METHODIST
COLLEGE OF ENGINEERING & TECHNOLOGY

METHODIST
COLLEGE OF ENGINEERING

Estd: 2008

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Abids, Hyderabad, Telangana, 500001

DEPARTMENT OF CIVIL ENGINEERING

ENGINEERING GRAPHICS & DESIGN LABORATORY
LABORATORY MANUAL
(As per 2020-2021 Academic Regulations)

BE I/II Semester (AICTE): 2020-21

Name: ....

Roll No: ....

Branch:...SEM:.......................

Academic Year: ....

Empower youth - Architects of Future World

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VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

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ENGINEERING GRAPHICS & DESIGN LABORATORY

LABORATORY MANUAL
STUDENT MANUAL

B.E I/II SEMESTER
ACADEMIC YEAR:2020-21

Department of
CIVIL ENGINEERING

Prepared
By

Mrs. S. Deva Samyuktha, Assistant Professor, Civil Engg Dept

&

Mohammed Shahed Ali, Assistant Professor, Civil Engg Dept

DEPARTMENT OF CIVIL ENGINEERING

VISION

To evolve into a centre of excellence for imparting holistic civil engineering education contributing towards sustainable development of the society.

MISSION

- To impart quality civil engineering education blended with contemporary and interdisciplinary skills.

- To provide enhanced learning facilities and professional collaborations to impart a culture of continuous learning.

- To involve in trainings and activities on communication skills, teamwork, professional ethics, environmental protection and sustainable development.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

The Graduates of the programme shall be able to:

PEO 1: Engage in planning, analysis, design, construction, operation and maintenance of built environment.

PEO 2: Apply the knowledge of civil engineering to pursue research or to engage in professional practice.

PEO 3: Work effectively as individuals and as team members in multidisciplinary projects with organizational and communication skills.

PEO 4: Demonstrate the spirit of lifelong learning and career enhancement aligned to professional and societal needs

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1.Engineering knowledge: Apply the basic knowledge of mathematics, science and engineering fundamentals along with the specialized knowledge of mechanical engineering to understand complex engineering problems.

PO2.Problem analysis: Identify, formulate, design and analyse complex mechanical engineering problems using knowledge of science and engineering.

PO3.Design/development of solutions: Develop solutions for complex engineering problems, design and develop system components or processes that meet the specified needs with appropriate consideration of the public health and safety, and the cultural, societal, and environmental considerations.

PO4.Conduct investigations of complex problems: Formulate engineering problems, conduct investigations and solve using research-based knowledge.

PO5.Modern tool usage: Use the modern engineering skills, techniques and tools that include IT tools necessary for mechanical engineering practice.

PO6.The engineer and society: Apply the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7.Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities during professional practice.

PO9.Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities to various groups, ability to write effective reports and make effective presentations.

PO11. Project management and finance: Demonstrate and apply the knowledge to understand the management principles and financial aspects in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in Independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

Civil Engineering Graduates will be able to:

PSO 1. Investigate properties of traditional and latest construction materials using standard testing methods.

PSO 2. Use AutoCAD, STAAD Pro, ETABS, Revit Architecture and ANSYS software for computer aided structural analysis and design.

PSO 3. Describe the principles of sustainable development and green buildings for environmental preservation.

LABORATORY CODE OF CONDUCT

1. Students should report to the concerned labs as per the time table schedule.

2. Students who turnup late to the labs will innocase be permitted to perform the experiment scheduled for the day.

3. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.

4. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.

5. Staff member in-charge shall award 25 marks for each experiment based on continuous evaluation and will be entered in the continuous internal evaluation sheet.

6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff memberin-charge.

7. Not more than three students in a group are permitted to perform the experiment on a set-up for equipment-based labs. Only one student is permitted per computer system for computer-based labs.

8. The group-wise division made in the beginning should be adhered to, and no student is allowed to mix up with different groups later.

9. The components required pertaining to the experiment should be collected from the stores in-charge, only after duly filling in the requisition form/log register.

10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/ instruments taken for the purpose.

11. Any damage of the equipment or burn-out of components will be viewed seriously by either charging penalty or dismissing the total group of students from the lab for the semester/year.

12. Students should be present in the labs for the total scheduled duration.

13. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.

14. Procedure sheets/data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

Lab Rules of conduct, DO'S & DON'Ts
Engineering Graphics & Design Laboratory

Do's :
1. All the systems in the Laboratory should be handled with care.
2. Use of mobile phones is restricted in the Laboratory.
3. If any important data needs to be accessed or copied, take the help of an in-charge faculty or laboratory assistant.
4. All the users should save their files in their allotted directories only.
5. Bags and other items should be kept at the allocated place.
6. Shutdown the system before leaving the Laboratory.
7. Silence and discipline must be observed in the Laboratory

Don'ts :
1. Do not change the settings of the system.
2. Contact the Laboratory assistant for any clarification
3. CD's, Pen drives & other storage devices are not allowed in the Laboratory.
4. Antivirus checks are must if any inserting pen drives in the system.
5. Do not leave the system open after completing the drawing

Sheet No	Description of the Topic	CO'S MAPPED
1.	Principles of Engineering Graphics and their significance, usage of drawing instruments.	CO1
2.	**Conic Sections - I** Construction of ellipse, parabola and hyperbola given focus and eccentricity.	CO2, CO3
3.	**Conic Sections - II** Construction of ellipse (given major and minor axis), parabola (Given base and height), rectangular hyperbola.	CO2, CO3
4.	**Cycloids** (Cycloid & Epicycloid)	CO2, CO3
5.	**Involutes** (Involute of triangle, square & circle)	CO2, CO3
6.	**Scales** (Plain & diagonal scales)	CO2, CO3
7.	**Introduction to AutoCAD** Basic commands and simple drawings.	CO1, CO2
8.	**Orthographic Projection** Projections of points situated in different quadrants.	CO2, CO4
9.	**Projections of straight lines - I** Line parallel to both the reference planes, line perpendicular or inclined to one reference	CO2, CO4
10.	**Projections of straight lines - II** Line inclined to both the reference planes.	CO2, CO4
11.	**Projections of planes - I** Perpendicular planes	CO2, CO4
12.	**Projections of planes - II** Oblique planes	CO2, CO4
13.	**Projections of solids - I** Polyhedra and solids of revolution, Projections of solids in simple position.	CO2, CO4
14.	**Projection of solids - II** Projections of solids when the axes inclined to one or both the reference planes.	CO2, CO4
15.	**Section of solids - I** When the sectional plane is parallel or perpendicular to one reference plane.	CO2, CO5
16.	**Section of solids - II** When the sectional plane is inclined to one reference plane.	CO2, CO5
17.	**Development of surfaces - I** Prisms and Cylinders	CO2, CO5
18.	**Development of surfaces - II** Pyramids and Cones	CO2, CO5
19.	**Intersection of surfaces - I** Intersection of cylinder and cylinder	CO2, CO5
20.	**Intersection of surfaces - II** Intersection of cylinder and cone	CO2, CO5
21.	**Isometric projection - I** planes and simple solids	CO2, CO6
22.	**Isometric projection - II** combination of two or three solids	CO2, CO6
23.	Conversion of Isometric Views to Orthographic Views	CO2, CO6
24.	**Floor plans** of 2 or 3 rooms including windows, doors, and fixtures such as WC, bath, sink, shower, etc.	CO2, CO6

CO-PO'S MAPPING

Course Code	Course Title	CO No.	Course Outcome	Taxonomy level	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
Es156 CE	Engineering Graphics & Design Laboratory	CO1	**Demonstrate** the significance & Principles of Engineering Graphics related drawing Instruments and Software AutoCAD	Understanding	3			2	3			3						3	
		CO2	**Explain** the Procedure of constructing Conic Sections, Cycloids and Involutes using both AutoCAD & Drawing Instruments	Understanding	3			2	3			3						3	
		CO3	Explain the Basic Terminology related to Engineering Drawing and Commands of AutoCAD software	Understanding	3	2		2	3			3	3	3				3	
		CO4	**Demonstrate** the Projection of Points, Planes and Solids	Understanding	3	2		2	3			3	3	3				3	
		CO5	**Apply** and Make use of Knowledge regarding Sectional Views for Development & Intersection of Solid Surfaces	Applying	3	2		2	3			3	3	3				3	
		CO6	**Develop** the Isometric Projections of Planes, Solids & Plans	Applying	3	2		2	3			3	3	3				3	
		AVG			3	2		2	3			3	3	3				3	

Course Code	Course Title						Core/Elective
ES156CE	**Engineering Graphics & Design Laboratory**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Laboratory	**1**	**0**	**-**	**4**	**50**	**50**	**3**

Course Objectives:

1. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

2. Communicate effectively using graphical methods

3. Understand the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes:

1. Demonstrate the significance & Principles of Engineering Graphics related drawing Instruments and Software AutoCAD

2. Explain the Procedure of constructing Conic Sections, Cycloids and Involutes using both AutoCAD & Drawing Instruments

3. Explain the Basic Terminology related to Engineering Drawing and Commands of AutoCAD software

4. Demonstrate the Projection of Points, Planes and Solids

5. Apply and Make use of Knowledge regarding Sectional Views for Development & Intersection of Solid Surfaces

6. Develop the Isometric Projections of Planes, Solids& Plans.

Sheet No	Description of the Topic
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6.	**Scales** (Plain & diagonal scales)
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Index

EXP. NO	EXPERIMENT NAME	DATE	PAGE NO	MARKS				REMARKS/ SIGNATURE
				A	P	R	V	

A: ASSIGNMENT (10) P: PRACTICAL (10) R: RECORD (10) V: VIVA (20)

Index

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A: ASSIGNMENT (10) P: PRACTICAL (10) R: RECORD (10) V: VIVA (20)

Date: _____

The Principles of Engineering Drawing

The art of Drawing is very old. Drawing is the language of Engineer. An engineering drawing, a type of technical drawing, is used to fully and clearly define requirements for engineered items. It must be understood by all Engineer, whatever their language, nationality or culture. Before trying to communicate with such a language, one should learn its basics principles, just like any other language.

Those basic of engineering Drawing are:
1. Line
2. Signs
3. Symbols

A variety of line styles graphically represent physical objects. Types of lines include the following:

1. Visible Line: Visible line is continuous lines used to depict edges directly visible from a particular angle.

2. Hidden Line: Hidden line is short-dashed lines that may be used to represent edges that are not directly visible.

3. Centre Line: Centre line is alternately long- and short-dashed lines that may be used to represent the axes of circular features.

4. Cutting Plane Line: Cutting plane line is thin, medium-dashed lines, or thick alternately long- and double short-dashed that may be used to define sections for section views.

5. Section Line: Section line is thin lines in a pattern (pattern determined by the material being "cut" or "sectioned") used to indicate surfaces in section views resulting from "cutting." Section lines are commonly referred to as "cross-hatching."

6. Phantom Line: Phantom line (not shown) is alternately long- and double short-dashed thin lines used to represent a feature or component that is not part of the specified part or assembly. E.g. billet ends that may be used for testing, or the machined product that is the focus of a tooling drawing.

Lines can also be classified by a letter classification in which each line is given a letter.

1. Type A: Type A lines show the outline of the feature of an object. They are the thickest lines on a drawing and done with a pencil softer than HB.

2. Type B: Type B lines are dimension lines and are used for dimensioning, projecting, extending, or leaders. A harder pencil should be used, such as a 2H.

3. Type C: Type C lines are used for breaks when the whole object is not shown. These are freehand drawn and only for short breaks. 2H pencil

4. Type D: Type D lines are similar to Type C, except these are zigzagged and only for longer breaks. 2H pencil

5. Type E: Type E lines indicate hidden outlines of internal features of an object. These are dotted lines. 2H pencil

6. Type F: Type F lines are Type F[typo] lines, except these are used for drawings in electro technology. 2H pencil

7. Type G: Type G lines are used for centre lines. These are dotted lines, but a long line of 10–20 mm, then a gap, then a small line of 2 mm. 2H pencil

8. Type H: Type H lines are the same as Type G, except that every second-long line is thicker. These indicate the cutting plane of an object. 2H pencil

9. Type K: Type K lines indicate the alternate positions of an object and the line taken by that object. These are drawn with a long line of 10–20 mm, then a small gap, then a small line of 2 mm, then a gap, then another small line. 2H pencil.

Fig1: Different kinds of lines

Date: _____

Linetype	Description
ACAD_ISO02W100	ISO dash __ __ __ __ __ __ __ __ __ __ __ __ __
ACAD_ISO03W100	ISO dash space __ __ __ __ __ __
ACAD_ISO04W100	ISO long-dash dot ____ . ____ . ____ . ____ . _
ACAD_ISO05W100	ISO long-dash double-dot ____ .. ____ .. ____ .
ACAD_ISO06W100	ISO long-dash triple-dot ____ ... ____ ... ____
ACAD_ISO07W100	ISO dot . . . .
ACAD_ISO08W100	ISO long-dash short-dash ____ __ ____ __ ____ _
ACAD_ISO09W100	ISO long-dash double-short-dash ____ __ __ ____
ACAD_ISO10W100	ISO dash dot __ . __ . __ . __ . __ . __ . __ .
ACAD_ISO11W100	ISO double-dash dot __ __ . __ __ . __ __ .
ACAD_ISO12W100	ISO dash double-dot __ .. __ .. __ .. __ ..
ACAD_ISO13W100	ISO double-dash double-dot __ __ .. __ __ .. _
ACAD_ISO14W100	ISO dash triple-dot __ ... __ ... __ ... _
ACAD_ISO15W100	ISO double-dash triple-dot __ __ ... __ __ ..
BATTING	Batting SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
BORDER	Border __ __ . __ __ . __ __ . __ __ . __ __ .
BORDER2	Border (.5x) __.__.__.__.__.__.__.__.__.'
BORDERX2	Border (2x) ____ ____ . ____ ____ . ____
CENTER	Center ____ _ ____ _ ____ _ ____ _ ____
CENTER2	Center (.5x) __ _ __ _ __ _ __ _ __ _ __
CENTERX2	Center (2x) _____ __ _____ __ _____
DASHDOT	Dash dot __ . __ . __ . __ . __ . __ . __ .
DASHDOT2	Dash dot (.5x) _._._._._._._._._._._._._
DASHDOTX2	Dash dot (2x) ____ . ____ . ____ . ____
DASHED	Dashed __ __ __ __ __ __ __ __ __ __ __ __ _
DASHED2	Dashed (.5x) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
DASHEDX2	Dashed (2x) ____ ____ ____ ____ ____ ____
DIVIDE	Divide ____ .. ____ .. ____ .. ____ .. ____
DIVIDE2	Divide (.5x) __.__.__.__.__.__.__.__.__.
DIVIDEX2	Divide (2x) _____ . . _____ . . _
DOT	Dot . . . .
DOT2	Dot (.5x) ....
DOTX2	Dot (2x) . . . .
FENCELINE1	Fenceline circle ---0----0----0----0----0----0--
FENCELINE2	Fenceline square ---[]---[]---[]---[]---[]---
GAS_LINE	Gas line ---GAS---GAS---GAS---GAS---GAS---GAS--
HIDDEN	Hidden __ __ __ __ __ __ __ __ __ __ __ __ __
HIDDEN2	Hidden (.5x) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
HIDDENX2	Hidden (2x) ____ ____ ____ ____ ____ ____
HOT_WATER_SUPPLY	Hot water supply ---- HW ---- HW ---- HW ----
PHANTOM	Phantom _____ __ __ _____ __ __ _____
PHANTOM2	Phantom (.5x) ___ __ __ ___ __ __ ___ __ __
PHANTOMX2	Phantom (2x) _____ ____ ____ _
TRACKS	Tracks ++++++++++++++++++++++++++
ZIGZAG	Zig zag /\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\

Fig2: Different kinds of lines in AutoCAD

3

Engineering Drawing requires three essential skills:

1. The ability to draw any object by representing its lines and features in a clear and precise way leading to the understanding of the drawing and imagining what the object drawn looks like.

2. Knowledge of the used conventions to save time and convey the exact information.

3. The ability to work very accurately with all drawing instruments and convey the exact information.

Engineering drawings common features:

Drawings convey the following critical information:

1. **Geometry** – the shape of the object; represented as views; how the object will look when it is viewed from various angles, such as front, top, side, etc.

2. **Dimensions** – the size of the object is captured in accepted units.

3. **Tolerances** – the allowable variations for each dimension.

4. **Material** – represents what the item is made of.

5. **Finish** – specifies the surface quality of the item, functional or cosmetic. For example, a mass-marketed product usually requires a much higher surface quality than, say, a component that goes inside industrial machinery.

Engineering Drawing Equipment:

1. **Drawing Plate:**

Flat surface, the four sides are perpendicular, no change (bending compression and expansion) due to the weather.

Fig3: Drawing Plate

2. Drawing Sheet:

Drawing Sheet should be strong paper, no damage due to hard pencils or erasing the drawing, no change in colour by time, draw by ink or graphite and no change due to the weather.

4

Drawing Sheet Size

Serial No.	Paper Code	Paper Dimensions in mm
1	A0	1189 x 841
2	A1	841 x 594
3	A2	594 x 420
4	A3	420 x 279
5	A4	279 x 210

Drawing Sheet in Drawing Plate
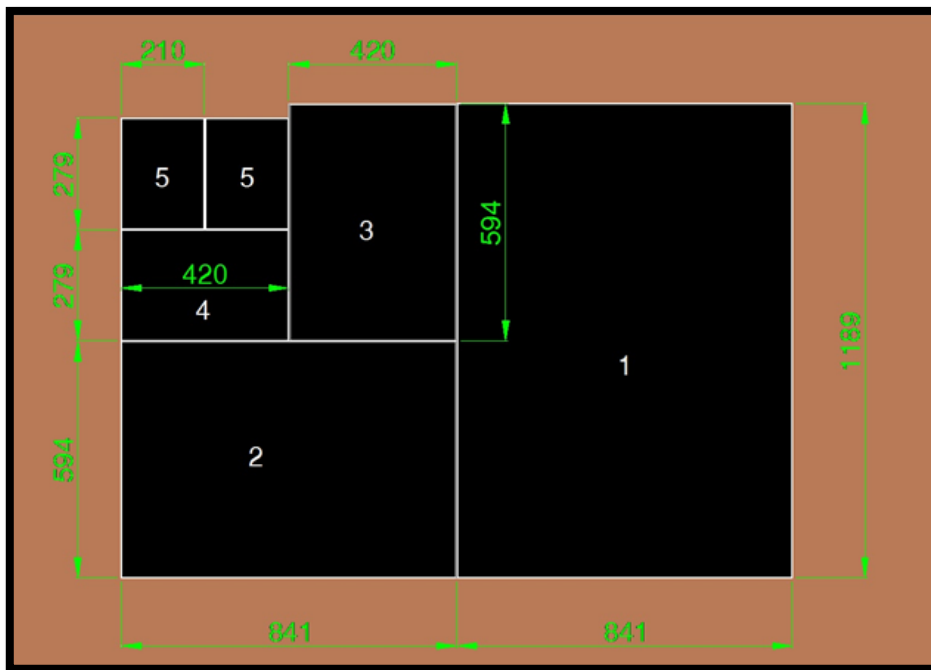
Fig4: Drawing sheet in Drawing Plate

3. **Pencils**

Engineering Drawing Pencils mainly two kinds

1. Wooden Pencils &
2. Mechanical Pencils

Characteristics of Drawing Pencils

H = Hard (1-9), B = Soft (1-7) & HB = Medium Hard/Soft

9H - 6H	Extra Hard
5H - 4H	Hard
3H – 2H	Medium Hard
HB, B, F, H	Medium Soft
2B – 7B	Soft

4. **T-square:**
Flat surfaces, the two parts are perpendicular, no change (bending compression or expansion) due to the weather
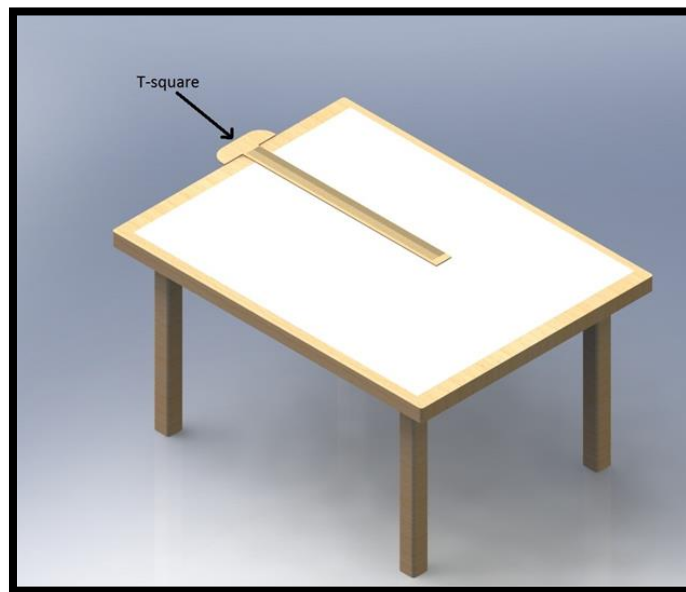
Fig4: T- Square

5. **Set-square (Triangle):**
Triangle mainly two kinds 90°-45°-45° & 90°-60°-30°. These two triangles can be arranged into diverse angle (see figures below)
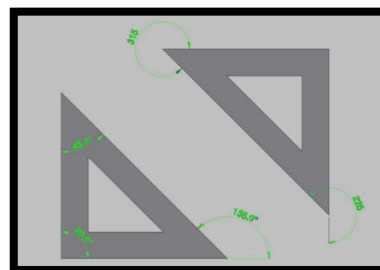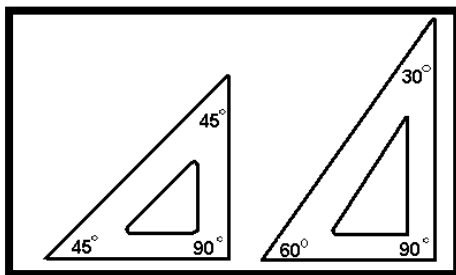
Figure 5: 90°-45°-45° & 90°-60°-30° Triangle   Figure 6: 90°-45°-45° arranged angle
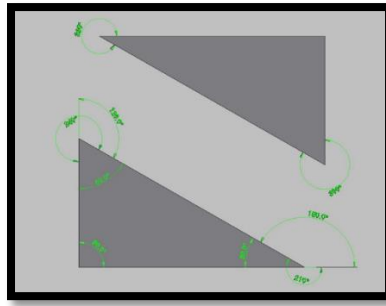
Figure 7: 90°-60°-30° arranged angle
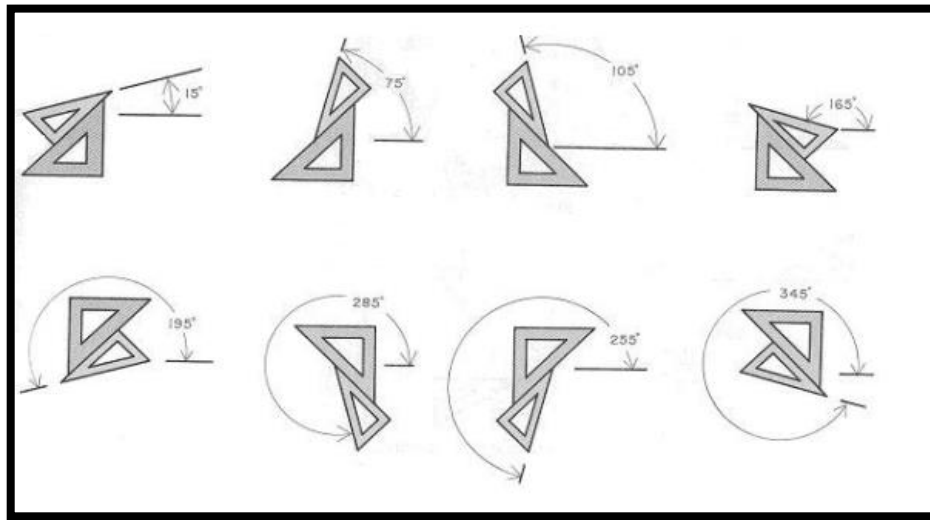
Figure8: 90°-45°-45° & 90°-60°-30° arranged angle

6. **Protractor:**
   Protractor is used for making different kinds angle. Protractor half circle is 180° and full circle is 360°
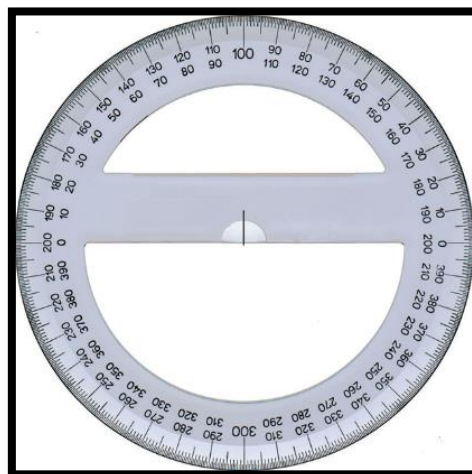
Fig9: Protractor

7. **Drafting angles (French Curves):**
   They are used to draw the different angles that cannot be drawn by the two triangles.

7
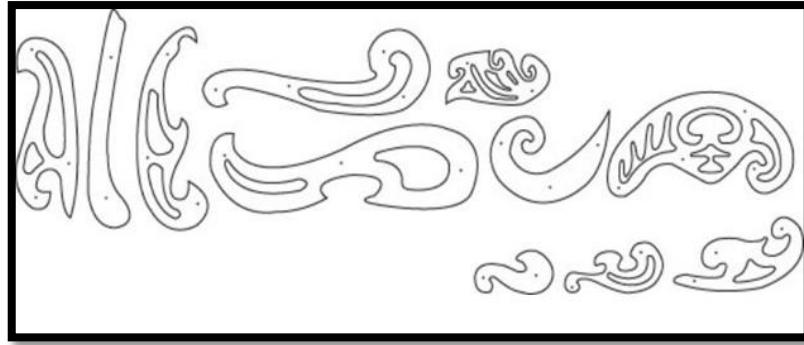
Fig 10: French Curves

8. **Compass:**

Compass is used to draw circles and curves.
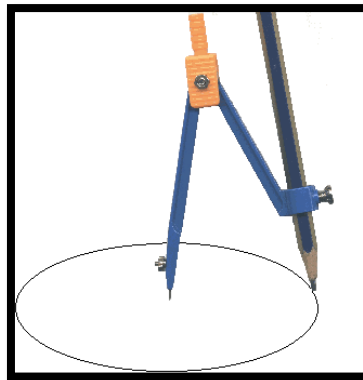
Fig11: Compass

9. **Measuring Ruler:**

They are made of metal, wood or plastic. Some special rulers are used for latter, numbers and shapes.
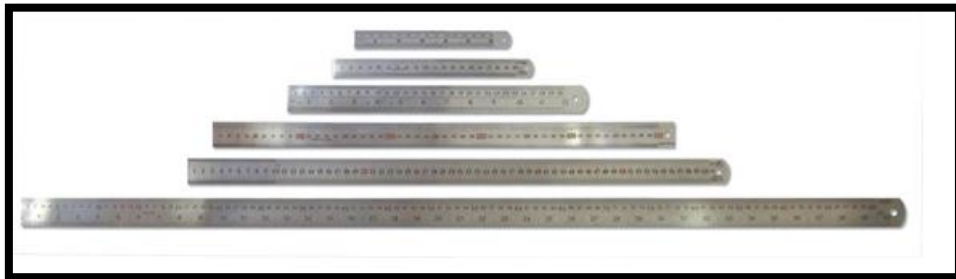
Fig12: Measuring Ruler

10. **Scales**

The dimensions of some parts are very large or very small to be represented in their actual size on the drawing paper. In such cases, the drawing should be reduced or enlarged to be in good visible size.

Full Scale: 1:1

Enlarged Scale: 2:1, 5: 1, 10:1, 100:1

Reduced Scales: 1:2, 1:5, 1:10, 1:100

Date: _____
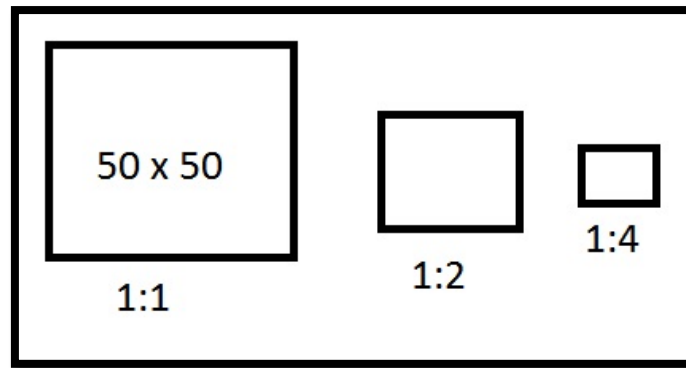
Fig13: Scales

CONIC SECTIONS

Definition:

Conic sections are mathematically defined as the curves formed by the locus of a point which moves a plant such that its distance from a fixed point is always in a constant ratio to its perpendicular distance from the fixed-line.

The three types of curves sections are

1. **Ellipse**
2. **Parabola**
3. **Hyperbola**.

The curves, Ellipse, Parabola and Hyperbola are also obtained practically by cutting the curved surface of a cone in different ways.

The profiles of the cut-flat surface from these curves hence called **conic sections.**
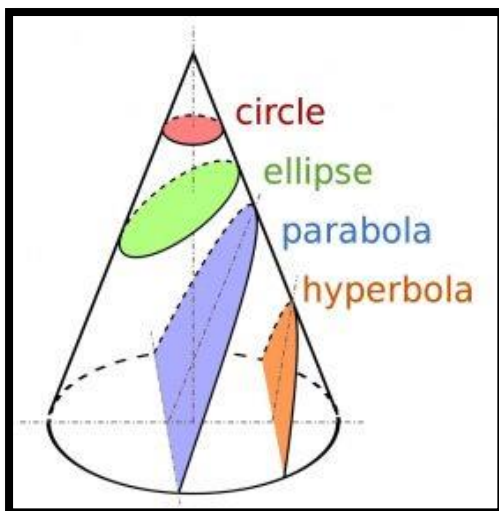
Figure1
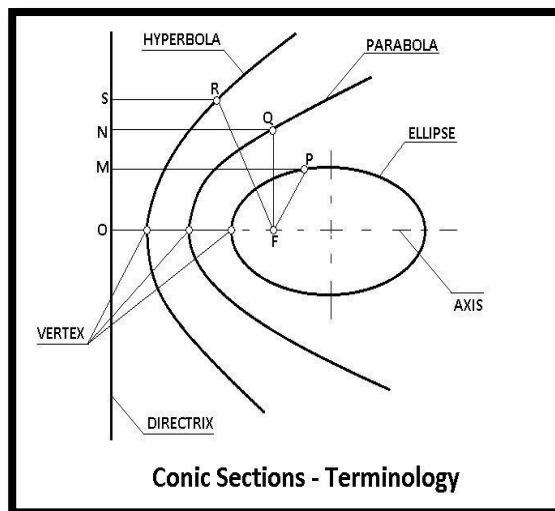
Figure2

These are the loci of points moving in a plane such that the ratio of its distances from a *fixed point*and a *fixed line* always remains constant.
The Ratio is called **ECCENTRICITY. (E)**

9

A) **For Ellipse   E<1**
B) **For Parabola   E=1**
C) **For Hyperbola E>1**

Sheet No:2

CONIC SECTIONS (Focus And Eccentricity Method)

1. A fixed point is 50mm away from a fixed line. Draw the path traced by a point P moving such that its distance from the fixed point is
   i)   2/3 times its distance from the fixed line (E=2/3; ellipse)
   ii)   Equal to its distance from the fixed line (E=1; Parabola)
   iii)   3/2 times its distance from the fixed line. (E=3/2; Hyperbola)
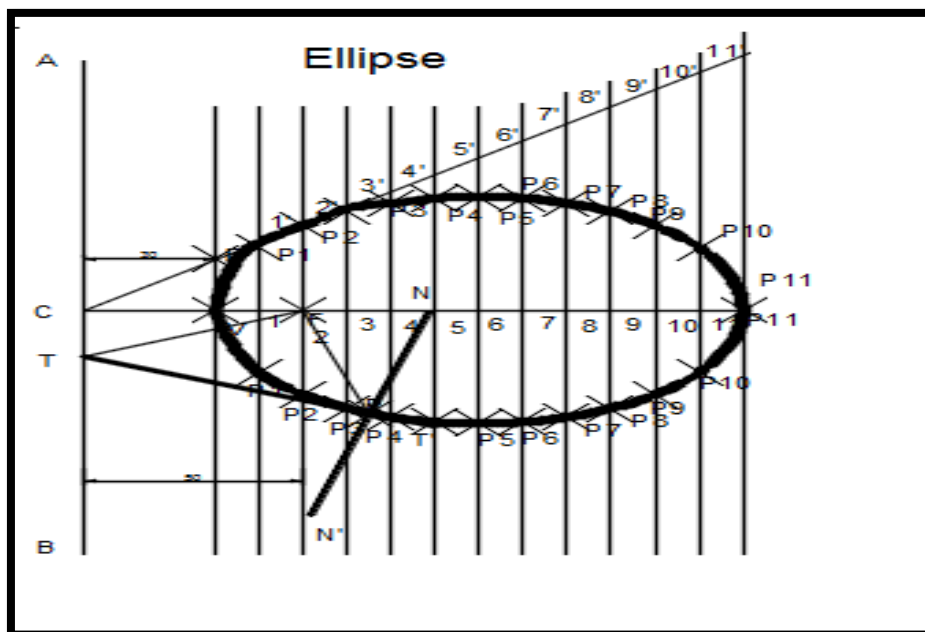
Figure1:**ELLIPSE**

Commands:
1. Line
2. Offset
3. Spline
4. Arc/ Circle
5. Dtext
6. Rotate
7. Dimlin/ Dimalign/Dimang

Procedure:
1. Draw a vertical line AB as Directrix.
2. At mid-point of AB mark, it as C, draw the axis perpendicular to AB (Directrix).
3. Mark a focus F on the axis such that CF=50mm.
4. Divide CF into 5 equal divisions
5. Mark the vertex V on the third division-point from C (e=2/3)

6. At V, draw a perpendicular VE equal to VF. Draw a line joining C & E. Thus, in the triangle CVE, (VE/VC) = (VF/VC) = 2/3.

7. Mark any point 1 on the axis & through it, draw perpendicular to meet CE- produced at 1'

8. With centre F and radius equal to 1-1', draw arcs to intersect the perpendicular through 1 at point P_1 and P'_1

9. These are the points on the Ellipse, because the distance of P_1 from AB is equal to C1 P_1 F= 1-1', similarly mark points 2,3 etc on the axis and obtain points P_2 and P'_2, P_3 and P'_3 etc.

10. **Draw the ellipse through these points. It is a closed curve having two foci and two directrices**

To draw tangent & normal:

11. Join P with F.

12. From F, draw a line perpendicular to PF to meet AB at T.

13. Draw a line through T and P. This line is the tangent to the curve.

14. Through P, draw a line NM perpendicular to TP. NM is the normal to the curve.

ii)
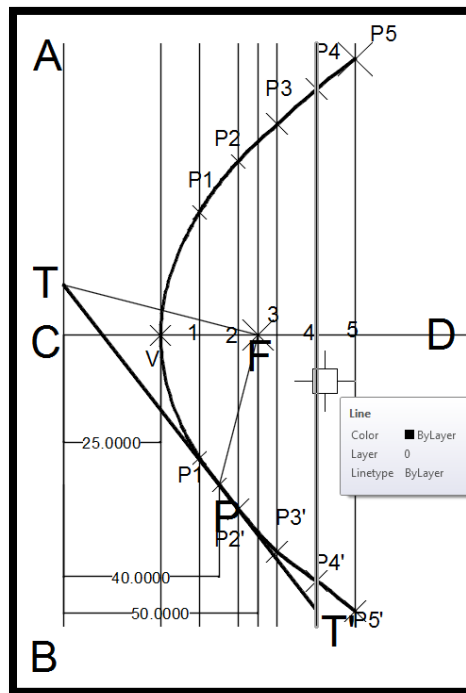
Figure2:PARABOLA

Commands:
1. Line
2. Offset
3. Spline
4. Arc/ Circle
5. Dtext
6. Rotate
7. Dimlin/ Dimalign/Dimang

Procedure:
1. Draw the directrix AB and the axis CD
2. Mark focus F on CD, 50 mm from C.
3. Bisect CF in V the Vertex(E=1)
4. Mark a number of points 1,2,3 etc on the axis and through them, draw the perpendiculars to it
5. With centre F and radius equal to C1, draw arcs cutting the perpendicular though 1at P_1 and P'_1
6. Similarly locate points P_2 and P'_2, P_3 and P'_3 etc. on both sides of axis.
7. **Draw a smooth curve through these points. This curve is required Parabola. It is an open curve.**

To Draw Tangent & Normal
8. Join P with F.
9. From F, draw a line perpendicular to PF to meet AB at T.
10. Draw a line through T and P. This line is the tangent to the curve.
11. Through P, draw a line NM perpendicular to TP. NM is the normal to the curve.

iii)
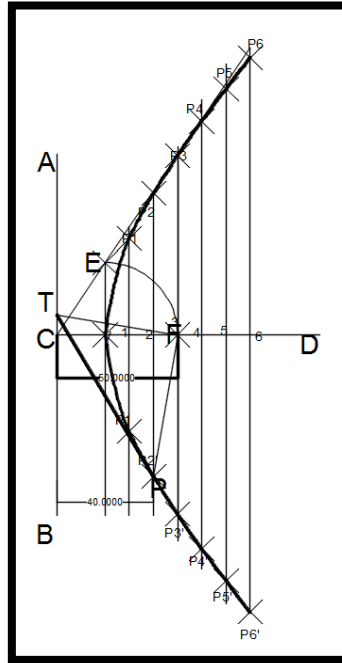
Figure3:**HYPERBOLA**

Commands:
1. Line
2. Offset
3. Spline
4. Arc/ Circle
5. Dtext
6. Rotate
7. Dimlin/ Dimalign/Dimang

Procedure:
1. Draw the directrix AB and the axis CD
2. Mark the focus F on CD and 65mm from C
3. Divide CF into 5 equal divisions and mark V the vertex, on the second division from C. Thus, eccentricity = VF /VC= 3/2
4. To construct the scale for the ratio, draw a line VE perpendicular to CD such that VE =VF. Join C with E.
   Thus, in triangle CVE, VE/VC=VF/VC=3/2.
5. Mark any point 1 on the axis and through it, draw a perpendicular to meet CE-produced at 1 '.
6. With centre F and radius equal to 1-1 ', draw arcs intersecting the perpendicular through 1 at P_1 and P'_1.
7. Similarly, mark a number of points 2, 3 etc. and obtain points P_2 and P'_2 , P_3 and P'_3 etc.
8. Draw the hyperbola through these points.

To draw tangent & normal:
1. Join P with F.
2. From F, draw a line perpendicular to PF to meet AB at T.
3. Draw a line through T and P. This line is the tangent to the curve.
4. Through P, draw a line NM perpendicular to TP. NM is the normal to the curve.

SHEET NO:3
CONIC SECTIONS II

ELLIPSE

1. Draw the ellipse whose major axis is 150mm & minor axis is 100mmby using
   (i)   Concentric circle method
   (ii)   Oblong Method
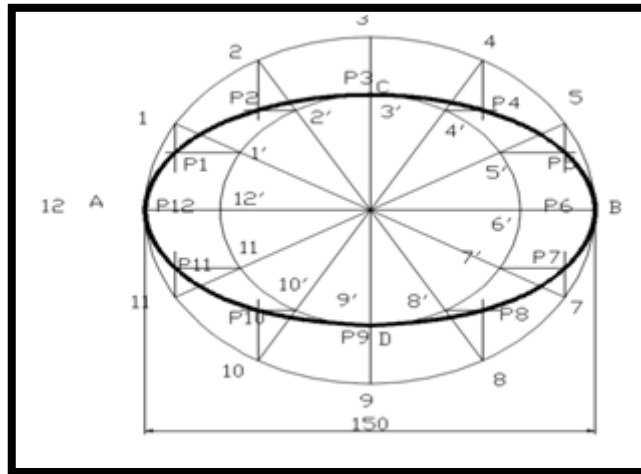
Figure1:CONCENTRIC CIRCLE METHOD

Commands:

1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Point
7. Ptype
8. Spline
9. Array

Procedure:

1. Draw the major axis AB and the minor axis CD intersecting each other at O
2. With centre O and diameters AB and CD respectively, draw two circles.
3. Divide the major-axis-circle into a number of equal divisions, say 12 and mark points 1, 2 etc. as shown.
4. Draw lines joining these points with the centre O and cutting the minor-axis-circle at points 1 ', 2' etc.
5. Through point 1 on the major-axis-circle, draw a line parallel to CD, the minor axis
6. Through point 1' on the minor-axis-circle, draw a line parallel to AB, the major axis. The point P1, where these two lines intersect is on the required ellipse.
7. Repeat the construction through all the points. Draw the ellipse through A, P1, P2. etc

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ii)
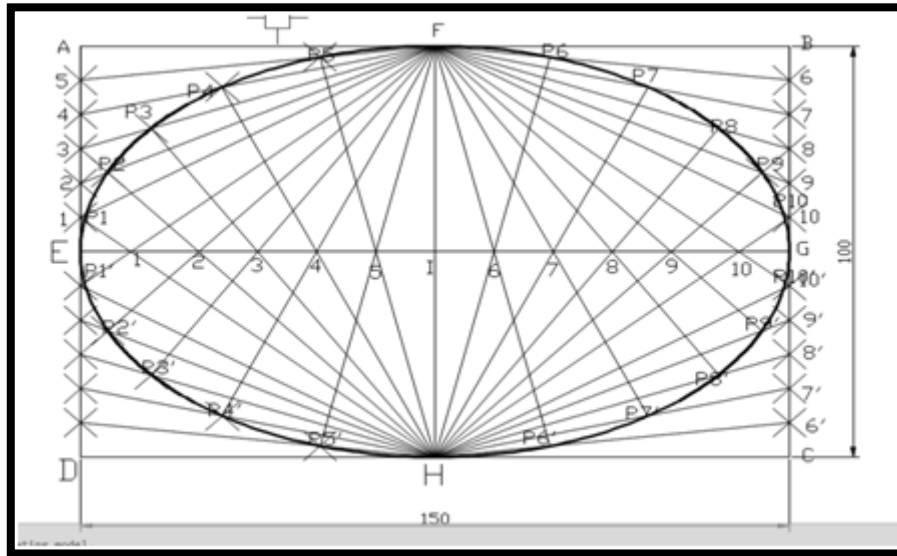
Figure2:OBLONG METHOD

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Point
7. Ptype
8. Spline
9. Division

Procedure:
1. Draw the two axes AB and CD intersecting each other at 0.
2. Construct the oblong EFGH having its sides equal to the two axes.
3. Divide the semi-major-axis AO into a number of equal parts, say 4, and AE into the same number of equal parts, numbering them from A as shown.
4. Draw lines joining 1 ', 2' and 3' with C.
5. From D, draw lines through 1, 2 and 3 intersecting C'1, C'2 and C'3 at points P1, P2 and P3 respectively.
6. Draw the curve through A, P1. C. It will be one quarter of the ellipse.
7. Complete the curve by the same construction in each of the three remaining quadrants.

PARABOLA

2. A ball thrown up in the air reaches a maximum height of 45 metres and travels a horizontal distance of 75 metres. Trace the path of the ball, assuming it to be parabolic. (Rectangle method)
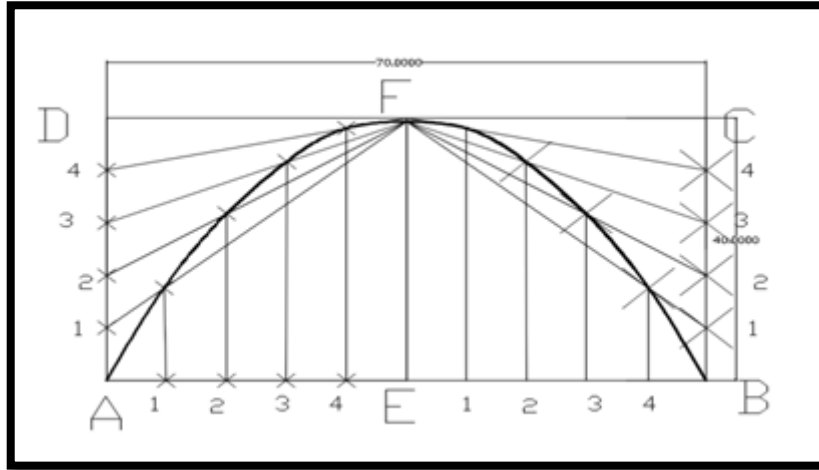
Figure3: RECTANGLE METHOD

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin
7. Ptype
8. Point
9. Division

Procedure:
1. Draw the base AB.
2. At its mid-point E, draw the axis EF at right angles to AB.
3. Construct a rectangle ABCD, making side BC equal to ff.
4. Divide AE and AD into the same number of equal parts and name them as shown (starting from A).
5. Draw lines joining F with points 1, 2 and 3. Through 1 ', 2' and 3', draw perpendiculars to AB intersecting F1, F2 and F3 at points P1, P2 and P3 respectively.
6. Draw a curve through A, P1, P2 etc. It will be a half parabola.

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3. A fountain jet discharges water from the ground level at an angle of 45^0 to the ground. It travels a maximum horizontal distance of 8.5m from the point of discharge and falls on the ground. Trace the path of the jet. Assuming it to be Parabolic (Tangent method)
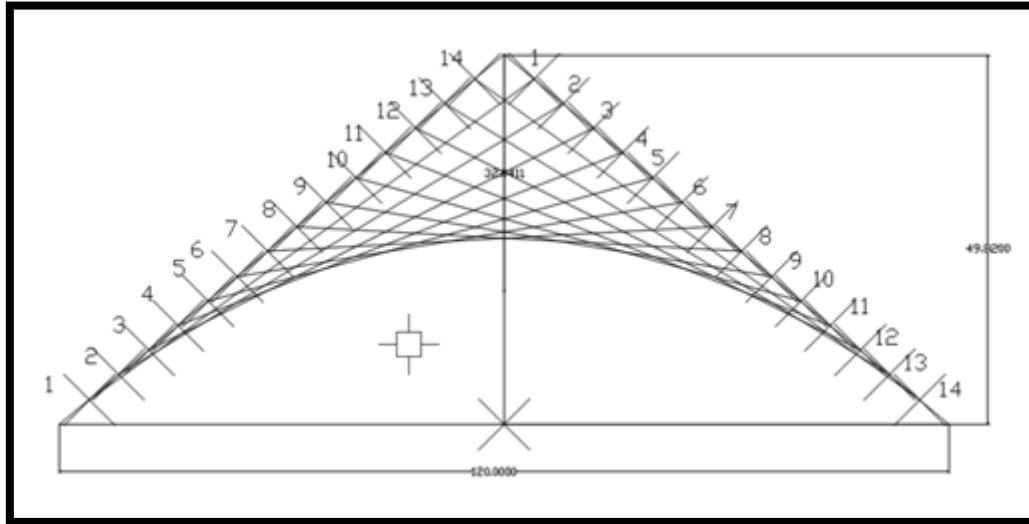
Figure4: PARABOLIC (TANGENT METHOD)

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin
7. Ptype
8. Point
9. Division

Procedure:
1. Draw the base AB and the axis EF.
2. Produce EF to O so that EF = FO. 112 Engineering Drawing.
3. Join O with A and 8. Divide lines OA and OB into the same number of equal parts, say 8.
4. Mark the division-points as shown in the figure.
5. Draw lines joining 1 with 1 ', 2 with 2' etc. Draw a curve starting from A and tangent to lines 1-1 ', 2-2' etc. This curve is the required parabola.

HYPERBOLA

4. A point P is 40 mm and 50 mm respectively from two straight lines which are at right angles to each other. Draw a rectangular hyperbola from P within 10 mm distance from each line.

Figure5:HYPERBOLA (RECTANGLE METHOD)

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin
7. Ptype
8. Point
9. Division

Procedure:
1. Draw lines OA and OB at right angles to each other.
2. Mark the position of the point P.
3. Through P, draw lines CD and EF parallel to OA and OB respectively.
4. Along PD, mark a number of points 1, 2, 3 etc. not necessarily equidistant.
5. Draw lines 01, 02 etc. cutting PF at points 1 ', 2' etc.
6. Through point 1, draw a line parallel to OB and through 1', draw a line parallel to OA, intersecting each other at a point P1.
7. Obtain other points in the same manner.
8. For locating the point, say P6, to the left of P, the line 06 should be extended to meet PE at 6'.
9. Draw the hyperbola through the points P6, P, P1 etc.

Date: _____

Viva Questions:

1. What are conic sections and why are they called so?
2. Define eccentricity?
3. Define Ellipse?
4. Name the methods to draw an ellipse?
5. Define Parabola?
6. Name the methods to draw Parabola?
7. Define Hyperbola?
8. Name the methods to draw Hyperbola?
9. What is the significance of normal and tangent on a curve?
10. What are the methods to draw normal and tangent on conics?
11. what are applications of conic sections?

CYCLOIDAL CURVES

These curves are generated by a fixed point on the circumference of a circle, which rolls without slipping along a fixed straight line or a circle. The rolling circle is called generating circle and the fixed straight line or circle is termed directing line or directing circle. Cycloidal curves are used in tooth profile of gears of a dial gauge.

```
                           ┌──────────────┐
                           │  CYCLOIDAL   │
                           │   CURVES     │
                           └──────────────┘
        ┌─────────────┬──────────┴──────────┬─────────────┐
   ┌─────────┐   ┌─────────┐          ┌─────────┐    ┌─────────┐
   │ INVOLUTE│   │ CYCLOID │          │  SPIRAL │    │  HELIX  │
   └─────────┘   └─────────┘          └─────────┘    └─────────┘
```

INVOLUTE:
- 1. Involute of a circle.
  - a. a) String Length = πD
  - b. String Length > πD
  - c. String Length < πD
- 2. Pole having Composite shape.
- 3. Rod Rolling over a Semi-circular Pole.

CYCLOID:
- 1. General Cycloid
- 2. Trochoid (superior).
- 3. Trochoid (Inferior)
- 4. Epi-Cycloid
- 5. Hypo-Cycloid

SPIRAL:
- 1. Spiral of One Convolution.
- 2. Spiral of Two Convolutions

HELIX:
- 1. On Cylinder
- 2. On a Cone

CYCLOID: It is a locus of a point on the periphery of a circle which rolls on a straight line path.
SUPERIORTROCHOID: If the point in the definition of cycloid is outside the circle
INFERIOR TROCHOID: If it is inside the circle
EPI-CYCLOID: If the circle is rolling on another circle from outside
HYPO-CYCLOID: If the circle is rolling from inside the other circle
INVOLUTE: It is a locus of a free end of a string when it is wound round a circular pole
SPIRAL: It is a curve generated by a point which revolves around a fixed point and at the same moves towards it.
HELIX: It is a curve generated by a point which moves around the surface of a right circular cylinder / cone and at the same time advances in axial direction at a speed bearing a constant ratio to the speed of rotation.

SHEET NO:4
CYCLOIDS

1. A circle of 50 mm diameter rolls along a straight line without slipping. Draw the curve traced out by a point P on the circumference, for one complete revolution of the circle. Name the curve. Draw a tangent to the curve at a point on it 40 mm from the line.
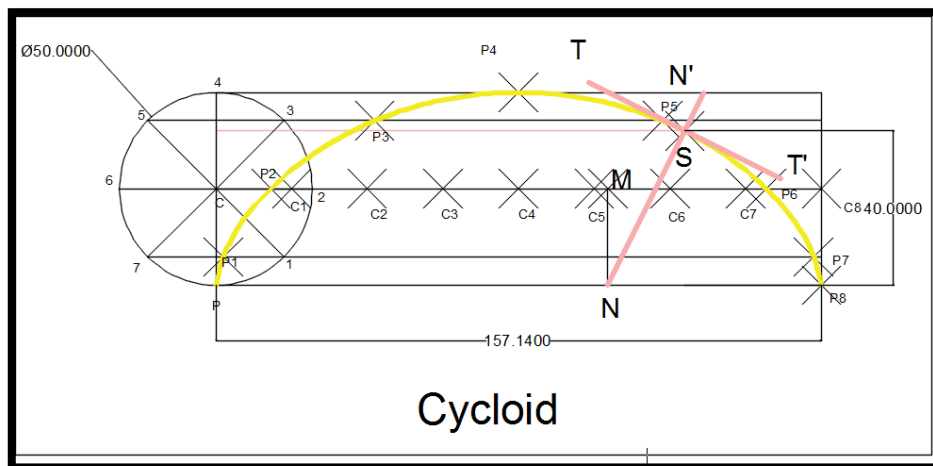
Figure1:CYCLOIDS

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin/ Dimalign/ Dimangle
7. Ptype
8. Point
9. Division
10. Circle
11. Polar Array
12. Copy
13. Rotate

Procedure:
1. With centre C and given radius R, draw a circle. Let P be the generating point.
2. Draw a line PA tangential to and equal to the circumference of the circle.
3. Divide the circle and the line PA into the same number of equal parts, say 12, and mark the division-points as shown.
4. Through C, draw a line CB parallel and equal to PA.
5. Draw perpendiculars at points 1, 2 etc. cutting CB at points C1, C2 etc.
6. Assume that the circle starts rolling to the right.

7. When point 1' coincides with 1, centre C will move to C1
8. In this position of the circle, the generating point P will have moved to position P1 on the circle, at a distance equal to P'1 from point 1.
9. It is evident that P1 lies on the horizontal line through 1' and at a distance R from C1.
10. Similarly, P2 will lie on the horizontal line through 2' and at the distance R from C2
11. Through the points 1 ', 2' etc. draw lines parallel to PA.
12. With centres C1, C2 etc. and radius equal to R, radius of generating circle, draw arcs cutting the lines through 1 ', 2' etc. at points P1, P2 etc. respectively.
13. Draw a smooth curve through points P, P1, P2 •••• A. This curve is the required cycloid.

Tangent and Normal
1. With centre N and radius equal to R, draw an arc cutting CB at M.
2. Through M, draw a line MO perpendicular to the directing line PA and cutting it at 0. 0 is the point of contact and M is the position of the centre of the generating circle, when the generating point P is at N.
3. Draw a line through N and 0. This line is the required normal.
4. Through N, draw a line ST at right angles to NO. ST is the tangent to the cycloid.

2. A circle of 50 mm diameter rolls on the circumference of another circle of 150 mm diameter and outside it. Trace the locus of a point on the circumference of the rolling circle for one complete revolution. Name the curve. Draw a tangent and a normal to the curve at a point 85 mm from the centre of the directing circle.
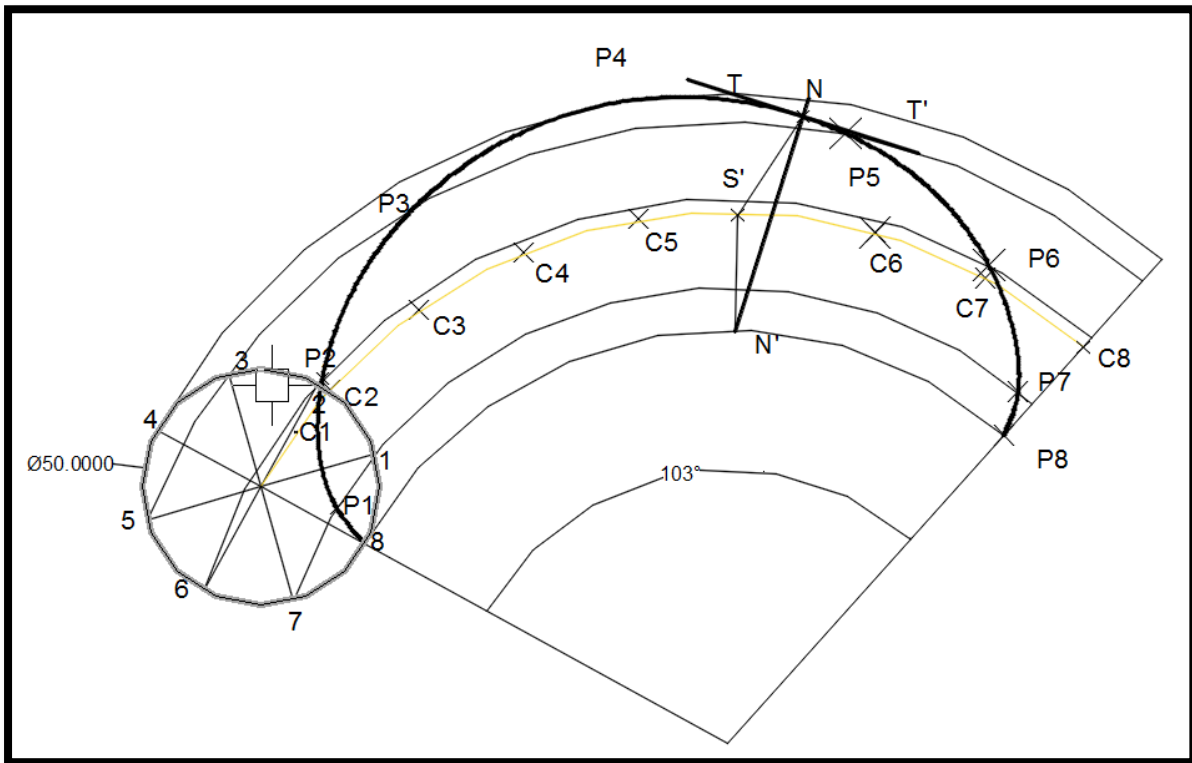
Figure2:EPI-CYCLOIDS

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin/ Dimalign/ Dimangle
7. Ptype
8. Point
9. Division
10. Circle
11. Polar Array
12. Copy
13. Rotate

Procedure:
1. With centre O and radius R, draw the directing circle (only a part of it may be drawn). Draw a radius OP and produce it to C, so that CP = r.
2. With C as centre, draw the generating circle. Let P be the generating point.

3. In one revolution of the generating circle, the point P will move to a point A, so that the arc PA is equal to the circumference of the generating circle.
4. The position of A may be located by calculating the angle subtended by the arc PA at centre 0, by the formula,

$$\frac{\angle POA}{360} = \frac{Arc\ PC}{Circumference\ of\ directing\ circle} = \frac{2\pi r}{2\pi R} = \frac{r}{R}$$

Therefore $\angle POA = \frac{r}{R}$

5. Set-off this angle and obtain the position of A.
6. With centre O and radius equal to OC, draw an arc intersecting QA-produced at B. This arc CB is the locus of the centre C.
7. Divide CB and the generating circle into twelve equal parts.
8. With centre 0, describe arcs through points 1\ 2', 3' etc.
9. With centres C1, C2 etc. and 2 TC r 2 TC R radius equal to r, draw arcs o r = R M cutting the arcs through 1 ', Hypocycloid 2' etc. at points P1, P2 etc. FIG. 6-35 Draw the required epicycloid through the points P, P1, P2. A.

Tangent and Normal
1. With centre N and radius equal tor, draw an arc cutting the locus of the centre C at a point D.
2. Draw a line through O and D, cutting the directing circle at M.
3. Draw a line through N and M. This line is the normal.
4. Draw a line ST through N and at right angles to NM. ST is the tangent.

Viva questions:

1. What are cycloidal curves?
2. Define Cycloid?
3. Define Epicycloid?
4. What property of cycloidal curves is used to draw?
5. normal and tangent on the curve?
6. What are the applications of cycloidal curves?

SHEET NO:5
<u>INVOLUTES</u>

1. Draw the Involutes of the following:
   a. Circle of 50mm diameter
   b. Square of 30mm sides
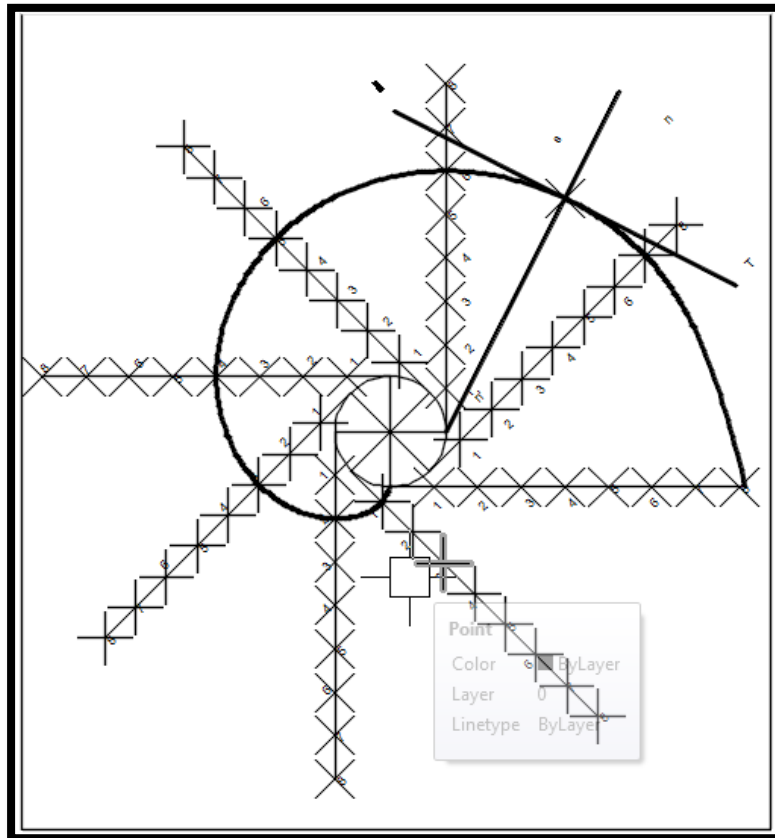
<u>Figure1:CIRCLE</u>

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin/ Dimalign/ Dimangle
7. Ptype
8. Point
9. Division
10. Circle
11. Polar Array
12. Copy
13. Rotate

Procedure:

1. Draw a line PQ, tangent to the circle and equal to the circumference of the circle.
2. Divide PQ and the circle into 12 equal parts.
3. Draw tangents at points 1, 2, 3 etc. and mark on them points P_1, P_2, P_3 etc. such that $1P_1 = P_1'$, $2P_2 = P_2'$, $3P_3 = P_3'$ etc.
4. Draw the involute through the points P, P_1, P_2 •... etc.

Tangent and Normal

1. Draw a line joining C with N.
2. With CN as diameter describe a semi-circle cutting the circle at M.
3. Draw a line through N and M. This line is the normal. Draw a line ST, perpendicular to NM and passing through N. ST is the tangent to the involute.
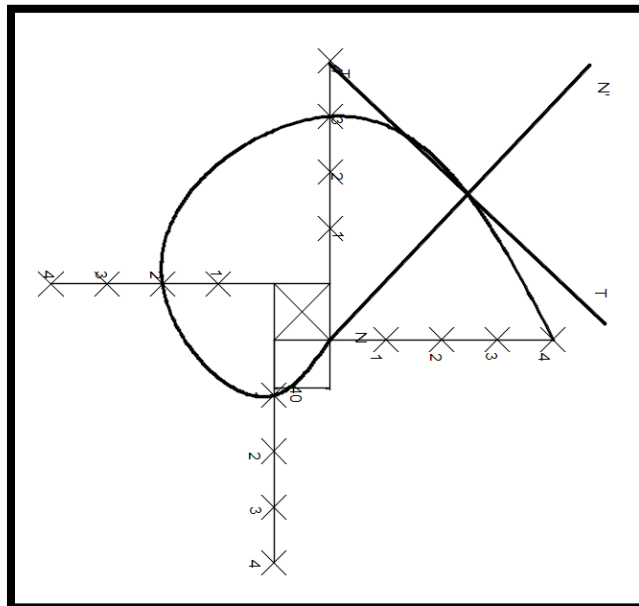
Figure2:SQUARE INVOLUTE

Commands:

1. Units
2. Limits
3. Line
4. Dtext
5. Spline
6. Dimlin/ Dimalign/ Dimangle
7. Ptype
8. Point
9. Division
10. Copy
11. Rotate

Procedure:

1. let ABCD be the given square.
2. With centre A and radius AD, draw arc to cut the line BA-produced at a point P_1.
3. With centre B and radius BP1 (i.e. BA + AD) draw an arc to cut the line CB-produced at a point P2.
4. Similarly, with centres C and D and radii CP2 (i.e. CB + BA + AD) and DP3 (i.e. DC + CB + BA + AD = perimeter) respectively, draw arcs to cut DC-produced at a point P3 and AD-produced at a point P_4.
5. The curve thus obtained is the involute of the square.

Assignment:

1. A thin triangular equilateral plate of 20 mm side is pinned at its centroid 0. An inelastic string circumscribes complete perimeter of the plate. One end of the string is attached to one of the apex of the plate. Draw the curve traced out by other end of the string keeping it tight, when the string is unwounded.
2. A regular pentagonal plate of 20 mm side is fixed at its centre. An inelastic rope is circumscribed along the perimeter of the pentagonal. Draw the path of free end of the rope when it is unwounded keeping, tight for one complete tum.
3. A thin semi-circular plate with C as centre and radius equal to 32 mm is fixed. OP is the inelastic rope of 140 mm horizontal length. End O of the rope is fixed. The end O is 20 mm above and 20 mm on the left of C. The rope is wound in anti-clockwise direction around the circumference of the plate. Draw the locus of free end P of the rope.

Date: _____

SCALES

DIMENSIONS OF LARGE OBJECTS MUST BE REDUCED TO ACCOMMODATE ON STANDARD SIZE DRAWING SHEET.THIS REDUCTION CREATES A SCALE OF THAT REDUCTION RATIO, WHICH IS GENERALLY A FRACTION..
SUCH A SCALE IS CALLED REDUCING SCALE
AND
THAT RATIO IS CALLED REPRESENTATIVE FACTOR.

SIMILARLY IN CASE OF TINY OBJECTS DIMENSIONS MUST BE INCREASED FOR ABOVE PURPOSE. HENCE THIS SCALE IS CALLED ENLARGING SCALE. HERE THE RATIO CALLED REPRESENTATIVE FACTOR IS MORE THAN UNITY.

FOR FULL SIZE SCALE
R.F.=1 OR (1:1)
MEANS DRAWING
& OBJECT ARE OF
SAME SIZE.
Other RFs are described as
1:10,   1:100,
1:1000, 1:1,00,000

USE FOLLOWING FORMULAS FOR THE CALCULATIONS IN THIS TOPIC.

A REPRESENTATIVE FACTOR (R.F.) $= \dfrac{\text{DIMENSION OF DRAWING}}{\text{DIMENSION OF OBJECT}}$

$= \dfrac{\text{LENGTH OF DRAWING}}{\text{ACTUAL LENGTH}}$

$= \sqrt{\dfrac{\text{AREA OF DRAWING}}{\text{ACTUAL AREA}}}$

$= \sqrt[3]{\dfrac{\text{VOLUME AS PER DRWG.}}{\text{ACTUAL VOLUME}}}$

B LENGTH OF SCALE = R.F. X MAX. LENGTH TO BE MEASURED.

BE FRIENDLY WITH THESE UNITS.

1 KILOMETRE   = 10 HECTOMETRES
1 HECTOMETRE = 10 DECAMETRES
1 DECAMETRE = 10 METRES
1 METRE   = 10 DECIMETRES
1 DECIMETRE = 10 CENTIMETRES
1 CENTIMETRE = 10 MILIMETRES

TYPES OF SCALES:

1.	PLAIN SCALES	(FOR DIMENSIONS UP TO SINGLE DECIMAL)
2.	DIAGONAL SCALES	(FOR DIMENSIONS UP TO TWO DECIMALS)
3.	VERNIER SCALES	(FOR DIMENSIONS UP TO TWO DECIMALS)
4.	COMPARATIVE SCALES	(FOR COMPARING TWO DIFFERENT UNITS)
5.	SCALE OF CORDS	(FOR MEASURING/CONSTRUCTING ANGLES)

Date: _____

SHEET NO:6
SCALES

1. Construct a scale of 1 : 4 to show centimetres and long enough to measure upto 5 decimetres.
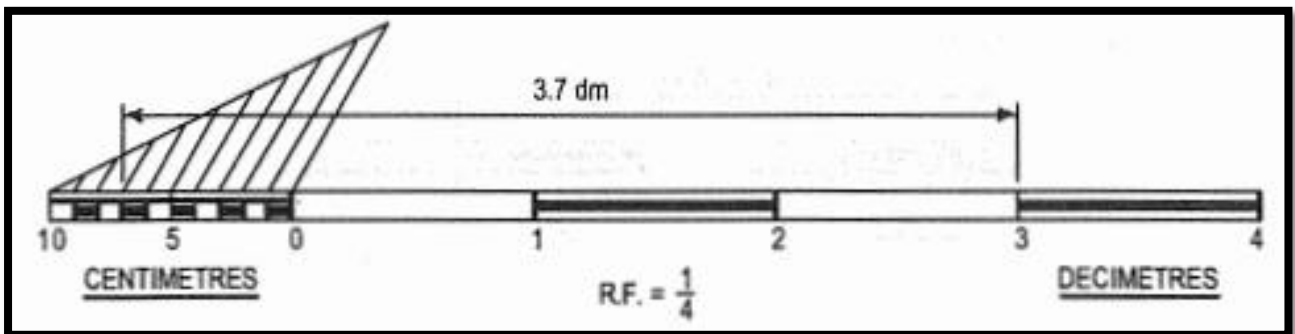
Figure1

Commands:
1. Units
2. Limits
3. Line
4. Division
5. Points
6. Ptype
7. Dimlin
8. Dtext

Procedure:
1. Determine R.F. of the scale. Here it is ¼.
2. Determine length of the scale.
3. Length of the scale == R.F. x maximum length =1/ 4 x 5 dm == 12.5 cm.
4. Draw a line 12.5 cm long and divide it into 5 equal divisions, each representing 1 dm.
5. Mark O at the end of the first division and 1, 2, 3 and 4 at the end of each subsequent division to its right.
6. Divide the first division into 10 equal sub-divisions, each representing 1 cm.
7. Mark ems to the left of O as shown in the figure.

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2. Draw a plain scale of 1:60 showing meters & decimetre & to measure upto 6 meters. Show the length of 3.7m & 4.9m
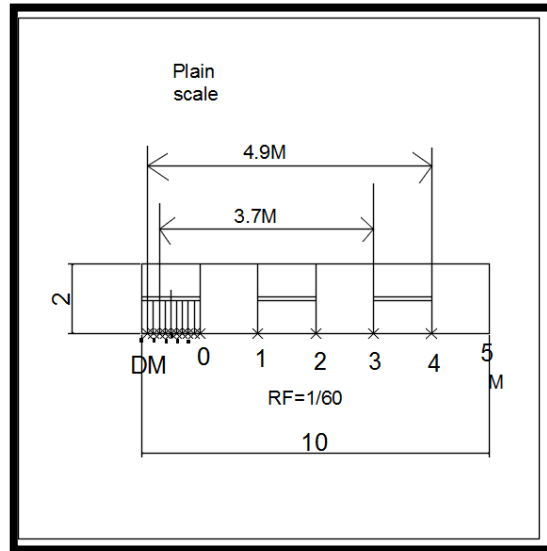
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Division
5. Points
6. Ptype
7. Dimlin
8. Dtext

Procedure:
1. Determine R.F. of the scale, here R.F. = 1/60
2. Determine length of the scale.
3. Length of the scale = 1/60 x 6 m = 1/10 metre = 10 cm.
4. Draw a line 10 cm long and divide it into 6 equal parts.
5. Divide the first part into 1 O equal divisions and complete the scale as shown.
6. The length 3.7 metres is shown on the scale.

3. Construct a diagonal scale of 3: 200 i.e. 1:$66\frac{2}{3}$ showing meters, decimetres and centimetres and to measure upto 6 metre
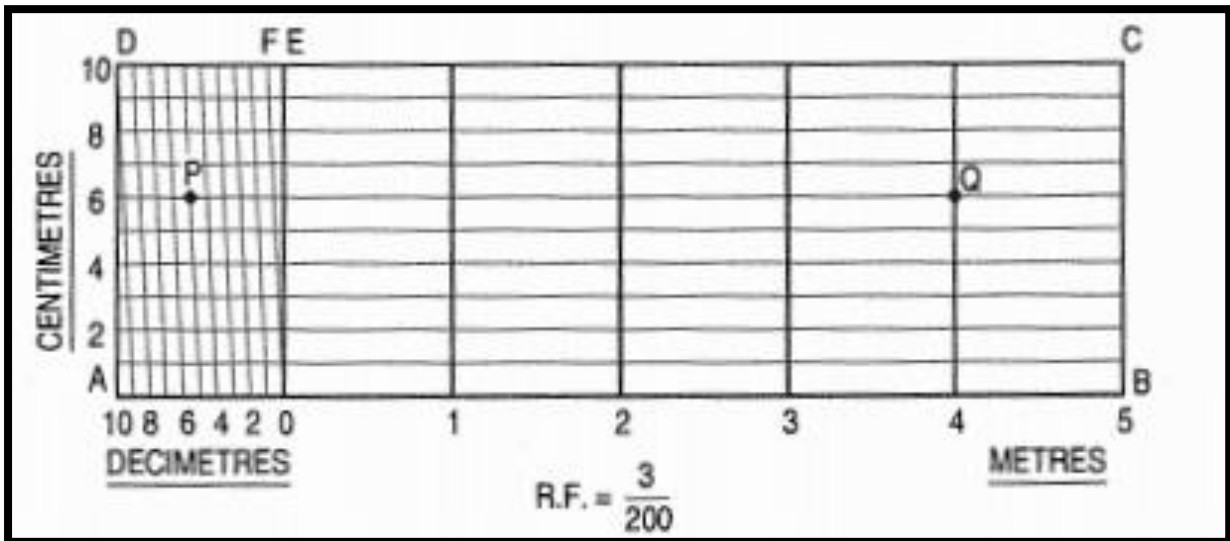
Figure3

Commands:
1. Units
2. Limits
3. Line
4. Division
5. Points
6. Ptype
7. Dimlin
8. Dtext

Procedure:
1. Draw a line AB 9 cm long and divide it into 6 equal parts. Each part will show a metre.
2. Divide the first part AO into 10 equal divisions, each showing a decimetre or 0.1 m.
3. At A erect a perpendicular and step-off along it, 10 equal divisions of any length, ending at 0. Complete the rectangle ABCD.
4. Erect perpendiculars at metre-divisions 0, 1, 2, 3 and 4.
5. Draw horizontal lines through the division-points on AD.
6. Join O with the end of the first division along AO, viz. the point 9.
7. Through the remaining points i.e. 8, 7, 6 etc. draw lines parallel to D9.

Assignments
1. Draw a scale of 1: 60 to show metres and decimetres and long enough to measure upto 6 metres.
2. Construct a scale of 1.5 inches = 1 foot to show inches and long enough to measure up to 4 feet.

3. Construct a diagonal scale of R. F= 1/32 showing yards, feet and inches and to measure up to 4 yards.
4. Draw a scale of full-size, showing 1/100 inch and to measure up to 5 inches.

Viva Questions:

1. Define R.F.?
2. How will you find L.O.S?
3. How many types of scales are used in Engineering Drawing?
4. What is the difference between Plain Scale and Diagonal Scale?
5. What is scale of chords and why it is called so?
6. What is RF of scale of chords?
7. How will you measure given angle using scale of chords?
8. How will you draw given angle using scale of chords?

INTRODUCTION TO AUTOCAD:

A part to be manufactured is defined first in terms of its geometry which also includes dimensions, tolerances, surface finish, and in some cases the type of fit between two mating parts. The two-dimensional representation of a part, called an engineering drawing or a blueprint, shows three orthogonal views of the part. Sometimes, when three views are not enough to define the part, additional sectional views, auxiliary views may have to be added for conveying the right information.

Any design is finally represented in the form of orthographic views and auxiliary views so that production can be carried out. Hence, the computer aided drafting is an important tool for Computer Aided Design. The Computer Aided Drafting (CAD) system is the computerization of technical, production, electronics and architectural drawings.CAD is the product of computer era. Its development originated from early computer graphics systems. CAD can find its roots to the development of Interactive Computer Graphics (ICG). A system called Sketchpad was developed at Massachusetts Institute of Technology, U.S.A., in 1963 by Ivan Sutherland.

In the beginning, CAD systems were no more than graphics editors with some built-in design symbols. The geometry available to the user was limited to lines, circular arcs, and a combination of the two. The development of free-form curves and surfaces such as Coon's patch, Ferguson's patch, Bezier's curve, and 8-splines enabled a CADsystem to be used for more sophisticated work. A 30 CAD system allows a user todo very sophisticated design and analysis work.

Computer aided drawing and drafting system uses the computer to assist in generation of blueprint data. CAD systems are essential in design and a large number of computer based systems are commercially available. 20 drawing systems correspond directly to traditional engineering drawings, and they are developed to substitute manual drafting.

The advantages offered by computerized drafting systems can be summarized as:
(a) It increases the accuracy and productivity of designer.
(b) It allows design alterations to be made easily.
(c) It offers better drawing visualization through colours.
(d) It improves the quality of drawings produced.
(e) Drawings are easier to store and retrieve.
(f) Storage space required is less.
(g) Transfer of drawings is faster and cheaper.
(h) It permits the use of library of standard symbols for more productive CAD Work

VERSION OF AUTOCAD
1. AutoCAD software was firstly launched by Autodesk company in Dec. 1982. It comes in India in 1988.
2. The first version of AutoCAD was R1 after that R2, R3, R4……………. and so on
3. In 2000, Autodesk launched a version of AutoCAD 2000 after that 2001,2002…… so on.
4. This time, we have the latest version of AutoCAD is 2014, which is launched on 27th march 2013
5. Latest version is easy to use and overcome the difficulties of old version.

Date: _____

AUTOCAD SCREEN

6.
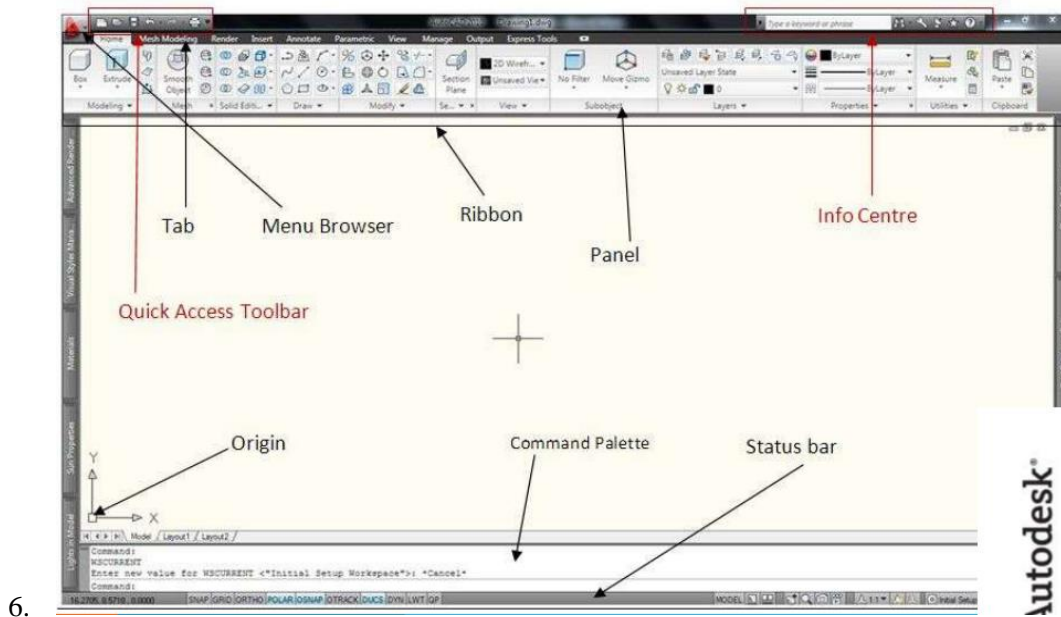
HOW AutoCAD WORKS

- ✓ There is a co-ordinate system used in AutoCAD.

- ✓ Every drawing shows its co-ordinate.

- ✓ In above next slide the line shows its co-ordinate that is (9,6) and (-10,-4).

- ✓ There is so many commands like copy, move ,rotate ,mirror in 2D, path array , rectangular array, polar array & more.

- ✓ Different types of drawing can be made in the same time by using a command that is LAYER.

- ✓ Using line , arc , circle , rectangle , ellipse & polygon , so many drawing of different type can be made.

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CO-ORDINATE SYSTEM

✓ Every thing that we draw in AutoCAD is exact.

✓ All object drawn on screen is based on simple X-Y co-ordinate system.

✓ In AutoCAD it is known as world co-ordinate system (WCS).

✓ We are drawing a line, so we have two points A(-10,-4) and B(9,6). As shown in figure.
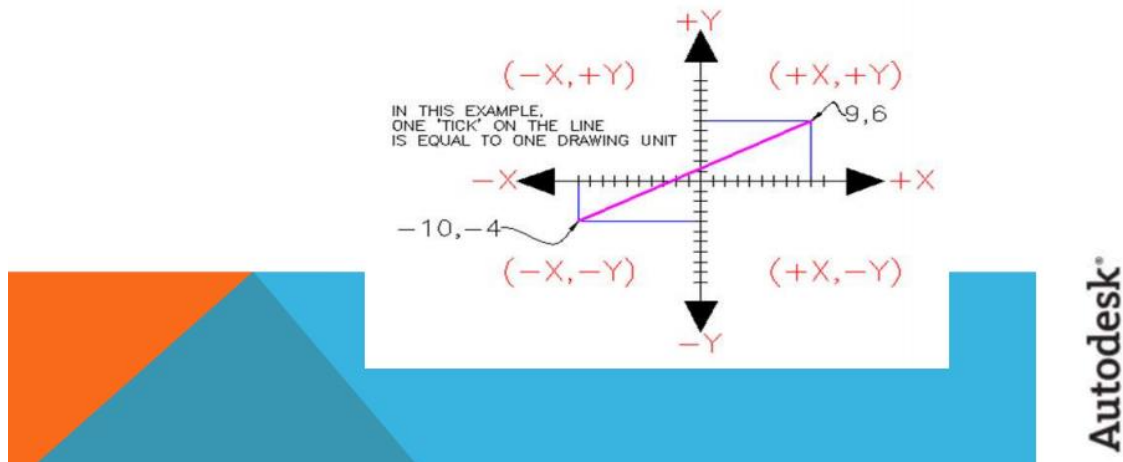
The UCS and WCS

✓ The AutoCAD world is 3 dimensional. However, if we want to draw a 2d object, such as a plan or a section, we will use only 2 dimensions (x and y).

✓ WCS (world coordinate system) is the imaginary plane that is parallel to the ground. It is the default coordinate system.

✓ Modifications made to the World Coordinate System (WCS) result in a User Coordinate System (UCS). It is the plane that you work on. It enables the user to draw 3 dimensional objects.

✓ To create a new UCS, type ucs on the command window, then say New and specify 3 points on your new UCS plane.

DRAW TOOLBAR AND MODIFY TOOLBAR :

Following image shows two very basic tool bars, these will be heavily used as you progress towards the end of your drawing. You can access these tool bars under Home tab.

As we move cursor over any tool in the tool bar a tooltip appears stating the name of that tool. And if we further wait for about three seconds, it turns into a brief description about that particular tool. As shown by the following image.

DIMENSION TOOLBAR :

AutoCAD provides a whole range of dimensioning tools which can be used to quickly dimension any drawing without the need for measurement. Dimensioning in AutoCAD is automatic; lines, arrows and text are all taken care of by the dimension commands. AutoCAD dimensions are special blocks which can easily be edited or erased as necessary.

AutoCAD provides lots of control over the way dimensions look. Using a system similar to text styles, dimension styles allow you to design dimensions so that they look just the way you want them to.
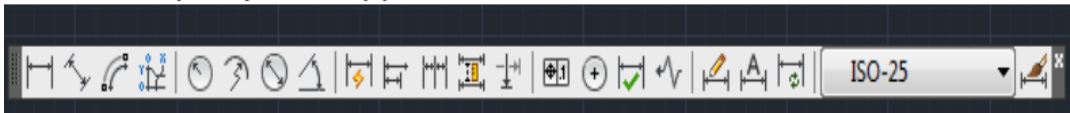
HOW TO SET DRAWING UNITS:

To set the drawing units, go to the drop down window at the top let side of the AutoCAD 2013 screen labeled as **Format** or just press **Alt + o** key to do so. And from this menu select **units**. A pop up window will appear that will set our drawing units as shown below.
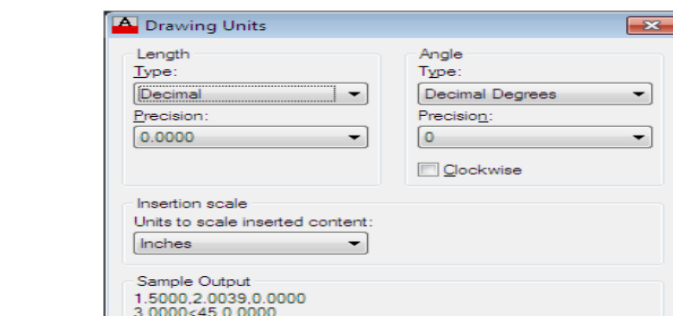
DRAW/BASIC COMMANDS OF AutoCAD
(Drawing Entities)

POINT

Plot a point at the location (8, 6)
Command: point ↵
Point: 8, 6 ↵
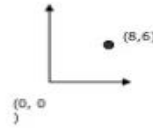
LINE

Lines can be drawn by any one of the following three methods using LINE command.

(a) Using Absolute Co-ordinates:

Drawing a line from point (5, 5) to point (10, 10)
Command: Line ↵
From point: 5, 5(select the point by mouse or Enter the Co-ordinates by keyboard) ↵
To Point: 10, 10 ↵
To Point: ↵
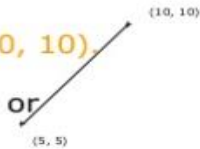
(b) Using Relative Co-ordinates

Draw a line from point (2, 2) to point 5 units in X-axis and 8 units in Y-axis relative to first co-ordinate.

Command: Line↵
From point: 2, 2↵
To point: @ 5, 8↵
To point: ↵
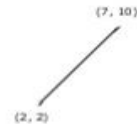
(c) Using Polar Co-ordinates

Draw a line from point (1, 2) to a length of 6 units at 90 degree.

Command: Line↵
From point: 1, 2↵
To point:@6<90↵
To point: ↵

Toggle Drawing Modes

F1	Display Help
F2	Toggle text screen
F3	Toggle object snap mode
F4	Toggle 3DOsnap
F5	Toggle Isoplane
F6	Toggle Dynamic UCS

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F7	Toggle grid mode
F8	Toggle ortho mode
F9	Toggle snap mode
F10	Toggle polar mode
F11	Toggle object snap tracking
F12	Toggle dynamic input mode

DRAW COMMANDS	MODIFY COMMANDS	VIEW COMMANDS & OTHERS
LINE	MOVE	REDRAW
CIRCLE	COPY	REGEN
ARC	OFFSET	ZOOM
PLINES	TRIM	PAN
RECTANGLE	EXTEND	3DORBIT
ELLIPSE	ROTATE	HIDE
MLINE	SCALE	SHADE
XLINE	CHAMFER	RENDER
RAY	LENGTHEN	VIEWPORT
DONUT	ARRAY	DDEDIT
SPLINE	BREAK	SNAP
MLSTYLE	MEASURE	GRID
MLEDIT	PROPERTIES	OSNAP
POLYGON	ERASE	LIMITS
TEXT	FILLET	EXPLODE
DTEXT	BLOCK	LIST
MTEXT	WBLOCK	AREA
LINETYPE	INSERT	TIME
LTSCALE	PEDIT	STATUS
HATCH	DIVIDE	DIM
LAYERS	MIRROR	PLOT

VIVA QUESTIONS:

1. Define AutoCAD
2. What are the draw commands?
3. What the modify commands
4. What is use of the function keys?
5. What are the methods to draw a line?
6. Define WCS & UCS?
7. What are the advantages of AutoCAD?
8. Define Coordinates?

Date: _____

PROJECTIONS

WHAT IS PROJECTION?

The figure or view formed by joining, in correct sequence, the points at which these lines meet the plane is called the **Projection of the object**.
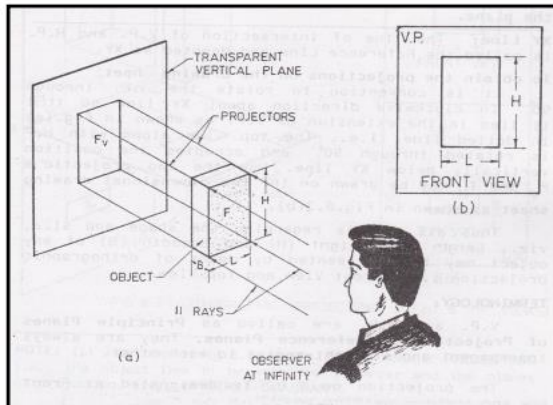
- The lines or rays drawn from the object to the plane are called **Projectors**.
- The transparent plane on which the projections are drawn is known as **Plane of Projection**.

Note: It is obvious that the outlines of the shadow arc the projections of an object.

TYPES OF PROJECTION

- Pictorial Projections
  - Perspective Projections
  - Isometric Projections
  - Oblique Projections
- Orthographic Projections

PICTORIAL PROJECTION

The Projection in which the description of the object is <u>completely understood</u> in one view is known as **Pictorial Projection**.

The pictorial projections have the advantage of conveying an immediate impression of the general shape and details of the object, but no its true dimensions or sizes.
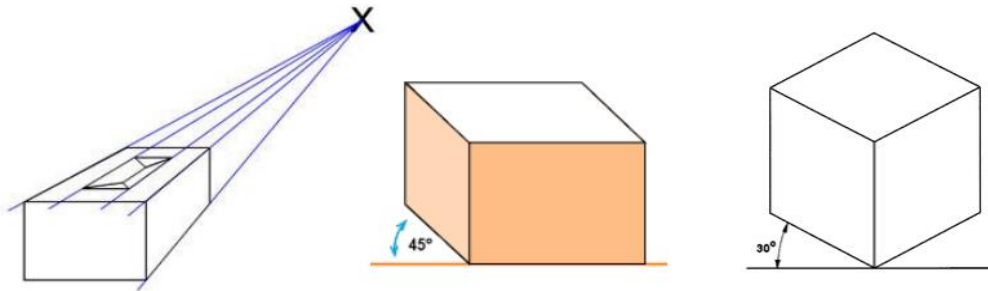
PERSPECTIVE PROJECTION
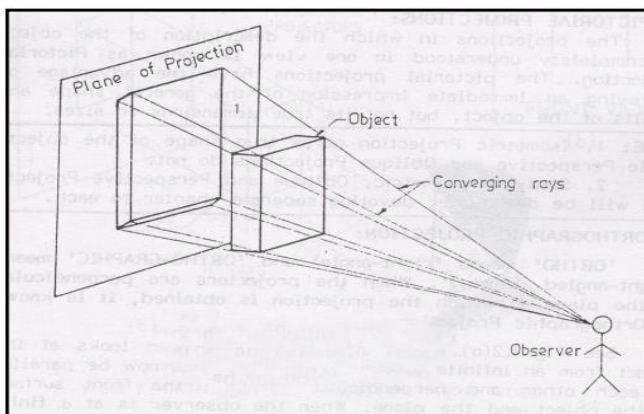
If any transparent plane is introduced such that the object is in between the observer and the plane. The image obtained on the plane/screen is as shown. This is called **Perspective View** of the object.

Here straight lines (rays) are drawn from various points on the contour of the object to meet the transparent plane, thus the object is said to be projected on that plane

ISOMETRIC PROJECTION

"**Iso**" means '**equal**' and "**metric projection**" means '**a projection to a reduced measure**'.

An *Isometric Projection* is one type of pictorial projection in which the three dimensions of a solid are not only shown in one view, but also their dimension can be scaled from this drawing.
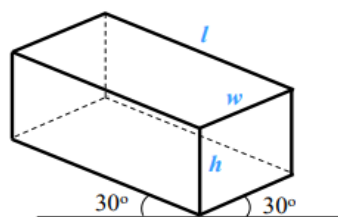
Fig. Isometric Projection

OBLIQUE PROJECTION

The word "**oblique**" means "**slanting**" There are three axes-vertical, horizontal and oblique. The oblique axis, called receding axis is drawn either at 30° or 45°. Thus an oblique drawing can be drawn directly without resorting to projection techniques
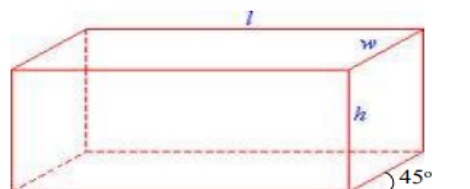
Fig. Oblique Projection

Date: _____

ORTHOGRAPHIC PROJECTION

'**Ortho**' means '**right-angle**' and '**Ortho-graphic**' means '**right-angled drawing**.'

When the projections are perpendicular to the plane on which the projection is obtained, it is known as **Orthographic Projection**.
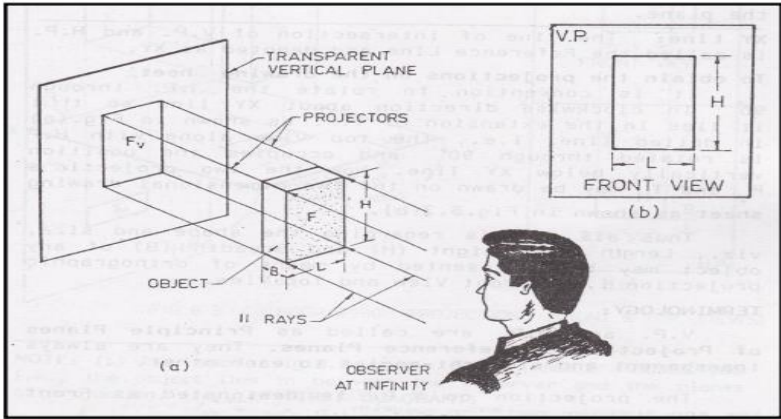
Vertical Plane:

Extend the rays or projectors further to meet a Vertical (Transparent) Plane (V.P) located behind the object. Join the points at which the projectors meet the plane, in correct sequence. The resulting view (F$_v$) is called the Front View of the object which is shown in fig. (b)

Front view shown only two dimensions of the object i.e. Length (L) and Height (H). It does not show the breadth (B). Thus one view or projection is insufficient for the complete description of the object.
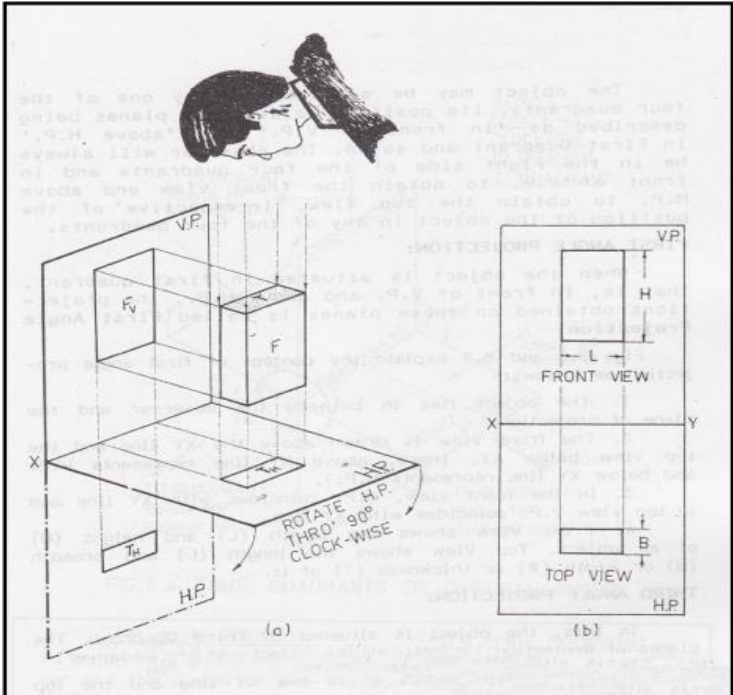
Look at the object from the top. The projection of the top surface T is T$_H$. T$_H$ is the Top View of the object. Both T and T$_H$ are of exactly the same shape and size.

Thus T$_H$ gives the Length (L) and Breadth (B) of the block but not the Height (H).

Date: _____

Difference between first- and third-angle projections

First angle projection	Third-angle projection
Object is kept in the first quadrant.	Object is assumed to be kept in the third quadrant.
Object lies between observer and the plane of projection.	Plane of projection lies between the observer and the object.
The plane of projection is assumed to be non-transparent.	The plane of projection is assumed to be transparent.
Front (elevation) view is drawn above the XY line	Front (elevation) view is drawn below the XY line
Top (plan) view is drawn below the XY line	Top (plan) view is drawn above the XY line
Left view is projected on the right plane and vise versa	Left view is projected on the left plane itself.
Followed in India, European countries	Followed in USA

Symbol of projection

The method of projection used should be indicated in the space provided for the purpose in the title box of the drawing sheet. The symbol recommended by BIS is to draw the two sides of a frustum of a cone placed with its axis horizontal.

FRUSTRUM OF A CONE

LEFT VIEW

FRONT VIEW   LEFT VIEW
FIRST ANGLE PROJECTION

PICTORIAL VIEW

LEFT VIEW   FRONT VIEW
THIRD ANGLE PROJECTION

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Date: _____
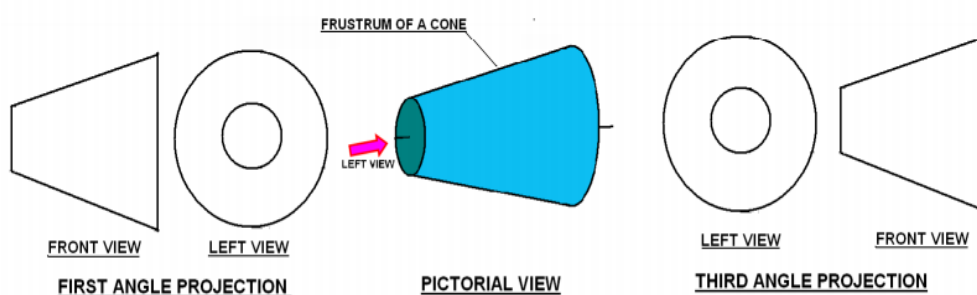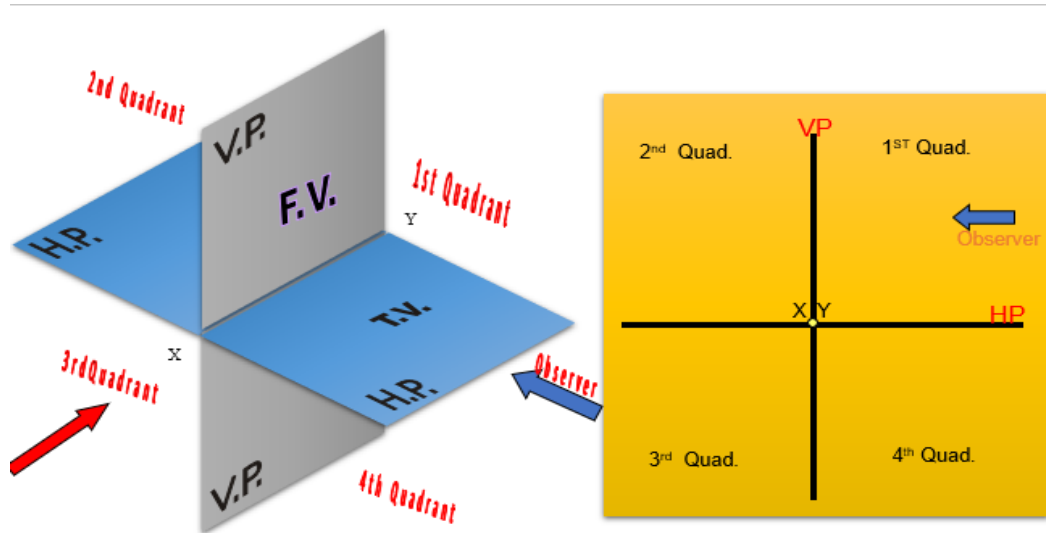
THIS QUADRANT PATTERN,
IF OBSERVED ALONG X-Y LINE (IN RED ARROW DIRECTION)
WILL EXACTLY APPEAR AS SHOWN ON RIGHT SIDE AND HENCE,
IT IS FURTHER USED TO UNDERSTAND ILLUSTRATION PROPERLLY.

A POINT

Define its position with respect to the coordinates.

With respect to the VP, HP, & PP
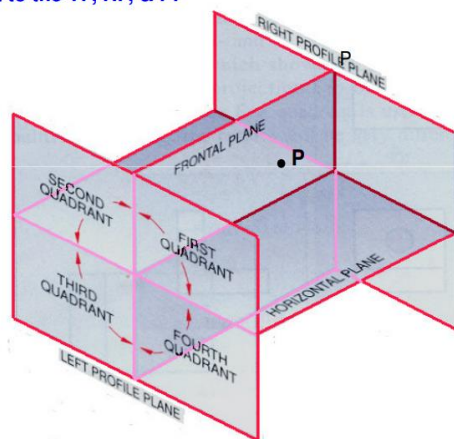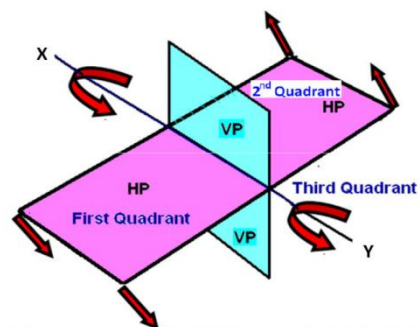
- **Top views are represented by only small letters eg. *a*.**

- **Their front views are conventionally represented by small letters with dashes eg. *a´***

- **Profile or side views are represented by small letters with double dashes eg. *a´´***

SHEET NO: 8
PROJECTION OF POINTS

1. Draw the projections of the following points on the same ground line, keeping the projectors 25 mm apart.
a. A, in the H.P. and 20 mm behind the V.P.
b. B, 40 mm above the H.P. and 25 mm in front of the V.P.
c. C, in the V.P. and 40 mm above the H.P.
d. D,25 mm below the H.P. and 25 mm behind the V.P.
e. E, 15 mm above the H.P. and 50 mm behind the V.P.
f. F, 40 mm below the H.P. and 25 mm in front of the V.P.
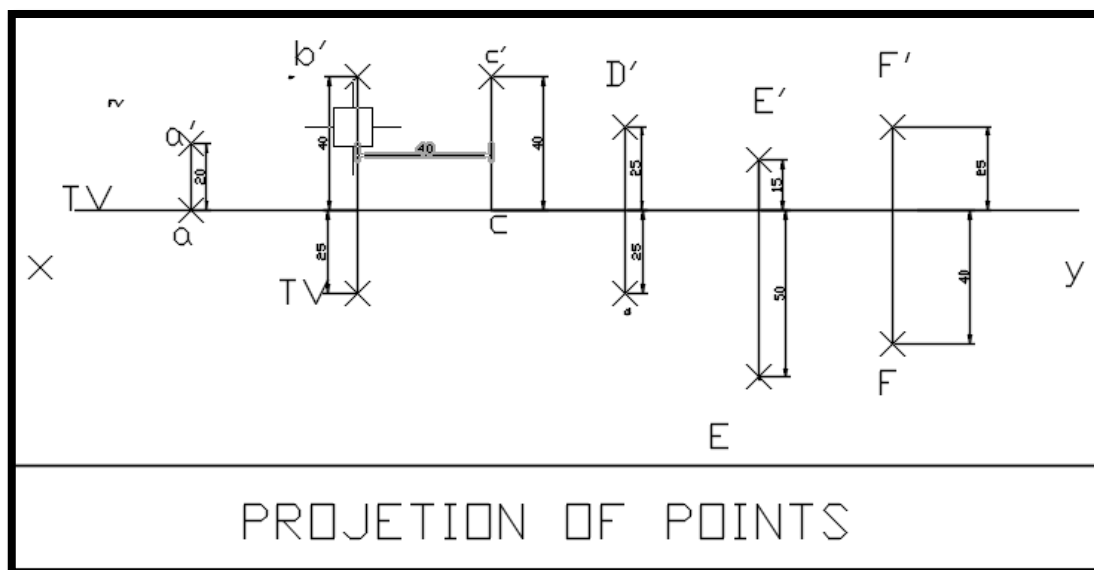
Figure1:

Commands:
1. Units
2. Limits
3. Line
4. Points
5. Dtext
6. Dimlin

Procedure:
1. Draw the reference line xy
2. On xy line mark a point a and mark a point a' 20mm above xy line
3. Mark a point below xy line, b 25mm & above xy line 40mm mark as b'
4. On xy line mark a point c and mark a point c' 40mm above xy line
5. Mark a point below xy line, d' 25mm & above xy line 25mm mark as d
6. Mark a point above xy line e' 15mm & 50mm on the e' line and denote it as e
7. Mark a point below xy line f' 25mm & 40mm on the f' line and denote it as f'

Date: _____

Assignments:
1. A point P is 50 mm from both the reference planes. Draw its projections in all possible positions.
2. A point P is 15 mm above the H.P. and 20 mm in front of the V.P. Another point Q is 25 mm behind the V.P. and 40 mm below the H.P. Draw projections of P and Q keeping the distance between their projectors equal to 90 mm. Draw straight lines joining (i) their top views and (ii) their front views.
3. A point P is 20 mm below H.P. and lies in the third quadrant. Its shortest distance from xy is 40 mm. Draw its projections.
4. A point A is situated in the first quadrant. Its shortest distance from the intersection point of H.P., V.P. and auxiliary plane is 60 mm and it is equidistant from the principal planes. Draw the projections of the point and determine its distance from the principal planes.
5. A point 30 mm above xy line is the plan-view of two points P and Q. The elevation of P is 45 mm above the H.P. while that of the point Q is 35 mm below the H.P. Draw the projections of the points and state their position with reference to the principal planes and the quadrant in which they lie.

   Viva questions:
1. What is orthographic projection and why it is called so?
2. What is the difference between first angle projection and third angle projection?
3. What is symbol of first angle projection?
4. What is symbol of third angle projection?
5. What do you mean by elevation?
6. What do you mean by plan?
7. If Front of a Line is A Point, What Will be its Top View
8. What are principle plane of projection?
9. What do you mean by four quadrants?
10. Normally projection in 1st angle or 3rd angle projection system. Why not in II and IV angle projection systems
11. Students should know to draw the projection of a point, when point lies in either of four quadrants.

PROJECTION OF LINES

Definition: A straight line is the shortest distance between two points. Hence, the projections of a straight line may be drawn by joining the respective projections of its ends which are points.

PROJECTIONS OF STRAIGHT LINES.

INFORMATION REGARDING A LINE *means*
IT'S LENGTH,
POSITION OF IT'S ENDS WITH HP & VP
IT'S INCLINATIONS WITH HP & VP WILL BE GIVEN.
AIM:- TO DRAW IT'S PROJECTIONS - MEANS FV & TV.

SIMPLE CASES OF THE LINE

1. A VERTICAL LINE (LINE PERPENDICULAR TO HP & // TO VP)

2. LINE PARALLEL TO BOTH HP & VP.

3. LINE INCLINED TO HP & PARALLEL TO VP.

4. LINE INCLINED TO VP & PARALLEL TO HP.

5. LINE INCLINED TO BOTH HP & VP.
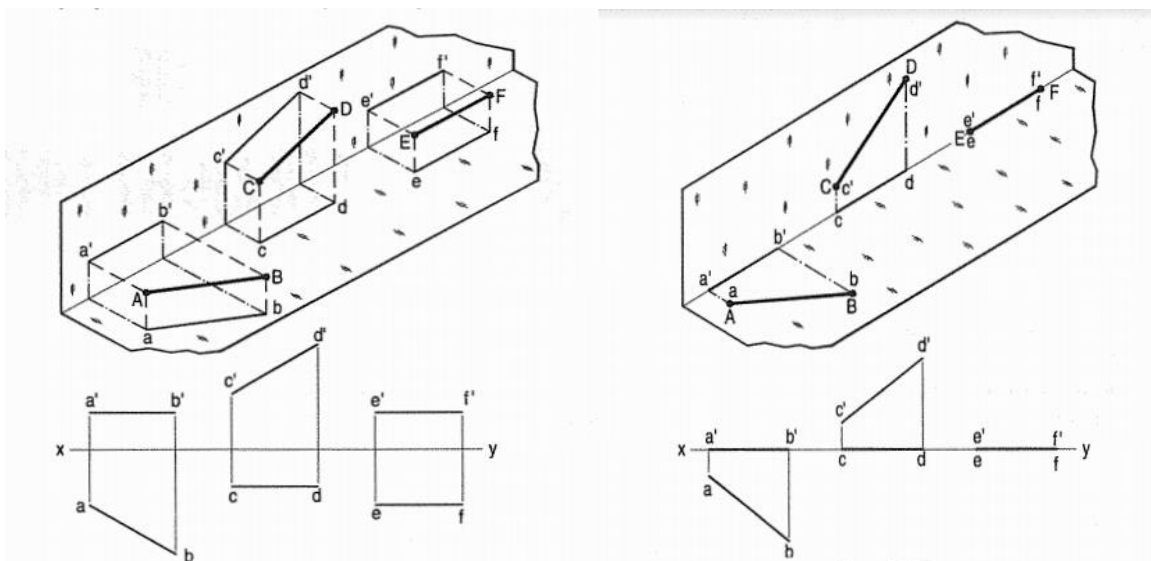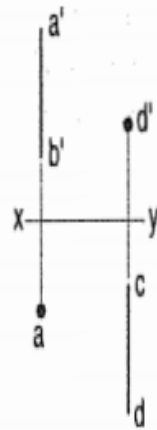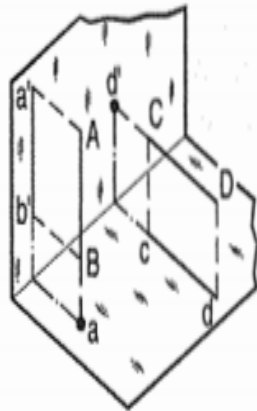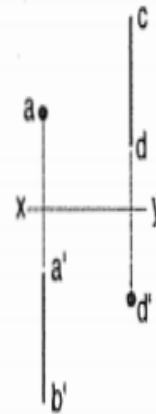
(FIRST-ANGLE PROJECTION)   (THIRD-ANGLE PROJECTION)
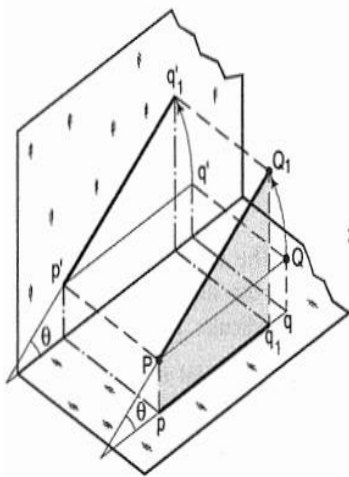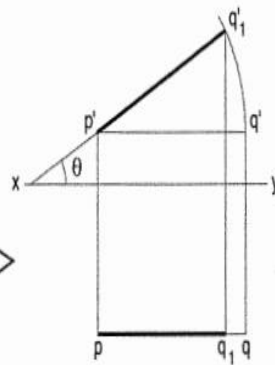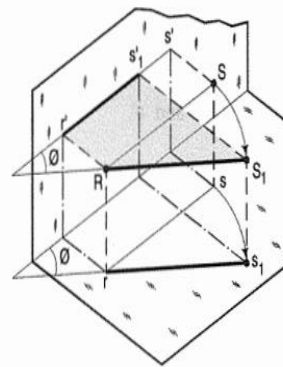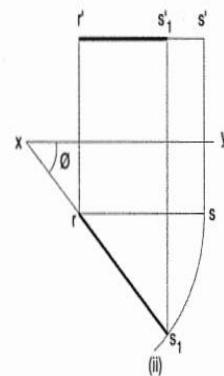
(i)   (ii)   (i)   (ii)

Notations used for *Straight Line*

True length of the line:

Denoted by Capital letters. e.g. AB=100 mm, means that *true length* of the line is 100 mm.

Front View Length:

Denoted by small letters. e.g. a'b'=70 mm, means that *Front View Length* is 70 mm.

Top View Length:

Denoted by small letters. e.g. ab=80 mm, means that *Top View Length* is 80 mm.

End Projector Distance:

It is the distance between two projectors passing through end points of F.V. & T.V. measured parallel to XY line.

SR.NO	POSITION OF LINE	FRONT VIEW	TOP VIEW
1	LINE PERPENDICULAR TO H.P AND PARALLEL TO V.P	VERTICAL LINE SHOWING T.L	POINT
2	LINE PERPENDICULAR TO V.P AND PARALLEL TO H.P	POINT	VERTICAL LINE SHOWING T.L
3	LINE PARALLEL TO BOTH V.P & H.P	HORIZONTAL LINE PARALLEL TO XY SHOWING T.L	HORIZONTAL LINE PARALLEL TO XY SHOWING T.L
4	LINE PARALLEL TO H.P AND INCLINED TO V.P AT ANGLE "θ"	LINE PARALLEL TO XY WITH APPARENT LENGTH	INCLINED LINE SHOWING TRUE LENGTH
5	LINE PARALLEL TO V.P AND INCLINED TO H.P AT ANGLE"θ"	INCLINED LINE SHOWING TRUE LENGTH	LINE PARALLEL TO XY WITH APPARENT LENGTH
6	LINE INCLINED TO V.P AT ANGLE "Ø" AND INCLINED TO H.P AT ANGLE"θ"	INCLINED LINE SHOWING APPARENT LENGTH	INCLINED LINE SHOWING APPARENT LENGTH

TRACES OF A LINE

Definition: When a line is inclined to a plane, it will meet that plane, produced if necessary. The point where the line or line produced meets the plane is called trace.

Horizontal Trace: The point of intersection of the inclined line with the H.P. is called Horizontal Trace or simply H.T.

A line itself or it's extension, where ever touches H.P., That point is called trace of the line on H.P. (It is called H.T.)

H.T.:- It is a point on HP.
    It's FV comes on XY line (point h).

Traces of A line

Vertical Trace: The point of intersection of the inclined line with the V.P. is called Vertical Trace or simply V.T.

Similarly, a line itself or it's extension, where ever touches V.P., That point is called trace of the line on V.P.(It is called V.T.)

V.T.:- It is a point on VP.
    It's TV comes on XY line (point V).

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SHEET NO: 9
PROJECTION OF LINES-I

1. Draw the projections of a 75 mm long straight line, in the following positions:
a. Parallel to both the H.P. and the V.P. and 25 mm from each.
b. Parallel to and 30 mm above the H.P. and in the V.P.
c. Parallel to and 40 mm in front of the V.P. and in the H.P.
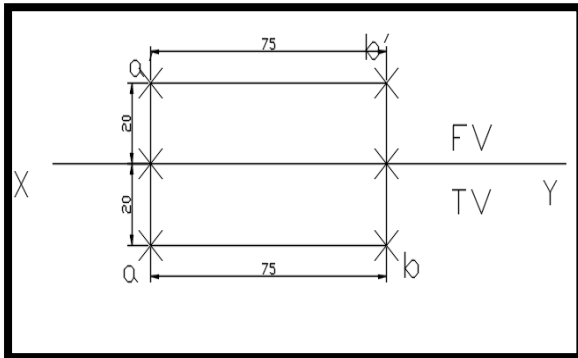
Figure1
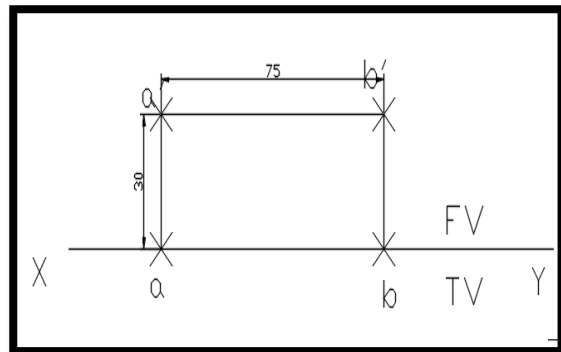
Figure2
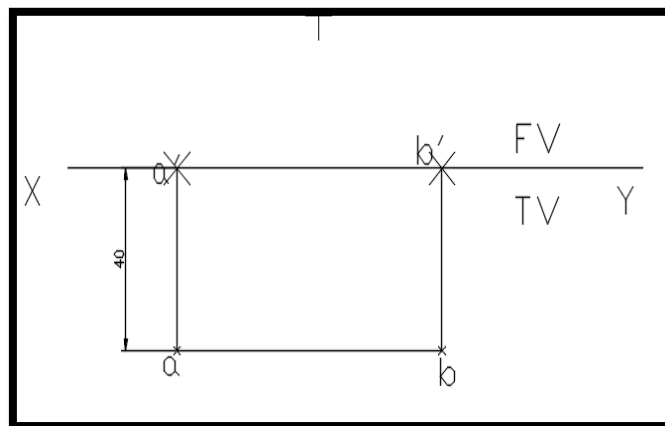
Figure3

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin

Procedure:
1. Draw the reference line xy
2. Draw a line 20mm above xy of length 75mm, denote it a'&b'
3. Draw a line 20mm below xy of length 75mm, denote it a&b
4. Draw a line on xy line of length 75mm denote it as c & d
5. Draw a line 30mm above xy of length 75mm, denote it c'&d'

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6. Draw a line on xy line of length 75mm denote it as e' & f'
7. Draw a line 40mm below xy of length 75mm, denote it e & f

Assignment:

1. Draw the projections of a 75 mm long straight line, in the following positions:
    a. Perpendicular to the H.P., 20 mm in front of the V.P. and its one end15 mm above the H.P.
    b. Perpendicular to the V.P., 25 mm above the H.P. and its one end in the V.P.
    c. Perpendicular to the H.P., in the V.P. and its one end in the H.P.
2. Draw the projections of a 75 mm long straight line, in the following positions:
    a. Inclined at 45° to the V.P., in the H.P. and its one end in the V.P.
    b. Inclined at 30° to the H.P. and its one end 20 mm above it; parallel to and 30 mm in front of the V.P.
    c. Inclined at 60° to the V.P. and its one end 15 mm in front of it; parallel to and 25 mm above the H.P.

SHEET NO: 10
PROJECTION OF LINES-II

1. A Line 50 mm long, has its end A in both the HP. and the VP. It is inclined at 30^0 to the HP and at 45^0 to the V.P. Draw its projections.
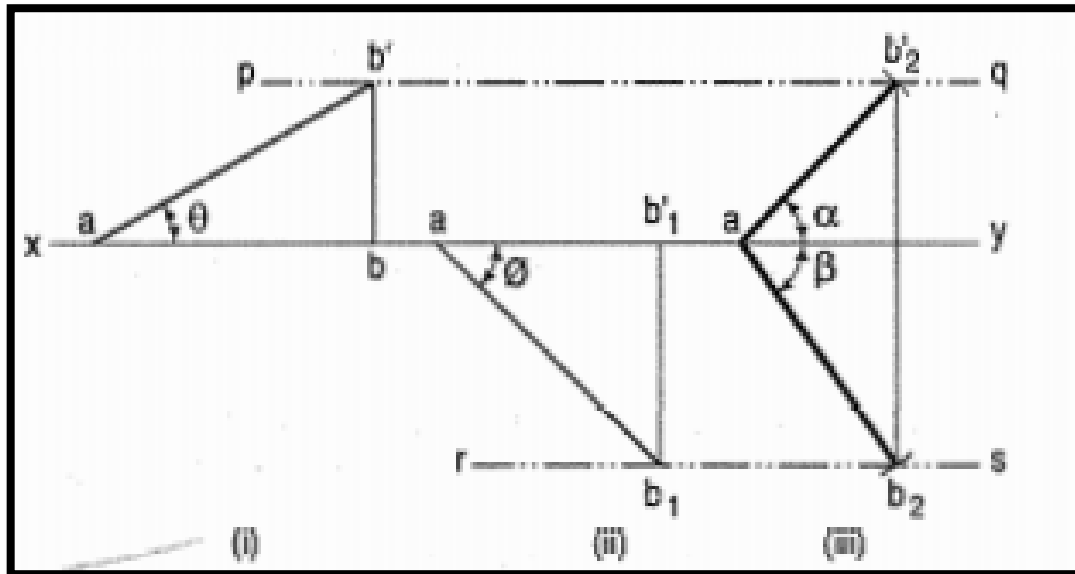
Figure1

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Point
6. Ptype
7. Arc
8. Dimalign/ dimang

Procedure:
1. Assuming AB to be parallel to the V.P. and inclined at θ (equal to 30°) to the H.P., draw its front view ab' (equal to AB) and project the top view ab.
2. Again assuming AB to be parallel to the H.P. and inclined at 0 (equal to 45°) to the V.P., draw its top view ab1 (equal to AB). Project the front view ab'1.
3. ab and ab'1 are the lengths of AB in the top view and the front view respectively, and pq and rs are the loci of the end B in the front view and the top view respectively.
4. With a as centre and radius equal to ab' 1, draw an arc cutting pq in b'2.
5. With the same centre and radius equal to ab, draw an arc cutting rs in b2.
6. Draw lines joining a with b'2 and b2 • ab'2 and ab2 are the required projections.

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2. The top view of a 75 mm long line AB measures 65 mm while the length of its front view is 50 mm. It's one end A is in the H.P. and 12 mm in front of the V.P. Draw the projections of AB and determine its inclinations with the H.P. and the V.P.
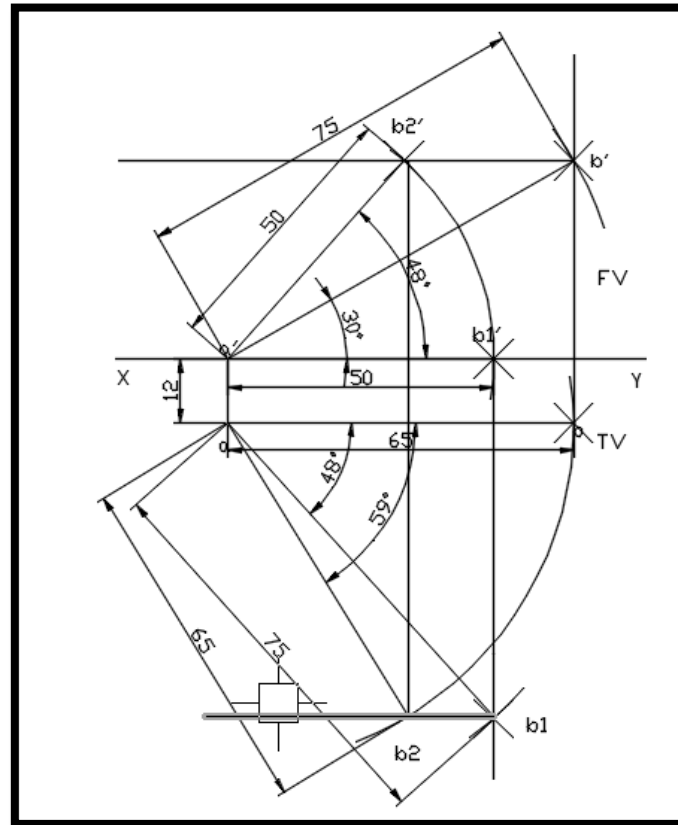
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Point
6. Ptype
7. Arc
8. Dimalign/ dimang

Procedure:
1. Mark the front view a' and the top view a of the given end A.
2. Assuming AB to be parallel to the V.P., draw a line ab equal to 65 mm and parallel to xy.
3. With a' as centre and radius equal to 75 mm, draw an arc cutting the projector through b at b'.
4. The line cd through b' and parallel to xy, is the locus of B in the front view and 8 is the inclination of AB with the H.P.
5. Similarly, draw a line a'b'1 in xy and equal to 50 mm.

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6. With "a" as centre and radius equal to AB, draw an arc cutting the projector through b'1 at b 1.
7. ef is the locus of B in the top view and 0 is the inclination of AB with the V.P.
8. With a' as centre and radius equal to a'b'1, draw an arc cutting cd in b'2 .
9. With a as centre and radius equal to ab, draw an arc cutting ef in b2.
10. a'b'2 and ab2 are the required projections.

Assignment:
1. A line AB, 65 mm long, has its end A 20 mm above the H.P. and 25 mm in front of the V.P. The end B is 40 mm above the H.P. and 65 mm in front of the VP. Draw the projections of AB and show its inclinations with the H.P. and the V.P.
2. A line AB, 90 mm long, is inclined at 45° to the H.P. and its top view makes an angle of 60° with the V.P. The end A is in the H.P. and 12 mm in front of the V.P. Draw its front view and find its true inclination with the V.P.
3. The top view of line AB measures 60 mm and inclined to reference line at 60°. The end point A is 15 mm above the H.P. and 30 mm in front of the V.P. Draw the projections of the line when it is inclined at 45° to the H.P. and is situated in the first quadrant. Find true length and inclination of the line with the V.P. and traces.

Viva questions:

1. What are traces of a straight line and how are they located?
2. What is the difference between true inclination and apparent inclination?
3. What do you mean by HT & VT of a line?
4. What Do You Infer When the Top View & Front View ofa Point Are 15mm Below The XY Line?
5. What is The Difference B/W True Inclination of a Line and Apparent Angles?
6. If Front of a Line is A Point, What Will be its Top View

PROJECTIONS OF PLANES

A plane is a two dimensional object having length and breadth only. Its thickness is always neglected. Various shapes of plane figures are considered such as square, rectangle, circle, pentagon, hexagon, etc.
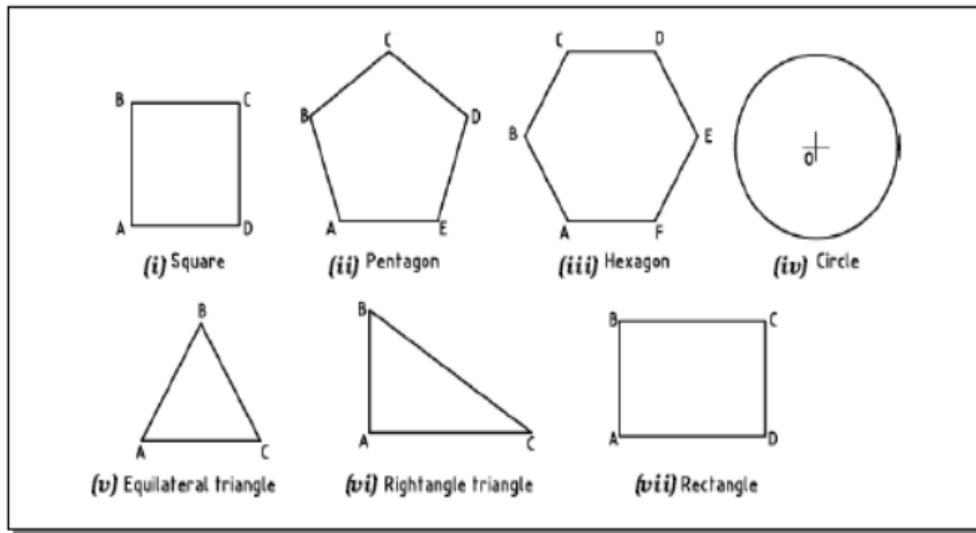
Figure1

Position with HP & VP will be:

1.Inclination of its SURFACE with one of the reference planes will be given.

2. Inclination of one of its EDGES with other reference plane will be given (Hence this will be a case of an object inclined to both reference Planes.)
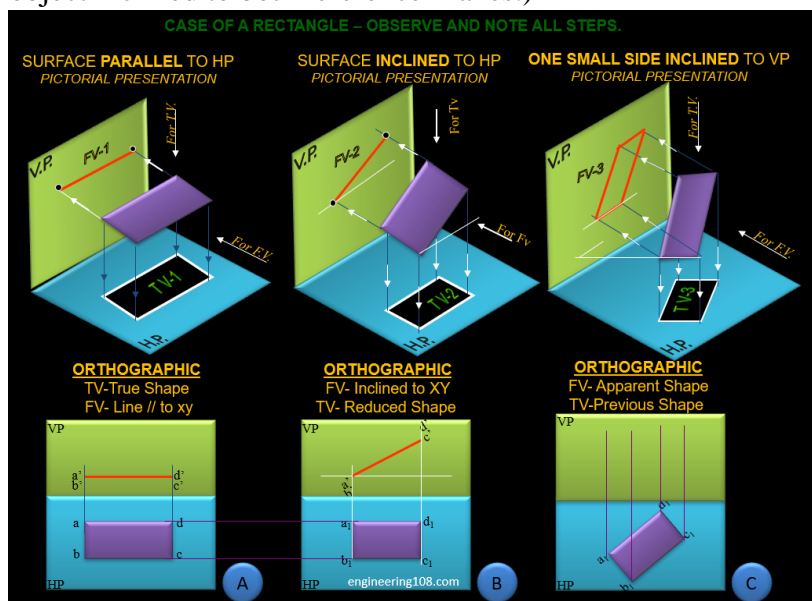
Figure2

SHEET NO: 11
PROJECTION OF PLANES-I

1. An equilateral triangle of 50 mm side has its V.T. parallel to and 25rnm above xy. It has no H. T. Draw its projections when one of its sides is inclined at 45° to the V.P.
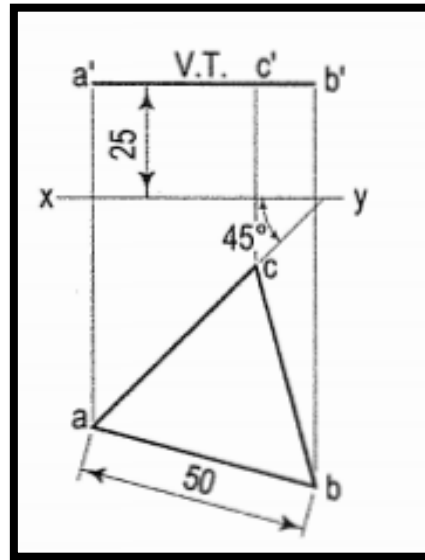
Figure1

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/Dimalign

Procedure:
1. As the V.T. is parallel to xy and as there is no H.T. the triangle is parallel to the H.P. Therefore, begin with the top view.
2. Draw an equilateral triangle abc of 50 mm side, keeping one side, say ac, inclined at 45° to xy.
3. Project the front view, parallel to and 25 mm above xy, as shown.

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2. A square ABCD of 40 mm side has a corner on the H.P. and 20 mm in front of the V.P. All the sides of the square are equally inclined to the H.P. and parallel to the V.P. Draw its projections and show its traces.
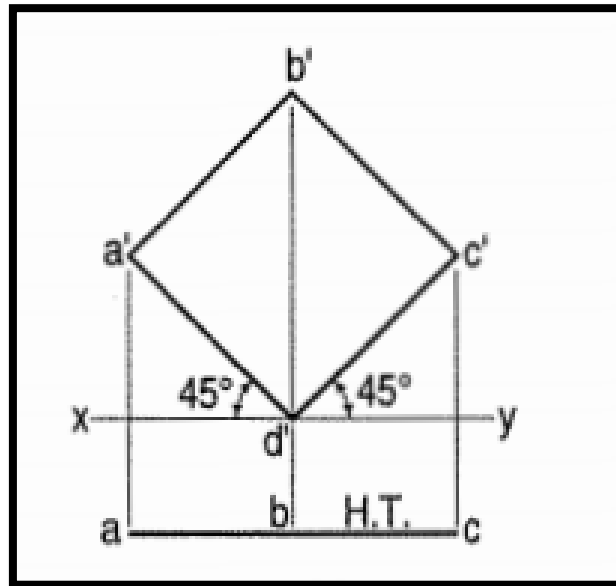
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/Dimalign

Procedure:
1. As all the sides are parallel to the V.P., the surface of the square also is parallel to it. The front view will show the true shape and position of the square.
2. Draw a square a'b'c'd' in the front view with one corner in xy and all its sides inclined at 45° to xy.
3. Project the top view keeping the line ac parallel to xy and it. The top view is its H.T. It has no V.T.

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SHEET NO: 12
PROJECTION OF PLANES-II

1. A regular pentagon of 25 mm side has one side on the ground. Its plane is inclined at 45° to the H.P and perpendicular to the V.P Dravv its projections and show its traces.
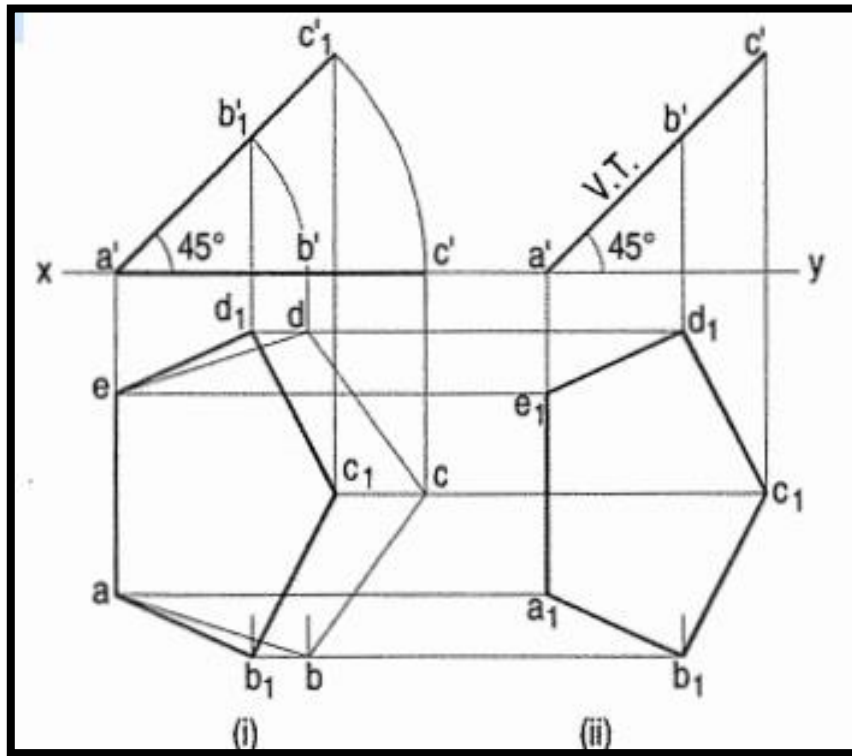
Figure1

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Polygon (pentagon)
6. Dimlin/dimalign/dimang

Procedure:
1. Assuming it to be parallel to the H.P.
2. Draw the pentagon in the top view with one side perpendicular to xy. Project the front view. It will be the line a'c' contained by xy.
3. Tilt the front view about the point a', so that it makes 45° angle with xy.
4. Project the new top view $ab_1c_1d_1e$ upwards from this front view and horizontally from the first top view.
5. It will be more convenient if the front view is reproduced in the new position separately and the top view projected from it.

6. The V.T. coincides with the front view and the H.T. is perpendicular to xy, through the point of intersection between xy and the front view-produced.

2. Draw the projections of a regular hexagon of 25 mm side, having one of its sides in the H.P. and inclined at 60° to the V.P. and its surface making an angle of 45° with the H.P.
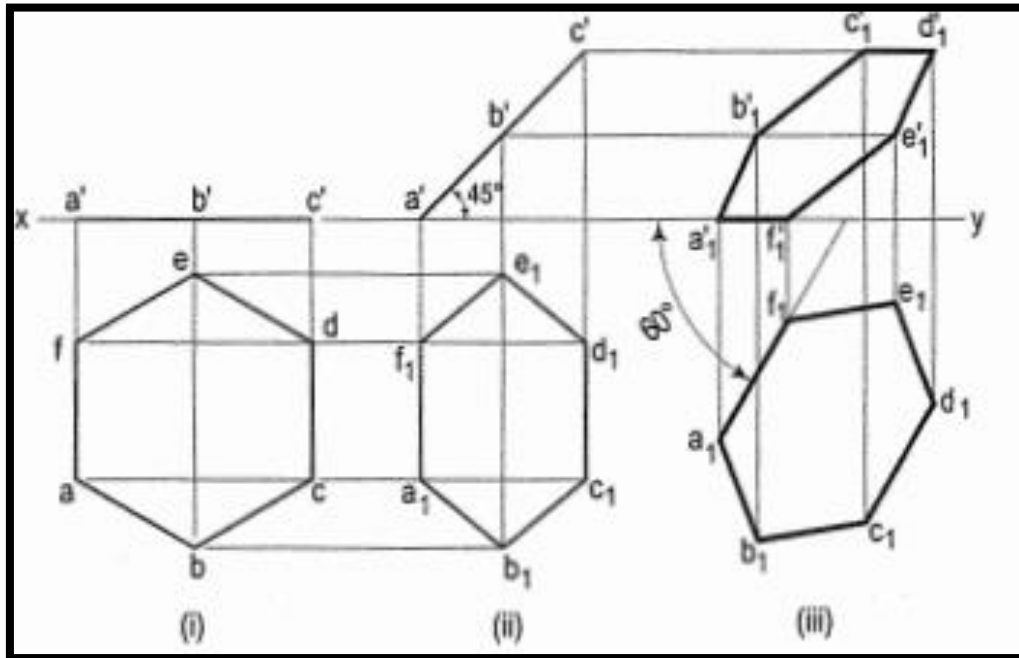
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Polygon (hexagon)
6. Dimlin/dimalign/dimang

Procedure:
1. Draw the hexagon in the top view with one side perpendicular to xy.
2. Project the front view a'c' in xy.
3. Draw a'c' inclined at 45° to xy keeping a' or c' in xy and project the second top view.
4. Reproduce this top view making al1 inclined at 60° to xy and project the final front view.

Assignment:
1. Draw the projections of a circle of 50 mm diameter having its plane vertical and inclined at 30° to the V.P. Its centre is 30 mm above the H.P. and 20 mm in front of the V.P. Show also its traces.
2. A composite plate of negligible thickness is made-up of a rectangle 60 mm x 40 mm, and a semi-circle on its longer side. Draw its projections when the longer side is parallel to the H.P. and inclined at 45° to the V.P., the surface of the plate making 30° angle with the H.P.
3. A 60° set-square of 125 mm longest side is so kept that the longest side is in the H.P. making an angle of 30° with the V.P. and the set-square itself inclined at 45° to the H.P. Draw the projections of the set-square.
4. A semi-circular plate of 80 mm diameter has its straight edge in the V.P. and inclined at 45° to the H.P. The surface of the plate makes an angle of 30°with the V.P. Draw its projections.

Viva Questions:
1. What do you mean by oblique plane?
2. Describe the strategy to draw projections of an oblique plane?
3. What is auxiliary plane?
4. How will you classify auxiliary planes?
5. What do you mean by A.I.P.?
6. What do you mean by A.V.P.?
7. What do you mean by P.P.?
8. How auxiliary planes are represented?
9. What is the Difference in The Shape of Trace of a Line & Trace of a Plane?

Date: _____

PROJECTION OF SOLIDS

INTRODUCTION

A solid has three dimensions, viz. length, breadth and thickness. To represent a solid on a flat surface having only length and breadth, at least two orthographic views are necessary.
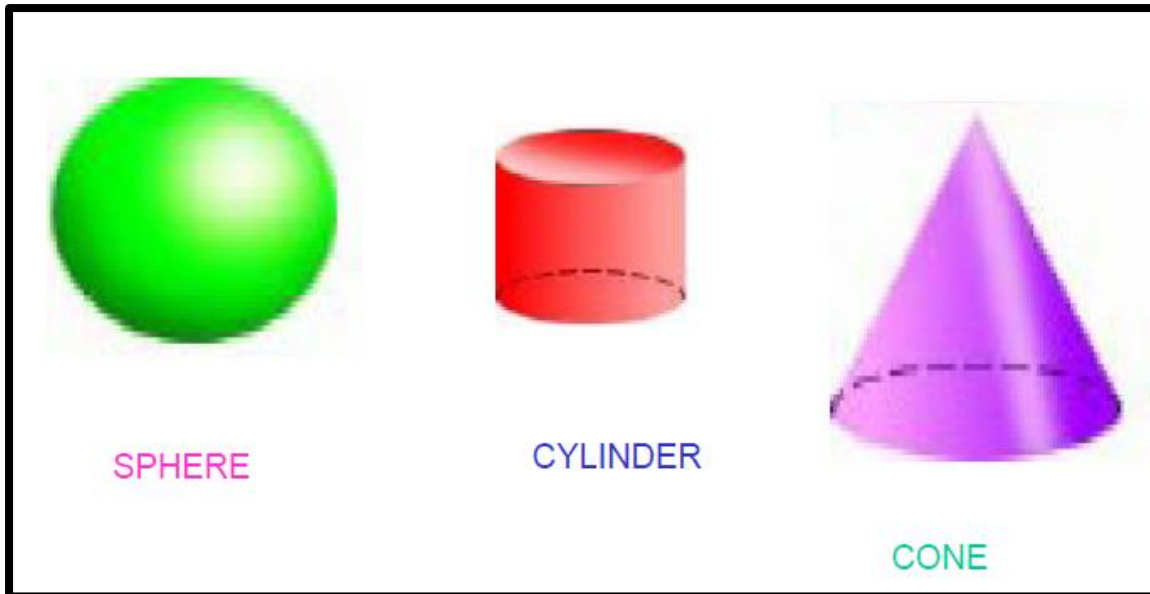
SOLIDS OF REVOLUTION
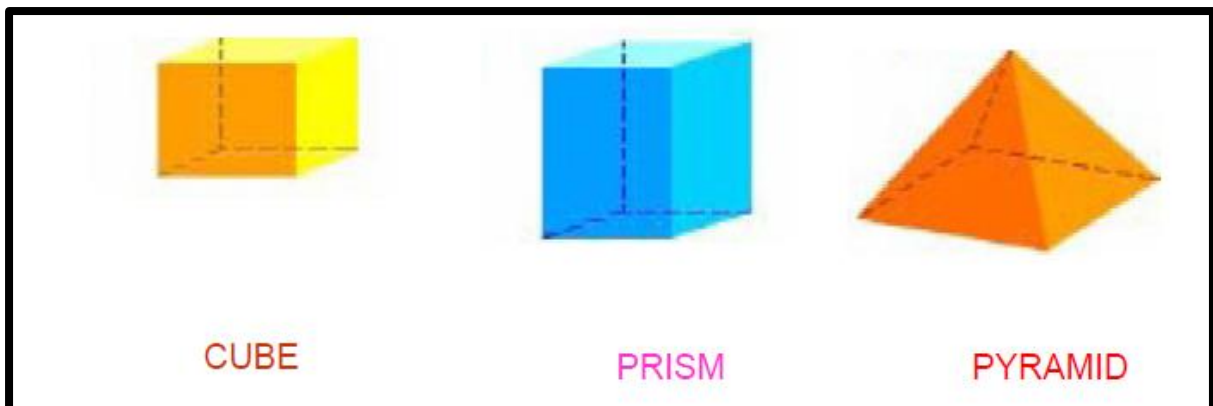
POLYHEDRONS

Types of Solids

Solids may be divided into two main groups:

i. Polyhedron   ii. Solids of revolution.

i. Polyhedron: A polyhedron is defined as a solid bounded by planes called faces. When all the faces are equal and regular, the polyhedron is said to be regular.

There are six regular polyhedron

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

Tetrahedron

b. **Cube or Hexahedron** : It has six faces, all equal squares.

c. **Octahedron** : It has eight equal equilateral triangles as faces.

d. **Dodecahedron** : It has twelve equal and regular pentagons as faces.
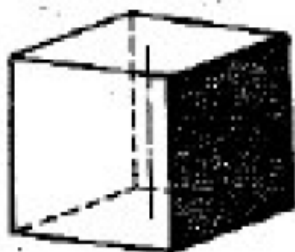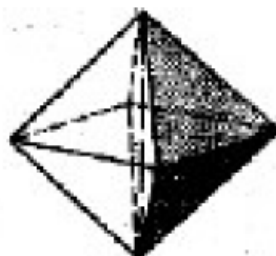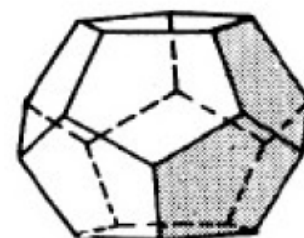
Cube   Octahedron   Dodecahedron

Prism: This is a polyhedron having two equal and similar faces called its ends or bases, parallel to each other and joined by other faces, which are parallelograms. The imaginary line joining the centers of the bases is called the axis.

A right and regular prism has its axis perpendicular to the bases. All its faces are equal rectangles.

| Triangular | Square | Pentagonal | Hexagonal |

Prisms
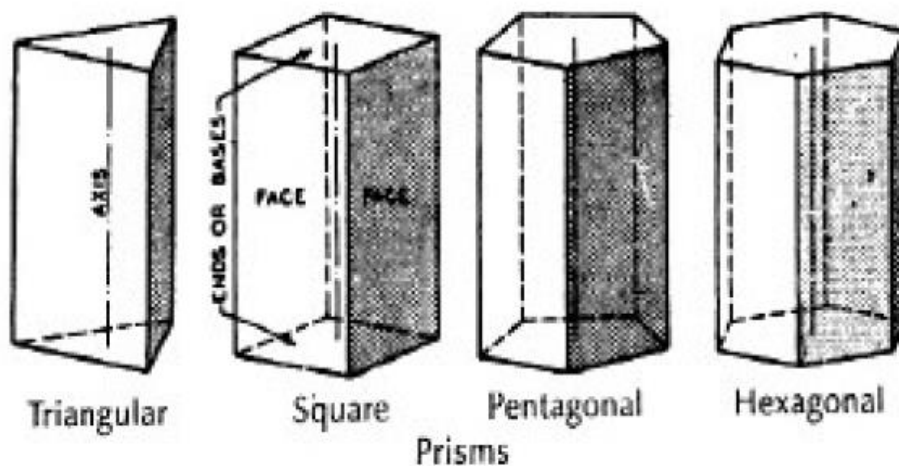
Pyramid: This is a polyhedron having a plane figure as a base and a number of triangular faces meeting at a point called the vertex or apex. The imaginary line joining the apex with the centre of the base is its axis.

A right and regular pyramid has its axis perpendicular to the base, which is a regular plane figure. Its faces are all equal isosceles triangles.

Triangular   Square   Pentagonal   Hexagonal

Pyramids
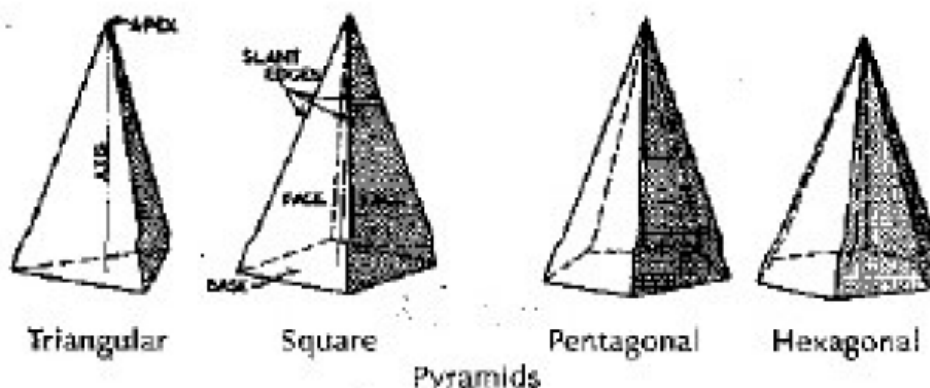
Solids of Revolution

Definition:

Solids which are generated by rotating a plane surface about one of its sides

Three Types

Cylinder   Cone   Sphere
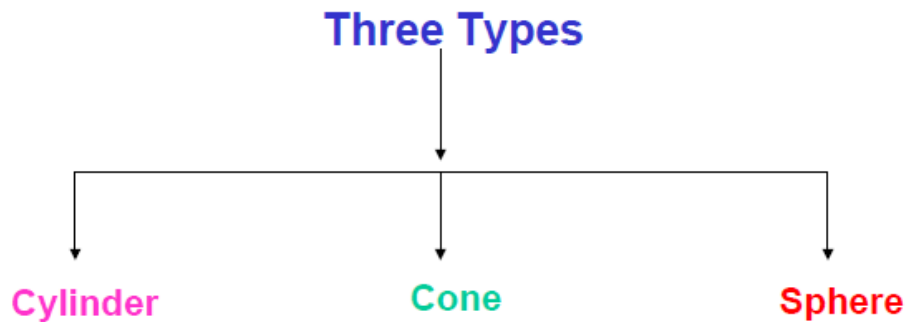
a) Cylinder

A right circular cylinder is a solid generated by the revolution of a rectangle about one of its sides, which remains fixed. It has two equal circular bases. The line joining the centers of the bases is the axis. It is perpendicular to the bases.

Cylinder
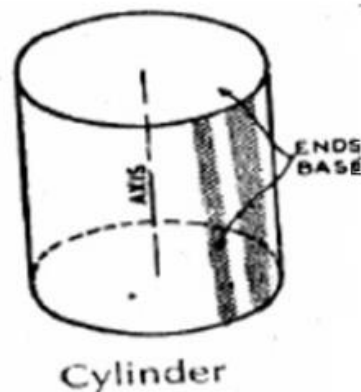
b. Cone :

A right circular cone is a solid generated by the revolution of right-angled triangles about one of its perpendicular sides, which is fixed.
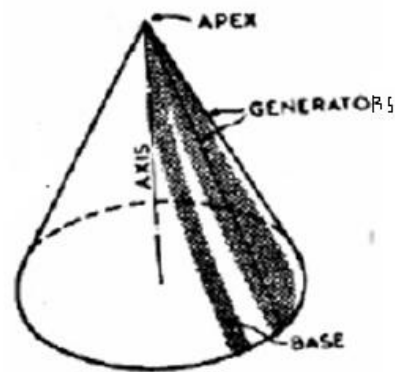
Cone

It has one circular base. Its axis joins the apex with the centre of the base to which it is perpendicular. Straight lines drawn from the apex to the circumference of the base-circle are all equal and are called generators of the cone.
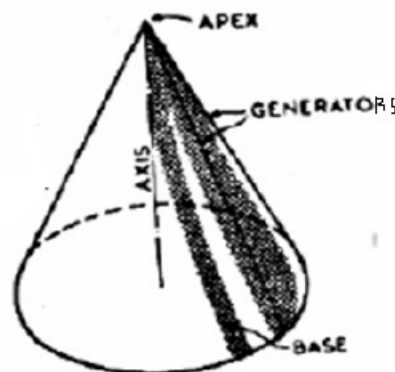
Cone

Date: _____

c. Sphere :

A sphere is a solid generated by the revolution of a semi-circle about its diameter as the axis. The mid-point of the diameter is the centre of the sphere. All points on the surface of the sphere are equidistant from its centre.

Sphere

d. **Frustum:** When a pyramid or a cone is cut by a plane parallel to its base, thus removing the top portion, the remaining portion is called its frustum.

e. **Truncated:** When a solid is cut by a plane inclined to base it is said to be truncated.

Unless and otherwise stated, the given solid should be understood as right and regular.
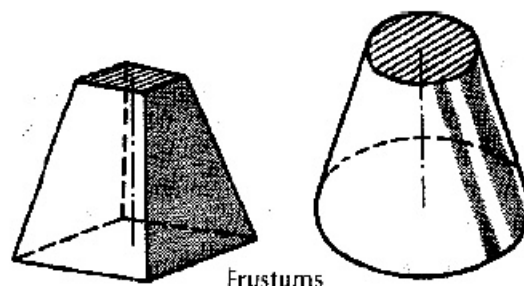
Frustums

Projections of Solids in Simple Positions
1. A solid in simple position may have its axis perpendicular to one reference plane or parallel to both.
2. When the axis is perpendicular to one reference plane, it is parallel to the other. Also, when the axis of a solid is perpendicular to a plane, its base will be parallel to that plane.

3. We have already seen that when a plane is parallel to a reference plane, its projection on that plane shows its true shape and size.
4. Therefore, the projection of a solid on the plane to which its axis is perpendicular will show the true shape and size of its base.
5. Hence, when the axis is perpendicular to the ground, i.e. to the H.P., the top view should be drawn first and the front view projected from it.
6. When the axis is perpendicular to the V.P., beginning should be made with the front view. The top view should then be projected from it.
7. When the axis is parallel to both the H.P. and the V.P., neither the top view nor the front view will show the actual shape of the base. In this case, the projection of the solid on an auxiliary plane perpendicular to both the planes, viz. the side view must be both the planes, viz. the side view must be drawn first. The front view and the top view are then projected from the side view. The projections in such cases may also be drawn in two stages.

Date: _____

SHEET NO: 13
PROJECTION OF SOLIDS-I

1. Draw the projections of a pentagonal pyramid, base 30 mm edge and axis 50 mm long, having its base on the H.P. and an edge of the base parallel to the V.P. Also draw its side view.
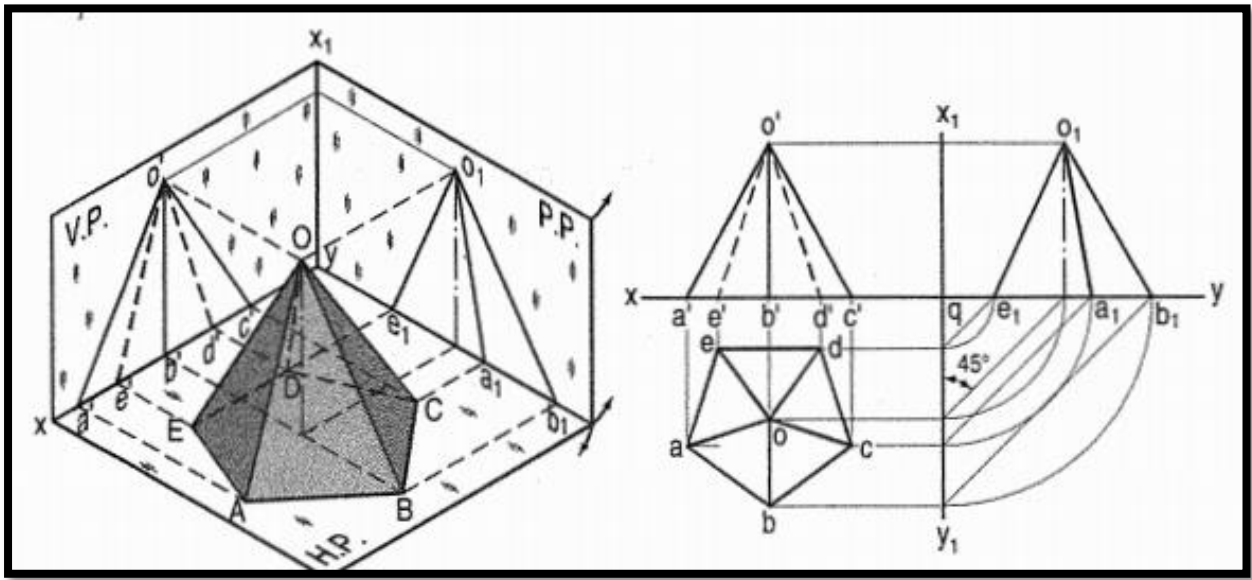
Figure1

Commands:

1. Units
2. Limits
3. Polygon
4. Line
5. Dtext
6. Dimlin
7. Point
8. Ptype
9. Copy
10. Extend
11. Trim
12. Erase

Procedure:

1. Assume the side DE which is nearer the V.P., to be parallel to the V.P.
2. In the top view, draw a regular pentagon abcde with ed parallel to and nearer xy. Locate its centre o and join it with the corners to indicate the slant edges.

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3. Through o, project the axis in the front view and mark the apex o', 50 mm above xy. Project all the corners of the base on xy. Draw lines o'a', o'b' and o'c' to show the visible edges. Show o'd' and o'e' for the hidden edges as dashed lines.

4. For the side view looking from the left, draw a new reference line x1y1 perpendicular to xy and to the right of the front view. Project the side view on it, horizontally from the front view as shown. The respective distances of all the points in the side view from x1y1, should be equal to their distances in the top view from xy. This is done systematically

5. From each point in the top view, draw horizontal lines upto x1y1 . Then draw lines inclined at 45° to x1y1 (or xy) as shown. Or, with q, the point of intersection between xy and x1y1 as centre, draw quarter circles.

6. Project up all the points to intersect the corresponding horizontal lines from the front view and complete the side view Lines o1d1and o1c1 coincide with o1e1 and o1a1 respectively.

2. Draw the projections of
   (i)   a cylinder, base 40 mm diameter and axis 50 mm Jong, and
   (ii)   a cone, base 40 mm diameter and axis 50 mm long, resting on the H.P. on their
           respective bases.
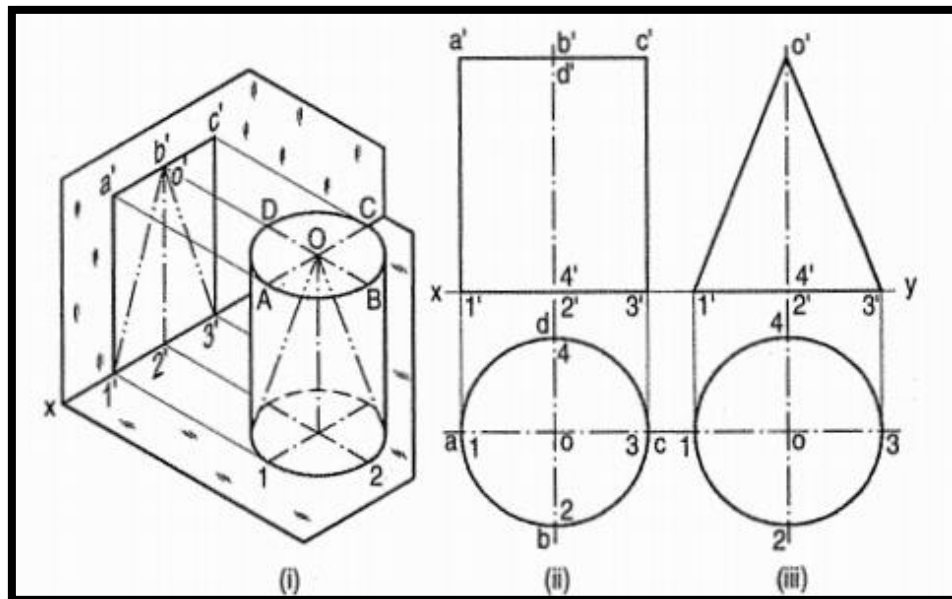
Figure2

Commands:

1. Units
2. Limits
3. Polygon
4. Line
5. Dtext
6. Dimlin
7. Point
8. Ptype
9. Copy
10. Extend
11. Trim
12. Erase

Procedure:

1. Draw a circle of 40 mm diameter in the top view and project the front view which will
   be a rectangle [fig.(ii)]
2. Draw the top view [fig.(iii)]. Through the centre o, project the apex o', 50 mm above
   xy.
3. Complete the triangle in the front view as shown.

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Date: _____

3. A cube of 50 mm long edges is resting on the H.P. with its vertical faces equally inclined to the V.P. Draw its projections.
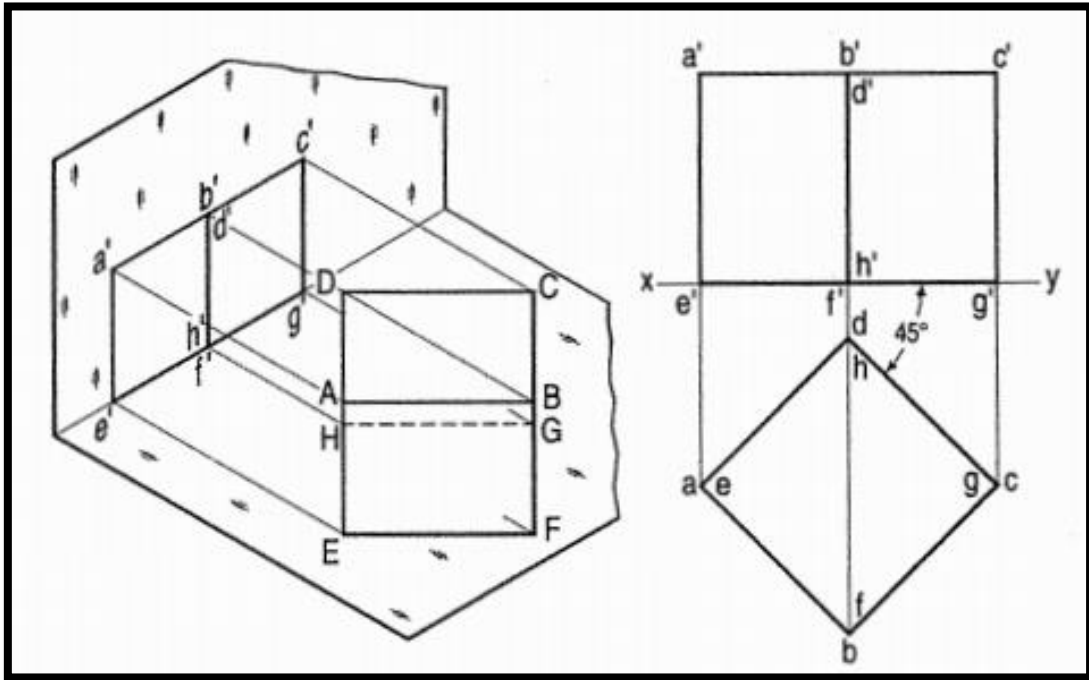
Figure3

Command:

1. Units
2. Limits
3. Line
4. Extend
5. Copy
6. Dtext
7. Dimlin

Procedure

1. Begin with the top view.
2. Draw a square a, b, c, d with a side making 45° angle with xy.
3. Project up the front view. The line d' h' will coincide with b' f'.

Assignment:

1. Draw the projections of a hexagonal pyramid, base 30 mm side and axis 60 mm long, having its base on the H.P. and one of the edges of the base inclined at 45° to the V.P.
2. A triangular prism1 base 40 mm side and height 65 mm is resting on the H.P. on one of its rectangular faces with the axis parallel to the V.P. Draw its projections.
3. A square pyramid, base 40 mm side and axis 65 mm long, has its base in the V.P. One edge of the base is inclined at 30° to the H.P. and a corner contained by that edge is on the H.P. Draw its projections.

SHEET NO: 14
PROJECTION OF SOLIDS-II

1. Draw the of a pentagonal prism, base 25 mm side and axis 50 rnm long, resting on one of its rectangular faces on the H.P. with the axis inclined at 45^0 to the V.P.
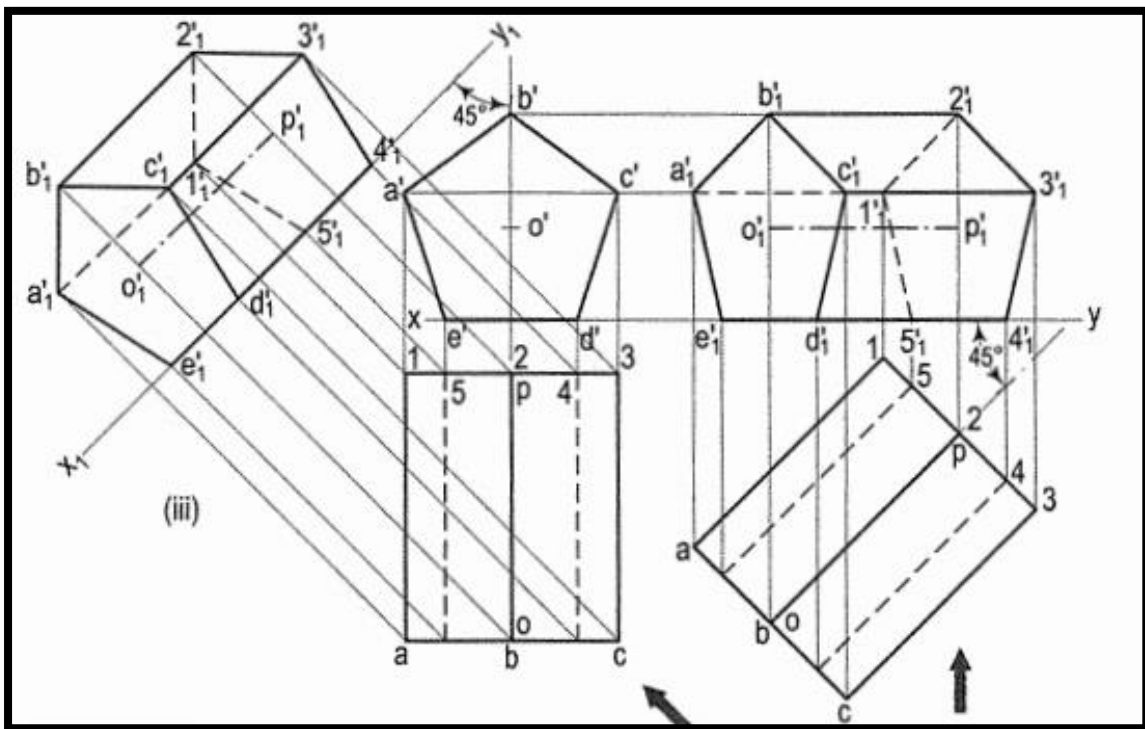
Figure1

Command:

1. Units
2. Limits
3. Line
4. Dtext
5. Polygon
6. Point
7. Ptype
8. Copy
9. Rotate
10. Erase
11. Dimlin/dimalign/dimang

Procedure:

1. In the simple position, assume the prism to be on one of its faces on the ground with the axis perpendicular to the V.P.

2. Draw the pentagon in the front view with one side in xy and project the top view.
3. The shape and size of the figure in the top view will not change, so long as the prism has its face on the H.P. The respective distances of all the corners in the front view from xy will also remain constant.
4. Alter the position of the top view, i.e. reproduce it so that the axis is inclined at 45° to xy.
5. Project all the points upwards from this top view and horizontally from the first front view, e.g. a vertical from a intersecting a horizontal from a' at a point a'_1.
6. Complete the pentagon $a'_1 b'_1 c'_1 d'_1 e'_1$ for the fully visible end of the prism.
7. Next, draw the lines for the longer edges and finally, draw the lines for the edges of the other end. Note carefully that the lines $a'_1 1'_1$, $1'_1 2'_1$ and $1'_1 5'_1$ are dashed lines. $e'_1 5'_1$ is also hidden but it coincides with other visible lines.

2. A hexagonal pyramid, base 25 mm side and axis 50 mm long, has an edge of its base on the ground. Its axis is inclined at 30° to the ground and parallel to the V.P. Draw its projections.
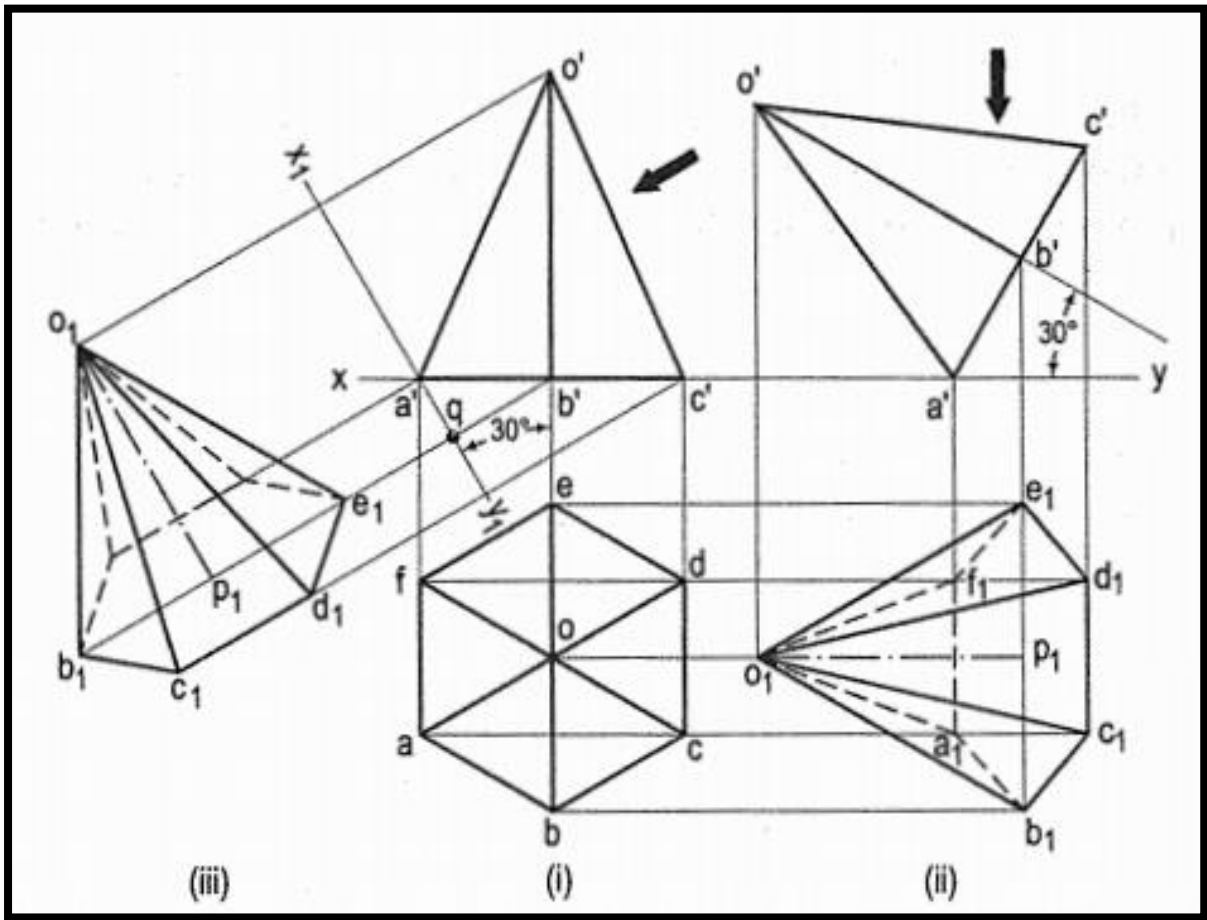
Figure2

Command:

1. Units
2. Limits
3. Line
4. Dtext
5. Polygon
6. Point
7. Ptype
8. Copy
9. Rotate
10. Erase
11. Dimlin/dimalign/dimang

Procedure:

1. In the initial position assume the axis to be perpendicular to the H.P.

2. Draw the projections with the base in xy and its one edge perpendicular to the V.P[fig. (i)].
3. If the pyramid is now tilted about the edge AF (or CD) the axis will become inclined to the H.P. but will remain parallel to the V.P. The distances of all the corners from the V.P. will remain constant.
4. The front view will not be affected except in its position in relation to xy. The new top view will have its corners at same distances from xy, as before.
5. Reproduce the front view so that the axis makes 30° angle with xy and the point a' remains in xy.
6. Project all the points vertically from this front view and horizontally from the first top view. Complete the new top view by drawing (a) lines joining the apex o'1 with the corners of the base and (b) lines for the edges of the base.
7. The base will be partly hidden as shown by dashed line a_1b_1, e_1 and f_1a_1.
8. Similarly, o_1 and o_1a_1 are also dashed lines.

3. Draw the projections of a cone, base 45 mm diameter and axis 50 mm long, when it is resting on the ground on a point on its base circle with
(a) the axis making an angle of 30° with the H.P. and 45° with the V.P.
(b) the axis making an angle of 30° with the H.P. and its top view making 45° with the V.P.
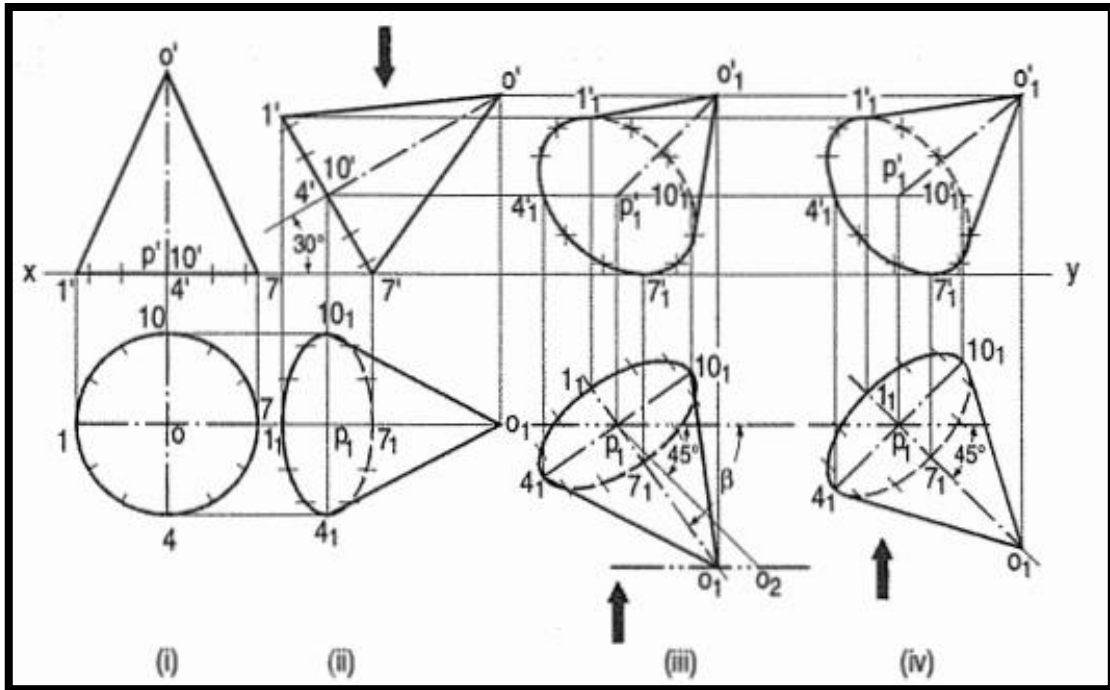
Figure3

Command:

1. Units
2. Limits
3. Line
4. Dtext
5. Circle
6. Array
7. Point
8. Ptype
9. Copy
10. Rotate
11. Erase
12. Dimlin/dimalign/dimang

Procedure:

1. Draw the top view and the front view of the cone with the base on the ground.
2. Tilt the front view so that the axis makes 30° angle with xy. Project the second top view.

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Date: _____

(a)In order that the axis may make an angle of 45° with the V.P., let us the apparent angle of inclination which the top view of the axis, viz. o_1p_1 should make with xy and which will be greater than 45°.

3. Mark any point p1 below xy. Draw a line p_1o_2 equal to the true length of the axis, viz, o'p', and inclined at 45° to xy.
4. With p1 as centre and radius equal to p1o1 (the length of the top view of the axis) draw an arc cutting the locus of o_2 at o_1.
5. Then β is the apparent angle of inclination and is greater than 45°.
6. Around p $_1o_1$ as axis, reproduce the second top view and project the final front view as shown.

   Note that the base of the cone is not visible in the front view because it is nearer xy in the top view.

(b)When the top view of the axis is to make 45° angle with the V.P., it is evident that p_1o_1 should be inclined at 45° to xy. Hence, reproduce the top view accordingly and project the required front view [fig.(iv)].

Assignment:

1. Draw the projections of a cylinder 75 mm diameter and 100 rnm long, lying on the ground with its axis inclined at 30" to the V.P. and parallel to the ground.
2. Draw the projections of a cone, base 75 mm diameter and axis 100 mm long, lying on the H.P. on one of its generators with axis parallel to the V.P.
3. A pentagonal pyramid, base 25 mm side and axis 50 mm long has one of its triangular faces in the V.P. and the edge of the base contained by that face makes an angle of 30° with the H.P. Draw its projections.

Viva questions:

1. What is the difference between frustum of solid and truncated solid?
2. What do you mean by right solid?
3. What is the difference between prism and pyramid?
4. What is difference between line, plane and solid?
5. What is difference between prism and pyramid?
6. What do you mean by right & regular prism, pyramid, cone & cylinder?
7. What is difference between cone & cylinder?

PROJECTION OF SECTION OF SOLIDS

1. Cutting plane or section plane: The imaginary plane which is assumed to cut the object as required is called a cutting plane or section plane.
2. Section: The surface produced when a section plane cuts a solid is termed a section.
3. Sectional view: The drawing showing that part of the object which is between the plane of projection and the section plane is called a sectional view.
4. True Shape of Section: If a solid is sectioned by a section plane and it is projected to a plane parallel to it, the shape of the section obtained will be exactly the section exposed by the section plane. This shape is called True Shape of Section.
5. Apparent Shape of Section: If the section plane is inclined to the plane ofprojection, the shape obtained will not bethe true shape. Such a shape is calledApparent Shape of Section.
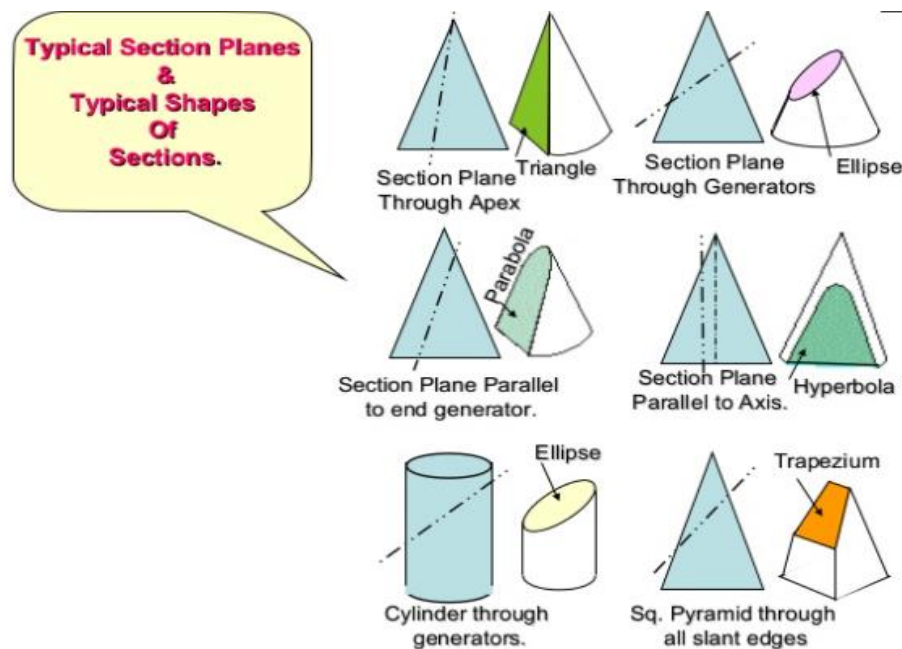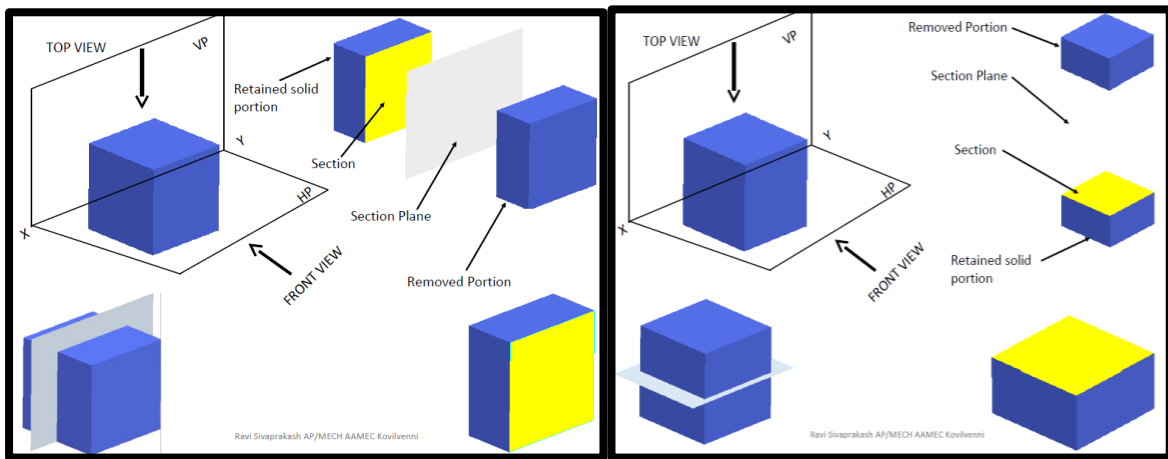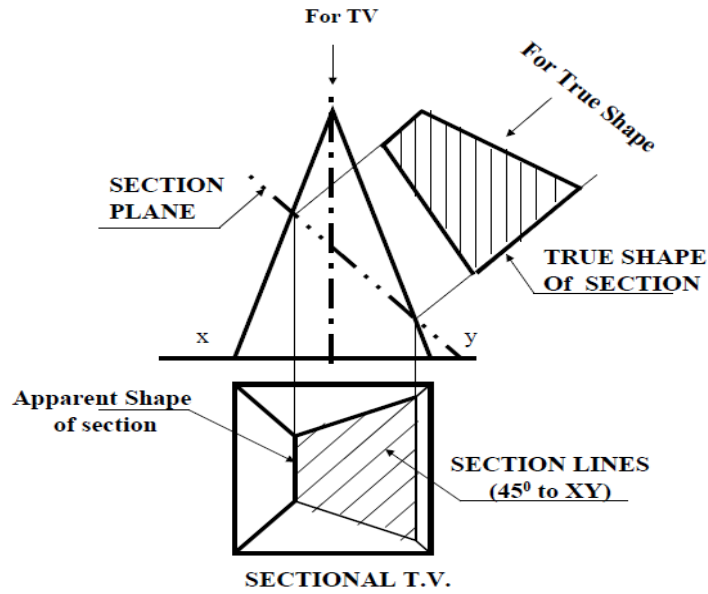
SECTIONS OF DIFFERENT SOLIDS:
1. Sections of prisms
2. Sections of pyramids
3. Sections of cylinders
4. Sections of cones
5. Sections of spheres.

TYPES OF SECTION PLANES
1. Section Plane Perpendicular to HP and parallel to VP.
2. Section Plane Perpendicular to VP and parallel to HP.
3. Section Plane Perpendicular to VP and Inclined to HP.
4. Section Plane Perpendicular to HP and Inclined to VP.
5. Section Plane Perpendicular to both HP and VP.

Date: _____

SHEET NO:15
SECTION OF SOLIDS-I

SECTIONS OF PRISMS

1. A cube of 35 mm long edges is resting on the H.P. on one of its faces with a vertical face inclined at 30° to the V.P. It is cut by a section plane parallel to the V.P. and 9 mm away from the axis and further away from the V.P. Draw its sectional front view and the top view.
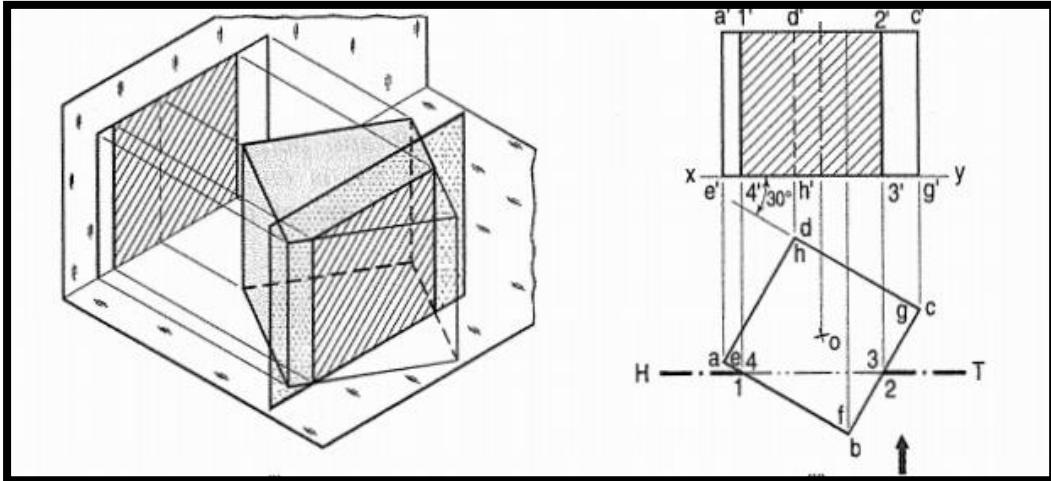
Figure1

Commands:

1. Units
2. Limits
3. Line
4. Dtext
5. Rotate
6. Copy
7. Extend
8. Hatch

Procedure:
1. Draw a line H.T. in the top view (to represent the section plane) parallel to xy and 9 mm from o.
2. Name the points at which the edges are cut, viz. ab at 1, be at 2, gf at 3 and fe at 4.
3. Project these points on the corresponding edges in the front view and join them in proper order.
4. As the section plane is parallel to the V.P., figure 1' 2' 3' 4' in the front view, shows the true shape of the section.
5. Show the views by dark but thin lines, leaving the lines for the cut-portion fainter.
6. Draw section lines in the rectangle for the section.

Date: _____

SECTIONS OF PYRAMIDS

1. A pentagonal pyramid, base 30 mm side and axis 65 mm long has its base horizontal and an edge of the base parallel to the V.P. A horizontal section plane cuts it at a distance of 25 mm above the base. Draw its from view and sectional top view.
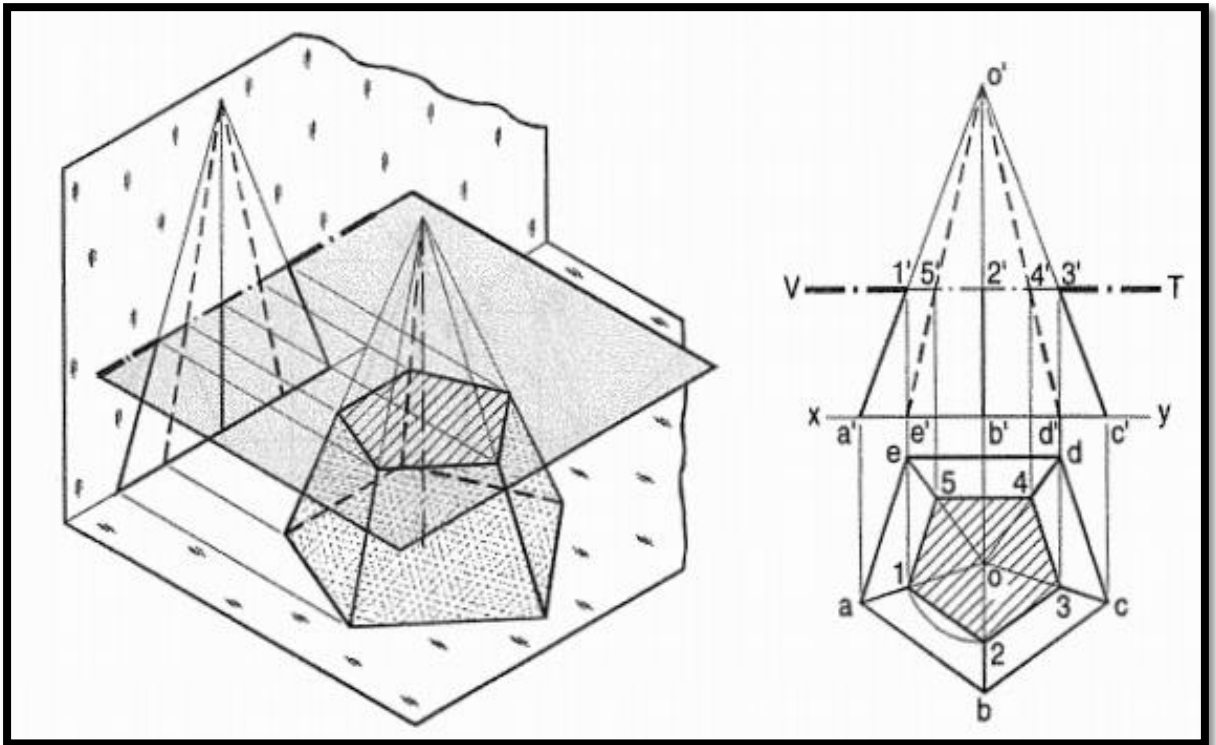
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Polygon
5. Dtext
6. Rotate
7. Copy
8. Extend
9. Hatch

Procedure:
1. Draw the projections of the pyramid in the required position and show a line V.T. for the section plane, parallel to and 25 mm above the base. All the five slant edges are cut.
2. Project the points at which they are cut, on the corresponding edges in the top view. The point 2' cannot be projected directly as the line ob is perpendicular to xy. But it is quite evident from the projections of other points that the lines of the section in the top view, viz. 3-4, 4-5 and 5-1 are parallel to the edges of the base in their respective faces and that the points 1, 3, 4 and 5 are equidistant from o.
3. Hence, line 1-2 also will be parallel to ab and o2 will be equal to o1, o3 etc. Therefore, with o as centre and radius o1, draw an arc cutting ob at a point 2 which

will be the projection of 2'. Complete the sectional top view in which the true shape of the section, viz. the pentagon 1, 2, 3, 4 and 5 is also seen.

4. Hence, when a pyramid is cut by a plane parallel to its base, the trueshape of the section will be a figure, similar to the base; the sides of the section will be parallel to the edges of the base in the respective faces and the corners of the section will be equidistant from the axis.

Date: _____

SHEET NO:16
SECTION OF SOLIDS-II

1. A triangular pyramid, having base 40 mm side and axis 50 mm long, is lying on the H.P. on one of its faces, with the axis parallel to the V.P. A section parallel to the V.P. cuts the pyramid at a distance of 6 mm from the axis. Draw its sectional front view and the top view.
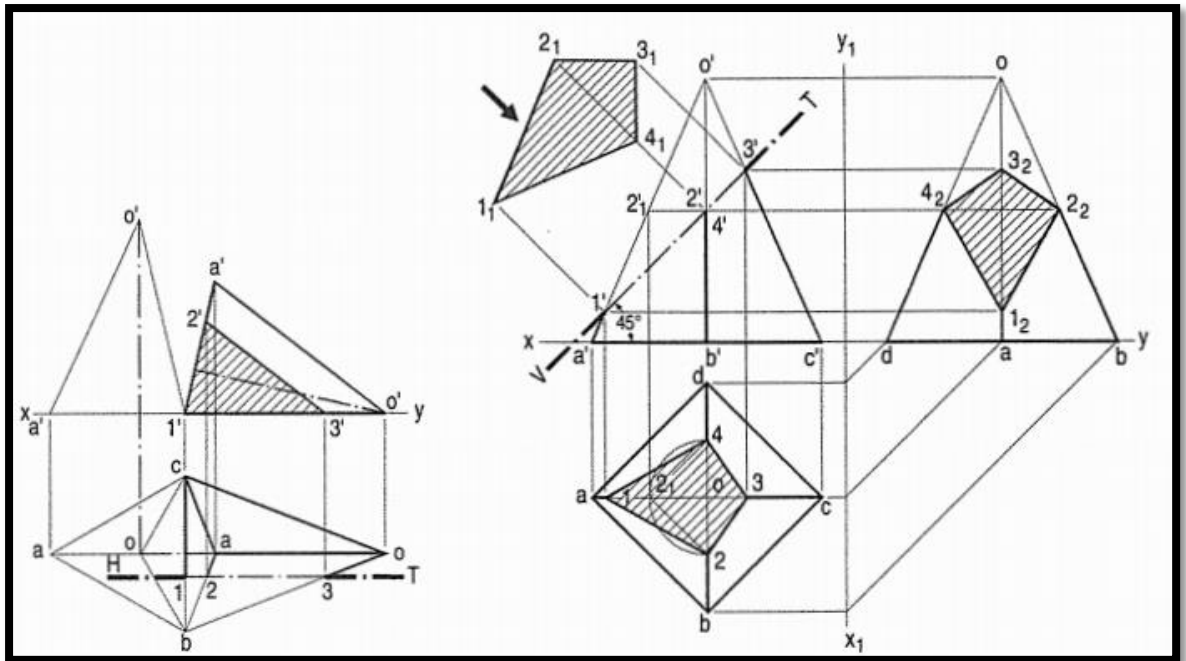
Figure1

Commands:

1. Units
2. Limits
3. Line
4. Dtext
5. Rotate
6. Copy
7. Extend
8. Hatch

Procedure:

1. Draw the projections of the pyramid in the required position and show a line H.T. (for the cutting plane) in the top view parallel to xy and 6 mm from the axis.
2. Project points 1, 2 and 3 (at which the edges are cut) on corresponding edges in the front view and join them. Figure 1' 2' 3' shows the true shape of the section.

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SECTIONS OF CYLINDERS

1. A cylinder of 40 mm diameter, 60 mm height and having its axis vertical, is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and intersecting the axis 32 mm above the base. Draw its front view, sectional top view, sectional side view and true shape of the section.
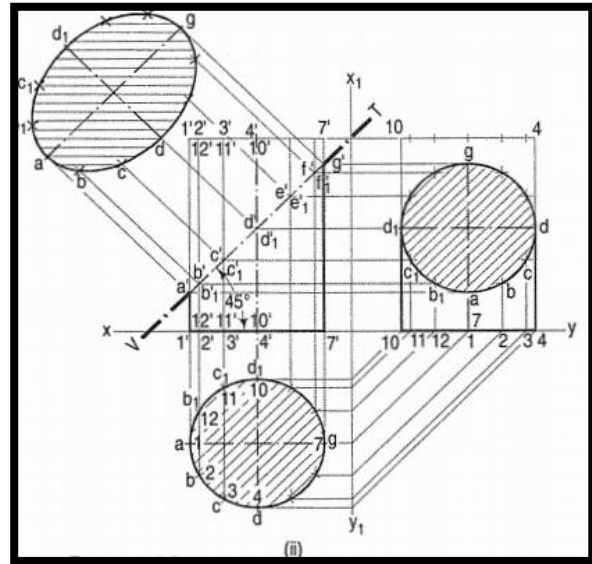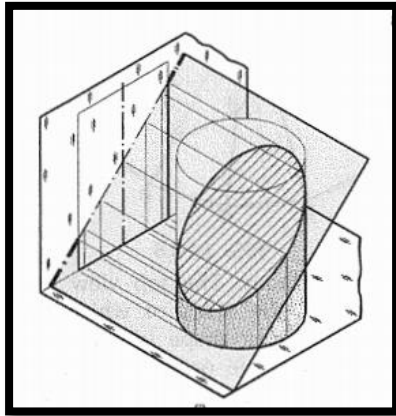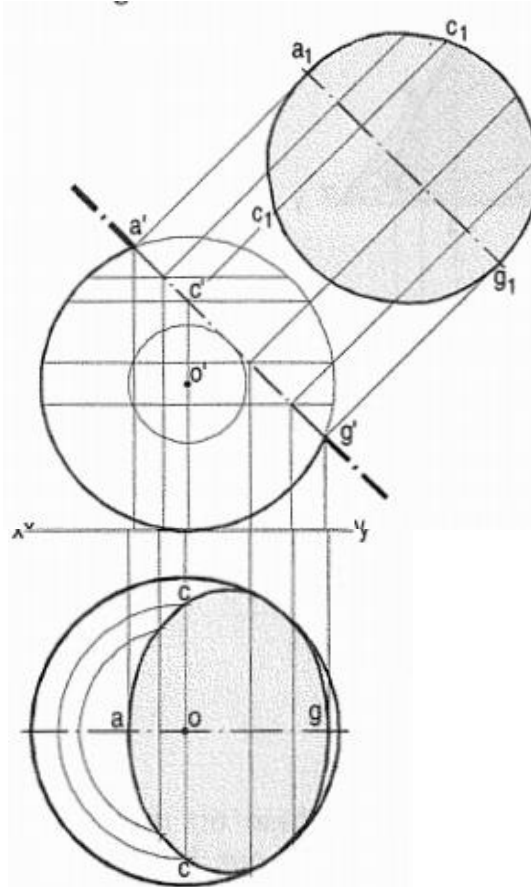

Figure2

Commands:

1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Rotate
7. Copy
8. Extend
9. Hatch
10. Polar array

Procedure:

1. As the cylinder has no edges, a number of lines representing the generators may be assumed on its curved surface by dividing the base-circle into, say 12 equal parts.
2. Name the points at which these lines are cut by the V.T. In the top view, these points lie on the circle and hence, the same circle is the top view of the section. The width of the section at any point, say c', will be equal to the length of the chord cc1 in the top view.
3. The true shape of the section may be drawn around the centre line ag drawn parallel to V.T. as shown. It is an ellipse the major axis of which is equal to the length of the section plane viz. a'g', and the minor axis equal to the diameter of the cylinder viz. dd_1
4. Project the sectional side view as shown. The section will be seen as a circle because the section plane makes 45° angle with xy.

SECTIONS OF CONES

1. A cone, base 75 mm diameter and axis 80 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P. inclined at 45° to the H.P. and cutting the axis at a point 35 mm from the apex. Draw its front view, sectional top view, sectional side view and true shape of the section.
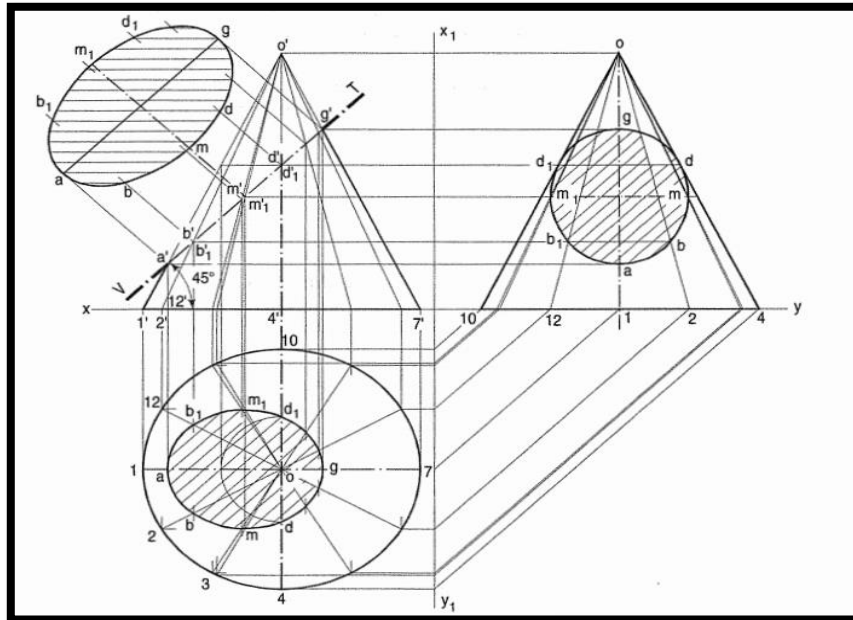
Figure3

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Rotate
7. Copy
8. Extend
9. Hatch
10. Polar array

Procedure:
1. Divide the base-circle into a number of equal parts, say 12. Draw lines (i.e. generators) joining these points with o. Project these points on the line representing the base in the front view.
2. Draw lines o' 2', o' 3' etc. cutting the line for the section at points b', c' etc. Project these points on the corresponding lines in the top view.For example, point b' on o' 2', also represents point b'$_1$ on o'-12' which coincides with o'-12'. Therefore, project b' to b on o$_2$ and to b$_1$ on o'-12'. b and b$_1$ are the points on the section (in the top view). FIG. (i)
3. Similarly, obtain other points. Point d' cannot be projected directly. Hence, the same method as in case of pyramids should be employed to determine the positions d and

d_1, as shown. In addition to these, two more pointsfor the maximum width of the section at its centre should also be obtained.

4. Mark m', the mid-point of the section and obtain the points m and m 1.
5. Draw a smooth curve through these points.
6. The true shape of the section may be obtained on the V.T. as a new reference line or symmetrically around the centre line ag, drawn parallel to the V.T. as shown. It is an ellipse whose major axis is equal to the length of the section and minor axis equal to the width of the section at its centre.

SECTIONS OF SPHERES

1. A sphere of 50 mm diameter is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and at a distance of 70 rnm from its centre. Draw the sectional top view and true shape of the section.

Figure4

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Rotate
7. Copy
8. Extend
9. Hatch
10. Polar array

Procedure:
1. Draw a line (for the section plane) inclined at 45° to xy and tangent to the circle of 10 mm radius drawn with o' as centre. Mark a number of points on this line.
2. Find the width of section at each point in the top view as shown in Fig. For example, the chord cc is the width of section al the point c'.
3. Draw a curve through the points thus obtained. It will be an ellipse. The true shape of the section will be a circle of diameter a'g'.

Assignments:
1. A triangular prism, base 30 mm side and axis 50 mm long, is lying on the H.P. on one of its rectangular faces with its axis inclined at 30° to the V.P. It is cut by a horizontal section plane, at a distance of 12 mm above the ground. Draw its front view and sectional top view.
2. A pentagonal pyramid, base 30 mm side and axis 65 mm long has its base horizontal and an edge of the base parallel to the V.P. A horizontal section plane cuts it at a distance of 25 mm above the base. Draw its· from view and sectional top view.
3. A hollow cylinder; 50 mm outside diameter axis 70 mm long and thickness 8 mm has its axis parallel to the V.P. and inclined at 30° to the vertical. It is cut in two equal halves by a horizontal section plane. Draw its sectional top view.
4. A cone, diameter of base 50 mm and axis 50 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P., inclined at 75° to the H.P. and passing through the apex. Draw its front view, sectional top view and true shape of the section.
5. The projections of a hemisphere 50 mm diameter, placed centrally on the top of a frustum of a hexagonal pyramid, base 32 mm side, top 20 mm side and axis 50 mm long are given. Draw the sectional front view when the vertical section plane H.T. inclined at 45° to the V.P. and 10 mm from the axis, cuts them. Also draw the- true shapes of the sections of both the solids.

Viva questions:
1. How cutting planes are represented?
2. What is the significance of section of solid?
3. Define cutting plane?
4. What are the types of section of planes?
5. Define Frustum?
6. Define truncated?
7. Difference between Frustum and truncated?

DEVELOPMENT OF SURFACES

Development is a graphical method of obtaining the area of the surfaces of a solid. When a solid is opened out and its complete surface is laid on a plane, the surface of the solid is said to be developed. The figure thus obtained is called a *development of the surfaces of the solid* or simply *development*. Development of the solid, when folded or rolled, gives the solid.

Examples

Prism – Made up of same number of rectangles as sides of the base

One side: Height of the prism

Other side: Side of the base
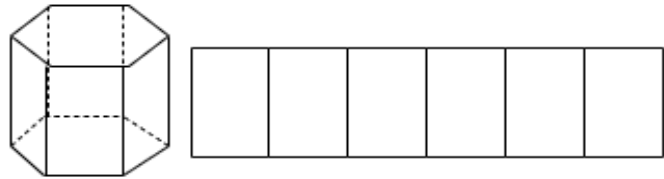
Cylinder – Rectangle

One side: Circumference of the base

Other side: Height of the cylinder
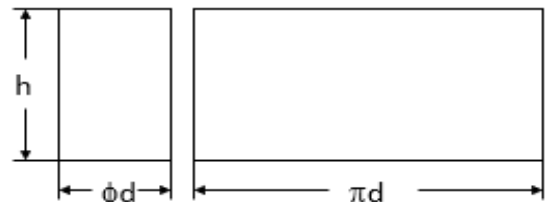
Pyramid – Number of triangles in contact

The base may be included

if present

Date: _____
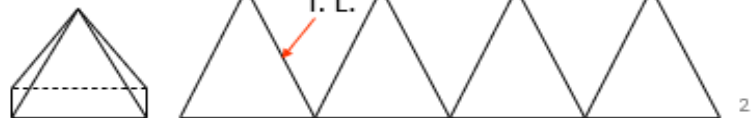
Methods used to develop surfaces

1. **Parallel-line development:** Used for prisms, cylinders etc. in which **parallel lines are drawn along the surface** and transferred to the development.

2. **Radial-line development:** Used for pyramids, cones etc. in which the **true length of the slant edge** or generator is used as **radius.**

3. **Triangulation development:** Complex shapes are **divided into a number of triangles** and transferred into the development (usually used for transition pieces).

4. **Approximate method:** Surface is divided into parts and developed. Used for surfaces such as spheres, paraboloids, ellipsoids etc.

Note:- The surface is preferably cut at the location where the **edge will be smallest** such that welding or other joining procedures will be minimal.

Parallel line development: This method is employed to develop the surfaces of **prisms and cylinders.** Two parallel lines (called **stretch-out lines**) are drawn from the two ends of the solids and the lateral faces are located between these lines.

(a)   (b)

Date: _____
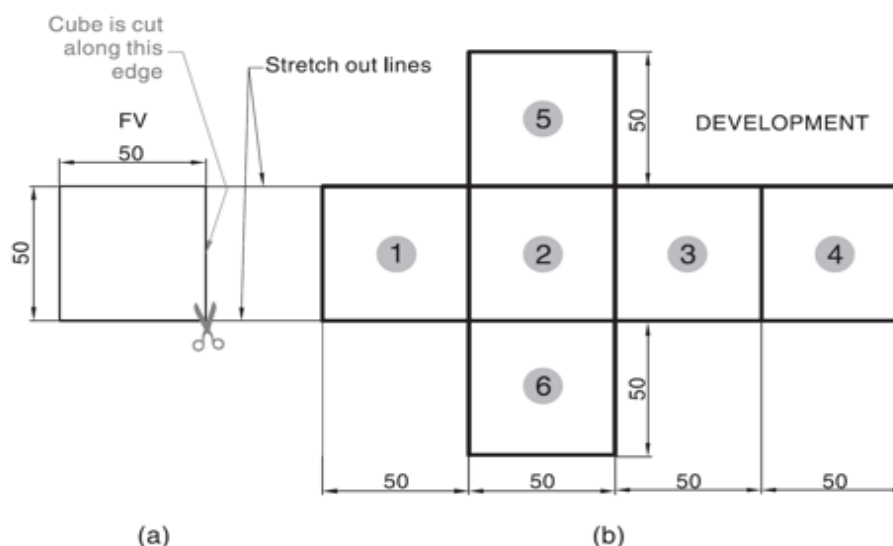
Development of lateral surfaces of different solids.
(Lateral surface is the surface excluding top & base)

Cylinder: A Rectangle

H

πD

D

H= Height   D= base diameter

Cone: (Sector of circle)

L

θ

R=Base circle radius.
L=Slant height.
$\theta = \frac{R}{L} \times 360^0$

Radial-line development

Pyramids: (No.of triangles)

S

S

L

L= Slant edge.
S = Edge of base

Prisms: No.of Rectangles

H

S   S   H= Height   S = Edge of base

Parallel-line development

Cube: Six Squares.

Tetrahedron: Four Equilateral Triangles

All sides equal in length

5

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Date: _____
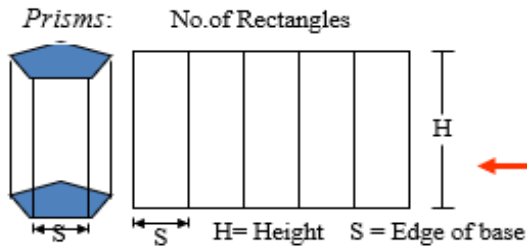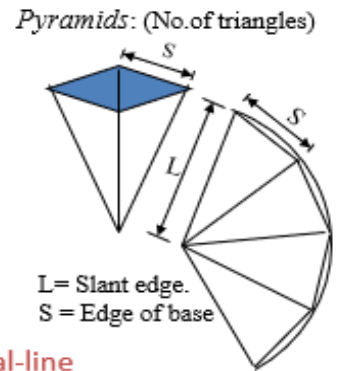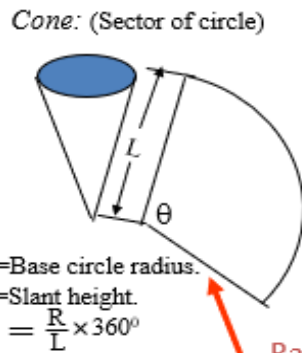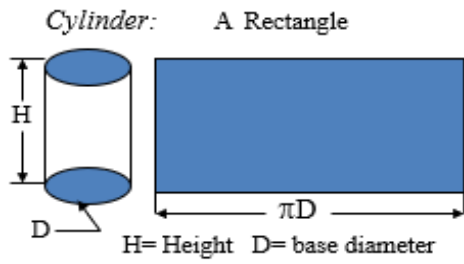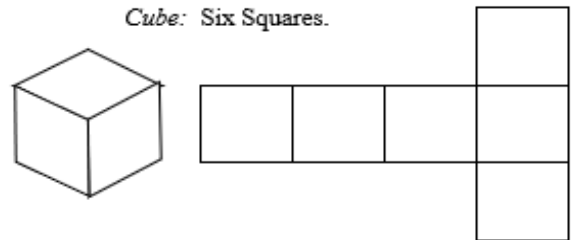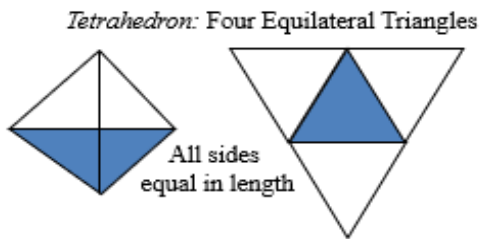
FRUSTUMS

DEVELOPMENT OF
FRUSTUM OF CONE
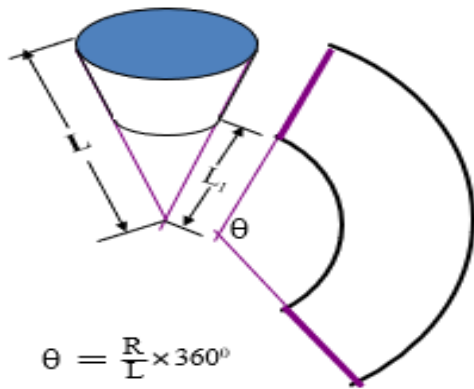
$$\theta = \frac{R}{L} \times 360^0$$

R= Base circle radius of cone
L= Slant height of cone
L_1 = Slant height of cut part.

DEVELOPMENT OF
FRUSTUM OF SQUARE PYRAMID
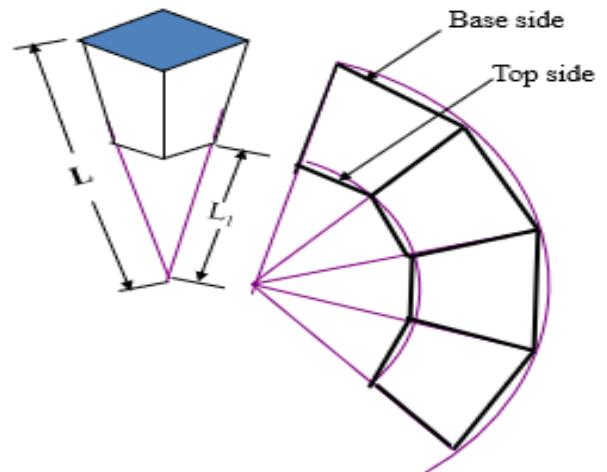
L= Slant edge of pyramid
L_1 = Slant edge of cut part.

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Date: _____

SHEET NO:17
DEVELOPMENT OF SURFACES (PRISMS AND CYLINDERS)

1. A pentagonal prism of base 20mm side and axis 40mm long rests on H.P on its base with its axis perpendicular to H.P. It is cut by a sectional plane, inclined at 45^0 to the H.P. and bisects the axis. Draw the development of truncated portion of solids.
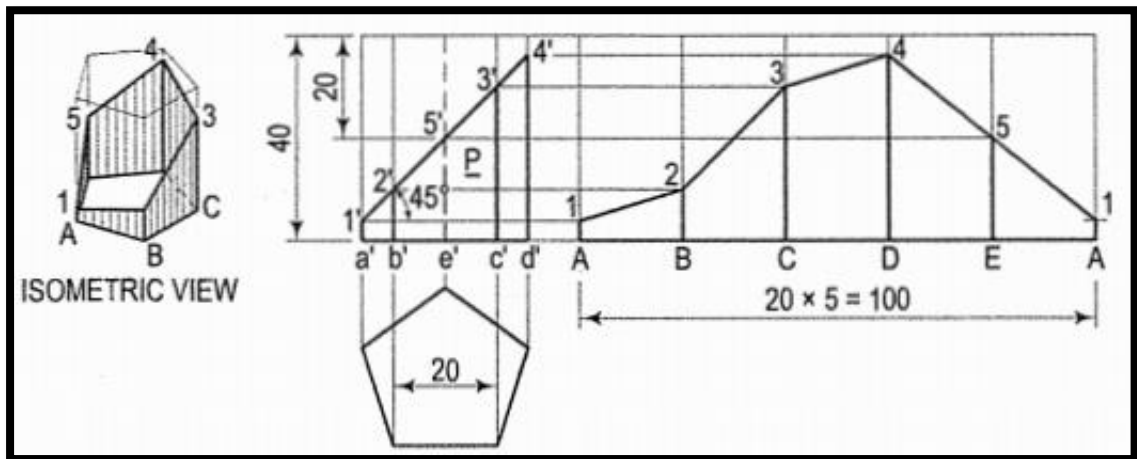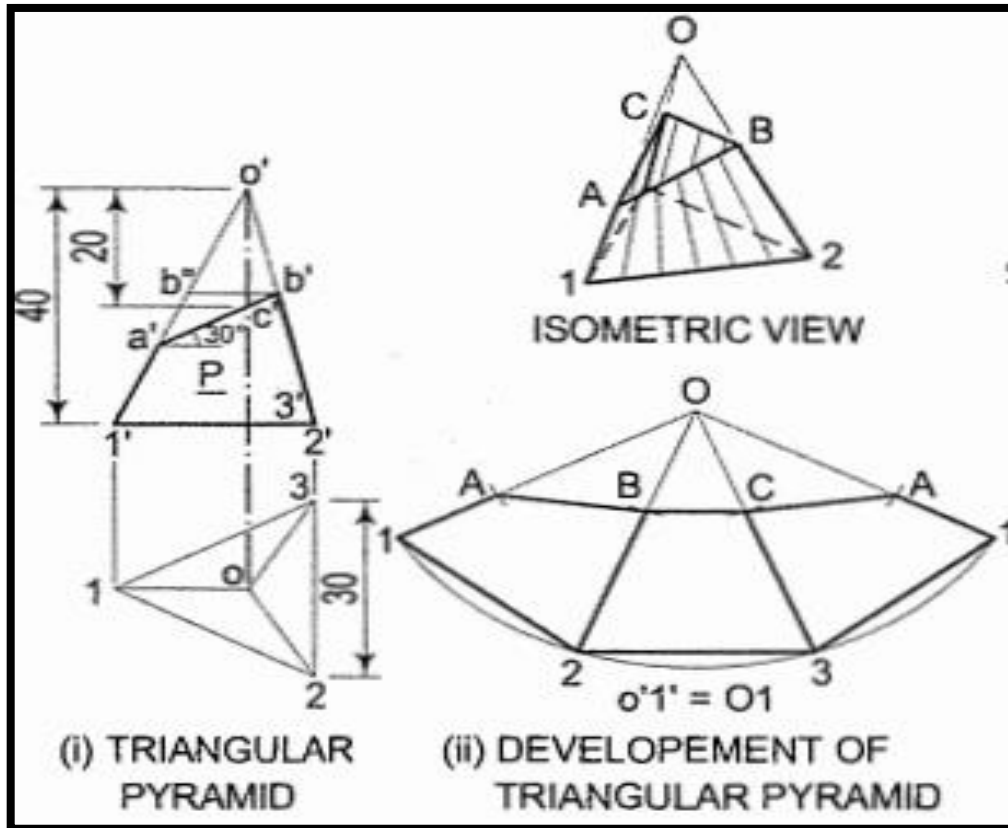

Figure1

Commands:

1. Units
2. Limits
3. Line
4. Polygon
5. Dtext
6. Rotate
7. Copy
8. Extend
9. Hatch
10. Point
11. Ptype

Procedure:
1. Name the corners of the prism and the points at which the edges are cut.
2. Draw the development assuming the prism to be whole fig.(ii). It is made up of five equal rectangles.
3. Draw horizontal lines through, points $1^1, 2^1$ to cut the lines for the corresponding edges development at points 1, 2 etc.
4. Draw lines joining these points and complete the development as shown.

Date: _____

2. A cylinder of base 45mm diameter and axis 60mm long rests on the HP on its base and its axis is perpendicular to the HP. It is cut by a section plane inclined at some angle to HP such that it cuts the cylinder at 15mm above HP on one side and ends at top of the cylinder at the other end as shown in the figure below. Draw the development of truncated portion of the cylinder by parallel line method.
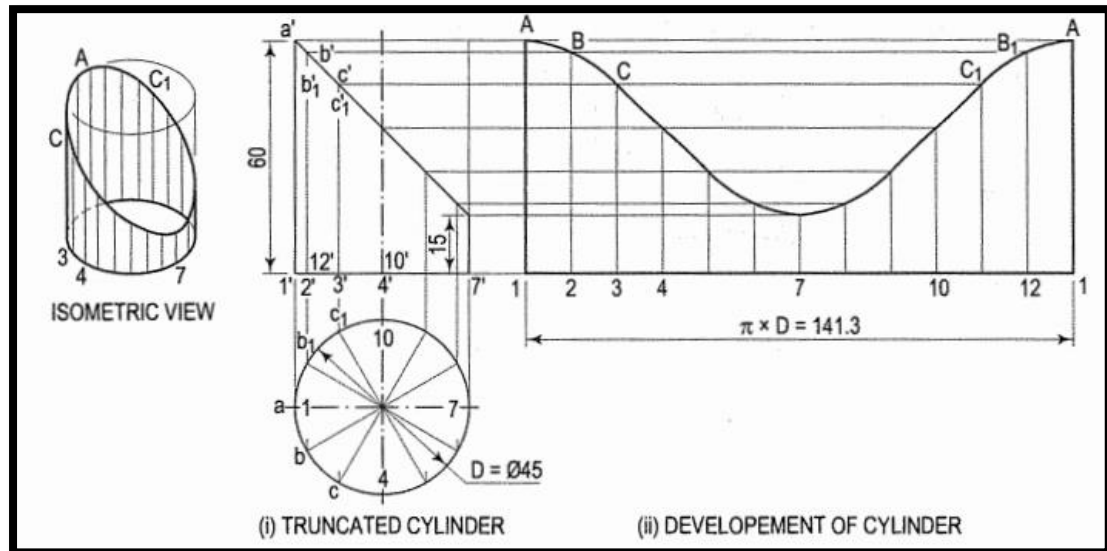
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Dtext
6. Copy
7. Extend
8. Hatch
9. Point
10. Ptype
11. Polar array
12. Dimlin/dimang

Procedure:
1. Divide the circle in the top view into twelve equal parts.
2. Project the division points to the front view and draw the generators.
3. Mark points a', b' and b'1, c' and c'1 etc. in which the generators are cut.
4. Draw the development of the lateral surface of the whole cylinder along with the generators [fig.(ii)].
5. The length of the line 1-1 is equal to n x D (circumference of the circle).
6. This length can also be marked approximately by stepping off with a bow divider, twelve divisions, each equal to the chord-length ab.
7. Draw horizontal lines through points a', b' and b'1 etc. to cut the corresponding generators in points A, B and 81 etc.
8. Draw a smooth curve through the points thus obtained.
9. The figure 1-A-A-1 is the required development.

Assignments:

1. A triangular prism of base 40mm sides and axis 60mm long rests on HP on its base with an edge of base perpendicular to VP. It is cut by two section planes, one inclined at 30^0 to the HP and other inclined at 45^0 to HP as shown in the figure below. Draw the development of the prism.
2. A cylinder of base 40mm diameter and axis 60mm long rests on HP on its base with its axis perpendicular to HP. It is cut by three section planes inclined at 30^0, 45^0 and 30^0 to HP. Draw the development of surfaces of cylinder

Date: _____

SHEET NO:18
DEVELOPMENT OF SURFACES (PYRAMIDS & CONES)

1. A Triangular pyramid of base 30mm sides and axis 40mm long rests on HP on its base with an edge of the base perpendicular to VP. It is cut by a section plane inclined at 30^0 to the HP and bisects the axis. Draw the development of the truncated portion of the pyramid.
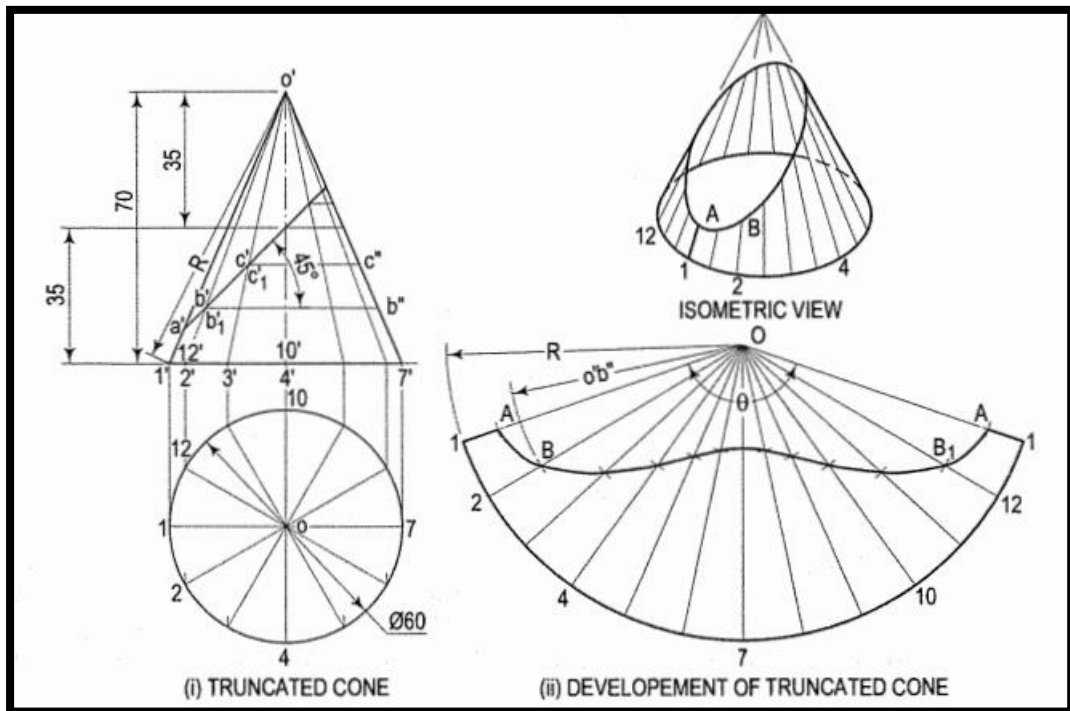

Figure1

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/dimalign
6. Arc
7. Extend

Procedure:
1. Draw the development of the lateral surface of the whole pyramid [fig.(ii)]
2. On 01 mark a point A such that OA = o'a'. o'2' (with which o'3' coincides) is not the true length of the slant edge.
3. Hence, through b', draw a line parallel to the base and cutting o' a' at b" o'b" is the true length of o'b' as well as o'c'. Mark a point B in 02 and C in 03 such that OB = OC = o'b".
4. Draw lines AB, BC and CA and complete the required development as shown. Keep the arc and the lines for the removed

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2. A pentagonal pyramid of base 25mm sides and axis 50mm long rests on HP on its base with an edge of its base parallel to VP. It is cut by the section palne inclined at 30^0 to the HP and starts from the left bottom corner of the base. Draw the development
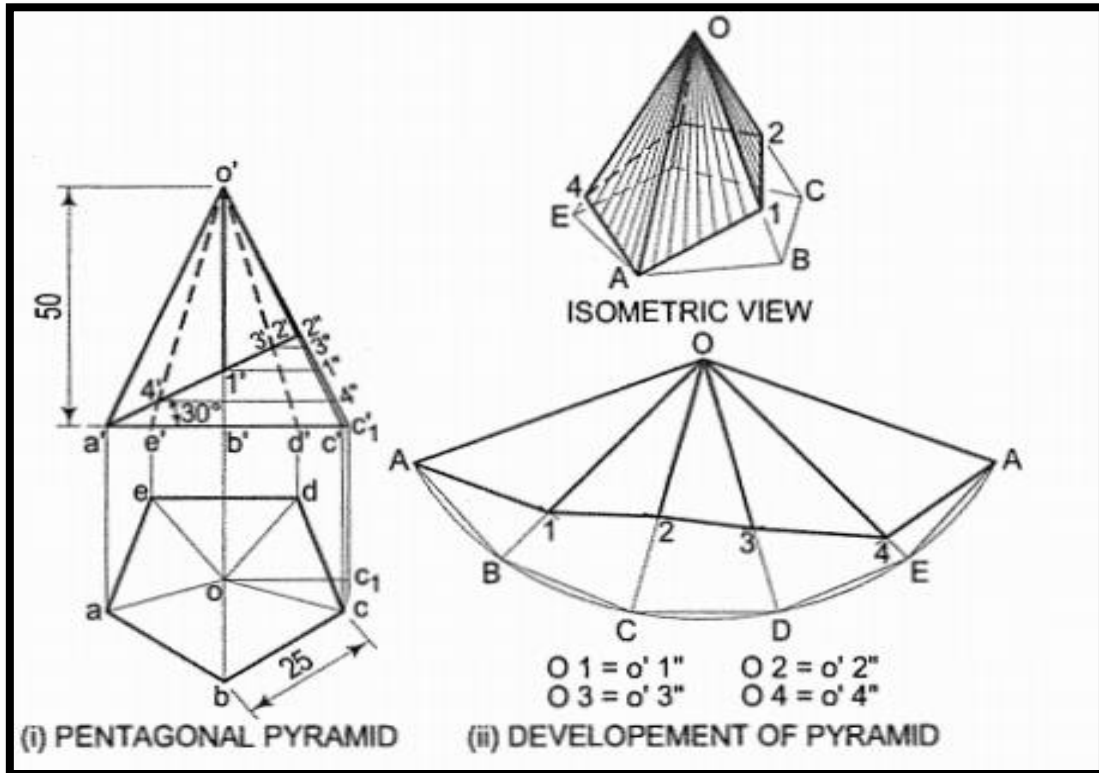
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Polygon
5. Dtext
6. Dimlin/dimalign
7. Arc
8. Extend

Procedure:
1. None of the lines in thefront view shows the true length of the slant edges. Hence, draw the top view and determine the true length o'c'1. Through points 1 ', 2' etc., draw lines parallel to the base and obtain the true lengths o'1 ", o'2" etc.
2. Draw the development of lateral surfaces of whole pyramid
3. Mark 1,2,3 etc. on line OB, OC, ODetc. such that that o1 = o'1 ", 02 = o'2", 03 = o'3" etc.
4. Draw lines joining points A, 1, 2 etc. in correct sequence and complete the required development. Note that the lines for the lower part should be fainter.

3. A cone of base 60mm diameter and axis 70 mm long rests on HP on its base. It is cut by a section plane inclined at 45^0 to the HP and bisects the axis. Draw the development of surfaces of the truncated portion of the cone.

Figure3

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Polar array
6. Dtext
7. Dimlin/dimalign
8. Arc
9. Extend

Procedure:
1. Draw the base-circle in the top view and divide it into twelve equal parts.
2. With any point O as centre and radius equal to o'1' or o'7', draw an arc of the circle [fig.(ii)].
3. The length of this arc should be equal to the circumference of the base circle. This can be determined in two ways.
4. Calculate the subtended angle 8 by the formula,

$$\theta = 360 * \frac{radius\ of\ the\ base\ circle.}{slant\ height}$$

5. Cut-off the arc so that it subtends the angle 8 at the centre and divide it into twelve equal parts.

6. Join the division-points with 0, thus completing the development of the whole cone with twelve generators.
7. The truncated portion of the cone may be deducted from this development by marking the positions of points at which generators are cut and then drawing a curve through them. For example, generators o'2' and o'12' in the front view are cut at points b' and b'1 which coincide with each other. The true length of o' b' may be obtained by drawing a line through b', parallel to the base and cutting o'7' at b". Then o'b" is the true length of o'b'.
8. Mark points B and 81 on generators 02 and 0-12 respectively, such that OB = OB$_1$ = o' b". Locate all points in the same way and draw a smooth curve through them. The figure enclosed this curve and the arc is the development of the truncated cone.

Assignment:

1. A cone of base 50mm diameter and axis 60 mm long rests on HP on its base. It is cut by a section plane inclined at 60^0 to the HP and bisects the axis. Draw the development of surfaces of the truncated portion of the cone
2. Draw the projections of a cone resting on the ground on its base and show on them, the shortest path by which a point B starting from a point on the circumference of the base and moving around the cone will return to the same point. Base of cone 61 mm diameter; axis 75 mm long.

Viva questions:
1. What do you mean by Development of solid?
2. Classify the methods of development of solids?
3. What are the methods for development of sphere?
4. What do you mean by Antidevelopment?
5. What is parallel line method and when it is used?
6. What is radial line method and when it is used?
7. What is triangulation method and when it is used?
8. what are approximate methods and on which solids

Date: _____

INTERSECTION OF SURFACES

INTERSECTION OF SOLIDS AND DEVELOPMENT OF SURFACES

Most objects in reality are formed by the intersection of solids. Development of surfaces teaches about objects made from thin sheets.

It means that one solid is entering another solid. It may be easy to connect any object of plane surfaces to a plane wall. But it is very difficult for an object of curved surfaces. For example, a pipe is to be connected at right angles to another pipe. In the ordinary way it is almost impossible. Here the role of intersection of solids comes into existence. The pipe in which another pipe is to be inserted has to be cut with certain peculiar curves, only then the second pipe can be inserted. These special curves or contours are called curves of penetration.

Between plane objects, there will be lines of intersection. Lines of intersection are common to both the surfaces. Between two curved surfaces, there will be curves of penetration.

Consider the following cases:

- Intersection of two prisms
- Intersection of two cylinders
- Intersection of two cones
- Intersection of a prism and a cylinder
- Intersection of a prism and a cone
- Intersection of a prism and a sphere
- Intersection of a pyramid and a cylinder
- Intersection of a pyramid and a cone
- Intersection of a pyramid and a sphere
- Intersection of a cone and a cylinder
- Intersection of a cone and a sphere
- Intersection of a sphere and a cylinder

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Date: _____
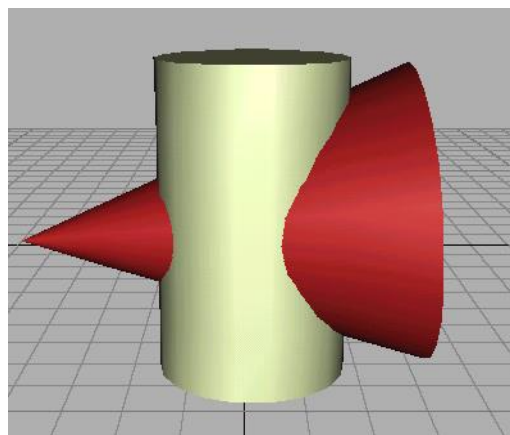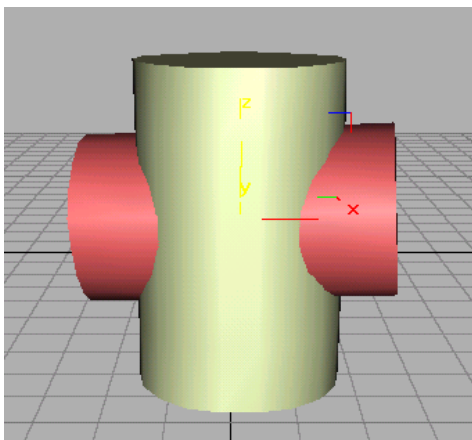
SHEET NO:19
INTERSECTION OF SURFACES (CYLINDER VS CYLINDER)

1. A Vertical cylinder of 80 mm diameter is completely penetrated by another cylinder of 60 mm their axes bisecting each other at right angles. Draw their projections curves of penetration, assuming the axis of the penetrating cylinder to be parallel to V.P.
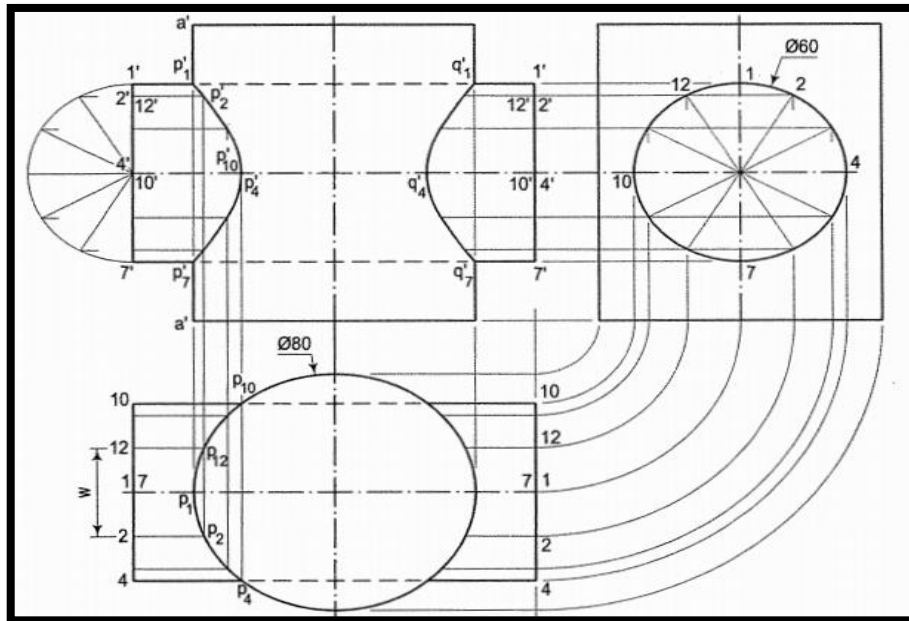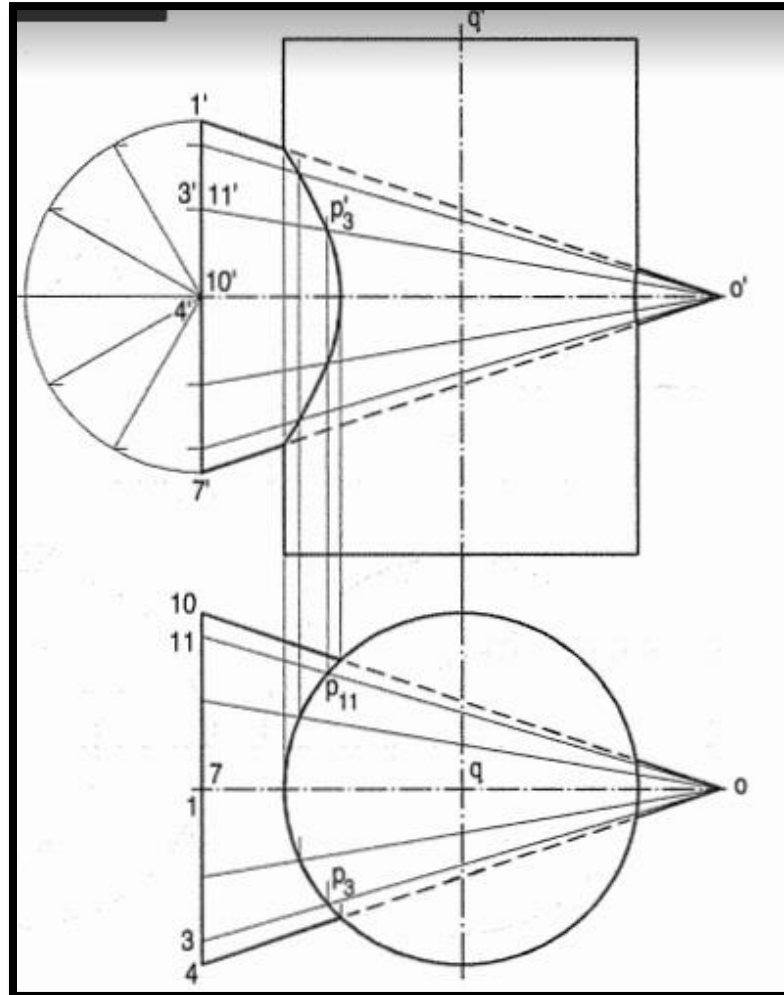

Figure1

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Polar array
6. Dtext
7. Dimlin/dimalign
8. Arc
9. Spline
10. Extend

Procedure:
1. Draw the front view and the top view and show lines for twelve generators in the horizontal cylinder in both views.
2. Mark points p1, p2 etc. at which lines 1-1, 2-2 etc. intersect the circle (showing the surface of the vertical cylinder) in the top view and project them to p'1,p'2 etc. on corresponding lines 1 '1 ', 2'2' etc. in the front view.
3. Draw the required curves on both sides of the axis through points thus located.
4. Hidden portions of the curves coincide with the visible portions. Points p'1, p'4, p'7 and p'10 are the key points where the curve changes direction.

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2. A vertical cylinder of 80 mm diameter is penetrated by another cylinder of 60 mm diameter, the axis of which is parallel to both the H.P. and the V.P. The two axes are 8 mm apart. Draw the projections showing curves of intersection.
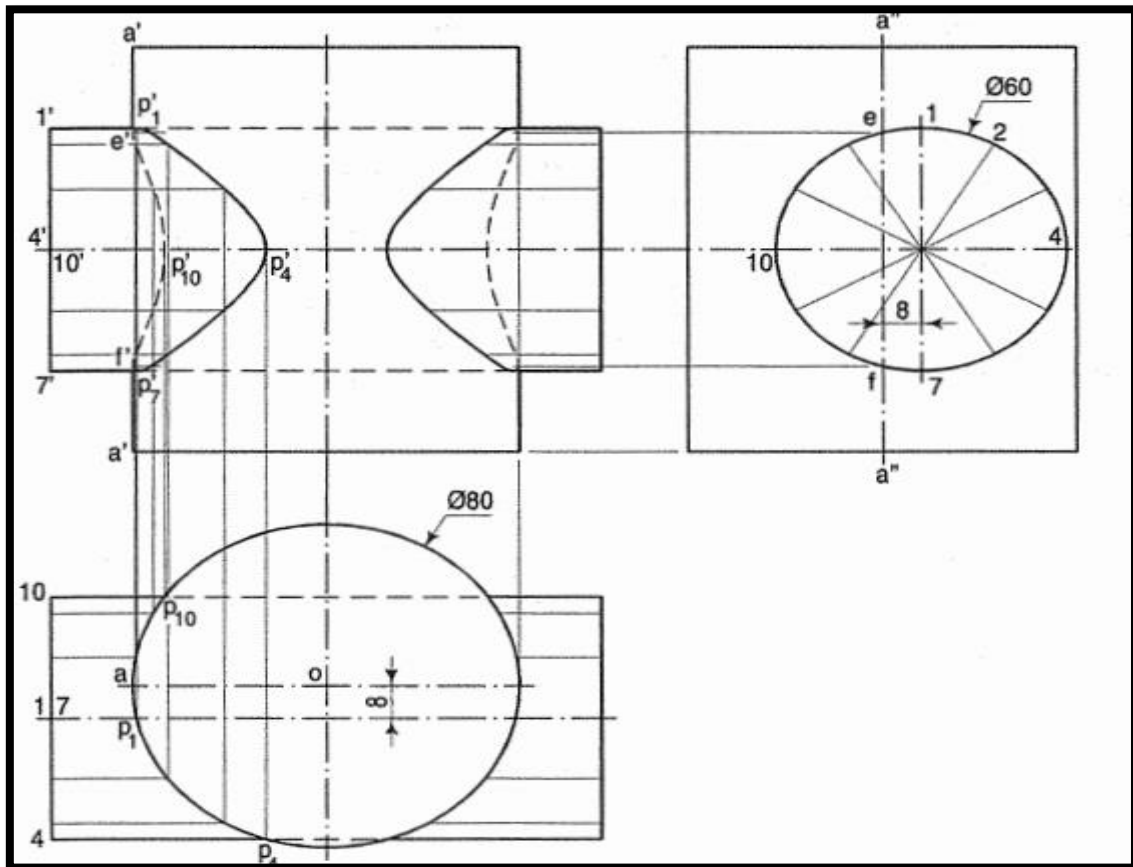
Figure2

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Polar array
6. Dtext
7. Dimlin/dimalign
8. Arc
9. Spline
10. Extend

Procedure:
1. Obtain the twelve points. Two more key points at which the extreme line a'a' of the vertical cylinder is cut, must be located. These are found from the side view.
2. Mark points e and f at which the line a"a" intersects the circle.
3. Project these points to e' and f' on the line a'a'.
4. Draw the curve passing through all the points in correct sequence, showing the hidden portion by dotted lines.
5. Plot a similar curve on the other side of the axis.

SHEET NO:20
INTERSECTION OF SURFACES (CYLINDER VS CONE)

1. A cylinder of 80 mm diameter and 100 mm axis is completely penetrated by a cone of 80 mm diameter and 120 mm long axis horizontally. Both axes intersect & bisect each other. Draw projections showing curve of intersections.

Figure1

Commands:
1. Units
2. Limits
3. Line
4. Circle
5. Polar array
6. Dtext
7. Dimlin/dimalign
8. Arc
9. Spline
10. Extend

Procedure:
1. Divide the base circle of the cone into twelve equal
2. parts and draw lines for the generators in both views. Assume a series of cutting planes perpendicular to the V.P. and passing through the apex. They will be seen as

lines in the front view. The sections of the cone will be triangles and those of the cylinder will be ellipses.

3. Take a cutting plane coinciding with a line $3_1 0_1$

4. In the top view, the section of the cone is shown by the triangle o-3-11 and that of the cylinder by the circle (the top view of the cylinder). The sides of the triangle intersect the circle at points p_3 and p_{11} •

5. Project these points in the front view to p_3 on the line $3^1 0^1$ with which 11 'o' coincides. Obtain other points in the same manner and draw a curve through them. Points on the curve on the right-hand side of the axis of the cylinder are obtained simultaneously and in the same manner.

Viva questions:

1. What ate the cases of intersection of solids?
2. Define intersection
3. What are methods of Intersection of solids
4. What are applications of intersection of solid?
5. What are the types of Intersections?
6. Which method of development is employed in case of pyramid?
7. What is the importance for use the development of surface of intersection?

ISOMETRIC PROJECTION

Isometric Projections and Isometric Views

- Isometric projection is often constructed using isometric scale which gives dimensions smaller than the true dimensions.
- However, to obtain isometric lengths from the isometric scale is always a cumbersome task.
- Standard practice is to keep all dimensions as it is. The view thus obtained is called *isometric view* or *isometric drawing*.
- As the isometric view utilizes actual dimensions, the isometric view of the object is seen larger than its isometric projection.
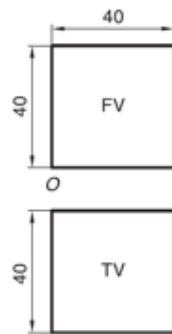
Orthographic Views

Isometric View: Rectangle/Square
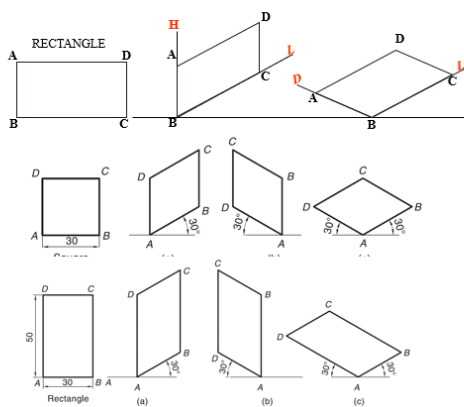
Isometric View: Triangle

Date: _____
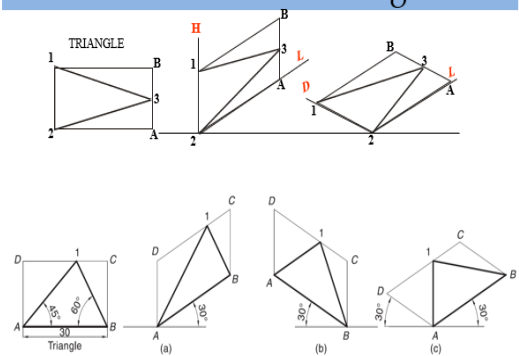
Isometric View: Pentagon/Hexagon

PENTAGON

Pentagon

(a)

(b)

(c)

HEXAGON

(a)

(b)

(c)
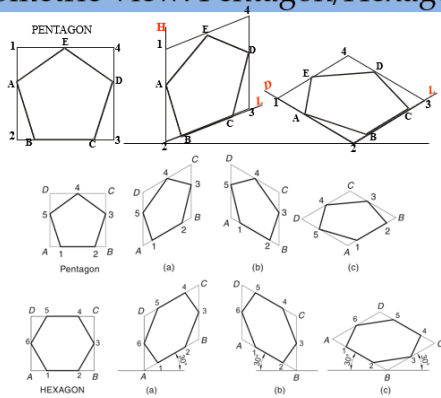
Isometric View: Circle

Isometric View: Prism

Axis length

ISOMETRIC VIEW OF HEXAGONAL PRISM STANDING ON H.P.
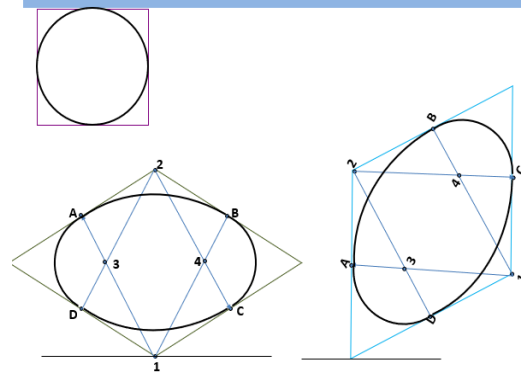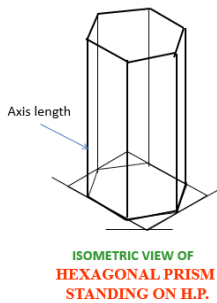
ISOMETRIC VIEW OF PENTAGONAL PRISM LYING ON H.P.

ISOMETRIC VIEW OF BASE OF PENTAGONAL PYRAMID STANDING ON H.P.

Axis length

Isometric View: Pyramid
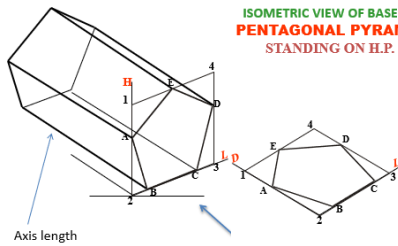
ISOMETRIC VIEW OF PENTAGONAL PYRAMID STANDING ON H.P.
(Height is added from center of pentagon)
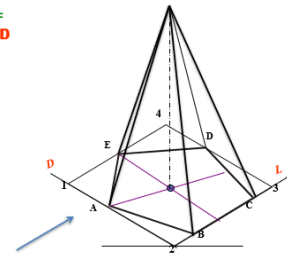
Isometric View: Cylinder

CYLINDER STANDING ON H.P

CYLINDER LYING ON H.P.

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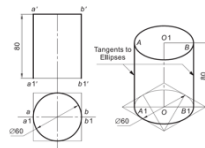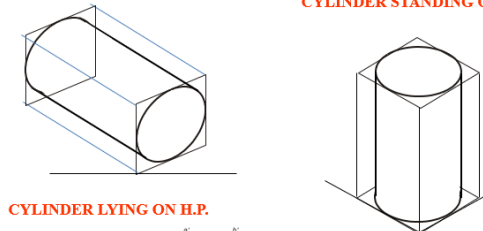
SHEET NO:21
ISOMETRIC PROJECTION
(PLANES & SIMPLE SOLIDS)

1. Draw three isometric view of a square of side 40mm
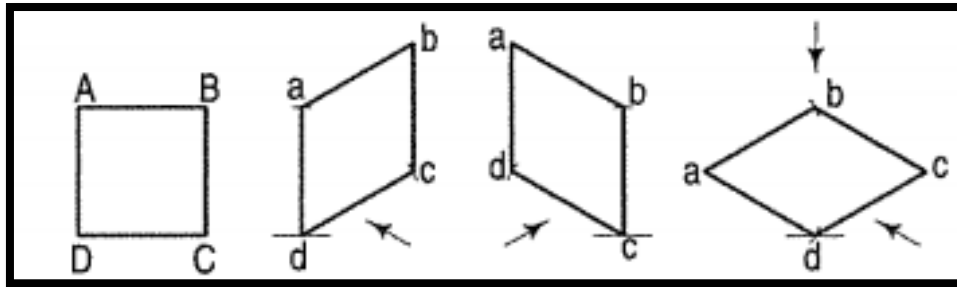
Figure1   **Figure2**   **Figure3**   **Figure 4**

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/dimalign
6. Copy

Procedure:
1. As the front view is a square, the surface of the square is vertical. In isometric view, vertical lines will be drawn vertical, while horizontal lines will be drawn inclined at 30° to the horizontal.
2. Through any point d, draw a vertical line da = DA [fig.(ii)].
3. Again through d, draw a line de = DC inclined at 30° to the horizontal
4. and at 60° to da.
5. Complete the rhombus abed which is the required isometric view. Theview can also be drawn in direction of the other sloping axis as shown.

2. Draw the isometric view of a circle of a given diameter 50mm.
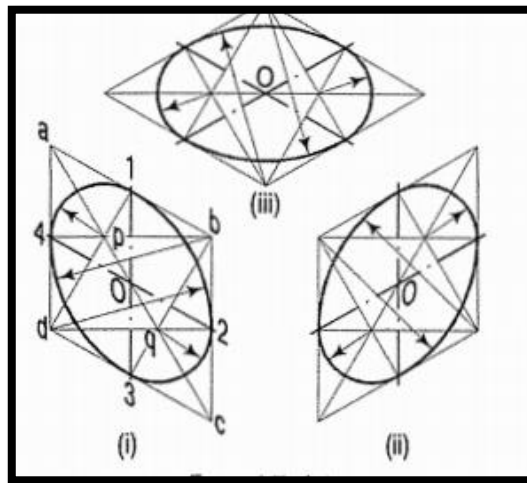
Figure5

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/dimalign
6. Copy
7. Circle
8. Spline
9. Polar array

Procedure:
1. Let O be the given point and D the diameter of the circle.
2. When the surface of the circle is vertical [fig. (i)].
3. Through 0, draw a vertical centre line and another centre line inclined at 30° to the horizontal, i.e. parallel to a sloping isometric axis. On these lines, mark points 1, 2, 3 and 4 at a distance equal to 0.5D from 0.
4. Through these points, draw lines parallel to the centre lines and obtain the rhombus abed of sides equal to D.
5. Draw the required ellipse in this rhombus by the four-centre method. By drawing the second centre line parallel to the other sloping axis, the isometric view is obtained in another position

Date: _____

3. Draw the isometric view of a square prism, side of the base 20 mm long and the axis 40 mm long, when its axis is (i) vertical and (ii) horizontal.
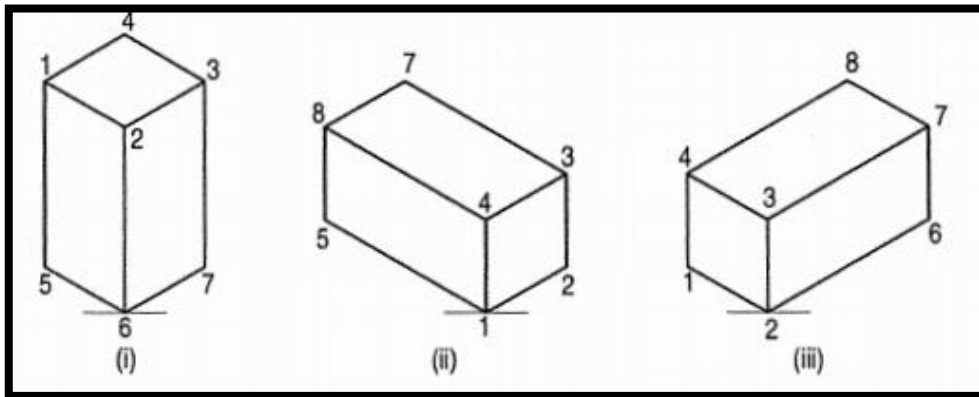
Figure6

Commands:
1. Units
2. Limits
3. Line
4. Dtext
5. Dimlin/dimalign
6. Copy

Procedure:
1. When the axis is vertical, the ends of the prism will be horizontal. Draw the isometric view (the rhombus 1-2-3-4) of the top end [fig.(i)].
2. Its sides will make 30°-angles with the horizontal.
3. The length of the prism will be drawn in the third direction, i.e. vertical. Hence, from the corners of the rhombus, draw vertical lines 1-5, 2-6 and 3-7 of length equal to the length of the axis. The line 4-8 should not be drawn, as that edge will not be visible.
4. Draw lines 5-6 and 6-7, thus completing the required isometric view. Lines 7-8 and 8-5 also should not be drawn. Beginning may also be made by drawing lines from the point 6 on the horizontal line and then proceeding upwards.
5. When the axis is horizontal, the ends will be vertical. The ends can be drawn in two ways as shown in fig. (ii) and fig. (iii).
6. In each case, the length is shown in the direction of the third isometric axis.

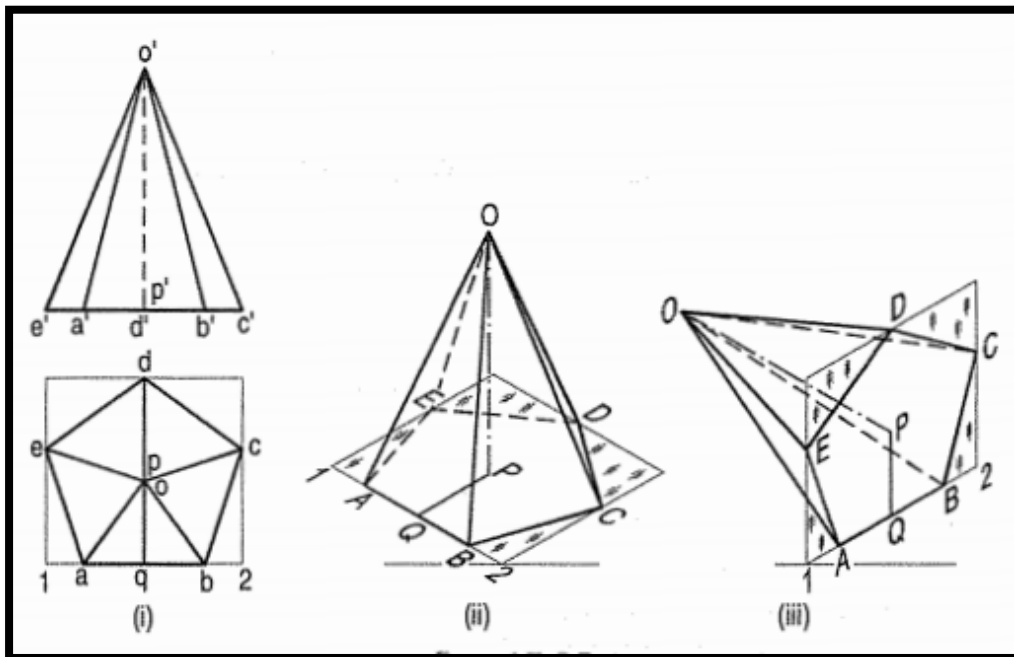4. Draw the isometric view of the pentagonal pyramid of base 30mmside and axis 50mm long.

Figure:7

Commands:
1. Units
2. Limits
3. Line
4. Polygon
5. Dtext
6. Dimlin/dimalign
7. Copy

Procedure:
1. Enclose the base (in the top view) in an oblong.
2. Draw an offset oq (i.e. pq) on the line ab.
3. Draw the isometric view of the oblong and locate the corners of the base in fig. (ii)
4. Mark a point Q on the line AB such that AQ = aq. From Q, draw a line QP equal to qo and parallel to 2C. At P, draw a vertical OP equal to o'p'.
5. Join O with the corners of the base, thus completing the isometric view of the pyramid.

Assignment:
1. Draw the three isometric view of a Pentagon of a given side 25mm.
2. Draw the three isometric view of a Hexagon of a given side 30mm.
3. Draw the three isometric view of a Rectangle of a given length 100mm &30mm.
4. Draw the isometric view of a cone, base 40 mm diameter and axis 55 mm long
   (i) when its axis is vertical and (ii) when its axis is horizontal.

SHEET NO:22
ISOMETRIC PROJECTION
(COMBINATION OF TWO OR THREE SOLIDS)

1. A cylindrical block of base, 60 mm diameter and height 80 mm, standing on the H.P. with its axis perpendicular to the H.P. Draw its isometric view.
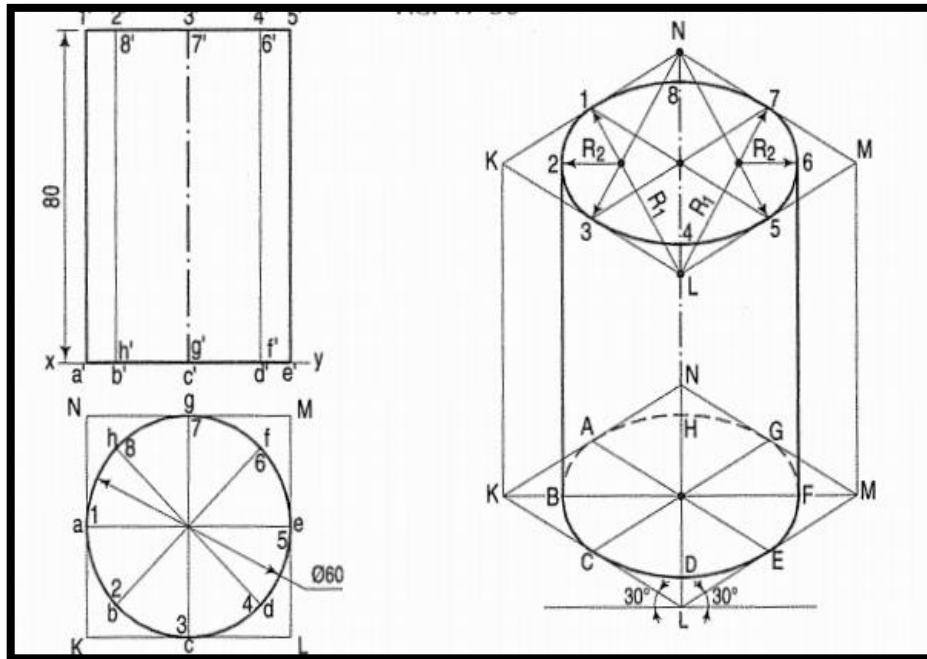

Figure1

Commands:
1. Units
2. Limits
3. Circle
4. Polar array
5. Line
6. Dtext
7. Copy
8. Extend

Procedure:
1. Let O be the given point and D the diameter of the circle.
2. When the surface of the circle is vertical [fig. (i)].
3. Through 0, draw a vertical centre line and another centre line inclined at 30° to the horizontal, i.e. parallel to a sloping isometric axis. On these lines, mark points 1, 2, 3 and 4 at a distance equal to 0.5D from 0.
4. Through these points, draw lines parallel to the centre lines and obtain the rhombus abed of sides equal to D.
5. Draw the required ellipse in this rhombus by the four-centre method. By drawing the second centre line parallel to the other sloping axis, the isometric view is obtained in another position
6. Draw the lines from the ends of the ellipse and repeat the same Procedure to draw top ellipse

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SHEET NO:23
CONVERSION OF ISOMETRIC VIEWS TO ORTHOGRAPHIC VIEWS

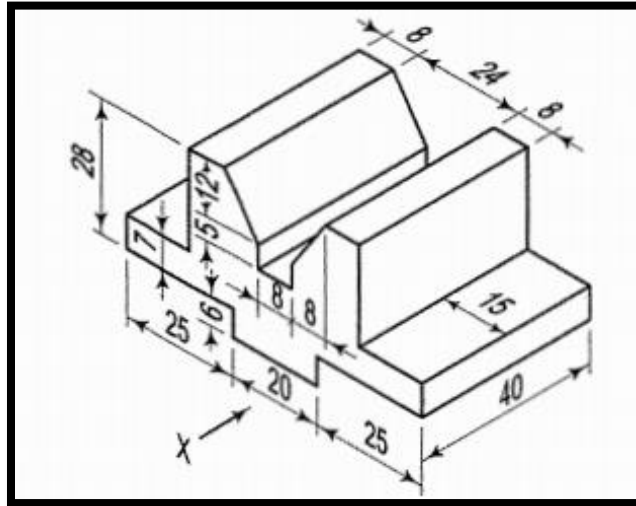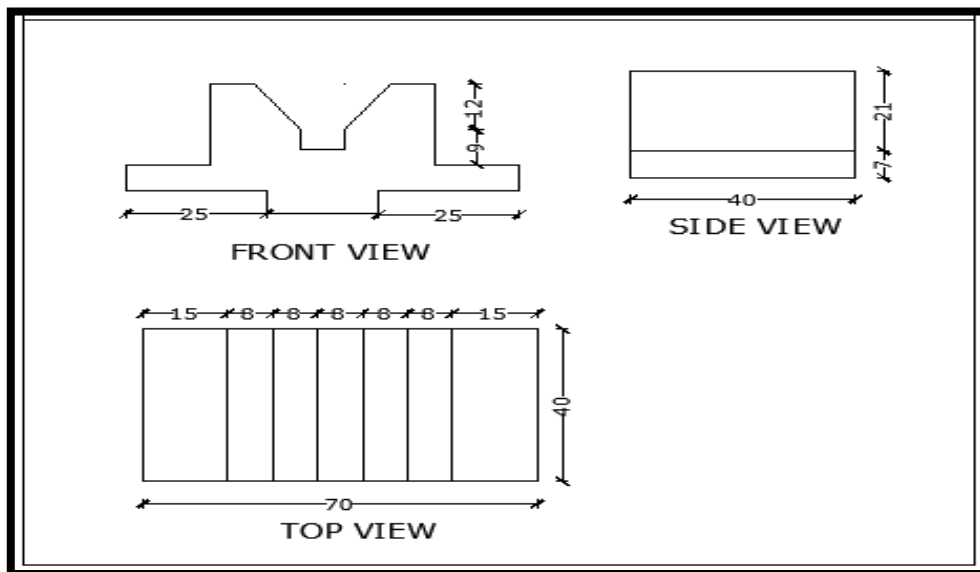1. Draw the i) Front View ii) Side View iii) Top View of the given diagram

Figure1

Commands:
1. Units
2. Limits
3. Line
4. Offset
5. Copy
6. Erase
7. Dimlin

Procedure:

Figure2

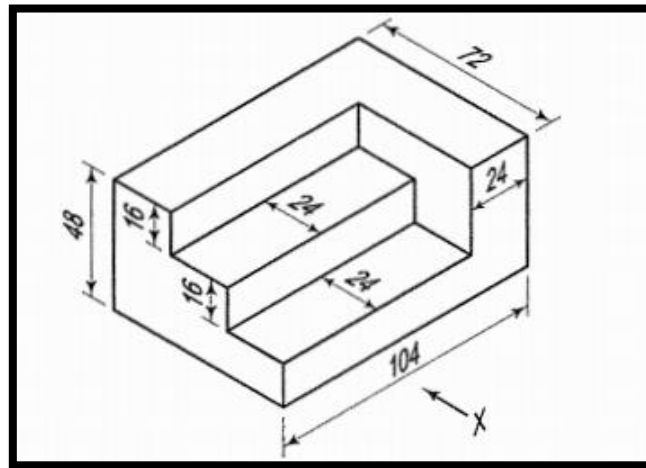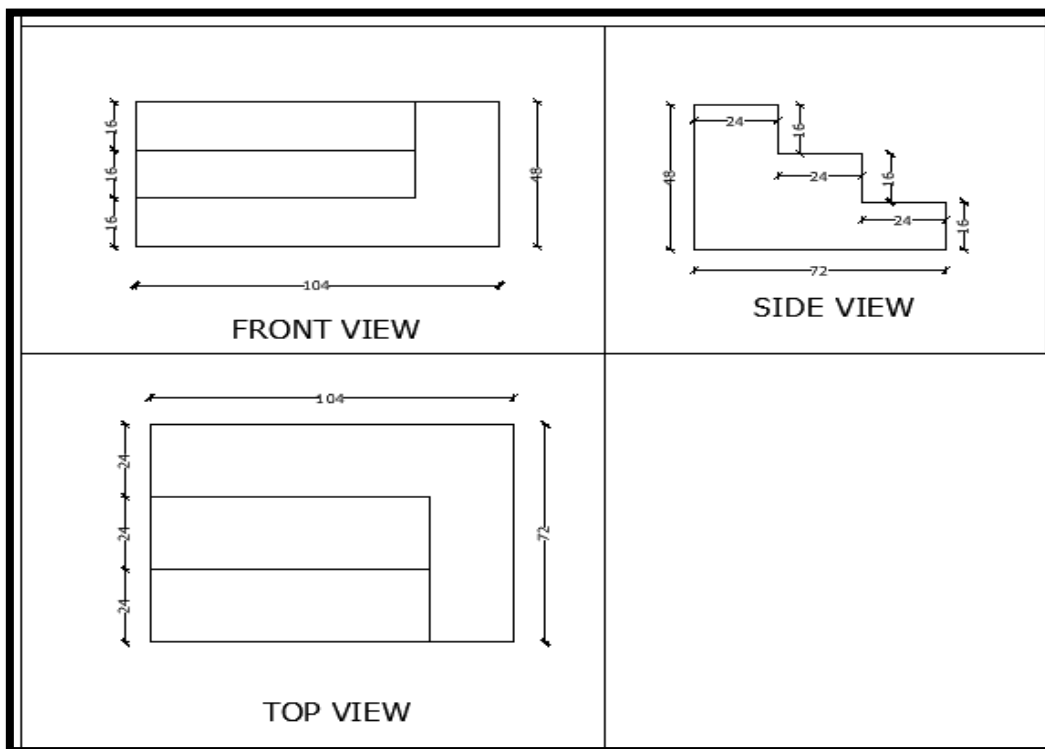2. Draw the i) Front View ii) Side View iii) Top View of the given diagram

Figure3

Commands:
1. Units
2. Limits
3. Line
4. Offset
5. Copy
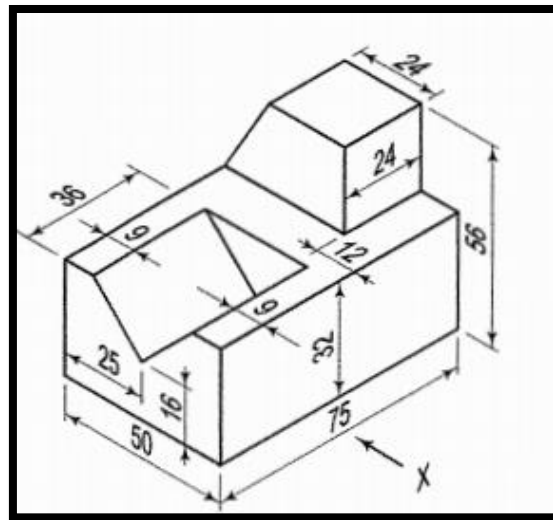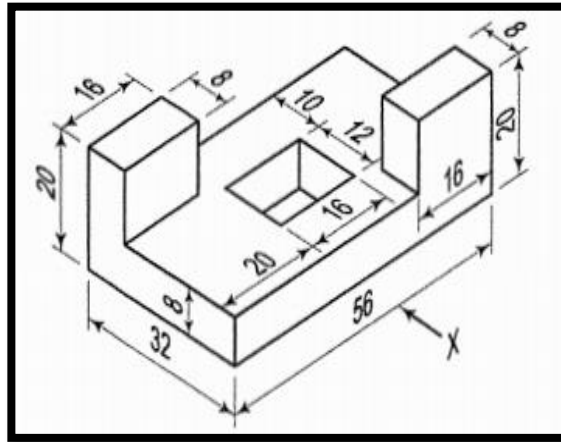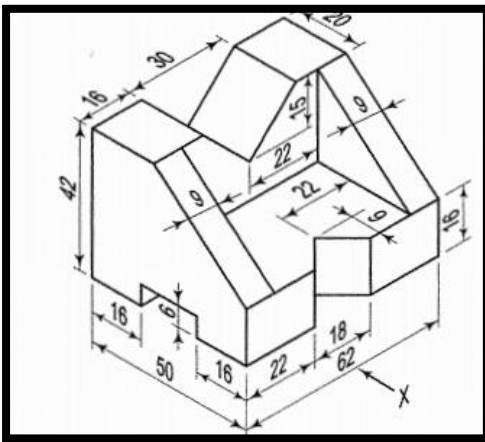6. Erase
7. Dimlin

Procedure:

Figure4

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Assignment:
1.Draw the i) Front View ii) Side View iii) Top View of the given below diagrams

VIVA QUESTIONS
1. What is the difference between isometric view and isometric projection?
2. What are the advantages of isometric projections?
3. How will you draw isometric projection of sphere?
4. Define Isometric projection?
5. What are the advantages of isometric drawing over isometric projections?
6. How will you draw orthographic projections of a regular tetrahedron?
7. What do you mean by isometric axes?
8. What do you mean by isometric planes?

Date: _____

SHEET NO:24

FLOOR PLAN (Optional)

1. Draw the given 2 BHK floor plan of Area 1225 sqft. by using AutoCAD Software.

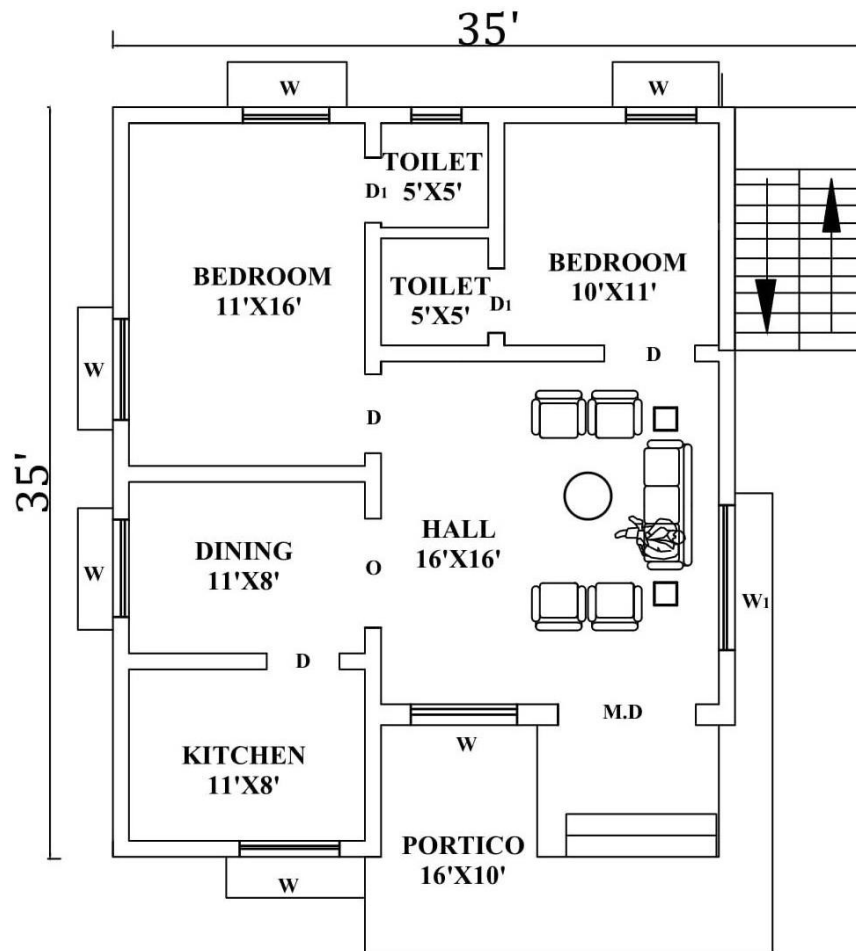**Fig1**

METHODIST

COLLEGE OF ENGINEERING

Estd: 2008

METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

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