DEBREMARKOS UNIVERSTY

INSTITUTE OF TECHNOLOGY

MECHANICAL AND INDUSTRIAL ENGINEERING

MEng 1032

INTRODUCTION TO ENGINEERING DRAWING

MATERIAL FOR PRE ENGINEERING STUDENTS

PREPARED BY : *CHEKOL YRDIE*

DEBREMARKOS

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(MEng 1032)

ADVANCED MATERIAL FOR PRE ENGINEERING STUDENTS

Prepared by:

CHEKOL YRDIE

MECHANICAL ENGINEERING STUDENT

"being an engineer is being proud, specialy being a mechanical engineer is being blessed"

DEBRE MARKOS UNIVERSITY

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Preface

Debre markos University is a university that is dedicate to be a world classical institution in a short period of time up to 2030. To realize this, capacitating the department facilities to the most is important. As a young university Debre markos University suffers from readymade learning materials for students.

Here I have done my efforts to contribute for the very success of our university. This material is aimed to give a clue for the students what to learn and how to learn course syllabus in Introduction to Engineering Drawing. This helps the students to earn the basic knowledge of introduction to engineering drawing.

This course is delivered as introduction to Engineering drawing where students are expected to have a background on different types of projection techniques, able to sketch multi-view drawings of any given pictorial drawings, sketch pictorial drawings of objects from given multi view drawings, and section drawing parts convert to pictorial section drawing.

Generally, since this is a first work I expect a lot of improvements to undergo in future. Hence, I kindly request and encourage you to forward all your comments and suggestions you wish to be included in this material.

This material has a collection of different objects. Exercises, Worksheets and prepared examinations are included at the end of chapters. You can find the pdf file of this material from the author.

The main aim for preparing this material, when the students enter to pre engineering and learn this course at that time by seeing this type of drawing they afraid the department of mechanical and industrial engineering, but they want to enter this stream, so to remove this type of acceptance I prepare type of easy and short material.

Chekol Yrdie

Chekolyrdie03@gmail.com

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INTRODUCTION

After finishing this chapter students be able

- Know the historical background and definition of engineering drawing.
- Understand the definition and advantages.
- Able to draw and criteria of title block.
- Know the lettering technique and drawing instruments.

Definitions:

Engineering drawing, most commonly referred to as engineering graphics, is the art of manipulation of designs of a variety of components, especially those related to engineering. It primarily consists of sketching the actual component, for example, a machine, with its exact dimensions, and using entities such as points, lines, arcs, etcetera. The scale of dimensions is suitably adjusted so as to properly fit within the contours of the drawing sheet.

In some cases, depending on the discipline, there are areas of particular focus, such as in the case of Structural Engineering. Another consideration is in regards to the units of measure used; these could be not only Metric or Imperial but also the way these are noted is relevant because it will also reflect the precision of a dimension.

Hence, engineering drawing plays a vital role both in manufacture and design, as it not only explains the string of arrangement in a machine, but also tells us about the method to be employed to manufacture the individual blocks.

An engineering drawing not only helps convey ideas and convert concepts into reality, an engineering drawing follows criteria and conventions to eliminate confusion by the standardization of nomenclature and practices, as a way to clearly relay the information to the individual who understands it when it is read, and very importantly.

Generally Drawing is:

- ✓ A graphic representation of a real thing, an idea, or a proposed design for later manufacture orconstruction.
- ✓ A graphic that represents an idea, a concept, or an entity which actually or potentially exists inlife.
- ✓ A way of communicating all necessary information about an abstraction such as an idea or aconcept.

1.1 History of Drawing

Technical drawing has existed since ancient times. Complex technical drawings were made in renaissance times, such as the drawings of Leonardo da Vinci. Modern engineering drawing, with its precise conventions of orthographic projection and scale, arose in France at a time when the Industrial Revolution was in its infancy. L. T. C. Rolt's biography of Isambard Kingdom Brunel says of his father, Marc Isambard Brunel, that "It seems fairly certain that Marc's drawings of his block-making machinery (in 1799) made a contribution to British engineering technique much greater than the machines they represented. For it is safe to assume that he had mastered the art of presenting three-dimensional objects in a two-dimensional plane which we now call mechanical drawing. It had been evolved by Gaspard Monge of Mezieres in 1765 but had remained a military secret until 1794 and was therefore unknown in England."

Standardization and disambiguation

Engineering drawings specify requirements of a component or assembly which can be complicated. Standards provide rules for their specification and interpretation. Standardization also aids internationalization, because people from different countries who speak different languages can read the same engineering drawing, and interpret it the same way.

One major set of engineering drawing standards is ASME Y14.5 and Y14.5M (most recently revised in 2009). These apply widely in the United States, although ISO 8015 (Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules) is now also important. In 2018, ASME AED-1 was created to develop advanced practices unique to aerospace and other industries and supplement to Y14.5 Standards.

In 2011, a new revision of ISO 8015 (Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules) was published containing the Invocation Principle. This states that, "Once a portion of the ISO geometric product specification (GPS) system is invoked in a mechanical engineering product documentation, the entire ISO GPS system is invoked." It also goes on to state that marking a drawing "Tolerancing ISO 8015" is optional. The implication of this is that any drawing using ISO symbols can only be interpreted to ISO GPS rules. The only way not to invoke the ISO GPS system is to invoke a national or other standard. Britain, BS 8888 (Technical Product Specification) has undergone important updates in the 2010s.

Common features

Drawings convey the following critical information:

- *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.
- *Dimensions* – the size of the object is captured in accepted units.
- *Tolerances* – the allowable variations for each dimension.
- *Material* – represents what the item is made of.

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.

Purpose of engineering drawing:

To appreciate the need for technical drawings, one must understand the design process, which ranges from identification of the problem or need up to development of working drawings.

We can generally conclude purpose of engineering drawing as:

- ✓ to clarify problem or need
- ✓ to document the various ideas and concepts formed
- ✓ to document the proposed solution

We can divide drawing into two basic types. These are:

- Artistic drawing
  - Range in scope from the simplest line drawing to the most famous paintings. It depends on painting skill rather than the technical skill. On the other hand it reflects the individuals work.
  - Used to express aesthetic, philosophic, feelings, beliefs, or other abstract ideas. So that it is necessary to understand the artists' idea in order to read the drawing.
- Technical drawing
  - It is a means of clearly and concisely communicating all of the information necessary to transform an idea or concept into reality.
  - It is not an abstract or subtle. It does need an understanding of its creator. It is a universal communication means for the professionals.
  - Nevertheless of its graphical representation it conveys notes, dimensions, and specifications (material).

Drawing instruments:

The preparation of technical drawing is possible only through knowledge and skill in the use of a variety instruments. With the aid of knowledge and skill practice will bring perfection!

The following listed drawing instruments are the basic ones:

- Pencils: conventional wood pencil, or lead holder(mechanical pencil)
- Papers and drafting media(A4, A3,A0, tracing paper, polyster film, tracing cloth, …….)
- Drafting machines like T-square, drawing board or binder, ruler, set squares, compasses,protractors, French curves, templates, eraser, dividers, … etc

Drawing paper:

For this course, we use 210mm X 297mm sized paper or A4 for the assignments or class works. We havethe following elements to be noticed over the format of our drawing paper:

Border line: it is the peripheral heaviest lines which enclose all drawings.

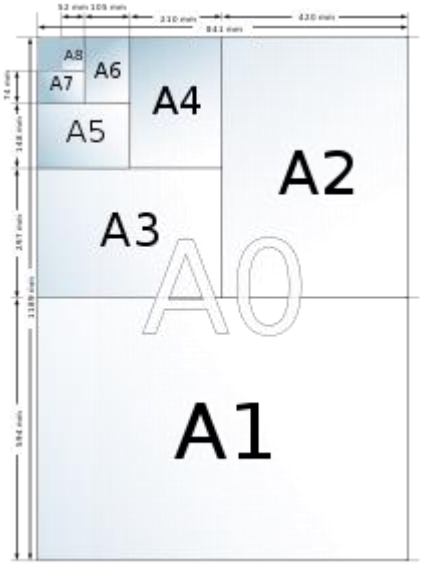
Title Block: It is a box where all information about the drawing such as drawn by, checked by, date,scale, title of drawing, drawing number and company name are specified.

Guide line: is the lightest line used to guide the height of alphabets.

In general there are different types of papers on their sizes and thickness

- They are available in variety of size.
- Standard sheet size (JIS) in mm.
  - A4
    210 x 297
  - A3
    297 x 420

- A2
  420 x 594
- A1
  594 x 841
- A0
  841 x 1189 ..... all are in mm units

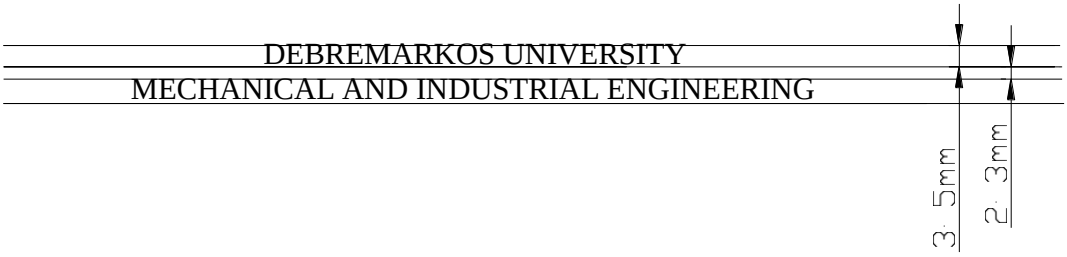


Iso paper size

Lettering technique:

Most of the time it is recommended to use 3mm height of letters to write in the title block except titleof the drawing which is slightly larger than the others, 5mm. Between lines of sentences we use a gap of about 3/5th of the height of letters. All words in title blocks should be written in upper case letters.

Technical lettering is the process of forming letters, numerals, and other characters in technical drawing. It is used to describe, or provide detailed specifications for an object. With the goals of legibility and uniformity, styles are standardized and lettering ability has little relationship to normal writing ability. Engineering drawings use a Gothic sans-serif script, formed by a series of short strokes. Lower case letters are rare in most drawings of machines. ISO Lettering templates, designed for use with technical pens and pencils, and to suit ISO paper sizes, produce lettering characters to an international standard. The stroke thickness is related to the character height (for example, 2.5mm high characters would have a stroke thickness - pen nib size - of 0.25mm, 3.5 would use a 0.35mm pen and so forth). The ISO character set (font) has a seriffed one, a barred seven, an open four, six, and nine, and a round topped three, that improves legibility when, for example, an A0 drawing has been reduced to A1 or even A3 (and perhaps enlarged back or reproduced/faxed/ microfilmed &c). When CAD drawings became more popular, especially using US American software, such as AutoCAD, the nearest font to this ISO standard font was Romantic Simplex (RomanS) - a proprietary shx font) with a manually adjusted width factor (over ride) to make it look as near to the ISO lettering for the drawing board. However, with the closed four, and arced six and nine, romans.shx typeface could be difficult to read in reductions. In more recent revisions of software packages, the TrueType font ISOCPEUR reliably reproduces the original drawing board lettering stencil style, however, many drawings have switched to the ubiquitous Arial.ttf.



Conventional parts (areas)

Title block

Every engineering drawing must have a title block.

The title block (T/B, TB) is an area of the drawing that conveys header-type information about the drawing, such as:

- Drawing title (hence the name "title block")
- Drawing number
- Part number(s)
- Name of the design activity (corporation, government agency, etc.)
- Identifying code of the design activity (such as a CAGE code)
- Address of the design activity (such as city, state/province, country)
- Measurement units of the drawing (for example, inches, millimeters)
- Default tolerances for dimension callouts where no tolerance is specified
- Boilerplate callouts of general specs
- Intellectual property rights warning

ISO 7200 specifies the data fields used in title blocks. It standardizes eight mandatory data fields:

- Title (hence the name "title block")
- Created by (name of draughtsman)
- Approved by
- Legal owner (name of company or organization)
- Document type
- Drawing number (same for every sheet of this document, unique for each technical document of the organization)
- Sheet number and number of sheets (for example, "Sheet 5/7")
- Date of issue (when the drawing was made)

Traditional locations for the title block are the bottom right (most commonly) or the top right or center.

Revisions block

The revisions block (rev block) is a tabulated list of the revisions (versions) of the drawing, documenting the revision control.

Traditional locations for the revisions block are the top right (most commonly) or adjoining the title block in some way.

Next assembly

The next assembly block, often also referred to as "where used" or sometimes "effectivity block", is a list of higher assemblies where the product on the current drawing is used. This block is commonly found adjacent to the title block.

Notes list

The notes list provides notes to the user of the drawing, conveying any information that the callouts within the field of the drawing did not. It may include general notes, flag notes, or a mixture of both.

Traditional locations for the notes list are anywhere along the edges of the field of the drawing.

General notes

General notes (G/N, GN) apply generally to the contents of the drawing, as opposed to applying only to certain part numbers or certain surfaces or features.

Flag notes

Flag notes or flag notes (FL, F/N) are notes that apply only where a flagged callout points, such as to particular surfaces, features, or part numbers. Typically the callout includes a flag icon. Some companies call such notes "delta notes", and the note number is enclosed inside a triangular symbol (similar to capital letter delta, Δ). "FL5" (flag note 5) and "D5" (delta note 5) are typical ways to abbreviate in ASCII-only contexts.

Field of the drawing

The field of the drawing (F/D, FD) is the main body or main area of the drawing, excluding the title block, rev block, P/L and so on

List of materials, bill of materials, parts list

bill of materials

The list of materials (L/M, LM, LoM), bill of materials (B/M, BM, BoM), or parts list (P/L, PL) is a (usually tabular) list of the materials used to make a part, and/or the parts used to make an assembly. It may contain instructions for heat treatment, finishing, and other processes, for each part number. Sometimes such LoMs or PLs are separate documents from the drawing itself.

Traditional locations for the LoM/BoM are above the title block, or in a separate document.

Parameter tabulations

Some drawings call out dimensions with parameter names (that is, variables, such a "A", "B", "C"), then tabulate rows of parameter values for each part number.

Traditional locations for parameter tables, when such tables are used, are floating near the edges of the field of the drawing, either near the title block or elsewhere along the edges of the field.

Views and sections

Each view or section is a separate set of projections, occupying a contiguous portion of the field of the drawing. Usually views and sections are called out with cross-references to specific zones of the field.

Zones

Often a drawing is divided into zones by an alphanumeric grid, with zone labels along the margins, such as A, B, C, D up the sides and 1,2,3,4,5,6 along the top and bottom. Names of zones are thus, for example, A5, D2, or B1. This feature greatly eases discussion of, and reference to, particular areas of the drawing.

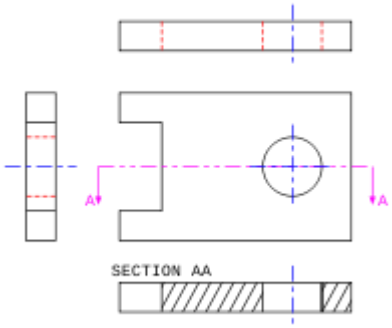
Abbreviations and symbols

As in many technical fields, a wide array of abbreviations and symbols have been developed in engineering drawing during the 20th and 21st centuries. For example, cold rolled steel is often abbreviated as CRS, and diameter is often abbreviated as DIA, D, or ⌀.

Most engineering drawings are language-independent—words are confined to the title block; symbols are used in place of words elsewhere.

With the advent of computer generated drawings for manufacturing and machining, many symbols have fallen out of common use. This poses a problem when attempting to interpret an older hand-drawn document that contains obscure elements that cannot be readily referenced in standard teaching text or control documents such as ASME and ANSI standards. For example, ASME Y14.5M 1994 excludes a few elements that convey critical information as contained in older US Navy drawings and aircraft manufacturing drawings of World War 2 vintage. Researching the intent and meaning of some symbols can prove difficult.

Example

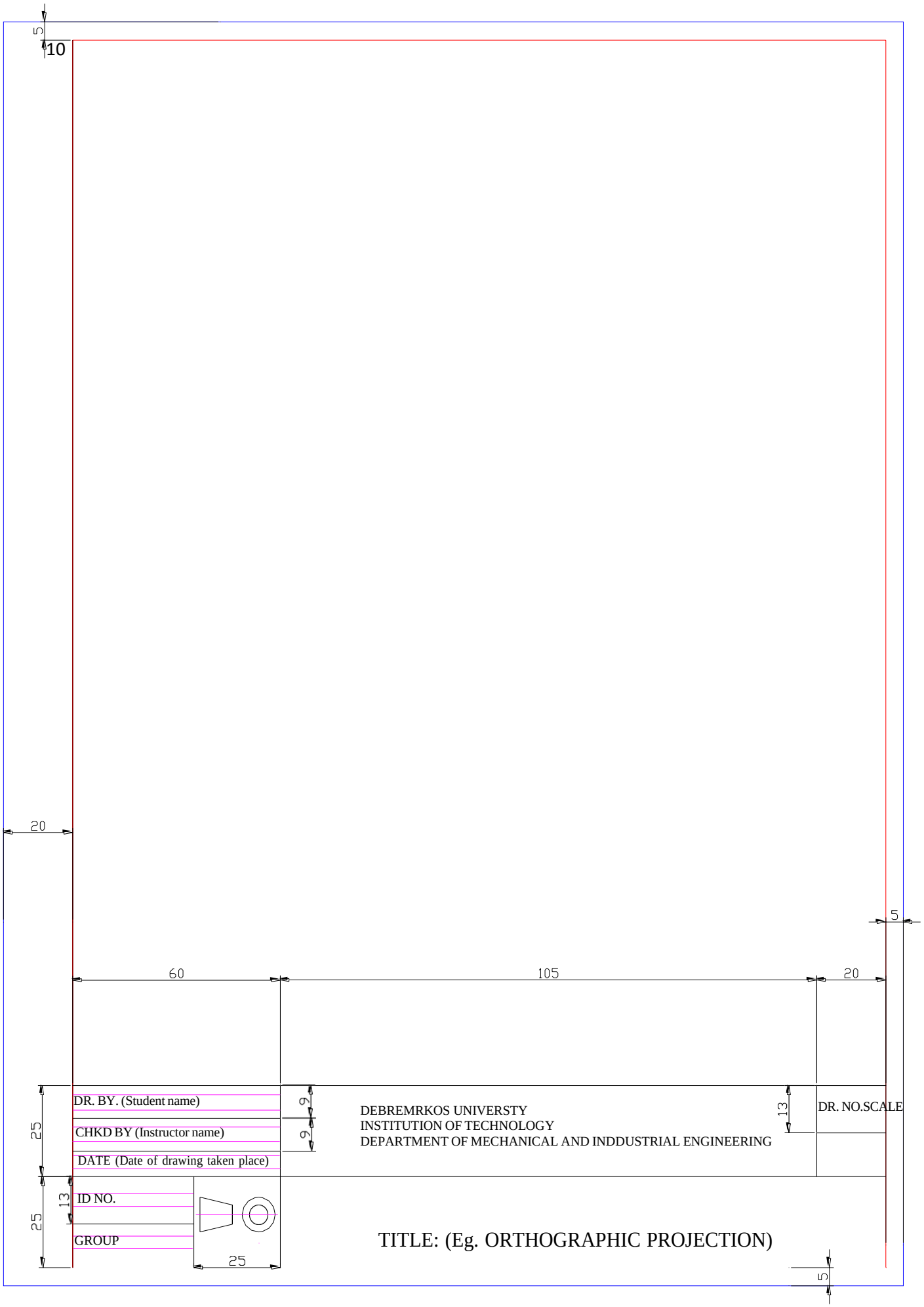


Example mechanical drawing

Here is an example of an engineering drawing (an isometric view of the same object is shown above). The different line types are colored for clarity.

- Black = object line and hatching
- Red = hidden line
- Blue = center line of piece or opening
- Magenta = phantom line or cutting plane line

Sectional views are indicated by the direction of arrows, as in the example right side.


5
10
20
5
60
105
20
25
DR. BY. (Student name)
CHKD BY (Instructor name)
DATE (Date of drawing taken place)
9
9
DEBREMRKOS UNIVERSTY
INSTITUTION OF TECHNOLOGY
DEPARTMENT OF MECHANICAL AND INDDUSTRIAL ENGINEERING
13
DR. NO.SCALE
25
13
ID NO.
GROUP
25
TITLE: (Eg. ORTHOGRAPHIC PROJECTION)
5

Line

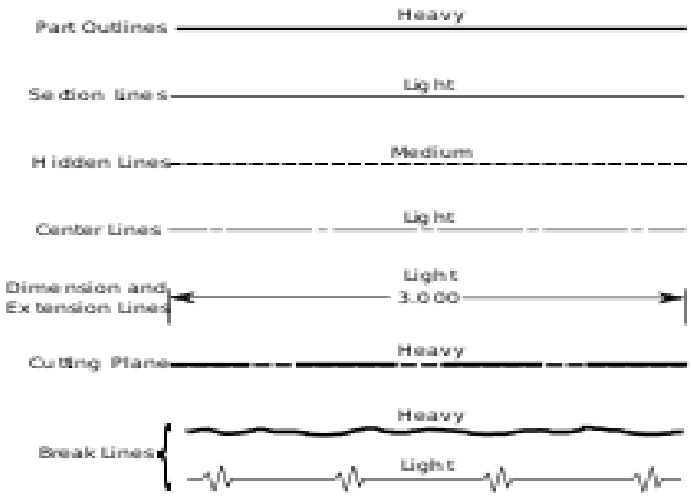
Line is the most basic design “tool”

Eg. ”” A line is a dot that went for a walk.”” – paul klee

In addition to the above there are different types of line that are used in technical drawing

- Visible line-dark and heavy line that have 0.6mm width and show the outline shape of an object
- Hidden line- show the outline of the feature that cannot be seen in a particular view
- Section line-the line drawn at 45 degree and indicate the material that has been cut through I a sectional view
- Center line- consist the line one long and one short lines to show center of holes ,slots ,paths of rotation etc …
- Dimension line-it is dark line having arrowheads to show the dimension of an object
- Extension line-a line used to show the starting and stopping points of a dimension
- Leader line-used to show the dimension feature or a note that is to large to be placed beside the feature itself
- Cutting plane line- shows where the part is mentally cut in half to better see the interior detail
- Break line- used to break out of sections for clarity or for shortening a part
  - Short break
  - Long break
  - Cylindrical break
- Phantom lines- thin line made up of long dashes alternating with pairs of short dashes

- Those different types of lines used in technical drawing briefly explained on chapter Three.



Conclusion

- *Drawing is the universal language of engineering.*
  - ***Communicating***
    - *Engineer to engineer / Engineer to non engineer / Non engineer to engineer*

THEORY OF PROJECTION

PROJECTION

Objectives of projection

- Knowing how to represent three-dimensional object by projecting all its points by straight lines, either parallel or converging to a picture plane.
- Knowing how to analyze the structure ,proportion and appearance of the object.

History of projection

Francis Jenkins and Thomas Armat developed a motion picture projection device which they called the Phantoscope. It was publicly demonstrated in Atlanta in September 1895 at the Cotton States Exposition. Soon after, the two parted ways, with each claiming sole credit for the invention.

All projection theory is **based on two variables: line of sight (projecting lines) and plane of projection**. A line of sight (LOS) is an imaginary line between an observer's eye and an object. A plane of projection (i.e., an image or picture plane) is an imaginary flat plane upon which the image is projected.

Generally projection is

- A projection is a drawing or representation of an entity on an imaginary plane or planes.It consist four components:
  - The actual object that the drawing or projection represents
  - The eye of the viewer looking at the object
  - The imaginary projection plane (Viewers drawing paper)
  - Imaginary lines of sight called projectors

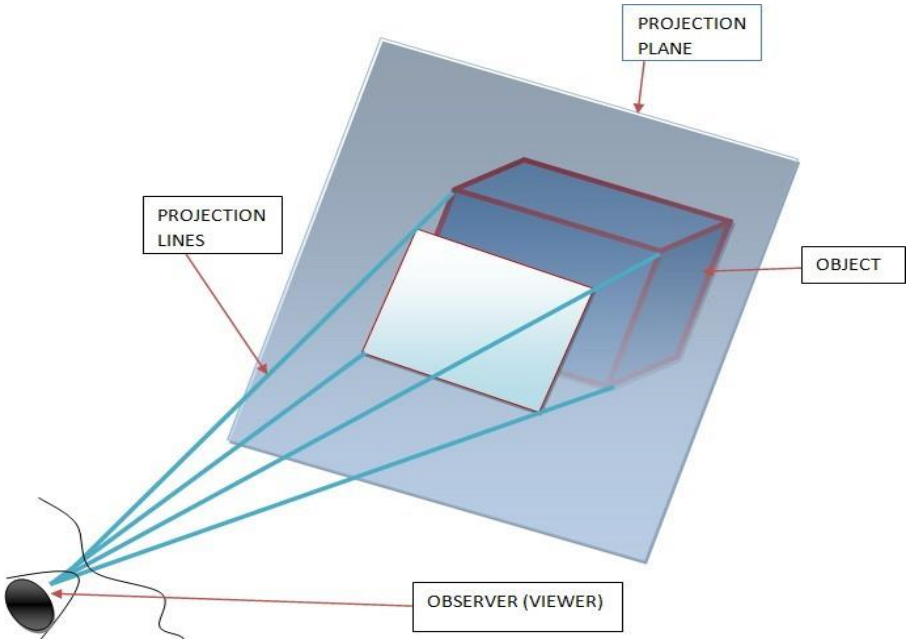


Fig.1 projection of a box

2.1 Classification of projections

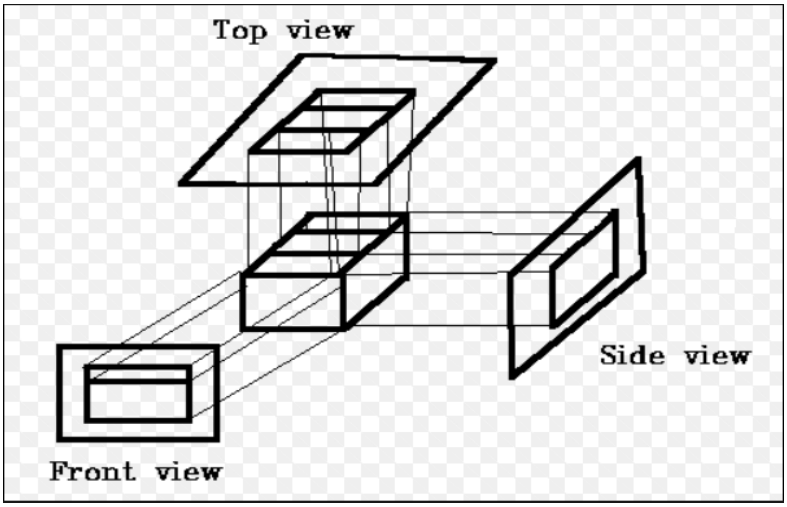
Two broad projection types are viable with different further classifications. These are:

1. Parallel projection
2. Perspective projection

Parallel projection:

It is a projection where imaginary projection lines will not converge as a point on the viewer's eye. Thisimplies that, all projection lines are either parallel or perpendicular to each other.

Parallel projection is orthographic if the plane of projection is placed between the observer and the object, and the plane is perpendicular to the parallel lines of sight. You can use parallel projection technique to create both multiview and pictorial (isometric and oblique) views.



There are ***three*** main types of parallel projection system elucidated below:

Orthographic projection

In this method the object is placed in space in such a way that the front view of it is captured in the vertical plane, and the top view of the same, is captured in the horizontal plane. The projections of the object are perpendicular with the planar screen, and hence, the name 'orthographic'.

or

- ✓ Is a system of views of an object formed by projectors from the object perpendicular to thedesired planes of projection.
- ✓ Here we have three principal projection planes. That is to say:
  - Horizontal projection plane (H)
  - Frontal projection plane (F)
  - Profile projection plane (P)

Principles of orthographic drawing

The following principles should be understood before drawing orthographic projections:

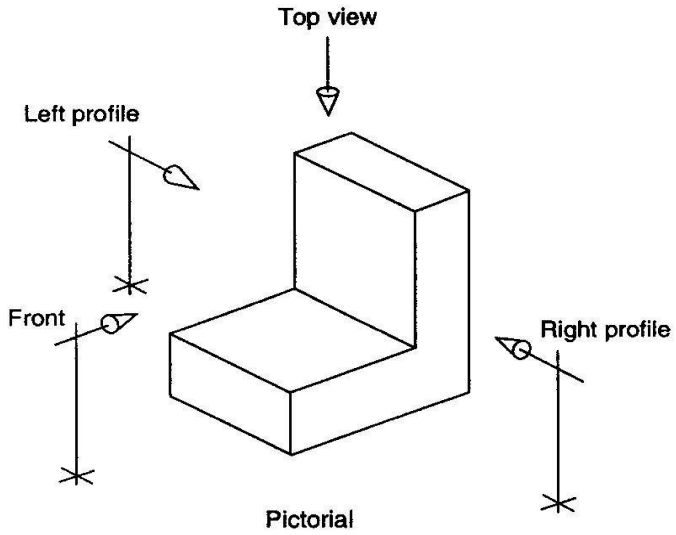
a. The top view (**plan**) and front view (elevation) are always in line vertically.
b. The front view (elevation) and side view (end elevation) are always in line horizontally.
c. The length of the top view is always the same as the length of the front view.
d. The breadth of the top view is always the same as the breadth of the side view.
e. The height of the side view is always the same as the height of the front view.
f. If a line is parallel to a plane of projection, then it will show its true length on that plane.
g. If a line is perpendicular to the plane of projection, then it will represent a shorter length than the true length on the plane of projection.
h. If a surface is parallel to a plane, then its projection on that plane will show its true shape and size.
i. If a surface is inclined to a plane, then the projection on that plane will be foreshortened.
j. If a surface is perpendicular to a plane, then its projection on that plane will be a line simply.

The following steps take you through the creation of an orthographic projection.

1. Choose a front view. This is the view that shows the most about the object.
2. Decide how many views are needed to completely describe the object. If you are unable to determine which views will be needed, draw the standard views (front, top and right side).
3. Draw the visible features of the front view.
4. Draw projectors off of the front view horizontally and vertically in order to create the boundaries for the top and right side views.
5. Draw the top view. Use the vertical projectors to fill in the visible and hidden features.
6. Project from the top view back to the front view. Use the vertical projectors to fill in any missing visible or hidden features in the front view.
7. Draw a 45° projector off of the upper right corner of the box that encloses the front view.
8. From the top view, draw projectors over to the 45° line and down in order to create the boundaries of the right side view.
9. Draw the right side view.
10. Project back to the top and front view from the right side view as needed.

11. Draw center lines while necessary.

For example:



For the above object we can have orthographic projection as follow:

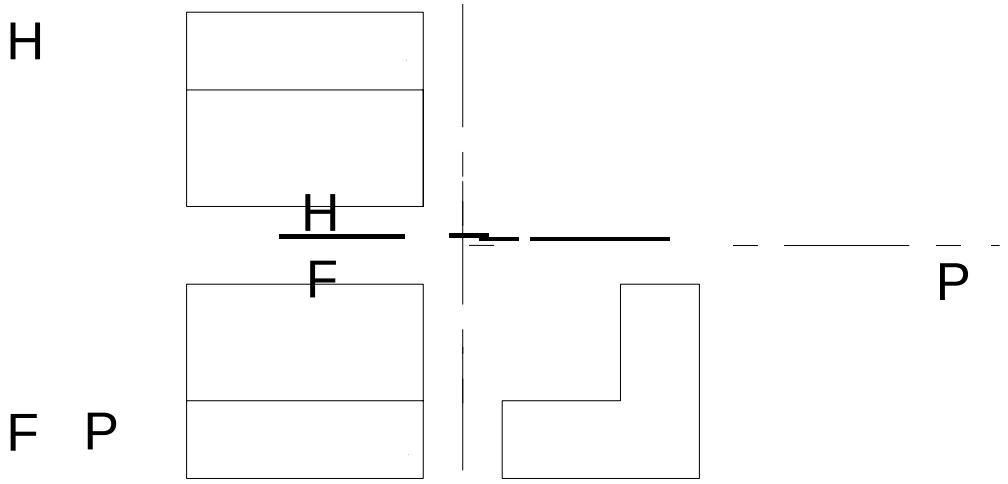


Fig. 2 Orthographic projection (Multi-view drawing)

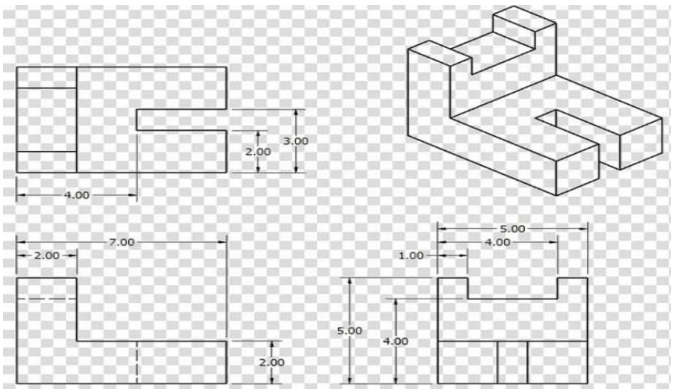


Figure of easy orthographic projection example

Oblique projections:

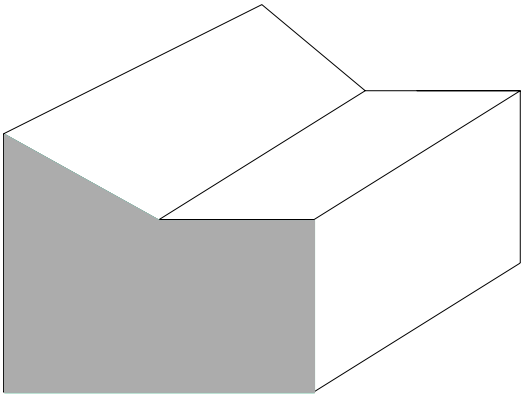
An oblique projection is a simple type of graphical projection used for producing pictorial, two-dimensional images of three-dimensional objects:

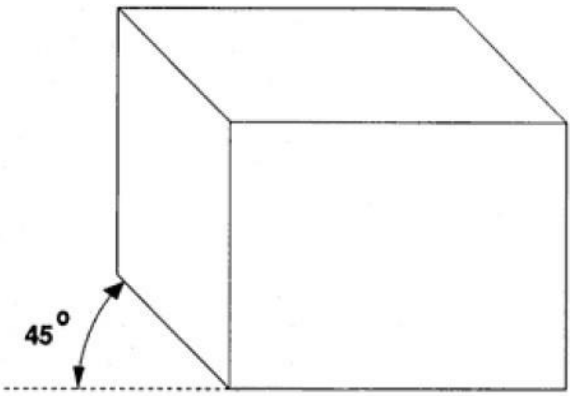
- t projects an image by intersecting parallel rays (projectors)
- rom the three-dimensional source object with the drawing surface (projection plan).

In both oblique projection and orthographic projection, parallel lines of the source object produce parallel lines in the projected image.

- ✓ If the observer is considered to be stationed at an infinite distance from the object, and looking toward the object so that the projectors are parallel to each other and oblique to the projection, the resulting drawing is an oblique projection.

We have two types of representations of an object. Viz. Cabinet (Half scale) and Cavalier (Full scale).





From the above object, you easily understand that the shaded face projection lines are 90°. Whereas therest are non 90°.

Here we conclude that, oblique projections show the full size of one view and are of two varieties. The larger angle between the projectors and the plane – the closer the oblique projection approaches the orthographic projection.

Axonometric projection:

Axonometric projections show an image of an object as viewed from a skew direction in order to reveal all three directions (axes) of space in one picture. Axonometric projections may be either *orthographic* or *oblique*. Axonometric instrument drawings are often used to approximate graphical perspective projections, but there is attendant distortion in the approximation. Because pictorial projections innately contain this distortion, in instrument drawings of pictorials great liberties may then be taken for economy of effort and best effect

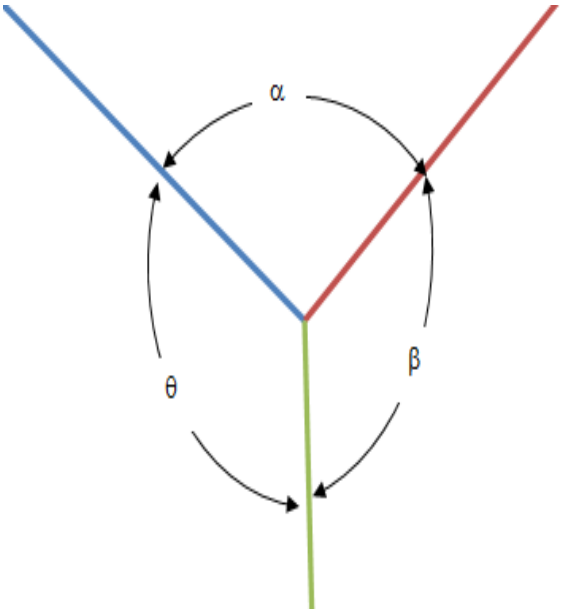
- ✓ Is a presentation of a design idea that is accurate and scientifically correct and can be easily understood by persons without technical training.
- ✓ Is a three dimensional drawing which is named alternatively as Pictorial drawing.

Depending on the angles found between the principal projection planes, we can sub divide axonometric projections into: isometric, dimetric and trimetric projection.

isometric projection, the most commonly used form of axonometric projection in engineering drawing, the direction of viewing is such that the three axes of space appear equally foreshortened, and there is a common angle of 120° between them. As the distortion caused by foreshortening is uniform, the proportionality between lengths is preserved, and the axes share a common scale; this eases one's ability to take measurements directly from the drawing. Another advantage is that 120° angles are easily constructed using only a compass and straightedge.

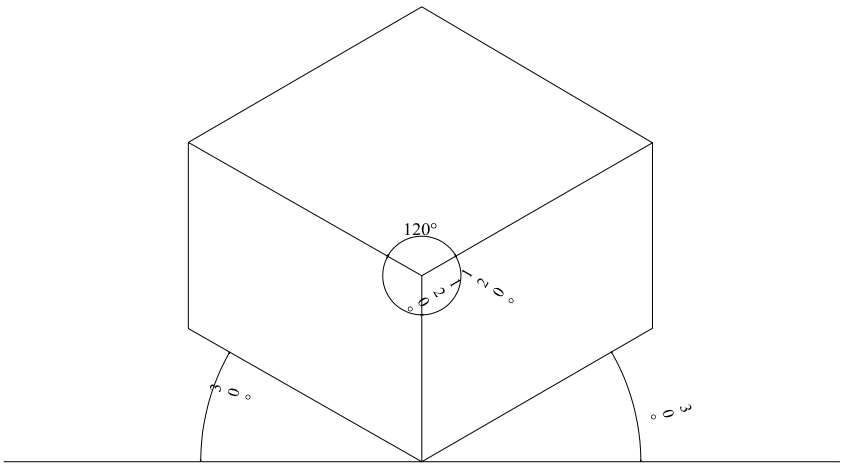
dimetric projection, the direction of viewing is such that two of the three axes of space appear equally foreshortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction is determined separately. Dimensional approximations are common in dimetric drawings

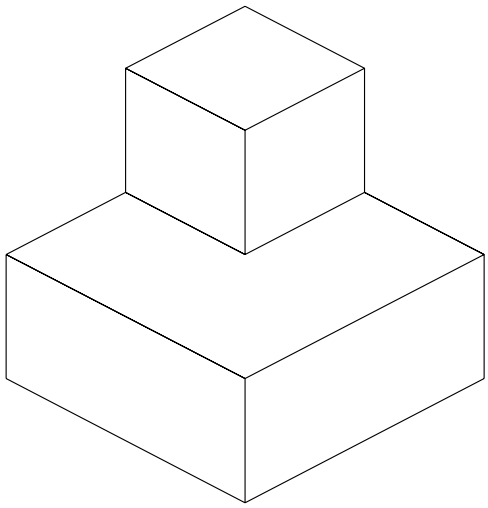
trimetric projection, the direction of viewing is such that all of the three axes of space appear unequally foreshortened. The scale along each of the three axes and the angles among them are determined separately as dictated by the angle of viewing. Dimensional approximations in trimetric drawings are common and trimetric perspective is seldom used in technical drawings.



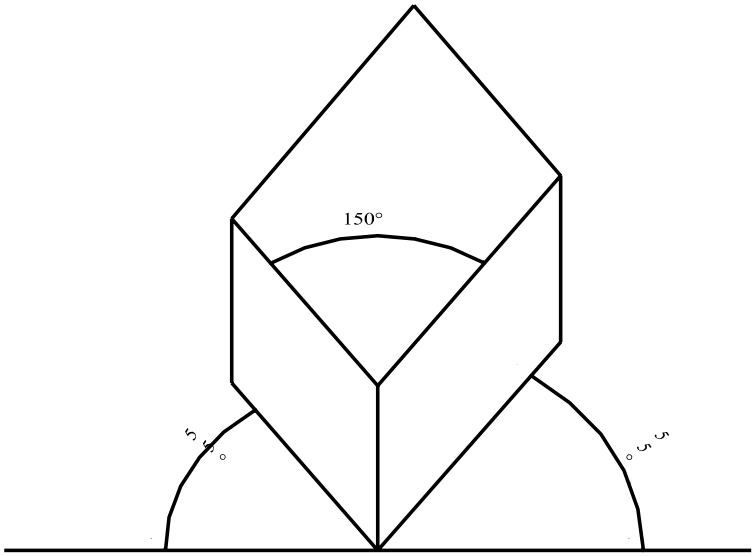
- If $\alpha = \beta = \theta$ it is an isometric axonometric
- projectionIf $\alpha \neq \beta = \theta$ it is dimetric axonometric projection
- If $\alpha \neq \beta \neq \theta$ it is trimetric axonometric projection

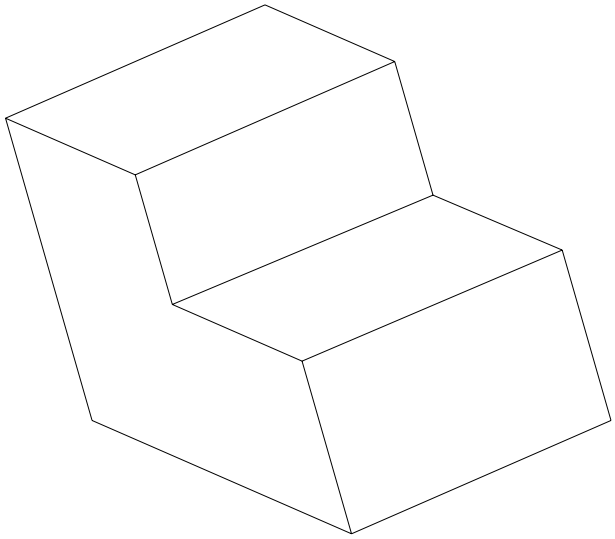
Example 1: Isometric axonometric projection



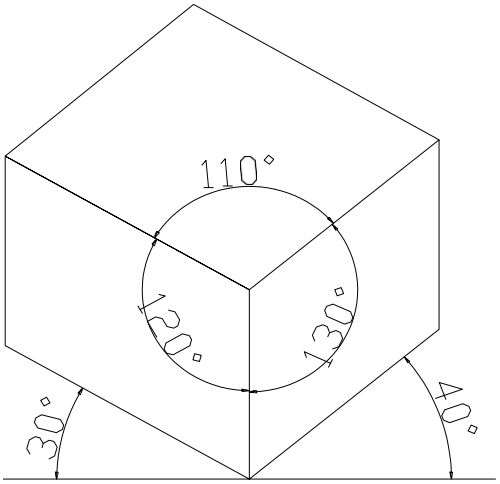


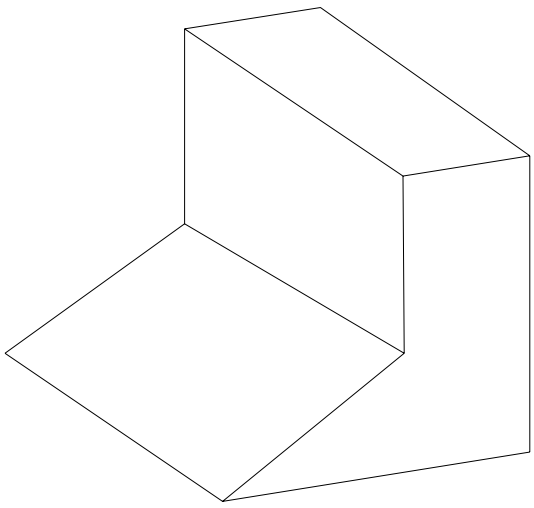
Example 2: Diametric axonometric projection





Example 3: Trimetric axonometric projection





Perspective projections: *(Central projection)*

Perspective projections are projections whose receding lines converge to ***vanishing point***. Vanishing point is where projectors converge to a point.

- ➲ Perspective sketches are visually accurate in that they look like what we see: objects fartheraway appear smaller than those that are closer.

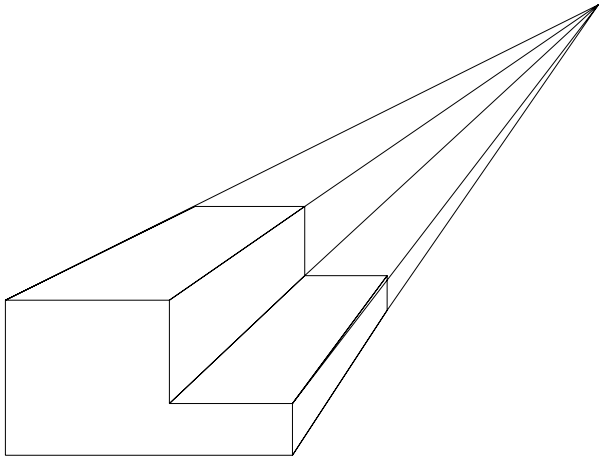
The receding lines of perspective drawings converge to vanishing points that are located on a theoreticalhorizon. The horizon is always located at eye level. Objects above the horizon line are appear to be above, and objects below the horizon appear to be below.

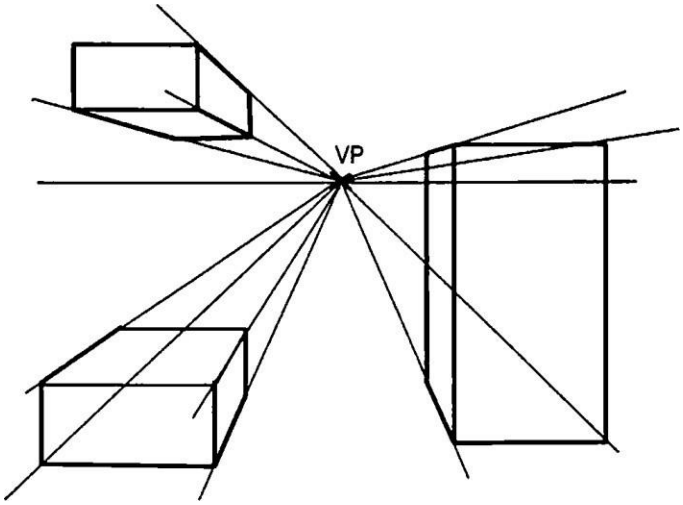
Perspective drawings are often referred to as pictorial drawing. Circles appear as irregular shape instead of elliptical feature.

- ➲ Ordinary photograph we take by photo camera is a typical example of perspective projections.

One point perspective projection:

When drawing using one point perspective all objects vanish to a common point somewhere on thehorizon. Examples:

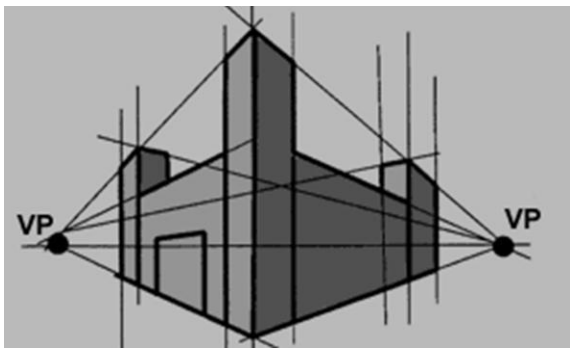


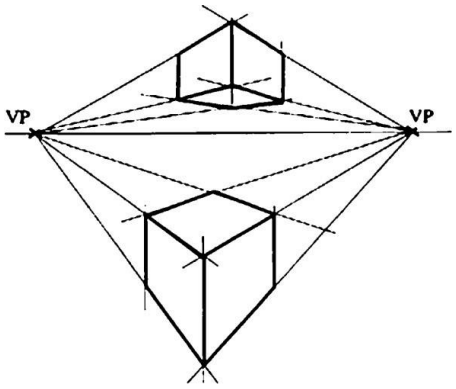


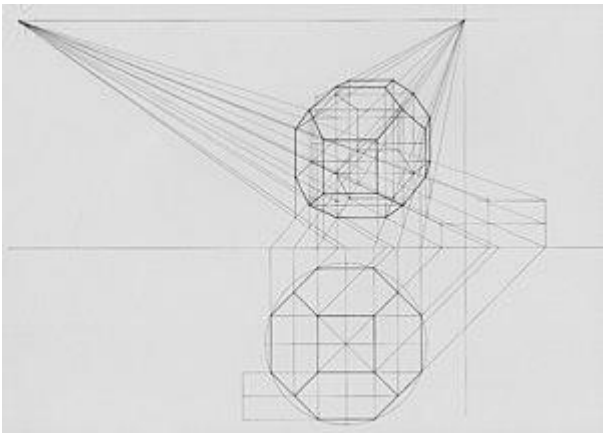
Note: all projectors none parallel to each other

Two Point perspective projection:

The object is placed so that one set of parallel edges is vertical and has no vanishing point, while the two other sets each havevanishing points.



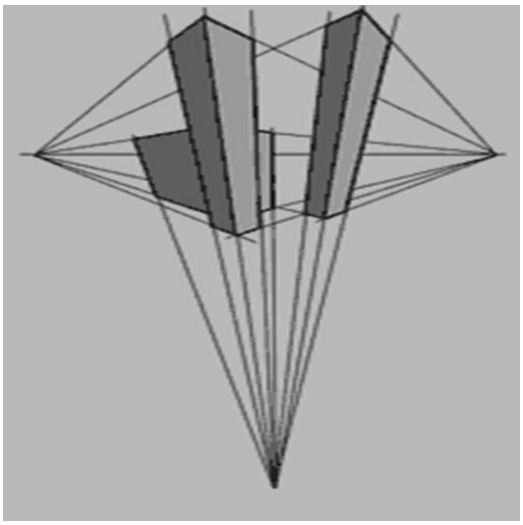




Three point perspective projection:

The object is placed so that none of its principal edges is parallel to the picture plane. Hence, each of the three sets of principal edges will have a *separate vanishing point.*

Example:



Notice:

The detail explanation will be given in the next chapters. Don't panic things will come smooth! Keep up!!

MULTIVIEW DRAWING

After finishing this unit, students be able to

- Visualize and interpret the Multiview of an object.
- Explain and analyze the difference and form of first angle and third angle projection.
- Explain how views are chosen and aligned in Multiview drawing.

definition

A *multiview projection* is a type of orthographic projection that shows the object as it looks from the front, right, left, top, bottom, or back (e.g. the *primary views*), and is typically positioned relative to each other according to the rules of either first-angle or third-angle projection. The origin and vector direction of the projectors (also called projection lines) differs, as explained below.

- In *first-angle projection*, the parallel projectors originate as if radiated *from behind the viewer* and pass through the 3D object tmuo project a 2D image onto the orthogonal plane *behind* it. The 3D object is projected into 2D "paper" space as if you were looking at a radiograph of the object: the top view is under the front view, the right view is at the left of the front view. First-angle projection is the ISO standard and is primarily used in Europe.
- In *third-angle projection*, the parallel projectors originate as if radiated *from the far side of the object* and pass through the 3D object to project a 2D image onto the orthogonal plane *in front of* it. The views of the 3D object are like the panels of a box that envelopes the object, and the panels pivot as they open up flat into the plane of the drawing. Thus the left view is placed on the left and the top view on the top; and the features closest to the front of the 3D object will appear closest to the front view in the drawing. Third-angle projection is primarily used in the United States and Canada, where it is the default projection system according to ASME standard ASME Y14.3M.

Until the late 19th century, first-angle projection was the norm in North America as well as Europe; but circa the 1890s, third-angle projection spread throughout the North American engineering and manufacturing communities to the point of becoming a widely followed convention, and it was an ASA standard by the 1950s Circa World War I, British practice was frequently mixing the use of both projection methods.

As shown above, the determination of what surface constitutes the front, back, top, and bottom varies depending on the projection method used.

Not all views are necessarily used Generally only as many views are used as are necessary to convey all needed information clearly and economically. The front, top, and right-side views are commonly considered the core group of views included by default, but any combination of views may be used depending on the needs of the particular design. In addition to the six principal views (front, back, top, bottom, right side, left side), any auxiliary views or sections may be included as serve the purposes of part definition and its communication. View lines or section lines (lines with arrows marked "A-A", "B-B", etc.) define the direction and location of viewing or sectioning. Sometimes a note tells the reader in which zone(s) of the drawing to find the view or section.

3.1 SYSTEM OF PROJECTIONS

There are two types of projection systems in use today. These are:

- *Third-angle projection* is used in the United States, Canada, and in many other countries.
- *First-angle projection* is used mainly in Europe.

Basically their difference relays on the position of projection plane or imaginary projection plane orviewer's drawing paper.

First angle projection system:

This is one of the most common methods used to obtain engineering drawings, mostly for orthographic projections. Orthographic projection is a graphical method used to represent three-dimensional structures or objects into different perspective projection images called views. The orthographic view typically consists of the top view, front view, and the side view. First angle projection is one of the methods used for orthographic projection drawings and is approved internationally except the United States. In this projection method, the object is placed in the first quadrant and is positioned in front of the vertical plane and above the horizontal plane.

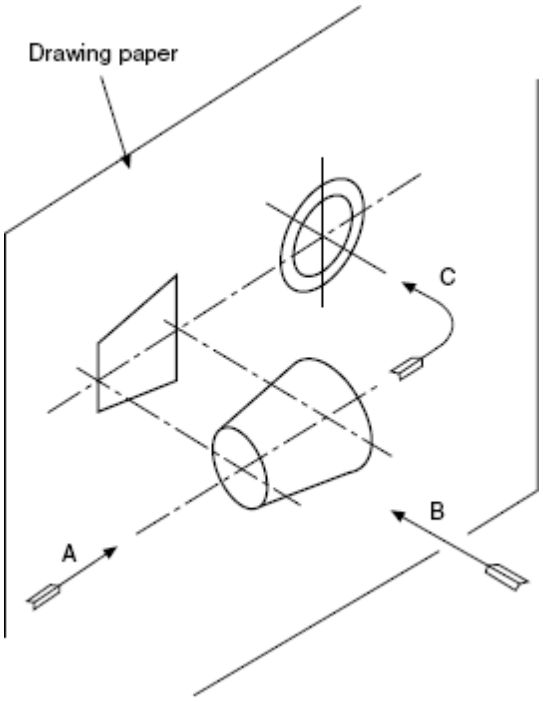
Read more: Difference Between First Angle Projection and Third Angle Projection | Difference Between http://www.differencebetween.net/technology/difference-between-first-angle-projection-and-third-angle-projection/#ixzz7mxKP79XT

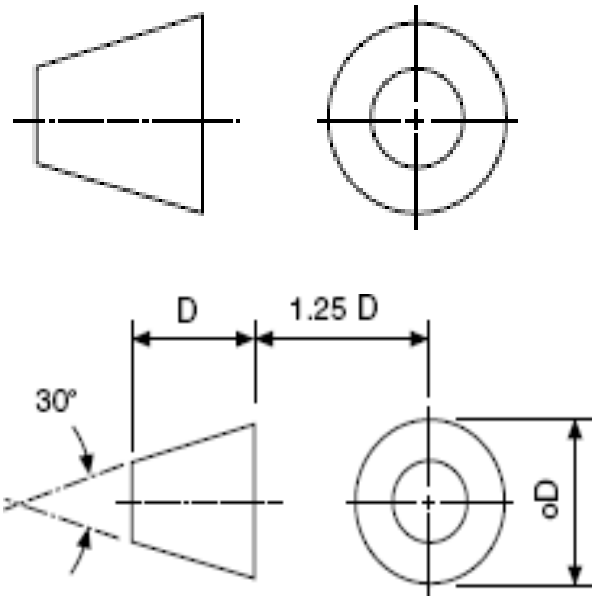
- Observer <==========> object <==========> Projection Plane

Here imagine that, the viewer is at left of the front view and looks at the object.Note:

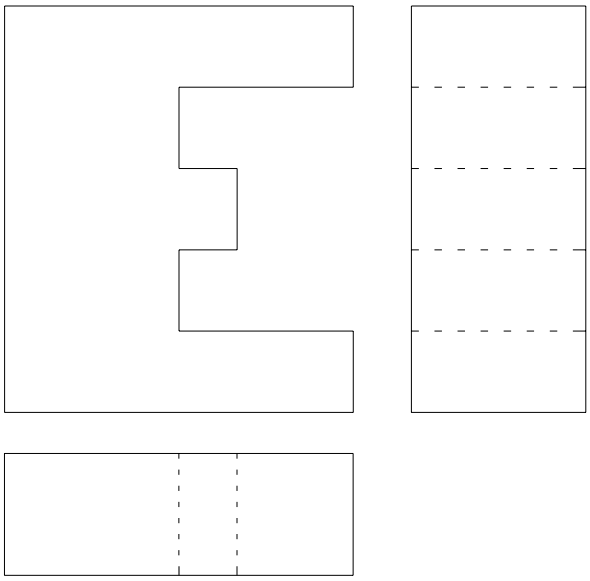
- ✓ Always top view will be placed below front view
- ✓ Always left side will be drawn on the right side of front view
- ✓ Always we place the right side to the left of the front view
- ✓ Bottom view will be shown above the front view

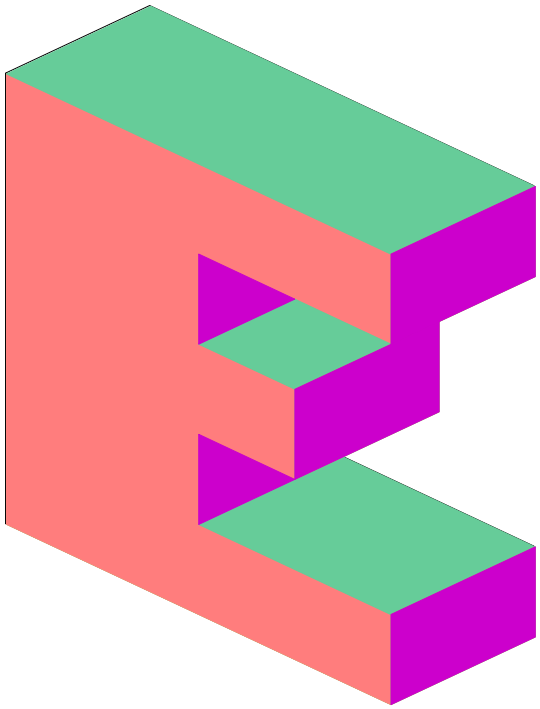
Symbolic representation of first angle orthographic projection is:





Example:





Third angle projection system:

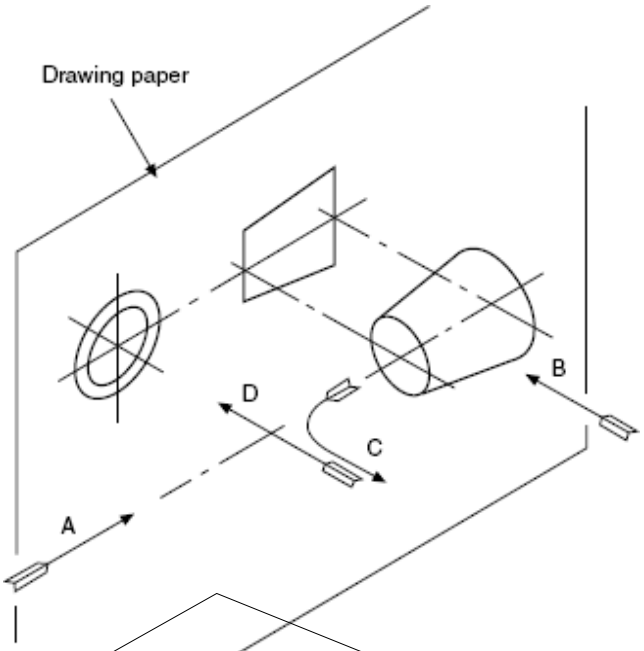
When the object is placed in the third quadrant it is known as third angle projection system. The projection plane is placed between the observer and the object. Therefore, in the projection process it is necessary to assume the plane of projection to be transparent. Here again the projections are perpendicular to the projection planes**.**

Observer <==========> Projection Plane <==========> object

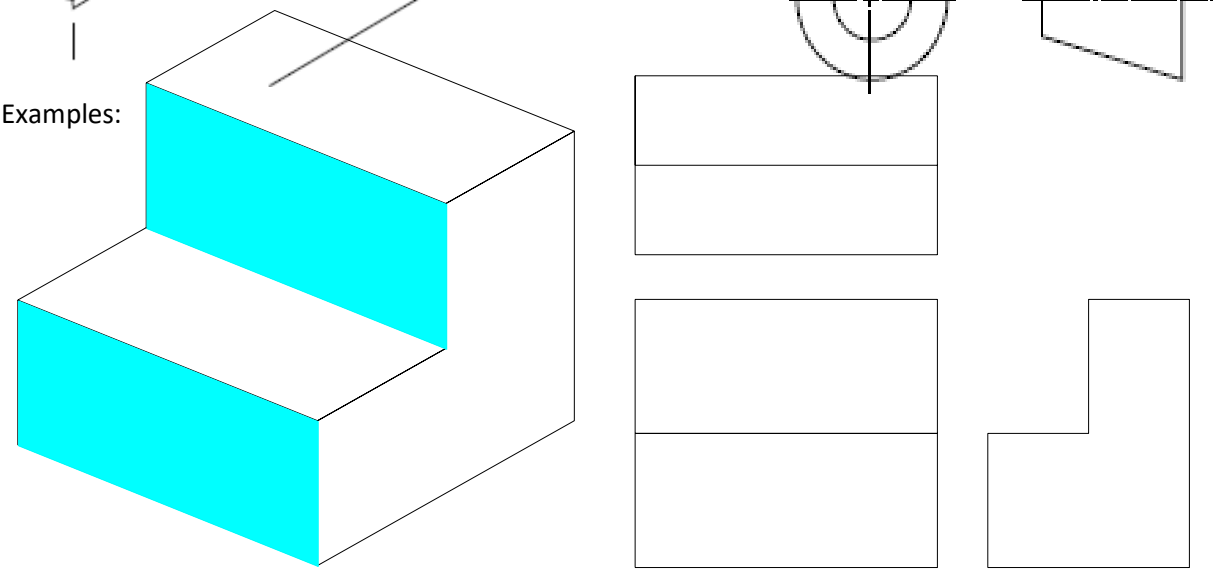
Note:

- Top view is always projected above the front view
- The right hand side view is shown on the right hand side of the front view
- The left hand side view is shown on the left hand side of the front view The standard symbolic

representation for the third angle projection is:



Examples:



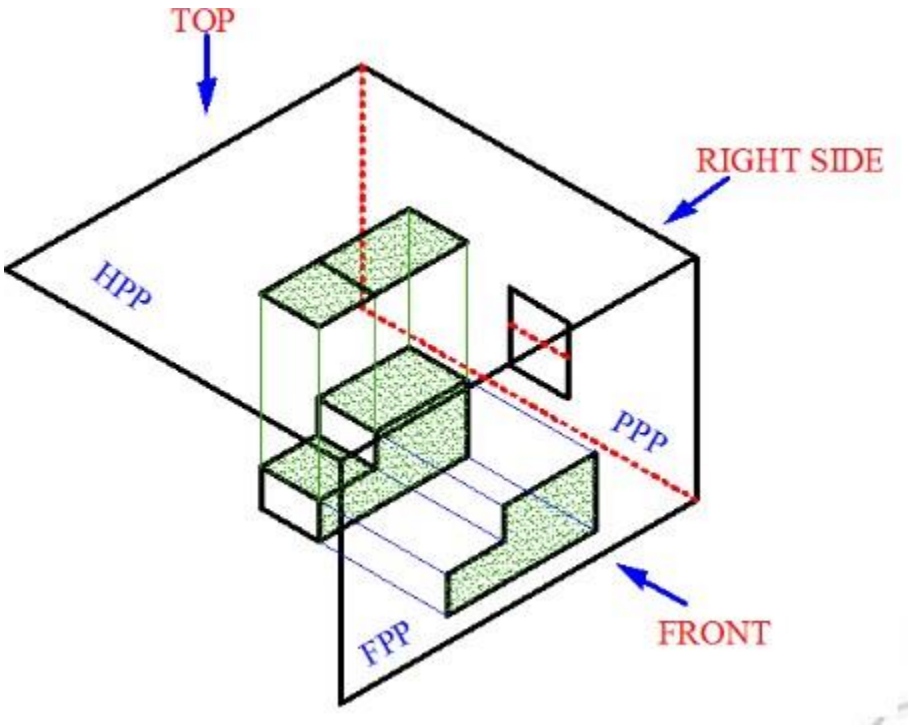
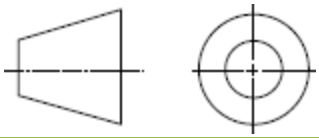
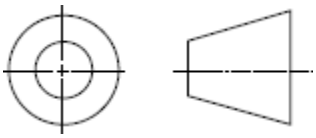


Fig. general description diagram for first and third angle projection

Comparisons

FIRST ANGLE PROJECTION	THIRD ANGLE PROJECTION
R.S.V F.V L.S.VT.V	T.V L.S.V F.V R.S.V
	

3.2 CHOICE & LAYOUT OF VIEWS

Six principal views can be obtained for any object by using the principles of multi view drawing or orthographic projection which are the maximum views. Width dimension remains the same for top,front and bottom views. Whereas height is common for right side, front, left-side, and rear views.

Only views that are necessary for a clear and complete description should be selected. Because the repetition of information may tends to confuse the reader. So that, it is important to have a set of views that describe an object clearly.

Technical drawings usually include only the front, top and right side orthographic views because together they are considered sufficient to completely define an object's shape.

GROUND RULES FOR SELECTION OF VIEWS

- Right hand side view should be used in preference to a left side view and a top view in preference toa bottom view.
- Place the object to obtain the smallest number of hidden lines. When both views of an equalnumbers of hidden lines exist, the right side view will be traditionally selected.

PRESEDENCE OF LINES

The following listed lines are the various types conventionally used over the world now a day;

- Visible Lines – solid thick lines that represent visible edges or contours
- Hidden Lines – short evenly spaced dashes that depict hidden features
- Section Lines – solid thin lines that indicate cut surfaces
- Center Lines – alternating long and short dashes

- Dimension Lines - solid thin lines showing dimension extent/direction
- Extension Lines - solid thin lines showing point or line to which dimension applies
- Leaders – direct notes, dimensions, symbols, part numbers, etc. to features on drawing

✎ Cutting-Plane and Viewing-Plane Lines – indicate location of cutting planes for sectional viewsand the viewing position for removed partial views

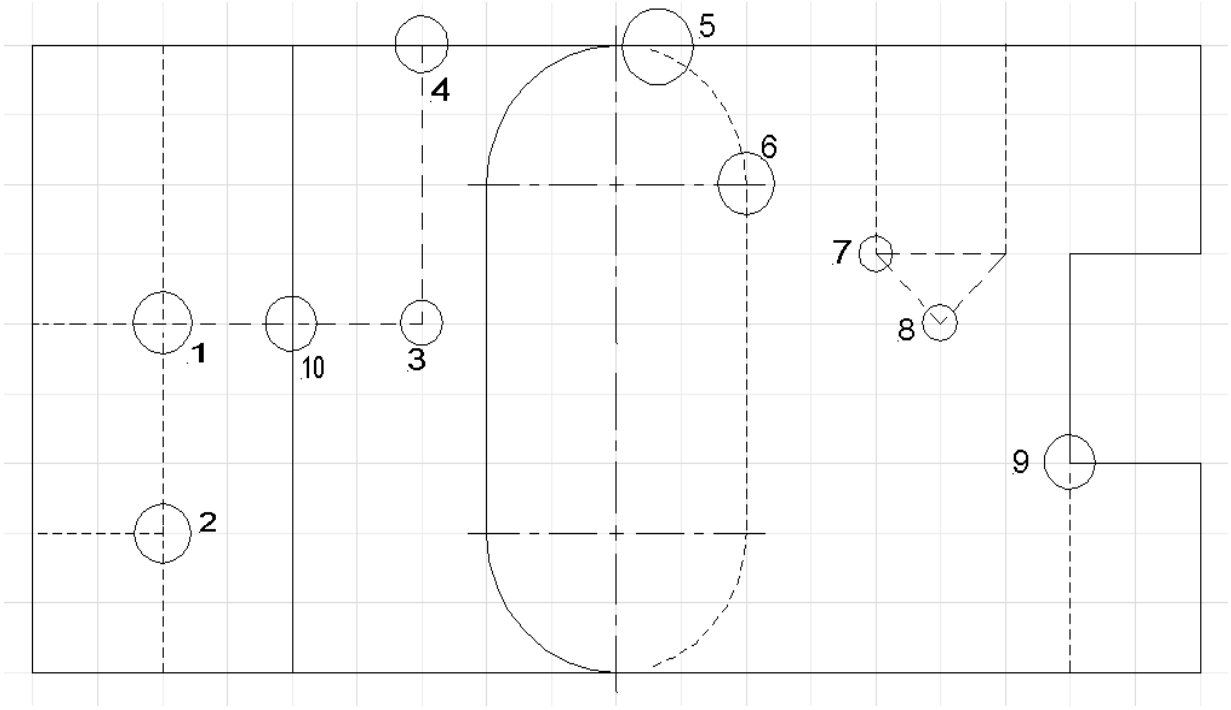
✎ Break Lines – indicate only portion of object is drawn. May be random "squiggled" line or thindashes joined by zigzags.

✎ Phantom Lines – long thin dashes separated by pairs of short dashes indicate alternate positionsof moving parts, adjacent position of related parts and repeated detail

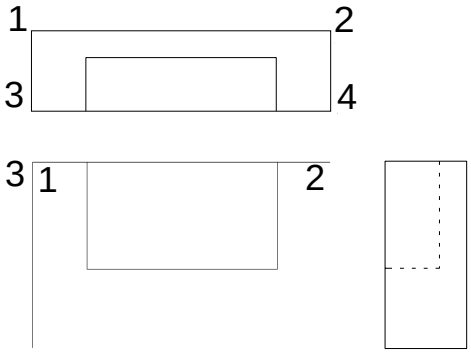
✎ Chain Line – Lines or surfaces with special requirements

☞ Visible object line dominates all others. Object hidden line has precedence than center line.

Below, there is a conventional representation for the precedence of lines. Places where required a greatattention are labeled and numbered. Please try to identify and understand.



When two hidden lines cross each other, precedence will be given for the more closure line. Refer labelnumber 1.



- From this multi view drawing we observe how we label multi view drawings.
- In numbering views, near points are labeled on the outside of the view and away points are labeled inside theview.

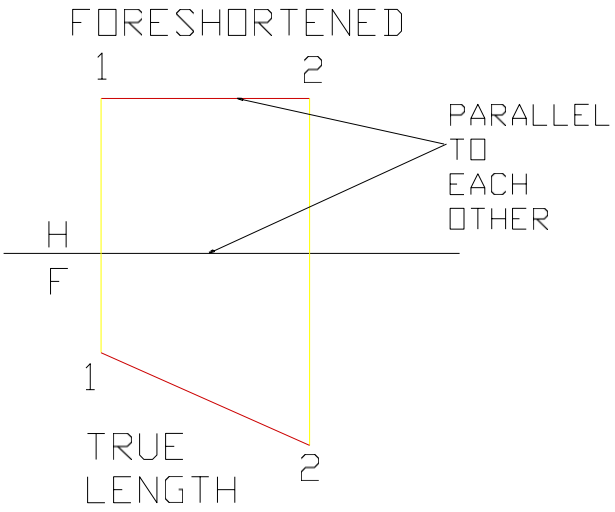
3.3 PROJECTIONS OF LINES AND SURFACES

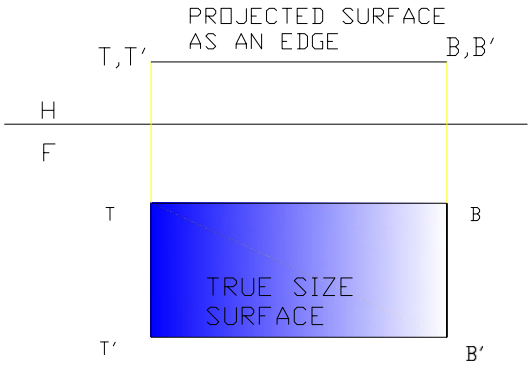
A plane in orthographic projection can appear true size, foreshortened, or as an edge. In the same manner, a line may be projected either in true length, foreshortened or as a point in a view dependingon its relationship to the projection plane.

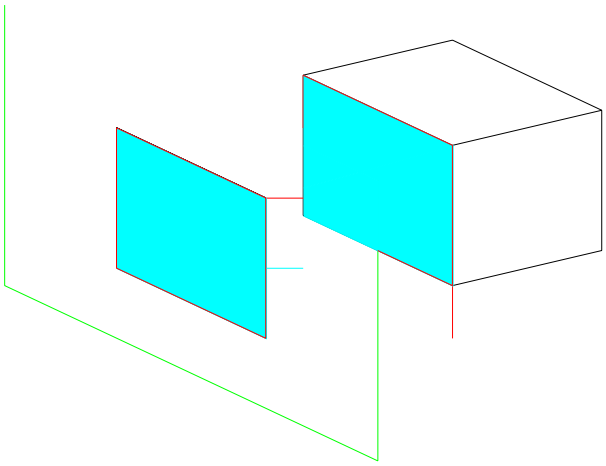
A surface or plane may be bounded by straight lines or curves, or a combination of them. A surface may be frontal, horizontal or profile, according to the plane of projection to which it is parallel.

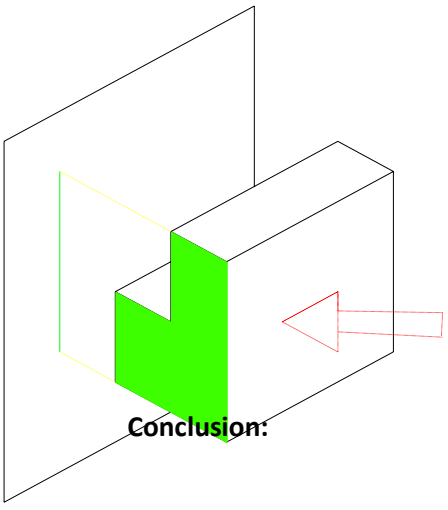
- If a plane surface is perpendicular to a plane of projection, it appears as a line, edge view. If it is parallel, it appears as a surface, true size. If it is situated at an angle, it appears as a surface, foreshortened. Thus, a plane surface always projects as a line or a surface. The intersection of two plane surfaces produces an edge, or a straight line.

- If an edge is perpendicular to a plane of projection, it appears as a point. Otherwise, it appearsas a line. If it is parallel to the plane of projection, it shows true length; if not parallel it appears foreshortened.







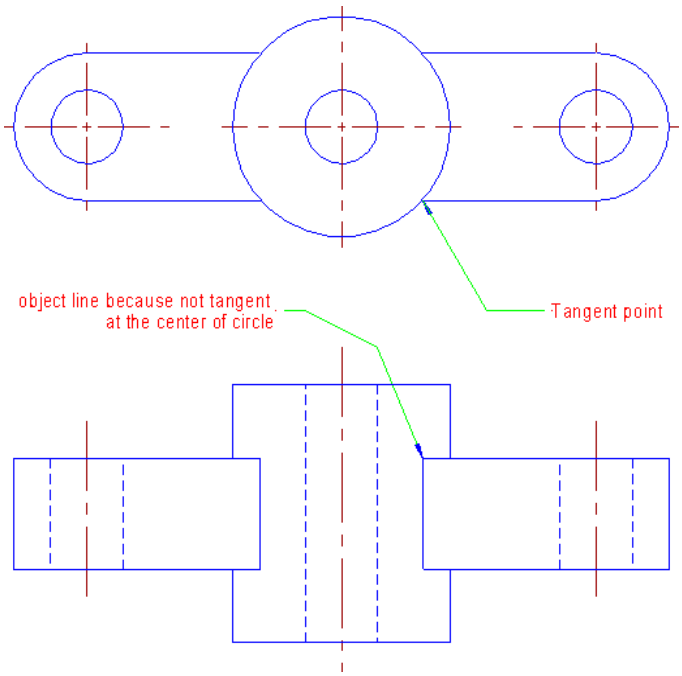


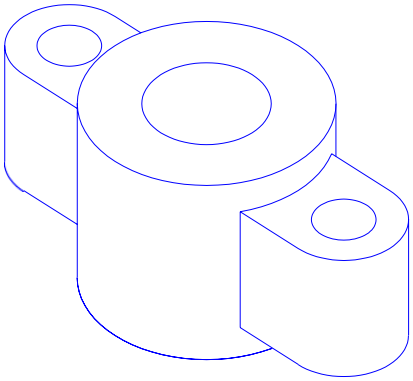
Conclusion:

- ➲ Planes or surfaces are projected either as an edge or plane.
- ➲ Lines can be projected as a point or a line.

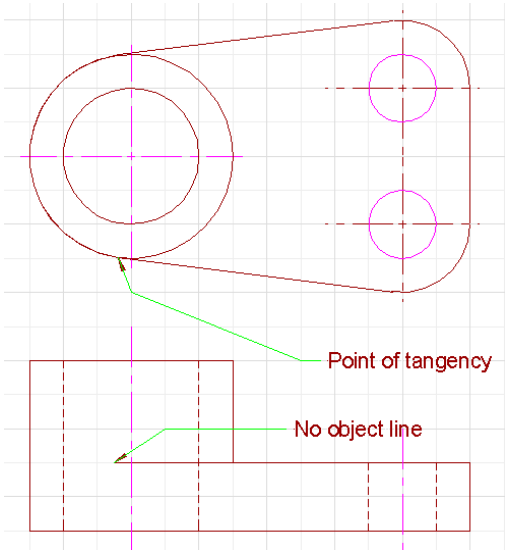
3.4 PROJECTION OF TANGENT SURFACES

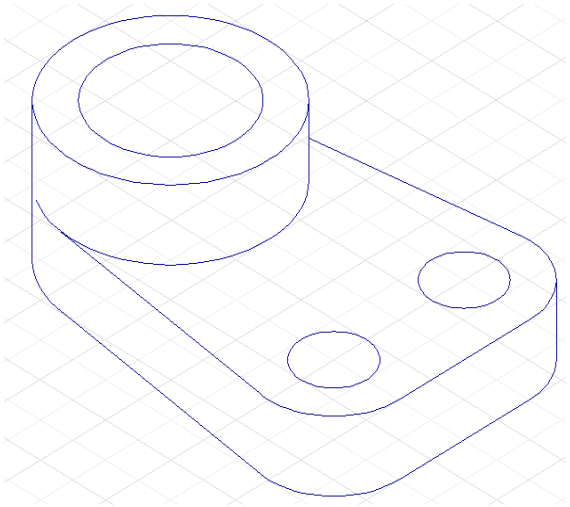
Tangent surfaces will be drawn by object line where the arcs are tangent not at the center lines.Example:





Tangent lines will be drawn with no object line if arcs are tangent at the center lines.





NOTICE;

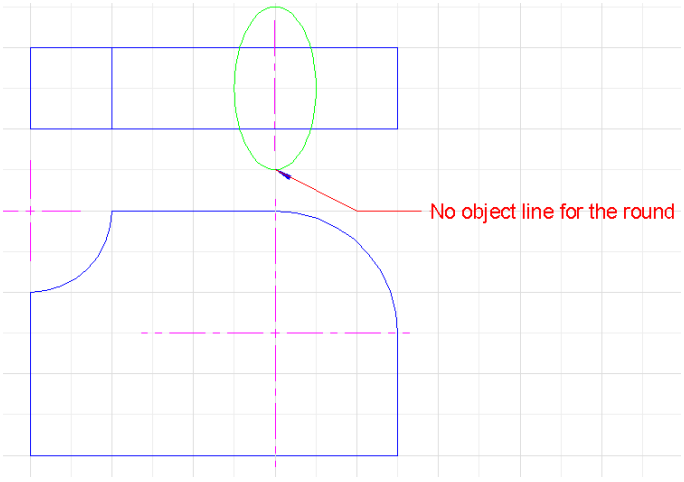
By this material we use third angle projection system to represent orthographic projection of different objects, unless mentioned.

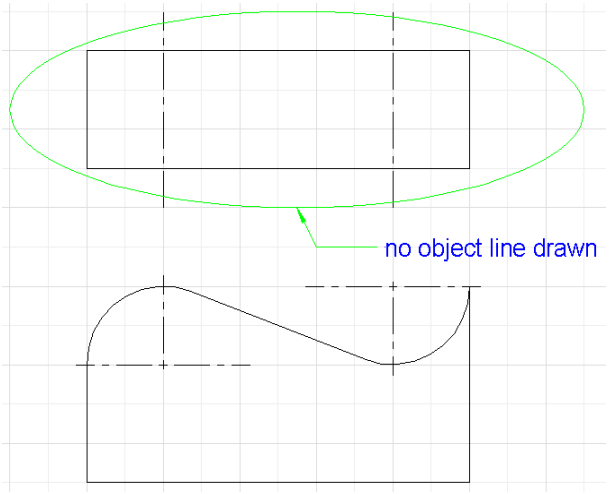
3.5 PROJECTION OF FILLETS, ROUNDS, AND RUN OUTS

Round: - is an exterior rounded edge. Round edges can be represented by object line if surfaces are perpendicular to orthographic projection, in that orthographic view. On the other hand if the arcs are joined by tangent lines, the intersection point is considered sufficient to require an edge on the view.

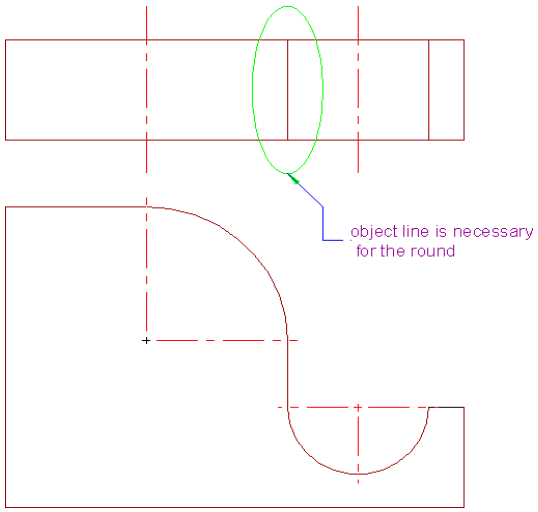
Observe the following examples:

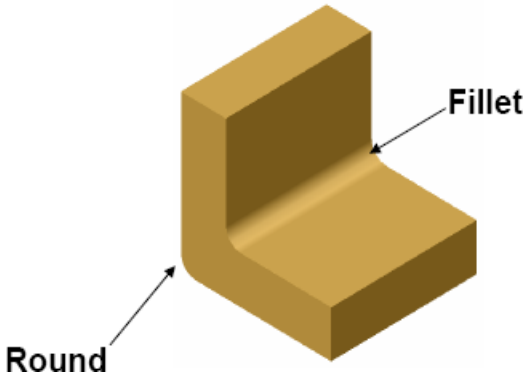
Curves which bended before the turning points will not be drawn with object lines:





If the rounds are turned at the center line of the curves, object line will be drawn to show the bending edge.

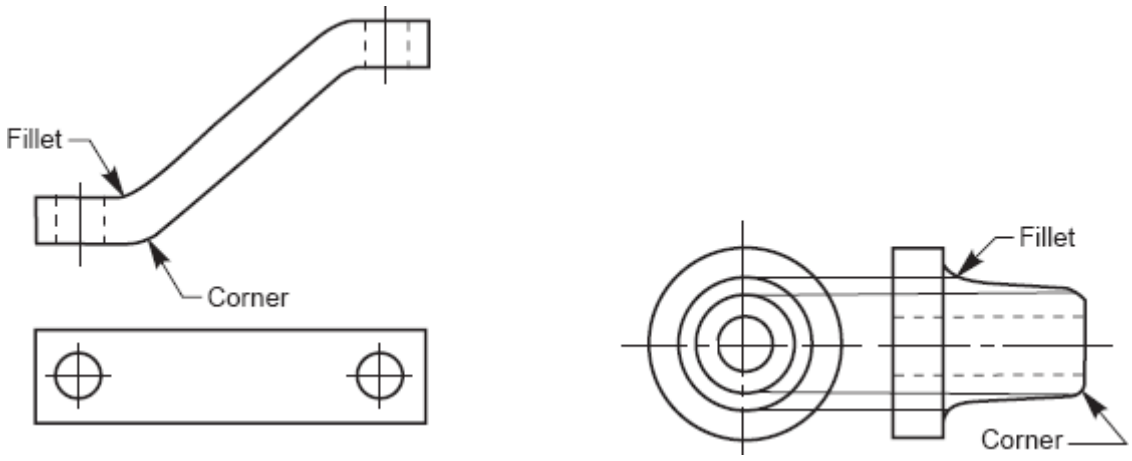




Fillets: - are rounded interior corners. They are preferred on design to avoid failures and stress concentrations. Especially during casting, it will be given an attention on the manufacturing.

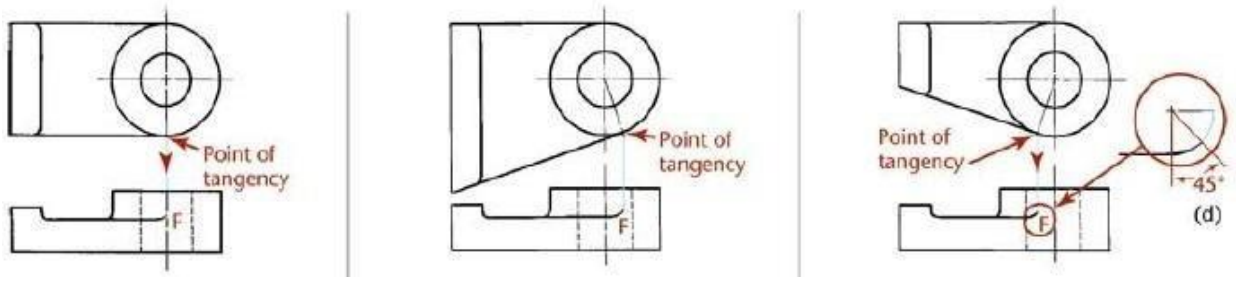
Note: On working drawings, fillets and rounds are never shaded. They are simply represented in arcs.

Examples:



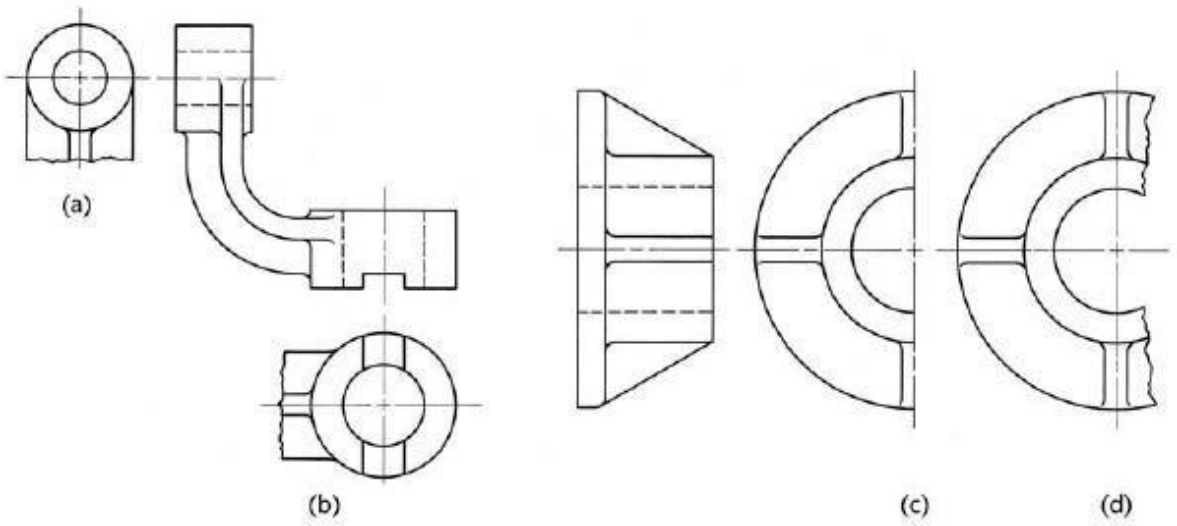
Run outs: - Small curves called run outs are used to represent fillets that connect with plane surfaces tangent to cylinders. In conventional practice, fillets and rounds are represented by lines called run outs.The run outs are terminated at the point of tangency.

Examples:



Partial views:

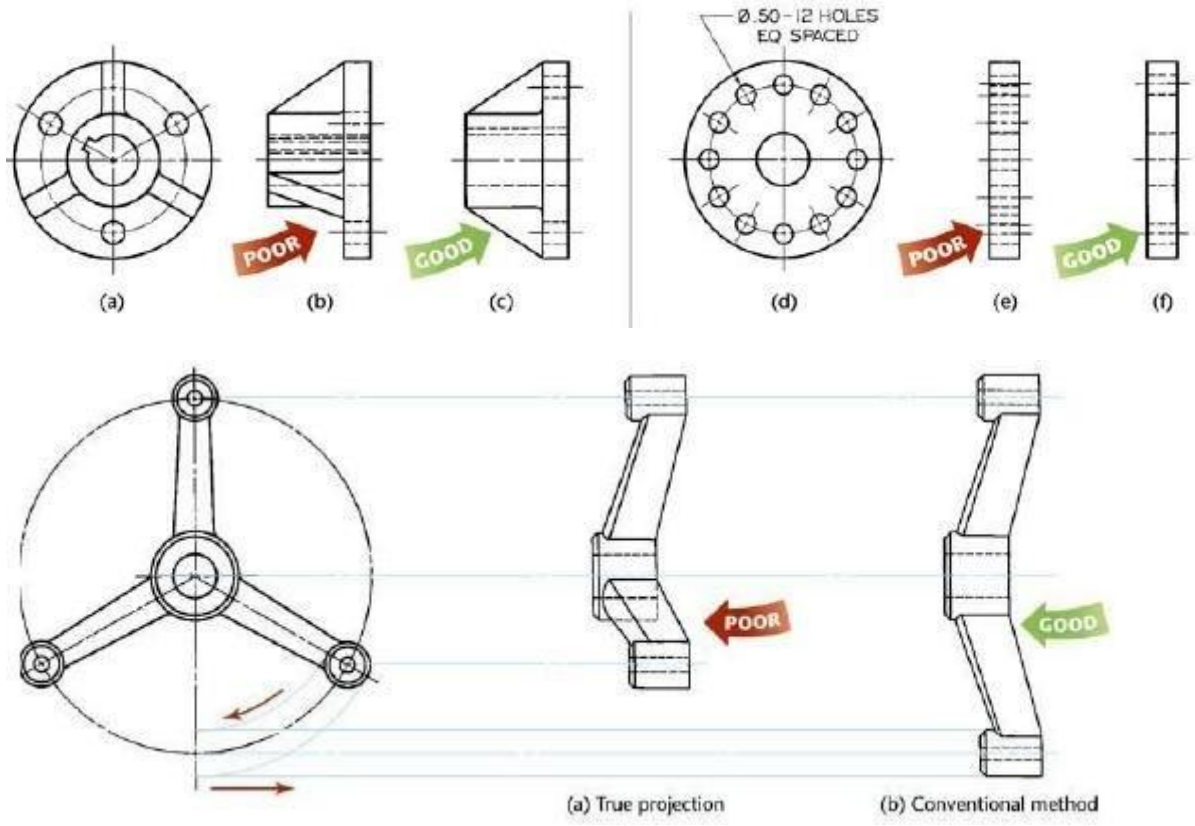
A view may not need to be complete but may show only what is necessary in the cleardescription of the object. Such a view is a ***partial view***. A break line may be used to limit the partial view (a,b,d). If surfaces are symmetrical to center lines, a **half view** may be drawn(c). Look the following drawings;



Revolution conventions or aligned views: -

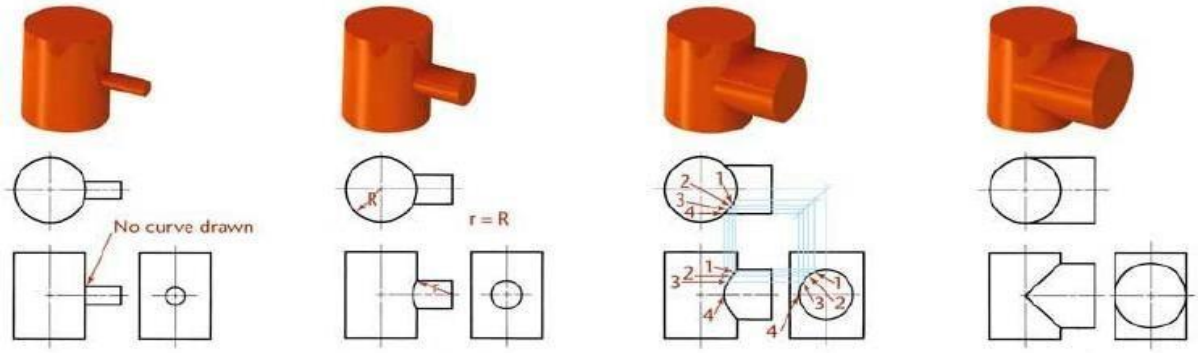
We use this convention for objects where regular multi view projections are awkward or actuallymisleading. Established violations of rules that are customarily made for the sake of clarity are called *Conventionalpractices.*

Study the following exercises:



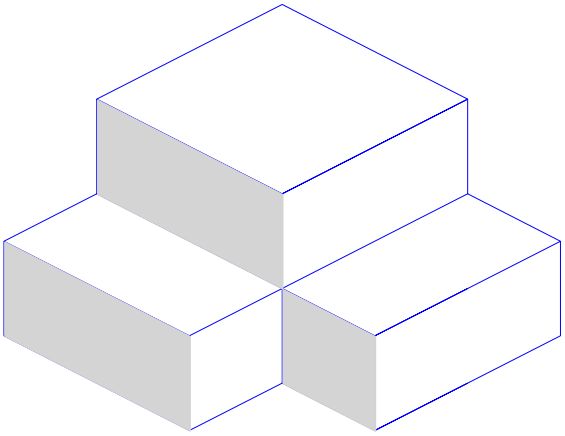
Intersections:

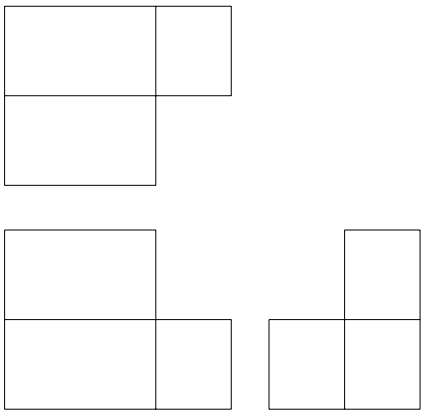
In orthographic projection, an intersection between planes results in a line. The standard types of intersections between cylinders are shown below:



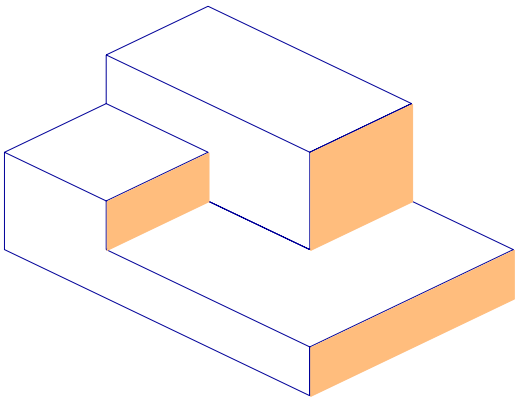
TUTORIAL SOLVED PROBLEMS

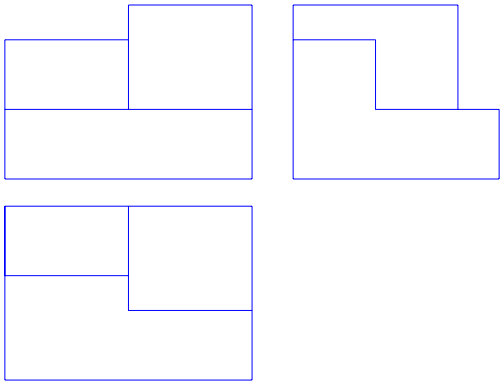
1. Orthographic projection of a box using third angle projection system:



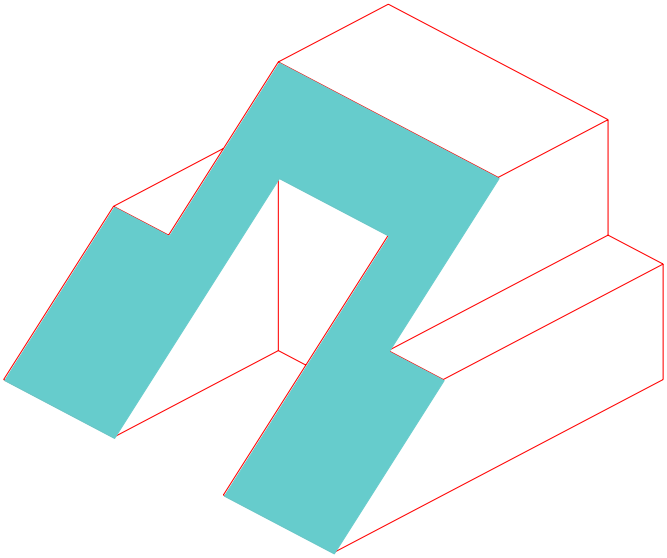


2. Orthographic projection for an object using first angle projection system:

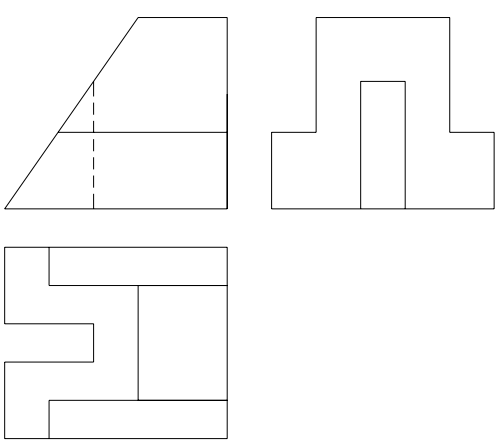




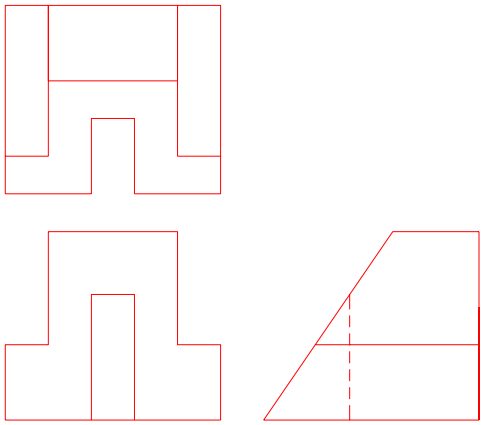
3. Draw the multi view drawing of the following object with both 1st and 3rd angle projection system.



Orthographic projection of the above object was given below with both projection systems.

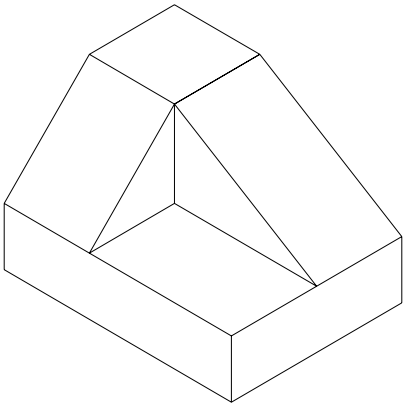


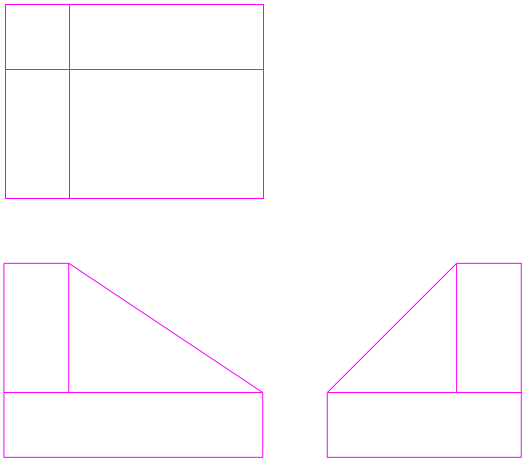
a. First angle projection system



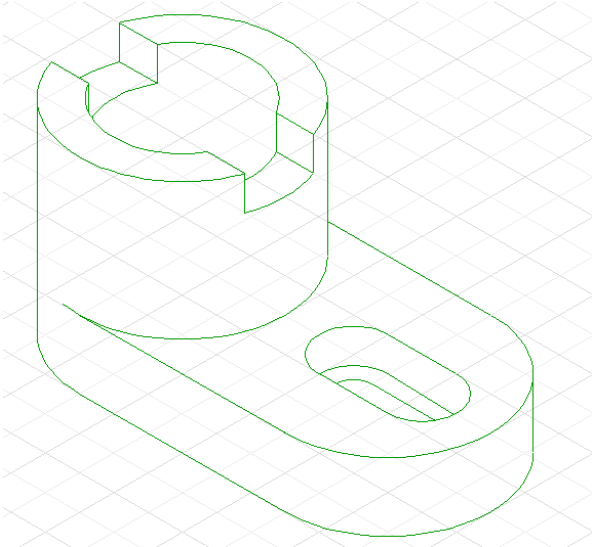
b. Third angle projection system

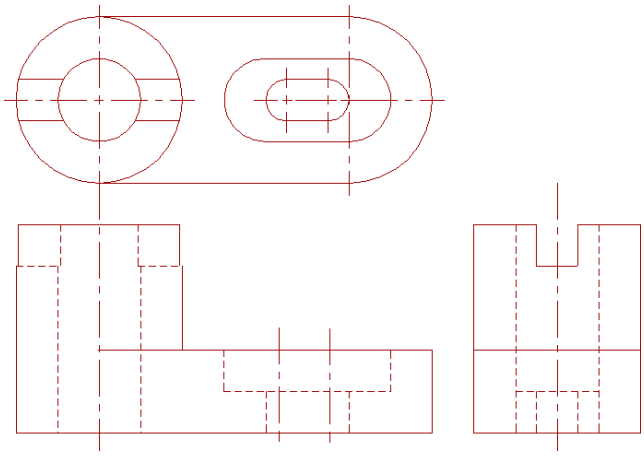
4. Draw orthographic projection of the following object using third angle projection system.





5. Draw orthographic view of the following object using third angle projection system:





Pictorial drawing

At the end of this chapter students are;
♣able to explain the difference between an axonometric and an oblique projection.
♣able to explain the difference between an isometric projection and anisometric drawing/sketch.
♣able to create an isometric and oblique sketches from an actual object and multi view drawing.

definition

A pictorial drawing is a method of producing a three-dimensional object from a two-dimensional view, that shows The three main faces indicating the height, width and depth simultaneously. It is an essential part of the graphic language.

4.1 COMPARISON OF MULTI VIEW DRAWING AND PICTORIAL DRAWING

Differences between multi view and pictorial drawings

Multiview Drawing

- ✓ It represents exact shape of an object.
- ✓ It uses two or more views of an object on different picture plane.
- ✓ It uses hidden line to represent the hidden parts of an object.
- ✓ It gives detail dimensions of a complex object.
- ✓ It needs prior knowledge of technical drawing to understand.
- ✓ It is used for manufacturing, construction, production , and the like.

Pictorial drawing

- ✓ It represents overview of an object.
- ✓ It represents several views of an object at once on a single picture plane.
- ✓ It rarely uses hidden line when necessary.
- ✓ It gives overall dimensions of a complex object.
- ✓ It can be easily understood using common sense.
- ✓ It is used for promotion, marketing and selling ,business transaction, and the like.

4.2 TYPES OF PICTORIAL DRAWING

The most common types are three. These are:

1. Oblique
2. Axonometric – Isometric
3. Perspective

♣Axonometric projection is a projected view in which the lines of sight are perpendicular to the plane of projection, but the three faces of a rectangular object are all inclined to the plane of projection.

♣Isometric projection: The receding lines are drawn at 300from the horizontal and the others are vertical. Consider a cubic object, the three principal faces and axes are equally inclined to the plane of projection.

♣Dimetric projection: Two of the principal faces and axes are equally inclined to the plane of projection.

♣Trimetric projection: All three principal faces and axes make different angles with the plane of projection.

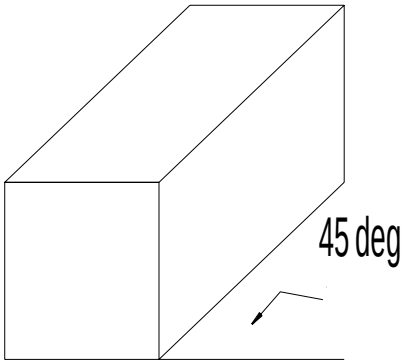
♣Oblique projection: the projectors are oblique to the plane of projection but parallel to each other, and one of the principal face (usually front view) of the object is generally parallel to the plane of projection. The receding line is drawn at 300, 450and 600from the horizontal.

1. OBLIQUE DRAWING:

It is easiest of the three to draw. But seldom used.
Front view is drawn exactly as it would appear in multi view drawing

- ✓ Circles appear as a true circle over the front view.
- ✓ Rectangles parallel to the frontal plane are in true size

You use 3-axes; two at right angles and one at an angle of convenient, but most of the time it is preferable to use 45^{o}.



The line of sight should not make an angle less than 45^{o} with the picture plane. This would result in areceding axis longer than true length, thereby distorting the pictorial.

Advantage:

- ➲ Circles or cylinders can easily drawn easily on the front face in their true shape
- ➲ Irregular shapes can be easily sketched on the front view in the same manner.

2. AXONOMETRIC DRAWINGS

In axonometric drawing the three faces of rectangular object are all inclined to the plane of projection. Here the observer is considered to be at infinity, and the visual rays are parallel to each other and perpendicular to the plane of projection.

By chapter one, we have already considered the three types of axonometric projections. These are:

A. Isometric drawing

B. Diametric drawing

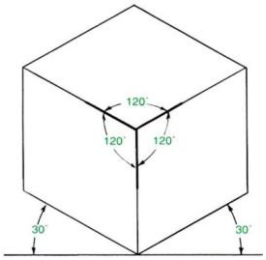
C. Trimetric drawing

A. Isometric drawing

In **isometric pictorials** (for methods, see Isometric projection), the direction of viewing is such that the three axes of space appear equally foreshortened, and there is a common angle of 120° between them. The distortion caused by foreshortening is uniform, therefore the proportionality of all sides and lengths are preserved, and the axes share a common scale. This enables measurements to be read or taken directly from the drawing.

mainly

- Isometric means *equal measure*.
- Makes equal angle with the principal plane (120º).
- Is the most commonly used axonometric drawing type.



Notice:

* Isometric drawing is similar to an Isometric projection except that it is not a true axonometric projection, but an approximate method of drawing a pictorial.

* Isometric projection is foreshortened by 82% of full size. The Isometric drawing is drawn full size for convenience.

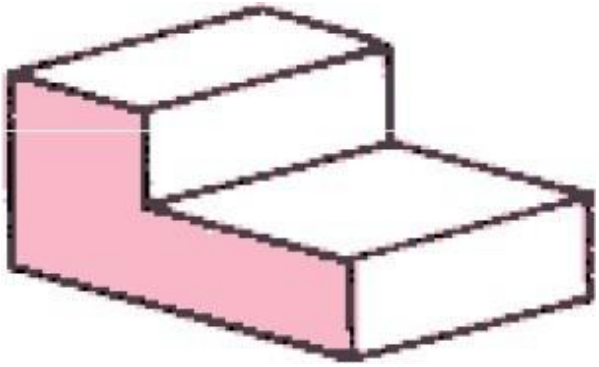
B. dimetric drawing

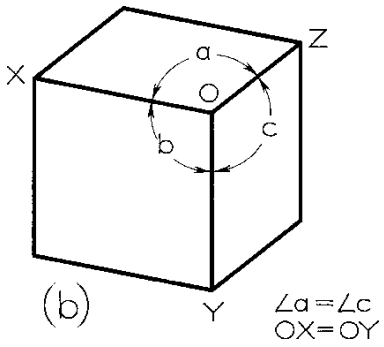
In **dimetric pictorials** (for methods, see Dimetric projection), the direction of viewing is such that two of the three axes of space appear equally foreshortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction (vertical) is determined separately. Approximations are common in dimetric drawings.

Two of the principal faces and axes are equally inclined to the plane of projection. Dimetrics have only two axes at the same scale and same angle to the picture plane. The vertical dimension is foreshortened. When the axes of the base are set at right angles, the drawing in essence begins with a plan view. A Dimetric projection is created using 3 axes but only two of these have equal angles. The smaller these angles are the less we see of the top surface. The angle is usually around 105°. In **dimetric pictorials**, the direction of viewing is such that two of the three axes of space appear equally foreshortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction (vertical) is determined separately. Approximations are common in dimetric drawings.

mainly

- Two principal planes have equal angle measurement.
- seldom used

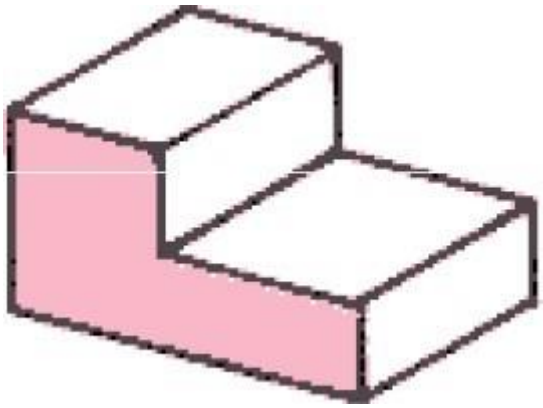


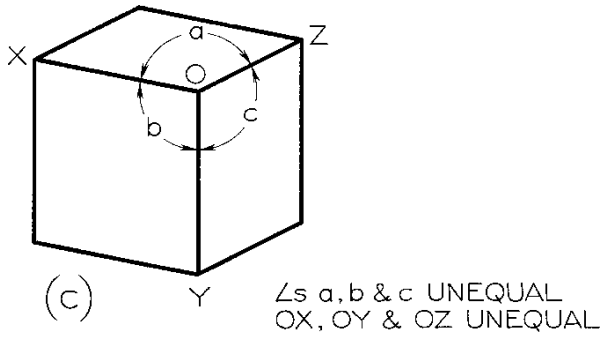


c. Trimetric drawing

In **trimetric pictorials** (for methods, see Trimetric projection), the direction of viewing is such that all of the three axes of space appear unequally foreshortened. The scale along each of the three axes and the angles among them are determined separately as dictated by the angle of viewing. Approximations in Trimetric drawings are common.

- All angles measured in principal planes are none equal.





Limitations of parallel projection

3. PERSPECTIVE DRAWING

- Perspective is a geometric method of representing on paper the way that objects appear in real life i.e. they get smaller and closer together the further away they are from the eye of an observer.
- It is the most realistic of all pictorial drawings.
- It is the way real three-dimensional objects are pictured in a photograph that has a two-dimensional plane.
- Perspective or central projection is used in creative art or technical sketching but seldom in technical drawing.

- Central projection is the other calling name.

It excels over all other types of projection in the pictorial representation of objects because it moreclosely approximates the view obtained by the human eye.

Terminology:

- The station of the observer's eye is called *Station point* (SP).
- The imaginary plane of projection is called *Picture plane* (PP).

- ➲ The point where all projection lines converge is called *vanishing point* (VP).
- ➲ A horizontal line in the front view representing an infinite horizontal is called *Horizon*.

The *three* basic types of perspectives are:

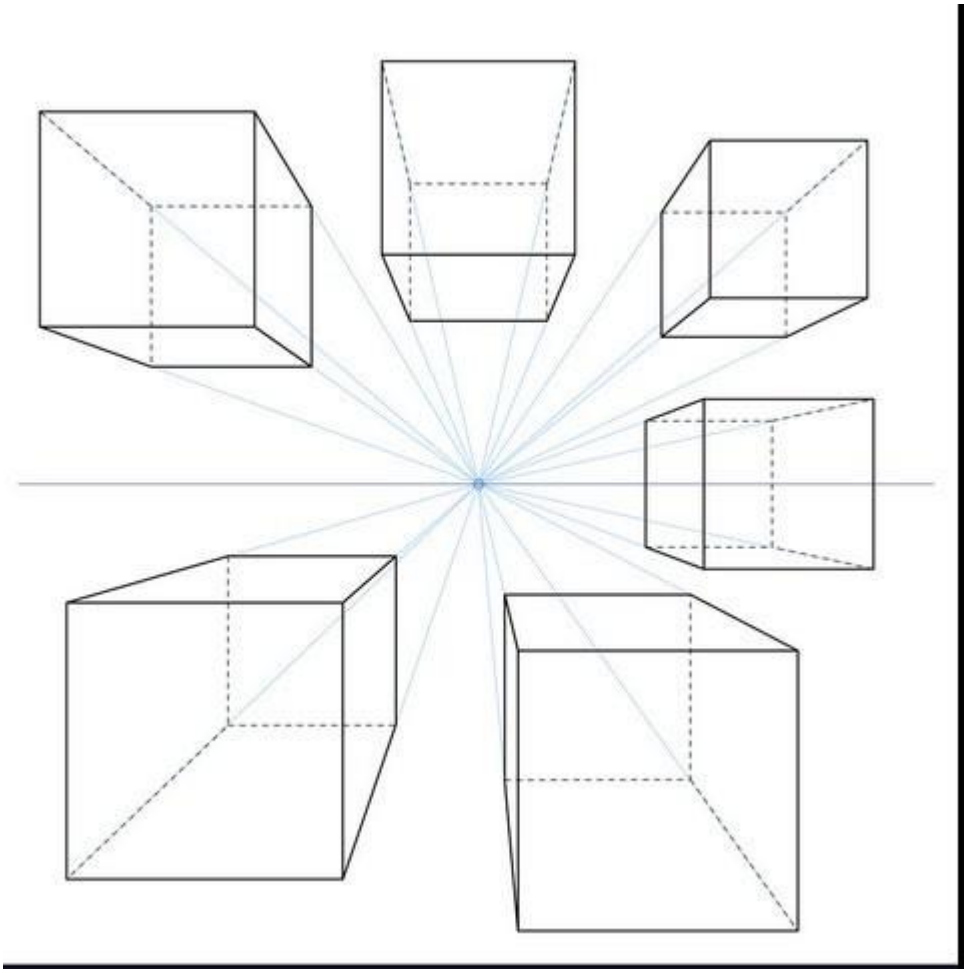
I. One point – single vanishing point
II. Two point – two vanishing point
III. Three point – three vanishing point

ONE POINT PERSPECTIVE DRAWING

Has one surface of the object parallel to the picture plane. However, other sides vanish to a single point.To draw one point perspective projection, we can develop from top and front views of an object.

- ✎ When drawing any perspective, the station point should be placed far enough away from theobject to permit the cone of vision to be less than 30^{o} to reduce distortion.

We can work one point perspective either by simply selecting a stationary point or by measuring points.The use of measuring point eliminates the need of placing top view above the front view.

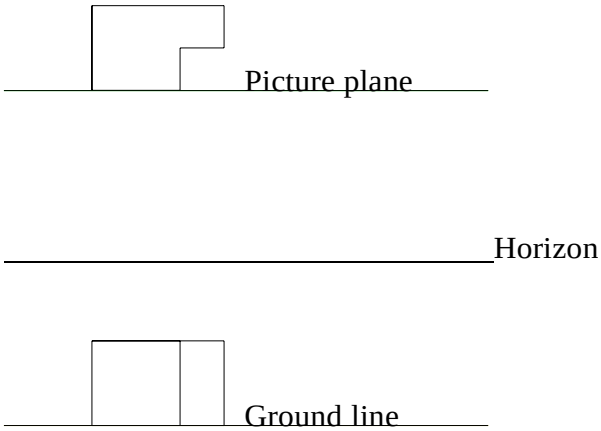


Simple figure for one point perspective drawing

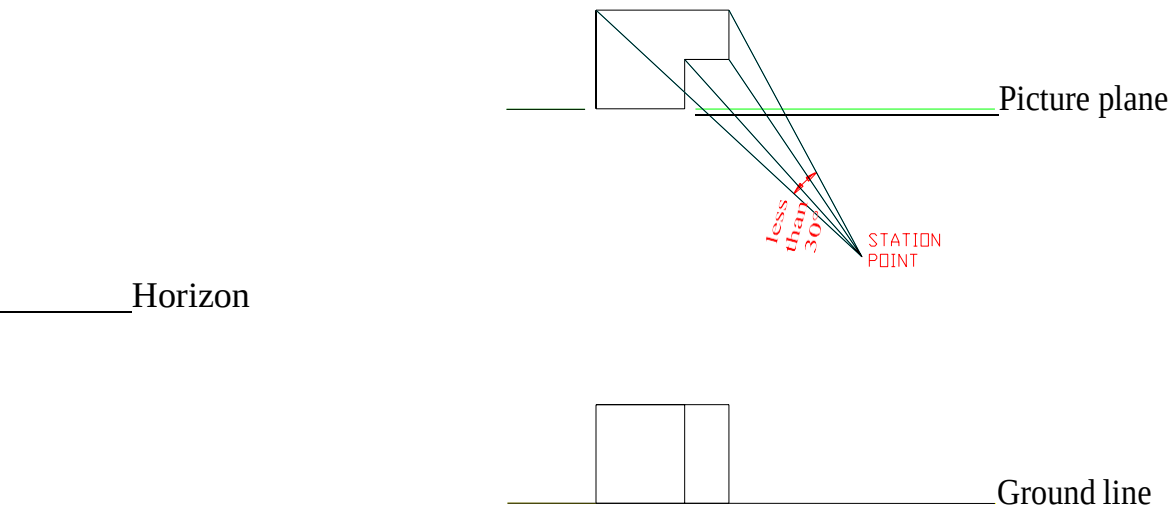
- **Construction of a one point perspective pictorial drawing:**

Procedures:

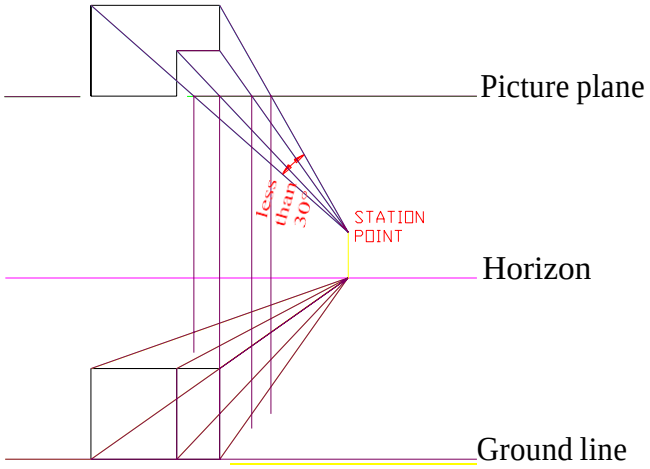
1. Select top and front view of your object. Then draw horizon, ground line and picture plane.



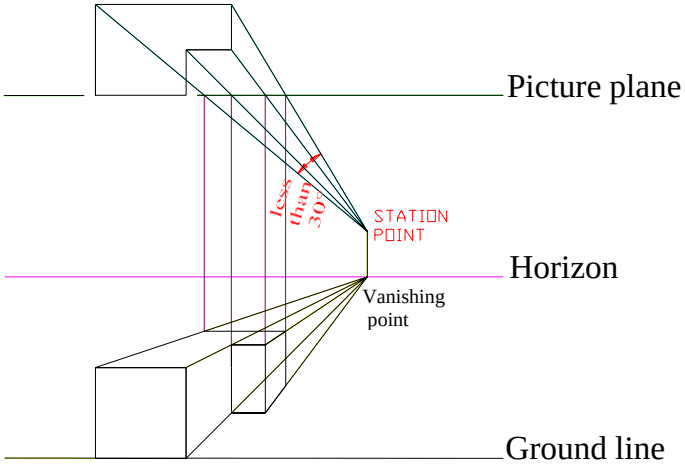
2. Project all intersection or corner points of the top view to a station point below top view at some distance approximately twice of the diagonal of top view, with below 30° inclusive angle for the vision corner.



3. Project a perpendicular line to your horizon to obtain your vanishing point and then project projection lines toward the front view. Here all upper lines intersection or corners have to be projected to the vanishing point. Finally, projected vertical projections from the intersection point ofstation point projectors with the picture plane. Finally consider the intersection point of vertical projectors with vanishing point projectors from the front view.



4. Finally your object will appear as the following:



Note:

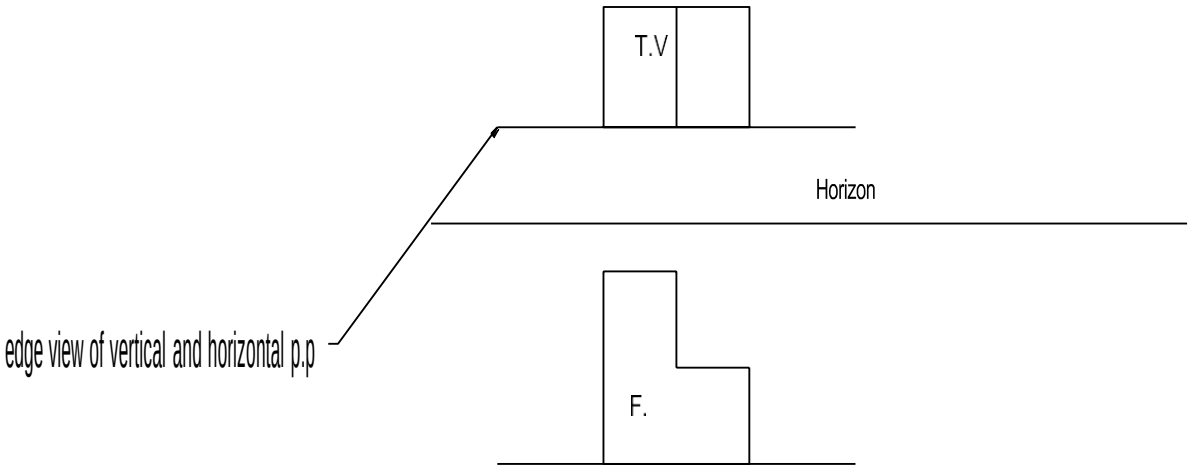
- We can easily sketch one point perspective simply projecting the upper corners of top view to station point, and upper corners of front view to the vanishing point. It is need not to project thelower corners of top view which already lay over the picture plane because it coincides with the edge of front view if we project perpendicular vertical projections.
- In order to obtain accurate shape we have to adjust our cone of vision less than 30°. If we increase the angle more, the shape will appear distorted.

Exercise: 1

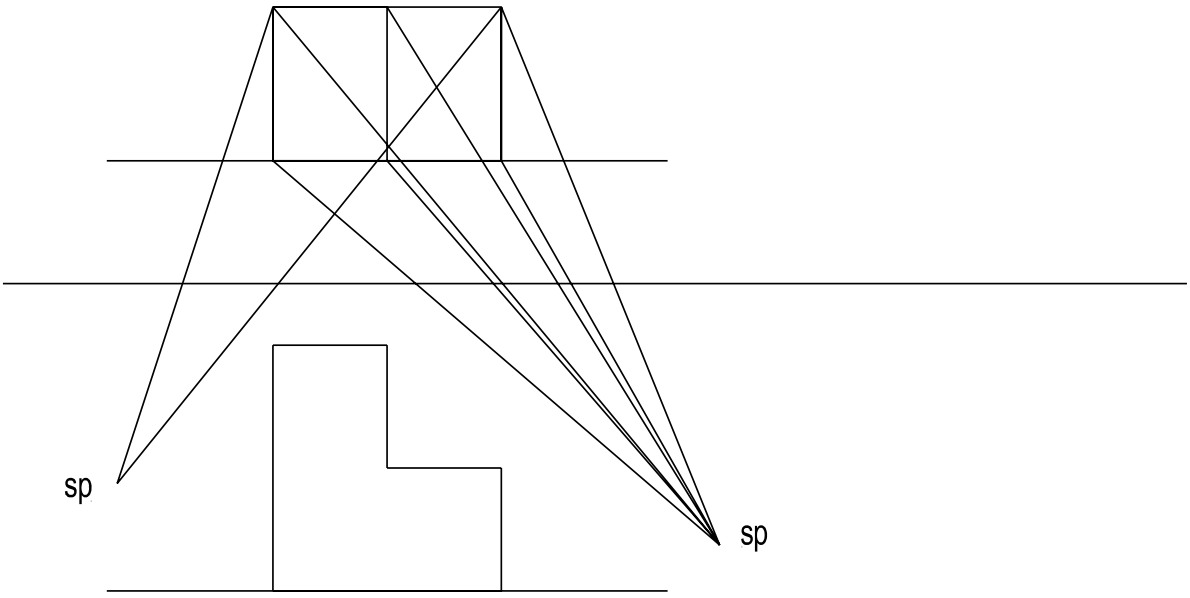
Draw a one point perspective for the following multi view drawing

Steps in constructing one point perspective drawing

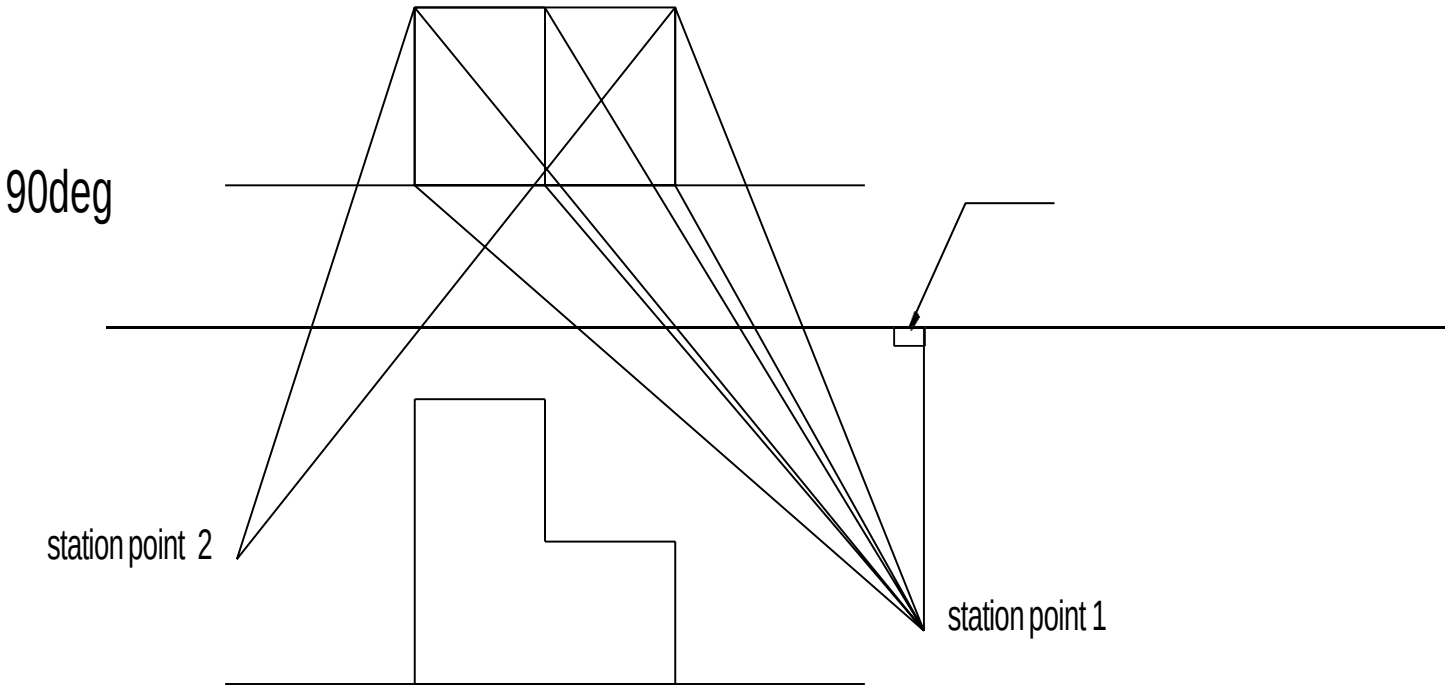
Step 1.



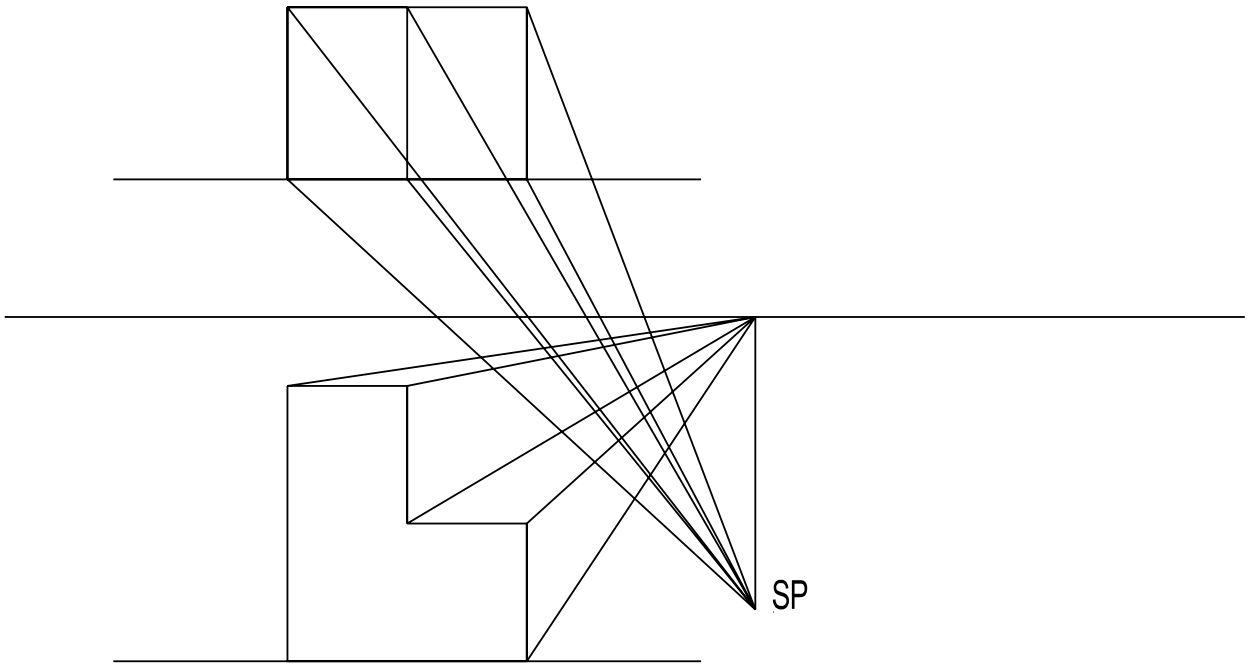
Step 2.



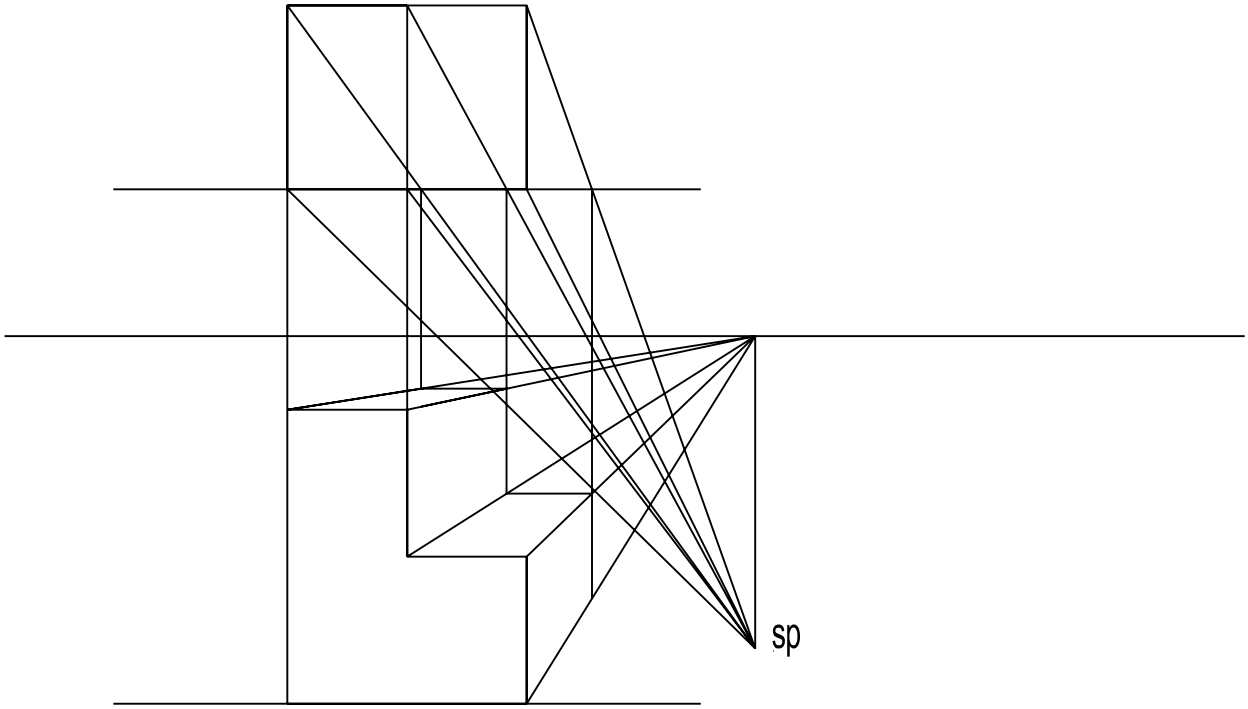
Step 3.



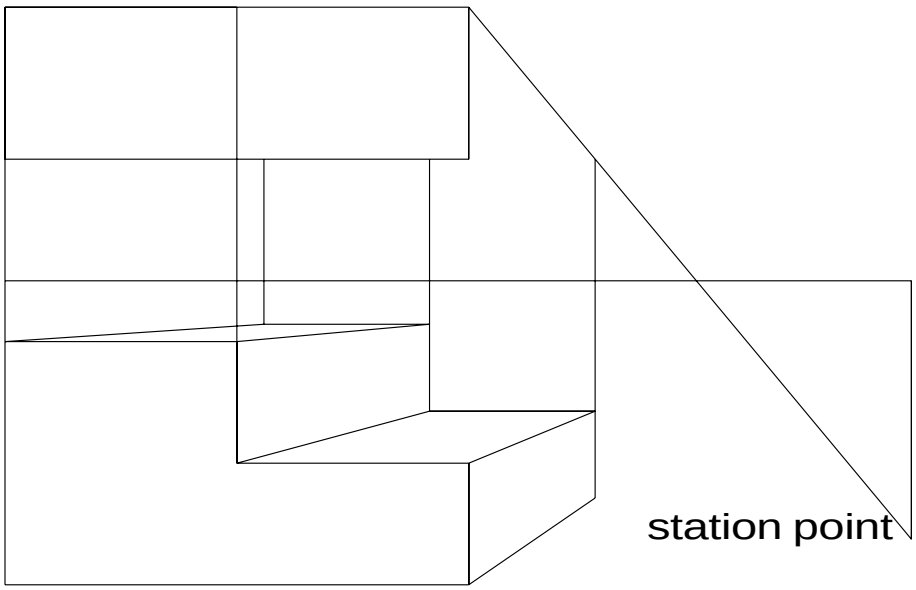
Step 4.



Step 5.

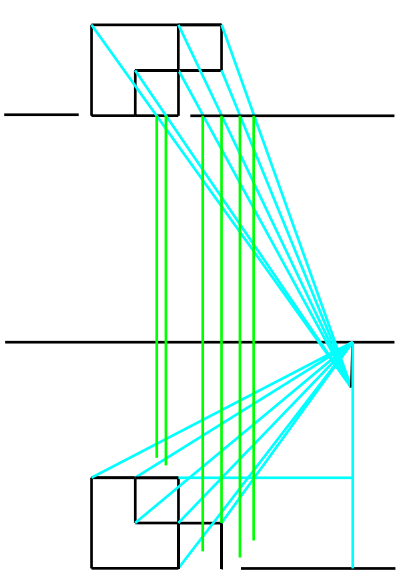


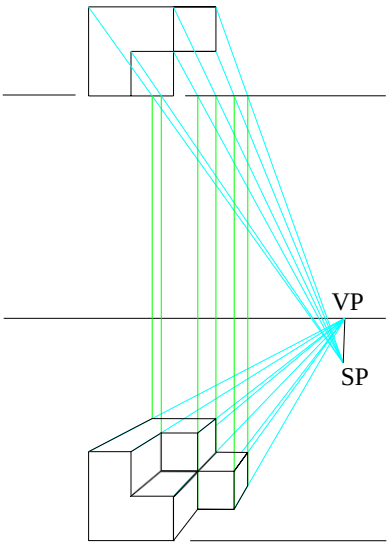
Step 6.



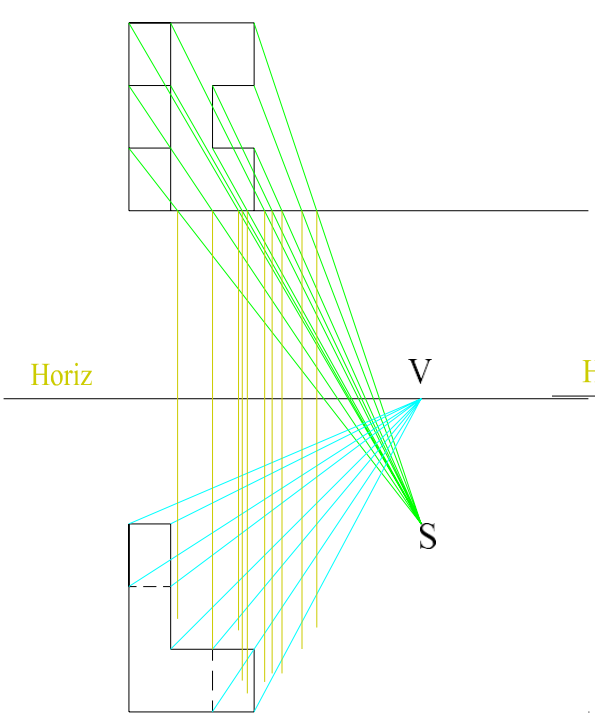
Exercise 2:

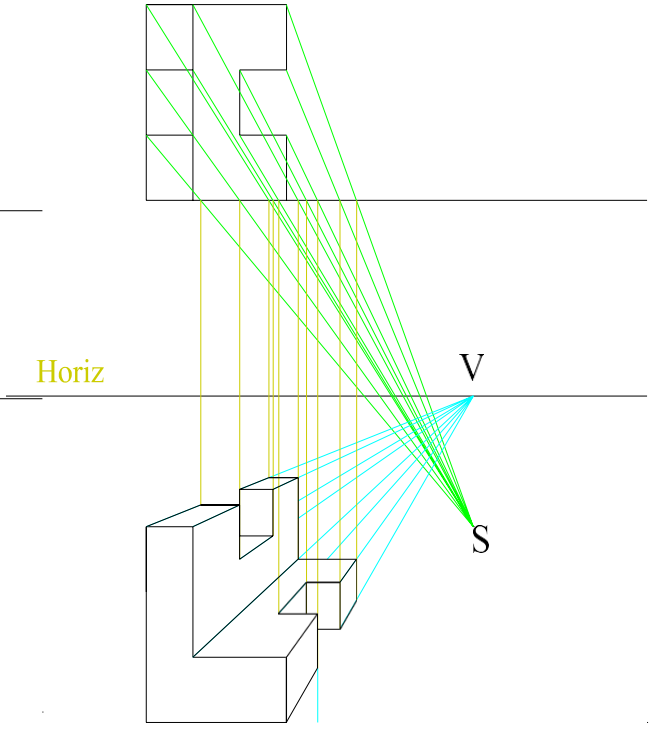
Draw a one point perspective for the following multi view drawing.





3. Study the following exercise:





Note:

We can place vanishing point at any place from station point. It can be above or below station point.

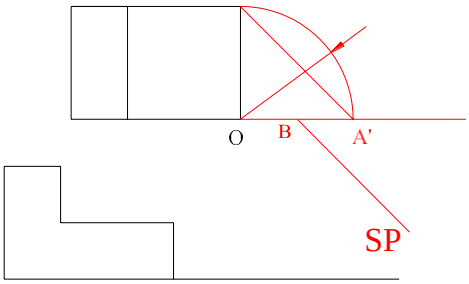
One point perspective using measuring method:

Procedures:

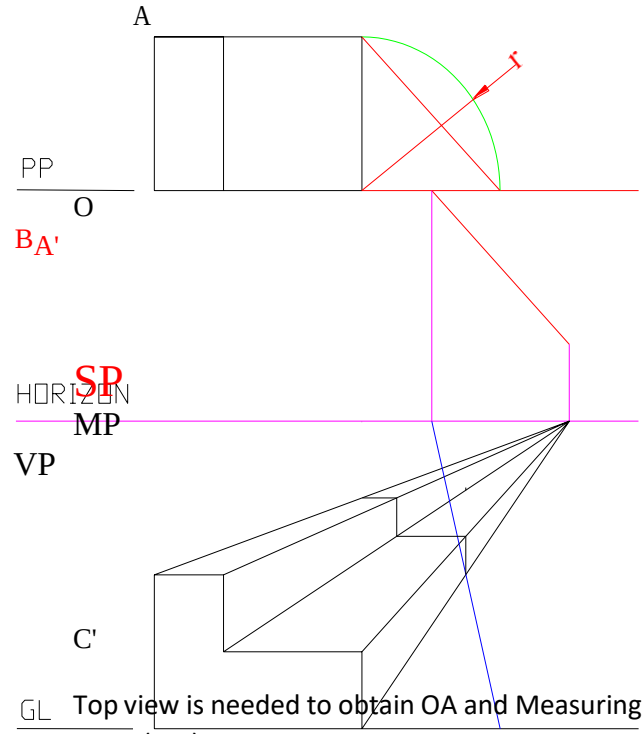
1. Prepare Top, and Front view.

2. Using point O as a center, draw an arc with OA radius. Label point A', where the arc intersect the picture plane.

3. Set your station point arbitrarily, that satisfy angle of inclusion for vision cone less than 30°. Then project a parallel line with AA', passing through station point to the picture plane. Label as B where the parallel projectedline intersect with the picture plane.



4. Draw a horizon line between top and front view. It can be above station point or below. Projecting perpendicular line from station point to the horizon we find *Vanishing point*. Then draw perpendicular line to the horizon that pass through point B. This point is called a *measuring point*.



5. Using 'r' or OA measurement, locate point D and project a line from MP to D in order to obtain point C'. Finally using point C' as a reference transfer all edges from top with parallel lines to the front edges.

Note:

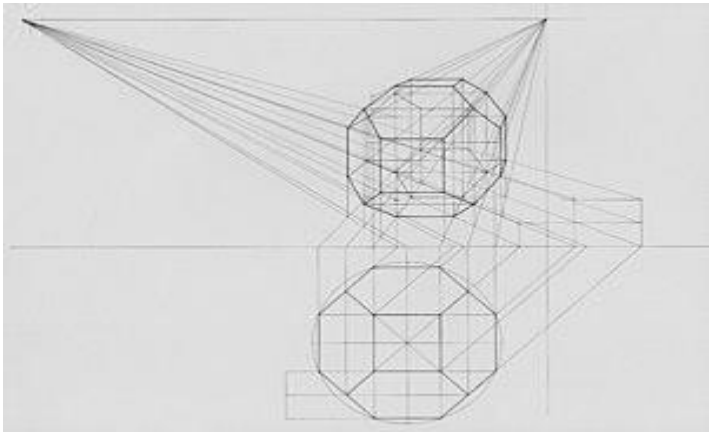
CD = OA = OA'SPB // A'A

BMP ⊥ HorizonSPVP ⊥ Horizon

Top view is needed to obtain OA and Measuring point (MP).

TWO POINT PERSPECTIVE DRAWING

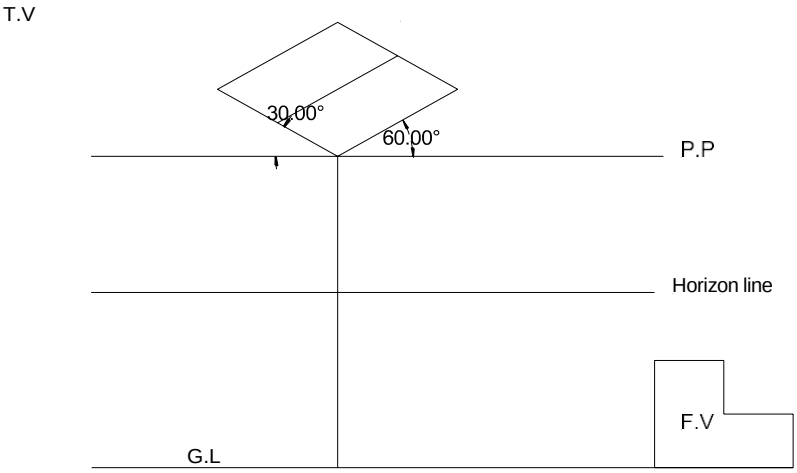
Two surfaces of an object are positioned at an angle to the picture plane. Here two vanishing points are required to draw the object as a perspective. In this perspective one of the principal axes of the object is parallel and the other two are inclined to the picture plane



Procedures of construction:

The following steps are employed for constructing a two point perspective.Step 1:

Draw top view in such a position that its principal edge makes angle of 30 and 60 with picture plane. And draw front view of the object to the left or to the right of the top view.

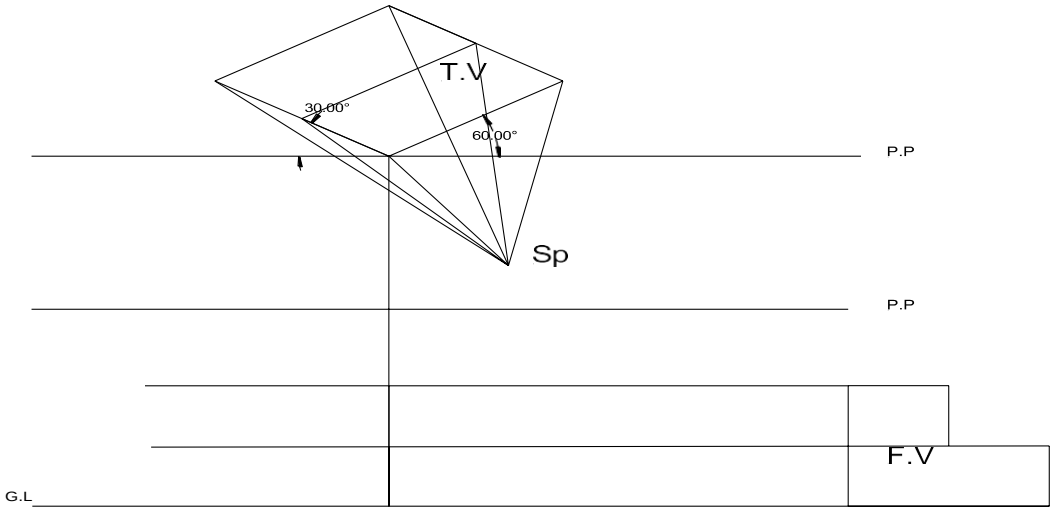


S

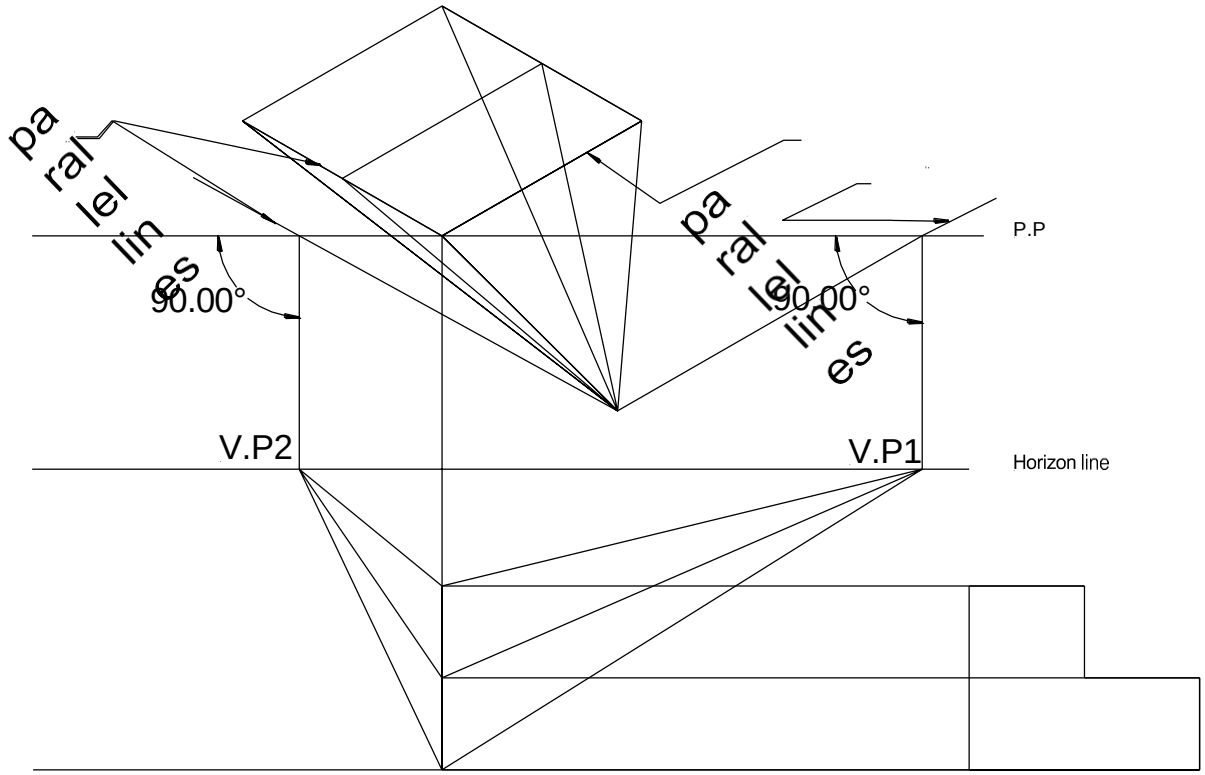
tep

2:

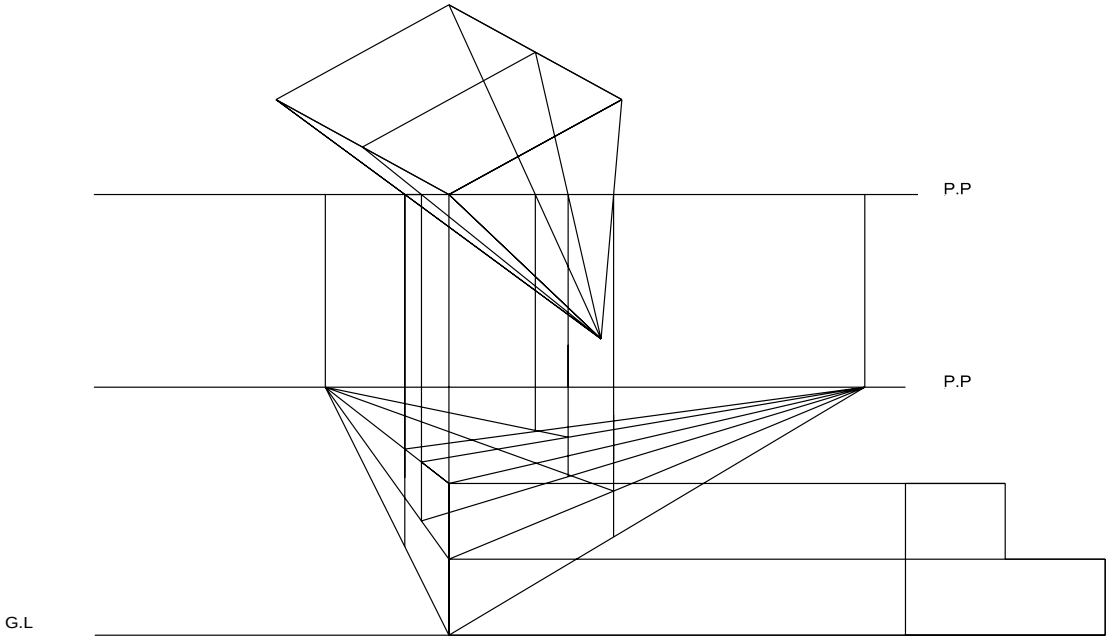
Select station point (SP), approximately to the center of the object. And draw the projectors from the station point to all points of the top, locating the piercing point of each projector with the P.P, and project all points of front view perpendicular to the vertical edge.


T.V
30.00°
60.00°
P.P
Sp
P.P
F.V
G.L

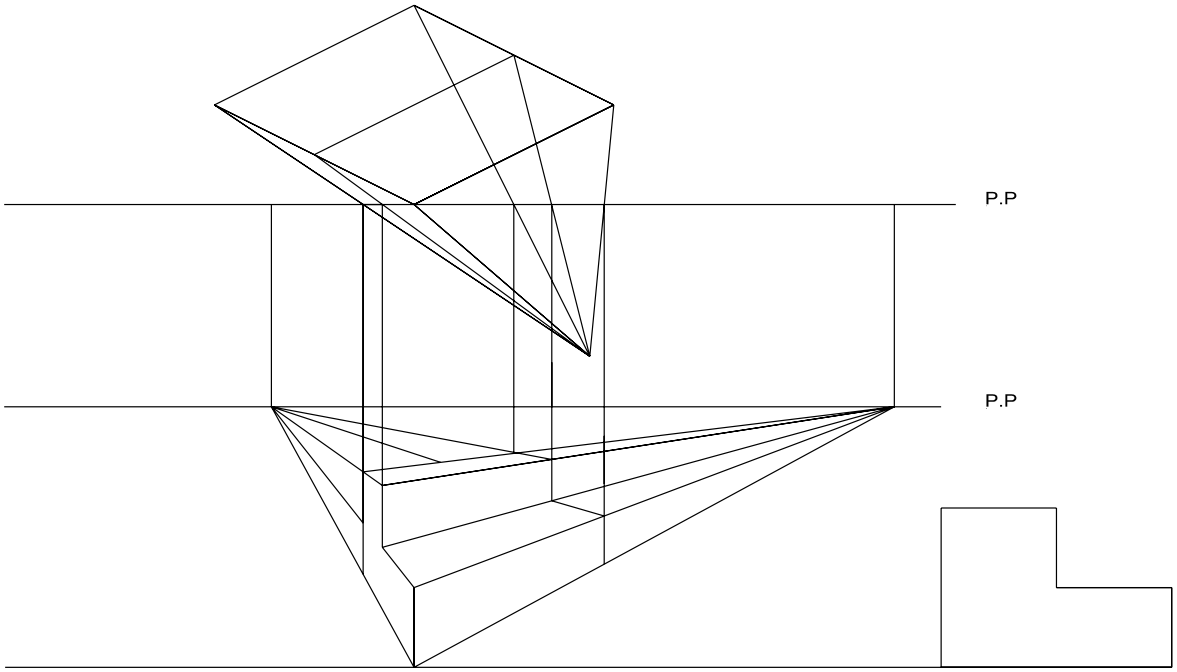
Step 3: Locate vanishing points on the H.L by first drawing a 30 and 60 line from Sp to horizon line.



Step 5: Project the piercing point

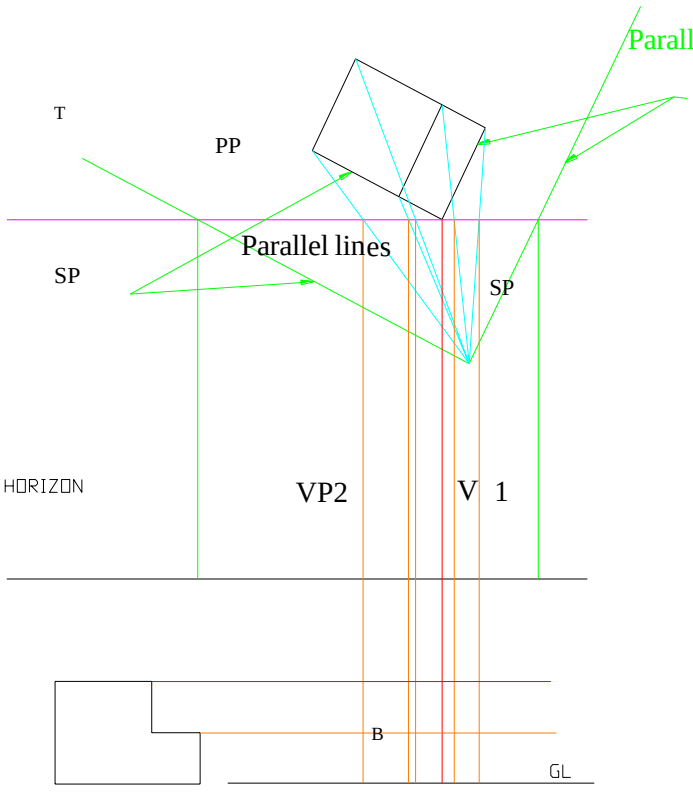


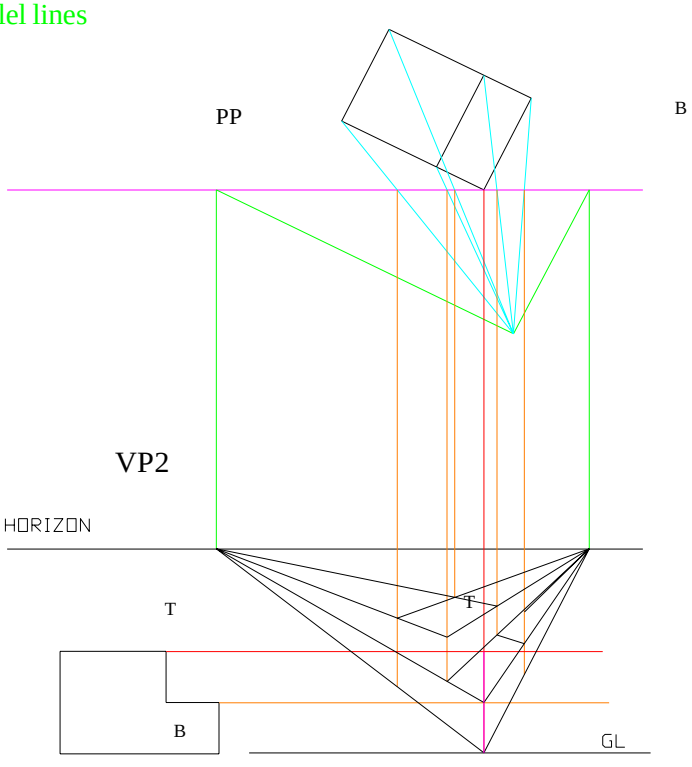
Step 6: Erase unnecessary lines and we gate the final object.



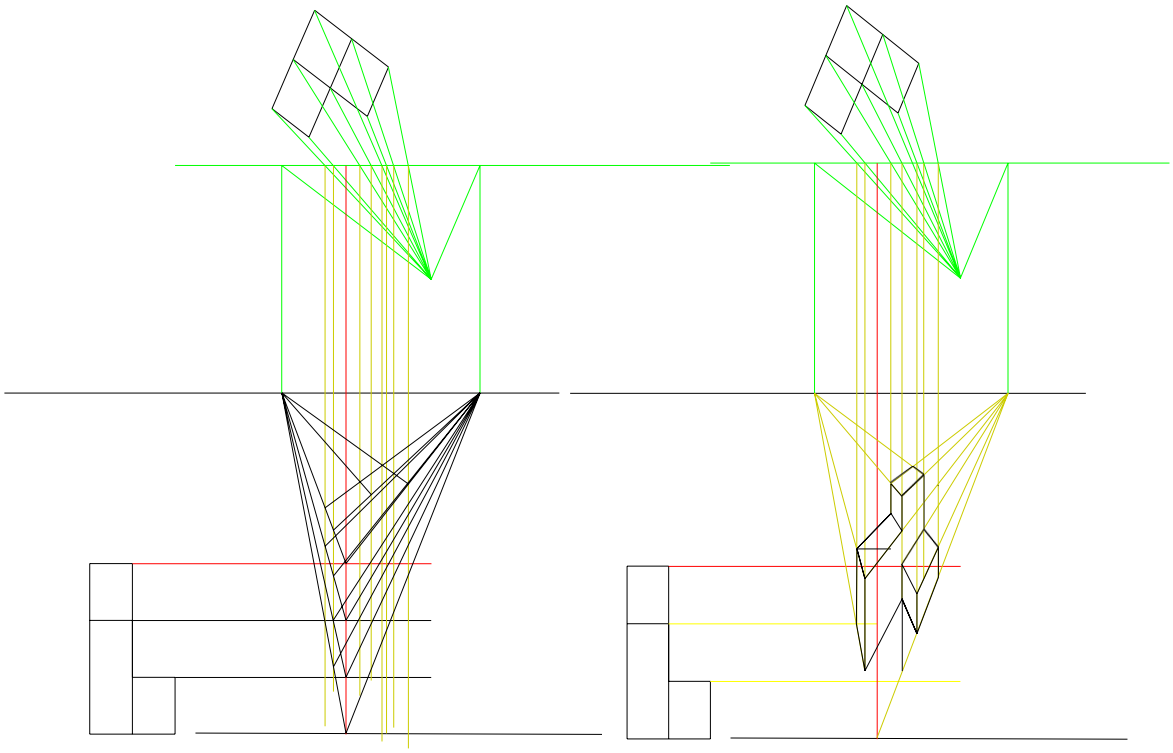
Exercises:

Draw a two point perspective drawing for the following multi views.1.





2. Please study the following questions:

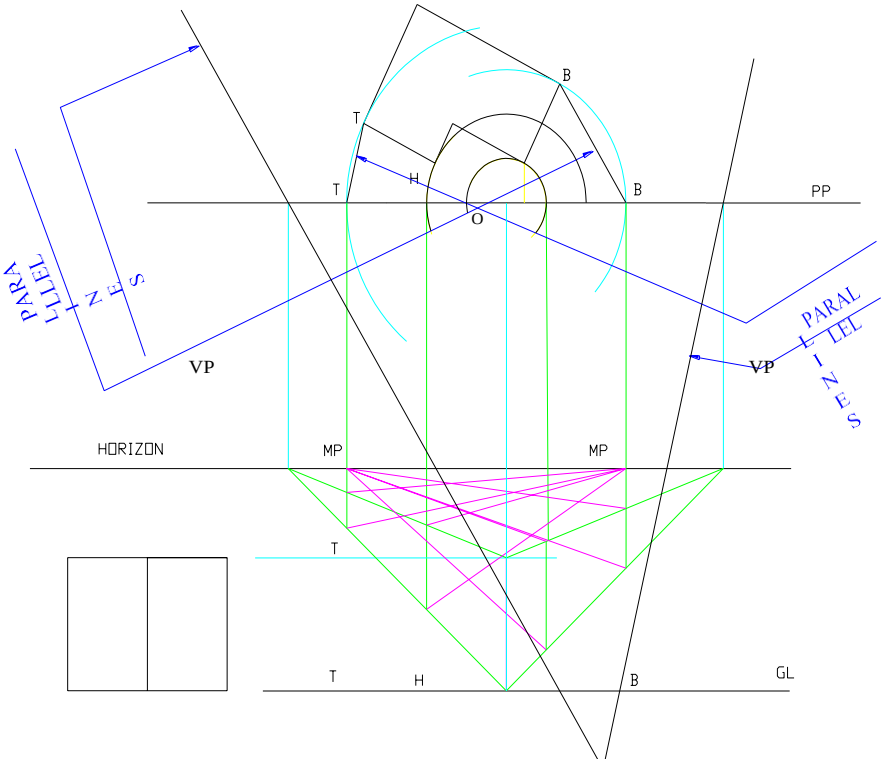


Note:

The shape of our perspective object goes distorted when cone opening to vanishing points is less than90.

Two point perspective using measuring point method:

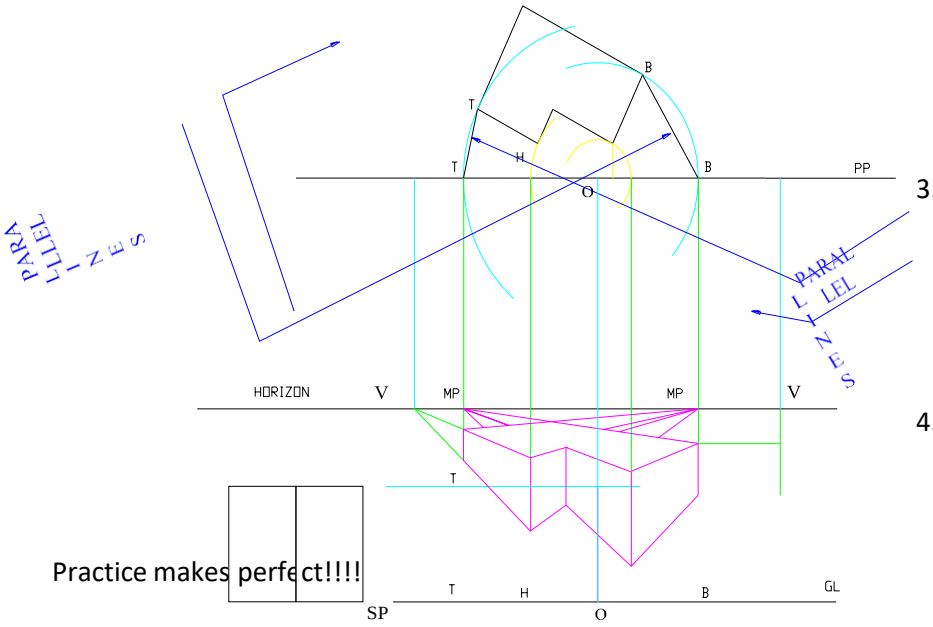
The same to one point perspective measuring point method, two point measuring method eliminatesthe need of top view above front view after vanishing point was determined.



Procedures:

1. Align top view offset to the front view. Using point O as a center of your arc, develop arcs to the most side ends and line intersections if there issome. Eg: Arc OH, OT,OB

2. Project a line passingthrough station point whichis parallel to line BB and TT. Then we will project a perpendicular line to the horizon where those lines



emerging from SP intersect with picture plane (PP). Here we will find Vanishing points (VP).

3. Now determining the trueedge from the front view,we project the ends of the true edge to vanishing points. And other back edges would be projected to measuring points (MP).

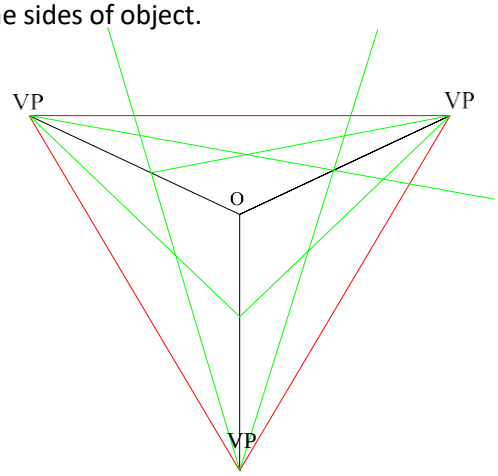
4. Finally transferring each edge by projection andinterpreting with the front view, we complete.

Practice makes perfect!!!!

THREE POINT PERSPECIVE DRAWING

A three point perspective can be constructed by positioning the object so that all of its sides makeangles with the picture plane.

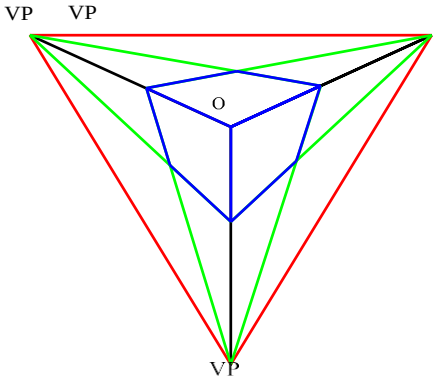
Three vanishing points are located by constructing lines form the two views of the station point that isparallel to the sides of object.



Procedure of construction

1. Construct an equilateral triangle. The vanishing points lie at each vertex. Locate point O anywhere within the triangle.

2. Draw a horizontal through point O. The width and depth can be laid off from point O. Top view will be
located on the upper two vanishing points projection to O.



3. The height is laid off along a line thatis parallel to one of the triangle's sides. Then the intersection point will be projected back to the other vanishing point.

4. measurements will be transferredon edge OVP. It is with true measurement going to be drawn.

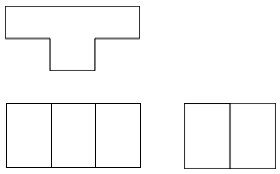
==========//==========

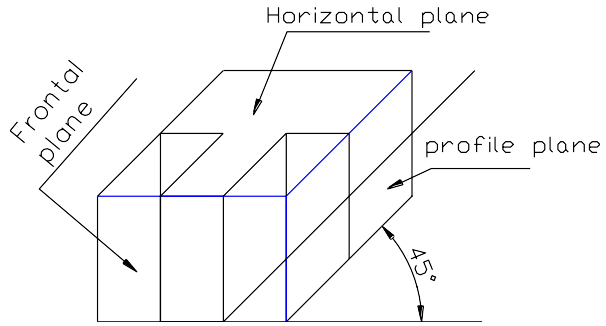
4.3 ISOMETRIC & OBLIQUE DRAWINGS

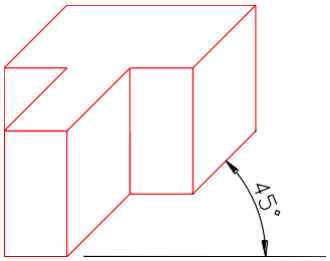
Most commonly used pictorial drawing type is Isometric drawing. However, Oblique drawing is thesimplest one. As a result this topic goes depth of Oblique and Isometric construction techniques respectively.

Oblique drawing exercises:

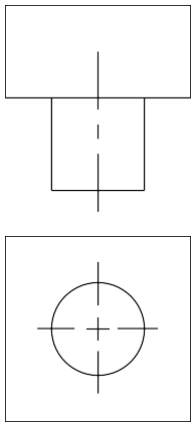
1.

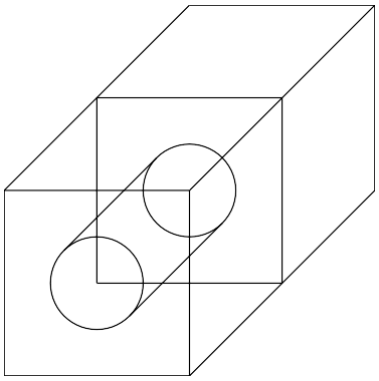


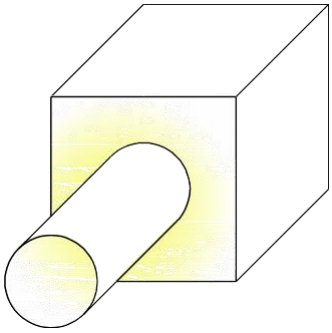




2.

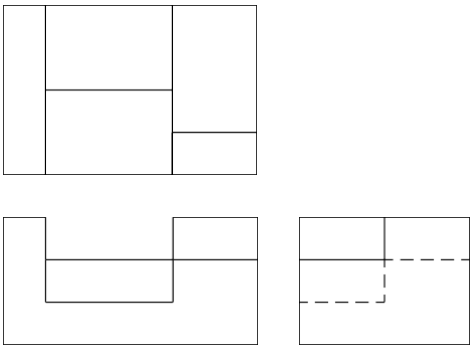


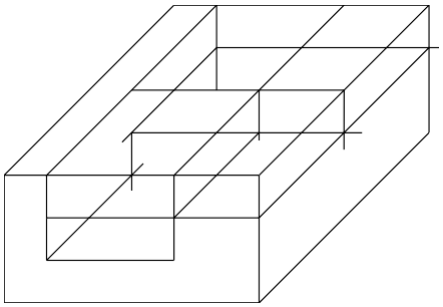


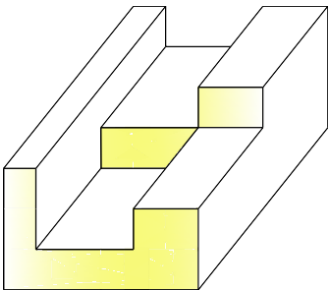


Note: Whenever we have a multi view with circular feature or irregular shape, it is better to selectfrontal plane for the circular and irregular feature.

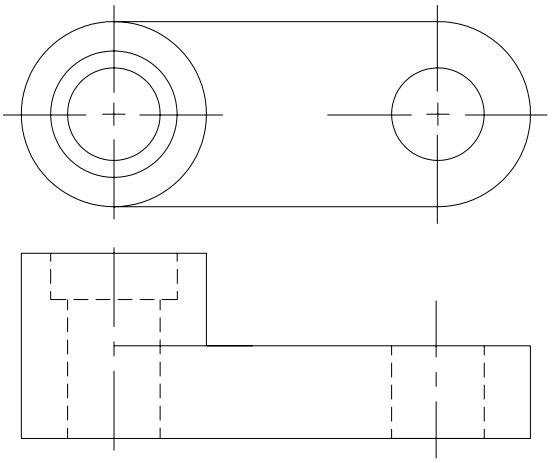
3.

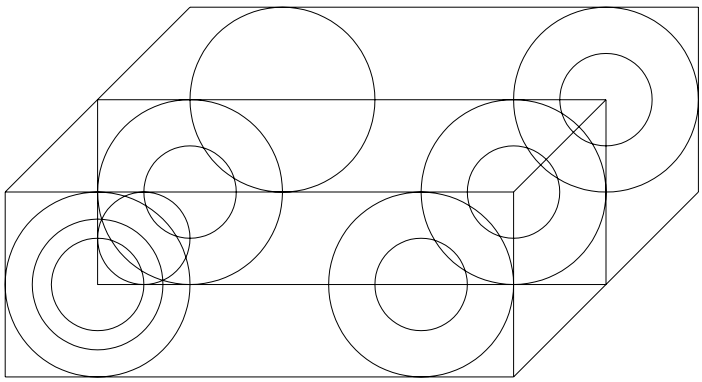


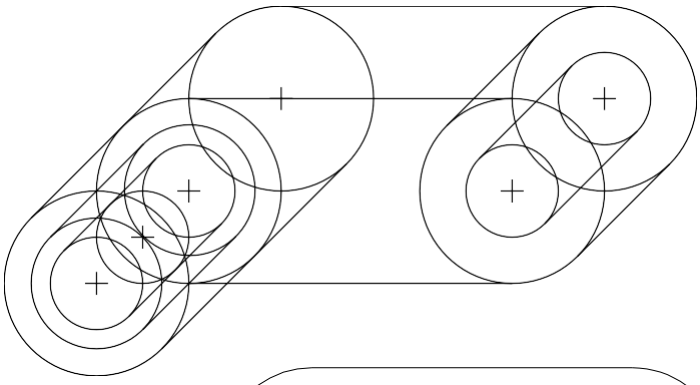


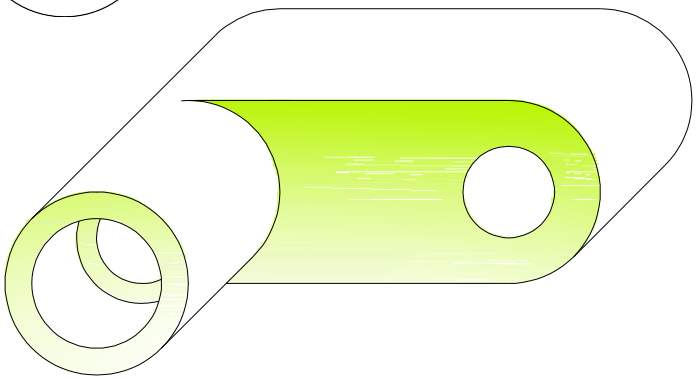


4.









Procedures:

a. Draw oblique drawing construction box. Then try to sketch all views on the principal planes.

Eg; Top view on the horizontal plane, Front view on frontal plane and finally profile will consist side view. *This time you have to place circular feature on frontal plane, because circles appear true shape on frontal plane of oblique drawing.* We can rotate theobject as indicated here.

b. Transfer each features from horizontal, frontal and profile. Then interpret the intersections of each lines.

Draw all arcs on frontal plane and connect with tangent lines.

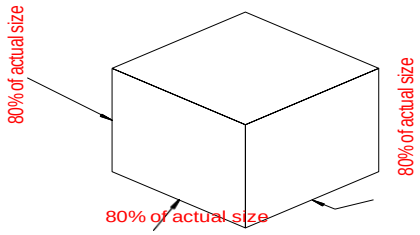
c. Remove all irrelevant construction lines. Complete making all edges of the object bold.

Notice:

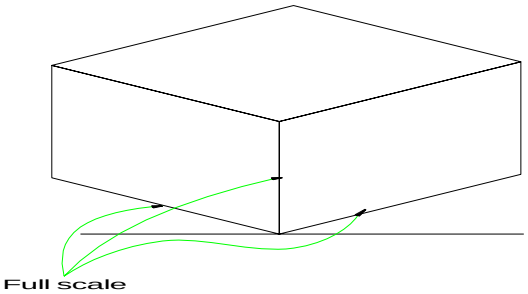
Construction lines have to appear on the drawing to indicate whether a student has followed the steps or not.

Isometric drawing exercises:

- ✓ Most common type of axonometric projection in which all three principle axes are oriented at the same angle to the projection plane (all three faces are equally inclined to the drawing surface) and are drawn on the same scale.
- ✓ When a drawing prepared with an isometric scale, or otherwise the object is actually projected on a plane of projection, it is an isometric projection. All distains in isometric scale are 80%of theactual size.
- ✓ A pictorial representation of an object(Isometric drawing) in which all three dimensions are drawn at full scale rather than foreshortening them to the true projection. An isometric drawing looks like an isometric projection but its all lines parallel to the three major axes are measurable.



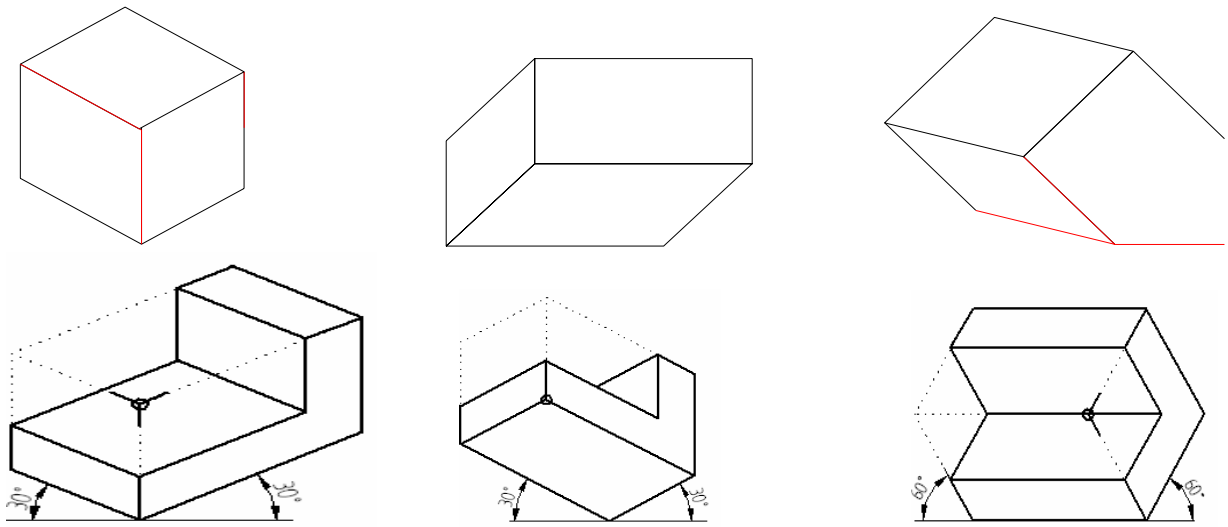
A) Isometric projection

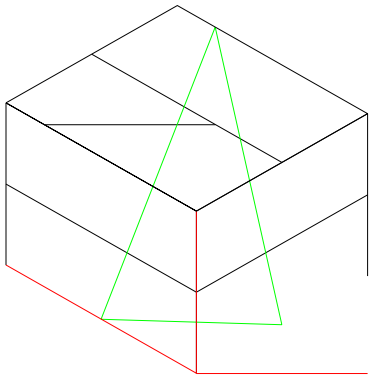


B) Isometric drawing

Position of isometric axes.

The isometric axes may be placed in any desired position that may be best describe the shapeof the object.

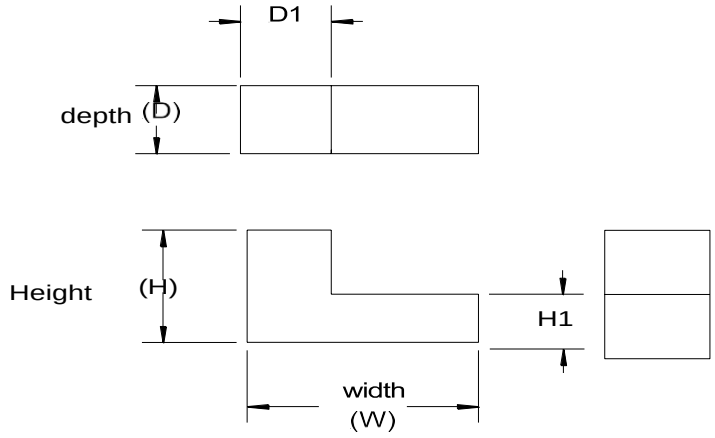


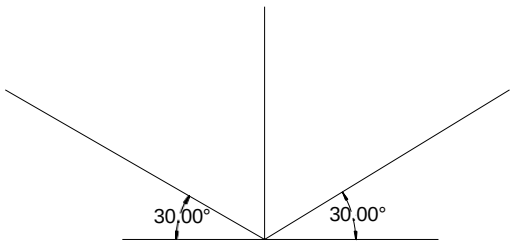


- Isometric axes are edges of the object that meets at thecorner nearest the observers.
- Lines which are parallel with isometric axes are calledisometric lines.
- Lines which are not parallel to isometric lines are called none-isometric lines (they are inclined lines).

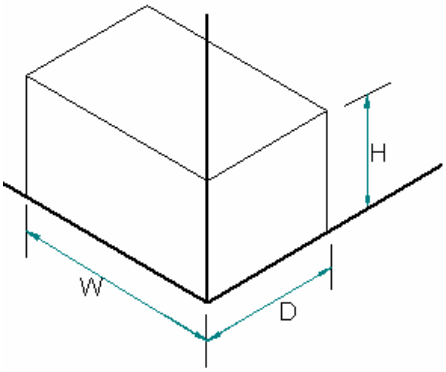
Steps in making isometric drawing

The steps in constricting an isometric drawing of an object composed only of normal surfaces are shownbellow.

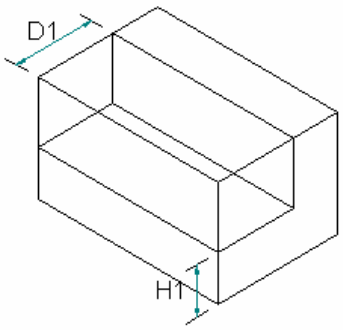




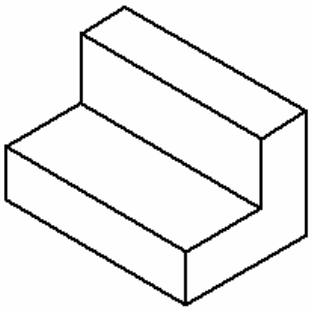
Step 1: create isometric axes



Step 2: Create B-box



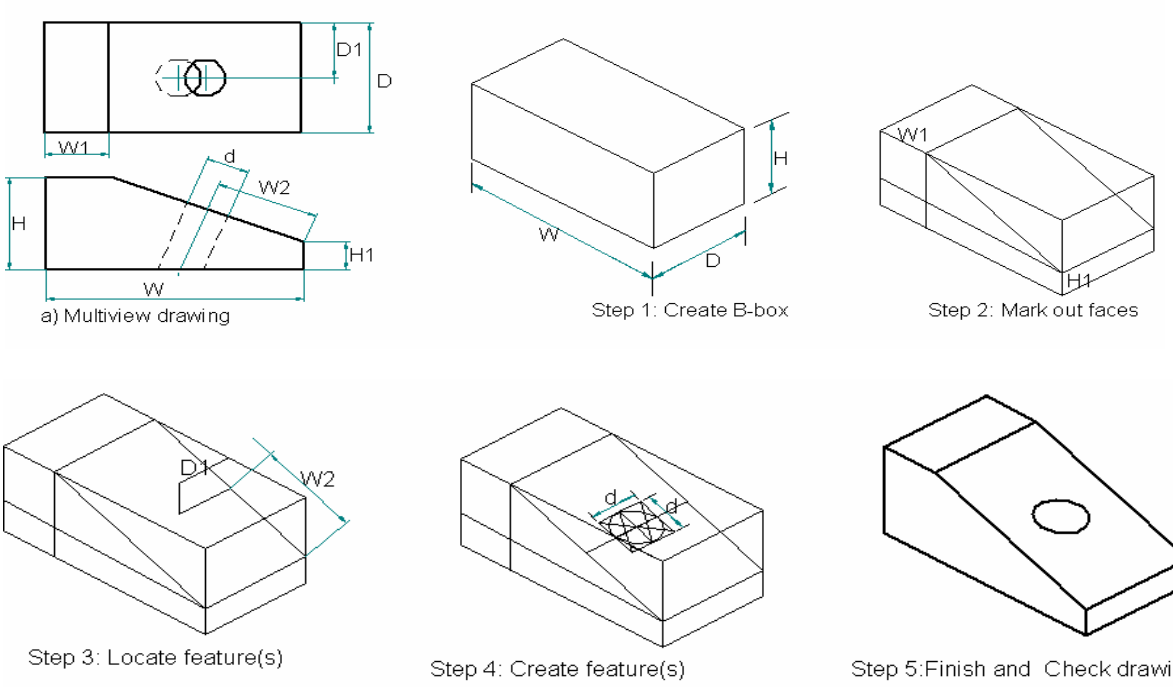
Step 3: Mark out faces



Step 4: Finish drawing

Object with Inclined Surface.

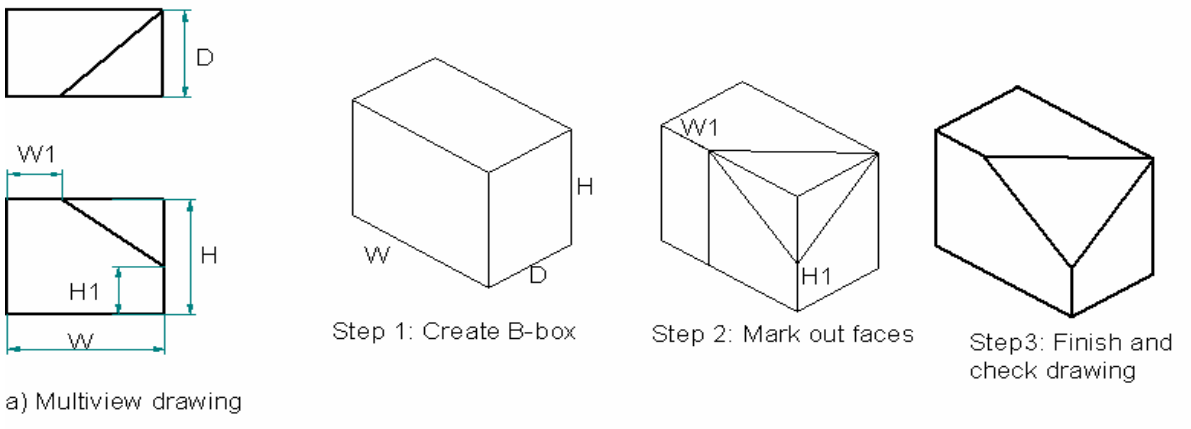
Below in the figure shows the construction of the isometric drawing of an object with inclined surface. Themulti-view drawing of the object is shown in **fig a**.



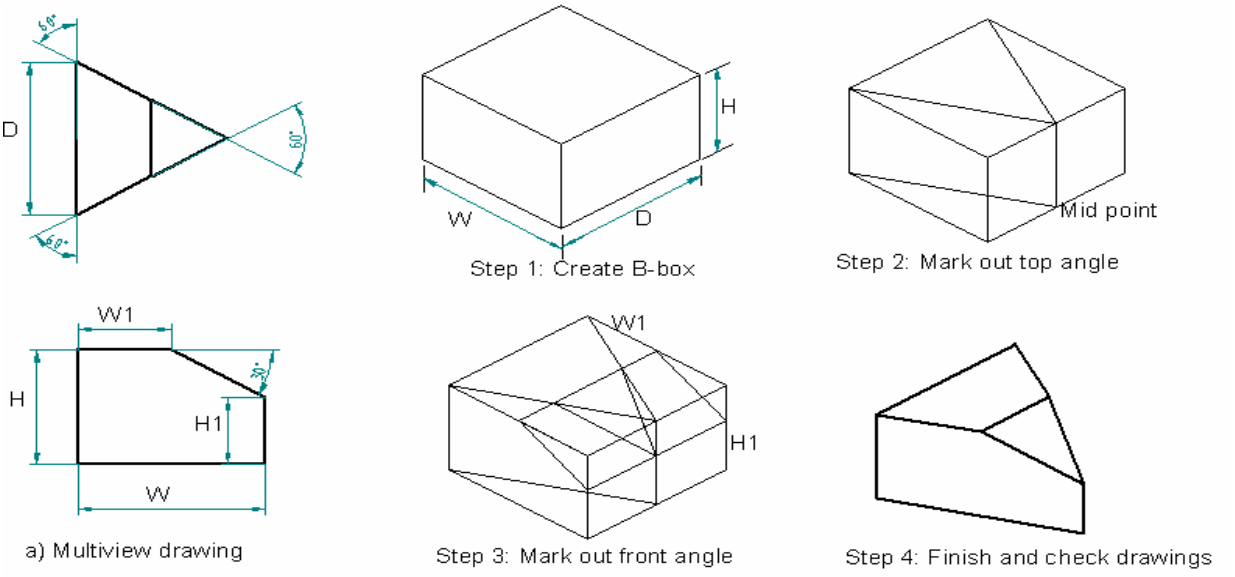
Box method for inclined face

Object with Oblique surfaces.

- Oblique surface in isometric may be drawn by establishing the intersection of the oblique surfacewith the isometric plane.



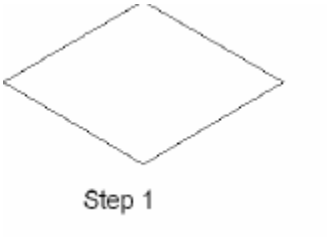
Angles in isometric drawing.



Circles in isometric drawing

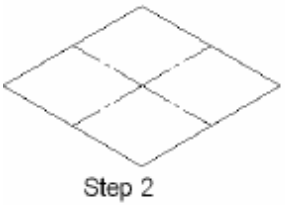
Circles in isometric drawing always appear as true ellipse. There are different methods to constructellipse. But here using four center method is more convenient.

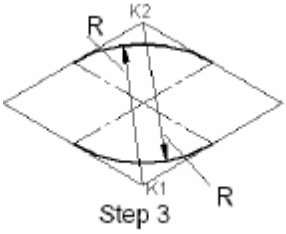
Steps to construct circles in isometric drawing



Step 1: **Draw a square using the circle diameter as size**
For the top isometric circle, the top isometric plane is the right surface to drawthe square. The top isometric plane is horizontal as can be seen in step 1 of the following figure. Draw the isometric square.

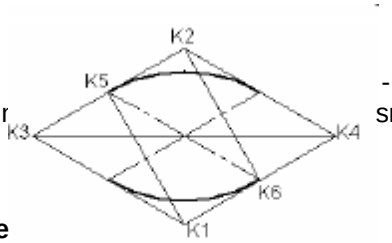
Step 2: **Draw the center lines of the square**
Draw the two center lines of the square as shown in Step 2.



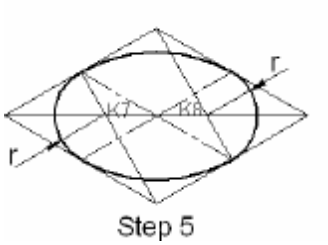


Step 3: **Draw the big arcs of the isomeric circle**
Identify the key points K1 and K2. These are two centers of the four centerellipse technique. Notice that these centers are located at the obtuse anglecorners of the isometric square. Using the radius R, with centers at K1 andK2 draw the two big arcs for the isometric circle as shown in Step 3

Step 4: **Locate the centers of the small arcs of the isometriccircle**
Draw the diagonal K3-K4 between the acute angle corners of thesquare. -K6. The intersection (K7)of the lines K3-K4 and K1-K5 in Step 5 locates one ce r small arc center is located at K8, the intersection of lines K3-K4 and K2-K6.



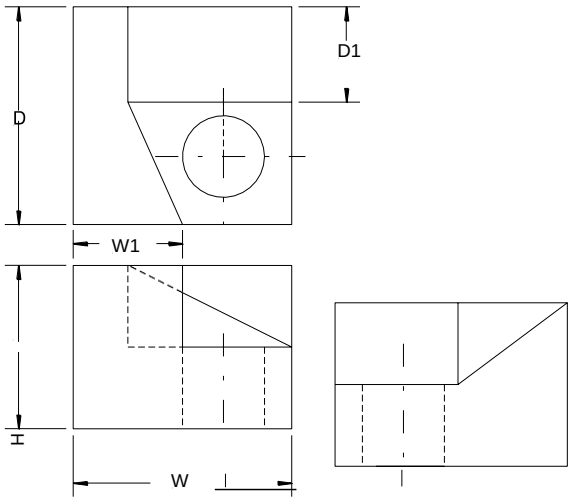
Step 4

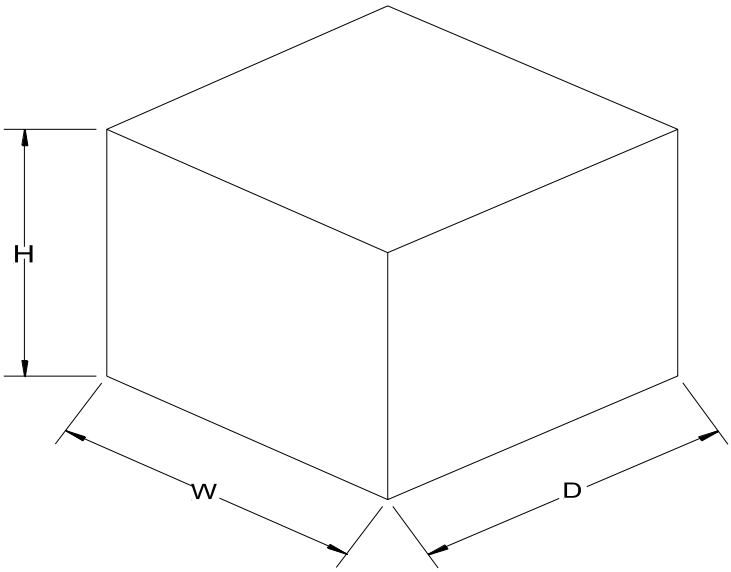


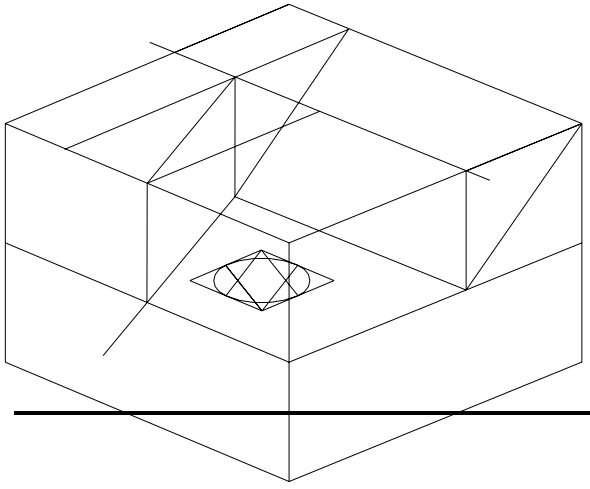
Step 5

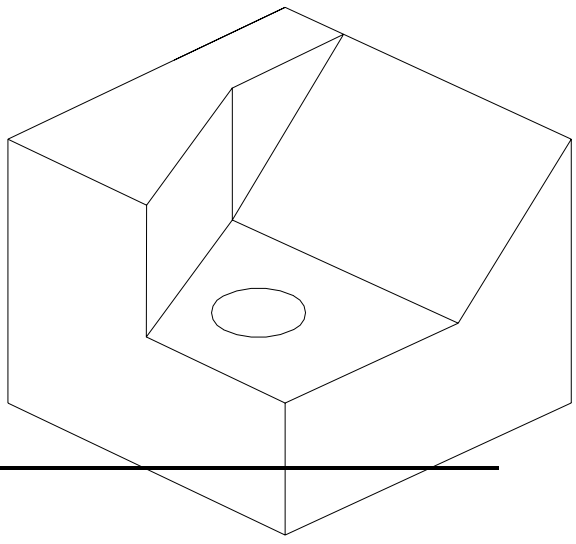
Step 5: **Draw the small arcs of the**
Using the centers of the small arcs I rcs of radius r, as shown in Step 5. Verify that the big and small arcs are tangent to the isometric square.

Examples.









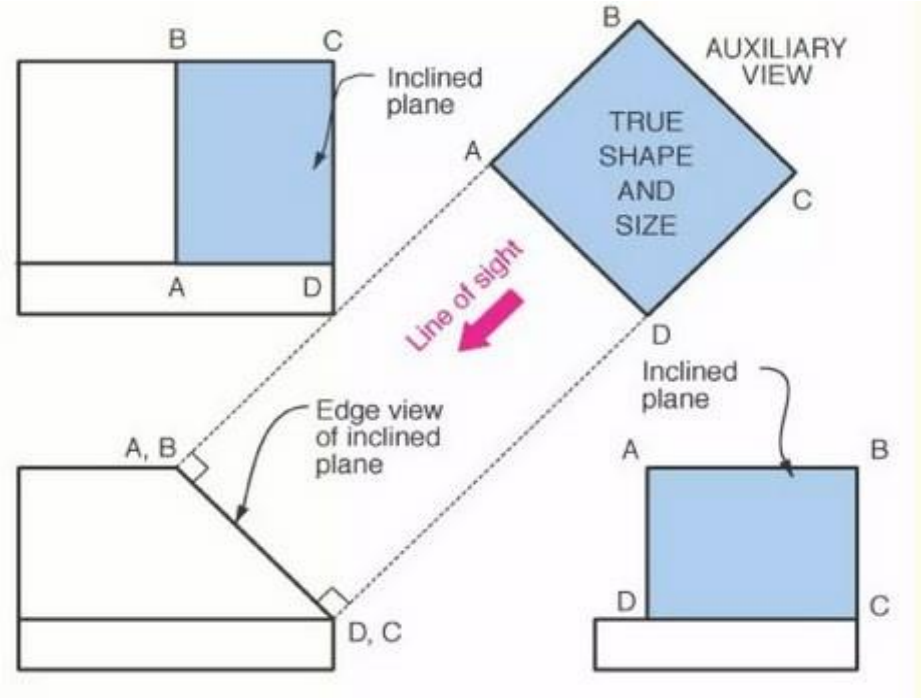
AUXILIARY VIEWS

Objectives

- Able to define auxiliary view**.**
- Understand how to create an auxiliary view of and inclined plane.
- know the situations where an auxiliary view is desired.
- Locate the top adjacent ,front adjacent and side adjacent auxiliary view constructed from primary views.

definition

An *auxiliary view* is an orthographic view that is projected into any plane other than one of the six *primary views*. These views are typically used when an object contains some sort of inclined plane. Using the auxiliary view allows for that inclined plane (and any other significant features) to be projected in their true size and shape. The true size and shape of any feature in an engineering drawing can only be known when the Line of Sight (LOS) is perpendicular to the plane being referenced. It is shown like a three-dimensional object. Auxiliary views tend to make use of axonometric projection. When existing all by themselves, auxiliary views are sometimes known as *pictorials.*



An auxiliary view serves three purposes:

- It illustrates the true size of a surface
- It illustrates the true shape of a surface, including all true angles.
- It is used to project and complete other views.

Note:

- Auxiliary view is projected 90^{o} from the inclined or slanted plane.

- Hidden lines should be omitted in auxiliary view, unless they are needed for clarity.

Orthographic projections fail to illustrate the true shape of a surface. Hence it is necessary to further project for auxiliary view. There are two types of auxiliary views. These are:

1. Primary auxiliary view &
2. Secondary auxiliary view

On the other hand, auxiliary views can be projected as

i. Partial auxiliary view and
ii. Complete auxiliary view.

5.1 PRIMARY AUXILIARY VIEW

- Is projected on a plane that is perpendicular to one of the principal planes of projection and isinclined to the other two.

During auxiliary view work:

- ✓ Projection is 90° from the inclined surface.
- ✓ Reference line is parallel to the inclined surface.
- ✓ All distances have to be transferred accurately.

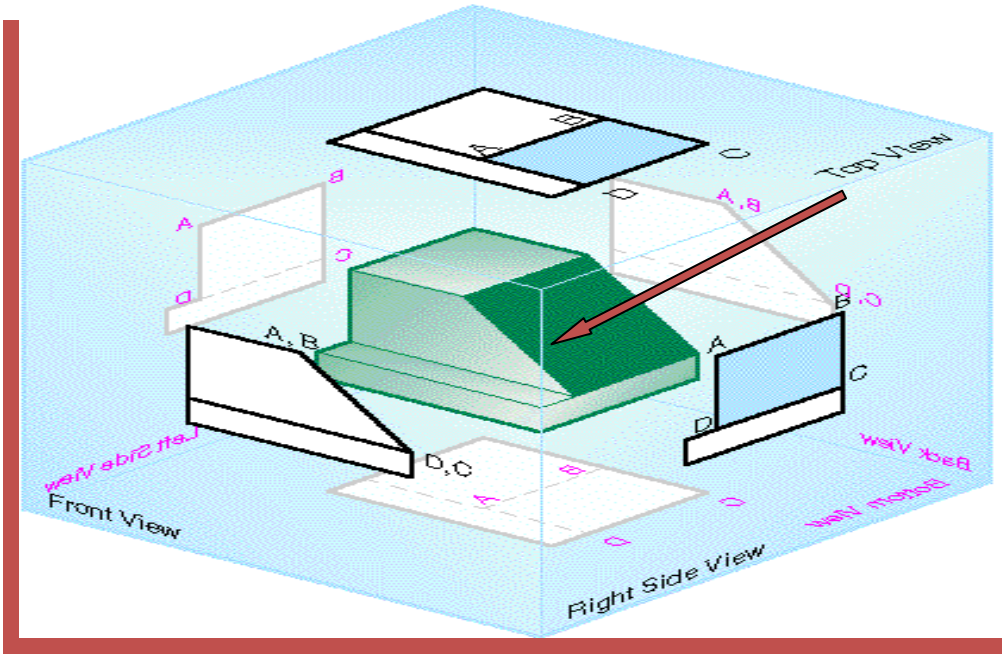


Figure of general auxiliary view(6 principal views) in drawing

5.2 Partial Auxiliary Views

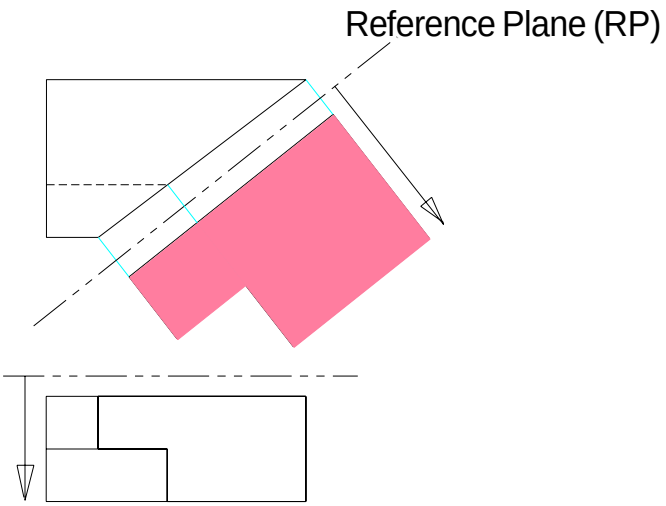
Purpose: To simplify the shape description. It shows only one surface of an object.

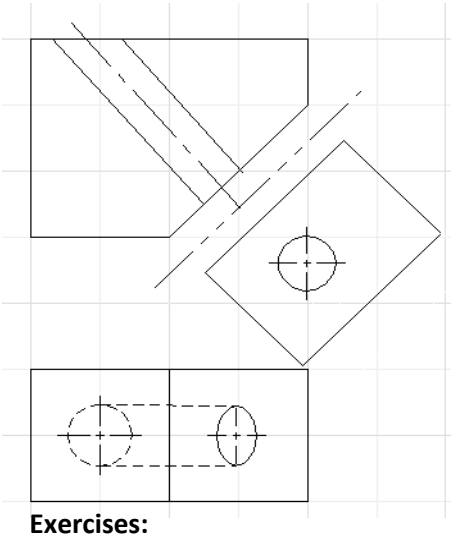
Rules:

1. Identify the view in which the surface is shown as a sloped line
2. Place the Reference Plane (RP) line in the other view
3. Draw lines perpendicular at every point on the sloped line
4. Draw RP line in the auxiliary view parallel to the sloped surface and far away to ensure there isroom to draw the object.
5. Draw the auxiliary view point by point starting from the RP and transport the distance betweenthe points in the true size and shape view.

Auxiliary view from top view:

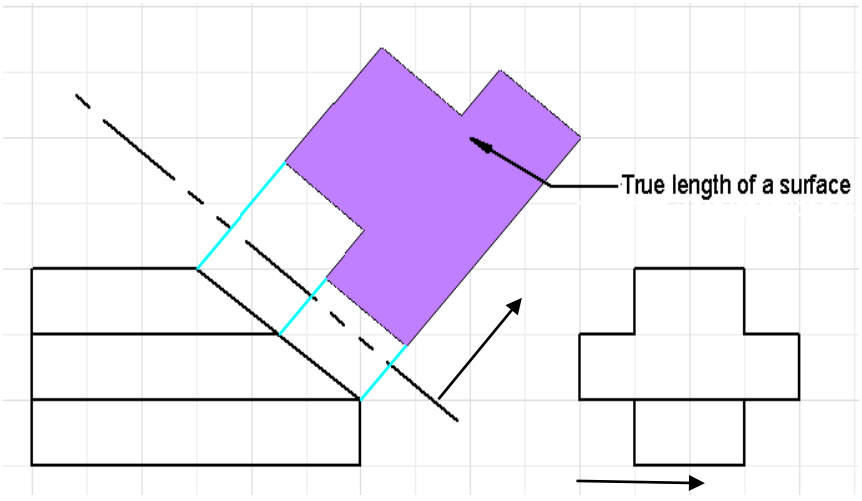
Top is expected to possess inclined plane and it is a view where, we project to obtain the auxiliary view.

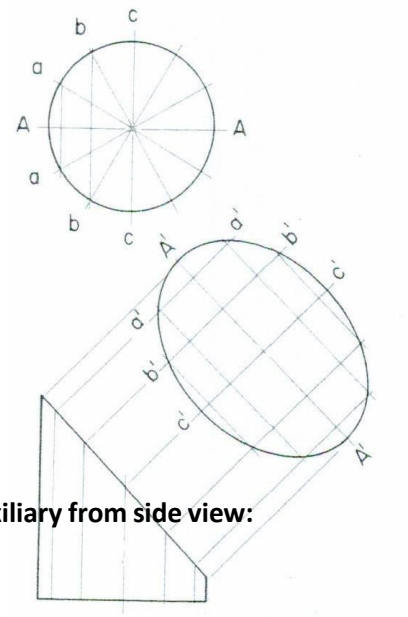




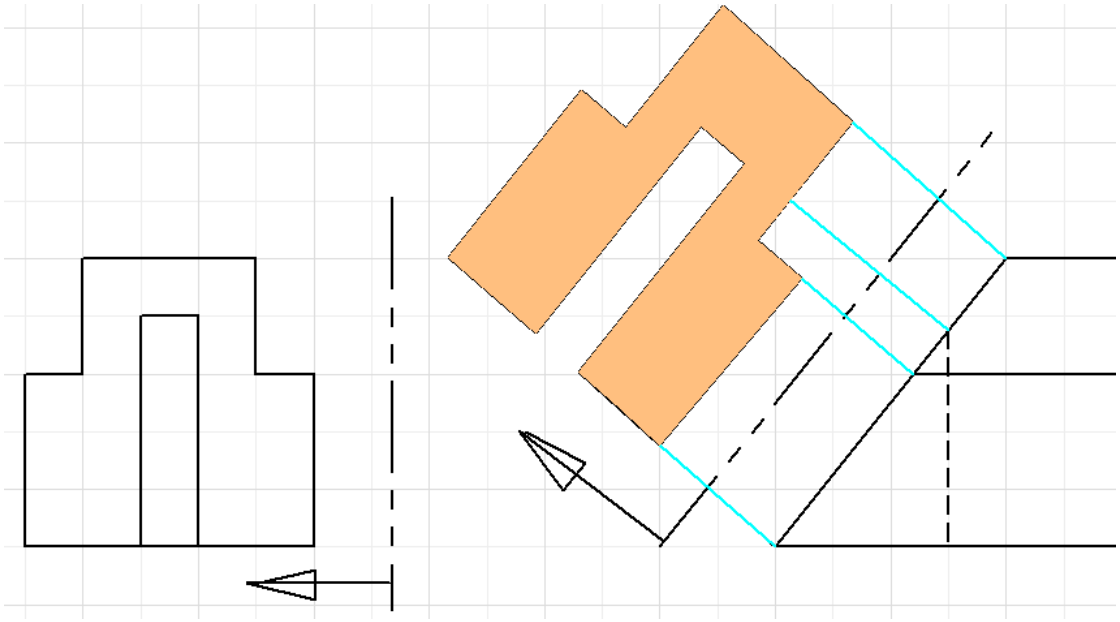
Exercises:

Auxiliary from front view:





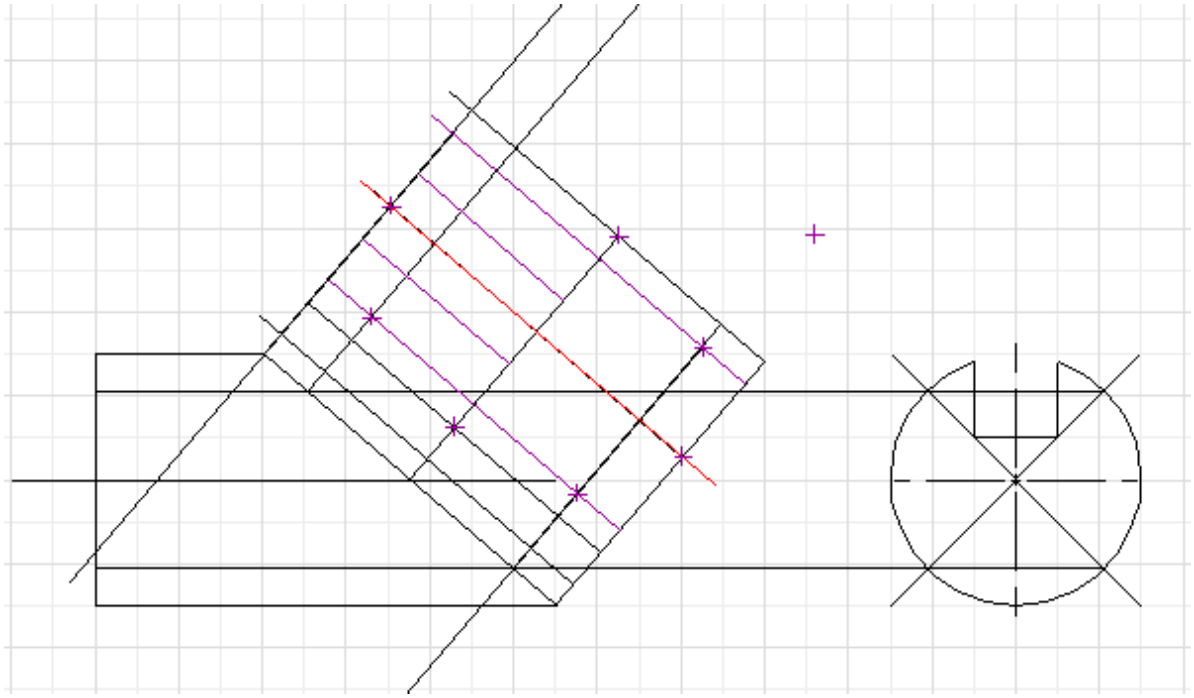
Auxiliary from side view:



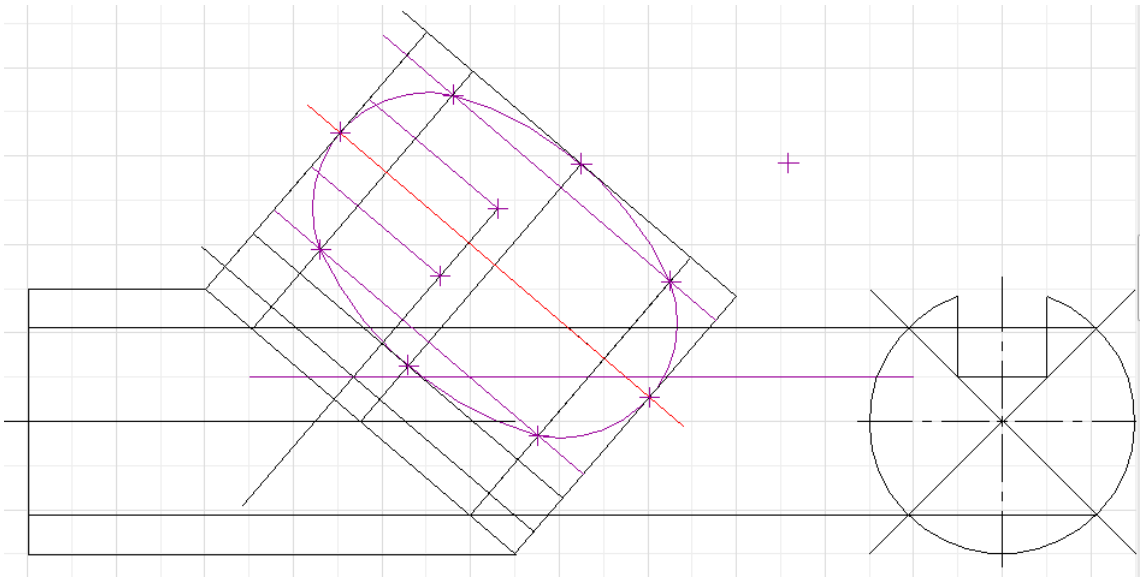
Objects with circular features:

Steps:

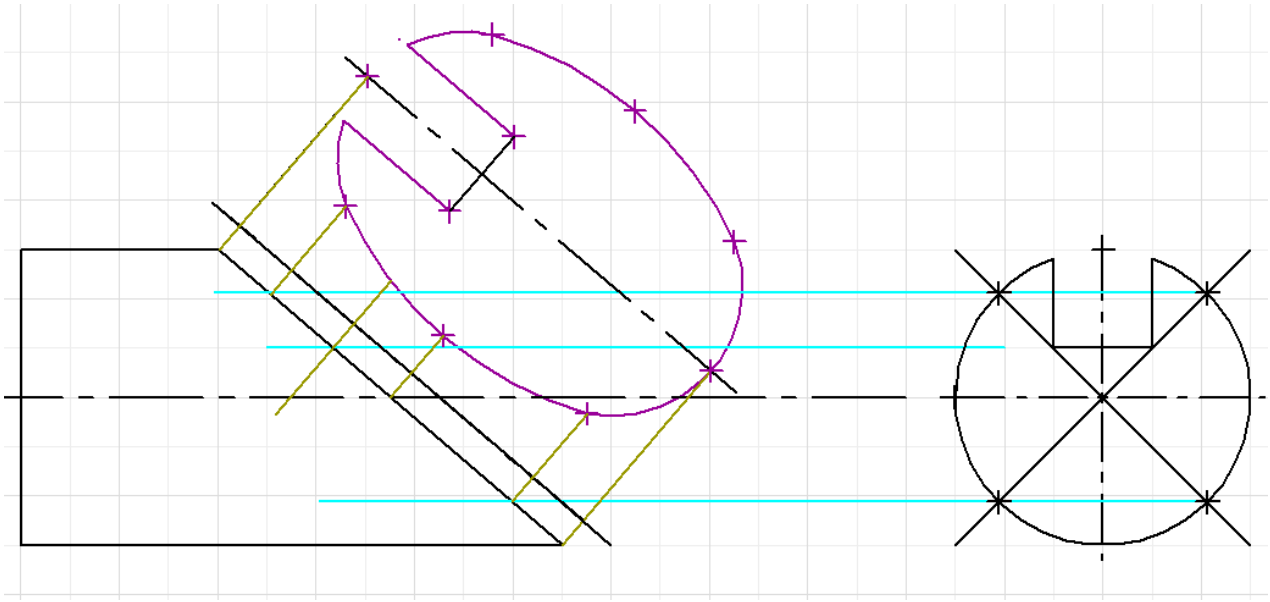
1. Divide the circular feature into equal parts i.e. to 4, 8, 12, 16, … and project each point from the circular part to the inclined edge. Then project each intersection points of the inclined edge to the working auxiliary area.



2. Transfer each dimensions from the circular feature accurately to the auxiliary view.



3. Finally complete connecting the points transferred from the circular feature view.

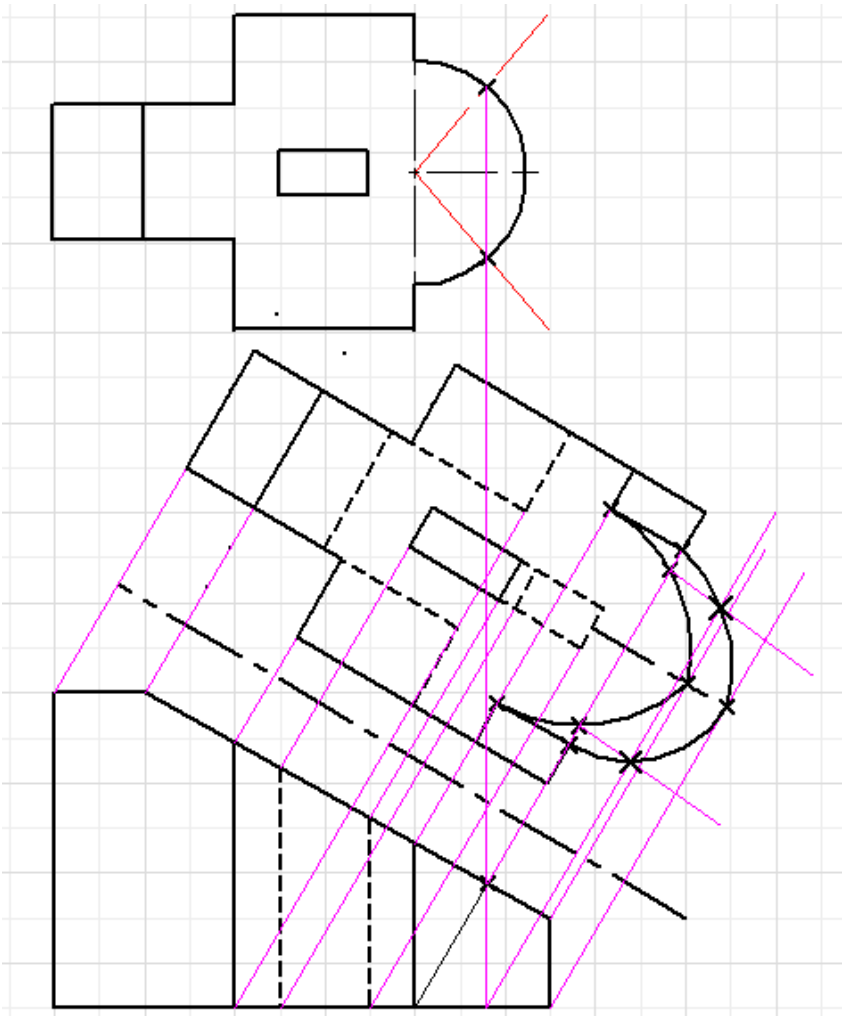


5.3 Complete auxiliary view

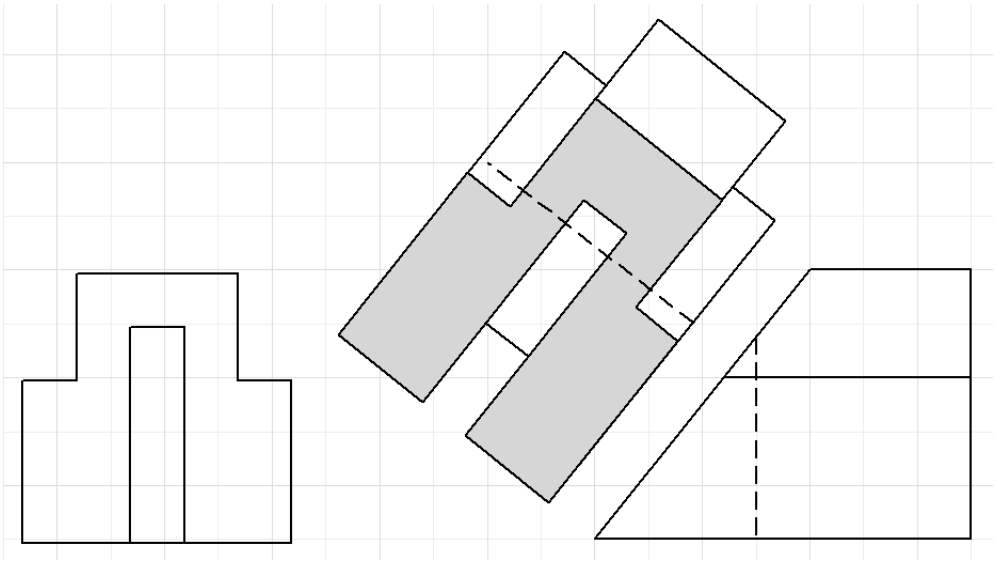
Here no edge will be missed. All visible and invisible edges have to be shown on the auxiliary view. On the other hand, all corners or intersection points of a view that consist the slanted edges have to be projected.

It is common to remove hidden line on auxiliary view. But for the starting point, it has to exist. Students can conventionally remove it as they specialize more on the course.

Study the following Exercises:1.



2.

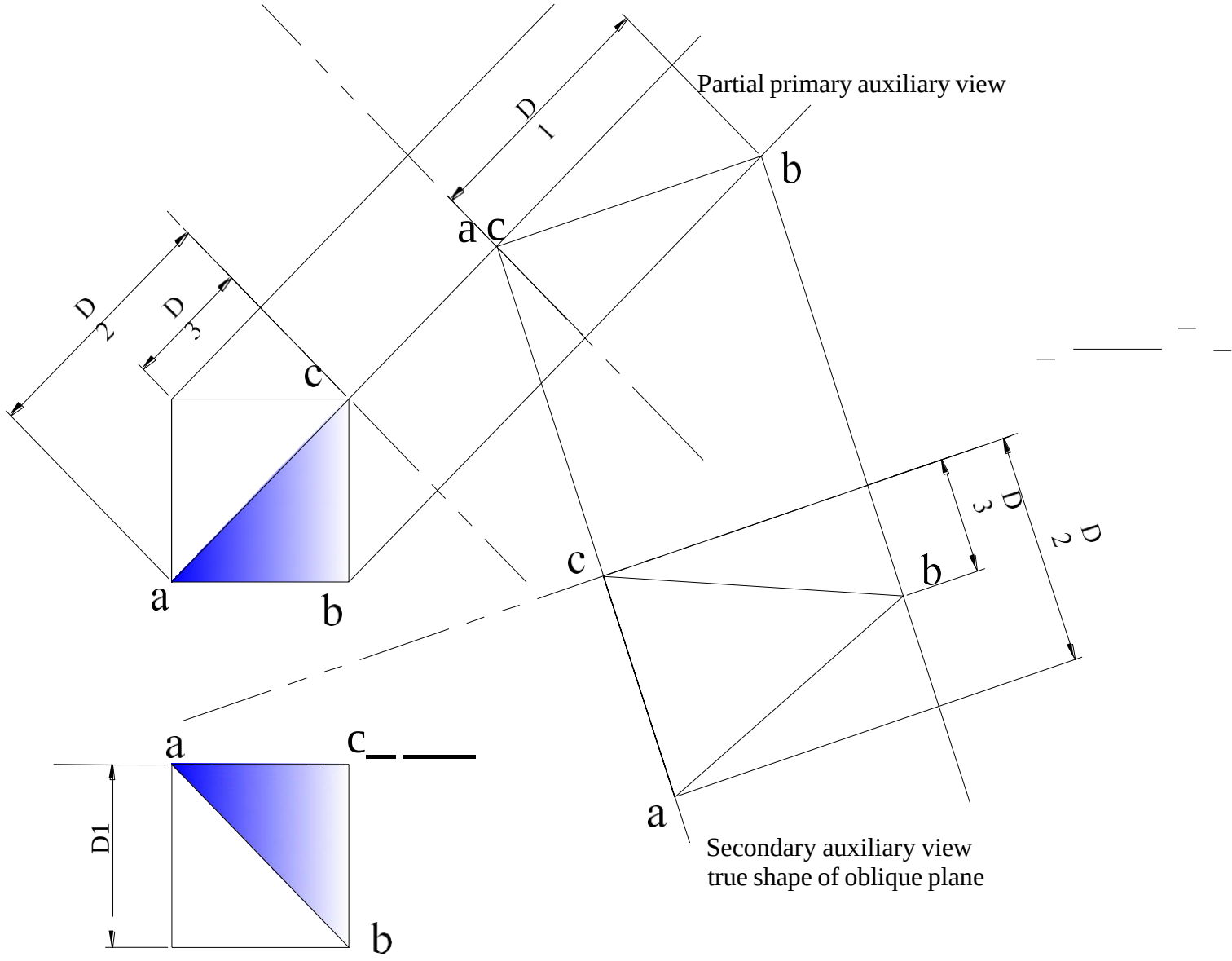


5.4 SECONDARY AUXILIARY VIEWS

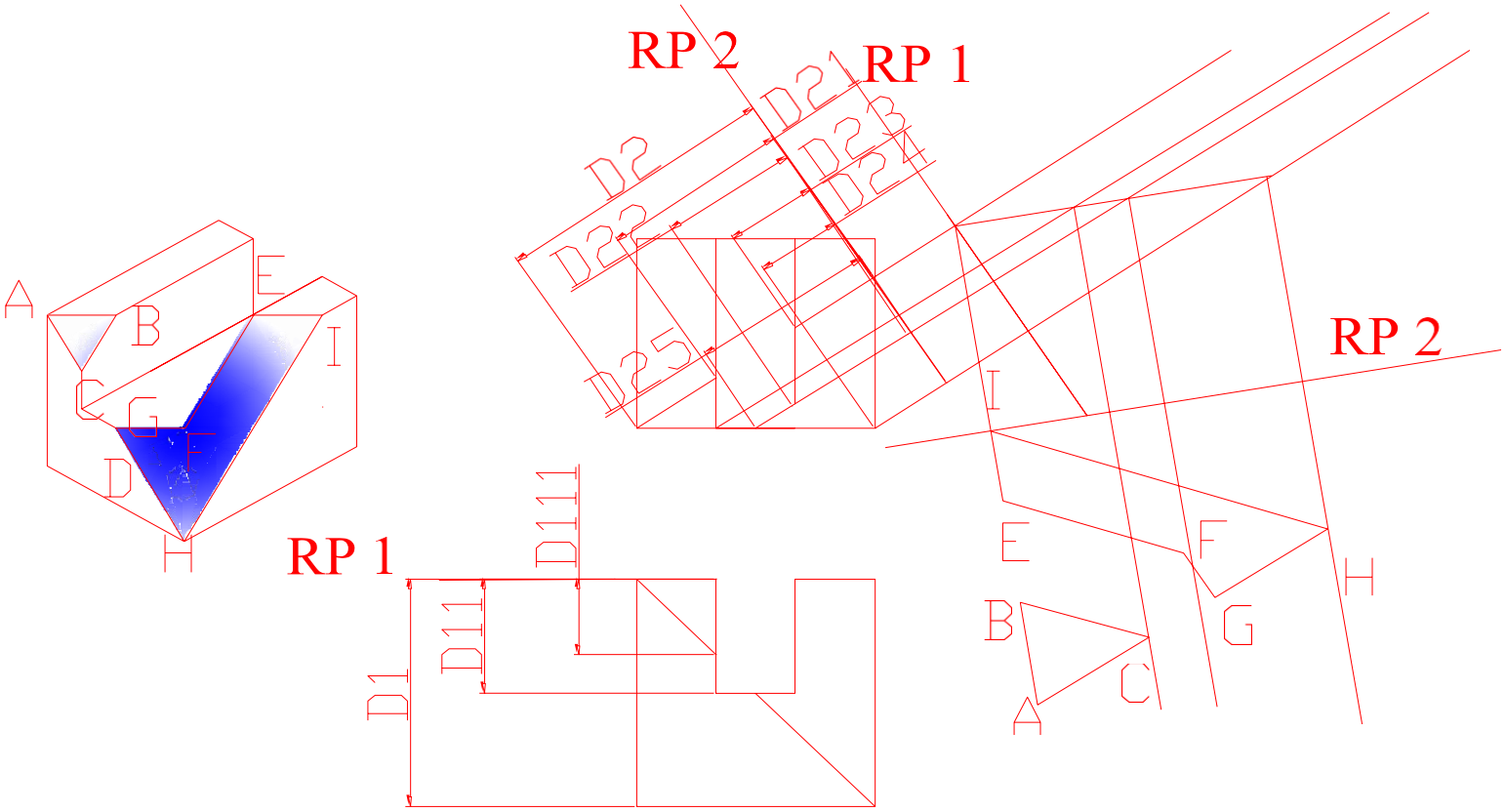
A secondary auxiliary view is projected from a primary auxiliary view and on a plane inclined toall three principal projection planes.

For oblique surfaces, it is difficult to find the true shape and size of a surface. Hence it is a mustto further project the primary auxiliary view. This projection is called Secondary auxiliary view.

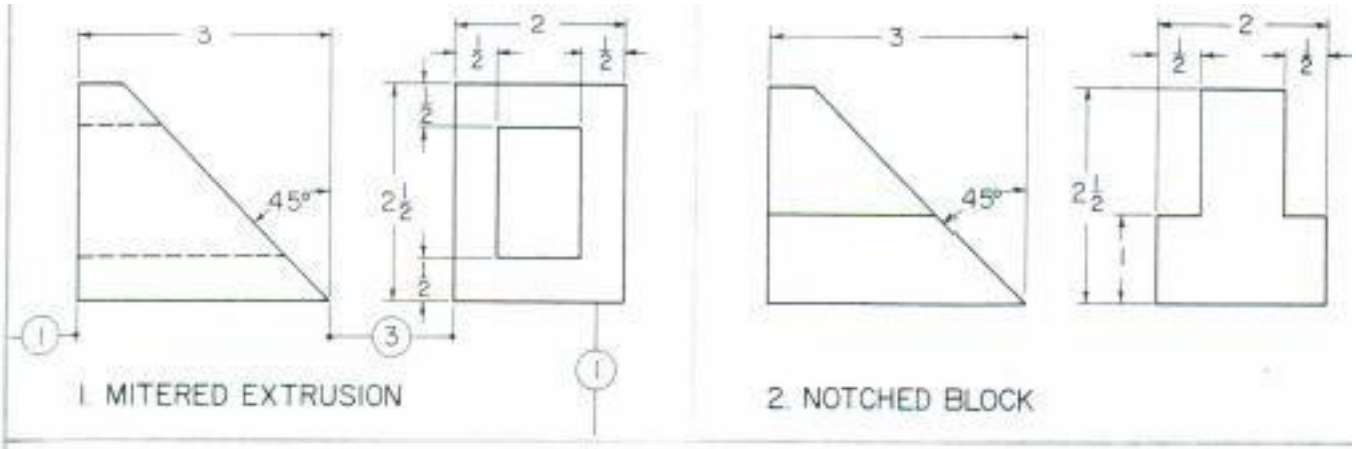
Exercises:



Exercise 2


RP 2
RP 1
D2
D21
D22
D23
D24
D25
RP 2
A
B
C
D
E
F
G
H
I
RP 1
D1
D11
D111
A
B
C
E
F
G
H
I

Exercises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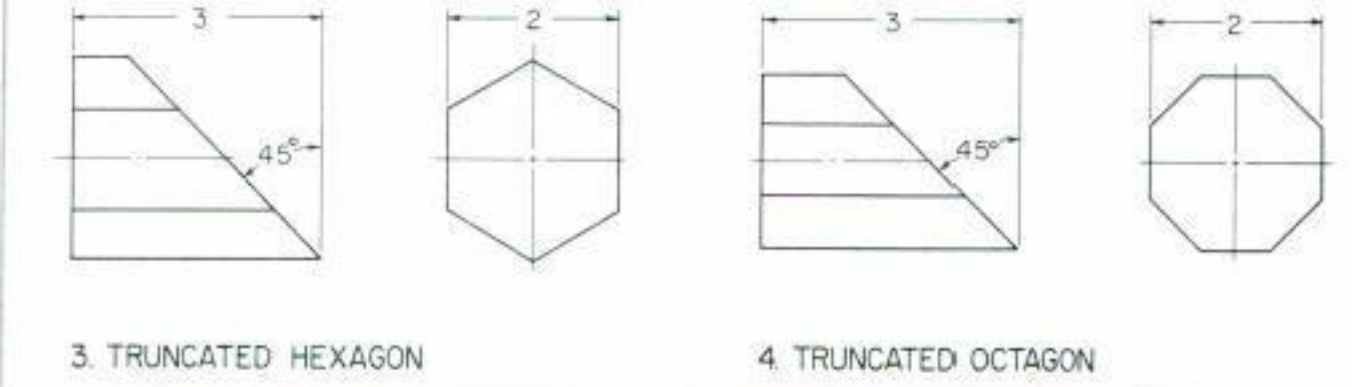
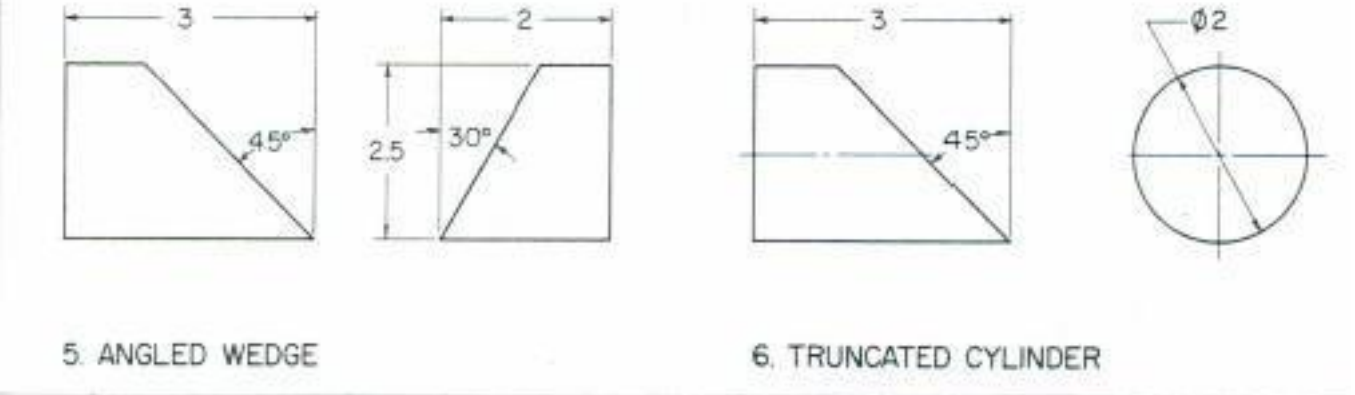
45°
2
2½
1. MITERED EXTRUSION

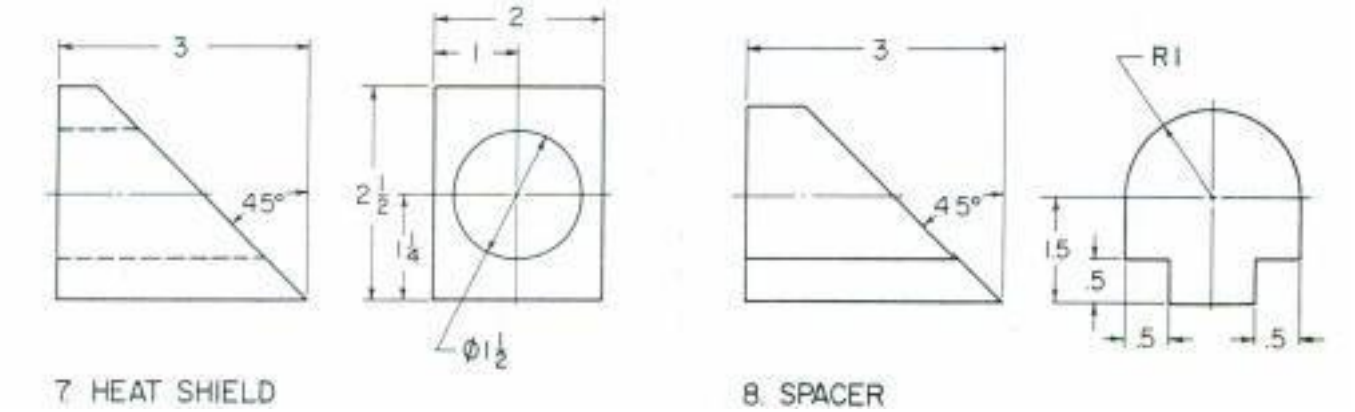
3
45°
2
2½
2. NOTCHED BLOCK


3
45°
2
3. TRUNCATED HEXAGON

3
45°
2
4. TRUNCATED OCTAGON


3
45°
2
2.5
30°
5. ANGLED WEDGE

3
45°
Ø2
6. TRUNCATED CYLINDER


3
45°
2
1
2½
1¼
Ø1½
7. HEAT SHIELD

3
45°
R1
1.5
.5
.5
.5
8. SPACER

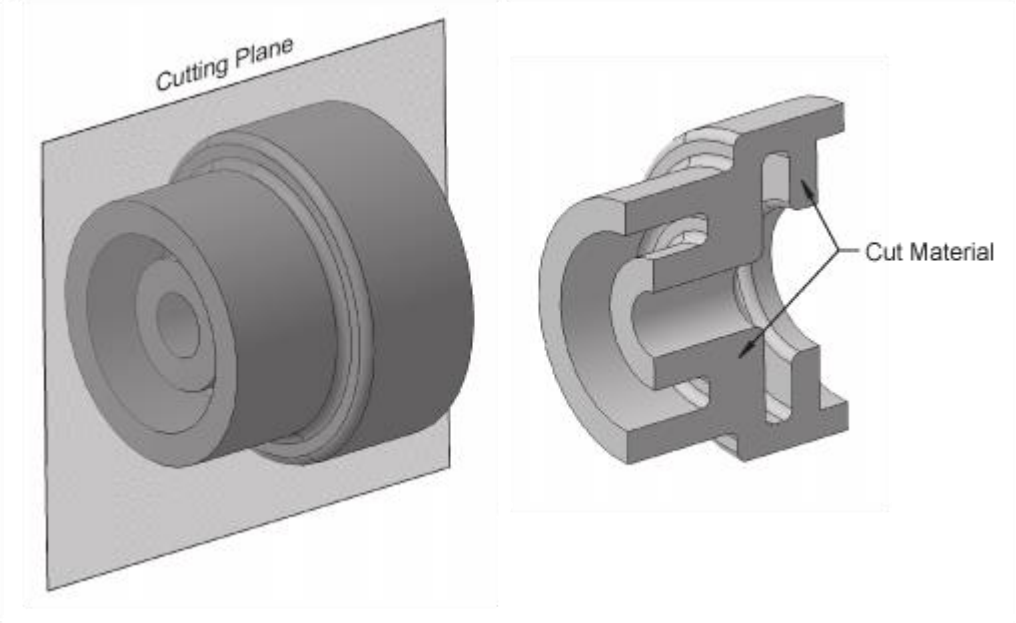
SECTIONAL VIEWS

objectives

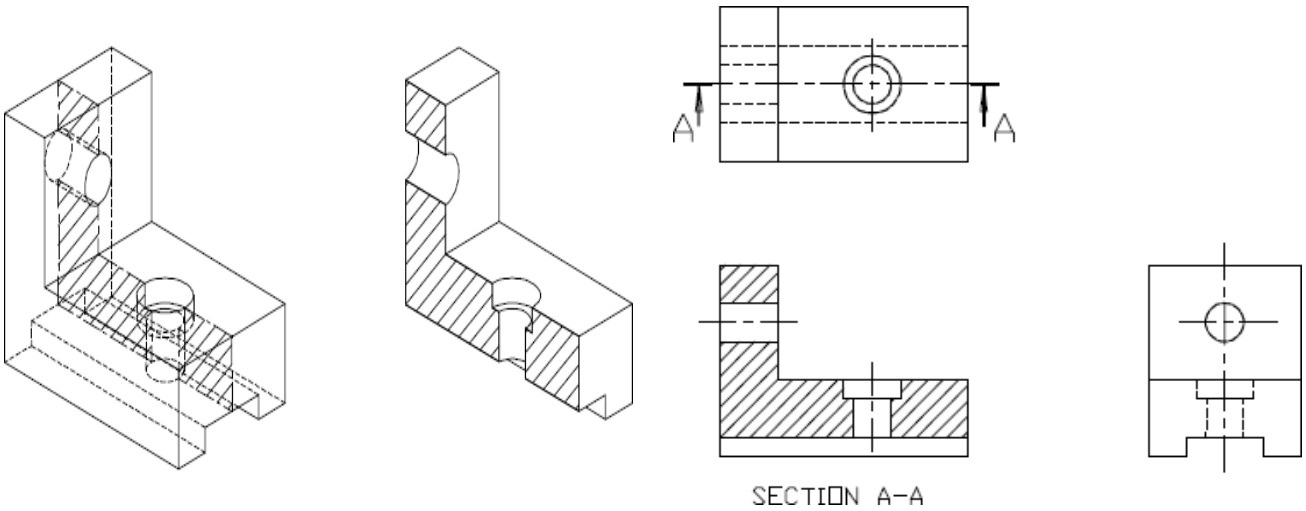
- **Knowing the definition and advantage of section drawing.**
- **Able to visualize which types of section is better to see the internal part of the drawing.**
- **Understand the Multiview and the pictorial drawings to convert into sectional drawing.**
- **Understand the hatching types for the material types.**

6.1 introduction

In an orthographic projection drawing, outlines and edges of an object are usually depicted with continuous lines and internal details are normally illustrated by using hidden lines. When dealing with complex objects, there may be many hidden lines and these hidden lines may become very confusing. Thus, you can use sectioning technique to 'cut sections' across the object to show internal details.



Using sectioning technique, the object is imagined to be cut by a plane and the portion nearer to the observer is imagined to be removed. This way, the interior is exposed and is shown in continuous lines. To specify the cutting, hatching is applied at the plane of cutting.



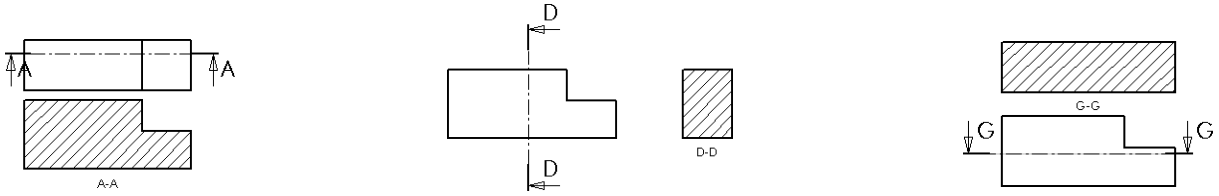
6.2 Hatching and sectioning Techniques

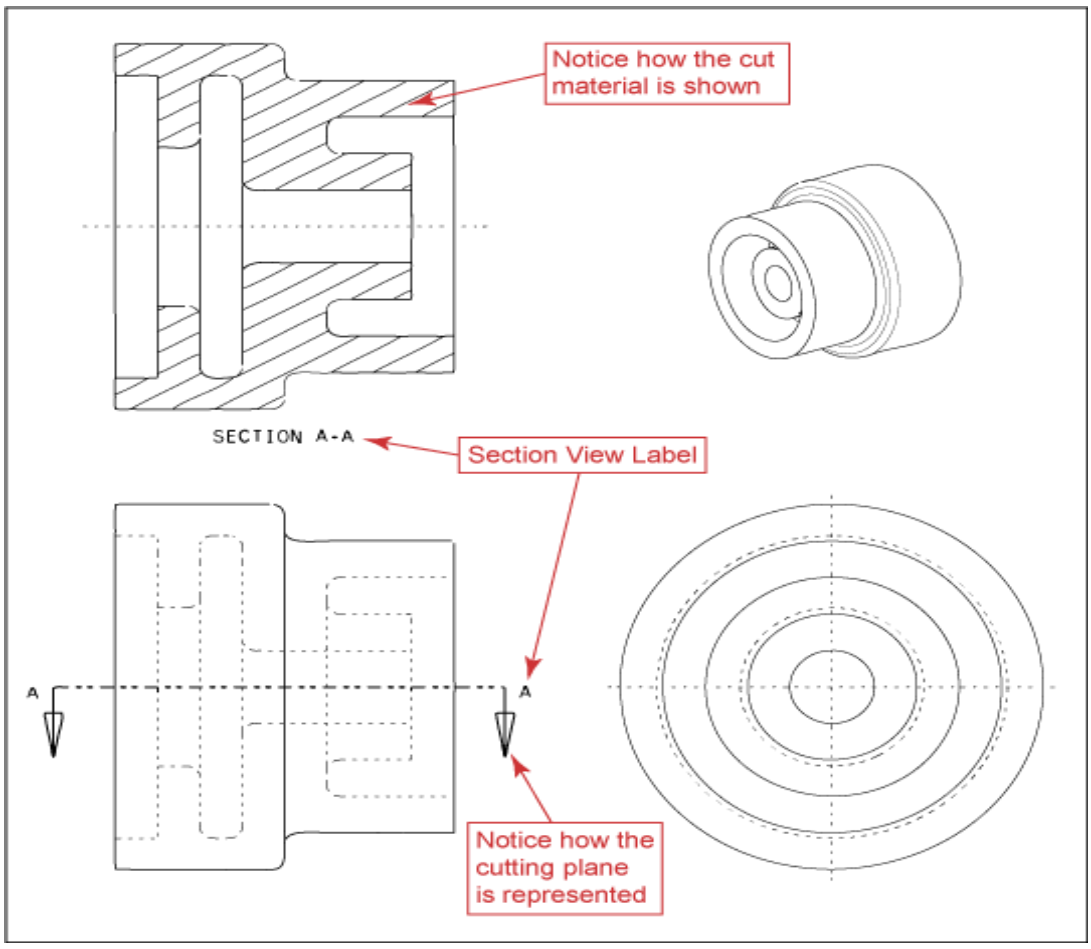
Hatching lines are thin lines and should preferably be inclining at 45 degrees. They should be evenly spaced. If there are two or more adjacent sectioned parts, the hatching lines should either be ofdifferent spacing or different direction. However, hatching pattern should be the same for separate areas of a single object.

☞ **Pay attention here:**

- ☑ Typical cutting plane (knife edge) looks: 
- ☑ The weight of the cutting plane is the same as that of a visible object line
- ☑ Letters can be placed at each end of the cutting plane to label the sectional view

The three standard positions of the cutting planes are:





Lines used in sectional drawing

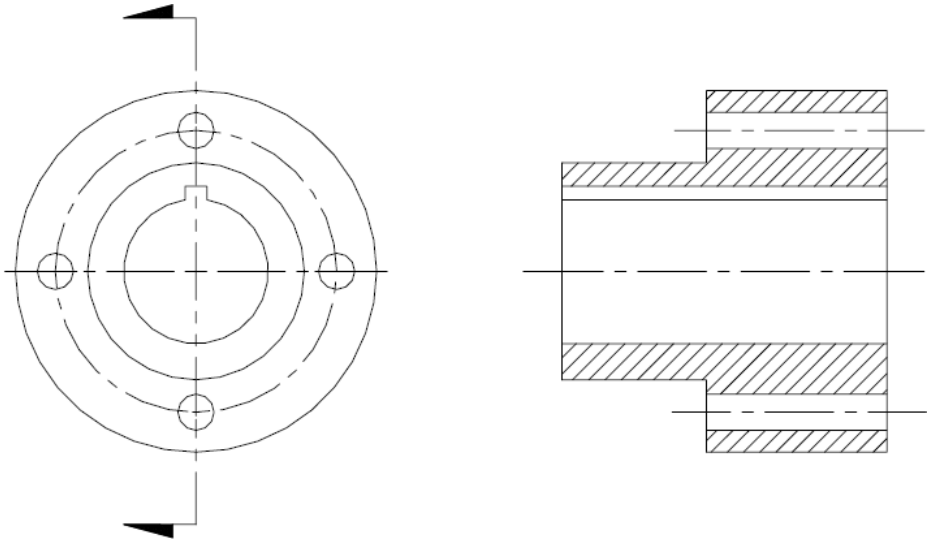
6.3 Types of Section

The various kinds of sectioning are:

- ✓ Full section,
- ✓ Half section,
- ✓ Offset section,
- ✓ Part section,
- ✓ Revolved section and
- ✓ Removed section.

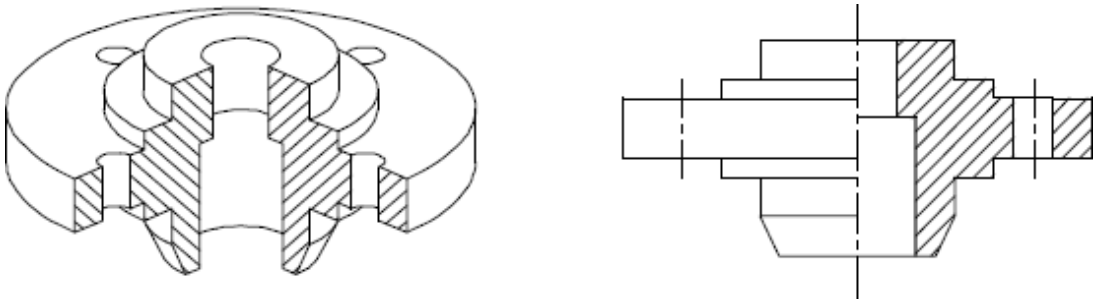
Full Section

This is the normal way of cutting a section. The cutting plane lies on a single plane and passes throughthe entire object. Half of the object is removed to show the internal detail structure of the object.



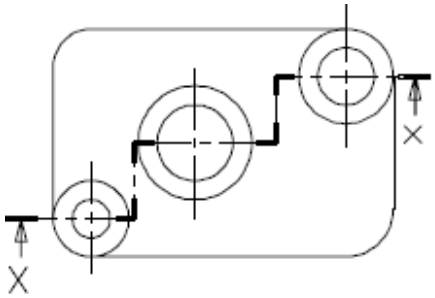
Half Section

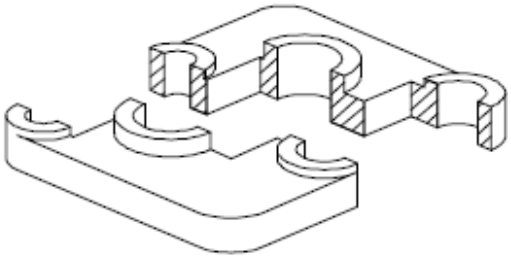
This technique is used to show the exterior and interior of a symmetrical object in a single projection view. The cutting plane cuts halfway to the axis or center of the object. A quarter of the object is imagined to be removed. The resulting drawing view is a half outside and half section view.

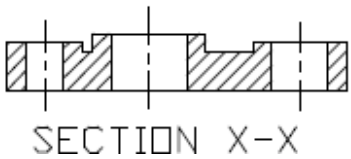


Offset Section

If the important internal features of an object are not lying on a single plane, a full section may not be able to show all the details. Offset section is a technique whereby the cutting plane offsets to pass through various features that would otherwise be missed by a full section. Thick lines should be used at the change of direction of the cutting plane.

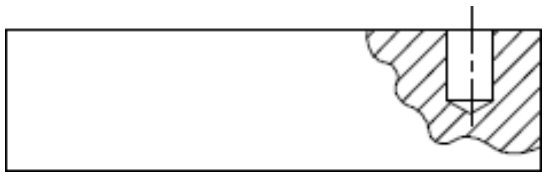






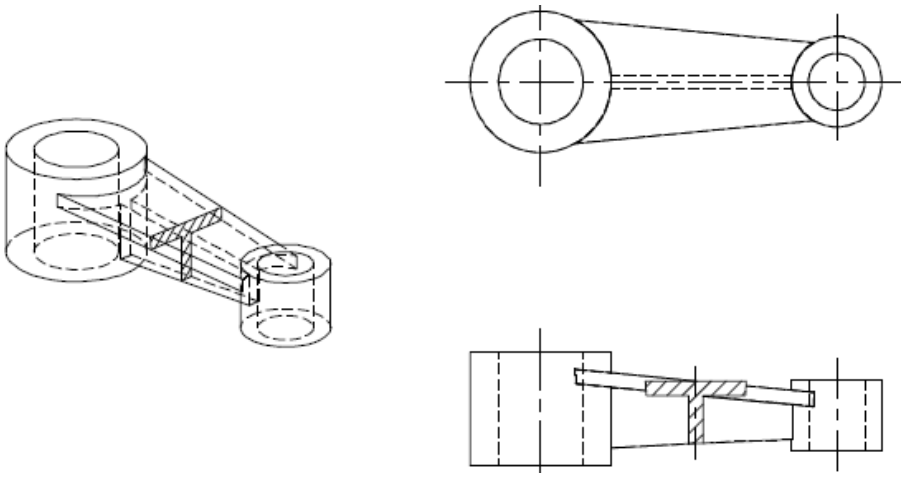
Part Section

Part section is a technique that is used to expose a small part of the interior of an object by removing a small part of the object. The view is basically an outside view with a small portion removed. The break line is illustrated with irregular thin continuous lines.



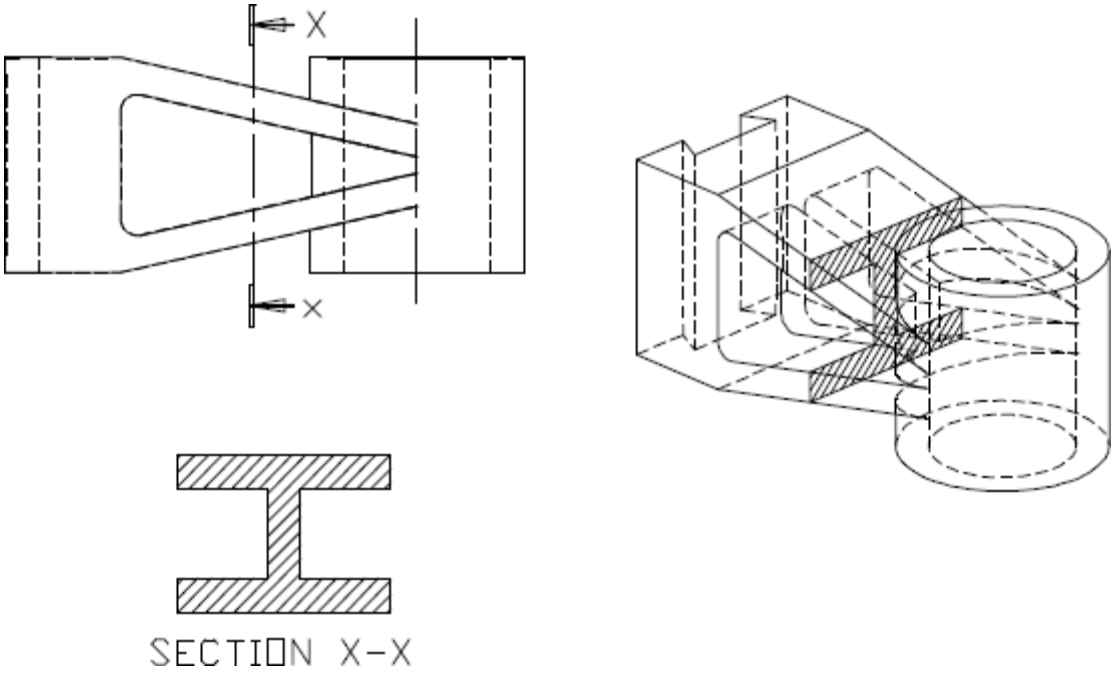
Revolved Section

Revolved section shows only the features on the cut plane. It is used to depict the section of an elongated object without the need to show the entire sectional view. Instead of projecting the section onto an adjacent view, the resulting section obtained from the cutting is revolved 90° and is placed on the same view.



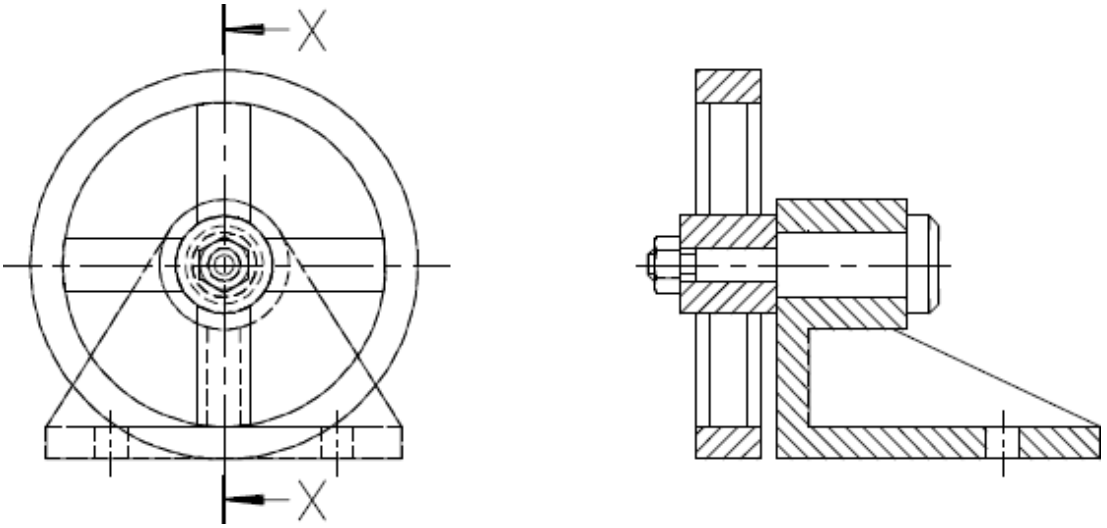
Removed Section

Removed section is similar to revolved section in that only the cut plane is shown. However, the sectionis placed elsewhere on the drawing.



Parts not sectioned

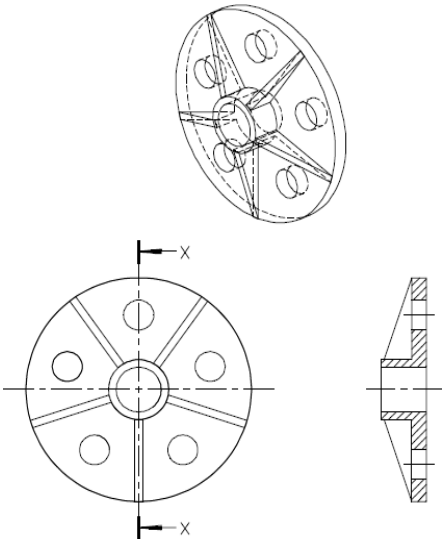
To improve clarity, standard parts will not be section-lined even though the cutting plane passes them.These standard parts are **solid shafts, bolts and nuts, ribs and spokes of wheels, and webs.**



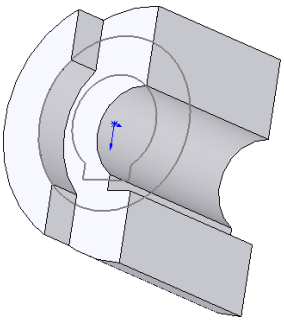
Conventional Revolutions

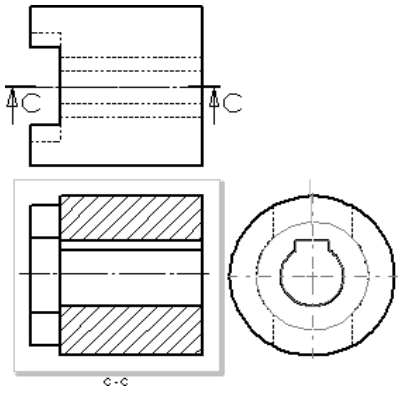
The strict rules of projection may sometimes be relaxed for the sake of better clarity. This happens withodd numbers of holes on a plate or odd number of spokes on a wheel.

Revolving and aligning the features on an outside view or sectional view will improve clarity.



Exercise:

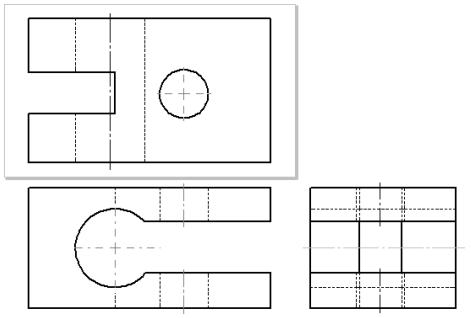


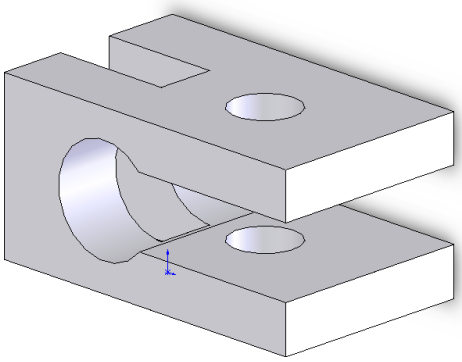


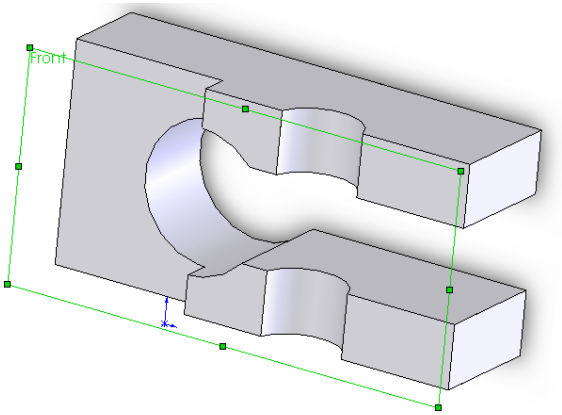
6.4 PICTORIAL SECTION

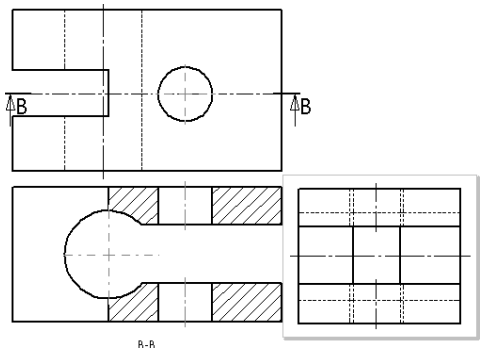
Pictorial section is a pictorial drawing showing the sectioned object. Normally we follow stepswe have followed in pictorial drawing technique so far. Try to consider the following exercises. **Exercises:**

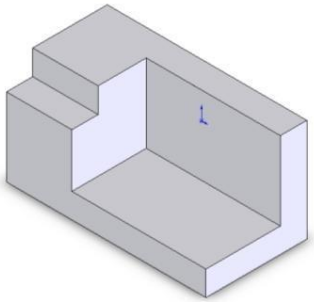
Draw the sectional pictorial and Sectional view drawing for the following views

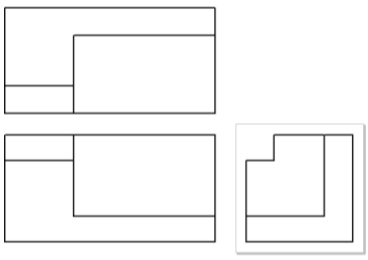


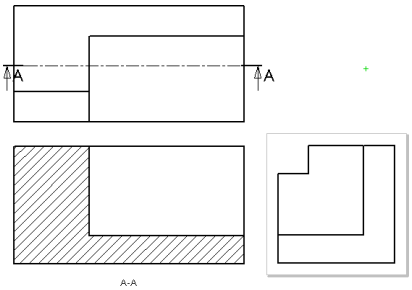












DEBREMARKOS UNIVERSTY

INSTITUTE OF TECHNOLOGY

MECHANICAL AND INDUSTRIAL ENGINEERING DEPARTMENT

INTRODUCTION TO ENGINEERING DRAWING

PREPARED:

:

- **EXERCISES**
- **WORKSHEETS**
- **PREPARED EXAMS**

PREPARED BY:

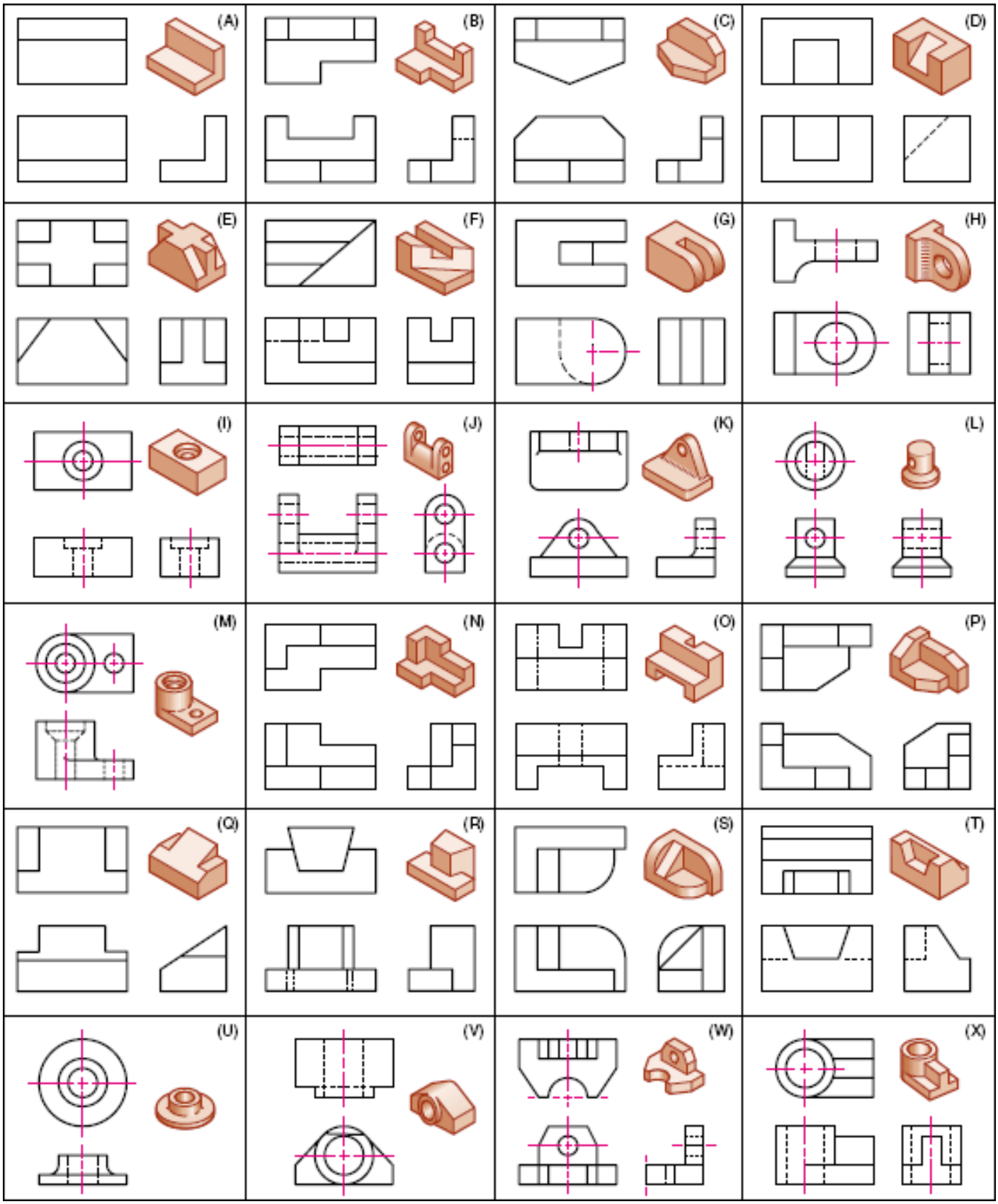
CHEKOL YRDIE

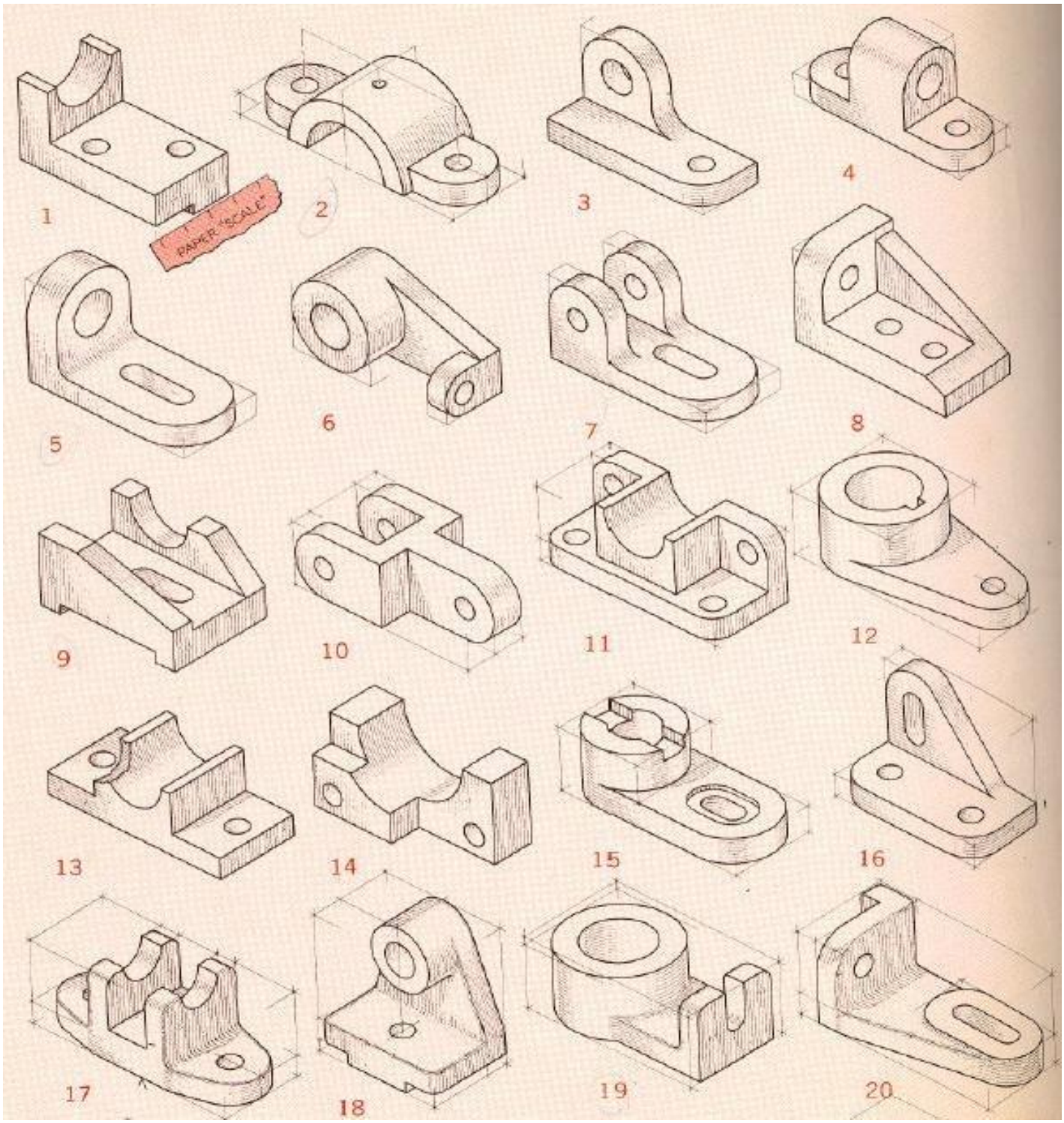
MECHANICAL ENGINEERING STUDENT

DEBREMARKOS UNIVERSTY

JUNE 2021/22

ATTAINTION!! PRACTICE AND STUDY THE FOLLOWING MULTIVIEW DRAWINGS

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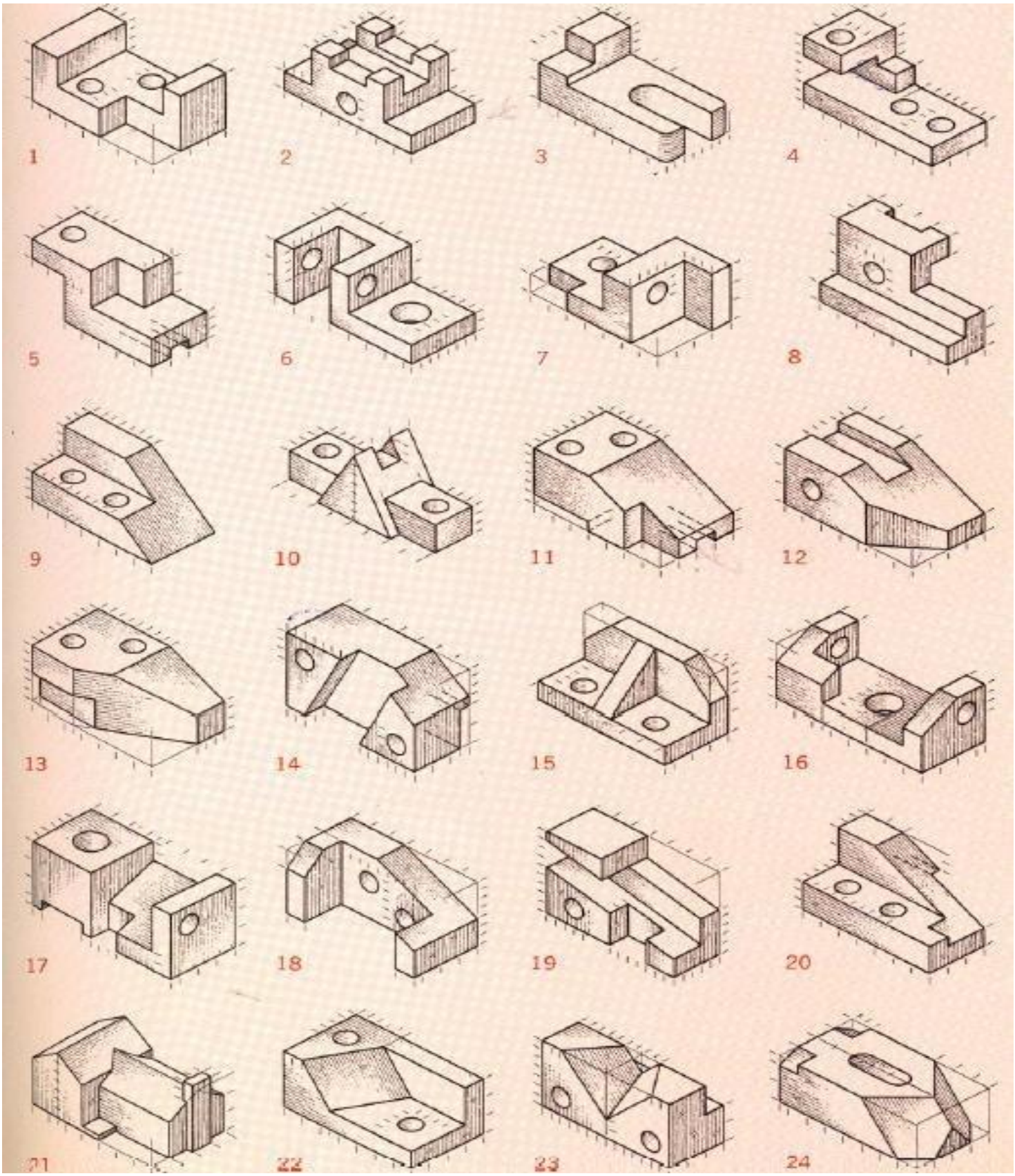
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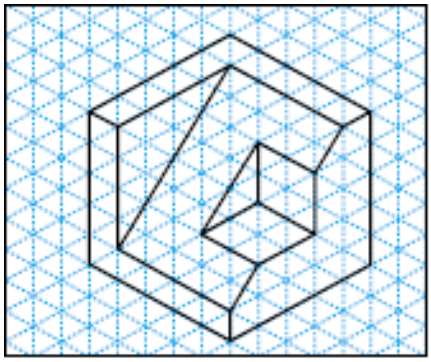
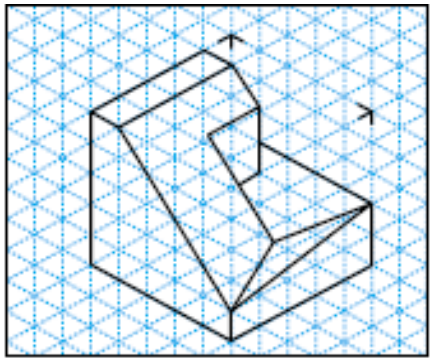


(1)



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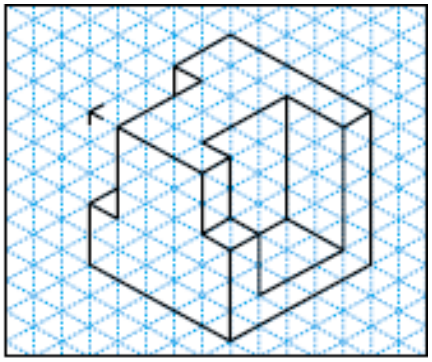

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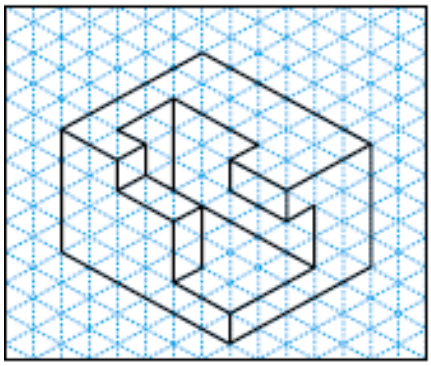

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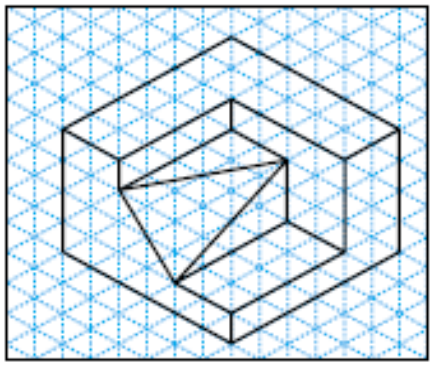

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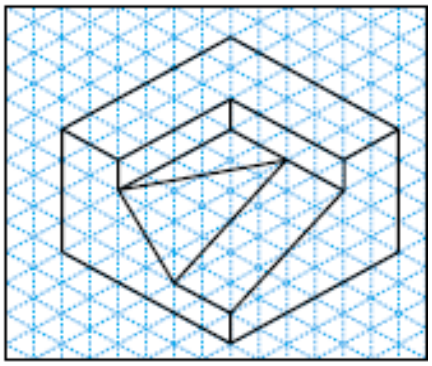

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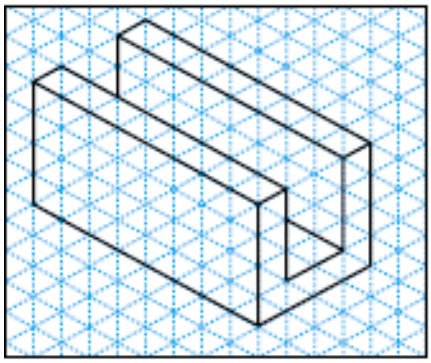

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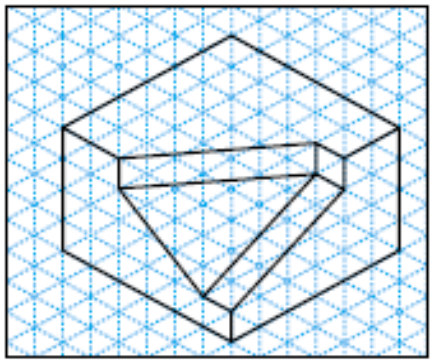

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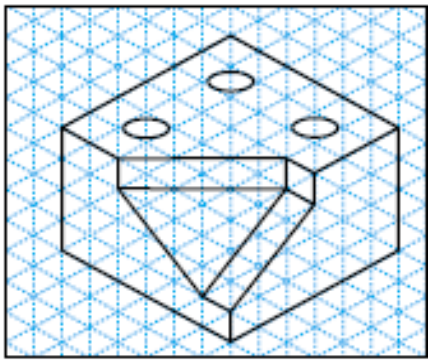

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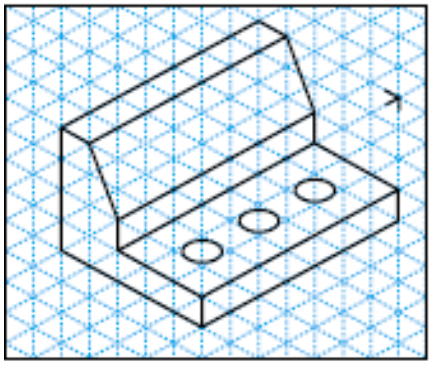

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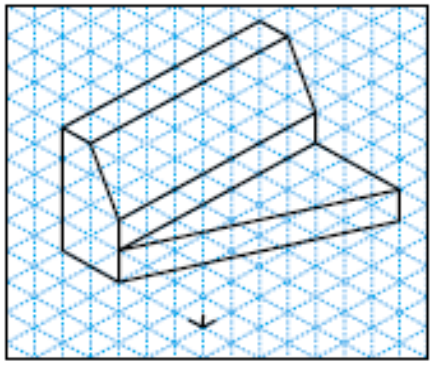

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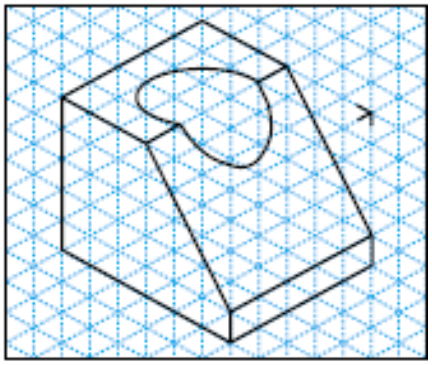
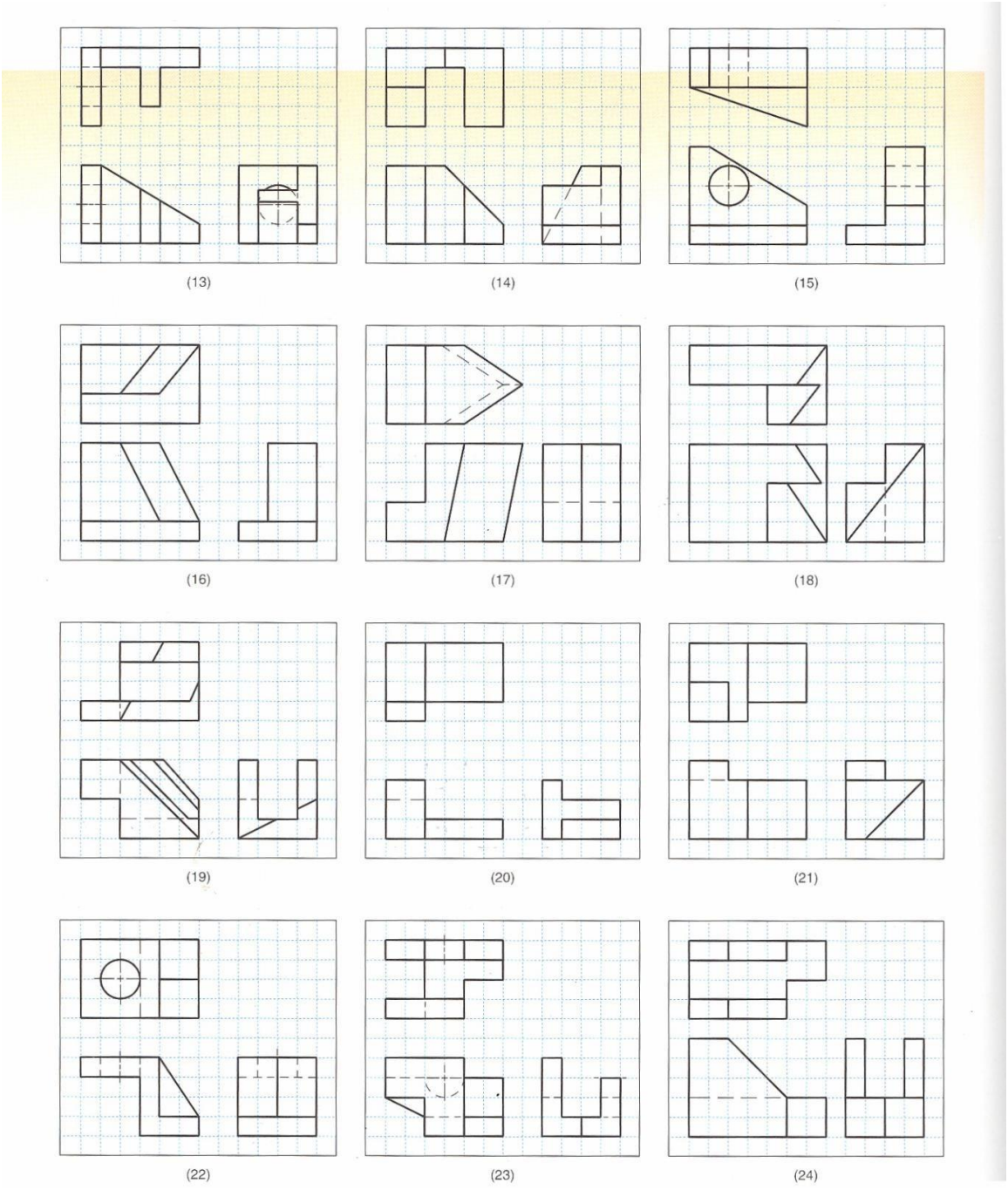
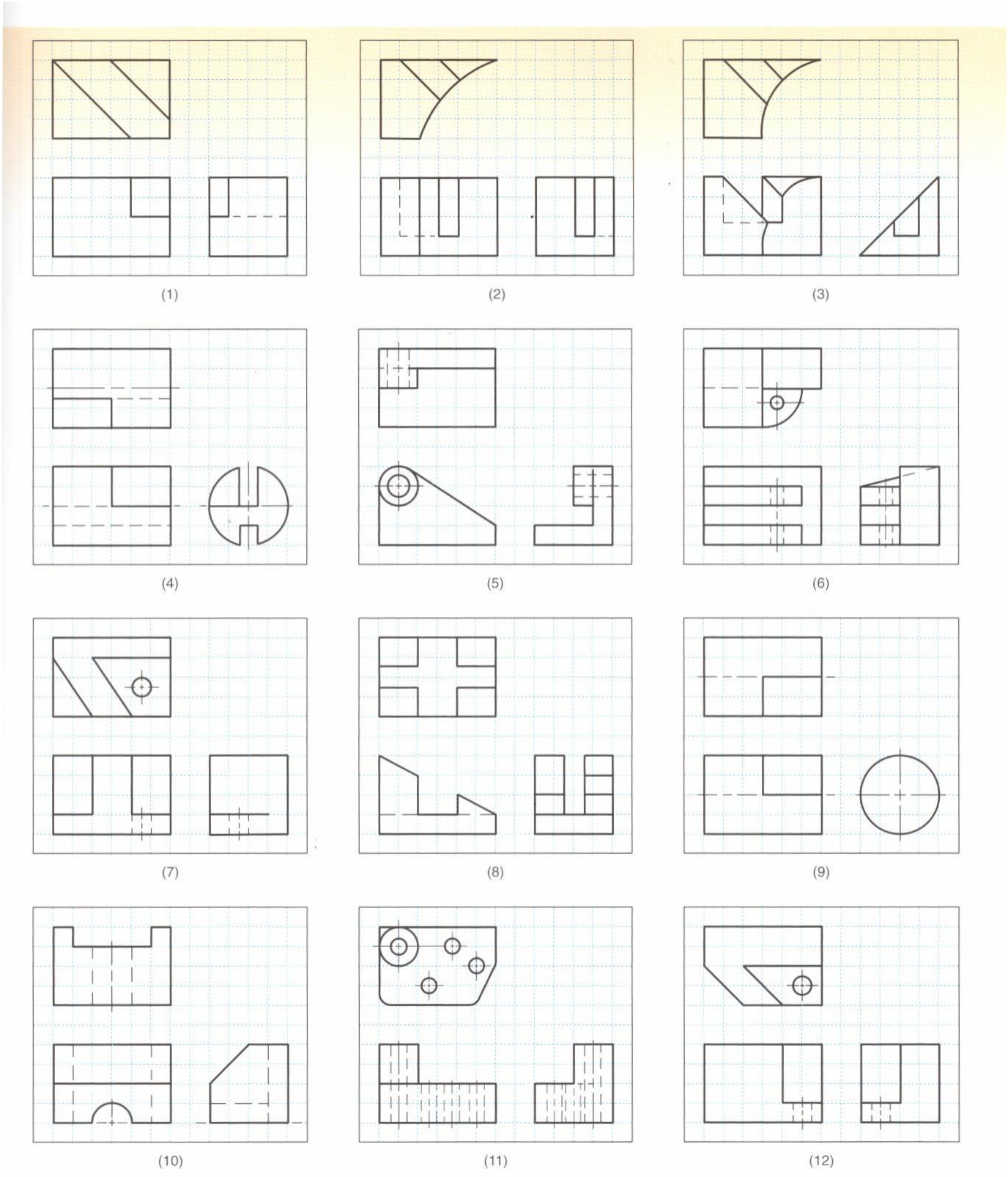


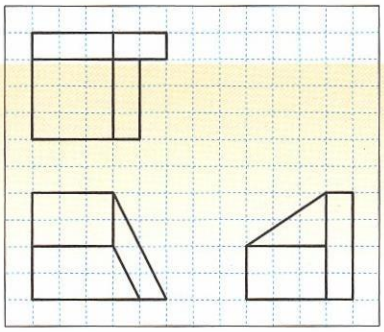
(12)

Attempt the following questions. Draw the appropriate pictorial drawing, for circular orthographicprojections draw oblique pictorial, and for the rest isometric pictorial.

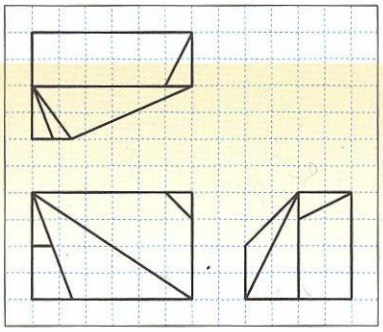


Complete the missing line and draw the pictorial drawing for the following multi views:





(1)



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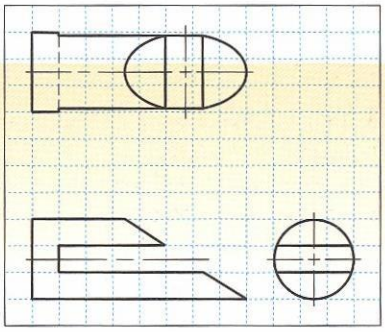

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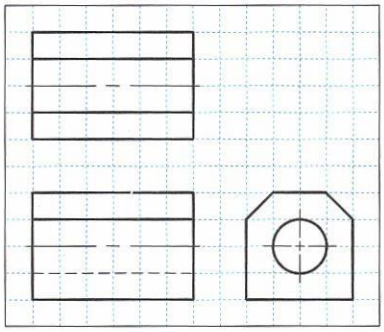

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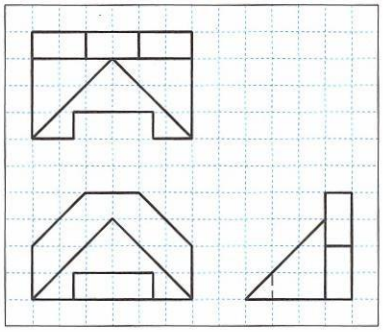

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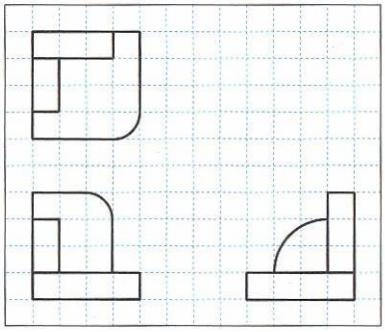

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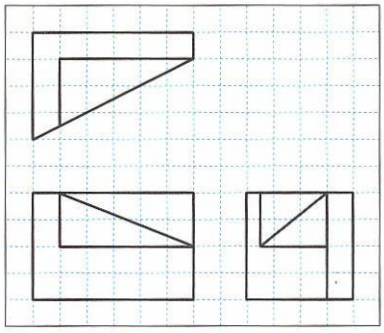

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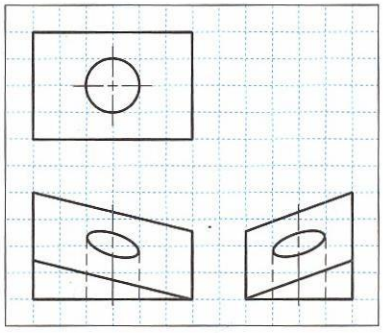

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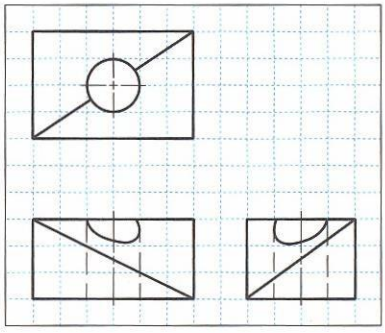

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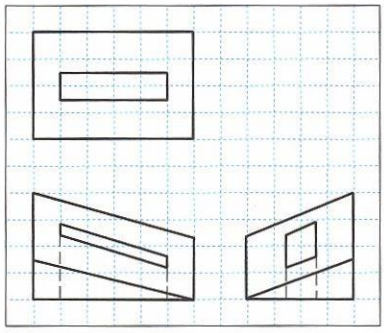

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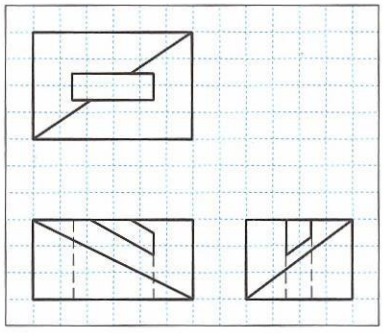

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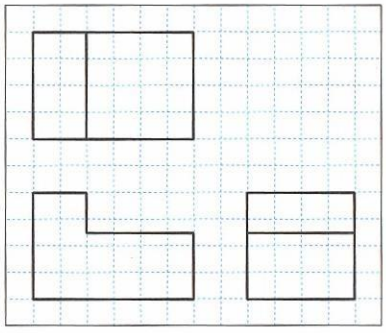

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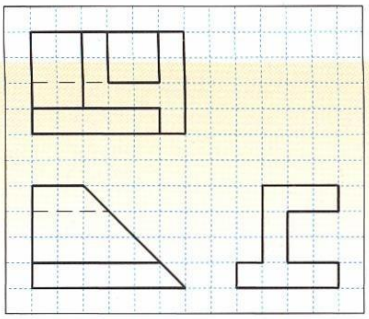

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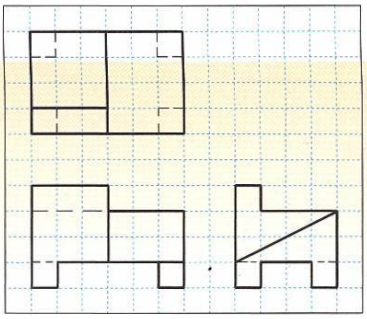

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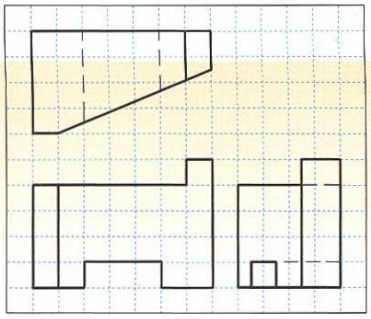

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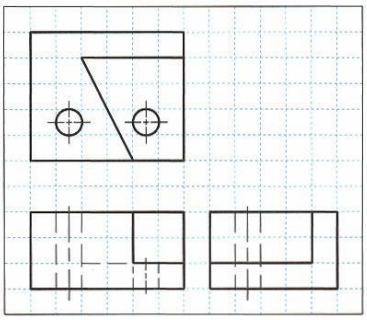

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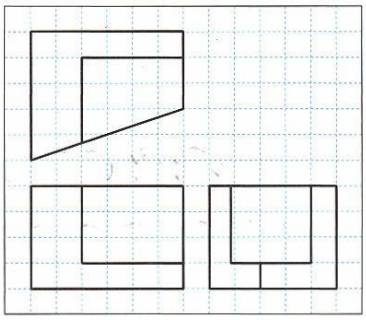

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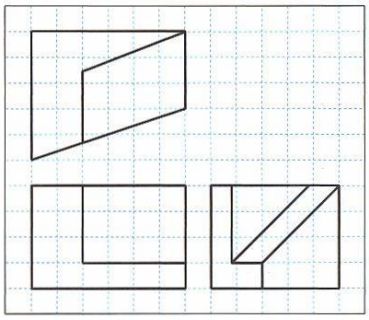

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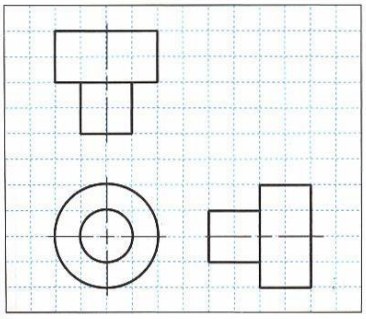

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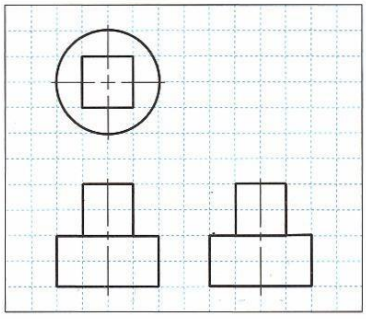

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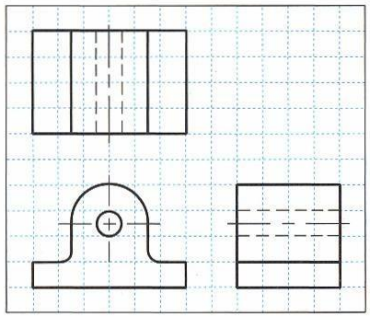

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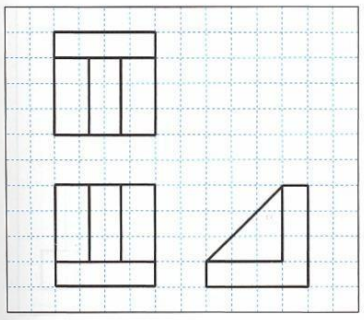

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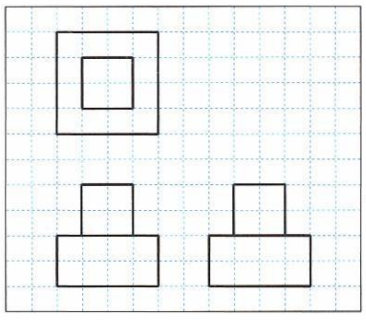

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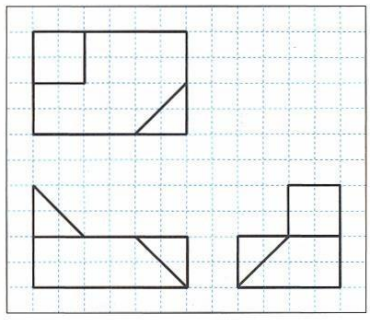
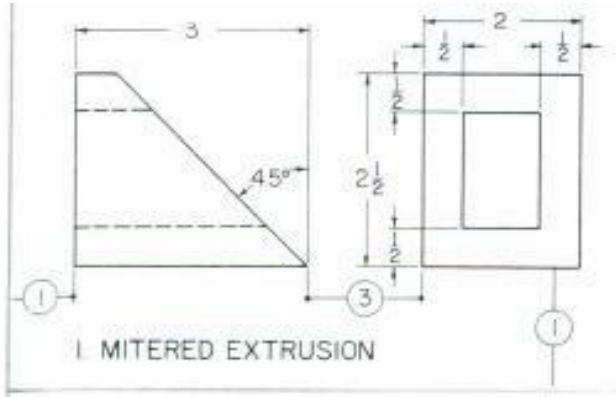


(36)

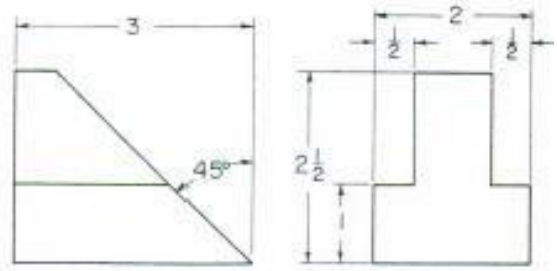
Work Sheet

AUXILIRY VIEW

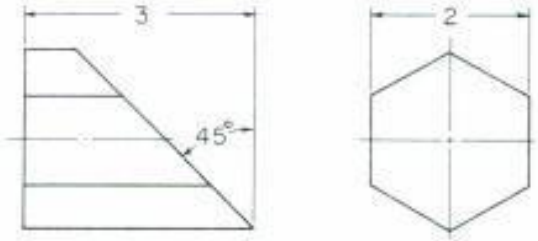
Draw the complete auxiliary view for the following Exercises



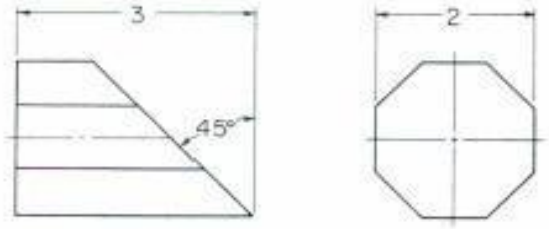
1. MITERED EXTRUSION



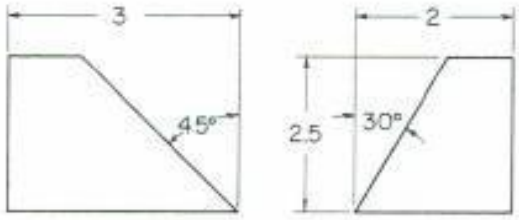
2. NOTCHED BLOCK



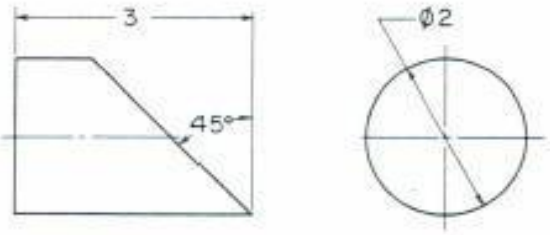
3. TRUNCATED HEXAGON



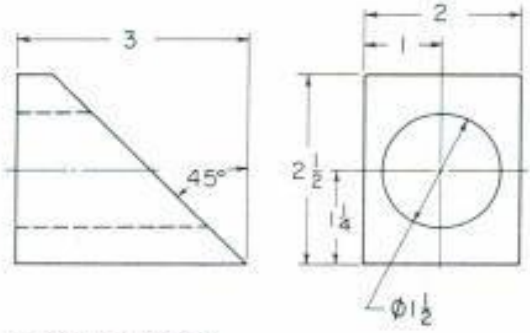
4. TRUNCATED OCTAGON



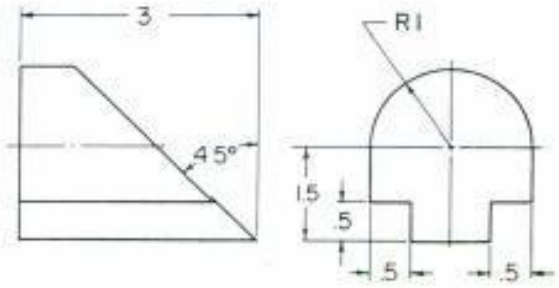
5. ANGLED WEDGE



6. TRUNCATED CYLINDER

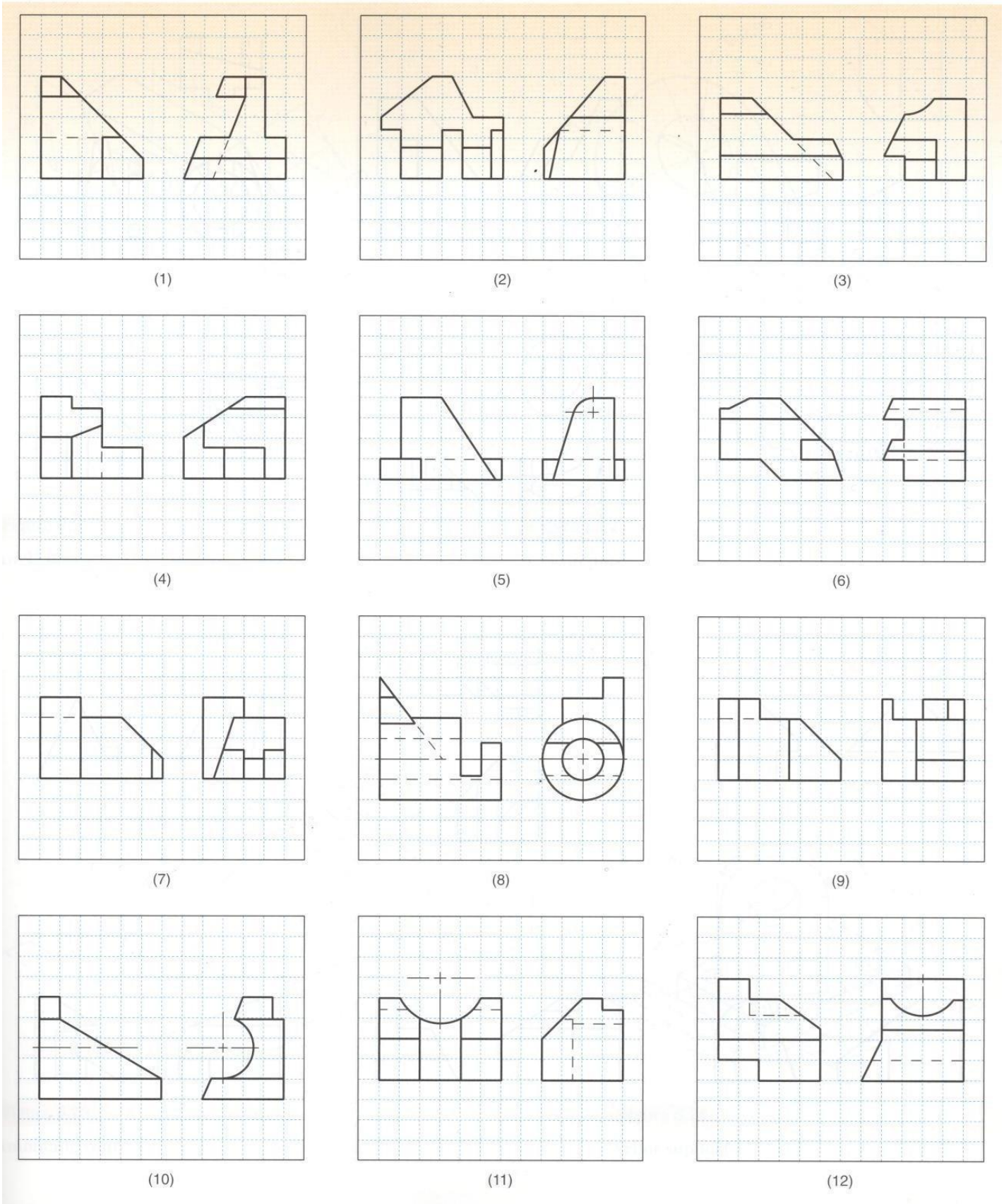


7. HEAT SHIELD



8. SPACER

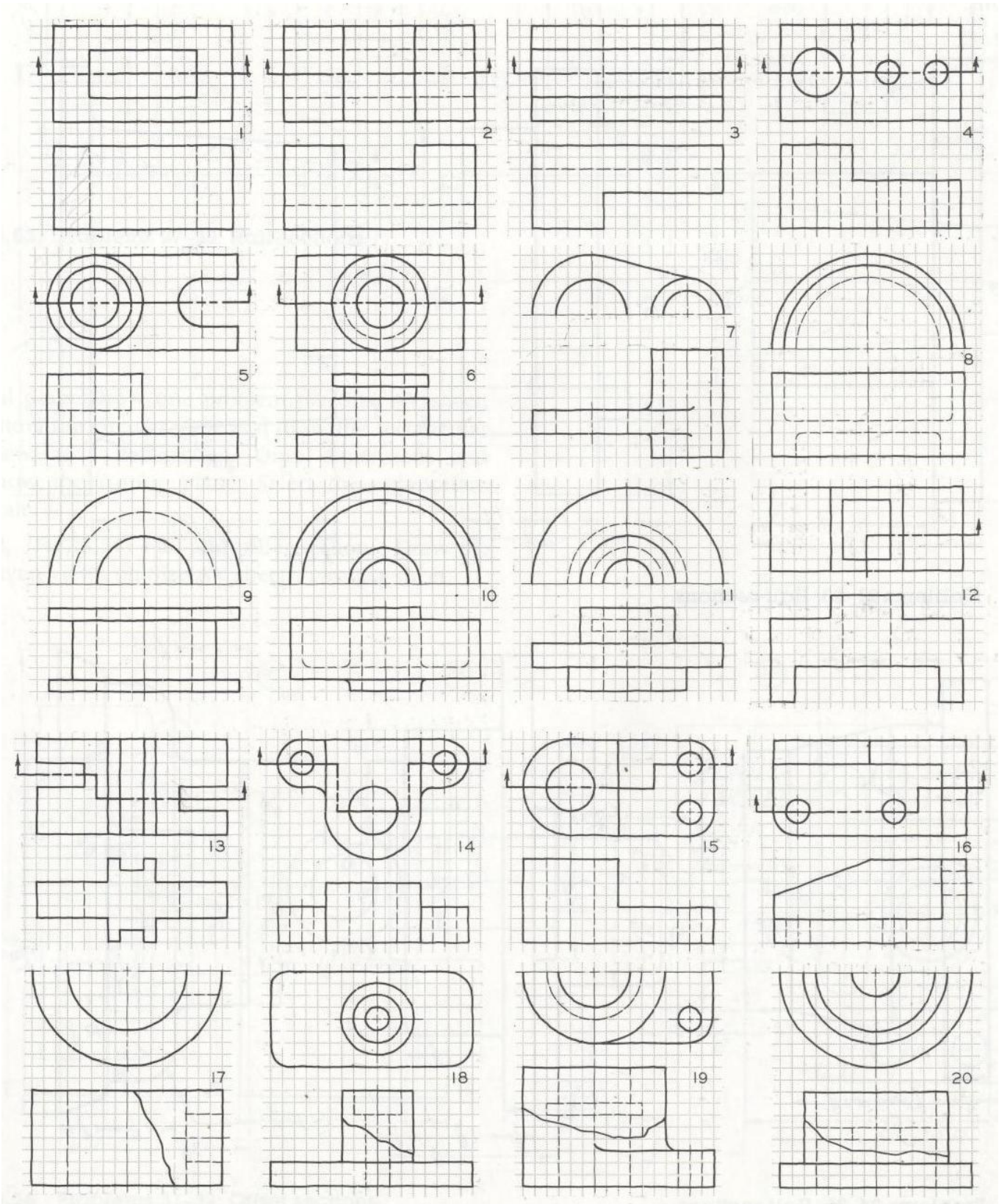
Draw the Partial Auxiliary View of the following multi view objects.



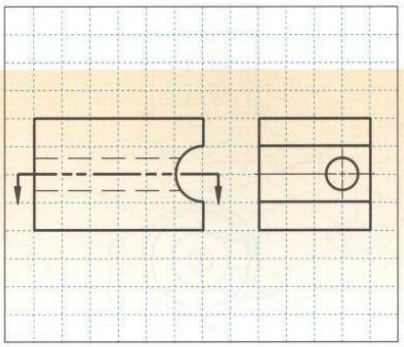
Work Sheet

SECTIONAL VIEW

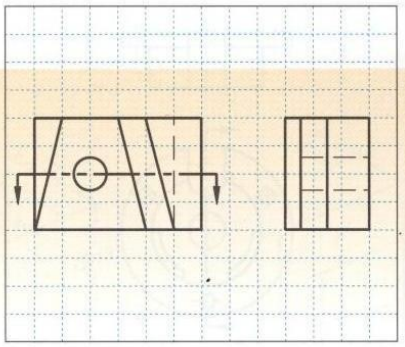
Draw the appropriate sectional view and sectional pictorial drawing of the following drawings.



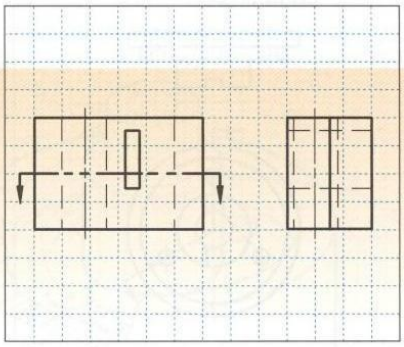
Draw the sectional view and sectional pictorial drawing



(1)



(2)



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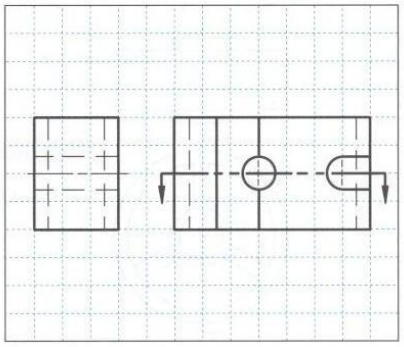

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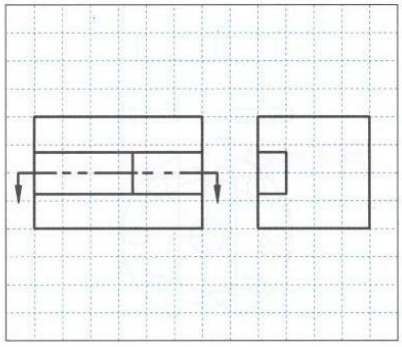

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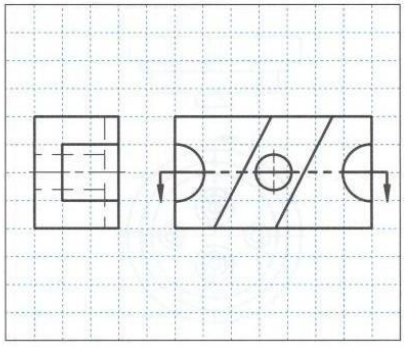

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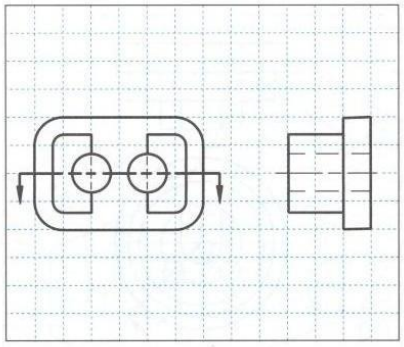

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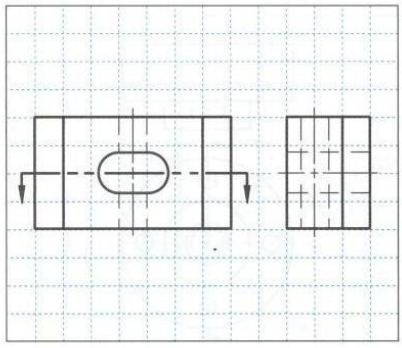

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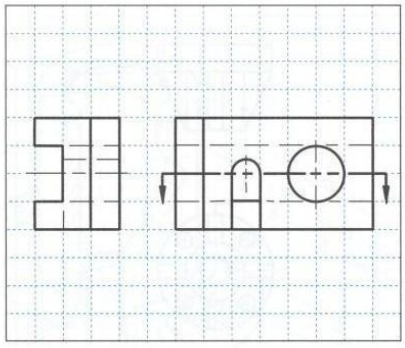

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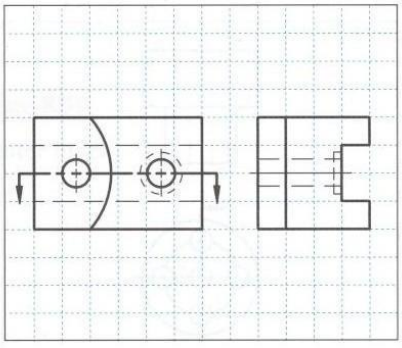

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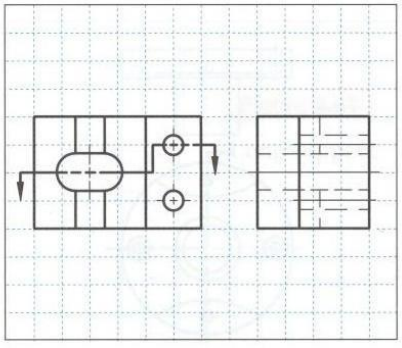

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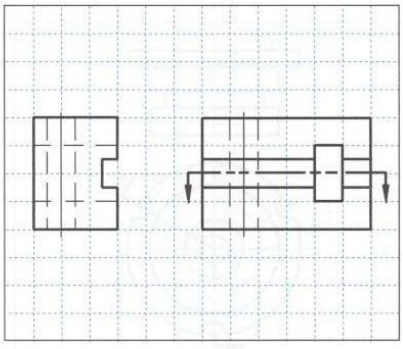


(12)

PREPARED EXAMS

PART ONE

CONCEPTUAL QUESTIONS

1. There are two types of auxiliary views depending on the type of plane we interested to show the trueshape and size of non normal planes. Please write the correct auxiliary view type for the following listedplane types

1. Objects having oblique plane

_____

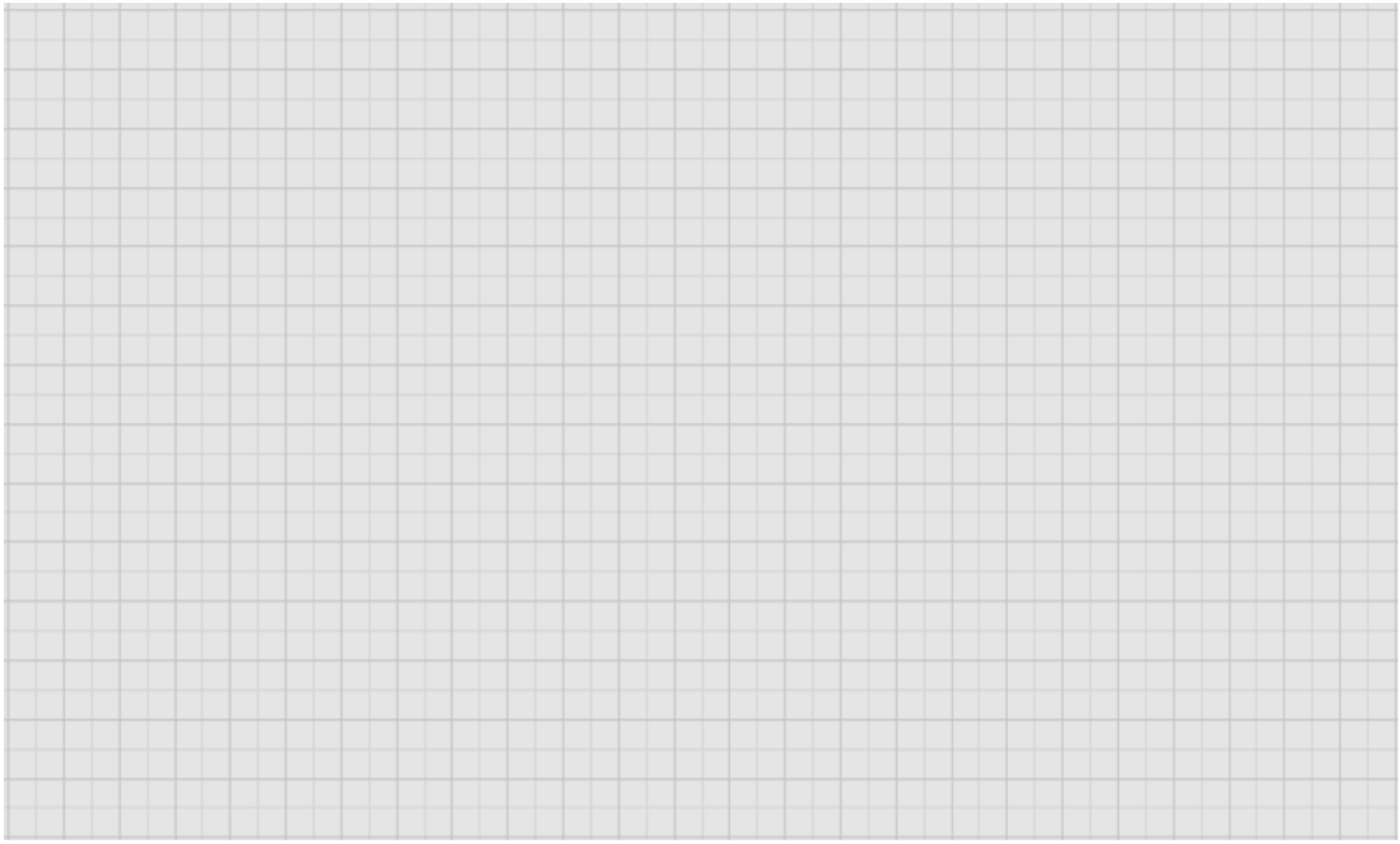
2. Objects having inclined plane

_____

2. There are six common sectioning techniques. All of them have their own special features. Draw multi view drawings with its respective sectional view with the appropriate position of cutting plane for each of:

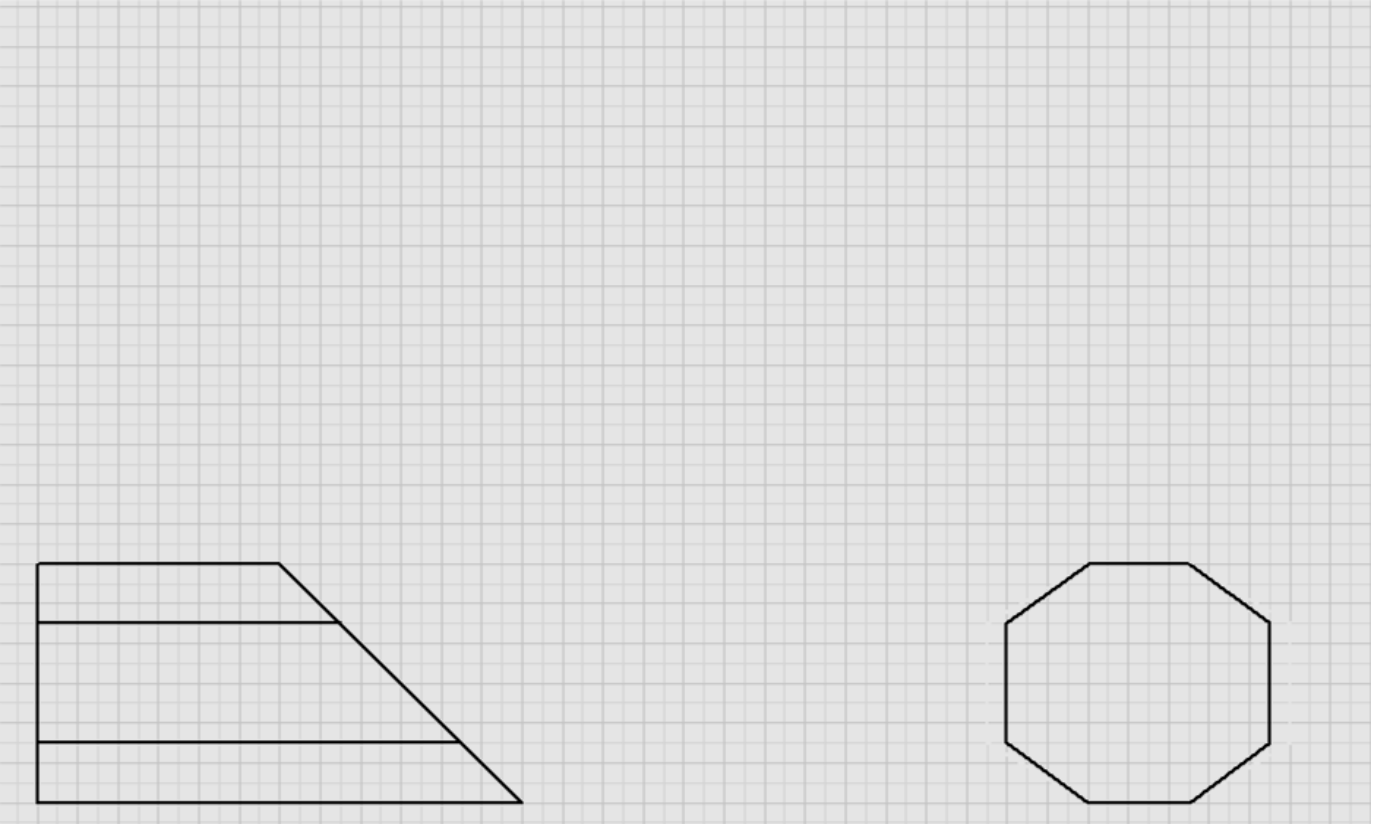
- Offset section,
- Revolved section and

- Broken out (Part) section.

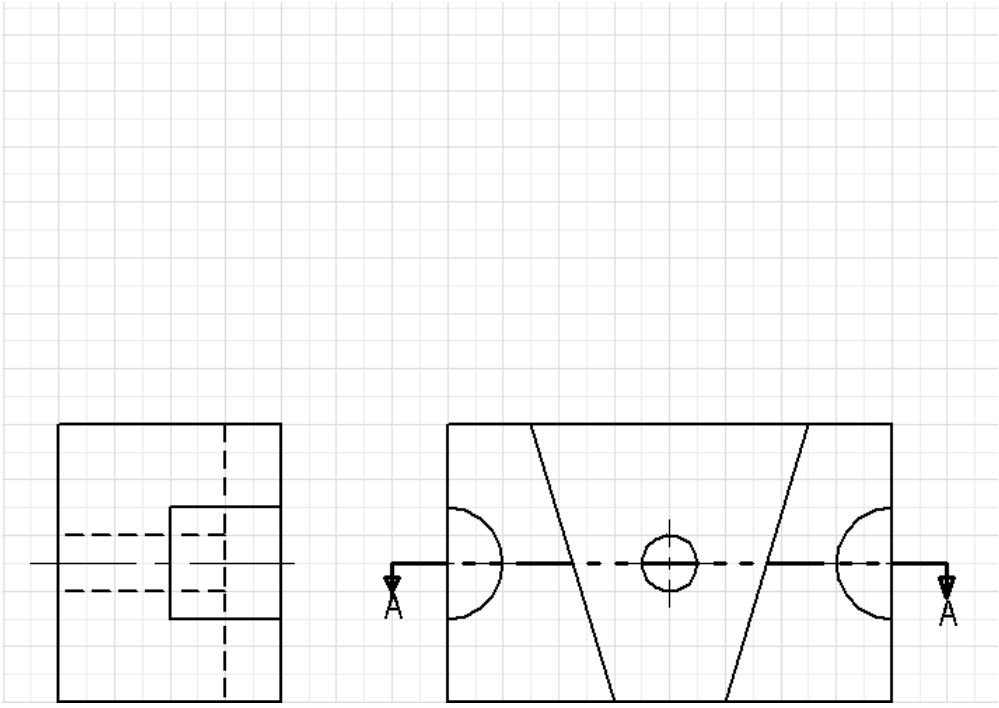


PART TWO WORKING DRAWINGS

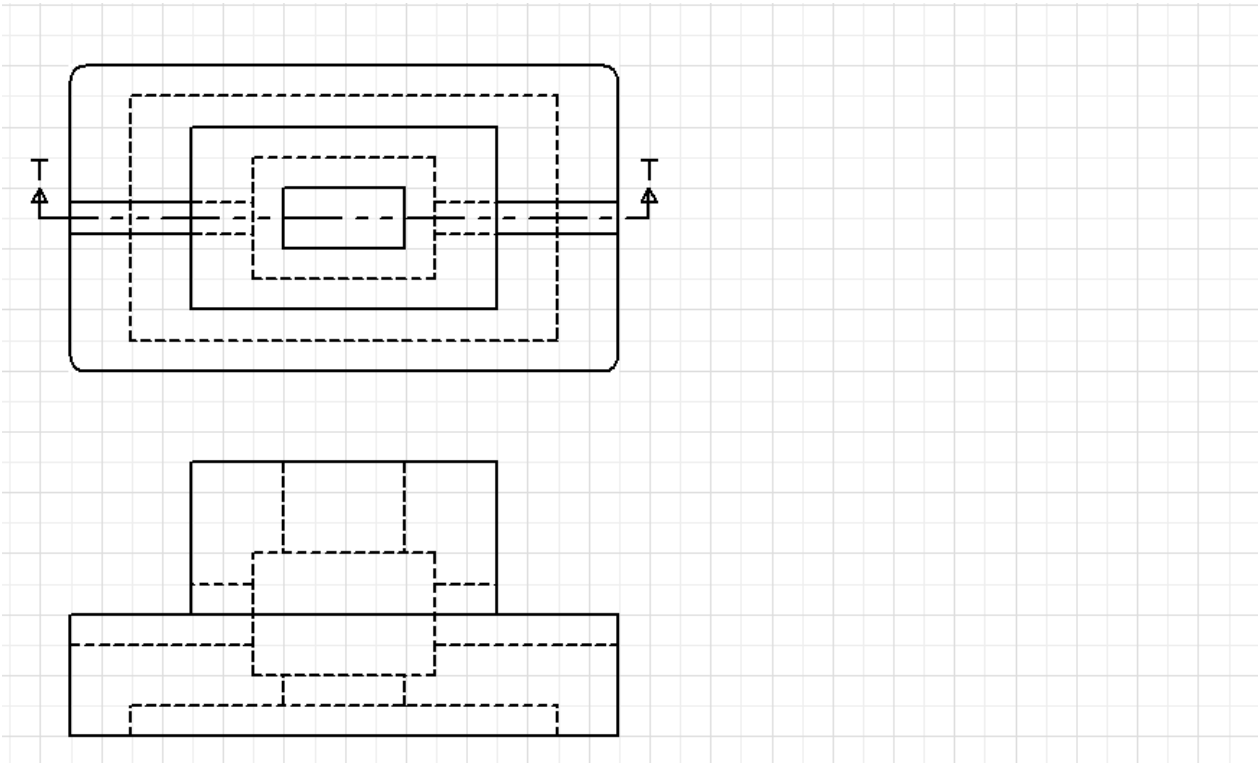
5. Draw the partial auxiliary view for the following multi view drawing. Show all the necessary steps.



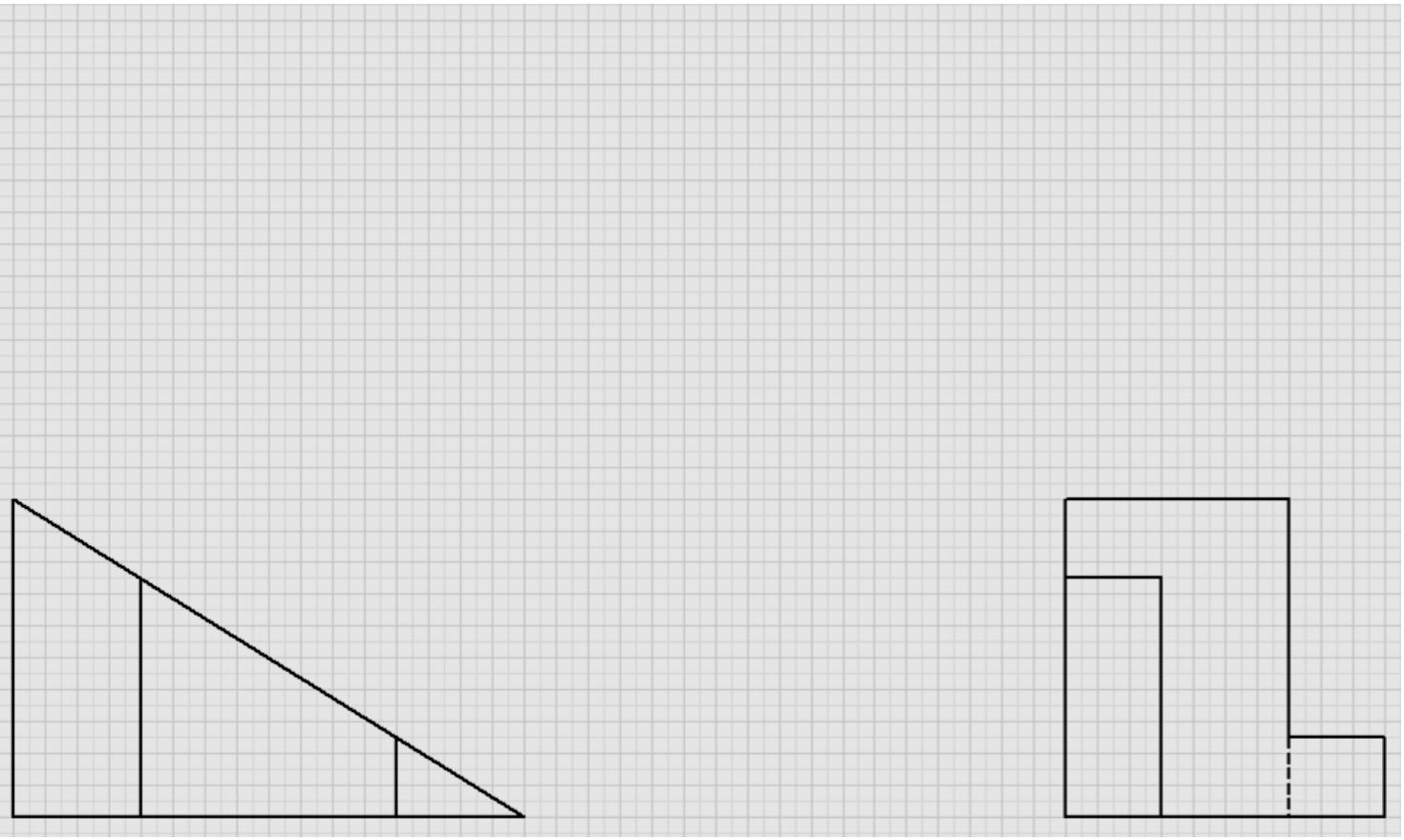
6. Draw the pictorial sectional only for the following orthographic projections. Use isometric pictorial drawing method.



7. Draw only the sectioned view for section T-T.



8. Draw the complete auxiliary view for the below multi view.
(Hint: you are expected to show both invisible and visible edges at the same time)



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