N4 Plating and Structural Steel Drawing

Gateways to Engineering Studies - Chris Brink

HYBRID LEARNING SOLUTIONS

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N4

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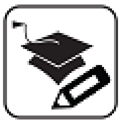
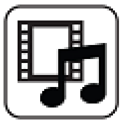
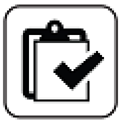
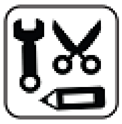
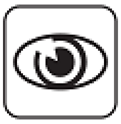
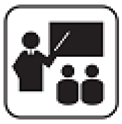
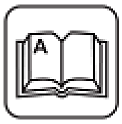
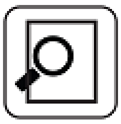
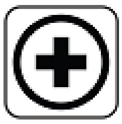
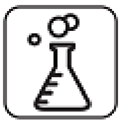
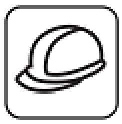
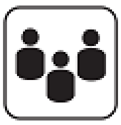
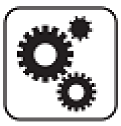
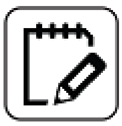
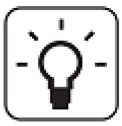
	Assessment / Activity		Multimedia
	Checklist		Practical
	Demonstration/ observation		Presentation/ Lecture
	Did you know?		Read
	Example		Safety
	Experiment		Site visit
	Group work/ discussions, role-play, etc.		Take note of
	In the workplace		Theoretical – questions, reports, case studies, etc.
	Keywords		Think about it

Module 1

Fundamentals

Learning Outcomes
On the completion of this module the student must be able to:

- Identify the drawing requirements necessary for a building drawing
- Describe the following:
  - Drawing as a medium
  - Dimensioning
  - Projection of a circle
  - Ellipse
  - Basic developments
  - True lengths
  - Orthographic projections
  - Printing

1.1 Introduction

In this module we will consider the fundamental drawing requirements and principals involved in drawing and printing. Most of this module isn't new material, but good revision.

1.2 Drawing requirements

1.2.1 Drawing board and paper

The drawing board must be big enough to accommodate an A2 drawing sheet (i.e. 594 mm x 420 mm).

You must use a high quality A2 drawing cartridge paper. Both sides of the paper must be used.

Adhesive tape or drawing clamps may be used for fixing the drawing paper onto the drawing board.

1.2.2 T-square

A true and good quality T-square must be used so that accurate drawings can be drawn.

1.2.3 Two set squares

The set square must be made from a good material such as celluloid/plastic and must be fairly big, ± 200 mm in length. Various sizes are available. There are also adjustable set squares available.

The aforementioned drawing instruments are illustrated in **Figure 1.1**.

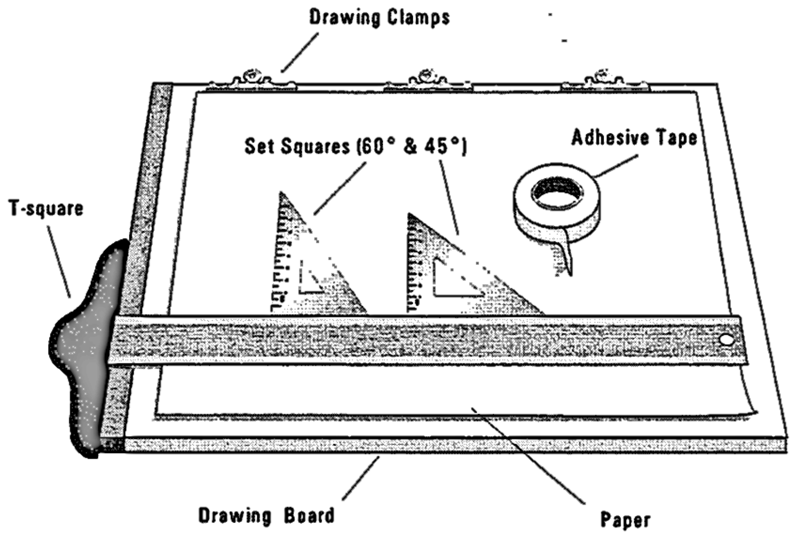


Figure 1.1 Drawing board and paper

1.2.4 Set square exercise

A standard set of set squares are available, namely the 30°, 60° and the 45°, each of which has a 900 angle.

Figure l.2 illustrates a set square exercise. By manipulation of the set squares additional angles can be obtained.

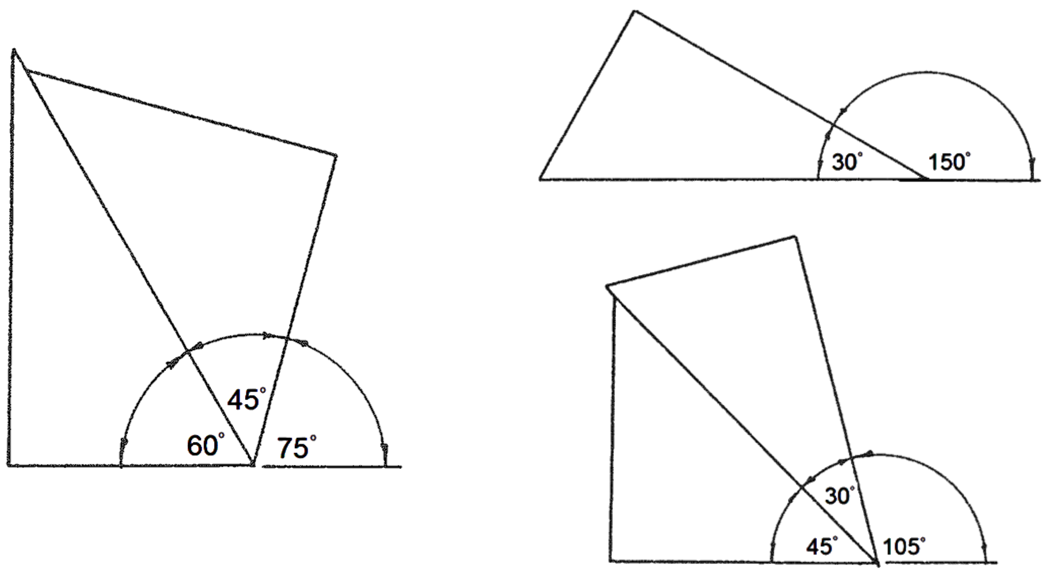


Figure 1.2 Exercise with set squares

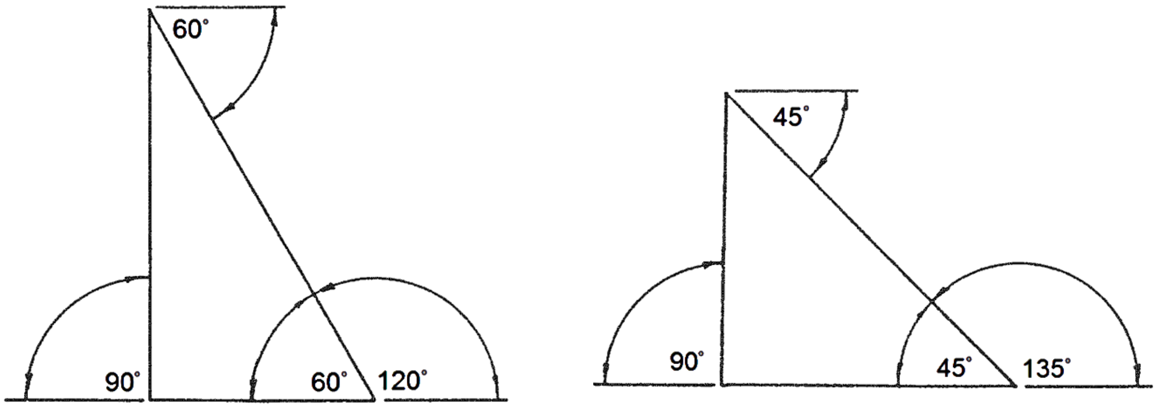


Figure 1.2 Exercise with set squares (continued)

1.2.5 Drawing instruments

It is not necessary to buy expensive drawing sets which may include drawing instruments which you might never need to use.

The instruments required for this building drawing course are:

- A good compass (with extension bar). The leg must be approximately 152 mm long.
- A divider of more or less the same size as the compass.
- A small spring bow compass.

These required building drawing instruments are illustrated in **Figure 1.3** below.

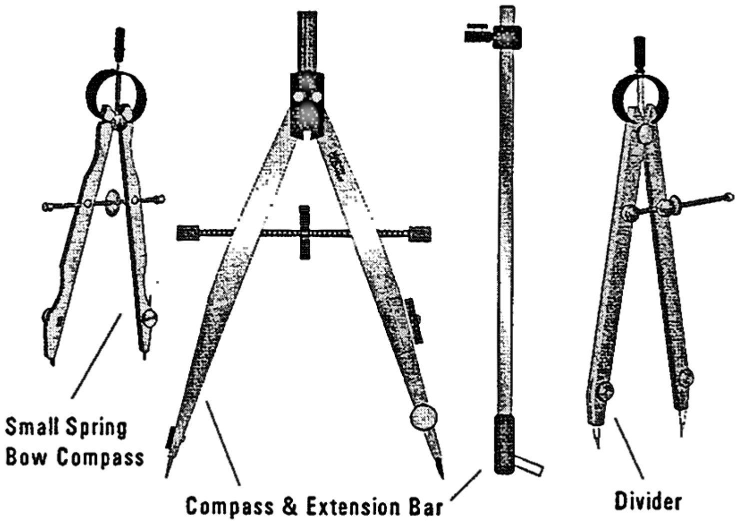


Figure 1.3 Drawing instruments

A yellow duster is necessary to clean all the instruments and the drawing board before they are used. This helps to keep the drawing paper clean.

1.2.6 Pencils and eraser

A draughtsman must have a supply of good drawing pencils or clutch pencils of different degrees of hardness, and thicknesses.

The degrees of hardness we recommend are H or F; 2H and HB. The sizes of leads for a clutch pencil should be 0,3 mm, 0,5 mm and 0,7 mm.

A good quality soft eraser is recommended. An erasing shield, as seen in **Figure 1.4**, is very convenient for erasing in small areas.

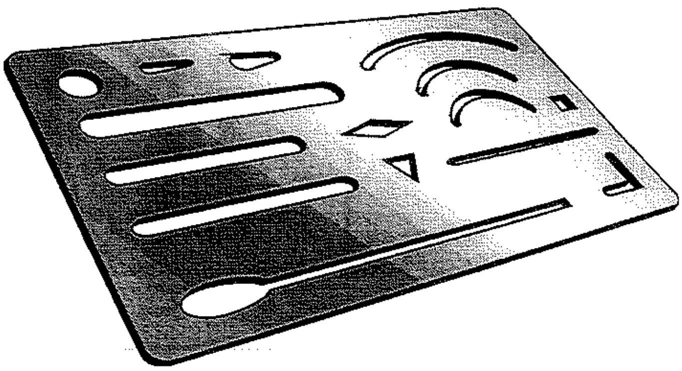


Figure 1.4 Erasing shield

1.2.7 Scale Ruler

A triangular plastic scale ruler with the following metric scales is essential: 1:1, 1:2, 1:5 and 1:10.

1.2.8 Dividing lines and scales

In many instances it is necessary to divide a line into equal parts. This can be done accurately by using a method shown in **Figure I.5**.

Other methods to obtain accurate scales are illustrated in **Figures 1.6** and **1.7**.

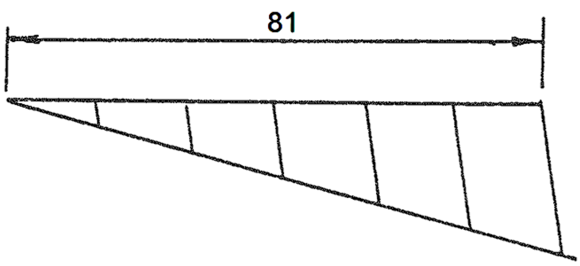


Figure 1.5 Divided into 6 parts

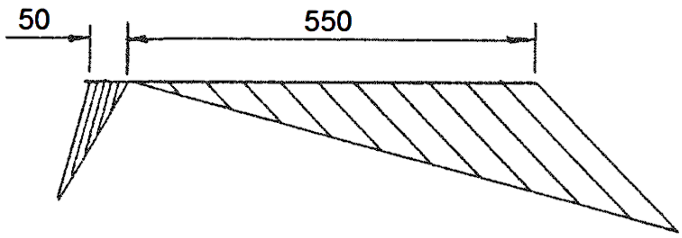


Figure 1.6 Scale 1:50 to measure 550 mm to the nearest 10 mm

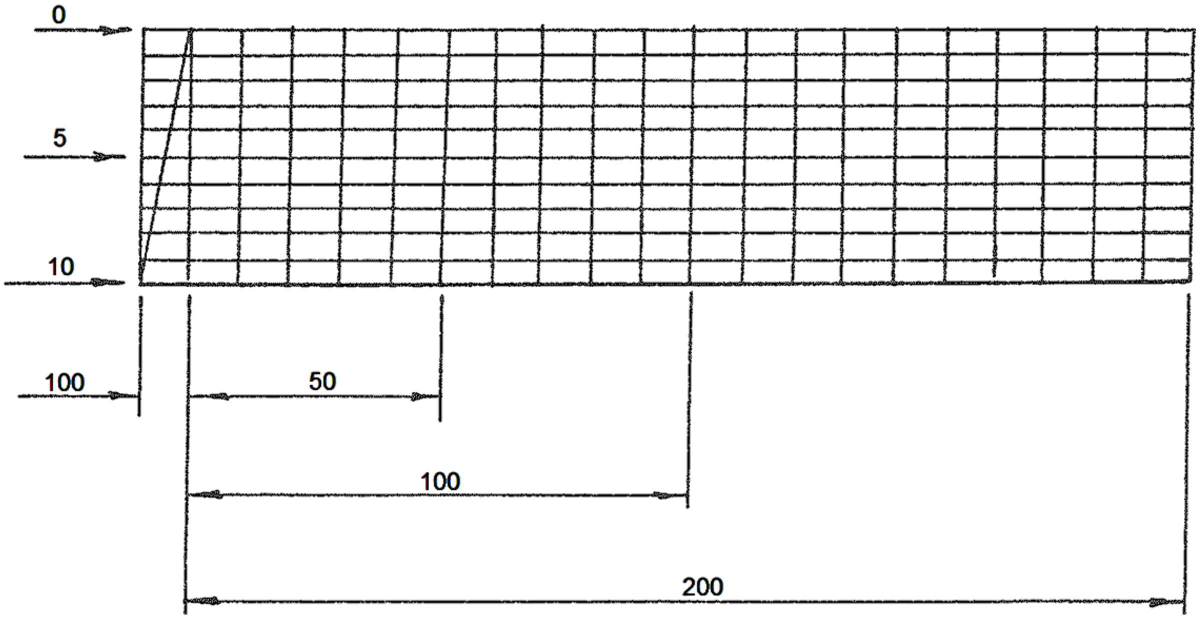


Figure 1.7 Scale 1:2 to measure up to 200 mm to the nearest mm

1.2.9 Radius/flexi curve
It will be worth your while to buy these instruments as it will save you time when drawing radii.

1.2.10 Printing Stencil
A printing stencil can also be used. Remember the stencil used must allow you to print 3,5 mm and 7 mm high letters and figures.

Note:
"Practice makes perfect". This saying is very applicable to the use of drawing instruments. Nobody other than yourself can develop your drawing skill.

These last three drawing instruments are well illustrated in **Figure 1.8** on the following page.

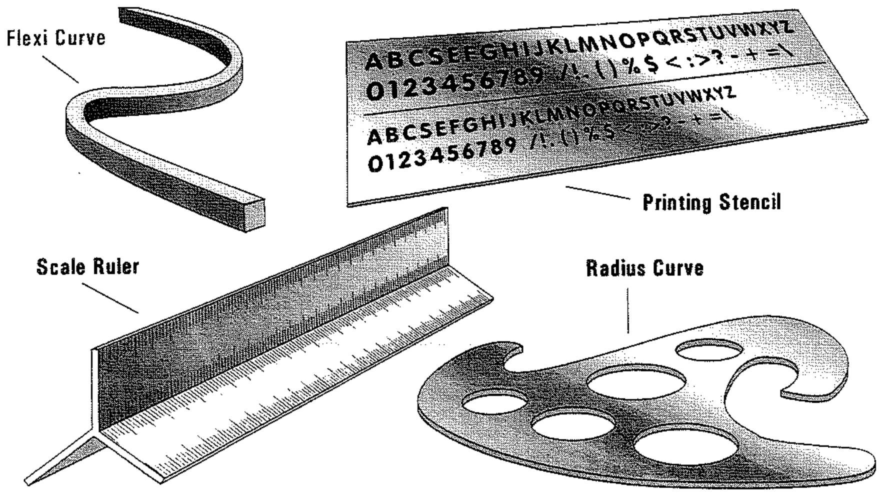


Figure 1.8 Various drawing instruments

1.3 Drawing as medium

Drawing, in a broad sense, is the art of producing on a flat surface the likeness of objects or of scenes.

In the restricted and more common use of the word, drawing usually includes only such representations as are produced in outline with some shading to show depth and perspective.

There are few studies which train so many faculties as does drawing.

Hand and eye are taught to cooperate with the powers of observation and memory, while the development of muscle control is no small part of the educational value of a thorough training in drawing.

That these facts are recognised generally is evidenced by the school curricula of nearly all nations, in which drawing features prominently from the primary grades upward.

In developing the art of producing good legible drawings, certain facts must be kept in mind.

There must be a definite difference in line work by the draughtsman to give distinct indications of what is needed. A set of lines is illustrated in **Figure 1.9.**

1.3.1 The drawing

- **General rules for drawing**
  The following is the procedure for setting out drawings:

- Consider the views required and the scale to be used.

- Estimate the space required for each drawing. First draw the centre line for each view to avoid overlapping of the drawings and therefore leaving insufficient space for the printing of measurements. The outside measurements of every view must be borne in mind. (The normal position of the different views will be given later in this course).

- The actual outline of the drawing is now built up lightly (2H pencil) around the centre lines.

- When all the lines have been drawn with a light pencil, the unnecessary lines are erased and outlines redrawn neatly. It is important that your measurements are accurate. Test your work while you are drawing to make sure it is exact.

- After the actual drawing has been completed, you can start printing in the measurements, cross hatching and printing the names and any other required information.

- **Types of lines**

The following types of lines follow the pattern laid down by the South African Bureau of Standards in the Code of Practice for Building Drawing.

We strongly recommend that if you intend to proceed to the more advanced grades of Building Drawing, purchase this book from the Bureau of Standards (No. SABS 0111-1990).

Lines must have the same thickness throughout. A thick line is twice or three times as thick as a thin line. The outline of a drawing must be its most outstanding feature.

Table 1.1 Shows different types of lines used in building drawing.

Line	Description	General Application
A	Continuous thick 0,5mm	Visible outlines Visible edges
B \ BB	Continuous thin 0,3mm (straight or curved) Continuous thin feint	Imaginary lines of intersection Dimension lines Projection lines Leader lines Hatching Construction and guide lines

C	Continuous thin freehand 0,3mm	Limits of partial or interrupted views and sections, if the limit is not a chain thin
F	Dashed thin 0,3mm	Hidden outlines Hidden edges
G	Chain thin 0,3mm	Centre lines Lines of symmetry Trajectories
H	Chain thin, thick at ends and changes of direction 0,3mm and 0,5mm	Cutting Top Viewes

Table 1.1 Types of lines used in building drawing

1.4 Dimensioning

In **Figure 1.9** the methods of dimensioning most widely used are shown. Dimensions should be written next to the drawings in order to keep the drawings clear.

Horizontal dimensioning should be above the line and vertical dimensions on the left. Dimensioning on the drawing itself should be kept to a minimum.

Remember that a drawing-is incomplete without the necessary annotations and dimensions. In this course dimensions on developments will be omitted for the sake of clarity.

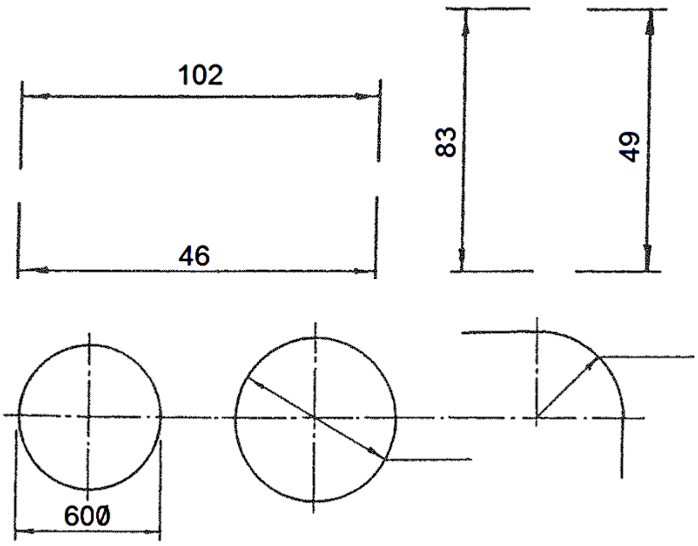


Figure 1.9 Dimensioning

1.5 Projection of a circle

The construction of the projection of a circle, which is very often used in this subject, is shown in **Figure 1.10**.

A circular plate is placed at an angle. An auxiliary view is drawn at an angle perpendicular to the plate.

The auxiliary view is divided into twelve equal parts and the points are numbered from I to 7 to I, which are projected horizontally and vertically from a centre line.

The distances a2; b3; c5; d6 are marked off, forming an ellipse when linked.

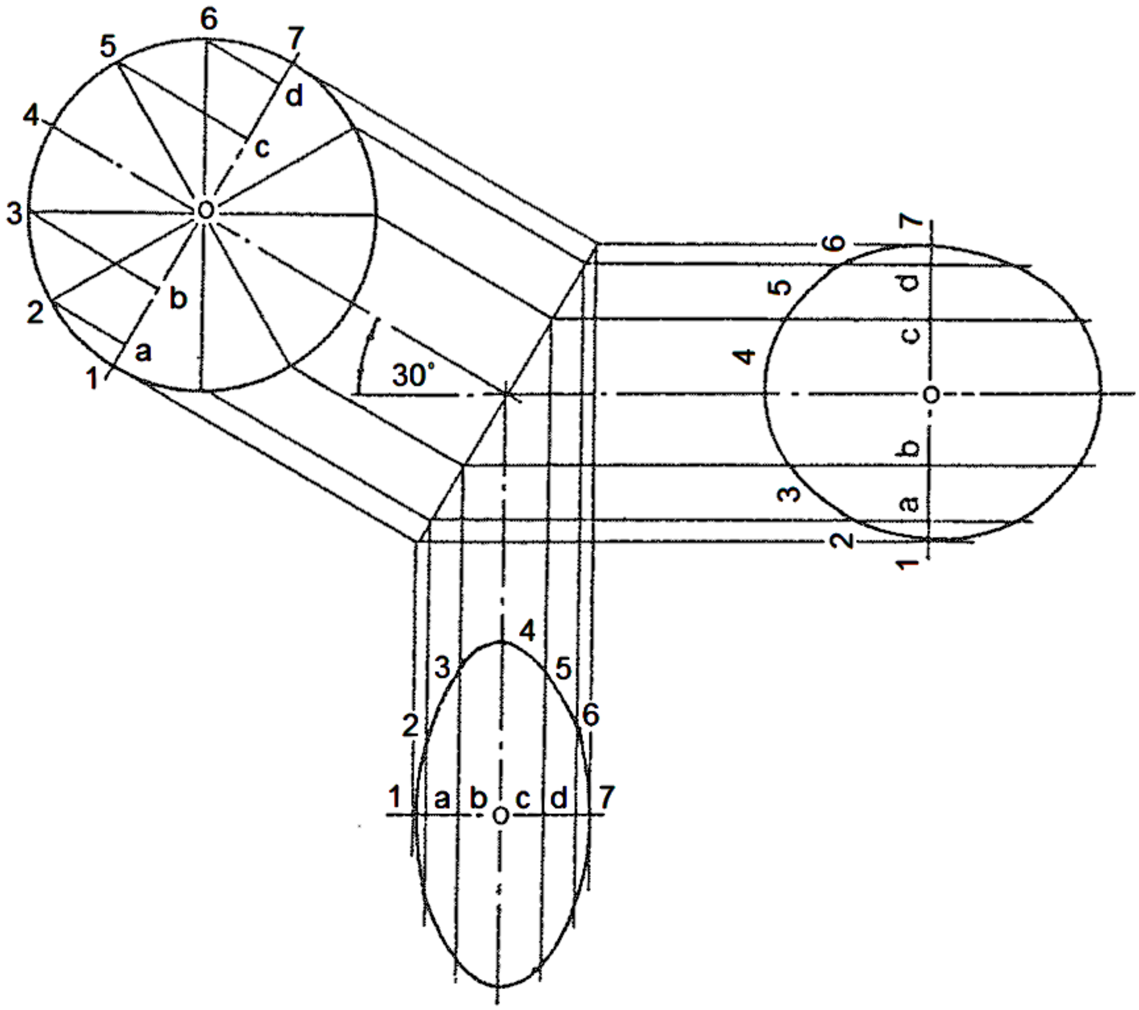


Figure 1.10 Projection of a circle

1.6 Ellipse

An ellipse is a figure bordered by an even curve. In **Figure 1.11,** on the following page, the construction of an ellipse is shown.

1.6.1 To construct the ellipse

The following steps should be taken to construct the ellipse:

- Draw the major and minor axes.
- With the radius OA scribe the arc AE.
- With the radius DE scribe the arc EF.
- Join BD but only bisect BF.
- Determine points G and H.
- Convert points G and H to the opposite side of the axes.
- Scribe the long arcs through CG and GD.
- Close the ends with the radius HB.

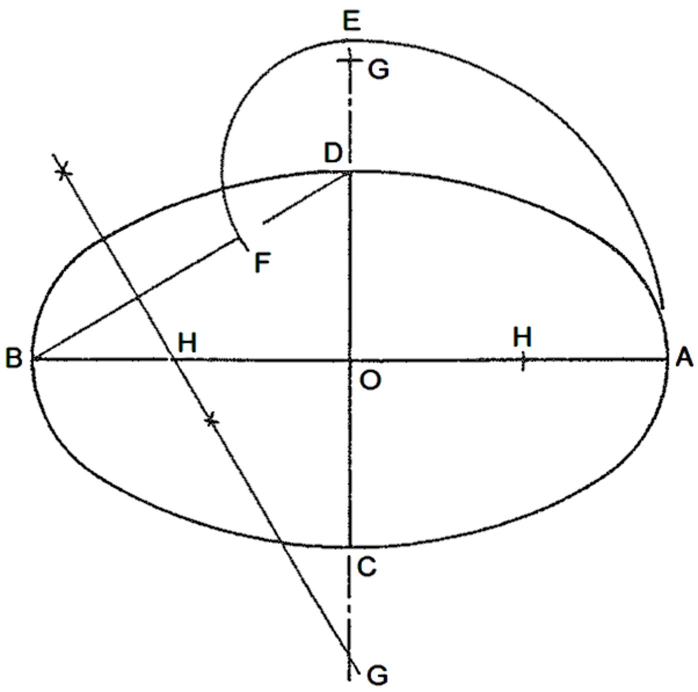


Figure 1.11 Ellipse

1.7 Basic developments

1.7.1 The Cylinder

Figure 1.12 shows the basic developments of a cylinder. The method adopted to develop the cylinder is known as the *parallel line* method.

The length of the plate is obtained by dividing the cylinder into twelve equal parts, which is marked on the plate, from which point parallel lines are drawn.

A more accurate method is to calculate the circumference of the cylinder, then draw the girth line on the plate, and divide the line by construction into twelve equal parts.

Note that the circumference is calculated on the main diameter.

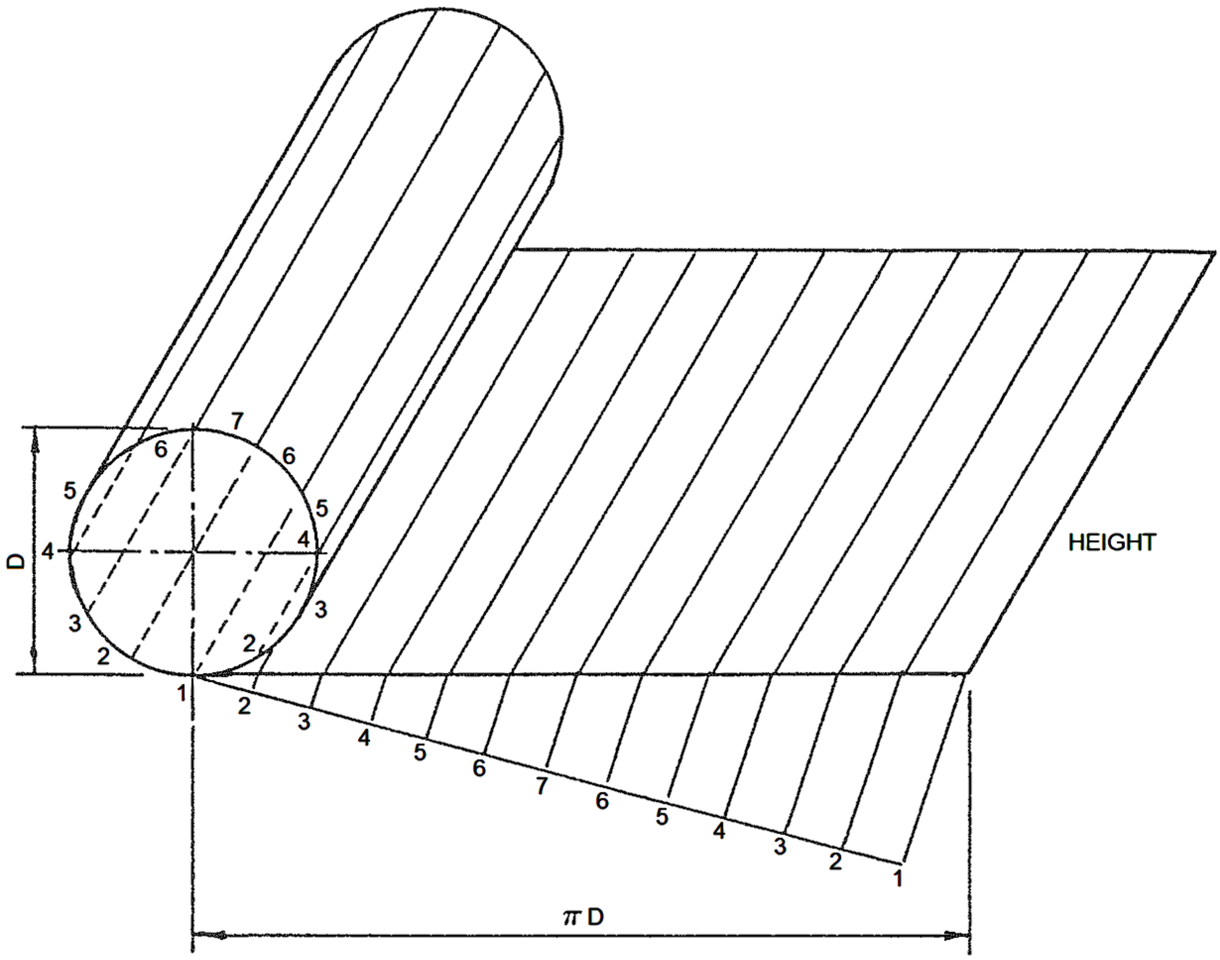


Figure 1.12 Development of a Cylinder

1.7.2 The cone

On the following page, **Figure 1.13** shows the basic development of a cone. The method applied to develop the cone is known as the *radial line* method.

Draw an arc, with the slant height as radius, on which twelve equal parts are marked off equal to the base of the cone

Or calculate the circumference of the base of the cone, and divide the figure into twelve equal parts.

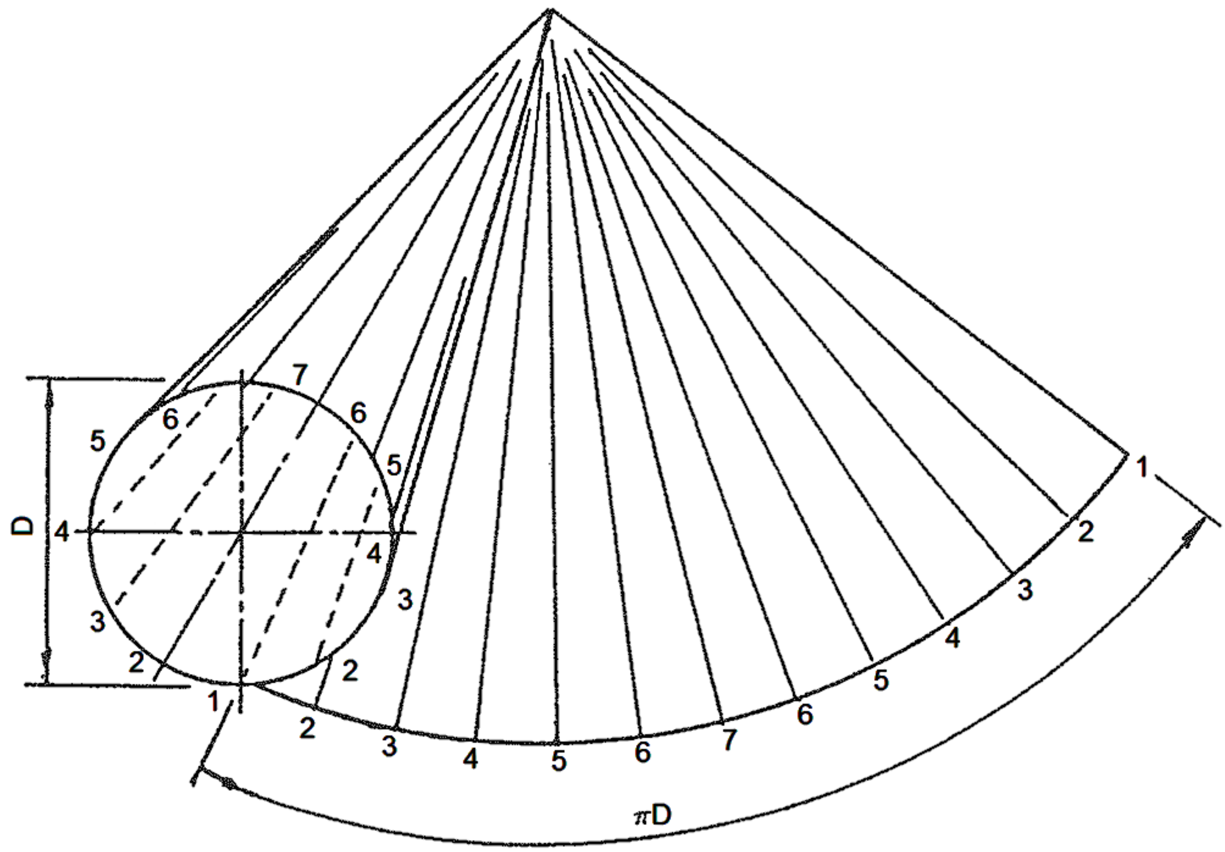


Figure 1.13 Development of a cone

1.8 True lengths

A third popular method of development is known as *triangulation*. This method is used to determine the true lengths of corner lines and diagonals in hoppers.

On the following page, **Figure 1.14** shows three views of a pole.

The true length of the pole can be determined as follows:

- Draw the vertical line CD according to the vertical height of the pole.
- Mark DE horizontal to the base of the pole.
- CE will be the true length of the pole.

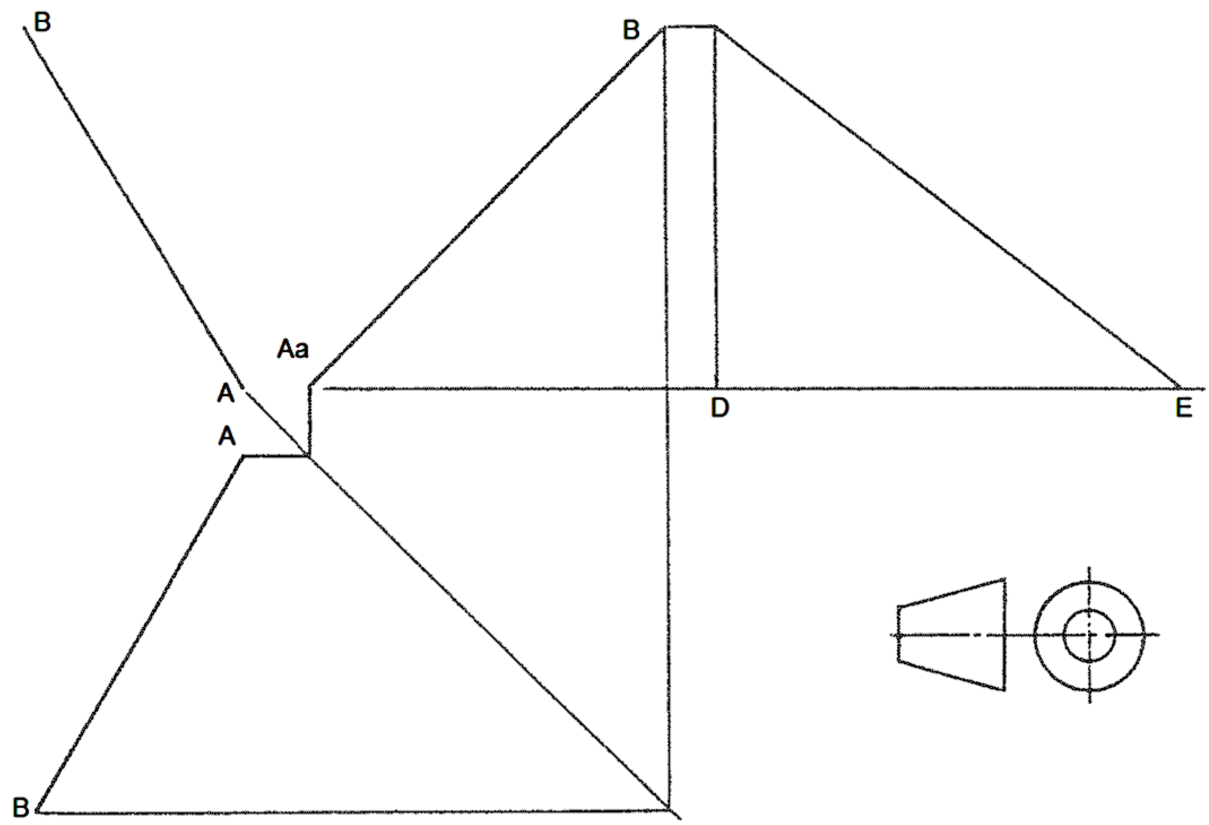


Figure 1.14 True length by triangulation

1.9 Orthographic projections

To distinguish the correct shape and proportion, views must be drawn as seen from different angles.

Three directions will be introduced. The two main projections are known as *first angle orthographic projection* and *third angle orthographic projection.*

In **Figure 1.15,** on the following page, an isometric view is shown. From the front, as seen in the direction of the arrow A, the length and height are shown; this is the front view.

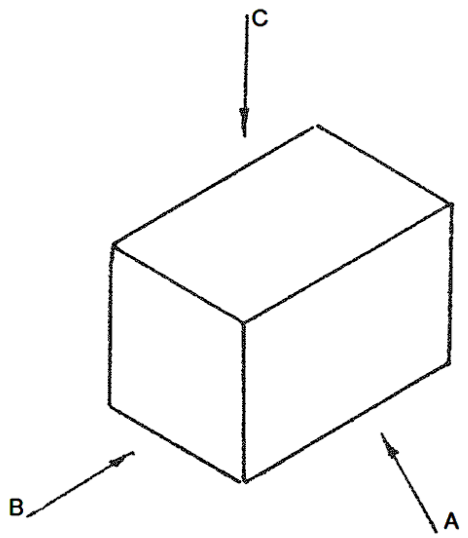
From the side as seen in the direction of the arrow B - or from the left - the breadth and height are shown; this is the left view.

From the top as seen in the direction of the arrow C, the length and the breadth are shown; this is the top view.

In **Figure 1.16,** on the following page, an isometric view in third angle orthographic projection is shown.

The front view is seen from direction A; the right view from direction B; and the top view from direction C, but it is drawn above the front view.

To indicate the projections, specific symbols are used; note the position of the double circle in each projection.



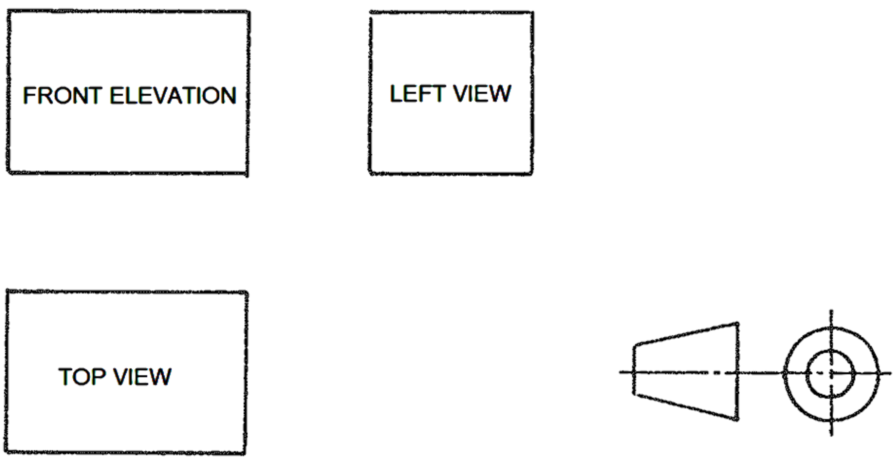


Figure 1.15 First angle orthographic projection

On the following page, **Figure 1.16** shows third angle orthographic projection. Take note of the three different views.

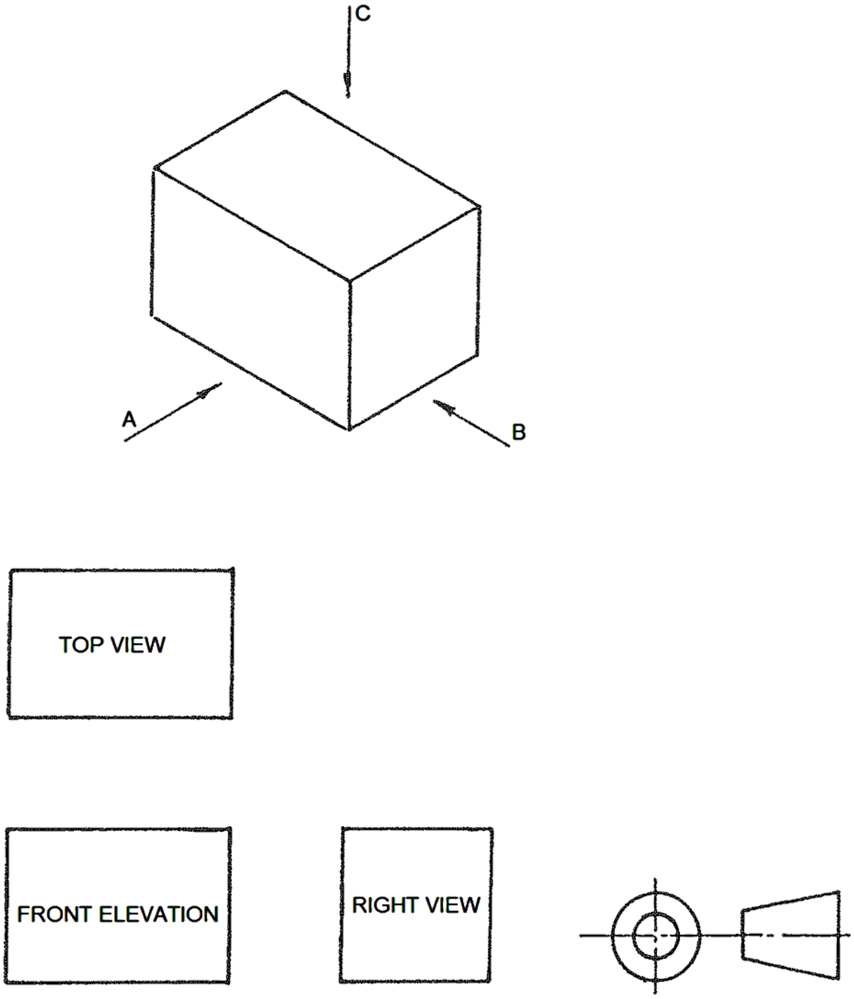


Figure 1.16 Third angle orthographic projection

1.10 Printing

All printing must be printed neatly on the drawing paper. Please use guide lines for this purpose. A printing stencil can also be used.

> **Note:**
> Remember the stencil used must allow you to print 3,5 mm and 7 mm high letters and figures.

1.10.1 Printing of measurements

All measurements will in future be given in metric units. Measurements may be written in metres or millimetres.

In this building drawing course all measurements are given in millimetres.

It is not necessary to add the abbreviation (mm) after each measurement. The abbreviation or symbol for diameter is dia, for example; 25 dia or scp 25 and for radius R, for example R12.

Often, a good architectural drawing is spoiled by poor printing of the measurements.

Note the following when printing measurements:

- Extension lines should start about 1 to 1,5 mm from the drawing and extend slightly beyond the arrow, as seen in **Table 1.1**.
- Measurements must be printed normal to the dimension lines and must be legible from the bottom or right hand side of the drawing, as seen in **Figure 1.5**.
- Measurement arrow heads must be clear with sharp points and must merely touch the lines they refer to, as seen in **Table 1.1**.
- A centre line must never be used as a dimension line. Nor should a dimension line be drawn where it can be mistaken for an outline.
- Measurements must be printed above the dimension line without touching it. Wherever possible, dimension lines should be drawn outside the actual drawing.
- Use extension lines. Try to insert all the measurements of your drawing equally amongst the views drawn as this will give your drawing a neat appearance.

Unless it is absolutely necessary, measurements should not be printed in a hatched portion of a drawing.

If this cannot be avoided, the hatching must be interrupted. For these reasons the hatching is always done last – after the measurements have been written in.

1.10.2 Printing of letters and figures

All letters and figures must be printed simply and clearly. The printed letters may be upright or slanting, but they must be the same throughout the drawing.

As it is difficult to print on the slant, we recommend the upright method for printing of letters and figures.

1.10.3 Types of lettering

Table 1.2 below shows types of lettering. In particular, the difference between vertical and oblique letting and figuring is shown.

Vertical lettering and Figuring	Oblique lettering and Figuring

ABCDEFGHI JKLMNOPQR STUVWXYZ	*ABCDEFGHI* *JKLMNOPQR* *STUVWXYZ*
ABCDEFGHIJKLM NOPQRSTUVWXYZ	*ABCDEFGHIJKLM* *NOPQRSTUVWXYZ*
ABCDEFGHIJKLM NOPQRSTUVWXYZ	*ABCDEFGHIJKLM* *NOPQRSTUVWXYZ*
abcdefghijklm nopqrstuvwxyz	*abcdefghijklm* *nopqrstuvwxyz*
1234567890	*1234567890*
1234567890	*1234567890*
1234567890	*1234567890*

Table 1.2 Types of lettering

Activity 1.1

Draw the two views and a top view to third angle orthographic projection using scale 1:1

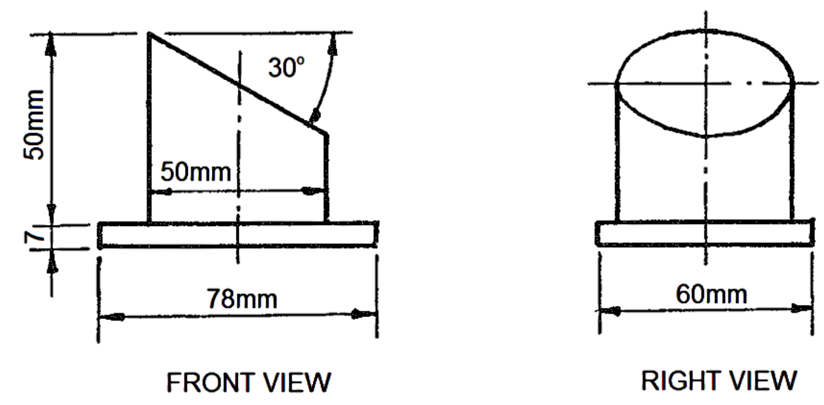


Figure 1.17 Front and right view

Activity 1.2

Figure 1.18 shows the front view of a welded steel connection that consists of the following parts:

Item 1 - 200 x 200 rolled steel joist (RSJ) - 1 off required
Item 2 - 200 x 85 rolled steel channel (RSC) - 1 off required
Item 3 - 20 mm thick shaped gusset plates - 2 off required

Draw the given front view and project according to first-angle orthographic projection the following views:

- The left view
- The top view

Print the title 'STEEL CONNECTION' and then 'SCALE' centrally beneath the views and insert the projection symbol.

SCALE 1:5

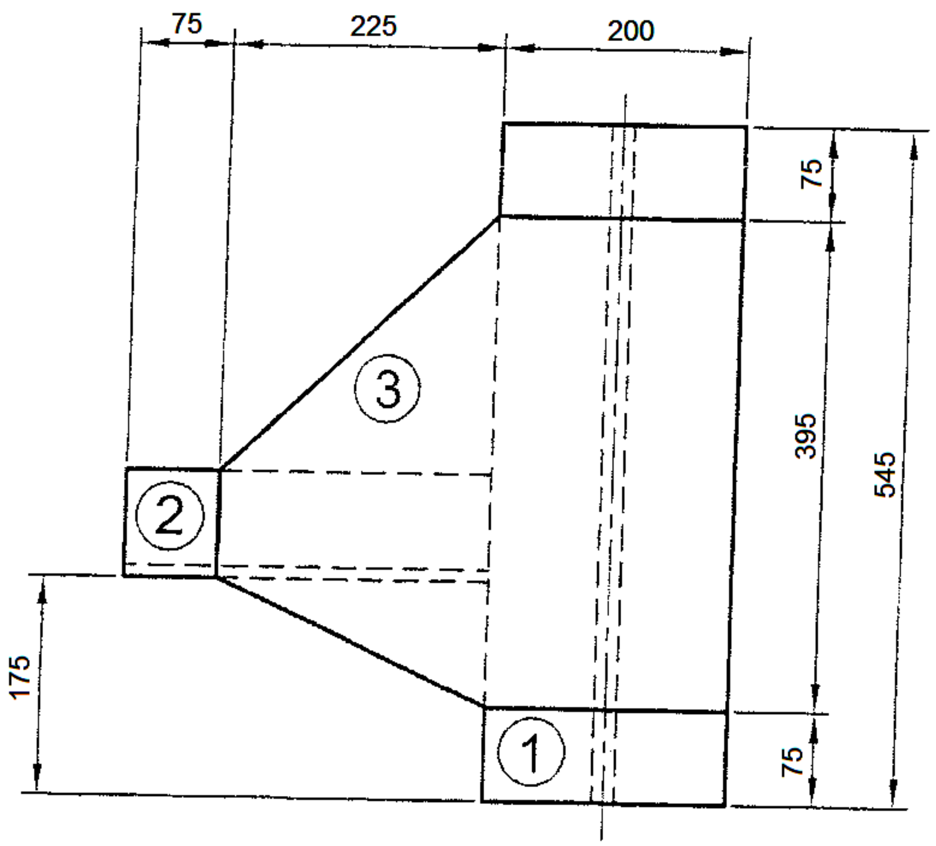


Figure 1.18 The front view of a welded steel

	Activity 1.3
Print:	

1. The alphabet (letters 7 mm high) using either the slant or upright method, whichever you prefer; and
2. The figures 1-10 (7mm high) using either the slant or upright method.

Activity 1.4

1. Draw five lines of each of the following lines, 150 mm long and 10 mm apart: (Print the name of the line above each set of lines)
   a) Outlines
   b) Dimension lines
   c) Dotted or chain lines
   d) Centre lines
   e) Construction lines

Self-Check

I am able to:	**Yes**	**No**
• Identify the drawing requirements necessary for a building drawing		
• Describe the following:		
o Drawing as a medium		
o Dimensioning		
o Projection of a circle		
o Ellipse		
o Basic developments		
o True lengths		
o Orthographic projections		
o Printing		

If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.

Module 2

Calculations

Learning Outcomes

On the completion of this module the student must be able to:

- Describe calculations standards
- Demonstrate the calculation of cones by proportions
- Demonstrate the calculation of cone frustrums by proportions
- Demonstrate the calculation of cones by smoleys
- Demonstrate the calculation of cone frustrum by smoleys
- Demonstrate the calculation of square to round by Trigonometry

2.1 Introduction

This module deals with calculations of cones and cone frustrums and the user of smoley tables. It also covers the calculation of square to round by trigonometry.

2.2 Calculation Standards

The following are some standards that it is necessary to know.

2.2.1 Circumference

π x Diameter or 2 x π x Radius

2.2.2 Pythagoras theorem

$a^2 + b^2 = c^2$

$c^2 - b^2 = a^2$

$c^2 - a^2 = b^2$

Note:
This theorem applies to right angle triangles only.

2.2.3 Trigonometric ratios

$$Sine\ \frac{opposite}{hypotenuse}\ Sin\ A = \frac{\delta}{c}$$

$$Cos - \frac{adjacent}{hypotenuse}\ Cos\ A - \frac{b}{c}$$

2.2.4 Sine Rule

$$\frac{Sine\ A}{a} = \frac{Sine\ B}{b} = \frac{Sine\ C}{c}$$

2.2.5 Cosine Rule

$$Cos\ B = \frac{a^2 + c^2 - b^2}{2ac}\ or\ b^2 = a^2 + c^2 - 2ac\ Cos\ B$$
$$Cos\ C = \frac{a^2 + b^2 - c^2}{2ab}\ or\ c^2 = a^2 + b^2 - 2ab\ Cos\ C$$

$$Cos\ A = \frac{b^2 + c^2 - a^2}{2bc}\ or\ a^2 = b^2 + c^2 - 2bc\ Cos\ A$$

2.2.6 Inverse Notation

$$\propto = 2\ (Sine^{-1}(\frac{C}{2R})$$

2.2.7 Radian measure

1. Degrees to radians;
   Angle in degrees x $\frac{\pi}{180}$ = Radians

2. Radians to degrees; Radians x $\frac{180}{\pi}$
   = Angle in degrees

3. A = R x $\propto$ where $\propto$ is in Radians

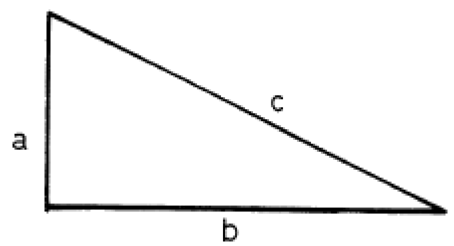


Figure 2.1 b

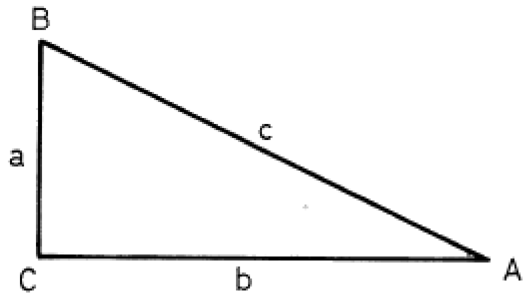


Figure 2.2 c,d & e

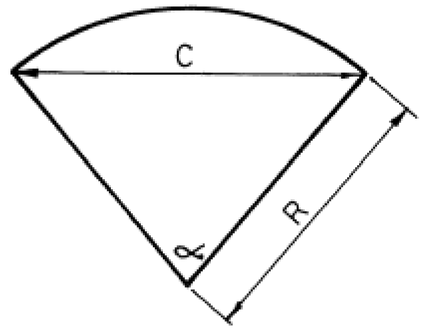


Figure 2.3 f

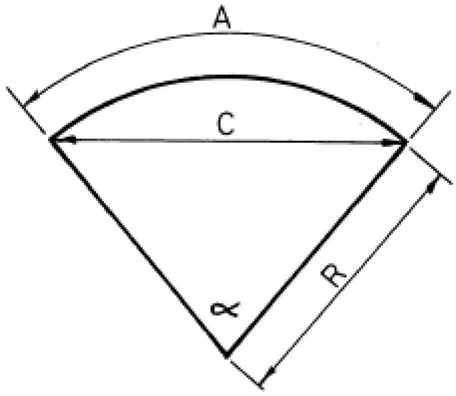


Figure 2.4 g

2.2.8 Standard 12 Division Constants

2.2.9 To Calculate the Cord "C" with Radius "R" and Angle "∝" given

i) Make use of the Cosine Rule

$C^2 = 2R^2 - 2R^2 Cos\ \propto$

$C = \sqrt{2R^2 - 2R^2 Cos \propto} \rightarrow$

ii) Make use of the Sine Rule; note the sum of the included angles of a triangle is equal to 180° and in these cases

$\beta_1 = \beta_2$

$\frac{C}{Sin \propto} = \frac{R}{Sin\ \beta_1}$

$C = \frac{R.Sin\propto}{Sin\beta_1} \rightarrow$

iii) Half the Angle ∝ so that angle $\theta = \frac{1}{2} \propto$

$Sin\ \frac{1}{2} \propto = \frac{opposite}{hypotenuse}$

$Sin\ \theta = \frac{\frac{1}{2}C}{R}$

$C = 2(R\ Sin\ \theta) \rightarrow$

2.2.10 To Calculate the Radius "R" with Cord "C" and Angle "∝" given

i) $R = \frac{CSinB_1}{Sin\propto}$

ii) $R = \frac{C}{2\ Sin\frac{1}{2}\propto}\ or\ R = 2\frac{C}{Sin\theta}$

2.2.11 To Calculate the Angle "<X" with Cord "C" and Radius "R" given

Here we make use of the inverse notation

$\propto = 2\ Sin^{-1}\left(\frac{C}{2R}\right)$

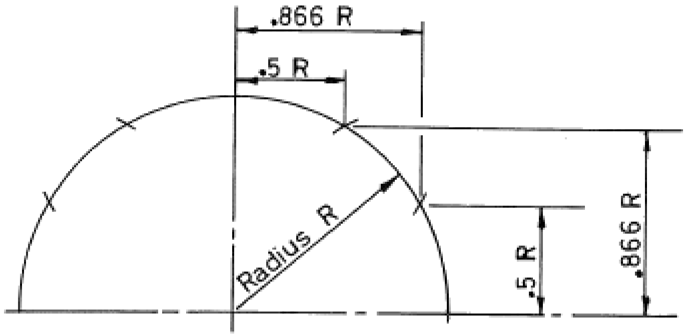


Figure 2.5 h

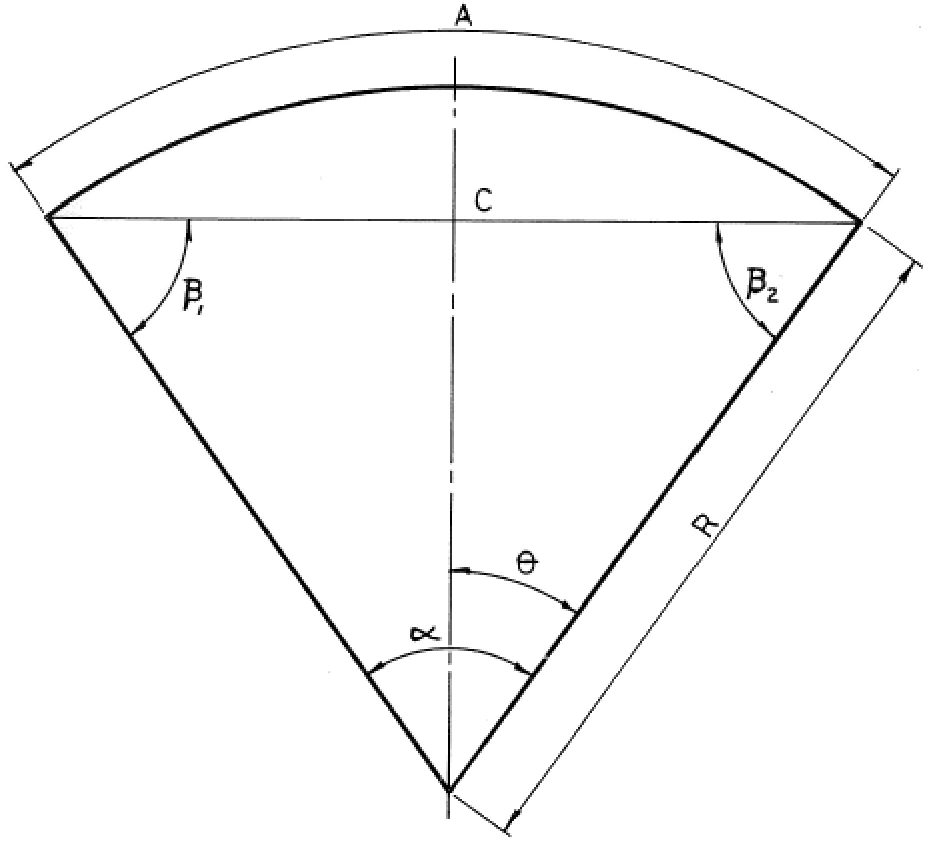


Figure 2.6 i

2.2.12 To Calculate Arc "A", Radius "R" and Angle "a" with Radial Geometry

Note:
In Radial Geometry the angle "∝" must always be in Radians.

$\propto \times \frac{\pi}{180} = x \ Radians$ and

$$\frac{Radians \ \times 180}{\pi} = \propto in \ degrees$$

i) $A = \ R \propto$ where ∝ is in Radians, by manipulation the following is also true.

ii) $R \ = \frac{A}{\propto}$ where ∝ is in Radians

iii) $\propto Rad = \frac{A}{R}$

as can be seen from these points ii and iii above.
The radius "R" can be calculated given the Arc "A" and the Angie ∝ (note the angle will have to be converted to radians). As well as the Angle "a" given the Arc "A" and Radius "R"

Note:
The angle will be in radians and will have to be converted to degrees.

2.2.13 To Calculate the Mid-Ordinate "M" given the Angle "∝" and the Radius "R"

$H \ + \ M \ = \ R$ equation (1)

But

$H \ = \ R \ Cos \ \theta$ equation (2)

Now substitute H in equation (2) with H in equation (1).

$R \ Cos \ \theta \ + \ M = R$
$M = R - R \ Cos \ \theta$

You will also find that given any other two knowns such as "C" and "R" or "A" and "R", the mid-ordinate "M" can be calculated by using the formulae as given in **2.2.9 to 2.2.12**.

2.2.14 Calculating "R" where the apex of the Cone is not given

i) Given a) r_1 and r_2 and W and

With the ratios of equal triangles we find

$$\frac{R-W}{r_2} = \frac{R}{r_1}$$

$$r_1(R-W) = Rr_2$$
$$r_1R - r_1W - Rr_2$$
$$r_1W - r_1R - r_2R$$
$$r_1W - R(r_1 - r_2)$$

$$R = \frac{r_1W}{r_1 - r_2}$$

$$R = \frac{W}{1-r_2} \rightarrow$$

ii) Given r_1 and r_2 and the height H
We have to calculate W as follows

$$W^2 = H^2 + (r_1 \; - r_2)^2$$
$W - \sqrt{H^2 + (r_1 - r_2)^2}$ (Pythagoras)

$\rightarrow$

When W has been calculated the previous formula is used.

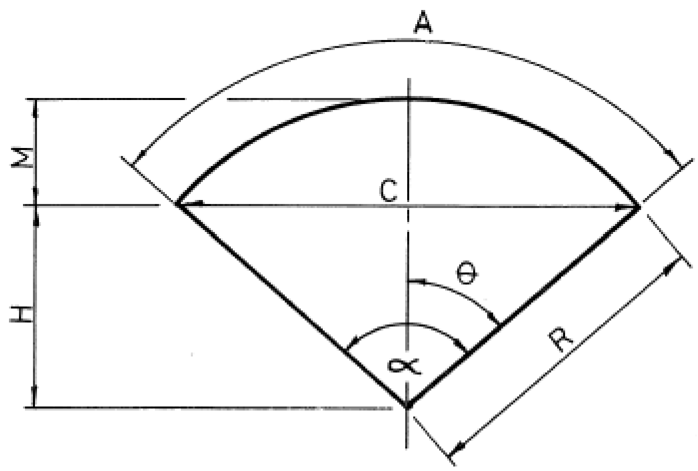


Figure 2.7 m and n

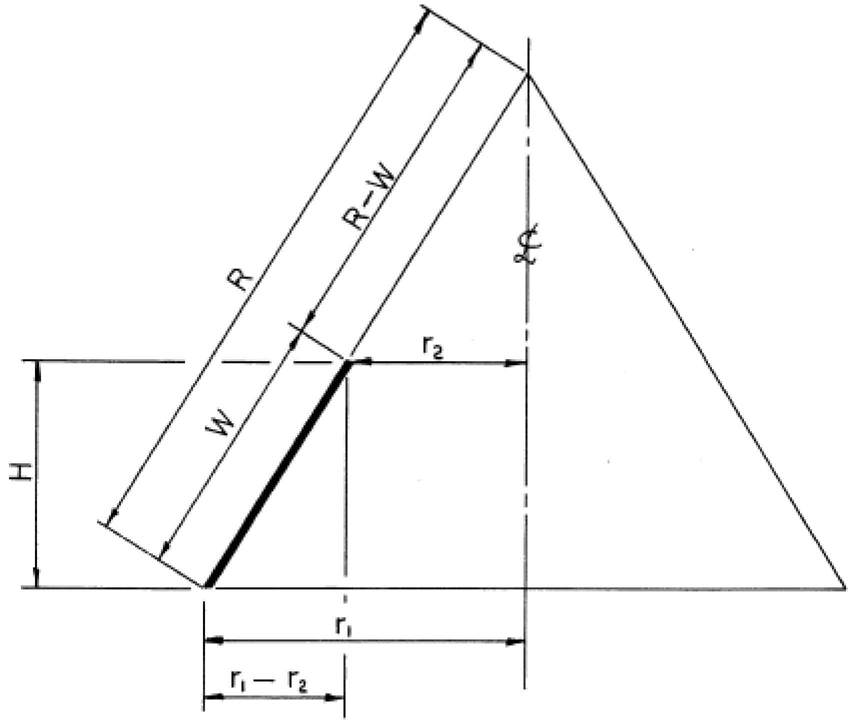


Figure 2.8 o

10.3 Right Cone calculation (with apex)

Given:

a) Vertical height "H"

b) Diameter "D" or Radius "R"

i) Calculate Development pattern radius "R"
$R = \sqrt{H^2 + r^2}$ (Pythagoras)

ii) Calculate Circumference (Development pattern Arc "A")
$s\pi r$ or πD

iii) Develop pattern in any number of segments 2,3 ext. by dividing the Arc "A" by the number of segments required.

iv) Calculate Development pattern Angle "∝"
$\propto = \frac{A}{R} \times \frac{180}{\pi}$

v) Calculate the cord length "C"
$C = \sqrt{2R^2 - 2R^2\, Cos\ \propto}$ (Cosine rule)

vi) Calculate the Mid-ordinate "M"
$M\ =\ R -\ R\, Cos\ \theta\ (where\ \theta\ is\ half\ \ \propto)$

vii) Complete the development pattern by drawing the curve required between the three points obtained as the extremes of the Cord "C" and the Mid-ordinate "M".

10.4 Right Cone frustrum calculation

Given:

a) Vertical height "H"

b) Diameter "D" or Radius "R"

i) Calculate the width of the development pattern "W"

$W = \sqrt{H^2 + (r_1 - r_2)^2}$ (Pythagoras)

ii) Calculate development pattern outside radius "R_2"

$R_2 = \dfrac{W}{1 \frac{-r_2}{r_1}}$

iii) Calculate development pattern inside radius R1

$R_1 = R_2 - W$

iv) Calculate circumferences (Pattern Arc's AI andA2)

v) Remembering that you now have to work with 2 Arc's 2 Cords and 2 Mid-ordinates follow the same procedure as 10.3 points iii to vii for both the cords and mid-ordinates.

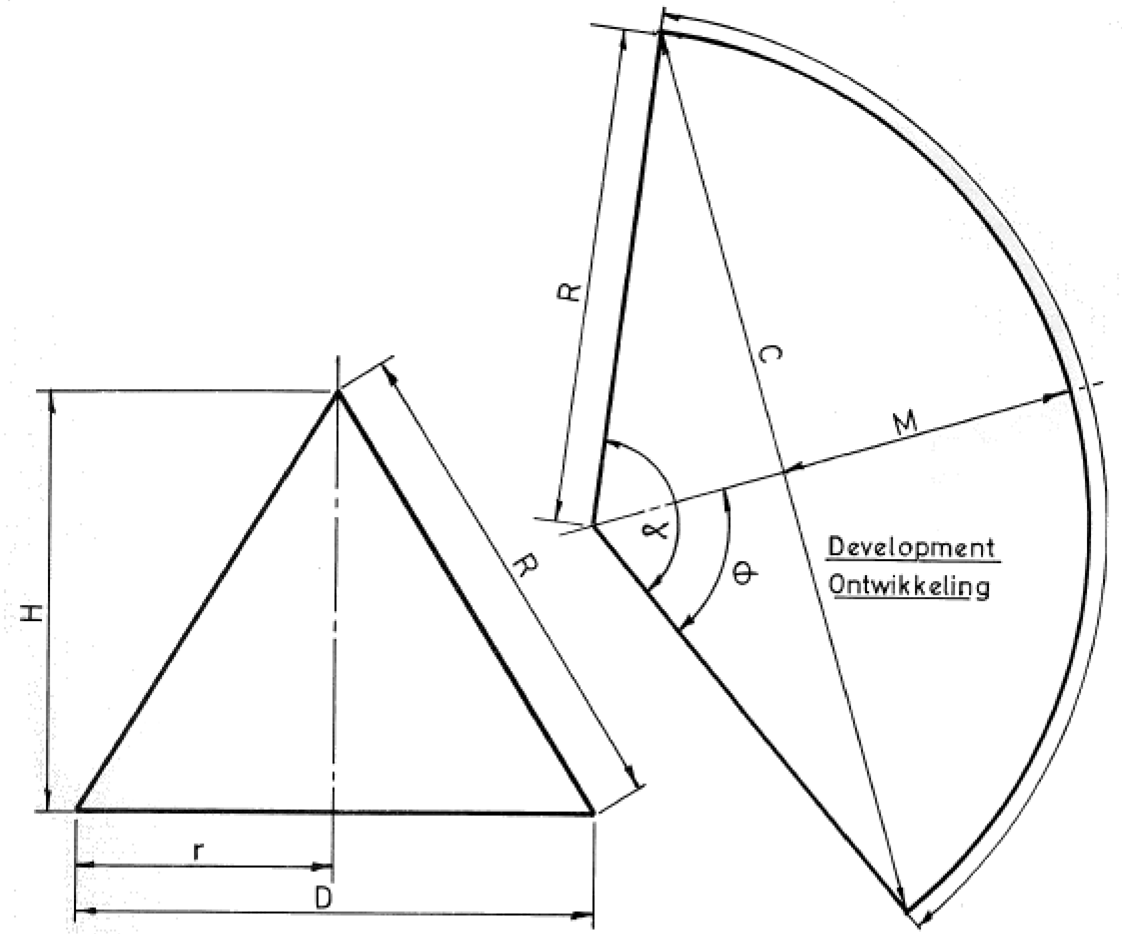


Figure 2.9

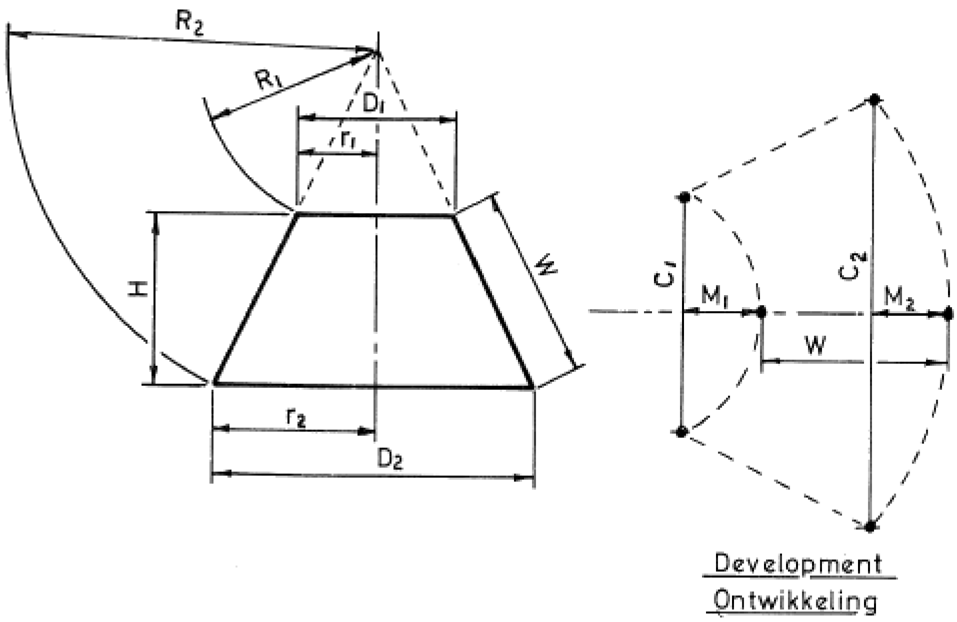


Figure 2.10

10.5 Right Cone Calculations with Smoleys tables

For simplicity and better understanding this example is done with figures to enable you to follow the method in the Smoleys tables.

i) $\mathrm{R}^2 = 5^2 + 15^2$
$R^2 = 250$
$\underline{R = 15{,}81}$ the log in Smoleys 1.19893 →

ii) Circumference $= \pi \times D$
= 3,142 x 10
Arc = 31,42 →

iii) Now you have to decide on the number of segments, in this example we use 4 segments.
$Arc + 4$
$= \frac{31{,}42}{4}$
$\boldsymbol{Arc = 7,86}$ log in Smoleys 0.8954 2

iv) With the Radius "R'~ and the Arc "A" we find in the Smoleys tables under "Digest of Solutions" on segments in the Segmental functions preamble the following formula for Radius and Arc given:
$log\ a = log\ A - log\ R$ …………..………. equation a
$log\ C = log\ A - \log \propto$ …………..………. equation b
$log\ M = log\ A + log \propto - log\ R$ ……….. equation c

a) $log\ a = log\ A - log\ R$
$log\ a = 0{,}89542 - 1{,}19893$ (see points I and ii)
$\boldsymbol{log\ a = 9,69646}$ →

in Segmental functions section under $a = \frac{A}{R}$ in tables we look up 0,69649 and find the Angle in the pages as 28° - 29' - 6'' (see page 42 in Smoleys)
$log\, a = 9{,}69649$
a= 28° - 29' - 6'' →

b) $log\, C = log\, A - log\, \propto$
$log\, C = 0{,}89542 - 0{,}00448$ (on the angle 28° - 29' - 6'' (in the same line as, $a = \frac{A}{R}$ under $\frac{A}{C}$ we find 0,0048)
$C = 7{,}7792$ (find antilog under logs and squares)

c) $log\, M = 2log\, A + logd - log\, R$
$log\, M = (2 \times 0{,}89542) + 9{,}09467 - 1{,}19893$ note log ∝ is found on the Angle 28° - 29'- 6'' in the same line as, a = $\frac{A}{R}$ under ∝= $\frac{r}{a}$
$log\, M = 1{,}68658$
$\underline{\boldsymbol{M = 0.48593}}$ (find antilog under logs and Squares)→

With these answers we complete the layout as in **Figure 2.11**.

10.6 Right Cone frustum calculations with Smoleys tables

For calculating the cone frustum we follow the same procedure considering the top cut off as a cone.

We calculate the bottom diameter, Arc, Cord and Mid-ordinate as one section (see the red lines in **Figure 2.11b**), then the top diameter, Arc Cord and Mid-ordinate (see black line in **Figure 2.11b**), and construct as follows:

On centre line OX through 0 place the Cone Bottom Cord AB, from 0 normal to cord AB; add the Mid-ordinate to give point C.

Taking the difference between the two radii R1 and Rz as the width of the cone frustum plate and using centre C scribe to cut centre line OX at E and with E as centre and compass set to the top mid-ordinate dimension, scribe to cut centre line OX at D, then through D normal to centre line OX draw a line to represent the top cord and mark G.H. Connect points G to A and H to B, then draw Arcs G. E. H. and C. B.

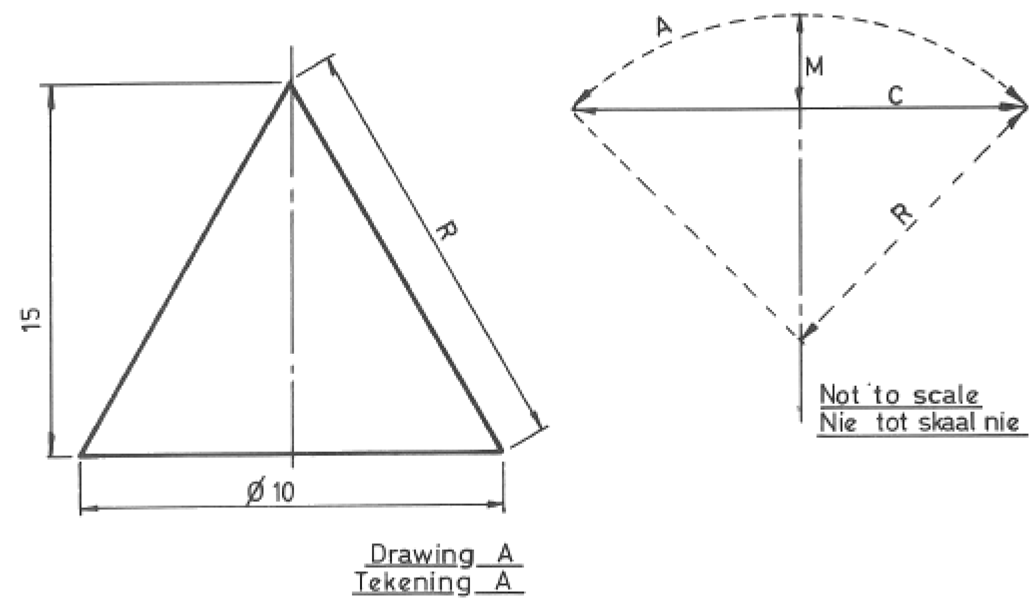


Figure 2.11a

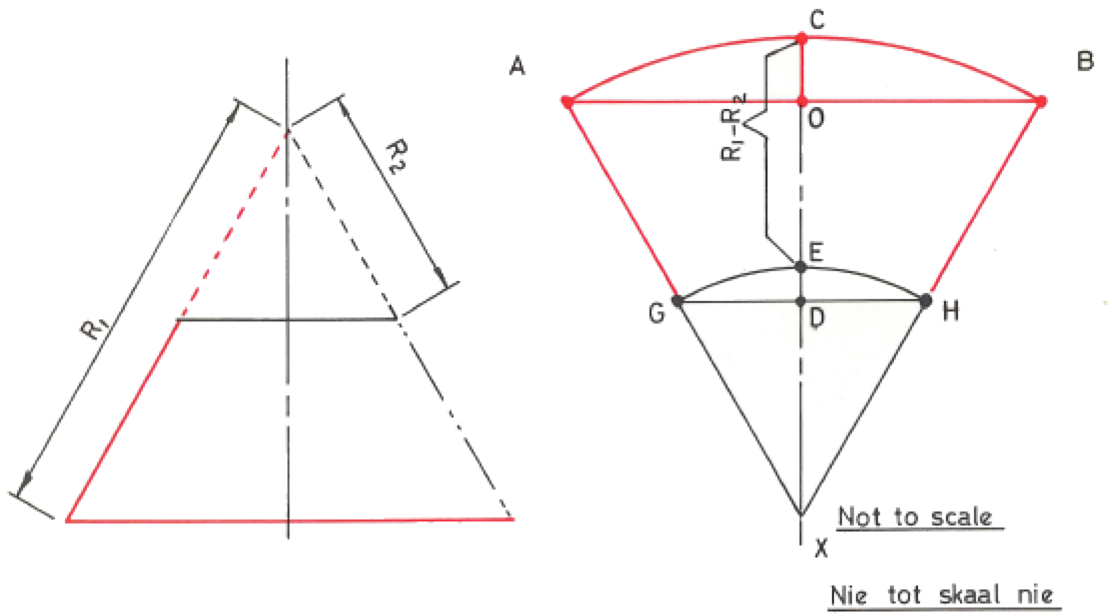


Figure 2.11b

10.7 Square to Round Calculation (Triangulation)

Vertical Height = 75 m

The basis of this and similar calculations on triangulation is Pythagoras' Theorem. As you should know by now, this is the same procedure as used in ordinary triangulation developments except that we now calculate the diagonals, instead of measuring them graphically from our true length diagram as applied in the developments.

i) Calculate circumference of circle and divide by number of divisions.
Circumference = πD

Length, 1-2, 2-3, 3-4 $ext = \frac{\pi D}{12} = \frac{\pi \times 90}{12}$
$\mathbf{1 - 2 = 23,5619} \rightarrow$

ii) Calculate Ae and Ah (Ae = Ah = f3)
Ae = AC - ,5 Rad
= 60 - (,5 x 45)
= 60 – 22,5
f3, Ae and Ah = 37,5 →

iii) Calculate Af and Ag (Ag = ag = e2)
Af = AC – 0,866 Rad.
= ,60 - (,866 x 45)
= 60 – 38,97
e2, Af and Ag = 21,03 →

iv) Calculate A1 (A1 = A4)
$A1 = \sqrt{AC^2 + C1^2 + H^2}$
$A1 = \sqrt{60^2 + 15^2 + 75^2}$
$A1 = \sqrt{9450}$
A1 and A4 = 97,2111 →

v) Calculate A2 (A2 = A3)
$A1 = \sqrt{Ae^2 + e2^2 + H^2}$
$= \sqrt{37,5^2 + 21,03^2 + 75^2}$
$= \sqrt{7473,5109}$
A2 and A3 = 86,44947 →

Summary
As calculated:
A1 and A4 = 97,2111 →
A2 and A3 = 86,44947 →
1-2, 2-3, 3-4, ext. = 23,5619 →

True length
on plan

ACB = 120 →
ADB =120 →

Using these figures, it is now possible to complete the development pattern by completing triangles similar to the graphical method.

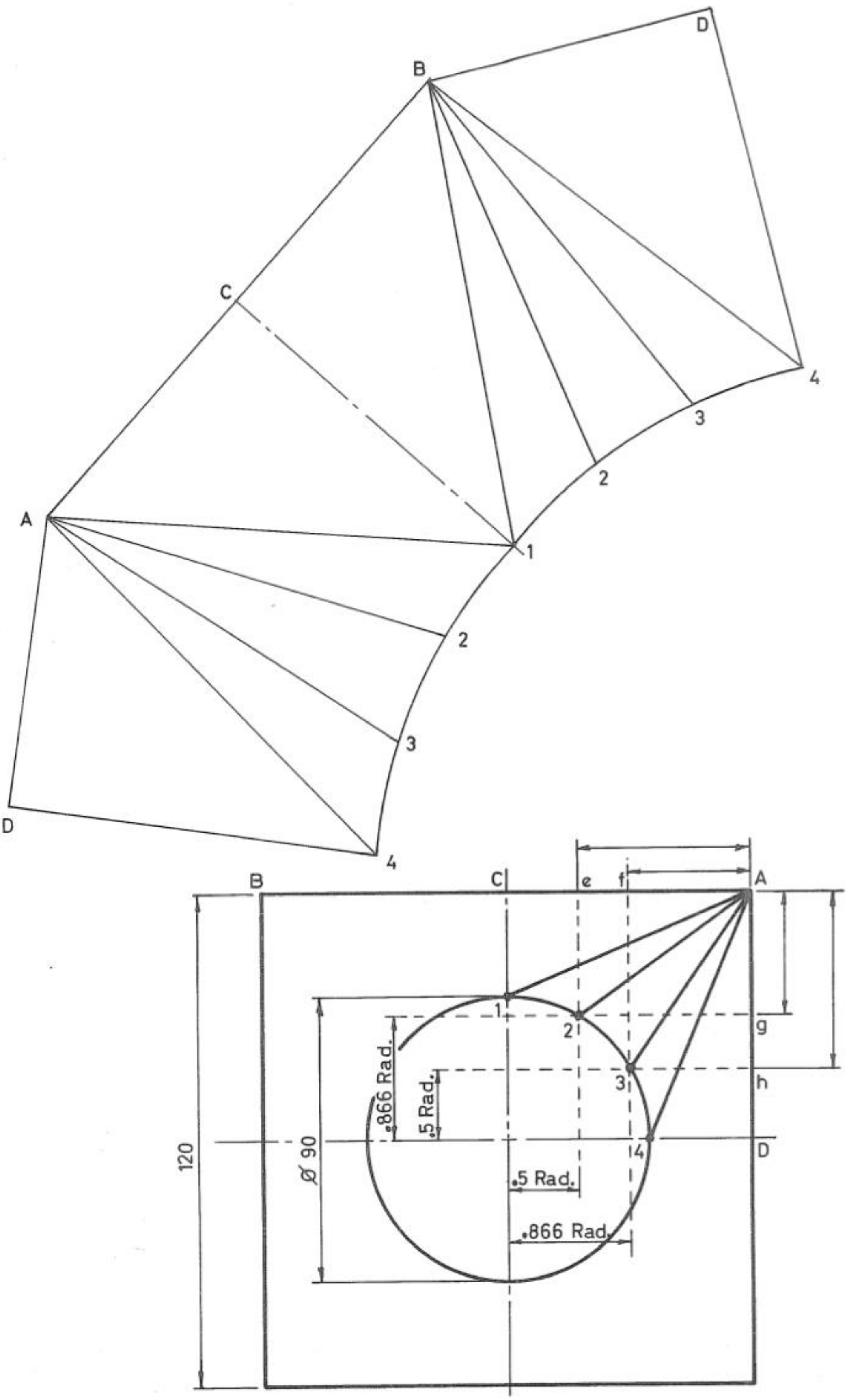

B
D
C
4
3
2
A
1
2
3
D
4
B
C
e
f
A
1
2
g
3
h
4
D
.866 Rad.
.5 Rad.
120
Ø 90
.5 Rad.
.866 Rad.

Figure 2.12

Activity 2.1

1. How would you calculate cones by proportions?
2. How would you calculate a cone frustrum by proportions?
3. How would you use smoley tables to calculate cones?
4. How would you calculate a cone frustrum using smoley tables?
5. How do you calculate square to round using trigonometry?

Self-Check

I am able to:	Yes	No
• Describe calculations standards		
• Demonstrate the calculation of cones by proportions		
• Demonstrate the calculation of cone frustrums by proportions		
• Demonstrate the calculation of cones by smoleys		
• Demonstrate the calculation of cone frustrum by smoleys		
• Demonstrate the calculation of square to round by Trigonometry		

If you have answered ‘no’ to any of the outcomes listed above, then speak to your facilitator for guidance and further development.

Module 3

Spiral developments

Learning Outcomes
On the completion of this module the student must be able to:

- Describe spiral facts
- Demonstrate drawing the spiral on the
    - horizontal plane
    - vertical plane
- Demonstrate radial line development on the
    - horizontal plane
    - vertical plane
- Demonstrate vertical straight line development
- Demonstrate triangulation development

3.1 Introduction

Spiral developments are usually considered the most awesome and difficult developments but are in actual fact quite simple to develop. It is once again important to note that accuracy in the layout is accuracy in the development.

3.2 Spiral facts

- Horizontal spirals have no bend lines but are pulled or pressed over a jig to form the complete article.
- Vertical spirals have bend lines and can also be rolled.
- On spiral developments, accuracy is of the utmost importance, therefore, all circumferential and diagonal dimensions have to be calculated.
- The pitch of a spiral is the height of rise a spiral has in 360 o.

3.3 Drawing the spiral (horizontal plane)

Draw the pitch line to length as the centre line of the spiral and at the bottom, draw the half plan of the spiral (both inside and outside diameter). Divide and number as shown (note the more divisions, the more accurate the drawing will be).

Then divide the spiral pitch into the same number, the same as the plan. Now project the number up from the plan to cut the pitch divisions to give the points of the spiral.

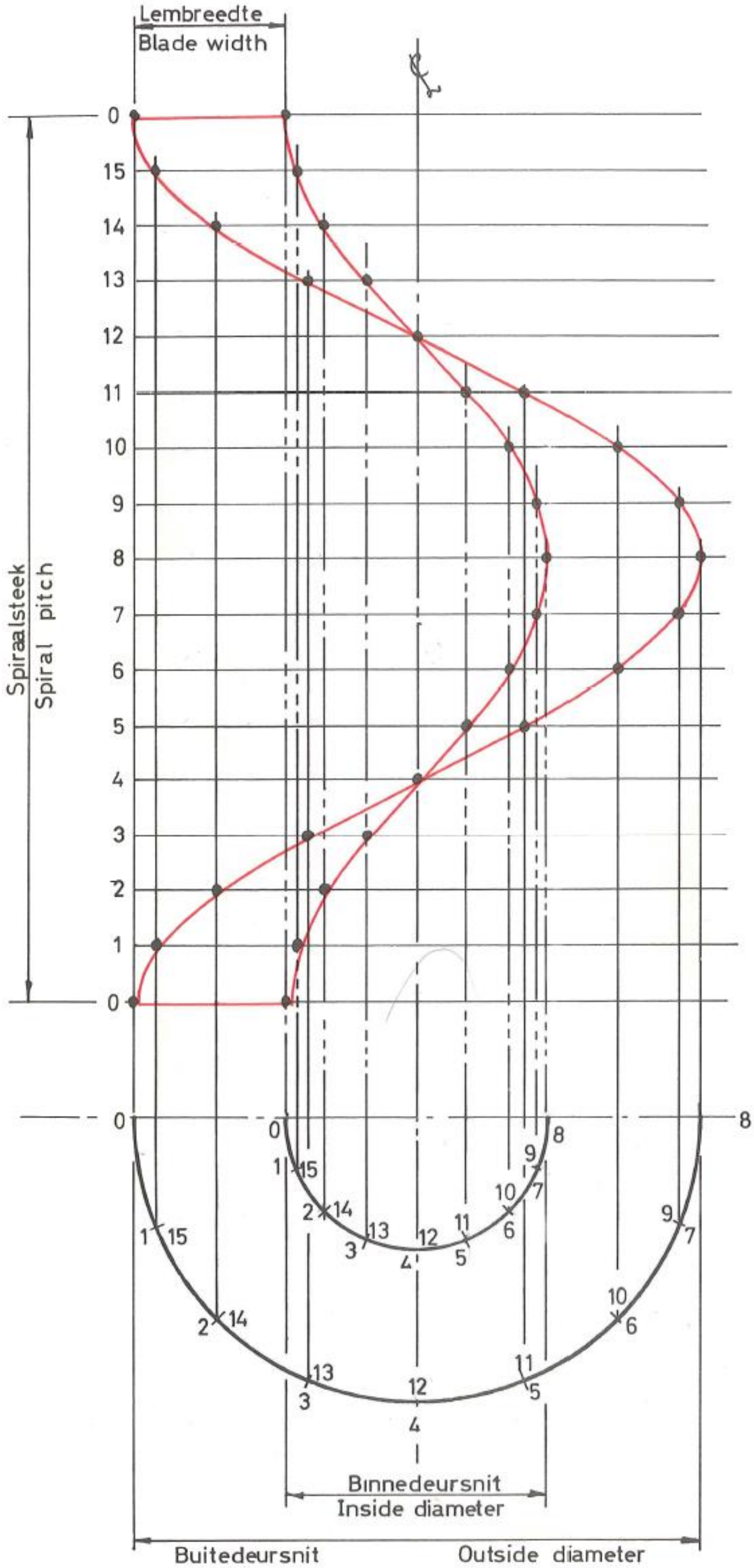


Figure 3.1

Note:
It is advisable to first complete the outer diameter spiral and then only project up the inner diameter spiral as this will lead to less errors due to all the projection lines that can confuse you.

3.4 Drawing the spiral (vertical plane)

Follow the same procedure for the first spiral, then add on the height of the spiral blade to the projection lines and complete the second spiral.

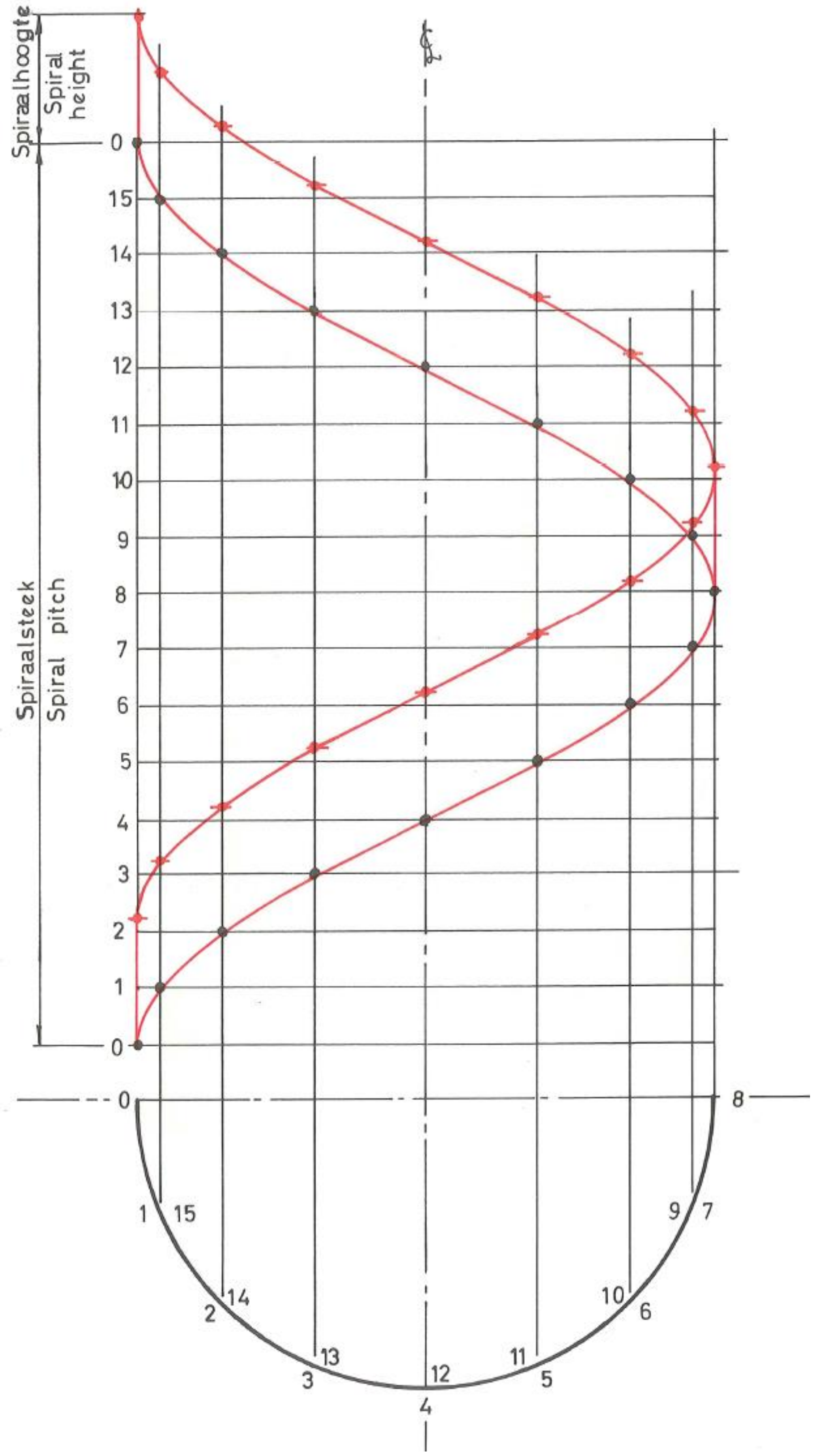


Figure 3.2

3.5 Radial line development (horizontal plane)

For the development of the horizontal spiral it is not necessary to draw the spiral as we need only know the outer diameter, the inner diameter and the pitch of the spiral.

Commence by drawing the true length diagram as a triangle with the vertical leg being the pitch and the horizontal leg being the inner and outer circumference of the spiral diameters (calculated).

Note:
This diagram need not be to scale as it is much safer to calculate these dimensions to reduce errors. The true lengths can now be calculated as the diagonals of these triangles by means of Pythagoras's theorem. $A^2 + B^3 = C^2$

Therefore true inner circumference will be 100^2

$+ 157{,}079^2 = C^2 = 10\ 000 + 24\ 673{,}81 = C^2$
$= 34\ 673{,}81 = C^2$
$C = \sqrt{34\ 673\ 81}$
$C = 186{,}2$ mm

Similarly the outer true circumference will be 329,69 mm. We commence by marking down the width of the blade on a centre line and marking AB.

Now, we consider the number of development segments, which can be any number but 10 will be the most convenient as we have to divide the circumferences by the number of segments required.

Taking one segment length of outer circumference ie 329,69 ÷ 10 = 32,96 mm. Say 33 mm. Set compass to size and with centre A scribe a circle. Similarly we take the inner circumference and divide by 10 ie 18,6, say 18½ mm.

Set compass to size and with centre B scribe circle now draw tangent lines touching the circles and extend to cut the centre line at O.

With O as centre, set compass to A and scribe a circle.

Now set compass to outer circumference segment size and starting at point A step off 5 paces to the left along the circle and 5 paces to the right along the circle and mark the last points XX to O.

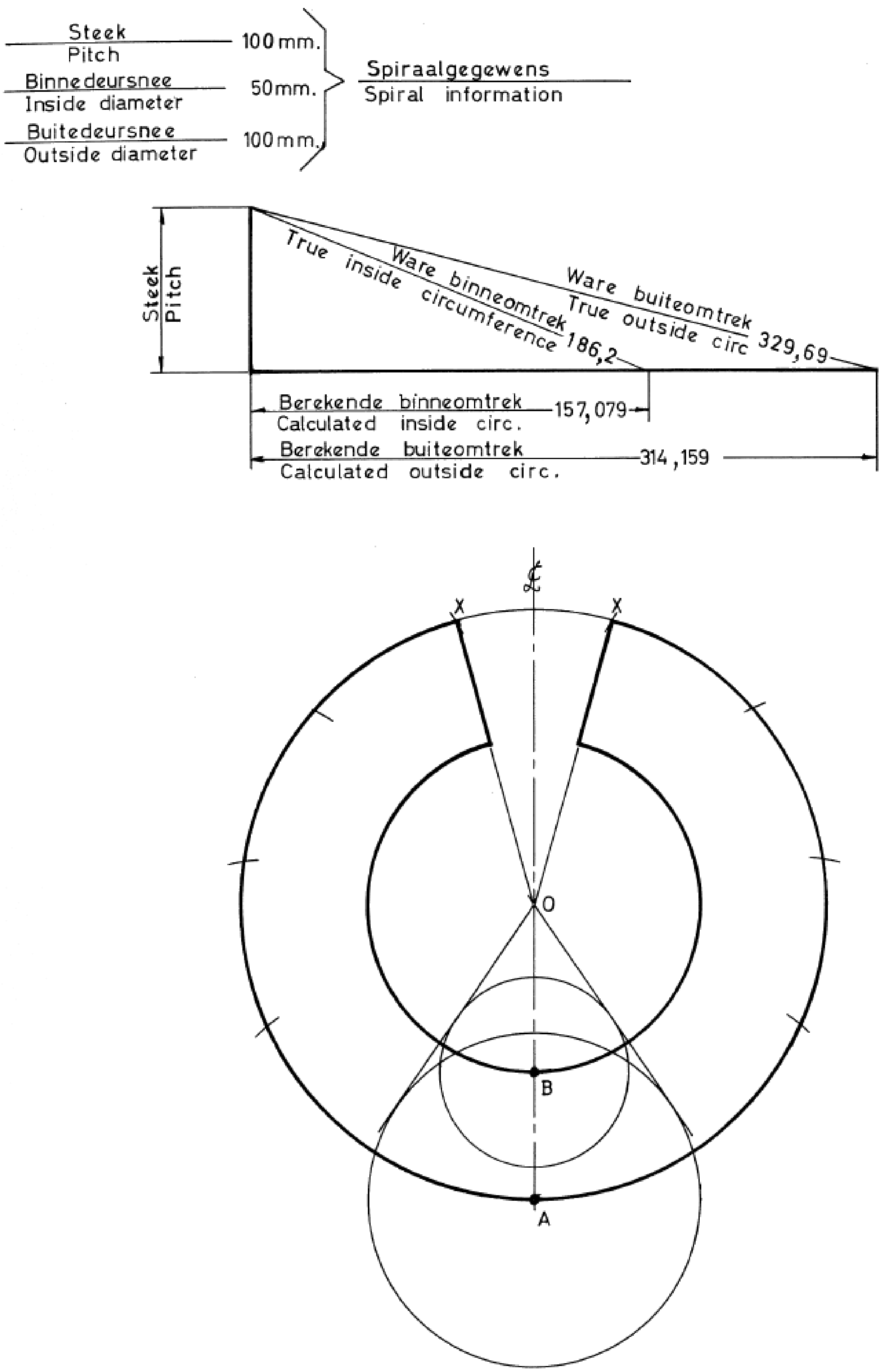

Steek
Pitch
100 mm.
Binnedeursnee
Inside diameter
50mm.
Buitedeursnee
Outside diameter
100 mm.
Spiraalgegewens
Spiral information
Steek
Pitch
True inside circumference 186,2
Ware binneomtrek
Ware buiteomtrek
True outside circ 329,69
Berekende binneomtrek
Calculated inside circ.
157,079
Berekende buiteomtrek
Calculated outside circ.
314,159
X
X
O
B
A

Figure 3.3

Then scribe in the inner circle with centre O and radius OB from lines XO to XO to complete the development.

Note:
The development pattern will never be a full circle.

3.6 Straight line development (vertical plane)

To develop the vertical spiral we commence exactly the same as the horizontal spiral. The only difference is that we do not have an inside and outside circumference, but we have only one which is the mean circumference. Draw the true length diagram preferably to full scale with the vertical leg AB the pitch of the spiral and the horizontal leg AC the calculated circumference.

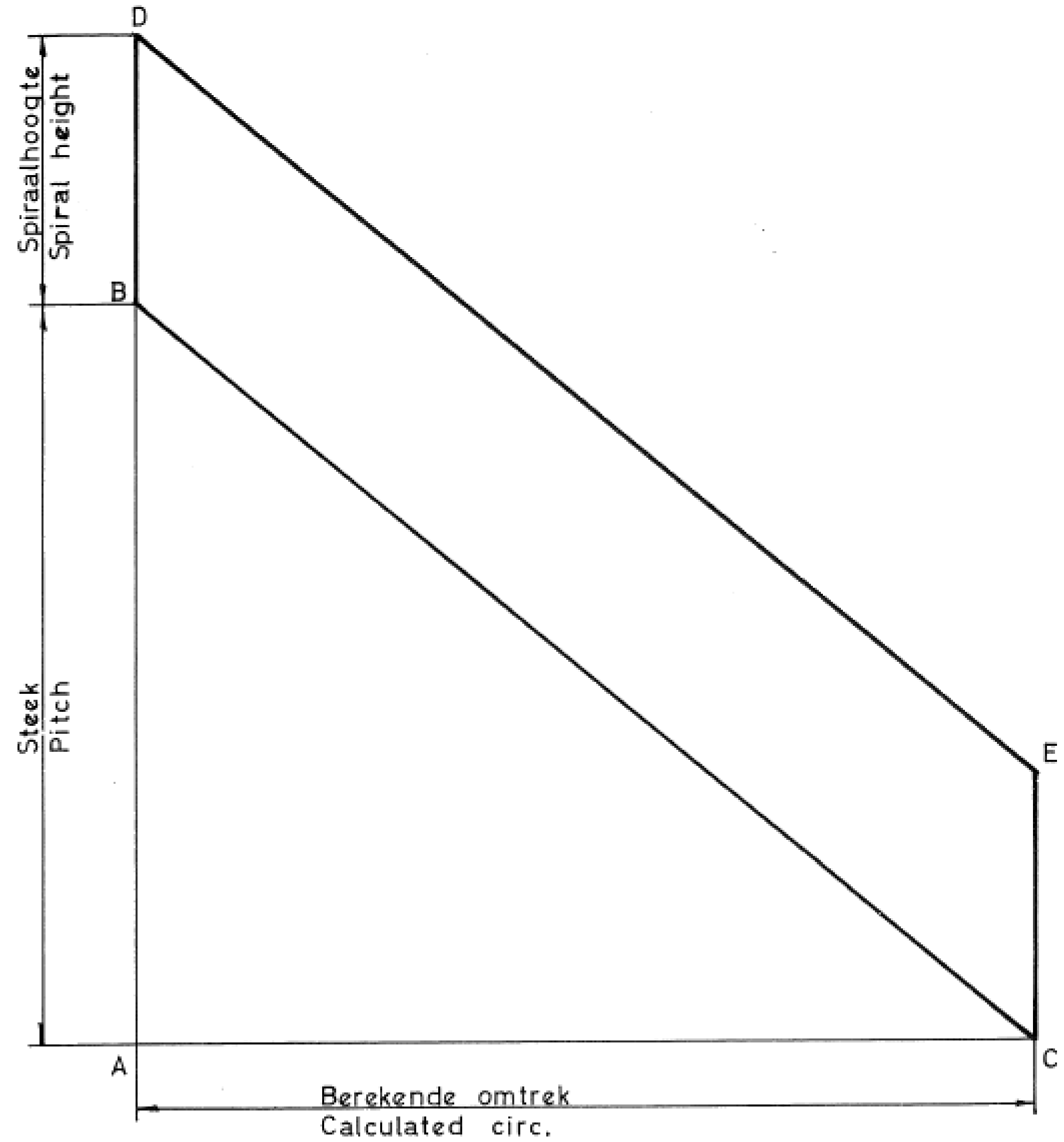


Figure 3.4

Draw in the diagonal between points B and C then we add the height of the spiral blade to the extension of the vertical leg and mark D. Then from D parallel to BC draw a line to E to complete the development.

3.7 Triangulation to development of spirals

As the triangulation method is dependent on 4 dimensions repeated by means of a compass, the possible accumulated error does not warrant the consideration of triangulation on the spiral development.

Activity 3.1

1. Draw a full pitch of the following horizontal spiral.
   Pitch 120;
   Outside diameter 80;
   Inside diameter 40.

2. Develop a half pitch horizontal spiral with the following dimensions:
   Pitch 120;
   Outside diameter 75:
   Blade width 25.

3. Develop the following spiral chute

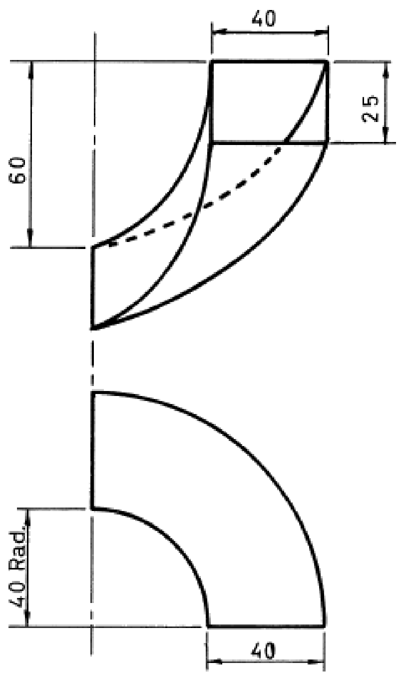


Figure 3.5

Self-Check

I am able to:	**Yes**	**No**
• Describe spiral facts		
• Demonstrate drawing the spiral on the		
o horizontal plane		
o vertical plane		
• Demonstrate radial line development on the		
o horizontal plane		
o vertical plane		
• Demonstrate vertical straight line development		
• Demonstrate triangulation development		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 4

Triangulation

Learning Outcomes
On the completion of this module the student must be able to:

- Explain the triangulation theorem
- Determine the bend lines
- Demonstrate square to round on parallel planes that are centrally placed
- Demonstrate square to square on parallel planes that are centrally placed
- Demonstrate cone frustrum on parallel planes
  - Right cone
  - Oblique cone
- Demonstrate triangulation on converging planes
  - Pyramid frustrum
  - Cone frustrum
- Demonstrate a taper lobster back bend
- Determine kinks and splays
- Demonstrate hopper with converging planes

4.1 Introduction

The triangulation method used for developing is the most versatile, as it is possible to do any development with triangulation, and in fact, as there are many developments that can only be done by triangulation.

It is therefore of the utmost importance to understand the basic principles of triangulation.

4.2 Triangulation theorem

Imagine a round bar bent as shown in the sketch with a string attached to points A and B.

If you look at a plan of this object it would seem that the length of the string between points A and B is 300 mm, but we know from the front elevation that the true length is 500 mm.

It is not true to say that all lines in the front elevation are true lengths as they might be sloping away from you or towards you. To overcome all these problems we always work from the plan view of an object to obtain the true length.

The example that was used can be seen to conform to Pythagoras's theorem (which you will be required to know and use later on).

Looking at the example and the explanations we can derive the most important rule around which all triangulation developments revolve.

Example

Rule:
To obtain the true length of a line, take the plan length and place, normal to the Vertical height between the points considered.

(a) Draw a vertical line with height corresponding to vertical height of the cone.
(b) Take plan length of XY and place normal to the vertical line drawn to represent the vertical height.
(c) Now set compass to the length across the hypotenuse of the triangle formed thus.

This will represent the true length X.Y (Check with front elevation).

We can summarise this rule as follows: PLACE THE PLAN LENGTH AGAINST THE VERTICAL HEIGHT AND MEASURE THE SLANT LENGTH WHICH IS THE TRUE LENGTH.

The main points to observe:
(a) Draw neatly and accurately.
(b) Plan view is of most importance.
(c) Draw front elevation.
(d) Determine the bend lines.
(e) Number each plane differently i.e. bottom plane A, B, C, etc., and top plane, 1, 2, 3, etc.
(f) Calculate the circumference and obtain unit length (circumference + 12).
(g) Obtain true lengths.
(h) Start developing on the opposite side of the required joint and work symmetrical about the starting points.
(i) As you complete each successive triangle, mark the points and draw in the appropriate lines.

Note:
By numbering the two planes differently, you immediately know which dimensions taken from the plan are true and for which we should find the true lengths. Measuring between A, B, C, etc., and 1,

	2, 3, etc., will be true lengths, whereas if we measure from letters to numbers we have to find the true lengths

.

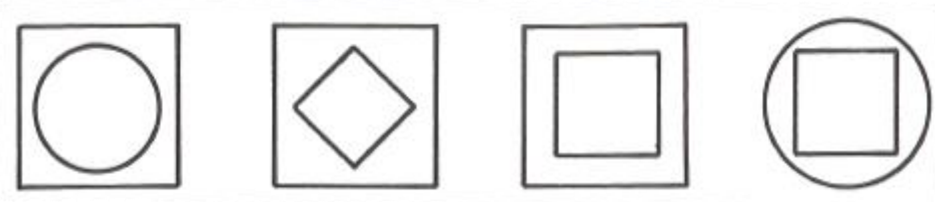


Figure 4.1

4.3 Determining the bend lines

After being able to determine the true length, the second and last very important point is to determine the bend lines on development.

We basically have to do with straight lines combined with curved lines or straight lines as shown in plan.

(a) Determine the bend lines by placing your rule or "T" square along a straight line having two ends marked.
(b) Move the rule towards the second shape (straight or curved) ensuring that the rule stays parallel with the straight line, until you touch the second shape and mark these touch point or points (see examples).

Worked Example 4.1

Mark the square A.B.C.D. Now move the rule parallel to AB until you touch the circle and mark. We now have the 2 points A and Band 1 point on the circle. By connecting them we have our first two bend lines.

Continue in this manner with the other three sides to complete the outline. This gives us four points on the circle and ·as we have seen, we require more points for accuracy. We therefore divide the circle into 12 parts in the usual way using the existing paints.

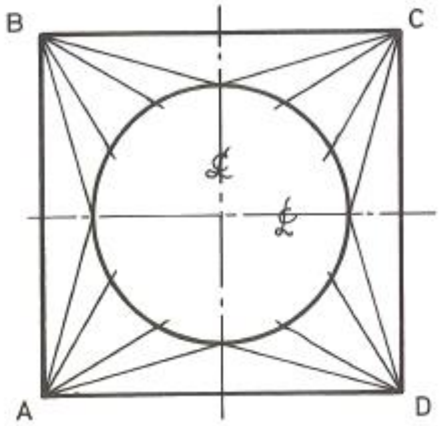


Figure 4.2

Note:
From our notes on tangent lines it will be found that the points on the circle will always be on the centre lines of the circle.

Worked Example 4.2

By applying above method we once again see that from points AB we get one point on the inside square. Continue in this manner until all four sides have been done.

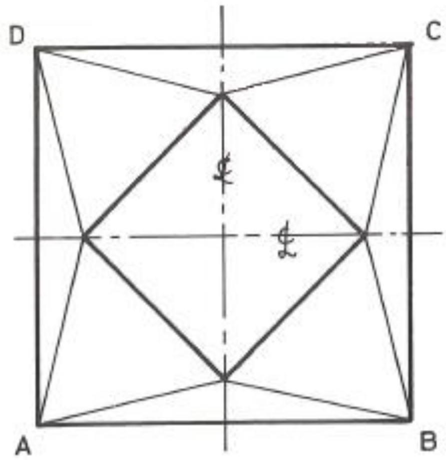


Figure 4.3

4.4 Square to round on parallel planes

After drawing front elevation, plan and true height scale, the drawing has to be numbered, each plane differently.

Start developing at the opposite side of the joint; in this case between points D and C. Draw a line D.Y.C. as taken from plan which is a true length and construct a perpendicular on point Y.

Measure Y.6 on plan and obtain the true length, then place on development and draw in the bend lines C.6 and D.6.

The next point C to 5 obtain true length and scribe on arc with centre C. Then use unit length 6 to 5 calculated and with centre 6 scribe an arc to cut arc C at point 5. Number this point and draw in the bend line C.5.

Similarly work around on both sides until you have completed points 5, 4 and 3 on the one side and points 7, 8 and 9 on the other side. You should have seen, by this time, that we are continually completing triangles such as 6.Y.D.6, 6.C.Y.6, C.6.5.C, etc.

The next triangle we have to complete is A.D.9.A (looking at the plan). Set compass on A.D. (true length) and with centre Don development scribe an arc, then measure A.9 and obtain true length, then with 9 as centre on the development, scribe an arc to cut arc A.D and mark point A obtained.

Complete the triangle by drawing in the lines AD and A9. Proceed in this manner until you have done the last two triangles AO.X.A and B.O.X.B (Note: To check whether your development is correct and true, the angles O.X.A and O.X.B. must be right angles 90°).

Complete the development by connecting all the points 0 to 11 with a continuous curve.

Note:
It is also possible when working with round areas to see when you are making a mistake, as the points on the curve will always form a flowing curve. There should never be any radical change in direction.

Note:
For this development it was in actual fact necessary to obtain the true lengths only three times as the following should be noted for this development.

C.6, D.6, D.9, A.9, A.O, B.O, B.3 and C.3, were of the same length and C.4, C.5, D;7, D.8, A.10, A11, B.1, B.2, were of the same length, it was also necessary to obtain Y.6 and X.O which was the same length.

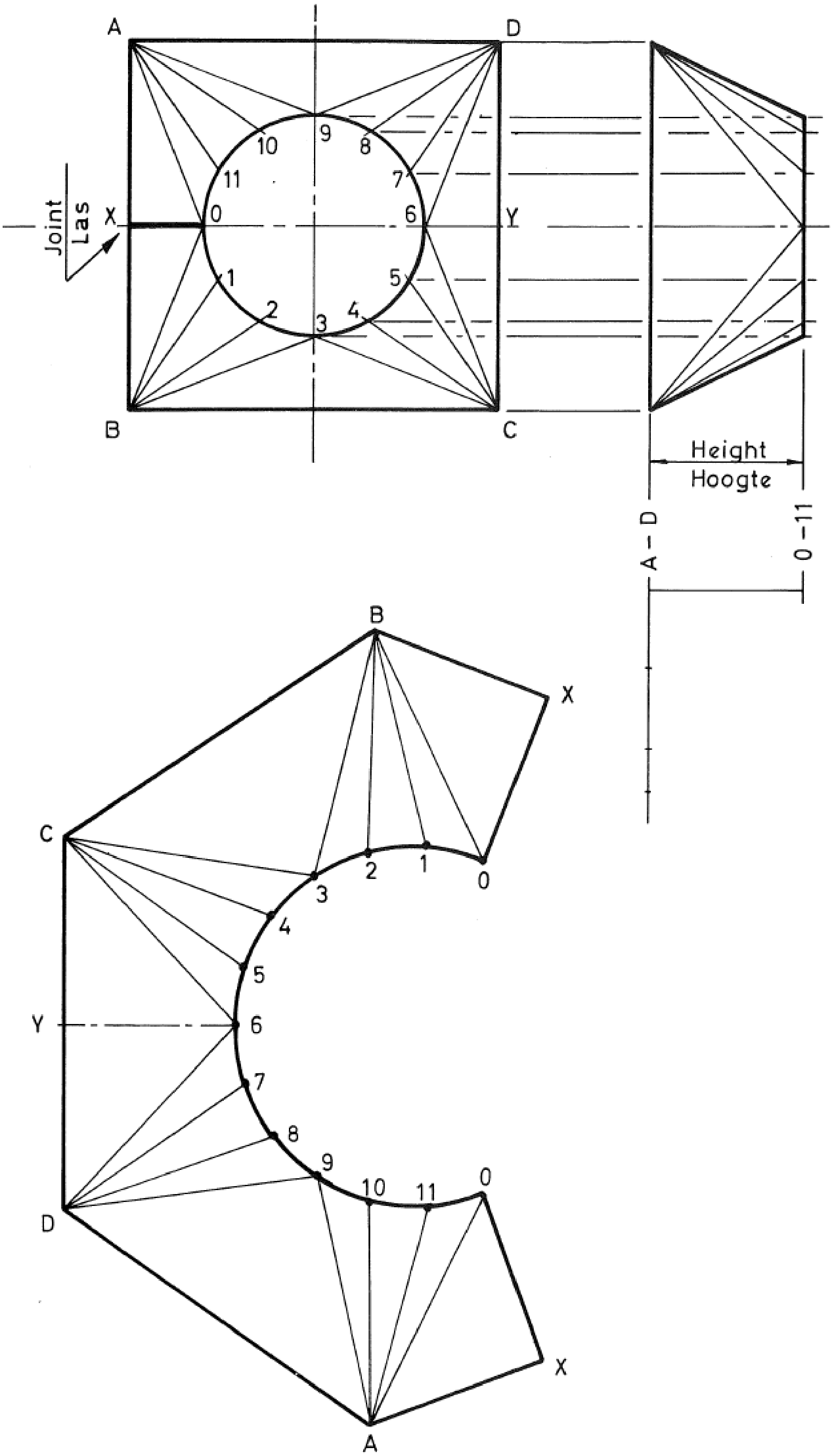

A
D
B
C
X
Y
Joint
Las
0
1
2
3
4
5
6
7
8
9
10
11
Height
Hoogte
A – D
0 – 11
B
C
D
A
X
Y
X
0
1
2
3
4
5
6
7
8
9
10
11
0

Figure 4.4

4.5 Square to square on parallel planes

As for **square to round** you start off by drawing the front elevation, plan and the true length scale. Then number with letters on one plane and numbers on the other plane.

Looking at the sketch (1) in **Figure 4.5** you will note that we have no triangles formed by the bend lines and the outside lines and as we need triangles we have to add auxiliary lines to form triangles (see dotted lines on the sketch (2)).

Commence by drawing D.C (opposite to joint), then complete triangle D.C.4.D. and draw in the lines. D.4 and D.C. will be full lines and 4.C will be dotted as shown on the plan.

Next we do triangle 4.3.C.4 and the other triangles are then done in sequence until you have completed triangles A.X.XO.A and X.XO.B.X.

Note:
To check development, the angles A.X,XO and B.X.XO should be right angles.

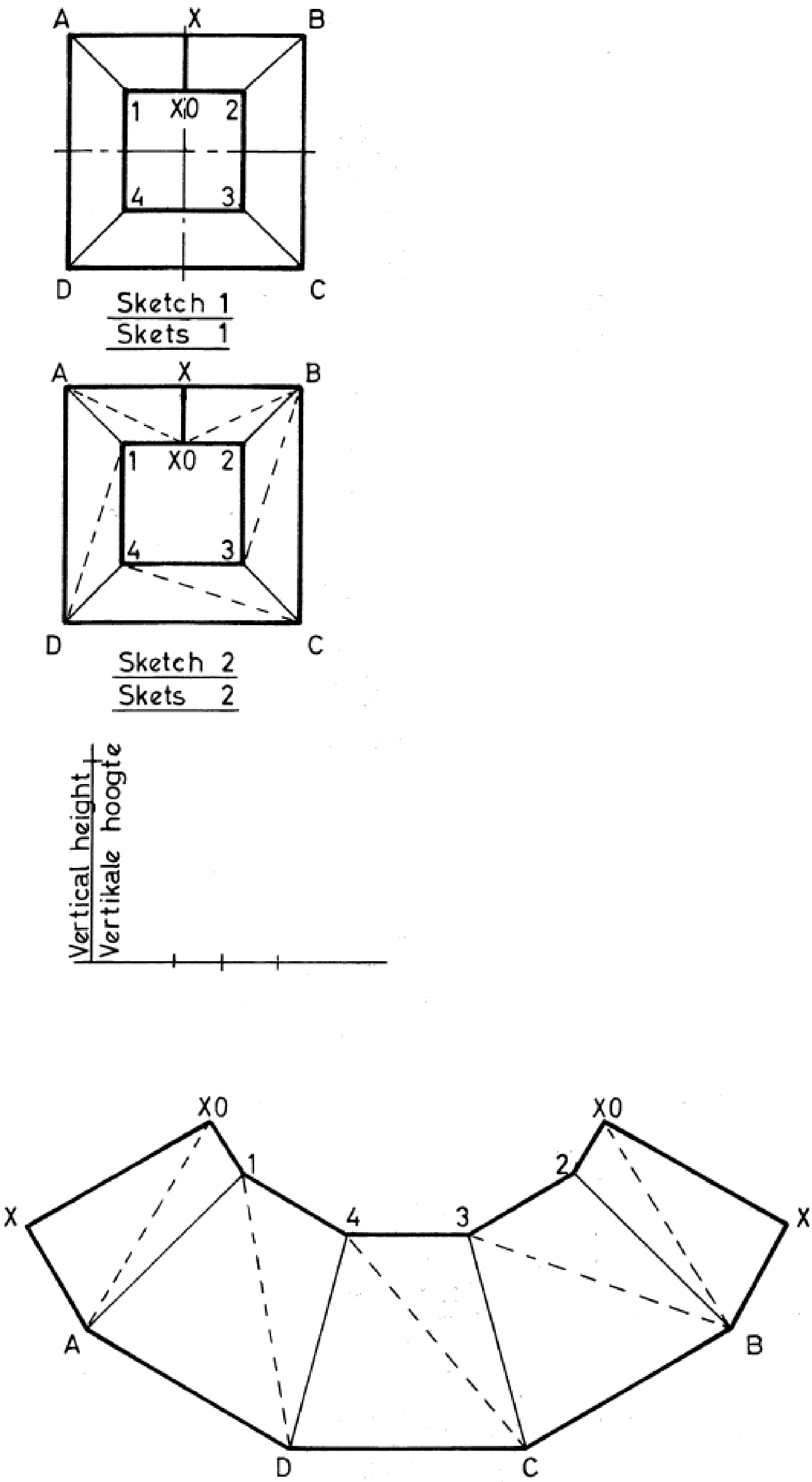

A
X
B
1
X0
2
4
3
D
C
Sketch 1
Skets 1
A
X
B
1
X0
2
4
3
D
C
Sketch 2
Skets 2
Vertical height
Vertikale hoogte
X0
1
4
3
2
X0
X
X
A
B
D
C

Figure 4.5

4.6 Cone frustrum on parallel planes (right cone)

Draw the front elevation, plan and true length scale, obtain bend lines by dividing the circles and number the planes using different notations.

You once again find that you have no triangles and have to add auxiliary lines (dotted).

Calculate the two circumferences and get the unit lengths (circumference + 12). Then complete the development by completing each successive triangle until done.

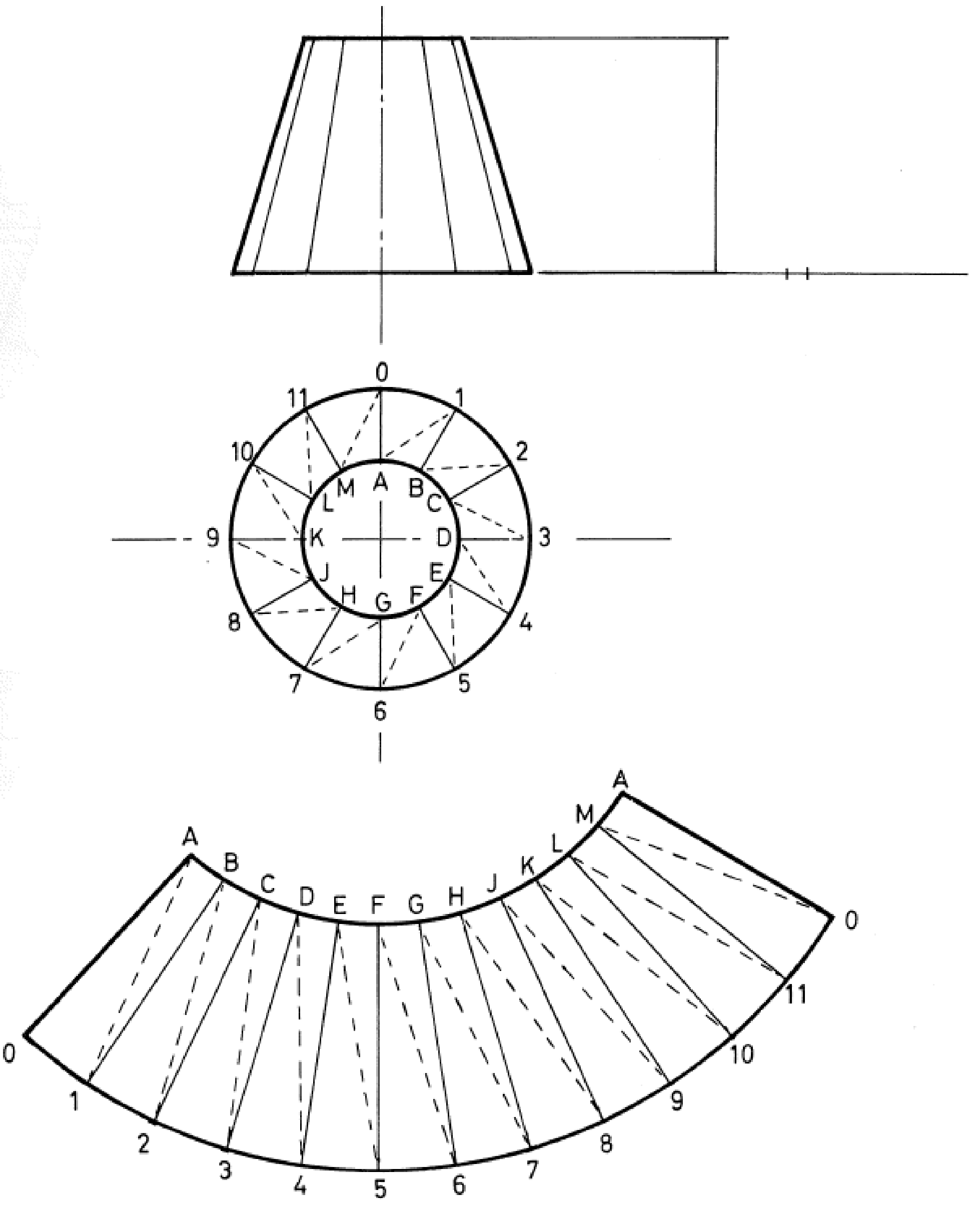
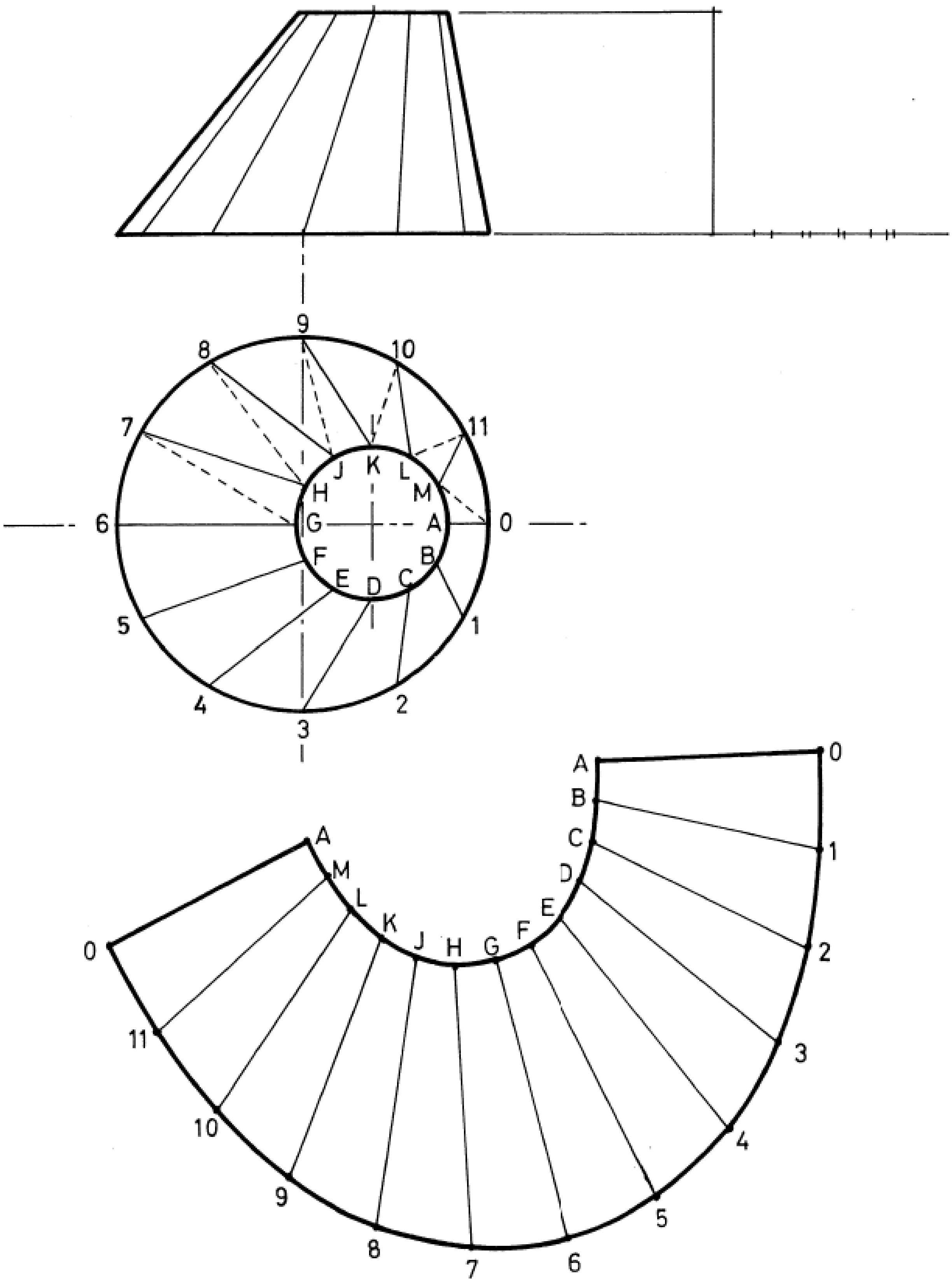


Figure 4.6

4.7 Cone frustrum on parallel planes (oblique cone)

As per right cone.



9
8
10
7
11
J
K
L
H
M
6
G
A
0
F
B
E
D
C
5
1
4
2
3
A
0
B
A
C
1
M
D
L
E
K
F
0
J
H
G
2
11
3
10
4
9
5
8
7
6

Figure 4.7

4.8 Triangulation on converging planes (pyramid frustrum)

We start developing at line A.I by obtaining the true length, take plan length A.I and place on the plane line of point A (see true length diagram) and measure the true length to the apex of the triangle on the plane line of point 1.

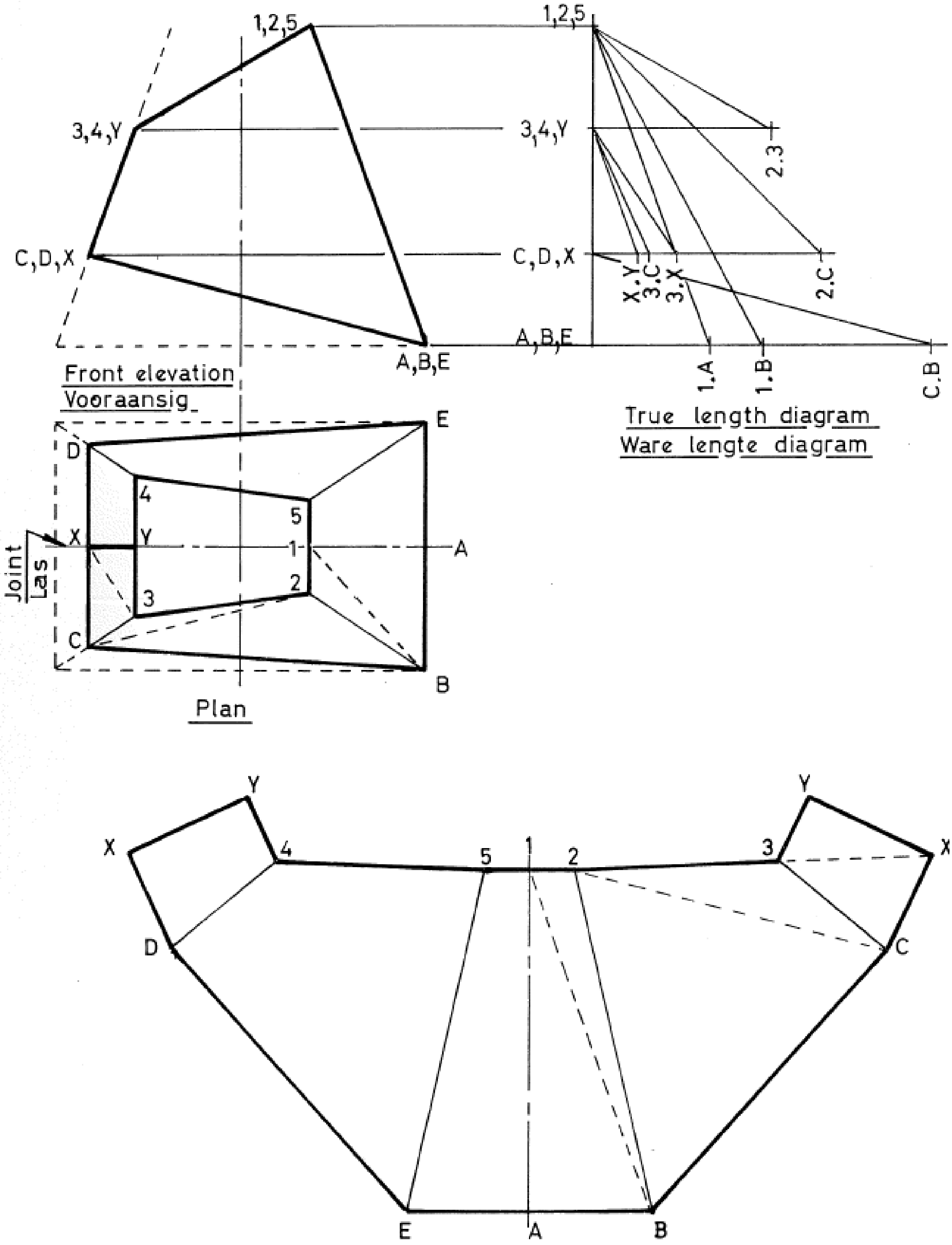


Figure 4.8

Now complete triangle A.I.B (note AB is a true length as they are on the same plane).

Then complete triangle I.B.2 (note 1.2. is a true length). The following triangle to do will be B.2.C (note C.B. is not a true length as they are not on the same plane line and should be obtained between plane lines C and B - (see true length diagram). The rest of the development is done on the same basis.

4.9 Triangulation on converging planes (cone frustrum)

This development is done on the same pattern but it is important to note that none of the dimensions used are true lengths as all the points lie on different planes.

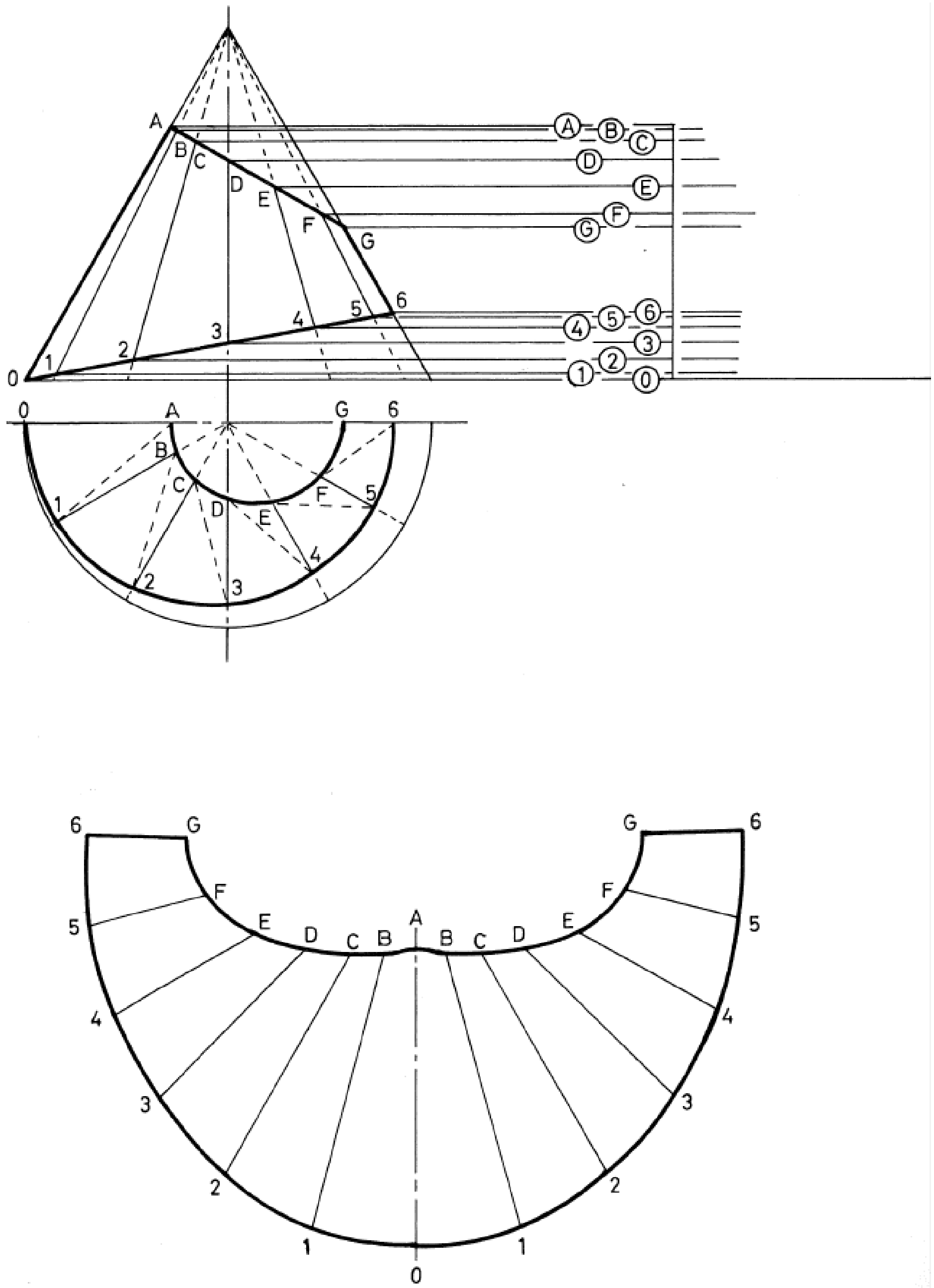


Figure 4.9

In a development of this kind it is very important to mark your true length diagram with the utmost care to avoid any errors.

Note:
It is assumed that the student knows by now how to obtain the plan view of a cone cut at an angle.

4.10 Taper lobster back bend

The only problem in the development of the taper lobster back bend is the layout and segment divisions, as the actual development is as for right conical segments.

We will now consider the layout and divisions of a four segment taper lobster back bend with predetermined diameters, centre radius and numbers of segments.

First we layout the centre Radius line AE with large diameter XX and small diameter YY at the base and the 900 lines. The centre radius should be divided according to the number of segments required similar to the division methods for the straight lobster bends.

For a 4 segment bend we need 2 full segments. Therefore, we divide the centre radius line AE into 4 + 2 (halves) = 6 halves. Then project point A perpendicular to XX . To cut the first division line at B from B draw a tangent line to the centre radius line AE to cut the 3rd division line at C. From C we do the same to obtain D and we complete this centre line sequence by projecting E normal to YY to connect to D.

Now extend point A projection to obtain the apex point 0, along this centre line step of the centre line distances AB, BC, CD, and DE and mark C^1, D^1, E^1 through point E^1. Draw and extend a line normal to E^1 A and mark small diameter dimension Y^1 E^1 Y^1. From points X through Y^{11} obtain apex 0 on centre line AO.

Note:
This will give us the complete cone frustrum that will be required.

To obtain the cut-off points and segments we commence as follows:
Using the central ball theorem with centre B, draw a circle to touch the cone frustrum XX Y^1 Y^1, then from B extend the tangent line B.C. to represent the next conical section centre line, then with B as centre and radius B.O. scribe to cut new centre line at O^1.

If we now continue (following the central ball theorem) draw tangent lines from

O^1 to circle B to form a new cone with centre line O^1 B. Where outsides at cone AO touch cone O^1 B we obtain F&G which when connected forms interpenetration line (centre ball theorem).

Following the same procedure with centre C, draw a circle to touch the cone O^1 .FG. then, from C, extend the tangent line CD to represent the next conical section centre line. Then with C as centre and radius C^1 O scribe to cut new centre line at O^{11}.

From O^{11} draw tangent lines to touch the circle about centre C to form new cone with centre line O C. Where outsides of cone O^{11} C touch outsides of cone O^1 B at points H&J. we have our second line of interpenetration.

Follow the same procedure with centre D to obtain the last intersection line K.L. It should now be clear to you that all these segments are cone frustrums and could be developed as such.

Note:
If we place all the segments together by rotating each alternate segment 180° it will be seen that they form the cone frustrum XXY^1 Y^1 see red lines in drawing.

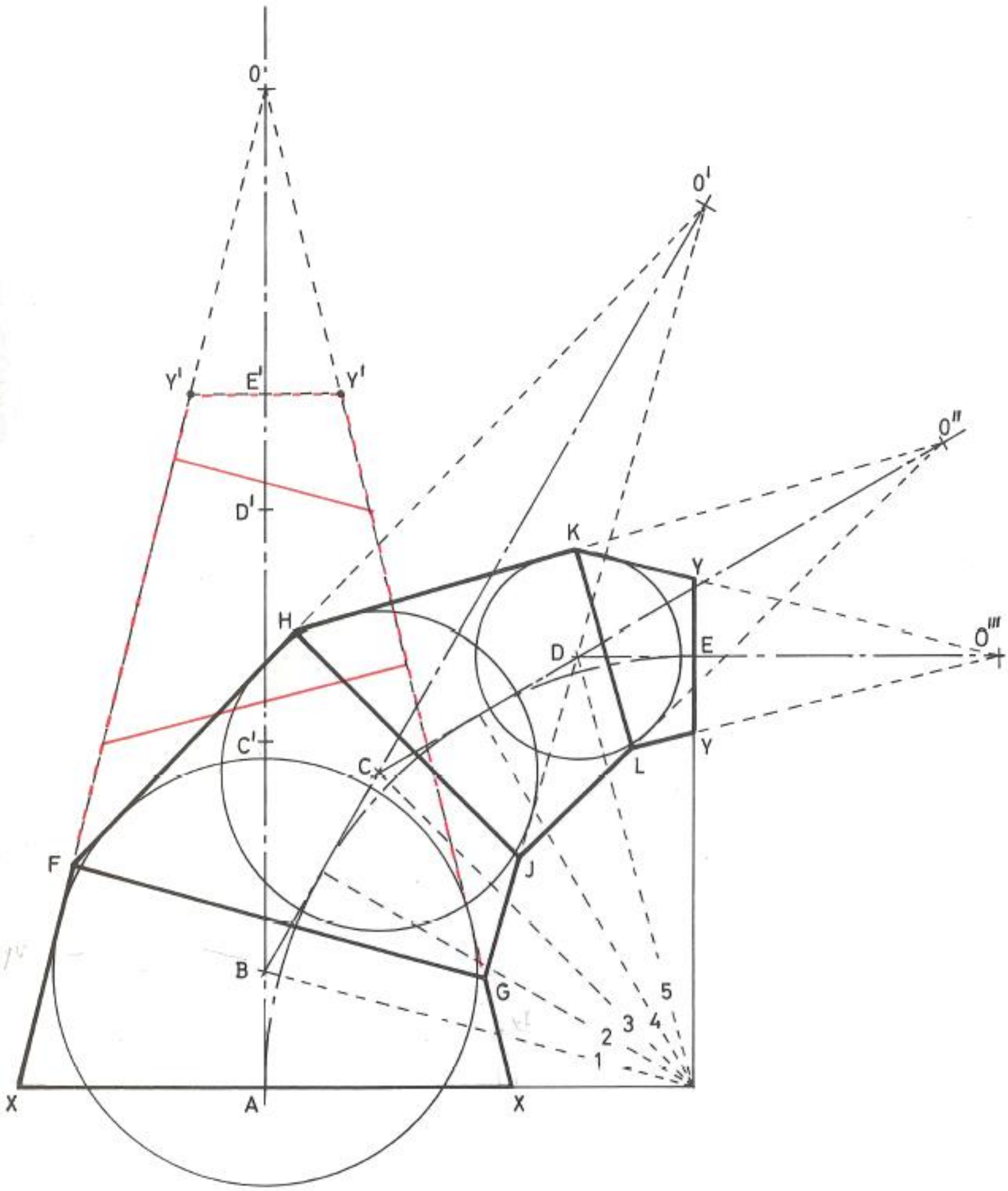


Figure 4.10

4.11 Determining kinks and splays

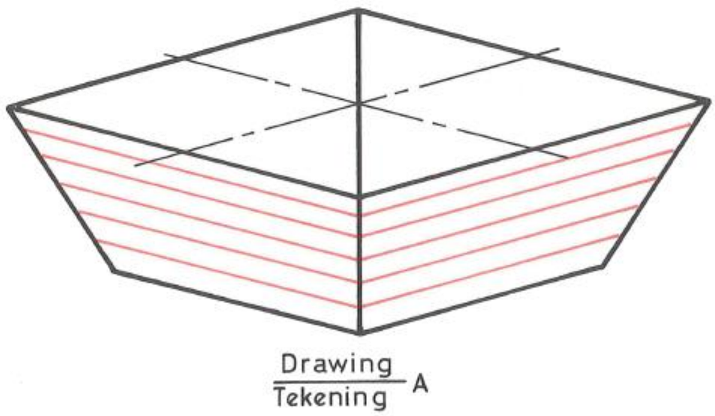
All development problems are not as simple as you will see in the projections opposite. In drawing A we find that the plates have the top and bottom parallel and as can be seen from the shading lines the plate shows straight.

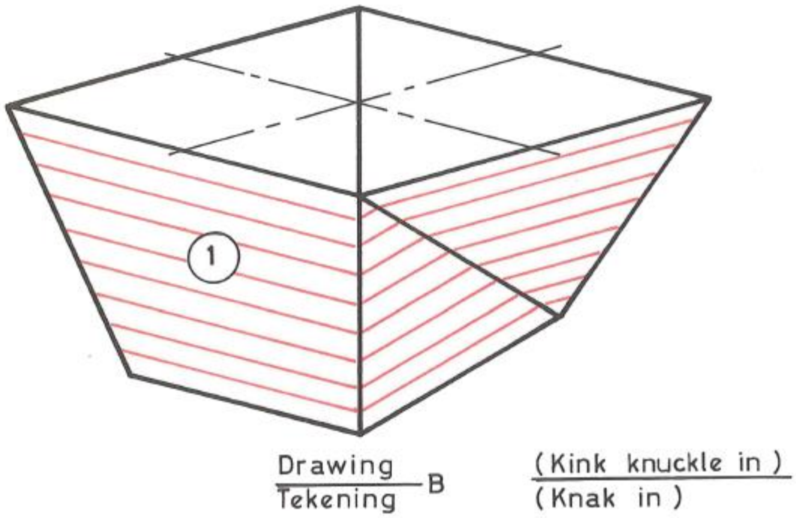
But note in drawing B plate (1) shows straight but side plate shows a bend. This is due to the fact that the top and bottom planes are not parallel. This bend is referred to as a kink. In drawing C we have a similar hopper except that the kink has now been moved across the other diagonal.

Important note:

1. If a pyramid frustrum has a base and top not parallel and shows in plan as rectangle there will be a kink.
2. The kink can either knuckle in or knuckle out giving a different appearance and development pattern but achieving the same goal.
3. The kink is always marked from either top corner to the diagonally opposite bottom corner and is a bend line.
4. The pattern development is carried out similar to the normal pyramid development.

Note:
On developments of this type, it is sometimes required to ascertain the angle of the splays of the corner bends and the kink bends; therefore, the following graphical method:


Drawing
Tekening
A


1
Drawing
Tekening
B
(Kink knuckle in)
(Knak in)

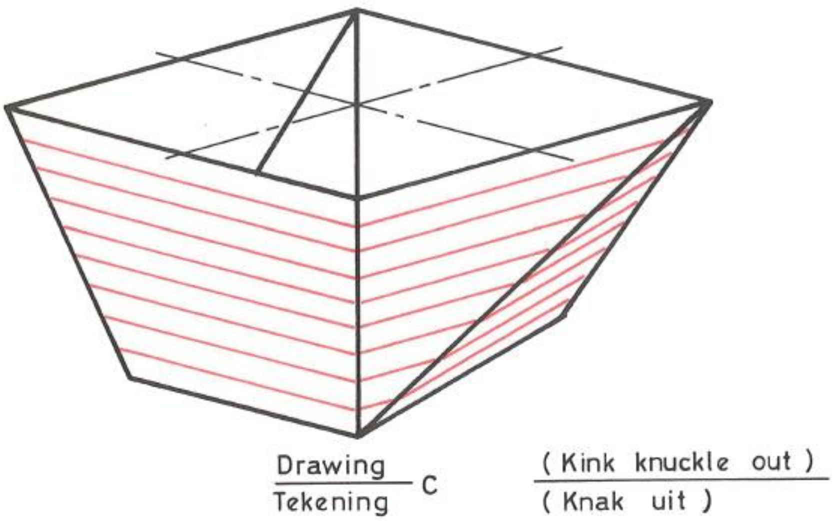

Drawing
Tekening
C
(Kink knuckle out)
(Knak uit)

Figure 4.11

4.12 Splays (by projections)

Considering the sketch opposite, we obtain the splays by cutting plane projections.

Note:

1. Cutting plane always normal to the bend considered.
2. Project cutting points to plan view and measure to centre line.
3. Projects in line with bend under consideration.
4. Always work to a datum centre line to obtain the bend angle.
5. It will be noticed that the kink bend will always have three points from the centre line.

4.12.1 Angle of bend line $A.A^1$

Take a cutting plane (1) anywhere normal to the bend considered and mark $Y.B^1$. Project in line with bend line, both the points Y and B^1. Now, normal to these projection lines, draw the datum centre line 00.

Then project points Y and B^1 down to plan, measure the distances from Y and B^1 to the plan centre line and place them on the projections from the datum centre line giving the points 0, Y, B^1. Join these points to give the angle of the bend.

4.12.2 Angle of bend line $B.B^1$

Carry out the same procedure as above.

4.12.3 Angle of kink bend line $A.B^1$

Similar to above procedure.

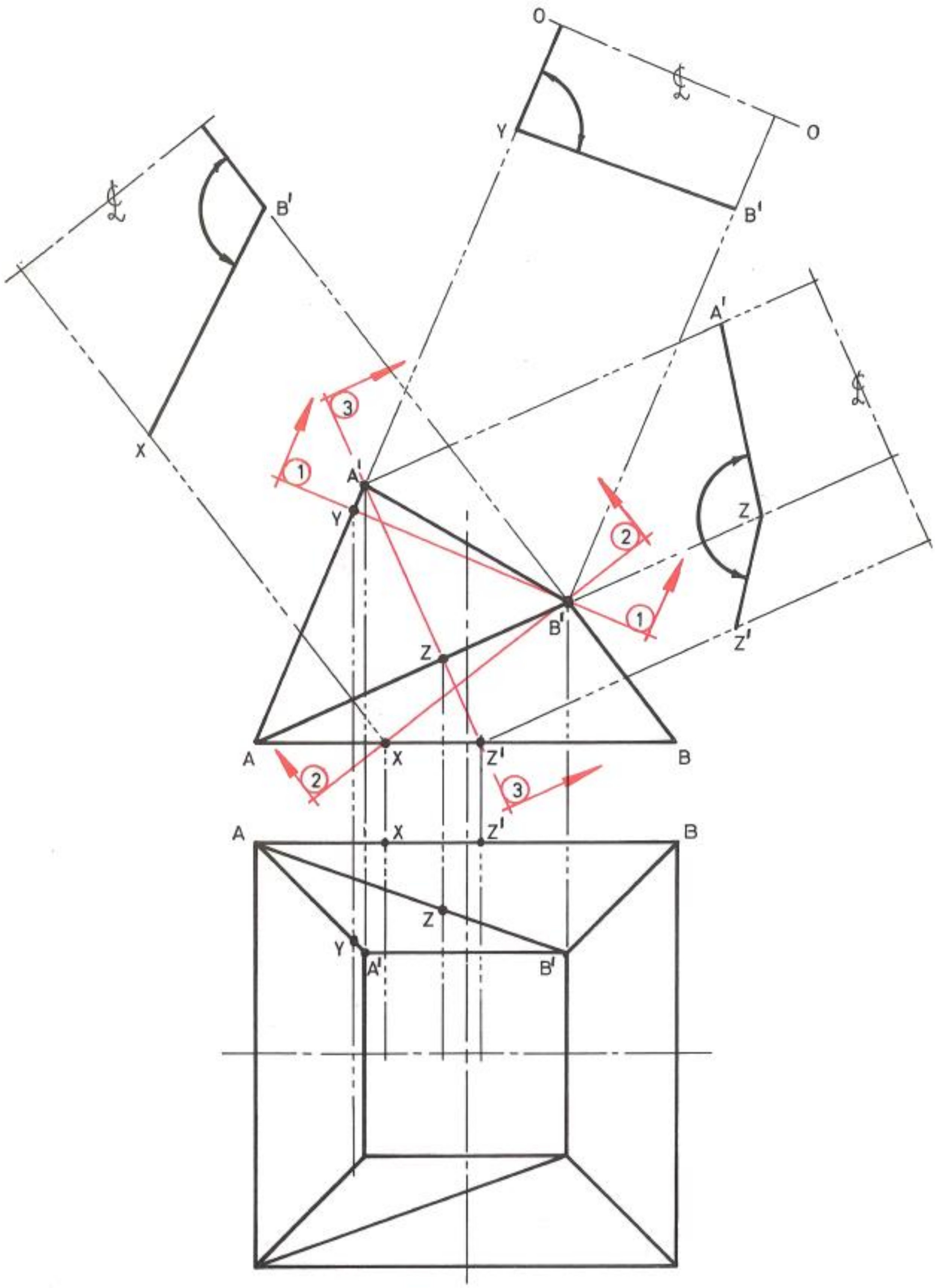


Figure 4.12

4.13 Developing hopper with converging planes (kink knuckle out)

If this development is compared to Triangulation of converging planes (pyramid frustrum) shown in **Figure 4.8** it will be seen that it will be required to place kinks on the side plates.

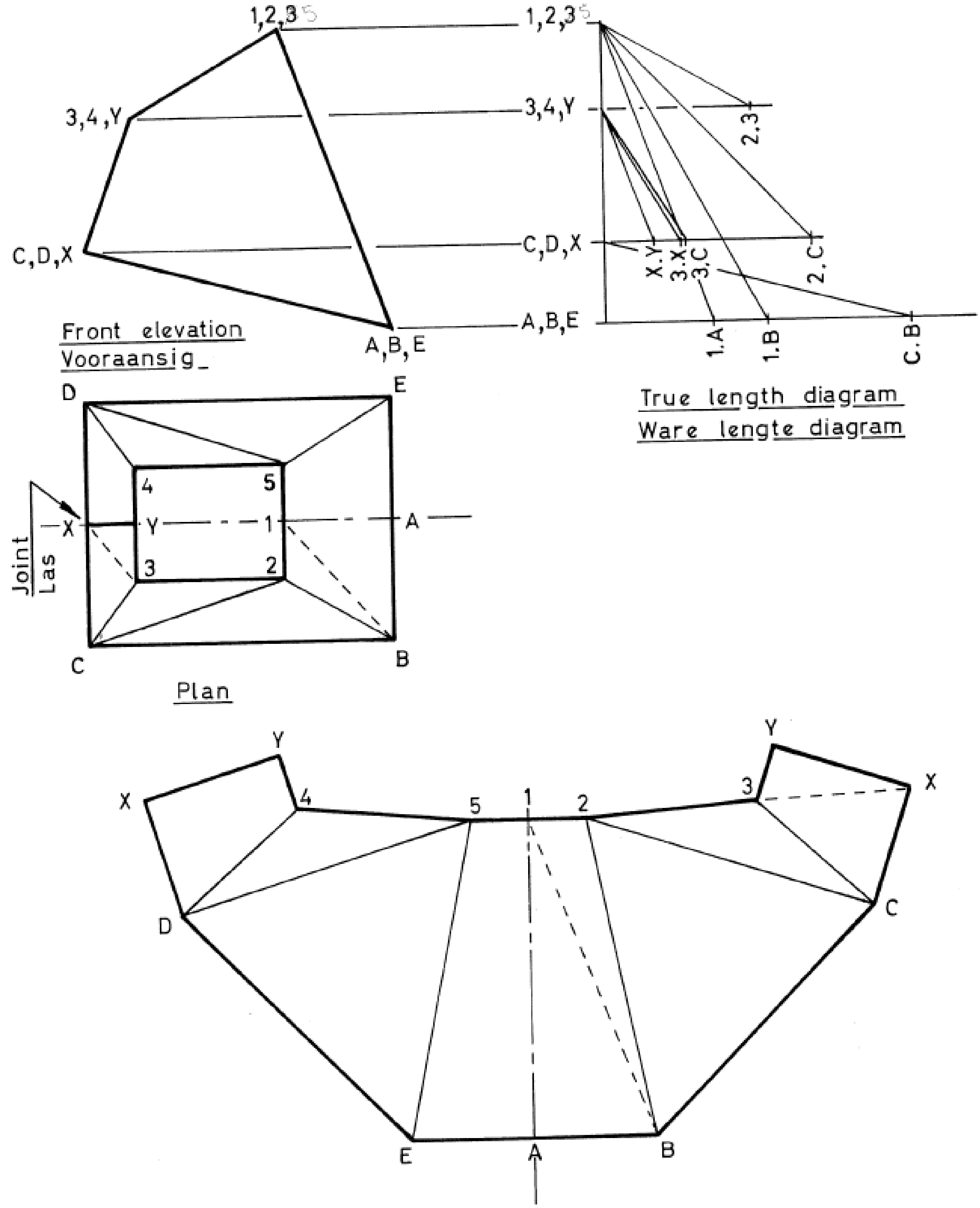


Figure 4.13

Activity 4.1

1. Develop the hopper shown in plan, the vertical height is 45 mm.

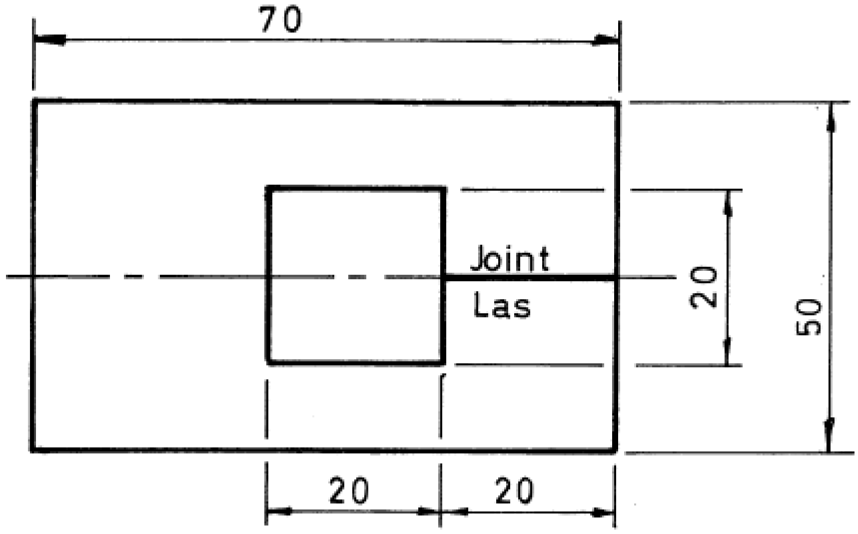


Figure 4.14

2. Develop the hopper shown, kink knuckle in.

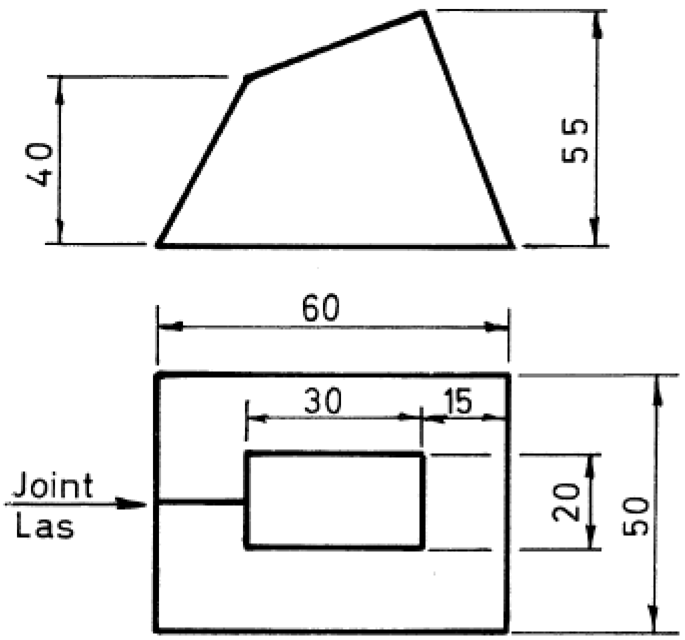


Figure 4.15

3. Develop the square to round shown.

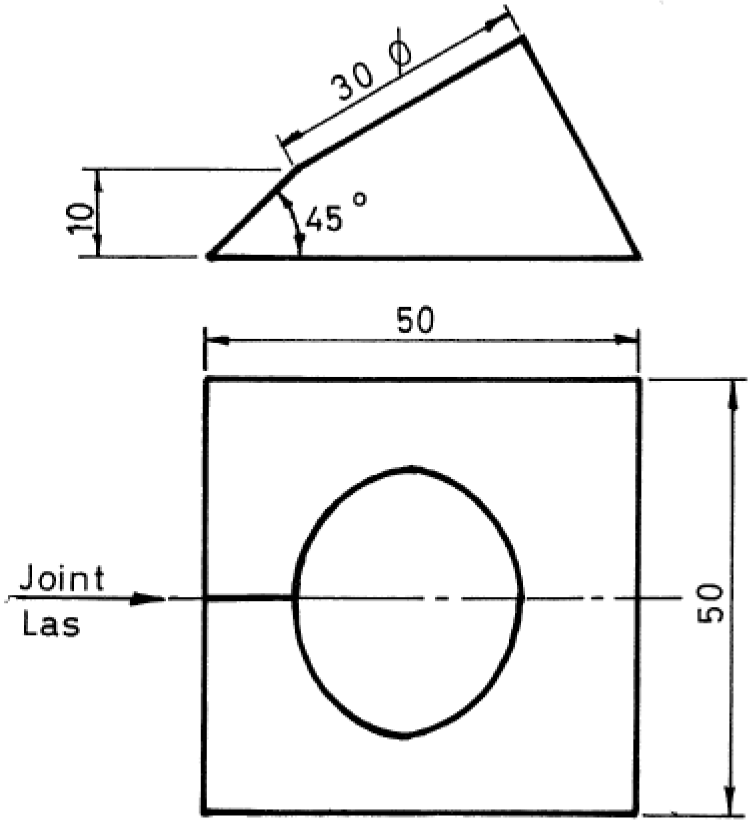


Figure 4.16

	Self-Check

I am able to:	**Yes**	**No**
• Explain the triangulation theorem		
• Determine the bend lines		
• Demonstrate square to round on parallel planes that are centrally placed		
• Demonstrate square to square on parallel planes that are centrally placed		
• Demonstrate cone frustrum on parallel planes		
o Right cone		
o Oblique cone		
• Demonstrate triangulation on converging planes		
o Pyramid frustrum		
o Cone frustrum		
• Demonstrate a taper lobster back bend		
• Determine kinks and splays		
• Demonstrate hopper with converging planes		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 5

Cutting plane interpenetrations

Learning Outcomes
On the completion of this module the student must be able to:

- Explain the cutting plane theorem
- Explain the central ball theorem
- Develop pipes to cones
    - Horizontal pipe
        - Cutting plane method
        - Basic central ball theorem
        - Advanced central ball theorem
    - Pipe at an angle
        - Cutting plane method
        - Cutting plane method alternative
        - Central ball theorem
    - Pipe off centre
        - Cutting plane method
- Develop cones to pipes
- Develop cones to cones using the cutting plane method

5.1 Introduction

Interpenetrations are of such a varied nature that it would be an impossible task to show all the different interpenetrations that are possible. Therefore, we will show only the basic theorems and some of their applications.

It is of interest to note that, with a little consideration, the draughtsman or designer can in some cases simplify interpenetrations to straight line joints by applying the central ball theorem concept.

5.2 Cutting plane theorem

Due to the fact that the cutting plane method of obtaining interpenetrations is the most common method used and in some cases the only method that can be used, we will consider this method first.

This method is based on the concept that, if two bodies intercept, whether of the same shape or not, each body has to be cut to find points of mutual dimension to fit, thereby giving a perfect joint that would not require a filler to close up any gaps or steps formed by the joint.

EXAMPLE:

Considering drawing shown in **Figure 5.1**, of a cone and an intercepting hexagon, we find:

(a) Points 0 and 3 in elevation will automatically join the cone where they touch the side of the cone as they are single lines on the centre.

(b) Lines X and Y will not stop at the side as seen in elevation but will move straight past until they touch the cone (see sketch).

> **Note:**
> To show this, we draw a sectional plan along lines X and Y. If these touch points are now projected straight back to the elevation, we have our true points of interpenetration in elevation.

(c) The other lines can be similarly constructed.

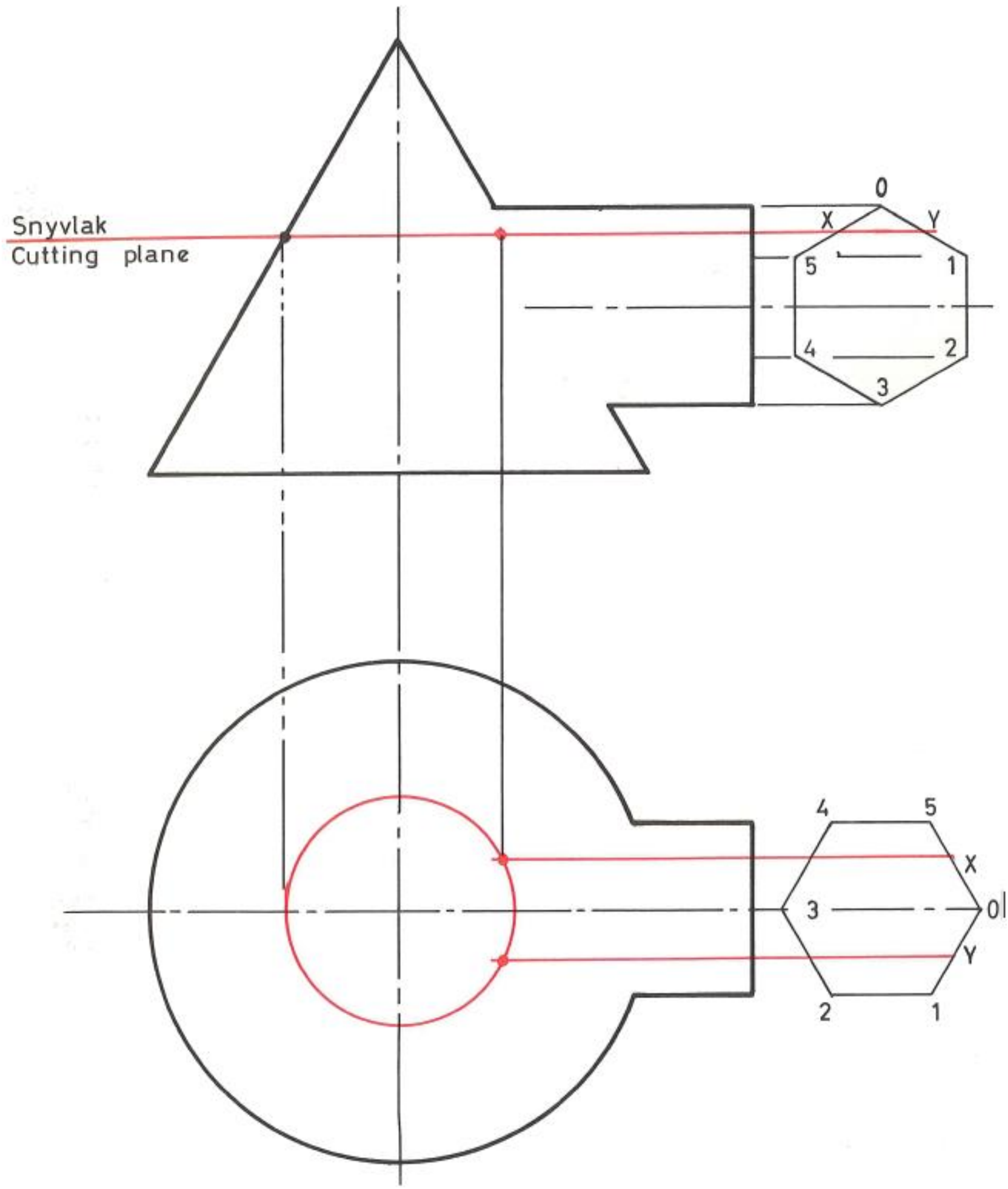


Figure 5.1

Rules to follow

1. Draw the side elevation.
2. Draw the plan (it is not necessary to draw the full plan if the interpenetration is symmetrical about the central line).
3. Divide up the penetrating object and number as for developing i.e. bend lines. (Note: in the elevation as well as the plan)

4. Where the line in elevation meets the side of the cone, drop the point to the plan and with cone centre as centre. Scribe the radius with this point until it intercepts the correspondingly numbered line in the plan. This is the intercepting point.
5. Then project this intercepting point straight up to again intercept the correspondingly numbered line in elevation to give the point in elevation.
6. When we have all the intercepting points the following should be noted:
   (a) The penetrating body must be developed from the elevation.
   (b) The hole in the penetrated body is picked up from the base plan as well as from the elevation.

5.3 Central ball theorem

As this theorem is not by this time foreign to us thus a short summary.
If intercepting bodies have both sides in elevation touching a common central ball with centre on a mutual centre, the lines of interpenetration will be straight lines.

Note:
The critical criteria is that the centre lines of the separate bodies must intercept in elevation and in plan.

The line of interpenetration is found by drawing a straight line across the points formed where the outside body lines intercept.

Note:
This basic theorem should be designed in as it is very seldom found possible to use it in its basic concept on problems arising.

5.4 Pipes to cones

Under this heading we will only consider three basic problems that can be encountered. But it must be understood that these theorems can be applied to any development.

At this stage it is expected that the fundamentals of cone and pipe developments are understood, therefore, the concentration falls on the lines of interpenetration.

5.4.1 Horizontal pipe cutting plane method

Starting from the drawn elevation and plan, it should be noted that the pipe divisions have been properly numbered in both elevations.

Project division pipe lines in elevation right through to the far side of the cone and number to 6.

Note:
We use the far side for clarity to avoid too many lines in an area that could lead to confusion.

Now project these points down to centre line of plan and number. Then with centre O^1 of the cone as centre and with radii 01 02, 03, 04, 05 scribe arcs (this shows the cutting plane of the cone in plan as circles) to cut corresponding numbered pipe division lines, forming points of interpenetration (by connecting these points we have the plan of the hole in the cone).

Now project these interpenetration points straight up to cut the corresponding numbered division lines in the elevation, this in turn gives us the pipe cut of points (point of interpenetration) for development (by connecting these points we have the line of interpenetration).

On developing the cone the hole has to be added. This can be done by transferring the points of interpenetration in the plan onto the actual development pattern of the cone.

For transferring the hole onto the cone pattern we use apex 0 as centre and radii 00, 01, 02, etc., to scribe arcs on the pattern and number each (see part development of cone).

It now remains to fix the points on these arcs as follows: (see part plan X for clarity). Join all the points of interpenetration with centre of cone and extend these lines to the base line of the cone and number, then working from a centre line 0,6 on the cone pattern, we take the arc measurements on the base in the part plan and step them off on the pattern in sequence and number.

It now only remains to connect these points on the cone pattern base to the cone centre and where these lines cut the corresponding numbered arc lines we have the points of the hole.

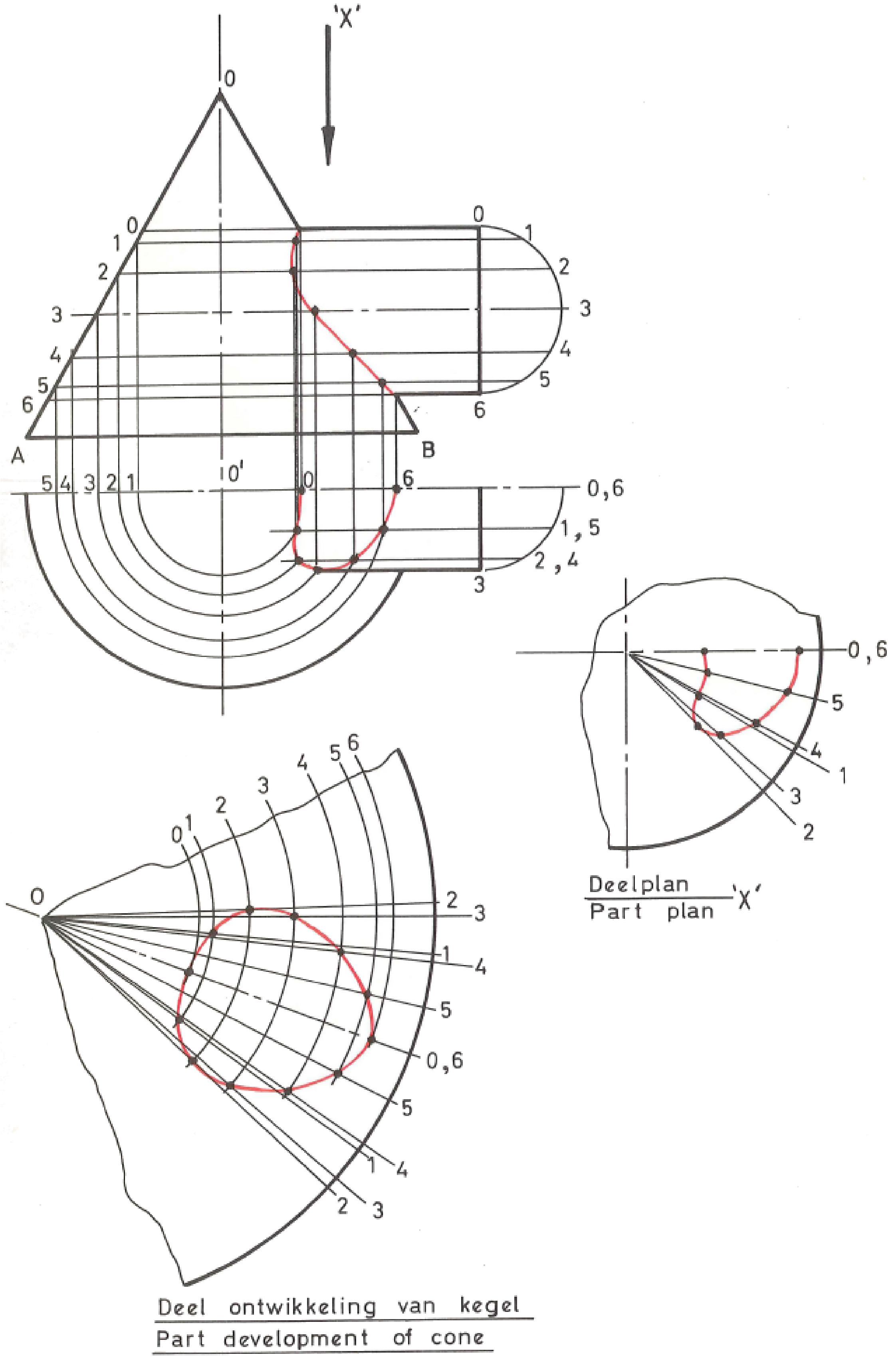

'X'
A
B
0'
0,6
1,5
2,4
Deelplan
Part plan
Deel ontwikkeling van kegel
Part development of cone

Figure 5.2

5.4.2 Horizontal pipe (basic central ball theorem)
Draw the outline of the cone, then the central ball touching the sides of the cone; now we draw in the pipe with sides touching the central ball.

⚠	**Note:** This method can only be used when the ball touches the sides of the cone and the sides of the pipe.

We now extend the pipe outside lines to touch the far side of the cone, where the pipe outside lines 0 and 6 cut the cone outside lines XB and XA we get points C, F, D and E; we then connect C to E and D to F and where these lines cross at Z we mark out turning point in our interpenetration line.

To complete the line of interpenetration connect points C,Z,F.

Only now do we divide and number the pipe in both elevation and plan, then project the division lines in the elevation to touch the line of interpenetration, then down to intercept the correspondingly marked pipe division lines in the plan to give us the shape of the hole in the plan.

⚠	**Note:** In some cases it is possible to have alternative interpenetration lines. See **Figure 5.3** (in this case the top of the cone falls away).

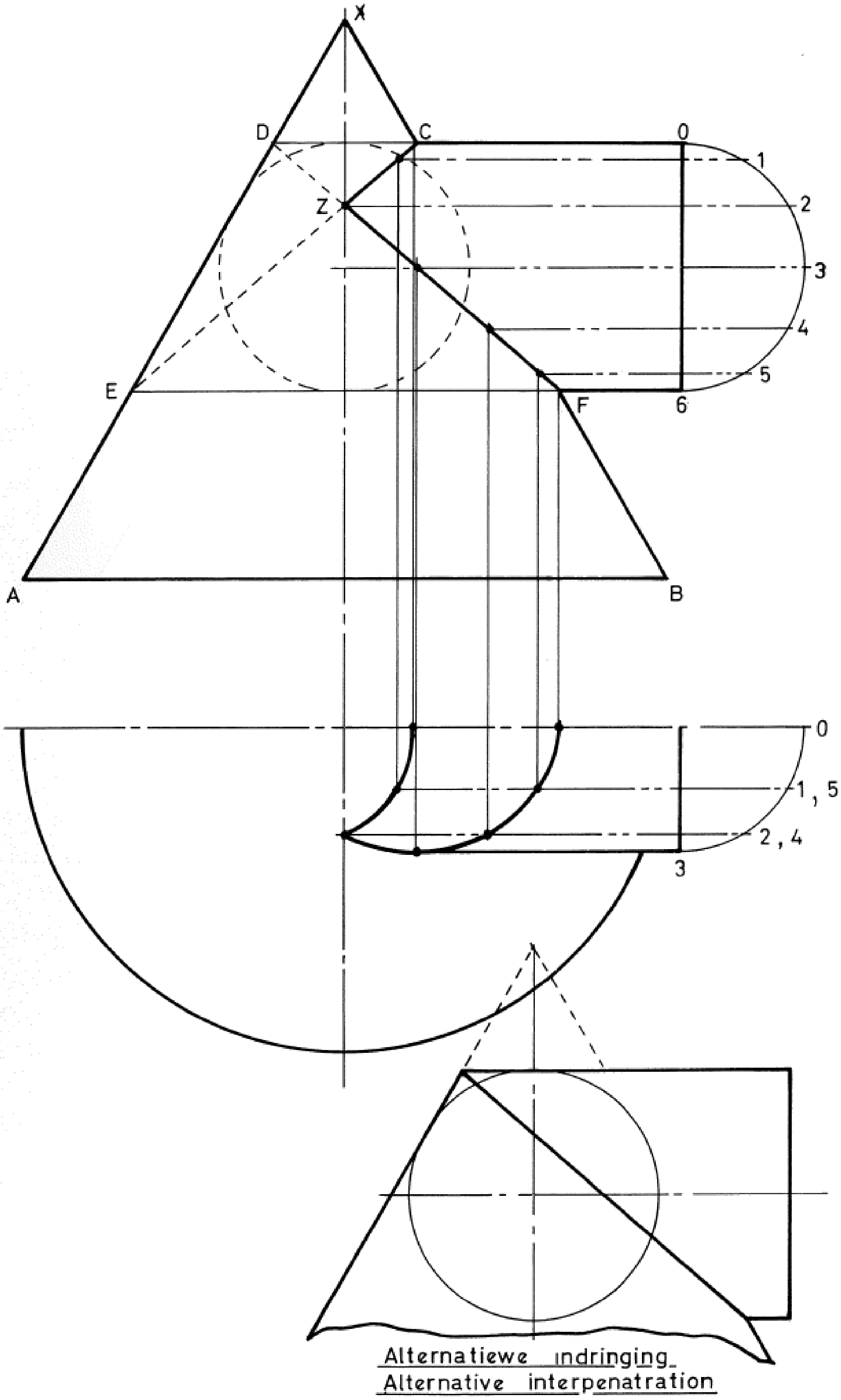

X
D
C
0
1
2
3
4
5
6
Z
E
F
A
B
0
1, 5
2, 4
3
Alternatiewe indringing
Alternative interpenatration

Figure 5.3

5.4.3 Horizontal pipe (advanced central ball theorem)

It will be seen in this drawing that there is in fact not one central ball that touches the sides of the cone and the side of the pipes, this is why the line of interpenetration will not be a straight line. This is also why it is advisable not to use this method on any but horizontal pipe to cone connection.

After drawing the side elevation without the normal pipe divisioning we put in points at random along the side of the cone line A, B, between the pipe outside lines (see enlarged section for clarity) and draw lines vertical from pipe side to pipe side and number these 1, 2, etc. Now with the centre line's intersection marked Y as centre and radius Y1, scribe an arc.

WHERE THE ARC CUTS THE SIDE OF THE CONE LINE AB draw a line horizontally back to cut the vertical line 1; this intersection is your point of interpenetration.

Continue on the same pattern with points 2, 3, 4, 5, 6, 7, and after completion join the points to form the line of interpenetration.

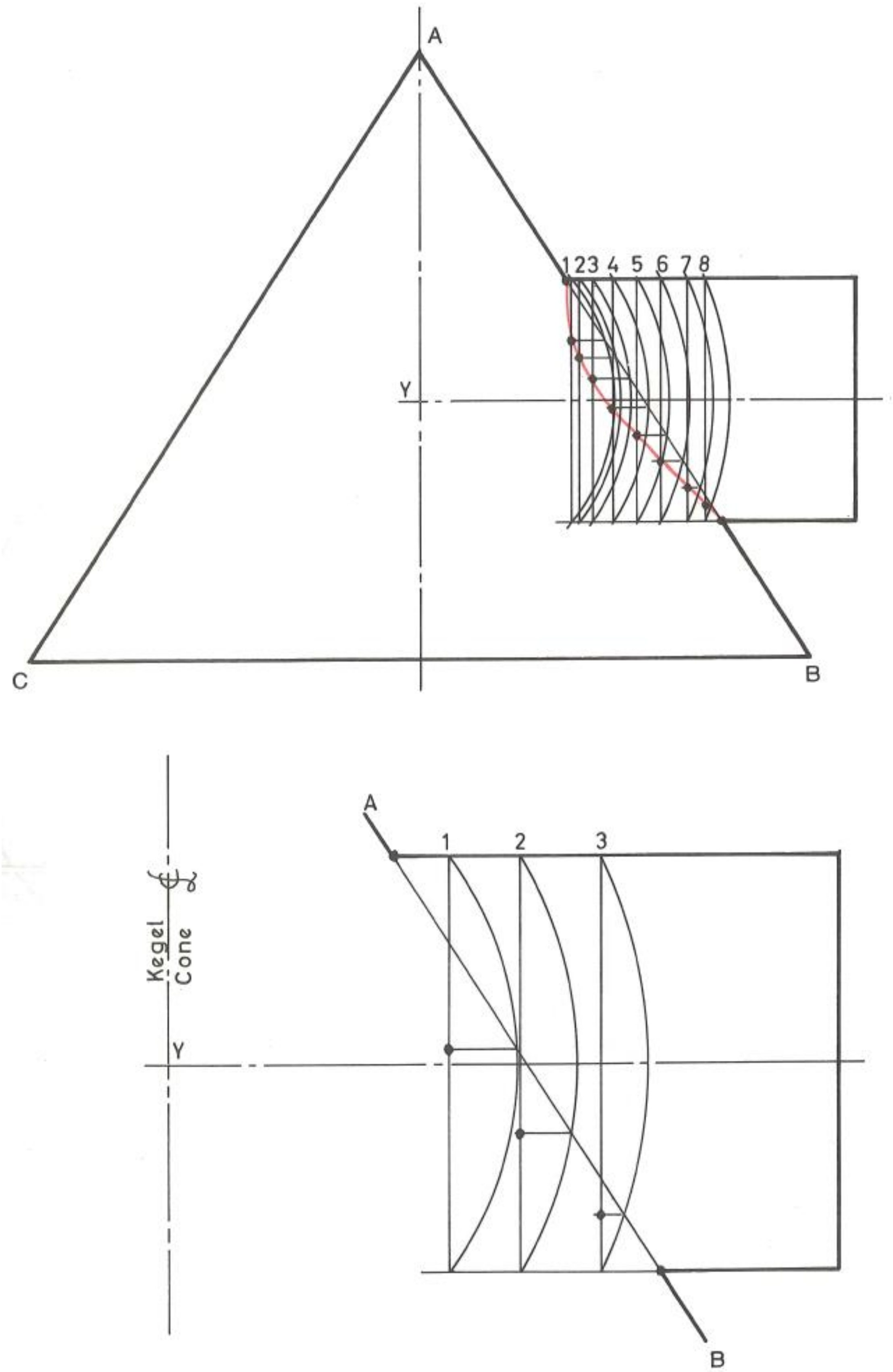


Figure 5.4

5.4.4 Pipe at an angle (cutting plane method)

In this development we use cutting planes along the bend lines of the pipe i.e. not normal to the cone centre line and we should by now know that the cutting plane on the cone will show in plan as an ellipse.

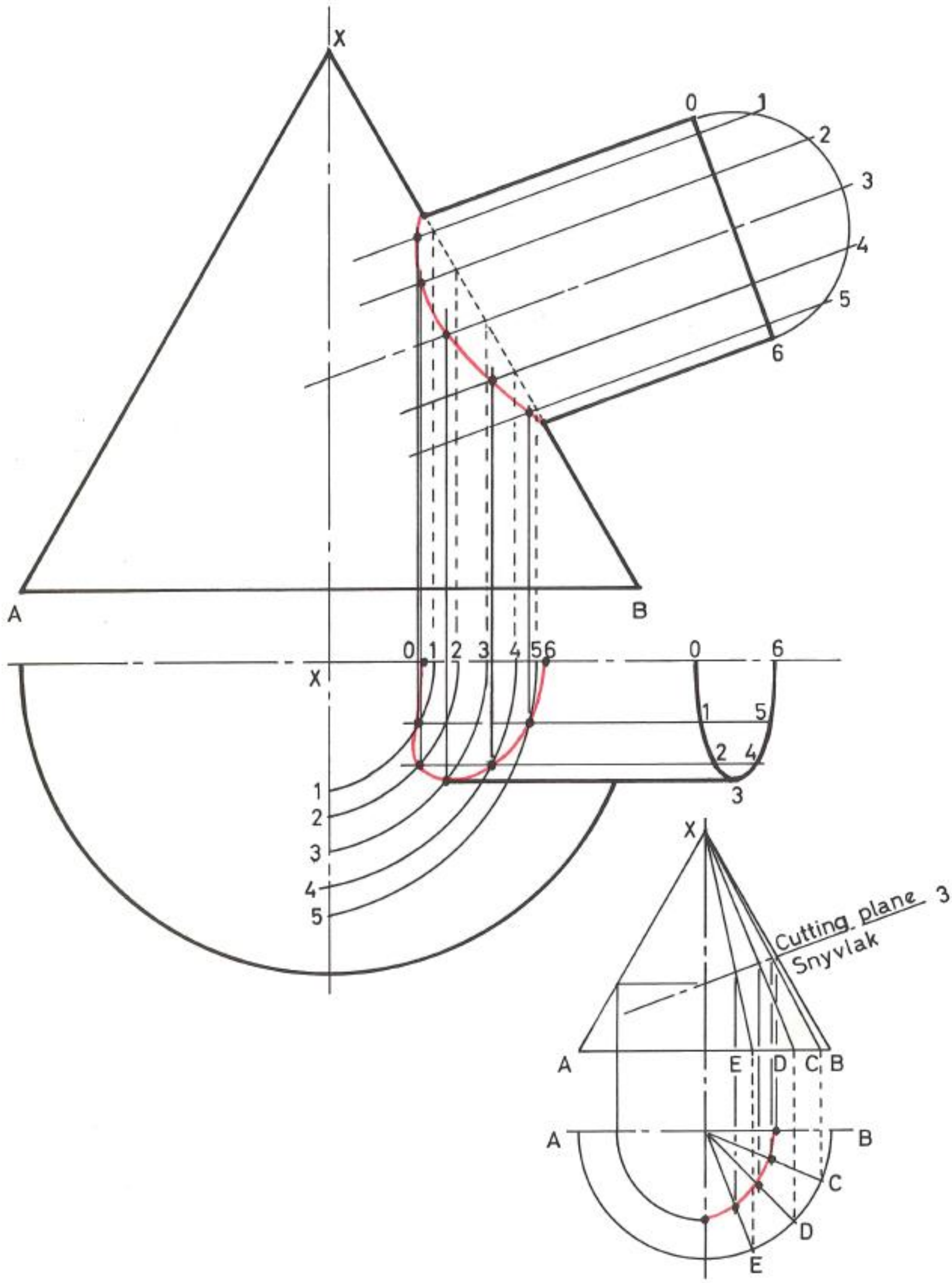
We now see that as we intend taking cutting planes marked 1, 2, 3, 4 and 5 on the pipe divisions, we will have to construct 5 ellipses.

Note:
As a reminder in the inset drawing we show the method of drawing ellipses.

After the 5 ellipses have been drawn and numbered in the plan, we project the numbered pipe division lines across to cut the like-numbered ellipses to give us the points of interpenetration.

These points are then in turn projected up to the like-numbered pipe division lines in elevation to give the line of interpenetration in elevation.

Note:
The construction lines of the ellipses in plan are not shown for clarity of the actual points of interpenetration.


X
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2
3
4
5
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B
0 1 2 3 4 56
X
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4
3
1
2
3
4
5
X
Cutting plane
Snyvlak
3
A
E
D
C
B
A
B
C
D
E

Figure 5.5

5.4.5 Pipe at an angle (cutting plane method, alternative)

In this development we take cutting planes normal to the cone centre lines which, of course, will show the cone cutting planes in plan as circles but the pipe cutting plane will be an ellipse.

Note:
This method is sometimes considered preferable as it is only necessary to draw 1 ellipse instead of 5 as in the previous case as we can make a template of this elliptical cutting plane and use this on the various positions as required. To clarify this idea, see the inset drawing.

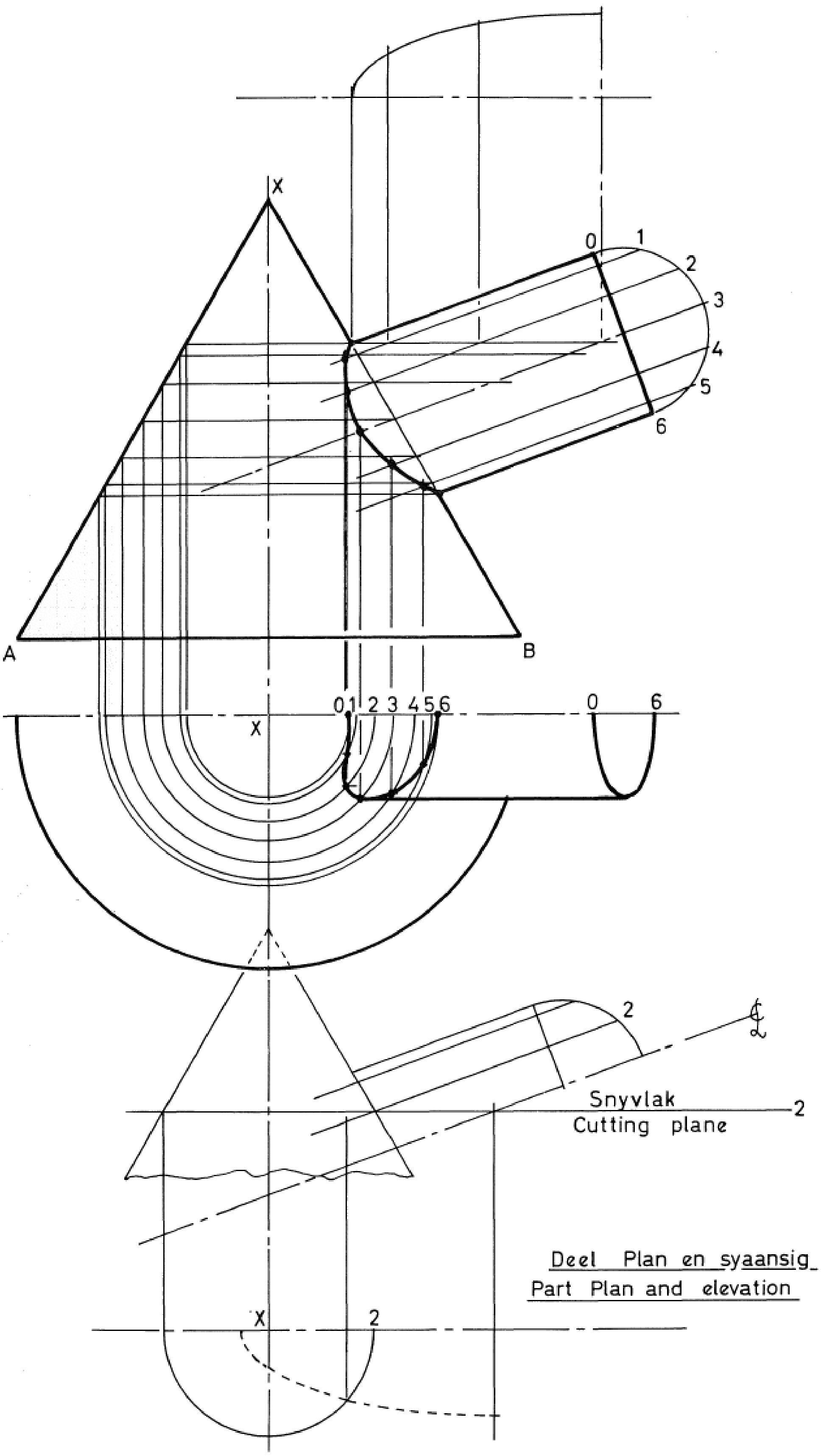
To avoid misunderstanding in this explanation, we consider only one line i.e. the pipe division line 2. Where this line touches the side of the cone, we draw the cutting plane 2.

By projecting down to plan the point where the cutting plane cuts the side of the cone and using X on plan as centre, scribe circle marked 2 to show cutting plane of cone.

Now where cutting plane 2 in elevation cuts the centre line of the pipe we have the centre of the elliptical cutting plane of the pipe; project this down to the plan and with the aid of the elliptical template placed on the centre, draw the ellipse to cut the circle, marked 2, giving the point of interpenetration.

By repeating this procedure for all the cutting planes you are assured of an accurate and easy conclusion to this development.

Note:
These last 2 examples indicate clearly that the cutting plane method is very versatile and can be used in different ways.


X
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0 1 2 3 4 5 6
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2
Snyvlak
Cutting plane
2
Deel Plan en syaansig
Part Plan and elevation
X
2

Figure 5.6

5.4.6 Pipe at an angle (central ball theorem)
This development is carried out as for the horizontal pipe in **section 5.4.2**.

5.4.7 Pipe off centre (cutting plane method)
In this development we use the same principles as shown for horizontal pipe cutting in **section 5.4.1** with one difference, i.e. that we draw the full pipe in plan as this pipe development is not symmetrical and it is necessary to have all the pipe lines numbered.

Care should also be taken when projecting these points in plan to the elevation to ensure the correct placing of two points.

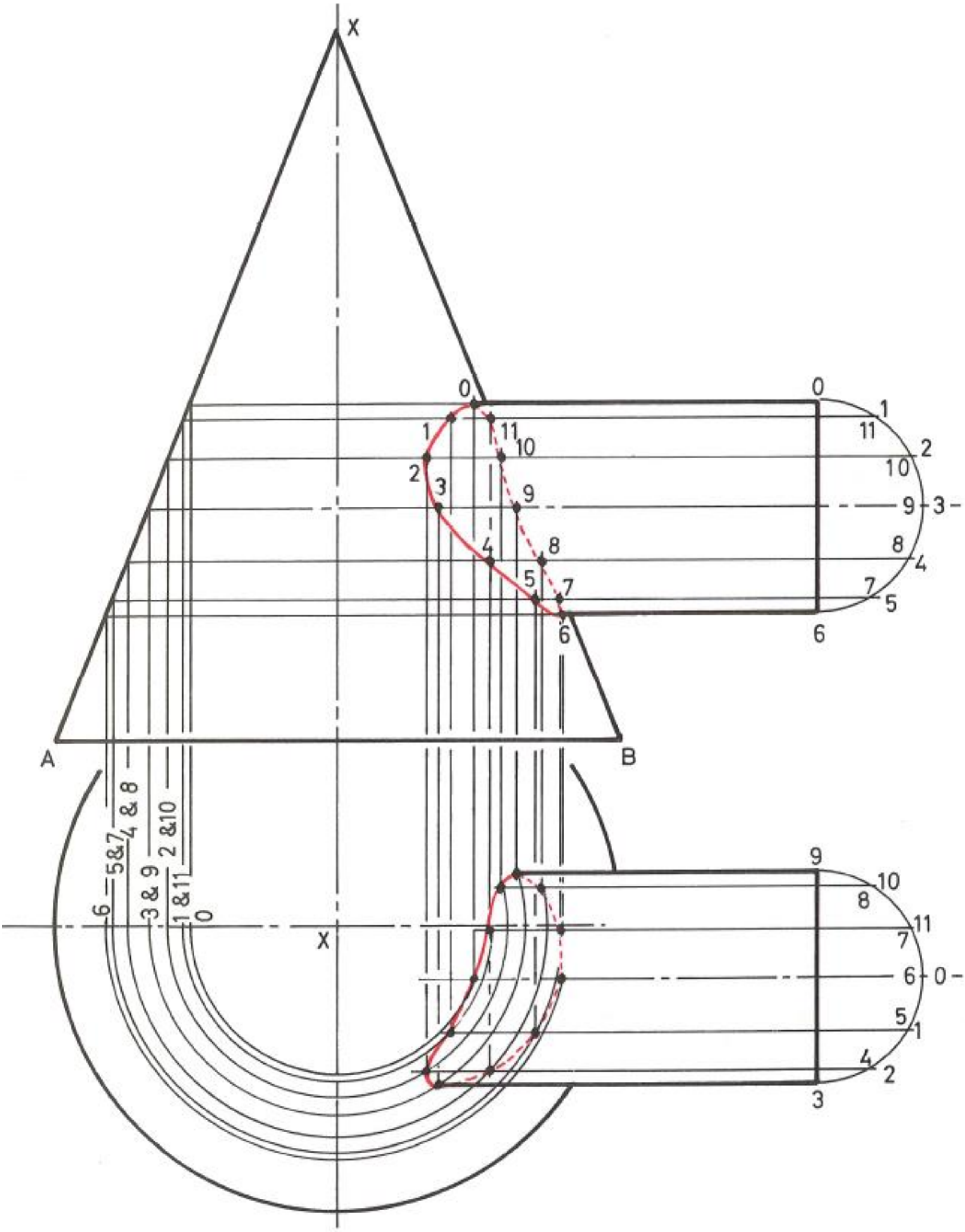


Figure 5 .7

5.5 Cones to pipes

This development is done on the same basic principles as in a pipe to pipe of equal diameter.

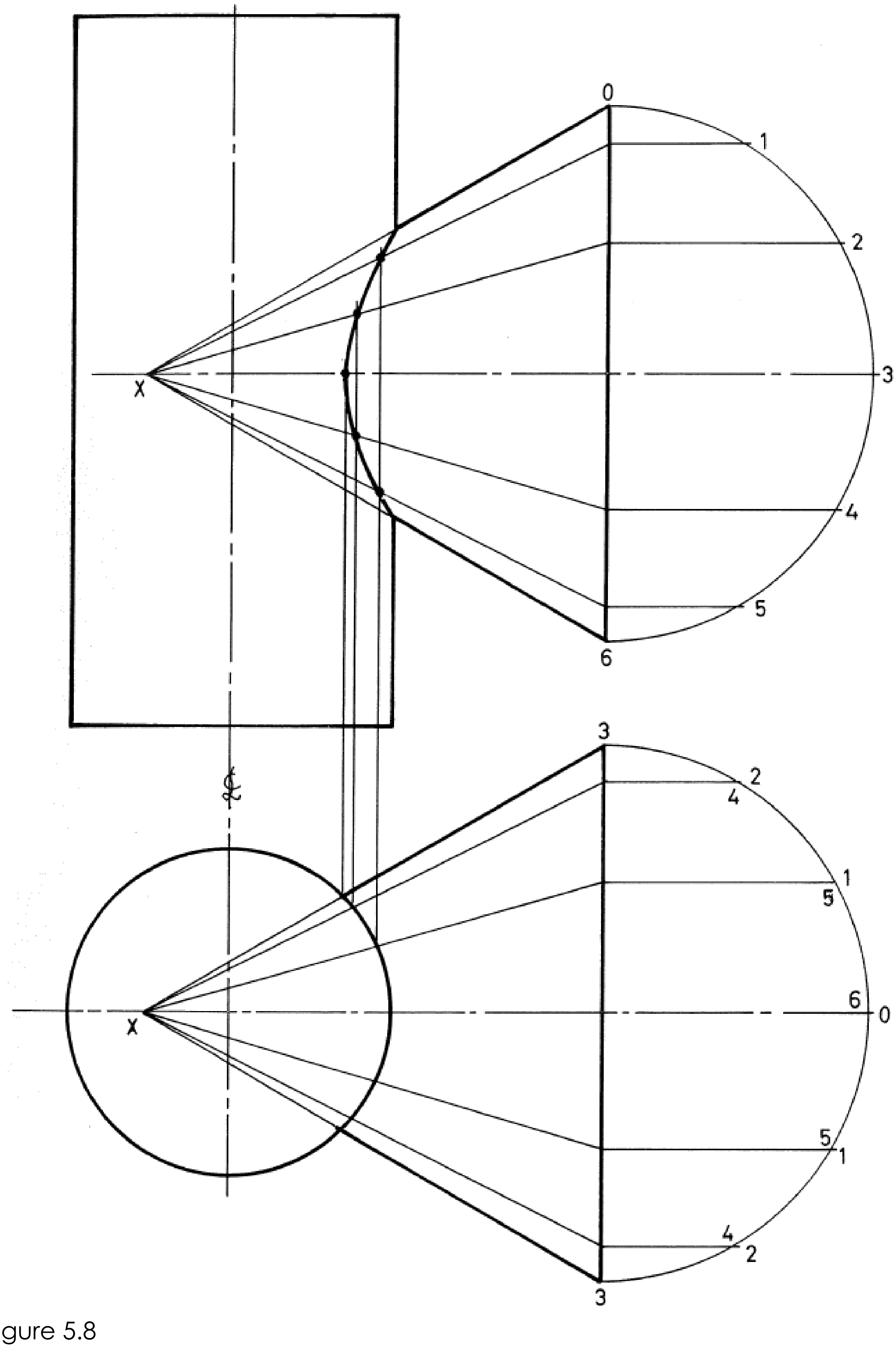


Figure 5.8

5.6 Cones to cones (cutting planes)

As for pipe at an angle in **section 5.4.4** and pipe at an angle in **section 5.4.5**, this development can be done in different ways by considering what cutting plane to use.

(a) Cutting planes in line with cone "Z" bend lines which will give cutting plane shapes in plan as follows: cone Z will be triangles (3 in number). Cone Y will be 4 ellipses and 1 circle (line 3).
(b) Cutting planes normal to cone "Y" centre line which in turn will give cutting plane shapes in plan as follows:
Cone Z will be 4 hyperbolas and 1 triangle (Line 3).
Cone Y will be 5 circles.

A good choice in this would be (a). As shown in **Figure 5.9**, use cutting planes in line with cone Z bend ' lines. Except for different cutting plane shapes continue as for **section 5.4.4**.

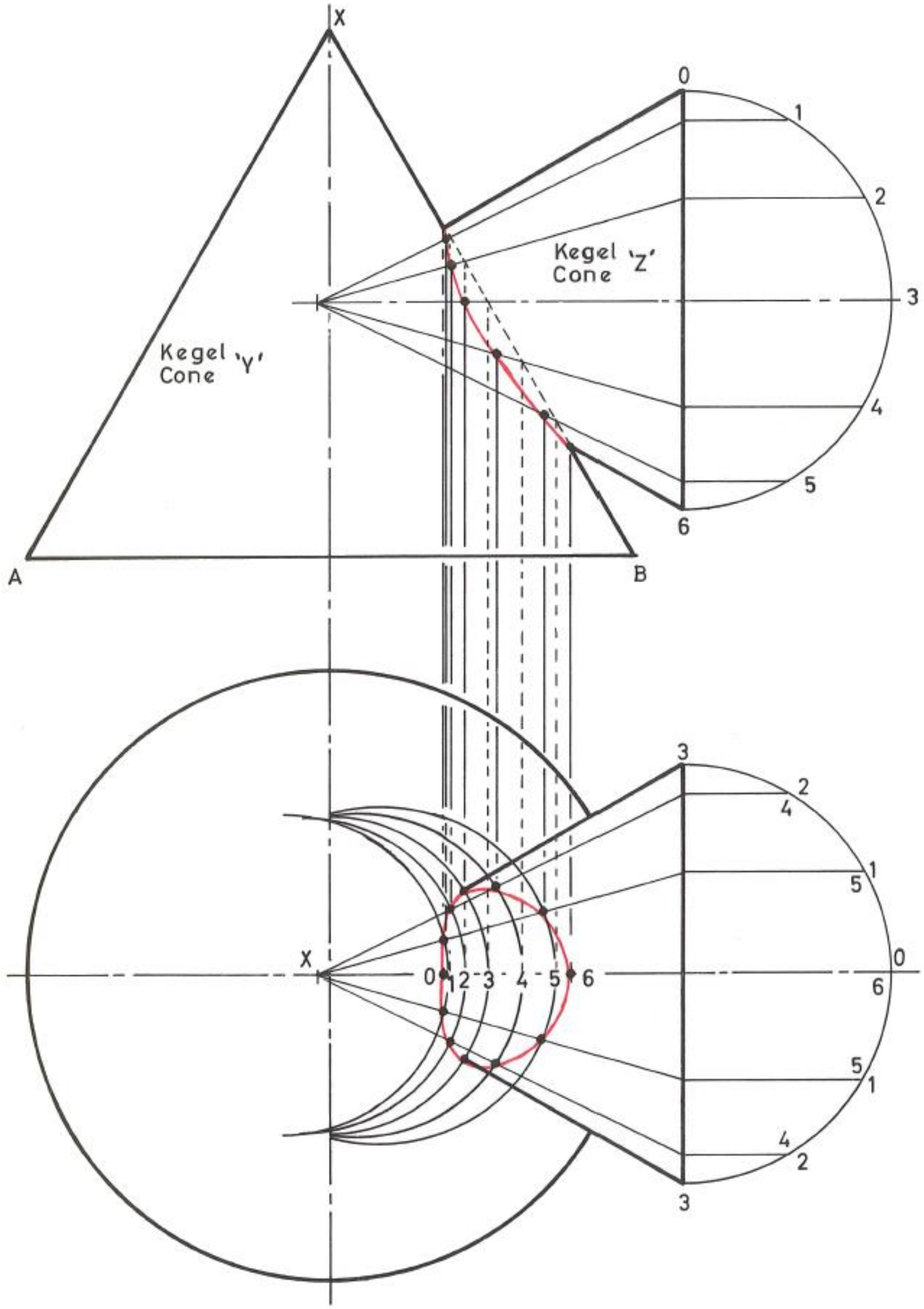

X
0
1
2
3
4
5
6
Kegel 'Z'
Cone
Kegel 'Y'
Cone
A
B
3
2
4
1
5
0
6
5
1
4
2
3
X
0 1 2 3 4 5 6

Figure 5.9

Activity 5.1

1. Draw the following cutting planes as seen in plan.

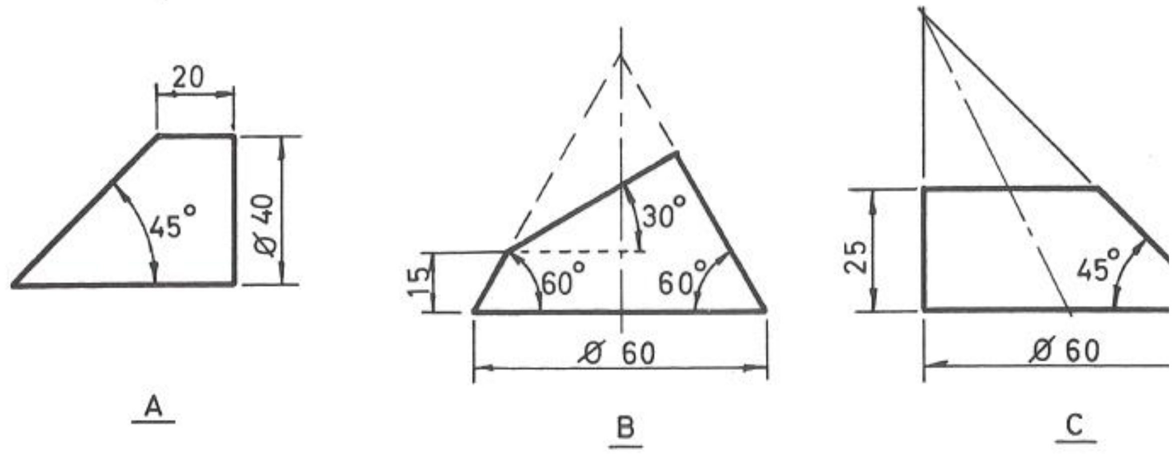


Figure 5.10

2. Determine the lines of interpenetration of the following.

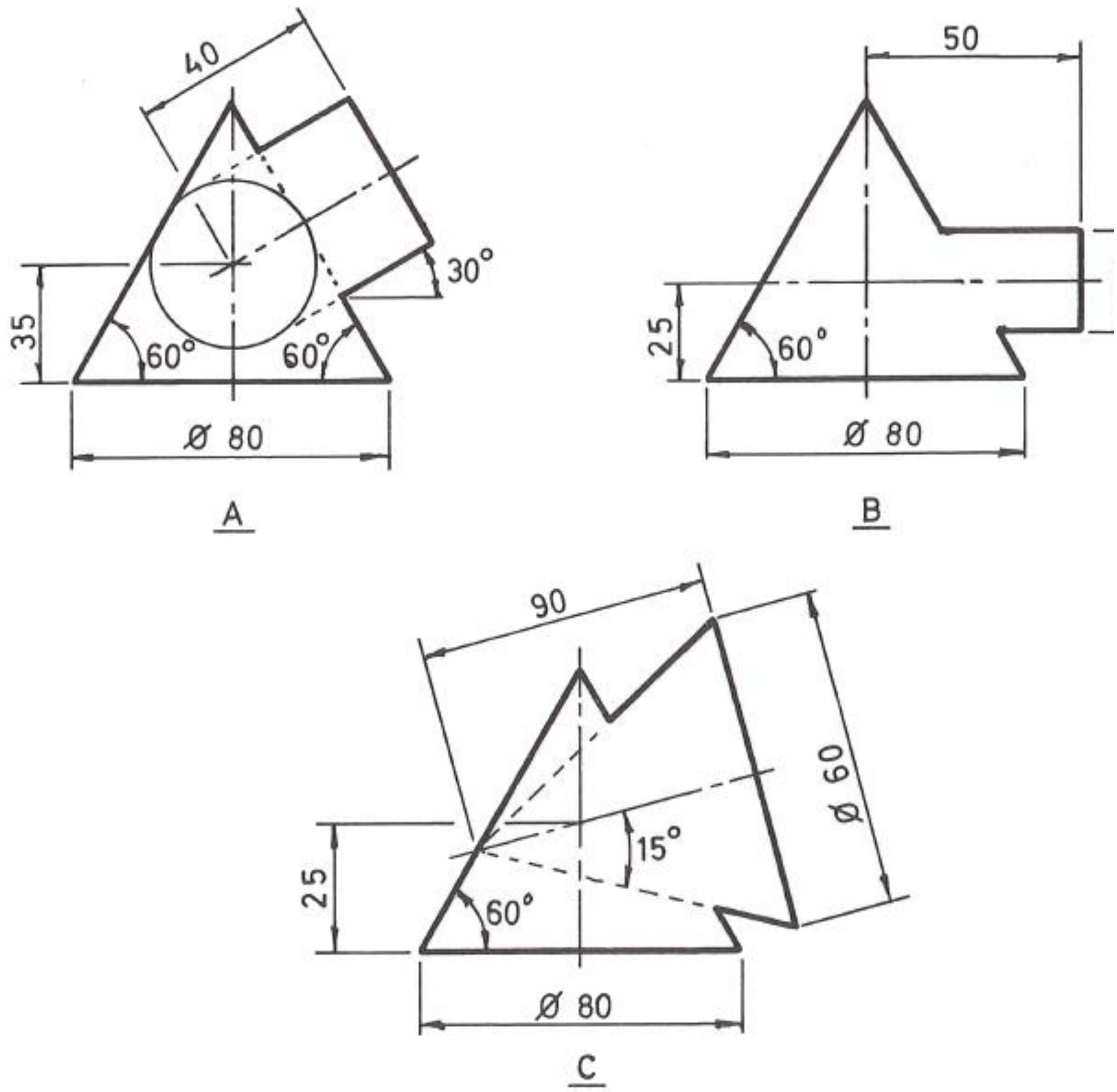


Figure 5.11

3. Develop the cone and the pipe in development 2B.

Self-Check

I am able to:	Yes	No
• Explain the cutting plane theorem		
• Explain the central ball theorem		
• Develop pipes to cones		
o Horizontal pipe		
– Cutting plane method		
– Basic central ball theorem		
o Advanced central ball theorem		
o Pipe at an angle		
– Cutting plane method		

– Cutting plane method alternative		
– Central ball theorem		
o Pipe off centre		
– Cutting plane method		
• Develop cones to pipes		
• Develop cones to cones using the cutting plane method		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 6

Advanced penetrations

Learning Outcomes
On the completion of this module the student must be able to:

- Develop cutting plane on square to round
- Develop pipes to square to round
- Develop multiple breeches
- Demonstrate specific consideration

6.1 Introduction

In this module the aim is to show that although we talk about advanced penetration, there is nothing new. It is the same principles that will be used namely the cutting plane method for obtaining the lines of interpenetrations and triangulation for developing.

6.2 Cutting plane on square to round

Although we should by now be able to obtain cutting plane projections, it is necessary to note the varying radii projections as found in the square to round development.

As can be seen in the drawing opposite, the radius of the square to round varies from O.B at the top to zero at point A and of course from this it is logical to determine, that a cutting plane anywhere on the development will vary between O,B and Zero.

Therefore it follows that the centre line for these radii lies between 0 and A (see **Figure 6.1**). It also follows that the radii fall on the area between the bend lines of the radial parts of the development.

The procedure to obtain the cutting plane is thus: Where the cutting plane 1 cuts the line A.O. (which in elevation presents both the centre line of the radii and the bend line where the radius start) we project down to plan to cut line AO in plan and the bend line AX, giving points 1 and 1^1 which represents the centre of the radius and the start of the curve i.e. using the centre 1 and radius $1,1^1$, scribe arc between bend lines.

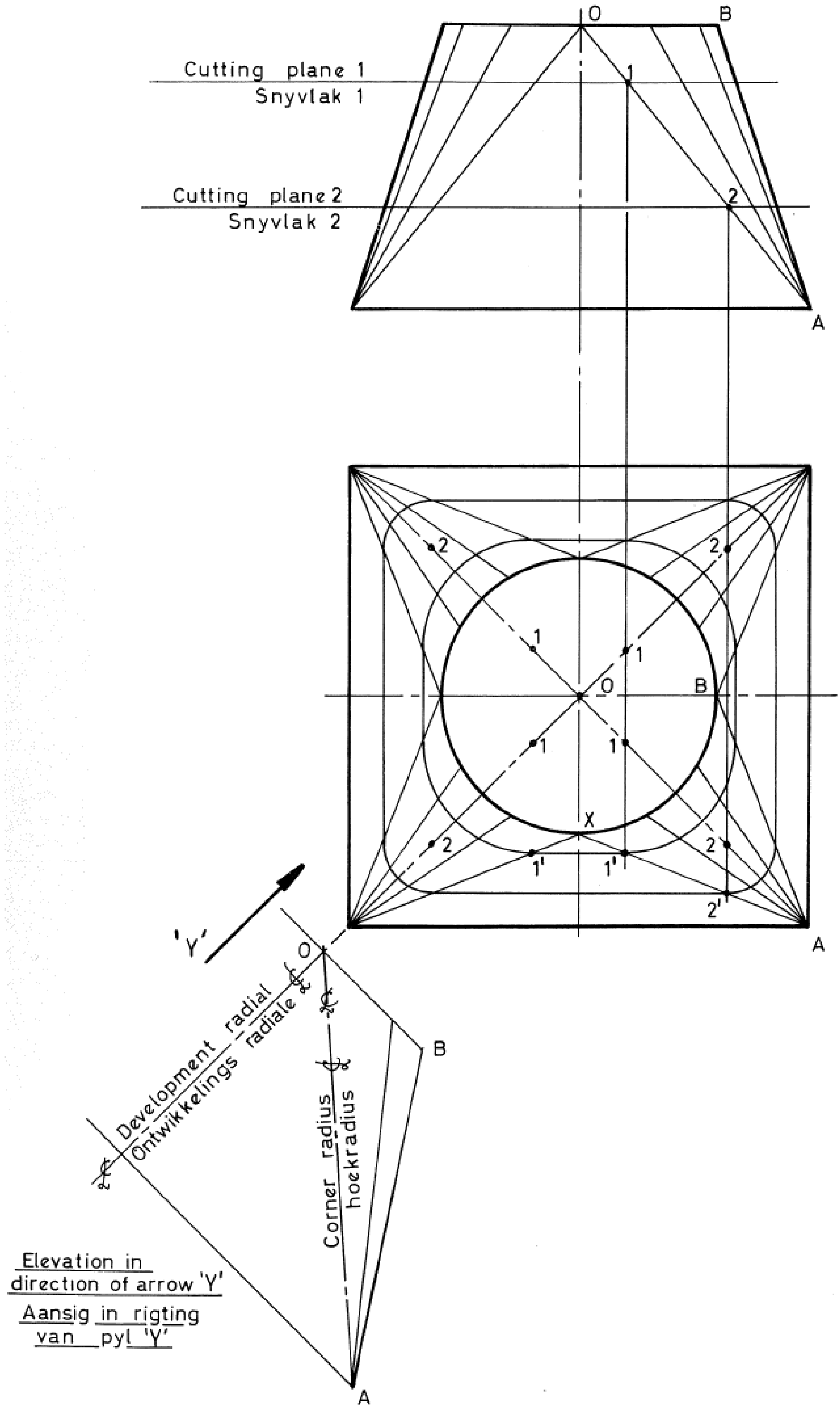

O
B
Cutting plane 1
Snyvlak 1
Cutting plane 2
Snyvlak 2
1
2
A
O
B
X
1'
2'
A
'Y'
O
Development radial
Ontwikkelings radiale
Corner radius
hoekradius
B
A
Elevation in direction of arrow 'Y'
Aansig in rigting van pyl 'Y'

Figure 6.1

Thus, with all 4 corners then draw tangent lines between these radii to complete the cutting plane. Similarly we have the cutting plane 2 which will clearly show that the radii reduces as we move nearer point A.

6.3 Pipes to square to rounds

By following the standard cutting plane method it will now be seen that this development is done similarly to any other development using the cutting plane method see **Module 5.**

Note:
It is important to note that in various developments it is necessary to have additional points to enable you to ascertain the exact point of plane or line of interpenetration direction change.

See points X and Y. It will be seen that the area between YOY falls on the flat area of the development as well as the area between the points XX at the bottom of the pipe. These points are determined on the plan and then projected to the elevation.

Note:
The points X and Y should be taken on the last bend line i.e. where the radius ends and the flat area begins, and by projecting these onto the pipes they in actual fact become new cutting planes that are used to determine the line of interpenetration.

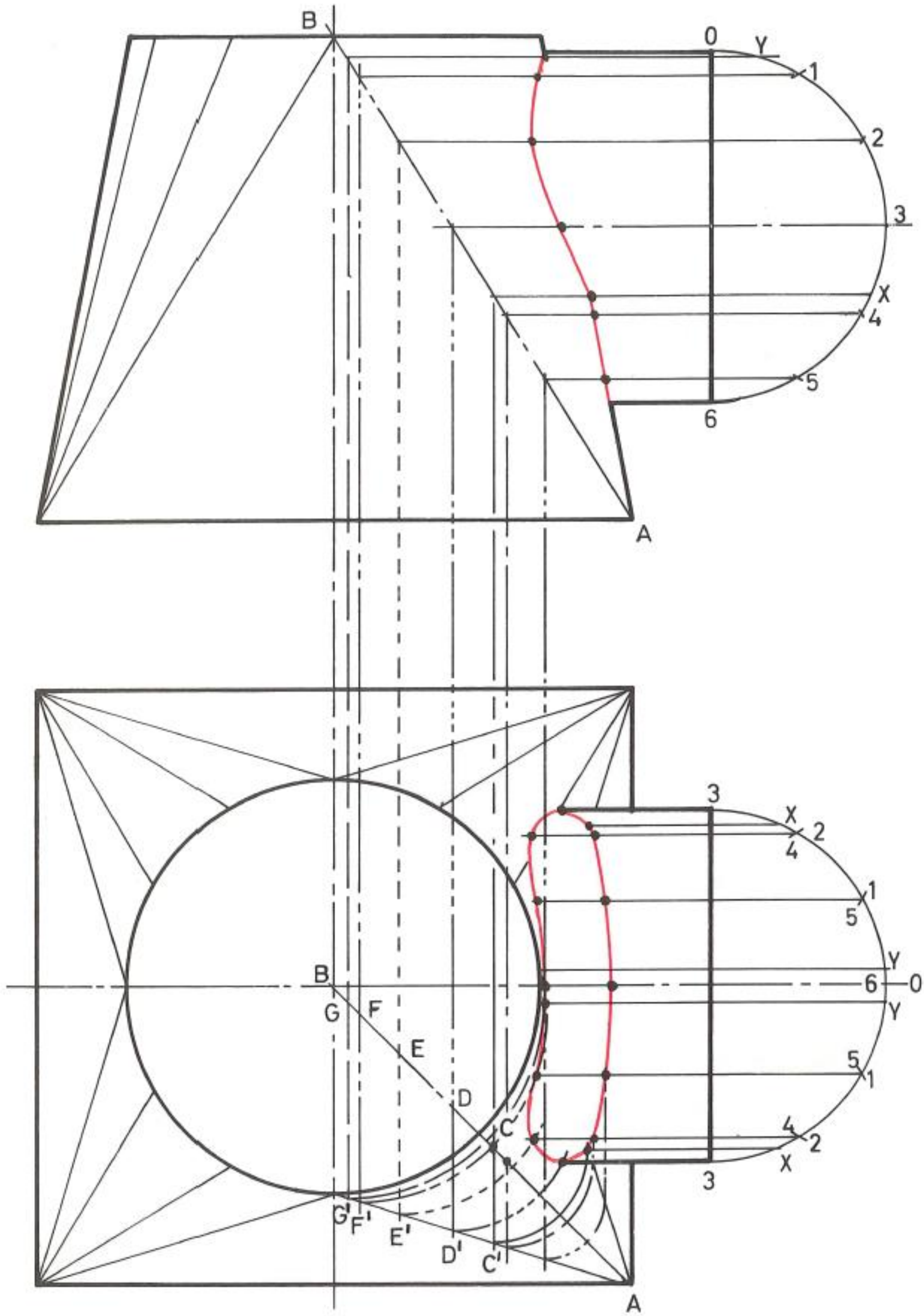


Figure 6.2

6.4 Multiple breeches

In the drawings under consideration we have a three way breech of round to round. This development is done on cutting planes but in this case, as it is possible to have three identical sections, it is possible to predetermine the sections as shown AO, EO, JO, being the lines of interpenetration (this is usually the case in conical sections in this nature of development).

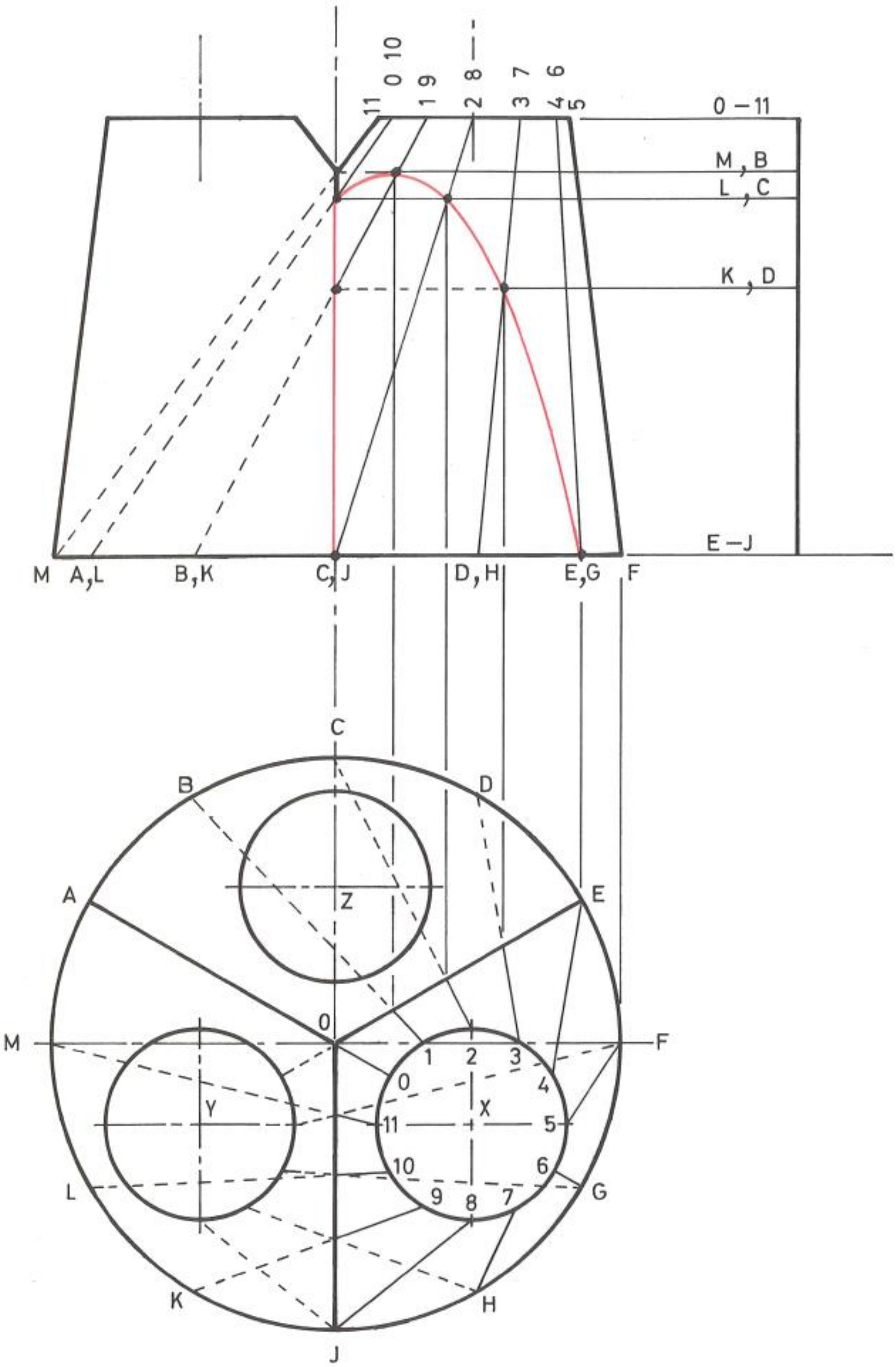


Figure 6.3

Note:
The developments can be done with triangulation or as frustrum of an oblique cone, with, the radial line method.

6.5 Specific consideration

To show the versatility of the basic theorems of development the following design is done. The aim is a dividing transition piece from a square feed to round outlets, with one outlet drawing half the feed and the other two dividing the remainder.

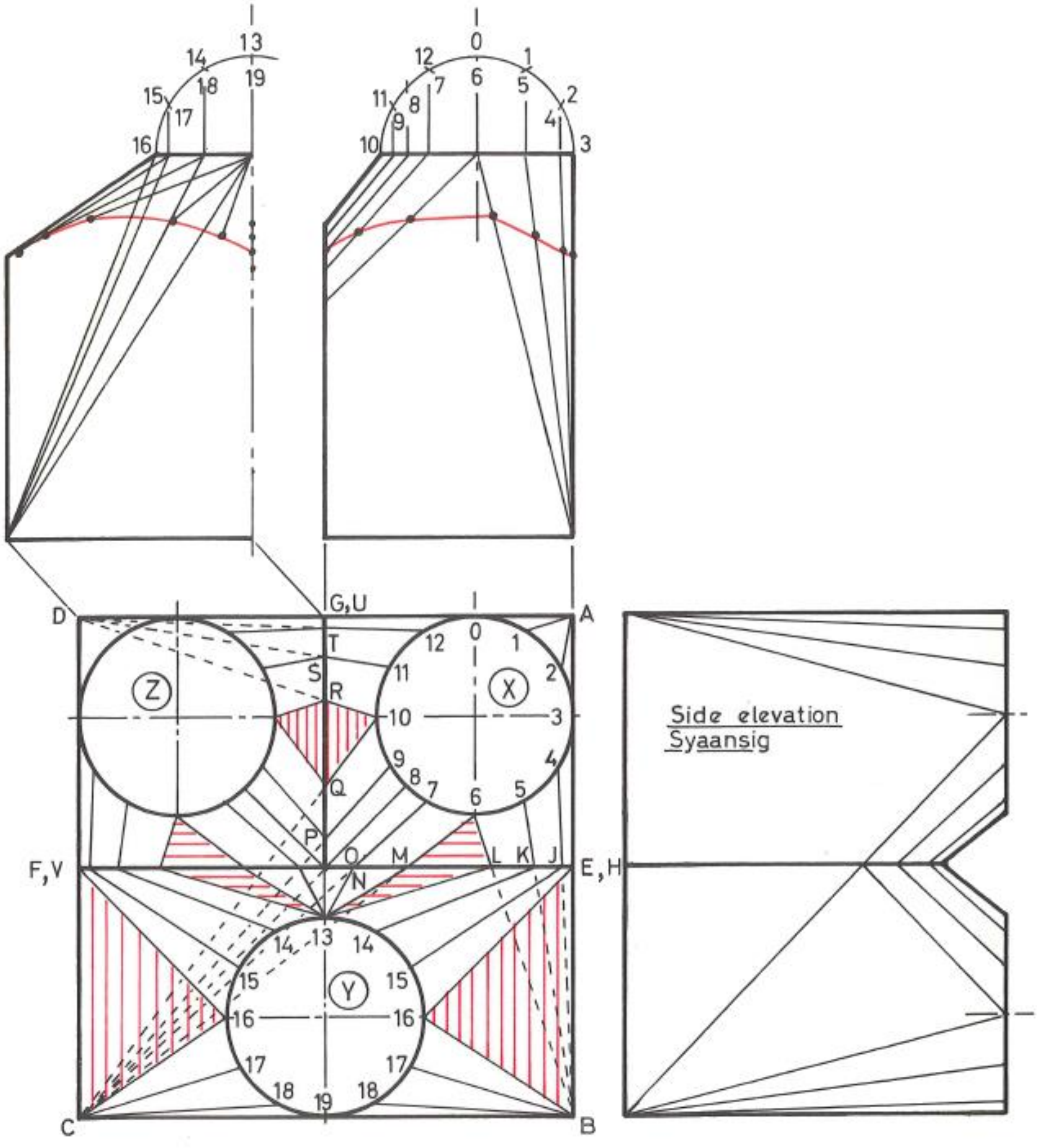


Figure 6.4

Note:

(a) Opening Z and X were taken as two square to rounds with the square base ABCD interpenetrating symmetrically along the centre line GO.

(b) Then the half of the plan section below FV, EH was cut away and replaced by a special development of a square to round nature to suit the cut away part.

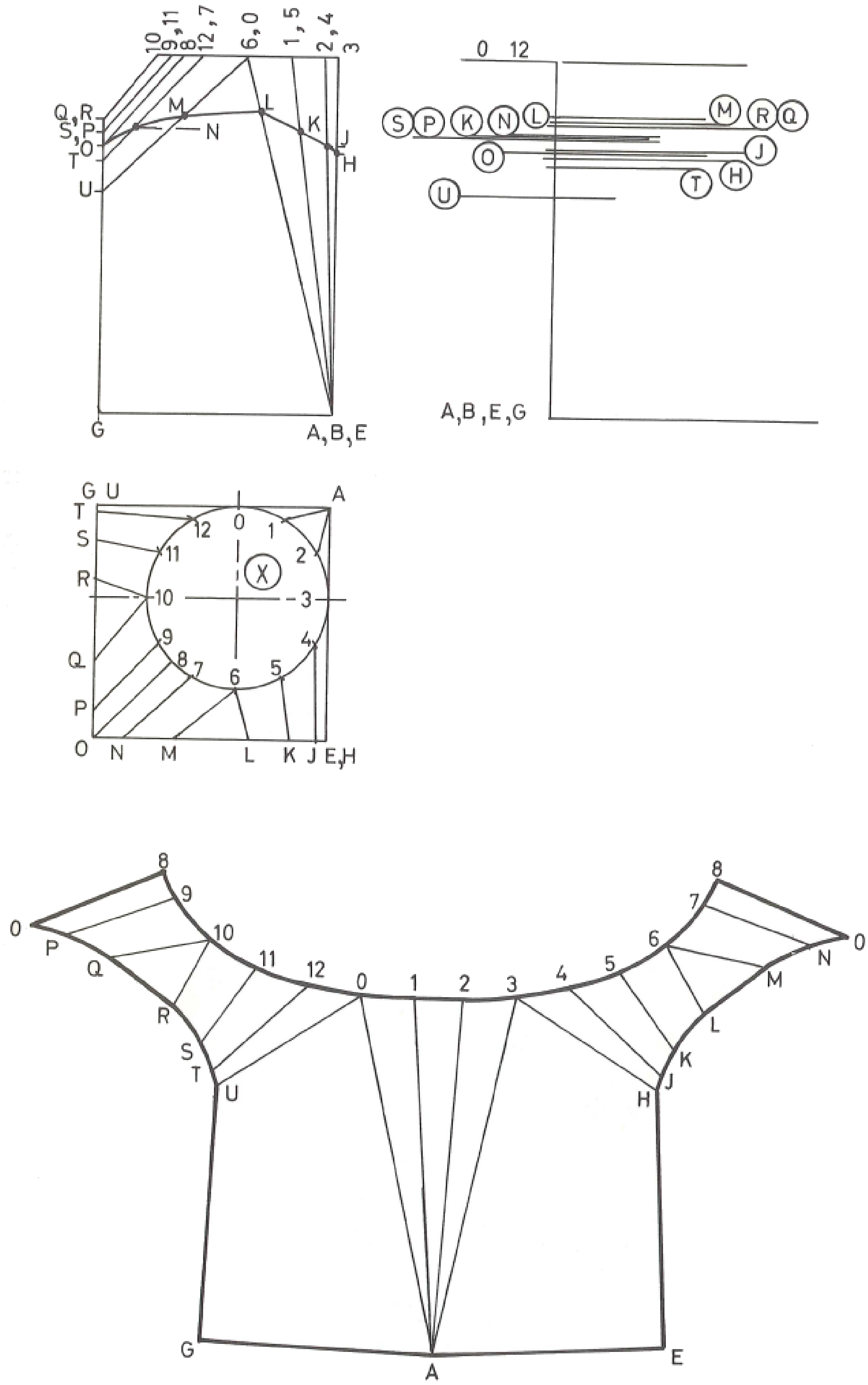
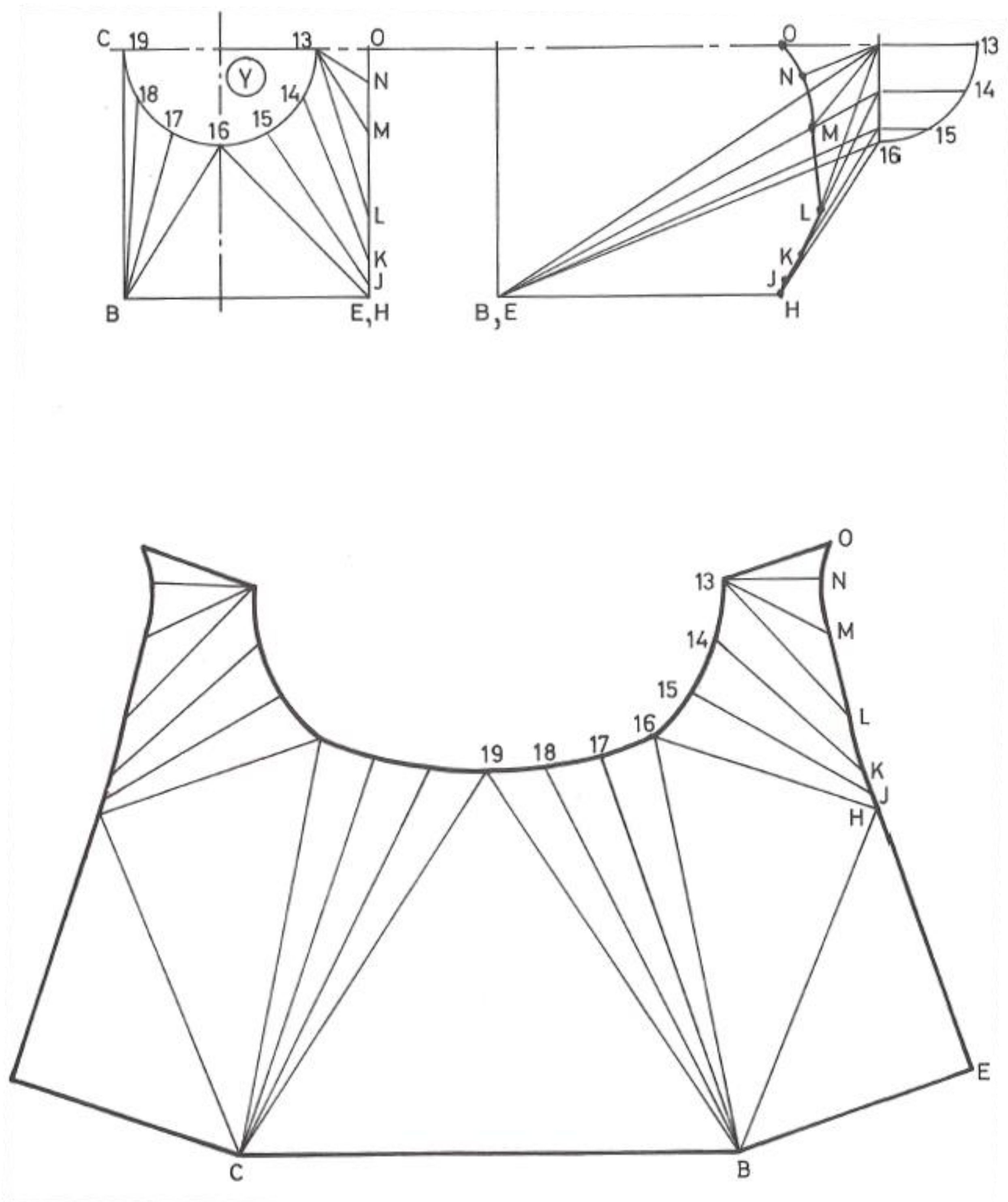


Figure 6.5


C
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16
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13
N
M
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Figure 6.6

Activity 6.1

1. Draw the following cutting plane as seen in plan.

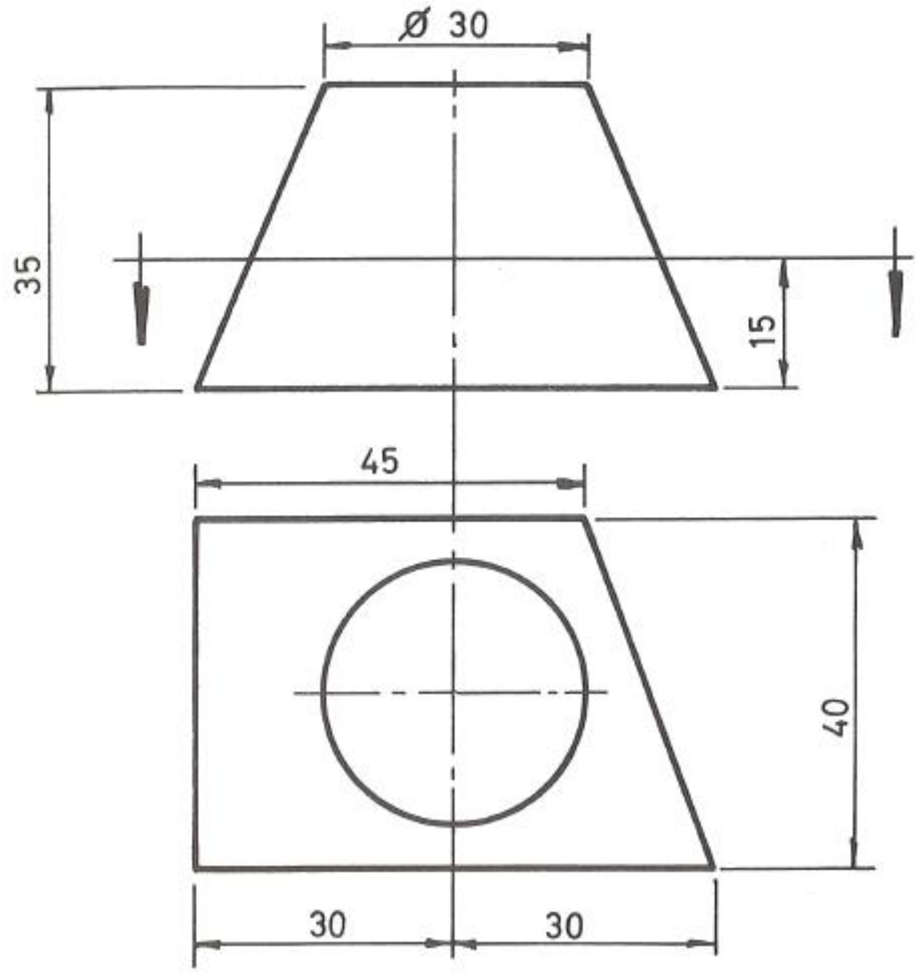

Figure 6.7

2. Develop the following.

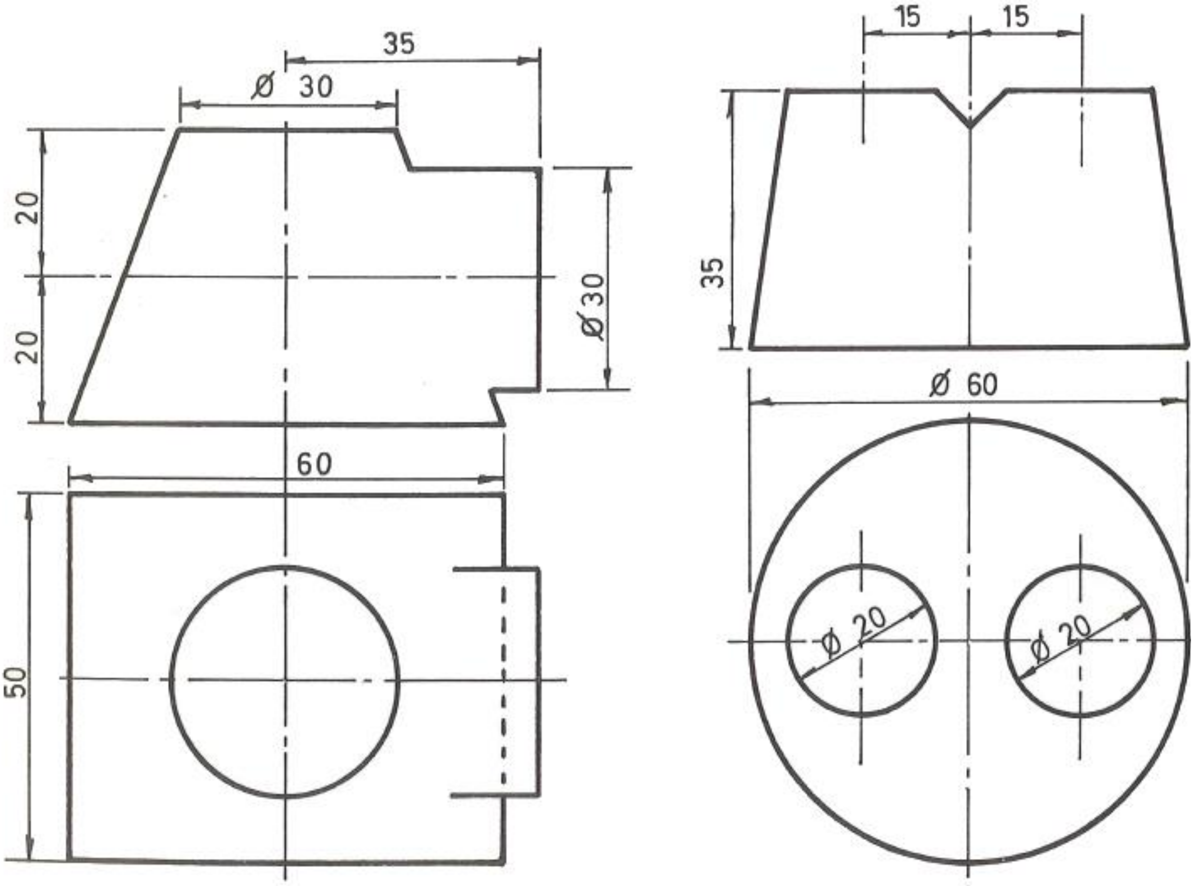

Figure 6.8

	Self-Check	
I am able to:	**Yes**	**No**
• Develop cutting plane on square to round		
• Develop pipes to square to round		
• Develop multiple breeches		
• Demonstrate specific consideration		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 7

Double projection on pipes

Learning Outcomes
On the completion of this module the student must be able to:

- Describe the general procedure
- Demonstrate when given
  - front elevation and plan
  - front and side elevation

7.1 Introduction

If there is a difficult section in development, the double projections can be said to be it, as a tremendous difficulty exists to do any problem where double projections are required.

Important Note!
Although the above statement is valid, it must be made clear that it is not the development that is difficult, as they are usually simple straight line pipe developments. The problem arises where our drawing knowledge on projections fails us, and we fail to "see" what is required.

It must also be noted that here it is of the utmost importance to know the principles in projections and to be able to "turn" a view to present a single plane.

The problems arise at the design and draughting stage as drawings are made in accordance to the orthographic principles and the draughtsman rarely goes to the trouble of placing the views on the drawing to help the artisan.

This brings about that many simple problems of developments involve a difficult set of projections. As the draughtsman does not usually go to the trouble to obtain the true lines of interpenetration it is necessary to "turn" the drawing to obtain these (see **Figure 7.1**).

This sketch shows a pipe elbow leaning towards you, as can be seen from the plan. To be able to develop the patterns for this pipe, it will be necessary in this case to turn the drawing as shown in Sketch 2.

	Note: From the front view in Sketch 1 it is also interesting to note that the angle is not seen true, and will not be the actual development angle as in Sketch 2, as it is seen as a complex angle.

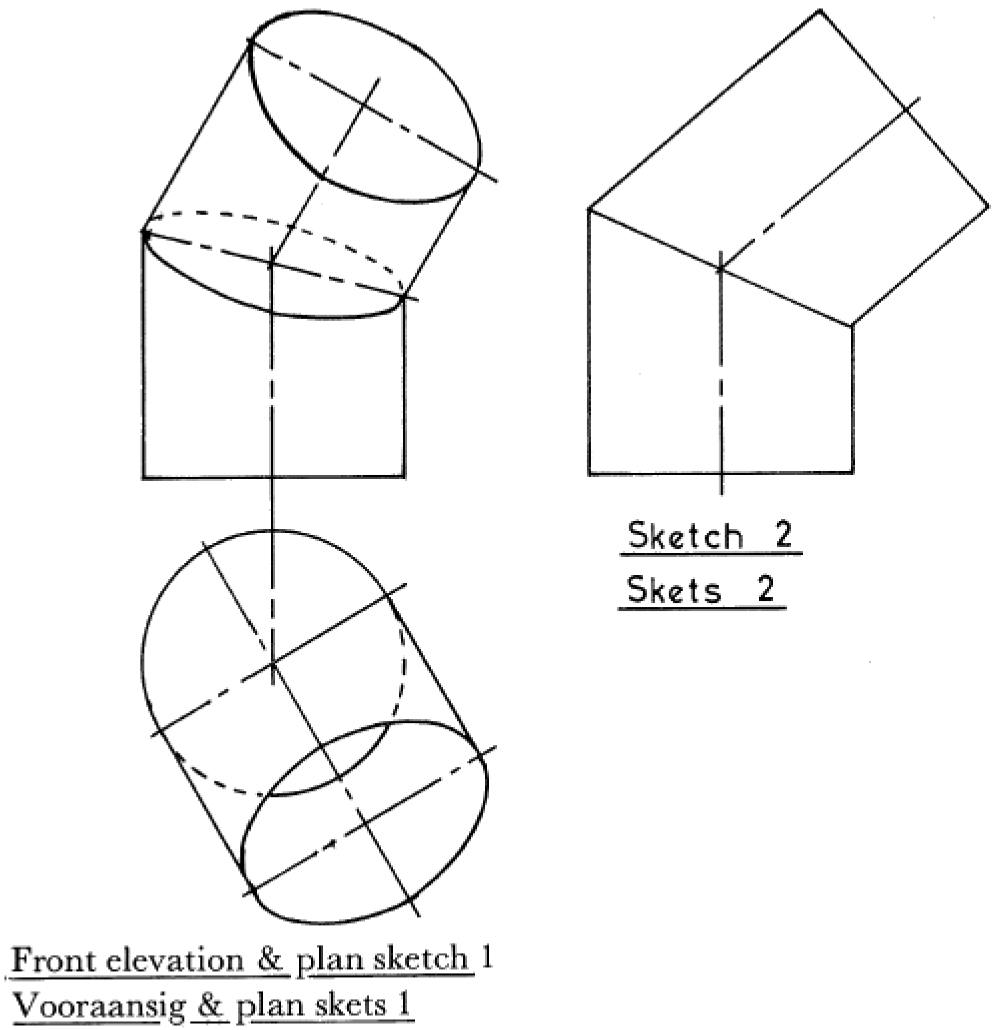

Figure 7.1

7.2 General procedure

1. Draw front elevation and plan centre line construction only with dimensional points.
2. Do the first projection from these centre line elevations.
3. Complete this first projection by adding the pipe dimensions.
4. Divide and number the first projection.
5. Project bend lines up to the plan and then to the front elevation.

6. To draw the line of interpenetration in the front elevation take the lengths of the bend lines in the first projection and measure off on the like numbered lines in front elevation.
7. Do the pattern development from the first projection as this is the true "Flat" elevation.

> **Note:**
> For practical pattern development it is not necessary to, and is in actual fact much simplified, if the pipe is not drawn completely in the elevations as this tends to lead to confusion in the numbering of the bend line and of line of interpenetration.

7.3 Given front elevation and plan

In this exercise it will be found that we only need one projection as shown and the following procedure is followed:

- Draw front elevation centre line construction ABC and the plan centre line construction A^1 B^1 C^1.
- Then project points A^1 B^1 and C^1 out normal to centre line A^1 B^1 and C^1.
- Mark line A^{11} B^{11} to dimension AB given in elevation.
- From point B^{11} normal to line A^{11} B^{11} project a line to cut projection line from C^{11} at X^{11} and from X^{11} along projection line; mark the rise C.X of the elbow taken from front elevation and mark C^{11}.
- Now connect centre points A^{11} B^{11} C^{11}; this will be the true centre line construction.
- The first projection is now completed by marking in the pipe diameter, divide and number.
- The pattern development can now be done from this projection.
- If it is required to obtain the line of interpenetration and complete the front elevation of the plan, the General procedure (**section 7.2**) should be followed from 3 to 7.

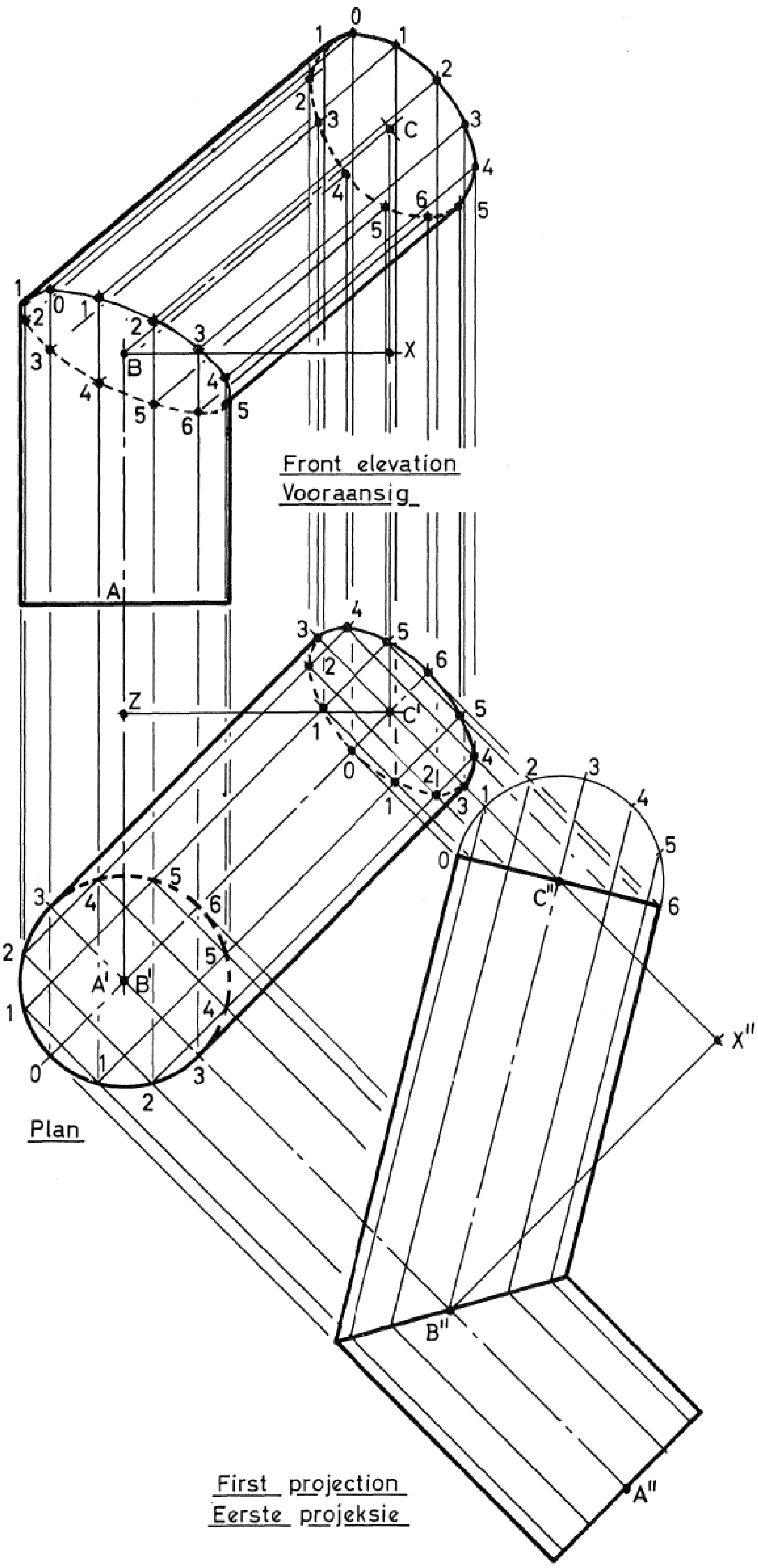
Front elevation
Vooraansig
Plan
First projection
Eerste projeksie

Figure 7.2

7.4 Given front and side elevation

In this exercise we once again start by drawing the centre line construction for the front and side elevation, then we have to first complete the plan by projecting from the two elevations.

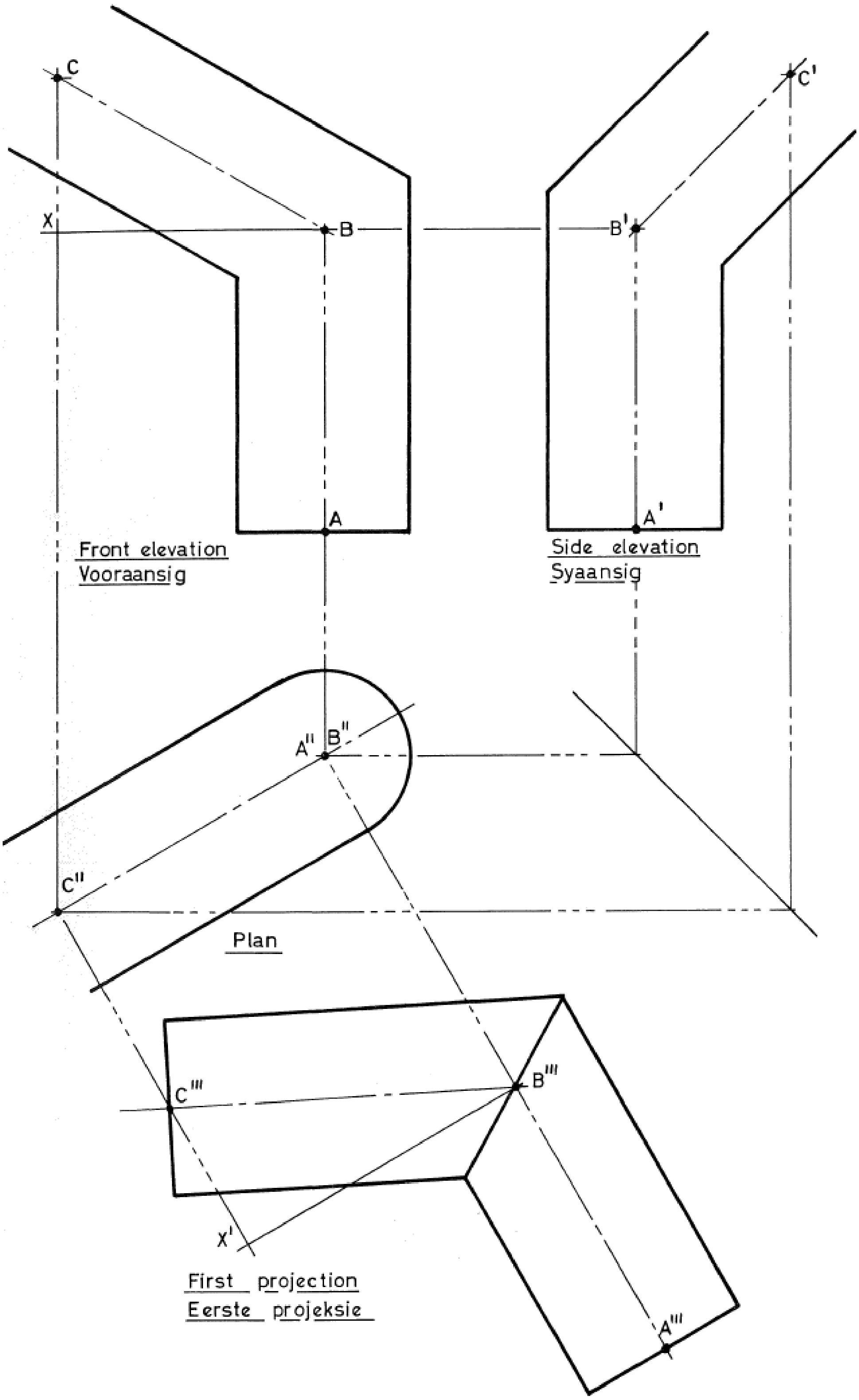

Figure 7.3

The true "flat" projection can now be done from the plan by projections as per **section 7.2**.

Note:
In this case we have not completed the front and side elevation and the plan as we are only interested in developing the pattern and this is done from the first projection.

Activity 7.1

1. Draw the views as shown and project the second (Flat) projection from which you could develop the elbow. Show the true line of interpenetration on all the views.

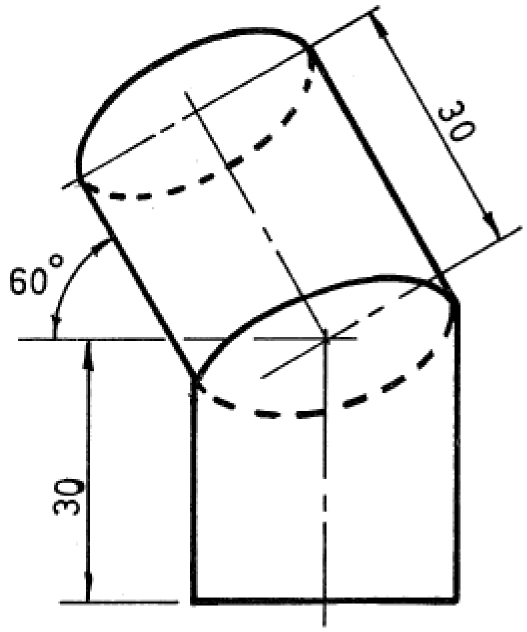

Figure 7.4

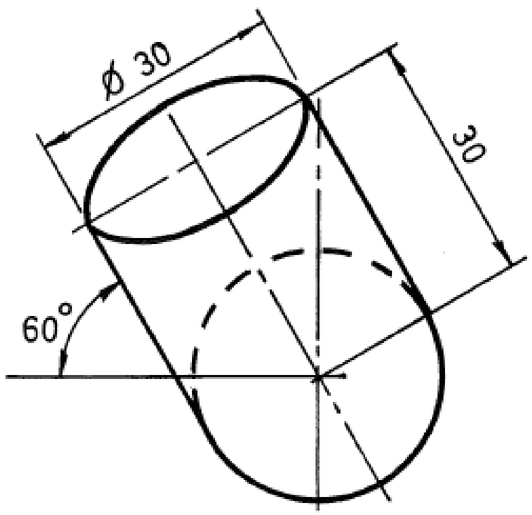

Figure 7.5

2. Complete all the views required to develop the pipe to pipe interpenetration and show the lines of interpenetration.

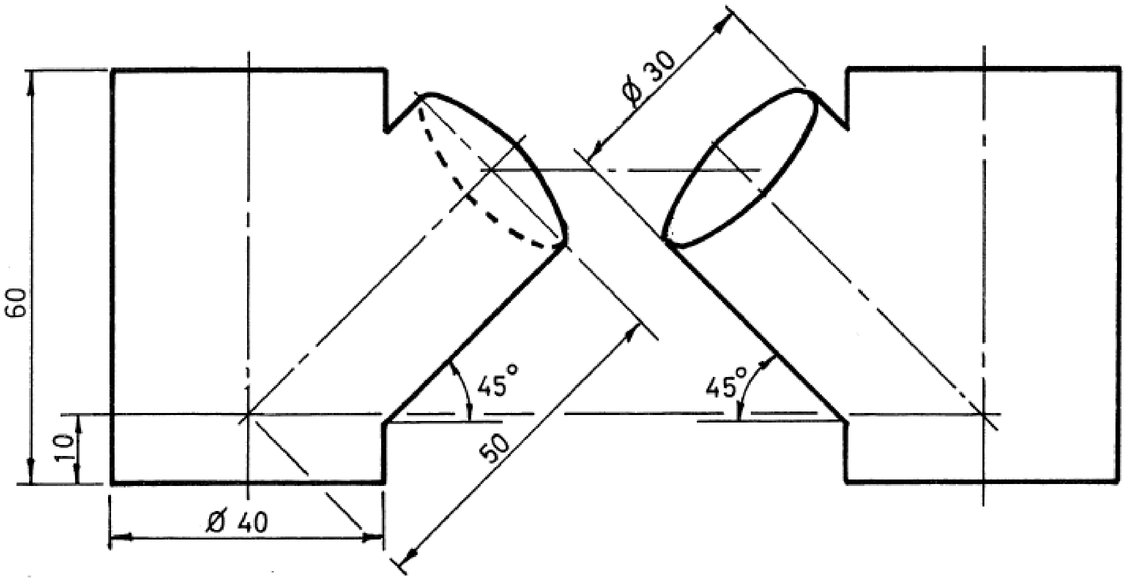

Figure 7.6

	Self-Check	
I am able to:	**Yes**	**No**
• Describe the general procedure		
• Demonstrate when given		
o front elevation and plan		
o front and side elevation		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Past Examination Papers

higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2013

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

(8090124)

26 March 2013 (X-Paper)
09:00 – 13:00

Requirements: ONE A2 drawing paper

This question paper consists of 4 pages and 2 diagram sheets.

TIME: 4 HOURS
MARKS: 125

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Show ALL the calculations on the drawing paper.
5. Insert dimensions, title and the scale on each drawing.
6. Do TWO questions on the front and TWO questions on the reverse side of the drawing paper.
7. Write neatly and legibly

QUESTION 1

FIGURE 1, DIAGRAM SHEET 1, shows a ventilator head which fits on a square duct.
Draw the given views and develop the following:

1.1 Pattern for back panel

1.2 Pattern for front panel

1.3 Pattern for side panels

Ventilator head -Scale 1 : 10

[25]

QUESTION 2

FIGURE 2, DIAGRAM SHEET 1, shows two views of a rectangular to square hopper.

Calculate the true lengths and use these lengths *to* develop the pattern for the hopper.

ALL the calculations must be done on the drawing sheet.

NOTE: No marks will be allocated for lengths taken from a drawing to scale.
Rectangular to square hopper - Scale 1 : 1

[25]

QUESTION 3

FIGURE 3, DIAGRAM SHEET 1, shows an incomplete view of a conical hopper on a hemispherical dome.

Draw the complete view and develop the shape of the plate required for the conical hopper.

Conical hopper- Scale 1 : 2

[25]

QUESTION 4

FIGURE 4, DIAGRAM SHEET 2, shows the intersection of two square pipes.

Draw the given views, show the line of penetration and develop the patterns for the square pipes.

Intersection of two square pipes -Scale 1 : 1

[25]

QUESTION 5

FIGURE 5, DIAGRAM SHEET 2, shows a pipe connection to a dome.

Draw the given views and construct the curve of interpenetration. Develop the pattern for the pipe connection "A".

Pipe connection to a dome - Scale 1 : 5

[25]
TOTAL: 125

DIAGRAM SHEET 1

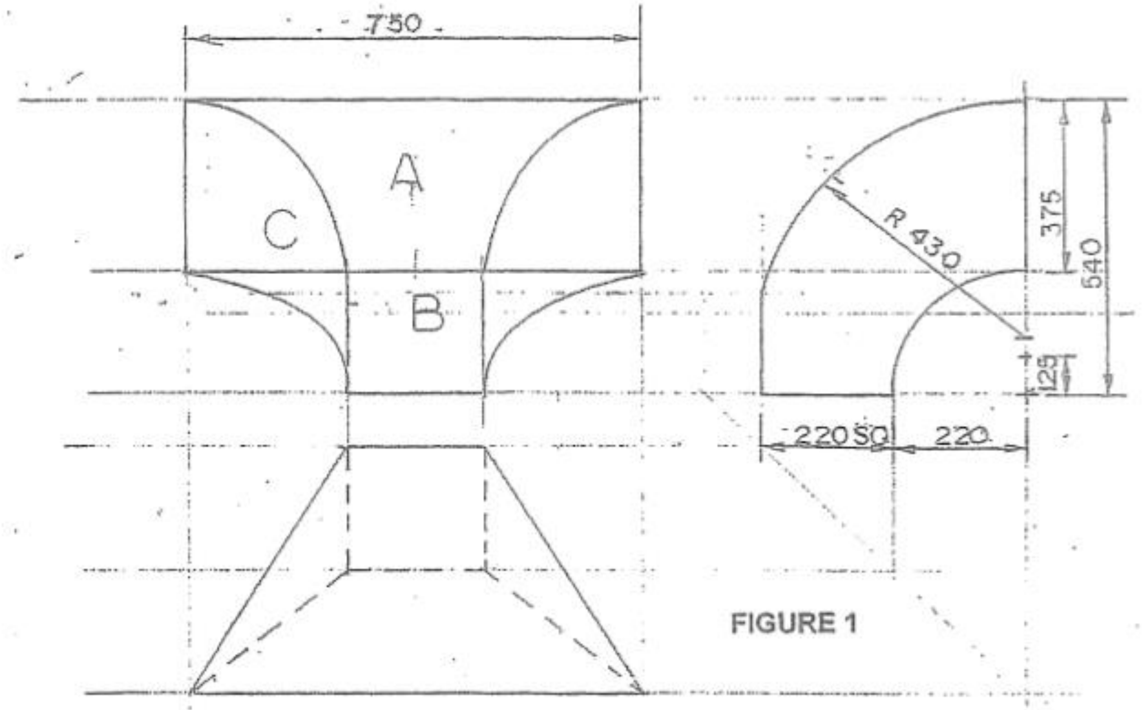

FIGURE 1

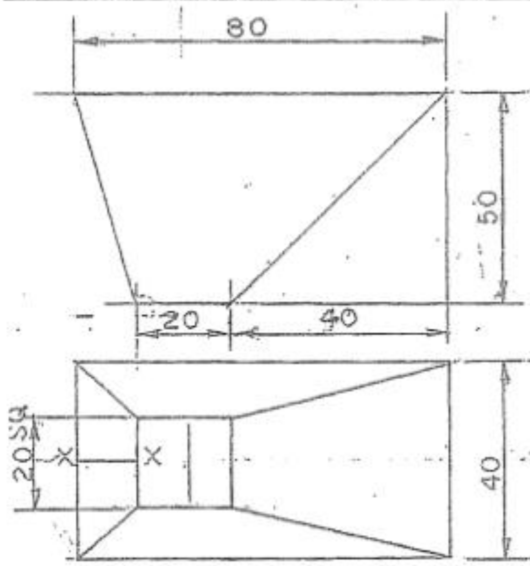

FIGURE 2

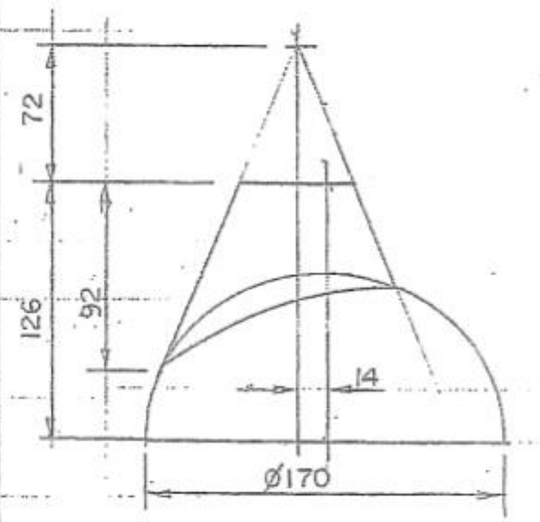

FIGURE 3

DIAGRAM SHEET 2

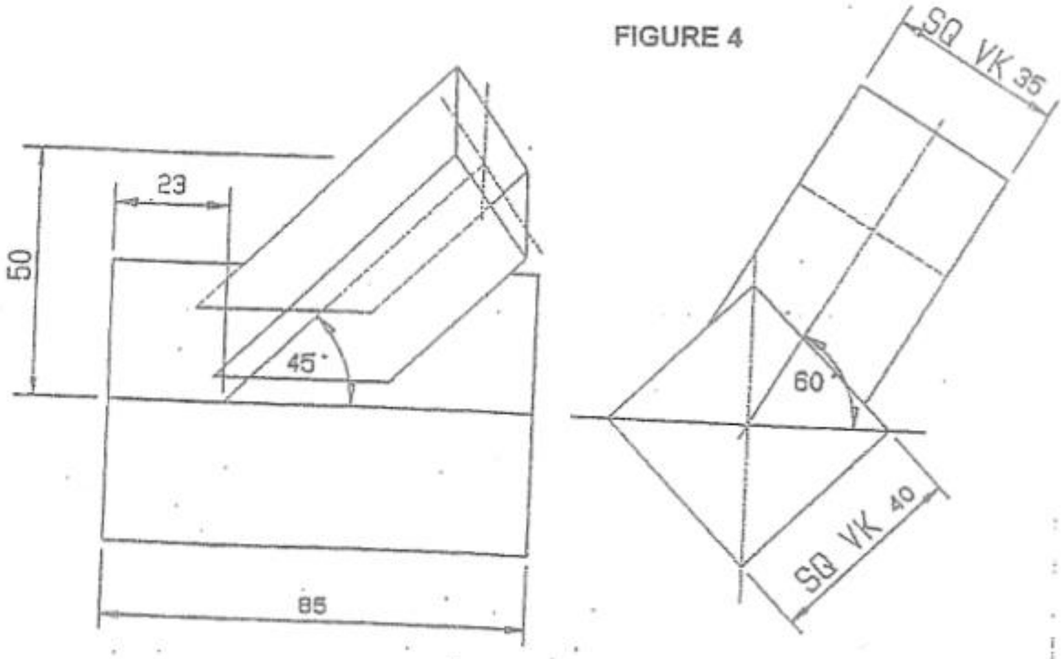

FIGURE 4

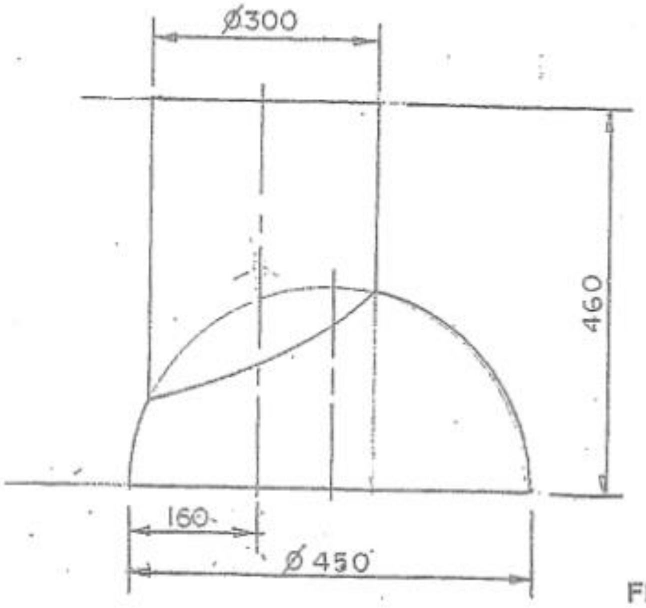

FIGURE 5

Marking Guidelines

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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2013

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

(8090124)

QUESTION 1

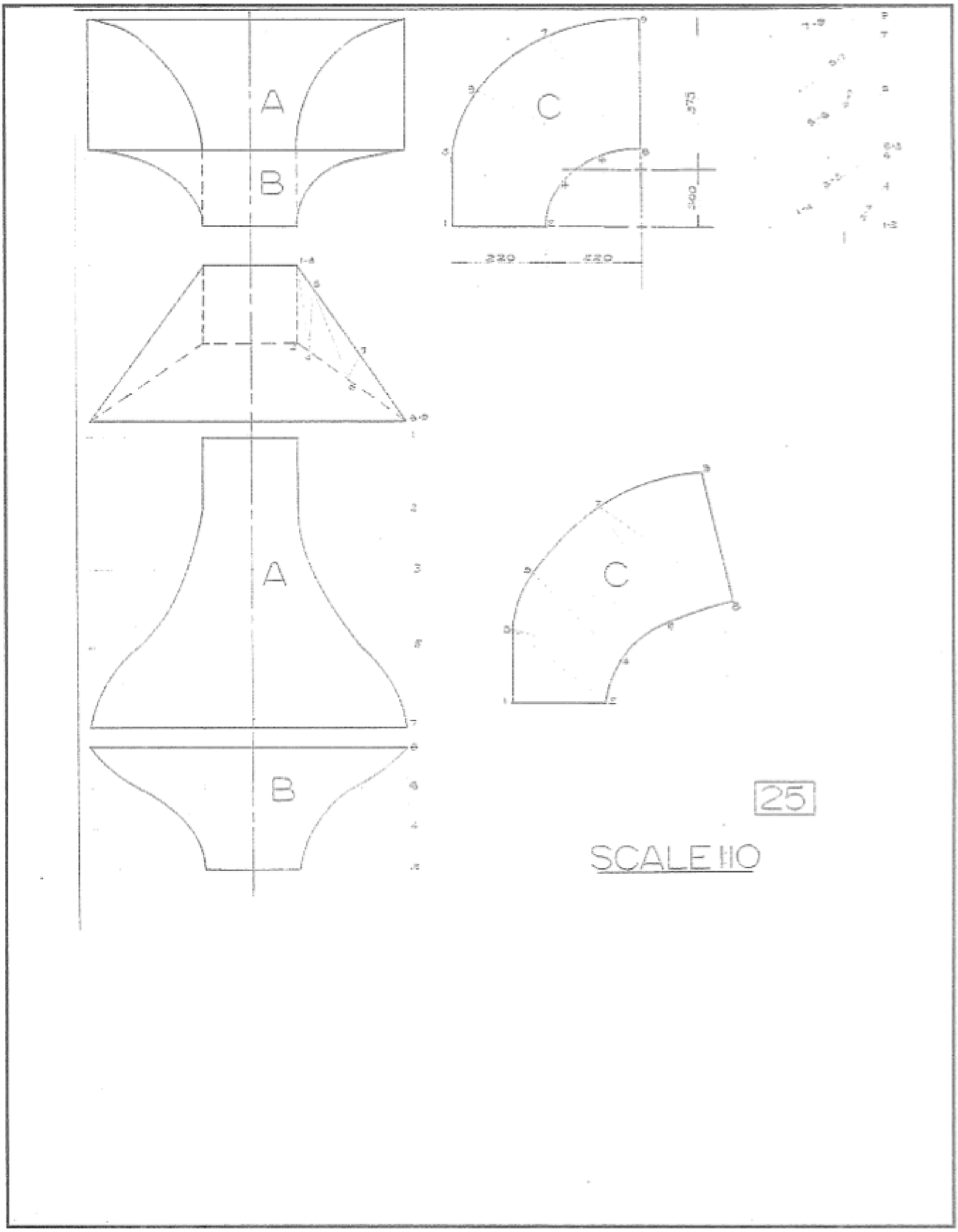

FIGURE 1 [25]

QUESTION 2

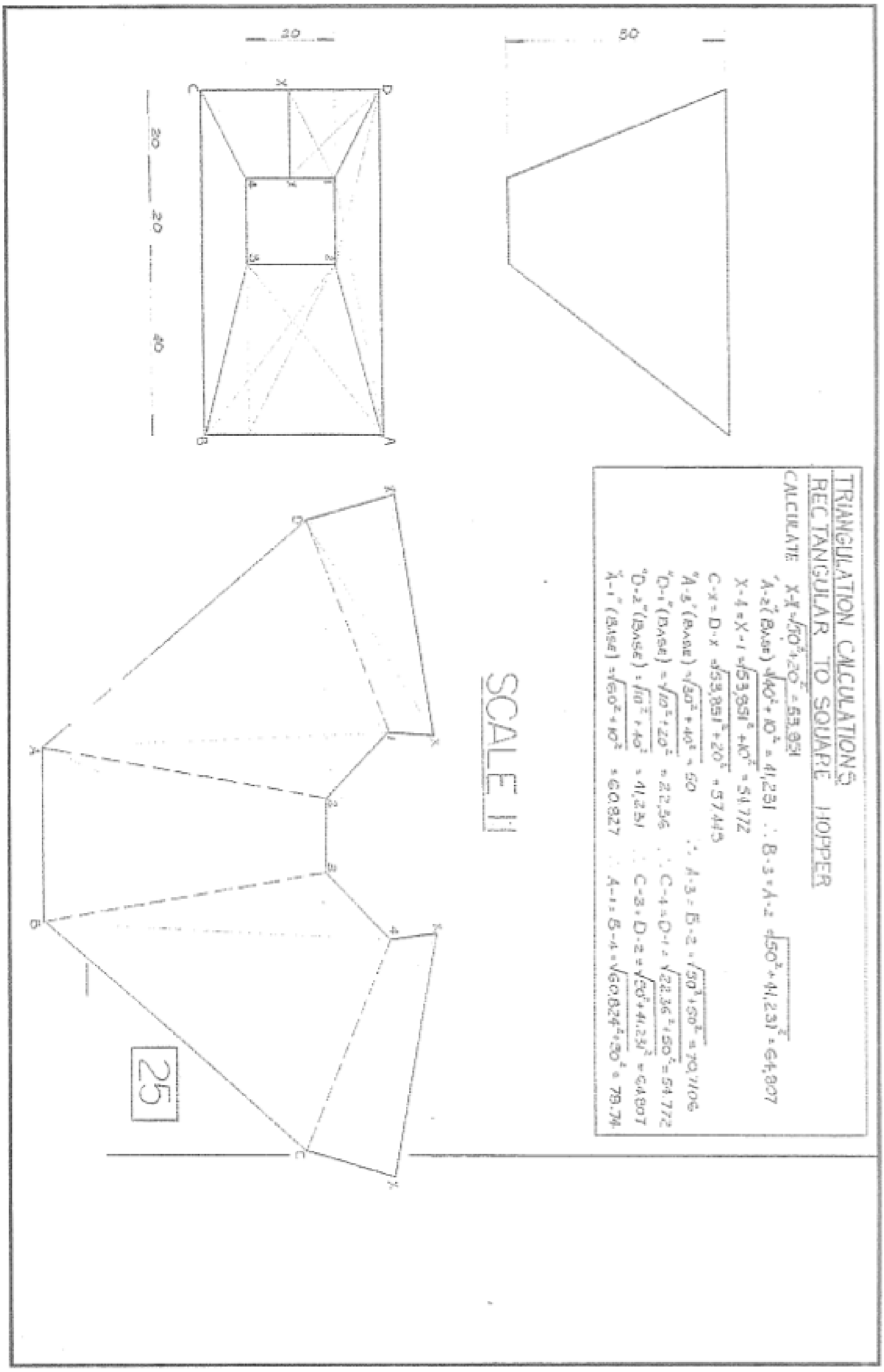

FIGURE 2 [25]

QUESTION 3

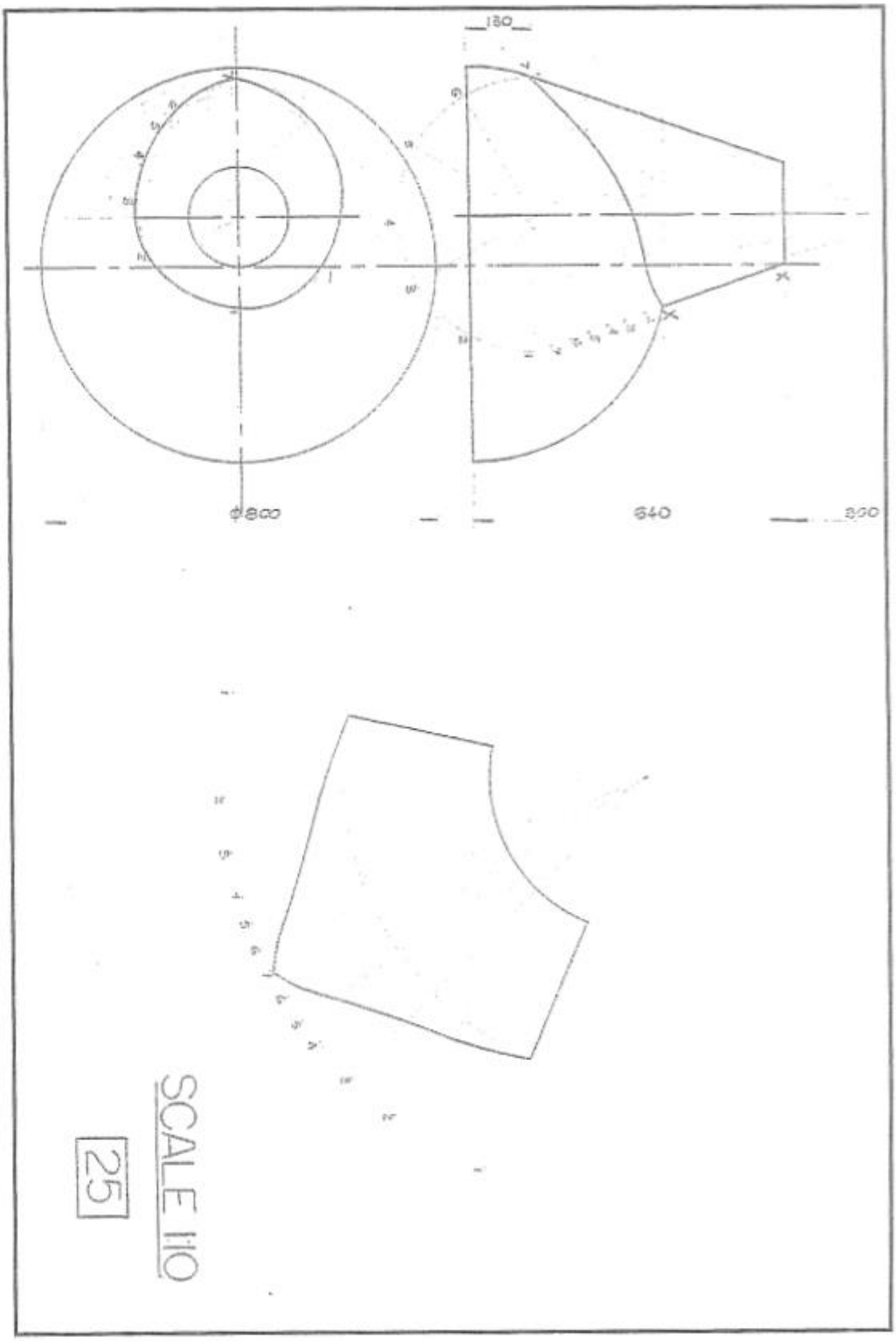

FIGURE 3 [25]

QUESTION 4

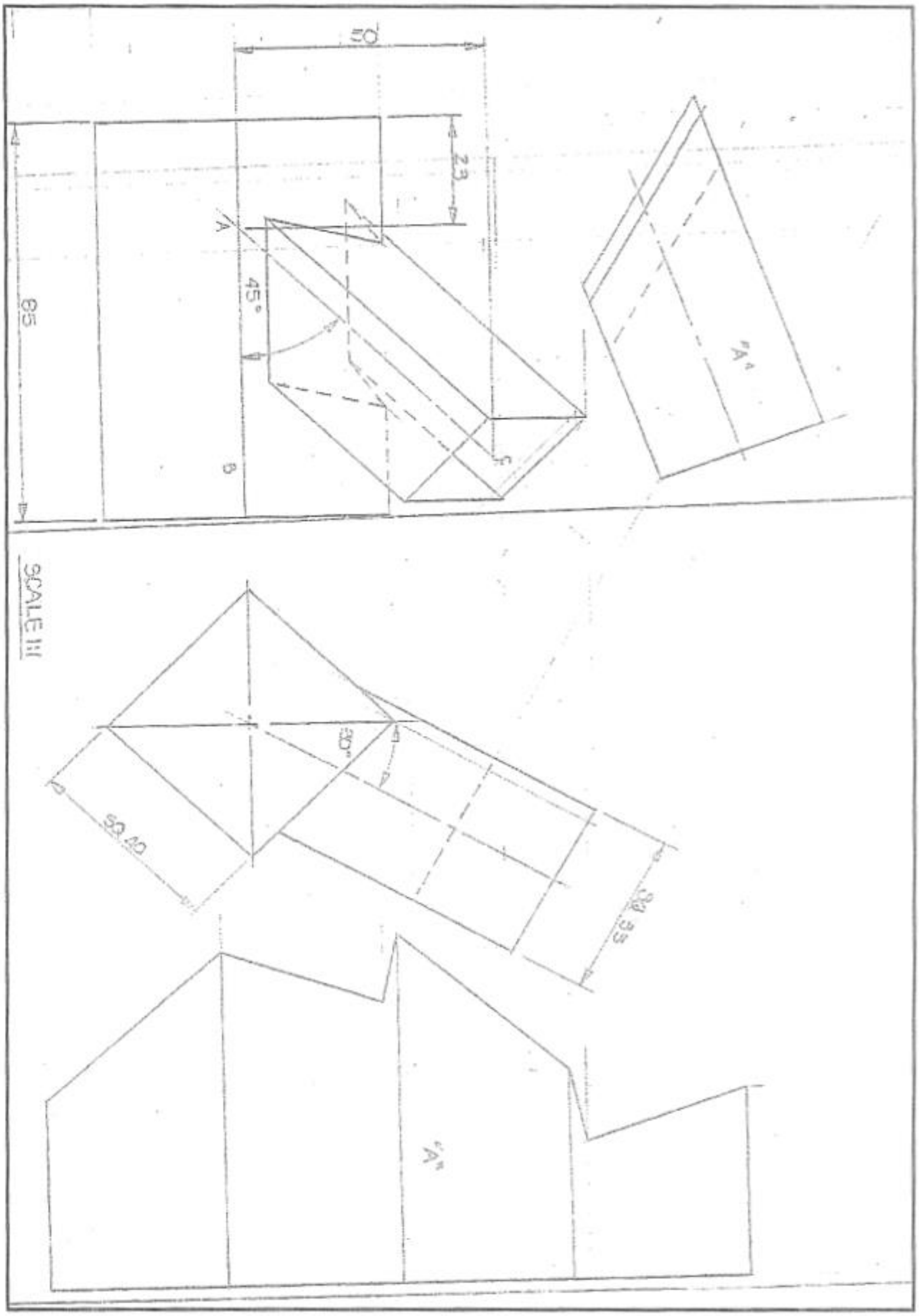

FIGURE 4 [25]

QUESTION 5

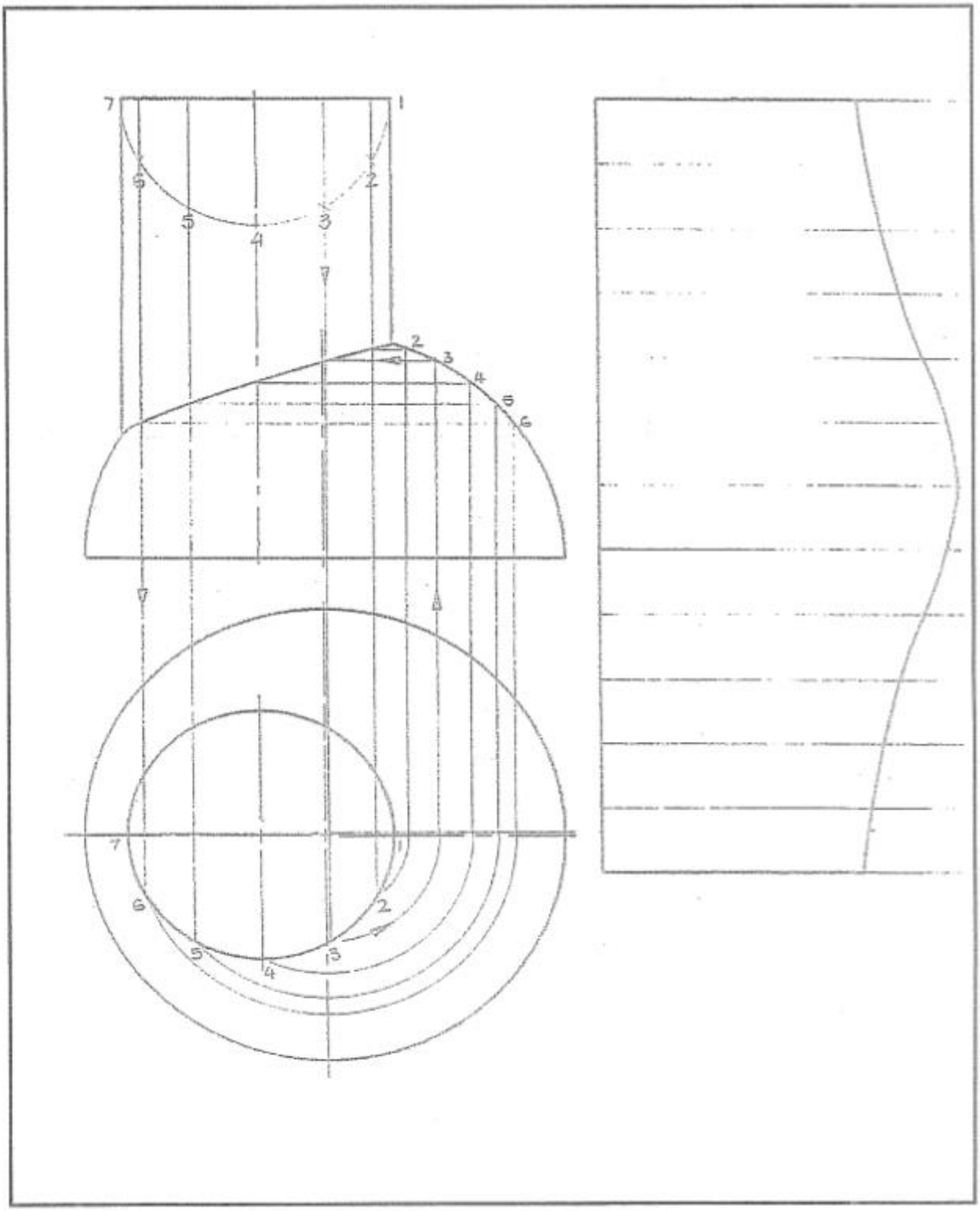

FIGURE 5

[25]

TOTAL 125

Past Examination Papers

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Department: Higher Education and Training REPUBLIC OF SOUTH AFRICA

NOVEMBER 2011

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

(8090124)

15 November 2011 (X-Paper)
09:00 – 13:00

Requirements: ONE sheet A2 drawing paper

This question paper consists of 4 pages, a 2-page diagram sheet and a 2-page answer sheet.

TIME: 4 HOURS
MARKS: 100

NOTE: If you answer more than the required number of questions, only the required number of questions will be marked. All work you do not want to be marked, must be clearly crossed out.

INSTRUCTIONS AND INFORMATION

1. Answer only FOUR of the five questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Show ALL the calculations on the drawing paper.
5. Insert dimensions, title and the scale on each drawing.
6. Answer TWO questions on the FRONT and the other TWO questions on the REVERSE side of the drawing paper.
7. Write neatly and legibly

QUESTION 1

FIGURE 1, DIAGRAM SHEET 1 (attached) shows an off-centre rectangle-to-circle transition piece.

Calculate the true lengths and use these lengths to draw half of the pattern of the transition piece.

Do the calculations on the DRAWING PAPER and on the ANSWER SHEET attached.

NOTE: Marks will NOT be awarded for lengths taken from the drawing to scale.

RECTANGLE-TO-CIRCLE TRANSITION PIECE
SCALE: 1:1

[25]

QUESTION 2

FIGURE 2, DIAGRAM SHEET 1 (attached) shows a connection between right conic connections to conical cover.

Draw the given views and develop the pattern for the right cone and the conical cover.

RIGHT CONIC CONNECTION
SCALE: 1:10

[25]

QUESTION 3

FIGURE 3, DIAGRAM SHEET 1 (attached) shows three views of a flared ventilator head.

Develop the shape of the template to mark off the FOUR limbs of the transition piece.

FLARE VENTILATION HEAD
SCALE: 1:10

[25]

QUESTION 4

FIGURE 4, DIAGRAM SHEET 2 (attached) shows a rectangle-to-circle transformer connection.

Draw the given views and develop the shape of the plates required to form the transformer.

RECTANGLE-TO-CIRCLE TRANSFORMER
SCALE: 1:5

[25]

QUESTION 5

5.1 **FIGURE** 5, DIAGRAM SHEET 2 (attached) represents the intersection of two right cones. The central axes of both cones lie in the same vertical plane.

5.1 Draw the front lines accurately, as seen in the top view and the front view.

5.2 Develop the pattern for the upright cone.

5.3 Develop the pattern for the inverted cone.

INTERSECTION OF TWO RIGHT CONES
SCALE: 1:5

[25]

TOTAL: 100

Diagram Sheet 1
Diagramvel 1

FIG. 1

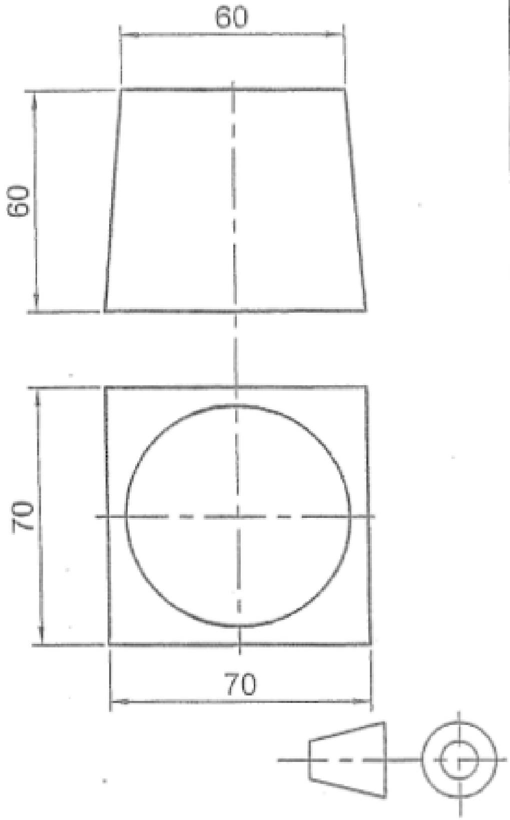


FIG. 2

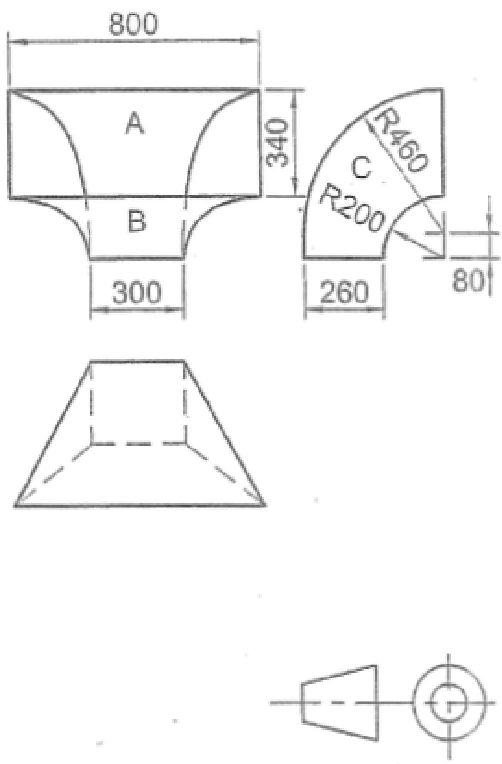


FIG. 3

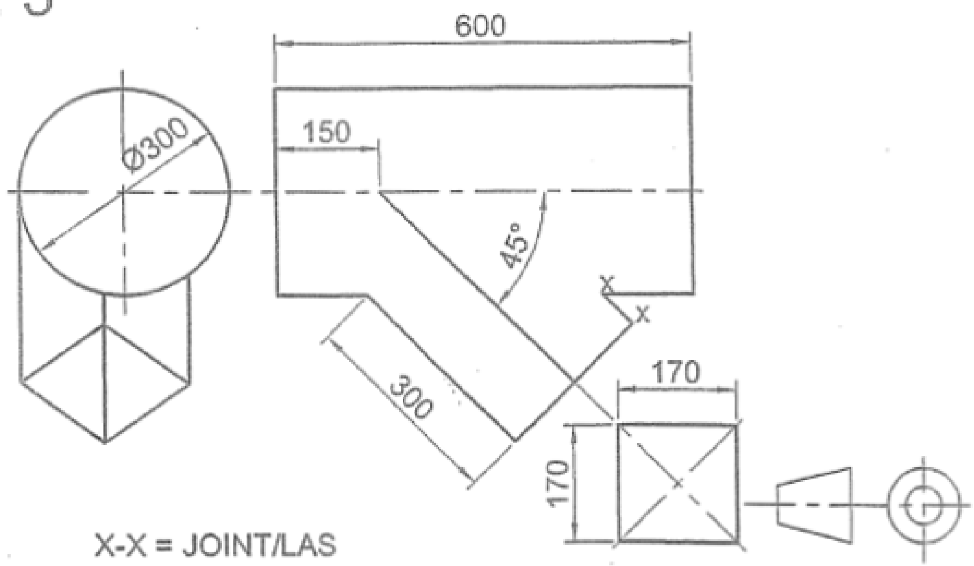


Diagram Sheet 2
Diagramvel 2

FIG. 4

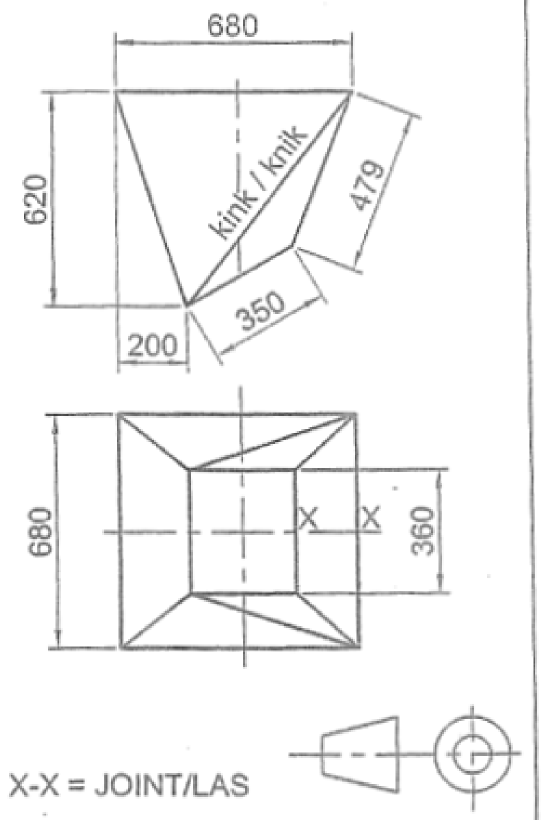


FIG. 5

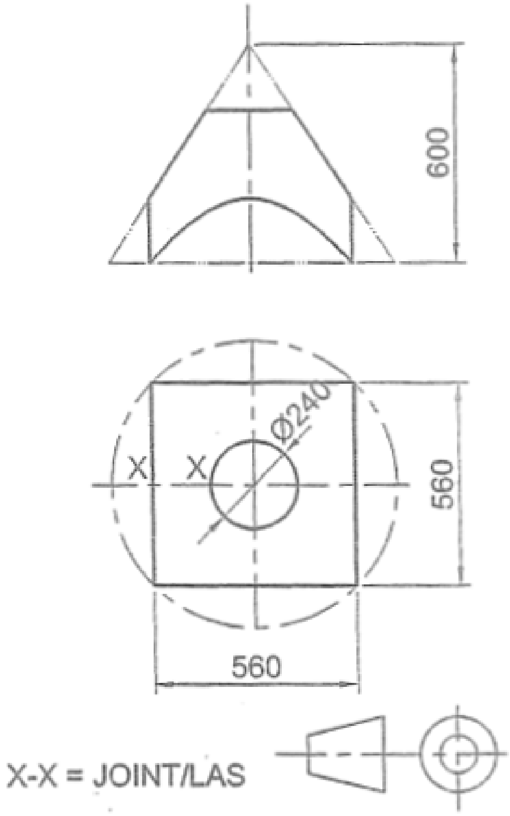
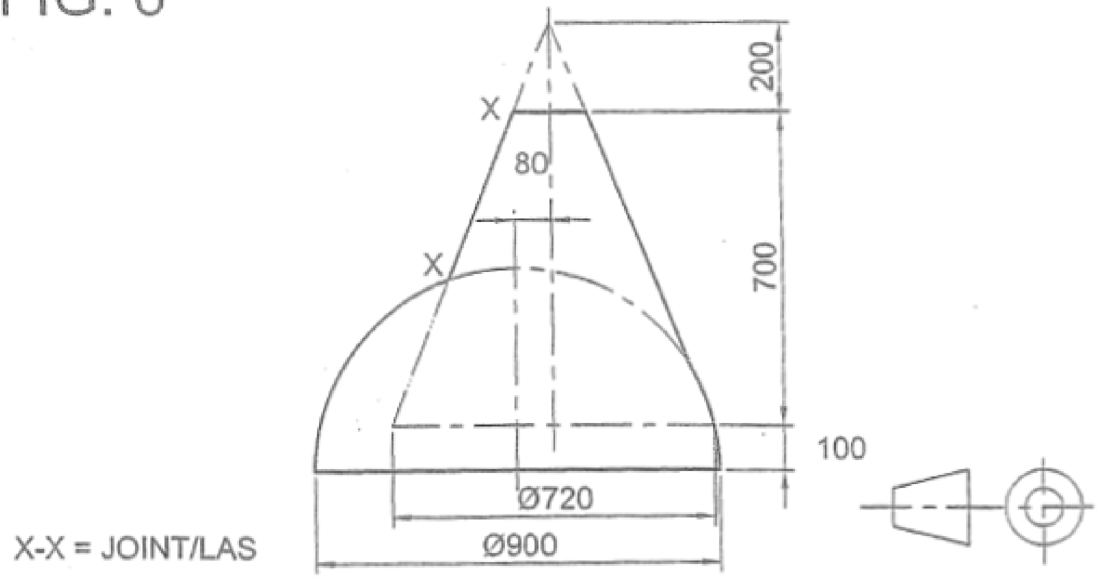


FIG. 6



T1890(E)(N15)T

ANSWER SHEET **EXAMINATION NUMBER:**

QUESTION 1

This table must be handed in with the A2 drawing-paper.

The calculations must be done on the drawing paper.

CALCULATE	TRUE LENGTHS	%
A□		(1)
A□		(1)
A□		(1)
A□		(1)
B□		(2)
B□		(2)
B□		(2)
B□		(2)
1 – 2; 2 - 3		(1)
A – B		(1)
X – A		(1)
X – B		(1)
X – 1		(1)
TOTAL		(18)

QUESTION 3

FIGURE 3

GR = ∏ X D
= ∏ X 40
12
= 10.4
1 – 2, 7 – 7 = 10,47
X – A = 23 A – B = 76
X – 1 = $15^2 + 30^2$
X – 7 = 30,4
A – 1 = (Hc – r cos 0°) + (Vc – R SINO°)^2 + H^2
= (25 – 20 COS 0^1)^2 + (23 – 20 SIN O^2)^2 + 30^2
= $5^2 + 23^2 + 30^2$
= 38,13
A□ $7{,}679^2 + 13^2 + 30^2$
33,58
A□ $15^2 + 5{,}679^2 + 30^2$
34,018

ANSWER SHEET EXAMINATION NUMBER:

A□ $25^2 + 3^2 + 30$
39,166

B□ $(51 - 20 \text{ COS } 90°)^2 + (25 - 20 \text{ SIN } 90°)^2 + 30^2$
$= 51^2 + 5^2$
$= 59{,}38$

B□ $(41^2 + 7{,}673^2 + 30^2)$
$= 51{,}38$

B□ $(33{,}67^2 + 15^2 + 30^2)$
$= 47{,}525$

B□ $(31^2 + 25^2 + 30^2)$
$= 49{,}8$

$X - 7 = (31^2 + 30^2)$
$= 43{,}13$

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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

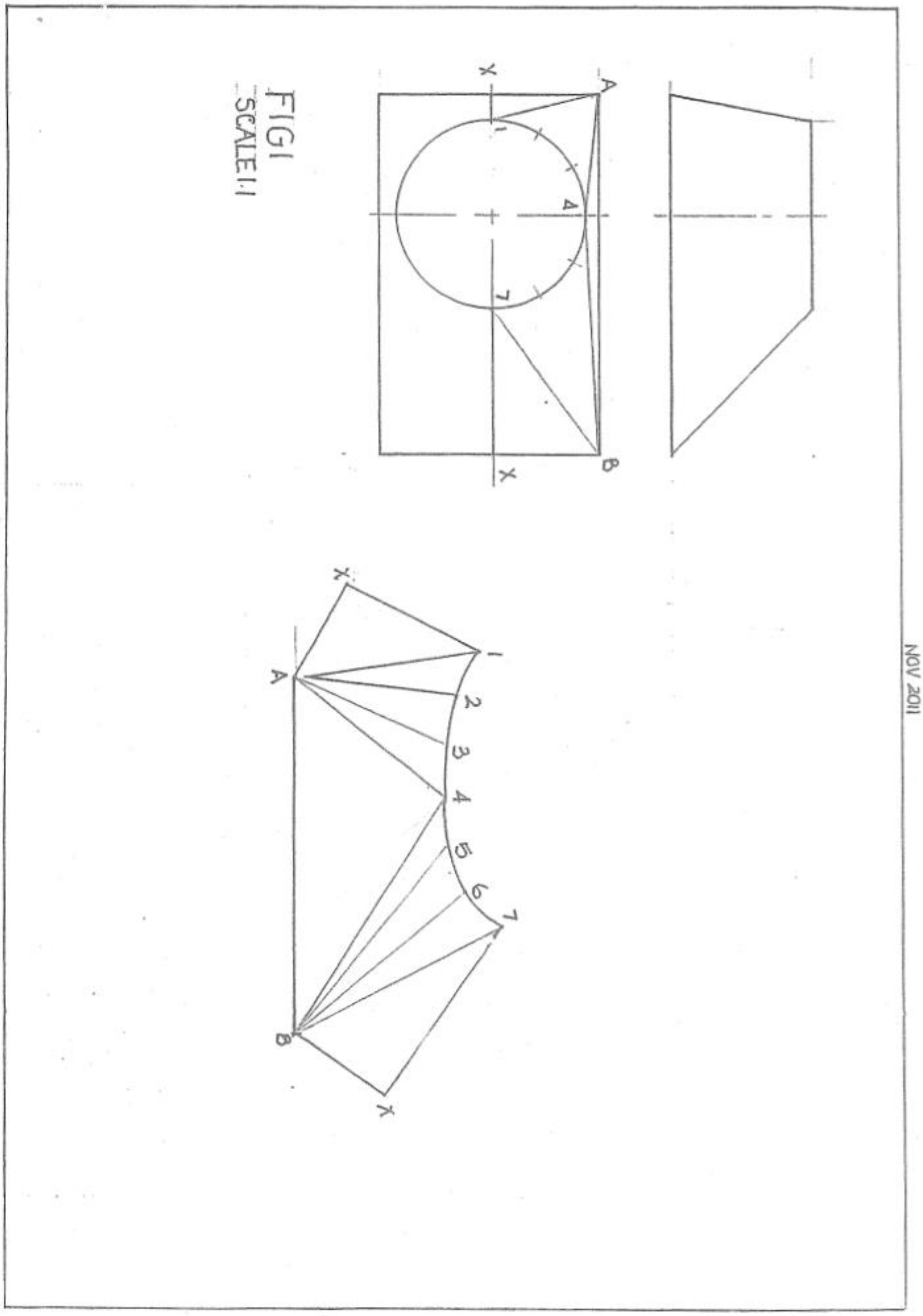
NOVEMBER 2011

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

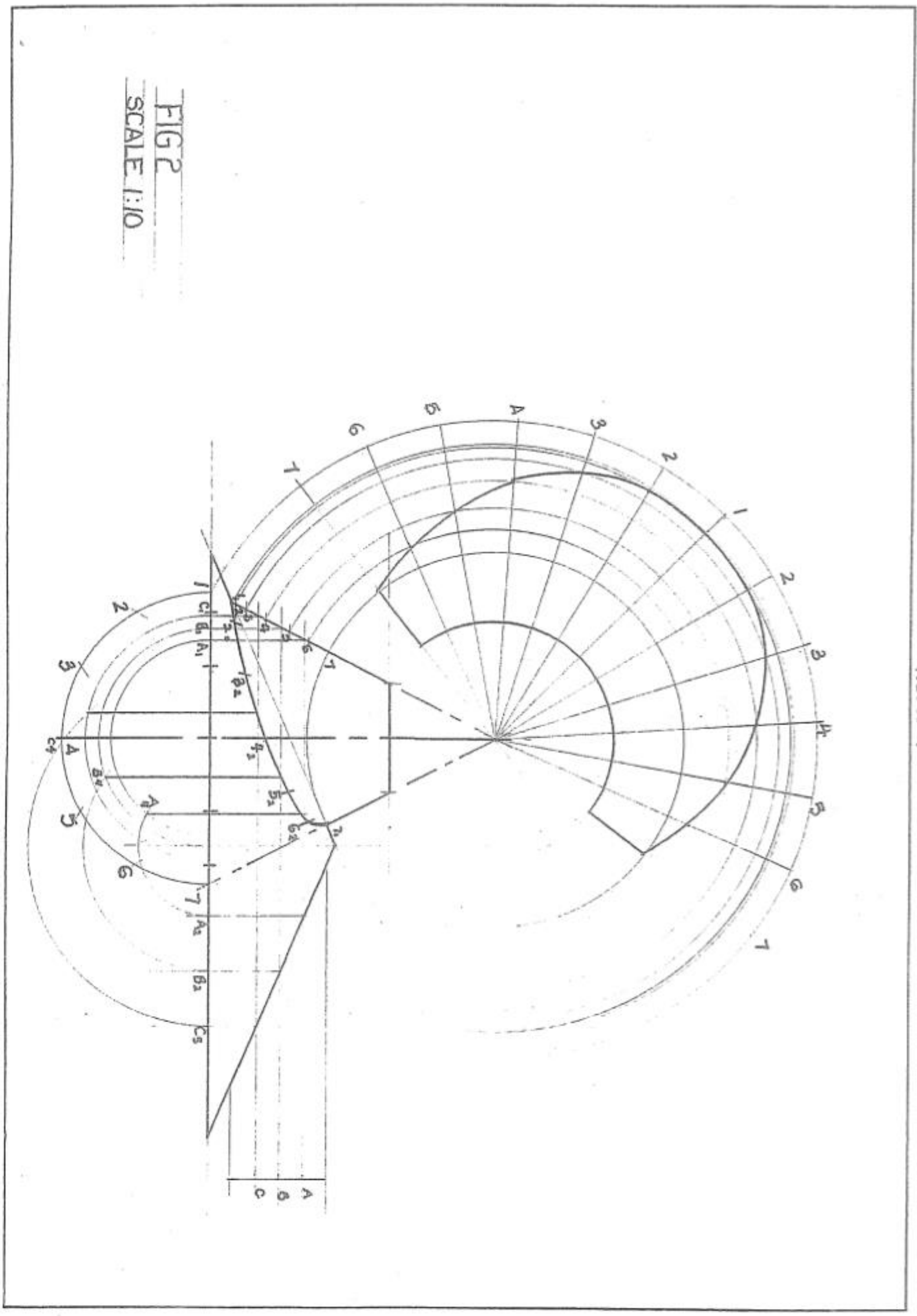
(8090124)

QUESTION 1



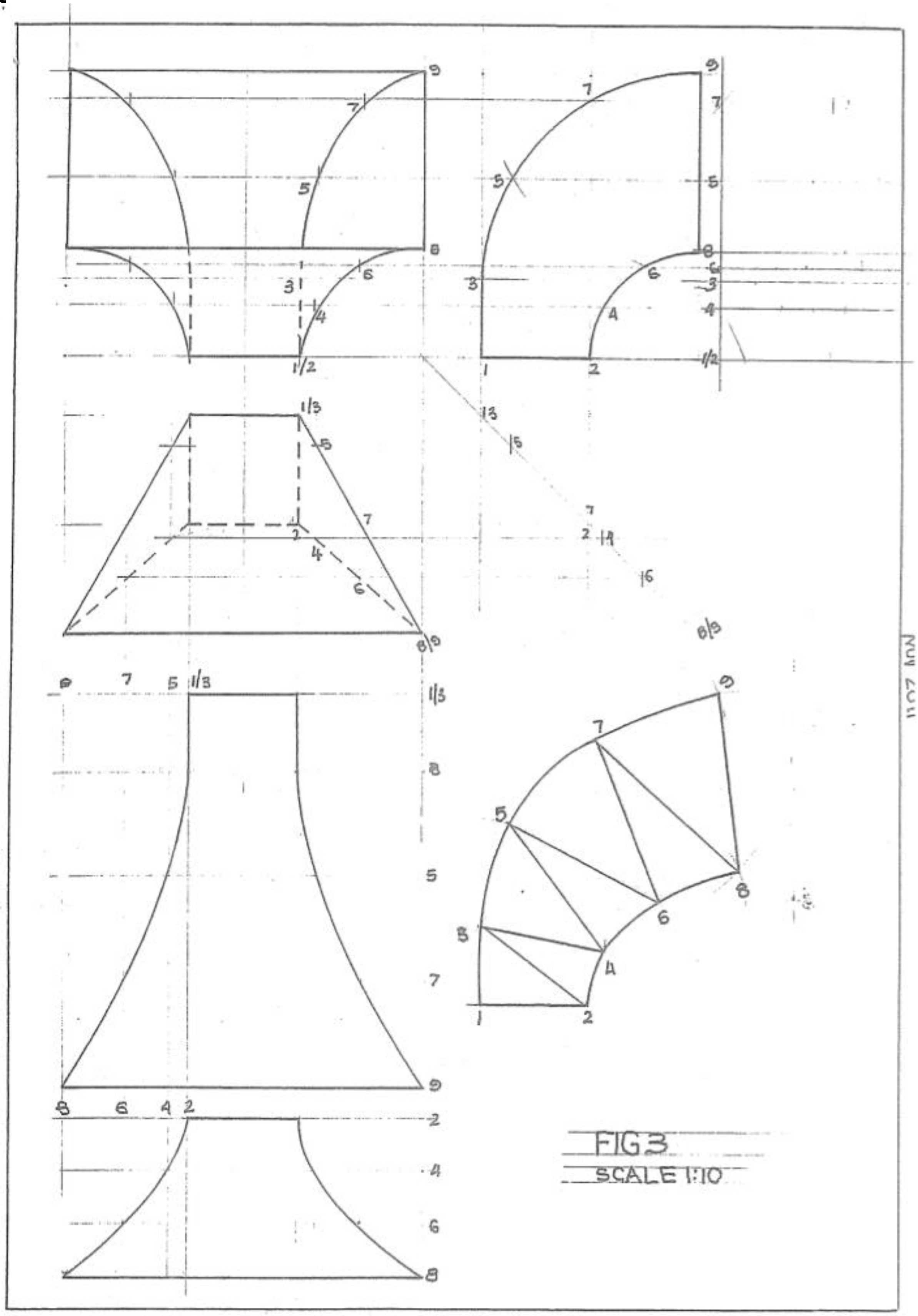
[25]

QUESTION 2



[25]

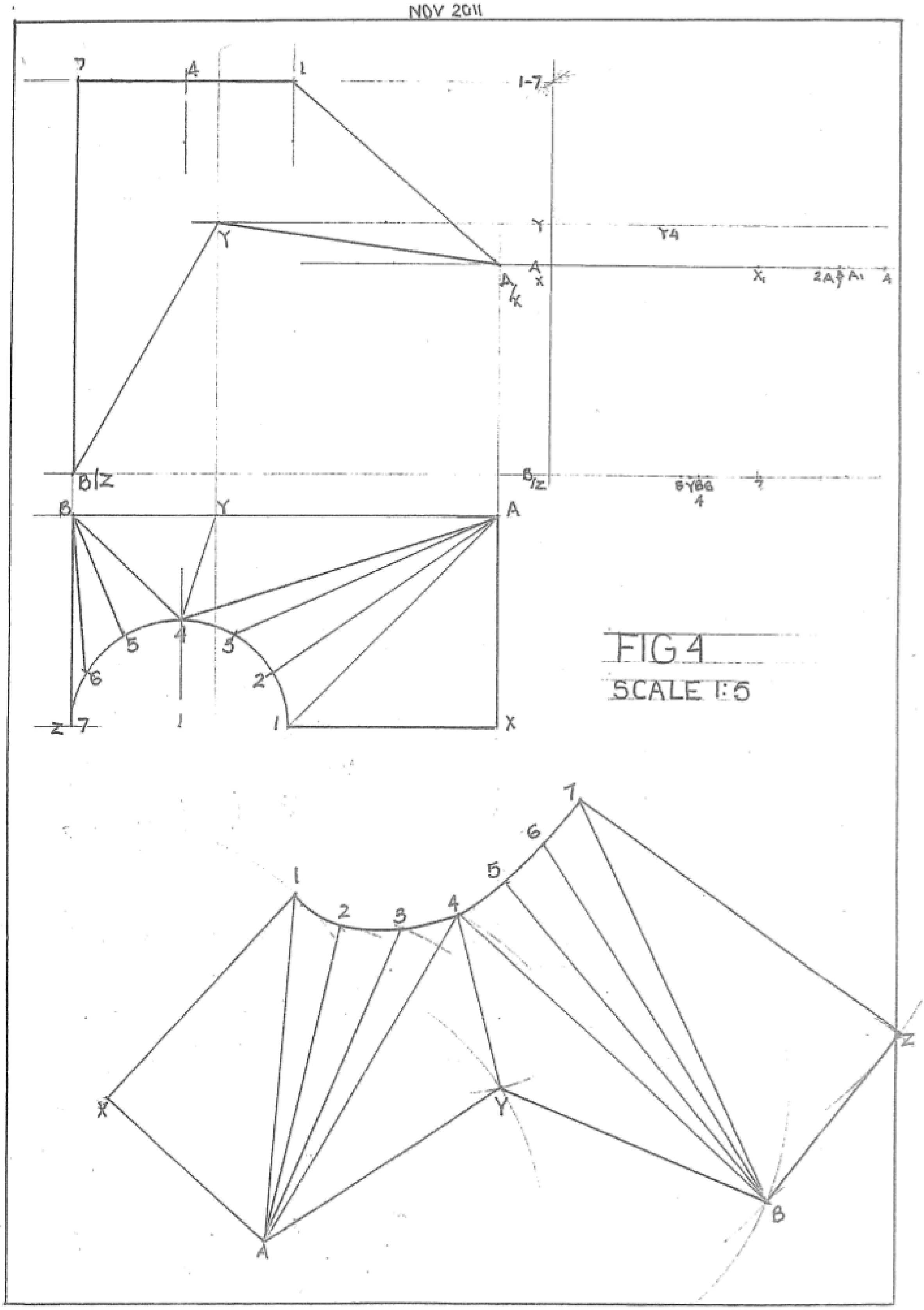
QUESTION 3



[25]

QUESTION 4

NOV 2011



[25]

QUESTION 5

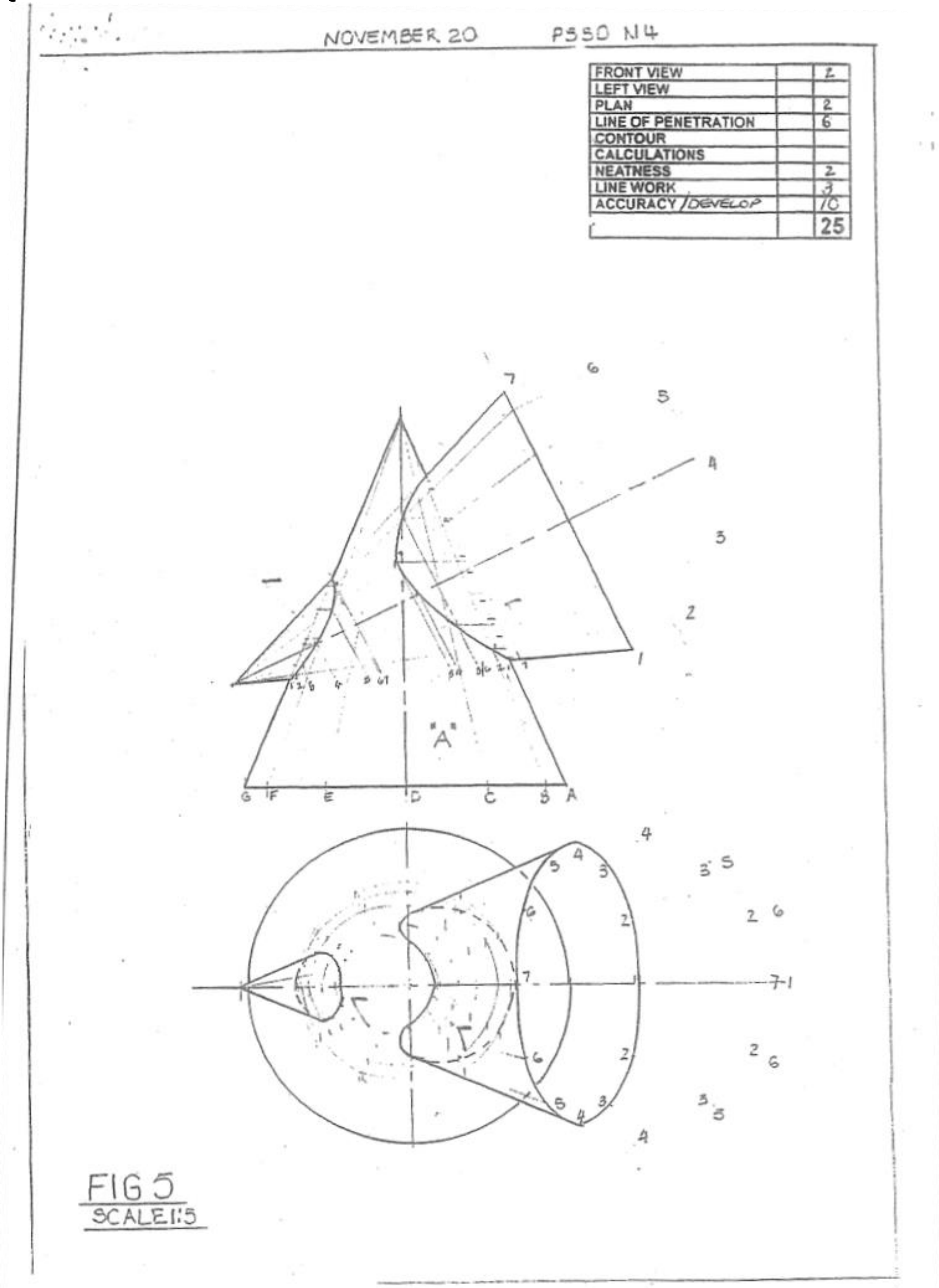


FIG 5
SCALE 1:5

[25]

TOTAL: 100

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APRIL 2011

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

(8090124)

24 March 2011 (X-Paper)
09:00 – 12:00

REQUIREMENTS: ONE A2 drawing paper

Candidates may use drawing instruments.

This question paper consists of 4 pages and a 2-page diagram sheet and 1-page answer sheet.

TIME: 4 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer any FOUR questions.
2. Read ALL the questions carefully.
3. Show ALL the calculations on the DRAWING PAPER.
4. Insert dimensions, title and the scale on each drawing.
5. Answer TWO questions on the FRONT and TWO questions on the REVERSE side of the DRAWING PAPER.
6. Write neatly and legibly

QUESTION 1

FIGURE 1, DIAGRAM SHEET 1 (attached), shows TWO views of a transition piece.

Draw the given views and develop the shape of the plates to form the transition piece.

TRANSITION PIECE

SCALE 1:10

[25]

QUESTION 2

FIGURE 2, DIAGRAM SHEET 1 (attached), shows an incomplete view of a conical hopper on a hemispherical dome.

Draw the complete view and develop the shape of the plate required for the conical hopper.

CONICAL HOPPER

SCALE 1:2

[25]

QUESTION 3

FIGURE 3, DIAGRAM SHEET (attached), shows a rectangular to circular transformer.

Calculate the true lengths and use these lengths to develop the pattern for the transformer and layout the plate.

NOTE: Marks will NOT be awarded for lengths taken from a drawing to scale. Make use of the ANSWER SHEET.

RECTANGULAR TO CIRCULAR TRANSFORMER

SCALE 1:2

[25]

QUESTION 4

FIGURE 4, DIAGRAM SHEET 2 (attached), shows a transformer segment which connects a square duct and a cylindrical pipe.

Draw the given views, an auxiliary view and develop the pattern for the transformer segment.

TRANSFORMER SEGMENT

SCALE 1:10

[25]

QUESTION 5

5.1 FIGURE 5, DIAGRAM SHEET 2 (attached), shows TWO views of a half round-to-rectangular off-centre transition piece.

Draw the given views and develop the shape of the plate 'A' to form the transition piece.

TRANSITION PIECE

SCALE 1:1

[25]

TOTAL: 100

DIAGRAM SHEET 1

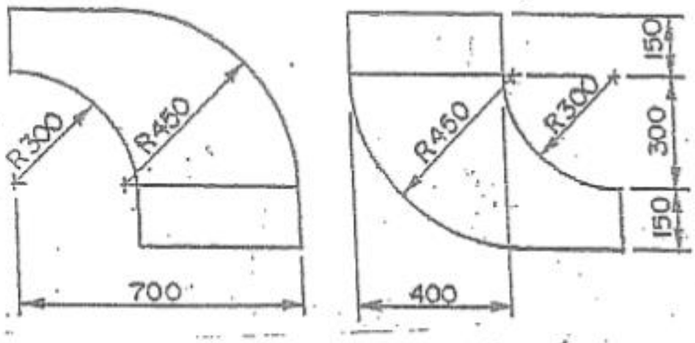

FIG 1

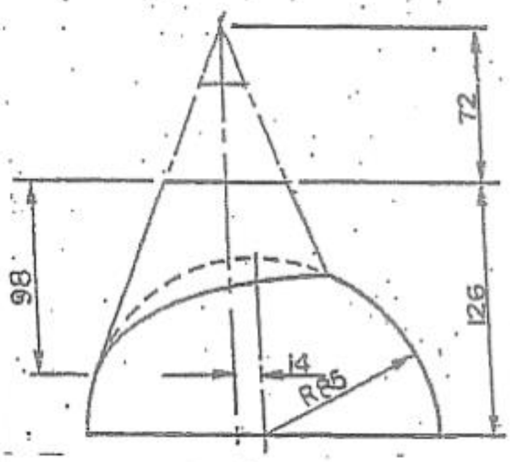

FIG 2

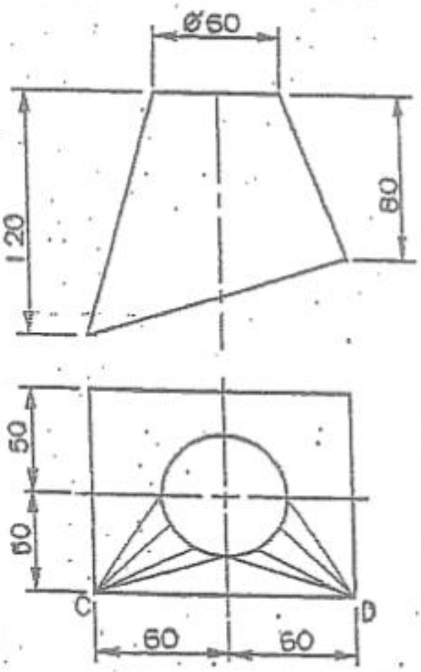

FIG 3

DIAGRAM SHEET 2

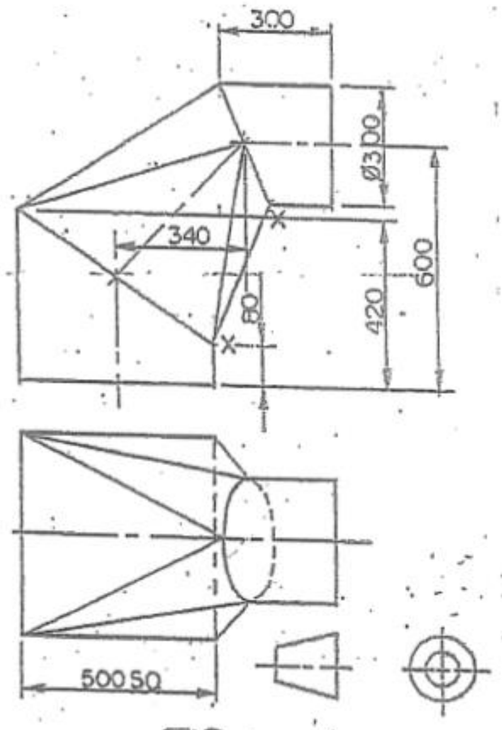

FIG 4

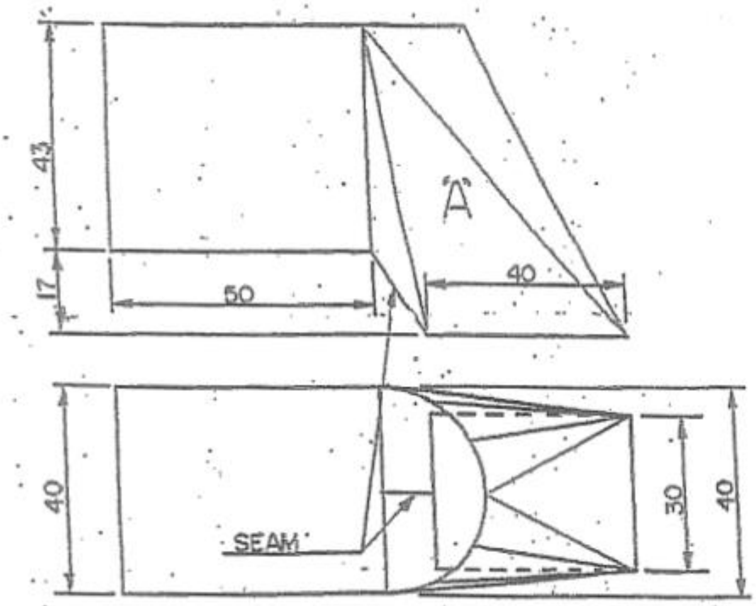

FIG 5

ANSWER SHEET	EXAMANATION NUMBER

QUESTION 3

This table must be handed in with the question paper.

The calculations must be done on the drawing paper.

1 – 2, 2 – 5		(½)
B – 1		(½)
B – C		(½)
E – 7		(½)
C – D		(1)
C1		(1½)
D7		(1½)
C2		(1½)
D6		(1½)
C3		(1½)
D5		(1½)
C4		(1½)
D4		(1½)
	TOTAL	(15)

Marking Guidelines

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REPUBLIC OF SOUTH AFRICA

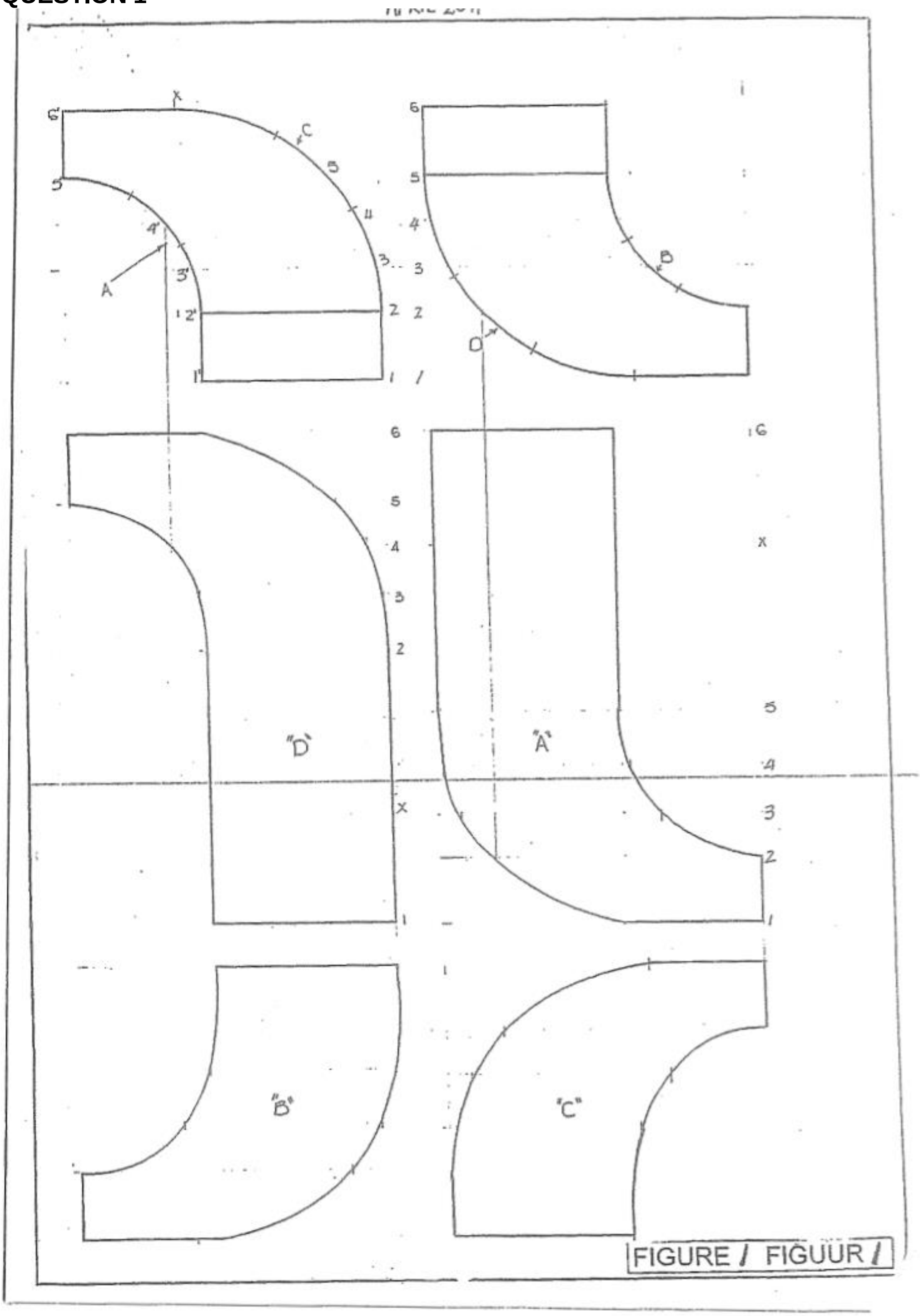
APRIL 2011

NATIONAL CERTIFICATE

PLATING AND STRUCTURAL STEEL DRAWING N4

(8090124)

QUESTION 1



[25]

QUESTION 2

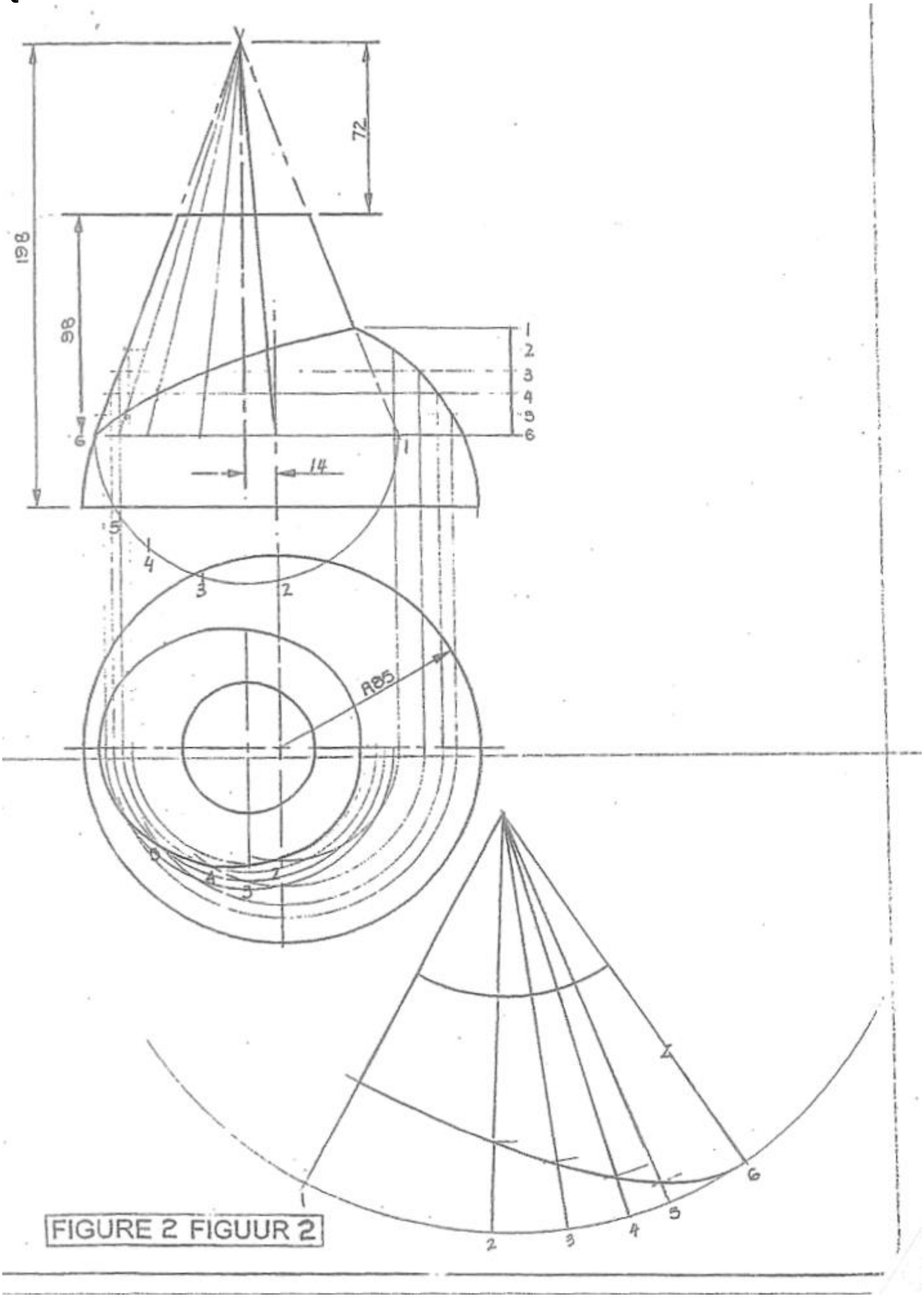


FIGURE 2 FIGUUR 2

[25]

QUESTION 3

FIG 3

B – 1 $= \sqrt{30^2 + 120^2}$

$=$ 123.69mm (½)

E – 7 $= \sqrt{80^2 + 30^2}$

$=$ 85.44mm (½)

B – C $=$ 50mm (½)

D – E

1 – 2, 2 – 3 $= \dfrac{\pi D}{12}$

$= \dfrac{\pi x 60}{12}$

15.7mm (½)

C – D $=$ 120 – 80

$= \sqrt{40^2 + 120^2}$

$=$ 126.49mm (1)

C – 1 $= \sqrt{(HC - R\cos 0°)^2 + (Vc - R\sin 0°)^2 + H^2}$

$= \sqrt{(60 - 30\cos 0°)^2 + (50 - 30\sin 0°)^2 + 120^2}$

$= \sqrt{30^2 + 50^2 + 120^2}$

$=$ 133.416mm (1½)

D – 7 $= \sqrt{30^2 + 50^2 + 80^2}$

$=$ 98.99mm (1½)

C – 2 $= \sqrt{(60 - 30\cos 30°)^2 + (50 - 30\sin 30°)^2 + 120^2}$

$= \sqrt{34^2 + 35^2 + 120^2}$

$=$ 129.5mm (1½)

$$D-6 = \sqrt{34^2 + 35^2 + 80^2}$$
$$= \underline{93.7mm} \qquad (1½)$$

$$C-3 = \sqrt{(60 - 30\cos 60°)^2 + (50 - 30\sin 60°)^2 + 120^2}$$
$$= \sqrt{45^2 + 24^2 + 120^2}$$
$$= \underline{130.38mm} \qquad (1½)$$

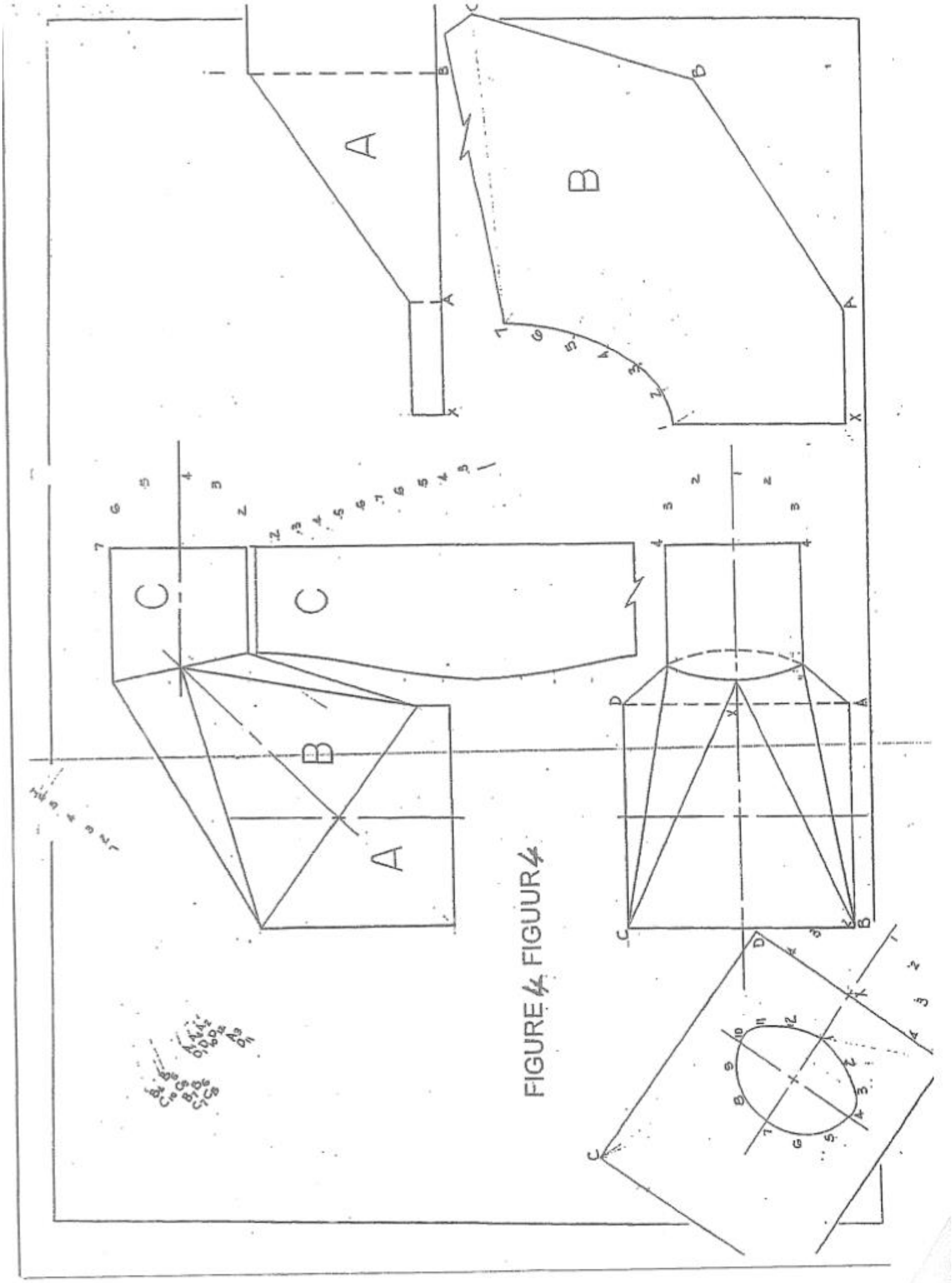
$$D-5 = \sqrt{45^2 + 24^2 + 80^2}$$
$$= \underline{94.87mm} \qquad (1½)$$

$$C-4 = \sqrt{(60 - 30\cos 90°)^2 + (50 - 30\sin 90°)^2 + 120^2}$$
$$= \sqrt{60^2 + 20^2 + 120^2}$$
$$= \underline{135.64mm} \qquad (1½)$$

$$D-4 = \sqrt{60^2 + 20^2 + 80^2}$$
$$= \underline{101.98mm} \qquad (1½)$$

[25]

QUESTION 4



[25]

QUESTION 5

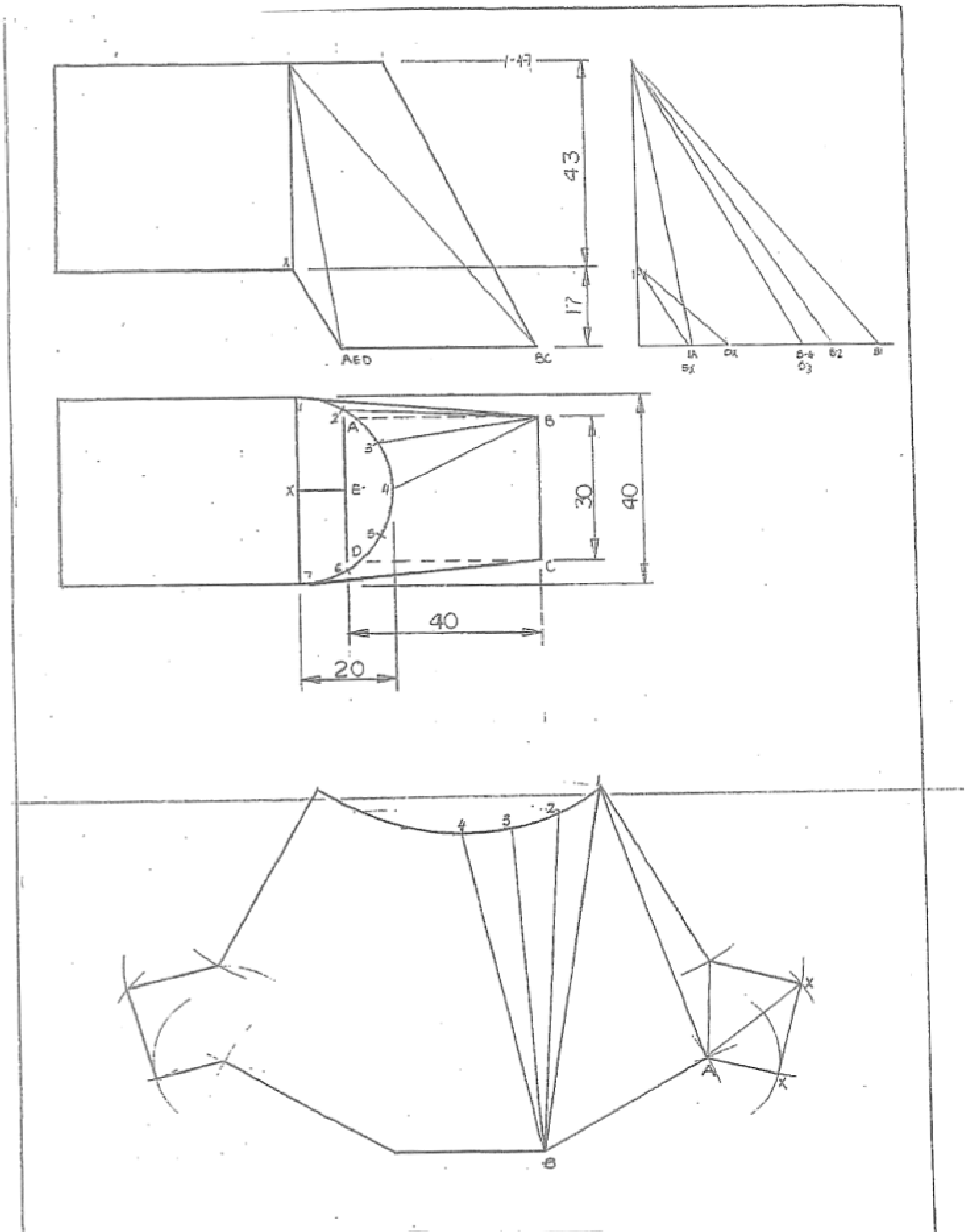


FIGURE 5 FIGUUR 5

[25]

TOTAL: 100

N4 Plating and Structural Steel Drawing is one of many publications introducing the gateways to Engineering Studies. This course is designed to develop the skills for learners that are studying toward an artisanship in the water and waste water treatment and related technology fields and to assist them to achieve their full potential in an engineering career.

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