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CENTRE FOR OPEN DISTANCE AND e-LEARNING (CODeL)

ENGINEERING DRAWING
TCD 111

COURSE DEVELOPMENT TEAM

ENGINEERING DRAWING
TCD 111

Course Editor
Prof. Gambari, Amosa Isiaka
Science Education Department,
Federal University of Technology, Minna, Nigeria.

Programme Coordinator
Mrs O. A. Abisoye
Computer Science Department
Federal University of Technology, Minna, Nigeria.

Instructional Designers
Dr. Gambari, Amosa Isiaka
Mr. Falode, Oluwole Caleb
Centre for Open Distance and e-Learning,
Federal University of Technology, Minna, Nigeria.

Editor
Chinenye Priscilla Uzochukwu
Centre for Open Distance and e-Learning,
Federal University of Technology, Minna, Nigeria.

Director
Prof. J. O. Odigure
Centre for Open Distance and e-Learning,
Federal University of Technology, Minna, Nigeria

ENGINEERING DRAWING PRACTICE

Introduction

The ability to read and understand information contained on drawings is essential to perform most engineering-related jobs. Engineering drawings are the industry's means of communicating detailed and accurate information on how to fabricate, assemble, troubleshoot, repair, and operate a piece of equipment or a system. To understand how to "read" a drawing it is necessary to be familiar with the standard conventions, rules, and basic symbols used on the various types of drawings. But before learning how to read the actual "drawing," an understanding of the information contained in the various non-drawing areas of a print is also necessary. This course is intended to introduce you to the basic principles of engineering drawing. Because of the extreme variation in format, location of information, and types of information presented on drawings from vendor to vendor and site to site, all drawings will not necessarily contain the following information or format, but will usually be similar in nature.

In this course we shall be looking at the basic principles of producing engineering components on paper, commonly referred to as engineering drawing. We shall be looking at the graphic portion, the title block, the revision block, and the notes and legend areas.

Course Objectives

At the end of the course, you should be able to:

(i) Develop simple surfaces
(ii) Find intersection of surfaces
(iii) Identify the various types of projections used in producing engineering drawings
(iv) List the types of information provided in drawing title blocks
(v) Interpret simple technical drawings
(vi) Itemize the various types of drawing paper sizes
(vii) Identify the various drawing instruments

Problems

Note: It is common practice under the metric system to give all dimensions, that are not critical, in full millimeters. It is recommended that the student attempt to do likewise in laying out and dimensioning a problem that has bee dual-dimensioned. Where dimensions are given in imperial units use a conversion factor 1inch = 25mm.

Reading

K. Morling, “Geometric and Engineering Drawign. 2nd Edition” Butterworth-Heinemann

Colin H. Simmons and Dennis E. Maguire Manual Of Engineering Drawing 2nd Edition to British and International Standards

K. Venkata Reddy Textbook of Engineering Drawing 2nd gsp BS Publications

UNIT 1: THE ROLE AND ANATOMY OF ENGINEERING DRAWING

CONTENT

1.0 Introduction

Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualise objects.

Drawings prepared in one country may be utilised in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. Any language to be communicative, should follow certain rules so that it conveys the same meaning to everyone. Similarly, drawing practice must follow certain rules, if it is to serve as a means of communication. For this purpose, Bureau of Indian Standards (BIS) adapted the International Standards on code of practice for drawing. The other foreign standards are : DIN of Germany, BS of Britain and ANSI of America.

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Describe the role of engineering drawing in product development
(ii) Describe the anatomy of engineering drawing
(iii) Use appropriate language of engineering drawing

3.0 Main Body

3.1 Role of Engineering Drawing

The ability to read drawing is the most important requirement of all technical people in any profession. As compared to verbal or written description, this method is brief and more clear. Some of the applications are : building drawing for civil engineers, machine drawing for mechanical engineers, circuit diagrams for electrical and electronics engineers, computer graphics for one and all.

The subject in general is designed to impart the following skills.

1. Ability to read and prepare engineering drawings.
2. Ability to make free — hand sketching of objects.
3. Power to imagine, analyse and communicate, and
4. Capacity to understand other subjects.

Self-Assessment Exercise

3.2 Anatomy of a Drawing

A generic engineering drawing can be divided into the following five major areas or parts.

1. Title block
2. Grid system
3. Revision block
4. Notes and legends
5. Engineering drawing (graphic portion)

The information contained in the drawing itself will be covered in subsequent modules. This module will cover the non-drawing portions of a print. The first four parts listed above provide important information about the actual drawing. The ability to understand the information contained in these areas is as important as being able to read the drawing itself. Failure to understand these areas can result in improper use or the misinterpretation of the drawing.

Self-Assessment Exercise

3.3 The Rules and `Grammar' of Drawing

It has been fashionable for some time to believe that grammar does not matter so long as the meaning is clear. Fair enough so far as it goes, but that is not very far. A missing comma can sink a ship, and there is a great deal of difference between "no-one shall save me, I will drown" and "no-one will save me, I shall drown"; life and death, in fact. Loose constructions and punctuation in the written and spoken word can result in loss of clarity, but in the drawing office - or even on the sketch-pad -loose construction or careless presentation *always* leads to misunderstanding, sometimes fatal. This being so, ` the rules and grammer of engineering drawing will be considered here.

3.31 Lines

Drawings are, of course, made up of lines, and whether they be made with pencil, drawing pen, or even a window marker there are rules about which sort the draughtsman is to use for each purpose. The actual thickness used is determined by the type of drawing; one which is traced for reproduction as a white print will need thicker lines than, say, a design drawing dictates very thin lines. (I will deal with these various types later.) However, on the same drawing the general rule should be followed that (a) all lines should be *dense* which means using draughtsman's pencils, not those made for artists and (b) *thick* lines should be made from two to three times as wide as *thin* ones. When working in pencil the draughtsman achieves this by using a different *grade* of pencil, not by using a blunt one

Fig. a shows the conventional use of the various types of line. The explanations are fairly clear, but a few notes may help. **(A)** is for the main outline, but also includes any edges which can be seen on the object.

(C) refers to details within the object which cannot be seen e.g. a hole. **I** confess that my own practice is to make such lines a little thicker than thin. Good practice is to make the dashes twice the length of the spaces. **(D)** is, perhaps the most important line on the drawing in one respect, as it is very often the line from which dimensions are measured. Such lines should always be really sharp and, though thin, positive. The function of line **(E)** will appear in an example in a moment, and I shall be dealing with it in more detail later in the book. Current practice here is to use a thin line with thick ends for this purpose **(Fig. b)** but the full thick line should be used if there is risk of any confusidn. **(F)** seldom arises in

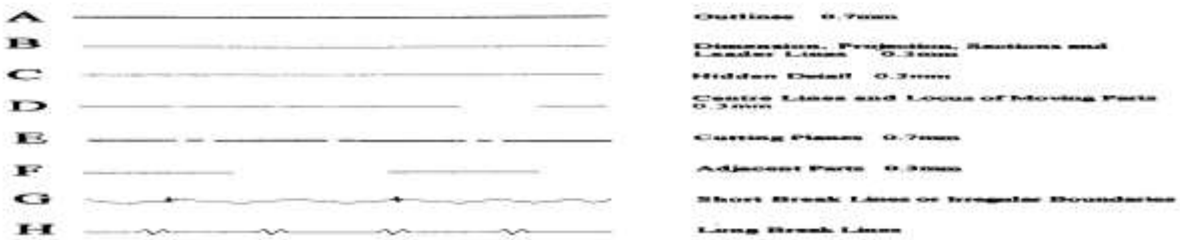


Fig. a: *Types of lines for use on engineering drawings*

Fig. b: Alternative method for indicating cutting planes. See text.

run-of-the-mill drawing, but when used it is important that the *length* of the dashes should be markedly less than those used for centrelines, **(D), (G)** and **(H)** are used to indicate that the whole of the object has not been drawn. In the case of long, round shafts the convention shown in **Fig. c** is used when details of the two ends are drawn but the centre part is not drawn. **Fig. d** is a drawing of a 'something' showing the application of the various types of line.

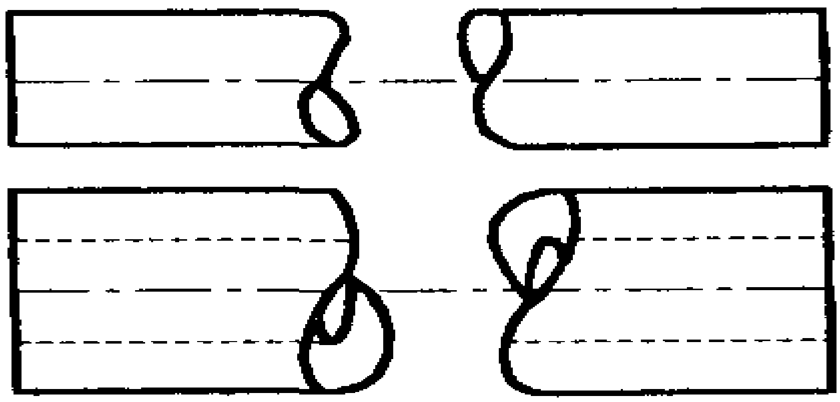


Fig. c *Break lines for circular parts, solid or hollow*

An important rule. Where centrelines cross they should always intersect on part of the long dash. As shown in **Fig. d.**

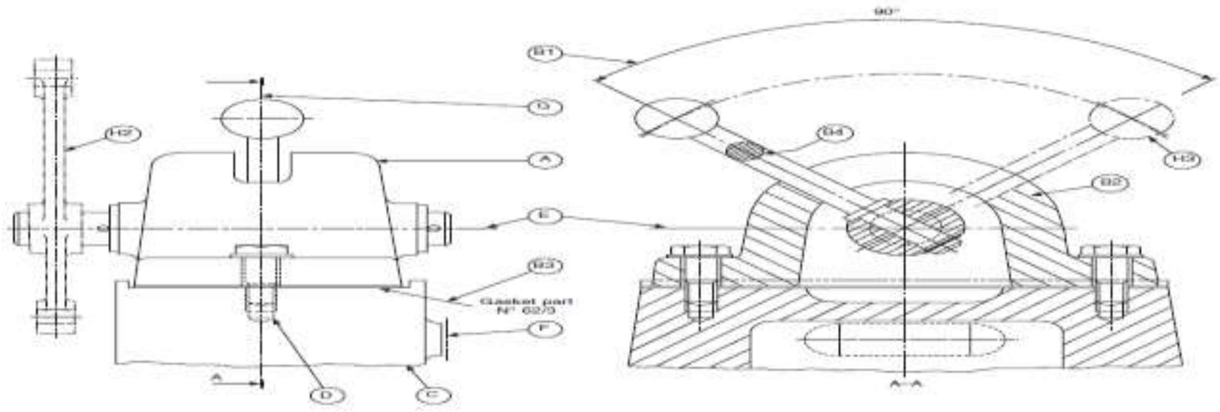


Fig. d: Crossing centrelines

3.32 Letters and Figures

It has previously been mentioned that technical drawings are prepared using only two line thicknesses and if reasonable care is taken a pleasing result can easily be obtained. Drawings invariably need dimensions and notes and if these are added in a careless and haphazard manner, then a very poor overall impression may be given. Remember that technical drawings are the main line of communication between the originator and the user. Between a consultant and his client, the sales manager and his customer, the designer and the manufacturer, a neat well executed technical drawing helps to establish confidence. The professional draughtsman also takes considerable pride in his work and much effort and thought is needed with respect to lettering, and spacing, in order to produce an acceptable drawing of high standard.

The following notes draw attention to small matters of detail which we hope will assist the draughtsman's technique of lettering.

1 Lettering may be vertical or slanted, according to the style which is customarily used by the draughtsman. The aim is to produce clear and unambiguous letters, numbers and symbols.

2 If slanted lettering is used, the slope should be approximately 65°–70° from the horizontal.

Legibility is important. The characters should be capable of being produced at reasonable speed and in a repeatable manner. Different styles on the same drawing spoil the overall effect.

3 Use single stroke characters devoid of serifs and embellishments.

4 All strokes should be of consistent density.

5 The spacing round each character is important to ensure that 'filling in' will not occur during reproduction.

6 Lettering should not be underlined since this impairs legibility.

7 On parts lists or where information is tabulated, the letters or numerals should not be allowed to touch the spacing lines.

8 All drawing notes and dimensions should remain legible on reduced size copies and on the screens of microfilm viewers.

9 Capital letters are preferred to lower case letters since they are easier to read on reduced size copies of drawings. Lower case letters are generally used only where they are parts of standard symbols, codes or abbreviations.

10 When producing a manual drawing the draughtsman should take care to select the proper grade of pencil for lettering. The pencil should be sharp, but with a round point which will not injure the surface. Mechanical pencils save time and give consistent results since no resharpening is necessary.

11 Typewritten, stencilled or letters using the 'Letraset' adhesive letter system may be used since these provide uniformity and a high degree of legibility.

3.33 Minimum Character Height for Capital Letters and Numerals

Table a gives the minimum recommended character heights for different sizes of drawing sheet and it is stressed that these are *minimum* sizes. If lower case letters are used then they should be proportioned so that the body height will be approximately 0.6 times the height of a capital letter.

The stroke thickness should be approximately 0.1 times the character height and the clear space between characters should be about 0.7 mm for 2.5 mm capitals and other sizes in proportion.

The spaces between lines of lettering should be consistent and preferably not less than half the character height. In the case of titles, this spacing may have to be reduced.

All notes should be placed so that they may be read from the same direction as the format of the drawing but there are cases, for example when a long vertical object is presented, where it may be necessary to turn the drawing sheet through 90° in the clockwise direction, in effect, to position the note which is then read from the right hand side of the drawing sheet

Table a: Recommended lettering style

Application	Drawing sheet size	Minimum character height
Drawing numbers etc.	A0, A1, A2 and A3	7 mm
	A4	5 mm
Dimensions and notes	A0	3.5 mm
	A1, A2, A3, and A4	2.5 mm

The shape and form of an acceptable range of letters and numbers is illustrated in **Fig. e**

Open styles are often used on drawings which are to be microfilmed, as increased clarity is obtainable on small reproductions.

Fig. e: Lettering style

Self-Assessment Exercise

3.4 Drawing Modifications

After work has been undertaken on a drawing for a reasonable amount of time, then that drawing will possess some financial value. The draughtsman responsible for the drawings must be concerned with the reproducible quality of his work as prints or photographic copies are always taken from the originals. Revisions and modifications are regularly made to update a product, due for example, to changes in materials, individual components, manufacturing techniques, operating experience and other causes outside the draughtsman's control.

When a drawing is modified its content changes and it is vital that a note is given on the drawing describing briefly the reason for change and the date that modifications were made. Updated drawings are then reissued to interested parties. Current users must all read from a current copy. Near the title block, on a drawing will be placed a box giving the date and Issue No., i.e. *XXX*A, *XXX*B, etc. These changes would usually be of a minimal nature.

If a component drawing is substantially altered, it would be completely redrawn and given an entirely new number.

Drawings on a computer, of course, leave no trace when parts are deleted but this is not necessarily the case if the work is undertaken manually on tracing film or paper. The point to remember is that on the area covered by the erasure, part of a new drawing will be added and the quality of this drawing must be identical in standard with the original. Obviously, if the surface of the drawing sheet has been damaged in any way during erasure, then the draughtsman performing the work starts with a serious disadvantage.

The following suggestions are offered to assist in the preservation of drawings when erasures have to be made.

1 Use soft erasers with much care. Line removal without damaging the drawing surface is essential.

2 An erasing shield will protect areas adjacent to modifications.

3 Thoroughly erase the lines, as a ghost effect may be observed with incomplete erasures when prints are made. If in any doubt, a little time spent performing experimental trial erasures on a sample of a similar drawing medium will pay dividends, far better than experimenting on a valuable original.

Self-Assessment Exercise

3.5 Care and Storage of Original Drawings

Valuable drawings need satisfactory handling and storage facilities in order to preserve them in first class condition. Drawings may be used and reused many times and minimum wear and tear is essential if good reproductions and microfilms are to be obtained over a long period of time. The following simple rules will assist in keeping drawings in ‘mint’ condition.

1 Never fold drawings.

2 Apart from the period when the drawing is being prepared or modified, it is good policy to refer to prints at other times when the drawing is required for information purposes.

3 The drawing board should be covered outside normal office hours, to avoid the collection of dust and dirt.

4 Too many drawings should not be crowded in a filing drawer. Most drawing surfaces, paper or plastics, are reasonably heavy and damage results from careless manipulation in and out of drawers.

5 Do not roll drawings tightly since they may not lie flat during microfilming.

6 Do not use staples or drawing pins. Tape and drawing clips are freely available.

7 When using drawings, try to use a large reference table. Lift the drawings rather than slide them, to avoid smudging and wear.

8 Drawings should be stored under conditions of normal heat and humidity, about 21°C and 40 to 60% relative humidity.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. How do you preserve your drawings?
2. How are drawings reviewed?
3. What is the place of engineering drawing in product development

7.0 References

UNIT TWO: DRAWING INSTRUMENTS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Identify the various instruments used in producing engineering drawing
(ii) Use various drawing instruments

3.0 Main Body

3.1 Drawing Instrument and Aids

The Instruments and other aids used in draughting work are listed below :

1. Drawing board 2. Mini draughter 3. Instrument box

4. Set squares 5. Protractor 6. Set of scales

7. French curves 8. Drawing sheets 9. Pencils

10. Templates

3.11 Drawing Board

Until recently drawing boards used are made of well seasoned softwood of about 25 mm thick with a working edge for T-square. Now a days mini-draughters are used instead of T-squares which can be fixed on any board. The standard size of board depends on the size of drawing sheet size required.

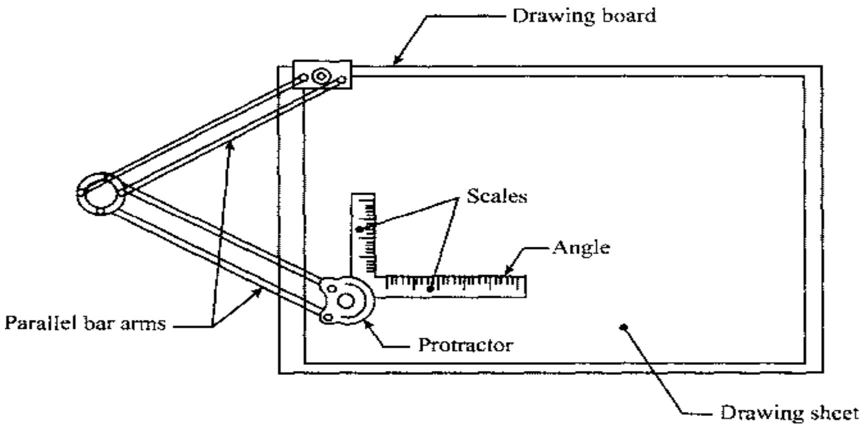


Fig. 1.1 Mini-draughter

3.12 Mini-Draughter

Mini-draughter consists of an angle formed by two arms with scales marked and rigidly hinged to each other (Fig.1.1). It combines the functions of T-square, set-squares, scales and protractor. It is used for drawing horizontal, vertical and inclined lines, parallel and perpendicular lines and for measuring lines and angles.

3.13 Instrument Box

Instrument box contains 1. Compasses, 2. Dividers and 3. Inking pens. What is important is the position of the pencil lead with respect to the tip of the compass. It should be atleast 1 mm above as shown in Fig.1.2 because the tip goes into the board for grip by 1 mm.

(a) Sharpening and position of compass lead

(b) Position of the lead leg to draw larger circles

3.14 Set of Scales

Scales are used to make drawing of the objects to proportionate size desired. These are made of wood, steel or plastic (Fig.1.3). BIS recommends eight set-scales in plastic/cardboard with designations Ml, M2 and so on as shown in Table 1.1 Set of scales

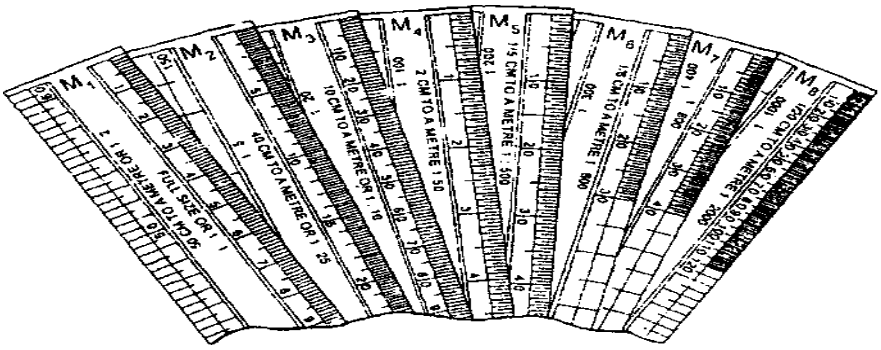


Fig. 1.3 Set of scales

Table 1.1 Set of Scales

	MI	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
Scale on one edge	1:1	1:2.5	1:10	1:50	1:200	1:300	1:400	1:1000
Scale on other	1:2	1:5	1:20	1:100	1:500	1.600	1:800	1:2000

Note : Do not use the scales as a straight edge for drawing straight lines.

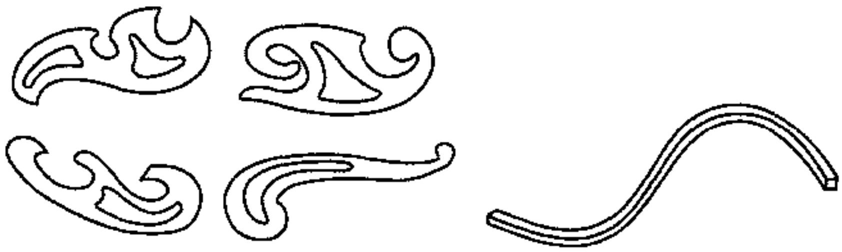
These are used for drawing irregular curved lines, other than circles or arcs of circles.

Table 1.2

Scales for use on technical drawings (IS :			
Category	**Recommended scales**		
Enlargement scales	50 : 1 •5:1	20 : 1 2:1	10:1
Full size	I :1		
Reduction	1 : 2 I : 20 1 : 200 1 . 2000	1:5 1 : 50 1 : 500 1 • 5000	1:10 1 : 100 I . 1000 110000

3.15 French Curves

French ¯curves are available in different shapes (Fig.1.4). First a series of points are plotted along the desired path and then the most suitable curve is made along the edge of the curve. A flexible curve consists of a lead bar inside rubber which bends conveniently to draw a smooth curve through any set of points.



(a) French curves (b) Flexible curve

Fig. 1.4

3.16 Templates

These are aids used for drawing small features such as circles, arcs, triangular, square and other shapes and symbols used in various science and engineering fields (Fig.1.5).

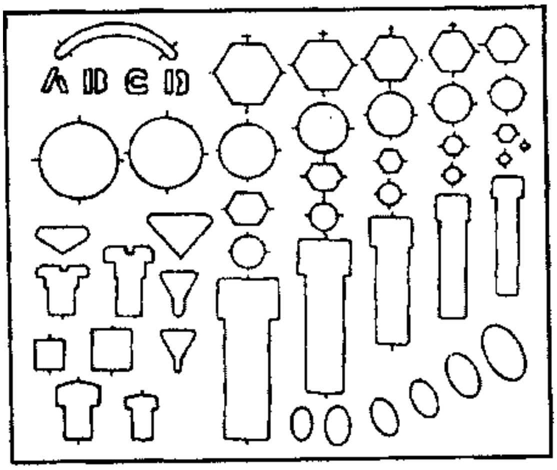


Fig. 1.5 Template

3.17 Pencils

Pencils with leads of different degrees of hardness or grades are available in the market. The hardness or softness of the lead is indicated by 3H, 2H, H, HB, B, 2B, 3B, etc. The grade FIB denotes medium hardness of lead used for general purpose. The hardness increases as the value of the numeral before the letter H increases. The lead becomes softer, as the value of the numeral before B increases (Fig.1.6).

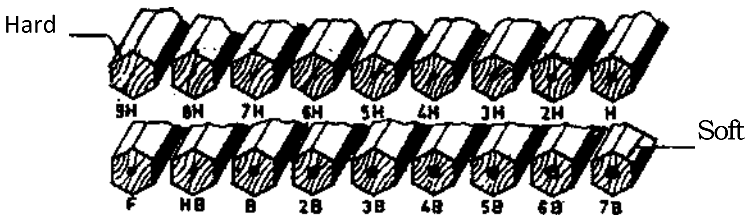


Fig. 1.6 Pencil Leads

The selection of the grade depends on the line quality desired for the drawing. Pencils of grades H or 2H may be used for finishing a pencil drawing as these give a sharp black line. Softer grade pencils are used for sketching work. HB grade is recommended for lettering and dimensioning.

Nowadays mechanical pencils are widely used in place of wooden pencils. When these are used, much of the sharpening time can be saved. The number 0.5, 0.70 of the pen indicates the thickness of the line obtained with the lead and the size of the lead diameter.

Micro-tip pencils with 0.5 mm thick leads with the following grades are recommended.

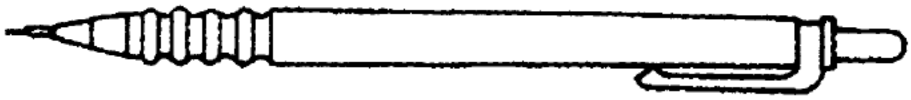


Fig. 1.7 Mechanical Pencil

HB Soft grade for Border lines, lettering and free sketching

H Medium grade for Visible outlines, visible edges and boundary lines

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Name any five drawing instruments
2 What are French curves used for?
3. What are drawing boards used for?

7.0 References

UNIT 3: TYPES OF DRAWINGS AND PAPER SIZES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Identify various components of an engineering drawing

(ii) Identify the various components of drawing title block

(iii) . Identify the various drawing paper sizes

(iv) Explain the various methods used in drawing projection and types of projection

3.0 Main Body

3.1 Types of Drawings

There are a number of drawing types associated with the mechanical engineering design process. A list of the Drawing Types covered in this lecture is provided below

1. General Arrangement Drawings
2. Arrangement Drawings
3. Assembly Drawings
4. Detail Drawings
5. Fabrication Drawings

It also include comments on item identification

General Arrangement Drawings

This drawing shows overall views of the equipment and provides all of the information to produce transportation, layout and installation drawings. The drawing includes a list of the arrangement drawings. The drawing includes overall dimensions, installation details, overall weight/mass, weights of sub systems, and service supply details.

The general arrangement drawing includes references to the design documents. The drawing often also identifies relevant internal and external contract numbers. An example of a typical general arrangement drawing is a roller conveyor system comprising a number of conveyors with independent drives and guards.

The drawn separate assemblies and parts will be identified with leader lines to balloons which include the arrangement reference number linking to the list of arrangement drawings.

Arrangement Drawing

Arrangement drawings represent self contained units used to make up the system drawn on the general arrangement drawing. Examples of arrangement drawings include drawings of assembled conveyers, drive systems, elevating units etc. The drawing should show in, at least three orthographic views, clear details to show all of the components used to make up the equipment items and how the component parts are located and fastened together.

Arrangement drawings include a table (parts list) identifying assemblies, fabrication drawings, detail drawings and proprietary items used to make up the equipment. Arrangement drawings include overall dimension, the weight/mass of the equipment drawn, the lifting points. All information needed to construct, test, lift, transport, and install the equipment should be provided in notes or as referenced documents.

The arrangement drawing may be a standard internal drawing which is repeatedly called up on different system general arrangement drawings.

The drawn separate assemblies and parts will be identified with leader lines to balloons which include the item reference number linking to the parts list.

Assembly Drawings

The assembly /sub-assembly drawings are drawings of discrete sub-systems showing in some detail how the component items fit together. Typical assembly drawings include gearbox drawings, roller drawings, guard system drawings.

The assembly drawing will generally include at least three orthographic views with sections as needed to clearly show all of the details and their relative positions. Overall and detail dimensions will be shown. The weight/mass of the assembly/sub-assembly will be noted. The drawing will include a parts list identifying all of the component details with quantities and materials and supply details. The assembly drawing will include a list of reference drawings and notes identifying the relevant codes and specifications and testing requirements.

The drawn separate items will be identified with leader lines to balloons which include the item reference number linking to the parts list.

Detail Drawings

All individual items required to produce mechanical equipment need to be described in some detail to ensure that they are manufactured in accordance with the designers requirements. Proprietary items are selected from technical data sheets obtained from manufacturer /supplier. Items manufactured specifically for the application need to be made to detail drawings which include the geometry, material, heat treatment requirements, surface texture, size tolerances, geometric tolerances etc.

The detail drawing should include all of the necessary information to enable procurement, manufacture and should identify all of the relevant codes and standards. The item weight/mass should also be included for reference.

Depending on the level of detail, a detail drawing can comprise one drawing on a sheet or a number of separate drawings on one sheet. It is sometimes possible to combine the detail drawings onto the assembly drawing. The detail drawing must cross reference, both ways,to the parent assembly or arrangement drawing.

Fabrication Drawings

The fabrication drawing is a specific type of detail drawing. Some fabrication drawings are virtually assembly drawing e.g. when a number of items are assembled together as a fabrication. The fabrication drawing generally includes a material parts list identifying all of the materials used to build up the fabrication. All weld details are included using the standard symbolic representation of welds as shown in BS EN 22553. All of the materials should be identified in accordance with the relevant standards and codes.

The fabrication drawing should clearly describe in notes or in referenced documents the heat treatment and stress relieving requirements prior to, during and following the completion of the fabrication processes. The dimensions and relevant linear and geometric tolerances should be indicated.

A fabrication drawing sometimes only includes the fabrication details, the final machining details are then shown on a separate drawing. It is equally acceptable to show all manufacturing information on one drawing.

The items used to make up the fabrication will be identified with leader lines to balloons which include the item reference number linking to the parts list. The listed items on a fabrication drawing do not identify items which can be disassembled, as on assembly and arrangement drawings. The numbering system should reflect this difference. Methods of numbering items on fabrication drawings include using lower case alphabet letters e.g a,b,c or optionally as sub units of the fabrication item number e.g 1/1, 1/2 1/3 ... or 1/a , 1/b, 1/c...

Item Identification

The method of identifying the parts must be clear and unambiguous. The equipment as represented on the general arrangement drawing and the sub-assemblies as shown on the arrangement and assembly drawing should be clearly identified with plant item numbers. The relevant drawing numbers are obtained by reference to the plant items list. Plant items are annotated by leader lines to a double balloon.

Typically a conveyor may have a plant item number e.g.H1040 and be shown on a drawing e.g. drawing number A0 12500.

The detail drawings are sub items of the arrangement drawings and are identified on the arrangement and assembly drawings. Typically an item say a conveyor frame may be identified from the conveyor plant item number e.g. H1040/3 . Optionally it may be identified using the arrangement drawing number e.g. A0 12500 /3. The frame will also have a discrete detail drawing number e.g A2 12503

The fabricated items which are based on sub-parts welded together should be identified as details but the individual sub-parts should be identified in a different way to avoid ambiguity. One option is to number the fabricated sub-parts alphabetically e.g a, b, c ...or as a combination of the fabrication detail number and the part number i.e 3/a , 3/b.... These sub-parts do not need to be identified as separate parts because following fabrication they will not exist as separate parts. If the sub-parts are complicated shapes or machined items and they cannot be described in sufficient detail on the fabrication drawing they should be drawn as separate detail drawings but still identified as sub-parts of the fabrication detail.

Self-Assessment Exercise

3.2 Drawing Title Blocks

Standards

BS ISO 7200 Technical Drawings- Title Blocks identifies the title block requirements to be used on engineering drawings.... The drawing sheet size should be in accordance with "BS EN ISO 5457 TD- Sizes and layout of drawing sheets"

Notes

A title block is the form on which the actual drawing is a section. The title block includes the border and the various sections for providing quality, administrative and technical information. The importance of the title block cannot be minimized as it includes all the information which enables the drawing to be interpreted, identified and archived.

The title should include sufficient information to identify the type of drawing e.g general arrangement, or detail. It should also clearly describe in a precise way what the drawing portrays

The notes below relate to the title boxes included on in the title block to convey the necessary information. The standard drawing sizes and layouts are described elsewhere.

The basic requirements for a title block located at the bottom right hand corner of a drawing are

1. The registration or ID number
2. The drawing title

3. The Legal Owner of the Drawing

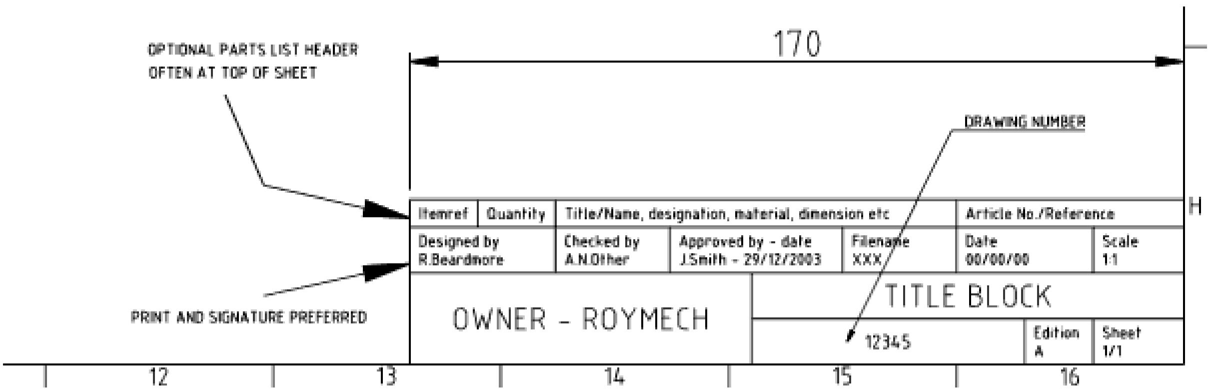
These items should be written in a rectangle which is at the most 170mm wide. The tile block should also include boxes for the legal signatures of the originator and other persons involved production of the drawing to the required quality.

The drawing should also include a symbol identifying the projection. The main scale and the linear dimension units if other than "mm".

Mechanical drawings should list the standards use for: indicating the surface texture: welds: general tolerances and geometric tolerances, as notes referring directly the relevant standards or a general note referring to the BS 8888. (BS 8888 lists all of the relevant standards.) BS 8888 should really only be referenced if the drawing is in full accordance.

The drawing title block should indicate the date of the first revision. In separate boxes to the title block the current revision with an outline description of the revision should be indicated. On completion of each drawing revision an additional revision box should be completed thus providing a detailed history of the drawing.

Typical Title Box



Typical Revision Box

Self-Assessment Exercise

3.3 Drawing Paper Sizes

The standard for drawing sheet sizes is the A series. The basic size in this series is the A0 size (1189mm x 841mm) which has an area of about 1-m3. The sides of every size in the series are in the ratio Sqrt(2) = 1.414 : 1 and each size is half the area of the next larger size.

Drawing Sheet Size	Size in millimeters	Size in inches
A0	1189 x 841	46.81 x 33.11
A1	841 x 594	33.11 x 23.39
A2	594 x 420	23.39 x 16.55
A3	420 x 297	16.55 x 11.69
A4	297 x 210	11.69 x 8.27
A5	210 x 148	8.27 x 5.84
A6	148 x 105	5.84 x 4.13

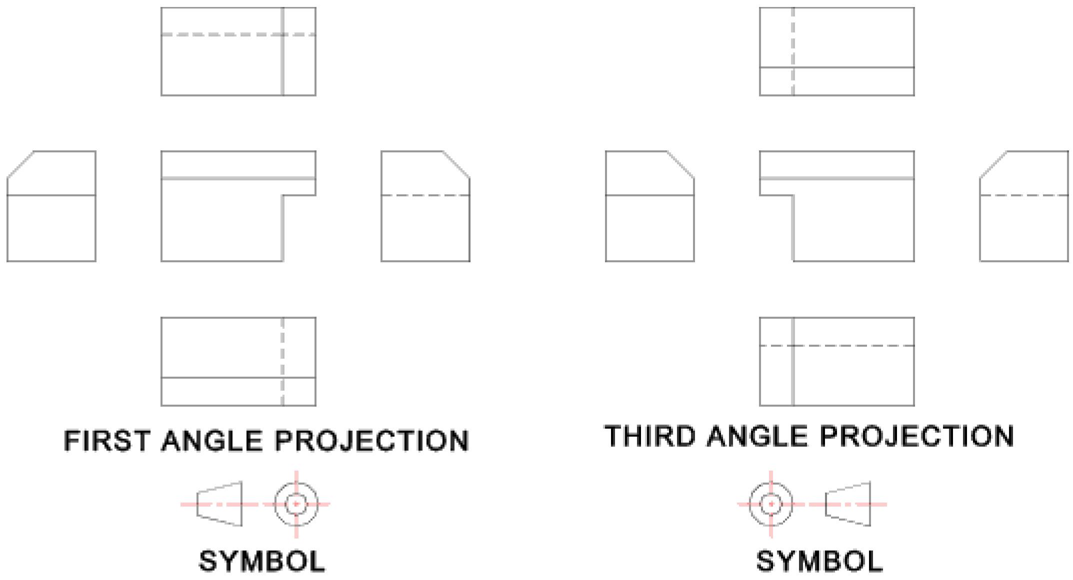
BS EN ISO 5457 Drawing Sheet Sizes

Designation	Trimmed Sheet		Drawing Space +/- 0.5mm		Untrimmed sheet +/- 2mm	
-	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)
A0	841	1189	821	1159	880	1230
A1	594	841	574	811	625	880
A2	420	594	400	564	450	625
A3	297	420	277	390	330	450
A4	210	297	180	277	240	330

Self-Assessment Exercise

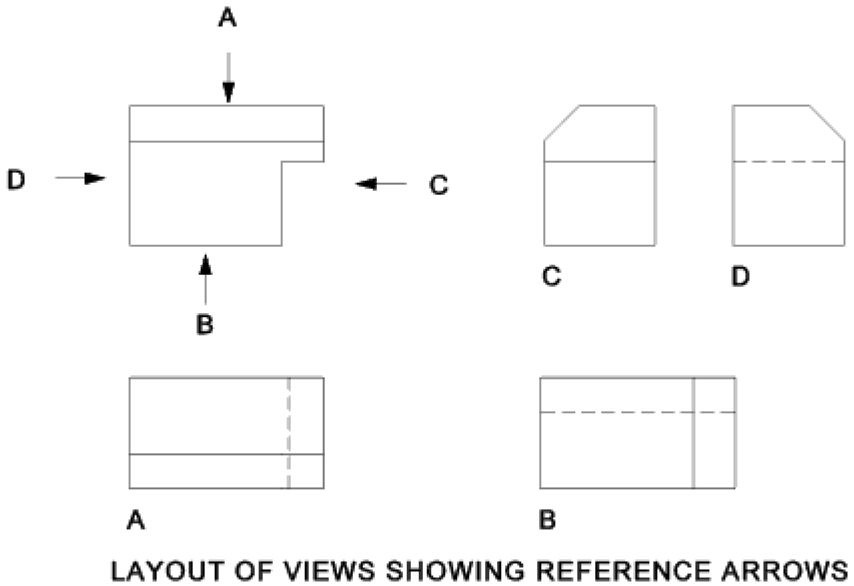
3.4 Projection Methods

First angle and third angle projection methods are acceptable.



The symbol identifying the type of projection used should be placed in a space provided in the drawing block

Views Using Reference Arrows.



Principal View

The principal view on which all of the other views are based should be selected as being the most informative. This may be the view which is most recognizable during manufacture or use. i.e. the front view of a house or the side view of a car.

Self-Assessment Exercise

3.5 The Theory of Orthographic Projection

The fundamental theory is rooted in the principles of solid geometry and need not *concern* us. The basic idea, so far as drawing is concerned, is that there are three planes mutually at right angles, like the sides of a box. The views are projected onto these planes which are then developed or opened out into a flat sheet - the paper we draw on.

In **first angle projection, Fig. 1.1** the object with faces A, B and C visible, is imagined to be suspended inside such a box. Three of the sides are shown, one on each of the three planes OX, OY and OZ. The object is viewed in three directions at right angles - I have shown a sketched eye and an arrow to indicate these directions of view. The image behind the object is then drawn on the plane *behind* it; the projection lines from object to plane run in the same direction as the lines of sight. Once all the views have been drawn on the inside of the imaginary box this is cut open and laid flat, as shown at (b). The relative positions of the three views is thus fixed by the projection convention used. The plan lies below the main elevation, and the eye follows the projection lines in that direction. Similarly for all other views. You will see that view of B seen in (b) is exactly what you would see if the object at A had been turned through 90 degrees - the first right angle. For a complete orthographic projection we should use all six sides of the box, producing six views in all. In third angle projection, **Fig. 1.2,** the object is imagined to be suspended within a transparent box, as shown at (a). The three planes OX, OY and OZ are the same, but the relationship between OY and OZ has changed. Look at the little diagram (c). ZOY forms one right angle - the first, and YOZ' forms another -the second. The third right angle is formed by Z'OY'. The imaginary box is formed round these last two planes, hence the term third angle.

I have again shown sketches of eyes and arrows to show the direction of sight, but this time the image is drawn on the face of the transparent plane, *between* the eye and the object. The line of projection runs *opposite* to the line of sight. Hence you see the face D on Z'OY' - compare with **Fig. 1.1.**

When the box is opened out we find the views disposed as shown at (b). The plan is now above the main elevation and you can see that to get the face C into that position from the elevation the object must be rotated through *three* right angles. Again, a complete projection would form six views.

Thus both systems are based on a valid conceptual theory. Both, in fact, are based on the same fundamental theories of descriptive geometry of Descartes, Monge and others. In a way, first angle projection is an evolution as the system, or one very similar, was in use long beforethe theory was propounded, whereas third angle seems to have been developed by American geometricians from scratch very much later. (It was not standardised, even in the US, until 1935.)

First angle is more or less universal in Europe except for some engineering firmswith US parents. Third angle is already standard in the US. As already stated, neither is right or wrong but it is *absolutely vital* to be consistent right throughout the works or drawing office, and essential to show on *every* drawing which system is in use. If any deviation from the chosen system is necessary, then direction of view arrows must be used.

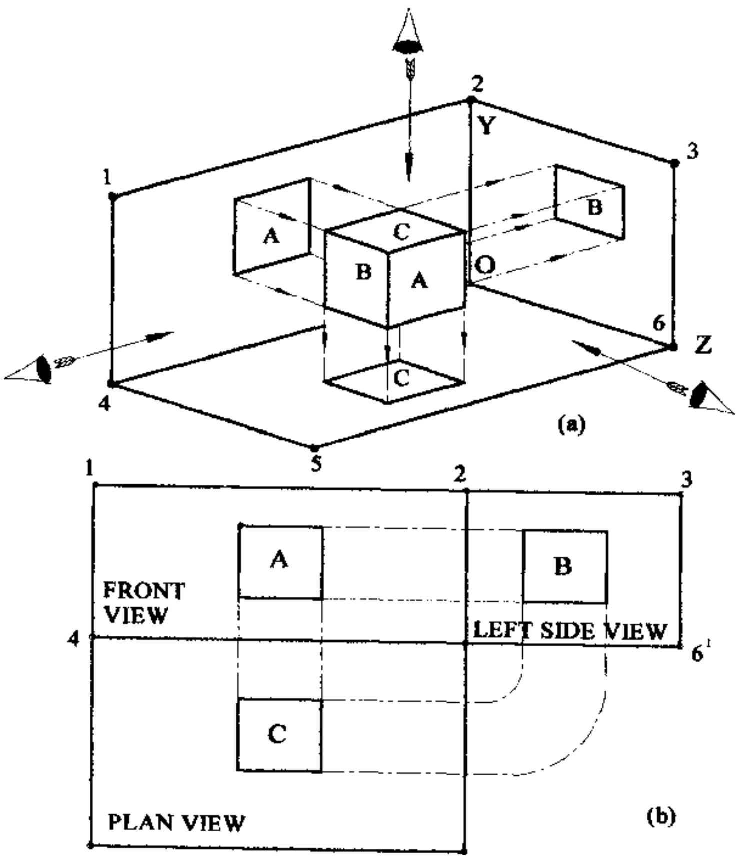


Fig. 89 *The planes of projection in "First Angle".*

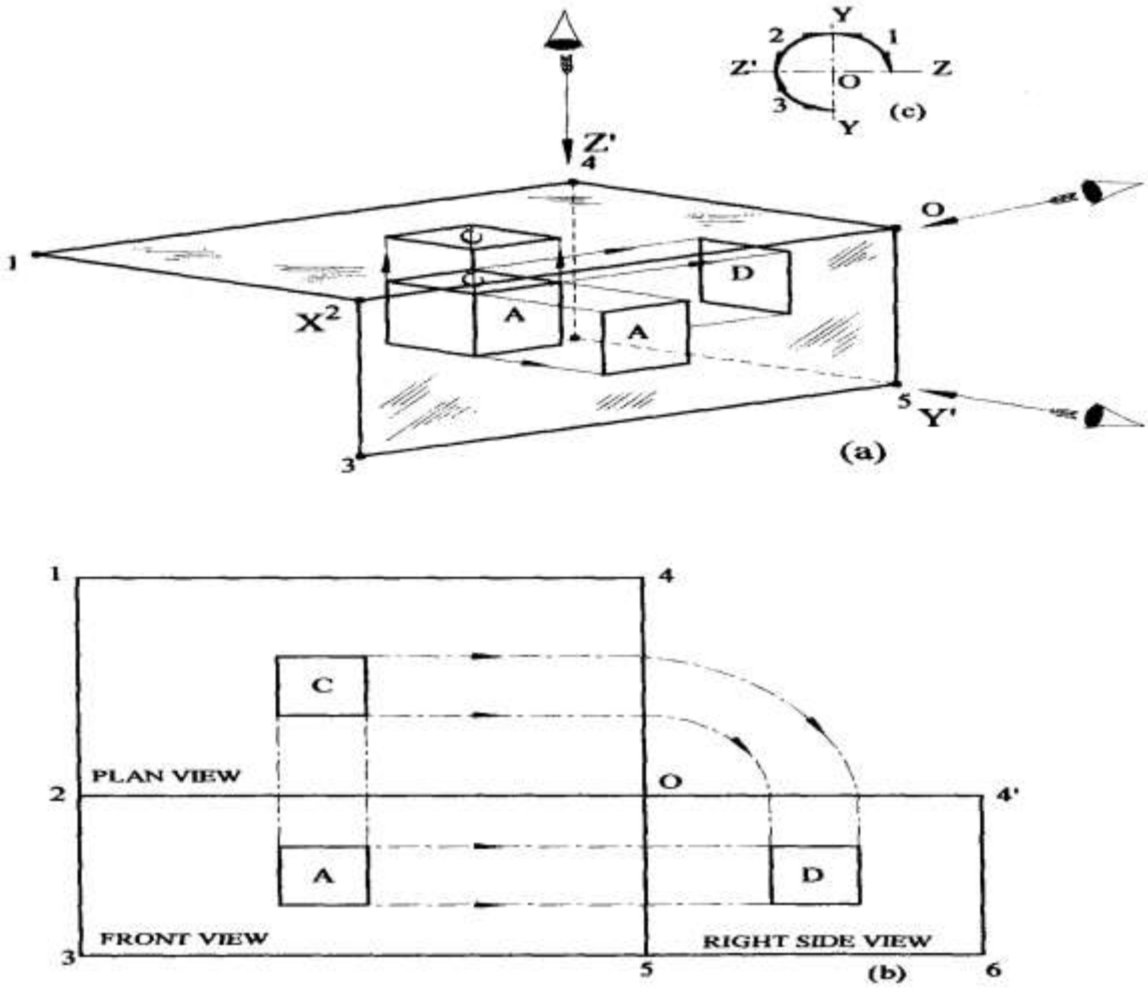


Fig. 90 *The planes of projection in 'Third An*

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. What are the two major methods of projection?
2. Sketch a typical title block
3. What are the different sizes of drawing papers?

7.0 References

UNIT 4: DEVELOPMENTS

CONTENT

1.0 Introduction

This is an aspect of workshop drawing that often arises when, for example, we need to cut out sheet metal which can be rolled into a specific shape, or when we need to cut a hole in a container - boiler or tank -which will be a close fit to a branching piece. A **development** is no more than the shape of the piece of sheet in the flat before folding and jointing. An intersection is the profile of the curve formed when two sections meet. You will find six of these on every nut where the cone of the chamfer meets the six flats. Normally we do not need to draw these accurately, but there can be occasions when this is necessary.

It is more than unfortunate that development drawings are usually a maze of lines. They can and do frighten off those not accustomed to them, and give the impression that this is very difficult; quite the wrong impression. Gypsy tinsmiths 100 years ago could lay out a development of (e.g.) a kettle spout almost in their sleep. And, of course, though there may be a maze of lines they are *all drawn one at a time,* and most will be a simple repetition of that drawn previously. but in a new place. However, there is an easy way to deal with going to show toy how to do the job yourself as you read the page. Make a neat sketch of the object, and follow the instructions. Then, if you have time, get out the drawing-board and have a go on a similar problem of your own.

2.0 Objectives

On completion of this Unit, you should be able to**:**

1 Describe the principles of development of simple surfaces

2 Describe the principles of development of shapes

3 Describe geometric objects and surfaces

3.0 Main Body

3.1 Geometric Surfaces

A geometric surface is generated by the motion of a geometric line, either straight or curved. Surfaces that are generated by a moving straight line are known as ruled surfaces, and those generated by a curved line are known as double-curved surfaces. Any position of the generating line, known as a generatrix, is called an element of the surface.

Ruled surfaces include planes, single curved surfaces, and warped surfaces.

A plane is generated by a straight line moving in such a manner that one point touches another straight line as it moves parallel to its original position.

A single-curved surface is generated by a straight line moving so that in any two of its near positions it is in the same plane.

A warped surface is generated by a straight line moving so that it does not lie in the same plane in any two near positions.

Double-curved surfaces include surfaces that are generated by a curved line moving in accordance with some mathematical law.

Self-Assessment Exercise

3.2 Geometric Objects

Geometric solids are bounded by geometric surfaces. They may be classified as follows:

1. Solids bounded by plane surfaces: Tetrahedron, cube, prism, pyramid, and others.
2. Solids bounded by single-curved surfaces: Cone and cylinder (generated by a moving straight line).
3. Solids bounded by warped surfaces: Conoid, cylindroid, hyperboloid of one nappe, and warped cone.
4. Solids bounded by double-curved surfaces: Sphere, spheroid, torus, paraboloid, hyperboloid, and so on (surfaces of revolution generated by curved lines).

Self-Assessment Exercise

3.3 Introduction to Surface Development

A layout of the complete surface of an object is called a development or pattern. The development of an object bounded by plane surfaces may be thought of as being obtained by turning the object, as illustrated in Figs. 2.1 and 2.2, to unroll the imaginary enclosing surface on a plane. Practically, the drawing operation consists of drawing the successive surfaces in their true sizes with their common edges joined.

The surfaces of cones and cylinders also may be unrolled on a plane. The development of a right cylinder (Fig. 2.3) is a rectangle having a width equal to the altitude of the cylinder and a length equal to the cylinder's computed circumference (7c-d). The development of a right circular cone (Fig. 2.4) is a sector of a circle having a radius equal to the slant height of the cone and an arc length equal to the circumference of its base.

Warped and double-curved surfaces cannot be developed accurately, but the may be developed by some approximate method. Ordinarily, an approximate pattern will prove to be sufficiently accurate for practical purposes if the material of which the piece is to be made is somewhat flexible.

Plane and single-curved surfaces (prisms, pyramids, cylinders, and cones), which can be accurately developed, are said to be developable. Warped and double-curved surfaces, which can be only approximately developed, are said to be nondevelopable.

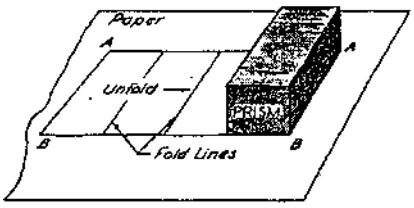


Figure 2.1 Development of a prism

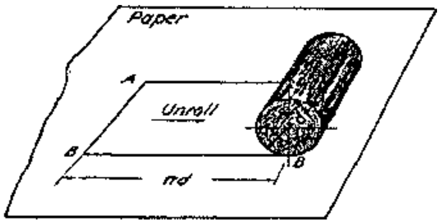
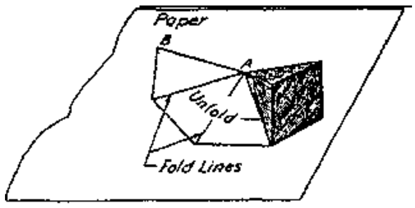


Figure 2.3. Development of a cylinder



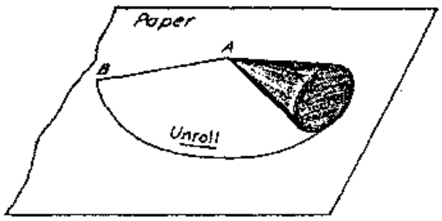


Figure 2.2 Development of a pyramid

Figure 2.4 Development of a cone

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Name four types of surface

2 How are the surfaces (1) above generated

7.0 References

UNIT 5: DEVELOPMENT OF PRISMS AND CYLINDERS

CONTENT

1.0 Introduction

2.0 Objectives

On completion of this unit, you should be able to**:**

1 Describe the principles of development of simple surfaces

2 Describe the principles of development of shapes

3 Identify geometric objects and surface

3.0 Main Body

3.1 Practical Developments

On many industrial drawings, a development must be shown to furnish the necessary information for making a pattern to facilitate the cutting of a desired shape from sheet metal. Because of the rapid advance of the art of manufacturing an ever-increasing number of pieces by folding, rolling, or pressing cut sheet-metal shapes, one must have a broad knowledge of the methods of constructing varied types of developments. Patterns also are used in stonecutting as guides for shaping irregular faces.

A development of a surface should be drawn with the inside face up, as it theoretically would be if the surface were unrolled or unfolded, as illustrated in Figs. 2.1-2.4. This practice is further Justified because sheet-metal workers must make the necessary punch marks for folding on the inside surface.

Although in actual sheet-metal work extra metal must be allowed for lap at seams, no allowance will be shown on the developments m this chapter. Many other practical considerations have been purposely ignored, as well, in order to avoid confusing the beginner.

Self-Assessment Exercise

3.2 Development of a Right Truncated Prism

Before the development of the lateral surface of a prism can be drawn, the true lengths of the edges and the true size of a right section must he determined. On the right truncated prism, shown in Fig. 2.5, the true lengths of the prism edges are shown in the front view and the true size of the right section is shown in the top view.

The lateral surface is "unfolded" by first drawing a "stretch-out line" and marking off the widths of the faces (distances 1-2, 2-3, 3-4, and so on, from the so top view) along it in succession. Through these points light construction lines are then drawn perpendicular to the line $l_o l_D$., and the length of the respective edge is set off on each by projecting from the front view. When projecting edge lengths to the development, the points should be taken in a clockwise order around the perimeter, as indicated by the order of the numbers in the lop view. The outline of the development is completed by joining these points. Thus far, nothing has been said about the lower base or the inclined upper face. These may be joined to the development of the lateral surface, if so desired.

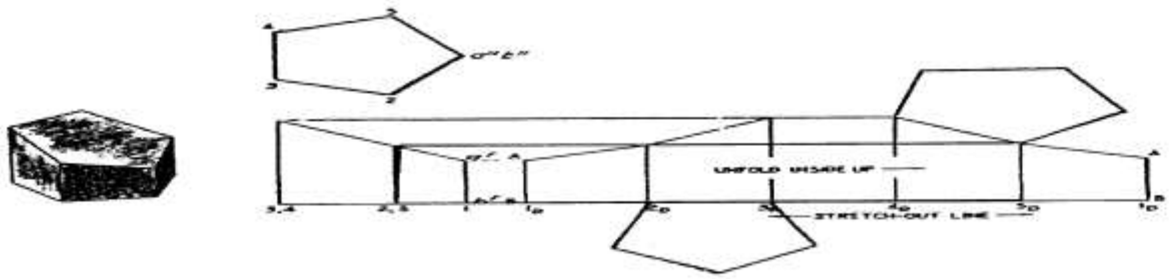


Figure 2.5 Standard method of developing the lateral surface of a right prism

In sheet-metal work, it is usual practice to make the seam on the shortest

element in order to save time and conserve solder or rivets.

Self-Assessment Exercise

3.3 Development of an Oblique Prism

The lateral surface of an oblique prism, such as the one shown in Fig. 2.6, is developed by the same general method used for a right prism. Similarly, the true lengths of the edges are shown in the front view, but it is necessary to find the true size of the right section by auxiliary plane construction. The widths of the faces, as taken from the auxiliary right section, are set off along the stretch-out line, and perpendicular construction lines representing the edges are drawn through the division points. The lengths of the portions of each respective edge, above and below plane XX. are transferred to the corresponding line in development. Distances above plane XX are laid off above the stretch-out line, and distances below XX are laid off below it. The development of the lateral surface is then completed by joining the end points of the edges by straight lines. Since an actual fold will be made at each edge line when the prism is formed, it is the usual practice to heavy these edge (fold) lines on the development.

The stretch-out line might well have been drawn in a position perpendicular to the edges of the front view, so that the length of each edge might be projected to the development (as in the case of the right prism)

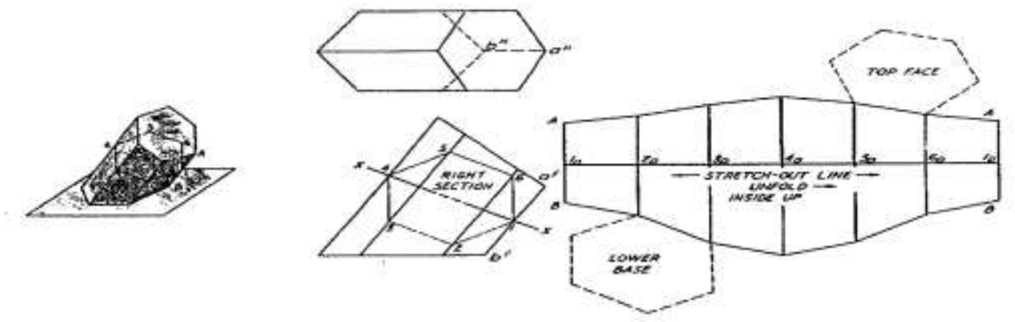


Figure 2.6 Development of an oblique prism

Self-Assessment Exercise

3.4 Development of a Right Cylinder

When the lateral surface of a right cylinder is rolled out on a plane, the base develops into a straight line (Fig. 2.7). The length of this line, which is equal to the circumference of a right section (7c- x diam), may be calculated and laid off as the stretch-out line $1_D 1_D$.

Since the cylinder can be thought of as being a many-sided prism, the development may be constructed in a manner similar to the method illustrated in Fig. 2.5. The elements drawn on the surface of the cylinder serve as edges of the man-sided prism. Twelve or 24 of these elements ordinarily are used, the number depending on the size of the cylinder. Usually they are spaced by dividing the circumference of the base, as shown by the circle in the top view, into an equal number of parts. The stretch-out line is divided into the same number of equal parts, and perpendicular elements are drawn through each division point. Then the true length of each element is projected to its respective representation on the development, and the development is completed by joining the points with a smooth curve, in joining the points, it is advisable to sketch the curve in lightly, freehand, before using the French curve. Since the surface of the finished cylindrical piece forms a continuous curve, the elements on the development are not heavied. When the development is symmetrical, as in this case, only one-half need be drawn.

A piece of this type might form a part of a two-piece, three-piece, or four-piece elbow. The pieces are usually developed as illustrated in Fig. 2.8. The stretch-out line of each section is equal in length to the computed perimeter of a right section.

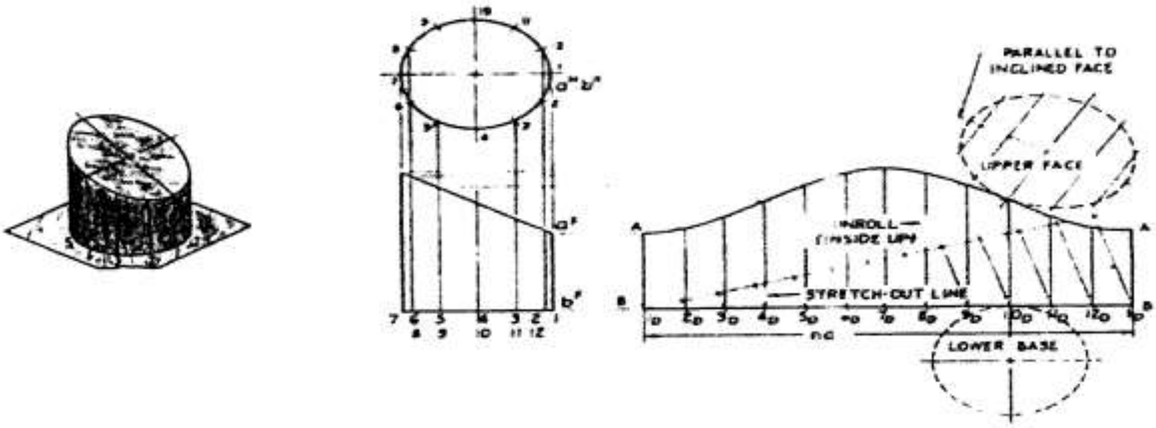


Figure 2.7 Development of a right circular cylinder

Self-Assessment Exercise

3.5 To Develop an Oblique Cylinder

Since an oblique cylinder theoretically may be thought of as enclosing a regular oblique prism having an infinite number of sides, the development of the lateral surface of the cylinder shown .in Fig. 2.9 may be constructed by using a method similar to the method illustrated in Fig. 2.6. The circumference of the right section becomes stretch out line $1_D 1_D$ "for the development.

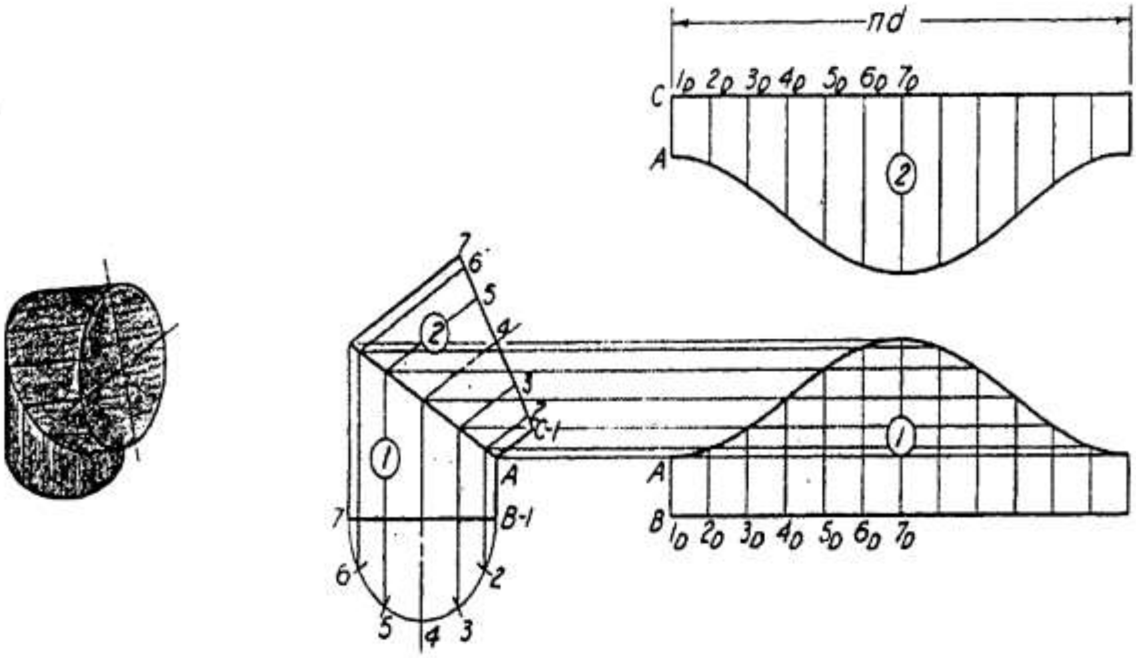


Figure 2.8 Two-piece elbow

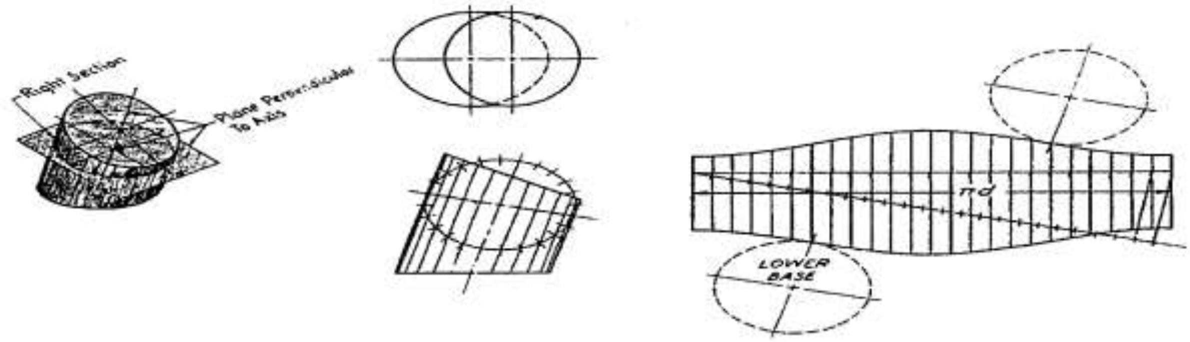


Figure 2.9 Development of an oblique cylinder

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Develop the lateral surface of the prisms shown in Figure Assignment 1.

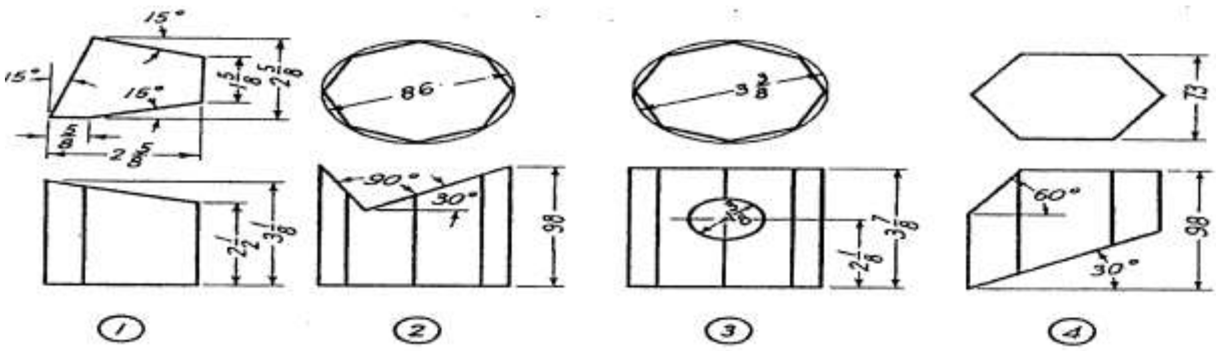


Figure: Assignment 1

7.0 References

UNIT 1: TRUE LENGTH LINES AND DEVELOPMENT OF SURFACES

CONTENT

1.0 Introduction

2.0 Objectives

On completion of this Unit, you should be able**:**

1 Determine true length of lines in space

2 Develop surfaces of the require true length lines

3 Develop pyramids and cones

3.0 Main Body

3.1 Determination of the True Length of a Line

In order to construct the development of the lateral surface of some objects, it is frequently necessary to determine the true lengths of oblique lines that represent the edges.

3.2 True-length Diagrams

When it is necessary in developing a surface to find the true lengths of a number of edges or elements, some confusion may be avoided by constructing a true-length diagram adjacent to the orthographic view, as shown in Fig. 2.10. The elements were revolved into a position parallel to the F (frontal) plane so that their true lengths show in the diagram. This practice prevents the front view in the illustration from being cluttered with lines, some of which would represent elements and others their true lengths

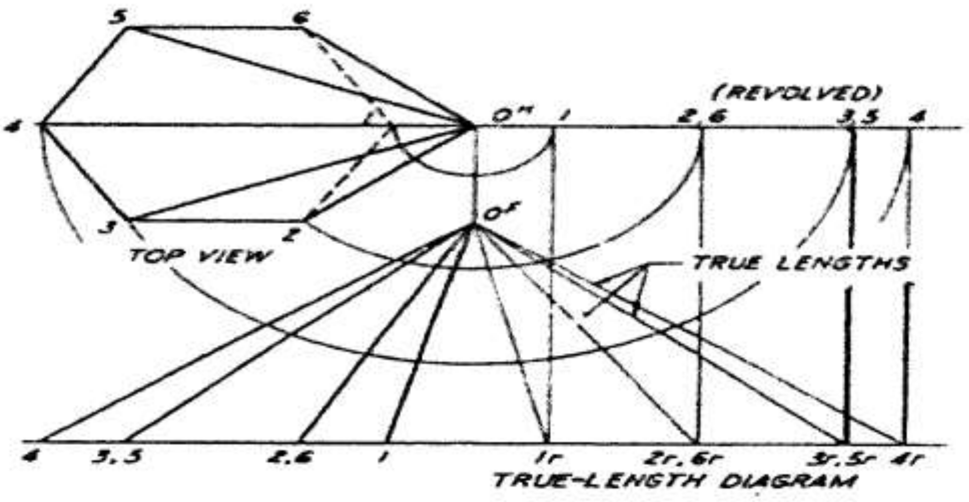


Figure 2.10. True-length diagram (the revolution method)

Figure 2.12 shows a diagram that give the true lengths of the edges of the pyramid. Each line representing the true length of an edge is the hypotenuse of right triangle whose altitude is the altitude of the edge in the front view and whose base is equal to the length of the projection of the edge in the top view. The lengths of the top projections of the edge of the pyramid are laid off horizontally from the vertical line, which could have been drawn at any distance from the from view. Since all the edges have the same altitude, this line is a common vertical leg for all the right triangles in the diagram The true-length diagram shown in Fig. 2.10 could very well have been constructed by this method.

Self-Assessment Exercise

3.3 Development of a Right Pyramid

To develop (unfold) the lateral surface of a right pyramid, it is first necessary to determine the true lengths of the edges and the true size of the base. With this information, the development can be constructed by laying out the races in successive order with the common edges joined. If the surface imagined to be unfolded by turning the pyramid, as shown in Fig. 2.2, each triangular face is revolved into the plane of the paper about the edge that is common to it and the preceding face.

Since the edges of the pyramid shown in Fig. 2.21 are all equal in length, it is necessary only to find the length of the one edge Al by revolving it into the position a' I r.. The edges of the base, 1-2, 2-3, and so on, are parallel to the horizontal plane of projection and consequently shown with true length in the top view. With this information, the development is easily completed by constructing the. four triangular surfaces.

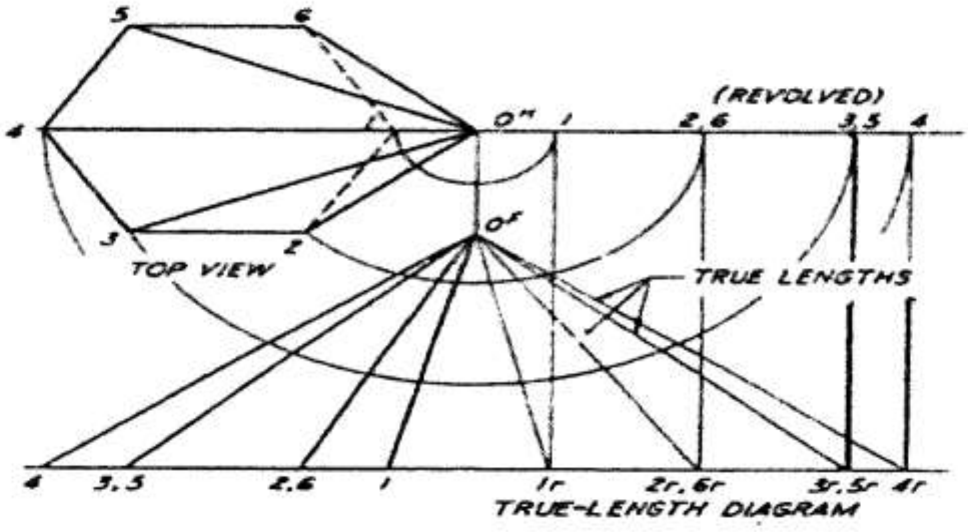


Figure 2.11 Development of a rectangular right pyramid

Self-Assessment Exercise

3.4 Development of the Surface of a Frustum of a Pyramid

To develop the lateral surface of the frustum of a pyramid (Fig. 2.12), it is necessary to determine the true lengths of edges of the complete pyramid as well as the true lengths of edges of the frustum. The desired development is obtained by first constructing the development of the complete pyramid and then laying off the true lengths of the edges of the frustum on the corresponding lines of the development.

It may be noted with interest that the true length of the edge B3 is equal to the length b'3' on the true-length line a^F3' and that the location of point b' can be established by the shortcut method of projecting horizontally from point VF. Point b' on a^F 3' is the true revolved position of point B, because the path of point B is in a horizontal plane that projects as a line in the front view.

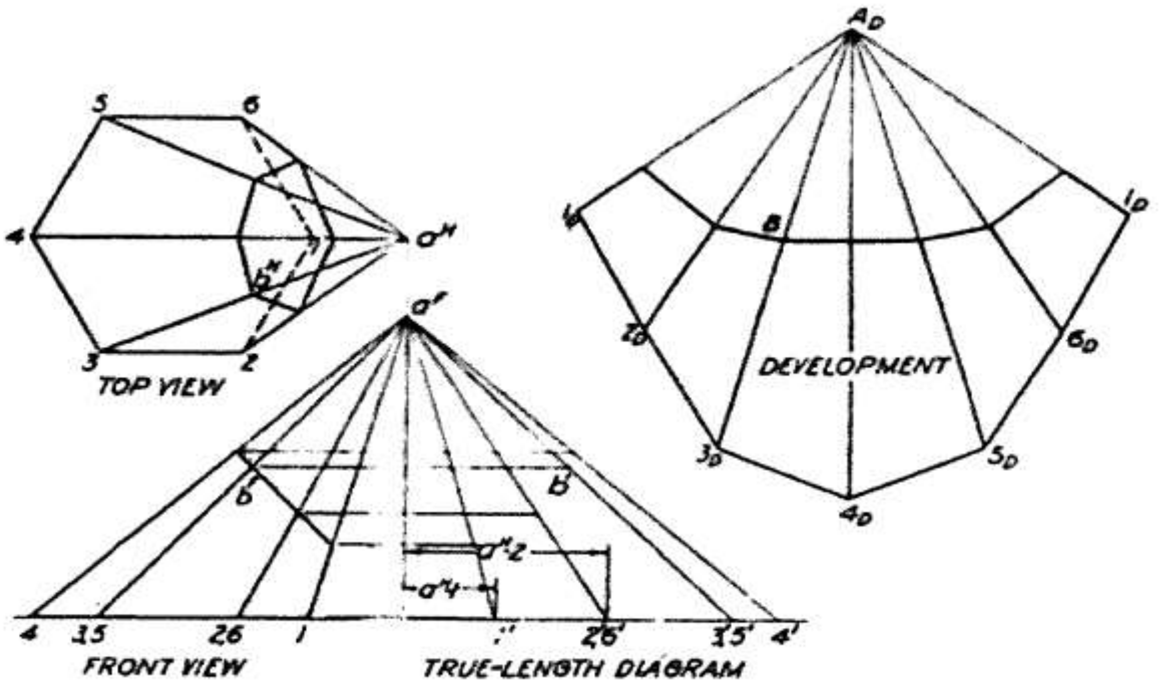


Figure 2.12 Development of the frustum of a pyramid

Self-Assessment Exercise

3.5 Development of a Right Cone

As previously explained in Sec. 2.4, the development of a regular right circular cone is a sector of a circle. The development will have a radius equal to the slant height of the cone and an included angle at the center equal to (r/s) x 360 (Fig. 2.13). In this equation, r is the radius of the base and s is the slant height.

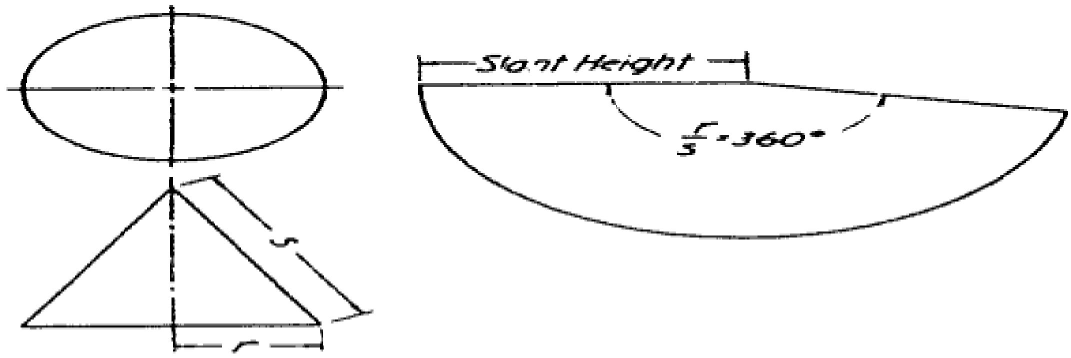


Figure 2.13 Development of a right cone

Self-Assessment Exercise

3.6 To Development of a Right Truncated Cone

The development of a right truncated cone must be constructed by a modified method of triangulation, in order to develop the outline of the elliptical inclined surface. This commonly used method is based on the theoretical assumption that a cone is a pyramid having an infinite number of sides. The development of the incomplete right cone shown in Fig. 2.14 is constructed on a layout of the whole cone by a method similar to the standard method illustrated for the frustum of a pyramid in Fig. 2.12.

Elements are drawn on the surface of the cone to serve as edges of the many-sided pyramid. Either 12 or 24 are used, depending on the size of the cone. Their location is established on the developed sector by dividing the arc representing the unrolled base into the same number of equal divisions, into which the top view of the base has been divided- At this point in the procedure, it is necessary to determine the true lengths of the elements of the frustum in the same manner that the true lengths of the edges of the frustum of a pyramid were obtained in Fig. 2.12. With this information, the desired development can be completed by setting off the true lengths on the corresponding lines of the development and Joining the points thus obtained with a smooth curve.

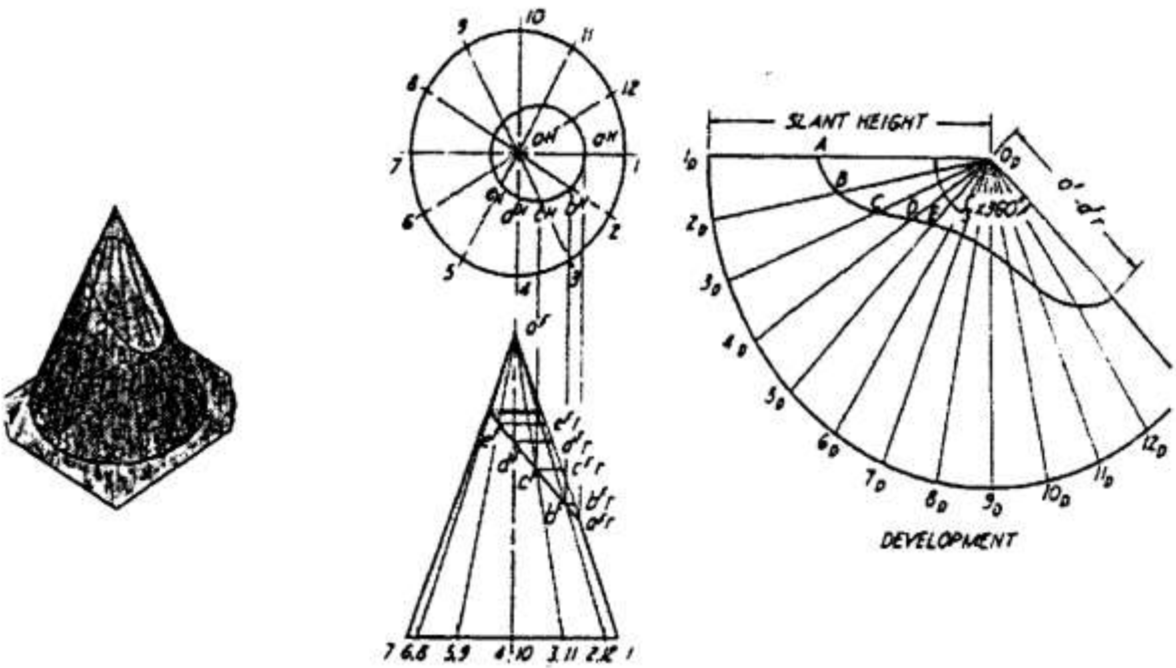


Figure 2.14 Development of a truncated cone

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

1. Develop the lateral surface of the pyramids shown in Figure Assignment 2. Make construction lines light. Show construction for finding the-true lengths of the lines

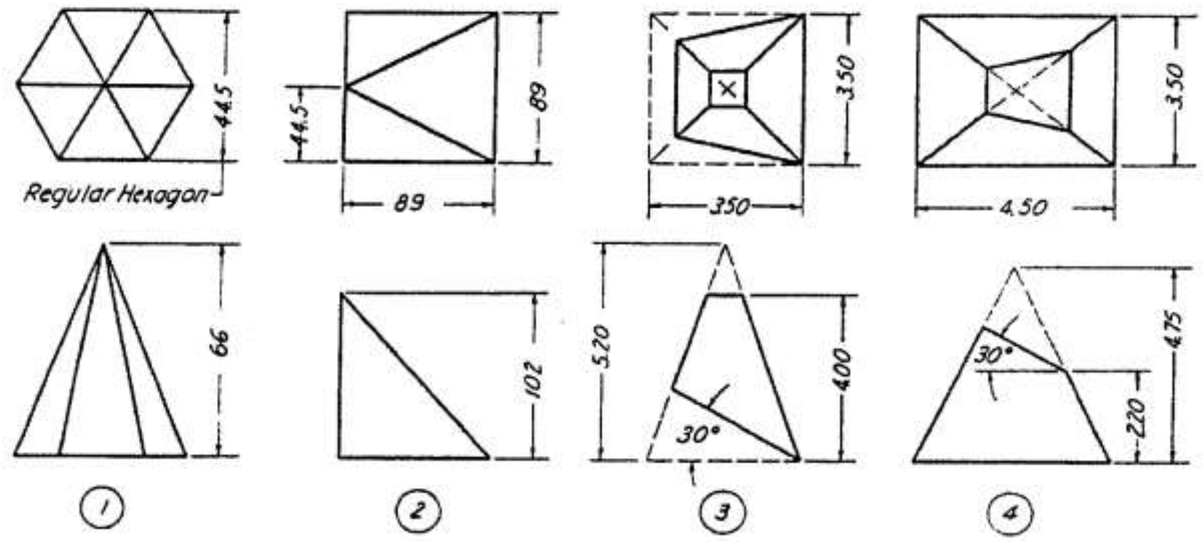


Figure Assignment 2

7.0 References

UNIT 2: TRUE LENGTH LINES AND DEVELOPMENT TRANSITION PIECES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

1 Discuss the principles of the development of transition pieces

2 Develop different types of transition pieces to connect different shapes

3.0 Main Body

3.1 Triangulation Method of Developing Approximately Developable Sur-Faces

A non-developable surface may be developed approximately if the surface is assumed to be composed of a number of small developable surfaces (Fig. 2.15). The particular method ordinarily used for warped surfaces and the surfaces of oblique cones is known as the triangulation method. The procedure consists of completely covering the lateral surface with numerous small triangles that will lie approximately on the surface (Fig. 2.16). These triangles when laid out in their true size with their common edges Joined, produce an approximate development that is accurate enough for most practical purposes.

Although this method of triangulation is sometimes used to develop the surface of a right circular cone, it is not recommended for such a purpose. The resulting development is not as accurate as it would be if constructed by one of the standard methods (Secs. 2.14 and 2.15).

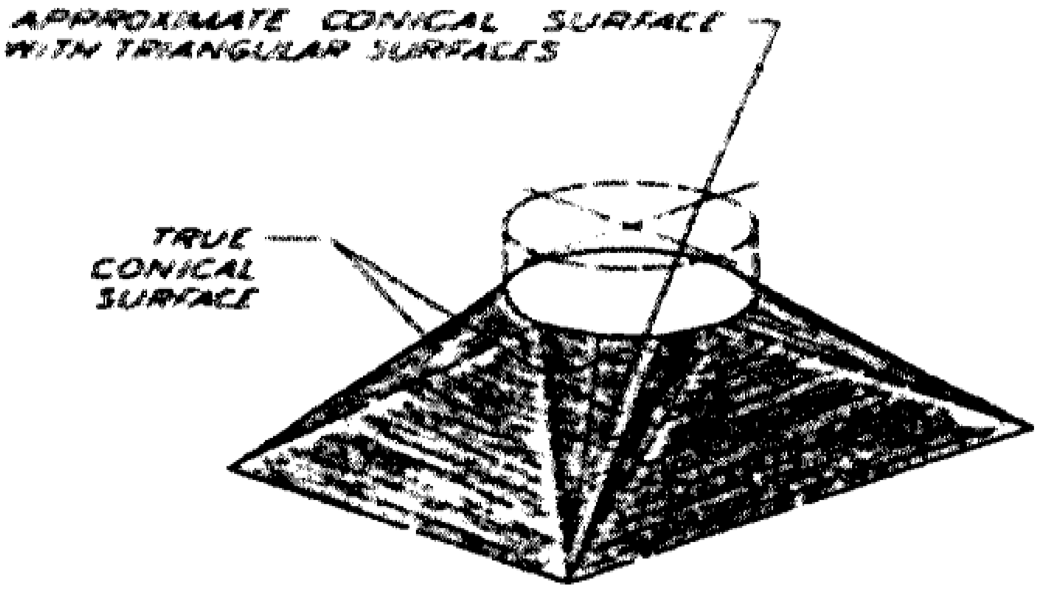


Figure 2.15 Triangulation of a surface

Self-Assessment Exercise

3.2 Development of an Oblique Cone Using the Triangulation Method

A development of the lateral surface of an oblique cone is constructed by a method similar to that used for an oblique pyramid. The surface is divided into a number of unequal triangles having sides that are elements on the cone and bases that are the chords of short arcs of the base.

The first step in developing an oblique cone (Fig. 2.17) is to divide the circle representing the base into a convenient number of equal parts and draw elements on the surface of the cone through the division points (1, 2, 3, 4, 5, and so on). To construct the triangles forming the development, it is necessary to know the true lengths of the elements (sides of the triangles) and chords. In the illustration, all the chords are equal. Their true lengths are shown in the top view. The true lengths of the oblique elements may be determined by one of the standard methods explained in Sec. 2.11.

Since the seam should be made along the shortest element, Al will lie on the selected starting line for the development and A7 will be on the center line. To obtain the development, the triangles are constructed in order, starting with the triangle A-1-2 and proceeding around the cone in a clockwise direction (as shown by the arrow in the top view). The first step in constructing triangle A-1-2 is to set off the true length a'1' along the starting line. With point A_D of the development as a center, and with a radius equal to aF2', strike an ale; then, with point I_D as a center, and with a radius equal to the chord 1-2, strike an arc across the first are to locate point 2_D. The triangle $A_D 2_0 3_D$ and the remaining triangles are formed in exactly the same manner. When all the triangles have been laid out, the development of the whole conical surface is completed by drawing a smooth curve through the end points of the elements

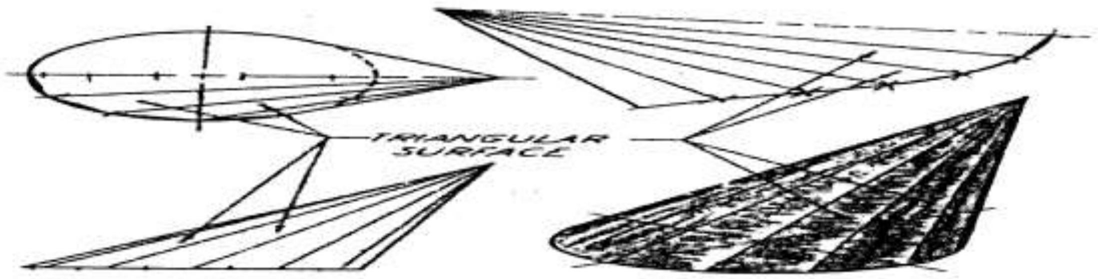


Figure 2.16 Trangulation of an oblique cone

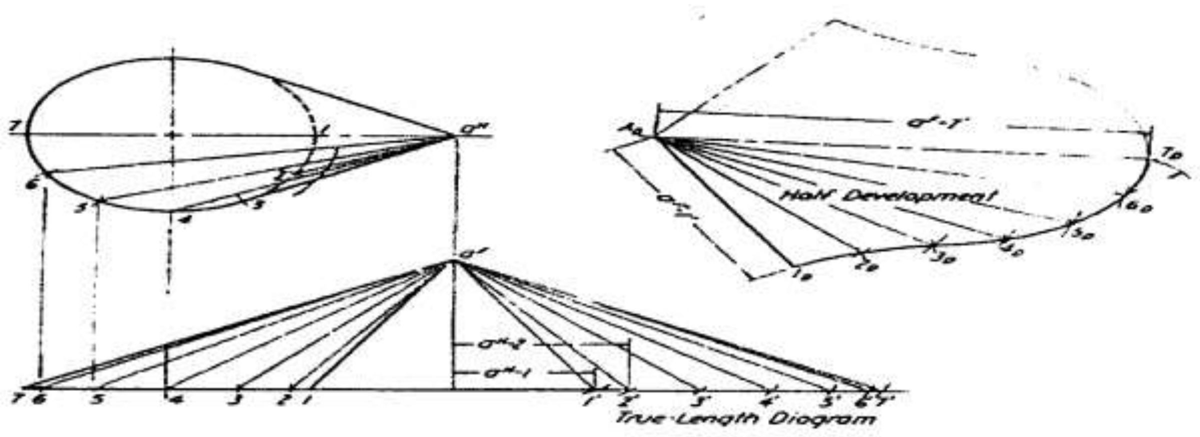


Figure 2.17 Development of an oblique cone

Self-Assessment Exercise

3.3 Transition Pieces

A few of the many types of transition pieces used for connecting pipes and openings of different shapes and sizes are illustrated pictorially in Fig. 2.18

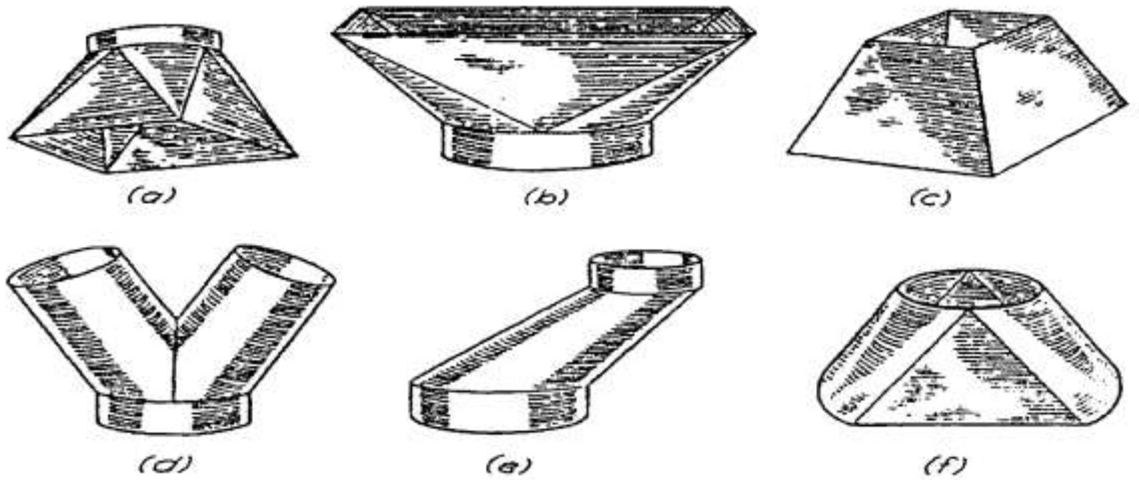
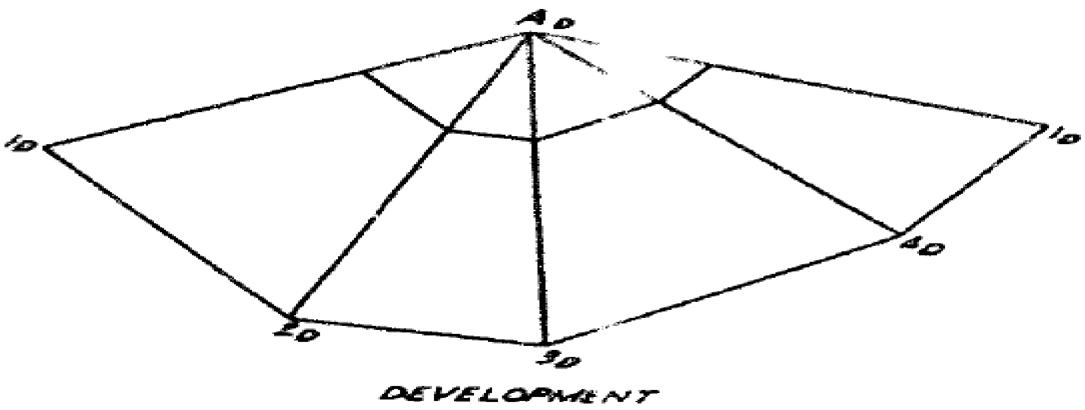


Figure 2.18 Transition pieces

3.4 Development of a Transition Piece Connecting Rectangular Pipes

The transition piece shown in Fig. 2,19 is designed to connect two rectangular pipes of different sizes on different axes. Since the piece is a frustum of a pyramid, it can be accurately developed by the method explained in Sec. 2.13



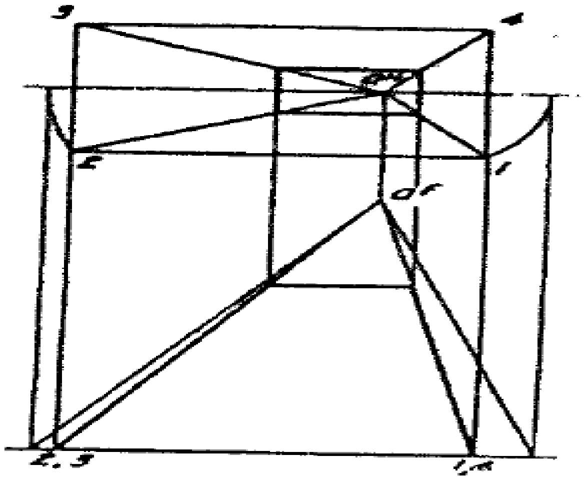


Figure 2.19 Transition piece

Self-Assessment Exercise

3.5 Development of a Transition Piece Connecting Two Circular Pipes

The transition piece shown in Fig. 2.20 connects two circular pipes on different axes. Since the piece is a frustum of an oblique cone, the surface must be triangulated, as explained in Sec. 2.17, and the development must be constructed by laying out the triangles in their true size in regular order. The general procedure is the same as that illustrated in Fig. 2.17. In this case. however, since the true size of the base is not shown in the top view, it is necessary to construct a partial auxiliary view to find the true lengths of chords between the end points of the elements.

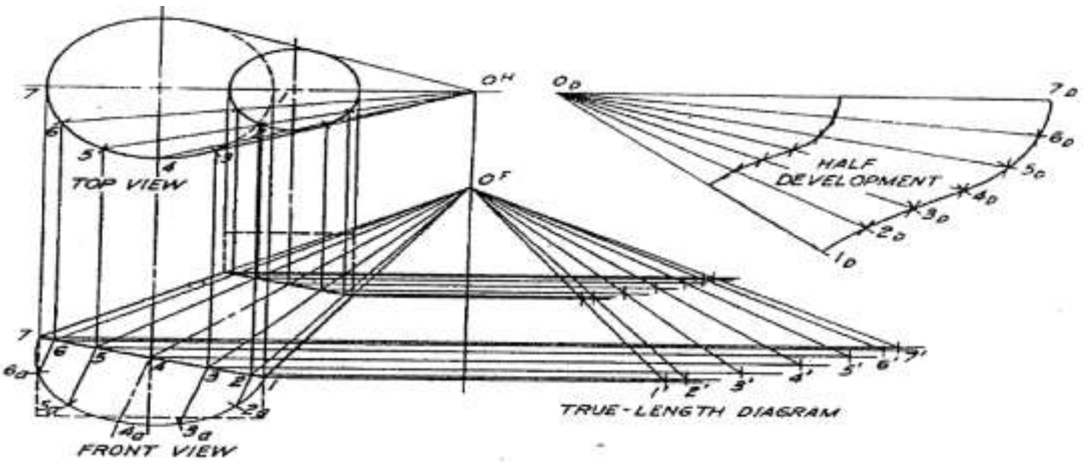


Figure 2.20 Transition piece connecting two pipes

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

1. Develop the lateral surface of the transition pieces shown in Figure Assignment 3. Show all construction lines in light, sharp pencil lines. Use a sufficient number of elements on the curved surfaces to ensure an accurate development.

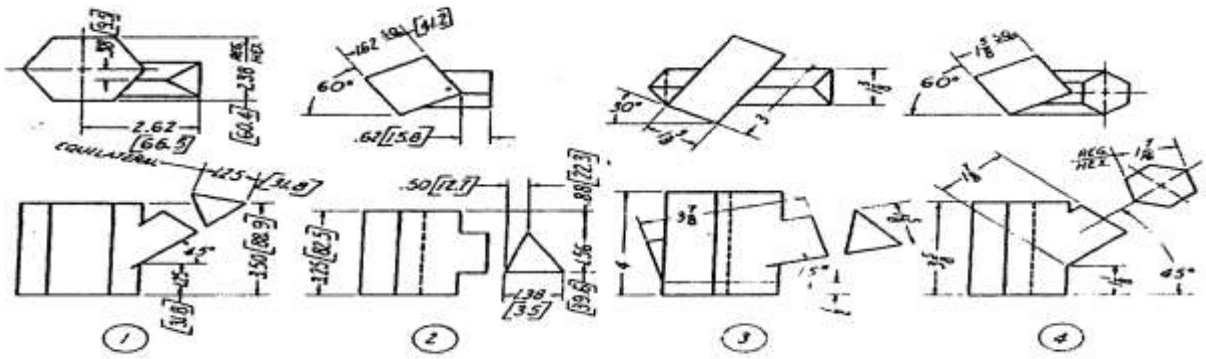


Figure Assignment 3

7.0 References

UNIT 3: TRUE LENGTH LINES AND DEVELOPMENT OF SURFACES

CONTENT

2.0 Objectives

At the end of this Unit, you should be able to**:**

1 Develop transition pieces connection circular and square shapes

2 Develop spheres

3.0 Main Body

3.1 Development of a Transition Piece Connecting a Circular and a Square Pipe

A detailed analysis of the transition piece shown in Fig. 2.21 reveals that it is composed of four isosceles triangles whose bases form the square base of the piece and four conical surfaces that are parts of oblique cones. It is not difficult to develop this type of transition piece because, since the whole surface may be "broken up" into component surfaces, the development may be constructed by developing the first and then each succeeding component surface separately (Fig. 2.15). The surfaces are developed around the piece in a clockwise direction, in such a manner that each successive surface is joined to the preceding surface at their common element. In the illustration, the triangles 1LO, 4LM, 7MN, and 10NO are clearly shown in top view. Two of these, 1LO and 10NO, are visible on the pictorial drawing. The apexes of the conical surfaces are located at the corners of the base.

Before starting the development, it is necessary to determine the true lengths of the elements by constructing a true-length diagram, as explained in Sec. 2.11. The true lengths of the edges of the lower base (LM, MN, NO, and OL) and the true lengths of the chords (1-2, 2-3, 3-4, and so on) of the short arcs of the upper base are shown in the top view. The development is constructed in the following manner: First, the triangle 1_DPL is constructed, using the length pHLH taken from the top view and true lengths from the diagram. Next, using the method explained in Sec. 2.17, the conical surface, whose apex is at L, is developed in an attached position. Triangle 4_DLM is then added, and so on, until all component surfaces have been drawn.

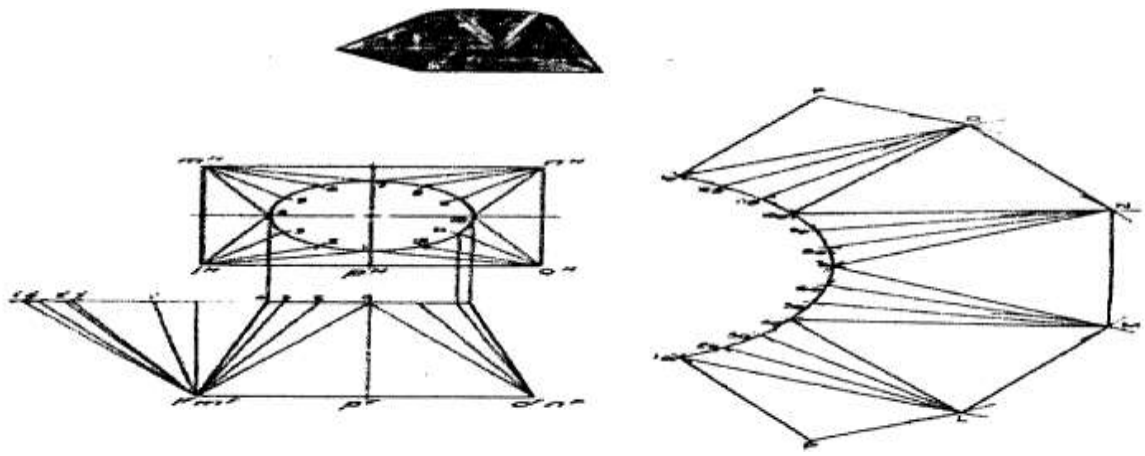


Figure 2.21 Transition piece connecting a circular and square pipe

Self-Assessment Exercise

3.2 Development of a Transition Piece Having an Approximately Developable Surface by the Triangulation Method

Figure 2.22 shows a half development of a transition piece that has a warped surface instead of a partially conical one, such as that discussed in Sec. 2.21. The method of constructing the development is somewhat similar, however, in that it is formed by laying out, in true size, a number of small triangles that approximate the surface. The true size of the circular intersection is shown in the top view, and the true size of the elliptical intersection is shown in the auxiliary view, which was constructed for that purpose.

The front half of the circle in the top view should be divided into the same number of equal parts as the half-auxiliary view. By joining the division points, the lateral surface may be initially divided into narrow quadrilaterals. These in turn may be subdivided into triangles by drawing diagonals, which, though theoretically curved lines, are assumed to be straight. The true lengths of the elements and the diagonals are found by constructing two separate true length diagrams by the method illustrated in Fig. 2.12.

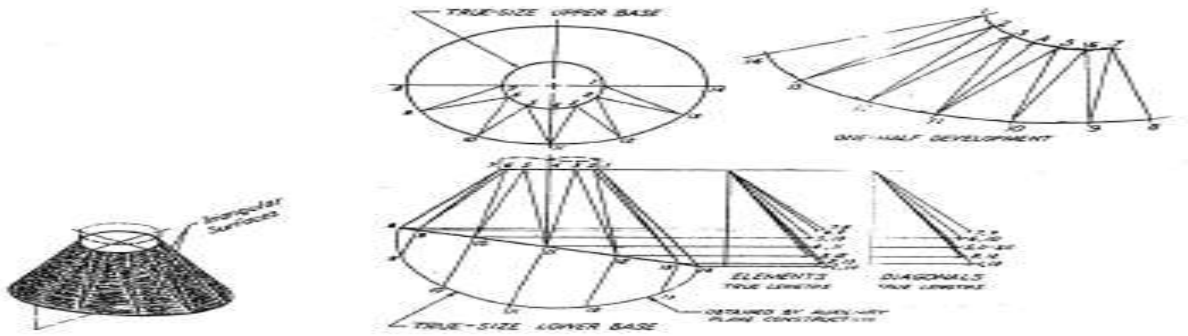


Figure 2.22 Development of transition piece by triangulation

Self-Assessment Exercise

3.3 Development of a Sphere

The surface of a sphere is a double-curved surface that can be developed only by some approximate method. The standard methods commonly used are illustrated in Fig. 2.23.

In (a) the surface is divided into a number of equal meridian sections of cylinders. The developed surfaces of these form as approximate development of the sphere. In drawing the development it is necessary to develop the surface of only one section, for this can be used as a pattern for the developed surface of each of the others.

In (b) the sphere is cut by parallel planes, which divide it into a number of horizontal sections, the surfaces of which approximate the surface of the sphere. Each of these sections may be considered the frustum of a right cone whose apex is located at the intersection of the chords extended.

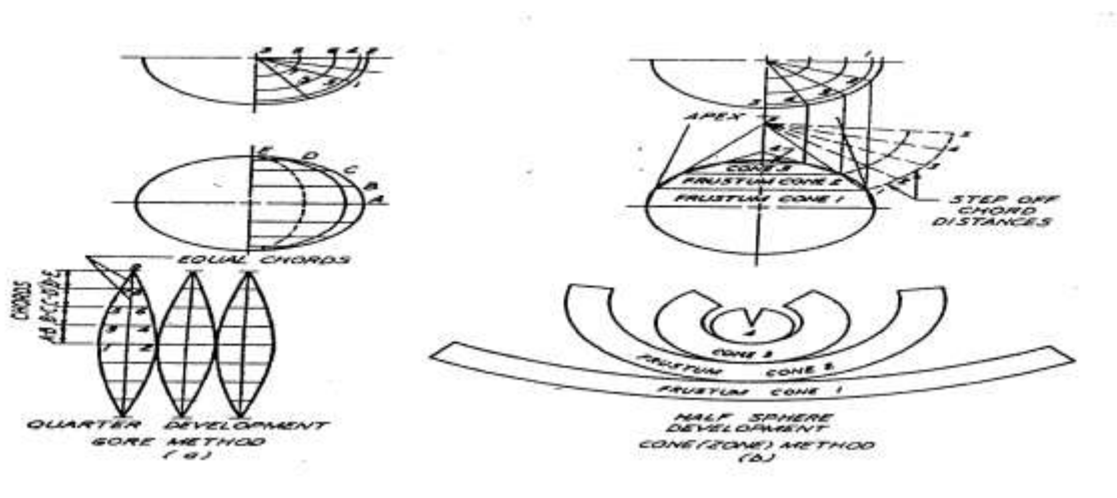


Figure 2.23 Approximate development of a sphere

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Develop the sheet-metal connections. On pieces 3 and 4, as shown in Figure Assignment 4; use a sufficient number of elemes..s to obtain a smooth curve and an accurate development.

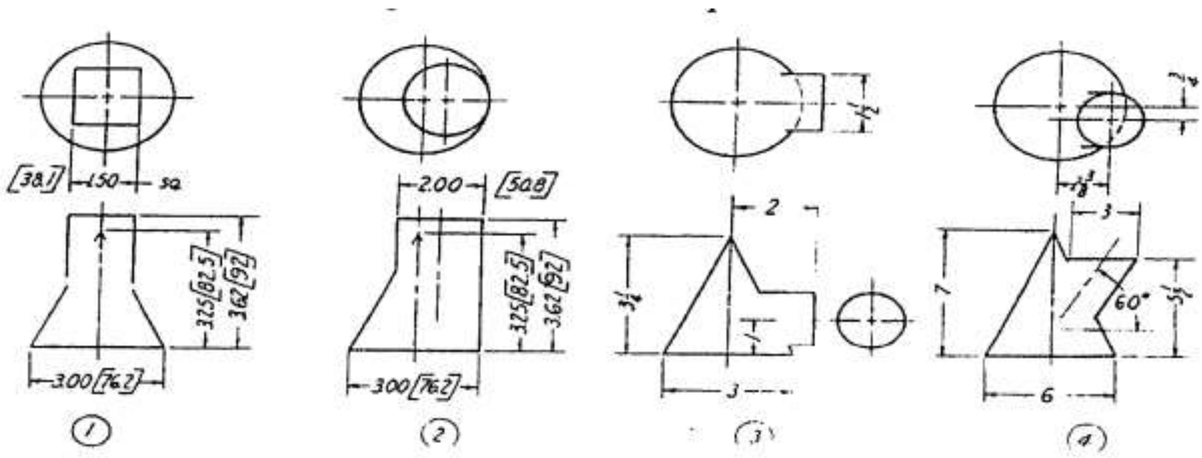


Figure Assignment 4

7.0 References

Unit 4: Determination of Intersection of Lines

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to**:**

1. Discuss the concept of Intersection of lines and surfaces
2. Determine points of intersection of lines and surfaces
3. Determine points of intersection of objects

3.0 Main Body

3.1 Lines of Intersection of Geometric Surfaces

The line of intersection of two surfaces is a line that is common to both. It may be considered the line that would contain the points in which the elements of one surface would pierce the other. Almost every line on a practical orthographic representation is a line of intersection; therefore, the following discussion may be deemed an extended study of the same subject. The methods presented in this chapter are the recognized easy procedures for finding the more complicated lines of intersection created by intersecting geometric surfaces.

In order to complete a view of a working drawing or a view necessary for developing the surfaces of intersecting geometric shapes, one frequently must find the line of intersection between surfaces. On an ordinary working drawing the line of intersection may be "faked in" through a few critical points. On a sheet-metal drawing, however, a sufficient number of points must be located to obtain an accurate line of intersection and an ultimately accurate development.

The line of intersection of two surfaces is found by determining a number of points common to both surfaces and drawing a line or lines through these points in correct order. The resulting line of intersection may be straight, curved, or straight and curved. The problem of finding such a line may be solved by one of two general methods, depending on the type of surfaces involved.

For the purpose of simplifying this discussion of intersections, it should be assumed that all problems are divided into these two general groups:

Group I. Problems involving two geometric figures, both of which are composed of plane surfaces.

Group II. Problems involving geometric figures which have either single-curved or double-curved surfaces.

For instance, the procedure for finding the line of intersection of two prisms is the same as that for finding the line of intersection of a prism and a pyramid; hence, both problems belong in the same group (Group **I).** Since the problem of finding the line of intersection of two cylinders and the problem of finding the line of intersection of a cylinder and a cone both involve single-curved surfaces, these two also belong in the same group (Group **II).**

Problems of the first group are solved by locating the points through which the edges of each of two geometric shapes pierce the other. These points are vertices of the line of intersection. Whenever one of two intersecting plane surfaces appears as a line in one view, the points through which the lines of the other surfaces penetrate it usually may be found by inspecting that view.

Problems of the second group may be solved by drawing elements on the lateral surface of one geometric shape in the region of the line of intersection. The points at which these elements intersect the surface of the other geometric shape are points that are common to both surfaces and consequently lie on their line of intersection. A curve, traced through these points with the aid of a French curve, will be a representation of the required intersection. To obtain accurate results, some of the elements must be drawn through certain critical points at which the curve chai-4,c,s sharply in direction. These points usually are located on contour elements. Hence, the usual practice is to space the elements equally around the surface, starting with a contour element.

Self-Assessment Exercise

3.2 Determination of a Piercing Point by Inspection

It is easy to determine where a given line pierces a surface when the surface appears as an edge view (line) in one of the given views. For example, when the given line AB is extended as shown in (a), the F-view of the piercing point C is observed to be at cf., where the frontal view of the line AB extended intersects the line view of the surface. With the position of cP known, the H-view of point C can be quickly found by projecting upward to the H-view of AB extended.

In (b) the H-view (V) of the piercing point F is found first by extending d"e" to intersect the edge view of the surface pierced by the line. By projecting downward, fP is located on dFel extended.

In (c) the views of the piercing point K are found in the same manner as•in (b), the only difference being that the edge view of the surface pierced by the line appears as a circle arc in the H-view instead of a straight line. It should be noted that a part of the line is invisible in the F-view because the piercing point is on the rear side of the cylinder.

The F- and H-views of the piercing point R in (d) may be found easily by projection after the P-view (r') of R has been once established by extending pPqP to intersect the line view of the surface.

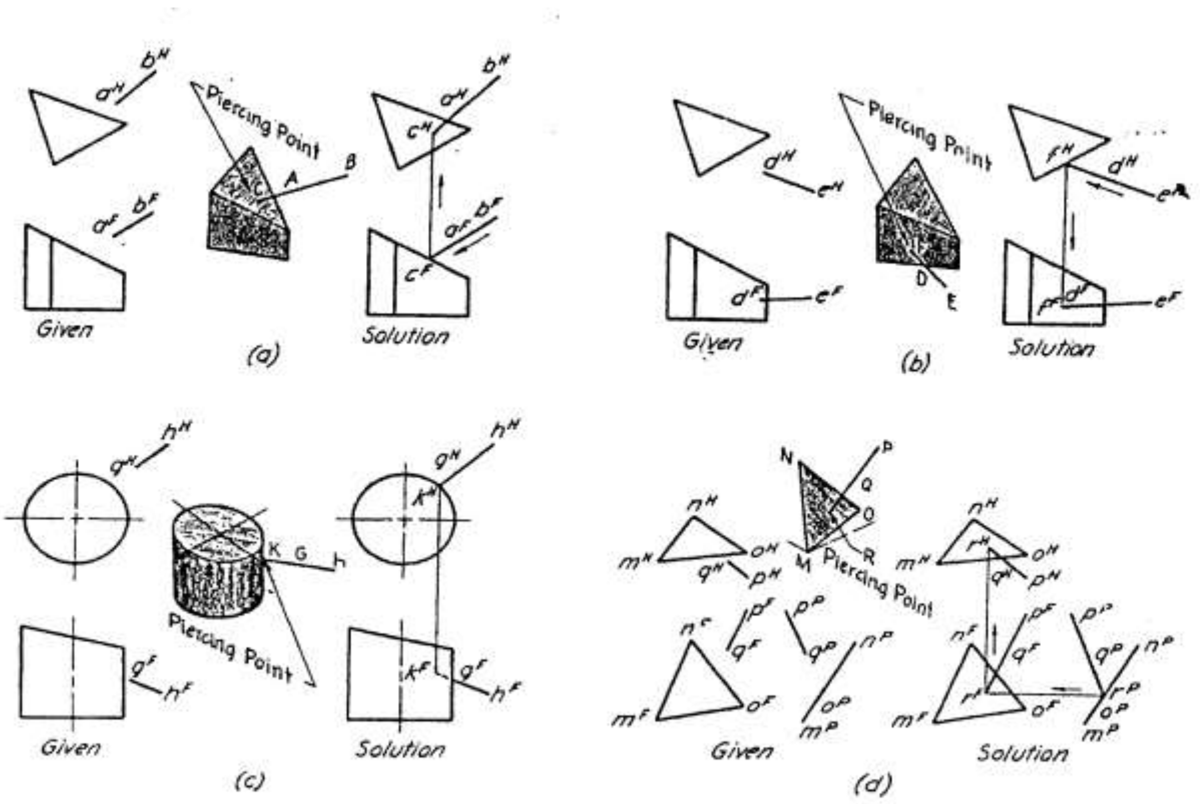


Figure 2.24 Determination of a piercing point by inspection

Self-Assessment Exercise

3.3 Determination of a Piercing Point Using a Line-projecting Plane

When a line pierces a given oblique plane and an edge view is not given, as in Fig. 2.25, a line-projecting plane (cutting plane) may be used to establish a line of intersection that will contain the piercing point. In the illustration, a vertical projecting plane was selected that would contain the given line RS and intersect the given plane ABC along line DE, as illustrated by the pictorial drawing.

Solution: Draw the H-view of the projecting plane through r"s"to establish d"e", as shown in the H-view in (c). Locate dFeF and draw the F-view of the line of intersection. Then, complete the line view rFsF to establish ^{p1F} at the point of intersection of rFsF and dFeF. Finally, locate p_i" on els" by projecting upward from p_iF, as shown in **(d).**

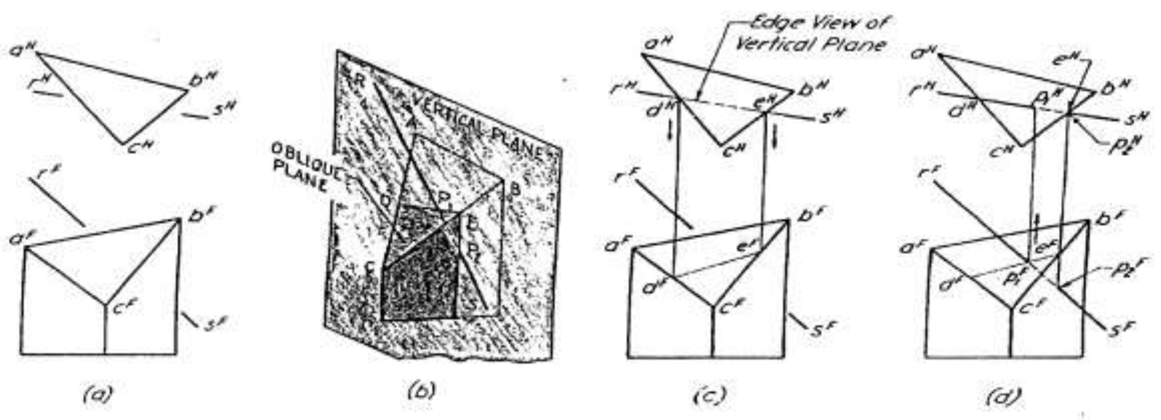


Figure 2.25 Use of a line-projecting plane

Self-Assessment Exercise

3.4 To Find Where a Line Pierces a Geometric Solid-cylinder-cone-sphere Using Projecting Planes

The points where a line pierces a cylinder, cone, or sphere may be found easily through the use of a projecting plane (cutting plane) that contains the given line, as illustrated in (a), (b), and (c).

In (a) the intersections of the projecting plane and the cylinder .ire straight-line elements because the projecting plane used is parallel to the axis of the cylinder. The use of planes parallel to the axis permits the rapid solution of this type of problem. As shown by the pictorial drawing, the vertical projecting plane cuts elements on both the right and left sides of the cylinder. The line AB intersects the element RS at C and the other element at D. Points C and D are the piercing points.

The piercing points of a line and a cone are the points of intersection of the line and the two specific elements of the cone that lie in the projecting plane containing the line as shown in (b). The vertex of the cone and the given line fix the position of the projecting plane, the plane of the elements. In the illustration, the vertical projecting plane, taken through the line EF and the vertex of the cone T, cuts the base of the cone at U and V, the points needed to establish the F-views of the elements lying in the plane. The points of intersection of the given line EF and these elements are points G and H, the points where the line pierces the cone. If the given line had not been in a position to intersect the axis of the cone, it would have been necessary to use an oblique cutting plane through the apex

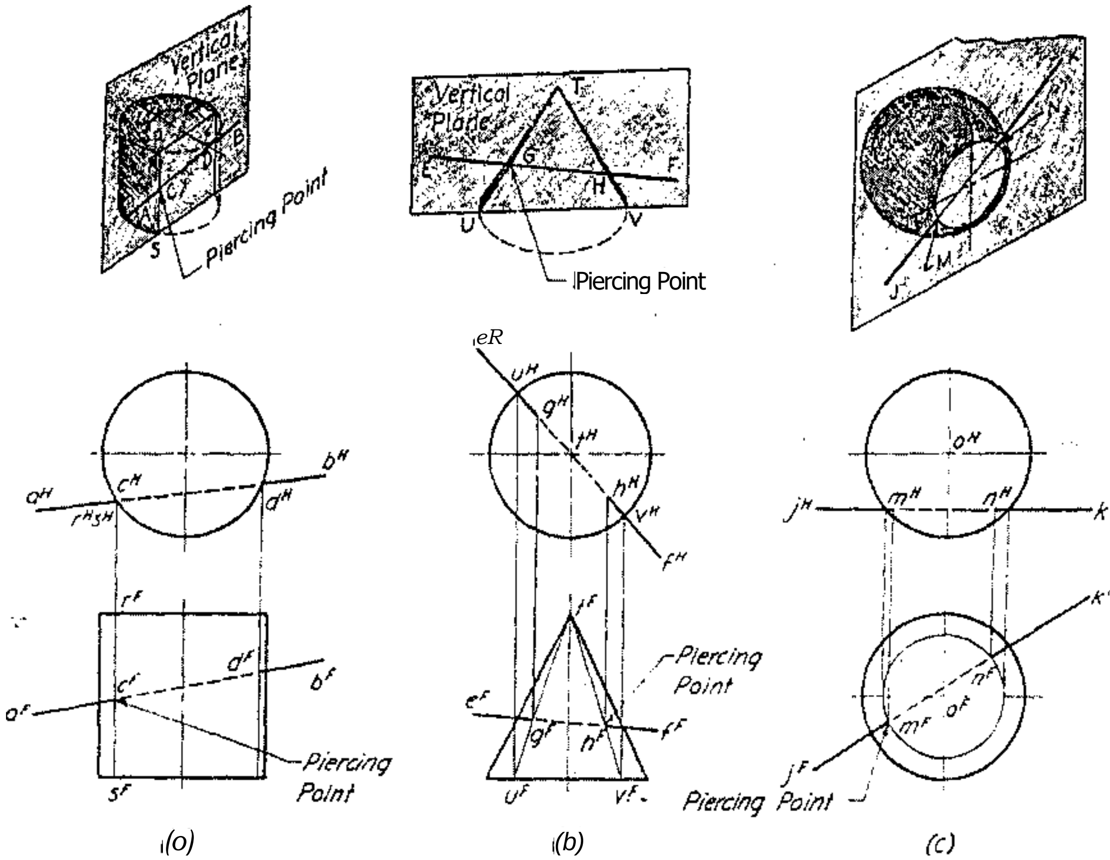


Figure 2.25 Use of line projection-plane

A projecting plane that contains a line piercing a sphere will cut a circle on the surface of the sphere; therefore, points where the given line intersects the circle will be points where the line pierces the sphere. [See the pictorial drawing in (c).] In the illustrations, a vertical projecting plane was used containing the given line JK. The F-views of the piercing points M and N (mFnF) were found first at the points of intersection of the line and the circle. The H-views (mHnH) of the piercing points were found by projecting upward from mF and nF in the F-view

Self-Assessment Exercise

3.5 Determination of the Points Where a Line Pierces a Cone, General Case

In Sec. 2.27, the statement was made that the piercing points of a line and a cone are the points of intersection of the line and the two specific elements of the cone that lie in the projecting plane containing the line and the apex of the cone [Fig. 2.26(b)]. This pertained to a special condition for which a line-projecting plane could be used. For other cases, the following general statement applies: The piercing points of a line and any surface must lie on the lines of intersection of the given surface and a cutting plane that contains the line. Obviously, an infinite number of cutting planes could have been assumed that would have contained the line AB in. Fig. 2.27, but all would have resulted in curved lines of intersection, except in the case of· the one plane that was selected to pass through the apex 0 of the cone. As can be noted by observing the pictorial drawing, this choice gives a plane that intersects the cone along two straight-line elements.

Solution: (1) Form a cutting plane containing the line AB and the apex 0 by drawing a line from 0 to an assumed point M on line AB. Lines AB and OM define the cutting plane. (2) Extend the elements of intersection OF1 and OF2 in the F-view. Points P_1F and P_2F, where the F-views of these elements intersect aFbF, are the F-views of the piercing points of the line AB and the given cone. (4) Project the F-views of the piercing points to the H-view to locate P,H and P_2H.

When the line and cone are both oblique an added view (auxiliary view), showing the base as an edge, may be needed to obtain a quick and accurate solution employing the steps illustrated in Fig. 2.27.

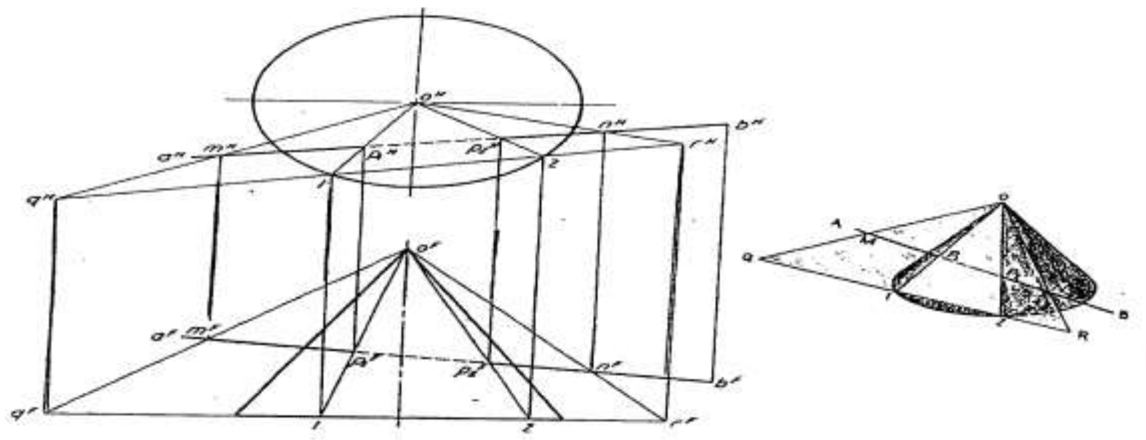


Figure 2.27 To determine the points where a line pierces a cone-general case

Self-Assessment Exercise

4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment

1. Draw the line of intersection of the intersecting geometric shapes as shown in Figure Assignment 5.. Show the invisible portions of the lines of intersection as well as the visible. Consider that the interior is open

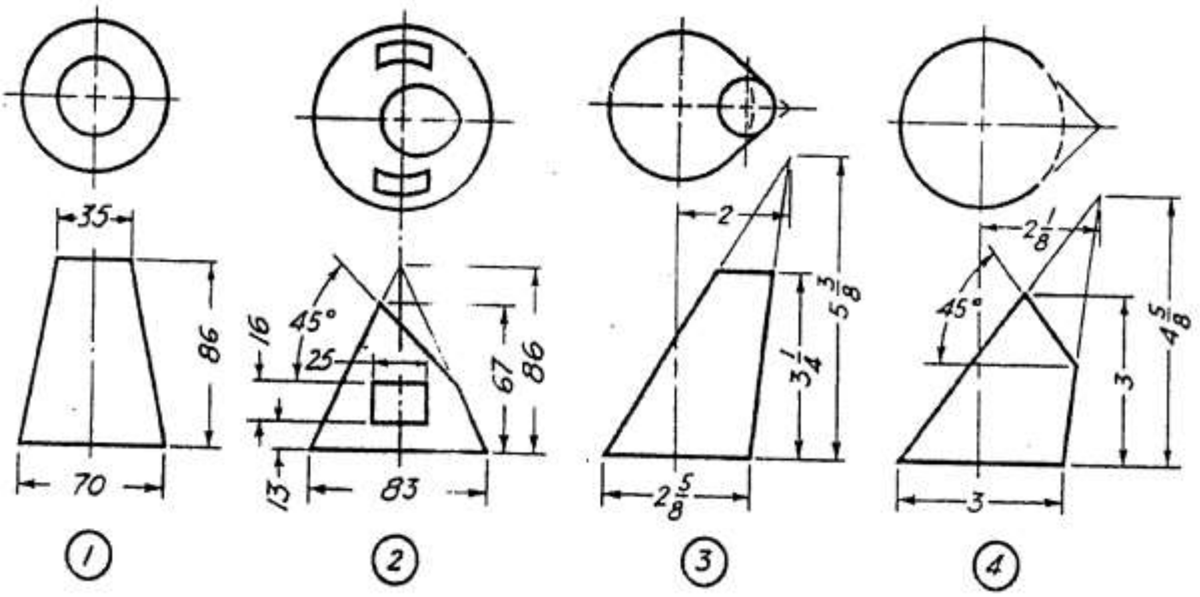


Figure Assignment 5

7.0 References

UNIT 5: DETERMINATION OF INTERSECTION OF PLANES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to**:**

1. Explain the concept of Intersection of planes
2. Determine points of intersection of cylinders and planes
3. Determine points of intersection oblique planes and objects

3.0 Main Body

3.1 To Find the Intersection of Two Planes, Line-projecting Plane Method

The intersection of two oblique planes may be determined by finding where two of the lines of one plane pierce the other plane, as illustrated by the pictorial drawing in Fig. 2.28. The procedure that is illustrated employs line-projecting planes to find the piercing points of the lines XY and XZ and the oblique plane RST. Therefore, it might be said that the solution requires the determination of the piercing point of a line and an oblique plane, as explained in Sec. 2.26.

Given: The oblique planes RST and XYZ.

Solution: Since the (vertical) line-projecting plane Cy, is to contain the line XY of the plane XYZ, draw the line-view representation of this projecting plane to conincide with xHyH. Next, project the line of intersection AB between the line-projecting plane Cy, and plane RST from the to the front view. Then, since it is evident that the line AB is not parallel to XY, which lies in the projecting plane (see F-view), the line XY intersects AB. The location of this intersection at E is established first in the F-view, where the line xFyF intersects aFbF at eF. The H-view of E, that is eH, is found by projecting upward from eF in the F-view to the line view xHyH. The other end of the line of intersection between the two given planes at F is found by using the line-projecting plane C_2P_2 and following the same procedure as for determining the location of point E.

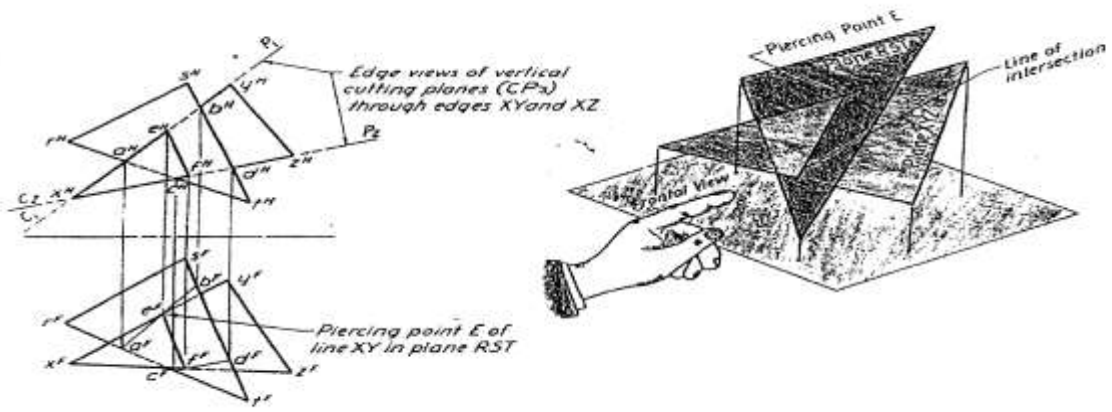


Figure 2.28 To find the intersection line of two planes

Self-Assessment Exercise

3.2 To Find the Intersection of a. Cylinder and an Oblique Plane

There are two distinct and separate methods shown in Fig. 2.29 for finding the line of intersection of an oblique plane and a cylinder. Both methods appear together on the drawing at the left. The selected line method is illustrated pictorially in (b), while the cutting-plane method is shown in (c).

In the application of the selected line method, any line of the given plane, such as line BR, is drawn in the F and H-views (a). It can be noted by observing, in the pictorial drawing in (b), that this particular line pierces the cylinder at points P_I and P_2 to give two points on the line of intersection. On the multiview drawing, the locations of the H-views of points P_1 and P_2 can readily be recognized as being at the points labeled p_iH and p_2H, where the line view bHrH intersects the edge view of the surface of the cylinder. The F-views (p_1F and p_2F) of points P_i and P, were found by projecting downward from p_1H and p_2H to the line view bFrF. Additional points along the line of intersection, as needed, can be obtained by using other lines of the plane.

The line of intersection of this same plane and cylinder could have been almost as easily determined through the use of a series of line-projecting (cutting) planes passed parallel to the axis of the cylinder, as illustrated in (c). It should be noted that the vertical cutting plane shown cuts elements on the cylinder that intersect XY, the line of intersection of the cutting plane and the given plan at points P_3 and P_4. Points P_3 [not visible in (c)] and P_4 are two points on the line of intersection, for they lie in both the cutting plane and the given plane and are on the surface of the cylinder. After the position of the cutting plane has been established in (a) by drawing the line representation in the H-view, xH and yH must be projected downward to the corresponding lines of the plane in the F-view. Line xFyF as then drawn is the F-view of the line of intersection of the cutting plane and given plane. Finally, as the last step, the intersection elements that appear as points in the H-view at p_3H and p_4H must be drawn in the F-view. The F-views of points P_3 and P_4 (P_3^F and p_4F) are at the intersection of the F-views of the elements and the line xFyF.

A series of selected planes will give the points needed to complete the F-view of the intersection.

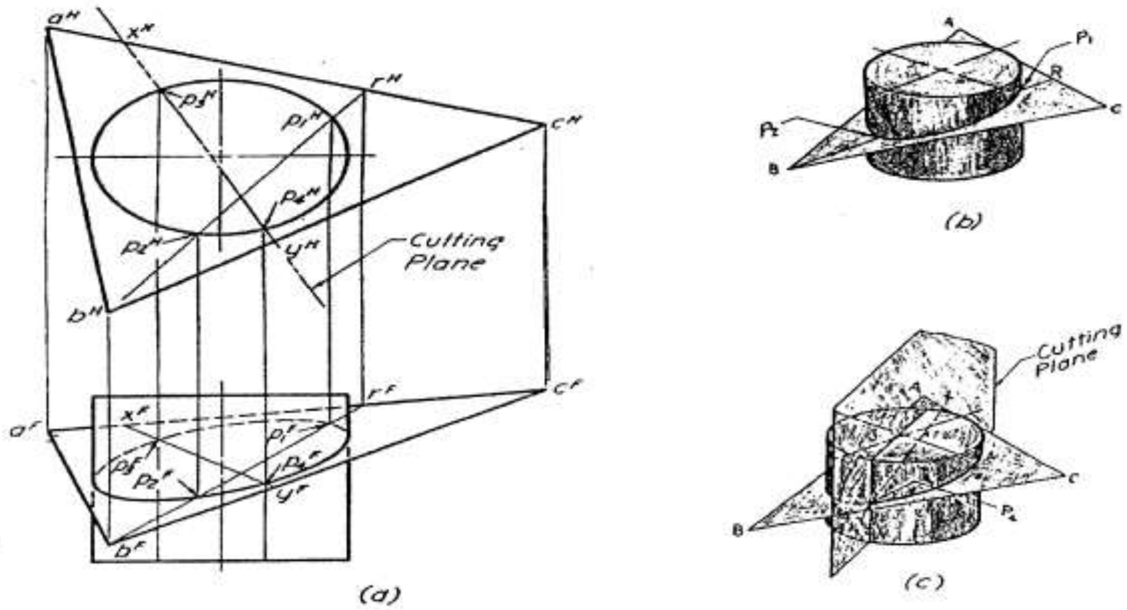


Figure 2.29 To find the intersection of a cylinder and a plane

Self-Assessment Exercise

3.3 To Find the Intersection of a Cone and an Oblique Plane

When the intersecting plane is oblique, as is true in Fig. 2.30, it is usually desirable to employ the cutting-plane method shown in (a) rather than to resort to the use of an additional view, as in (b). Since the given cone is a right cone, any one vertical cutting plane, passing through the apex 0, will simultaneously cut straight lines on the conical surface and across the given oblique plane. The pictorial illustration shows that the cutting plane XY intersects the cone along the two straight-line elements 0-2 and 0-8 and the plane along the line RS. Points G and H, where the elements intersect the line RS, are points along the required line of intersection because both points lie in the given plane ABCD and are on the surface of the cone. In (a), the tine representation of the cutting plane XY in the H-view establishes the position of the H-view (r''s'') of the line RS. The H-views of elements 0-2 and 0-8 also lie in the edge view of the cutting plane XY. With this much known, the F-views of the two elements and line RS may be drawn. Points gF and hF are at the intersection of rFsF and OF-2 and OF-8, respectively. A series of cutting planes passed similarly furnishes the points needed to complete the solution.

At times one might prefer to determine the line of intersection through the use of a constructed auxiliary view that shows the given plane as an edge. In this case, when selected elements may be seen to intersect the line view of the plane in the auxiliary view, the solution becomes quite simple, because all that is required is to project the point of intersection of an element and the line view of the plane to the F- and H-views of the same element. For example, the A-view (oA-8) of the eleinent 0-8 can be seen to intersect the edge line aAbAcAdA at hA, the A-view of point H. By projecting to line o"-8, the H-view of H (h") may be easily established. The F-view of H (h^F) lies directly below h" on OF-8. Through the projected views of other points, located similarly, smooth curves may be drawn to form the F- and H-view representations, as shown

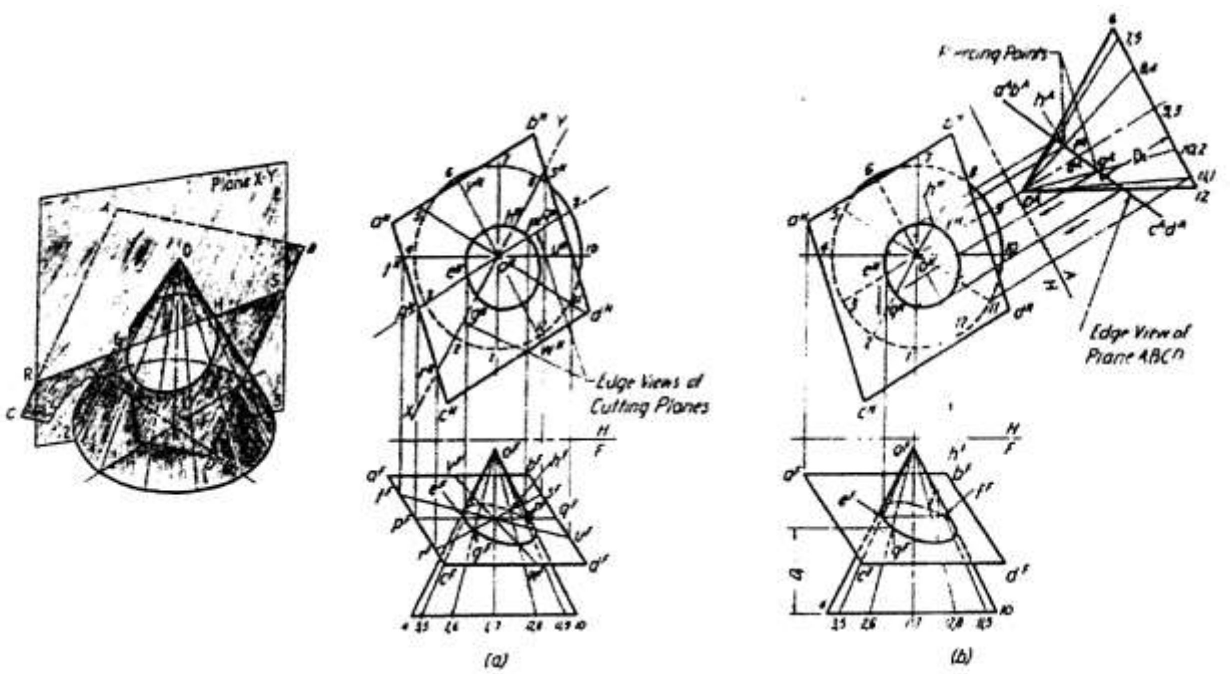


Figure 2.30 To find the intersection of a cone and a plane

Self-Assessment Exercise

3.4 To Find the Intersection of a Sphere and an Oblique Plane

Horizontal cutting planes have been used to find the line of intersection of the sphere and oblique plane shown in Fig. **2.31.** Two approaches to the solution have been given on the line drawing. The horizontal cutting planes, as selected, cut circles from the sphere and straight lines from the given oblique plane. For example, the cutting plane CP, in the F-view cuts the horizontal line 3-3 from plane ABCD and a circle from the sphere. This circle appears as an edge in the F-view and shows in its true diameter. In the H-view it will show in true shape. The line and circle intersect at two points that also have been identified by the number 3, the number assigned to the cutting plane in which these two points lie. These points now located in the H-view are projected to the CP_3 line in the F-view. The curved line through points, that have been determined by a series of planes, is a line common to both surfaces and is therefore the line of intersection.

This problem could also have been solved by using an auxiliary view showing the plane ABCD as an edge. As before, the horizontal cutting planes will cut circles from the sphere and lines from the plane. However, in this case both the lines and the intersections show as points in the A-view. For each CP these points must be projected from the auxiliary view to the corresponding circle in the H-view. The F-views of these points on the line of intersection may be found by projection and by using measurements taken from the A-view

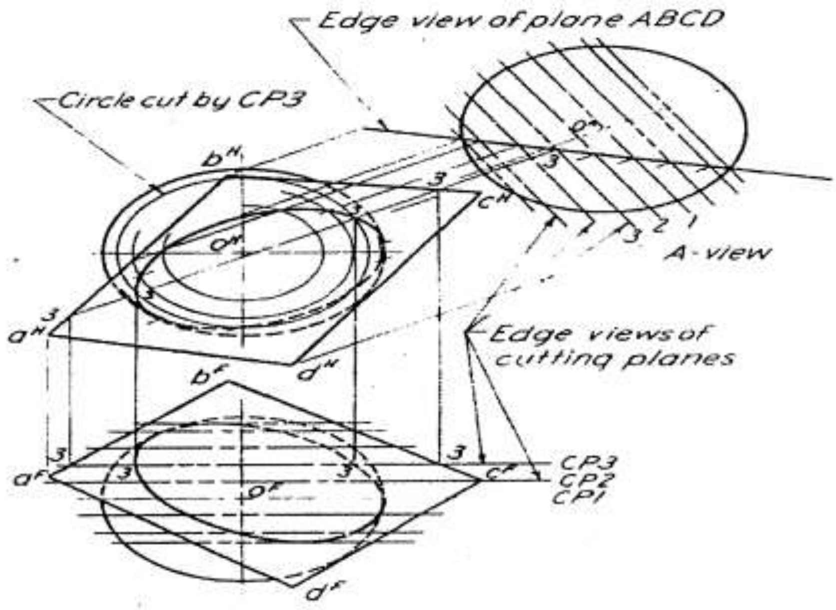


Figure 2.31 To fined the intersection of a sphere and an oblique plane

Self-Assessment Exercise

4.0 Conclusion
5.0 Summary
6.0 Tutor Marked Assignment

1. Draw the line of intersection of the intersecting geometric shapes as assigned. It is suggested that the elements used to find points along the intersection be spaced 15° apart. Do not erase the construction lines. One shape does not pass through the other

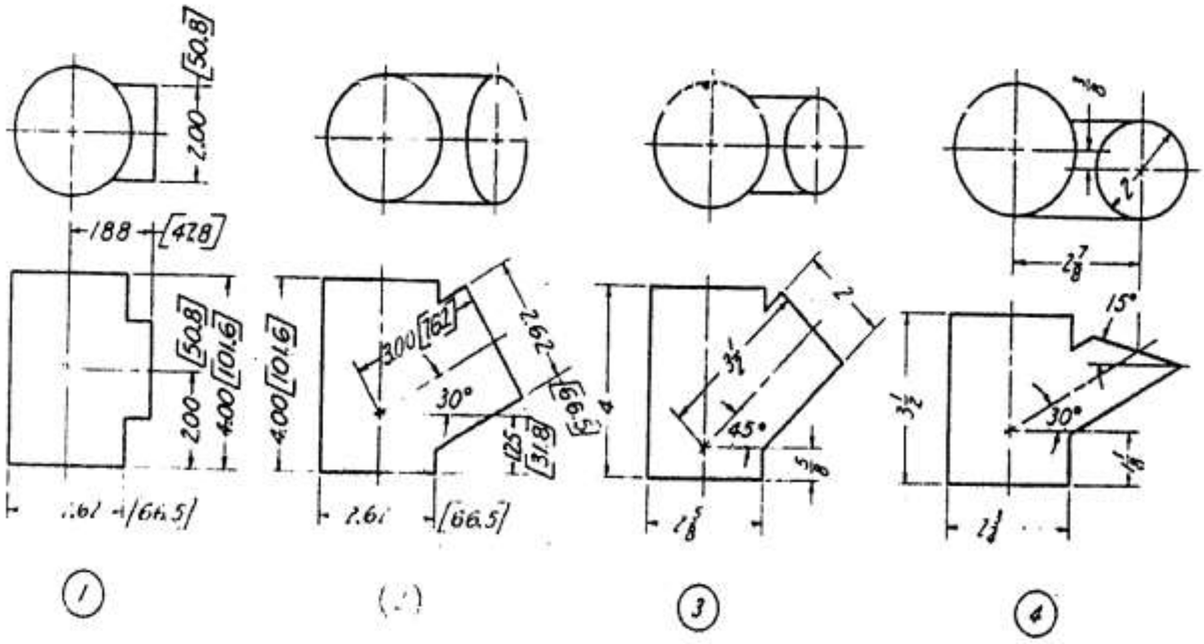


Figure Assignment 6

7.0 References

UNIT 1: DETERMINATION OF INTERSECTION OF OBJECTS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

1. Explain the concept of Intersection of various shapes
2. Determine points of intersection of pyramids and prisms
3. Determine of intersection of cylinders
4. Determine points of intersection oblique cylinders

3.0 Main Body

3.1 To Find the Intersection of Two Prisms

In Fig. 2.32, points A, C, and D, through which the edges of the horizontal prism pierce the vertical prism, are first found in the top view (a", c", and d") and are then projected downward to the corresponding edges in the front view. Point B, through which the edge of the vertical prism pierces the near face of the triangular prism, cannot be found in this manner because the side view from which it could be projected to the front view is not shown. Its location, however, can be established in the front view without even drawing a partial side view, if some scheme like the one illustrated in the pictorial drawing is used. In this scheme, the intersection line AB, whose direction is shown in the top view as line aHbH, is extended on the triangular face to point X on the top edge. Point xH is projected to the corresponding edge in the front view and a light construction line is drawn between the points aF and xF. Since point B is located on line AX (see pictorial) at the point where the edge of the prism pierces the line, its location in the front view is at point bF where the edge cuts the line aF xF

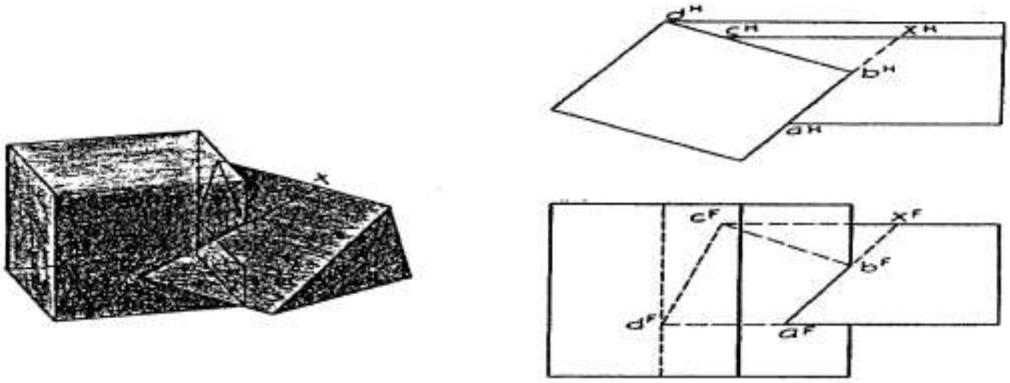


Figure 2.32 Intersecting prisms

Self-Assessment Exercise

3.2 To Find the Intersection of a Pyramid and a Prism

The intersection of a right pyramid and a prism may be found by the same general method used for finding the intersection of two prisms (Sec. 2.33)

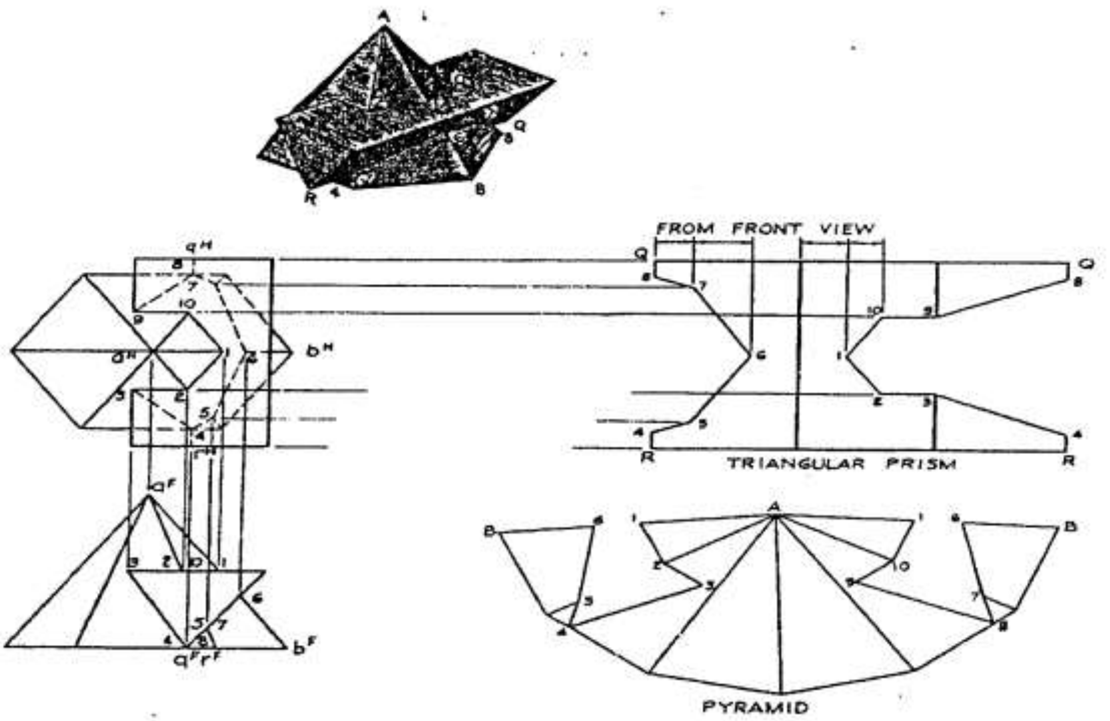


Figure 2.34 Intersecting pyramid and prism

Self-Assessment Exercise

3.3 To Determine the Intersection of a Prism and a Pyramid Using Line-Projecting Planes

Frequently, it becomes necessary to draw the line of intersection between two geometric shapes so positioned that the piercing points of edges cannot be found by inspection if only the principal views are to be used. In this case, one must resort to the method discussed in Sec. 2.26 to determine where a line, such as the edge line CD of the prism shown in Fig. 2.34, pierces a surface. As illustrated by the pictorial drawing, a vertical plane passed through the edge DG of the prism, intersects the surface ABC of the pyramid along line MN that contains point D, the piercing point of DG. In (a), the H-view (en") of the line MN lies along d" g" extended to in" on the edge of the pyramid, because the H-view of the cutting plane appears as an edge that coincide with d" g". With the F-view of MN established by projecting downward from rn" n" in the H-view, the frontal view of the piercing point D is at dF where the view of the edge line DG of the prism intersects mF nF. The H-view of D is four by projecting upward from dF. The two other piercing points, at E and F, are found in the same manner using two other line-projecting planes

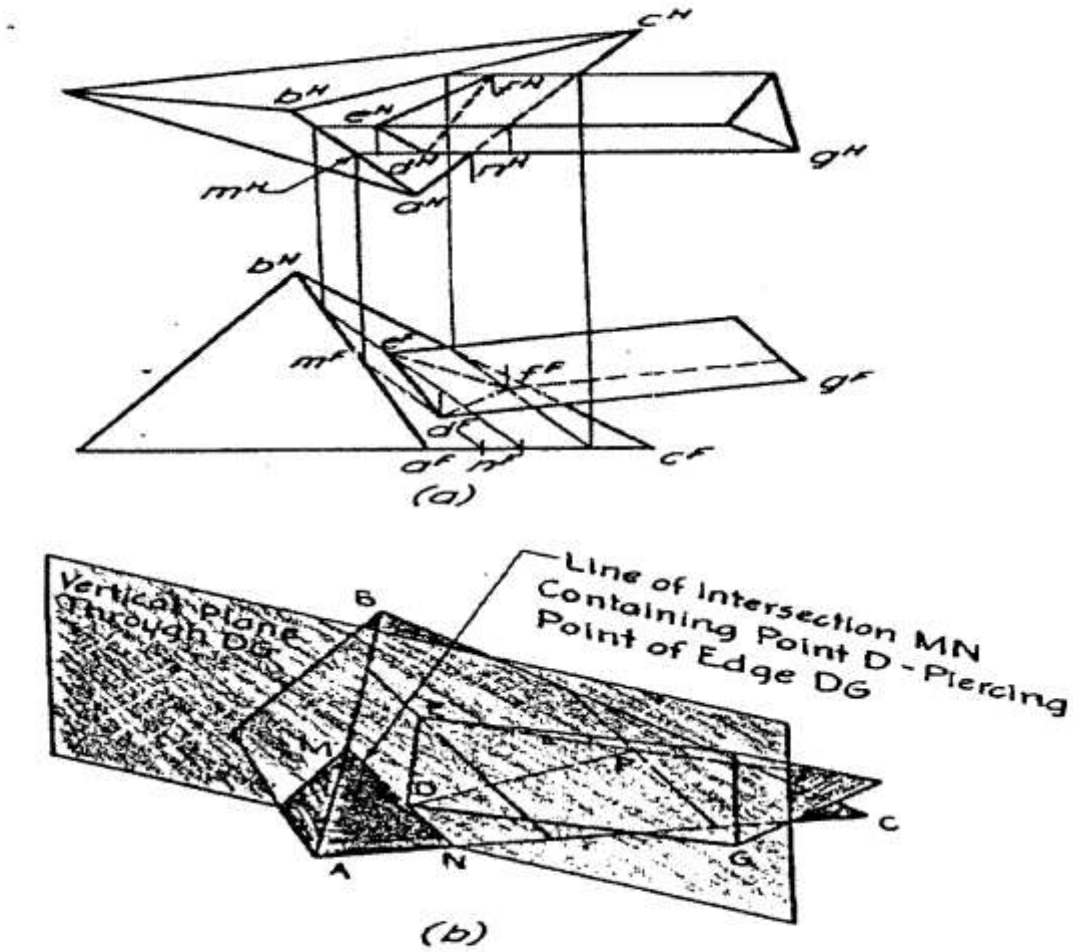


Figure 1.34 Intersecting pyramid and prism

Self-Assessment Exercise

3.4 To Construct a Development Using Auxiliary Views

When one of the component is oblique to the principal planes of projection, as is the prism in Fig. 2.35, the construction work needed for the development can be simplified somewhat thorough the use of an auxiliary view to find the true lengths of the edges and an oblique (secondary auxiliary) view to show a right section. Since the plane on which the auxiliary view is projected is a vertical one that is parallel to the edges of the prism, the distances perpendicular to the AH reference line are height distances. In making the construction, distances are taking from the F-view in the direction of single-headed arrow for use in the auxiliary view in the direction indicated by a similar arrow. For the oblique view, projected on an 0-plane that is perpendicular to both the A-plane and the edges of the prism, distances are taken from the AH reference line in the direction of the arrow numbered 2 to be laid out from the reference line for the 0-view. Since this is the second auxiliary, the arrows indicating the direction for equal distances have been given two heads.

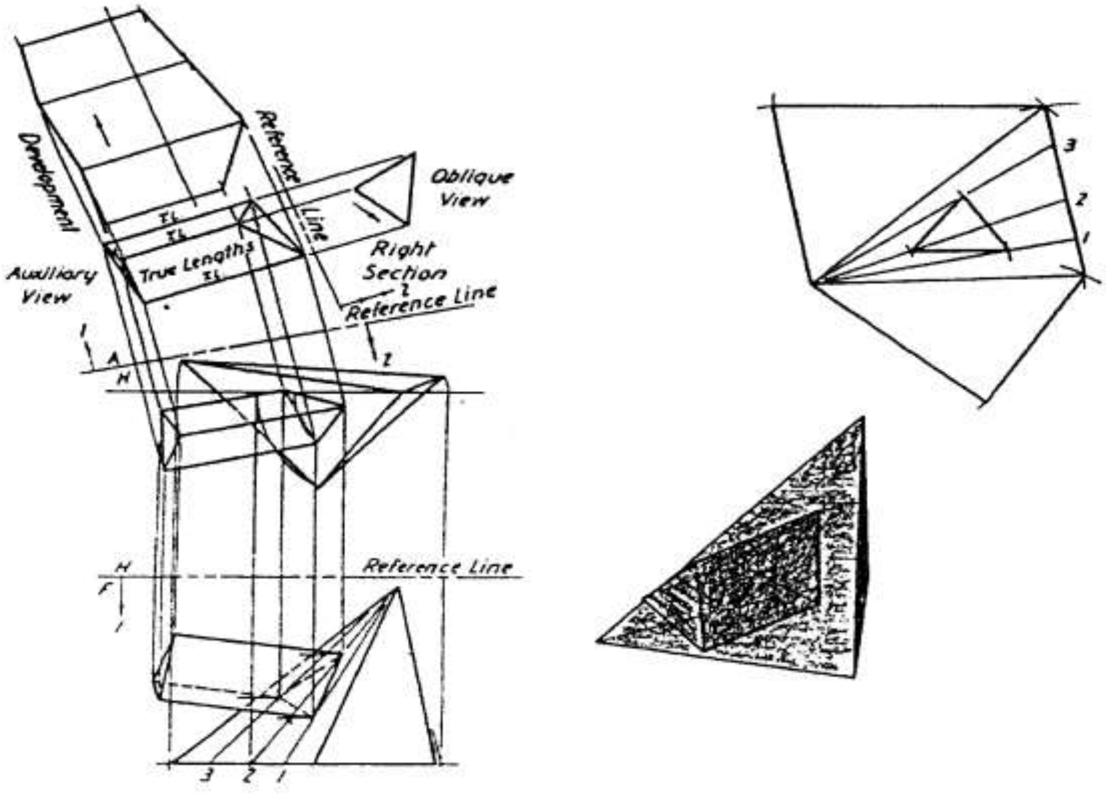


Figure 2.35 To construct a development using auxiliary view

If there is sufficient space available, the true-length measurements for the edges in the development may be projected directly from the auxiliary view showing the true lengths. The true distances between these edges, taken from the right section in the direction of the arrow, are laid off along the stretch-out line. The arrow on the development indicates the direction in which the successive faces are laid down when the prism is turned to unroll the lateral surface inside-up.

Self-Assessment Exercise

3.5 To Find the Intersection of Two Cylinders

If a series of elements are drawn on the surface of the small horizontal cylinder, as in Fig. 2.36, the points A, B, C, and D in which they intersect the vertical cylinder will be points on the line of intersection (see pictorial). These points, which are shown a^H, b^H, c^H and d^H in the top view, may be located in the front view by projecting them downward to the corresponding elements in the front view, where they are shown as points a^F, b^F, c^F, and d^F. The desired intersection is represented by a smooth curve drawn through these points..

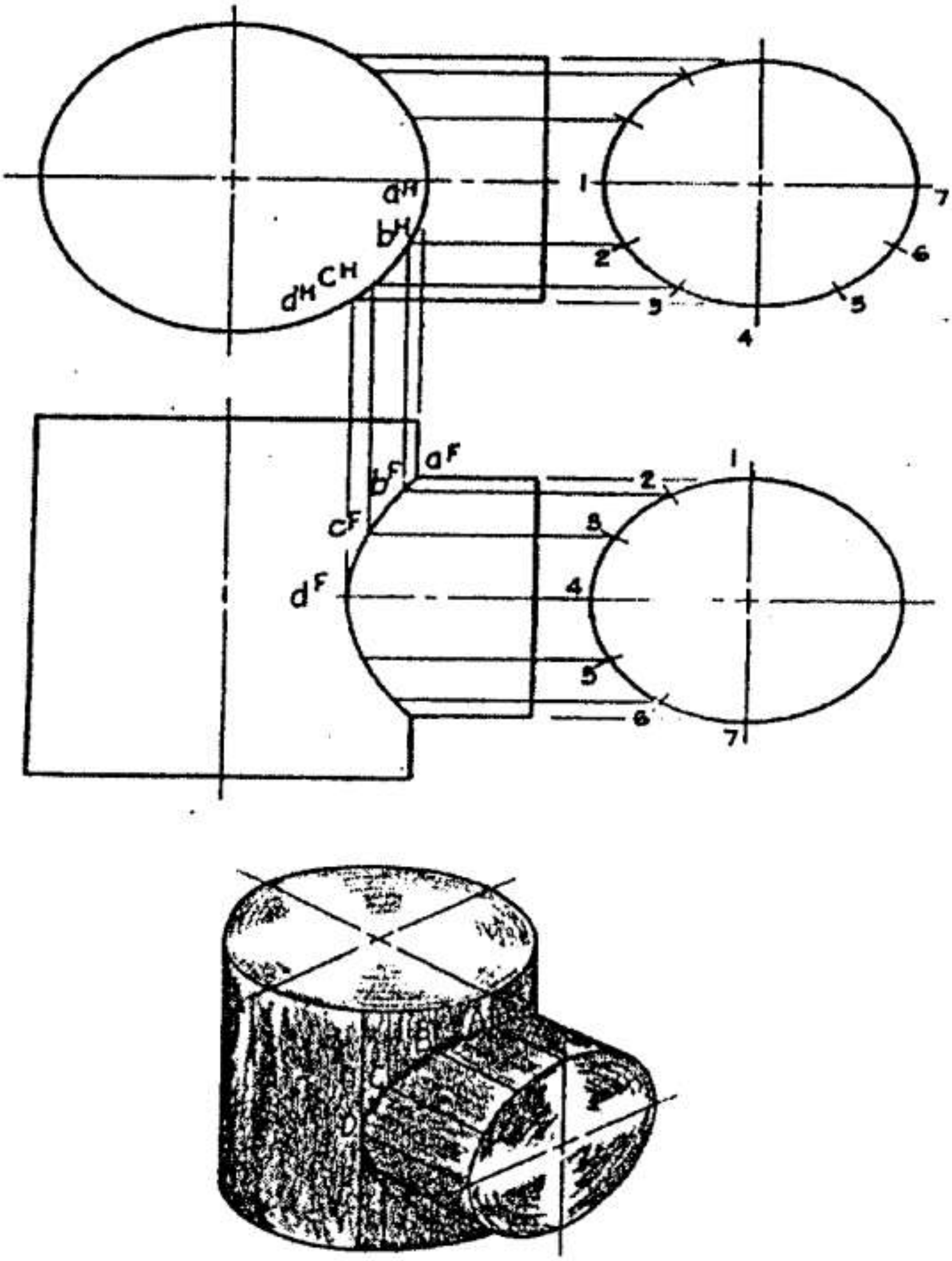


Figure 2.36 Intersecting cylinders

Self-Assessment Exercise

3.6 To Find the Intersection of Two Cylinders Oblique to Each Other

The first step in finding the line of intersection of two cylinders that are oblique to each other (Fig. 2.37) is to draw a revolved right section of the oblique cylinder directly on the front view of that cylinder. If the circumference of the right section is then divided into a number of equal divisions and elements are drawn through the division points, the points A, B. C, and D in which the elements intersect the surface of the vertical cylinder will be points on the line of intersection (see pictorial). In the case of the illustration shown, these points are found first in the top view and then are projected downward to the corresponding elements in the front view. The line of intersection in the from view is represented by a smooth curve drawn through these points.

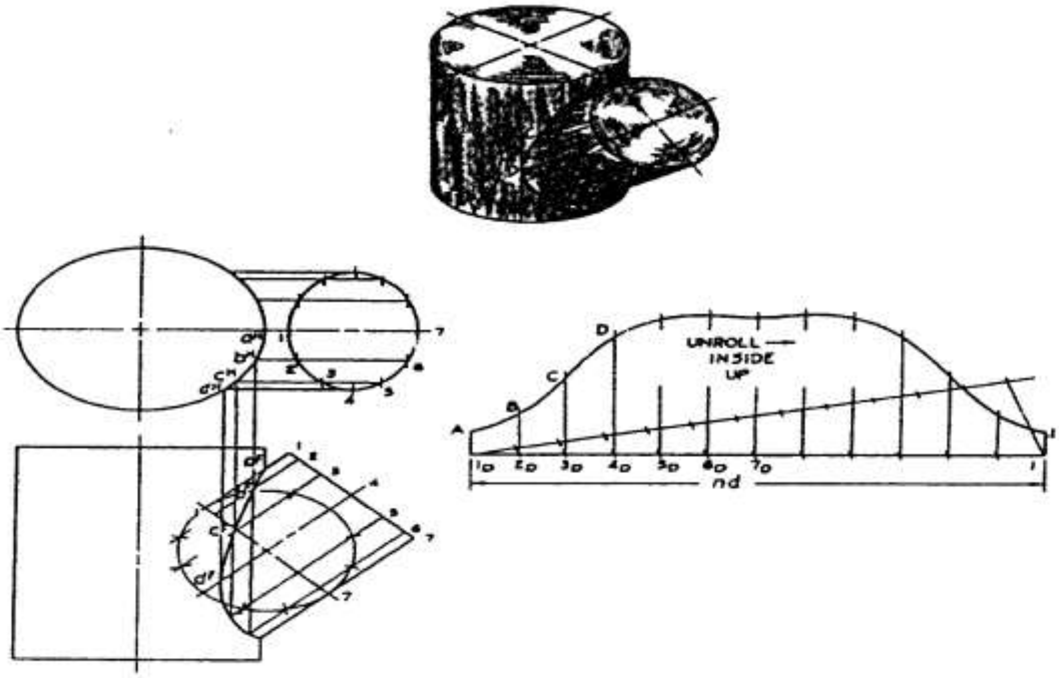


Figure 2.37 Intersecting cylinders

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1 Draw the line of intersection of the intersecting geometric shapes as shown in Figure Assignment 7. It is suggested that the elements used to find points along the intersection be spaced 15° apart. Do not erase the construction lines. One shape does not pass through the other

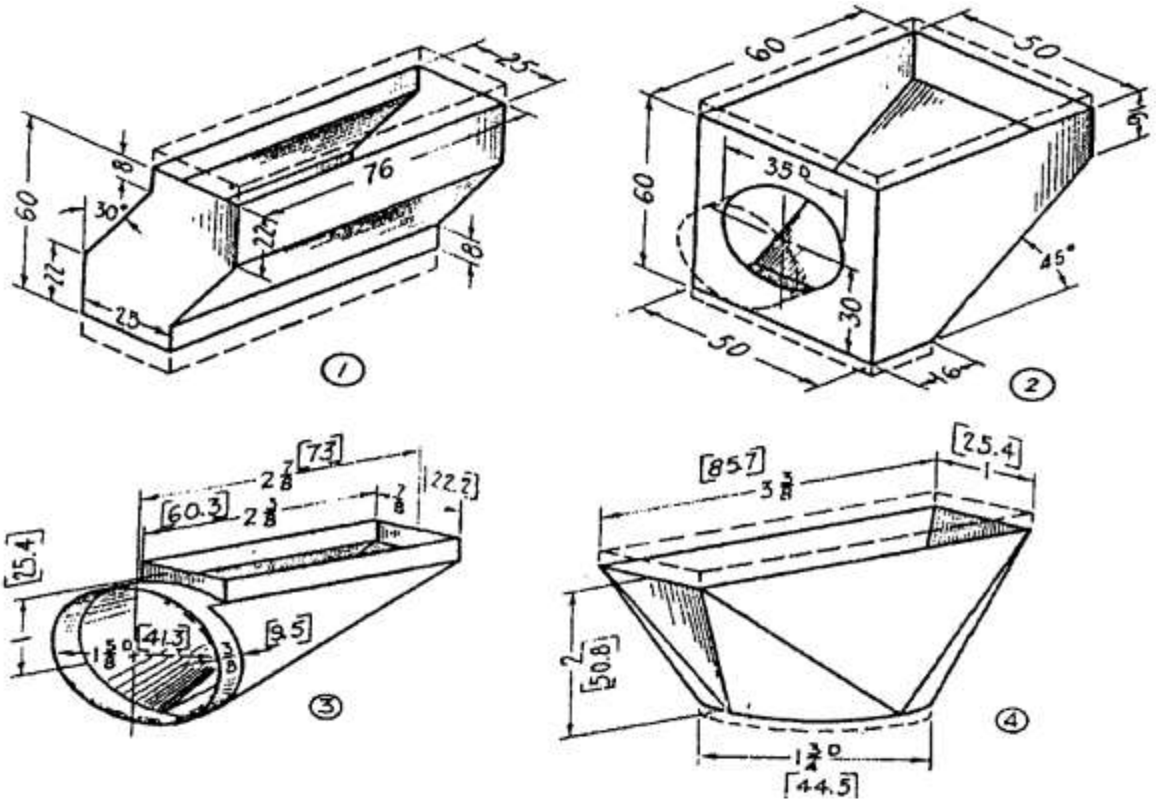


Figure Assignment 7

7.0 References

UNIT 2: DETERMINATION OF INTERSECTION OF OBJECTS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able:

1. Explain the concept of use of line projection to determine point of intersection
2. Determine points of intersection of cylinders and cones
3. Determination of intersection of cylinders and prisms
4. Determine points of intersection oblique cones and parabola

3.0 Main Body

3.1 To Find the Intersection of Two Cylinders Using Line-projecting (Cutting) Planes

The line of intersection of the two cylinders shown in Fig. 2.37 could have been determined through the use of a series of parallel line-projecting (cutting) planes passed parallel to their axes (Fig. 2.38). The related straight-line elements cut on the cylinders by any one cutting plane, such as C, intersect on the line of intersection of the cylinders. As many line-projecting planes as are needed to obtain a smooth curve should be used and they should be placed rather close together where a curve changes sharply

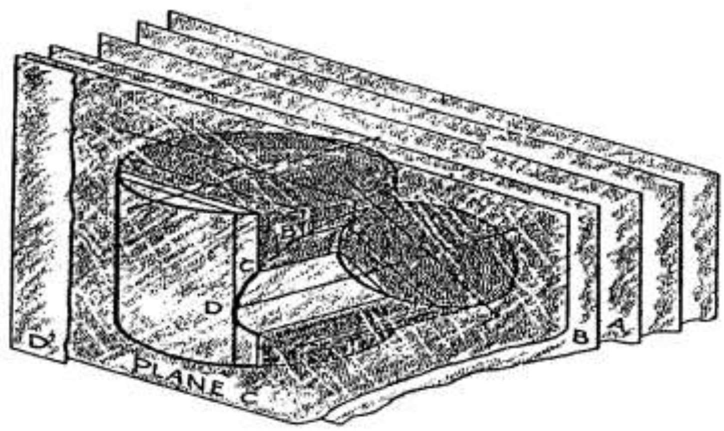


Figure 2.38 To find the intersection of two cylinders using line-projecting planes

Self-Assessment Exercise

3.2 To Find the Intersection of a Cylinder and a Cone

The intersection of a cylinder and a cone may be found by assuming a number of elements on the surface of the cone. The points at which these elements cut the cylinder are on the line of intersection (see Figs. 2.39 and 2.40). In selecting the elements, it is the usual practice to divide the circumference of the base into a number of equal parts and draw elements through the division points. To obtain needed points at locations where the intersection line will change suddenly in curvature, however, there should be additional elements.

In Fig. 2.39, the points at which the elements pierce the cylinder are first found in the top view and are then projected to the corresponding elements in the from view. A smooth curve through these points forms the figure of the intersection.

To find the intersection of the cone and cylinder combination shown in Fig. 2.40, line-projecting cutting planes were passed through the vertex 0 parallel to the axis of the cylinder to cut intersecting elements on both geometric forms. The partial auxiliary is needed to establish these planes, because it is only in a view showing the axis of the cylinder as a point that these planes and the surface of the cylinder will show as edge views. Each cutting plane cuts one needed straight-line element from the conical surface and two straight-line elements from the cylindrical surface. Cutting plane 5, for example, cuts one element (numbered 5) from the near side of the cone and an upper and lower element from the surface of the cylinder. The intersection of these three elements, all numbered 5, establish the location of points A and B on the line of intersection.

An alternative method for finding the line of intersection of a cylinder and a right cone is illustrated in Fig. 2.41. Here horizontal cutting planes are passed through both geometric shapes in the region of their line of intersection. In each cutting plane, the circle cut on the surface of the cone will intersect elements cut on the cylinder at two points common to both surfaces (see pictorial). A curved line traced through a number of such points in different planes is a line common to both surfaces and is therefore the line of intersection

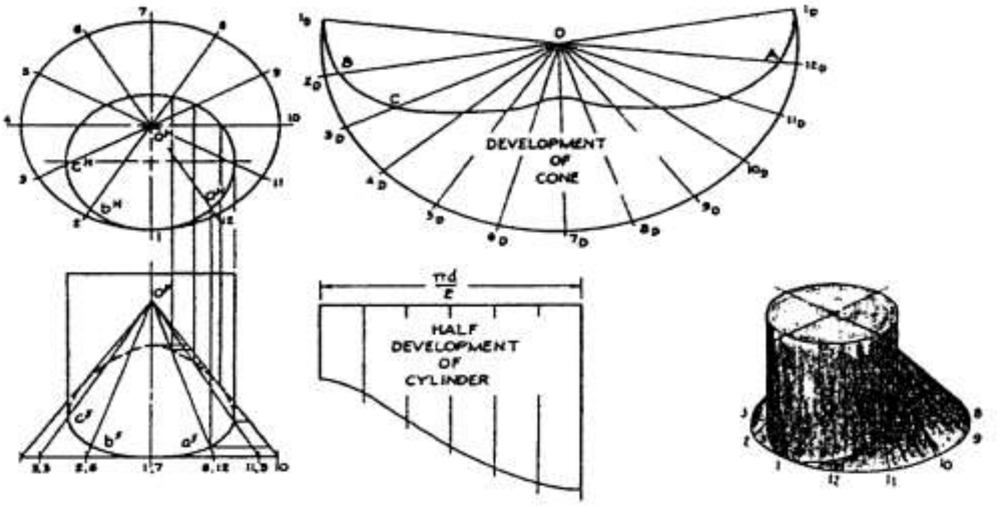
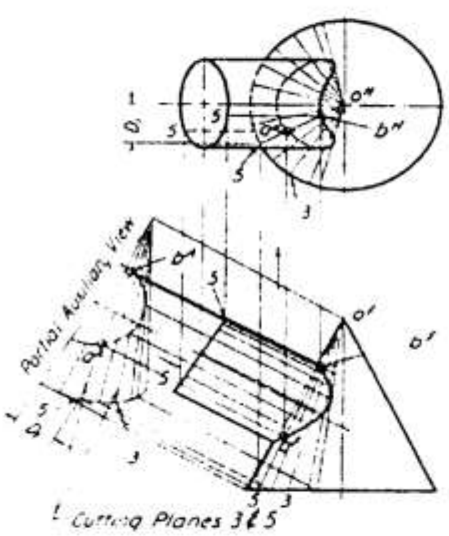


Figure 1.39 Intersecting cylinder and cone



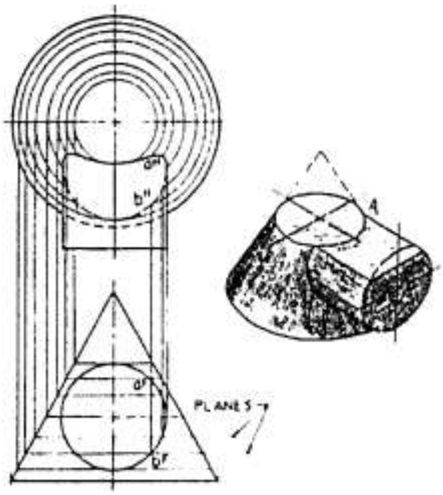


Figure 2.40 To find the intersection of a cone and a cylinder

Figure 2.41 Intersecting cylinder and cone

Self-Assessment Exercise

3.3 To Find the Intersection of an Oblique Cone and a Paraboloid

The method that is illustrated in Fig. 2.42 for finding the line of intersection of a cone and a paraboloid may be used effectively for the solution of many other intersection problems involving different geometric forms, such as two cones or a cone and a cylinder having parallel bases. For the arrangement as shown, a horizontal cutting plane will intersect each geometric form in a circle. When a number of horizontal cutting planes are passed through both geometric shapes in the region of their line of intersection, each plane cuts a circle on the cone that intersects a circle cut on the paraboloid at two points common to both surfaces. The curved line traced through the points that have been determined by the several planes is a line common to both surfaces and is therefore the line of intersection.

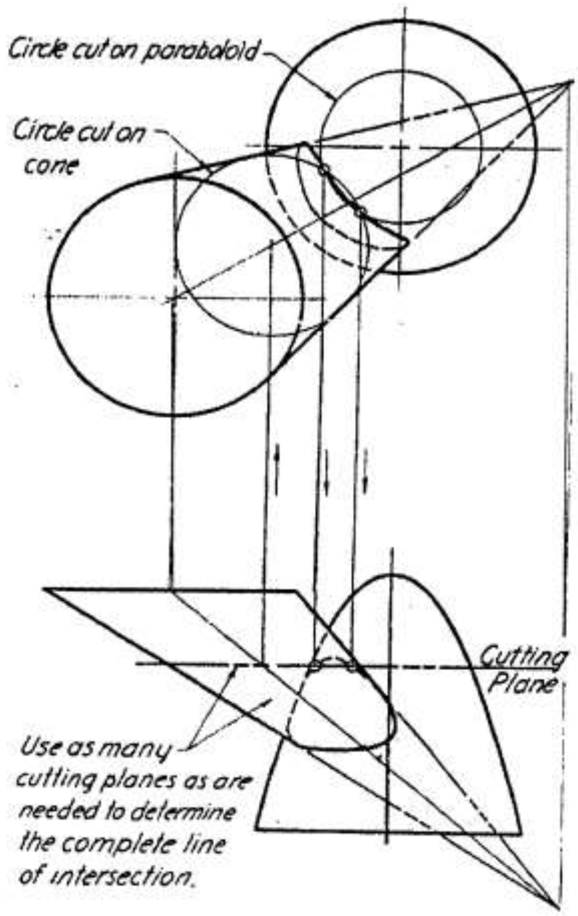


Figure 1.42 Intersecting cone and paraboloid

Self-Assessment Exercise

3.4 To Find the Intersection of a Prism and a Cylinder

In Fig. 2.43 it is required to find the intersection between the cylinder and two of the plane surfaces of the prism so that a pattern for the hole can be cut in the prism to match the cylinder. Although the intersection could have been secured merely by determining, through inspection, the piercing points of elements drawn arbitrarily on the

cylinder, vertical line-projecting planes were used to illustrate an approach to this type of problem that is used by many people. The cutting planes are located in the view showing the right section of the cylinder. From this first step, the positions for the lines and elements cut on the prism and cylinder, respectively, can be determined by projection. Each line-projecting (cutting) plane cuts a line on a plane surface of the prism and related elements on the cylinder that intersect on the line of intersection. A sufficient number of line-projecting planes should be used to enable one to draw a smooth curved-line representation of the intersection. If more points are desired, at a location where a curve changes sharply, additional cutting planes may be added.

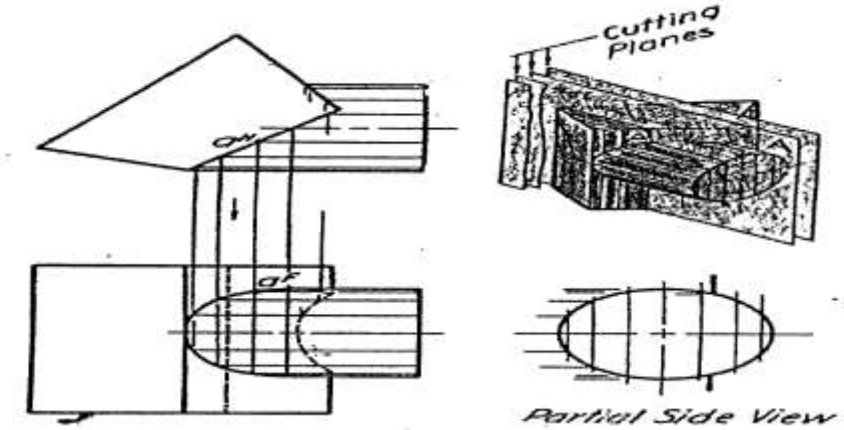


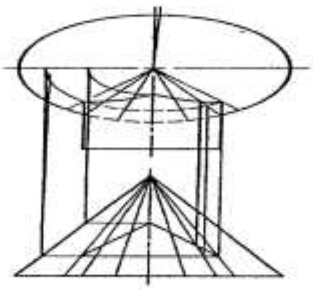
Figure 1.43 To find the intersection of a prism and a cylinder

Self-Assessment Exercise

3.5 To Find the Intersection of a Prism and a Cone

The complete line of intersection may be found by drawing elements on the surface of the cone (Fig. 2.44) to locate points on the intersection as explained in Sec. 2.40. To obtain an accurate curve, however, some thought must be given to the placing of these elements. For instance, although most of the elements may be equally spaced on the cone to facilitate the construction of its development, additional ones should be drawn through the critical points and in regions where the line of intersection changes sharply in curvature. The elements 9re draw.,..,, on the view that will reveal points on the intersection, then the determined points are projected to the corresponding elements in the other view or views. In this particular illustration a part of the line of intersection in the top view is a portion of the arc of a circle that would be cut by a horizontal plane containing the bottom surface of the prism.

If the surfaces of the prism are parallel to the axis of the cone, as in Fig. 2.45 the line of intersection will be made up of the tips of a series of hyperbolas. The intersection may be found by passing planes that will cut circles on the surface of the cone. The points at which these cutting circles pierce the faces of the prism are points common to the later surfaces of both shapes and are therefore points on the required line of intersection. It should be noted that the resulting solution represents a chamfered bolthead



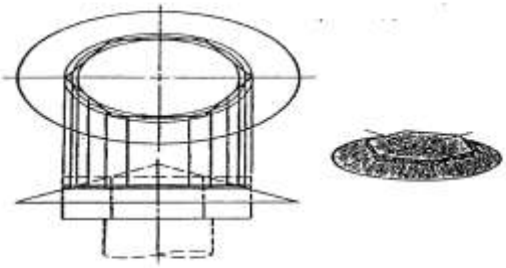


Figure1.44 Intersecting cone and prism. Figurel 45 Intersecting cone and hexagonal prism

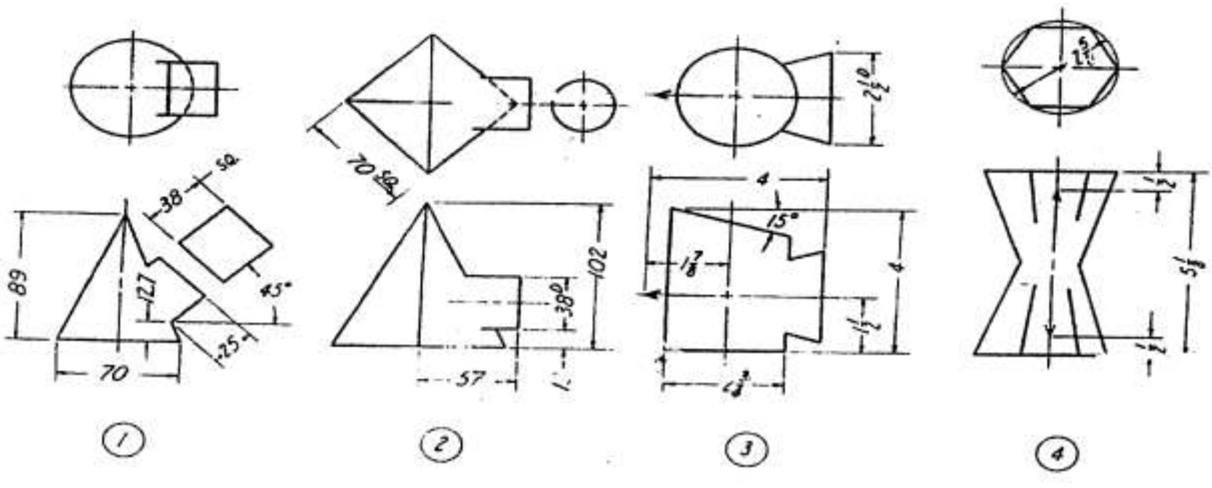
Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment

1. Draw the line of intersection of the intersecting geometric shapes as Figure Assignment 8. Show the invisible portions of the line of intersection as well as the visible. The interior of the combination is hollow. One shape does not pass through the other. Show construction with light, sharp lines drawn with a hard pencil.



7.0 References

UNIT 3: TRUE LENGTHS AND AUXILIARY PROJECTIONS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to;

1. Discuss the principles of true length in auxiliary projection
2. Determine the true length of a line located in space
3. Project simple shapes in product development

3.0 Main Body

3.1 Determination of True Lengths in Isometric Projection

An isometric view of a rectangular block is shown in Fig. 3.1. The corners of the block are used to position a line DF in space. Three orthographic views in first-angle projection are given in Fig. 3.2, and it will be apparent that the projected length of the line DF in each of the views will be equal in length to the diagonals across each of the rectangular faces. A cross check with the isometric view will clearly show that the true length of line DF must be greater than any of the diagonals in the three orthographic views. The corners nearest to the viewing position are shown as ABCD etc.; the corners on the remote side are indicated in rings. To find the true length of DF, an auxiliary projection must be drawn, and the viewing position must be square with line DF. The first auxiliary projection in Fig. 3.2 gives the true length required, which forms part of the right-angled triangle DFG. Note that auxiliary views are drawn on planes other than the principal projection planes. A plan is projected from an elevation and an elevation from a plan. Since this is the first auxiliary view projected, and from a true plan, it is known as a *first auxiliary elevation.* Other auxiliary views could be projected from this auxiliary elevation if so required.

The true length of DF could also have been obtained by projection from the front or end elevations by viewing at 90° to the line, and Fig. 3.3 shows these two alternatives. The first auxiliary plan from the front elevation gives triangle FDH, and the first auxiliary plan from the end elevation gives triangle FCD, both right-angled triangles.

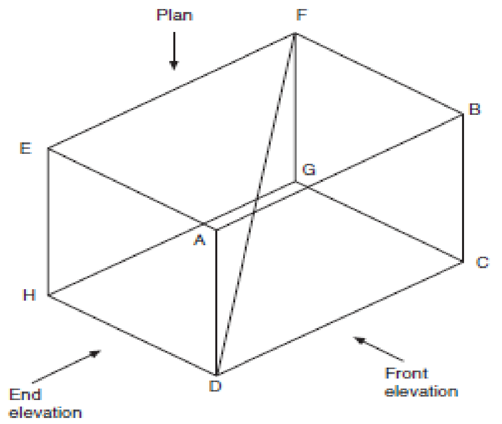


Figure 3.1 Line joining opposite corners of a box in space

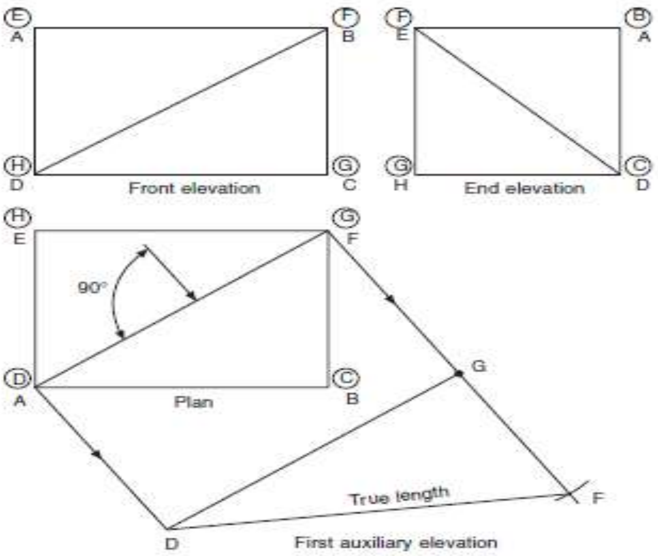


Figure 3.2 Projection of true length of line

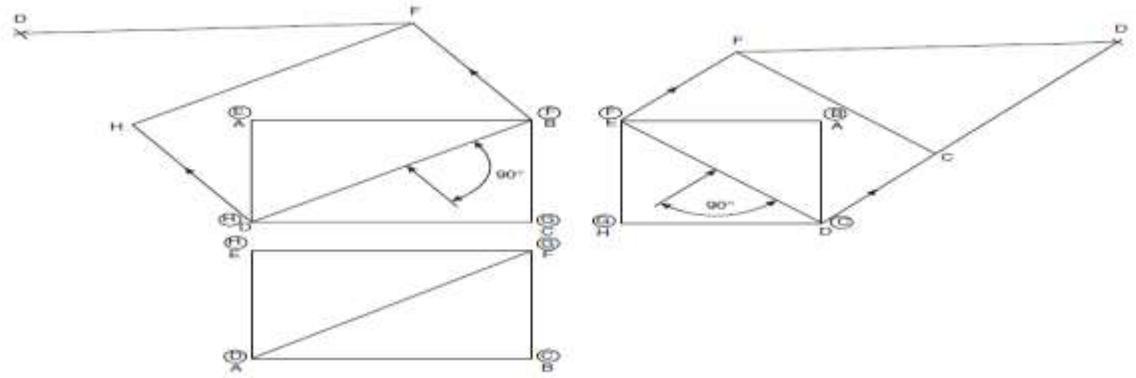


Figure 3.3 Projection of line from the front or end elevations

Self-Assessment Exercise

3.2 Isometric Projection

Figure 3.4 shows the front elevation and plan view of a box. A first auxiliary plan is drawn in the direction of arrow X. Now PQ is an imaginary datum plane at right angles to the direction of viewing; the perpendicular distance from corner A to the plane is shown as dimension 1. When the first auxiliary plan E view is drawn, the box is in effect turned through 90° in the direction of arrow X, and the corner A will be situated above the plane at a perpendicular distance equal to dimension 1. The auxiliary plan view is a true C view on the tilted box. If a view is now taken in the direction of arrow Y, the tilted box will be turned through 90° in the direction of the arrow, and dimension 1 to the corner will lie parallel with the plane of the paper. The other seven corners of the box are projected as indicated, and are positioned by the dimensions to the plane PQ in the front elevation. A match-box can be used here as a model to appreciate the position in space for each projection

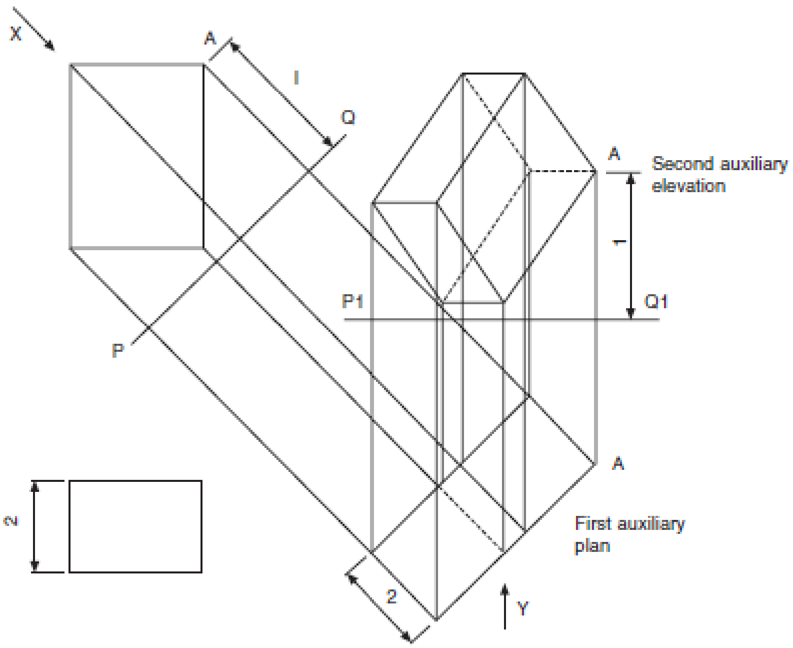


Figure 3.4 Isometric projection of a rectangular box from plan view

The same box has been redrawn in Fig. 3.5, but the first auxiliary elevation has been taken from the plan view in a manner similar to that described in the previous example. The second auxiliary plan projected in line with arrow Y requires dimensions from plane P1Q1, which are taken as before from plane PQ. Again, check the projections shown with a match-box. All of the following examples use the principles demonstrated in these two problems.

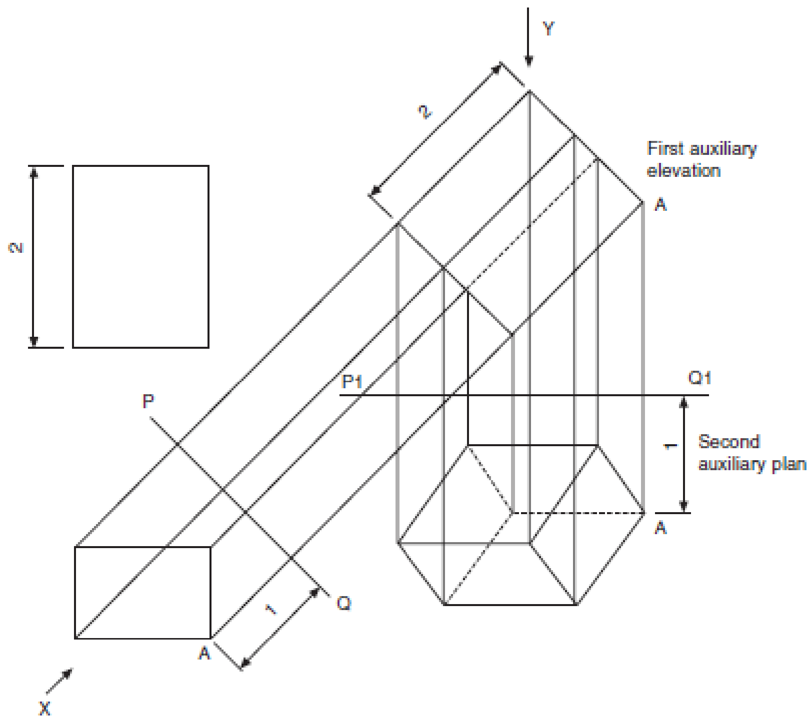


Figure 3.5 Isometric projection of a rectangular box from end view

Part of a constructions for the eight corners in both auxiliary views are identical with those described for the in Fig. 3.4.

Auxiliary projections from a cylinder are shown in Fig. 3.7; note that chordal widths in the first auxiliary plan are taken from the true plan. Each of twelve points around the circle is plotted in this way and then projected up to the auxiliary elevation. Distances from plane PQ square pyramid is shown in Fig. 3.6; the

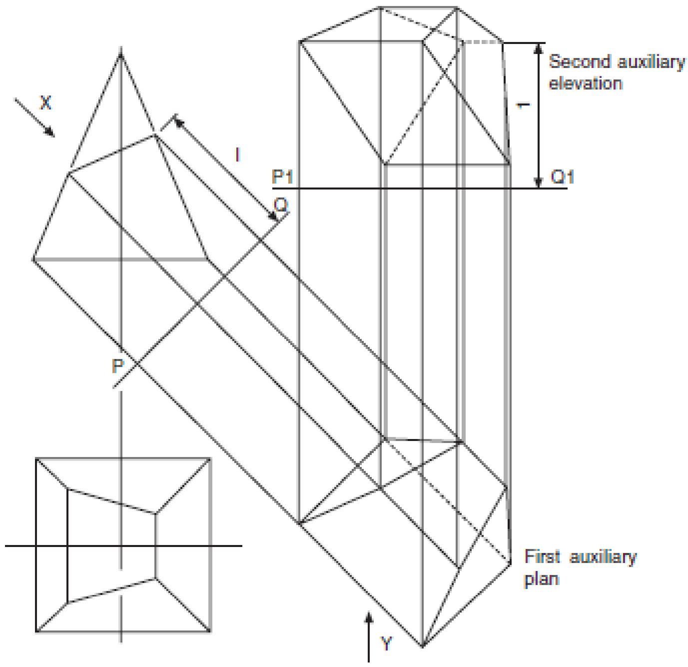


Figure 3.6 Projection of a truncated square pyramid

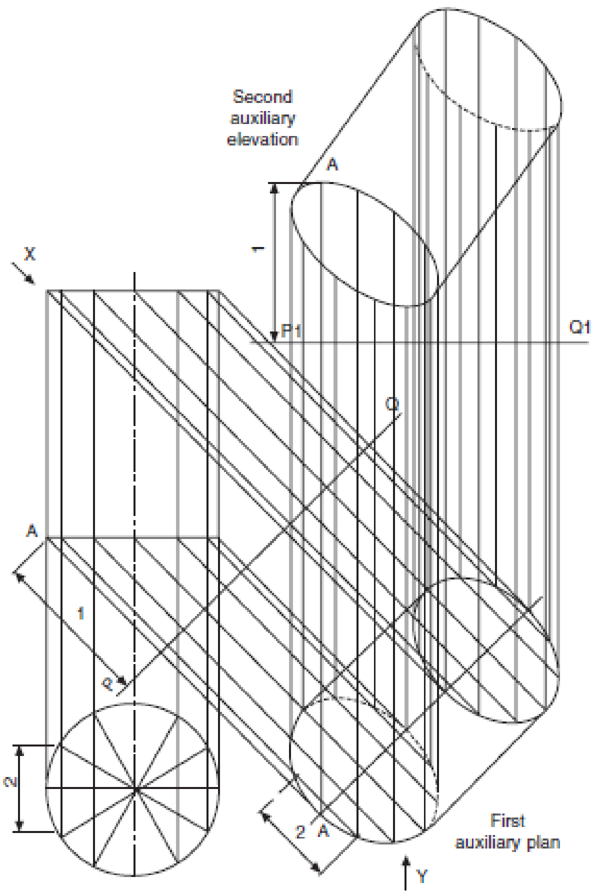


Figure 7 Auxiliary projections from a cylinder

are used from plane P_1Q_1. Auxiliary projections of any irregular curve can be made by plotting the positions of a succession of points from the true view and rejoining them with a curve in the auxiliary view.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References

UNIT 4: OBLIQUE PROJECTION OF AUXILIARY VIEWS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to;

1. Discuss the principles of oblique projection
2. Project objects inclined to the plane of projection

3.0 Main Body

3.1 Oblique Projection

Figure 3.8 shows a front elevation and plan view of a thin lamina in the shape of the letter L. The lamina lies inclined above the datum plane PQ, and the front elevation appears as a straight line. The true shape is projected above as a first auxiliary view. From the given plan view, an auxiliary elevation has been projected in line with the arrow F, and the positions of the corners above the datum plane P_1Q_1 will be the same as those above the original plane PQ. A typical dimension to the corner A has been added as dimension 1. To assist in comprehension, the true shape given could be cut from a piece of paper and positioned above the book to appreciate how the lamina is situated in space; it will then be seen that the height above the book of corner A will be dimension 2.

Now a view in the direction of arrow G parallel with the surface of the book will give the lamina shown projected above datum P_2Q_2. The object of this exercise is to show that if only two auxiliary projections are given in isolation, it is possible to draw projections to find the true shape of the component and also get the component back, parallel to the plane of the paper. The view in direction of arrow H has been drawn and taken at 90° to the bottom edge containing corner A; the resulting view is the straight line of true length positioned below the datum plane P_3Q_3. The lamina is situated in this view in the perpendicular position abovethe paper, with the lower edge parallel to the paper and at a distance equal to dimension 4 from the surface. View J is now drawn square to this projected view and positioned above the datum P_4Q_4 to give the true shape of the given lamina.

In Fig. 3.9, a lamina has been made from the polygon ACBD in the development and bent along the axis AB; again, a piece of paper cut to this shape and bent to the angle ö may be of some assistance. The given front elevation and plan position the bent lamina in space, and this exercise is given here since every line used to form the lamina in these two views is not a true length. It will be seen that, if a view is now drawn in the direction of arrow X, which is at right angles to the bend line AB, the resulting projection will give the true length of AB, and this line will also lie parallel with the plane of the paper. By looking along the fold in the direction of arrow Y, the two corners A and B will appear coincident; also, AD and BC will appear as the true lengths of the altitudes DE and FC. The development can now be drawn, since the positions of points E and F are known along the true length of AB. The lengths of the sides AD, DB, BC and AC are obtained from the pattern development

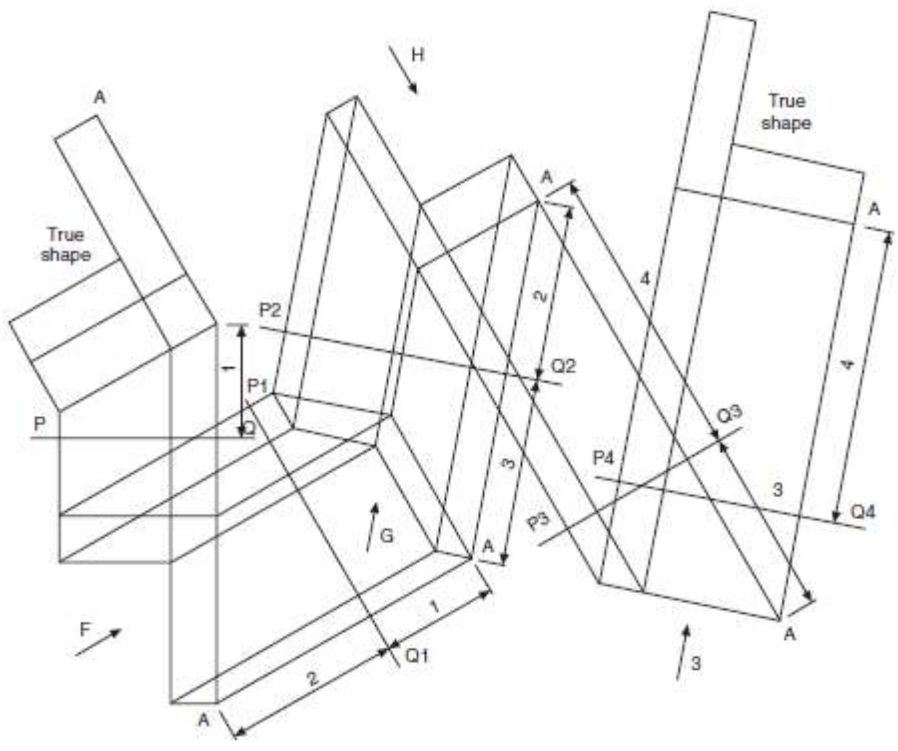


Figure 3.8 Projection of the true shape of a lamina

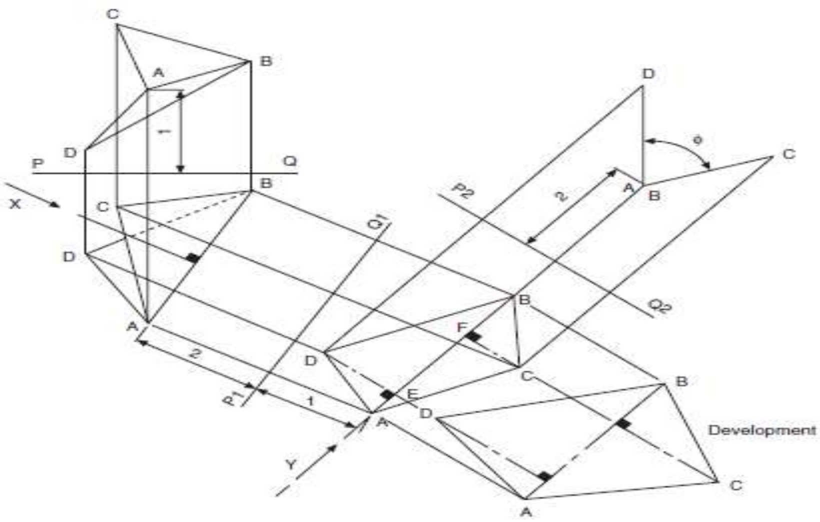


Figure 3.9 Projection of a lamina from a polygon

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Figure Assignment 1 shows two views of a small casting. Draw full scale, an oblique projection of the casting with face A towards you

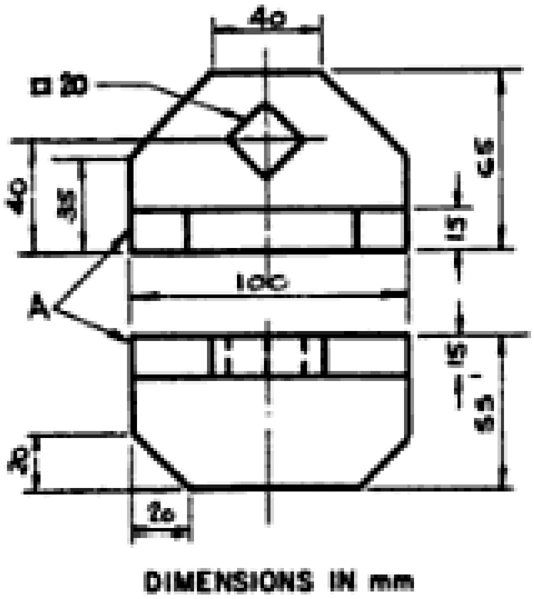


Figure Assignment 1

2. Figure Assignment 2 shows two views of a cast hinge block. Make an oblique drawing of the object, with face A towards you, omitting hidden details

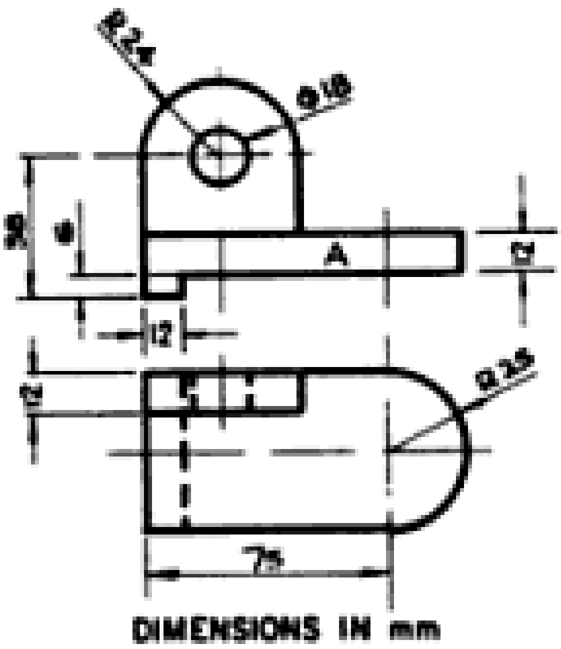


Figure Assignment 2

7.0 References