

## CHAPTER 2: TECHNICAL DRAWING

**Unit of learning code: CON/CU/PL/CC/02/5/A**

**Related Unit of Competency in Occupational Standard: Prepare and apply technical drawing**

### **2.1 Introduction to the unit of learning**

This unit covers the competencies required to prepare and apply technical drawing. It involves competencies in selecting, using and maintaining drawing equipment and materials. It also involves developing plane geometry drawings, solid geometry drawings, pictorial and orthographic drawings

### **2.2 Summary of Learning Outcomes**

1. Select, use and maintain drawing equipment and materials
2. Develop plane geometry drawings
3. Develop solid geometry drawings
4. Develop pictorial and orthographic drawings
5. Apply Computer Aided Design

#### **2.2.1 Learning Outcome 1: Select, use and maintain drawing equipment and materials**

##### **2.2.1.1. Introduction to the learning outcome**

The focus of this specific learning outcome is to introduce the different working drawings and their purpose during the planning of plumbing works. This section will give an understanding of the different types of working drawings, building symbols and different representations of drawings.

##### **2.2.1.2. Performance Standard**

The following performance criteria will be required to be met by trainees to be considered competent

1. Drawing equipment are identified and gathered according to task requirements
2. Drawing materials are identified and gathered according to task requirements
3. Drawing equipment are used and maintained as per manufacturer's instructions
4. Drawing materials are used as per workplace procedures

##### **2.2.1.3. Information Sheet**

Specific materials and drawing instruments are required in order to undertake technical drawing. As technical drawing is now a universal language it is governed by rules regarding methods of drawing and the symbols used.

## **Terms and concepts**

### **a) Technical Drawing**

According to Autodesk a technical drawing, also known as an engineering drawing, is a detailed, precise diagram or plan that conveys information about how an object functions or is constructed. Engineers, electricians, and contractors all use these drawings as guides when constructing or repairing objects and buildings

### **b) Importance of Technical Drawing**

Technical drawings bridge the communication between designers, the people who come up with ideas, and producers, the people who put those ideas into practice. They are designed as a universal language to be understood by engineers, contractors, and architects.

### **c) Types of Technical Drawings:**

#### **i. Mechanical Engineering Drawing**

It is pertaining to machine parts or components. It is presented through a number of orthographic views, so that the size and shape of the component is fully understood. Part drawings and assembly drawings belong to this classification.

Mechanical drawings rely on precise mathematical equations to accurately depict the mechanism and its component parts.

#### **ii. Electrical Drawing**

Electrical drawings are technical documents that depict and notate designs for electrical systems. They convey relevant information about lighting, wiring, and power sources, as well as information about voltage and capacity. Technicians rely on electrical drawings during a building's construction or when repairing a building's electrical system.

#### **iii. Architectural Drawing**

Architectural drawings are detailed, precise depictions of every aspect of the construction being proposed. Architects use the drawings to visualize ideas and concepts, turn a design idea into a coherent plan for a building, and decide the type of supplies and labor that is needed for the project.

### **Classification of drawings**

a) Part drawing

Component or part drawing is a detailed drawing of a component to facilitate its manufacture. All the principles of orthographic projection and the technique of graphic representation must be followed to communicate the details in a part drawing. A part drawing with production details is rightly called as a production drawing or working drawing.

**b) Assembly drawing**

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing. There are several types of assembly drawing namely;

**i. Design Assembly Drawing**

When a machine is designed, an assembly drawing or a design layout is first drawn to clearly visualize the performance, shape and clearances of various parts comprising the machine.

**ii. Detailed Assembly drawing**

It is usually made for simple machines, comprising of a relatively smaller number of simple parts. All the dimensions and information necessary for the construction of such parts and for the assembly of the parts are given directly on the assembly drawing. Separate views of specific parts in enlargements, showing the fitting of parts together, may also be drawn in addition to the regular assembly drawing.

**iii. Sub-assembly drawing**

A sub-assembly drawing is an assembly drawing of a group of related parts, that form a part in a more complicated machine.

**iv. Installation assembly drawing**

On this drawing, the location and dimensions of few important parts and overall dimensions of the assembled unit are indicated. This drawing provides useful information for assembling the machine, as this drawing reveals all parts of a machine in their correct working position.

**v. Assembly drawing for instruction manuals**

These drawings in the form of assembly drawings, are to be used when a machine, shipped away in assembled condition, is knocked down in order to check all the parts before reassembly and installation elsewhere. These drawings have each component numbered on the job.

**vi. Exploded assembly drawing**

In some cases, exploded pictorial views are supplied to meet instruction manual requirements. These drawings generally find a place in the parts list section of a company instruction manual.

**d) Drawing Office**

A drawing office is a room or set of rooms where designs and drawings are done and Drawing materials are stored.

A typical layout consists of drawing instruments and equipment, storage for these items, office for the drawing staff, drawing tables spread out in a spacious area for users.

**e) Drafting/Draughting**

This the ability to compose drawings that communicate how an object functions or is constructed

**f) Draughtsman**

This is the person who interprets and draws to scale the engineer's design.

**g) Drawing Instruments and Equipment**

Engineering drawing involves sketching with drawing instruments and the ability to:

- i.To produce clean accurate lines of the desired thickness.
- ii.To print clear alphabetical letters and numerals in dimensions or written Communications.
- iii.To understand and apply the necessary drawing conventions as used in engineering drawing.
- iv.Think in three dimensions
- v. Master the techniques of projecting drawing views from one another.
- vi.To practice the skills developed to enable production of professional drawings

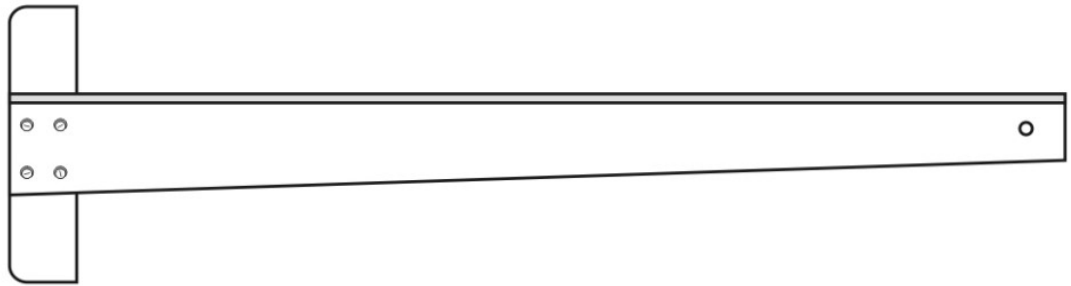
**h) Drawing equipment**

Some of the drawing instruments and equipment are:

**i. Tee or T-square**

A Tee or T-square is a wooden or plastic ruler having a short, sometimes sliding Perpendicular cross piece at the end.

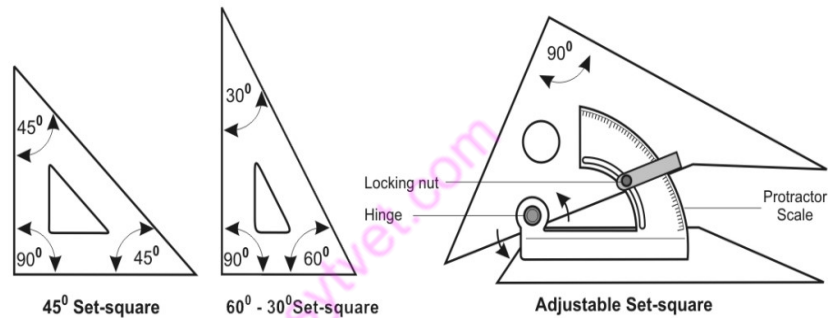
It is used to draw parallel lines. It is also used with other drawing instruments for Drawing lines at different angles.



**Figure 2: T-Square**

**ii. Set squares**

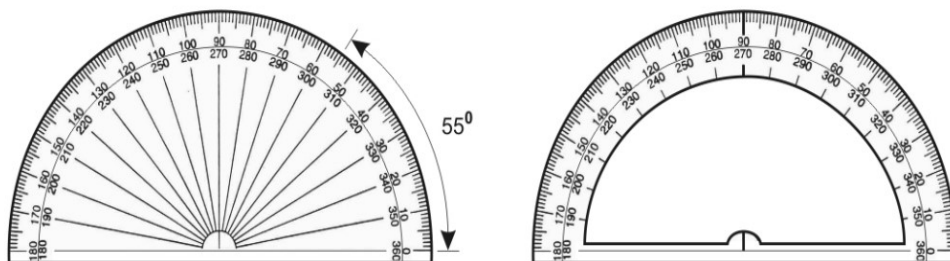
These are thin flat pieces of plastic, metallic or wooden shaped in right angled triangles. They are available in various sizes such as 30°-60°, 45° and the adjustable set square which can be adjusted to accommodate different angles.



**Figure 3 Set Squares**

**iii. Protractors**

It is a thin flat piece of plastics, metallic or wooden semi-circular instrument with a straight edge. The semi-circular part is graduated to measure angles while the straight edge is graduated to take straight measurements. Protractors are used to mark out angles on drawing.

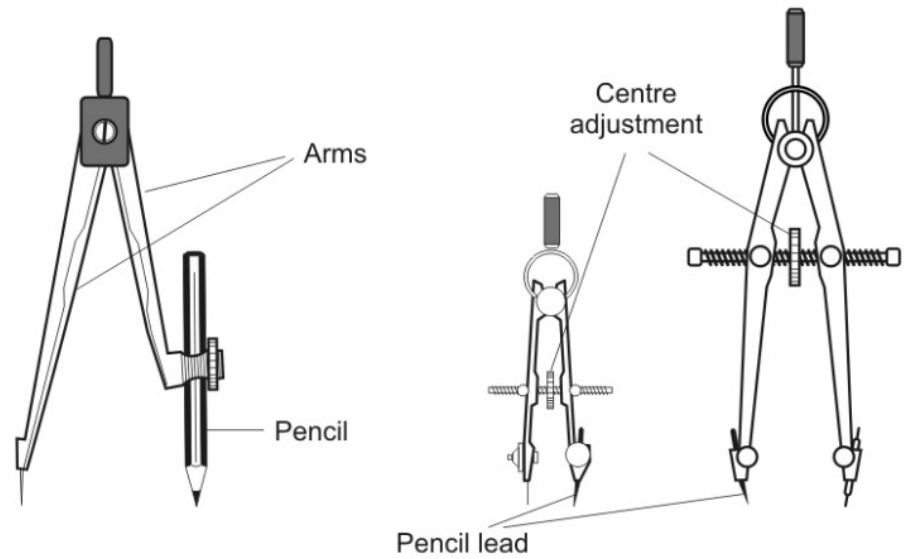


**Figure 4 Protractors**

**iv. Compasses**

It is an instrument with two arms joined together at the top; one has a sharp point that

acts the pivot while other arm has a provision for holding a pencil or a marker.  
It is used for drawing circles and arcs and for taking



**Figure 5 Compasses**

**v. Triangular Scale**

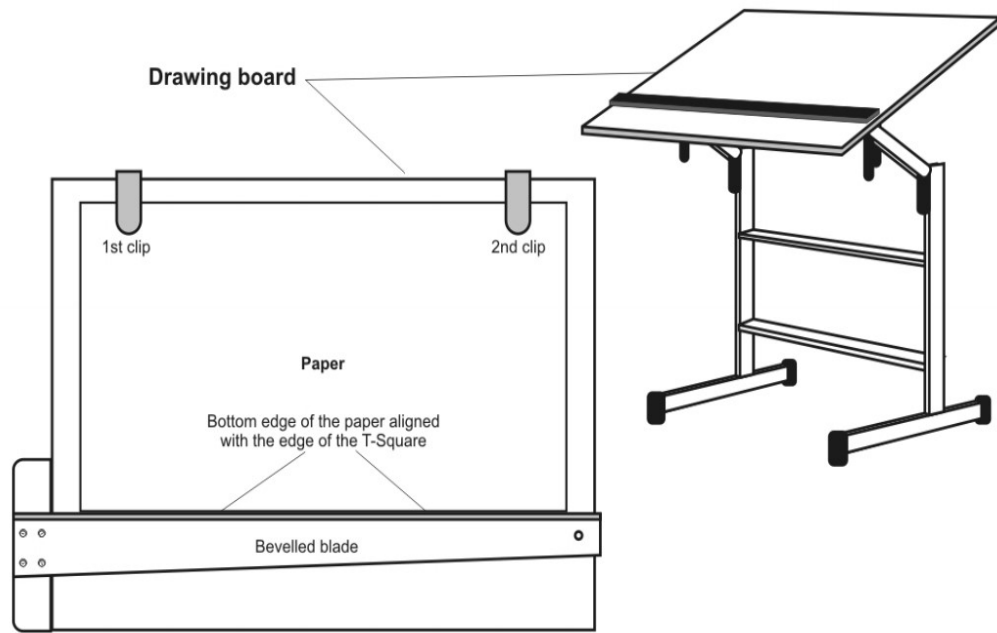
Drafters use two types of triangular scales in combination with the T-square to draw lines at various angles. These acts as guides for horizontal, vertical, and diagonal lines. They are also used to map out scales.



**Figure 6 Triangular scales**

**vi. Drawing board**

This is a flat smooth rectangular surface made of either wood, plastic, or metal. It is used for drawing purposes. Drawing board is either fixed or portable.

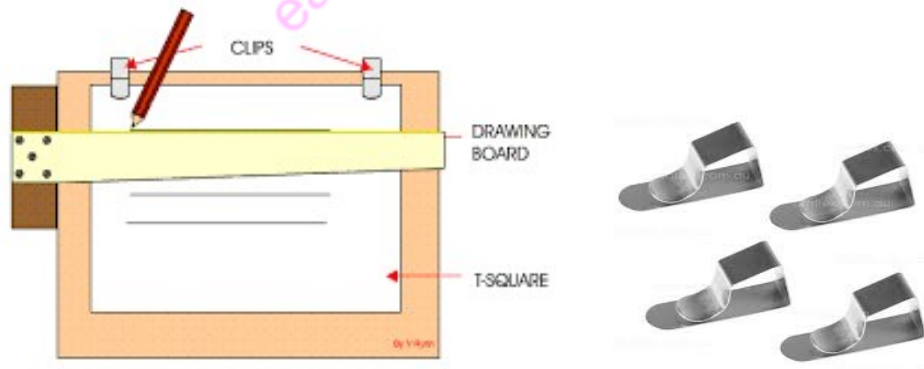


**Figure 7 Drawing Boards**

**vii. Clips and marking tapes**

A clip is a small metal or plastic object used for holding a drawing paper onto the drawing board.

A masking tape is a long narrow strip of material with a sticky substance on one side that is used to attach the drawing paper onto the drawing board



**Figure 8 Clips**



**Figure 9 Masking Tape**

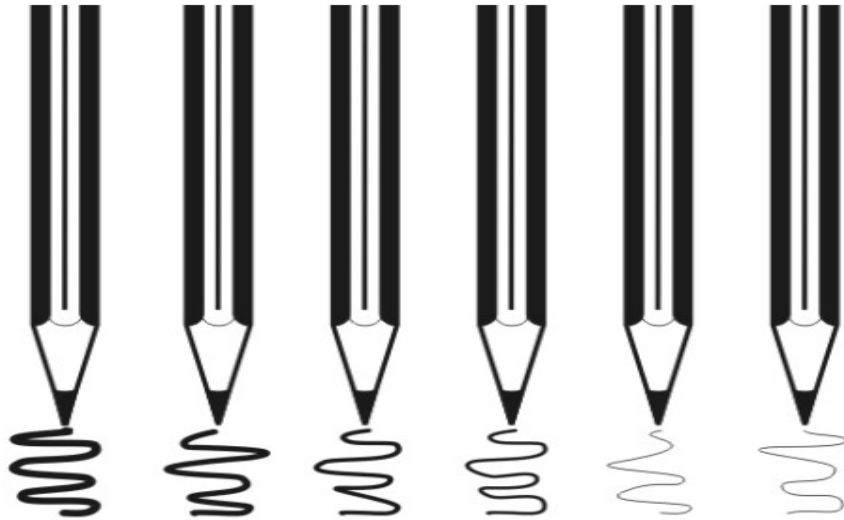
### **viii. Pencils and pencil sharpeners**

A pencil is a narrow cylindrical device for writing, drawing, or marking. It consists of a thin rod of graphite, coloured works or similar substance encased (covered) in wood or held in mechanical holder. This is one of the most important tools in drawing. It comes in various grades. The grade of pencil to be used depends on the quality of paper to be used. You must take into consideration also the type of line work required.

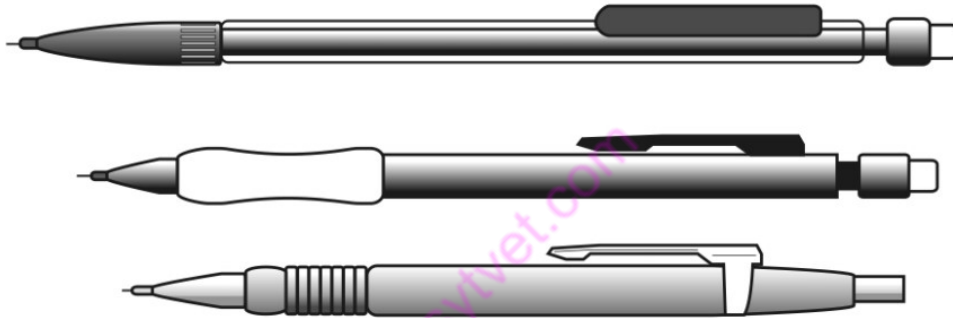
Pencils can be categorized in three classes, namely:

- a) The **soft range pencils** such as 2B, 3B, 4B, 5B, 6B, 7B. The 7B being the softest. These pencils are mostly used in artwork.
- b) The **medium range pencils** such as B, HB, BH, 2H, 3H; these are used for general drawing and sketching.
  - HB grade is recommended for lettering and dimensioning.
  - H Medium grade for Visible outlines, visible edges and boundary lines
  - 2H Hard grade for construction lines, Dimension lines, Leader lines, Extension lines, Centre lines, Hatching lines and Hidden lines.





**Figure 10 Wooden pencils-has graphite lead**



**Figure 11 Mechanical/Clutch pencils-uses replace lead**

The choice of which pencil to use is determined by the type of line desired.

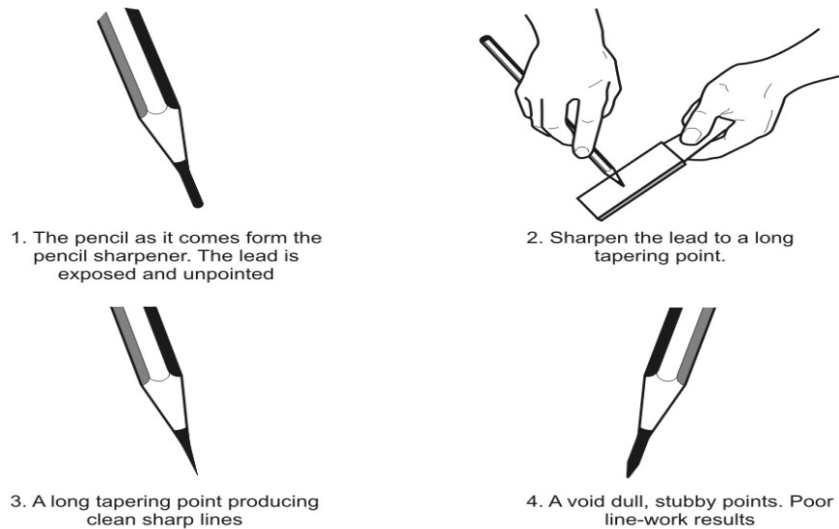
- c) The **hard range pencils** such as 4H, 5H, 6H, 7H, 8H, 9H. The 9H being hardest.

These pencils are used for accurate layout work.

### **Sharpening of pencils**

This can be done using a razor blade, a mechanical sharpener, or a knife. The procedure involves:

- a) Cutting the wood at about 20mm of the front part of the pencil.
- b) Shaping the internal lead into a conical shape using a sandpaper pad or a fine file while revolving the pencil, or shaping the lead to a flat or chisel edge by rubbing on two opposite's side of the lead. A long, tapering point produces clean sharp lines while a dull point produces poor line works.



**Figure 12 Sharpening a Pencil Procedure**

The sharpening of the pencil should be done away from the drawing paper and board. The pencils used should be of reasonable length and of the expected hardness to get the desired line result.

**ix. Geometrical sets**

This consists of compasses, dividers, erasers, protractors, sharpener and other Accessories.

**Divider**

A tool with two metal legs used to lay-out an arc circle or step off division on a line. Is like the compass in construction. As the name implies, divider is used for dividing distances into several equal parts by the trial-and-error method.



**Figure 13 Dividers**

**Steps in Using a Divider**

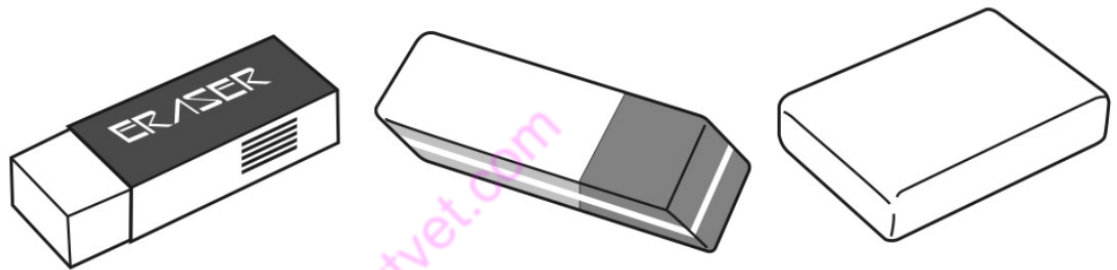
- a) Align each arm of the dividers so that one point is laying on the start point of

the measurement you want to transfer and the other divider point is laying on the endpoint of that same measurement.

- b) Lift the dividers off the measurement you intend to transfer, being careful not to change their alignment.
- c) Place the dividers over the location you'd like to transfer the measurement to, and make a pencil mark to indicate where each of the dividers' pointers sits. This duplicates the measurement.

### **Erasers**

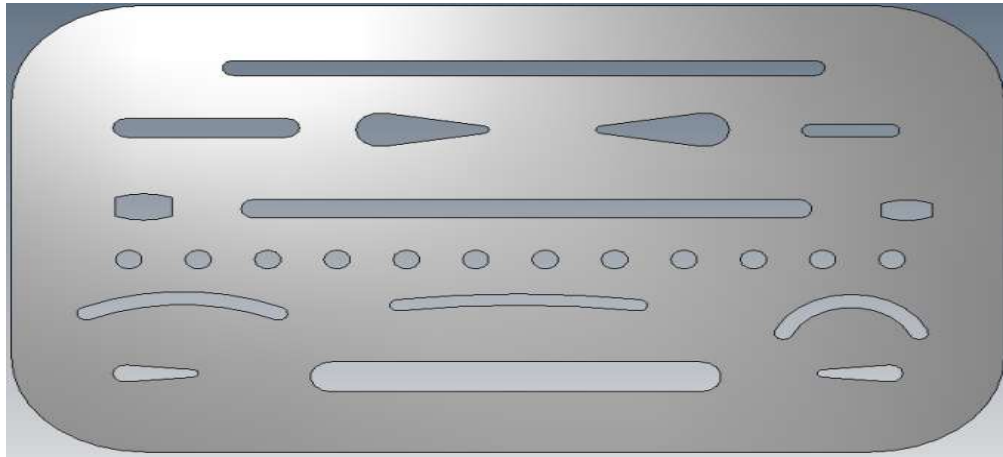
These are used to rub off the pencil works that need correction or removing untidy patches from drawing paper. Erasers are used to remove pencil works though care must be taken to avoid damaging the drawing.



**Figure 14 Erasers**

### **Eraser shields**

These can be made of metallic or plastic materials and are used for protecting line works that should not be erased. The shields have opening of various shapes that are placed on the area required to be rubbed and then the eraser is insert through these openings, shielding the blocked areas.



**Figure 15 Eraser Shield**

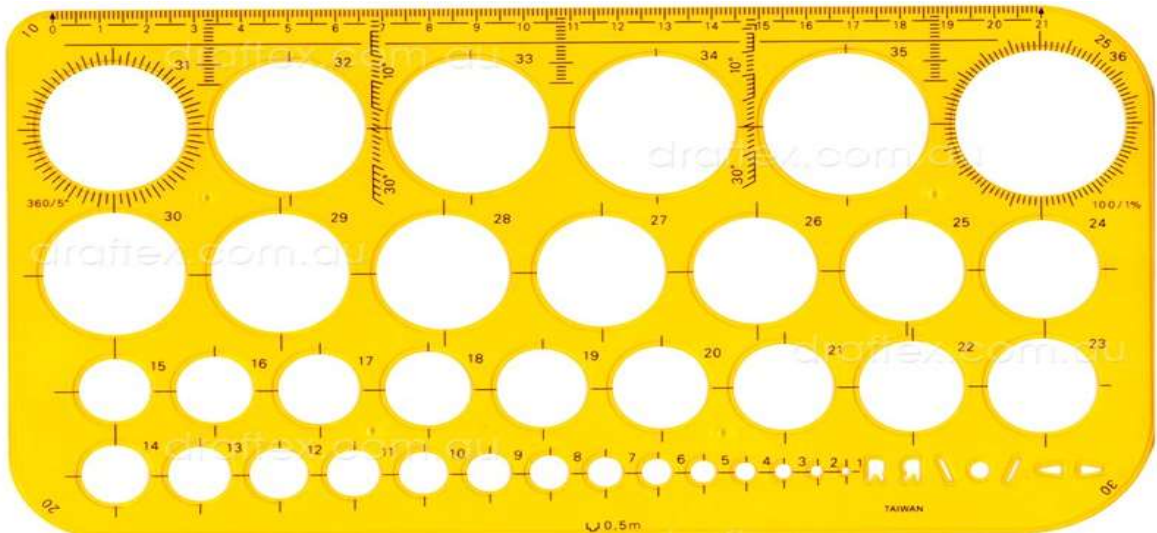
**x. Drawing template curves**

Drawing templates and lettering guides are precision drafting templates covering a wide variety of applications. They are used in architecture, interior design, landscaping, engineering, and map making are included;

- a) Lettering guides conforming to ISO 3098 standards.
- b) Line guides for establishing a set of hand lettering parameters.
- c) French curves and flexible curves which enable varieties of curved shapes to be drawn with minimal effort.



**Figure 16 French Curves**

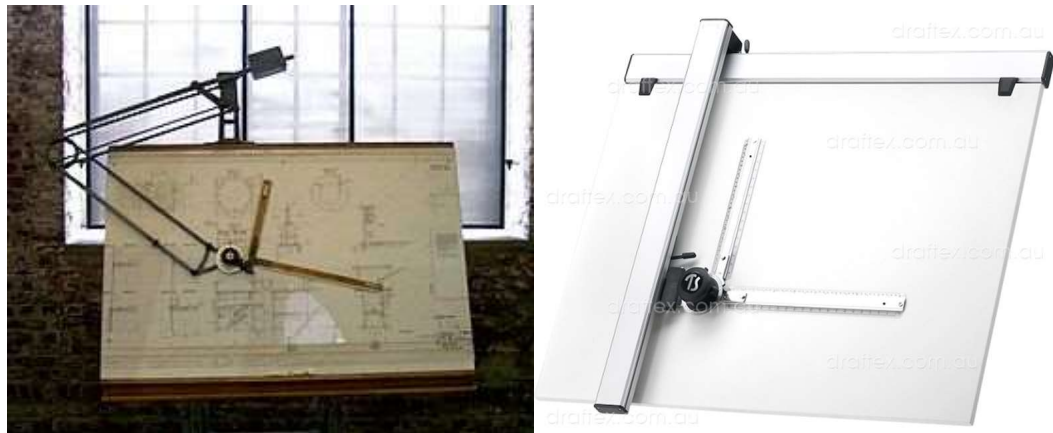


**Figure 17 Circle template**

### **xi. Draughting equipment**

“A draughting machine is a tool used in technical drawing, consisting of a pair of scales mounted to form a right angle on an articulated protractor head that allows an angular rotation. Draughting tools are instruments that can be used for measurement and layout of drawings or to improve consistency and the speed for creating standard drawing elements”.

Drafting machines combine the functions of the T-square, triangles, scales, and protractor. Allowing you to draw more quickly and with less work.



**Figure 18 Draughting Equipment**

### **xii. Computer-aided design (CAD)**

“Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design. ... The term CADD (for computer aided design and drafting) is also used.”

### xiii. Engineering drawing software's

These are various software's used by engineers, architects, draughtsman, and construction managers among others to replace manual drafting. They help users to create designs in either two dimensions (2D) or three dimensions (3D) enabling the user to visualize the object in different perspectives. CAD enables the development, modification, and optimization of the design process

## i) Drawing materials

### i. Drawing paper

Paper layout on the drawing board. Paper layout is the process of defining the workspace and orientation of the drawing paper. The following steps are involved in paper layout:

#### 1. Paper sizing

Drawing papers used in technical drawing are rectangular in shape.

The papers are serialized according to the sizes.

The table below shows the different paper sizes.

Series	Paper size in (mm)
A0	1189 × 841
A1	841 × 594
A2	594 × 420
A3	420 × 297
A4	297 × 210
A5	210 × 148
A6	148 × 105

**Figure 19 Paper sizes**

#### 2. Setting of the drawing papers

The drawing paper is placed on the drawing board according to the desired orientation. A T-square is then held firmly on the drawing board with the horizontal edge aligned to lower edge of the paper.

The paper is finally fixed in position with either clips or masking tape.

#### 3. Drawing of boundary lines.

Boundary line is a line that defines the working space of the drawing paper. It is always equidistant from all the edges of the paper and at least 10 mm from edge.

The figure below shows the drawing paper boundary.

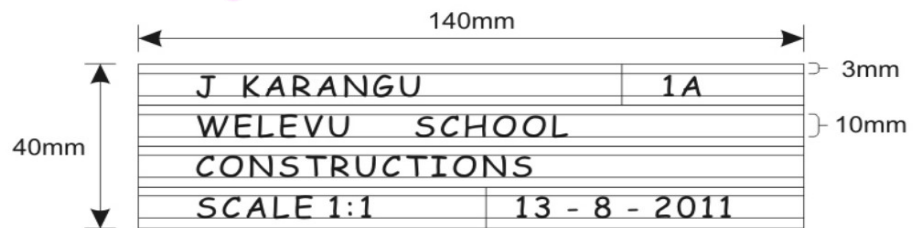


**Figure 20 Drawing Paper Layout**

#### 4. Drawing the title block

A title block is a designated area where the parameters for defining the drawing are stated. These parameters include details such as; name of the person drawing, scale and the institution. It is usually drawn at the bottom of the right-hand corner within the working area of the drawing paper.

The figure below is a sample of title block.



**Figure 21 Sample title block**

- ii. **Pencils-**covered above
  - iii. **Erasers-** covered above
  - iv. **Masking Tapes-** covered above
  - v. **Paper Clips-** covered above
- j) Use, care and maintenance of drawing equipment's**

Draughting tools, materials, and equipment are delicate and need good care for their applications to remain at its best. Keeping your drafting tools clean, well maintained, and

properly stored will result in better performance and longer service life. Below are some tips to properly use and take care of them.

- a) The performance of simple cleaning, maintenance, and storage procedures help a lot in keeping the efficiency of every drafting instrument. The early detection and reparation of any signs of deterioration will enable the drafter to save time and resources in the future.
- b) Perform safety procedures in maintaining drawing tools, drawing instruments, equipment, and other related accessories.
- c) Follow procedures in cleaning, tightening and simple repair of drawing tools, drawing instruments, equipment, and accessories.
- d) Identify common malfunction (unplanned or unusual events) when using tools, drawing instruments, equipment, and accessories. Always ensure you inspect tools before use, this is to check if they are in working condition.
- e) After using a tool, clean it thoroughly with a damp cloth. Wipe it dry with another piece of cloth before keeping it.
- f) The following are common good practices in handling and caring for your drafting tools and equipment.

**i. Pencils**

- Use soft cloth or tissue to clean the pencil to get rid of particles that may ruin your work.
- Sharpen your wooden pencil with a quality sharpener.
- Keep your pencils in a secure case or tie them together with rubber band to avoid breakage when transporting them.
- Never sharpen the pencil over the drawing or close to any of your equipment.
- Keep the pencil lead sharp and pointed when drawing.
- Avoid using solvents or other strong chemicals when cleaning your mechanical pencil. Such chemicals may corrode the material your pen is made of.
- Use only the lead designed for your mechanical pencil to avoid mechanical jam and clogging.
- Load your mechanical pencil with the recommended amount of lead.
- Observe correct refilling procedure.

**ii. T-square, triangles, and French curves**

- Do not use the T-square for any rough purposes.



- Never cut paper along its working edge, since the plastics can easily be damaged. Even light nick can ruin the T-square.
- When not in use, the T-square, triangles, or French curves is preferably hung by inserting the hole to a nail on a surface i.e a wall.
- Apply oil on all the movable parts of the measuring tools such as zigzag rules, calipers, dividers, and compasses to avoid rusting.
- Avoid unnecessary sliding of T-square or triangles protect the drawing. Pick up the triangle by its tip and tilt the T-square blade upward slightly before moving.

**iii. Ruler or scale**

- Scales should not be pricked with needle points of either the divider or compass when measurements are taken.
- Do not use scale as a ruler.

**iv. Dividers and compasses**

- Do not oil the joints of the legs of the dividers.
- Do not use the divider as substitute for clips in fastening the drawing paper on the drawing board or tabletop.
- The needle points must be sharp and of equal length.

**v. Drawing paper**

- It should be stored in rolled form.
- It should not be crumpled or wet or kept in a moist or cold place.

**vi. Masking tape, eraser and erasing shield**

- Should be kept together with other supplies to avoid losing it.

**vii. Drawing board or drawing tape**

- It should always be in good (drawing) working condition.
- It must always be clean on or before using.
- Do not leave any kind of marks on your board to retain its smoothness.

- g) Avoid dropping your tools and equipment by keeping them far from the edges of the board.
- h) Report defective measuring tools and any hazard to instructor immediately
- i) Never use measuring tools in cutting paper.
- j) Ensure measuring tools are protected and stored well
- k) Have a separate container for marking tools.
- l) Keep your drawing sheets in a plastic tube to protect them from a dust and dirt.

- m) Never borrow drafting tools and materials if you do not know how to use and store them.

Check out the lesson online on introduction to technical drawing for further explanation

<https://www.youtube.com/watch?v=YE0oZZO7vbk>

<https://www.youtube.com/watch?v=0Q6QwvtjVm8>

[http://www.depedbataan.com/resources/9/k\\_to\\_12\\_mechanical\\_drafting\\_learning\\_module.pdf](http://www.depedbataan.com/resources/9/k_to_12_mechanical_drafting_learning_module.pdf)

#### **2.2.1.4. Learning Activities**

Below is a wash hand basin drawn in isometric view? As a trainee you are required to;

- i. Identify and gather drawing equipment's according to the below task
- ii. Identify and gather drawing materials according to the task

easytv.com



#### 2.2.1.5. Self-Assessment

##### Exercise 1

Select the drafting material and tool/drawing applicable to a specific job.

1. A drafting tool used for drawing horizontal lines
  - a) Compass
  - b) Triangle
  - c) T-square
  - d) Triangular Scales
2. Drafting material used for fastening the drawing paper on the drawing table
  - a) Compass
  - b) Divider

- c) Masking Tape
  - d) Triangle
3. The main function of this tool is to reproduce the measurements of an object to any size.
- a) Compass
  - b) Protractor
  - c) Triangle
  - d) Triangular Scales
4. This drafting tool is used to protect the rest of the drawing when removing unnecessary lines.
- a) Erasing Shield
  - b) Eraser
  - c) Masking Tape
  - d) Pencil Sharpener
5. This drafting tool is used when drawing vertical lines.
- a) Compass
  - b) Triangle
  - c) Triangular Scales
  - d) Ruler

#### **2.2.1.6. Tools, Equipment, Supplies and Materials**

- i. Drawing boards
- ii. T squares
- iii. Set squares
- iv. Drawing sets
- v. Drawing paper
- vi. Protractors
- vii. Eraser Shield
- viii. Pencils
- ix. Erasers
- x. Masking tapes
- xi. Paper clips
- xii. Drawing curves
- xiii. Technical drawing software

### 2.2.1.7. References

1. Bhatt, N. D. (2011). *Engineering Drawing*. Gujarat: Charotar Publishing house.
2. Maguire, C. H. (2004). *Manual of Engineering drawing*. Oxford: Elsevier Newnes.
3. Morling, K. (2010). *Geometric and Engineering drawing*. London: Elsevier.
4. <https://www.youtube.com/watch?v=lk-FBgadTyA>
5. K.L Narayana, P.Kannaiah and K.venkata Reddy .(Third edition) Machine Drawing :New Age International (P) Limited, Publishers.

easytv.com

**Model answers.**

1. A drafting tool used for drawing horizontal lines

**C. T-square**

2. Drafting material used for fastening the drawing paper on the drawing table

**C.Masking Tape**

3. The main function of this tool is to reproduce the measurements of an object to any size.

**D.Triangular Scales**

4. This drafting tool is used to protect the rest of the drawing when removing unnecessary lines

**D. Erasing Shield**

5. This drafting tool is used when drawing vertical lines.

**B. Triangle**

easytvvet.com

## **2.2.2 Learning outcome 2: Develop plane geometry drawings**

### **2.2.2.1 Introduction to the learning outcome**

The focus of this specific learning outcome is to introduce the different working drawings and their purpose during the planning of plumbing works. This section will give an understanding of the different types of working drawings, building symbols and different representations of drawings.

### **2.2.2.2 Performance Standard**

The following performance criteria will be required to be met by trainees to be considered competent:

1. Freehand sketching of different types of geometric forms and diagrams is conducted.
2. Different types of lines used in drawing and their meanings are identified according to standard.
3. Drawing conventions.
4. Different types of geometric forms are constructed according to standard conventions.
5. Different types of angles are constructed, measured, and bisected according to principles of trigonometry.

### **2.2.2.3 Information Sheet**

#### **a) Terms and concepts**

##### **i. Freehand Sketching**

Sketching or freehand is a first step to the preparation of a scale-drawing, i.e., a drawing drawn with the aid of instruments. A designer records his ideas initially in the form of sketches which are later converted into drawings. Similarly, views of actual objects are in the first instance, sketched freehand.

Scale-drawings are then prepared from these sketches. Ideas and objects can be described in words, but the description is made more expressive with the aid of sketches. Thus sketching is of great importance in engineering practice.

Sketching is always done freehand. It is in fact a freehand drawing made in Correct proportions, but not to scale. A sketch should be so prepared as to give to others a clear idea, complete information, and true impression of the object to be constructed. It should never be drawn too small. The size of a sketch should be such that all the features of the object, together with their dimensions, explanatory notes etc. are clearly incorporated in it. Proficiency in sketching can be achieved with constant practice only.

- ii. Axonometric**  
Method of projection in which an object is drawn with its horizontal and Vertical axes to scale but with its curved lines and diagonals distorted
- iii. Detailed drawing**  
Drawing of a detail part usually in orthographic projection
- iv. Detail dimension**  
Measurements of the detail part or parts of the object
- v. Dimensioning**  
Process of placing measurements in a drawing in the metric or English System
- vi. Isometric axes**  
Light lines used as bases in constructing an isometric view of an object
- vii. Isometric drawing**  
Pictorial drawing showing the three views of the object tilted 30 degrees in front of the observer.
- viii. Multi-view drawing**  
Drawing that shows more than one view of an object
- ix. Notation**  
All lettering and other dimension found in a drawing or working sketch
- x. Oblique drawing**  
Kind of pictorial drawing of an object one surface of which is shown parallel to the frontal plane and the other is inclined to it.
- xi. Orthographic projection**  
Presentation of an object in two or more views by projecting the outline of the object to the plane of projection perpendicular to each other
- xii. Overall dimension**  
The total width, height, and depth of the object



**xiii. Perspective drawing**

A drawing which shows an object as it appears to our eyes

**xiv. Pictorial view**

The presentation of an object where it is viewed showing the three faces of an object

**xv. Working plan**

A freehand drawing showing all the information needed to construct an object.

**xvi. Types of drawings**

There are various drawings used in the construction sector, some of these are list below:

**Production drawing:**

A production drawing is legal document of a manufacturer. It is used by the technicians on the shopfloor for manufacturing the parts. It should provide information about part number, dimensions, tolerance, surface finish, material and stock size, manufacturing process, special finishing process if required, and no. off required for each assembly. It is further sub-classified as:

- Part drawing or detailed drawing
- Assembly drawing.

**Exploded Assembly Drawing**

It represents the details of machine in a pictorial form as it is assembled. It helps the plumber to dismantling machine for repairing purpose.

**Schematic assembly drawing**

This type of assembly drawing is used for explaining working principle of any machine

**Drawing for instructional manual**

This is assembly drawing without dimensions. Each part of machine is numbered so that it can be easily dismantled or assembled if required. This is also used for explaining working principle of each part.








**Drawing for installation**

This is assembly drawing with overall dimensions. It is used for the preparation of foundation for installing machine.

**b) Types of lines in drawings**

There are many lines used in technical drawing, the table below illustrates some of them;

- i. **Visible line** – a thick line that represents the visible edges or outline of the object; also known as the object line
- ii. **Hidden line** – a medium thick line composed of short dashes about 2-3 millimeters long with space between dashes about 1-2 millimeters wide; it represents the surface or edges that cannot be seen
- iii. **Center line** – a thin line consisting of two long dashes and short dash drawn alternately with a gap of at least 2 millimeters in between; it represents the axis or center of symmetrical shapes like a ball, washer, rectangular block, cube.
- iv. **Section line** – a thin lines to show the surface that has been cut; they are spaced evenly at 45 degrees with the horizontal to make shaded effect
- v. **Extension line** – a thin line that extends from the object to show dimension limits
- vi. **Dimension line** – a thin line with an arrowhead in one end used to indicate the Measurements of the object
- vii. **Long-break line** – a medium thick line consisting of broken and straight lines drawn alternately. This is also known as the limiting line. This limits the length of an elongated object without changing the size of its view.
- viii. **Short-break line** – thick line drawn in freehand to show details that a part has been cut off or broken out.
- ix. **Leader line** – a short inclined thin line with an arrowhead at the end and short horizontal line on the other end.
- x. **Phantom line** – a thin line that shows position(s) of part of an object that moves drawn by two short dashes and one long dash.
- xi. **Cutting-plane line** –thick lines used to indicate an imaginary cut through an object along the line. Made up of two long dashes broken in one end with an arrowhead and two short dashes drawn in between the long dashes.

Type of line	Used for drawing	Pencil Grade	Sample Drawing
Continuous thick	Visible outlines	H	
Continuous thin	Dimension line, leader line, extension, construction lines and hatching lines	2H	
Continuous thin (drawn free hand)	Irregular boundary line, short break line	2H	
Continuous thin with zigzag	Long break line	2H	
Short dashes (Hidden line)	Invisible edges	H	
Long chain (thin)	Center lines	2H	
Long chain (thick at ends and thin else where)	Cutting plane	H&2H	

**Figure 22 Types of lines and their applications**

**c) Freehand sketching**

A freehand sketch is a drawing in which all proportions and lengths are judged by eyes and all lines are drawn without the use of drawing instruments. Comparing with mechanical drawing, the use of freehand sketching in engineering

Communication provides the following advantages:

- i. A better means of visualizing problems
- ii. Organizing ideas more quickly
- iii. Avoiding wasting of time on formal drawing methods

The following requirements are necessary for sketching materials in plumbing,

**Sketching tools:**

A sketch communicates information and does not have to be an exact drawing. Many designs were visualized

on just a piece of paper or whatever is available. The tools that are used in freehand sketching are:

- i. Sketching paper cross-section paper or grid paper, help secure good proportions and serve as guides in sketching lines

- ii. Pencil medium lead (B) or soft lead (HB) type
- iii. Eraser soft type

Above the three things are essential for sketching. Sometimes, cross-sectioned graph paper ruled with light lines is also used instead of a plain paper. These lines and squares help in drawing straight lines and maintaining proportions.

As such papers may not always be readily available, it is advisable to learn sketching without their aid.

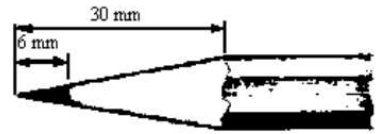
Freehand drawing is known as sketching. This technique is necessary in any area of drafting and an important skill for everyone. Skills in freehand drawing can be achieved through constant training and correct practice.

### **Use of pencils**

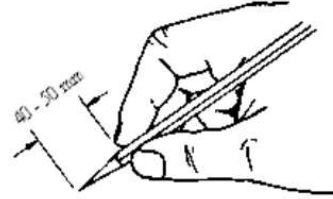
Although freehand lines will never be perfectly straight and absolutely uniform along their lengths, effort should be made to sketch distinct, black and uniform lines. Hints of using pencils that help sketching to be made to approach exacting uniformity are as follows:

easytv.com

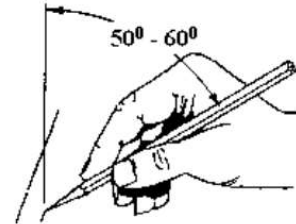
i) Sharpen the pencil to obtain a proper point



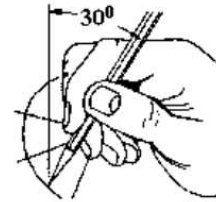
ii) Hold the pencil loosely, approximately 40 - 50 mm from the point



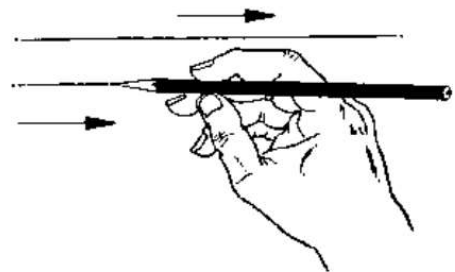
iii) Slant the pencil at an angle of 50 - 60 degrees from the vertical for sketching straight lines



iv) Slant the pencil at an angle of 30 degrees from the vertical for sketching circles

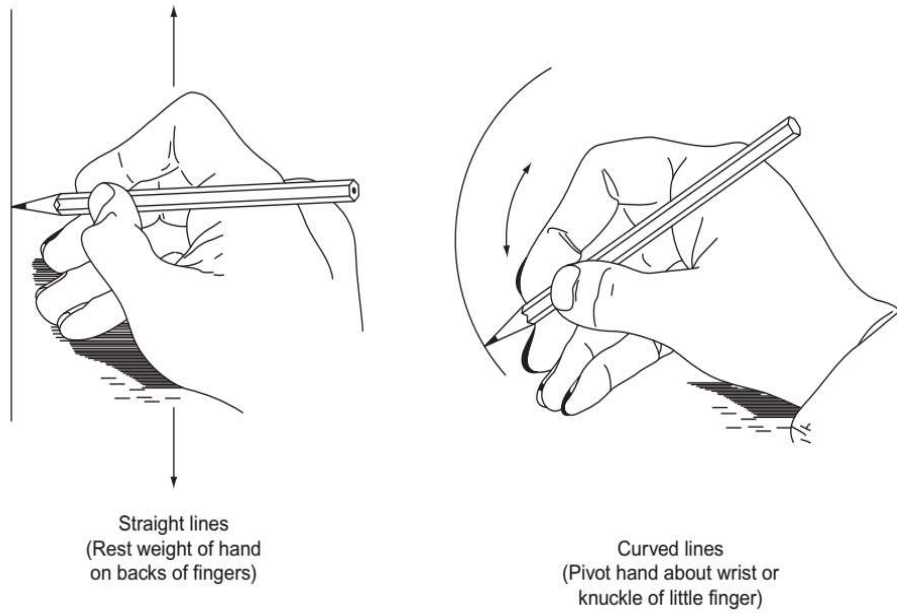


v) Pull the pencil when sketching straight lines or curves



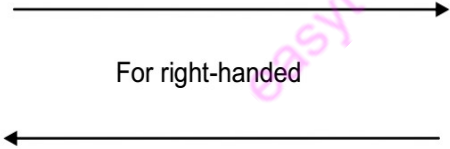
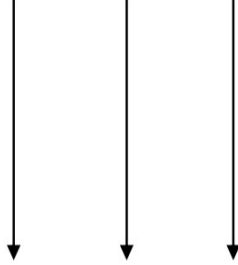
### Line Sketching

One advantage of freehand sketching is that it needs only patience and continuous Practice. Practice on a drawing paper the construction of following line without use of instruments. When drawing straight lines, as on the left, rest the weight of your hand on the backs of your fingers. When drawing curved lines, as on the right, rest the weight on that part of your hand between the knuckle of your little finger and your wrist. This provides a pivot about which to swing your pencil. Always keep your hand on the inside of the curve, even if it means moving the paper around.



**Figure 23 Freehand sketching technique (Source: H Morling)**

**Basic Line Sketching**

Kind of lines	Direction of strokes
<div style="text-align: center;">  <p>For right-handed</p> <p>For left-handed</p> </div> <p><b>Horizontal lines</b></p>	<p>Strokes are drawn from left to right for right-handed and from right to left for left-handed individuals.</p>
<div style="text-align: center;">  </div> <p><b>Vertical lines</b></p>	<p>Strokes are drawn downward.</p>

**Figure 24 Exercise 1 on drawing various lines in freehand**

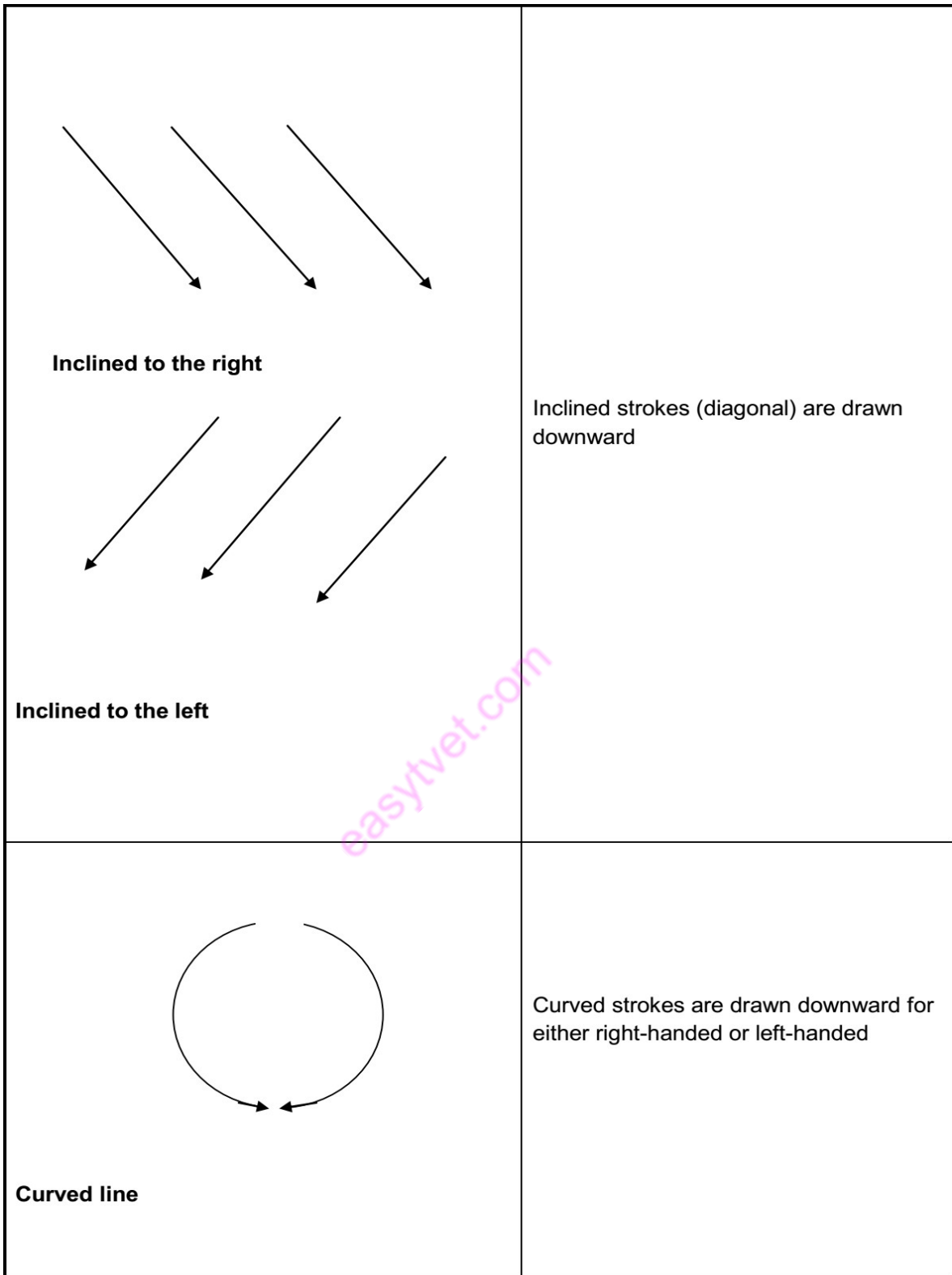
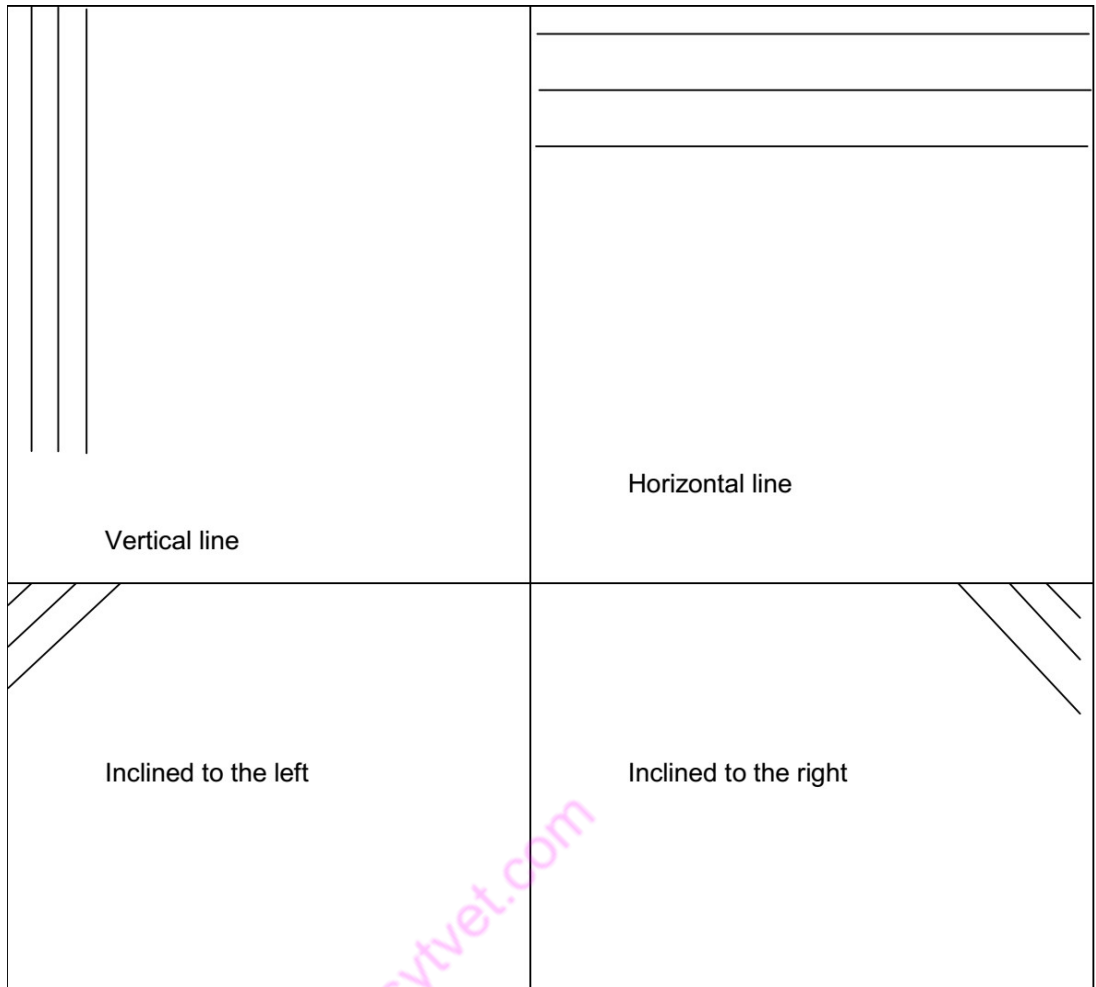
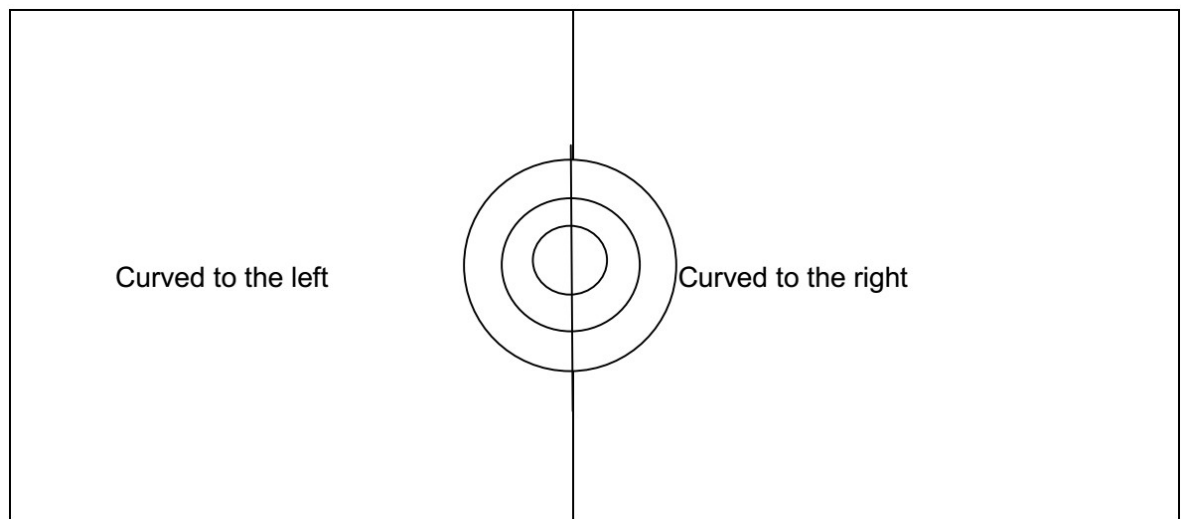


Figure 25 Exercise 2 on freehand sketching



**Figure 26 Exercise 3**

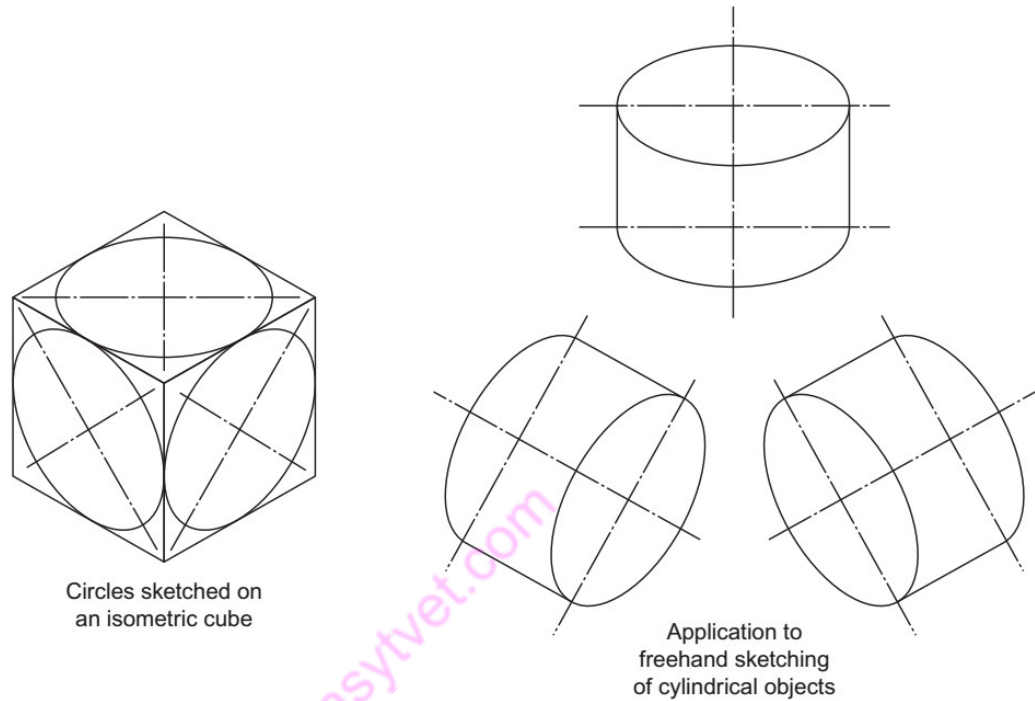


**Figure 27 Exercise 4**



## Pictorial Sketching

Freehand pictorial sketching looks very much like isometric drawing. Circles appear as ellipses and lines are drawn at approximately  $30^\circ$ . Circles have been sketched onto an isometric cube in figure below. You can see how these same ellipses appear on sketches of a round bar material.



**Figure 28 Pictorial exercises**

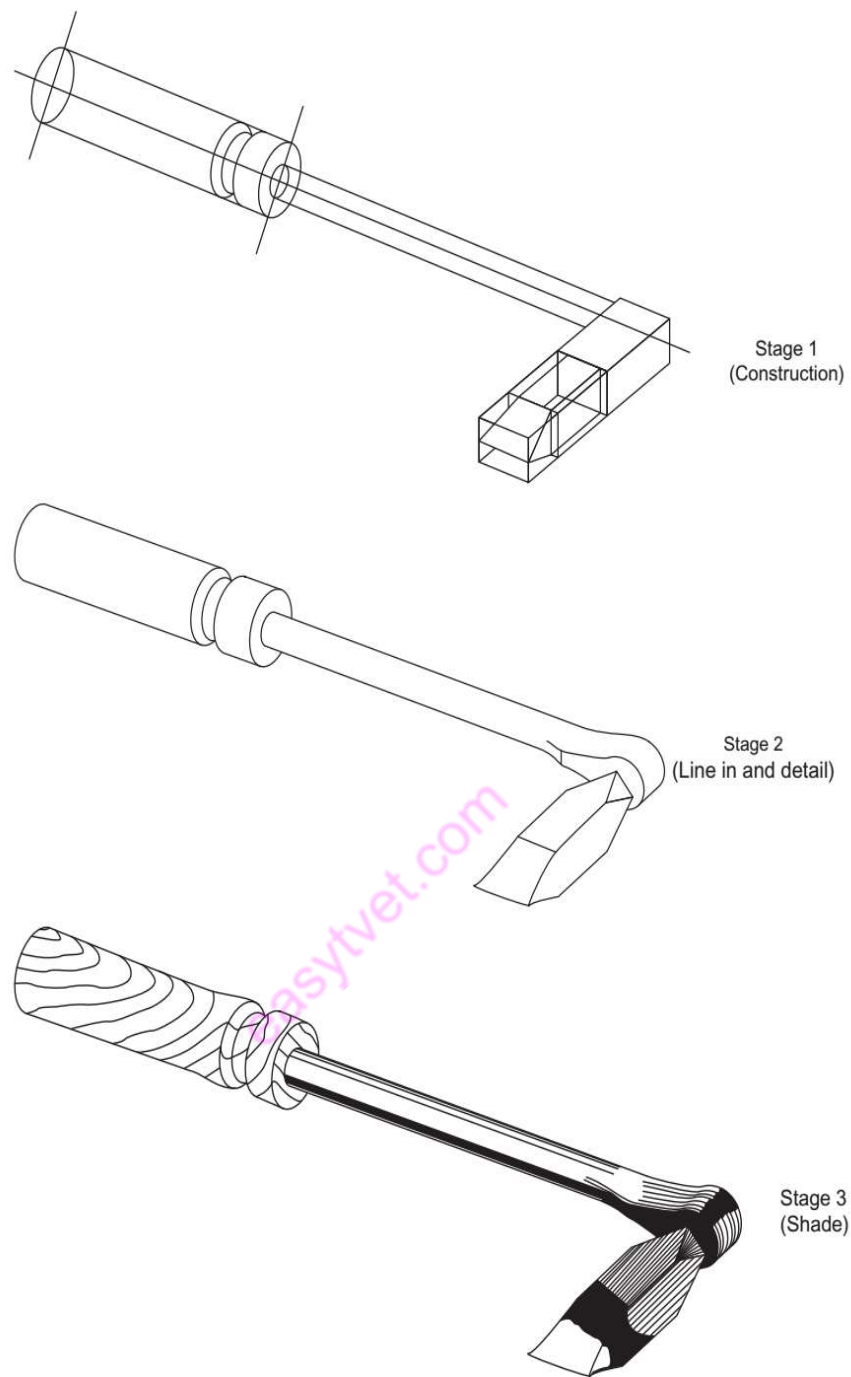
When sketching, you may find it an advantage to draw a faint 'box' first and draw in the ellipses afterwards. With practice you should find that you can draw quite a good ellipse if you mark out its centre lines and the major and minor axes. Although drawing is a continuous process, the work can be divided into three basic stages.

### Stage 1: Construction

This should be done with a hard pencil (3H), used lightly, and the strokes with the pencil should be rapid. Slow movements produce wavy, uncertain lines. Since these constructed lines are very faint, errors can easily be erased.

### Stage 2: Lining in

Carefully line in with a soft pencil (HB), following the construction lines drawn in stage 1. The completion of stage 2 should give a drawing that shows all the details and you may decide, particularly in an examination, not to proceed to stage 3



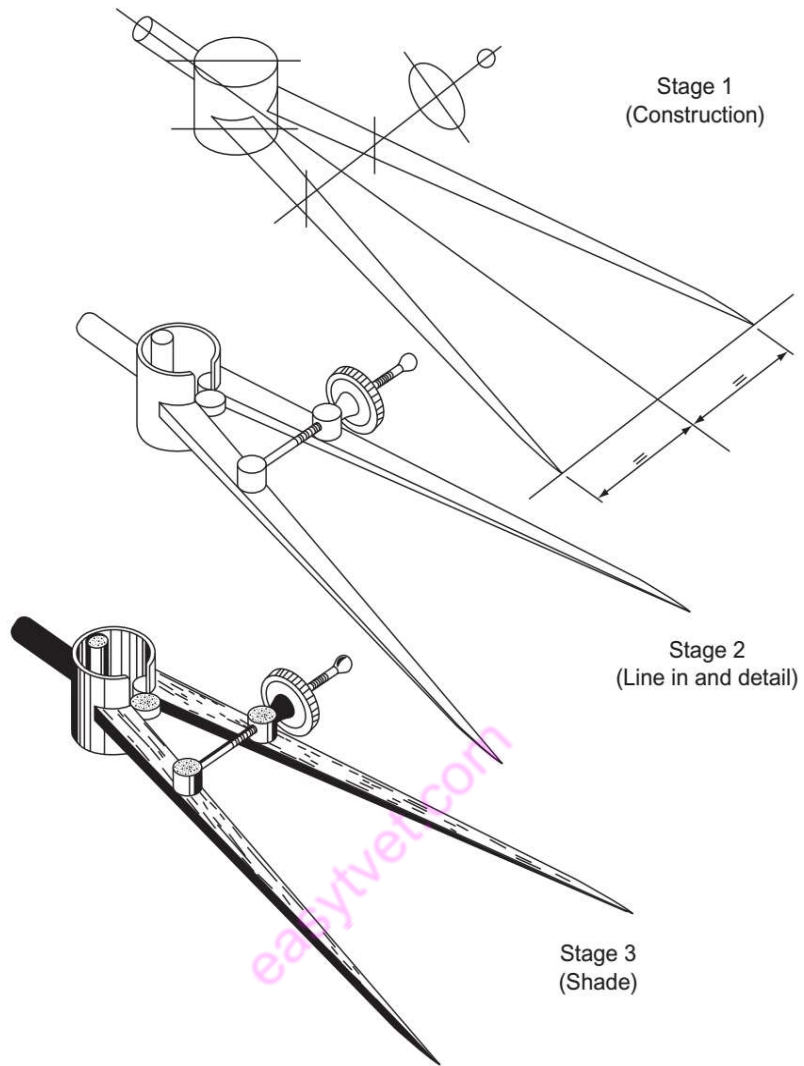
**Figure 29 3 stages of freehand sketching**

**Stage 3: Shading**

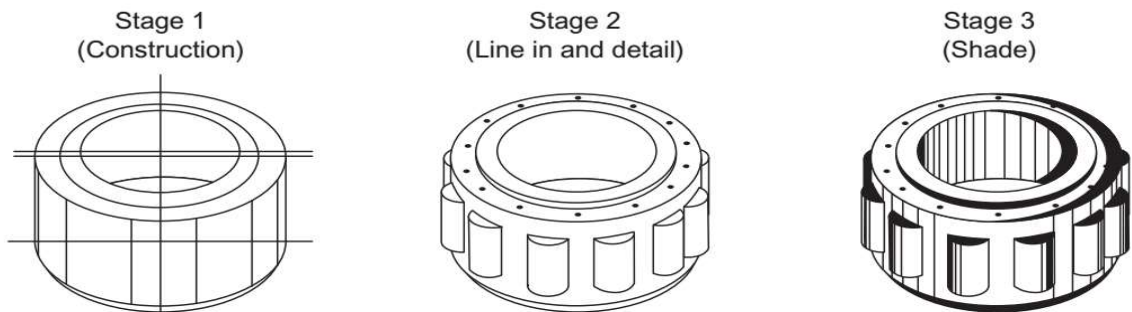
Shading brings a drawing to life. It is not necessary on most sketches, and in some cases it may tend to hide details that need to be seen. If the drawings are to be displayed, however, some shading should certainly be done.

Shading is done with a soft pencil (HB). It is very easy to overshade, so be careful. For the smooth merging of shading, the dry tip of a finger can be gently rubbed

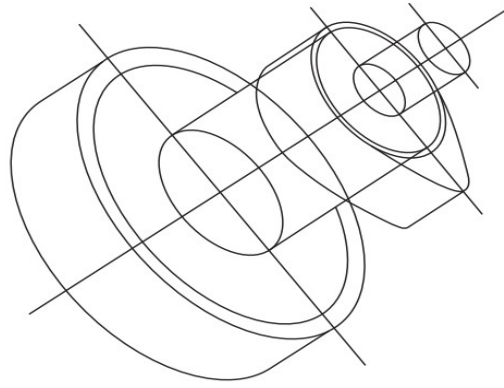
over the area.



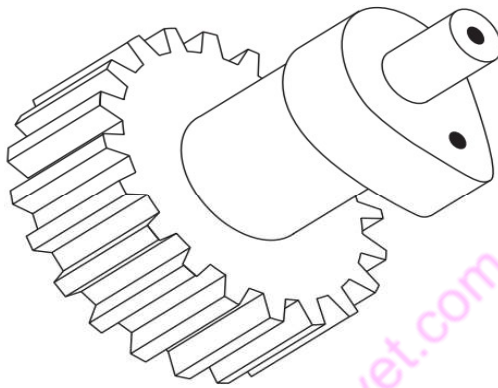
**Figure 30 Divider Exercise**



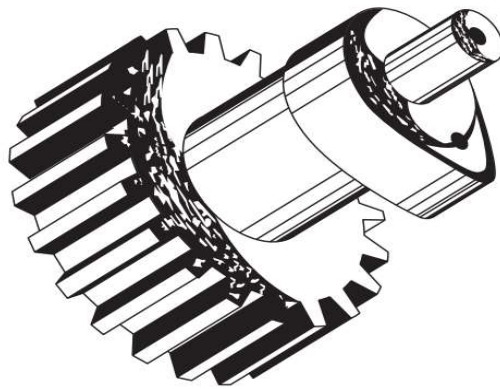
**Figure 31 Bearing exercise**



Stage 1  
(Construction)



Stage 2  
(Line in and detail)



Stage 3  
(Shade)

**Figure 32 Gear Exercise**

**Sketching in Orthographic Projection**

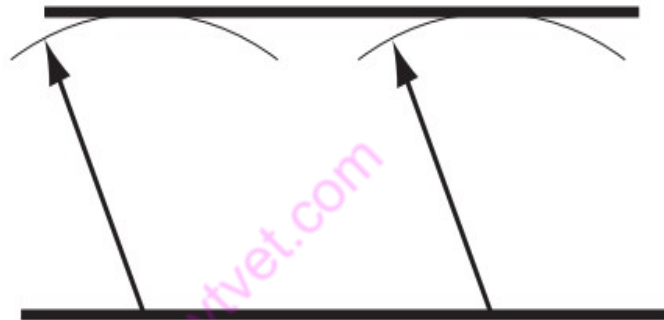
More detail can be seen on an orthographic drawing than on an isometric, mainly because more than one view is drawn. For this reason it is often advantageous for a draughts person to make an orthographic sketch. This will be undertaken below

Circles are difficult to draw freehand but you can use your hand as a compass. Hold your pencil upright and, using your little finger as a compass 'point', revolve the paper keeping your hand quite still.

**d) Construction, measurement, and bisection of angles**

The following constructions are important in preparation of drawing various objects:

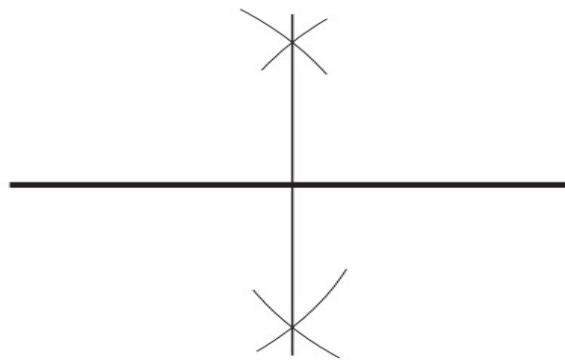
**i. Construction of a parallel line parallel to another using compasses and T-square**



**Figure 33 Construction of parallel lines**

- Construct the given line,
- using compasses set to wanted distance apart,
- make two arcs at different point on the lines
- Join the want line by T-square at the top of the two arcs

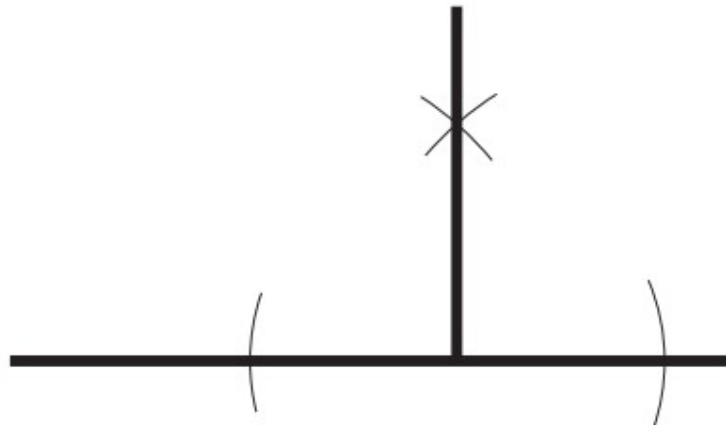
**ii. Bisection of a given line**



**Figure 34 Bisection of a line**

- Draw the given line using a T-square
- At each end of the line open the compasses approximately more than half and strike two arcs that meet as shown
- Join the meeting arc points as shown
- Where the line is cut by the bisector is the middle point.

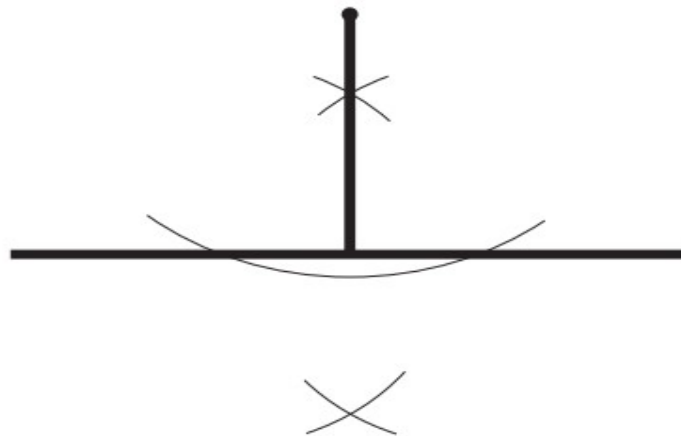
iii. **To erect a perpendicular from a point on a line.**



**Figure 35 Construction of a perpendicular line**

- Construct the given line using a T-square
- Using compasses with some distance from the line strike 2 arc on the line as shown
- Using the compasses at the 2 arc, strike arc to meet as shown
- Using T-square and a set square perpendicularly construct a line through the arc meeting point.

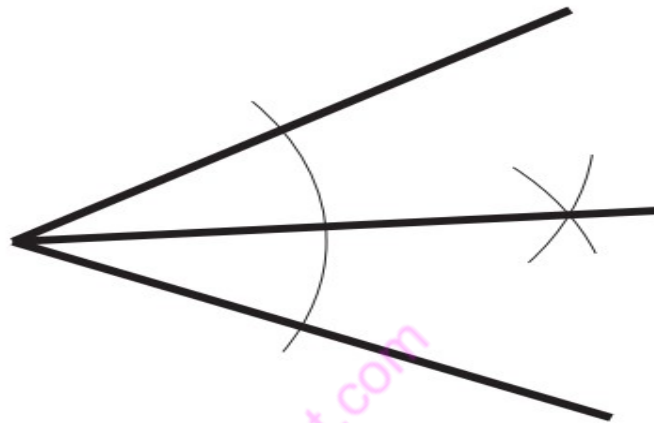
iv. **To erect a perpendicular from a point to a line.**



**Figure 36 Erecting a perpendicular line**

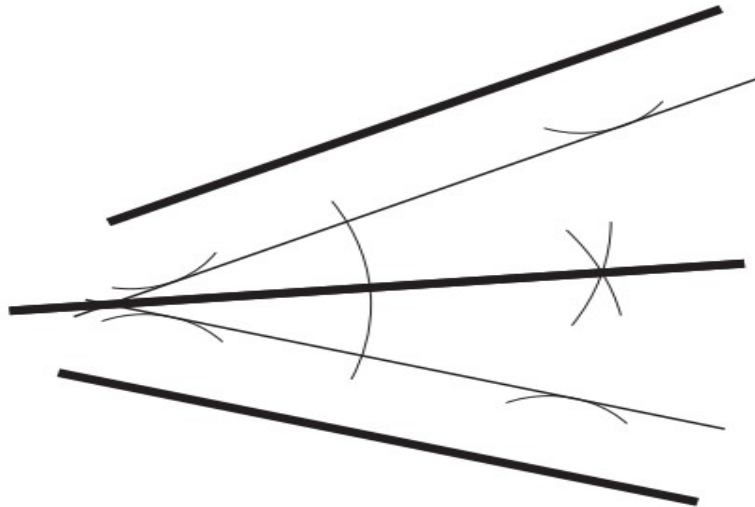
- Construct the line using a T-square
- With the compass at the given point extend it to cut the line at 2 points as shown
- At the 2 points open compasses to strike 2 arcs that meet above and below the line
- Join the meeting points of the arcs as shown.

v. **To bisect an angle.**



**Figure 37 Bisecting an Angle**

- Construct the angle as shown
  - With a compass mark an arc from the apex of the angle as shown
  - Using the points of the arc at both sides of the angle strike arc to meet as shown
  - Draw the bisector from apex to arc meeting point
- vi. **To bisect the angle formed by two converging lines.**



**Figure 38 bisecting 2 converging angles**

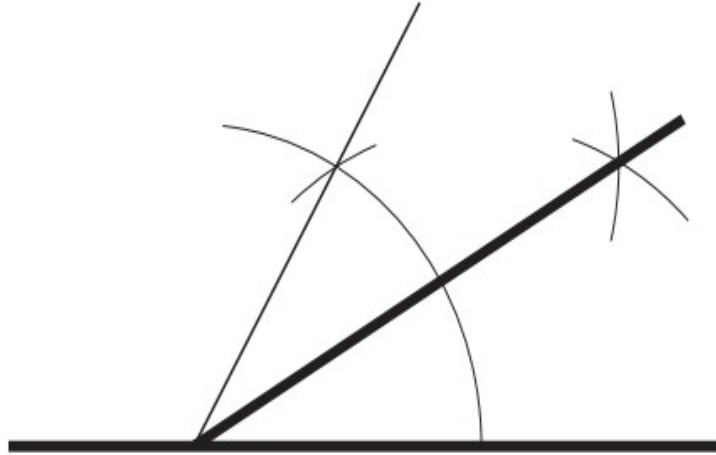
- Construct parallel lines to the two converging line as shown
  - Bisect the angle as shown above
- vii. To construct  $60^\circ$
- Construct a horizontal line as shown below using T-square
  - Using compass strike an arc from a marked point on the line
  - From the arc meeting point on the line strike an arc to cut the initial arc as shown.
  - Draw a line from the marked point on line through the arcs meeting point to get  $60^\circ$  angle as shown



**Figure 39 Constructing an angle of  $60^\circ$**

- viii. To construct an angle of  $30^\circ$



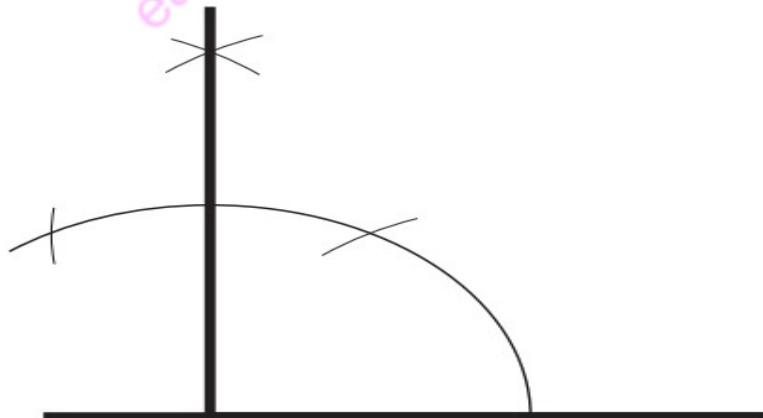


**Figure 40 Construct an angle of  $30^\circ$**

- This is done by constructing an angle of  $60^\circ$  and bisecting as shown

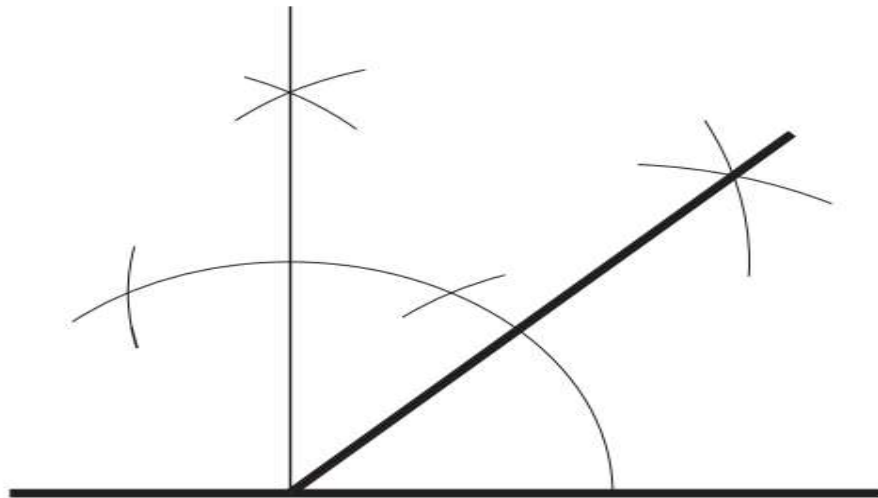
ix. **To construct  $90^\circ$**

- Construct a horizontal line as shown below
- With a compass mark a point on the line and draw a semi-circle on the line
- Mark from one end of semi-circle with same radius an arc which shows  $60^\circ$ , then another arc of  $60^\circ$  as shown
- Bisect the second  $60^\circ$  to get  $30^\circ$  as shown below



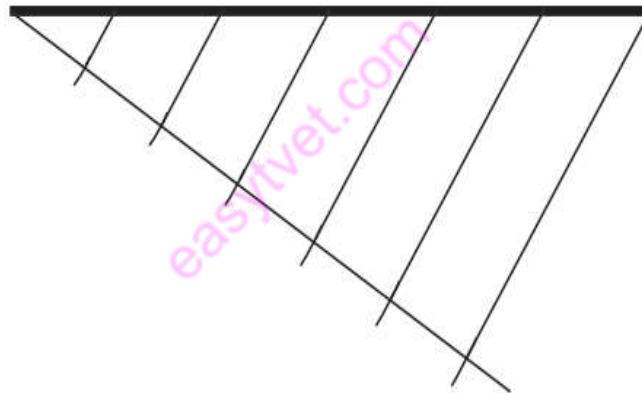
**Figure 41 constructing an angle of  $90^\circ$**

x. **To construct  $45^\circ$**



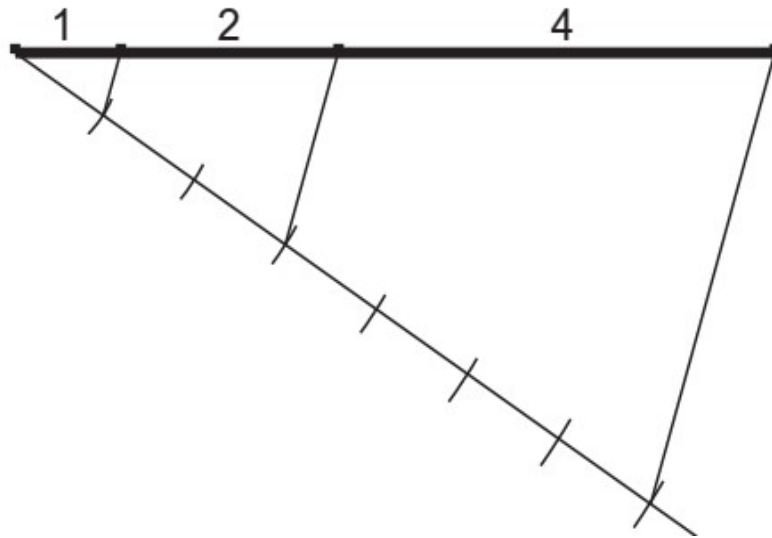
**Figure 42 constructing an angle of  $45^{\circ}$**

- Construct an angle of  $90^{\circ}$  and bisect as shown
- xi. To divide a line into several equal parts (e.g. six).**



**Figure 43 divide a line into equal parts**

- Construct the line using a T-square
  - Construct another line at an angle from the start of the line downwards
  - Divide the inclined line to same number of lines as the wanted number using a compass
  - Join the end point of inclined line to initial line
  - Construct parallel lines from the marked inclined line to the original. This marks the wanted divisions
- xii. To divide a line proportionally (e.g. 1:2:4).**



**Figure 44 dividing a line proportionally**

- Construct the given line using T-square
- Draw an inclined line and mark out the same number of equal arcs as the total wanted part i.e.  $1+2+3=6$  parts
- Join the end of the marked inclined line to the horizontal line and at the ratio point of point 1 and 2 construct parallel line to mark the ratio on the horizontal line.

### **Numbers and Alphabets**

In professional drawing, numbers and alphabets are used to present certain information. They are written or drawn following some rules to ensure maximum legibility. Numbers and alphabets can be presented either as vertical or slanting. Alphabets can either be in upper case or in lower case.

The following are illustrations of presentation of numbers and letters of the alphabets.

## **Numbers**

1234567890

Open style

1234567890

Slanting style

## **Alphabets**

ABCDEFGHIJKLMN

OPQRSTUVWXYZ &

Open style

ABCDEFGHIJKLMN

OPQRSTUVWXYZ &

Slanting style

abcdefghijklmnopqrs

tuvwxyz &

Open style

abcdefghijklmnopqrs

tuvwxyz &

Slanting style

**Figure 45 Alphabets and numbers**

### **Lettering in drawing**

Lettering plays major role in engineering. It indicates details like dimensioning, naming of the drawing, etc. The use of instruments for lettering is not advisable, as it will consume more time. Free hand sketching is used instead

#### **Rules and Features:**

- Lettering in drawing must be of standard height. The standard heights of letters used are 3.5mm, 5mm, 7mm and 10mm.

#### **Features:**

The essential features of lettering used in engineering drawing are:

- Legibility
- Uniformity
- Similarity

Single stroke letters are the simplest form of letters and are generally used in engineering drawing.

#### **Vertical Lettering:**

Vertical lettering is upright, i.e. 90° to the horizontal.

Both uppercase or large and lowercase or small letters are used.

#### **Inclined Lettering:**

Inclined lettering has letters inclined at 75° to the horizontal and as for vertical lettering both uppercase and lowercase letters are used.

The following are some of the rules to be observed in writing numbers and alphabets:

- a) Avoid unnecessary details in writing numbers and alphabets.
- b) Ensure that numbers and alphabets are properly spaced.
- c) Ensure that the numbers and alphabets fit into the printing guidelines.
- d) Use the right eraser or rubber when erasing.
- e) Use the same alphabet style and casing on the same drawing.
- f) Never use vertical and sloping numbers on the same drawing.

### **Dimensioning**

In addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.

Principles of dimensioning some of the basic principles of dimensioning are given below.

1. All dimensional information necessary to describe a component clearly and completely shall be written directly on a drawing.
2. Each feature shall be dimensioned once only on a drawing, i.e., dimension marked in one view need not be repeated in another view.
3. Dimension should be placed on the view where the shape is best seen .
4. As far as possible, dimensions should be expressed in one unit only preferably in millimeters, without showing the unit symbol (mm).
5. As far as possible dimensions should be placed outside the view .
6. Dimensions should be taken from visible outlines rather than from hidden lines

### **e) Construction of geometric forms e.g. squares, circles**

#### **Two dimensional representations**

These are representations which describe the length and area of an object. They are created from orthographic projections. Examples of some of the two dimensional representation are:

- a) Square.
- b) Triangle.
- c) Parallelogram.
- d) Circle.

The construction of some of the two –dimensional figures are illustrated below

### **The Quadrilateral**

#### **Definitions**

The quadrilateral is a plane figure bounded by four straight sides.

### Types of quadrilaterals

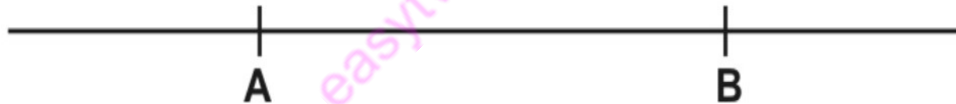
- i. **A square** is a quadrilateral with all four sides of equal length and one of its angles (and hence the other three) a right angle.
- ii. **A rectangle** is a quadrilateral with its opposite sides of equal length and one of its angles (and hence the other three) a right angle.
- iii. **A parallelogram** is a quadrilateral with opposite sides equal and therefore parallel.
- iv. **A rhombus** is a quadrilateral with all four sides equal.
- v. **A trapezium** is a quadrilateral with one pair of opposite sides parallel.
- vi. **A trapezoid** is a quadrilateral with all four sides and angles unequal.

### Square

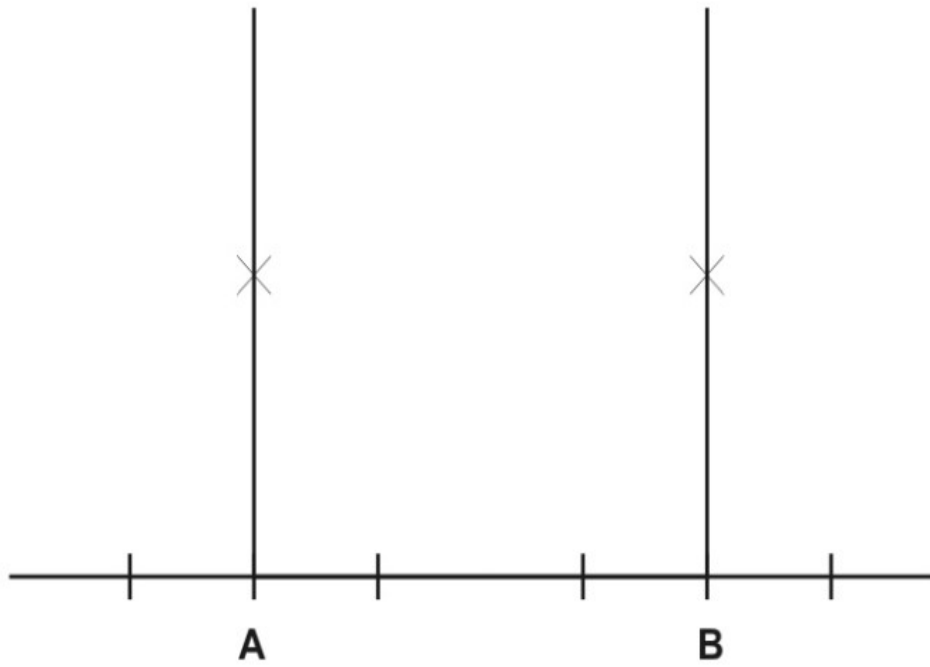
A square is a figure with four straight equal sides and four angles of  $90^\circ$ . The following is a procedure for constructing a square:

#### Procedure:

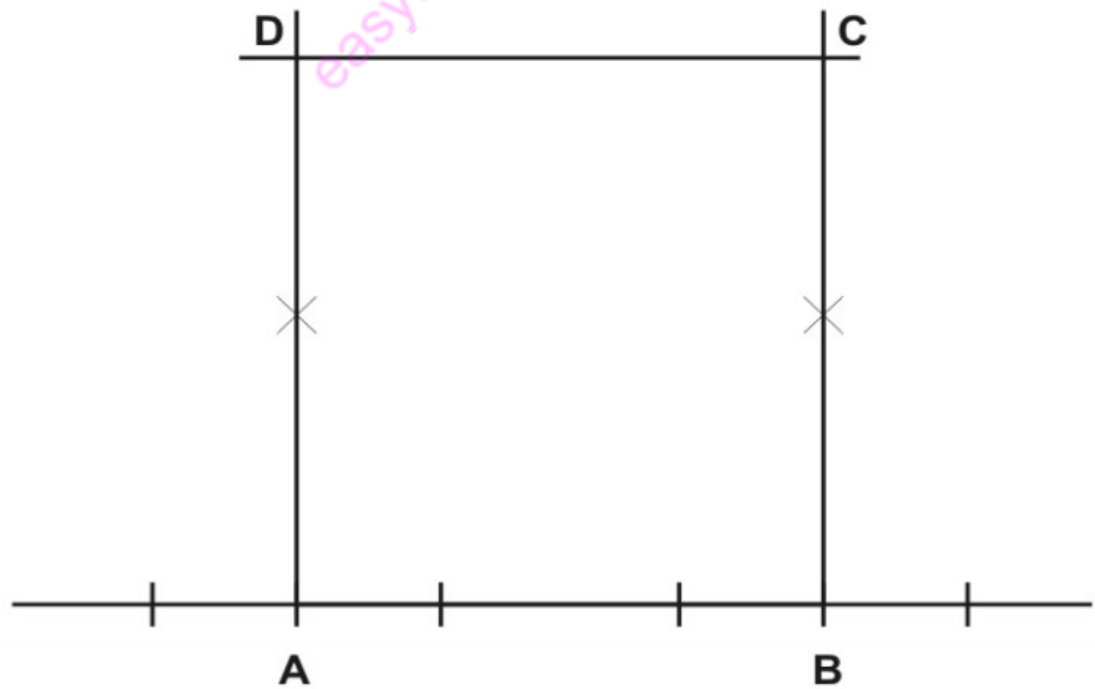
- i. Draw a line AB to a given length and extend it past the point A and B,



- ii. Construct perpendicular lines from points A and B.



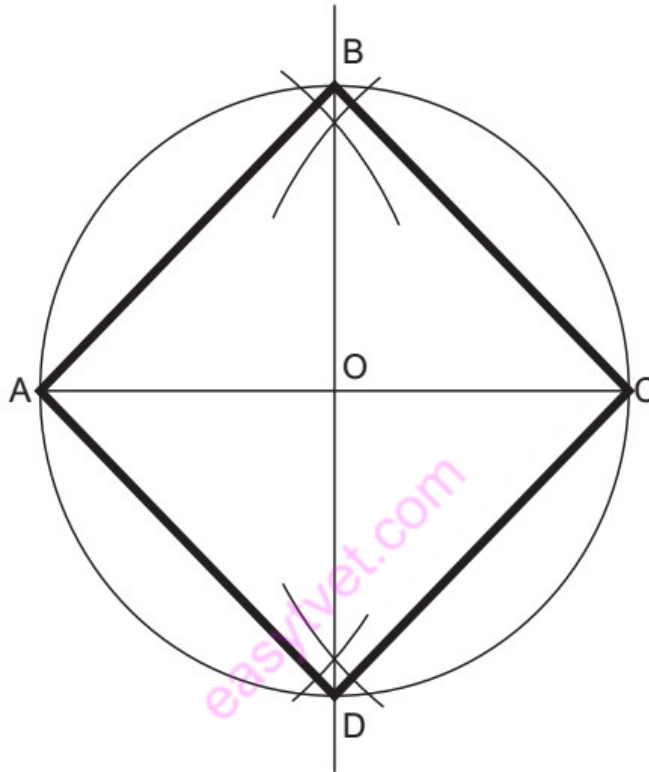
- iii. Using a pair of compasses mark lengths equal to length AB on the perpendicular lines from A and B and mark the new points C and D.
- iv. Join points C to D.



**To construct a square given the diagonal**

- i. Draw the diagonal AC.
- ii. Bisect AC.
- iii. With centre O and radius OA (OC), draw a circle to cut the bisecting line in B and D.

**ABCD is the required square.**



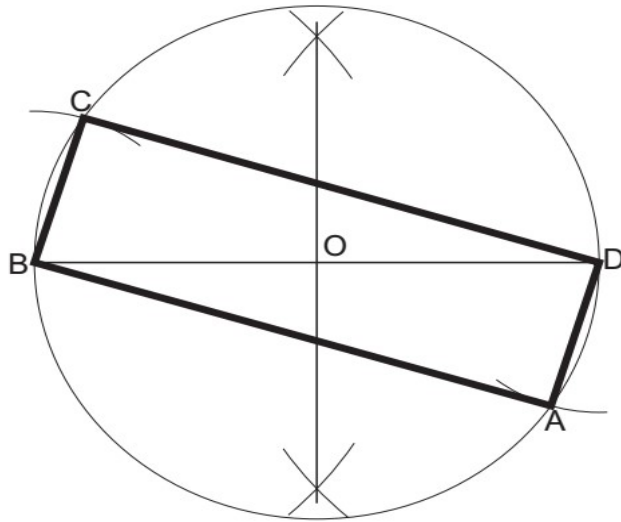
**Figure 46 Construction of a square given diagonal**

**To construct a rectangle given the length of the diagonal and one of the sides**

- i. Draw the diagonal BD.
- ii. Bisect BD.
- iii. With centre O and radius OB (OD), draw a circle.
- iv. With centre B and radius equal to the length of the known side, draw an arc to cut the circle in C.
- v. Repeat step 4 with centre D to cut at A.

**ABCD is the required rectangle**



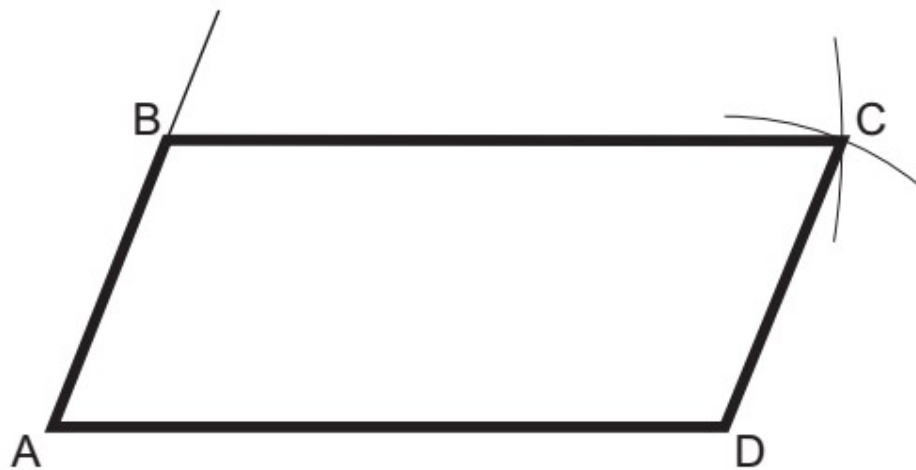


**Figure 47 Construction of a rectangle**

**To construct a parallelogram given two sides and an angle**

- i. Draw AD equal to the length of one of the sides.
- ii. From A construct the known angle.
- iii. Mark off AB equal in length to the other known side.
- iv. With compass point at B, draw an arc equal in radius to AD.
- v. With compass point at D, draw an arc equal in radius to AB.

**ABCD is the required parallelogram.**



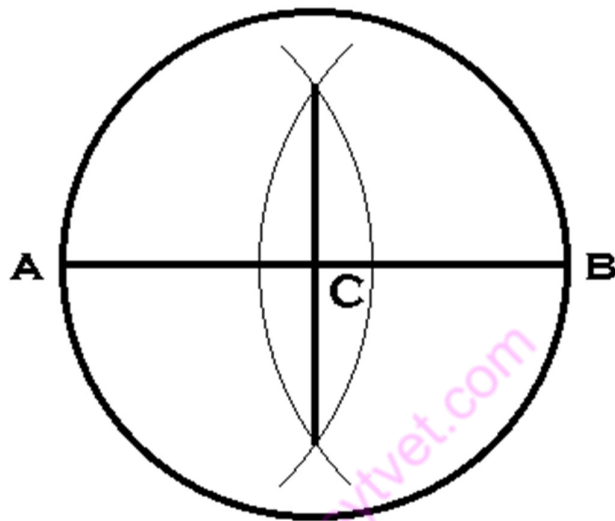
**Figure 48 Construction of a parallelogram**

**Circle**

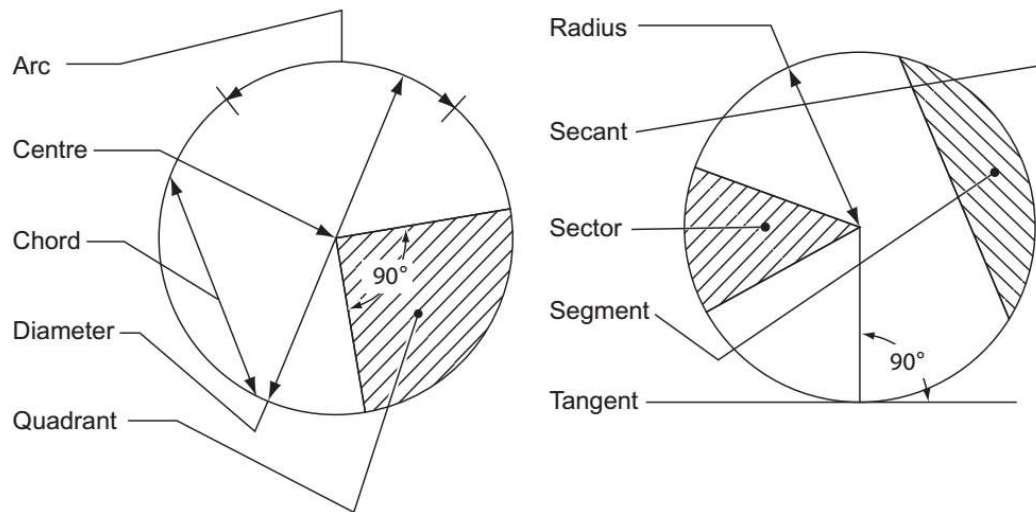
A circle is a path of points equidistant from a fixed point. A circle is the locus of a point which moves so that it is always a fixed distance from another stationary point. A circle is constructed as illustrated below:

**Procedure**

- i. Mark a point 'C', the centre of the circle by bisecting the given diameter.
- ii. Open the compass to radius =AC=CB.
- iii. Fix the pinned of the pair of compasses at the point 'C'
- iv. Rotate the penciled end of the pair of compasses through an angle of 360°, about point C



**Figure 49 Construction of a circle**



**Figure 50 Parts of a circle**

**Construction of a triangle**

**Definitions**

The triangle is a plane figure bounded by three straight sides.

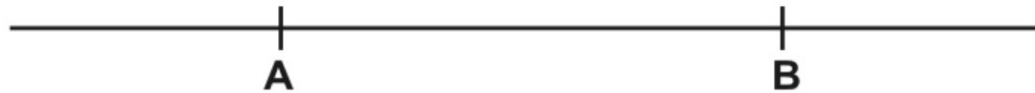
### Types of triangles

- i. A **scalene triangle** is a triangle with three unequal sides and three unequal angles.
- ii. An **isosceles triangle** is a triangle with two sides, and hence two angles, equal.
- iii. An **equilateral triangle** is a triangle with all the sides, and hence all the angles, equal.
- iv. A **right-angled triangle** is a triangle containing one right angle. The side opposite the right angle is called the 'hypotenuse'.

### Construction of an equilateral triangle

The following is a procedure for constructing an equilateral triangle.

- i. Draw a line AB of a given length.



- ii. With a pair of compasses mark an arc of length equal to AB, from point A and B to meet at point C.
- iii. Join points A to C and B to C.

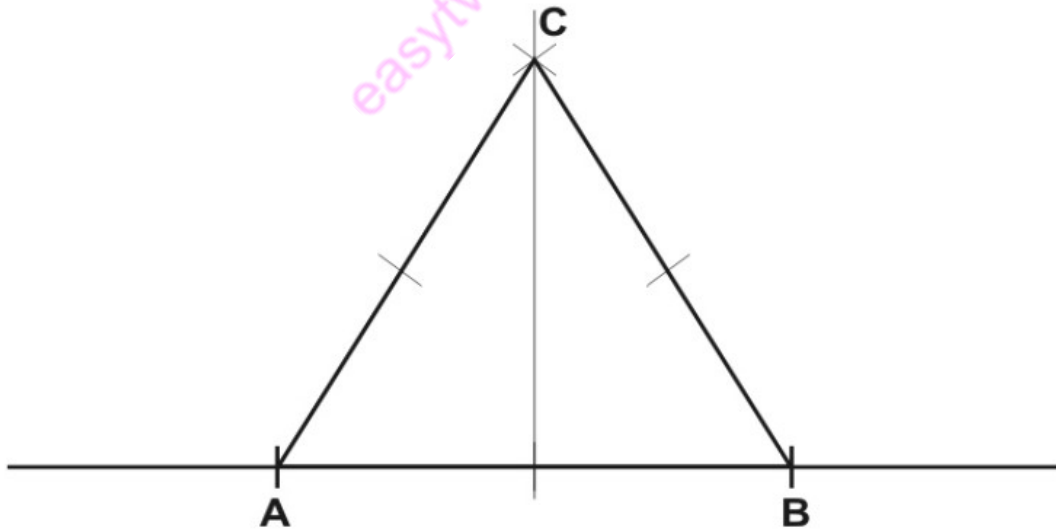
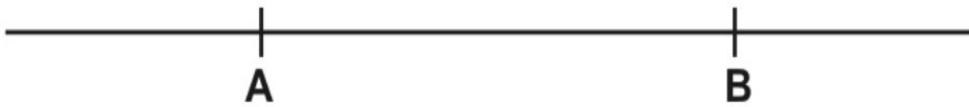


Figure 51 Construction of an Isosceles triangle

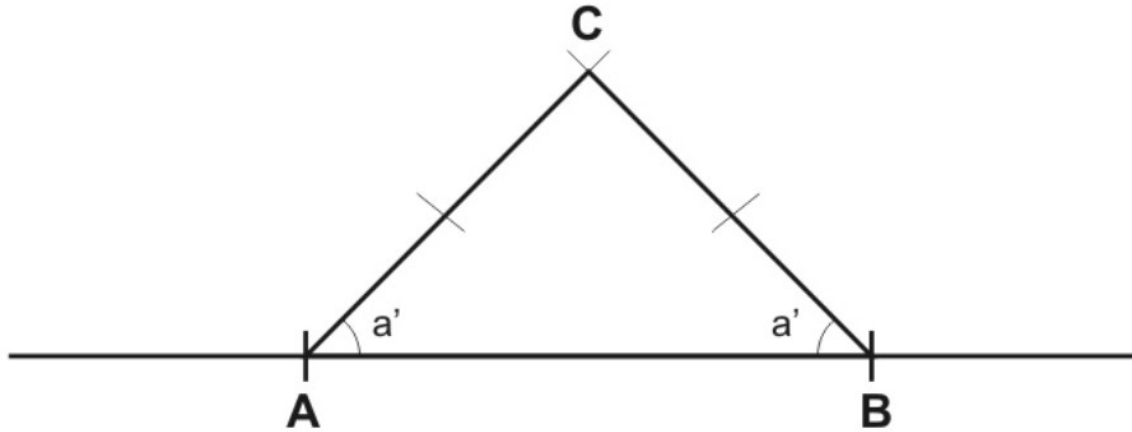
### Construction of an isosceles triangle

The following is a procedure for constructing an isosceles triangle.

- i. Draw a line AB.



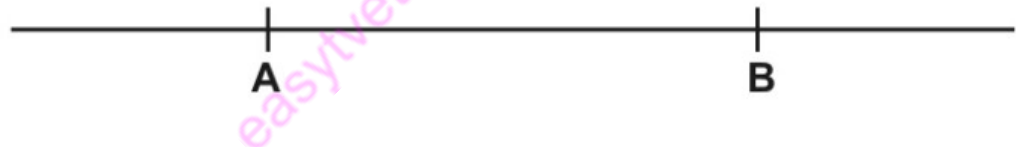
- ii. From point A, draw a line inclined at a specified angle.
- iii. From point B, draw a line BC inclined at an angle equal to that of AC.



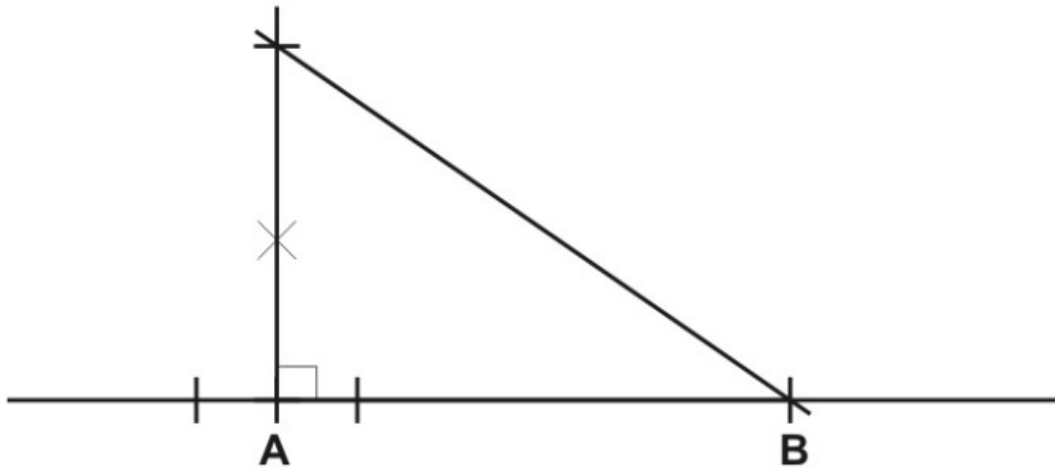
**Construction of a right-angled triangle.**

The following is the procedure for construction a right-angled triangle:

- i. Draw a line AB



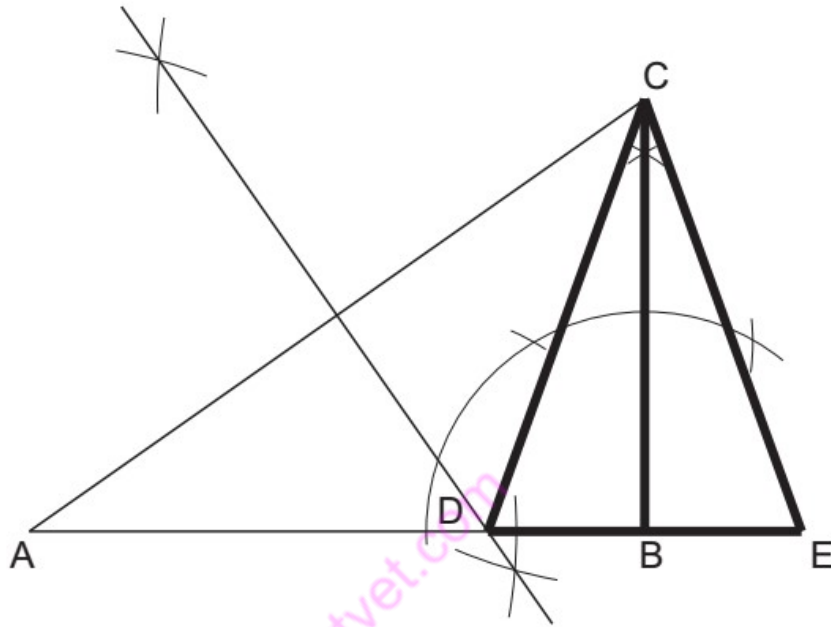
- ii. From A, draw a perpendicular line AC of a specified length.
- iii. Join B to C



**Figure 52 Construction of a right-angled triangle**

**To construct an isosceles triangle given the perimeter and the altitude;**

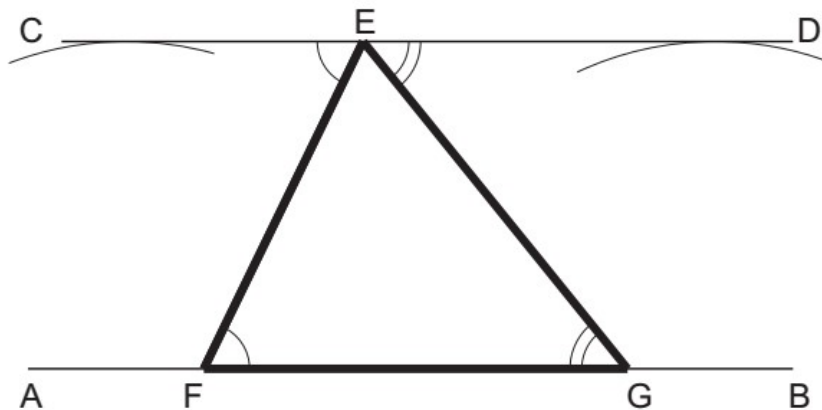
- i. Draw line AB equal to half the perimeter.
- ii. From B erect a perpendicular and make BC equal to the altitude.
- iii. Join AC and bisect it to cut AB in D.
- iv. Produce DB so that BE = BD. CDE is the required triangle.



**Figure 53 Construction of an Isosceles triangle given perimeter**

**To construct a triangle, given the base angles and the altitude**

- i. Draw a line AB.
- ii. Construct CD parallel to AB so that the distance between them is equal to the altitude.
- iii. From any point E, on CD, draw  $\hat{C} \hat{E} F$  and  $\hat{D} \hat{E} G$  so that they cut AB in F and G, respectively.



**Figure 54 Construction of a triangle given angles and height**

## **Polygons**

### **Definitions**

A polygon is a plane figure bounded by more than four straight sides. Polygons that are frequently referred to have names. Some of these are listed below.

**A pentagon is a plane figure bounded by five sides.**

**A hexagon** is a plane figure bounded by six sides.

**A heptagon** is a plane figure bounded by seven sides.

**An octagon** is a plane figure bounded by eight sides.

**A nonagon** is a plane figure bounded by nine sides.

**A decagon** is a plane figure bounded by ten sides.

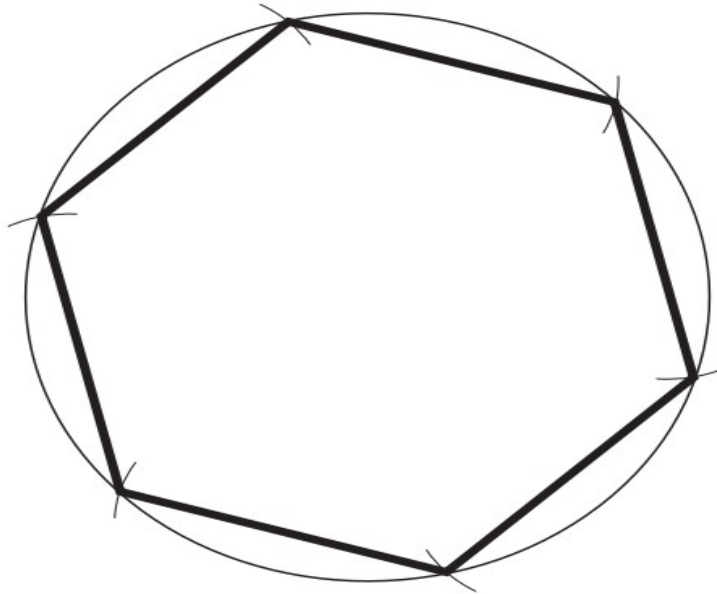
A regular polygon is one that has all its sides equal and therefore all its exterior angles equal and all its interior angles equal.

It is possible to construct a circle within a regular polygon so that all the sides of the polygon are tangential to that circle. The diameter of that circle is called the '**diameter of the polygon**'. If the polygon has an even number of sides, the diameter is the distance between two diametrically opposed faces. This dimension is often called the 'across-flats' dimension.

The diagonal of a polygon is the distance from one corner to the corner furthest away from it. If the polygon has an even number of sides, then this distance is the dimension between two diametrically opposed corners.

### **Constructions**

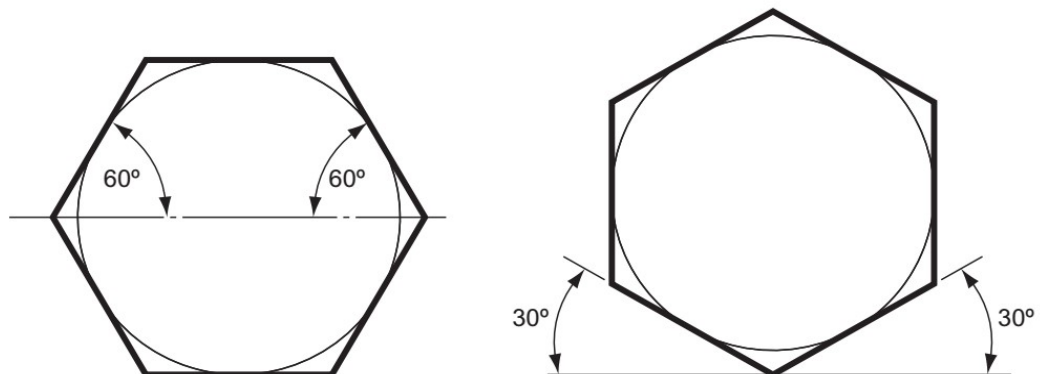
- i. To construct a regular hexagon given the length of the sides**
  - a) Draw a circle, radius equal to the length of the side.
  - b) From any point on the circumference, step the radius around the circle six times.  
If your construction is accurate, you will finish at the same place that you started.
  - c) Connect the six points to form a regular hexagon.



**Figure 55 General Construction of a regular polygon given the side**

**ii. To construct a regular hexagon given the diameter**

This construction, using compasses and straight edge only, is quite feasible but is relatively unimportant. What is important is to recognize that a hexagon can be constructed, given the diameter or across-flats dimension, by drawing tangents to the circle with a  $60^\circ$  set square. This is very important when drawing hexagonal-headed nuts and bolts.

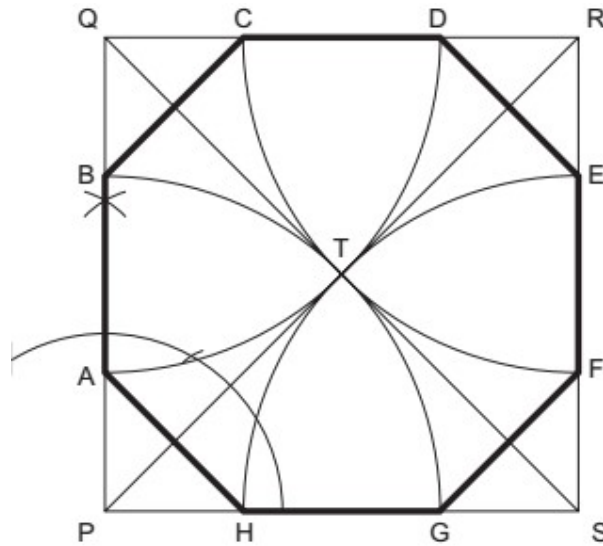


**Figure 56 Construction of a hexagon**

**iii. To construct a regular octagon given the diameter, i.e. within a given square**

- a. Construct a square PQRS, length of side equal to the diameter.

- b. Draw the diagonals SQ and PR to intersect in T.
- c. With centres P, Q, R and S draw four arcs, radius PT ( QT RT ST) to cut the square in A, B, C, D, E, F, G and H.



**Figure 57 Inserting Octagon in a square**

**ABCDEFGH is the required octagon**

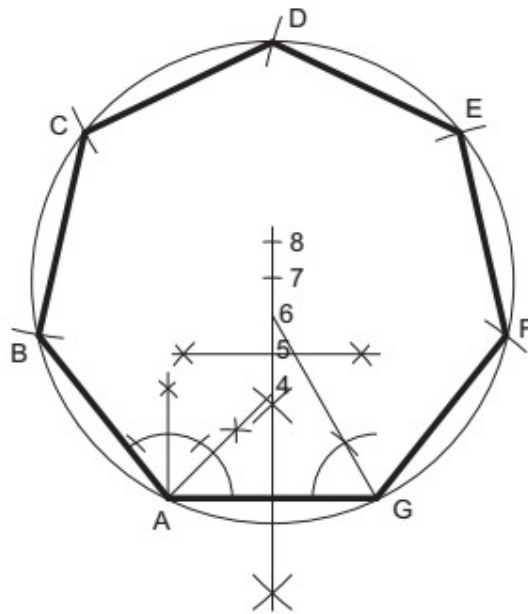
The following methods can be used to construct any polygon

To construct any given polygon, given the length of a side.

**Procedure**

- i. Draw a line GA equal in length to one of the sides.
- ii. Bisect GA.
- iii. From A construct an angle of  $45^\circ$  to intersect the bisector at point 4.
- iv. From G construct an angle of  $60^\circ$  to intersect the bisector at point 6.
- v. Bisect between points 4 and 6 to give point 5.
- vi. Point 4 is the centre of a circle containing a square. Point 5 is the centre of a circle containing a pentagon. Point 6 is the centre of a circle containing a hexagon. By marking off points at similar distances the centres of circles containing any regular polygon can be obtained.





**Figure 58 General construction of a polygon given a side**

vii. Mark off point 7 so that  $6 \text{ to } 7 = 5 \text{ to } 6 (= 4 \text{ to } 5)$ .

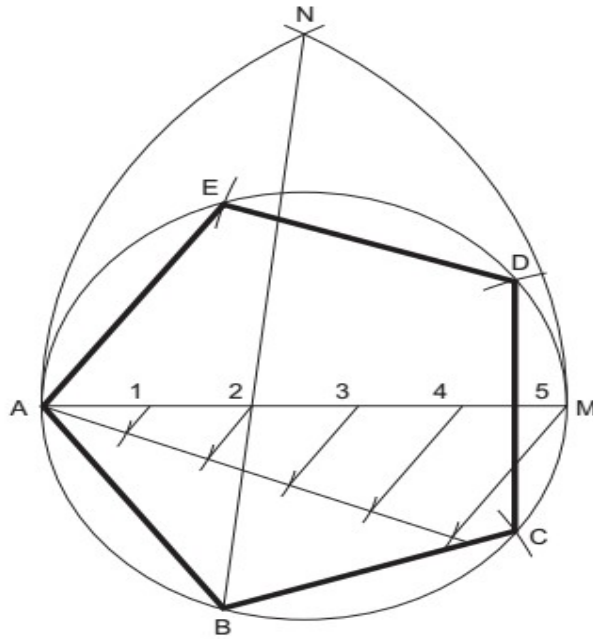
viii. With centre at point 7 draw a circle, radius 7 to A (= 7 to G).

ix. Step off the sides of the figure from A to B, B to C, etc.

**ABCDEFG is the required heptagon.**

**To construct a regular polygon given a diagonal, i.e. within a given circle**

- i. Draw the given circle and insert a diameter AM.
- ii. Divide the diameter into the same number of divisions as the polygon has sides.
- iii. With centre M draw an arc, radius MA. With centre A draw another arc of the same radius to intersect the first arc in N.
- iv. Draw N2 and produce to intersect the circle in B (for any polygon).
- v. AB is the first side of the polygon. Step out the other sides BC, CD, etc.



**Figure 59 Construction of a polygon given diagonal**  
**ABCDE is the required polygon.**

**f) Standards drawing conventions**

Conventions are a widely used practices or procedure in engineering drawing, they are a set of rules for drawing. Because drawings contain a lot of information, they can easily become cluttered and not easily understood by all working with them. One way to keep them tidy and consistent is to use standards and conventions.

**Some of the conventions are:**

**i. Scaling**

Sometimes we need to scale down some larger parts in order to see the whole object on a single sheet and for detailed parts we may need to scale them up in size in order to see the finer details.

**ii. Dimensioning**

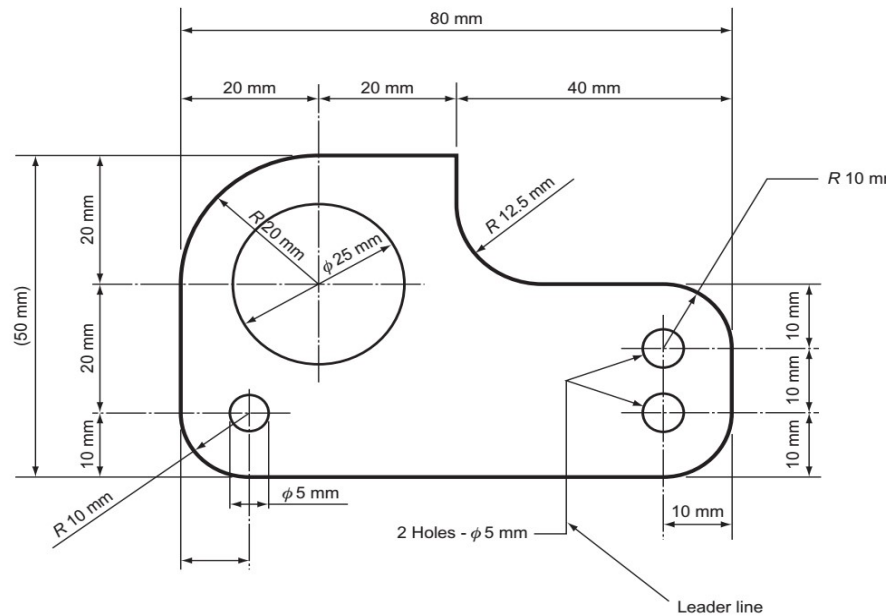
Dimensioning is the convention used for adding measurement notes, such as the length and breadth of the object, to a drawing. Dimensions include text, lines, extension lines and arrowheads.

When an engineering drawing is made, dimensioning is of vital importance. All the dimensions necessary to make the articles drawn must be on the drawing and they must be presented so that they can be easily read, easily found, and not open to misinterpretation. A neat drawing can be spoilt by bad dimensioning.

The conventions for drawing dimension lines are described below.

- a) Projection lines should be thin lines and should extend from about 1 mm from the outline to 3 mm to 6 mm past the dimension line.
- b) The dimension line should be a thin line and terminate with arrowheads at least 3mm long and these arrowheads must touch the projection lines.
- c) The dimension may be inserted within a break in the dimension line or be placed on top of the dimension line.
- d) The dimensions should be placed so that they are read from the bottom of the paper or from the right-hand side of the paper.
- e) Dimension lines should be drawn outside the outline, whenever possible, and should be kept well clear of the outline.
- f) Overall dimensions should be placed outside the intermediate dimensions.
- g) Centre lines must never be used as dimension lines. They may be used as projection lines
- h) Diameters may be dimensioned in one of two ways. Either dimension directly across the circle (not on a centre line) or project the diameter to outside the outline. 'Diameter' is denoted by the symbol  $\phi$  placed in front of the dimension.
- i) When dimensioning a radius, you must, if possible, show the centre of the radius. The actual dimension for the radius may be shown either side of the outline but should, of course, be kept outside if possible. The word radius must be abbreviated to R and placed in front of the dimension.
- j) When a diameter or a radius is too small to be dimensioned by any of the above methods, a leader may be used. The leader line should be a thin line and should terminate on the detail that it is pointing to with an arrowhead or, within an outline, with a dot. Long leader lines should be avoided even if it means inserting another dimension. The leader line should always meet another line at an acute angle.
- k) Dimensions should not be repeated on a drawing. It is necessary to put a dimension on only once, however many views are drawn. There is one exception to this rule. If, by inserting one dimension, it saves adding up lots of small dimensions then this is allowed.
- l) These types of dimensions are called 'auxiliary dimensions' and are shown to be so either by underlining the dimensions or putting it in brackets.

- m) Unless unavoidable, do not dimension hidden detail. It is usually possible to dimension the same detail on another view.
- n) When dimensioning angles, draw the dimension lines with a compass; the point of the compass should be on the point of the angle. The arrowheads may be drawn either side of the dimension lines, and the dimension may be inserted between the dimension lines or outside them. Whatever the angle, the dimension must be placed so that it can be read from either the bottom of the paper or from the right-hand side.
- o) If a lot of parallel dimensions are given, it avoids confusion if the dimensions are staggered so that they are all easier to read.
- p) If a lot of dimensions are to be shown from one projection line (often referred to as a datum line), either of the methods shown in Fig. 18.20 may be used. Note that in both methods, the actual dimension is close to the arrowhead and not at the centre of the dimension line.
- q) If most dimensions on a drawing are in one unit, it is not necessary to put on the abbreviation for the units used, i.e. cm or mm. In this case, the following note must be printed on your drawing.  
**UNLESS OTHERWISE STATED, DIMENSIONS ARE IN  
MILLIMETRES**
- r) If a very large radius is drawn, whose centre is off the drawing, the dimension line is drawn with a single zigzag in it.
- s) Dimensioning small spaces raises its own problems and solutions. Some examples are shown in figure below. There are one or two more rules that do not require illustrating.
- t) If the drawing is to scale, the dimensions put on the drawing are the actual dimensions of the component and not the size of the line on your drawing.



**Figure 60 Sample dimensioning**

### iii. Title blocks

You need a title panel to identify the name of the person to whom the drawing belongs as well as the name of the drawing, the scale at which it is drawn, and the date that it was completed

Every drawing should include information which identifies the drawing. A title block is often used to do this. It will contain information that includes the:

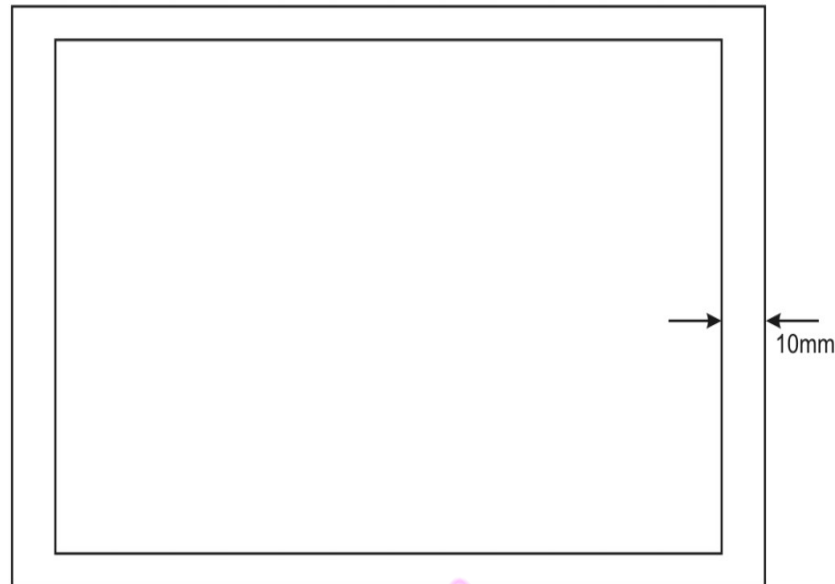
- a) name of the person the drawing belongs to
- b) date the drawing was completed
- c) number of the drawing
- d) scale at which it was drawn.
- e) Title of drawing

The title block is usually placed at the bottom right of the drawing. However, it may occupy the full width of the top or bottom of the paper to allow the drawing to fit within the size of the drawing paper.

### iv. Margins

Margins define the space where the drawings are to be done.

Your drawing must also be enclosed within a frame called a margin. Before starting the drawing, a manual drawing template should be drawn up. This will have the margins and the title block marked out and will allow you to see how much drawing space you have before you start.



**Figure 61 Paper Layout**

**v. Letters and Numbers**

All drawings require some form of lettering and numbers. The principles to remember are:

- a) They should be legible and clear – especially numbers, as they often must be read on their own.
- b) They should be of a suitable size and not less than 3mm tall. Title blocks and relative information are usually larger.
- c) They should be correctly spaced and positioned. Notes and captions should be placed so that they can be read in the same direction as in the title block. In other words it should not be necessary to turn a drawing on its side to read the information.
- d) Notes should be grouped together and not spread over the drawing.
- e) Underlining is not recommended.

**vi. Abbreviations**

A list of the standard abbreviations for some general engineering terms is shown

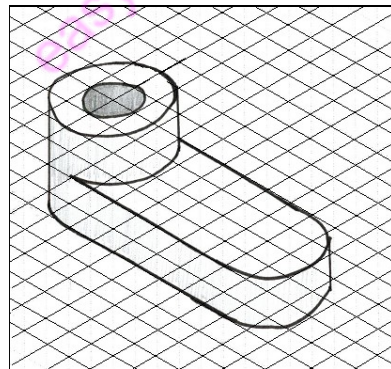
below. These abbreviations are used to save time, and space on drawings.

Although the abbreviations are shown in block capital letters, small letters may be used. For unit abbreviations always use small letters.

To read a drawing properly, and to understand what is happening, an agreed set of graphical symbols and abbreviations are used. All the different trades have a set of symbols pertaining to their respective works. The works of the plumber is often referred to as the “Mechanical Services”.

#### 2.2.2.4. Learning Activities

Study the isometric view below. Using the back side of grid paper, your engineering notebook, or graph paper (as indicated by your instructor) recreate the isometric view for practice. Be sure to use the techniques you have learned for sketching isometric circles to sketch the arcs and circles in this view.



#### 2.2.2.5. Self-Assessment

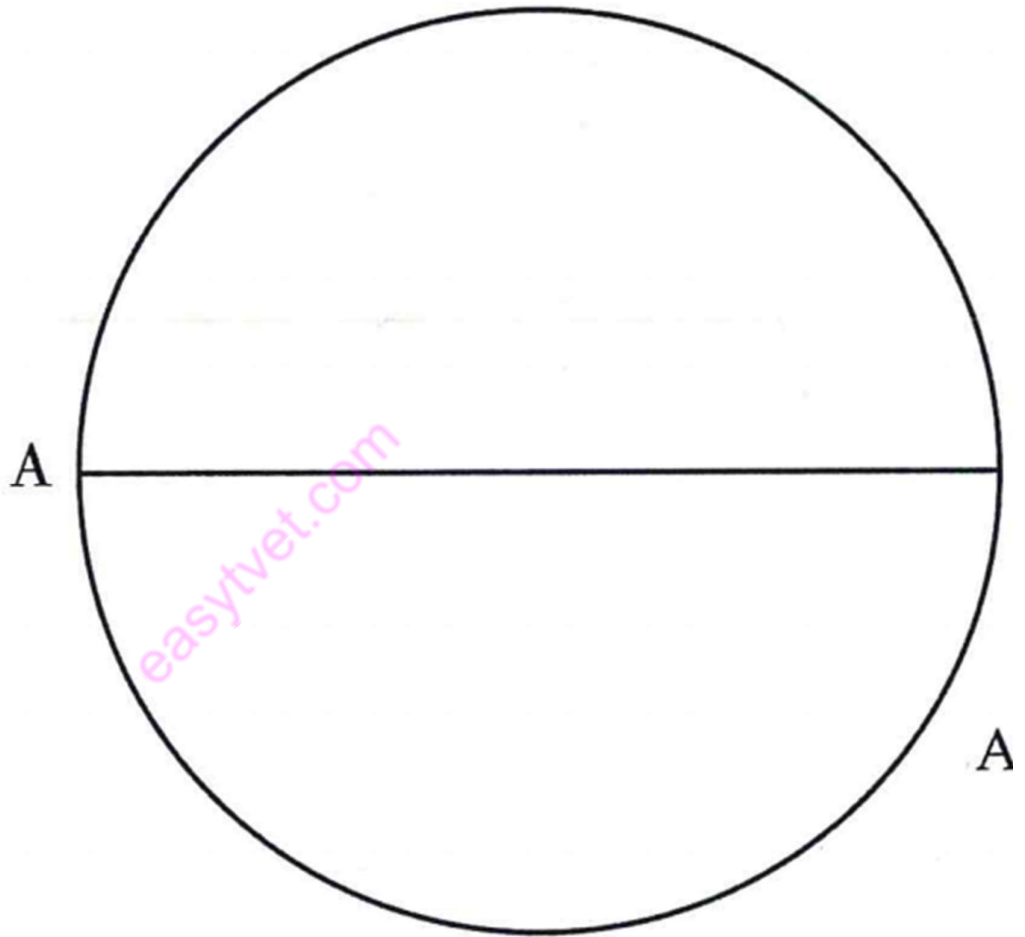
1. State the use of the following line;
  - i. Extension line
  - ii. Dimension line
  - iii. Long-break line
2. Construct the following angles;
  - i.  $30^{\circ}$
  - ii.  $60^{\circ}$

iii.  $45^\circ$

3. Explain the following types of triangles

- i. A **scalene triangle**
- ii. An **isosceles triangle**
- iii. An **equilateral triangle**
- iv. A **right-angled triangle**

4. Figure below shows a circle of diameter 80mm.



Construct a pentagon circumscribed by the circle.

5. Explain the following terms as used in polygons;

- a) **Pentagon**
- b) **A hexagon**
- c) **A heptagon**
- d) **An octagon**
- e) **A nonagon**



f) **A decagon**

**2.2.2.6. Tools, Equipment, Supplies and Materials**

- i. Drawing boards
- ii. T squares
- iii. Set squares
- iv. Drawing sets
- v. Drawing paper
- vi. Protractors
- vii. Eraser Shield
- viii. Pencils
- ix. Erasers
- x. Masking tapes
- xi. Paper clips
- xii. Drawing curves
- xiii. Technical drawing software'

**2.2.2.7. References**

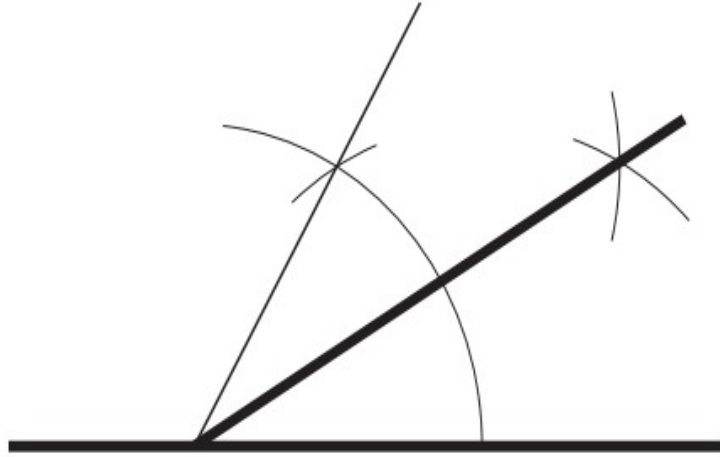
Bhatt, N. D. (2011). *Engineering Drawing*. Gujarat: Charotar Publishing house.

Maguire, C. H. (2004). *Manual of Engineering drawing*. Oxford: Elsevier Newnes.

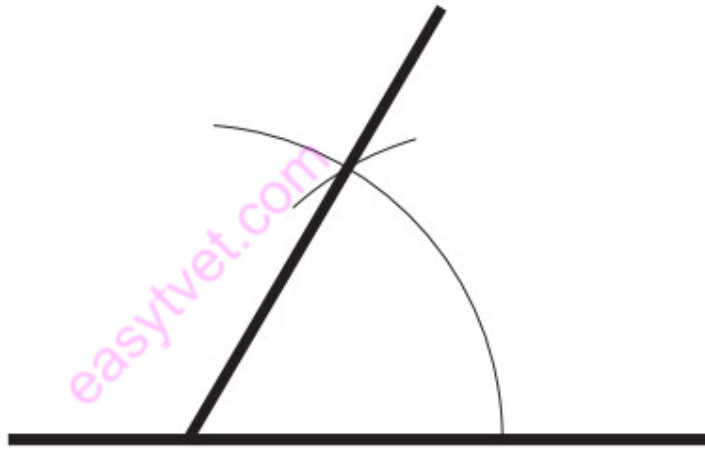
Morling, K. (2010). *Geometric and Engineering drawing*. London: Elsevier.

**2.2.2.8. Model answers.**

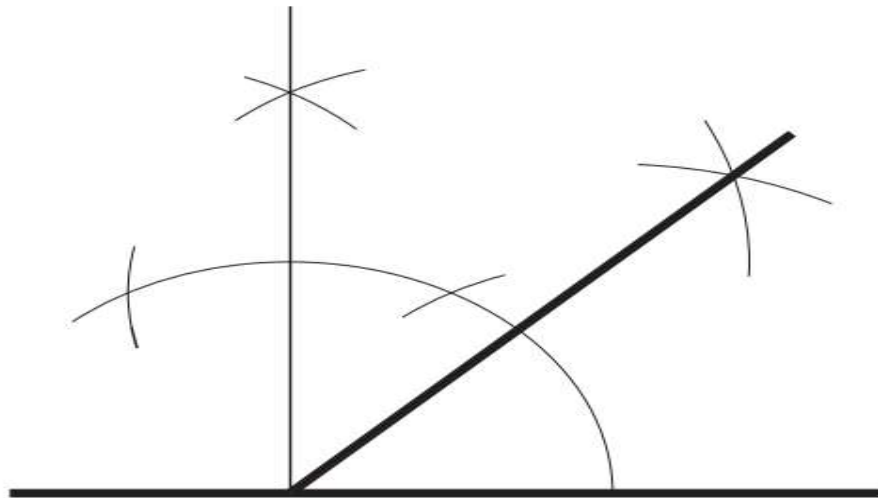
1. State the use of the following line;
  - i. **Extension line** – a thin line that extends from the object to show dimension limits
  - ii. **Dimension line** – a thin line with an arrowhead in one end used to indicate the
  - iii. Measurements of the object
  - iv. **Long-break line** – a medium thick line consisting of broken and straight lines drawn
2. Construct the following angles;
  - i.  $30^{\circ}$



ii.  $60^\circ$



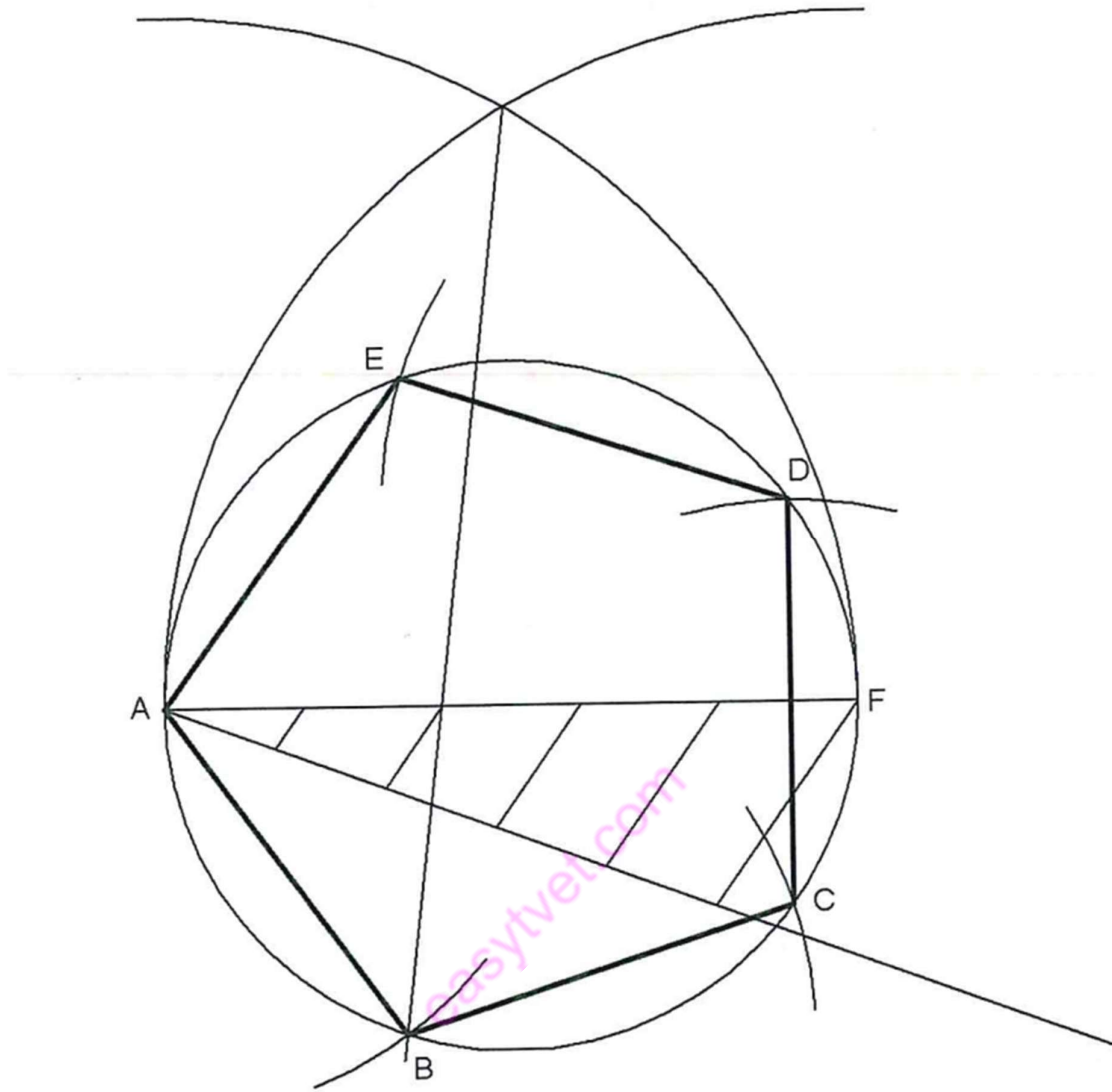
iii.  $45^\circ$



3. Explain the following types of triangles

- i. A **scalene triangle** is a triangle with three unequal sides and three unequal angles.
- ii. An **isosceles triangle** is a triangle with two sides, and hence two angles, equal.
- iii. An **equilateral triangle** is a triangle with all the sides, and hence all the angles, equal.
- iv. A **right-angled triangle** is a triangle containing one right angle. The side opposite the right angle is called the 'hypotenuse'.

4. Figure below shows a circle of diameter 80mm. Construct a pentagon circumscribed by the circle.



5. Explain the following terms as used in polygons;

- i. **Pentagon** is a plane figure bounded by five sides.
- ii. **A hexagon** is a plane figure bounded by six sides.
- iii. **A heptagon** is a plane figure bounded by seven sides.
- iv. **An octagon** is a plane figure bounded by eight sides.
- v. **A nonagon** is a plane figure bounded by nine sides.
- vi. **A decagon** is a plane figure bounded by ten sides.

## **2.2.3 Learning outcome 3: Develop solid geometry drawings**

### **2.2.3.1 Introduction to the learning outcome**

The focus of this specific learning outcome is to introduce the different working drawings and their purpose during the planning of plumbing works. This section will give an understanding of the different types of working drawings, building symbols and different representations of drawings.

### **2.2.3.2 Performance Standard**

The following performance criteria will be required to be met by trainees to be considered competent:

1. Pattern drawings are interpreted according to standard conventions
2. Solid Geometry drawings are constructed according to given plane geometry

### **2.2.3.3 Information Sheet**

#### **a) Terms and concepts**

##### **i. Auxiliary view**

This is when a view is projected on a plane that is parallel to the surface of the principal view. To see the true size of the surface the view must be shown at right angles to that surface. This is an Auxiliary view. Auxiliary views are often used to show the inclined surfaces true size

##### **ii. Development**

A layout of the complete surface of an object i.e it is the method of unfolding or unrolling a geometrical shape into a plane shape.

##### **iii. Dimensioning**

Process of placing measurements in a drawing in the metric or English System

##### **iv. Isometric axes**

Light lines used as bases in constructing an isometric view of an object

##### **v. Isometric drawing**

Pictorial drawing showing the three views of the object tilted 30 Degrees in front of the observer.

##### **vi. Multi-view drawing**

Drawing that shows more than one view of an object

##### **vii. Notation**

All lettering and other dimension found in a drawing or working sketch

**viii. Oblique drawing**

Kind of pictorial drawing of an object one surface of which is shown parallel to the frontal plane and the other is inclined to it.

**ix. Orthographic projection**

Presentation of an object in two or more views by projecting the outline of the object to the plane of projection perpendicular to each other

**x. Overall dimension**

The total width, height, and depth of the object

**xi. Perspective drawing**

A drawing which shows an object as it appears to our eyes

**xii. Pictorial view**

The presentation of an object where it is viewed showing the three faces of an object

**xiii. Truncated Object**

It is a geometrical object that has been cut

**xiv. Working plan**

A freehand drawing showing all the information needed to construct an Object.

- b) Interpretation of sketches and drawings of patterns e.g. cylinders, prisms, and pyramids

### **Orthographic Projection**

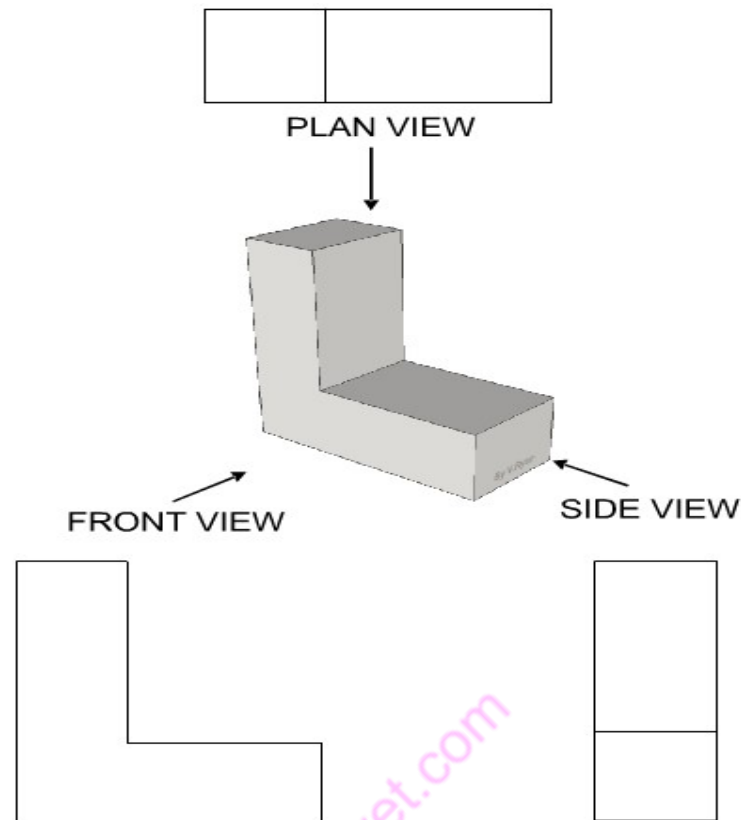
Orthographic Projection is a way of drawing an 3D object from different directions. Usually a front, side and plan view are drawn so that a person looking at the drawing can see all the important sides. Orthographic drawings are useful especially when a design has been developed to a stage whereby it is almost ready to manufacture.

There are two ways of drawing in orthographic - First Angle and Third Angle. They differ only in the position of the plan, front and side views. Below is an example of First Angle projection.

Opposite is a simple L-shape, drawn in three dimensions.

The front, side and plan views have drawn around the 3D shape. However this is not the correct way of drawing them as they are not in the right positions.

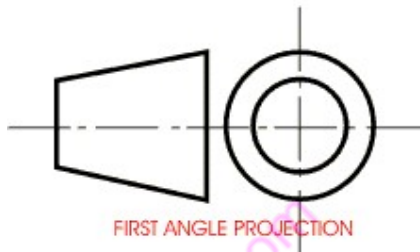
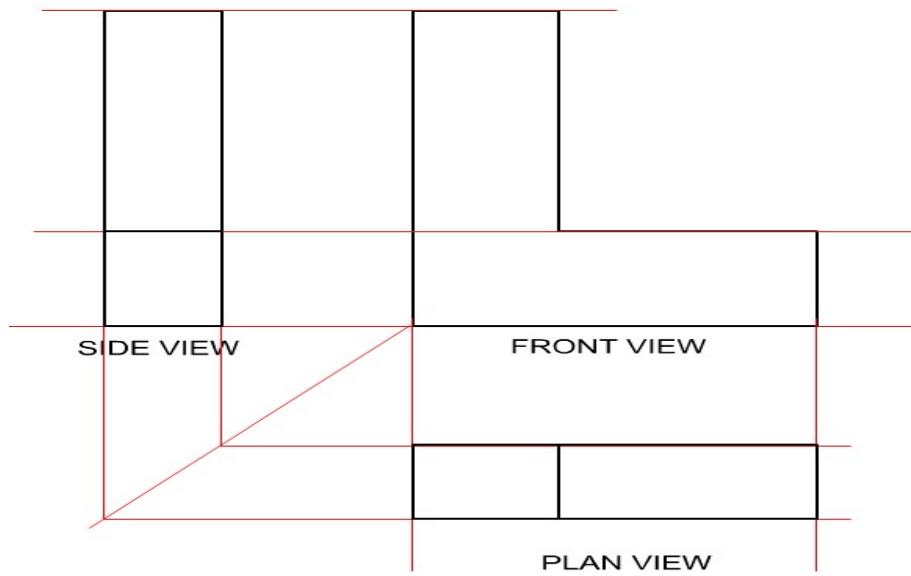
## First angle orthographic



**Figure 62 Example of orthographic views of an L shape figure**

The correct method of presenting the three views, in first angle orthographic projection is shown below. The drawing is composed of a front, end, and plan view of the L-shaped object. The first drawing is the front view (drawn looking straight at the front of the L-shape), the second is a drawing of the L-shape seen from the side (known as side view) and last of all a drawing from above known as a plan view. The red lines are faint guidelines and they are drawn to help keep each view in line, level, and the same size.

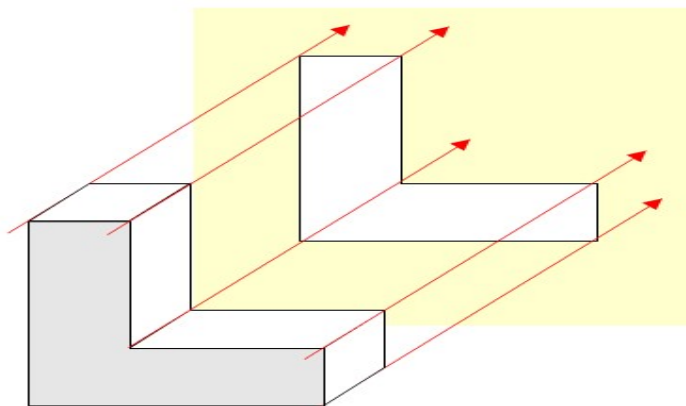
The correct first angle projection of the L shape is shown below



**First angle projection convention**

**Figure 63 First angle projection views of the L shape**

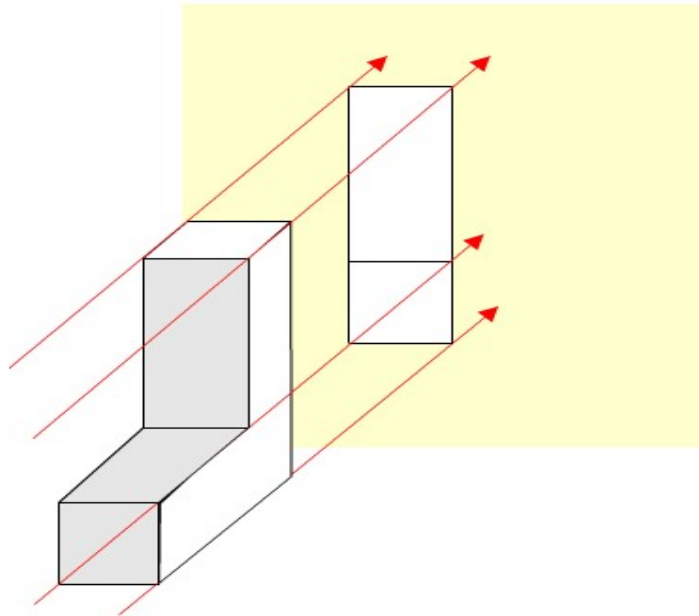
The views are obtained as by imagining you are standing directly in front of the L-shape, the drawing below shows exactly what you would see.



**Figure 64 Front Elevation**

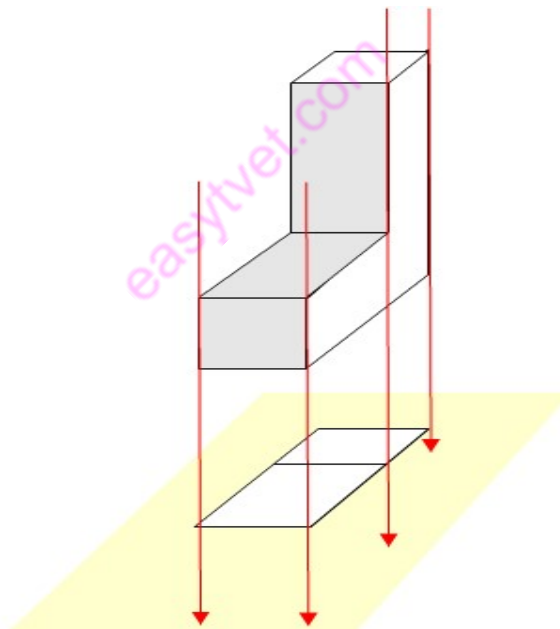
The end elevation is obtained as shown below from a side view





**Figure 65 End Elevation obtained from the side view**

The plan is obtained by viewing from the top as shown below



**Figure 66 Plan view from the top**

### **Third angle projection**

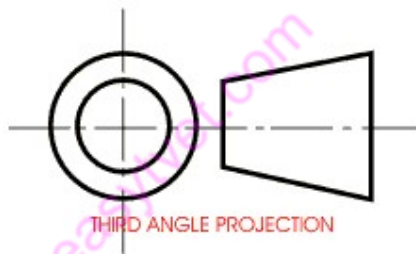
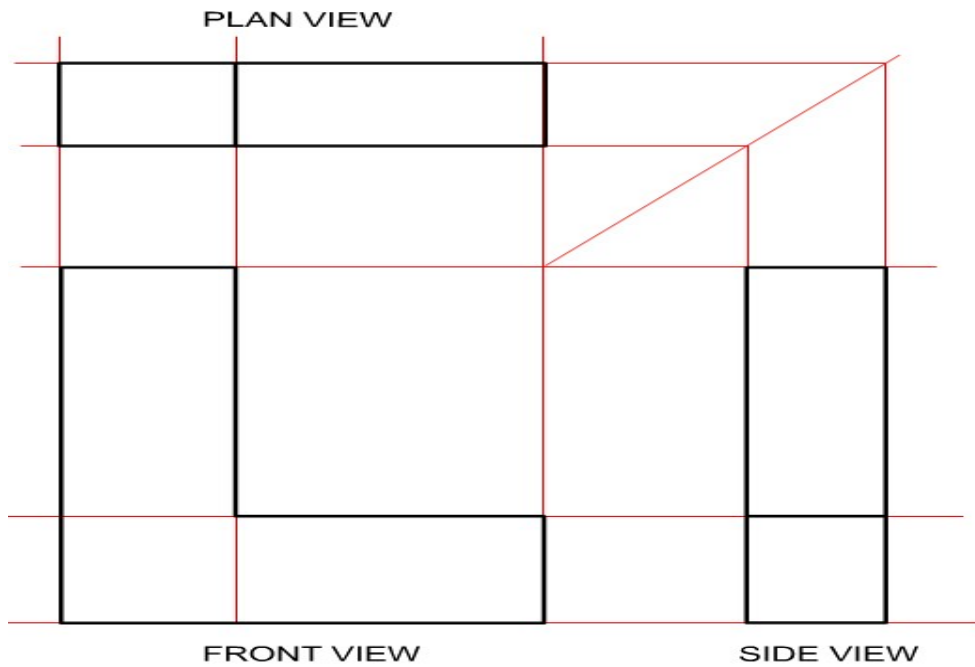
#### **An L-shaped object.**

The Plan View of the L-shape is drawn as a 'birds eye' view, a view from above.

The Front View is drawn as if stood in front of the L-shape.

The Side View is drawn as if stood at the side.

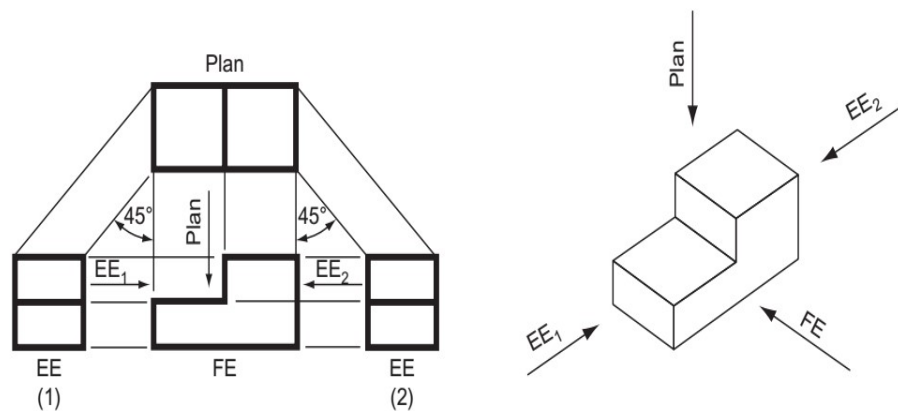
The following figures show another metal block with the views in third angle and then first angle projection.



Third Angle projection convention symbol

**Figure 67 Third angle orthographic projection of the L shape**

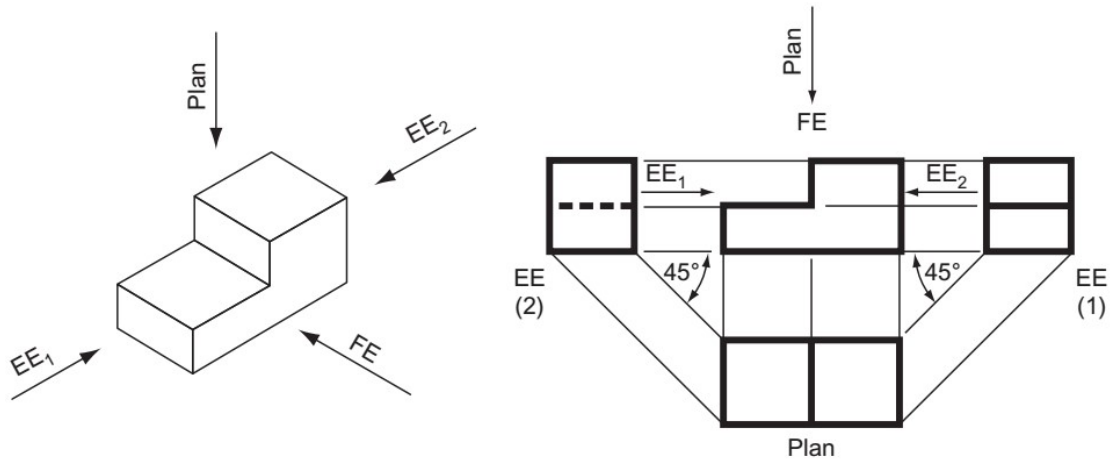
The only difference is the positioning of the end elevation and plan views, the process of viewing is similar.



**Figure 68 Third angle projection of a metal block**

The figure above on the right shows a isometric view of a metal block where we are required to draw orthographic views of the front elevation (FE), 2 end elevations (EE) and plan from the top as indicated by the arrows.

The figure on the left shows the solution to the question and the views are projected by using the third angle projection



**Figure 69 First angle orthographic projection**

Figure above shows the same figure using first angle projection

c) Develop geometrical solid figures e.g. prisms, cones, surface development

### Principle of Development

Every line on the development should show the true length of the corresponding line on the surface which is developed.

### Methods of Development

- i. Parallel-line development.  
Used for developing prisms and cylinders.
- ii. Radial-line development.  
For developing pyramids and cones.
- iii. Triangulation development.  
For developing transition pieces.

iv. Approximate development.

For developing spheres.

### Cylinder

Draw the development of the complete surface of a cylinder. Diameter is 40 mm and the height is 70 mm.

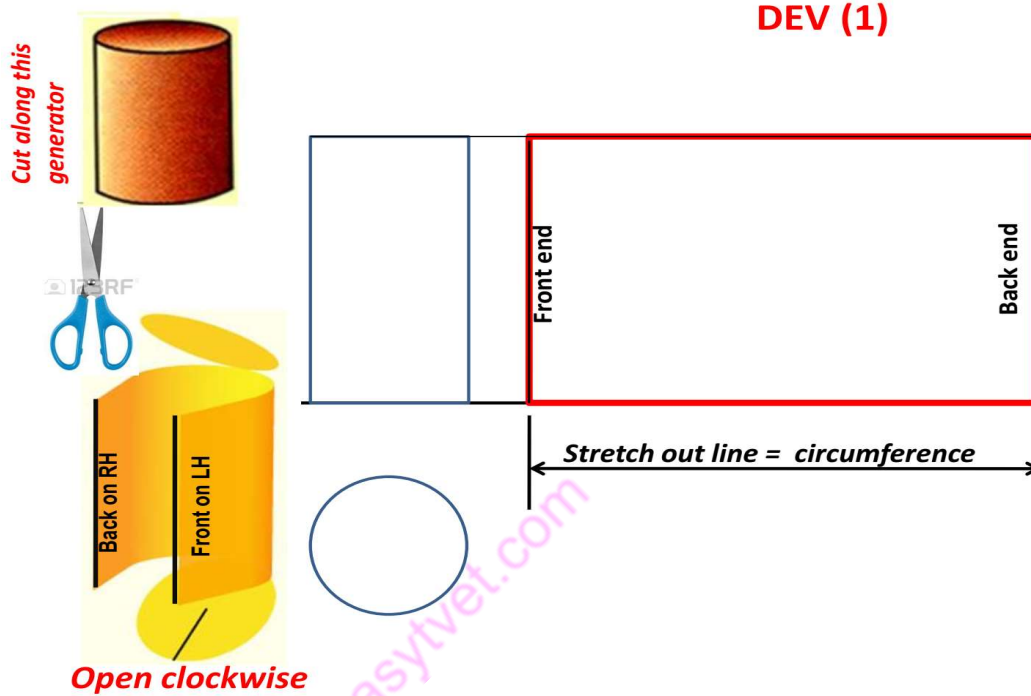
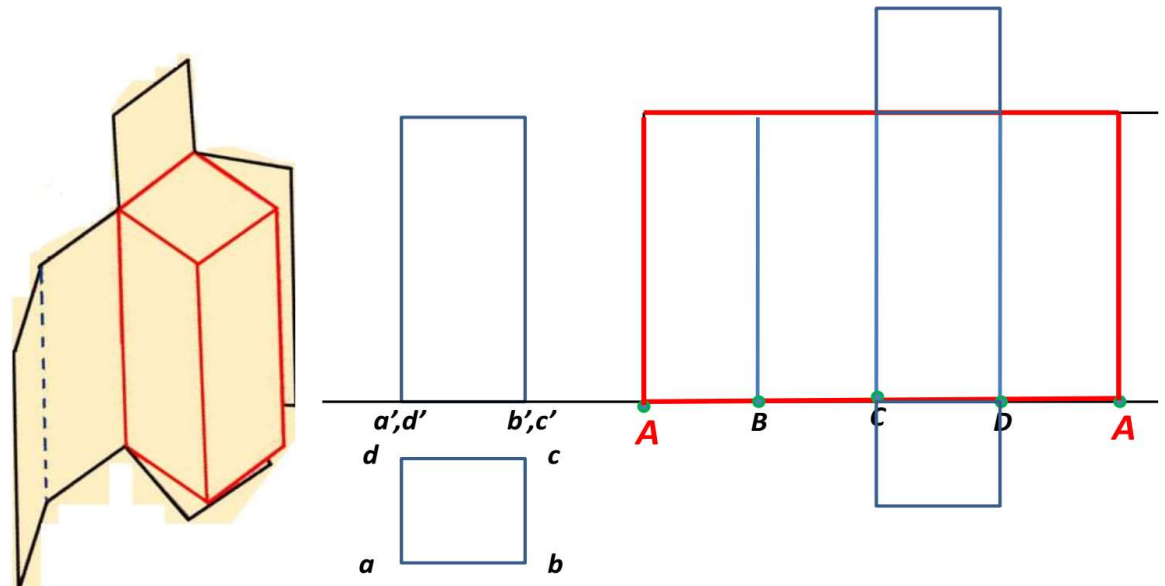


Figure 70 Development of a cylinder

### Prism

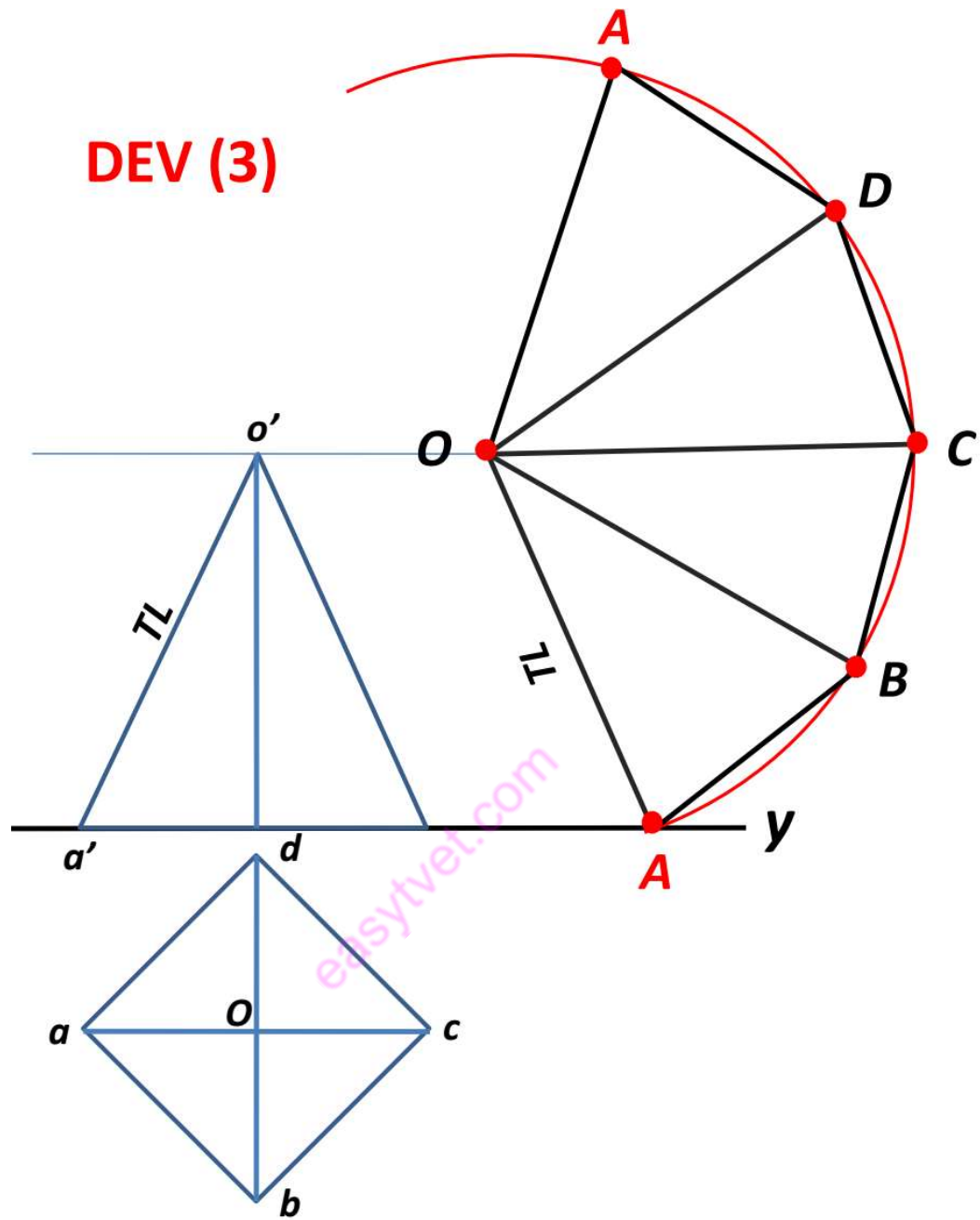
Develop the complete surface of a square prism of side of base 40 mm and height 80 mm.



**Figure 71 Square Prism development**

### Pyramid

Draw the development of the lateral surface of a square pyramid, side of base 30 mm and height 50 mm, resting with its base on H.P. All edge of the base are equally inclined to V.P.



**Figure 72 Pyramid development**

Draw the development of the lateral surface of a square pyramid, side of base 30 mm and height 50 mm, resting with its base on H.P. Two of its base edge are equally parallel to V.P.

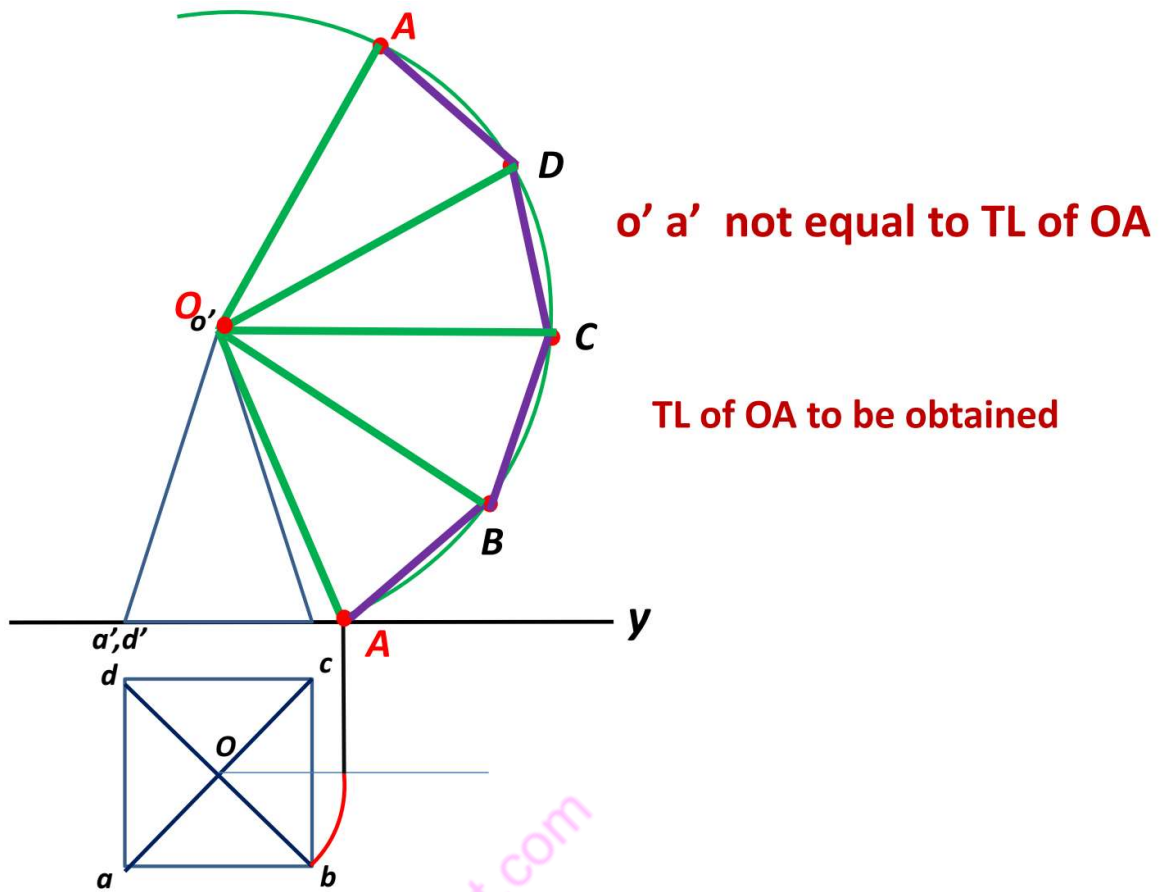


Figure 73 Square pyramid development 2

**Cone**

Draw the development of the lateral surface of a cone, base diameter 50 mm and height 70 mm, resting with its base on H.P.

## DEV (4)

$$\theta = 360 (R/L) \text{ degrees}$$

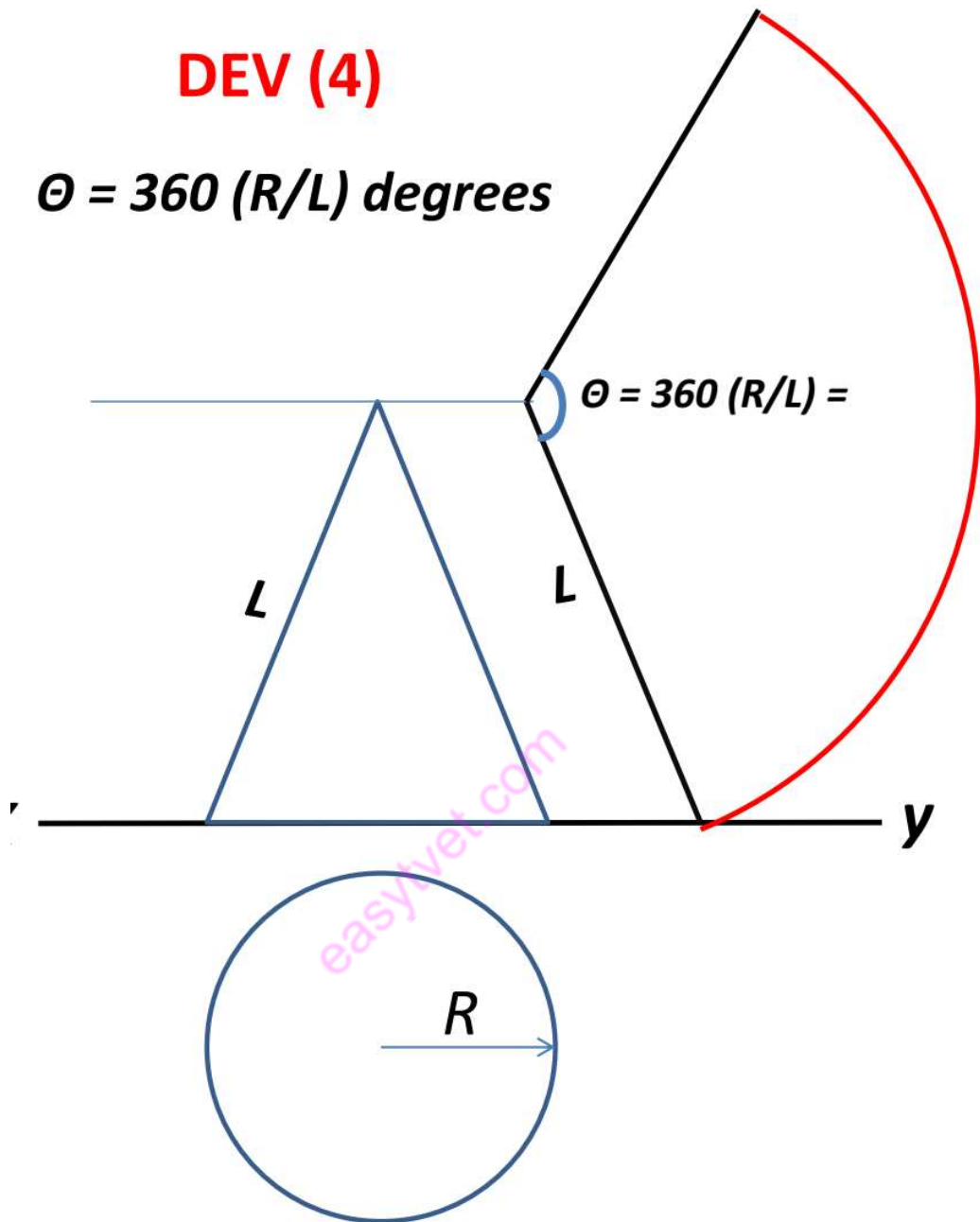


Figure 74 Cone development

Development of truncated cylinders, prisms, pyramids, and cones

Development of a truncated right circular cylinder



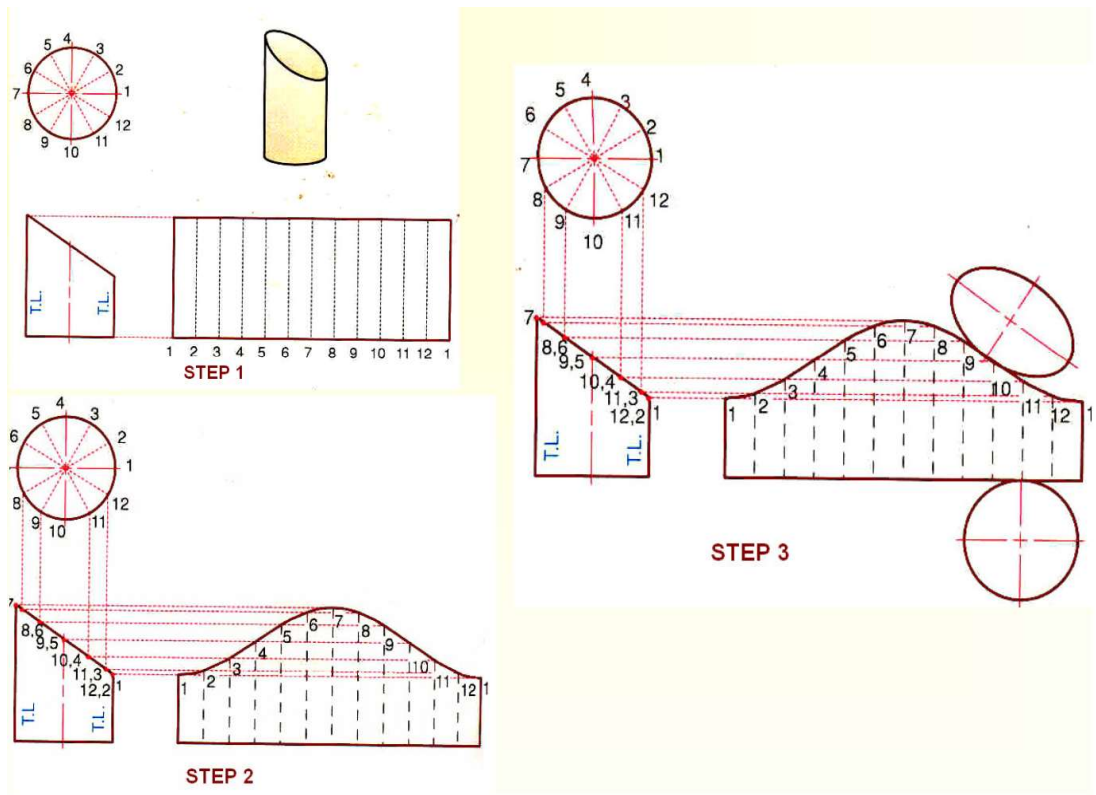


Figure 75 Truncated cylinder development

Development of a truncated prism

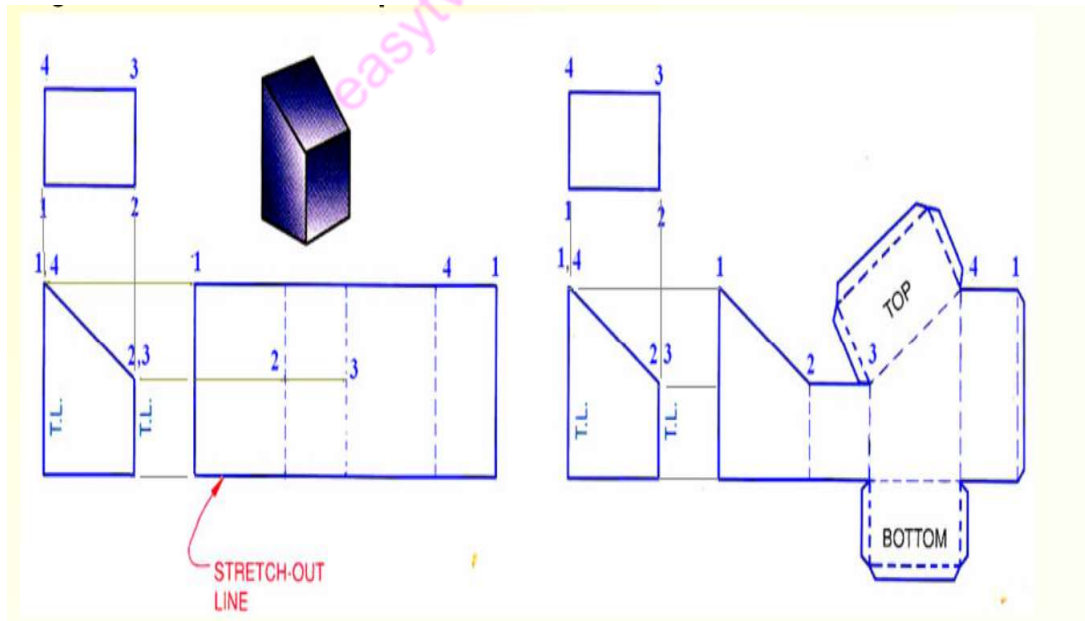


Figure 76 Truncated Prism Development

### Development of truncated cone

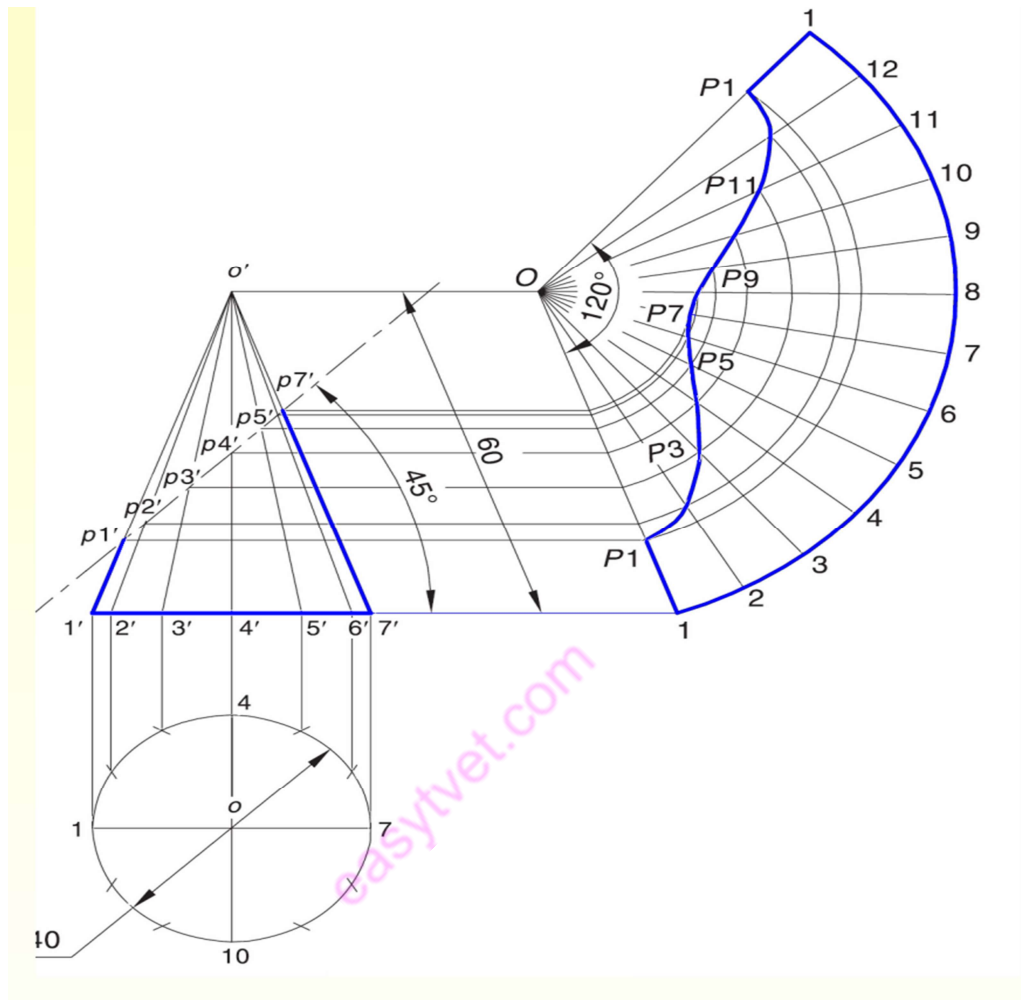


Figure 77 Truncated Cone development

### Development of truncated pyramid

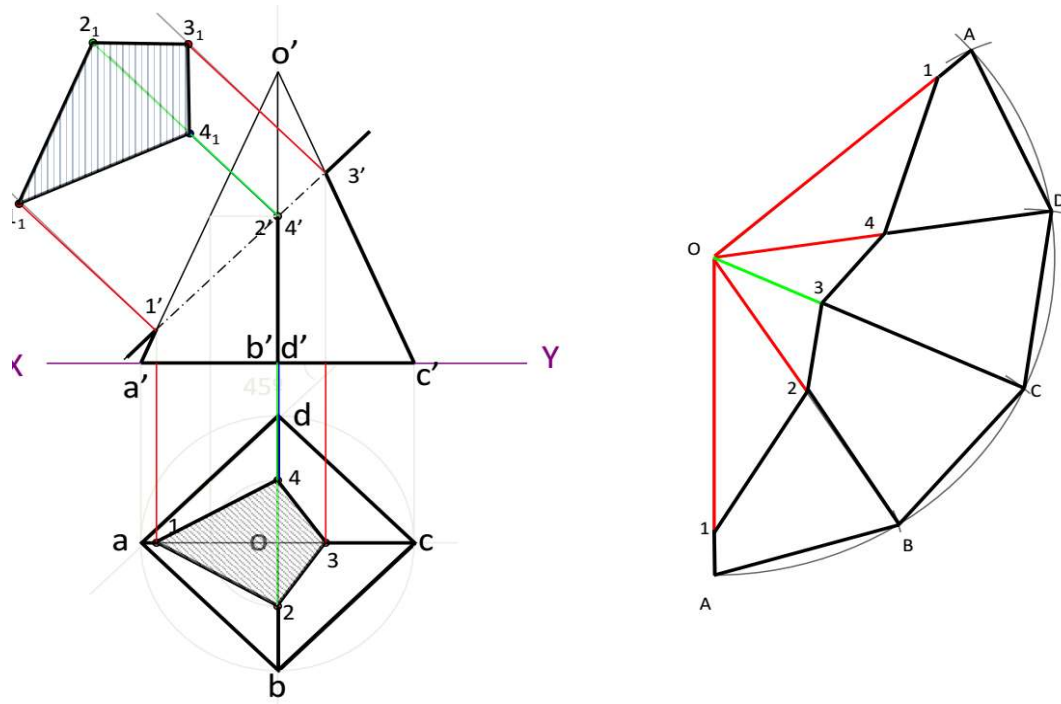
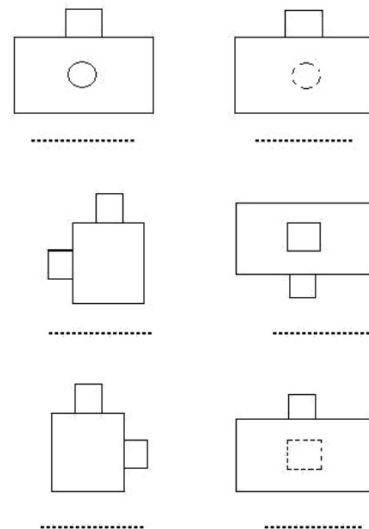
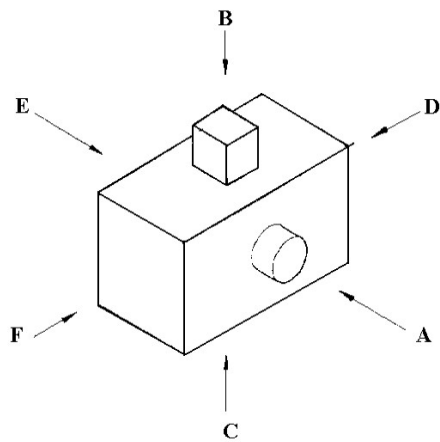


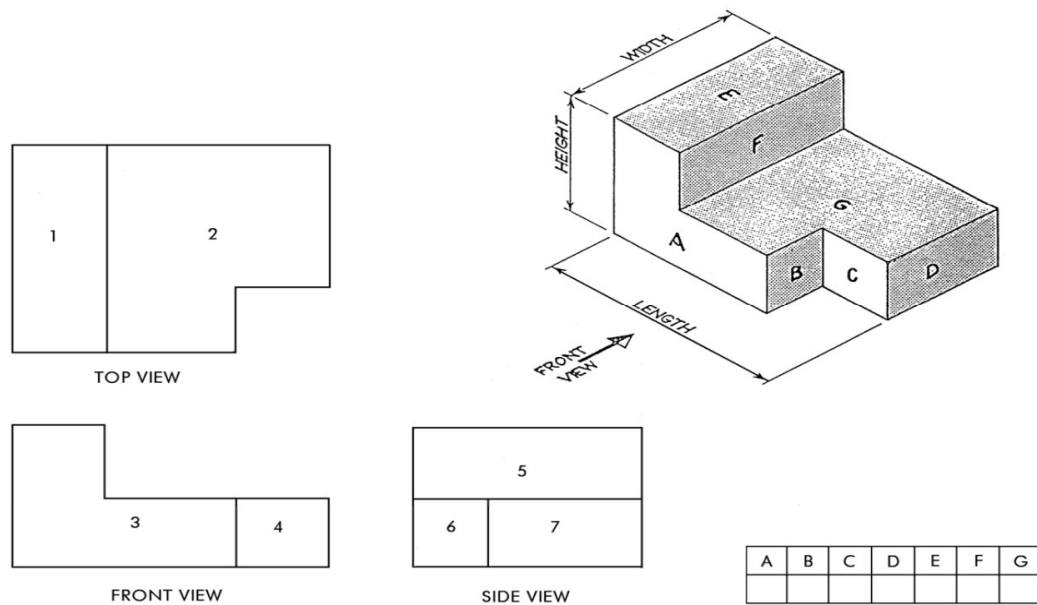
Figure 78 Truncated Pyramid development

#### 2.2.3.4. Learning Activities

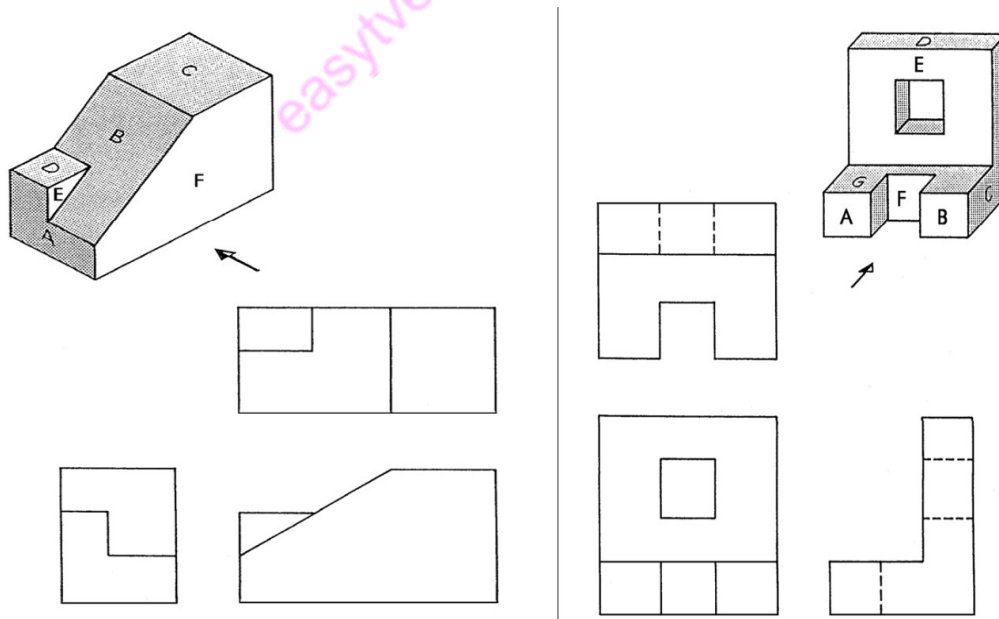
- i. In which direction must the object be viewed to produce the views shown opposite, taking 'A' as the FRONT VIEW. Put the appropriate letter under the view.



- ii. Study the two drawings and complete the table by matching the numbered surfaces of the orthogonal drawing with the lettered surfaces of the isometric drawing.



iii. Transfer the letters from the isometric drawing onto the same plane surfaces of the orthogonal drawing. Name each view.

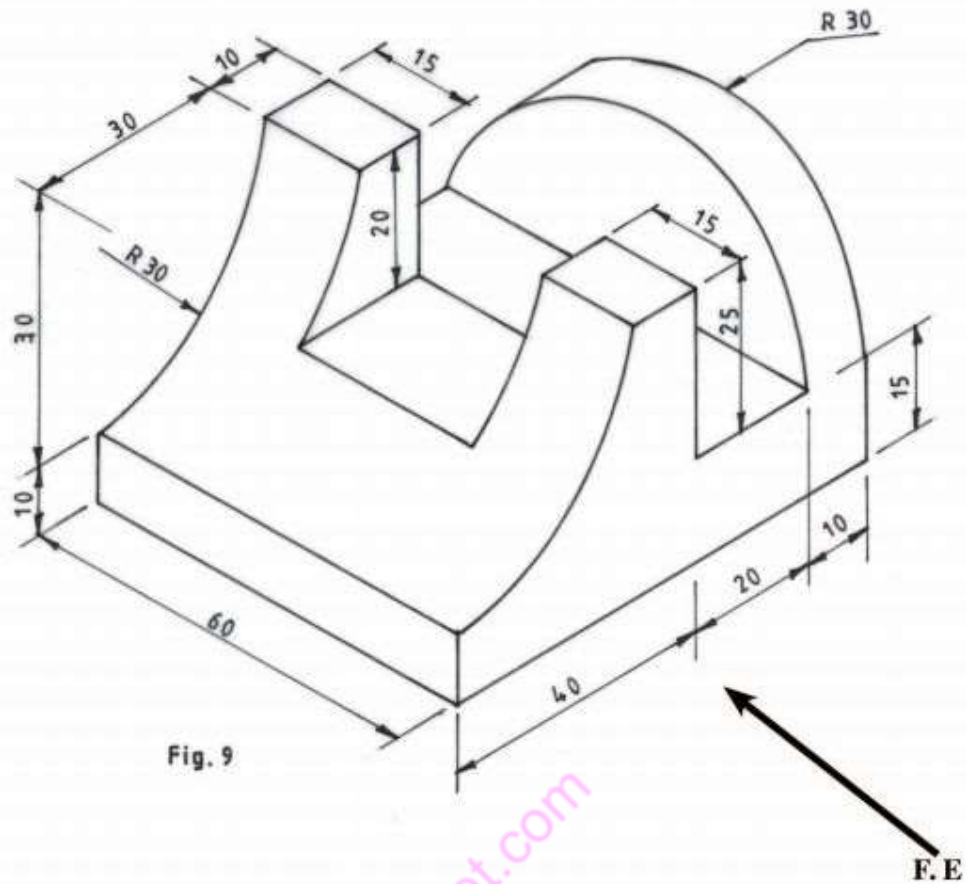


iv. Select the view which is requested in the table below. Place the number of this view in the appropriate position in the table.

							1	2	3
							4	5	6
							7	8	9
							10	11	12
							13	14	15
							16	17	18
	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>			
<b>DRAWING</b>									
FRONT view in direction of F	10								
PLAN view in direction of P									
SIDE view in direction of R									

### 2.2.3.5. Self-Assessment

1. Explain the following terms;
  - i. Pictorial view
  - ii. Truncated Object
  - iii. Working plan
  
2. Draw the third angle projection convention symbol.
  
3. Draw FULL SIZE in first angle projection the three orthographic views of the block.



#### 2.2.3.6. Tools, Equipment, Supplies and Materials

- i. Drawing boards
- ii. T squares
- iii. Set squares
- iv. Drawing sets
- v. Drawing paper
- vi. Protractors
- vii. Eraser Shield
- viii. Pencils
- ix. Erasers
- x. Masking tapes
- xi. Paper clips
- xii. Drawing curves
- xiii. Technical drawing software'

#### 2.2.3.7. References

Bhatt, N. D. (2011). *Engineering Drawing*. Gujarat: Charotar Publishing house.

Morling, K. (2010). *Geometric and Engineering drawing*. London: Elsevier.

### 2.2.3.8. Model Answers

1. Explain the following terms;

**i. Pictorial view**

The presentation of an object where it is viewed showing the three faces of an object

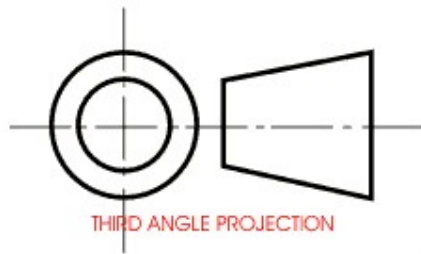
**ii. Truncated Object**

It is a geometrical object that has been cut

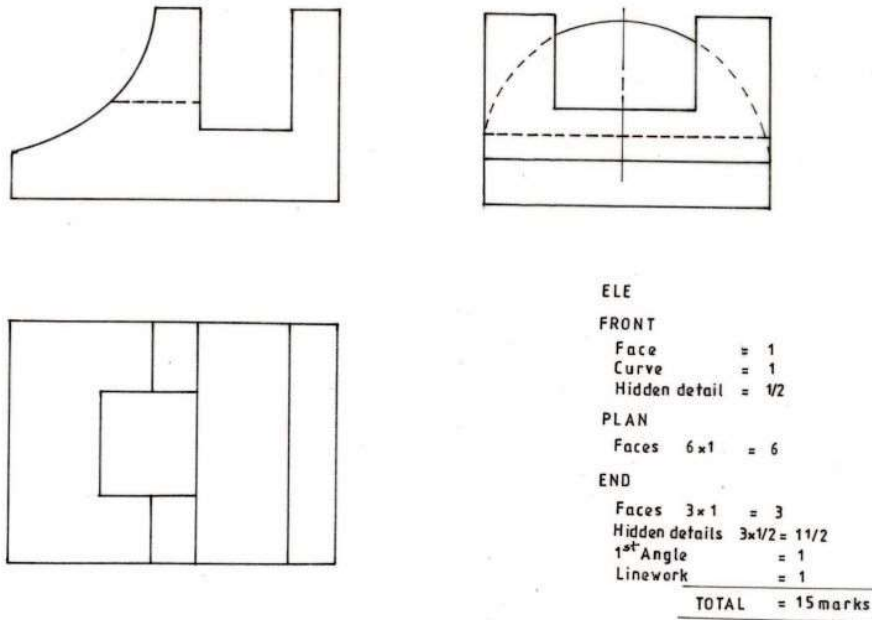
**iii. Working plan**

A freehand drawing showing all the information needed to construct an object.

2. Draw the third angle projection convention symbol.



3. Draw FULL SIZE in first angle projection the three orthographic views of the block.



## 2.2.4 Learning outcome 4: Develop orthographic and pictorial drawings

### 3.2.4.1. Introduction to the learning outcome

The focus of this specific learning outcome is to introduce the different working drawings and their purpose during the planning of plumbing works. This section will give an understanding of the different types of working drawings, building symbols and different representations of drawings.

### 3.2.4.2. Performance Standard

The following performance criteria will be required to be met by trainees to be considered competent:

1. Symbols and abbreviations are identified and interpreted according to standard drawing conventions
2. First and third angle orthographic drawings are interpreted and developed in accordance with the standard conventions
3. Orthographic elevations are dimensioned in accordance with standard conventions
4. Isometric drawings are interpreted and developed in accordance with standard conventions



5. Oblique drawings are interpreted and developed in accordance to standard conventions

### 3.2.4.3. Information Sheet

#### a) Terms and concepts

##### i. Plumbing drawing

Type of technical drawing used to visually represent and inform on a plumbing system conveying the engineering design to plumbers or other workers who install the plumbing system.

##### ii. Design drawing

Used to develop ideas about a new or developing design

##### iii. Concept drawings

These are sketches or drawings often freehand done, used by designers such as architects, engineers, and designers as a quick and simple way of exploring initial ideas for designs.

##### iv. Parallel Projection

These are projections where the line of sight or projectors are parallel and are perpendicular to the picture planes. It is subdivided in to the following three categories:

- Orthographic,
- Oblique and
- Axonometric Projections.

##### v. Orthographic projections

These are multi view drawings, which show flat representations of principal views of an object.

##### vi. Oblique Projections

“a projective drawing of which the frontal lines are given in true proportions and relations and all others at suitable angles other than 90 degrees without regard to the rules of linear perspective.” According to Mirriam webster dictionary.

##### vii. Axonometric Projections:

Axonometric projection creates a true plan set at 45°, which retains the original orthogonal geometry of the plan. It is particularly suitable for representing interior designs, such as kitchen layouts. Planning drawings can also be effectively represented as axonometric projections, showing the relationships between buildings and topography.

These are three-dimensional drawings that falls into three classifications:

- Isometric,
- Dimetric and

- Trimetric.

### **viii. Isometric drawing**

The isometric was the standard view until the mid-20th century. Unlike the axonometric projection, the isometric plan view is slightly distorted, using a plan grid at 30° from the horizontal in both directions. It can be used to show the nature of the design and explain construction details more clearly than an orthographic projection. It is sometimes used during concept design to help the client grasp the mass of the proposal.

### **b) Free hand sketching**

#### **i. Purpose of Technical Drawings**

To appreciate the need for technical drawings, one must understand the design process. The design process is an orderly, systematic procedure used in accomplishing a needed design.

Any product that is to be manufactured, fabricated, assembled, constructed, built, or subjected to any other types of conversion process must first be designed. For example, a house must be designed before it can be built.

#### **ii. Application of Technical Drawing**

Technical drawings are used in many different applications. They are needed in any setting, which involves design, and in any subsequent forms of conversion process. The most common applications of technical drawings can be found in the fields of manufacturing, engineering, and construction.

For instance, Surveyors, civil engineers, plumber use technical drawings to document such works as the layout of a new subdivisions, or the marking of the boundaries for a piece of property. Contractors and construction personnel use technical drawings as their blueprints in converting architectural and engineering designs into reality

- c) Pictorial and orthographic drawings
- d) Meaning of symbols and abbreviations
- e) Drawing and interpretation of orthographic elevations
- f) Dimensioning of orthographic elevations
- g) Conversion of orthographic to pictorial

### **g) Freehand sketching**

A freehand sketch is a drawing in which all proportions and lengths are judged by eyes and all lines are drawn without the use of drawing instruments. Comparing with mechanical drawing, the use of freehand sketching in engineering

Communication provides the following advantages:

- iv. A better means of visualizing problems
- v. Organizing ideas more quickly
- vi. Avoiding wasting of time on formal drawing methods

The following requirements are necessary for sketching materials in plumbing,

#### **Sketching tools:**

A sketch communicates information and does not have to be an exact drawing. Many designs were visualized

on just a piece of paper or whatever is available. The tools that are used in freehand sketching are:

- iv. Sketching paper cross-section paper or grid paper, help secure good proportions and serve as guides in sketching lines
- v. Pencil medium lead (B) or soft lead (HB) type
- vi. Eraser soft type

Above the three things are essential for sketching. Sometimes, cross-sectioned graph paper ruled with light lines is also used instead of a plain paper. These lines and squares help in drawing straight lines and maintaining proportions.

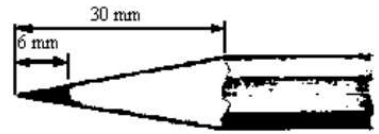
As such papers may not always be readily available, it is advisable to learn sketching without their aid.

Freehand drawing is known as sketching. This technique is necessary in any area of drafting and an important skill for everyone. Skills in freehand drawing can be achieved through constant training and correct practice.

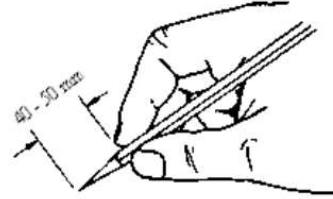
#### **Use of pencils**

Although freehand lines will never be perfectly straight and absolutely uniform along their lengths, effort should be made to sketch distinct, black and uniform lines. Hints of using pencils that help sketching to be made to approach exacting uniformity are as follows:

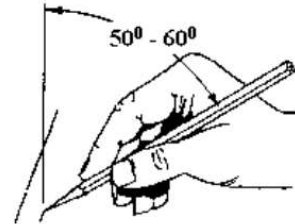
i) Sharpen the pencil to obtain a proper point



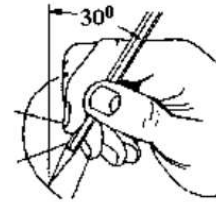
ii) Hold the pencil loosely, approximately 40 - 50 mm from the point



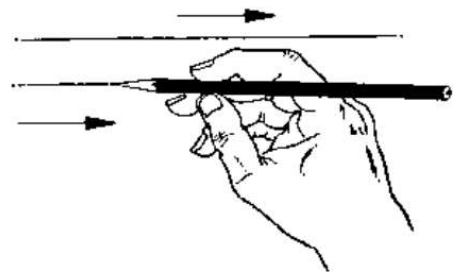
iii) Slant the pencil at an angle of 50 - 60 degrees from the vertical for sketching straight lines



iv) Slant the pencil at an angle of 30 degrees from the vertical for sketching circles



v) Pull the pencil when sketching straight lines or curves

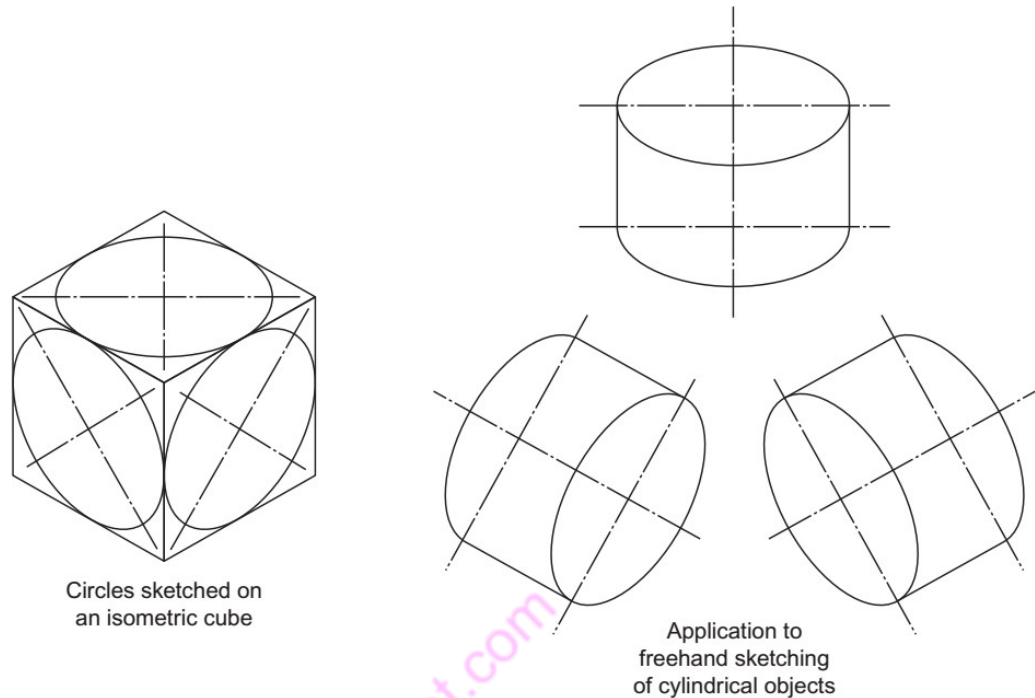


### Line Sketching

One advantage of freehand sketching is that it needs only patience and continuous Practice. Practice on a drawing paper the construction of following line without use of instruments. When drawing straight lines, as on the left, rest the weight of your hand on the backs of your fingers. When drawing curved lines, as on the right, rest the weight on that part of your hand between the knuckle of your little finger and your wrist. This provides a pivot about which to swing your pencil. Always keep your hand on the inside of the curve, even if it means moving the paper around.\

### Pictorial Sketching

Freehand pictorial sketching looks very much like isometric drawing. Circles appear as ellipses and lines are drawn at approximately  $30^\circ$ . Circles have been sketched onto an isometric cube in figure below. You can see how these same ellipses appear on sketches of a round bar material.



**Figure 79 Pictorial exercises**

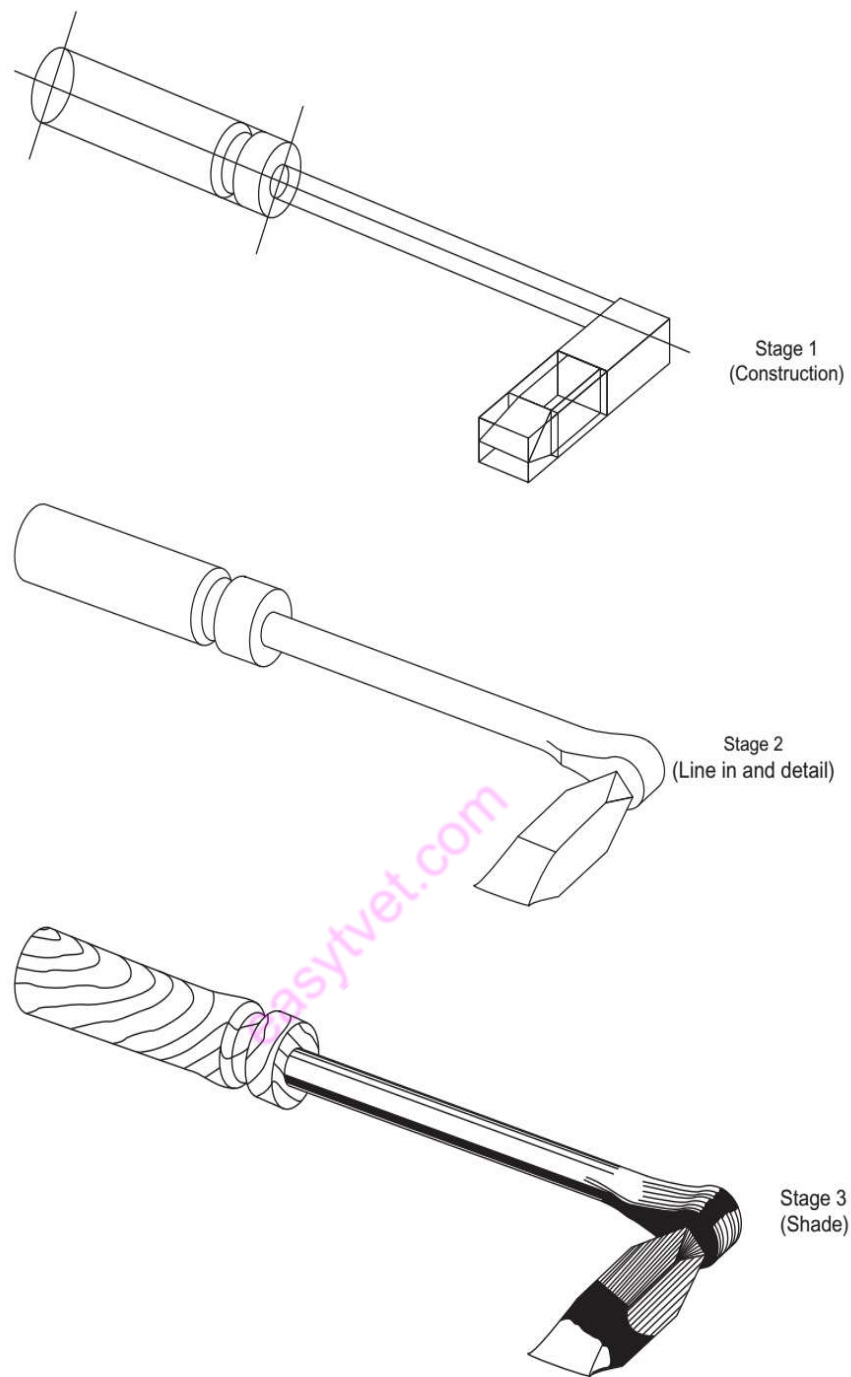
When sketching, you may find it an advantage to draw a faint 'box' first and draw in the ellipses afterwards. With practice you should find that you can draw quite a good ellipse if you mark out its centre lines and the major and minor axes. Although drawing is a continuous process, the work can be divided into three basic stages.

**Stage 1: Construction**

This should be done with a hard pencil (3H), used lightly, and the strokes with the pencil should be rapid. Slow movements produce wavy, uncertain lines. Since these constructed lines are very faint, errors can easily be erased.

**Stage 2: Lining in**

Carefully line in with a soft pencil (HB), following the construction lines drawn in stage 1. The completion of stage 2 should give a drawing that shows all the details and you may decide, particularly in an examination, not to proceed to stage 3



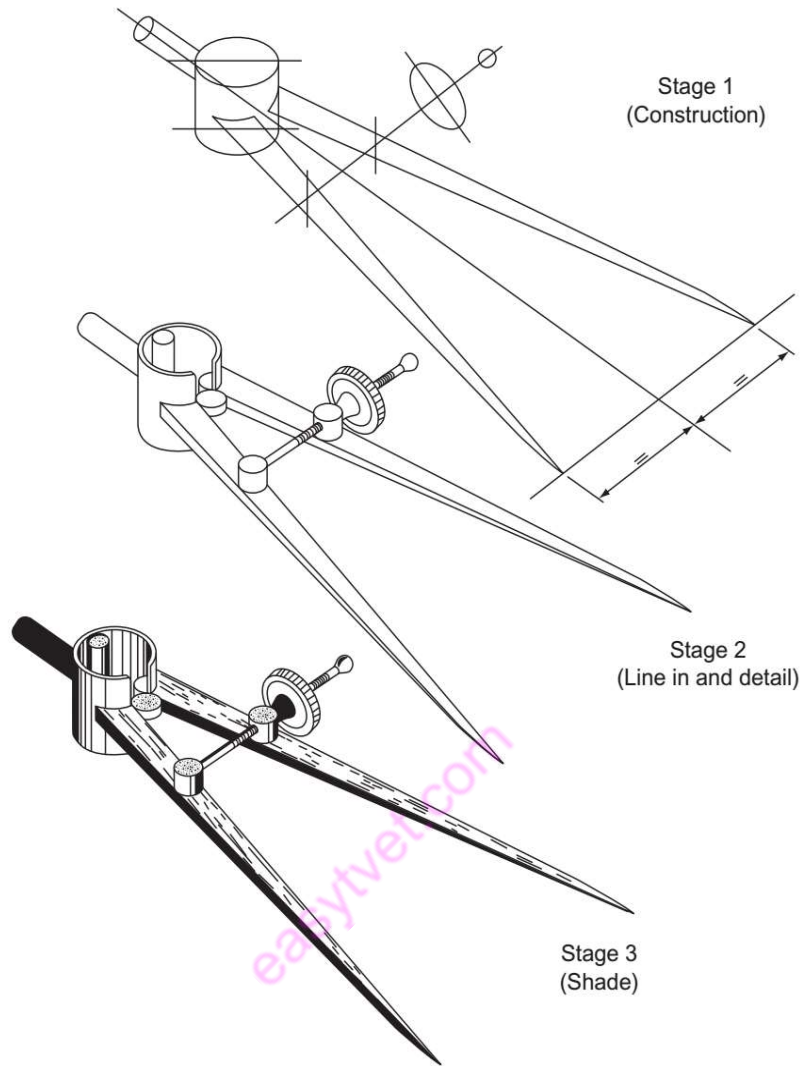
**Figure 80 3 stages of freehand sketching**

**Stage 3: Shading**

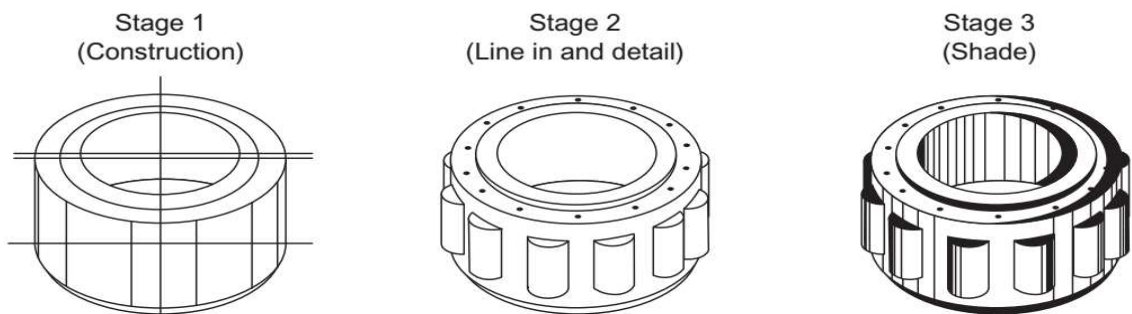
Shading brings a drawing to life. It is not necessary on most sketches, and in some cases it may tend to hide details that need to be seen. If the drawings are to be displayed, however, some shading should certainly be done.

Shading is done with a soft pencil (HB). It is very easy to overshade, so be careful. For the smooth merging of shading, the dry tip of a finger can be gently rubbed

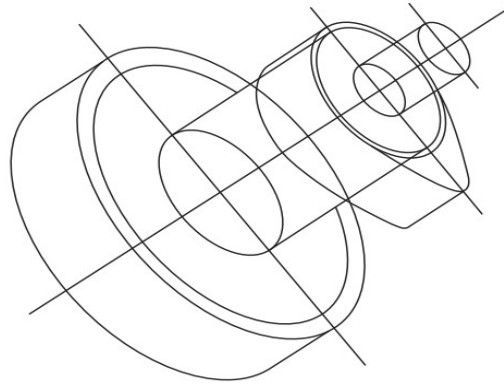
over the area.



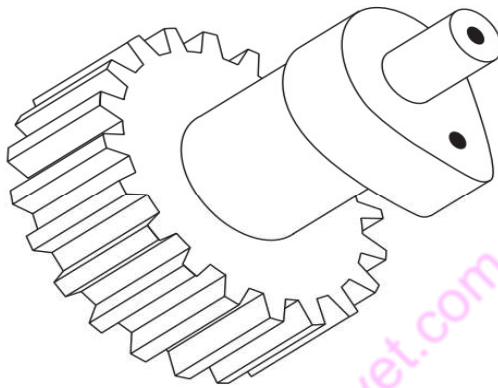
**Figure 81 Divider Exercise**



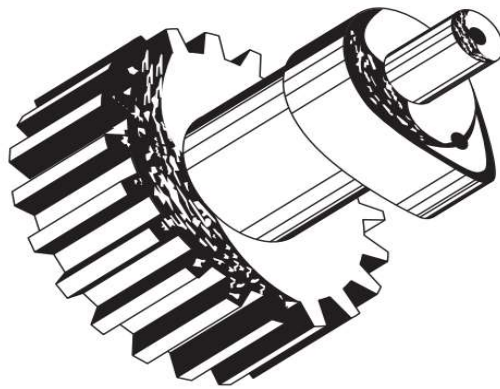
**Figure 82 Bearing exercise**



Stage 1  
(Construction)



Stage 2  
(Line in and detail)



Stage 3  
(Shade)

**Figure 83 Gear Exercise**

**Sketching in Orthographic Projection**



More detail can be seen on an orthographic drawing than on an isometric, mainly because more than one view is drawn. For this reason it is often advantageous for a draughts person to make an orthographic sketch. This will be undertaken below

Circles are difficult to draw freehand but you can use your hand as a compass. Hold your pencil upright and, using your little finger as a compass 'point', revolve the paper keeping your hand quite still.

## Orthographic projections

### First and third angle projection

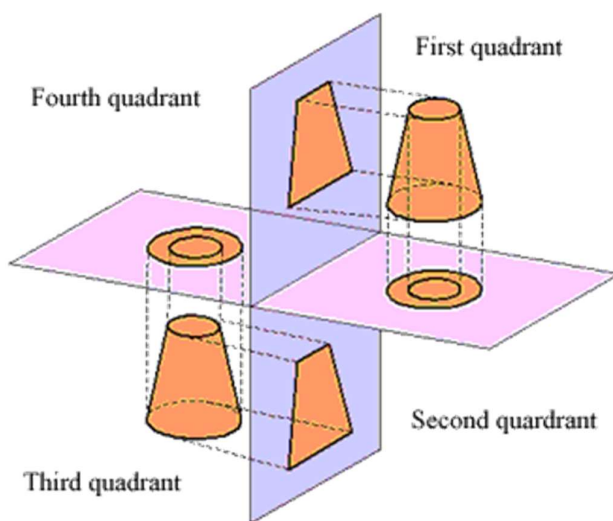
This is a graphical method used in engineering drawings. The word **orthographic** is derived from the Greek words **orthos**-*straight, rectangular* and **graphos**-*written, drawn*. A drawing of a structure or part thereof can be drawn using the following projection methods:

- (a) orthogonal      (b) oblique and/or      (c) perspective

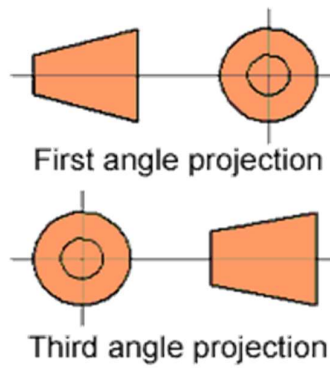
There are two methods of drawing **orthographic** projections:

- 1) first angle projection and      2) third angle projection

They are based on right angle planes with defined separate spaces, or quadrants. Each quadrant could obtain an object to be presented. However, only two are commonly used, the first and the third as shown.

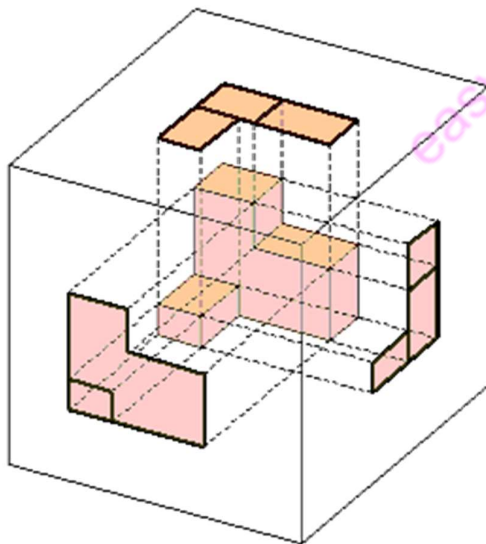


Both systems of projection are approved internationally and the system used is clearly indicated on all engineering drawings with the following illustrations:

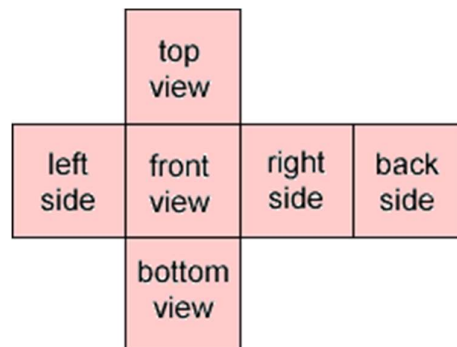


**Figure 84: Orthographic Projection**

In which projection architectural and builders working drawings are represented is generally insignificant. Nearly all of those drawings do not indicate in which projection they are drawn and it really does not matter. However, it is important that you understand the basic principles of orthographic projection and be able to construct orthographic views of objects.

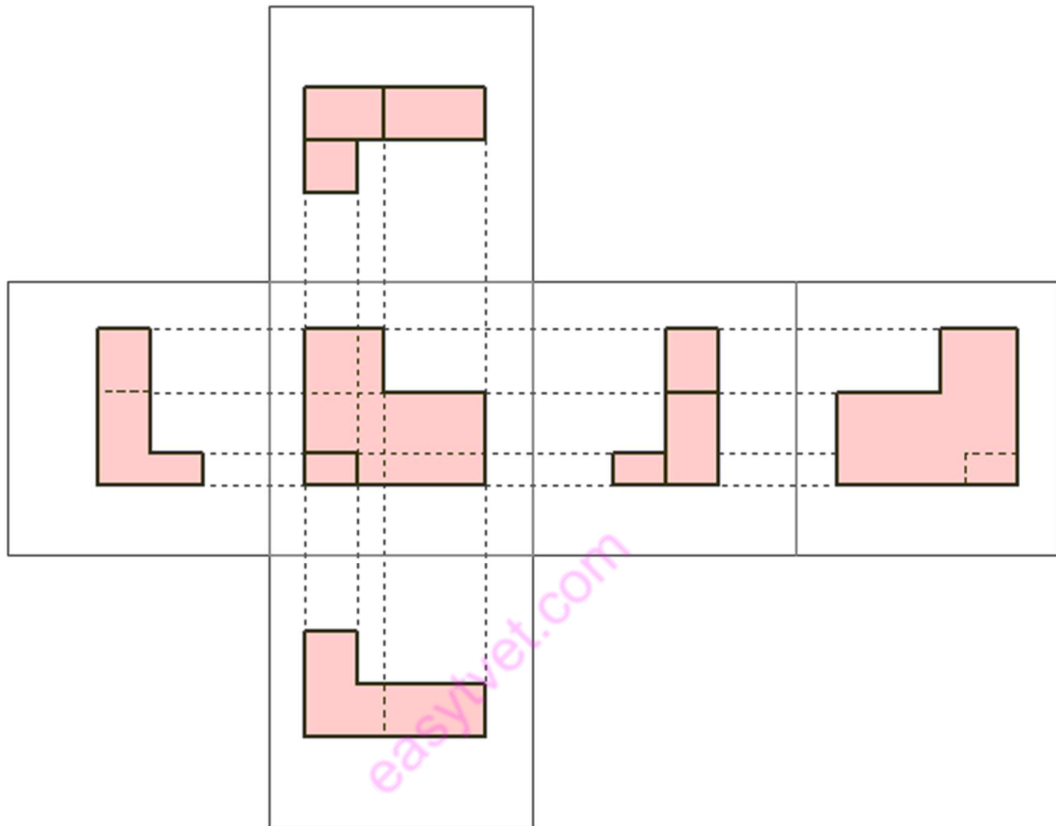


The easiest way to explain the development of an orthographic drawing is to place an object in a glass cube as shown in the opposite figure. The object surfaces are then projected on the faces of the cube. The cube like any card box can be unfolded so that all six surface areas are shown as blow.



**Figure 85: Views**

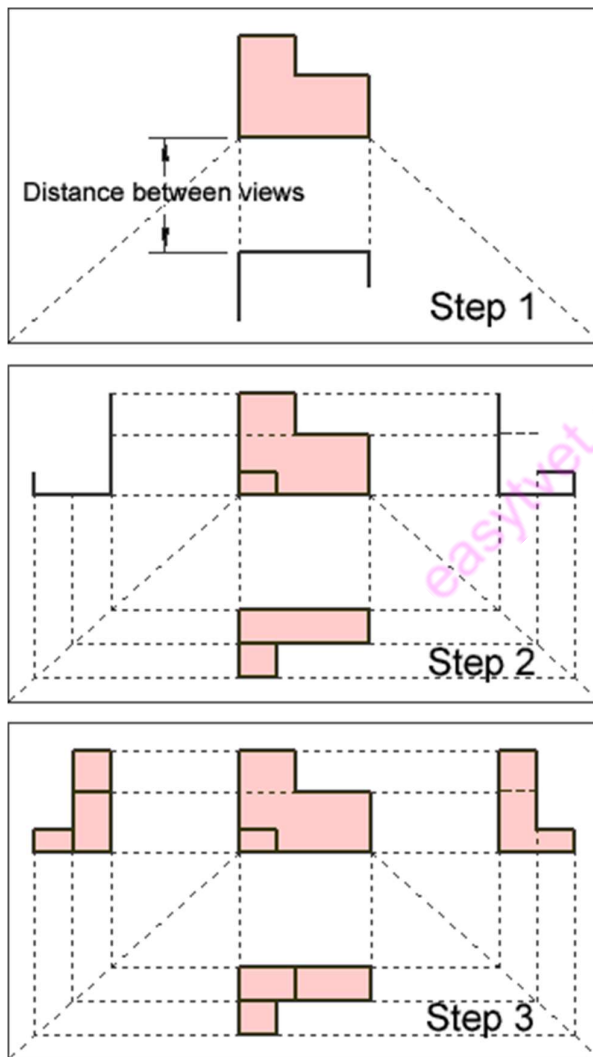
The figure below shows the unfolded box with the same object as shown.



**Figure 86: Unfolded Box**

## How to draw objects or components

Adopt the method below for drawing building objects or components.



Choose which view or direction or face will be used as the front view of the object or component.

The object or component you chose for the front view should have the longest straight edge..

From the bottom edge of the front view draw feint construction lines @  $45^\circ$  as shown in Step 1

Carry on finishing the top view. Start a line below the front view with sufficient distance for dimensioning of the object or component.

Complete the top view

Use feint construction lines and draw the outline of the side views as shown in Step 2

Complete the side view with the aid of construction lines as shown in Step 3

Always use this method for drawing objects or components.

**Figure 87: How to Draw objects/components**

In Drawing 1 you will draw a number of different objects. The views should always be aligned with each other allowing sufficient space between the views for dimensions (see Step 1 - Figure 6). Lines that cannot be seen in a specific view are hidden and shown as dashed lines.

### **Orthographic Projection**

Orthographic projection shows the views of an object in three different positions, namely:

#### **PLAN – ELEVATION – END VIEW.**

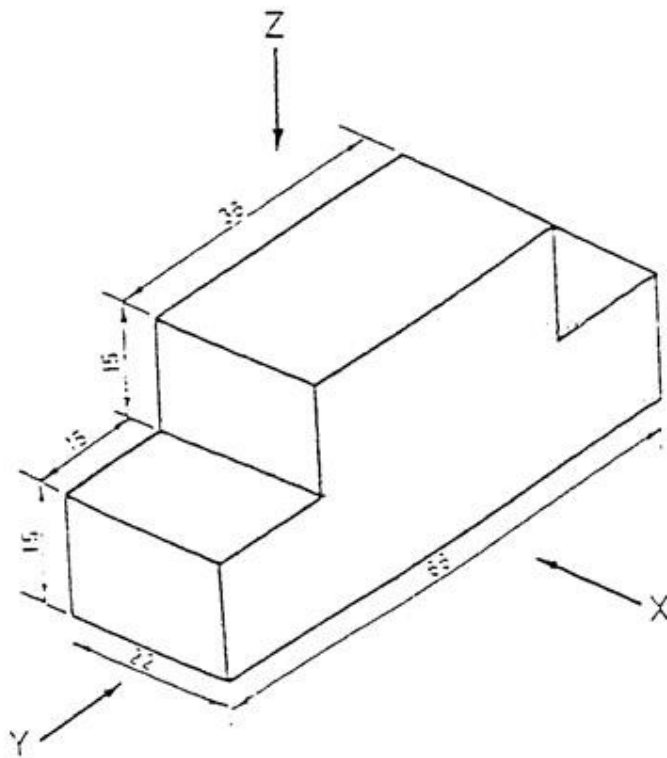
The plan is an outline of the object when viewed from above.

The elevation is what is seen when looking from the front.

The end view shows the view from one of the ends.

Orthographic projection is generally not used in the construction industry. It is more commonly found in the engineering sector where precise measurement is essential.

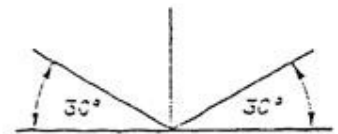
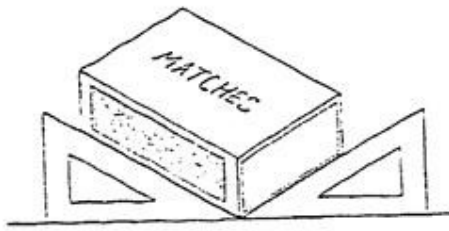
Try drawing the object below in orthographic projection i.e. draw a plan (z) an elevation (x) and an end view (y).



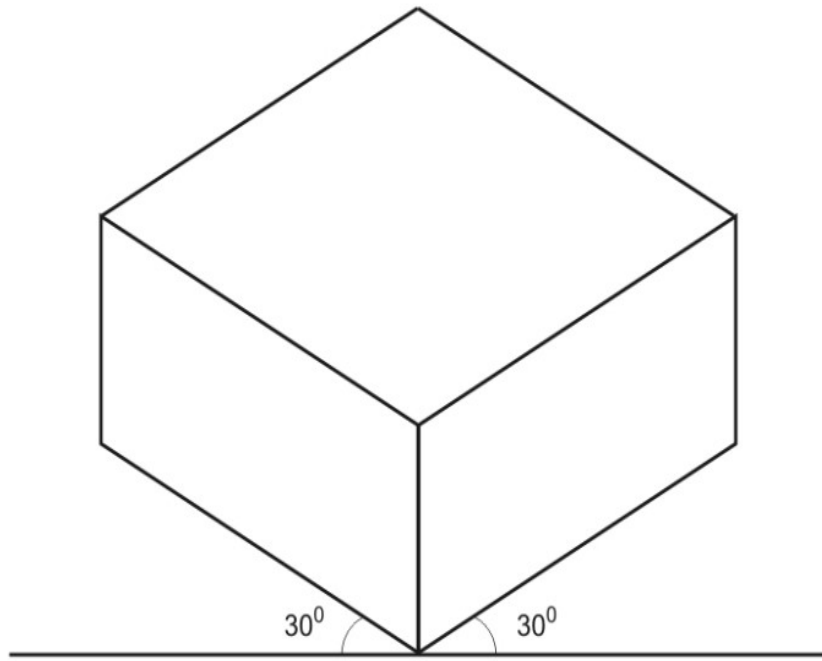
**Figure 88 Orthographic views**

**Isometric Projection**

In isometric projection all the horizontal lines are drawn at  $30^\circ$  to the horizontal plane while vertical lines are drawn vertical.



**Figure 89 Isometric axis**



**Figure 90 Isometric Box**

Isometric projection embraces the three views from orthographic projection in the one drawing. In the drawing of the matchbox below you can see the plan, elevation, and end view.

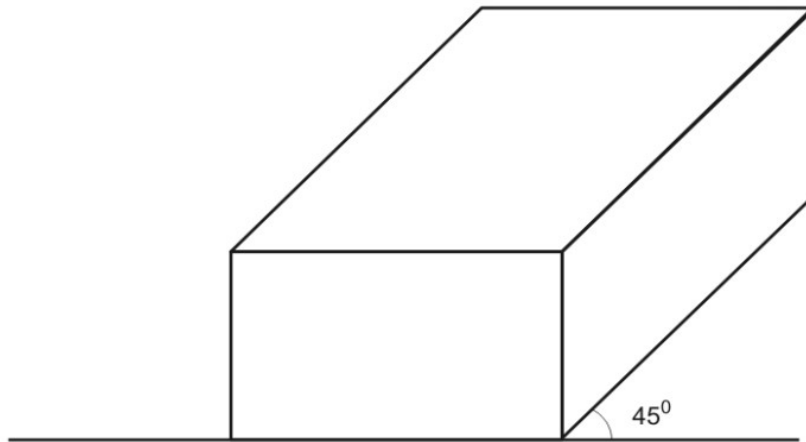
**Procedure for making an Isometric box**

- i. Draw a light horizontal baseline and a vertical line to represent the nearest corner.  
'A' of the box.



**Oblique drawing**

This is a representation such that the edge of one face is parallel to the horizontal reference line and the other edges are elevated at an angle of  $45^\circ$



**Figure 91 Oblique Box**

### **Perspective drawing**

**Parallel** – Parallel lines are lines that never touch... even if they are extended indefinitely.

**Horizontal Lines** – Lines drawn from side to side level with the horizon. Horizontal lines will be parallel the top and bottom edges of your paper.

**Vertical Lines** – Lines drawn up and down and perpendicular (right-angled) to the horizon. Vertical lines should be parallel to the sides of your paper.

**Slanted Lines** – Lines that are neither vertical nor horizontal; slanted lines are diagonal.

**Horizon Line** – The horizon line is a special horizontal line that represents eye level to the viewer.

**Vanishing Point** – A point on the horizon line where all perspective lines meet.

**Perspective Lines (orthogonal lines)** – The lines that meet at the vanishing point. Perspective lines are parallel in real life but converge in a one point perspective drawing.

### **One Point Perspective**

**One Point Perspective** is a type of linear perspective that uses a single vanishing point to create the illusion of depth in a work of art.

### **Abbreviations**

A list of the standard abbreviations for some general engineering terms is shown below. These abbreviations are used to save time, and space on drawings.



Although the abbreviations are shown in block capital letters, small letters may be used. For unit abbreviations always use small letters.

To read a drawing properly, and to understand what is happening, an agreed set of graphical symbols and abbreviations are used. All the different trades have a set of symbols pertaining to their respective works. The works of the plumber is often referred to as the “Mechanical Services”.

#### Abbreviations for Pipe Rises/Drops

<b>TA</b>	To Above
<b>FB</b>	From Below
<b>RTA</b>	Rise To Above
<b>DTB</b>	Drop To Below

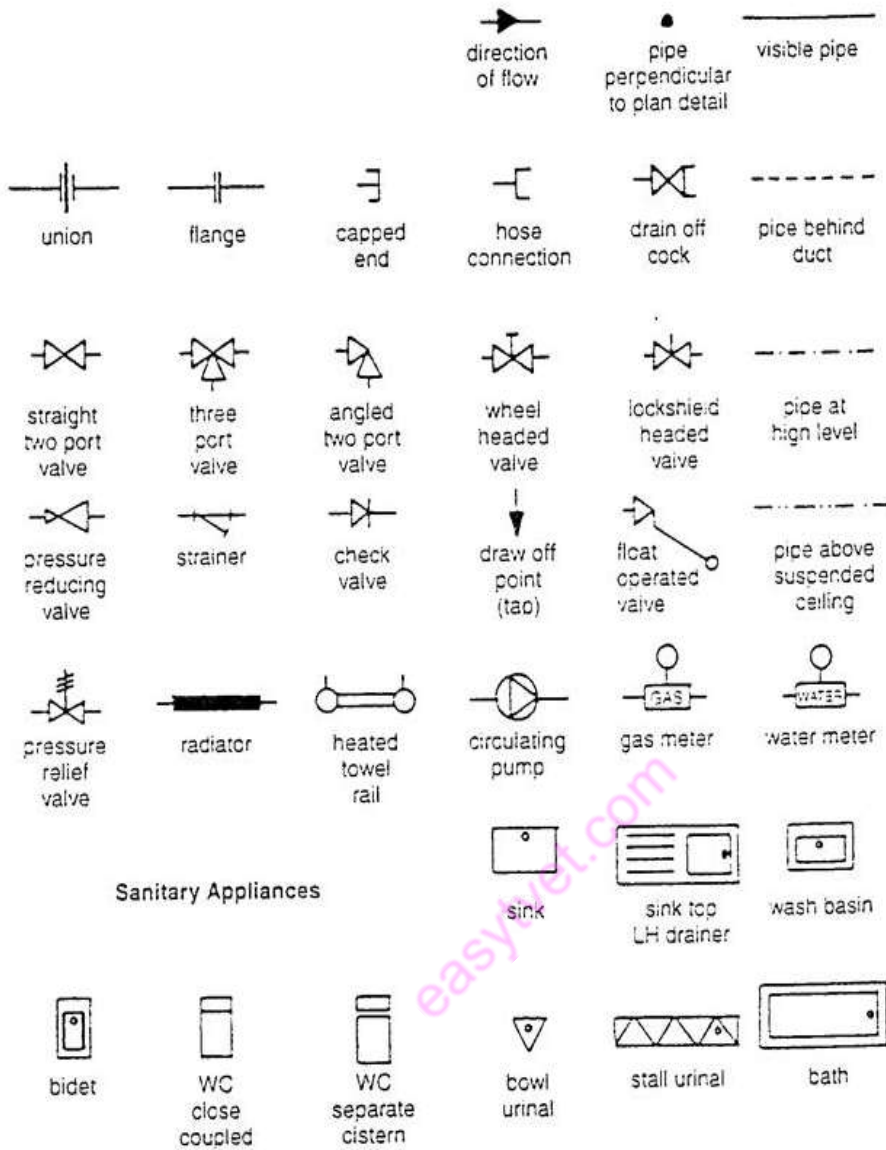
To identify individual services some of the following abbreviations may be used.

#### ▪ Service Abbreviations

<b>MWS</b>	Mains Water Services
<b>DW</b>	Drinking Water
<b>CWF</b>	Cold Water Flow
<b>CWS</b>	Cold Water Service
<b>HWSF</b>	Hot Water Service Flow
<b>HWSR</b>	Hot Water Service Return
<b>HWSVP</b>	Hot Water Service Vent Pipe
<b>FF</b>	Fire Fighting Services
<b>HRS</b>	Hose Reel Service
<b>CA</b>	Compressed Air
<b>F&amp;R</b>	Flow and Return

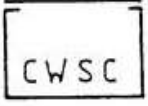
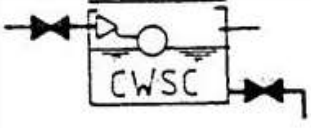
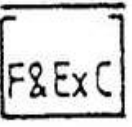
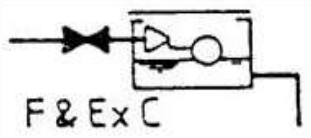

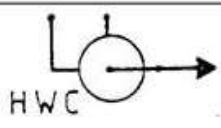

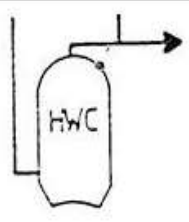
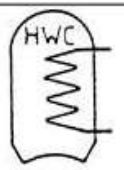
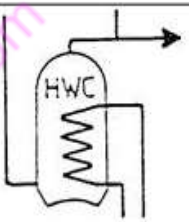
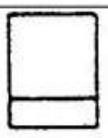
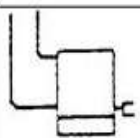



The symbols on the following pages are from the British Standards Institution and are used extensively in drawings relating to mechanical services.

**Figure 92 Abbreviations for Pipe Rises/Drops**



■ British Standards Institution Symbols

■ BSI Symbols

Symbol	Description	Application
	Cold water storage cistern (Storage and feed cistern) (Feed Cistern)	
	Feed and expansion cistern	
	Hot water storage cylinder or tank (plan)	
	Hot water storage cylinder or hot store vessel (Direct types) (elevation)	
	Hot water storage cylinder or hot store vessel (indirect types) (elevation)	
	Boiler (elevation)	
	Temperature relief valve	
	Tundish	

By dimensions, the shape and size of an object are explained. A worker can complete the job according to the dimensioning.

If the size of an object is represented then such a measurement is called **Size**

**Dimension**, Similarly, if the place of an object is represented then such a measurement is called Location Dimension.

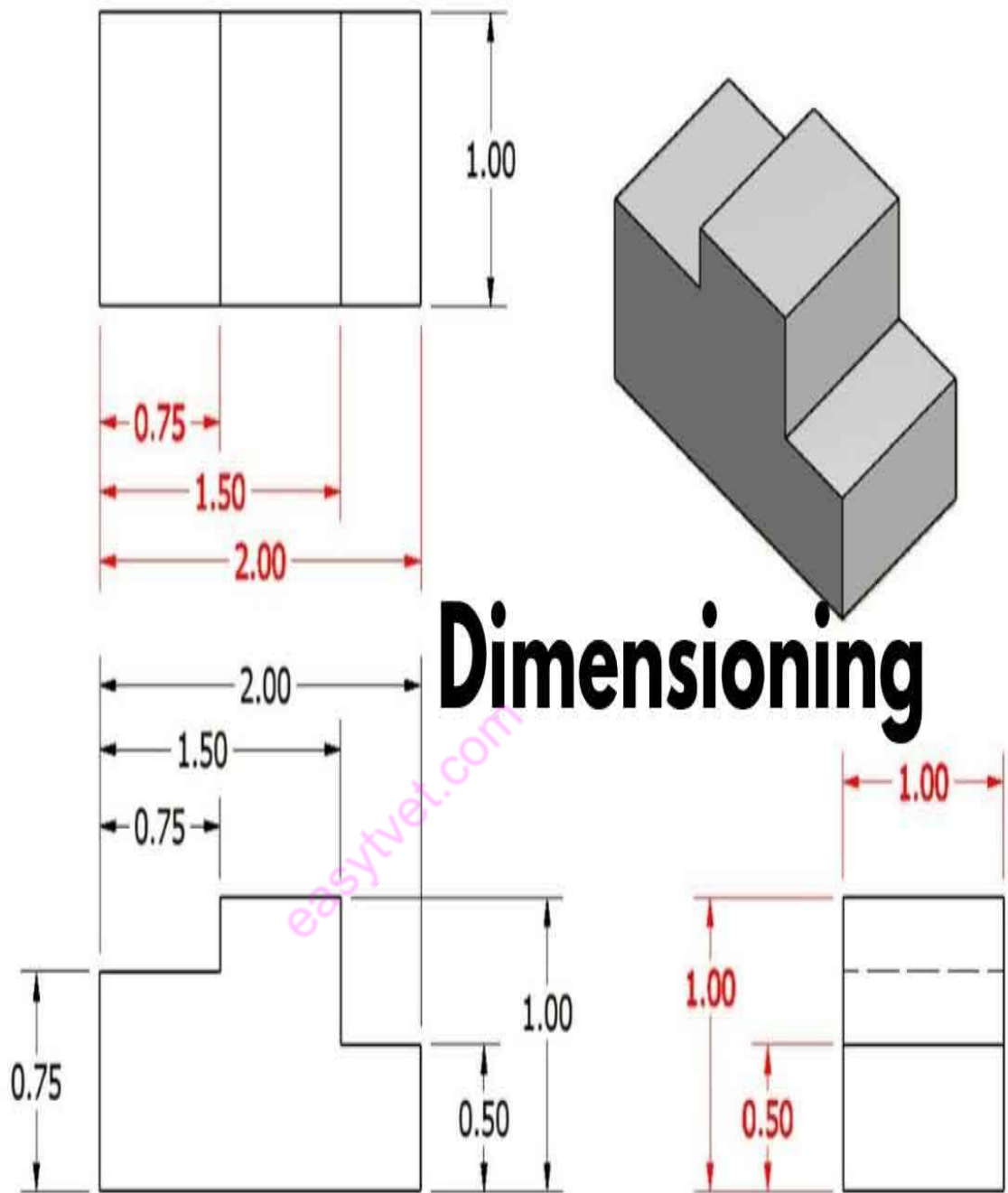
If the dimension is written in the same direction in the whole drawing, then such method is called **Unidirectional Method**.

If the dimension is written in two directions, then such method is called **Aligned Method**.

In addition to this, if dimension it is written parallel to the central line, then such method is called **Base Line Method**.

The beauty of a drawing depends on the beauty of dimensioning.

easytvvet.com



**Types of Dimensioning.**

There are two types of writing dimensions on a drawing.

1. Size Dimension.
2. Location Dimension.

**1. Size Dimension:**

In this type of dimension, the external size of an object is represented. Also, the sizes of different parts of a drawing are shown there.

This shows the length, breadth, and height.

Such a dimensioning is represented mostly by the front view.

## **2. Location Dimension:**

In this type of dimensioning, the distances between different parts of the object and the distances between the centers of circles are shown.

In addition to this, the distance of the center of a circle or that of any other part from some particular point is represented.

Location dimension is divided into three different ways:

1. Center to Center Distance.
2. Center to Surface Distance.
3. Surface to Surface Distance.

## **Order of Dimensioning.**

After completing a drawing, the following order is to be kept in mind.

This makes a drawing beautiful. It also saves time.

1. Drawing of Extension Line.
2. Drawing of Dimension Line.
3. Drawing of Arrow Heads.
4. Writing of Numerical Value.
5. Drawing of Cutting Plane Line.
6. Drawing of Leader Line.
7. Drawing of Center Line.
8. Writing of Notes and Specifications.

## **Systems of Dimensioning.**

Following are the three systems of writing dimension.

1. Unidirectional Method.
2. Aligned Method.
3. Base Line Method.

### **1. Unidirectional Method:**

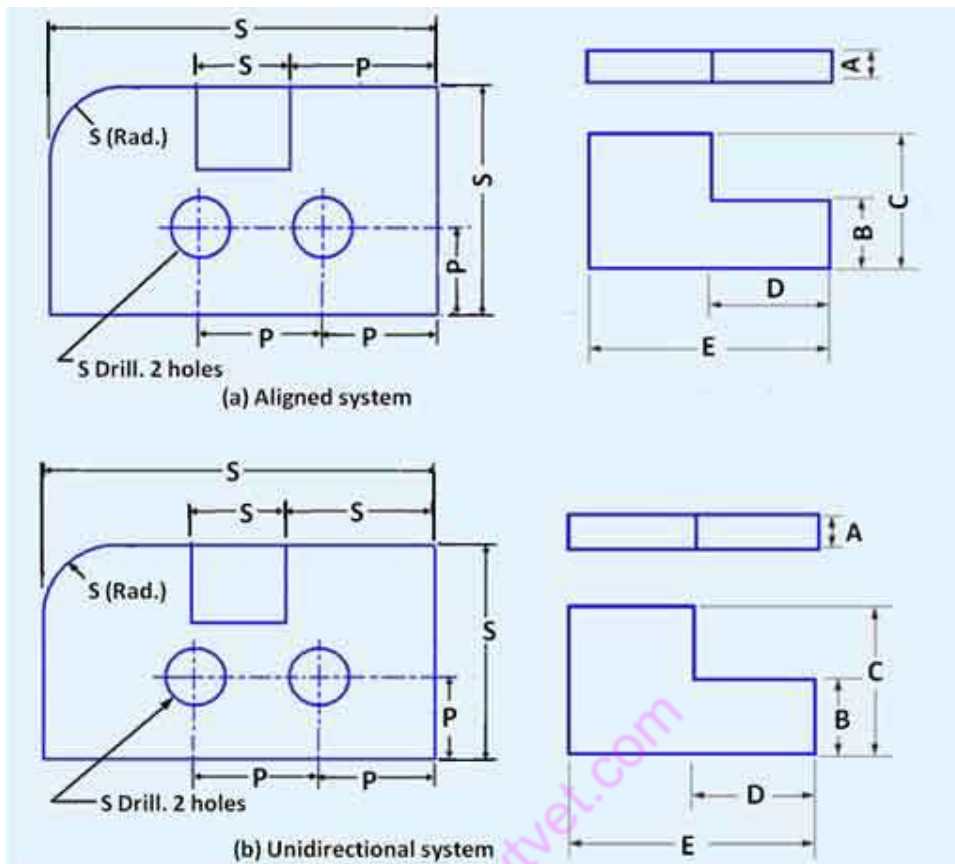
This method is mostly used in dimensioning. In this method, the whole dimension is written in the same direction in the whole drawing.

### **2. Aligned Method:**

In this method of dimensioning, it is written in two directions in the whole drawing.

It is written upward and at the right side and is read from the bottom and right side of a drawing.

Its advantage is this that the dimensions can be written in the horizontal direction which is very easy to write.



### 3. Base Line Method:

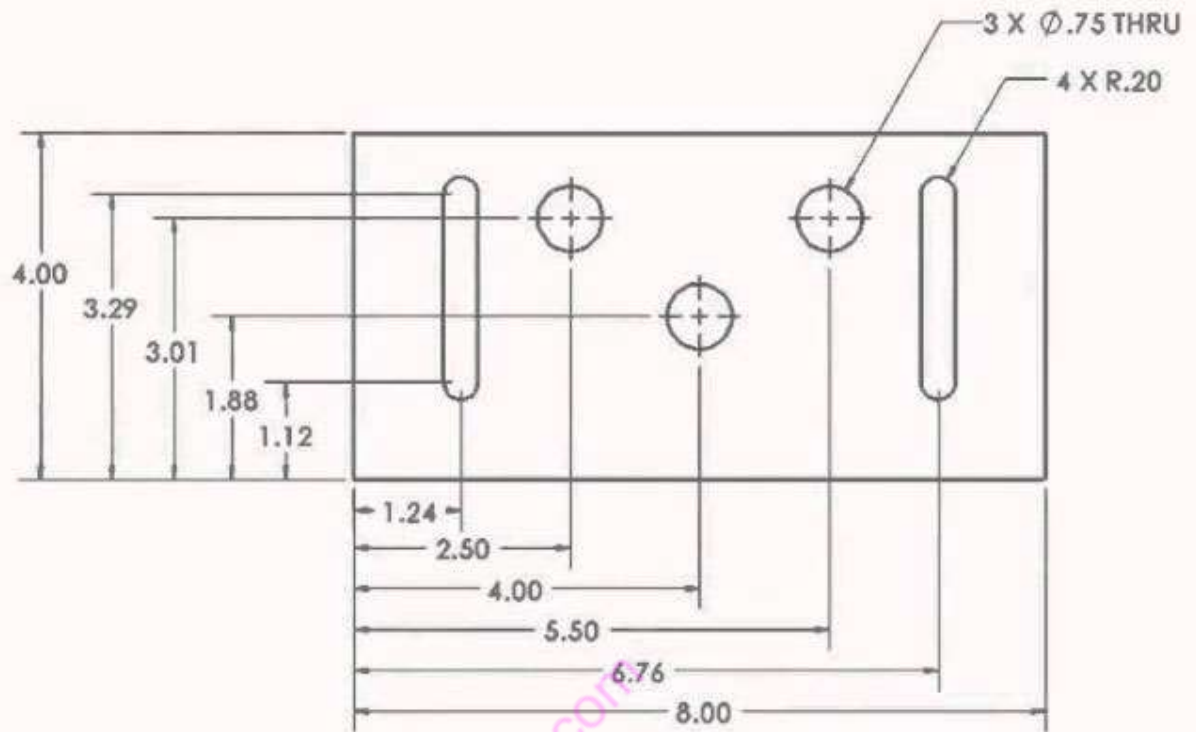
In this method of dimensioning, baseline is used to write the dimension of various parts of a drawing. Then all the dimensions are written parallel to the base line.

In writing dimension, the smallest one is written to the side of the object, and the biggest one is written on the external side of the object.

All other dimensions are written in between them.

In this system, the chances of mistake are very rare.

# BASELINE DIMENSIONING



## Elements of Dimensioning.

For any drawing to be workable, it is necessary that all the needful dimensions should be written on it, so that all information could be used properly.

For this purpose, the following elements are written down.

1. Dimension Line.
2. Extension Line.
3. Center Line.
4. Leader Line.
5. Arrow Head.
6. Numbers.

### 1. Dimension Line:

A Dimension Line is drawn for a given dimension of an object. This line should be at a distance from 10 mm to 15 mm from the object line.

For writing a dimension, this line is broken from the middle, and the dimension is written in the middle space. Alternatively, the dimension is written on it after its completion.

2H or 4H pencil is used for this purpose.

### 2. Extension Line:



Such lines which are drawn extending from the ends of a part of a drawing so that the dimension can be written in between them are called extension lines.

2H or 4H pencil is used for this purpose.

There should be a distance of 1 mm between them and the object line.

### **3. Center Line:**

Such a line is used to represent the center of a cylindrical part of a drawing.

**For example,** a hole shaft, etc.

This should be extended up to 1 mm distance from the object line.

### **4. Leader Line:**

Any note or specification is written on an object with the help of this line. This is drawn with 2H or 4H Pencil.

It consists of a circle and a leader.

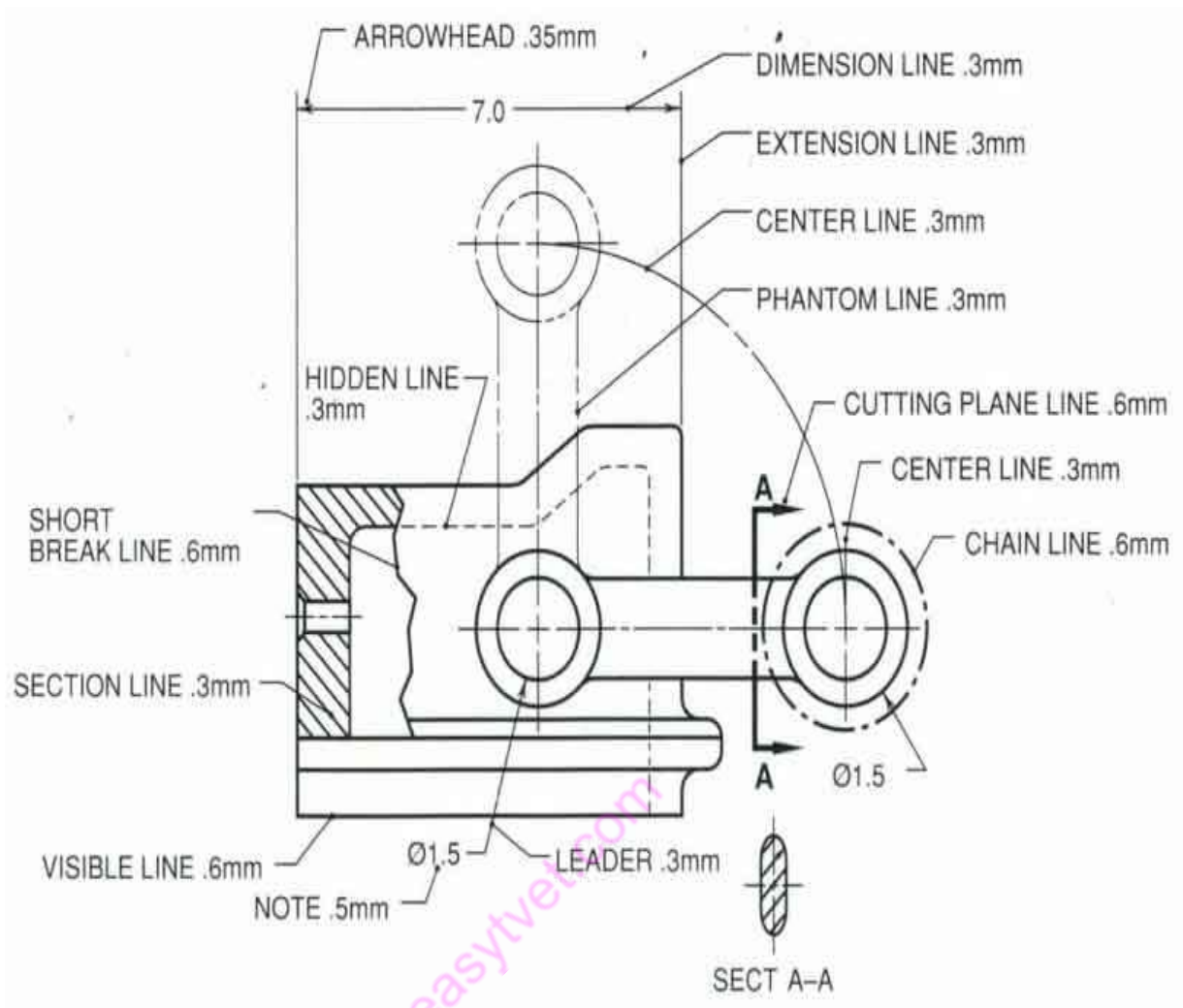
### **5. Arrow Head:**

This is used at the ends of a dimension and the end of a leader. The length of the arrow-head used in engineering drawing 3 mm.

### **6. Numbers:**

After the completion of any geometric shape of an object, the writing of its size is desired.

Numbers are used for this purpose. The height of the number is kept 3 mm.



### Principles of Dimensioning.

After completing a drawing, it is necessary that its measurements and notes should be written in such a way that they can be read easily.

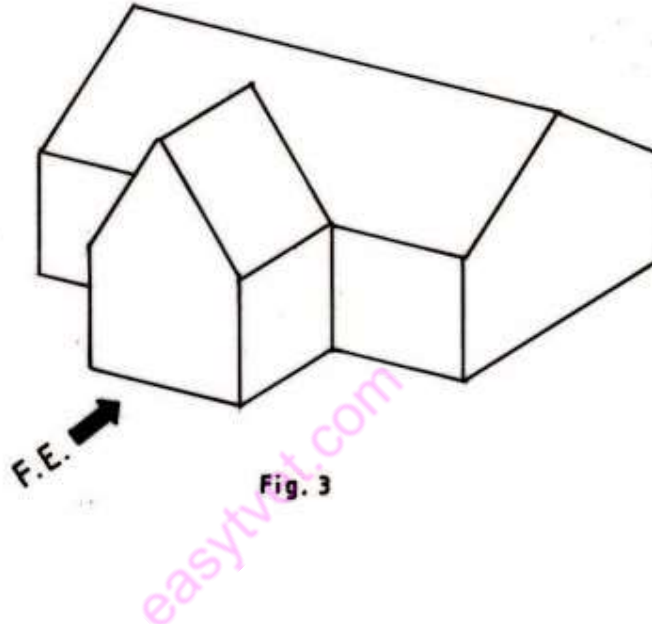
Follow are the Principles that have been devised for this purpose.

1. The dimensions should be given on such view which illustrates the true shape and size of an object.
2. As far as possible the dimensions should be given outside a view but can be given inside as well if unavoidable.
3. All the dimensions are given in group form. Scattering of these is not correct.
4. The dimensions should be intelligibly written.
5. All the dimensions should be written parallel to the object line and the numbers should be written such that they could be read easily.
6. The dimensions should not be repeated unless necessary.
7. The unnecessary dimensions should be avoided.

8. The extension and dimension lines should not intersect in any case.
9. While giving dimension after completing a drawing, it should be kept in mind that no unit should be written with any number.

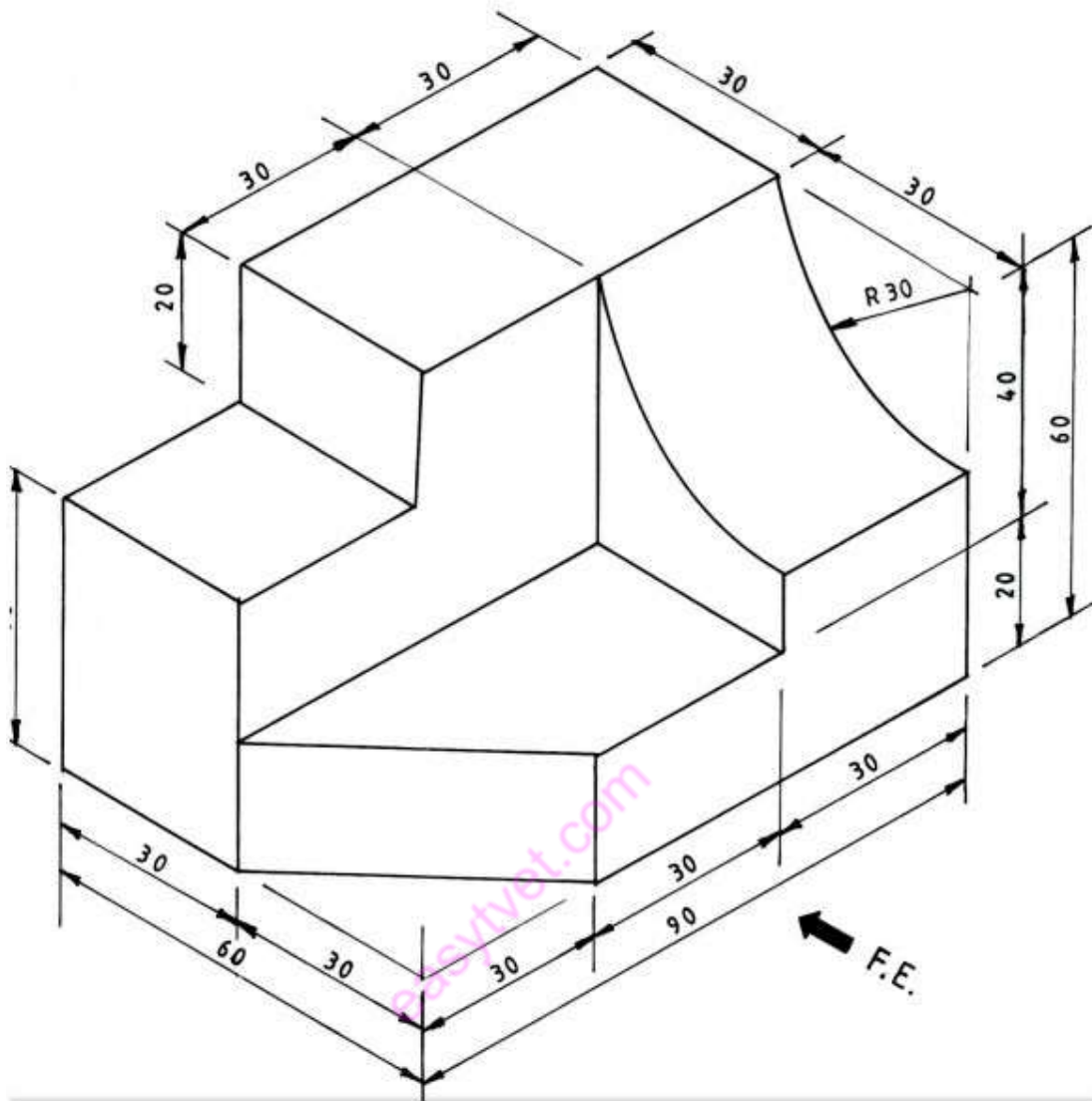
#### 3.2.4.4. Learning activities

Below is a single line pictorial view of a dwelling house. With the help of your trainer, you are required to develop it in third and first and label it using the dimensioning methods learned.



#### 3.2.4.5. Self-Assessment

1. State any three elements of dimensioning.
2. State two types of writing dimensions
3. Figure below shows a pictorial drawing of a shaped block. To a scale of 1:1 , draw three orthographic views of the block in 3'd angle projection. Dimensions.



4. State any three principles of dimensioning.

#### 3.2.4.6. Tools, Equipment, Supplies and Materials

- i. Drawing boards
- ii. T squares
- iii. Set squares
- iv. Drawing sets
- v. Drawing paper
- vi. Protractors
- vii. Eraser Shield
- viii. Pencils
- ix. Erasers

- x. Masking tapes
- xi. Paper clips
- xii. Drawing curves
- xiii. Technical drawing software'

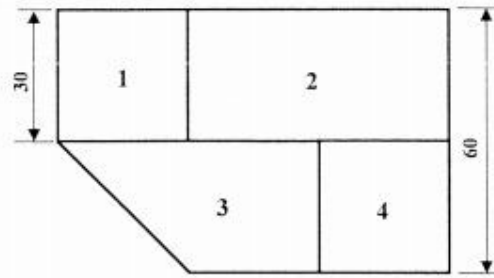
#### 3.2.4.7. References

Bhatt, N. D. (2011). *Engineering Drawing*. Gujarat: Charotar Publishing house.

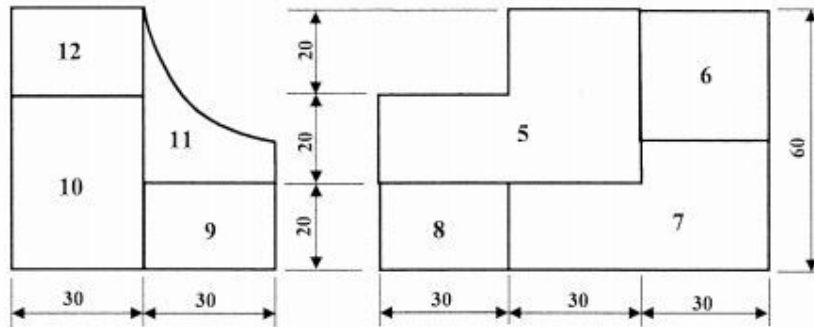
Morling, K. (2010). *Geometric and Engineering drawing*. London: Elsevier.

#### 3.2.4.8. Model Answers.

1. State any three elements of dimensioning.
  - Dimension Line.
  - Extension Line.
  - Center Line.
  - Leader Line.
  - Arrow Head.
  - Numbers.
2. State two types of writing dimensions
  - Size Dimension.
  - Location Dimension.
3. Figure below shows a pictorial drawing of a shaped block. To a scale of 1:1 , draw three orthographic views of the block in 3'd angle projection. Dimensions



PLAN



END ELEVATION

FRONT ELEVATION

3rd angle projection	=	1 mark
12 faces @ $\frac{1}{2}$	=	6 marks
6 dimensions @ $\frac{1}{2}$	=	3 marks
Naming the views	=	1 mark
Curve correctly drawn	=	1 mark
Lines drawn correctly	=	2 marks
Equal spacing of views	=	✓

4. state any three principles of dimensioning.

- The dimensions should be given on such view which illustrates the true shape and size of an object.
- As far as possible the dimensions should be given outside a view but can be given inside as well if unavoidable.
- All the dimensions are given in group form. Scattering of these is not correct.
- The dimensions should be intelligibly written.
- All the dimensions should be written parallel to the object line and the numbers should be written such that they could be read easily.
- The dimensions should not be repeated unless necessary.
- The unnecessary dimensions should be avoided.

- The extension and dimension lines should not intersect in any case.

## 2.2.5 Learning outcome 5: Apply computer Aided design

### 3.2.5.1. Introduction to the learning outcome

The focus of this specific learning outcome is to introduce the different working drawings and their purpose during the planning of plumbing works by the use of computer software to design and document a products design process.

### 3.2.5.2. Performance Standard

The following performance criteria will be required to be met by trainees to be considered competent:

1. Plane geometry drawings are developed using CAD
2. Geometry drawings are developed using CAD
3. Orthographic drawings are developed using CAD

### 3.2.5.3. Information Sheet

CADD is an electronic tool that enables us to make quick and accurate drawings with the use of a computer. Drawings created with CADD have a number of advantages over drawings created on a drawing board. CADD drawings are neat, clean and highly presentable.

#### a) Terms and concepts

**Chamfer** Creates a chamfered corner at the intersection of two selected lines

#### **Ortho mode**

Is the mode which is used for vertical axis.

**Orthographic Projection** The method of showing 2 or more views of same part in drawing a term used is orthographic projection.

**Pan**-is terminology used to move around drawing by dragging drawing area around your screen.

**Polar coordinates**-to input point based on distance and angle in your drawing.

**Snap**-this is the drawing mode that allows you to snap your cursor to precise points laid out in a grid pattern.

#### **CAD**

Computer-Aided Design, a term usually applied to the software.

**CADD**

Computer-Aided Design and Drafting.

**CAE**

Computer-Aided Engineering.

**Callout**

An annotation typically comprised of a leader line and a balloon.

**CAM**

Type of gear used to achieve irregular motion.

**Coordinates / Coordinate System**

A set of magnitudes represented as x, y, and z, coordinates that determine the relative positioning of an object within the drawing space.

**Coplanar surface**

**A given number of surfaces that follow the same planar path.**

**Cross Section**

A 2D, cut-through view of a 3D object.

**Draft**

Typically used to describe the 2D and isometric line drawings created from 3D objects and engineering drawings.

**Draftsman/Draftsperson**

The person responsible for creating drafts.

**Engineering Drawings**

2D drawings generated for manufacturing.

**Entity**

A given single object in a drawing. Does not include things like text style or dictionary items.

**Exploded view/Exploded drawing**

A 2D visualization of a disassembled assembly.

**Extrude**



A technique of dragging a 2D dimensional boundary, face or polygon into a 3D object, either along a single axis or with a taper.

(Sourced from <https://blog.bricsys.com/tuesday-tips-glossary-of-cad-terms/>)

### **Introduction**

The term computer aided design (CAD) refers to the use of computers to create graphical representations of physical objects to assist in the design process. It can also refer to the use of computers to prepare presentational images or to prepare production information enabling objects to be manufactured, although sometimes this is referred to as computer aided drafting as it does not necessarily involve designing. In combination, these processes may be referred to as computer-aided design and drafting (CADD).

CAD can be used to create 2D or 3D representations and can also be used to generate animations and other presentational material. It may allow the addition of supplementary information such as dimensions, descriptions of components, references to specifications and so on.

Specialist CAD software is available for specific purposes, and a wide range of software applications have been developed for use in the design and construction of built assets such as buildings.

### **Computer aided manufacturing**

The combination of computer aided draughting and computer aided manufacturing (CAM) has allowed computer numerical control (CNC) of highly automated end-to-end component design and manufacture. Computers can produce files that translate design information into commands to operate machines, singularly or collectively, to perform pre-set sequences of tasks in the production of building components.

See Computer aided manufacturing for more information.

More recently, the range of possibilities has been increased further by the introduction of economically viable 3D printing.

### **BIM**

The introduction of building information modelling (BIM) allows further reduction of errors and improvement to the quality of information and can enable the automatic generation of quantities, cost estimates, ordering and tracking information.

BIM is a very broad term that describes the process of creating and managing a digital model of a building or other facility (such as a bridge, highway, tunnel, and so on), which includes:

Level 0: Unmanaged CAD.

Level 1: Managed CAD in 2D or 3D.

Level 2: Managed 3D environment with data attached but created in separate discipline models.

Level 3: Single, online, project model with construction sequencing, cost and lifecycle management information.

See Building information modelling for more information.

Common standards and collaborative practices

Particularly important to the effective use of CAD is the ability to share and re-use information, and this requires the disciplined application of agreed standards of drawing preparation across project teams. This means that the effective use of CAD is as much about collaborative practices as it is about software.

Project standards can be formalised as standard methods and procedures (SMP's) which should be agreed as early in the project as possible and should describe how information is structured, how it will be produced and how it will be managed and exchanged.

The SMP might include agreed standards and procedures for:

- Software.
- Layering.
- Zoning.
- Co-ordination
- Origin.
- Orientation.
- Fonts, line types and weights.
- Dimensions, abbreviations and symbols.
- File structure and file naming.
- Standard templates (for example, drawing titles).

- Page sizes and scales.
- Permissions and change control procedures.

The great variety in the extent to which CAD and building information modelling can be used on a project means that it is important to clearly define what is expected and to set this out in tender documents and appointment documents.

- b) Geometry drawings
- c) Orthographic drawings

#### 4.1 Plane geometry drawings are developed using CAD

##### Introduction to CAD

Computer Aided Drafting (CAD) is a process of preparing a drawing of an object on the screen of a computer. There are various types of drawings in different fields of engineering and sciences.

In the fields of mechanical or aeronautical engineering, the drawings of machine components and the layouts of them are prepared. In the field of civil engineering, plans and layouts of the buildings are prepared. In the field of electrical engineering, the layouts of power distribution systems are prepared. In all fields of engineering use of computer is made for drawing and drafting.

The use of CAD process provides enhanced graphics capabilities which allows any designer To:

- Conceptualize his ideas
- Modify the design very easily
- Perform animation
- Make design calculations
- Use colors, fonts and other aesthetic features.

##### Reasons for Implementing a CAD System

- a) **Increases the productivity of the designer:** CAD improves the productivity of the designer to visualize the product and its component, parts and reduces the time required in synthesizing, analyzing and documenting the design
- b) **Improves the quality of the design:** CAD system improves the quality of the design.

A CAD system permits a more detailed engineering analysis and a larger number of design alternatives can be investigated. The design errors are also reduced because of the greater accuracy provided by the system

- c) **Improves communication:** It improves the communication in design. The use of a CAD system provides better engineering drawings, more standardization in the drawing, better documentation of the design, few drawing errors and legibility.
- d) **Create data base for manufacturing:** In the process of creating the documentation for these products, much of the required data base to manufacture the products is also created.
- e) **Improves the efficiency of the design:** It improves the efficiency of the design process and the wastage at the design stage can be reduced.

### **APPLICATION OF CAD:**

There are various processes which can be performed by use of computer in the drafting process:

- a) **Automated drafting:** This involves the creation of hard copy engineering drawings directly from CAD data base. Drafting also includes features like automatic dimensioning, generation of cross – hatched areas, scaling of the drawing and the capability to develop sectional views and enlarged views in detail. It has ability to perform transformations of images and prepare 3D drawings like isometric views, perspective views etc.,
- b) **Geometric modeling:** concerned with the computer compatible mathematical Description of the geometry of an object. The mathematical description allows the image of an object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by computer and the human designer.

### **BENEFITS OF CAD:**

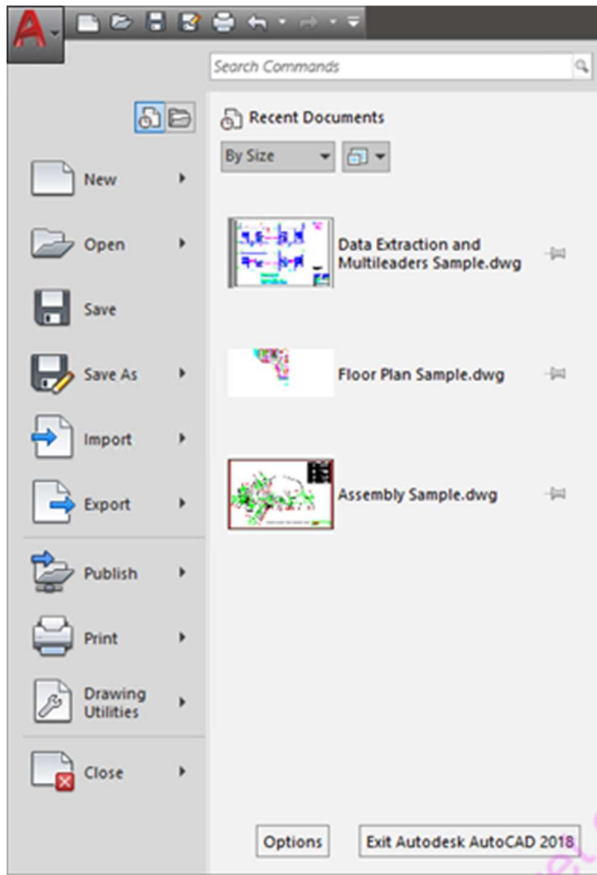
The implementation of the CAD system provides variety of benefits to the industries in design and production as given below:

- Improved productivity in drafting
- Shorter preparation time for drawing
- Reduced manpower requirement
- Customer modifications in drawing are easier
- More efficient operation in drafting
- Low wastage in drafting

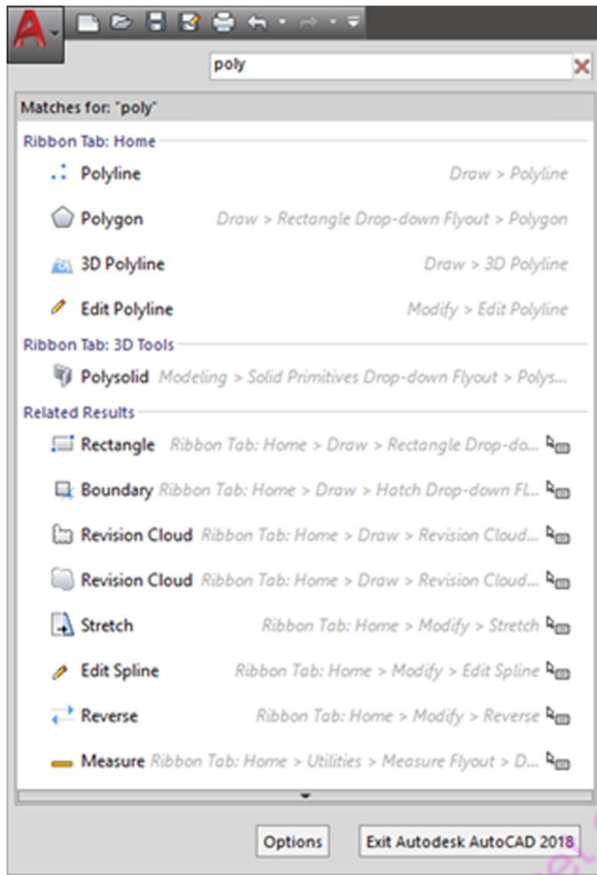
- Minimized transcription errors in drawing
- Improved accuracy of drawing
- Assistance in preparation of documentation
- Better designs can be evolved
- Revisions are possible
- Colours can be used to customize the product
- Production of orthographic projections with dimensions and tolerances
- Hatching of all sections with different filling patterns
- Preparation of assembly or sub assembly drawings
- Preparation of part list
- Machining and tolerance symbols at the required surfaces
- Hydraulic and pneumatic circuit diagrams with symbols
- Printing can be done to any scale

### **Application Menu**

The first thing you might see after launching AutoCAD is the Application Menu, in the far upper left corner. In AutoCAD, it's generally contains a big red "A". (Other products generally have a different color and letter). When you single-click this button a menu drops down that contains some of the same items in the QAT, plus more. Probably more importantly, the application menu contains links to your most recently accessed drawings, and sheet sets. With the click of a button you can change this to a list of currently open drawings. *(Tip: Do not double-click on the Application Menu button, unless you want to shut-down AutoCAD)*

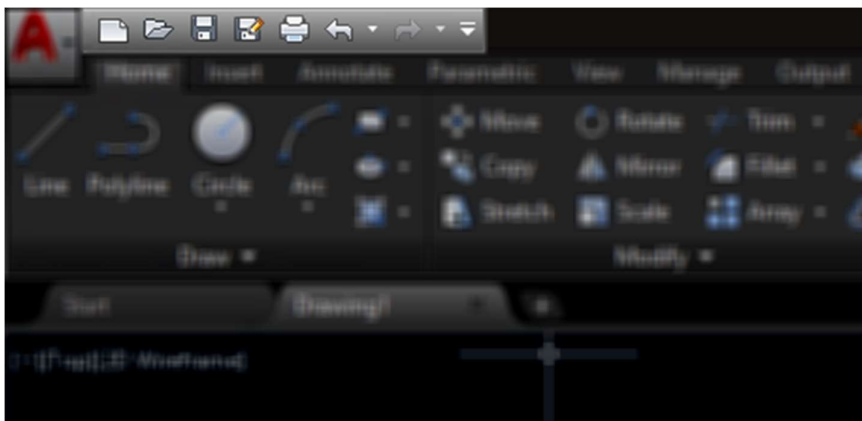


One feature of the Application Menu that many people overlook is the Search Commands portion. You can type in the full or partial name of any command and a search will be performed on the related commands in the menu. This can be helpful when you can't quite remember that command name or its location. In the image below, we have entered "poly" in the search box, and you can see the results.



### Quick Access Toolbar (QAT)

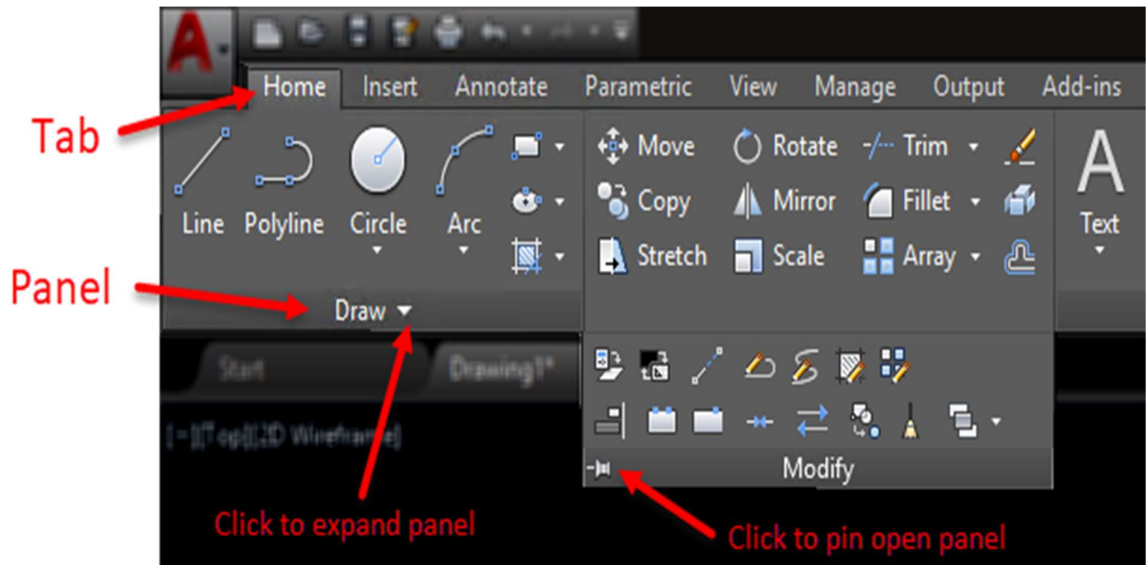
Right next to the At the top of the UI, in the title bar area, is the Quick Access Toolbar, or QAT. By default the QAT contains icons for the following commands: Qnew, Open, QSave, SaveAs, Plot, Undo, and Redo. But like most other UI elements, you can customize this to meet your desires. Below is the stock QAT, highlighted to show its position.



### Ribbon

The ribbon is a UI tool that first appeared in AutoCAD 2009. It contains various commands organized into tabs and panels. It can be heavily customized by administrators and end users.

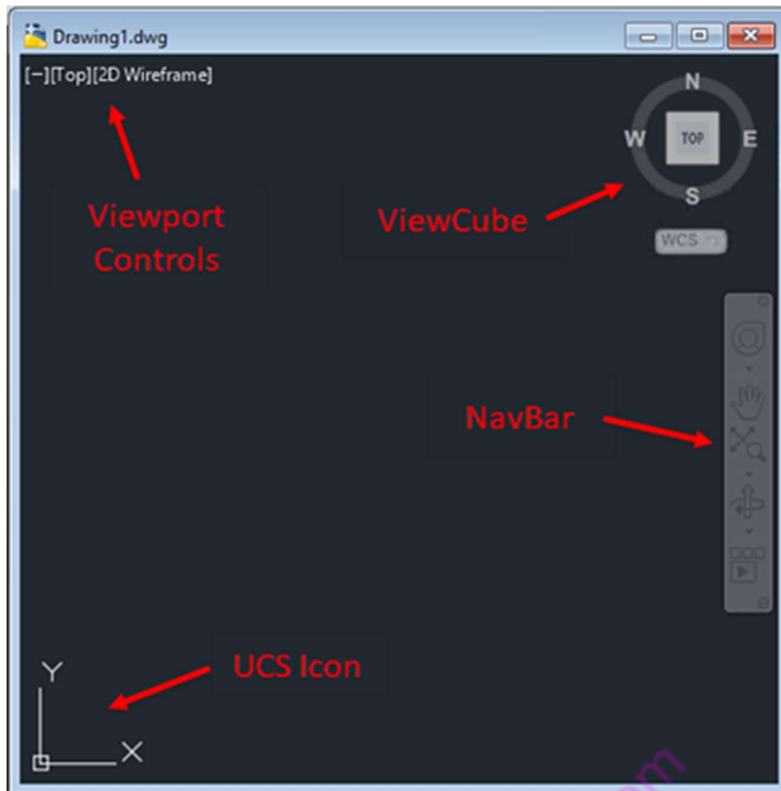
Contextual tabs are very powerful, they appear with panels of commands and options relating to whatever task is at hand and/or whatever entity type is selected. For example, if a HATCH object is selected, a contextual tab with hatch editing command appears automatically.



### In-Editor elements


There are a few elements you may find inside the drawing editor, and are shown in their default location in the image below. The visibility of each of these can be controlled by the user. The viewport controls are in the upper left corner, and allow you to change the view and visual style. The Viewcube is in the upper right, from which you can change the view and UCS. Just below that is the NavBar, that gives you controls for zooming, panning, orbiting, and more. Lastly, in the lower left hand corner, is the UCS icon, which can tell you at a glance if you are in WCS, and/or the general orientation of the UCS.

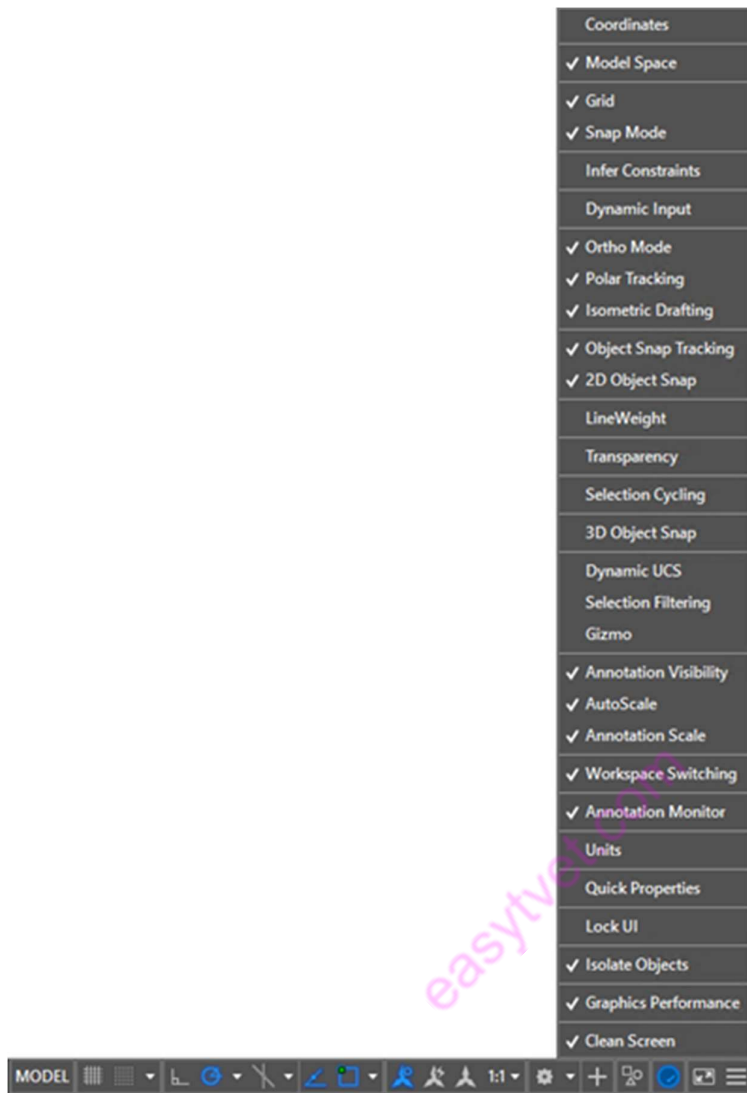




### Status Bar

Moving to the bottom of the application, you will find the Status Bar. Since AutoCAD 2015, the status bar contains icons only. By default several icons are not enabled, so you might want to turn them on. We believe Autodesk does this because on a small monitor, all of the icons may not fit across on one row. But the icons will wrap up to a second row if needed, and on any decent sized monitor these days, at 1920×1080 resolution, you can enable all of the status bar icons and they fit with ease.

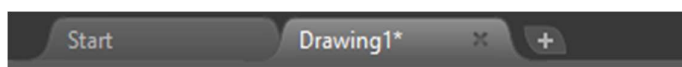
Below is a stock status bar, along with the control icon  on the far right, expanded to show you the other available icons (*Click on the image below for a full size version*)



You can hover your cursor over each icon to find its purpose. Generally speaking, gray means the toggle is off, and blue means the toggle is on.

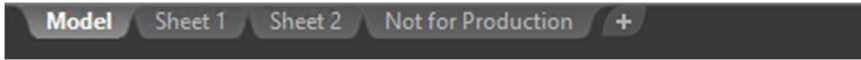
### File Tabs

File tabs provide access to all open documents in a minimal amount of space. Each open document has its own tab. Left-click on a tab to make it current, and right-click on a tab to access more options, such as Save and Close. There is always a tab containing a plus sign to open a new document using the QNEW command. By default, File Tabs are oriented at the top of the documents, below the Ribbon.



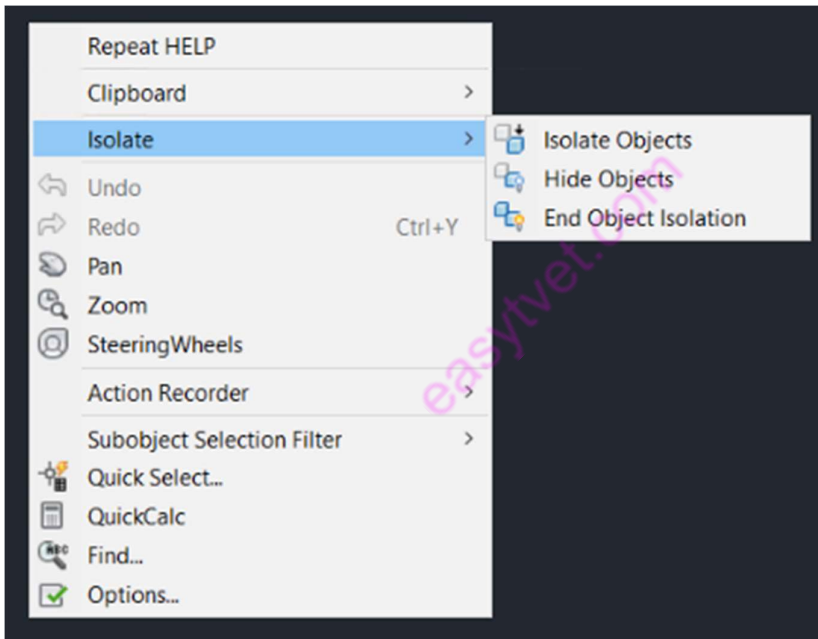
### Layout Tabs

Layout tabs provide access to Model Space and each Layout in a given document. Left-click on a tab to make it current, and right-click on a tab to access more options such as Print, Move, or Rename. There is always a tab containing a plus sign for the creation of a new layout. By default, Layout Tabs are oriented at the bottom of the editor window and if the command line is docked, below that – in the status bar area.



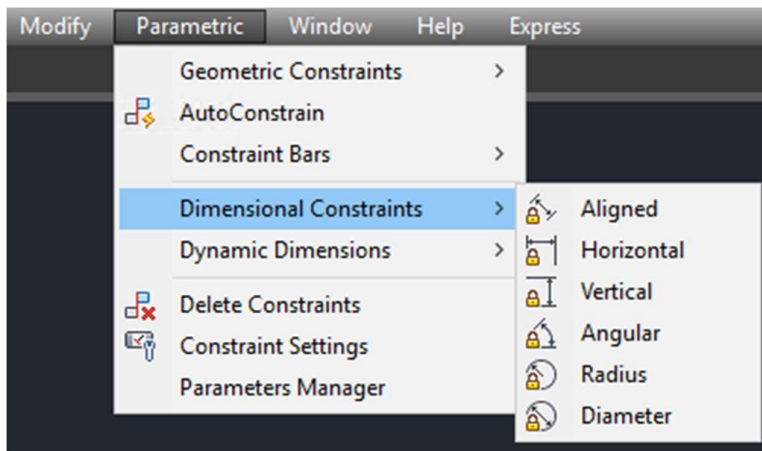
### Shortcut Menu

By default, with no command active, if you right-click in the drawing editor, you will get the Shortcut Menu. This pop-up menu contains recent commands, and other common commands. You can customize this menu, like most other UI items. If there is a command active, a different menu may appear when you right-click. This behavior is controlled by the SHORTCUTMENU system variable.



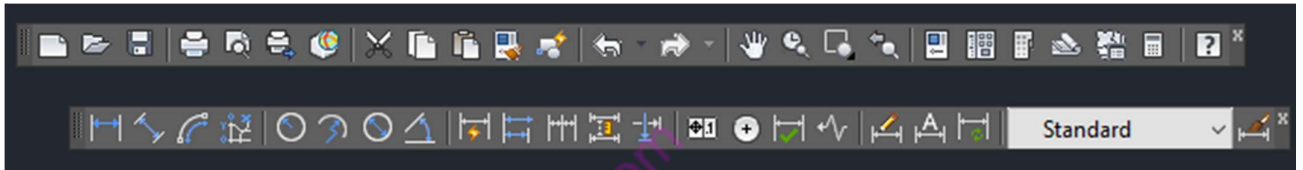
### Drop-Down Menus

Drop-down, or pull-down menus have been around since almost the beginning of AutoCAD, long before Windows was a platform. A top level clickable name reveals commands and/or sub menu below. These commands support macros and even autolisp statements. The menu disappears when a command is selected and/or the menu loses input focus. Drop-down menus are not enabled by default. You can turn them on by entering the command MENUBAR and setting it to 1. An example of a drop-down menu can be found below:



## Toolbars

Toolbars go back to the early 1990's in AutoCAD. These are flat panels that contain buttons and or drop-down lists. Each button contains an icon and a macro to perform a command or macro. Toolbars can be floating or docked.



## Palettes

There are various palettes available in AutoCAD. Palettes are special windows that can be docked, floating and made to collapse when not in use. You do not have to close palettes in order to work with graphic data on screen. Most palettes support transparency (with proper hardware support) to allow them to remain on screen during AutoCAD commands.

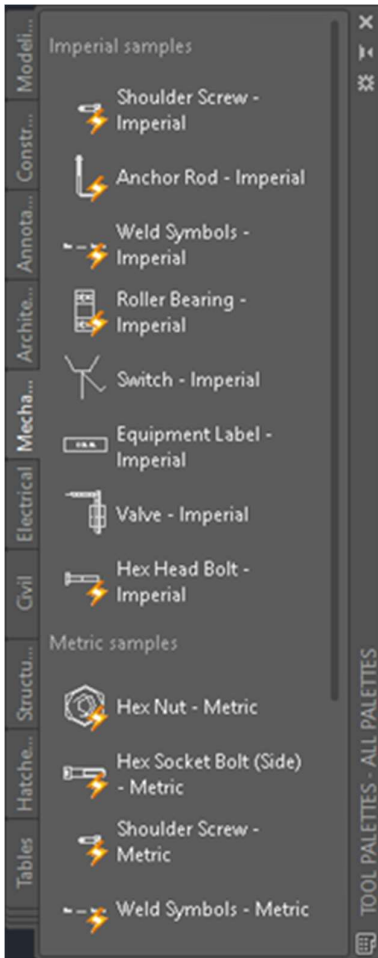
## Command Line

The command line is a palette where you can type in command names and/or command responses, and view the history of both. If the command line is docked, it has a fixed number of visible lines. Floating command line palettes can expand when needed to show you more data. The F2 key in both cases will toggle open/closed, a larger command line history window. A typical floating command line is shown here:



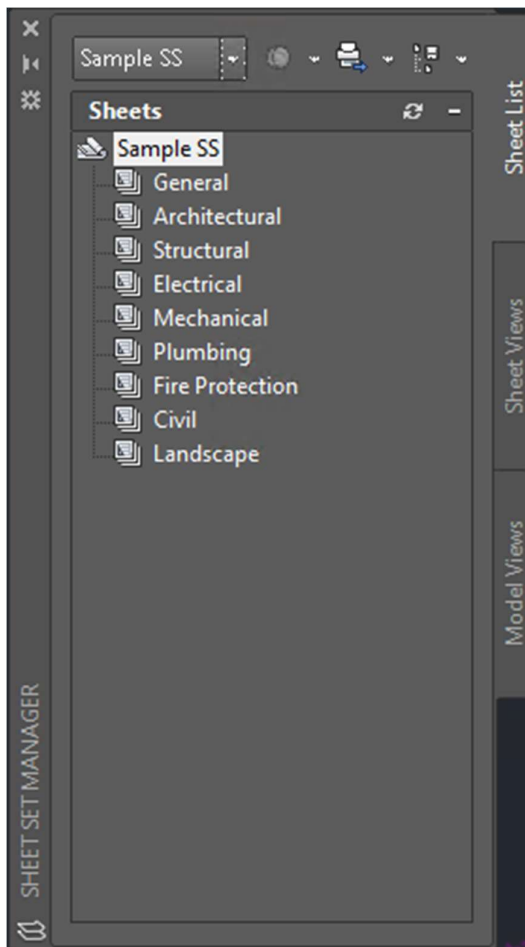
## Tool Palette

Tool Palettes contain buttons to insert blocks, execute commands, create hatches, just to name a few items. Users are free to customize the content. A sample is shown below:



## Sheet Set Manager

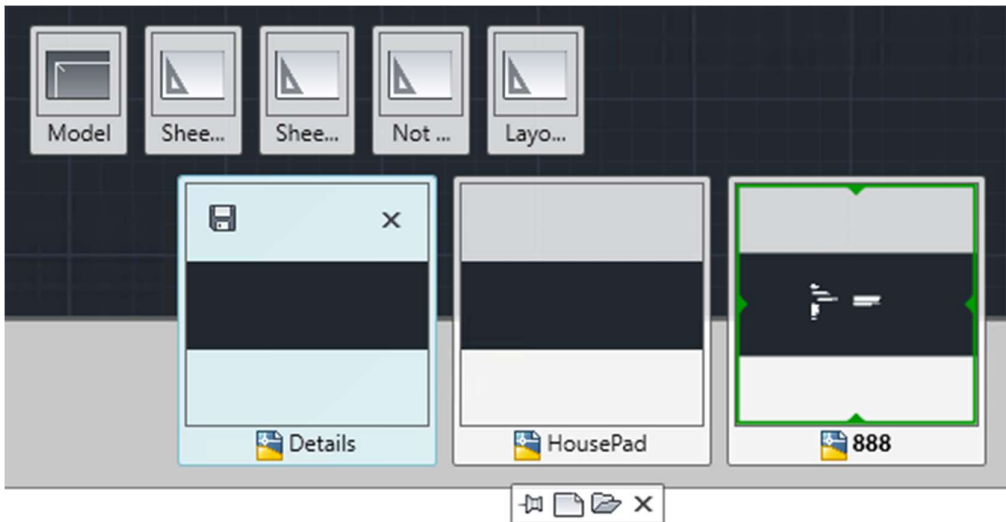
The Sheet Set Manager is a tool that allows you to organize sheets, streamline printing and archiving, and automate annotation on drawing sheets among other uses. A sample is shown below:



There are many other palettes, such as the Quick Calculator, Drawing Recovery Manager, Visual Styles Manager, the Materials Browser, etc.

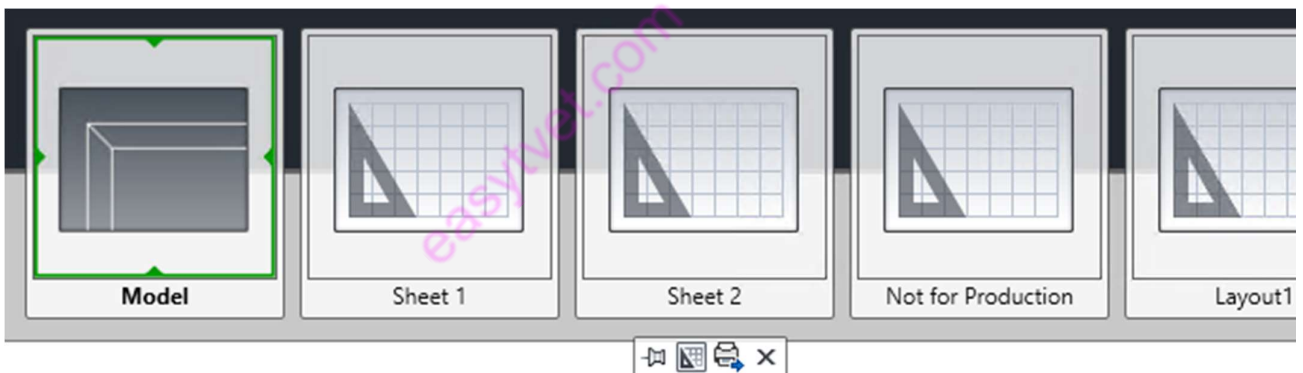
### **Quick View Drawings**

Before File Tabs, there was Quick View Drawings. Although no longer enabled by default as a UI element, this command still works from the command line (Command: QVD). It reveals a miniature preview of each open document, and allows you to switch to another document. As the mouse is hovered over a document preview, the layouts of that drawing appear, allowing you to switch directly to a selected layout.



### Quick View Layouts

Introduced as sort of replacement for Layout Tabs, Quick View Layouts has suffered the same fate as Quick View Drawings. That is to say it is still part of the software, but hidden away. This command (QVL) reveals miniature previews of all of the layouts of the current open document. Hover over a preview enables the option to print it, or clicking on one switches to that layout.



### Info Center

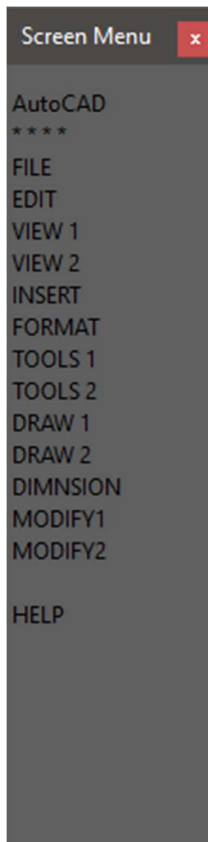
Info Center has been through a few iterations and name changes since it was introduced. It resides in the Title Bar area, just to the left of the Windows control buttons. It contains a help search bar, Autodesk A360 sign in, social media links, and a Help drop-down menu. InfoCenter has been linked to excessive “phoning home” and is frequently disabled and hidden by many CAD managers. There is no UI method of controlling the visibility of this element, it must be done in the registry, or with a 3rd party add-on such as this one. Below is the default InfoCenter bar.



### Screen Menu

The Screen Menu goes back to the beginnings of AutoCAD on DOS and UNIX. The Screen Menu is composed of nested menus. Clicking on one entry usually replaces the screen menu contents with another menu, until you get to a particular command. There is always a back and/or home choices too. Most people do not know it still exists in AutoCAD 2018 today. To access it, you must know the secret code.

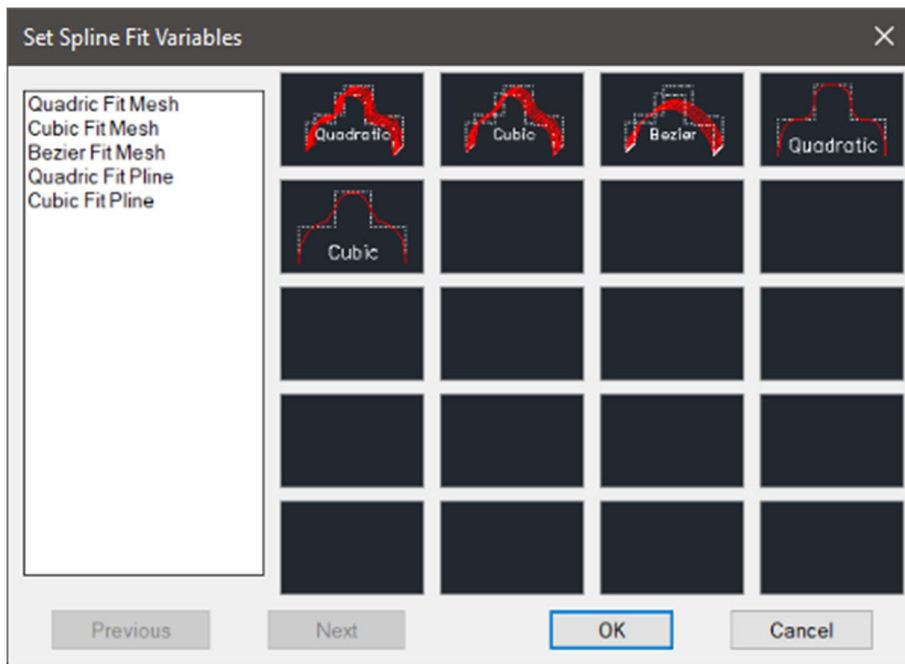
Well, it is not too secret, just type in.



### **Image Tile Menu**

Last, but not least, unless you've been around for ~20 years or so, you have probably never seen an Image Tile Menu. We were able to actually get one of these to work in AutoCAD 2018 as seen below. These were largely replaced by Tool Palettes and Design Center around the AutoCAD 2000 era.





## Lines

The line is the most basic and common object in AutoCAD drawings. To draw a line, click the Line tool.

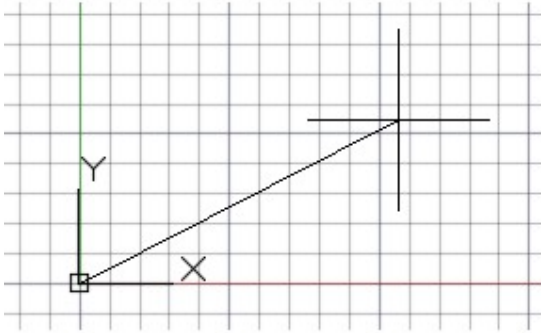


Alternatively, you can type LINE or just L in the Command window, and then press Enter or the Spacebar.

Notice the prompt in the Command window for a point location.



To specify the starting point for this line, you would type in the Cartesian coordinates 0,0. It's generally a good idea to locate one corner of your model at 0,0, which is called the origin point. To locate additional points, you could specify additional X,Y coordinate locations in the drawing area, however more efficient methods for specifying points are available, and will be presented in the Precision topic.



After you specify the next point, the LINE command automatically repeats itself, and it keeps prompting you for additional points. Press Enter or the Spacebar to end the sequence.

### Grid Display

Some people like working with grid lines as a reference, while others prefer working in a blank area. To turn off the grid display, press F7. Even with the grid turned off, you can force your cursor to snap to grid increments by pressing F9.

### Lines as Construction Aids

Lines can serve as reference and construction geometry such as

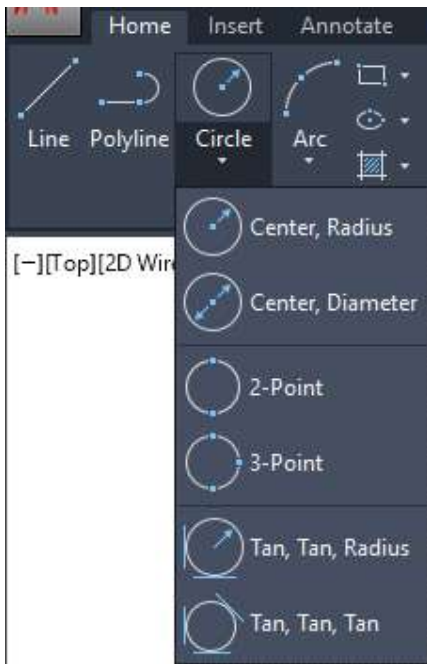
- Property line setbacks
- The mirror line of a symmetrical mechanical part
- Clearance lines to avoid interferences
- Traversal path lines

### Circles

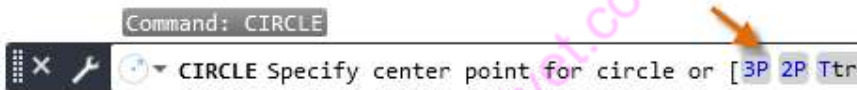
The default option of the CIRCLE command requires you to specify a center point and a radius.



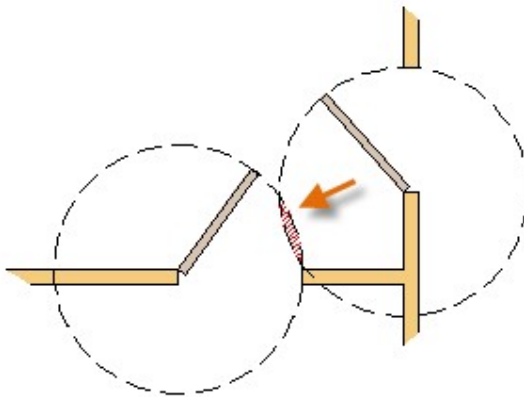
The other circle options are available from the drop-down:



Alternatively, you can enter CIRCLE or just C in the Command window and click to choose an option. If you do, you can specify a center point, or you can click one of the highlighted command options as shown below.



Circles can be useful as reference geometry. For example, you can see that the two doors in the illustration can interfere with each other.



### **Polylines and Rectangles**

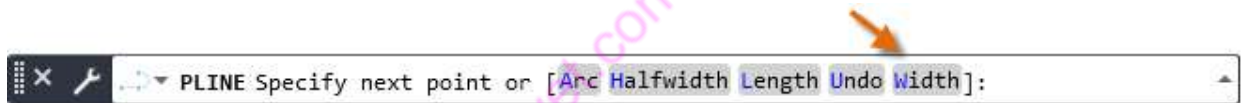
A polyline is a connected sequence of line or arc segments that is created as a single object.



Use the PLINE command to create open or closed polylines for

- Geometry that needs to have fixed-width segments
- Continuous paths for which you need to know the total length
- Contour lines for topographic maps and isobaric data
- Wiring diagrams and traces on printed circuit boards
- Process and piping diagrams

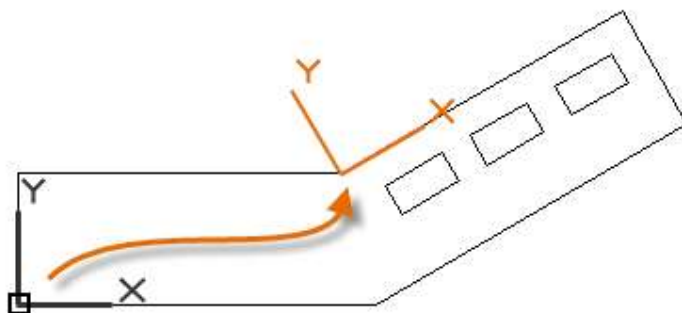
Polylines can have a constant width or they can have different starting and ending widths. After you specify the first point of the polyline, you can use the Width option to specify the width of all subsequently created segments. You can change the width value at any time, even as you create new segments.



### The User Coordinate System (Optional)

The user coordinate system (UCS) icon indicates the direction of the positive X and Y axis for any coordinates that you enter, and it also defines the horizontal and vertical directions in a drawing. In some 2D drawings, it can be convenient to click and place the UCS to change the origin point and the X or Y axis.

For example, by reorienting the UCS, you can create rectangles that are automatically aligned with the X axis as shown.



To restore the user coordinate system to its original location, enter UCS in the Command window and press Enter to specify the default <World> option.

## Hatches and Fills

In AutoCAD, a hatch is a single, compound object that covers a specified area with a pattern of lines, dots, shapes, a solid fill color, or a gradient fill



## LIMITATIONS OF CAD

- 32 – bit word computer is necessary because of large amount of computer memory and time
- The size of the software package is large
- Skill and judgment are required to prepare the drawing
- Huge investment

## SCALING OF DRAWING:

zoom command displays the object at a specified scale

factor. The value entered is relative to the limits of the drawing. for example, entering 2 doubles the apparent display size of any objects from what it would be if it were zoomed to the limits of the drawing. If you enter a value followed by xp, auto CAD specifies the scale relative to paper scale units for example; entering 0.5xp displays model space at half the scale of paper space units. The following illustration shows several viewports arranged in paper space. the view in each view port is scaled relative to paper space. the first view is scaled 1=1 relative to paper space (1xp), the second is scaled 0.5=1 relative to paper space (0.5xp), and so on.

## ZOOM

This increase or decreases the apparent size of objects in the current view port

At the command prompt, enter zoom

All/center/dynamic/extents/left/previous/vmax/window/<scale(x/xp)>: enter an option or value, specify a point, or press enter

**TEXT:** The text in software is indicated by fonts. the fonts define the shapes of the text characters that make up each character set. In AUTOCAD, you can use true type fonts in addition to AUTOCAD's own compiled shape (SHX) fonts.

A font is indicated by various parameters like

- i. Style :these are four types: normal,bold,italic,underline
- ii. Size: this is the size of characters
- iii. Colour: there are facilities to colour the characters selecting layer.
- iv. Type: different types of fonts may be used:

Mono text: COMPUTER AIDED DESIGN

Romans: COMPUTER AIDED DESIGN

Romand: COMPUTER AIDED DESIGN

Dtext: This displays text on the screen as it is entered. AutoCAD can create text with a variety of character patterns, or fonts. These fonts can be stretched, compressed, oblique, mirrored, or aligned in a vertical column by applying a style to the font .text can be rotated, justified, and made any size.

At the command prompt, enter text

Justify/style/<start point>: specify a point or enter an option

TEXT: This creates a single line of text. AutoCAD can create text with a variety of character patterns, or fonts. These fonts can be stretched, compressed, oblique, mirrored, or aligned in a vertical column by applying a style to the font.

At the command prompt, enter text

Justify/style/<start point>: specify a point or enter an option

QTEXT: This controls the display and plotting of text and attribute of objects.

At the command prompt, enter text

ON/OFF <current>: enter on or off, or press enter

**TRANSFORMATIONS:** These are the modifications in the drawn objects.

There are different types of transformations used

MOVE: This allows to move or displace objects a specified distance in a specified

Direction

At the command prompt, enter move

Select objects: use an object selection method

Base point or displacement: specify a base point (1)

Second point of displacement: specify a point (2) or press enter

**COPY:** This is used for producing a duplicate copy of the drawing.

At the command prompt, enter copy

Select objects: use an object selection method

<Base point or displacement >/multiple: specify a base point(1)

For a single copy or enter m for multiple copies

**ROTATE:** It moves objects about a base point

At the command prompt, enter rotate

Select objects: use an object selection method

<Rotate angle >/reference: specify an angle or enter r

**STRETCH:** This moves or stretches objects .AutoCAD stretches lines, arcs, elliptical arcs, splines, rays and polyline segments that cross the selection window.

At the command prompt, enter stretch

Select objects: use the CPOLYGON or cross object selection method(1,2)

Base point or displacement: specify a point (3) or press

Second point of displacement: specify a point (\$) or press

**EXTEND:** This extends an object to meet another object. Objects that can be extended include arcs, elliptical arcs, lines, open 2D, and 3Dpolylines and rays.

At command prompt, enter extend

Select boundary edges

(projmode=UCS, edge mode=no extend)

Select objects: use an object selection method

**SCALE:** This enlarges or reduces selected objects equally in X and Y directions

At the command prompt, enter scale

Select objects: use an object selection method

Base point: specify a point (1)

<Scale factor>/reference: specify a scale or enter r

**TRACE:** This creates solid lines.

From the miscellaneous tool bar choose

At the command prompt, enter trace

Trace width<current>: specify a distance, enter a value ,or press enter

From point: specify point (1)

To point: specify a point (2)

To point: specify a point (3) or press to end the command

**EXTRUDE:** This creates unique solid primitives by extruding existing twodimensional objects

extrudes also creates solids by extruding two-dimensional objects along

a specified path .we can extrude multiple objects with extrude

At the command prompt enter, extrude

Select objects: use an object selection method

Path/<height of extrusion>: specify a distance or enter p

**MIRROR:** This is used to producing mirror image of the object

At the command prompt enter, mirror

Select objects: use an object selection method

First point of the mirror line: specify a point (1)

Second point: specify a point (2)

**OFFSET:** This creates concentric circles, parallel lines and parallel curves, offset creates a new object at a specified distance from an existing object or through a specified point

At the command prompt enter, offset

Offset distance: specify a distance, enter t or press enter

**ARRAY:** This creates multiple copies of objects in pattern. Arrays are three types.

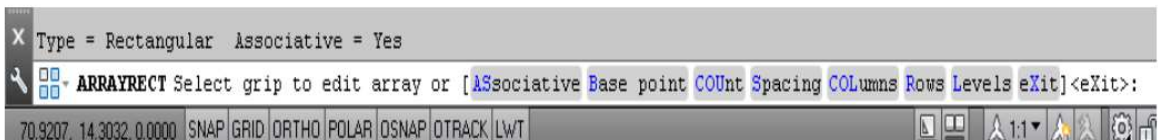
a) Rectangular Array

b) Path Array

c) Polar Array

Rectangular Array: In this, the object is arranged in an array of rows and columns.

At the command prompt: type ARRAYRECT or select the option from MODIFY toolbar. It asks you to select objects. Select the object and press enter. By default it shows an array of 3 rows and 4 columns. The no. of rows and columns can be changed by selecting the COUNT option (OR) by selecting COLUMNS and ROWS options separately

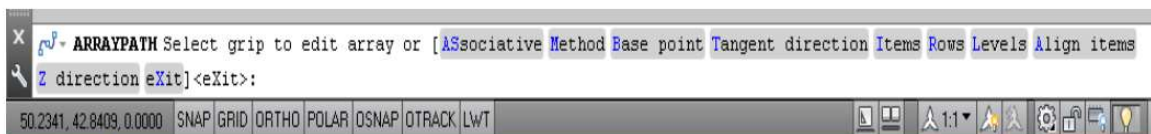


**Figure 93 Array Selection**

Path Array: In this, an object is arranged in a specified path.

At the command prompt: type ARRAYPATH or select the option from MODIFY toolbar.

Then select object to be arrayed. Then select the path through which the object is made to be Array



**Figure 94 Path Array**

## CUTTING OF OBJECTS



The drawn objects can be cut or trimmed by using following commands

**TRIM:** Trims objects at a cutting object defined by other objects. Objects that can be trimmed include arcs, circles, elliptical arcs, lines, open 2D and 3D polylines, rays and splines

At the command prompt, enter trim

Select cutting edges:

Select objects: use object selection method

<Select object to trim>/project/edge/undo: select an object, enter an option, or press enter

**BREAK:** This erases an object or splits the object in to two parts

From the modify toolbar select break flyout

At the command prompt, enter break

Select objects: use an object selection method

First point of the mirror line: specify a point (1) on an object

Enter second point: specify the second break point (2) or enter F

### **DIMENSIONING IN DRAWINGS:**

The dimensions are inserted in the drawing by use of DIM command. There are various types of dimensions used in AutoCAD.

#### **Linear dimensions:**

- i. Horizontal- this allows horizontal dimensions
- ii. Vertical- this allows vertical dimensions
- iii. Aligned- this allows inclined dimensions
- iv. Rotated- this allows inclined dimensions

#### **Angular dimensions:**

This allows angular dimensioning of objects

#### **Radial dimensions:**

This allows radial dimensioning of arc or circle

#### **Diametric dimensions:**

This allows diametral dimensions of the circle

For dimensioning of objects, the first point and second point has to be specified. The dimension text must be written and then the position of dimension must be specified at the command prompt ,enter dim

Dim: Enter a dimensioning mode command

#### **AREA:**

This allows calculation of the area and perimeter of objects or of defined areas

From the object properties toolbar, choose the inquiry flyout, then

At the command prompt, enter area

<First point>/object/add/subtract: specify a point or enter option

### **FILLET**

Rounds and fillets the edges of the object

At the command prompt enter fillet

Polyline / Radius / Trim / <Select first object>: use an object selection method or enter an option

Select first object

Select second object: use an object selection method

Enter radius <current>: specify a distance or press

Chain / Radius <Select edge>: Select edges or enter c or r their intersection

### **CO-ORDINATE SYSTEM**

The co- ordinate system can be modified in the AutoCAD. There are two types of coordinate systems used. The WCS (World co- ordinate system) is a universal system in which its origin is at the fixed position. The UCS (User co- ordinate system) is a system in which user can fix his origin at any point.

**UCS:** This manages user co- ordinate systems

At the command prompt enter **ucs**

Origin / z axis/ 3 point/ object/ view/ X/Y/Z / Prev/ Restore/Save/ Del/?/< world>: enter an option or press enter

**WCS:** This manages world co- ordinate system

### **EXPLODE:**

This breaks a compound object into its component objects

At the command prompt enter explode

Select objects: use an object selection method.

### **UNION:**

This measures the distance and angle between two points.

At the command prompt, enter union

Select object: Use an object selection method

**DIST:** This measures the distance and the angle between two points .

At the command prompt area enter dist

First point: Specify a point (1)

Second point : Specify a point (2)

Distance = calculated distance

Angle in XY plane = angle from XY plane = angle

Delta X = change in X

Delta Y = change in Y

Delta Z = change in Z.

#### REGENERATION OF DRAWING:

ACAD provides a facility of regenerating a drawing to clear the cross points or marks on the screen.

- i. REDRAW
- ii. REGEN
- iii. REGENALL
- iv. REGENAUTO

#### TOLERANCE

This creates geometric tolerances. Geometric tolerances define the maximum allowable variations of form or profile, orientation, location and run out from the exact geometry in a drawing. They specify the required accuracy for proper function and fit the objects drawn in AutoCAD

#### SKETCH

This creates a series of free hand line segments.

From the miscellaneous toolbar, choose

At the command prompt enter sketch

Follow the prompting

#### 3D FUNCTIONS

##### BOX

This creates a three-dimensional solid box.

At the command prompt enter box

Center/<corner of the box><0,0,0> :

Specify a point (1), enter c, or press enter

Corner of a box

Specifying a point or pressing defines the first corner of the box.

Cube/length /<other corner>: specify a point (2) or enter an option center

Creates the box by a specified center point

##### CONE

This creates a 3D solid cone. A cone is solid primitive with a circular or elliptical based tapering symmetrically to a point perpendicular to its base.

At the command prompt enter cone

Elliptical /<center point> <0,0,0> : specify a point , enter e or press enter

## **CYLINDER**

This creates a 3D solid cylinder. A cylinder is solid primitive with a circular or elliptical based to a point perpendicular to its base without a taper.

At the command prompt enter cylinder

Elliptical /<center point> <0,0,0> : specify a point , enter e or press enter

## **SPHERE**

This creates a 3D solid sphere. A sphere is positioned so that its central axis is parallel to the Z-axis of the current UCS. Latitudinal lines are parallel to the XY plane.

At the command prompt enter sphere

Center of the sphere <0,0,0> : specify a point , enter e or press enter

## **WEDGE**

This creates a three dimensional solid with a sloped face tapering along X axis.

At the command prompt enter wedge

Center <corner of the wedge> <0,0,0> : specify a point , enter e or press enter

Follow the prompting

## **ELEV**

This sets an elevation and extrusion thickness of new objects. The current elevation is the Z value that is used whenever a 3D point is expected but only X and y values are supplied.

At the command prompt enter elev

Follow the prompting

## **SHADE**

This displays a flat shaded image of the drawing in the current view port. SHADE removes hidden lines and displays a shaded picture of the drawing.

From the render toolbar, choose

At the command prompt, enter shade

## **REGION**

This creates a region object from a selection set of existing objects. Regions are 2Dimensional areas you create from closed shapes.

## **REINIT**

This reinitializes the input/output ports, digitizer, display and program parameters file.

## **REPLAY**

This displays a GIF, TGA or TIFF image.

From the tool's menu, choose image, then view.

## **REVOLVE**

This creates a solid by revolving a two – dimensional object about an axis. From the solids toolbar, choose

At the command prompt, enter revolve

### **SHAPE**

This inserts a shape. Before inserting a shape, you must load the file containing the desired shape.

### **ROTATE 3D**

This moves objects about a three-dimensional axis

From the modify toolbar, choose the rotate flyout then

Follow the prompting

### **SECTION**

This uses the intersection of a plane and solids to create a region.

AutoCAD creates regions on the current layer and inserts them at the location of the cross – section. Selecting several solids creates separate regions for each solid.

### **SLICE**

This slices a set of solids with a plane.

### **SHELL**

This accesses operating system commands.

### **REVOLVE**

This creates a solid by revolving a two-dimensional object about an axis.

### **RENDER**

This creates a realistically shaded image of a three-dimensional wireframe or solid model.

RENDER produces an image using information from a scene, the current selection set, or the current view.

### **STARTING THE DRAWING**

The figures we do in engineering are fitted into a template. In ACAD we manually draw a template known as Drawing sheet in two different formats.

The size of the drawing sheet is ISO A4 210 X 297.

The format is as given in the following figures

Polar Array: In this, an object is arranged in a circular shape.

At the command prompt: type ARRAYPOLAR or select the option from MODIFY toolbar.

Then select object to be arrayed. Then select the center point of array. By default, a six items array is created. The No. of items can be changed by selecting the Items option. Angle between the two items can also be changed.

Geometry drawings are developed using CAD

## 2D DRAWINGS

Aim: to draw the following figure using ACAD

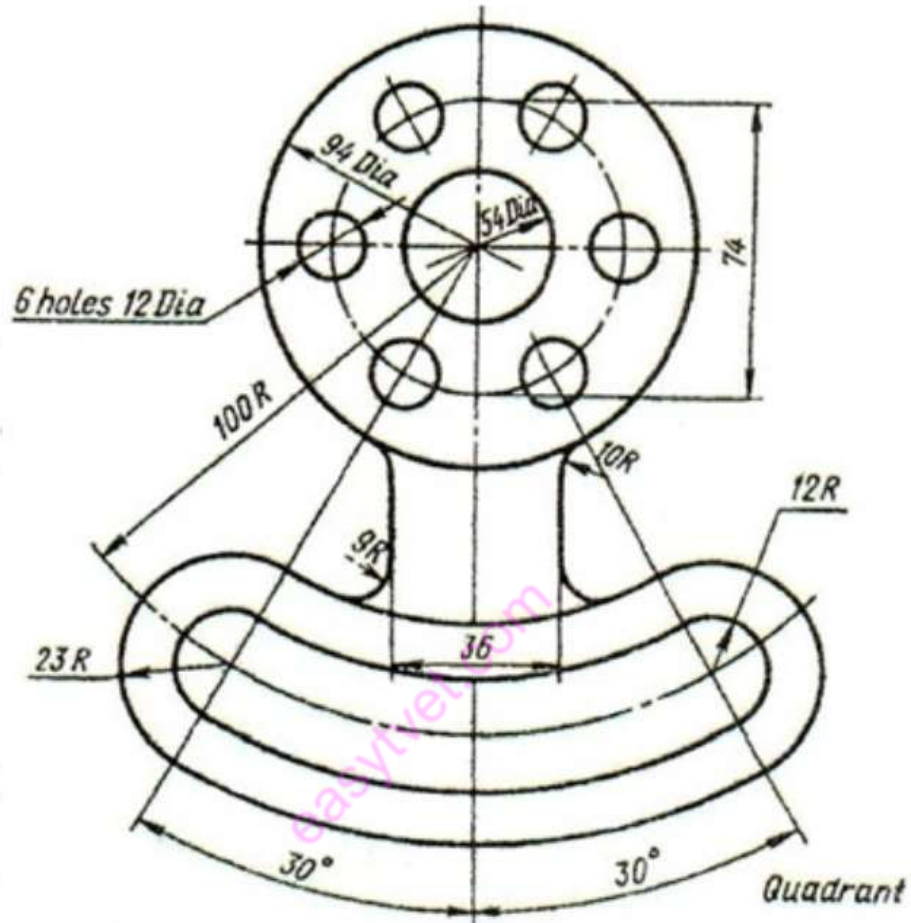


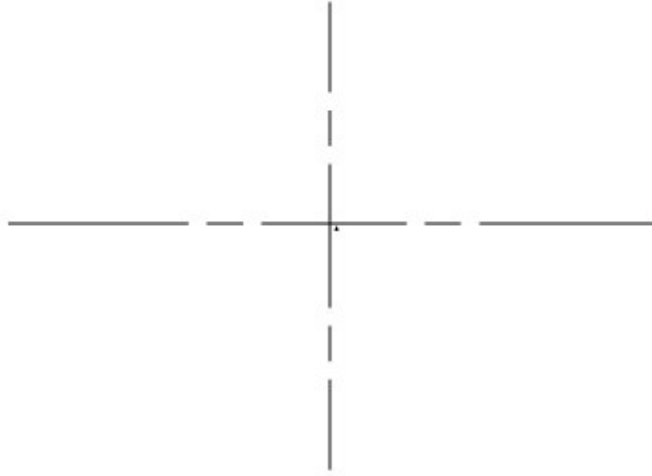
Figure 95 Exercise 1

### PROCEDURE

Set the limits of the drawing screen

**STEP 1:** Draw axis lines in the respective format with their intersection point at (0,0)

- Go to **PROPERTIES** tool bar
- Load line type as **ISO LONG DASH SHORT DASH** in the line type area.
- Select line type ISO LONG DASH SHORT DASH in the line type area.



**Figure 96 starting drawing center lines**

**STEP 2 a:** Draw circles of given dimensions using circle command with their centre as the intersection of the axis lines

- 3 circles of diameters 94, 74 and 54 are to be drawn
- The circle with 74 diameter is of **ISO LONG DASH SHORT DASH** format

**STEP 2 b:** Using **POLAR ARRAY** draw the 6 holes on the circle of diameter 74 each of 12 dia.

**STEP 3:** Draw two construction lines at an angle of 30o to the vertical axis line

**STEP 4:** With A as center an radius 100 draw an arc between the above lines

**STEP 5:** Offset the arc on the either side by the distances as mentioned in the figure.

**STEP 6:** Complete the figure by using fillet command.

**STEP 7:** Give dimensions to the completed figure.

**Command:** `_qsave`

**PRECAUTIONS:**

Put **ORTHO ON** where ever necessary.

Use the required modify tool bar commands like **TRIM, ERASE, COPY, MIRROR** ETC.,

**Aim: to draw the following figure using ACAD**

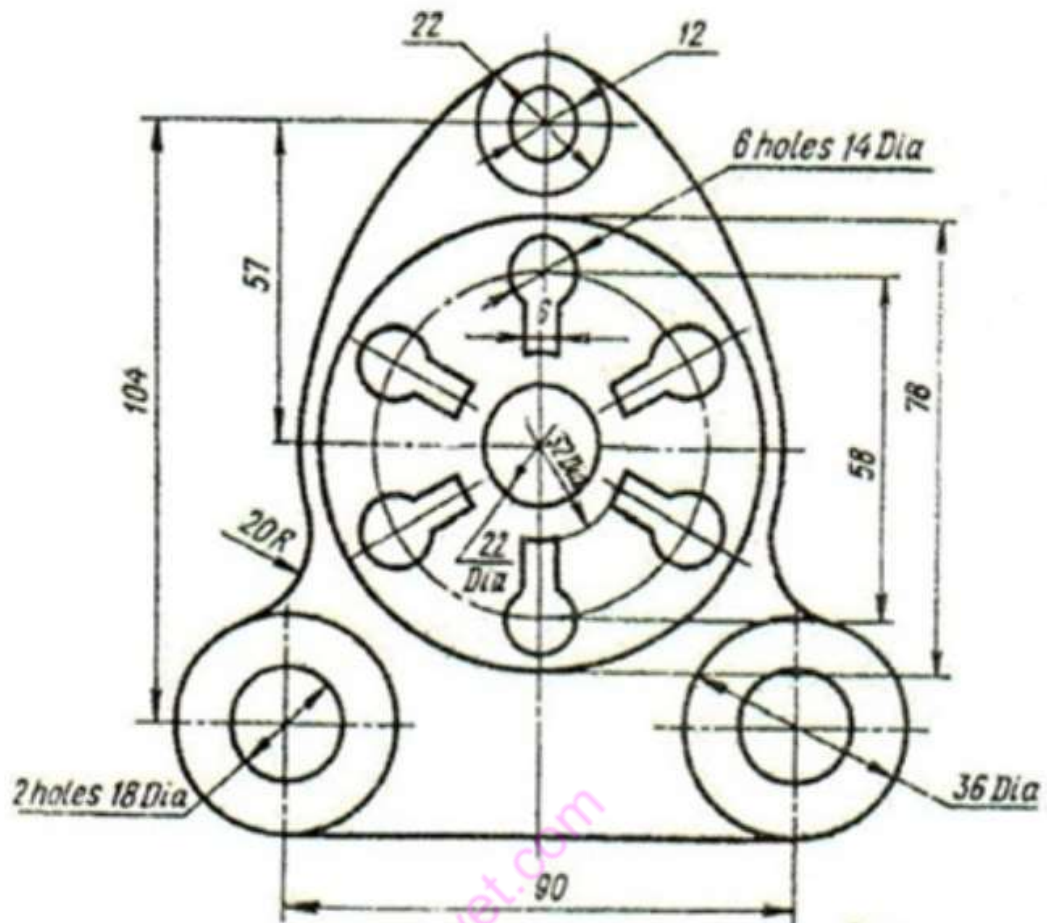


Figure 97 Exercise 2

## PROCEDURE

Set the limits of the drawing screen

**STEP 1:** Draw axis lines in the respective format with their intersection point at (0,0)

**STEP 2:** Draw circles of given dimensions using circle command with their centre as the intersection of the axis lines.

**STEP 3:** Using **POLAR ARRAY** draw the 6 key holes on the circle of diameter 58 of given dimensions

**STEP 4:** For the outer cover use **CIRCLE** command and the in-command prompt area type **TAN TAN RADIUS**. This gives the idea of drawing the outer cover

**STEP 5:** Give dimensions to the completed figure.

**Command:** `_qsave`

## PRECAUTIONS:

Put **ORTHO ON** wherever necessary.

Use the required modify tool bar commands like **TRIM, ERASE, COPY, MIRROR** ETC.,



## **Orthographic drawings are developed using CAD**

Orthographic drawings are a very common style of drawing and are easily created with CAD. In this exercise, we will use CAD to draw the front, top, and right side views of the object shown at the right. We will start with a third angle view then try some first angle views in the exercises. The dimensions of the object are shown at the right and we will make our CAD drawing dimensionally correct.

Unlike some of our previous drawings, we will use coordinates to draw the lines instead of simply clicking with the mouse. In the last assignment, you drew solid lines but sometimes you need dashed or dotted lines. CAD can draw many different types of lines but the line type or style must be loaded before they can be used. The line types are loaded with the commands:

### **Starting CAD**

You can start ACAD by either double clicking on the program Icon on the desktop or by clicking on the program name in the Start menu. The program will start and after a minute or so should display a screen similar to the one shown below. The dialog box in the middle will aid you in getting started

at either creating a new drawing or continuing your work on a drawing that is not finished.

If you are continuing work on a drawing, click on the “A” icon in the extreme upper left corner of the window and Open->Drawing. A “Select File” dialog box will open allowing you to select the drawing file you want to open.

### **The Initial Screen**

ACAD has a very versatile user interface that allows you to control the program in several different ways. At the top of the window is a row of menus. Clicking on the Home, Insert, or Annotate causes another selection of menus to appear. This new selection of commands is frequently called a Ribbon or a

Dashboard. You can operate the program by clicking on the icons in these menus. Another method of using the program is typing in the command names. This is frequently faster than using drop down menus for frequently used commands because you do not have to search for the correct menu or icon. You just type in the command name. For the most part, we will use

this approach in this series of tutorials. The commands that you type will appear at the bottom of the of the ACAD window.

### **The LINE Command**

Now that you have started AutoCAD and configured tool bars you want, you are ready to start learning to use the program. We will start with relatively simple commands and eventually, in later lessons, look at some of the more complex things that AutoCAD can do. The first command we will look at drawing straight lines. At the keyboard, type:

**line**

and press the ENTER key. You can use either upper or lower case when you type in ACAD commands.

The program will respond with:

#### **Specify First Point:**

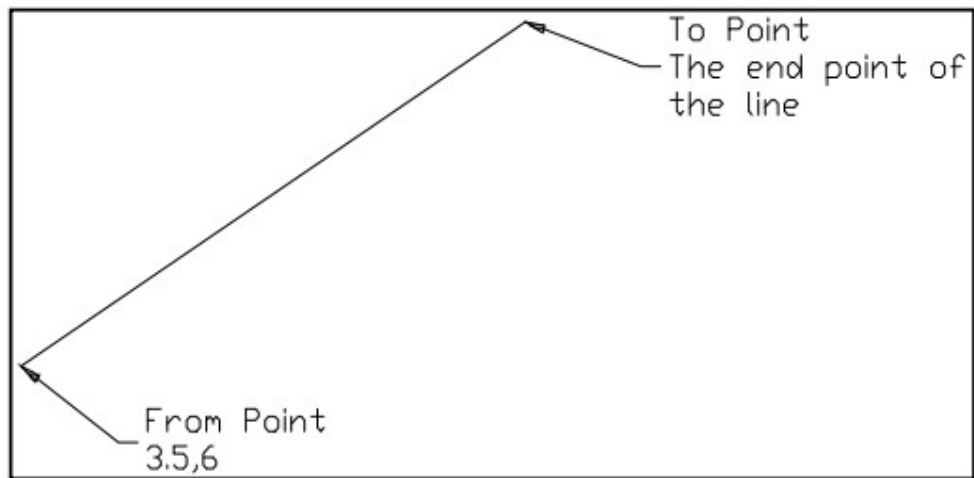
Each line has a beginning and ending point and the program wants you to specify the beginning point of the line. You enter the beginning point by either typing the point coordinates at the keyboard or by clicking the mouse on a location of the screen where you want the line to begin. It is certainly much simpler to click with the mouse than it is to type in coordinates but engineering drawings are drawn precisely to scale and for the most part we will have to enter coordinates from the keyboard.

When you type a coordinate, enter the X or horizontal coordinate first followed by a comma and the Y or vertical coordinate. You cannot enter a space between the two coordinates. AutoCAD interprets a space as the ENTER key and assumes that you have finished entering the coordinates.

For Example, you could type:

#### **Specify First Point: 3.5,6**

The 3.5 coordinate is the X or horizontal coordinate and the 6 is the vertical coordinate. After you enter the coordinates, press the enter key. The enter key tells the program that you have entered the first coordinate and are ready to enter the coordinates for the next which will be the end of the line. The program responds by displaying:



**Figure 98 Sample 1**

To Point:

If you want a horizontal line that is 5 units long, you enter the coordinates @5,0 which is shown below.

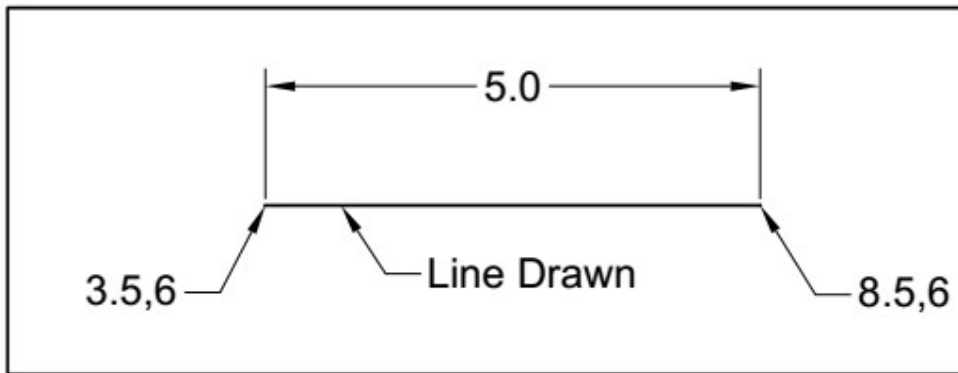
To Point: @5,0

The @ sign tells the program this coordinate is measured from the last coordinate entered. In other words, it says place the end of the line 5 units horizontally from the beginning point and 0 units vertically. The line drawn is shown above.

Using the @ sign to specify relative coordinates is easier than specifying absolute coordinates without the @ sign. The first point we drew had an absolute coordinate of 3.5,6 and the second point had an absolute coordinate of 8.5,6 since it is displaced 5 units horizontally from the first point.

We will continue with this to create the object shown on the right. It has lines, an arc, and a circle. We have drawn the first and we will continue drawing the rest of the lines.

As a shortcut, you can start the LINE command by typing L instead of the entire word LINE. Many AutoCAD commands can be abbreviated to just the first letter of the command.



**Figure 99 Sample 2**

### **Continue Drawing the Object**

We can continue drawing the object shown on the right by adding more lines. If the line command is

still operating, press ENTER to end it.

We will start it again to draw the remaining lines.

You can draw the remaining lines by typing:

#### **line**

Specify First Point: 8.5,6 {these are the coordinates of the end of the first line we drew}

To Point: @-2,2

To Point @2, 2

To Point @-5,0

To point {Press ENTER without entering coordinates. This will end the line command}

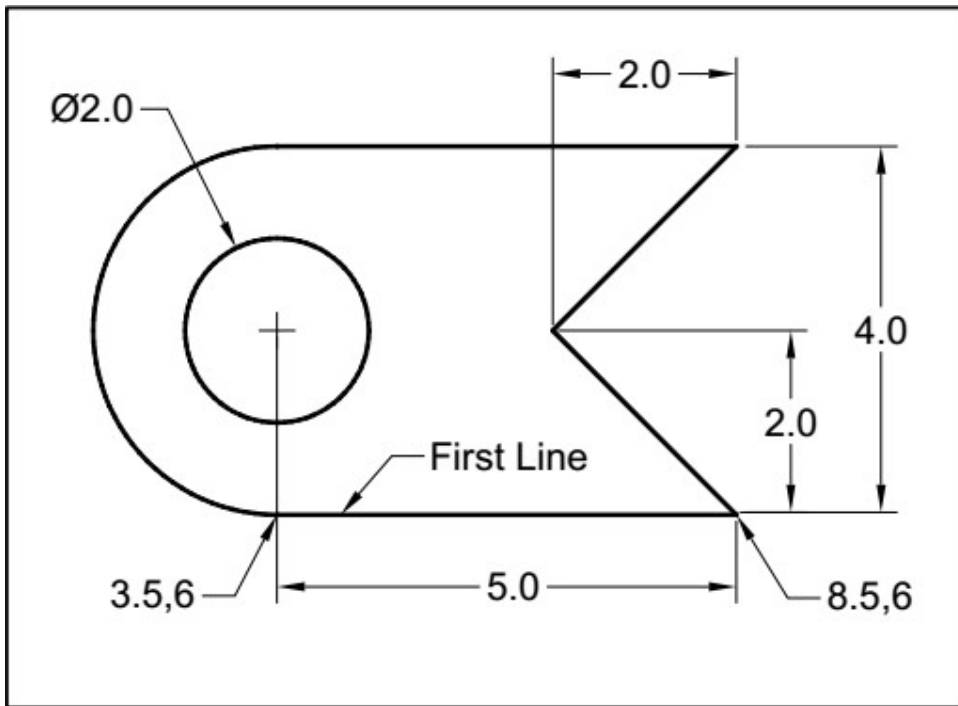
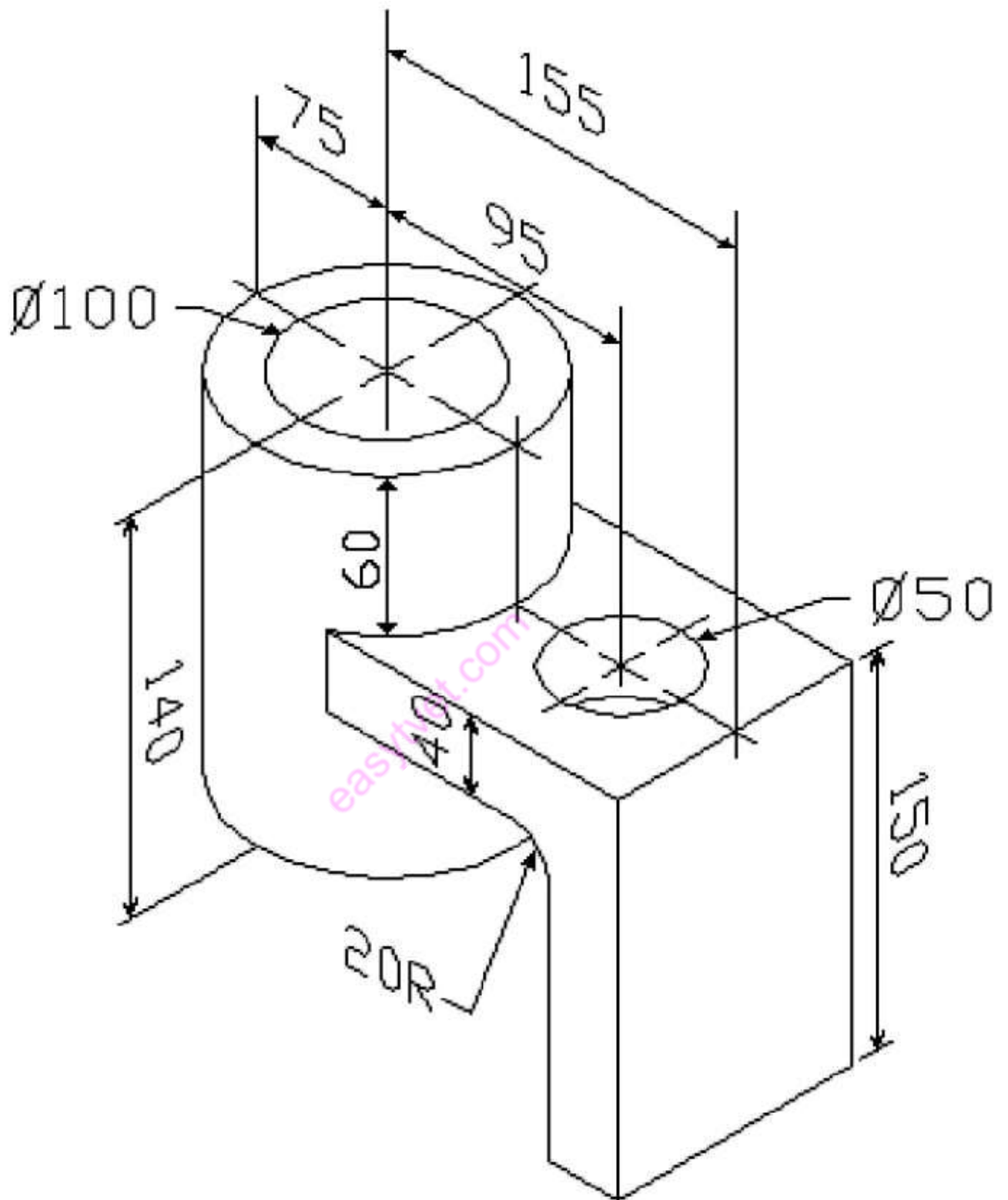


Figure 100 Orthographic figure

#### 3.2.5.4. Learning activities

Below is an orthographic drawing drawn in Isometric. With the help of your trainer, you are required to develop it using CAD.



### 3.2.5.5. Self-Assessment

1. Define the following

- i. CAD

ii. CADD

iii. CAE

2. List the three types of arrays.
3. List any three reasons for implementing CAD systems.
4. What are palettes?
5. List two types of coordinate systems.

### 3.2.5.6. Tools, Equipment, Supplies and Materials

- xiv. Drawing boards
- xv. T squares
- xvi. Set squares
- xvii. Drawing sets
- xviii. Drawing paper
- xix. Protractors
- xx. Eraser Shield
- xxi. Pencils
- xxii. Erasers
- xxiii. Masking tapes
- xxiv. Paper clips
- xxv. Drawing curves
- xxvi. Technical drawing software'

### 3.2.5.7. References

<https://www.designtechcadacademy.com/knowledge-base/introduction-to-cad>

[https://www.designingbuildings.co.uk/wiki/Computer\\_aided\\_design\\_CAD](https://www.designingbuildings.co.uk/wiki/Computer_aided_design_CAD)

<https://static.sdcpublications.com/pdfsample/1-58503-297-2-4.pdf>

### 3.2.5.8. Model Answers.

#### 1. Define the following

i. CAD

Computer-Aided Design, a term usually applied to the software.

**ii. CADD**

Computer-Aided Design and Drafting.

**iii. CAE**

Computer-Aided Engineering

**2. List the three types of arrays.**

- Rectangular Array
- Path Array
- Polar Array

**3. List any three reasons for implementing CAD systems.**

- Increases the productivity of the designer
- Improves communication:
- Create data base for manufacturing:
- Improves the efficiency of the design.

**4. What are palettes?**

Palettes are special windows that can be docked, floating and made to collapse when not in use

**5. List two types of coordinate systems.**

- World co-ordinate system
- Universal system