Teaching Aids Required for this Sheet
(The RA should bring them to the class)

- A pair of hinged square acrylic plates; this can be used to denote the quadrants.
- A square acrylic plate to denote auxiliary plane.
- The following shapes in wood or cardboard:
  - Prisms: Cubic, triangular, square, pentagonal, hexagonal, Cylindrical
  - Pyramids: Tetrahedral, Square, pentagonal, hexagonal, Conical.

Note: This is a longer presentation. So the important slides are indicated at the bottom right corner with a yellow star as in this slide.

ME119:
Engineering Drawing & Graphics

8. Development of Surfaces

Department of Mechanical Engineering
Indian Institute of Technology Bombay

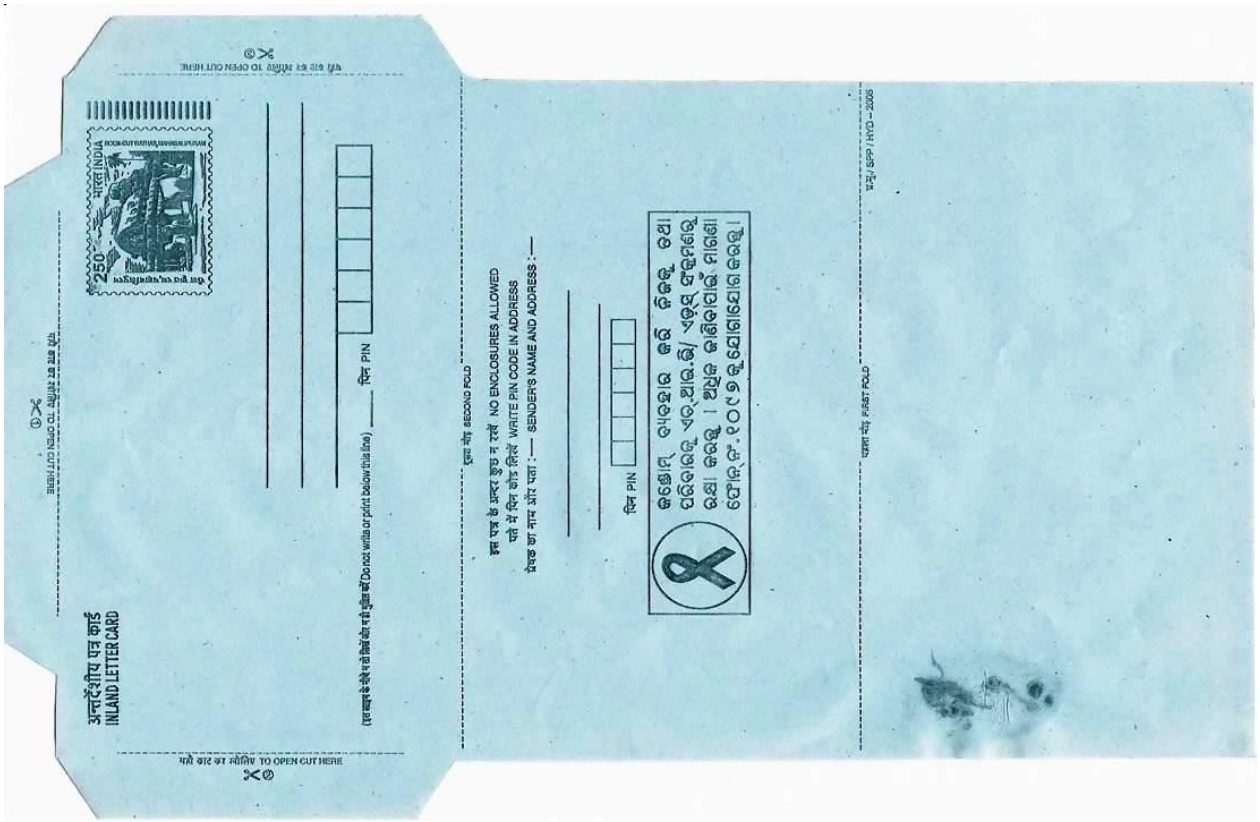
Outline

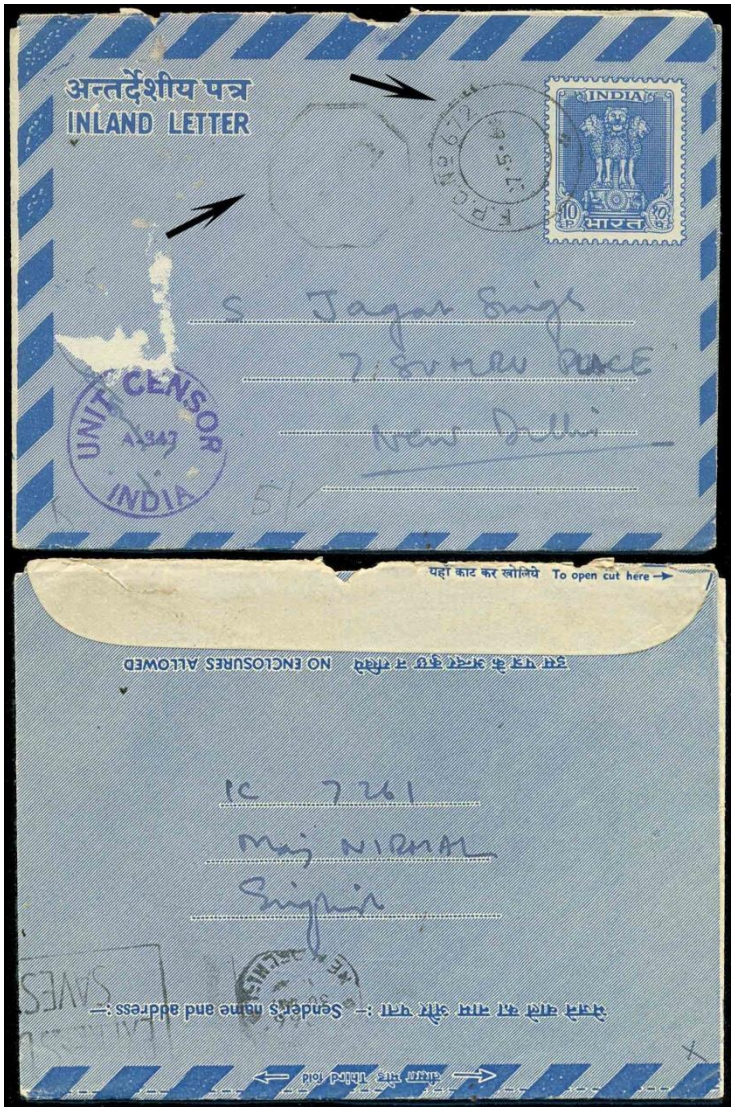
- General instructions/ Discussions
- Development of Prismatic Surfaces
- Development of Pyramidal Surfaces
- Development of Non-Developable Surfaces
- Development of Transition Connectors
- Conclusions

Development of Surfaces

Development of Surfaces

Examples: Inland letters





2D to 2D

Development of Surfaces

Examples: Envelopes & packing boxes

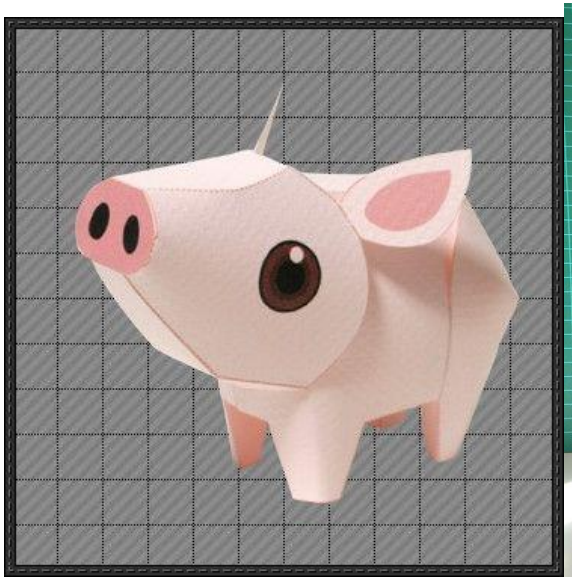
2D to 3D

2D to 2D

Development of Surfaces

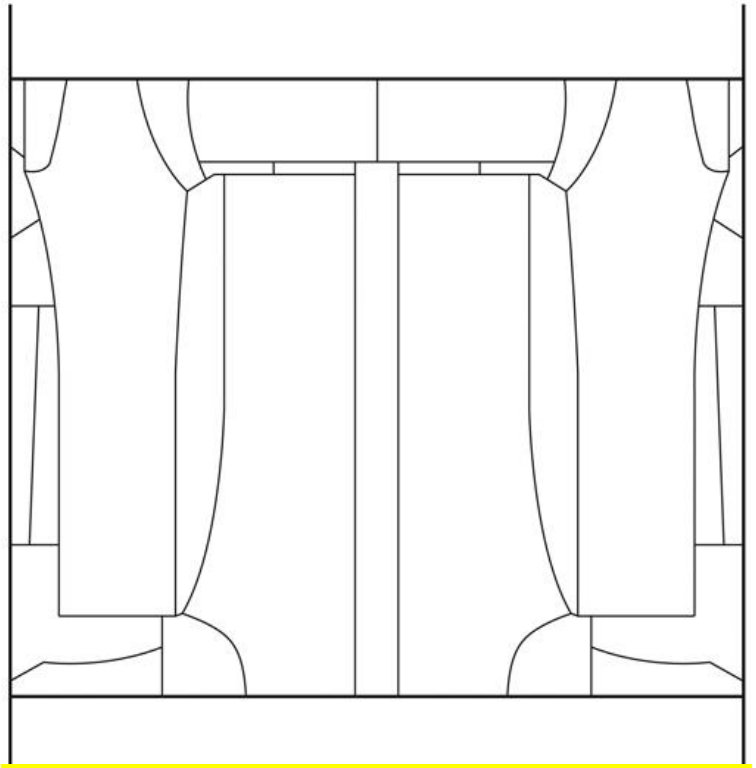
Examples: Toys

2D to 3D



Development of Surfaces

Examples: Garments

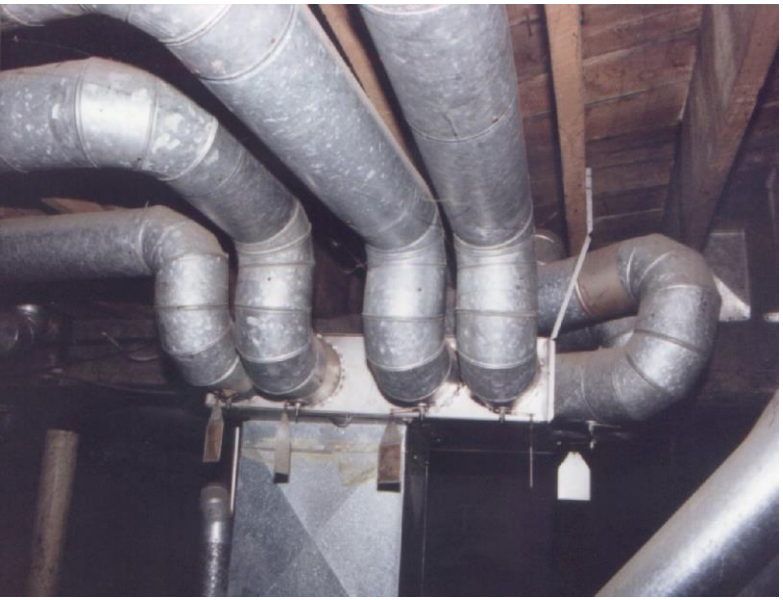


2D to 3D

Optimization too!

Development of Surfaces

Examples: Engineering objects



Development of Surfaces

Examples: Other engineering objects

Development of Surfaces

Need

- Many objects of desire have considerable sheet metal parts. Examples: aircraft, automobile, boiler, house-hold vessels, ducts, pipes, funnels, stapler etc. Simpler examples of sheet products are cardboard boxes, paper envelopes, inland letters, garments, etc.
- Most of these parts are hollow and their shapes are curved but the raw material is invariably available in the form of sheet (metal/ material), i.e., flat surfaces. The required planar shape, known as *Flat Pattern (FP)*, to produce the part has to be calculated, cut from the sheet stock optimally using nesting and then folded or formed. Note that these hollow objects can be manufactured from their solid blocks or molten liquid, perhaps to better geometric accuracy, but
  - it will be enormous waste of material and production resources
  - sometimes difficult due to poor access to the tools
  - strength will be better when made from sheet

Development of Surfaces

- The method of determining the FP for any part is known as development of the surface of the part.
- We shall presently neglect the thickness of the sheet although it is finite.

Developability of Surfaces

- Note that every surface is not developable. So, let us define the notion of *developability*. A surface, assumed to be of zero thickness, is developable if and only if it can be formed/flattened without (i) wrinkles or (ii) tears during development. For a real surface with thickness, these defects translate into (i) thinning or (ii) tear (extreme form of thinning, i.e., zero thickness) or (iii) thickening or (iv) wrinkles (extreme form of thickening, i.e., doubling of thickness).
- Alternately, a 3D sheet metal surface is said to be developable if we can identify a straight line along which it can be cut and opened into a planar shape without any variation in thickness.

Is a plane developable or not?

Classification of Surfaces

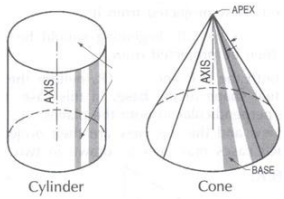
Surfaces

Singly Curved (Ruled)

Doubly Curved

Singly Ruled

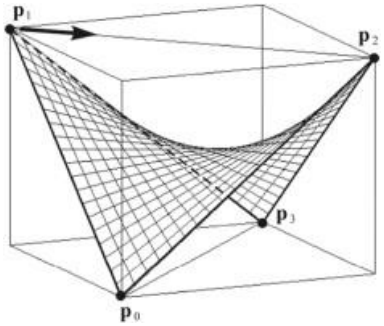
Multi-Ruled



Cylinder Cone

Developable

Hyperboloid



Bi-linear surface

Sphere

Non-developable

Development of Non-Developable Surfaces

- They are formed with wrinkles and thinning.
- Alternately, they can be built as polyhedral objects.
- If you cannot tolerate both the above, avoid sheet metal route and use other manufacturing processes such as machining or casting or welding.

Methods of Development of Surfaces

1. Parallel line development - for prisms including cylinders
2. Radial line development - for pyramids including cones
3. Triangulation development - for transition pieces
4. Approximate development - for non-developable surfaces

Note: For the purpose of development, it is required to obtain the true lengths.

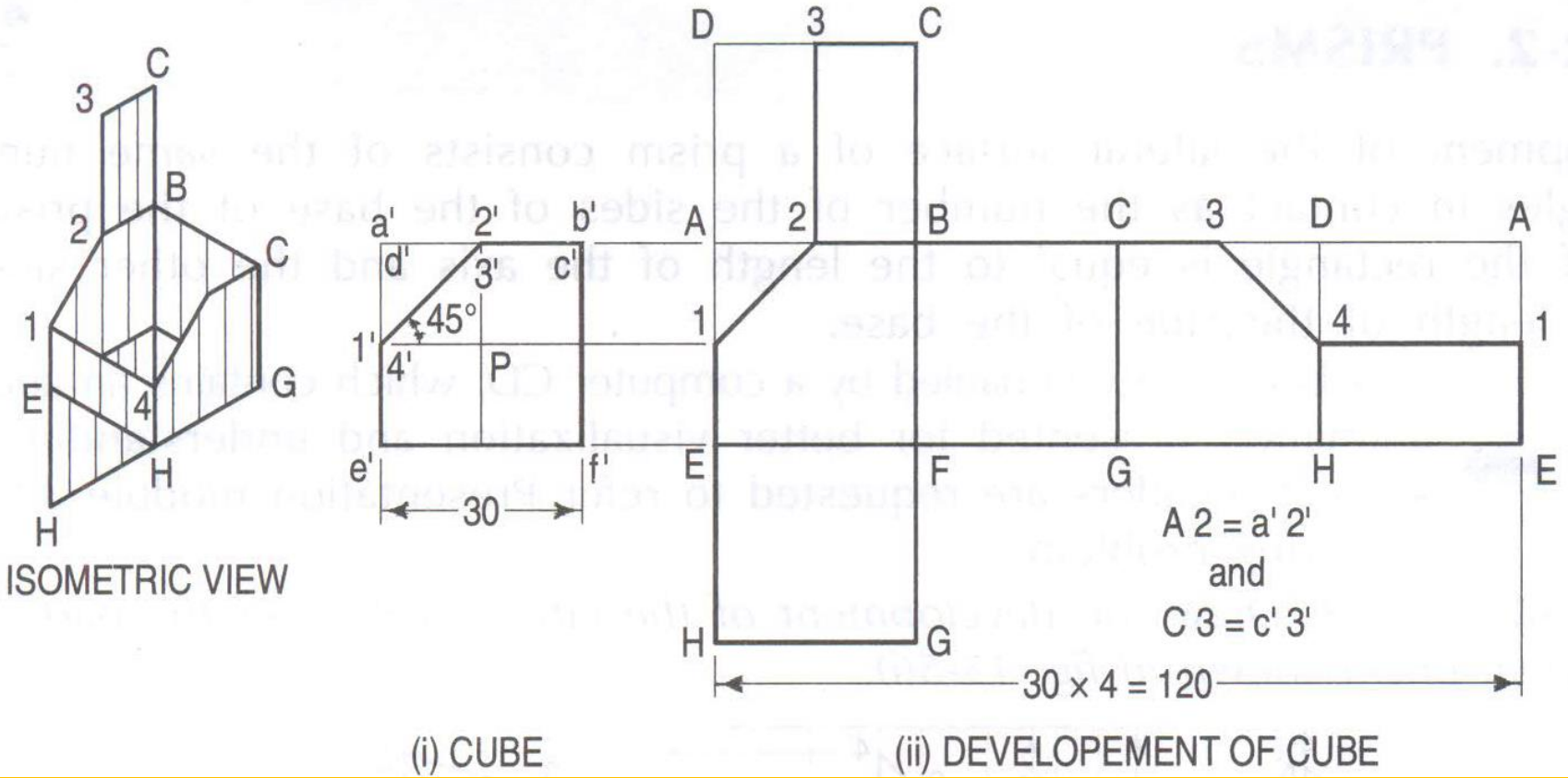
In this course, we shall be mostly concerned with the development of only developable surfaces.

Development of Prismatic Surfaces

Development of Surfaces

Example-1 (Solved Pb. 15-1, pp. 353)

Draw the development of a trimmed cube whose front view is given.

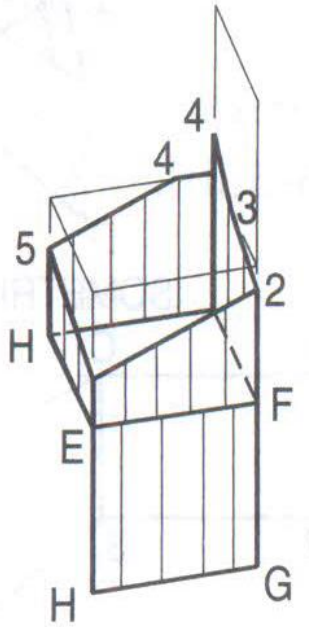


Proper labelling is essential. Points in FP are always in capital letters as they are 3D.

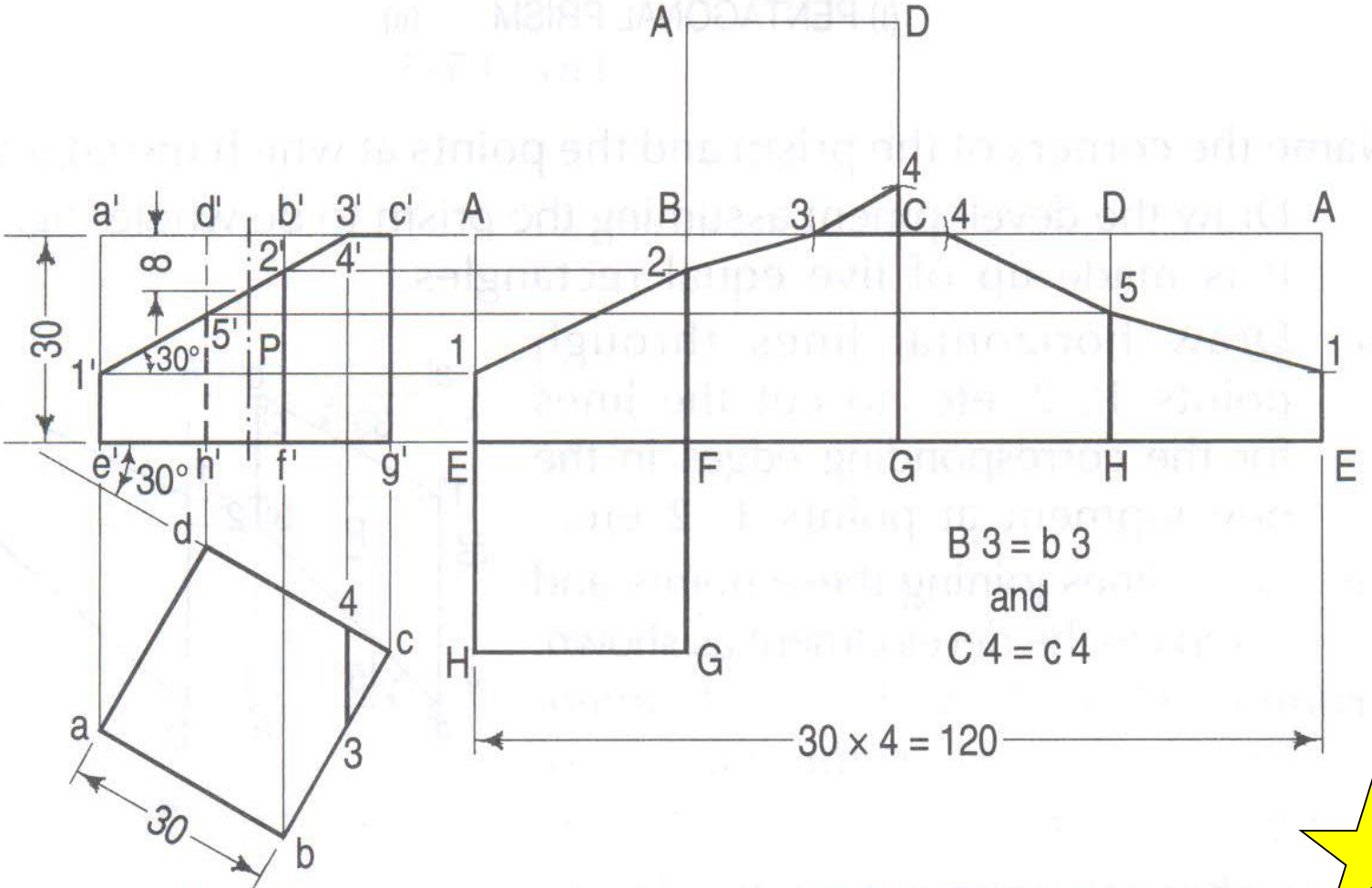
Development of Surfaces

Example-2 (Solved Pb. 15-2, pp. 353)

Draw the development of a trimmed cube whose two views are given.



ISOMETRIC VIEW



(i) CUBE

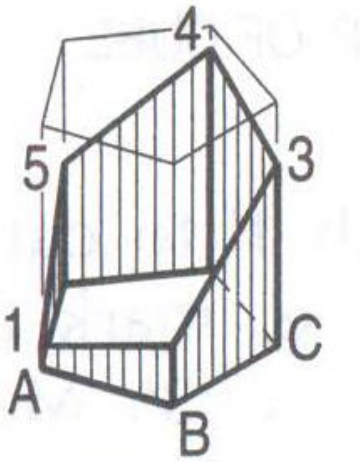
(ii) DEVELOPEMENT OF CUBE

Note the selection of top lid. This is to maintain continuity of the pieces.

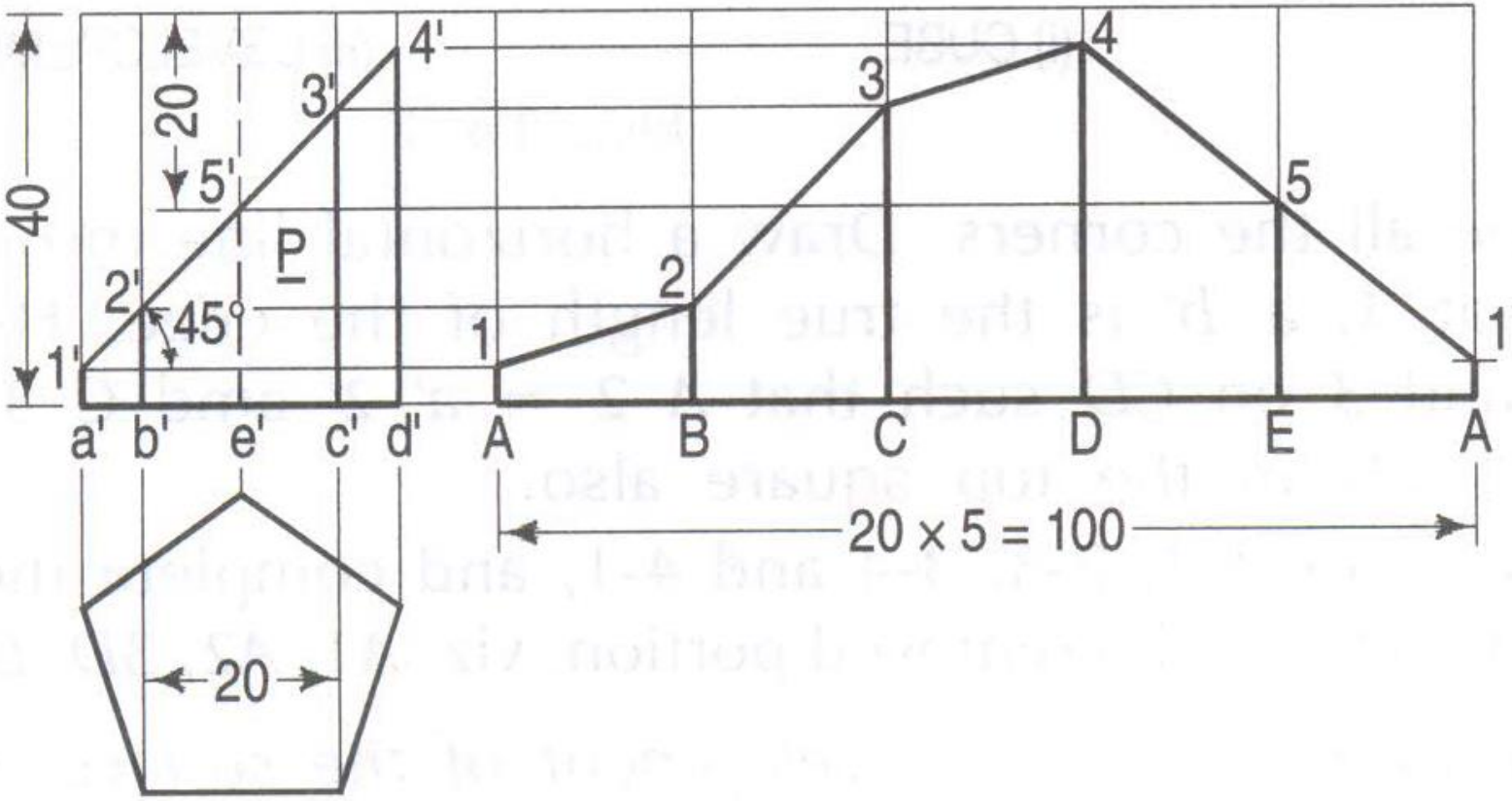
Development of Surfaces

Example-3 (Solved Pb. 15-3, pp. 354)

Draw the development of a trimmed pentagonal prism.



ISOMETRIC VIEW

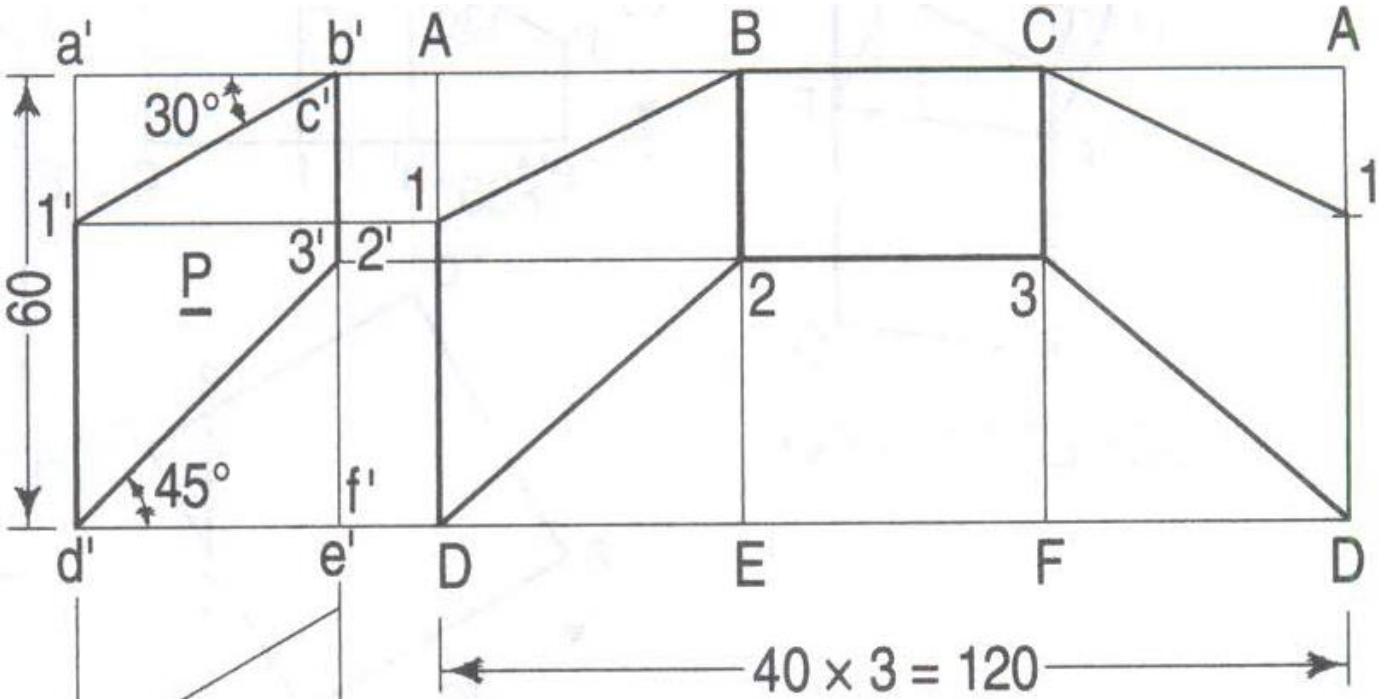


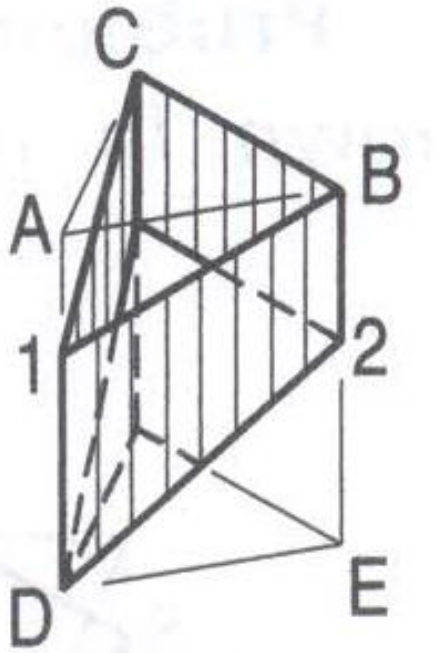
(i) PENTAGONAL PRISM (ii) DEVELOPEMENT OF PRISM

Development of Surfaces

Example-4 (Solved Pb. 15-4, pp. 354)

Draw the development of a trimmed triangular prism.



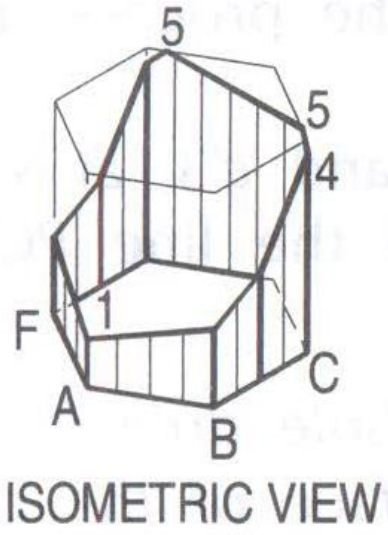


ISOMETRIC VIEW

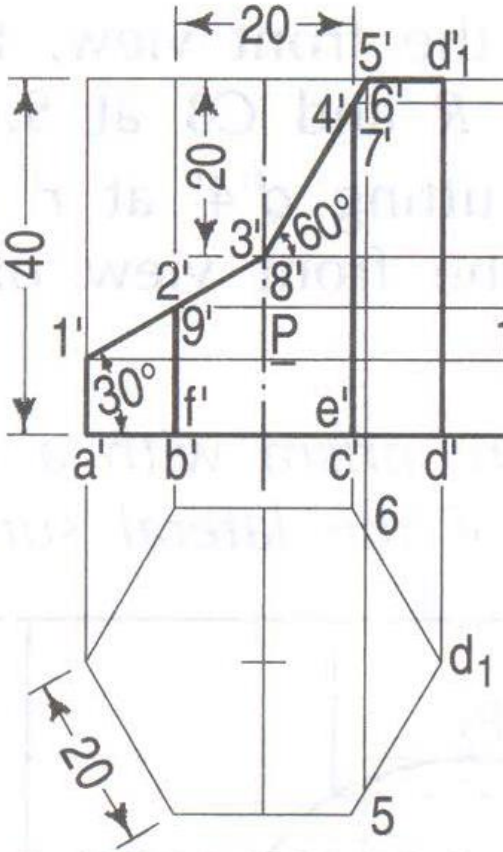
Development of Surfaces

Example-5 (Solved Pb. 15-5, pp. 355)

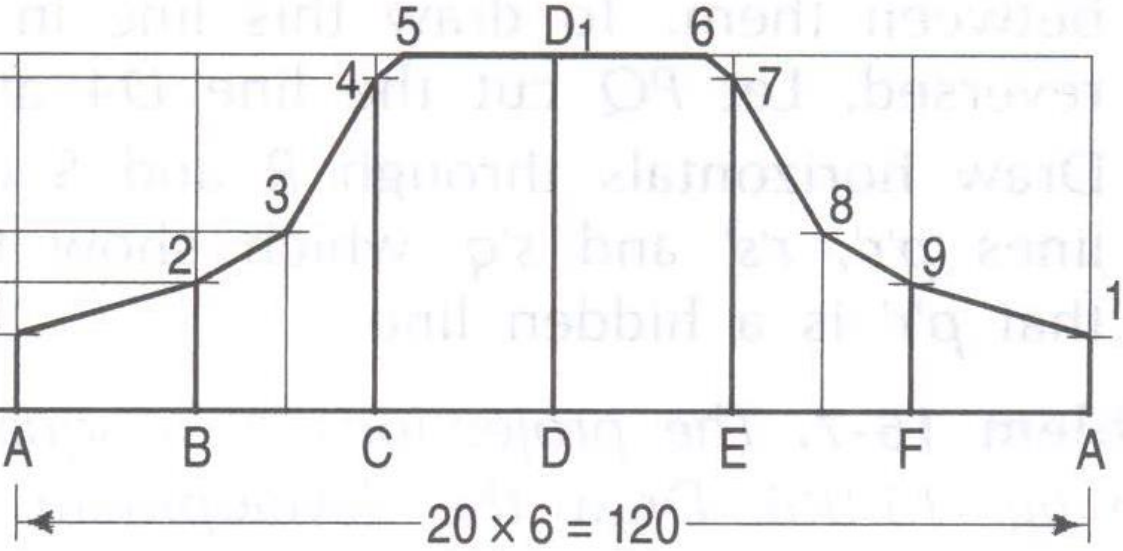
Draw the development of a trimmed hexagonal prism.



ISOMETRIC VIEW



(i) HEXAGONAL PRISM



$d_1 6 = D_1 6$

AND

$d_1 5 = D_1 5$

(ii) DEVELOPEMENT OF PRISM

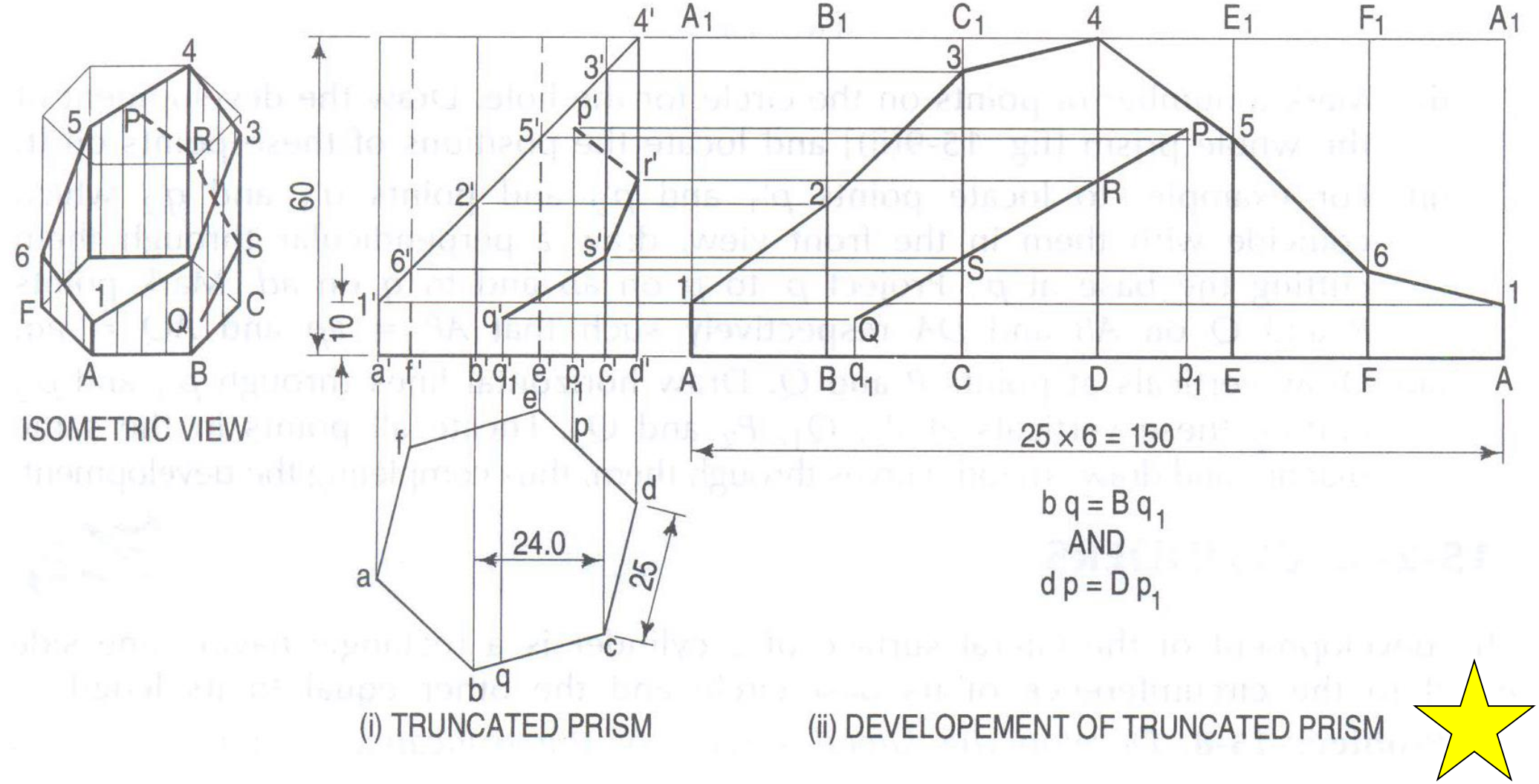
Development of Surfaces

Example-6 (Solved Pb. 15-6, pp. 355)

Draw the development of the lateral surface of the truncated prism shown in the figure. Also, draw the front view of the line joining the points P and Q (whose projections p, p’ and q, q’ are given) along the surfaces of the prism by the shortest distance.

Development of Surfaces

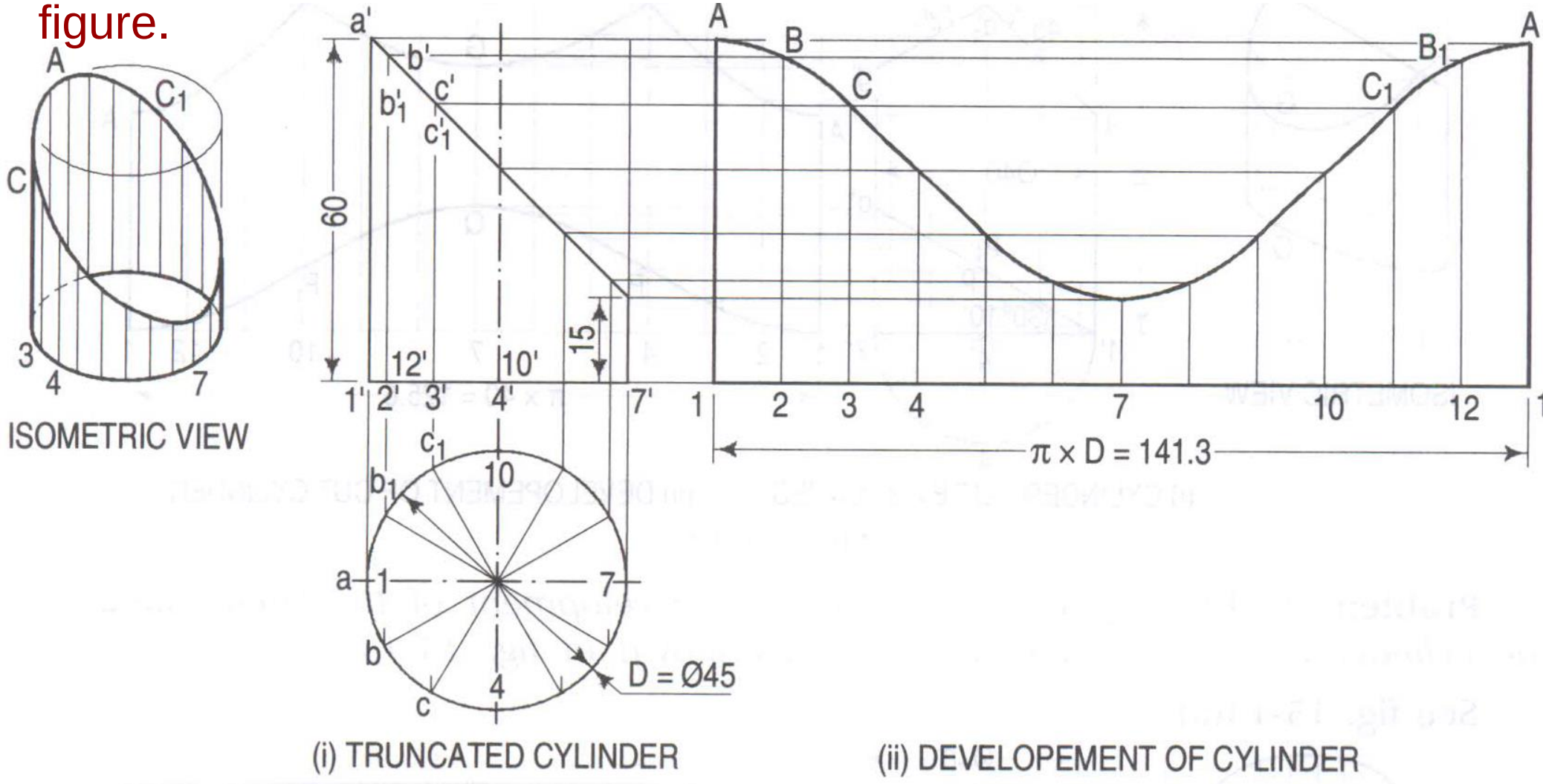
Example-6 (Solved Pb. 15-6, pp. 355) …



Development of Surfaces

Example-7 (Solved Pb. 15-8, pp. 356)

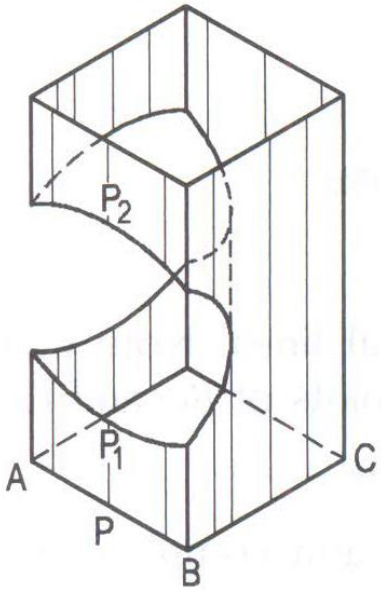
Develop the lateral surface of the truncated cylinder shown in the figure.



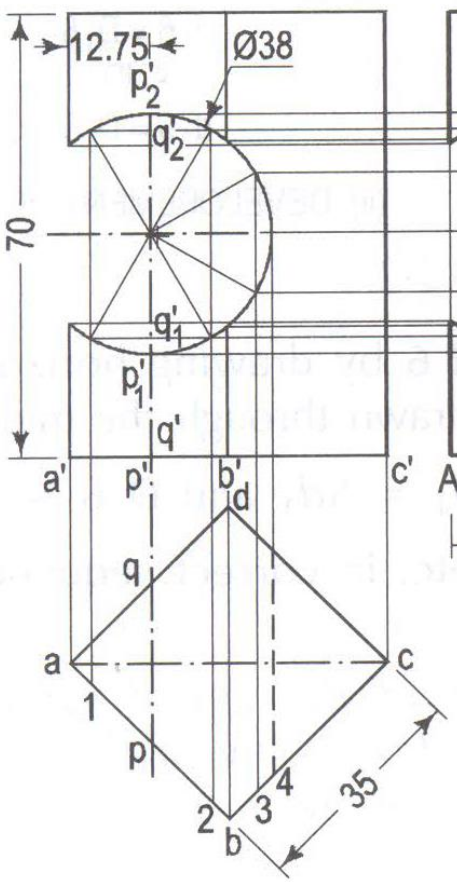
Development of Surfaces

Example-8 (Solved Pb. 15-7, pp. 356)

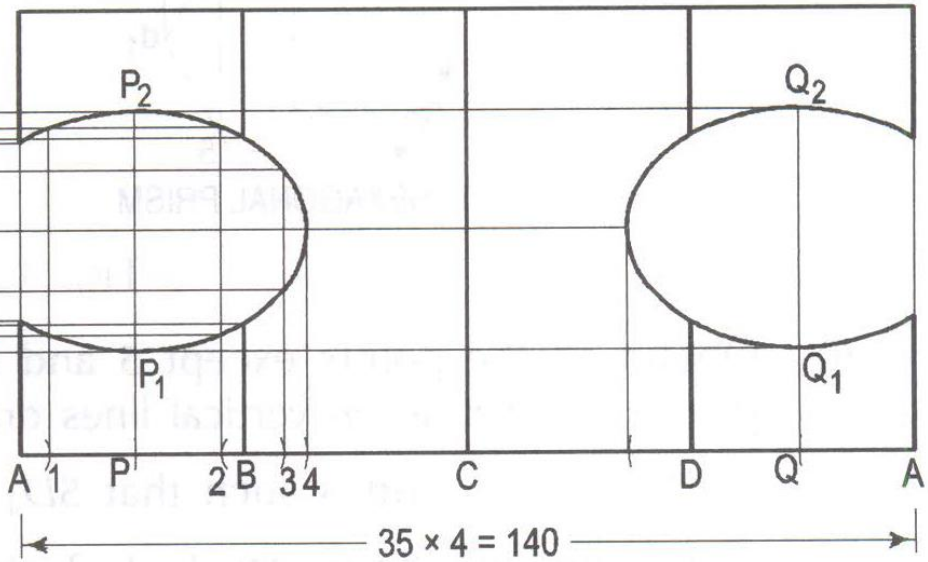
The projections of a square prism with a hole drilled in it are given in the figure. Draw the development of the lateral surface of the prism.



ISOMETRIC VIEW



(i) SQUARE PRISM



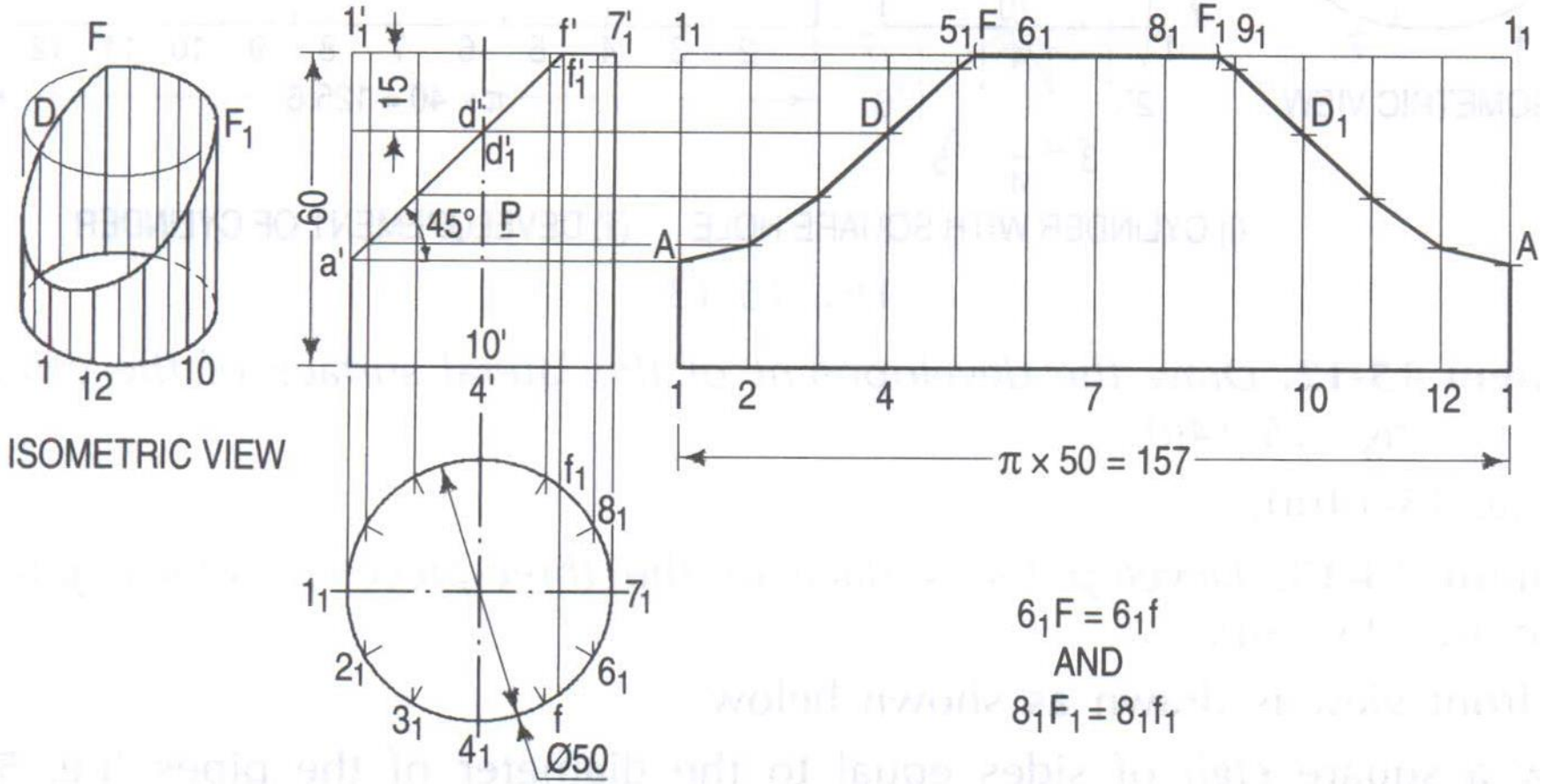
A P = a p
AND
A Q = a q

(ii) DEVELOPEMENT OF PRISM

Development of Surfaces

Example-9 (Solved Pb. 15-9, pp. 357)

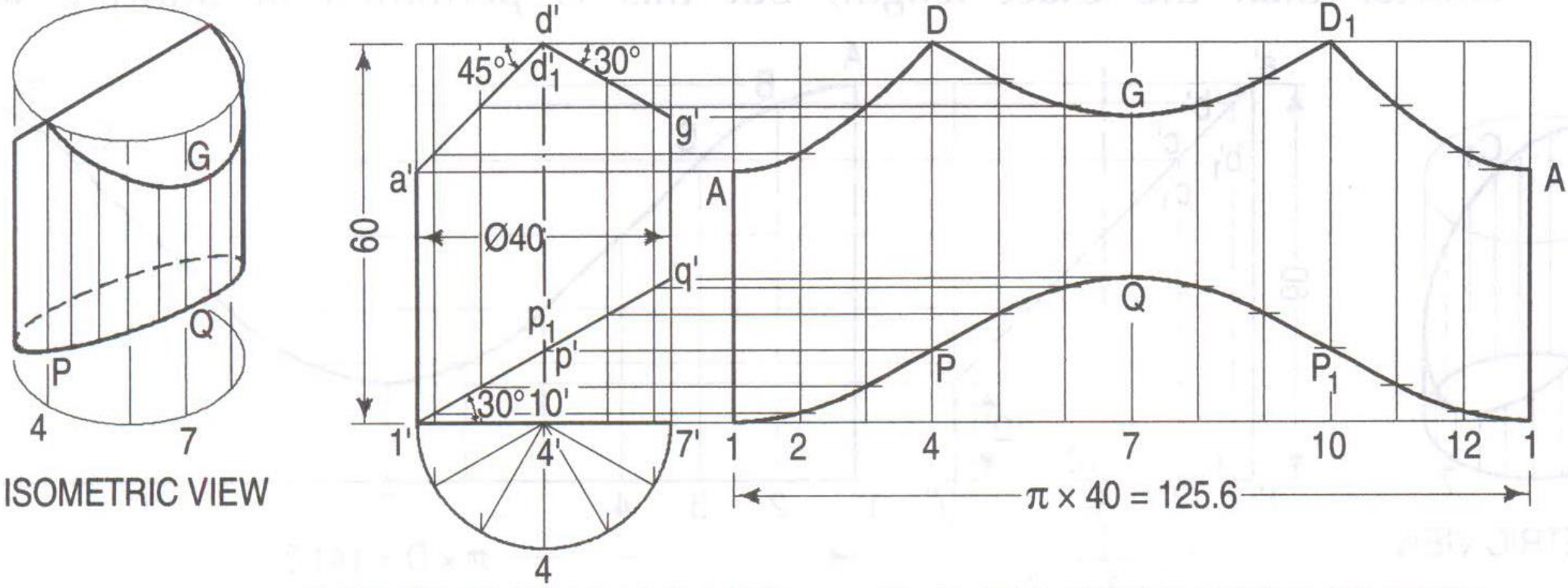
Draw the development of the lateral surface of the part P of the cylinder shown in the figure.



Development of Surfaces

Example-10 (Solved Pb. 15-10, pp. 358)

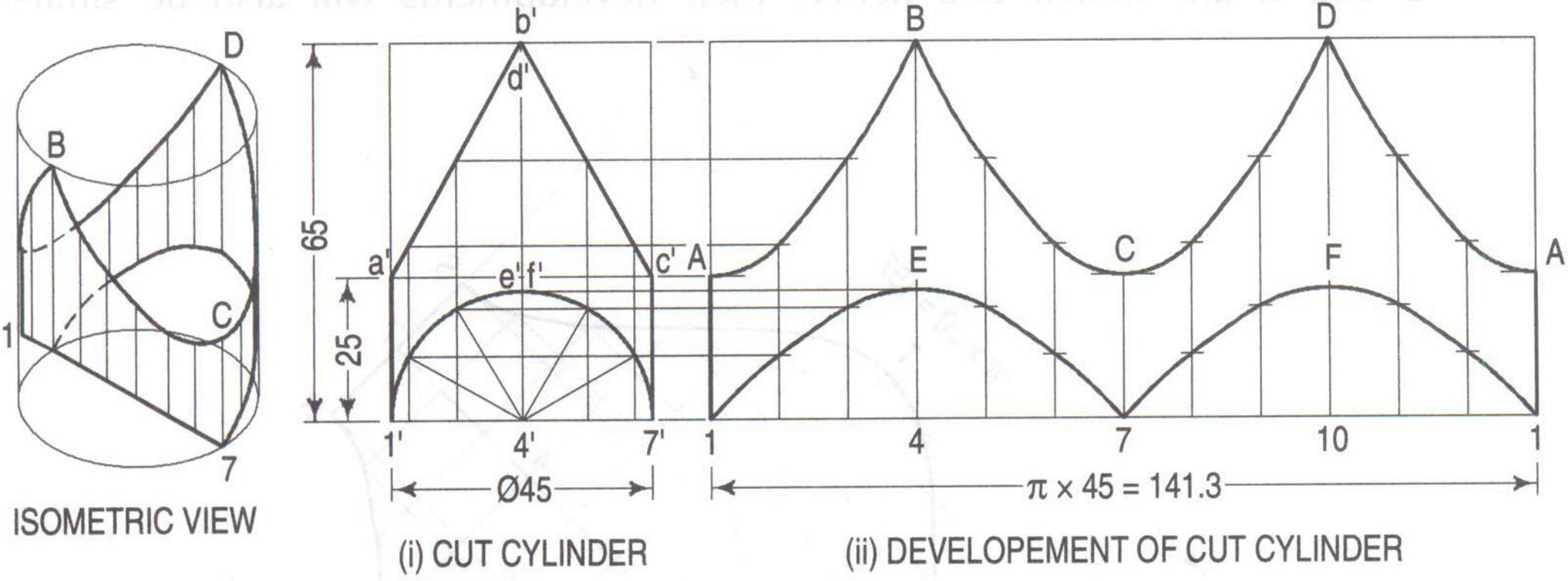
Draw the development of the lateral surface of the cylinder cut by three planes as shown in the figure.



Development of Surfaces

Example-11 (Solved Pb. 15-12, pp. 358)

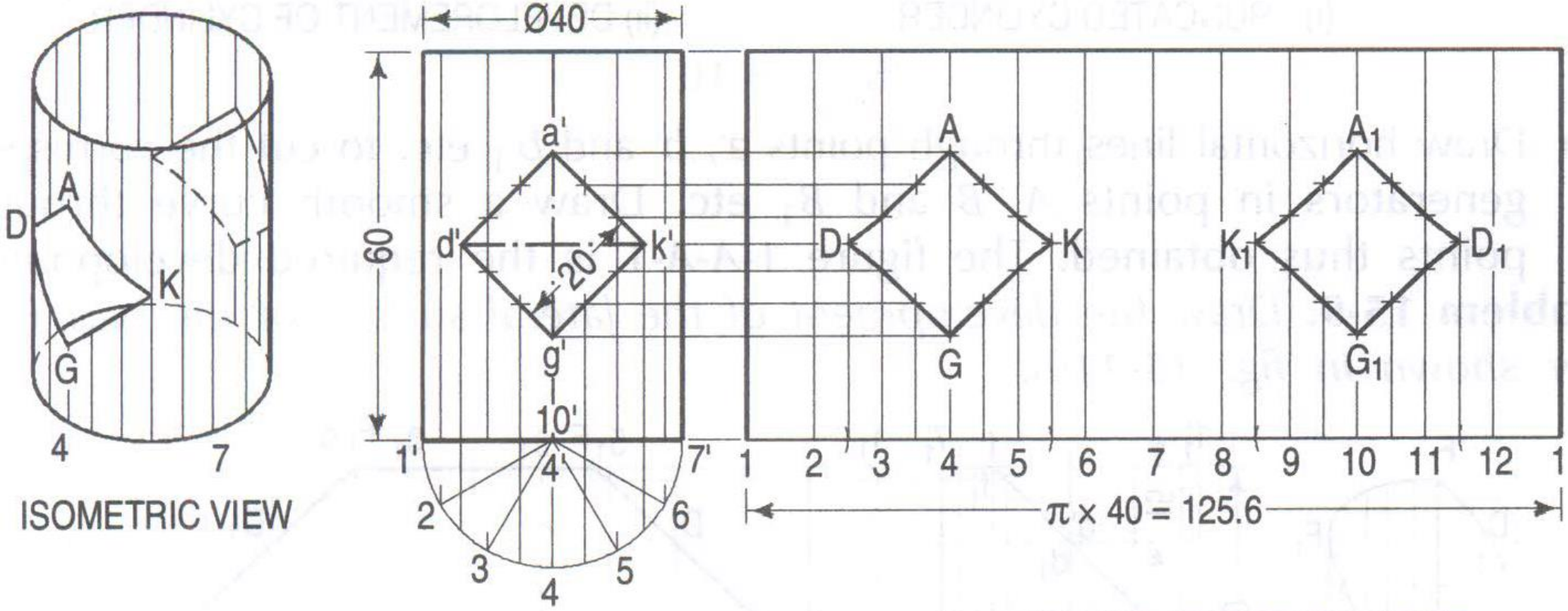
Draw the development of the lateral surface of the cylinder cut as shown in the figure.



Development of Surfaces

Example-12 (Solved Pb. 15-11, pp. 358)

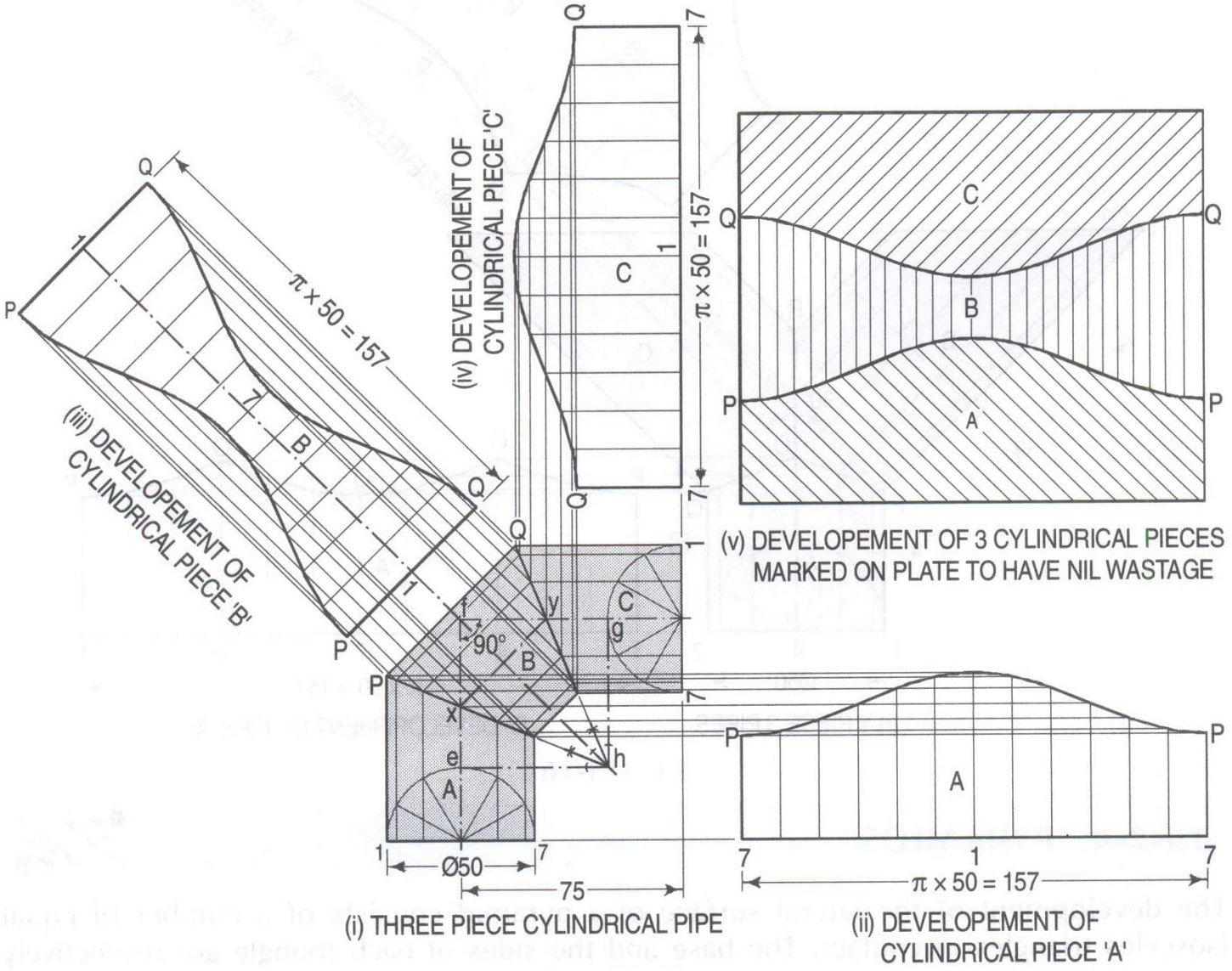
Draw the development of the lateral surface of the cylinder having a square hole in it as shown in the figure.



Development of Surfaces

Example-13 (Solved Pb. 15-13, pp. 359)

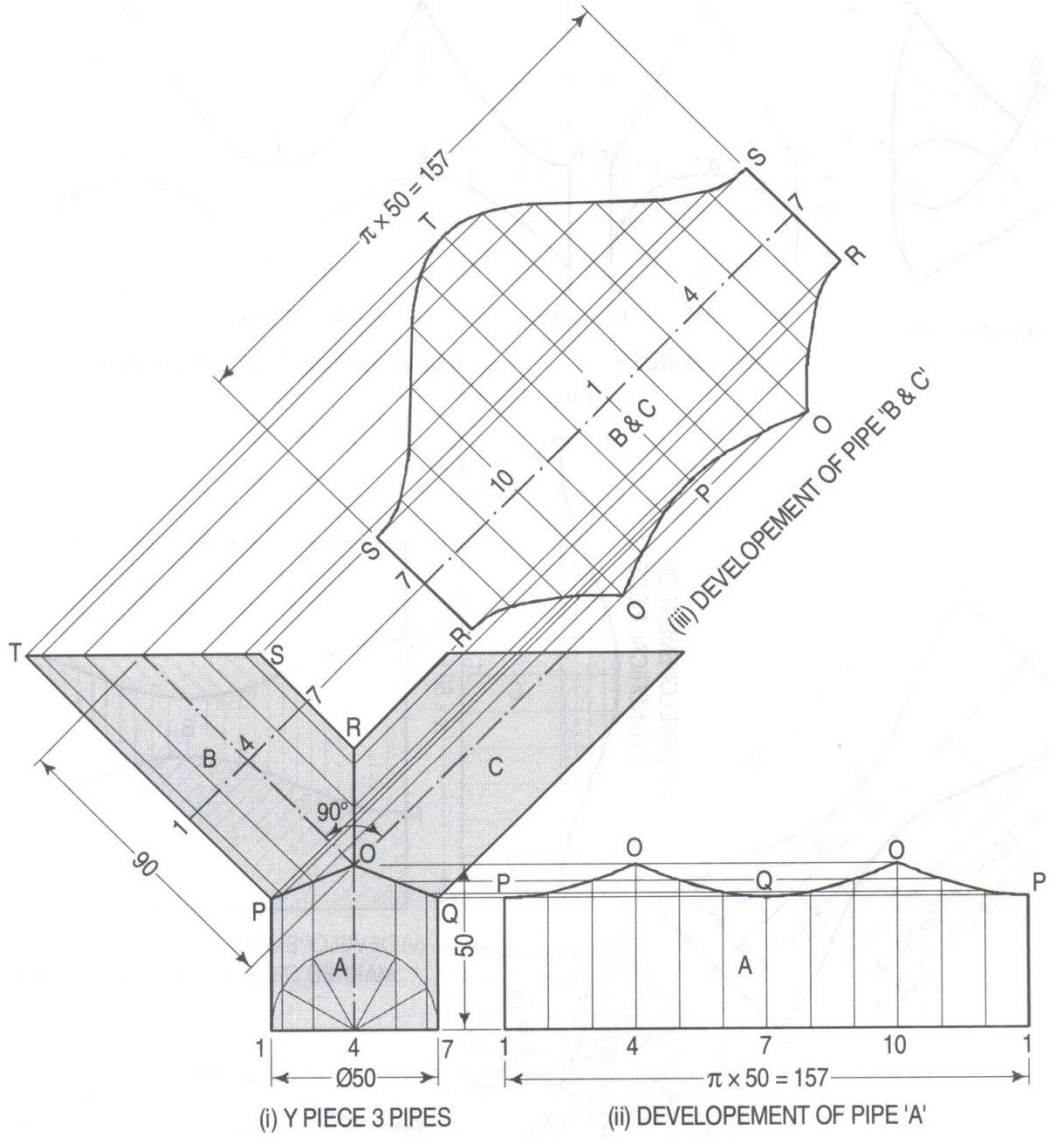
Develop the surface of the three-piece cylindrical pipe elbow shown in the figure.



Development of Surfaces

Example-14 (Solved Pb. 15-14, pp. 360)

Three cylindrical pipes of 50 mm diameter from a y-piece as shown in the front view of the figure. Draw the development of the surface of each pipe.



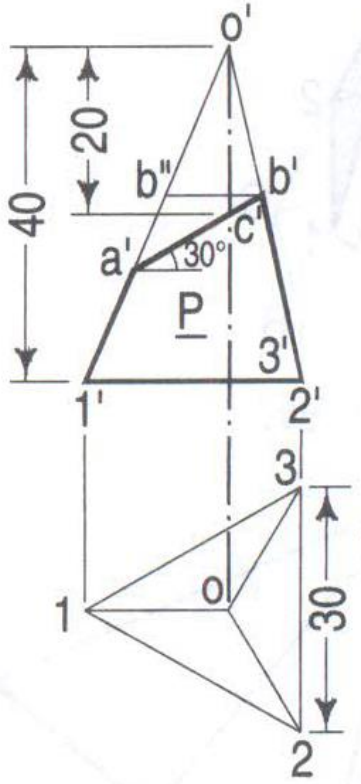
Development of Pyramidal Surfaces

Development of Surfaces

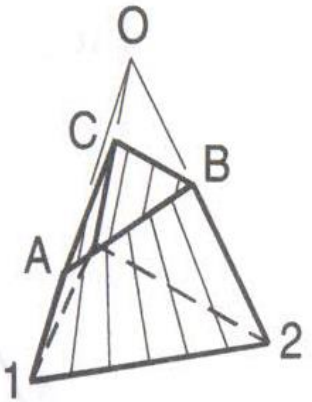
Example-15 (Solved Pb. 15-15, pp. 361)

Draw the development of the lateral surface of the part P of the triangular pyramid shown in the figure.

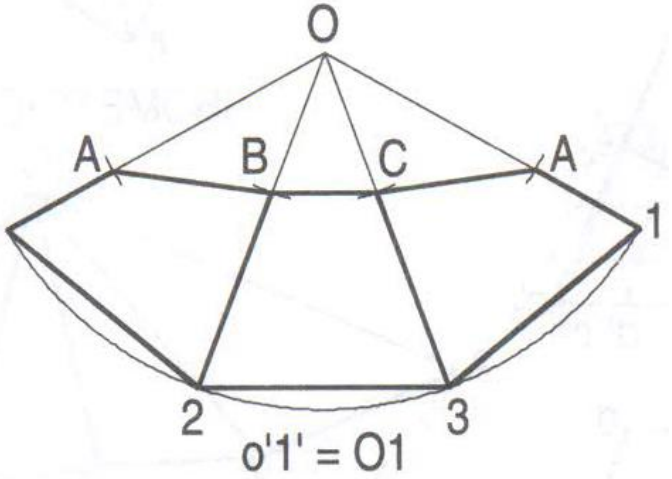
Hint: The line o'1' in the front view is the true length of the slant edge because it is parallel to xy in the top view. The true length of the side of the base is seen in the top view.



(i) TRIANGULAR PYRAMID



ISOMETRIC VIEW

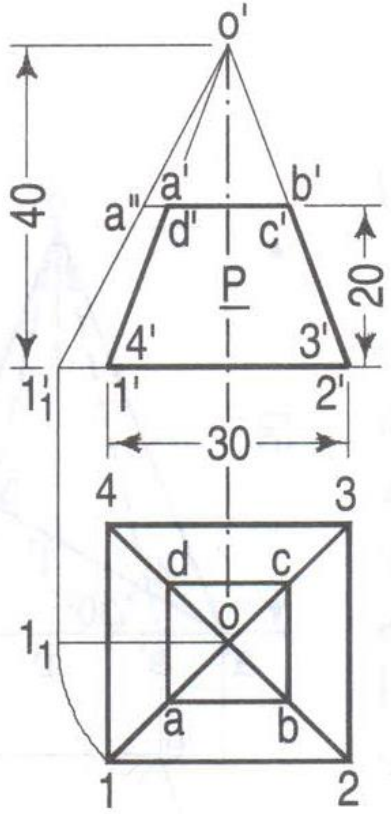


(ii) DEVELOPEMENT OF TRIANGULAR PYRAMID

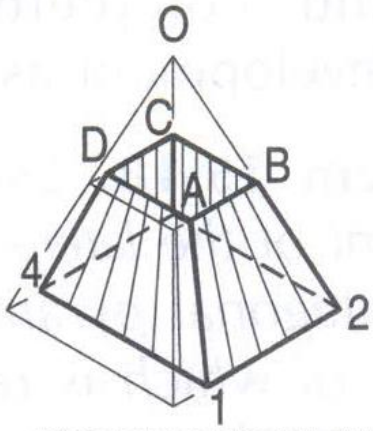
Development of Surfaces

Example-16 (Solved Pb. 15-16, pp. 361)

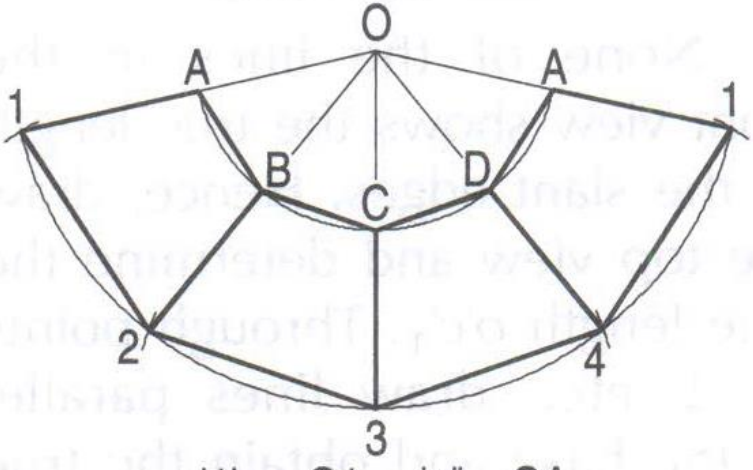
Draw the development of the lateral surface of the frustum of the square pyramid shown in the figure.



(i) SQUARE FRUSTUM PYRAMID



ISOMETRIC VIEW



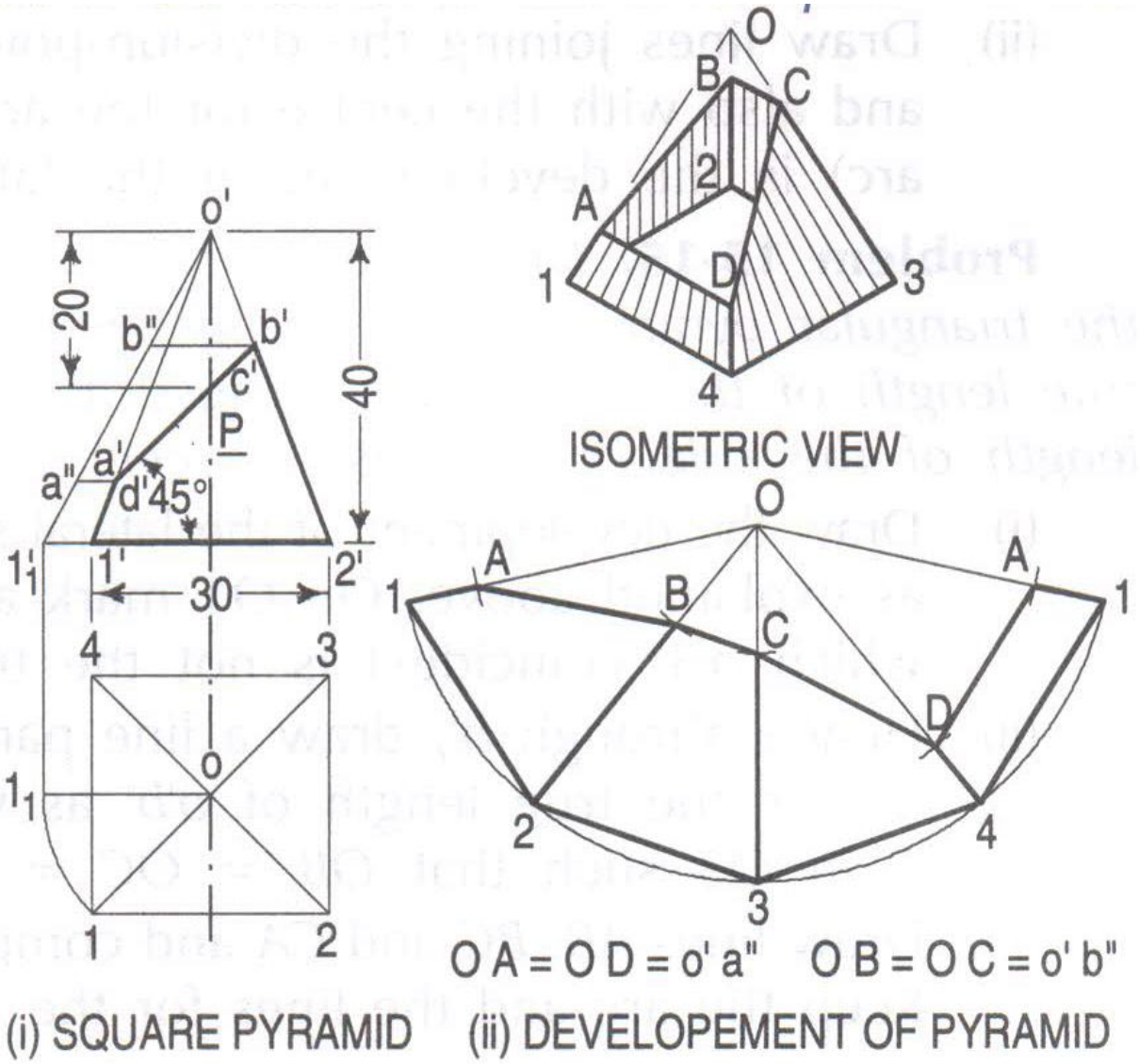
$o'1'_1 = O1$ $o'a'' = OA$

(ii) DEVELOPEMENT OF PYRAMID

Development of Surfaces

Example-17 (Solved Pb. 15-17, pp. 362)

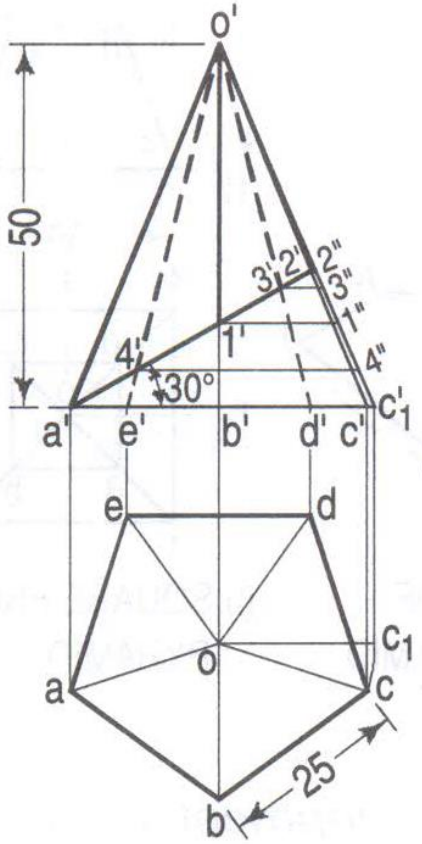
Draw the development of the lateral surface of the part P of the square pyramid shown in the figure.



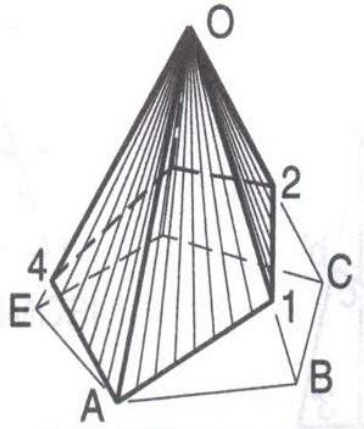
Development of Surfaces

Example-18 (Solved Pb. 15-18, pp. 362)

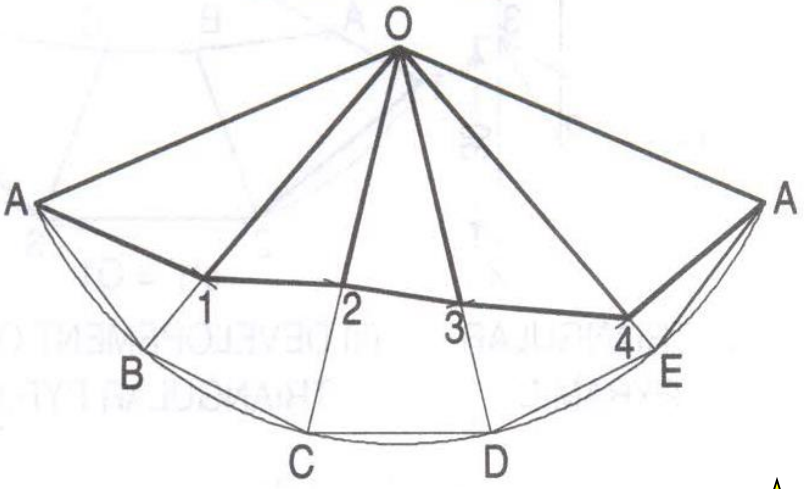
Draw the development of the lateral surface of the pentagonal pyramid, the lower part of which is removed as shown in the figure.



(i) PENTAGONAL PYRAMID



ISOMETRIC VIEW



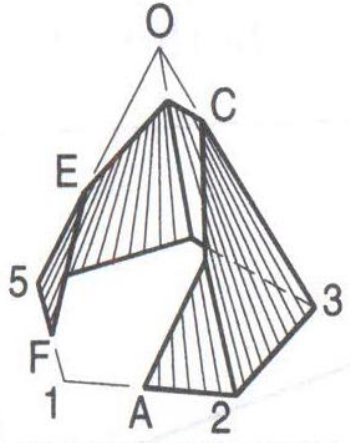
O 1 = o' 1" O 2 = o' 2"
O 3 = o' 3" O 4 = o' 4"

(ii) DEVELOPEMENT OF PYRAMID

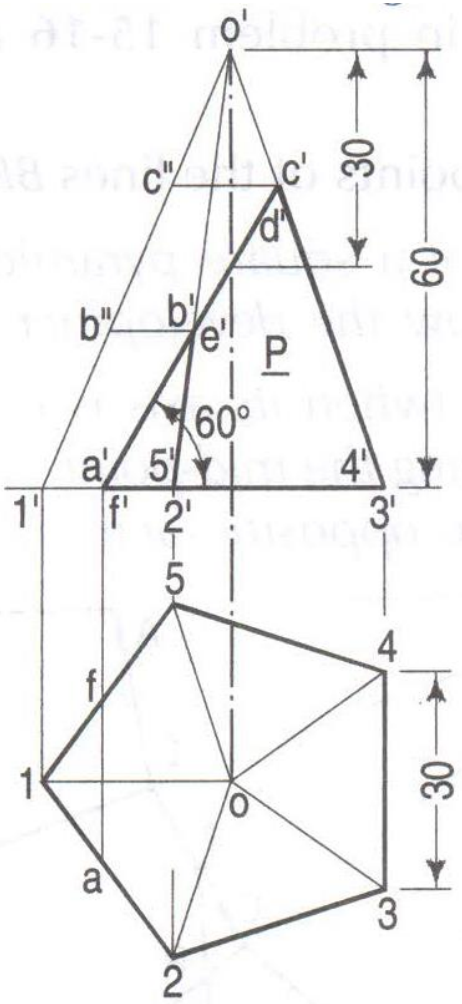
Development of Surfaces

Example-19 (Solved Pb. 15-19, pp. 363)

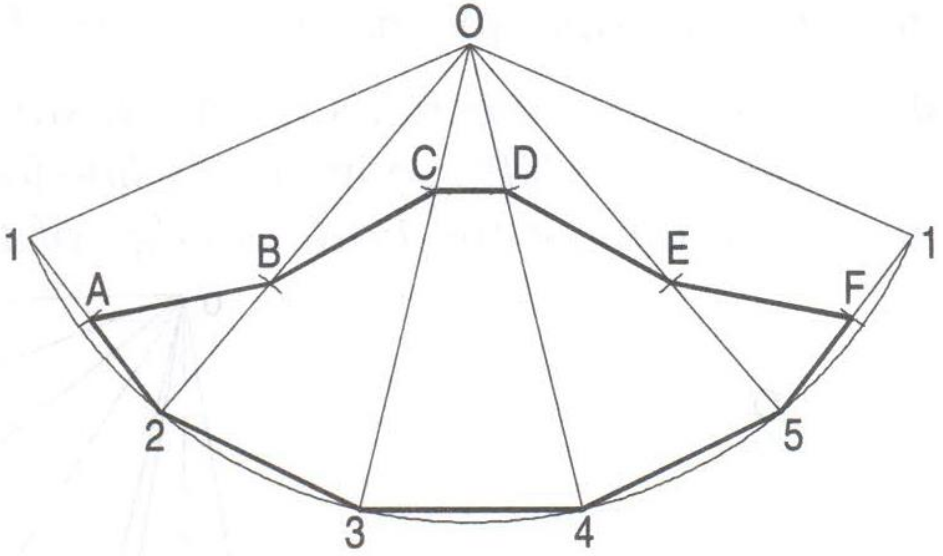
Draw the development of the lateral surface of the part P of the pentagonal pyramid as shown in the figure.



ISOMETRIC VIEW



(i) PENTAGONAL PYRAMID



O 1 = o' 1' O E = o' b" O B = o' b" 1 A = 1 a

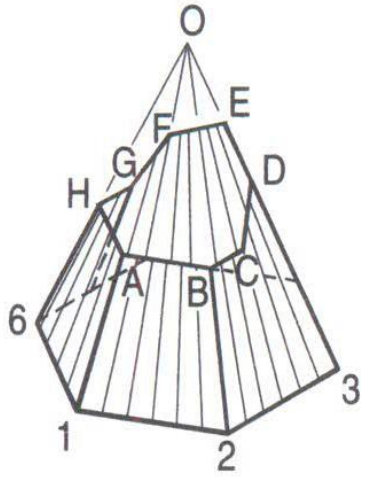
O C = o' c" 1 F = 1 f O D = o' c"

(ii) DEVELOPEMENT OF PYRAMID

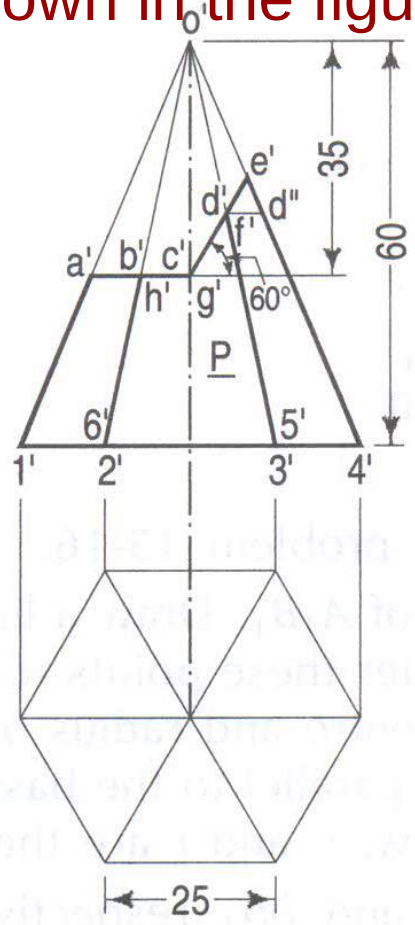
Development of Surfaces

Example-20 (Solved Pb. 15-20, pp. 363)

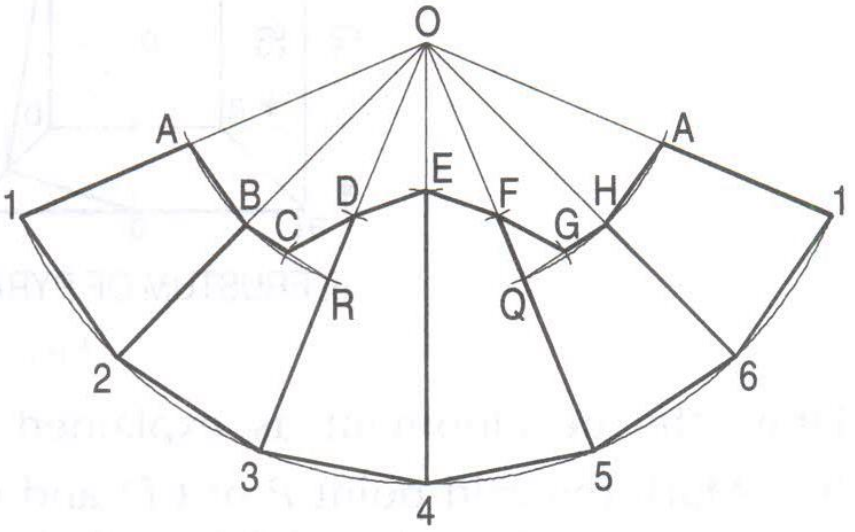
Draw the development of the lateral surface of the part P of the hexagonal pyramid shown in the figure.



ISOMETRIC VIEW



(i) HEXAGONAL PYRAMID



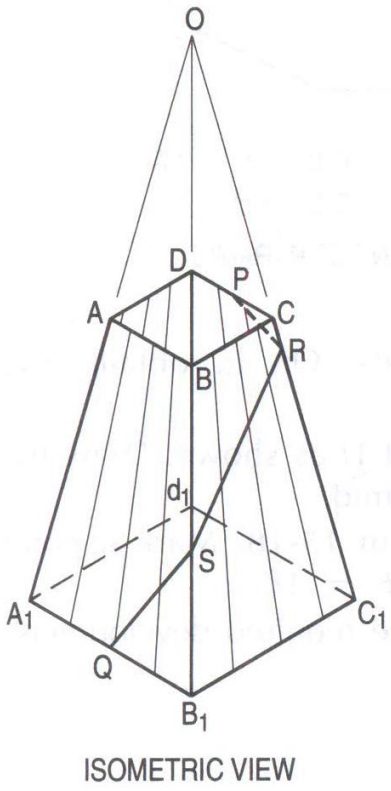
O 1 = o' 1' O E = o' e'
O A = O H = O Q = o' a'
O D = O F = o' d"
O A = O B = O R = o' a'
B C = C R H G = G Q

(ii) DEVELOPEMENT OF PYRAMID

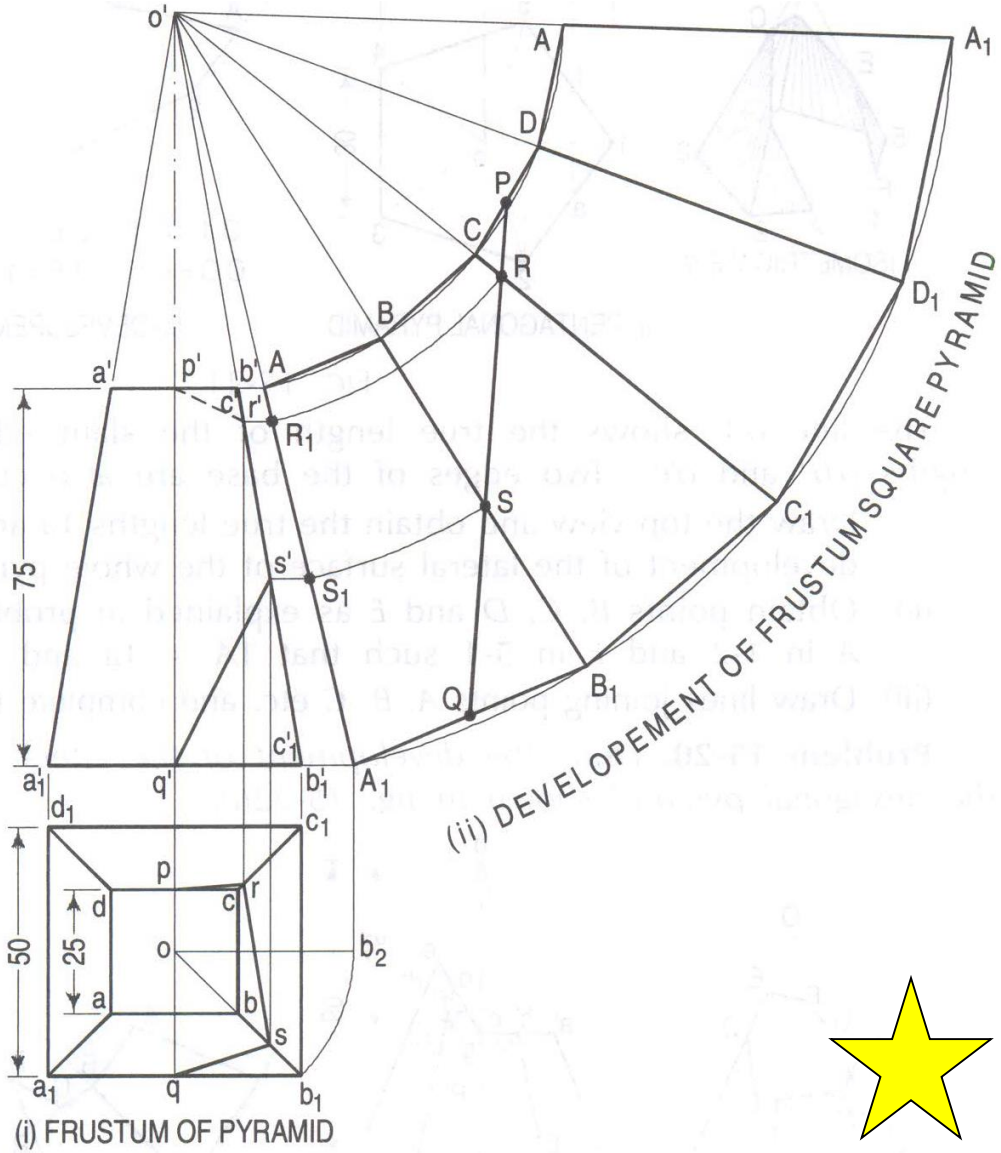
Development of Surfaces

Example-21 (Solved Pb. 15-21, pp. 364)

A frustum of a square pyramid has its base 50 mm side, top 25 mm side and height 75 mm. Draw the development of its lateral surface.



ISOMETRIC VIEW



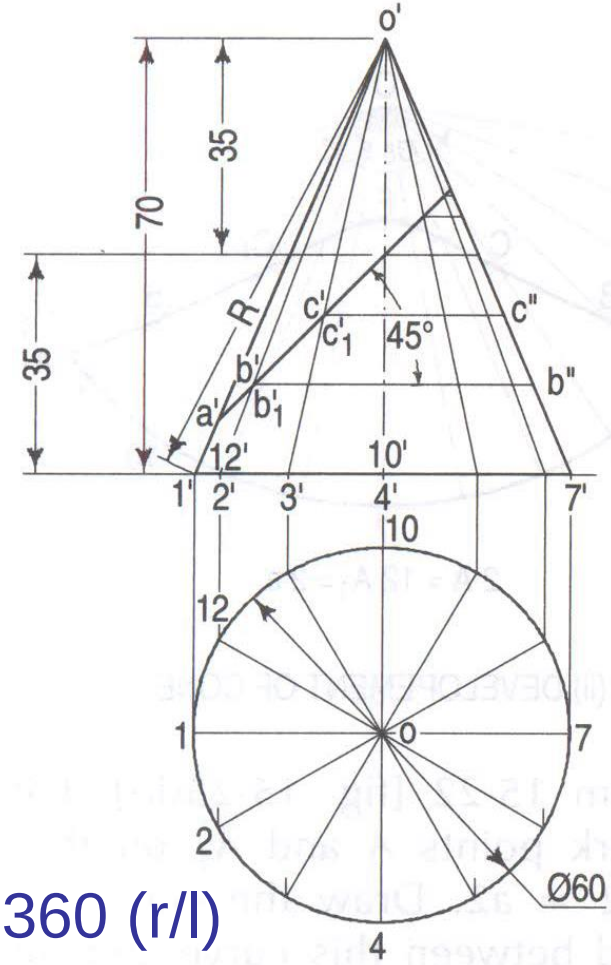
(ii) DEVELOPEMENT OF FRUSTUM SQUARE PYRAMID

(i) FRUSTUM OF PYRAMID

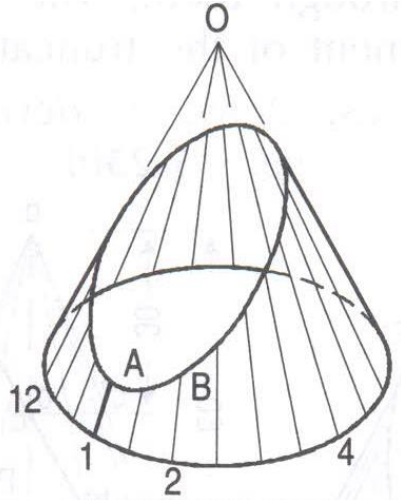
Development of Surfaces

Example-22 (Solved Pb. 15-22, pp. 365)

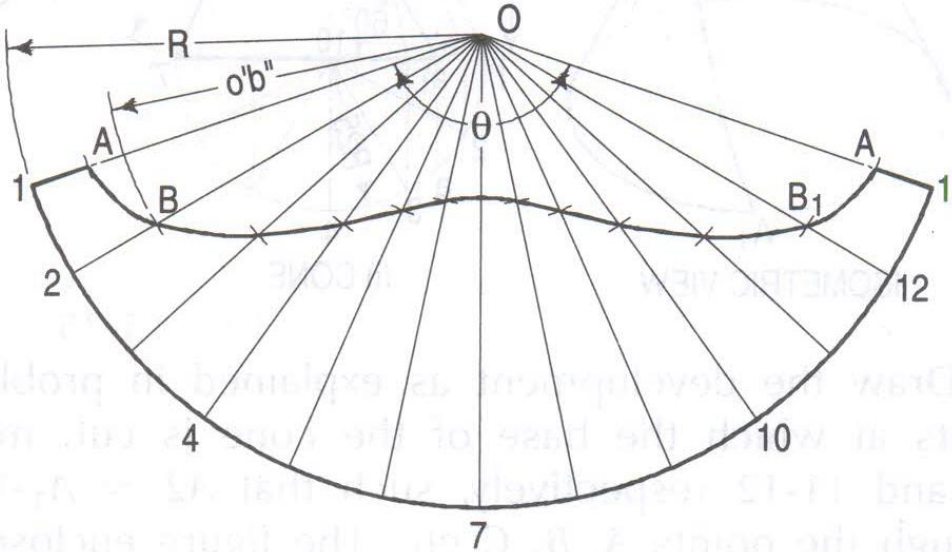
Draw the development of the lateral surface of the truncated cone shown in the figure.



(i) TRUNCATED CONE



ISOMETRIC VIEW



(ii) DEVELOPEMENT OF TRUNCATED CONE

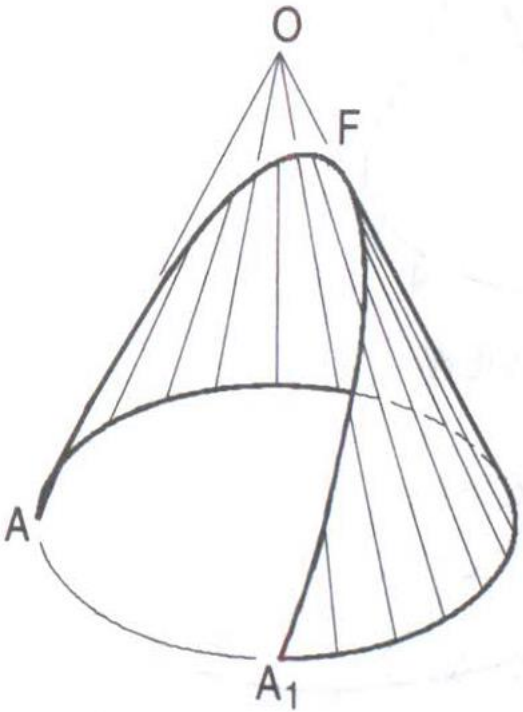
Note:

Sector angle = 360 (r/l)

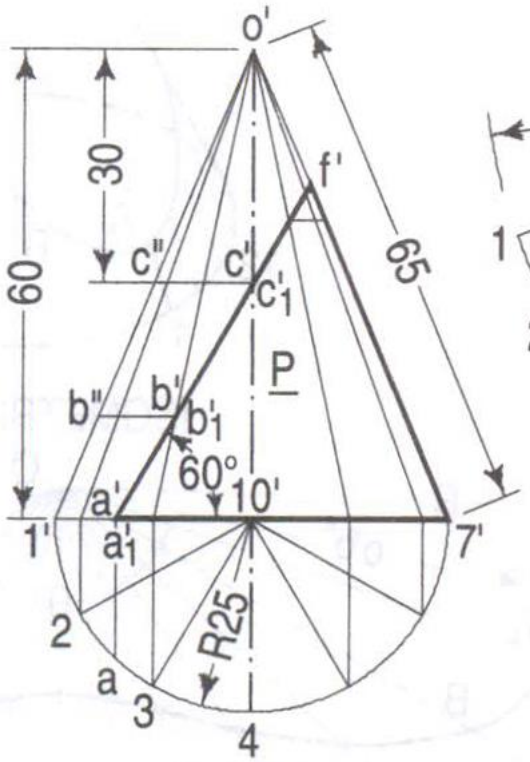
Development of Surfaces

Example-23 (Solved Pb. 15-23, pp. 366)

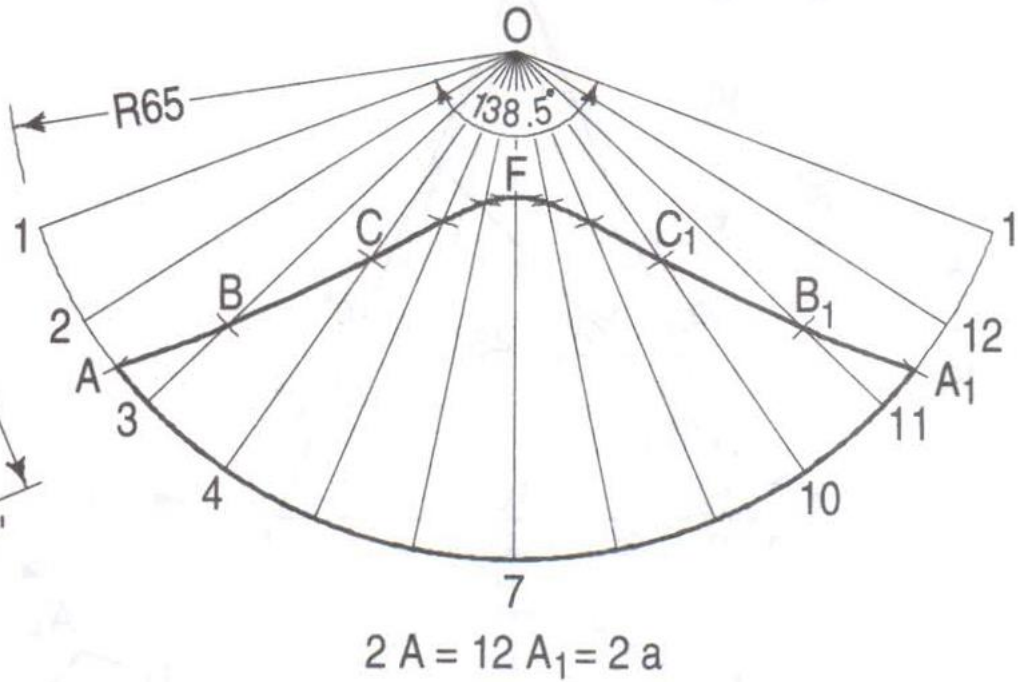
Draw the development of the lateral surface of the truncated cone shown in the figure.



ISOMETRIC VIEW



(i) CONE



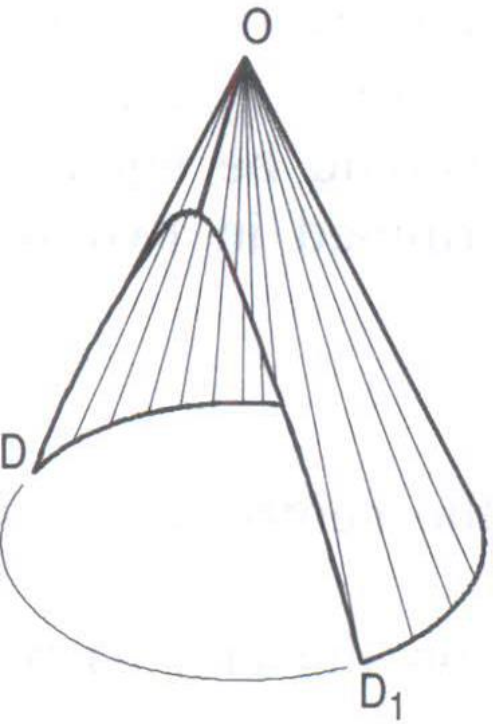
$2A = 12A_1 = 2a$

(ii) DEVELOPEMENT OF CONE

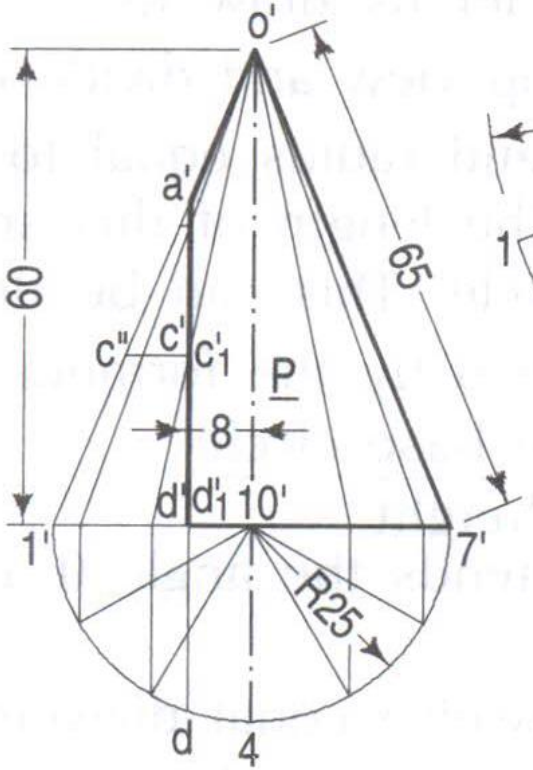
Development of Surfaces

Example-24 (Solved Pb. 15-24, pp. 366)

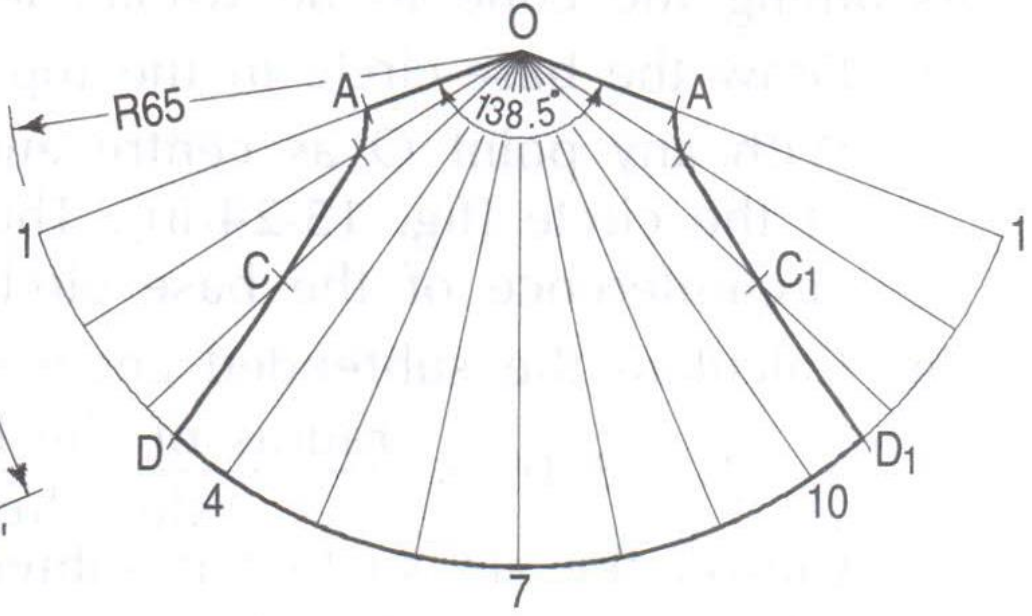
Draw the development of the lateral surface of the part P of the cone shown in the figure.



ISOMETRIC VIEW



(i) CONE



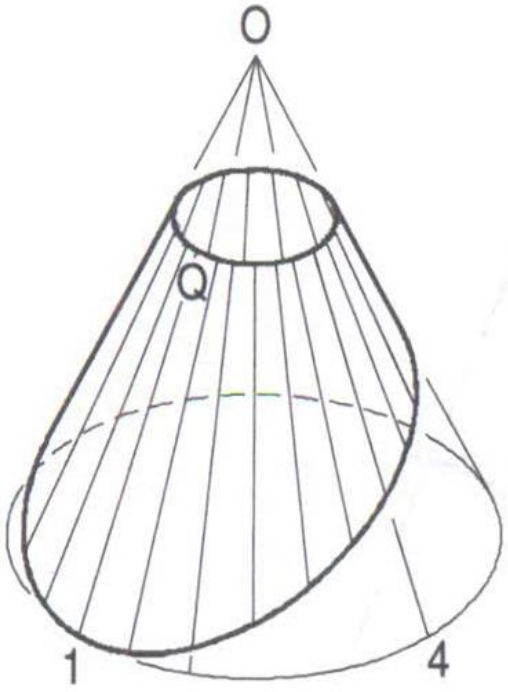
4 D = 10 D_1 = 4 d

(ii) DEVELOPEMENT OF CONE

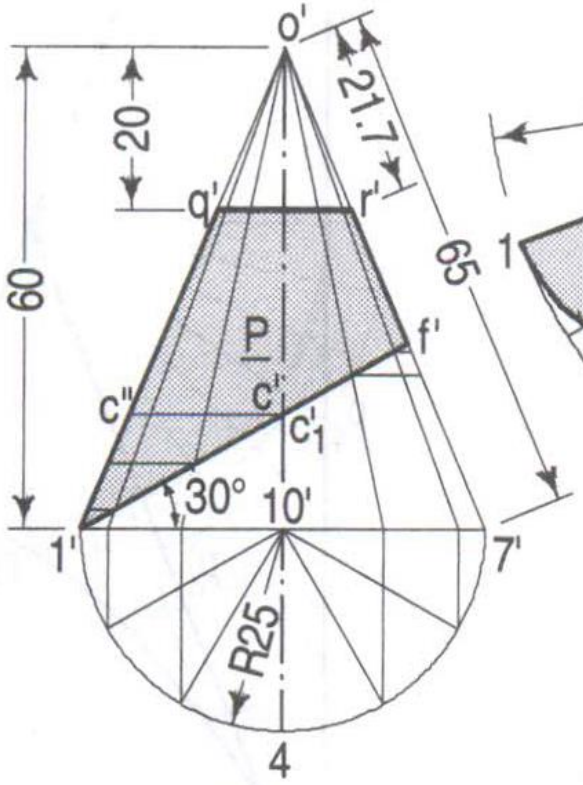
Development of Surfaces

Example-25 (Solved Pb. 15-25, pp. 367)

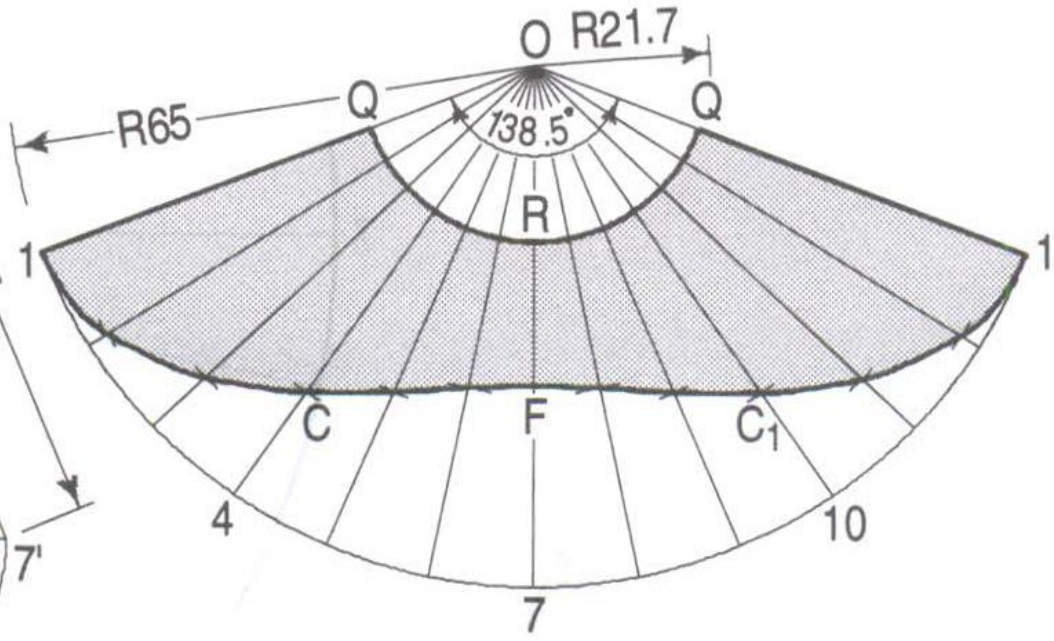
Draw the development of the lateral surface of the part P of the cone shown in the figure.



ISOMETRIC VIEW



(i) CONE



(ii) DEVELOPEMENT OF CONE

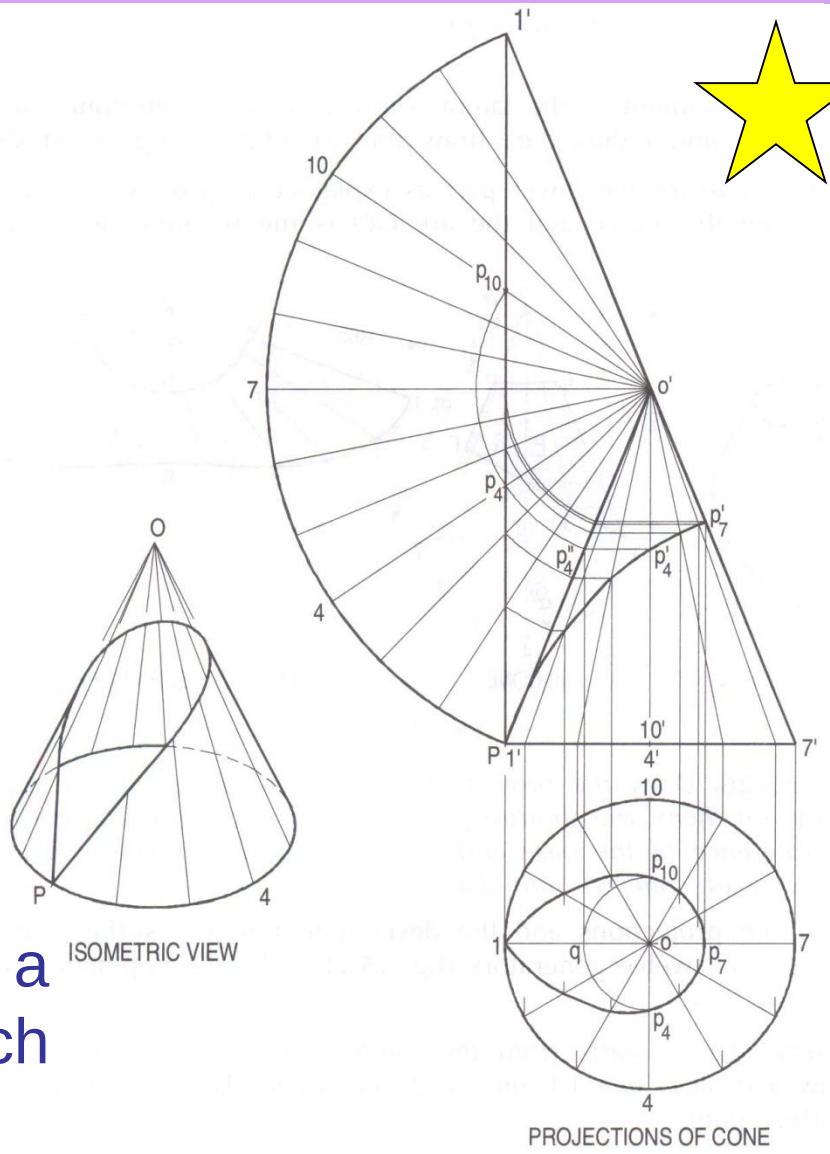
Development of Surfaces

Example-26 (Solved Pb. 15-26, pp. 367)

Draw the projections of a cone resting on the ground on its base and show on them, the shortest path by which a point P, starting from a point on the circumference of the base and moving around the cone will return to the same point. Base of cone 61 mm diameter; axis 75 mm.

Note:

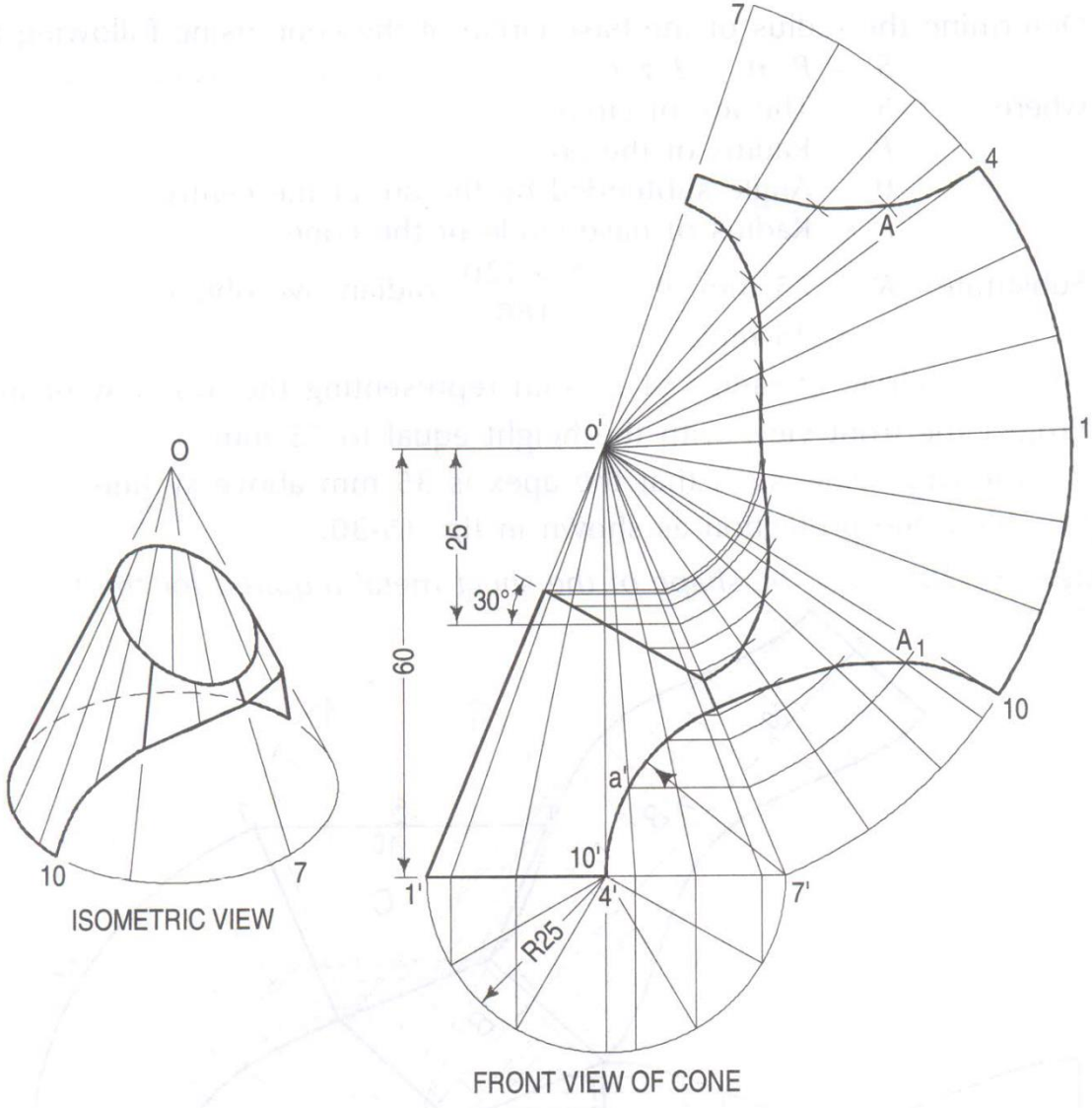
The shortest path between two points on a surface is knows as *geodesic curve*, which is not straight on the body!.



Development of Surfaces

Example-27 (Solved Pb. 15-27, pp. 368)

Draw the development of the lateral surface of the part of the cone, the front view of which is shown in the figure.



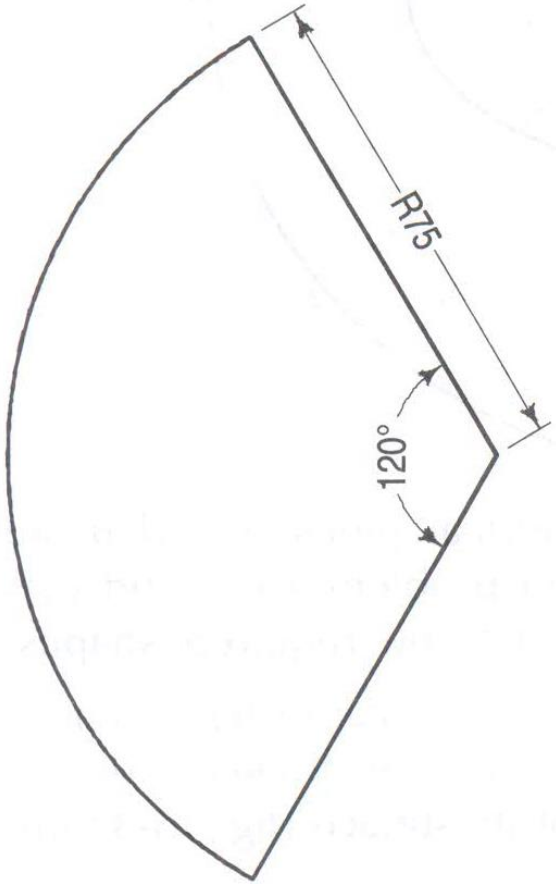
Development of Surfaces

Example-28 (Solved Pb. 15-28, pp. 368)

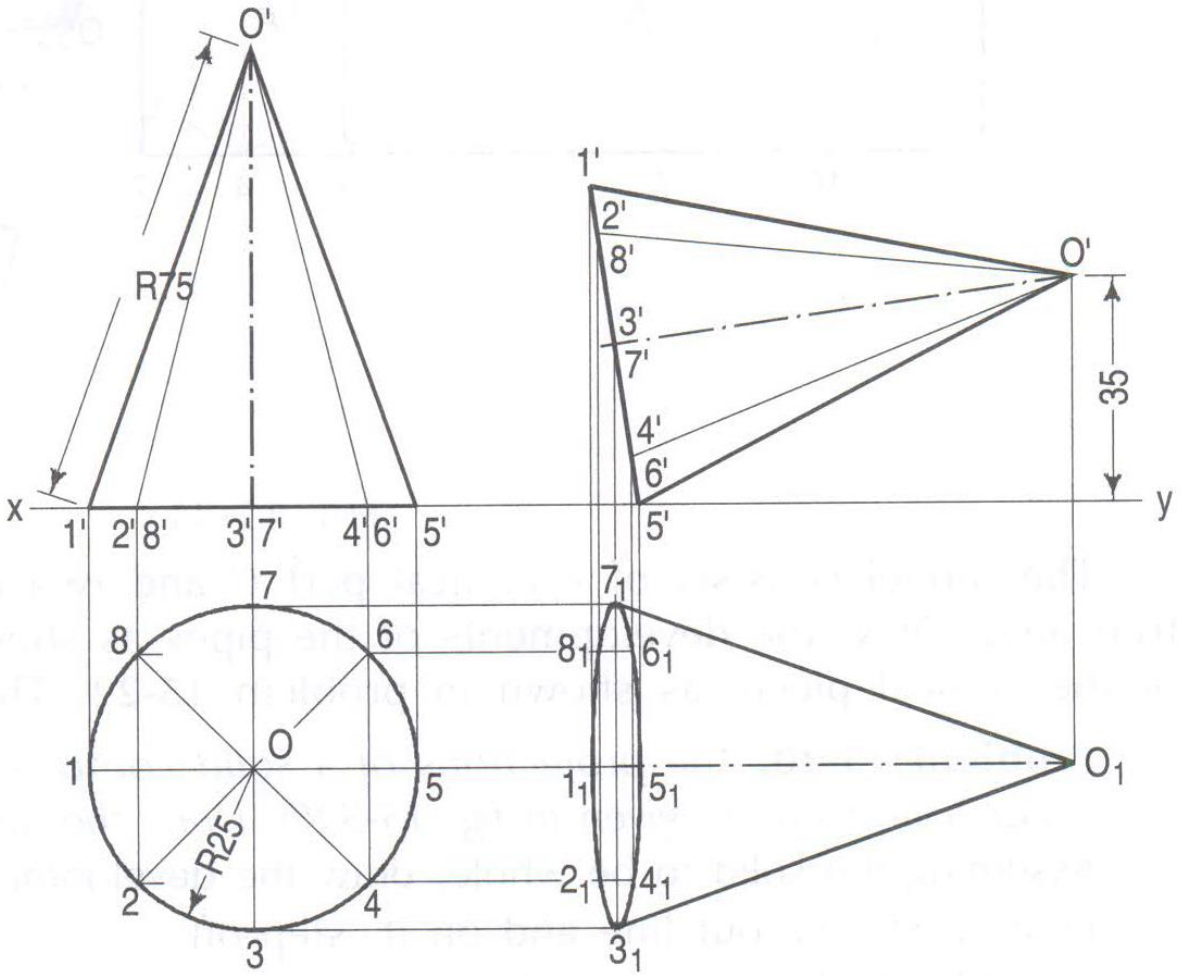
The development of the conical surface is a sector of a circle. The radius of the sector is 75mm and the angle subtended by the arc at the centre is 120°. Construct the cone and draw its projections when the apex is 35 mm above the H.P. and its axis is parallel to the V.P.

Development of Surfaces

Example-28 (Solved Pb. 15-28, pp. 368)



(i) DEVELOPEMENT OF CONE



(ii) CONE AND PROJECTIONS GENERATED FROM DEVELOPEMENT OF CONE

Development of Surfaces

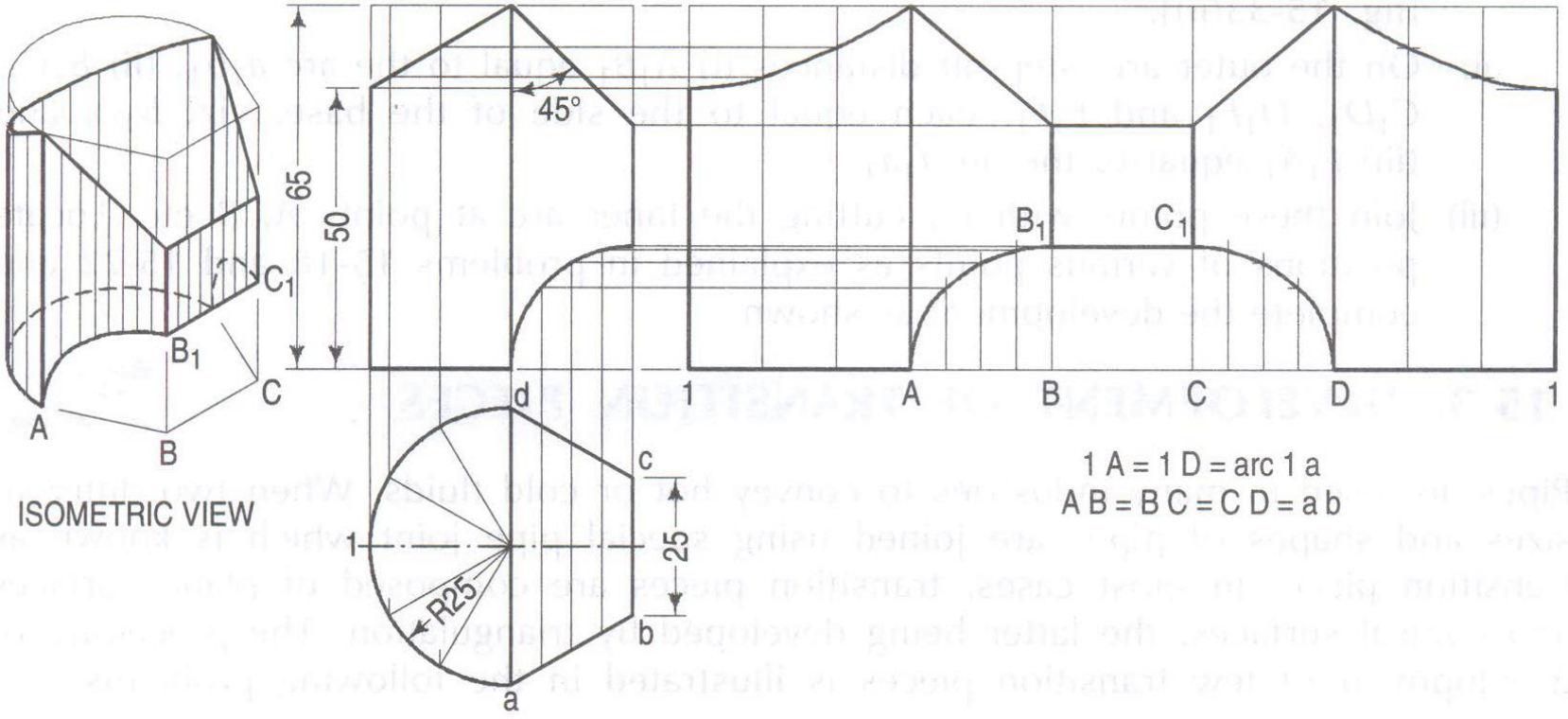
Example-29 (Solved Pb. 15-29, pp. 370)

Draw the shape of the sheet metal required for the funnel shown in the figure.

Development of Surfaces

Example-30 (Solved Pb. 15-30, pp. 370)

The projection of a solid composed of a truncated half-cylinder and cut a half-prism are given in the figure. Draw the development of its lateral surface.



ISOMETRIC VIEW

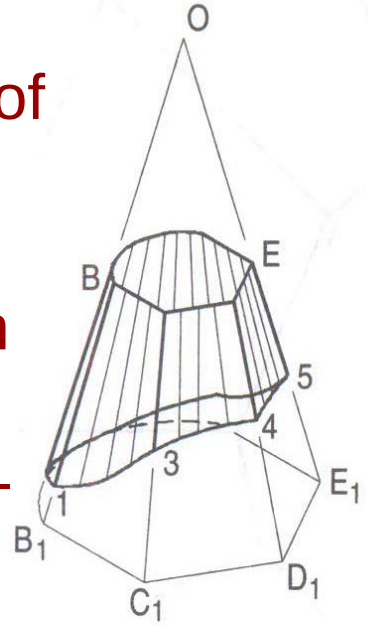
(i) TRUNCATED HALF CYLINDER AND CUT PRISM

(ii) DEVELOPEMENT OF TRUNCATED HALF CYLINDER AND CUT PRISM

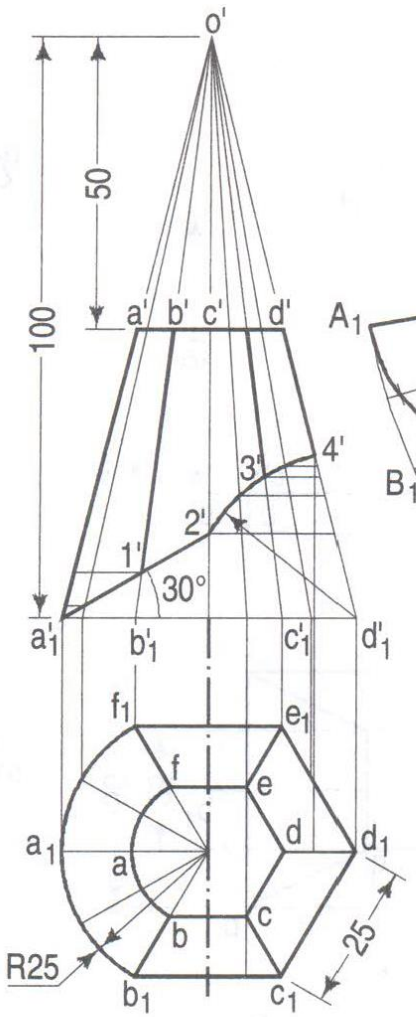
Development of Surfaces

Example-31 (Solved Pb. 15-31, pp. 371)

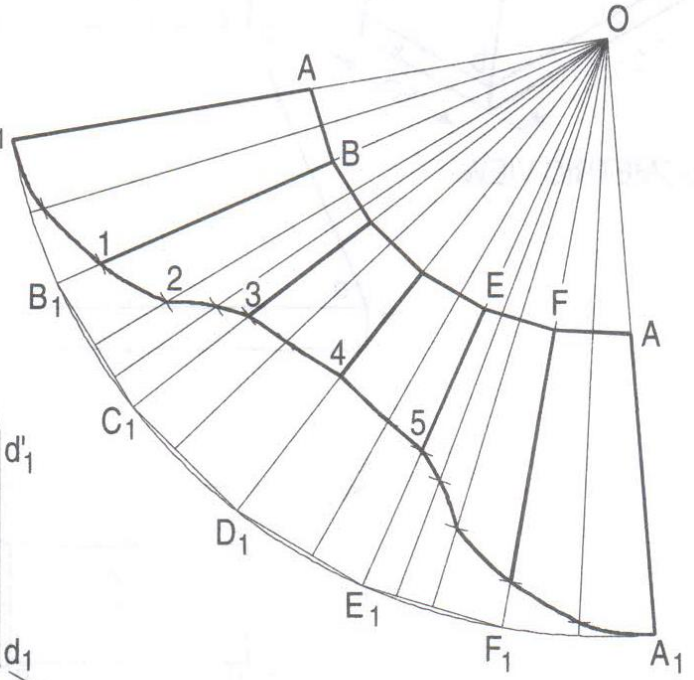
Draw the development of the lateral surface of the solid shown in two views (drawn in first-angle projection).



ISOMETRIC VIEW



(i) FRUSTA OF CONE AND HEXAGONAL PYRAMID



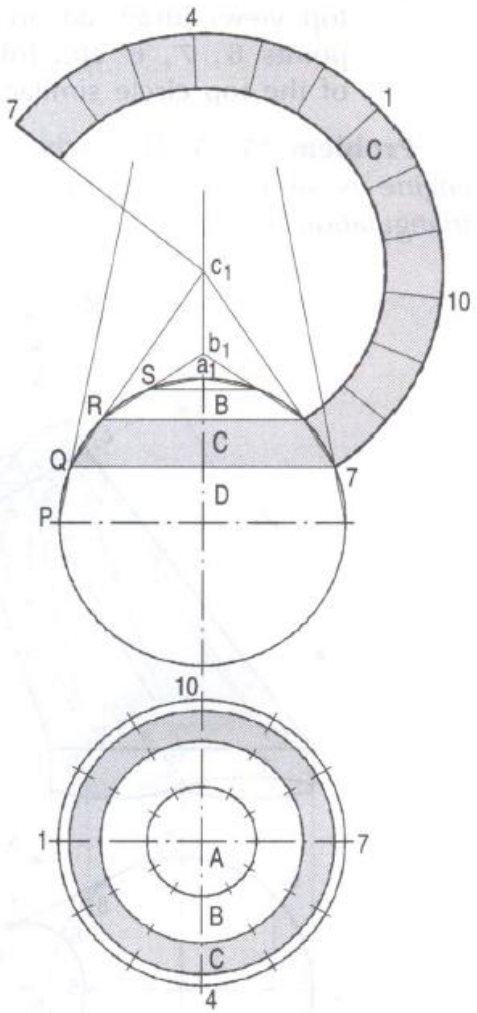
(ii) DEVELOPEMENT OF FRUSTA OF CONE AND HEXAGONAL PYRAMID

Development of Non-Developable Surfaces

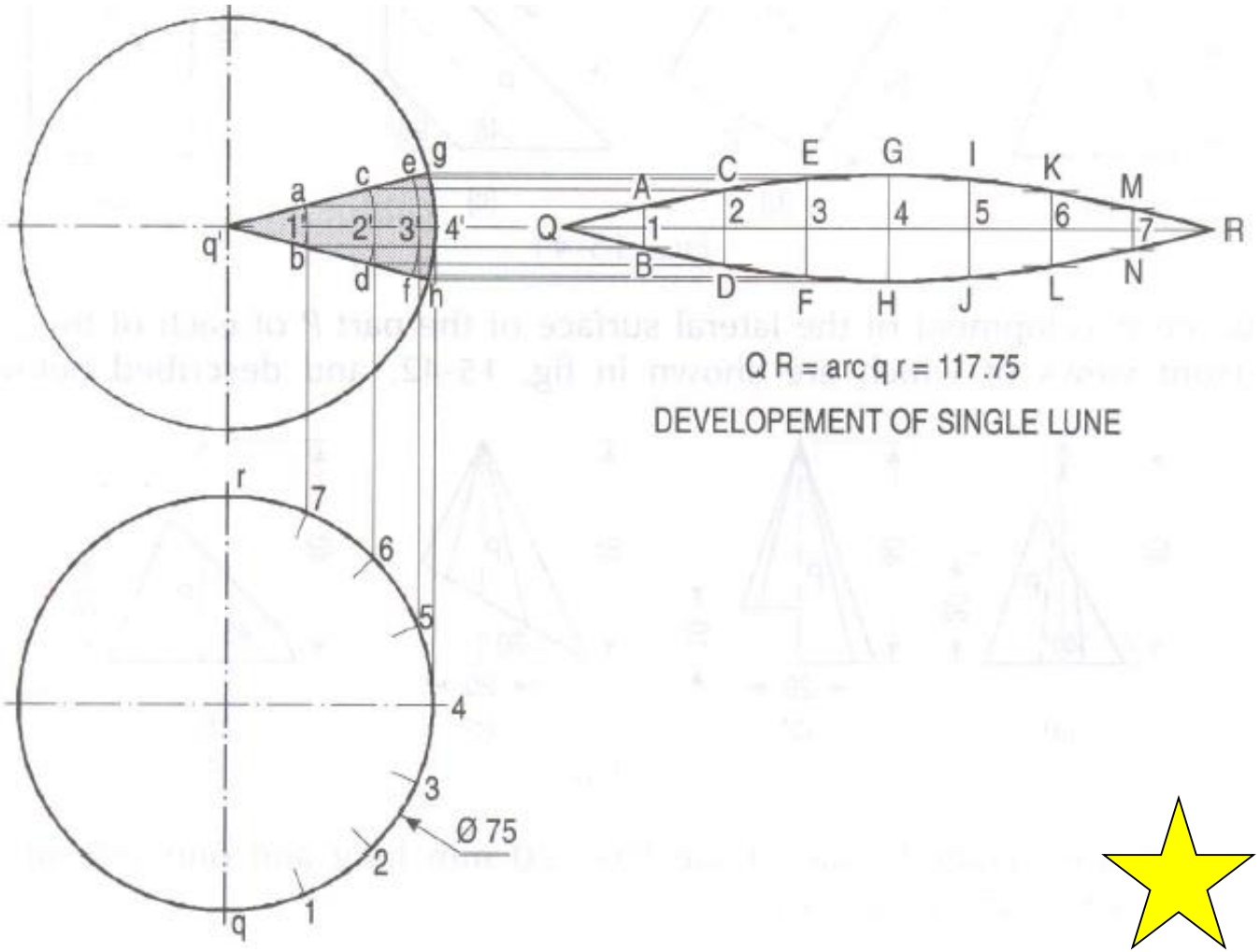
Development of Non-Developable Surfaces

Sphere

Zones Method:



Lunes Method:

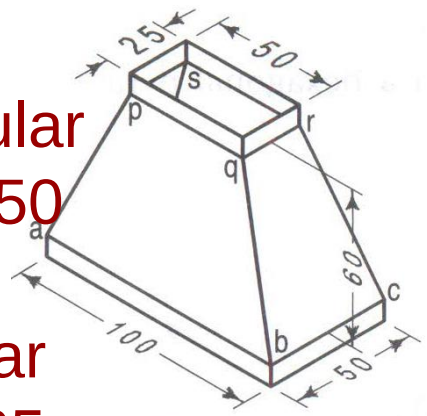


Development of Transition Connectors

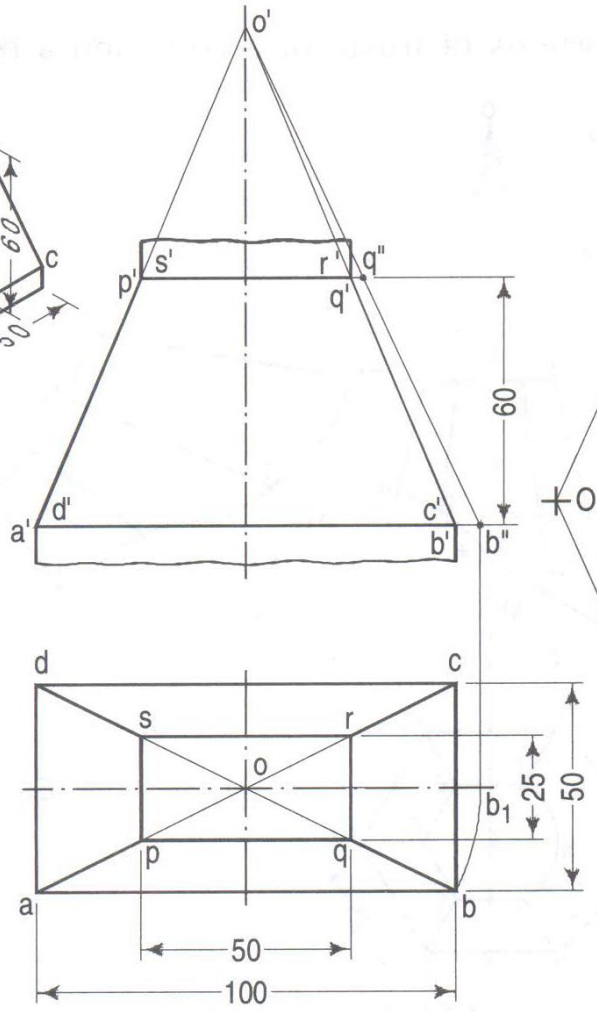
Development of Surfaces

Example-32 (Solved Pb. 15-32, pp. 372)

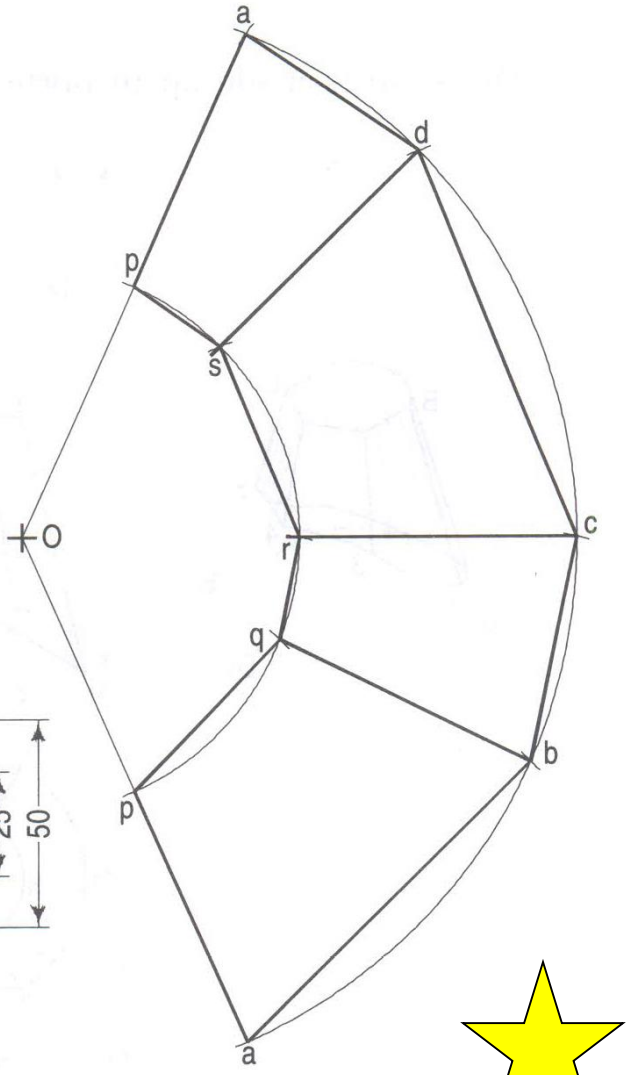
In air-conditioning system a rectangular duct of 100 mm X50 mm connects another rectangular duct of 50 mm X 25 mm through the transition piece as shown in the figure. Neglecting thickness of a metal sheet, develop the lateral surface of the transition piece.



ISOMETRIC VIEW



(i) RECTANGULAR DUCT

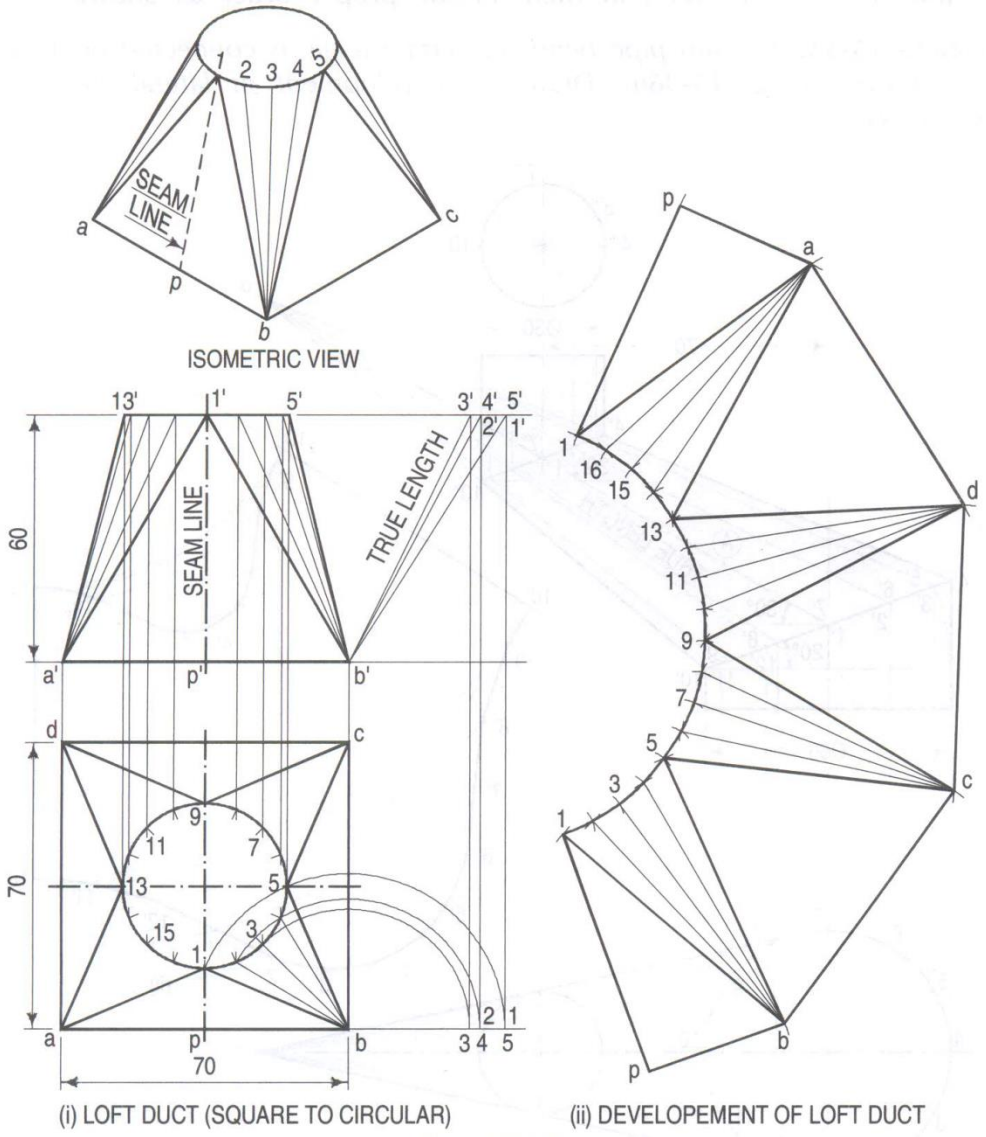


(ii) DEVELOPEMENT OF DUCT

Development of Surfaces

Example-33 (Solved Pb. 15-33, pp. 373)

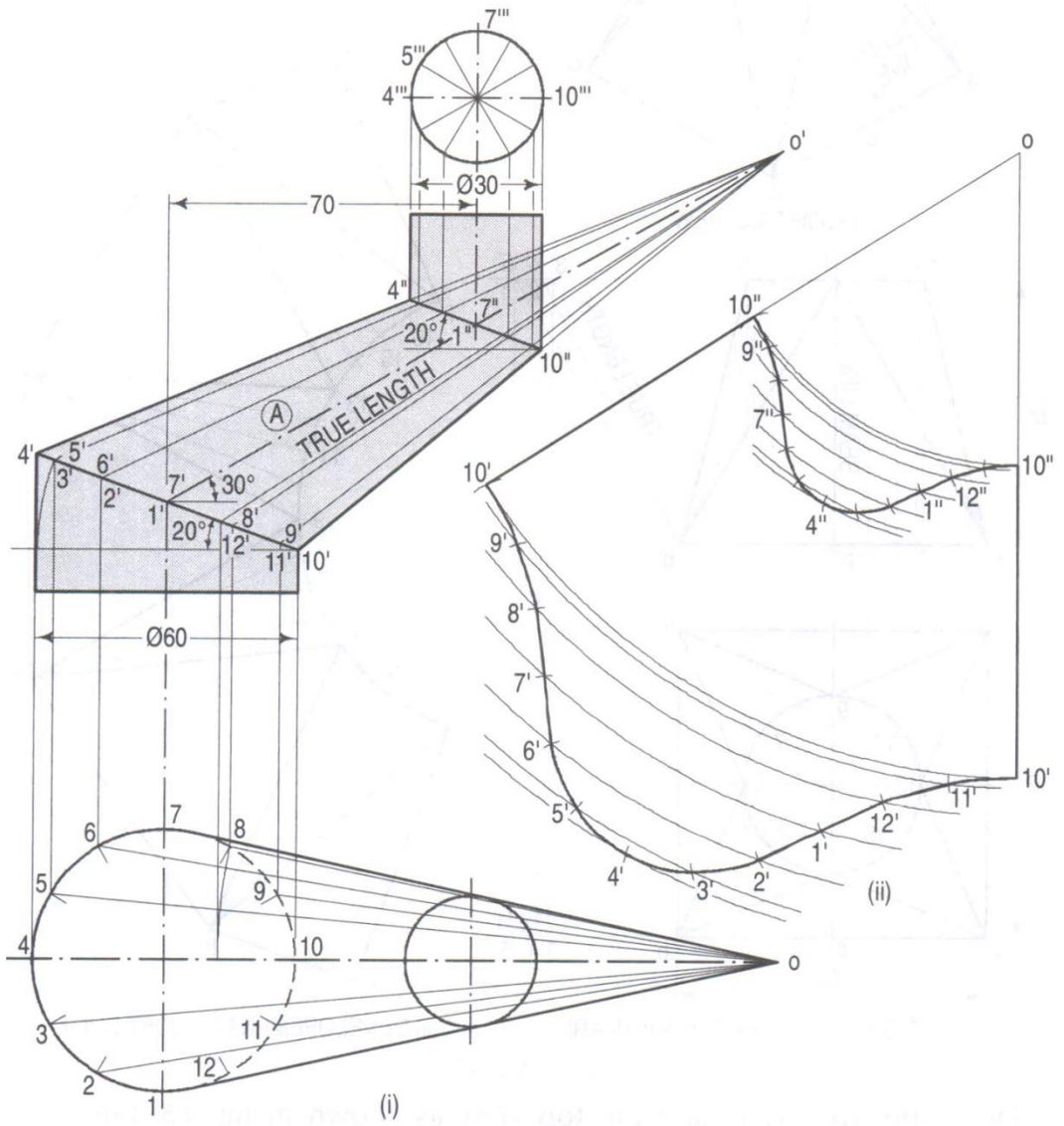
An air-conditioning duct of square cross-section 70 mm x 70 mm connects a circular pipe of 40 mm diameter through the transition piece. Draw the projection and develop the lateral surface of the transition piece.



Development of Surfaces

Example-34 (Solved Pb. 15-34, pp. 374)

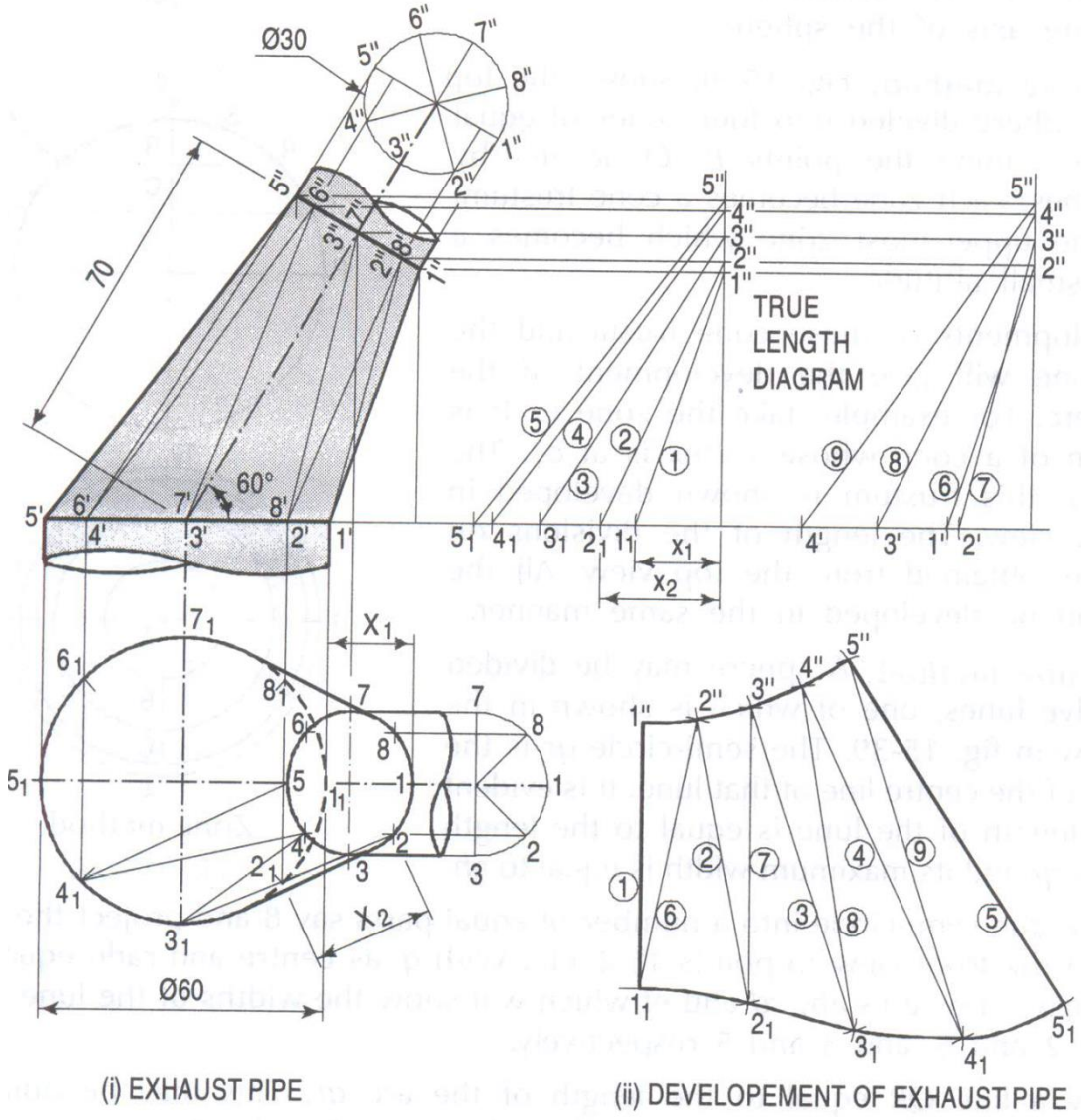
A steam pipe bends at certain angle is connected by a transition piece as shown in the figure. Draw the development of lateral surface of the transition piece A.



Development of Surfaces

Example-35 (Solved Pb. 15-35, pp. 374)

The orthogonal projection of an exhaust pipe required for an engine is shown in the figure. Draw the development of the transition connector by triangulation method.



Conclusions

- Roughly work out all the problems given to you. Only if you come prepared, you will be able to complete all problems of the sheet in the drawing session.


Thank You!