyramid.



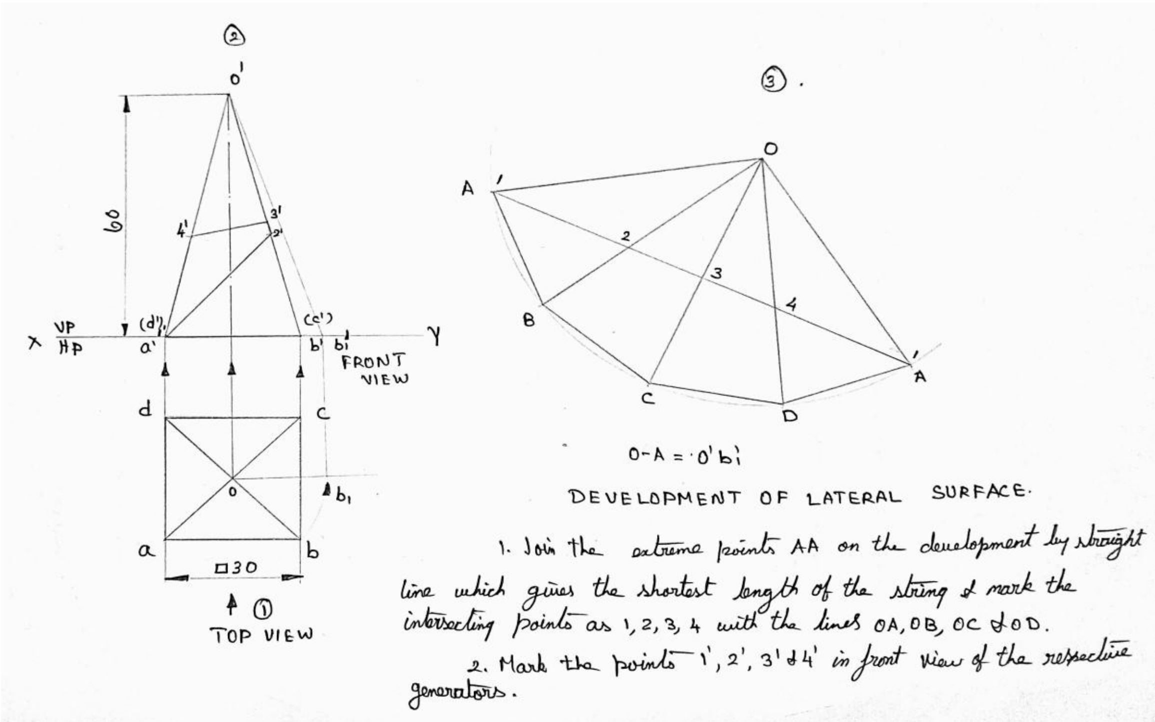
SCALE 1:1 ALL DIMENSIONS ARE IN mm

3. A square pyramid of base side 30 mm and axis length 60 mm rests on its base on the HP with the base edges equally inclined to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, meeting the axis at a point 20 mm above the HP. Draw the development of the lateral surface of the square pyramid.



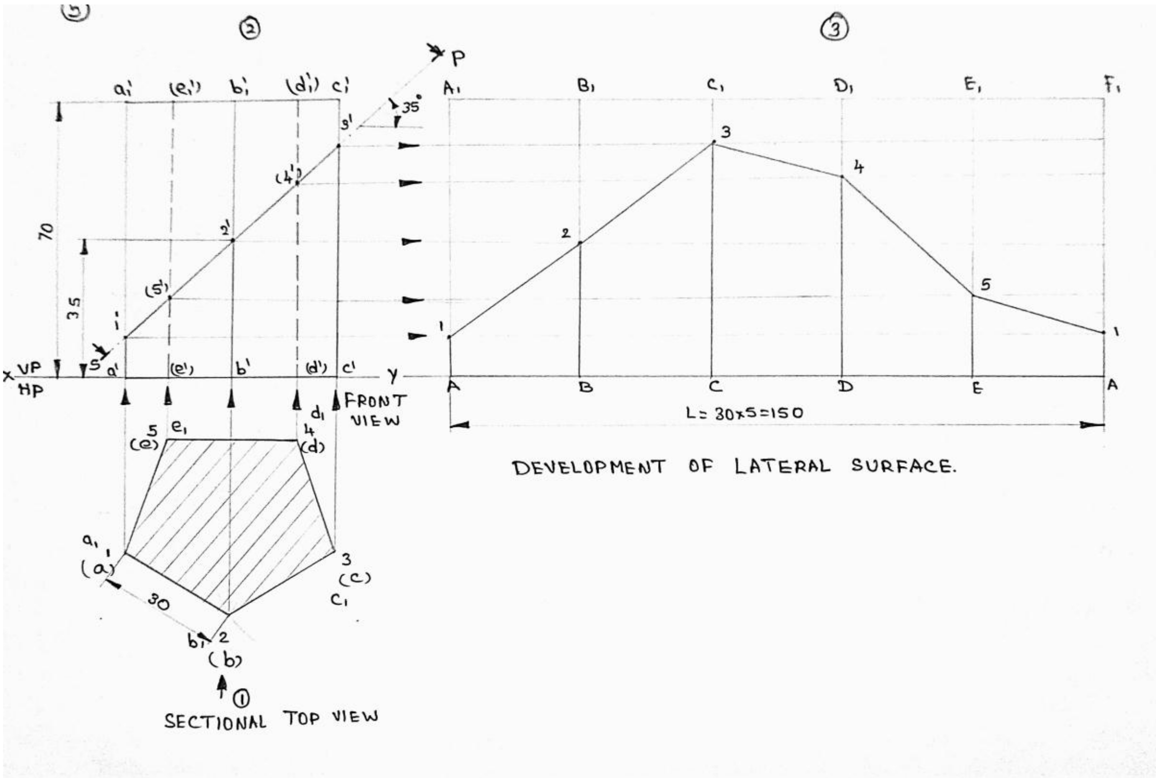
SCALE 1:1 ALL DIMENSIONS ARE IN mm

4. A square pyramid with base side 30 mm and axis length 60 mm rests on its base on the HP with one base edge parallel to the VP. A string is wound around the surfaces of the pyramid starting from the left extreme point on the base and ending at the same point. Find the shortest length of the string required. Also trace the path of the string in the front and top views.



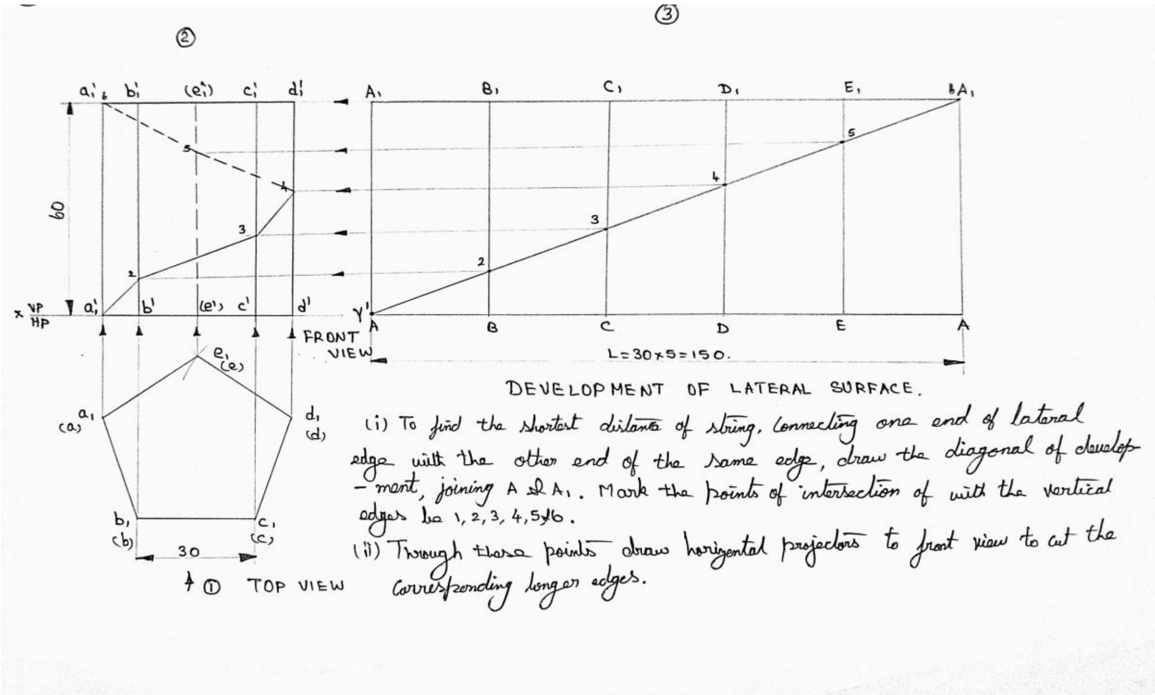
SCALE 1:1 ALL DIMENSIONS ARE IN mm

5. Draw the development of the lateral surface of a pentagonal prism having a base side 30 mm and axis length 70 mm, resting on its base on the HP such that one of the rectangular faces is parallel to the VP. It is cut by a plane whose vertical trace is inclined at 35° to the reference line and passes through the midpoint of the axis.



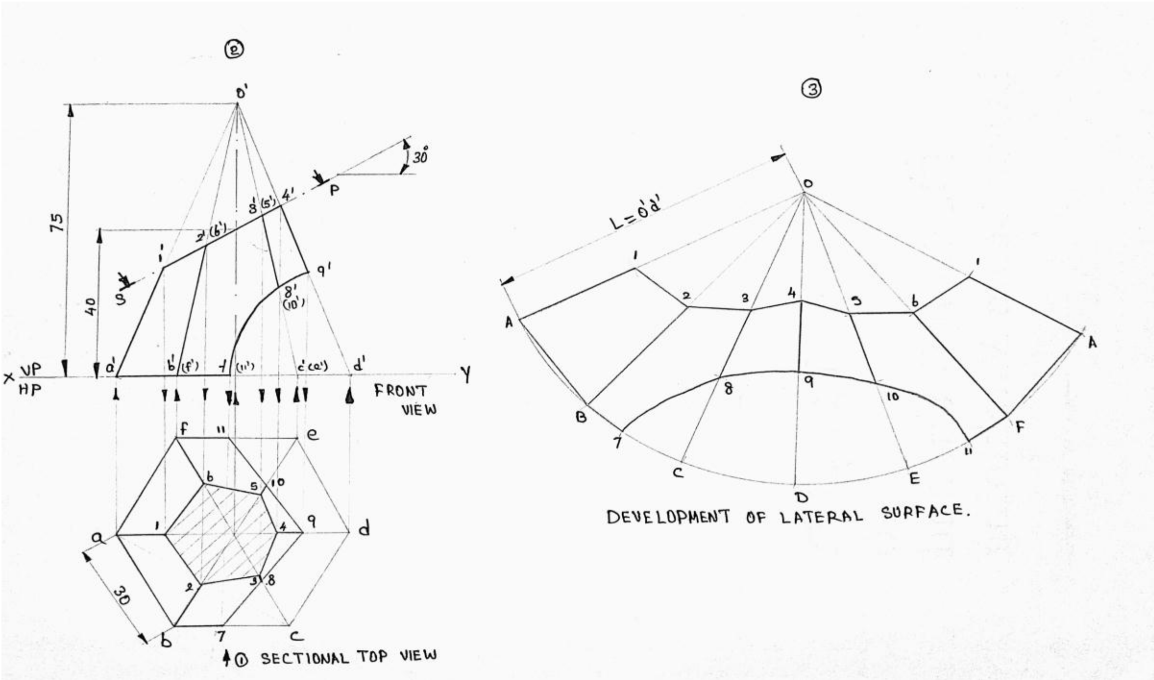
SCALE 1:1 ALL DIMENSIONS ARE IN mm

6. A pentagonal prism of base side 30 mm and axis height 60 mm rests on the HP with one of its base edges parallel to the VP and nearer to the observer. Find graphically the shortest length of a string connecting one end of a lateral edge to the other end of the same edge while covering all the lateral surfaces. Also trace the points on the development.



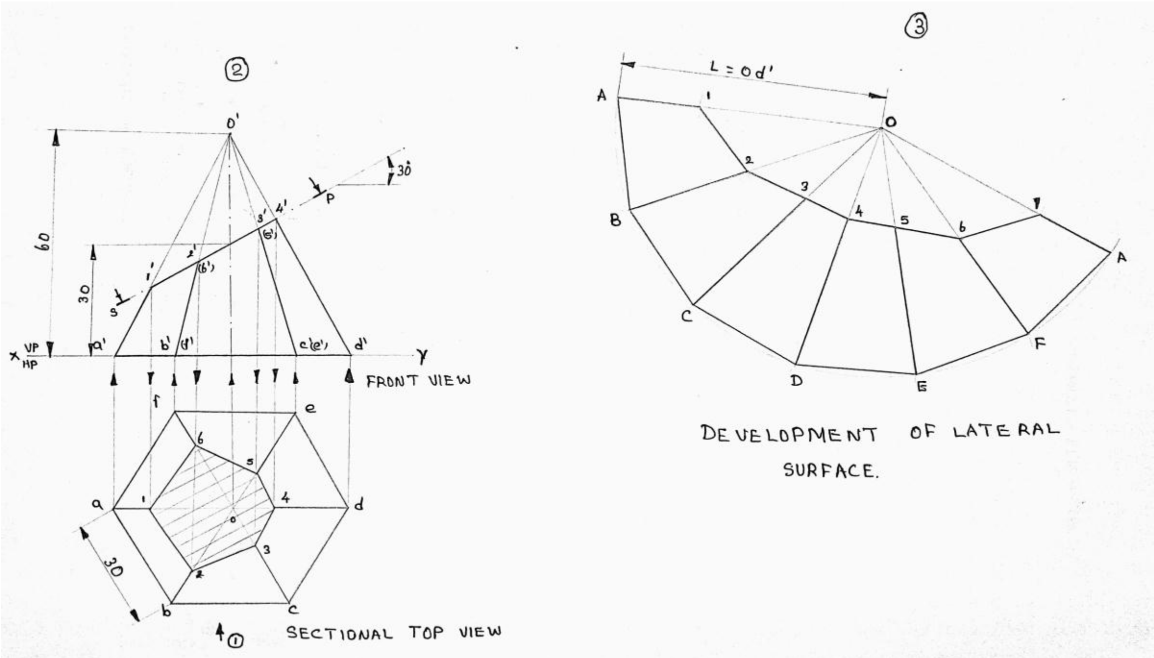
SCALE 1:1 ALL DIMENSIONS ARE IN mm

7. A hexagonal pyramid with base side 30 mm and altitude 75 mm rests on its base on the HP such that one base edge is parallel to the VP. It is cut by two cutting planes, both perpendicular to the VP. One plane is inclined at 30° to the HP and meets the axis at 40 mm from the base. The other is a curved plane of radius 30 mm with the right corner of the base as center. Draw the development of the lateral surfaces of the remaining portion of the pyramid.



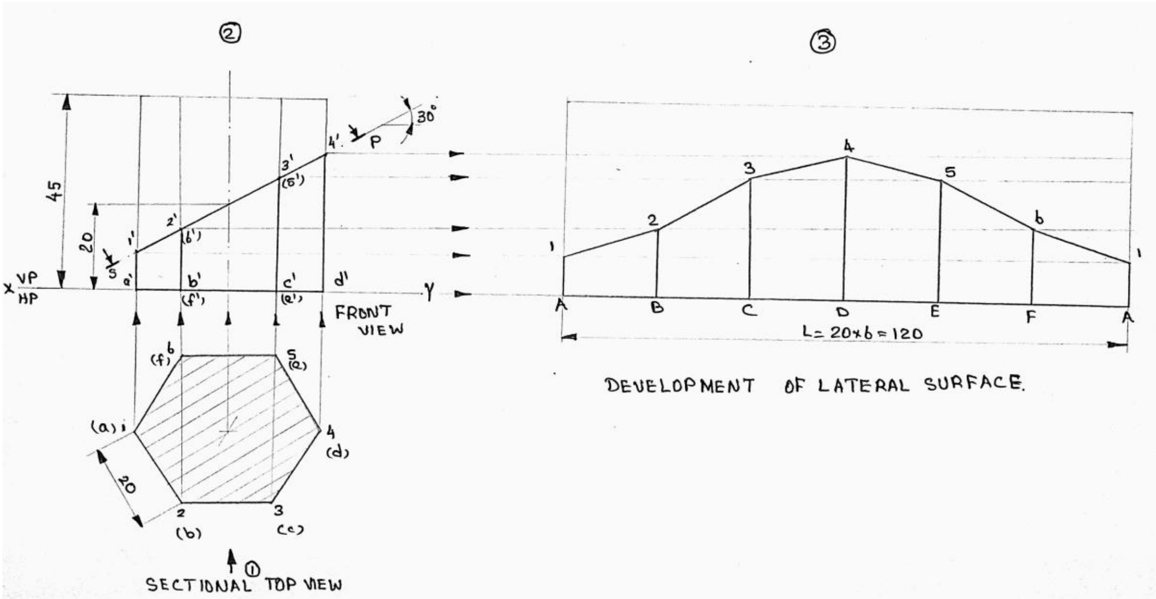
SCALE 1:1 ALL DIMENSIONS ARE IN mm

8. A hexagonal pyramid of base side 30 mm and height 60 mm rests vertically on its base on the HP with two base edges parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, meeting the axis at its midpoint. Draw the development of the lateral surfaces of the truncated pyramid.



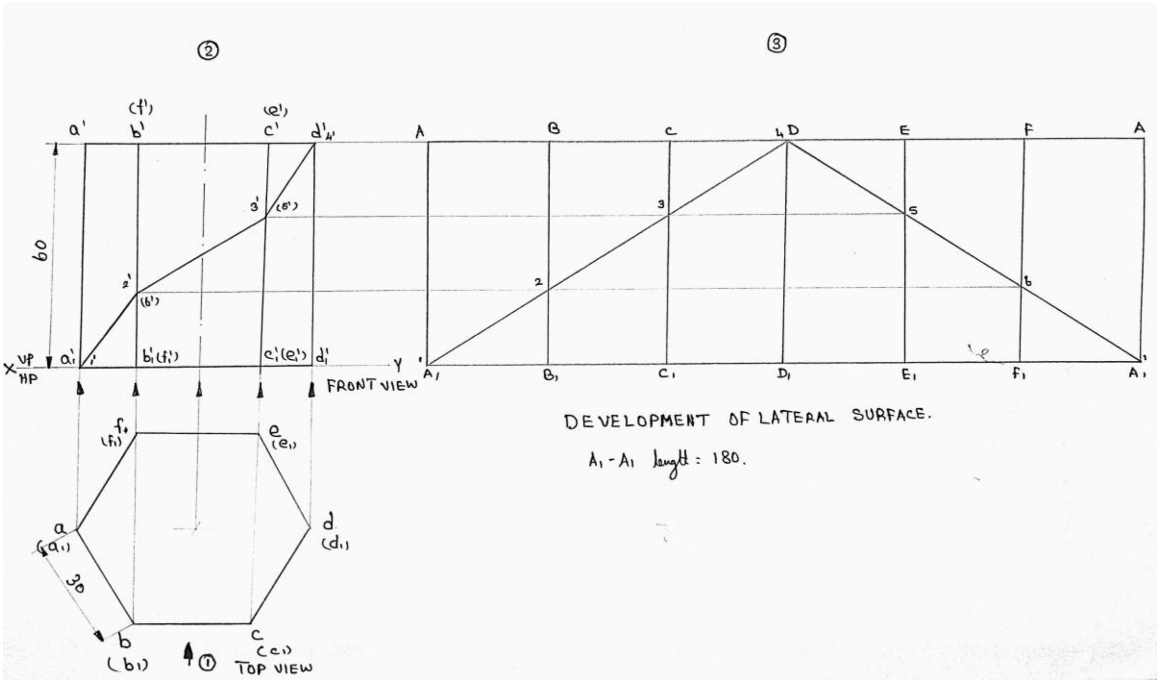
SCALE 1:1 ALL DIMENSIONS ARE IN mm

9. A hexagonal prism with base side 20 mm and axis height 45 mm rests on its base on the HP such that one rectangular face is parallel to the VP. It is cut by a plane perpendicular to the VP and inclined at 30° to the HP, meeting the axis at 20 mm from the base. Draw the development of the lateral surface of the lower portion of the prism.



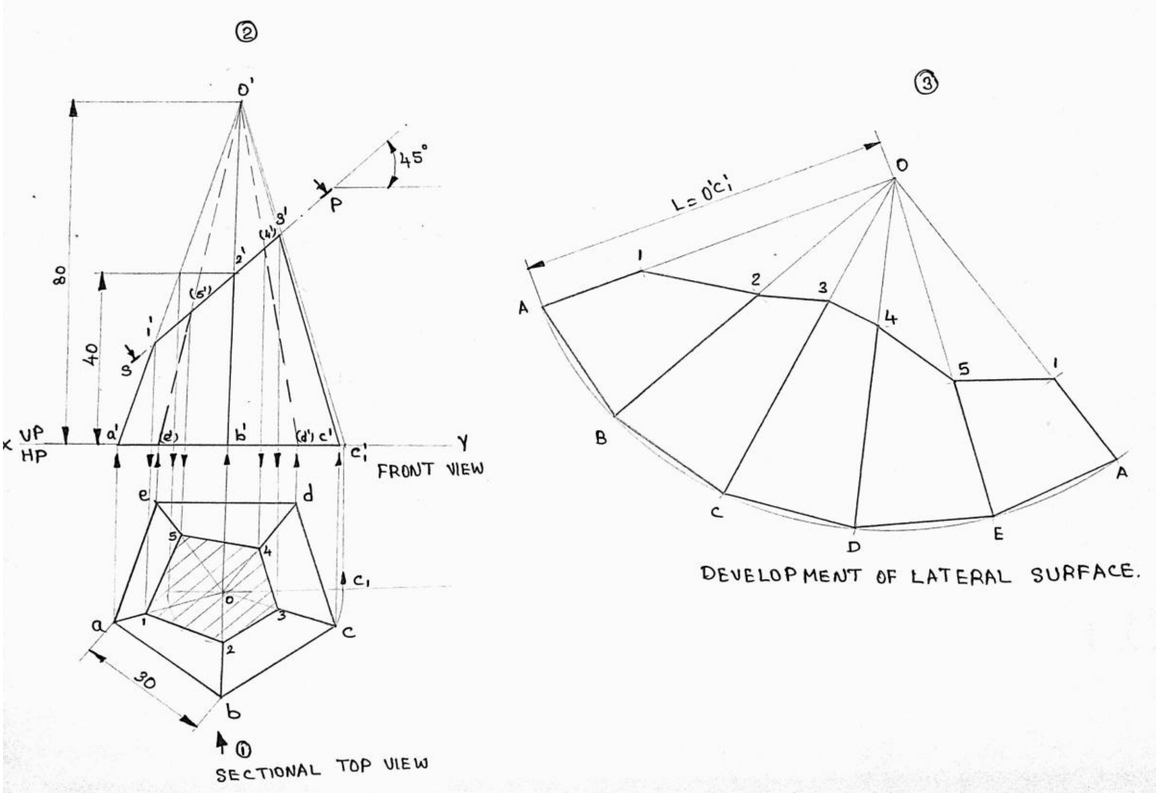
SCALE 1:1 ALL DIMENSIONS ARE IN mm

10. A hexagonal prism with base side 30 mm and axis length 60 mm rests vertically on the HP with one base side parallel to the VP. A string is wound around the surface starting from an extreme point on the base to the diametrically opposite corner on the top face and ending at the same point. Find graphically the shortest length of the string required and sketch its path in the front view.



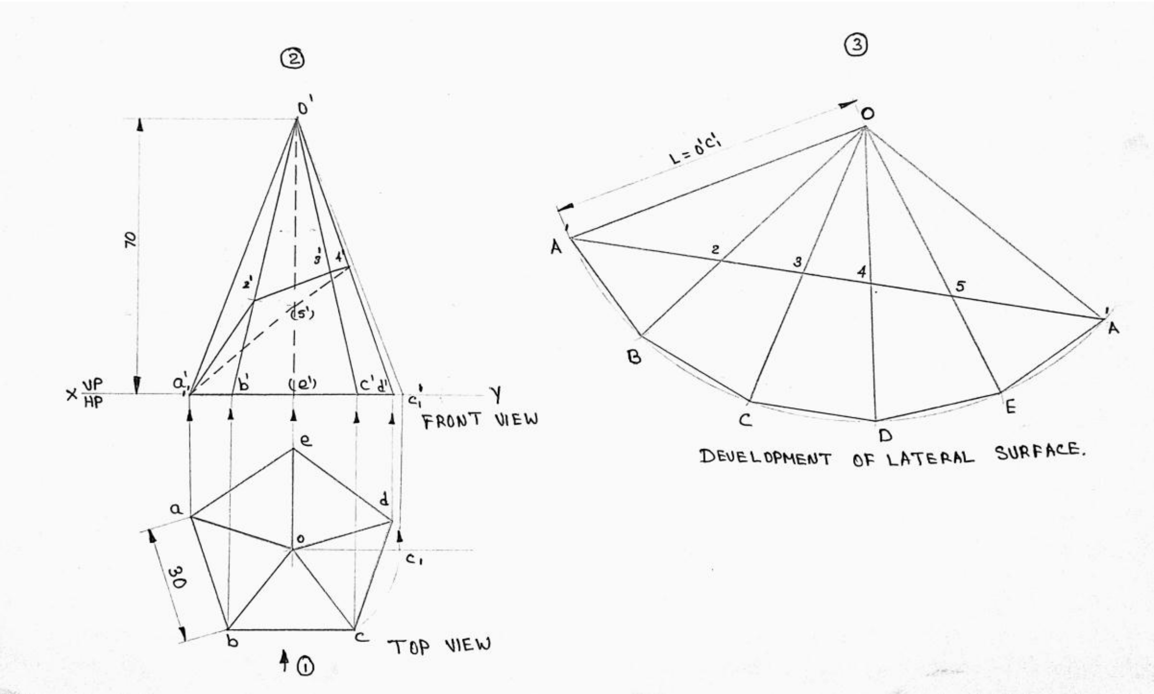
SCALE 1:1 ALL DIMENSIONS ARE IN mm

11. A pentagonal pyramid with base side 30 mm and height 80 mm stands on its base on the HP with one base edge parallel to the VP and nearer to it. It is cut by a plane inclined at 45° to the HP, bisecting the axis. Draw the sectional top view and develop the lateral surfaces of the truncated pyramid.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

12. A pentagonal pyramid with base side 30 mm and height 70 mm rests vertically on the HP with one base edge inclined at 36° to the VP. A string is wound around the surfaces of the pyramid starting from the left extreme point on the base and ending at the same point. Find graphically the shortest length of the string required and trace its path in the front and top views.



SCALE 1:1 ALL DIMENSIONS ARE IN mm

Engineering Graphics is a core subject that develops spatial visualization and accurate graphical representation skills essential for engineering practice.

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It covers key syllabus topics including projections of planes and solids, sectioned solids, and development of surfaces.

All drawings follow first-angle projection and standard engineering conventions.

The book serves as a practical learning aid for both students and faculty.

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