TVET CERTIFICATE V in PRODUCTION TECHNOLOGY

ASSEMBLY AND DRAWING DETAILS

PRTAD501

Perform assembly and drawing details

Competence

REQF Level: 5

Learning hours: 60

Credits: 6

Sector: Mining and Manufacturing

Sub-sector: Production Technology

Module Note Issue date: November, 2020

Purpose statement

This module describes the skills, knowledge and attitudes required to perform assembly and drawing details. At the end of this module, participants will be able to analyze the assembly drawing, drawing details, and perform assembly drawing in order to ensure that the functioning of a mechanism meet the specifications and requirements.

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Learning Unit 1 – Analyze the Assembly Drawing to be done

LO 1.1 – Identify assembly drawing

- Content/Topic 1: Types of assembly drawings

Introduction

A machine is an assembly of various links or parts. It is necessary to understand the relation between the various parts of the unit for the purpose of design and production. An assembly drawing is one which represents various parts of a machine in their working position.

These drawings are classified as:

- ✓ Design assembly drawings,
- ✓ Working assembly drawings,
- ✓ Sub-assembly drawings,
- ✓ Installation assembly drawings, etc.

An assembly drawing made at the design stage while developing a machine is known as

1. **Design assembly drawing.** It is made to a larger scale so that the required changes or modifications may be thought of by the designer, keeping in view both the functional requirement and aesthetic appearance.
2. **Working assembly drawings** are normally made for simple machines, comprising small number of parts. Each part is completely dimensioned to facilitate easy fabrication.
3. **A sub-assembly drawing** is an assembly drawing of a group of related parts which form a part of a complicated machine. Thus, a number of such sub-assembly drawings are needed to make a complete unit.
4. **An installation assembly drawing** reveals the relation between different units of a machine, giving location and dimensions of few important parts.

The final assembly drawings are prepared from design assembly drawings or from the working drawings (component drawings). The class-room exercises are designed to train the students to master fundamentals of machine drawing, such as principles of drawing, orthographic projections, etc. In addition, the student will understand the relation between the different parts of the components and working principles of the assembled unit. The following steps may be made use of to make an assembly drawing from component drawings:

1. Understand the purpose, principle of operation and field of application of the given machine. This will help in understanding the functional requirements of individual parts and their location.
2. Examine thoroughly, the external and internal features of the individual parts.
3. Choose a proper scale for the assembly drawing.
4. Estimate the overall dimensions of the views of the assembly drawing and make the outline blocks for each of the required view, leaving enough space between them, for indicating dimensions and adding required notes.
5. Draw the axes of symmetry for all the views of the assembly drawing.
6. Begin with the view from the front, by drawing first, the main parts of the machine and then adding the rest of the parts, in the sequence of assembly.
7. Project the other required views from the view from the front and complete the views.
8. Mark the location and overall dimensions and add the part numbers on the drawing.
9. Prepare the parts list.
10. Add the title block.

NOTE: It is not advisable to complete one view before commencing the other. The better method is to develop all the required views simultaneously

LO 1.2 – Identify drawing instruments

- Content /Topic 1: Different Drawing Instruments

Drawing Instruments and Accessories

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

1. Drawing board
2. Mini draughter
3. Instrument box
4. Set of scales
5. Protractor
6. French curves
7. Set of squares
8. Templates
9. Pencils
10. Drawing sheets

1. **Drawing Board**

The Drawing Board serves as the workstation in drawing and is made with a smooth level top surface onto which drawing paper is fixed using clamps, thumbnails (board pins), or using drawing tape.

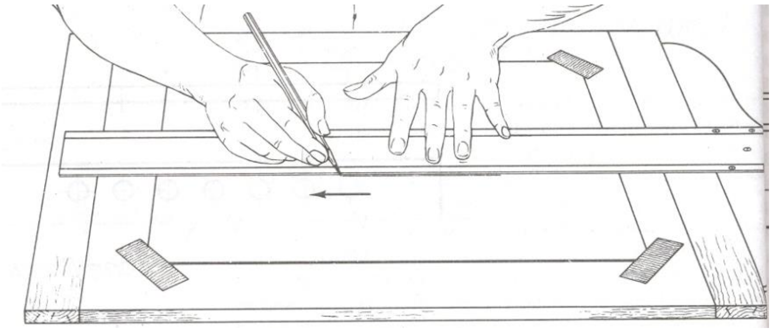


Figure 1.Drawing Board

2. **Mini-Draughter**

   one end of the mini- drafter is clamped by means of a clamping screw (C.S.) to the longer edge of the drawing Board (D.B). At its other end an adjustable knob (K) having protractor (P) markings is fitted. Two scales (S) of transparent celluloid, set at right angles to each other are attached to the knob. The mini- drafter machine is used to draw horizontal, vertical and inclined lines and also for measuring lines and angles.

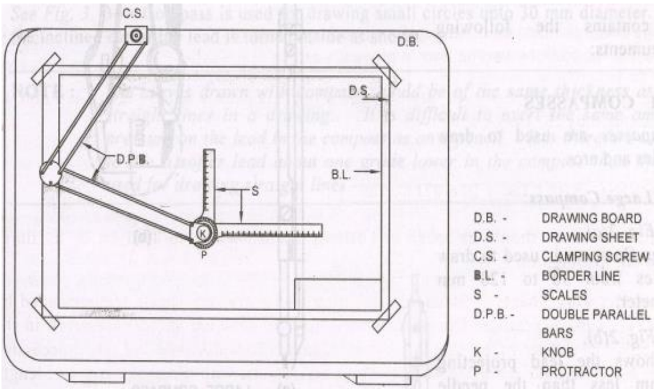


Figure 2.Mini-Draughter

3. **Instrument Box**

Instrument box contains 1. Compasses, 2. Dividers and 3. Inking pens. What is important is the position of the pencil lead with respect to the tip of the compass. It should be at least 1 mm above as shown in *Fig. I.2.3* because the tip goes into the board for grip by 1 mm.

(a) Sharpening and position of compass lead

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

Figure 3.(a) Sharpening and Position of Compass Lead, (b) Position of the Lead Led to Draw Larger Circles

4. Set of Scales

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

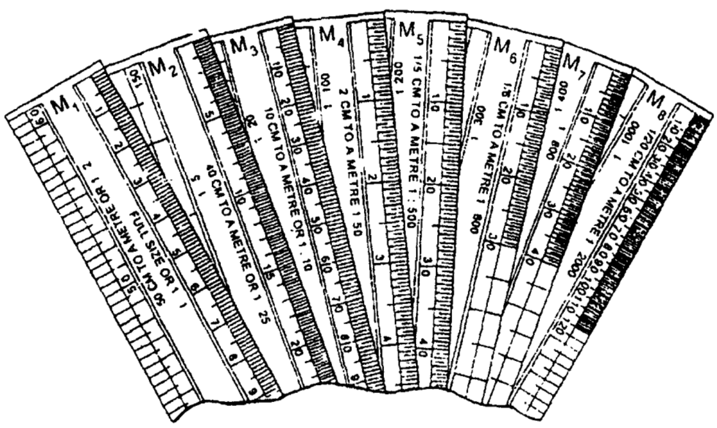


Figure 4.Set of scale

	M1	M2	M3	M4	M5	M6	M7	M8
Scale on one edge	1:1	1:2.5	1:10	1:50	1:200	1:300	1:400	1:1000
Scale on other edge	1:2	1:5	1:20	1:100	1:500	1.600	1:800	1:2000

Table Set of scales

5. Protractor

It is used for laying out and measuring angle.

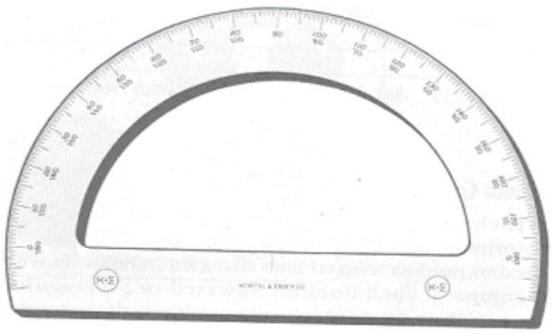


Figure 5.Protractor

6. **French Curves**

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

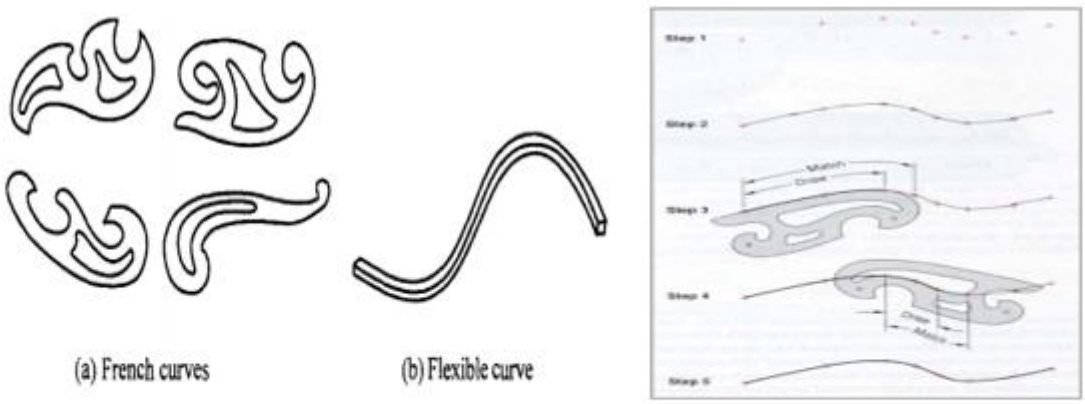


Figure 6.French Curves

7. **Set- Squares**

The set squares are made of transparent celluloid or plastic materials, etc. The set- square made of transparent celluloid are most satisfactory as the line underneath the set- square can be seen quite easily and this often prevents another line being drawn in the wrong place.

Types of Set Squares

- ✓ Thirty-sixty degree (30^0-60^0)
- ✓ Forty-five degree (45^0)

The 30^0-60^0 set square has three edges, one of which forms 90^0 and other edges forming angle of 30^0 and 60^0 with the other sides respectively

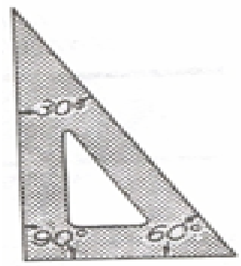


Figure 7.30-60 angles set square

The 45^0 set square is similar to the 30^0-60^0 set square, but its edges form an isosceles triangle in which two of the angles are of 45^0 each and other one's 90^0

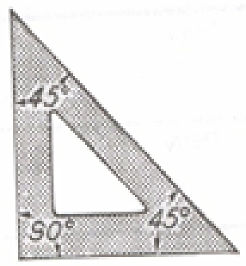


Figure 8.45angles set square

Sizes of set- squares

The set- squares can be available in different suitable lengths, but 30^0-60^0 set- squares of 250mm and45^0 set- square of 20^0mm are suitable for general work.

Uses of set squares

- ✓ The set-squares are used for drawing straight line except the horizontal lines which are usually drawn with T-square.
- ✓ The perpendicular lines or the lines at30^0, 60^0 and 90^0 to the horizontal can be drawn by using the set squares.
- ✓ The perpendicular lines or the lines inclined at 45^0 and 90^0 to the horizontal can be drawn by using the set- squares.
- ✓ By using two set-squares, angle of 150^0, 750^0 and 105^0 can be drawn.

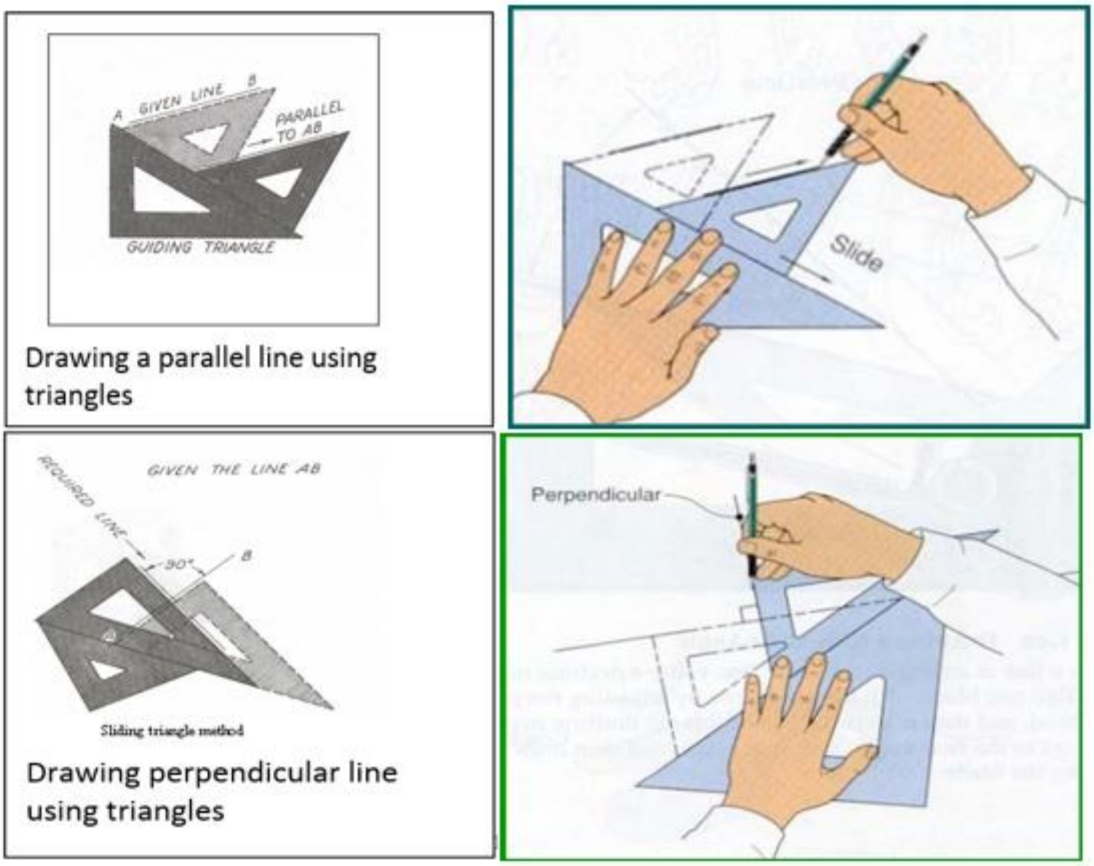


Figure 9.Uses of set squares

8. Templates

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

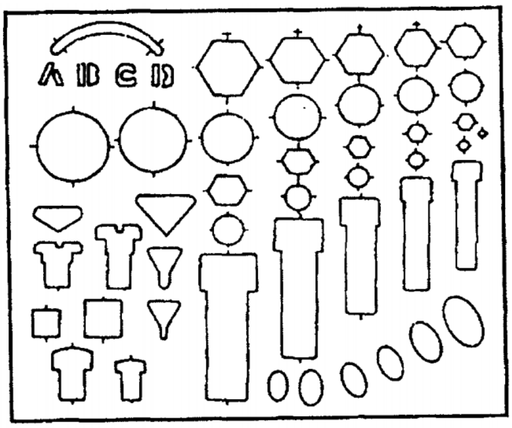


Figure 10.Template

9. Pencils

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

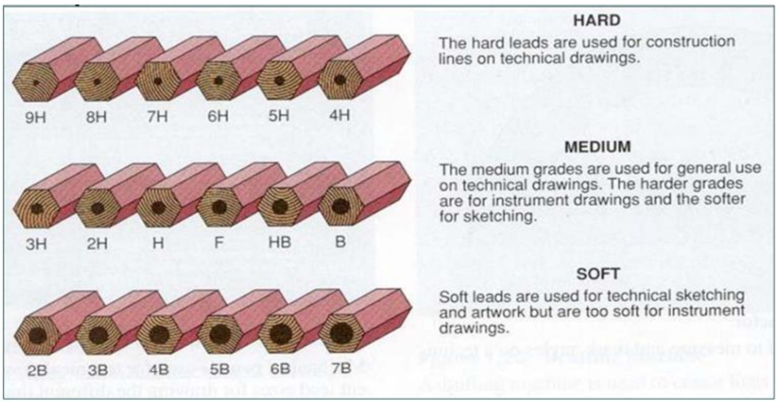


Figure 11.Pencils Leads

The selection of the grade depends on the line quality desired for the drawing. Pencils of grades H or 2H may be used for finishing a pencil drawing as these give a sharp black line. Softer grade pencils are used for sketching work. HB grade is recommended for lettering and dimensioning. Nowadays mechanical pencils are widely used in place of wooden pencils. When these are used, much of the sharpening time can be saved. The number 0.5, 0.70 of the pen indicates the thickness of the line obtained with the lead and the size of the lead diameter. Micro-tip pencils with 0.5 mm thick leads with the following grades are recommended.

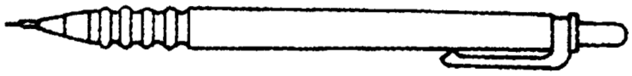


Figure 12.Mechanical Pencil

HB Soft grade for Border lines, lettering and free sketching

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.

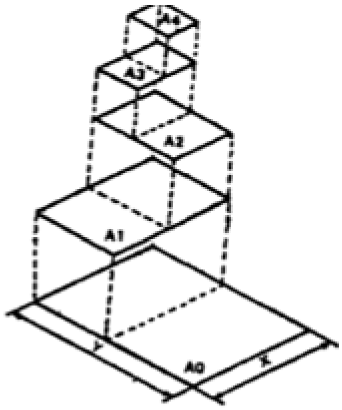
10. Drawing Sheet

The standard drawing sheet sizes are arrived at on the basic Principal of x: y = 1: *√2* and xy = 1 where x and y are the sides of the sheet. For example, AO, having a surface area of 1Sq.m;

x = 841 mm and y = 1189 mm. The successive sizes are obtained by either by halving along the length or doubling the width, the area being in the ratio 1:2. Designation of sizes is given in *Fig13.* and their sizes are given in *Table2.* for class work use of A2 size drawing sheet is preferred.

Designation	Dimension, mm Trimmed size
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

Sizes of Drawing Sheet



Drawing Sheet Formats

Figure 13.Drawing Sheet

11. Clinograph

Clinograph is an adjustable set square and is used to draw parallel lines at any inclination. The two sides of clinograph are fixed at 90 adjusted at any desired angle.

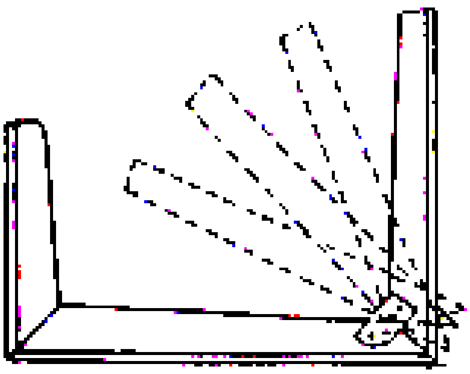


Figure 14.Clinograph

12. Compass

A compass, also known as a pair of compasses, is a technical drawing instrument that can be used for inscribing circles or arcs. As dividers, Compasses are usually made of metal or plastic, and consist of two "legs" connected by a hinge which can be adjusted to allow changing of the radius of the circle drawn.

they can also be used as tools to measure distances, in particular on maps. Compasses can be used for mathematics, drafting, navigation and other purposes.

A beam compass and a regular compass

A compass with an extension accessory for larger circles

Figure 15.Compass

13. Mini drafter

One end of the mini- drafter is clamped by means of a clamping screw (C.S.) to the longer edge of the drawing Board (D.B). At its other end an adjustable knob (K) having protractor (P) markings is fitted. Two scales (S) of transparent celluloid, set at right angles to each other are attached to the knob. The mini- drafter machine is used to draw horizontal, vertical and inclined lines and also for **measuring lines** and angles.

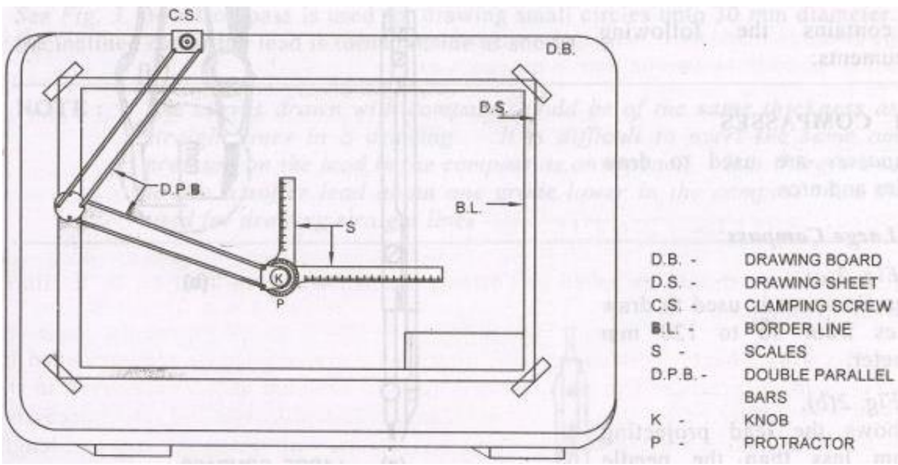


Figure 16.Mini drafter

- <u>Content /Topic 2: Functions of Drawing Instruments</u>

Measuring Instruments for Linear Dimensions

1. **Linear measurement**

Measuring instruments can be divided into two types: graduated and non-graduated. Graduated measuring devices include a set of markings (graduations) on a linear or angular scale to which the object's feature of interest can be compared for measurement.

Non-graduated measuring devices are used to make comparisons between dimensions or to transfer a dimension for measurement by a graduated device.

The most basic of the graduated measuring devices is the scale used to measure linear dimensions.

Scales: Scales are used to transfer and or to measure the dimensions. They are made of wood, steel, ivory, celluloid or plastic, stainless steel scales are more durable.

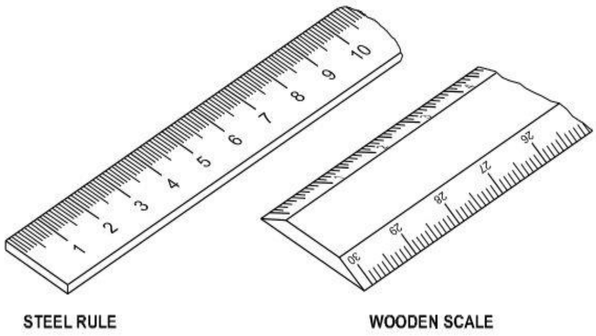


Figure 17.Scales

2. **Angular Measurements**

Protractor is an instrument for measuring angles. It is semi-circular or circular in shapes and is made of flat celluloid sheet. The angles can be set or measured from both sides, aligning the reference line and point '0' with the corner point of the angle.

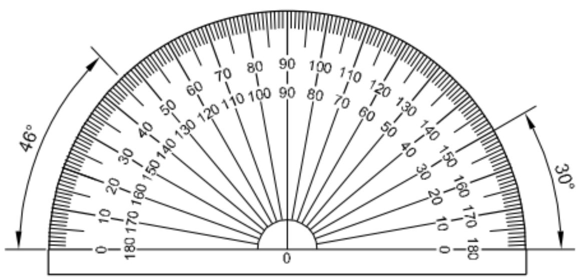


Figure 18.Protractor

LO 1.3 – Interpret drawing assembly

- Content/Topic 1: Overall dimensions

1. **Diameter**

Dimensioning a component is the means of specifying the design intent in the manufacture and verification of the finished part. A solid block with a circular hole in it is shown in *Fig 19.*and to establish the exact shape of the item we require to know the dimensions which govern its length, height and thickness, also the diameter and depth of the hole and its position in relation to the surface of the block. The axis of the hole is shown at the intersection of two centre lines positioned from the left hand side and the bottom of the block and these two surfaces have been taken as datum.

2. Length

The length and height have also been measured from these surfaces separately Dimensioning therefore, should be undertaken with a view to defining the shape or form and overall size of the component carefully, also the sizes and positions of the various features, such as holes, counter bores, tapping, etc.

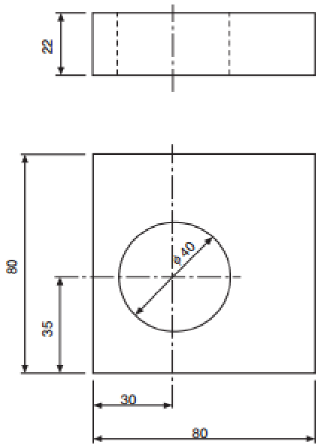


Figure 19. Solid block

- Content/Topic 2: Interpretation of Scale

Objects which are very big in size can't be represented in drawing to full size. In such cases the object is represented in reduced size by making use of reducing scales. Reducing scales are used to represent objects such as large machine parts, buildings, town plans etc. A reducing scale, say 1: 10 means that 10 unit's length on the object is represented by 1-unit length on the drawing. Similarly, for drawing small objects such as watch parts, instrument components etc., and use of full scale may not be useful to represent the object clearly. In those cases, enlarging scales are used. An enlarging scale, say 10: 1 means one-unit length on the object is represented by 10 units on the drawing. The designation of a scale consists of the word. SCALE, followed by the indication of its ratio as follows. (Standard scales are shown in *Fig.*

- ✓ Scale 1: 1 for full size scale
- ✓ Scale 1: x for reducing scales (x = 10, 20......etc.,)
- ✓ Scale x: 1 for enlarging scales.

Note: For all drawings the scale has to be mentioned without fail.

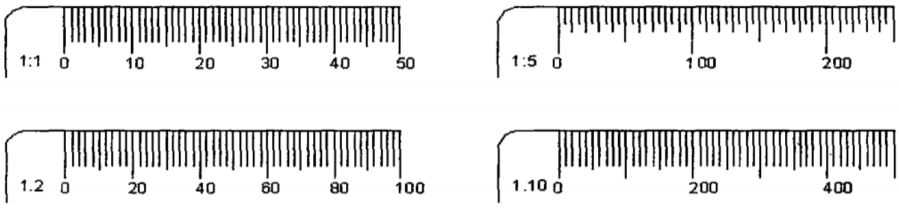


Figure 20.Standard Scales

Representative Fraction

The ratio of the dimension of the object shown on the drawing to its actual size is called the Representative Fraction (RF).

$$RF = \frac{\text{Drawing size of an object}}{\text{Its actual size}} \text{ (in same units)}$$

For example, if an actual length of 3 metres of an object is represented by a line of 15mm length on the drawing.

$$RF = \frac{15\text{mm}}{3\text{m}} = \frac{15\text{mm}}{(3 \times 1000)\text{mm}} = \frac{1}{200} \text{ or } 1:200$$

- ## Content /Topic 3: Drawing Symbol

SYMBOL FOR:	ASME Y14.5M–1994	ISO	CAN/CSA–B78.2–M91
STRAIGHTNESS	—	—	—
FLATNESS	▱	▱	▱
CIRCULARITY	○	○	○
CYLINDRICITY	⌭	⌭	⌭
PROFILE OF A LINE	⌒	⌒	⌒
PROFILE OF A SURFACE	⌓	⌓	⌓
ALL AROUND–PROFILE	←⊖—	←⊖—	←⊖—
ANGULARITY	∠	∠	∠
PERPENDICULARITY	⊥	⊥	⊥
PARALLELISM	//	//	//
POSITION	⌖	⌖	⌖
CONCENTRICITY/COAXIALITY	◎	◎	◎
SYMMETRY	⌯	⌯	⌯
CIRCULAR RUNOUT	↗	↗	↗
TOTAL RUNOUT	⌰	⌰	⌰
AT MAXIMUM MATERIAL CONDITION	Ⓜ	Ⓜ	Ⓜ
AT LEAST MATERIAL CONDITION	Ⓛ	Ⓛ	Ⓛ (PROPOSED)
REGARDLESS OF FEATURE SIZE	NONE	NONE	NONE
PROJECTED TOLERANCE ZONE	Ⓟ	Ⓟ	Ⓟ
DIAMETER	∅	∅	∅
BASIC DIMENSION	[50]	[50]	[50]
REFERENCE DIMENSION	(50)	(50)	(50)
DATUM FEATURE	[A]	OR [A]	[A]
DATUM TARGET	∅6 A1	∅6 A1	∅6 A1
TARGET POINT	×	×	×
DIMENSION ORIGIN	⌽→	⌽→	⌽→
FEATURE CONTROL FRAME	⌖ | ∅0.5Ⓜ | A | B | C	⌖ | ∅0.5Ⓜ | A | B | C	⌖ | ∅0.5Ⓜ | A | B | C
CONICAL TAPER	⌲	⌲	⌲
SLOPE	⌳	⌳	⌳
COUNTERBORE/SPOTFACE	⌴	⌴ (PROPOSED)	⌴
COUNTERSINK	⌵	⌵ (PROPOSED)	⌵
DEPTH/DEEP	↧	↧ (PROPOSED)	↧
SQUARE (SHAPE)	□	□	□
DIMENSION NOT TO SCALE	15	15	15
NUMBER OF TIMES/PLACES	8X	8X	8X
ARC LENGTH	⌒105	⌒105	⌒105
RADIUS	R	R	R
SPHERICAL RADIUS	SR	SR	SR
SPHERICAL DIAMETER	S∅	S∅	S∅
BETWEEN	←→	NONE	←→ (PROPOSED)

Figure 21.Drawing Symbols

Projection symbols

First angle projection is widely used throughout all parts of Europe and often called European projection. Third angle in the system used in North America and alternatively described as American projection. In the British Isles, where industry works in co-operation with the rest of the world, both systems of projection are regularly in use. The current British and ISO standards state that both systems of projection are equally acceptable but they should never be mixed on the same drawing. The projection symbol must be added to the completed drawing to indicate which system has been used.

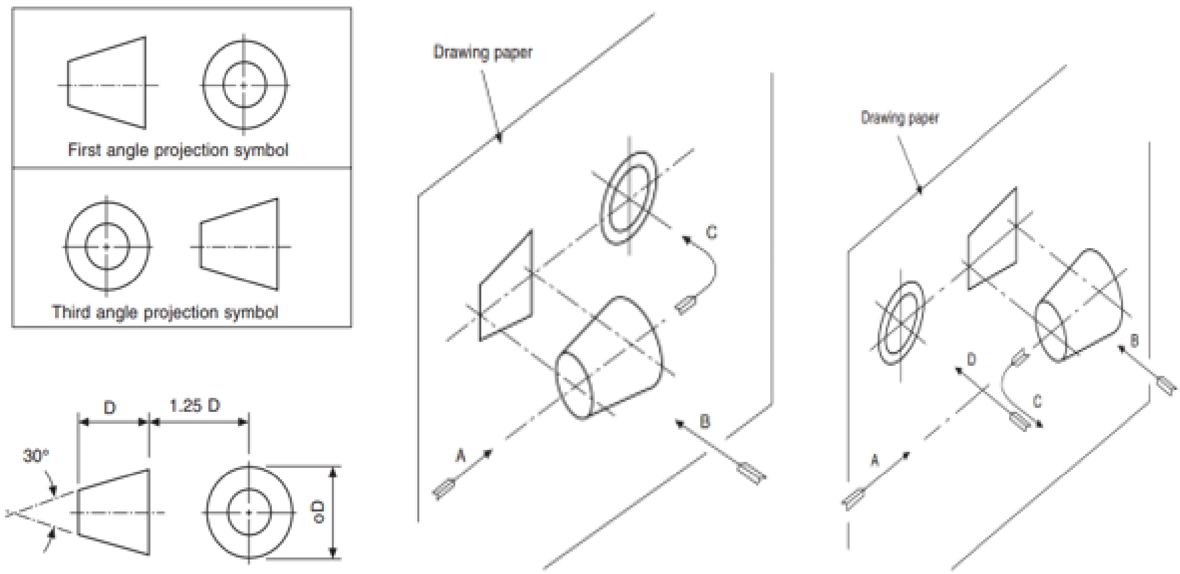


Figure 22.projection symbols

- <u>Content/Topic 4: Assembly Parts List</u>

A parts list is a table that contains information about each of the parts contained in an assembly. The item numbers correspond with the balloon numbers.

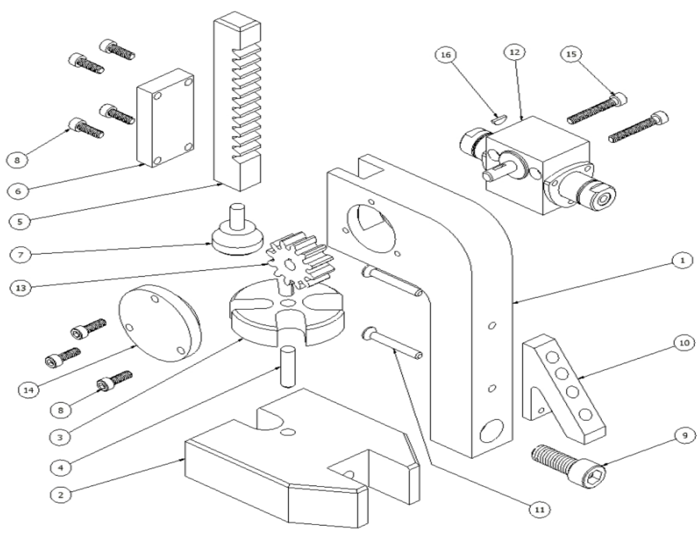


Figure 23.Exploded pictorial assembly

Example Parts List

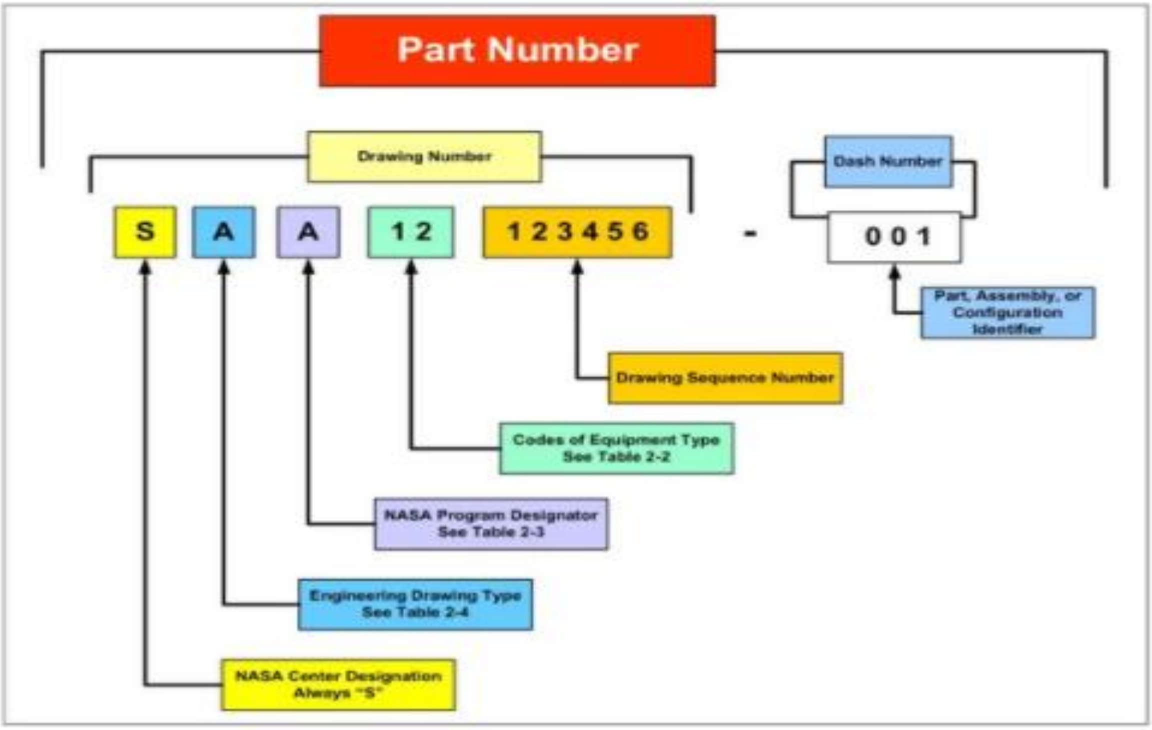
Item	Quantity	Name	Description	Material
1	1	Column		AL 6061
2	1	Base		AL 6061
3	1	Table		AL 6061
4	1	Table Pin		AL 6061
5	1	Rack		AL 6061
6	1	Cover Plate		AL 6061
7	1	Rack Pad		AL 6061
8	7	Cover Plate Screw	8-32 UNC x .50 cap screw	STL
9	1	Column Screw	3/8-16 UNC x 1.00 cap screw	STL
10	1	Punch Holder		AL 6061
11	2	Punch Holder Screw	8-32 UNC x 1.25 flat countersunk head cap screw	STL
12	1	Rotary Actuator	Bimba PT-006360-A1DV	--
13	1	Gear		AL 6061
14	1	Gear Plate		AL 6061
15	2	Actuator Screw	8-32 UNC x 1.25 cap screw ground to 1.1 length	STL
16	1	Key	Woodruff Key # 202.5	STL

1. Serial number

- Every drawing should be numbered.
- It is advisable to use simple serial numbers, but varies from industry to industry.
- It is advisable to avoid using drawing numbers to convey other information; however, some companies place a prefix such as A, B, C, or D in front of the number to denote the sheet size.
- The drawing number is usually the number of the part itself.
- The drawing number is bold, ¼” high, and located in the lower right and upper left corner of the sheet.
- When a drawing is completed it is turned over to the checker. It is checked for soundness of design, correct views, complete dimensioning, legibility, clearances, materials, standard parts, and title block information

According to the diagram below, SEB12100030 means: NASA Center Designation (S) multi-assembly drawing (E) of "Crew Systems" Supplying Division (B) crew personnel equipment (12) drawing number 100030.

Engineering Drawing System Manual	JPR No.	8500.4K
	Effective Date:	03/06/2006
	Expiration Date:	04/26/2016
	Page Number	Page 36 of 105



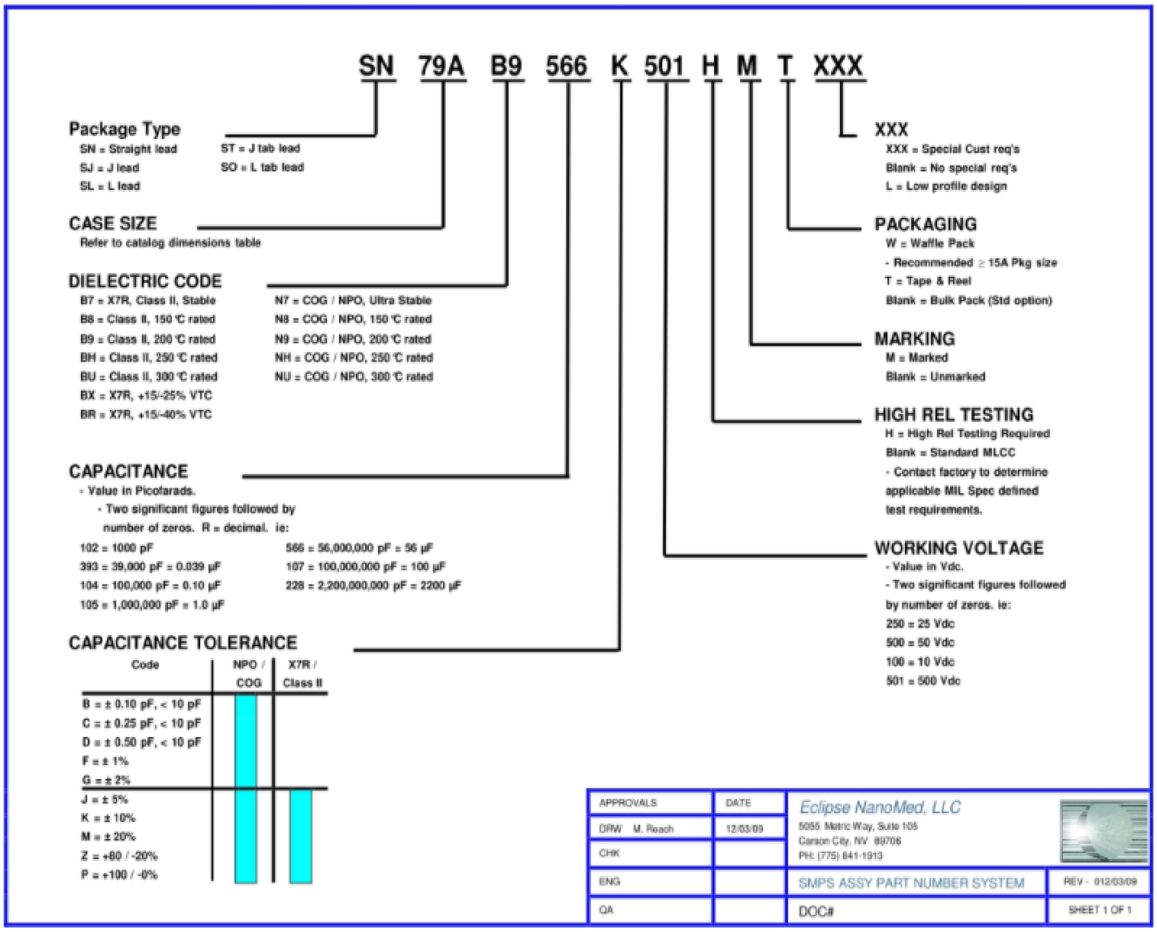
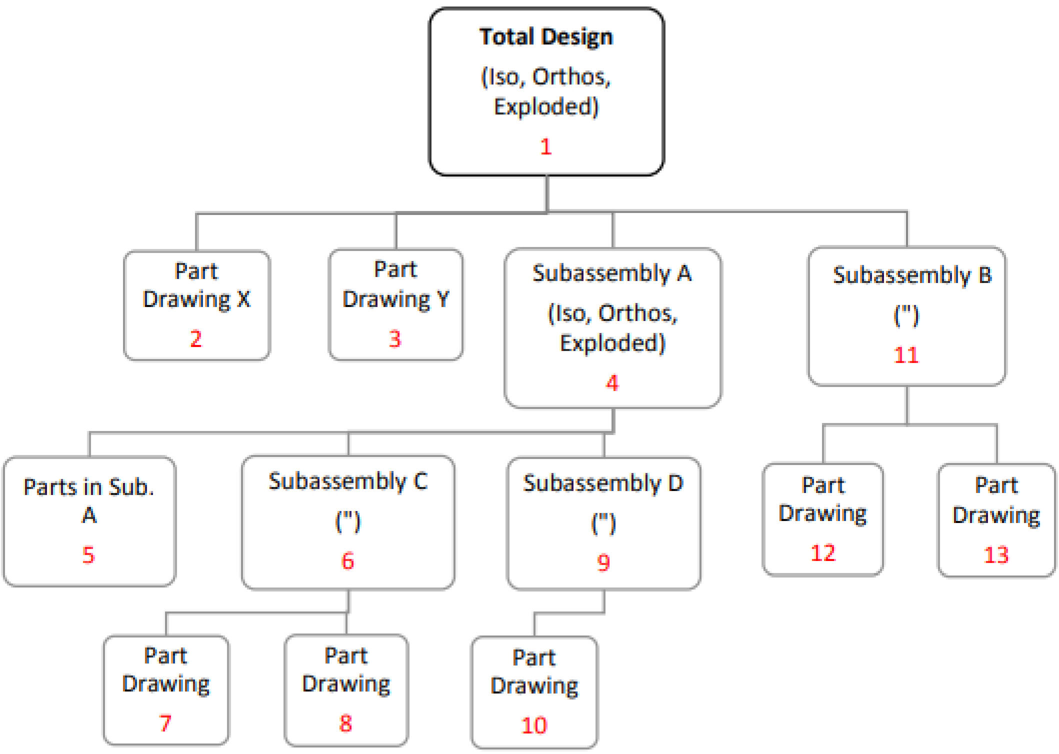


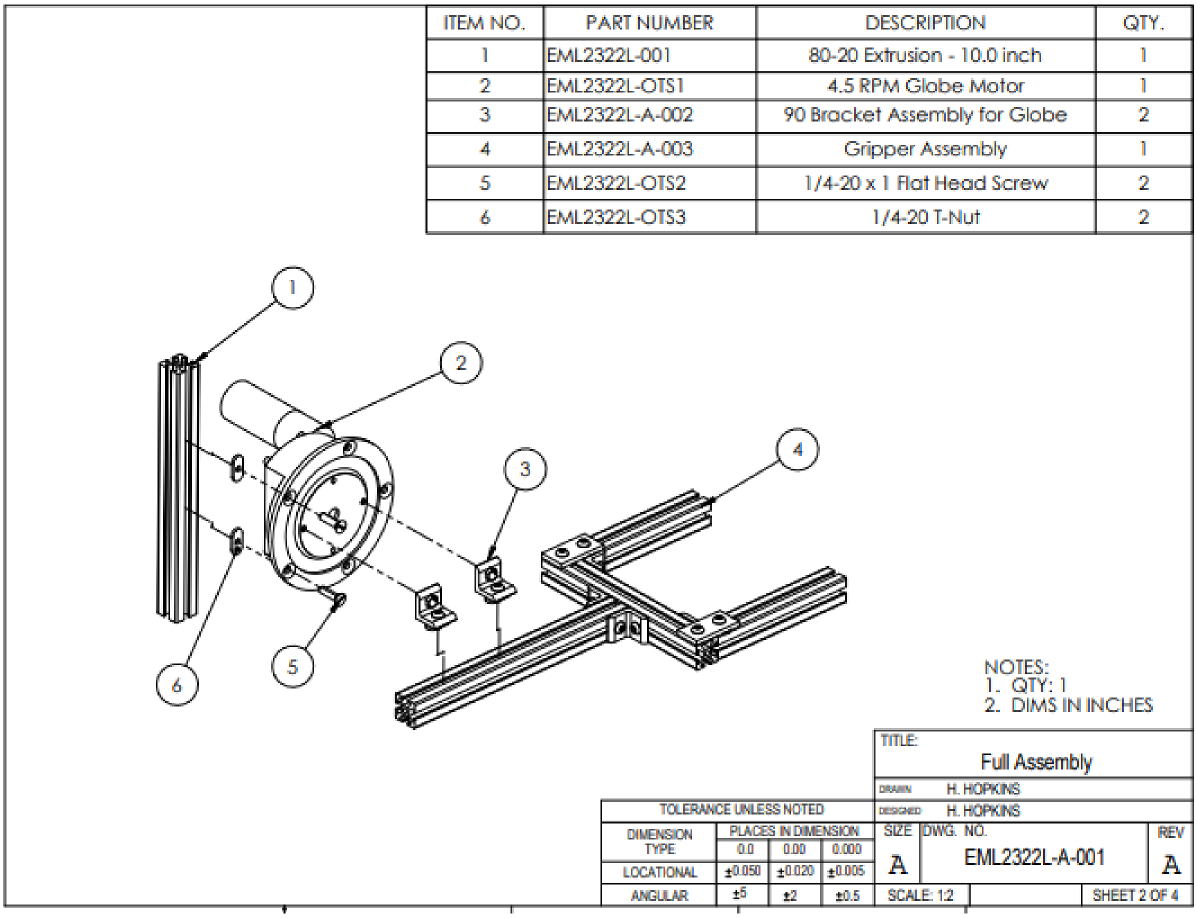
Table. Of Serial Number

2. Designation

If a design is comprised of subassemblies A and B, and components X and Y (which are not part of another subassembly (like a control box, for example)). First, the assembly drawings (iso, orthos, exploded views, BOM) for the entire design should be shown with proper dims between individual components / assemblies. Next, individual part drawings for parts X and Y should be shown. After all individual parts have been shown, assembly drawings for subassembly A are shown. The same sequence outlined above is repeated for this assembly. All parts not in other assemblies are listed first, followed by their constituent subassemblies (where the same ordering procedure is maintained). Notice how each subassembly is broken down immediately after it is shown before moving on to assemblies on the same level. Once everything under the tree in subassembly A has been shown, move on to subassembly B. If a part is an element of multiple subassemblies (for example if part 5 and part 12 are the same), it only needs to be shown once, in its earliest location. But, be sure to keep its item number / part name consistent in the BOM and exploded views.



Graphic Report Organization of Designation



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	EML2322L-001	80-20 Extrusion - 10.0 inch	1
2	EML2322L-OTS1	4.5 RPM Globe Motor	1
3	EML2322L-A-002	90 Bracket Assembly for Globe	2
4	EML2322L-A-003	Gripper Assembly	1
5	EML2322L-OTS2	1/4-20 x 1 Flat Head Screw	2
6	EML2322L-OTS3	1/4-20 T-Nut	2

Report of Designation

3. Material specifications

Material and component specifics are commonly provided in the title block of a production drawing. Sub-assemblies (or the main assembly of components) are usually shown and the production drawings may specify where each assembled component will be built. Production drawings also record the number of parts that are required for making the assembled unit and may form an essential part of the documentation required to authorize the production of the item described.

➢ **Three main sets of production drawings include the following**:

- Detail of each non-standard part on a drawing sheet, usually one part per sheet
- Assembly drawing showing all parts on one sheet
- A Bill of materials (BOM), essentially of each part

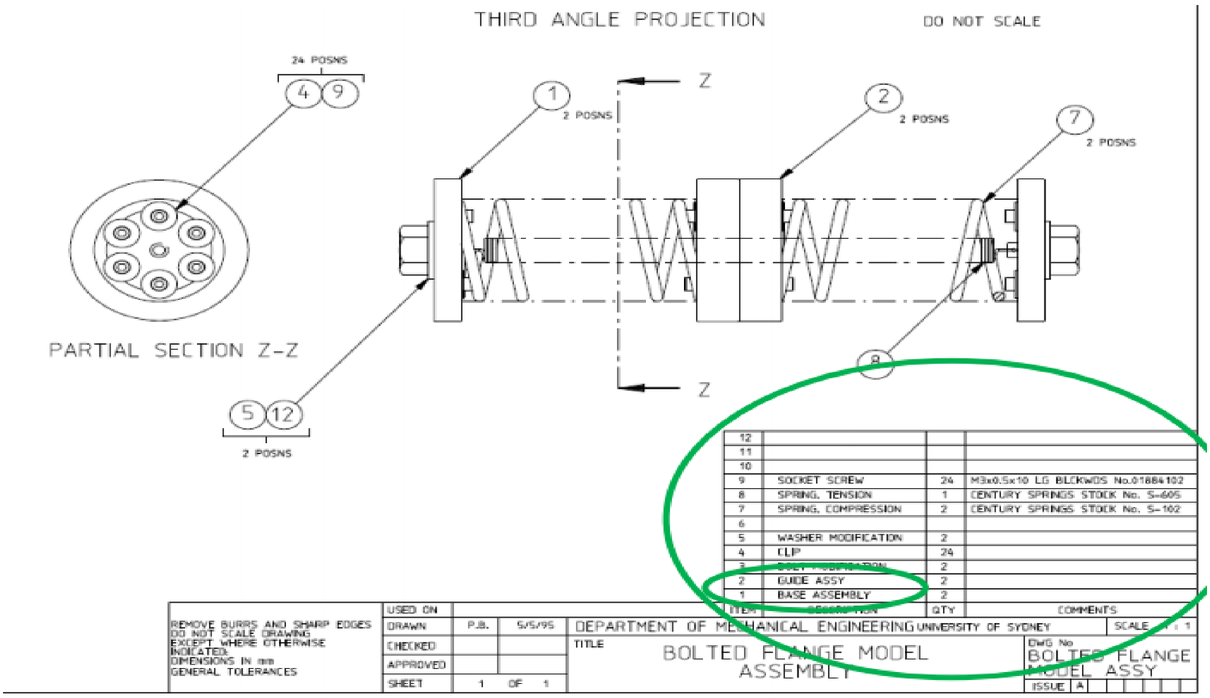


Figure 24.Parts List Location for materials

- **Parts List Information**

Items commonly found in a parts list include:

- ✓ Item number – from balloons.
- ✓ Quantity – the number of a particular part needed for the assembly.
- ✓ Part or drawing number – a reference back to the detail drawing.
- ✓ Description – usually the part name or complete description of a purchase part.
- ✓ Material identification – the material of the part.
- ✓ Information about vendors – for purchase parts.

- **Parts List Location**

The location of a parts list usually depends on company standards. Common locations include:

- ✓ Above the title block – most common
- ✓ Upper right corner
- ✓ Upper left corner
- ✓ A convenient location on the drawing

Learning Unit 2 – Analyze drawing details specification

LO 2.1 – Identify drawing details

- Content/Topic 1: Introduction to 2D and 3D drawing

The goal in engineering graphics, whether it is freehand sketching or CAD, is to represent a physical object. Objects can be shown as 3-D projections (**Pictorial projection**) or Multiview projections (**Orthographic projection**).

3-D projections are useful in that they provide an image that is similar to the image in the designer's mind's eye. But 3-D projections are often weak in providing adequate details of the object, and there is often some distortion of the object. For instance, a circular hole becomes an ellipse in an isometric 3-D projection.

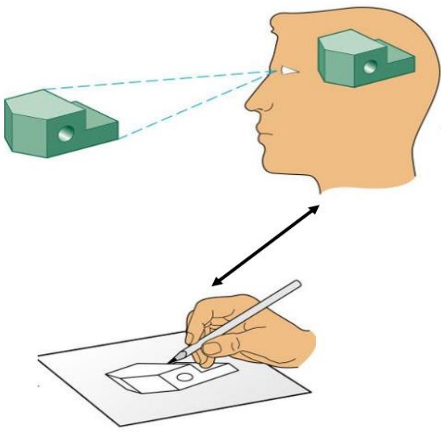


Figure 25.Pictorial projection

Multi view projections are used to overcome the weaknesses of 3-D projections. Multi view projections are a collection of flat 2-D drawings of the different sides of an object.

Projection is the representation of a figure or solid on a plane as it would look from a particular direction.

Types of Projections

1. Pictorial projection:

- ✓ Perspective projection
- ✓ Isometric projection
- ✓ Oblique projection

2. Orthographic Projections:

- ✓ First angle projection
- ✓ Third angle projection

1. Pictorial Projections

The Projections in which the description of the object is completely understood in one view is known as pictorial projection. They have the advantage of conveying an immediate impression of the general shape and details of the object, but not its true dimensions or sizes.

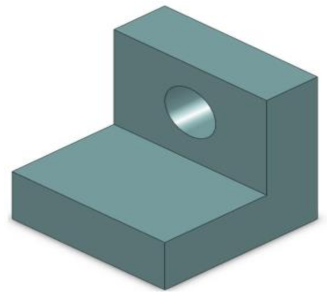


Figure 26.Pictorial Projection

2. Orthographic Projection

'ORTHO' means right angle and orthographic means right angled drawing. When the projectors are perpendicular to the plane on which the projection is obtained, it is known as orthographic projection.

Orthographic projection is a method of producing a number of separate 2D inter-related views, which are mutually at right angles to each other. Using this projection, even the most complex shape can be fully described. This method, however, does not create an immediate three –dimensional visual picture of the object, as does pictorial projection.

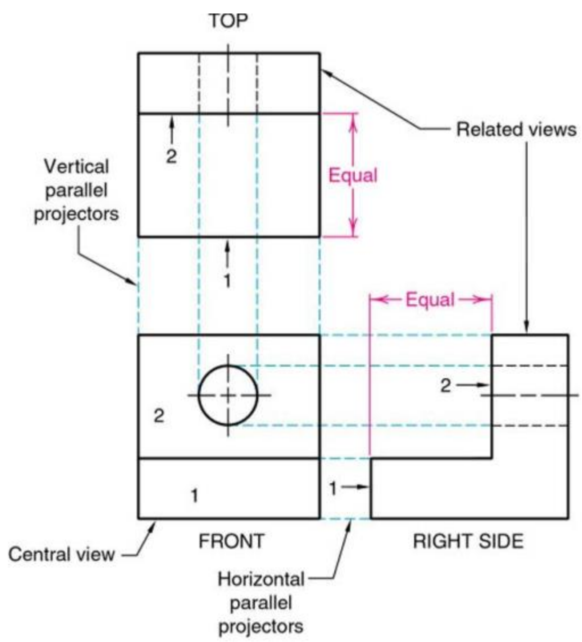


Figure 27.Orthographic Projection

- <u>Content/Topic 2: Detail View of Components</u>

1. **System of projection**

    - **Glass box method**

This method is in accordance with the theory of orthographic projection. The theory of orthographic projection states that the projection may be formed by extending perpendicular projectors from the object to the plane. It may be considered that planes of projection placed parallel to the six faces of an object form an enclosing glass box. The observer views the enclosed object from the outside. The views are obtained by running projectors from points of the object to the planes.

- ✓ Imagine the object is surrounded by a glass cube.
- ✓ Object surfaces are projected onto the faces

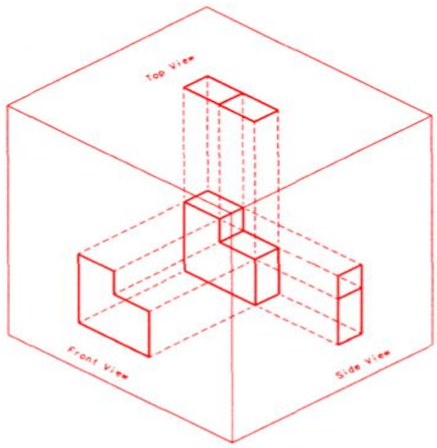


Figure 28.Glass cube method

- ✓ Unfold the cube so that it lies in a single plane.
- ✓ Three views of the object are now visible on the same plane in space

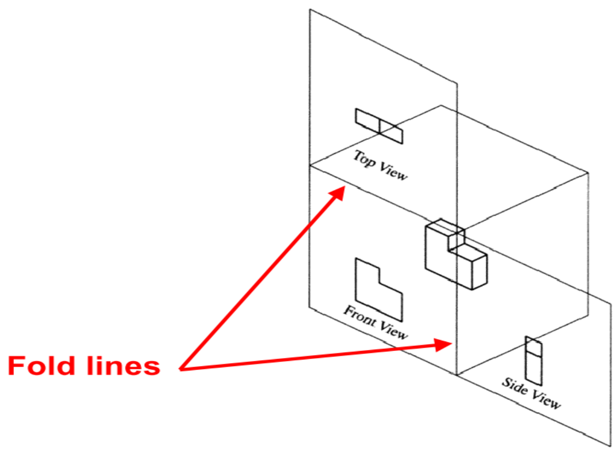


Figure 29.Unfolded glass cube

When the glass cube is unfolded:

- ✓ Front view: Height and Width
- ✓ Top view: Width and Depth
- ✓ Right view: Depth and Height

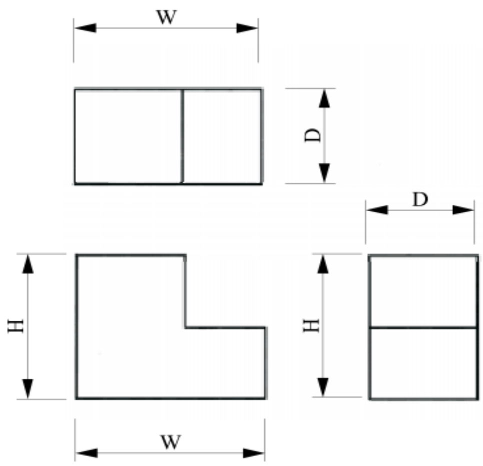


Figure 30.Three main view

Type of Views

1. Front view or elevation
2. Rear view
3. Top view or plan
4. Bottom view
5. Right view
6. left view or Side view or Side elevation or profile view and auxiliary view: The object is projected on an auxiliary plane

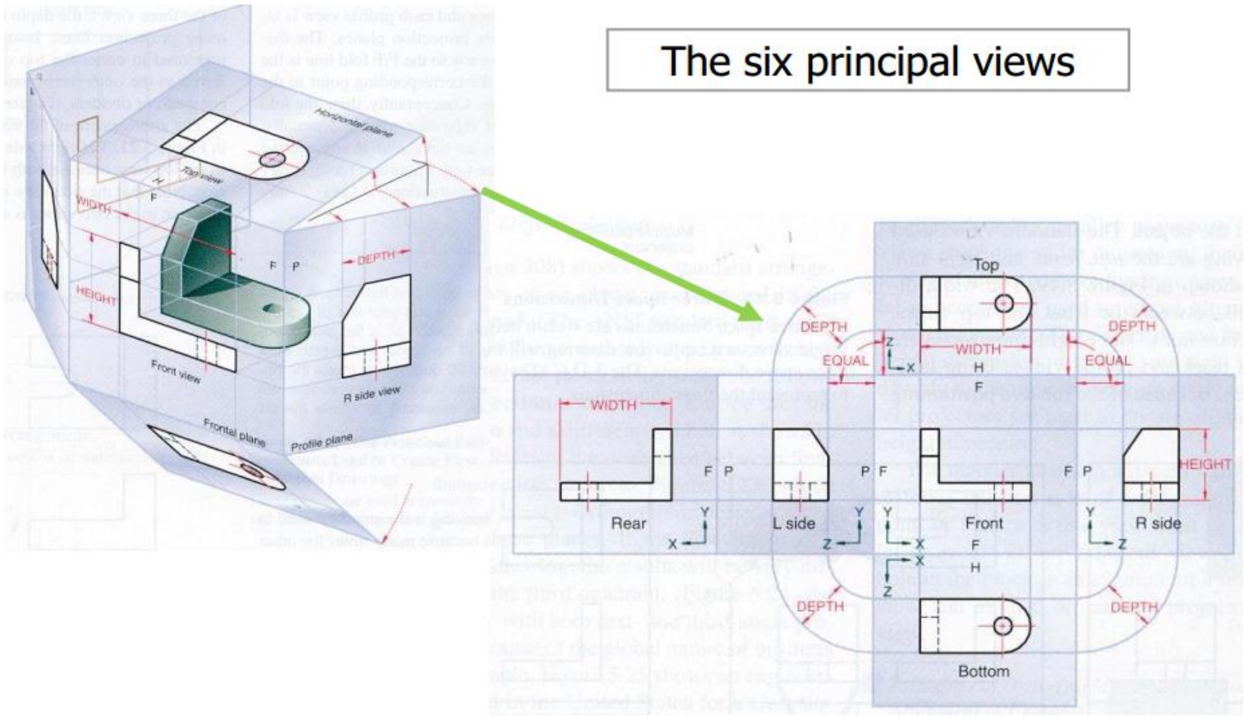


Figure 31.six principle views

Quadrants Method Approach

<u>Four Quadrants</u>

Orthographic projection is also done on the **Vertical Plane (VP)**, the **Horizontal Plane (HP)** and the **Profile Plane (PP)** all referred to as **principle planes**, which are defined with reference to the four quadrants shown in Figure below:

To start with let us draw two perpendicular planes a vertical one (VP) and a horizontal one (HP) that will make four quadrants:

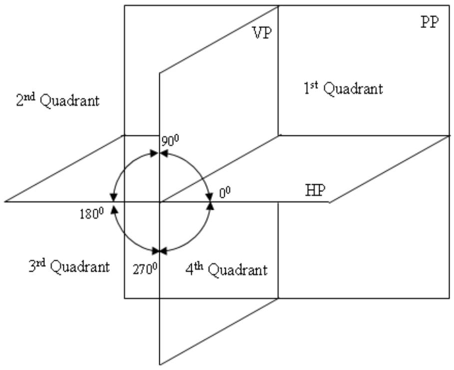


Figure 32.Four quadrants

The position of the object placed in any one of the quadrant is described above

1. In the first quadrant – above H.P and in front of V.P
2. In the second quadrant – above H.P and behind of V.P
3. In the third quadrant – below H.P and behind V.P
4. In the fourth quadrant – below H.P and in front of V.P

Methods of Obtaining Orthographic Views

View from the Front

The view from the front of an object is defined as the view that is obtained as projection on the vertical plane by looking at the object normal to its front surface. It is the usual practice to position the object such that its view from the front reveals most of the important features. *Fig.* shows the method of obtaining the view from the front of an object.

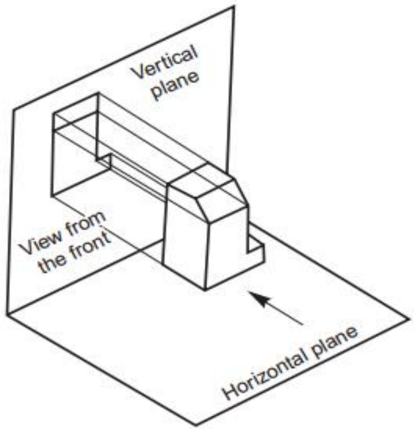


Figure 33.Principle of obtaining the view from the front

View from Above

The view from above of an object is defined as the view that is obtained as projection on the horizontal plane, by looking the object normal to its top surface. *Fig.* shows the method of obtaining the view from above of an object.

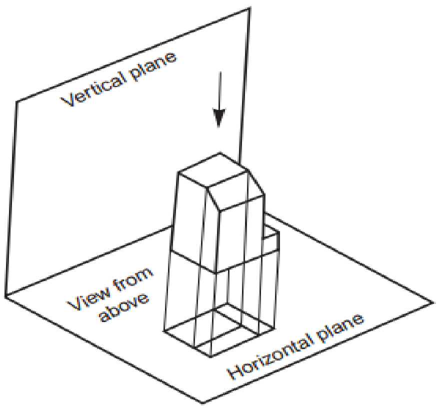


Figure 34.Principle of obtaining the view from above

View from the Side

The view from the side of an object is defined as the view that is obtained as projection on the profile plane by looking the object, normal to its side surface. As there are two sides for an object, viz., left side and right side, two possible views from the side, viz., view from the left and view from the right may be obtained for any object. *Fig.* shows the method of obtaining the view from the left of an object.

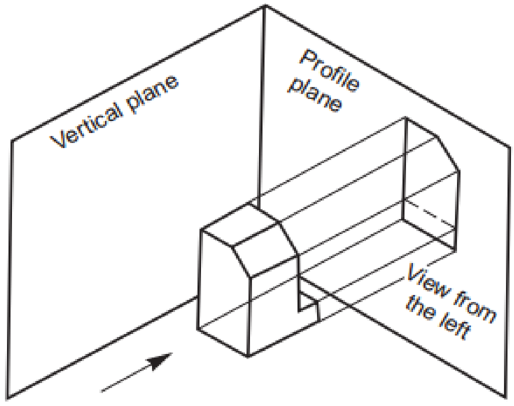


Figure 35.Principle of obtaining the view from the left

Presentation of Views

The different views of an object are placed on a drawing sheet which is a two dimensional one, to reveal all the three dimensions of the object. For this, the horizontal and profile planes are rotated till they coincide with the vertical plane. *Fig.* shows the relative positions of the views, viz., the view from the front, above and the left of an object.

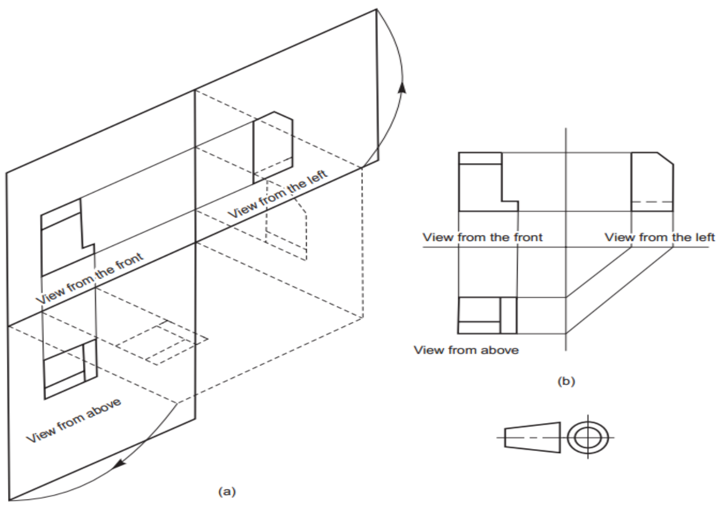


Figure 36.Relative positions of the three views and the symbol

Designation and Relative Positions of Views

An object positioned in space may be imagined as surrounded by six mutually perpendicular planes. So, for any object, six different views may be obtained by viewing at it along the six directions, normal to these planes. *Fig.* shows an object with six possible directions to obtain the different views which are designated as follows:

1. View in the direction **a** = view from the front
2. View in the direction **b** = view from above
3. View in the direction **c** = view from the left
4. View in the direction **d** = view from the right
5. View in the direction **e** = view from below
6. View in the direction **f** = view from the rear

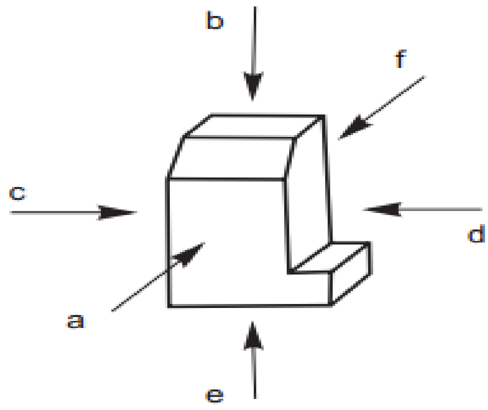


Figure 37.Designation of the views

Fig.a shows the relative positions of the above six views in the first angle projection and *Fig. b*, the distinguishing symbol of this method of projection. *Fig. a* shows the relative position of the views in the third angle projection and *Fig. b,* the distinguishing symbol of this method of projection.

NOTE A comparison of *Fig1.* and *Fig2.* reveals that in both the methods of projection, the views are identical in shape and detail. Only their location with respect to the view from the front is different.

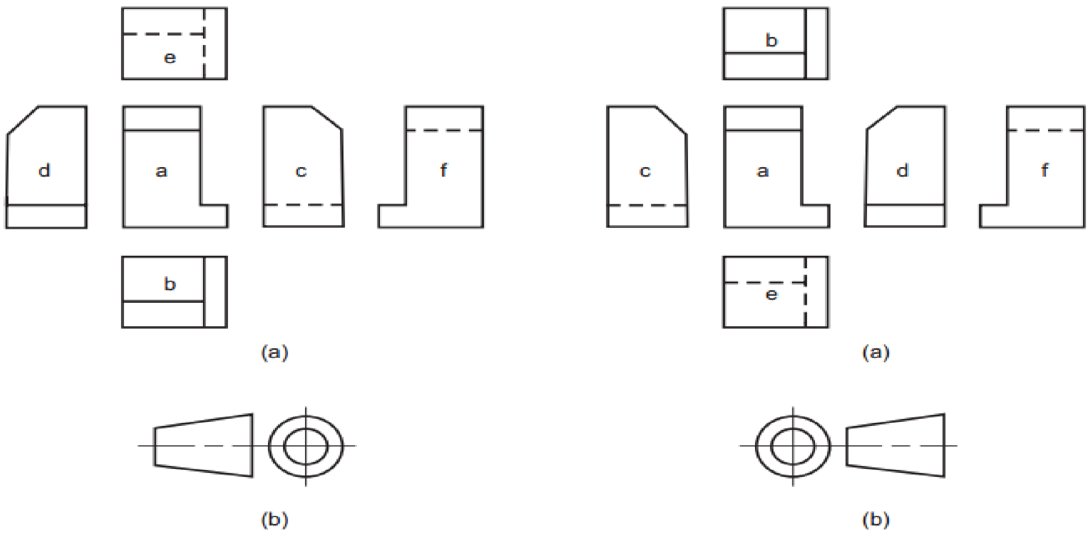


Figure 38.relative position of Six views in 1st angle projection and six views in 3rd angle projection

2. **Drawing Layout and Convention**

Creating orthographic projections

In creating the orthographic projections, normally you will be starting by drawing the Front View. In class exercises, the Front View is indicated by an arrow however when it is not given or during design it is a good practice to choose the view that will reveal most of the details about the object. This view will be the one showing the object in its natural position and be the one having less hidden parts. Draw the remaining views ensuring dimensional consistency. Let us do it through an example:

You will create the First Angle Projection of the following object showing its Front, Right and Top View.

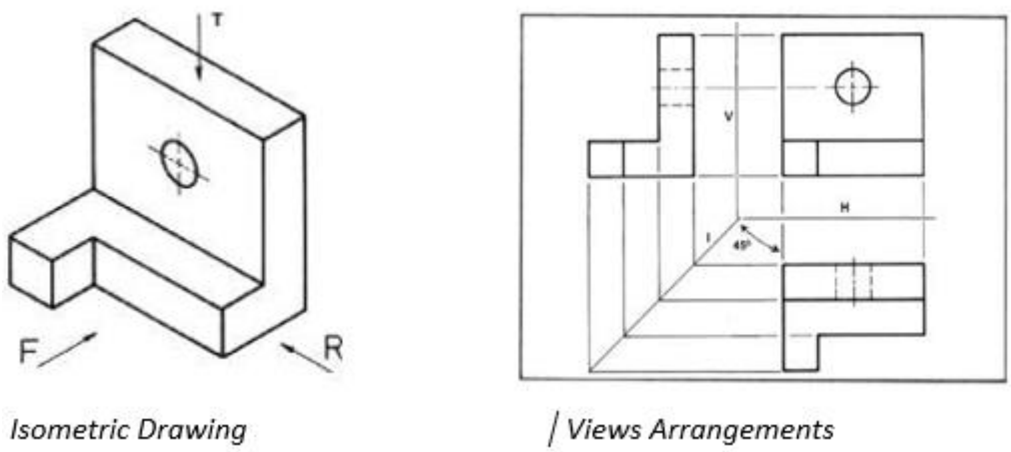


Figure 39.orthographic projections

Layout of an engineering drawing

Although the general sheet layout was given at the beginning, orthographic projection being a kind of drawing that gives multiple. It is important to show how those views should be presented.

- ✓ Margins should be drawn first. Note that though the recommended margin is 10 mm for an A4 size paper, it is good to leave 20 mm on the left side so that in case the paper needs to be punched and filed the drawing remains untouched.
- ✓ Student should make sure that he/she will be having enough space for the Side and Top or Bottom Views before placing the Front View.
- ✓ Student should try his/her best to place his/her drawings at the center of the paper.
- ✓ Student should fill in all the necessary information in the title block.

The drawing layout should be looking like below with slight changes due to a typical case

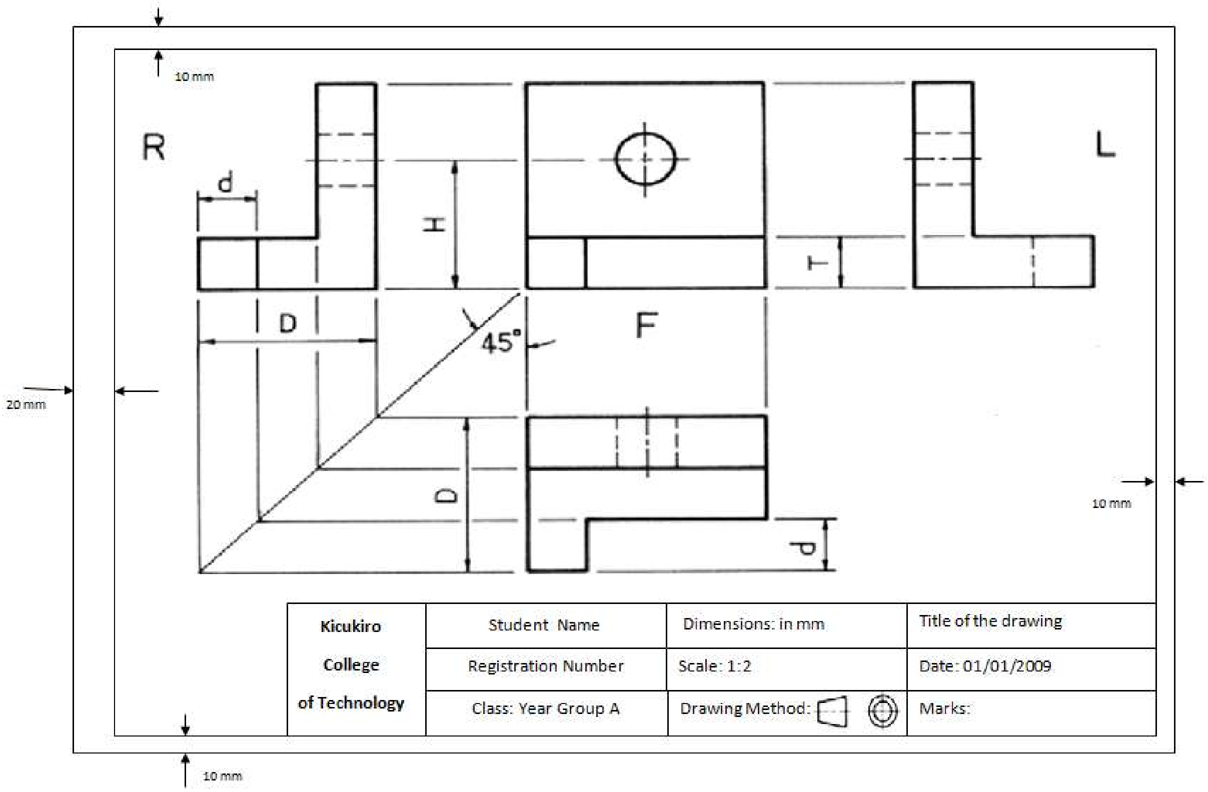


Figure 40.drawing layout

Examples

NOTE For all the examples given, the following may be noted: ***Figure a***-Isometric projection and ***Figure b***-orthographic views. Arrow indicates the direction to obtain the view from the front. The isometric views of machine components and their view from the front, the view from above and the view from the right.

Examples 1

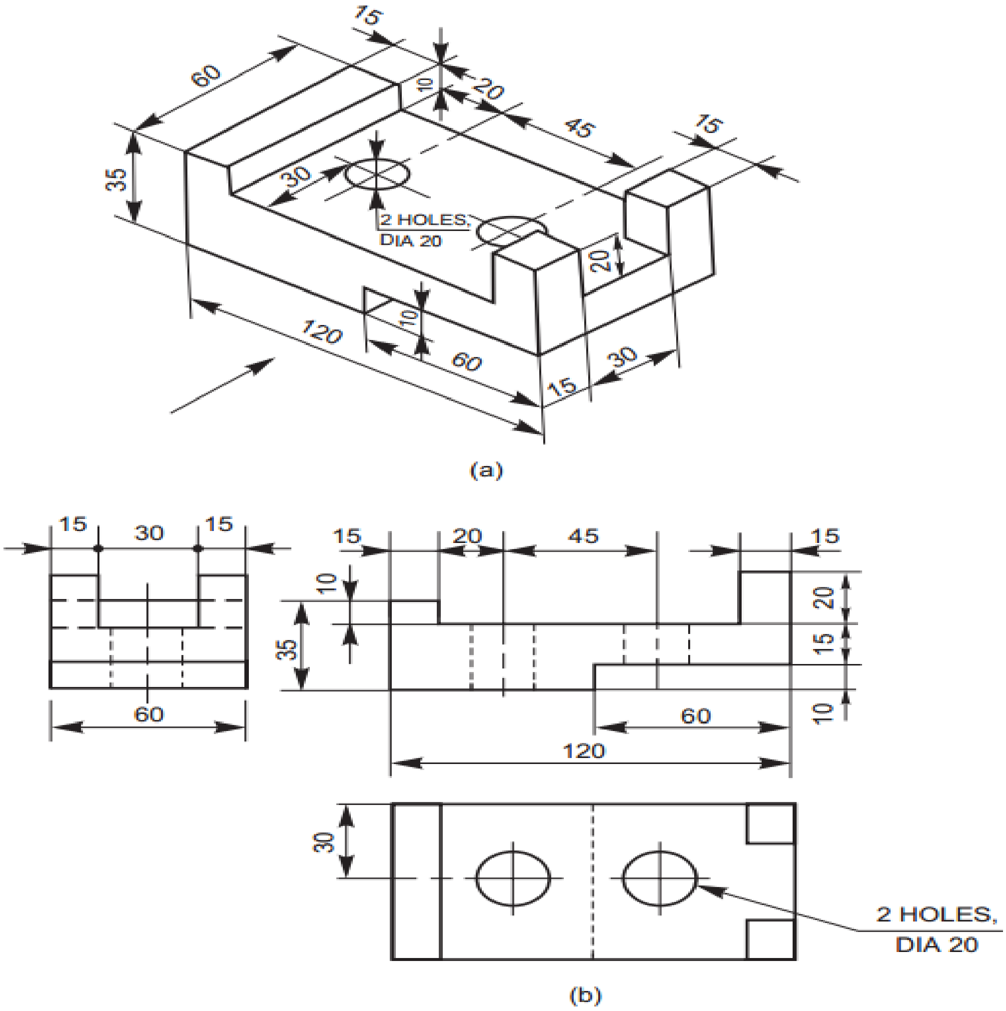
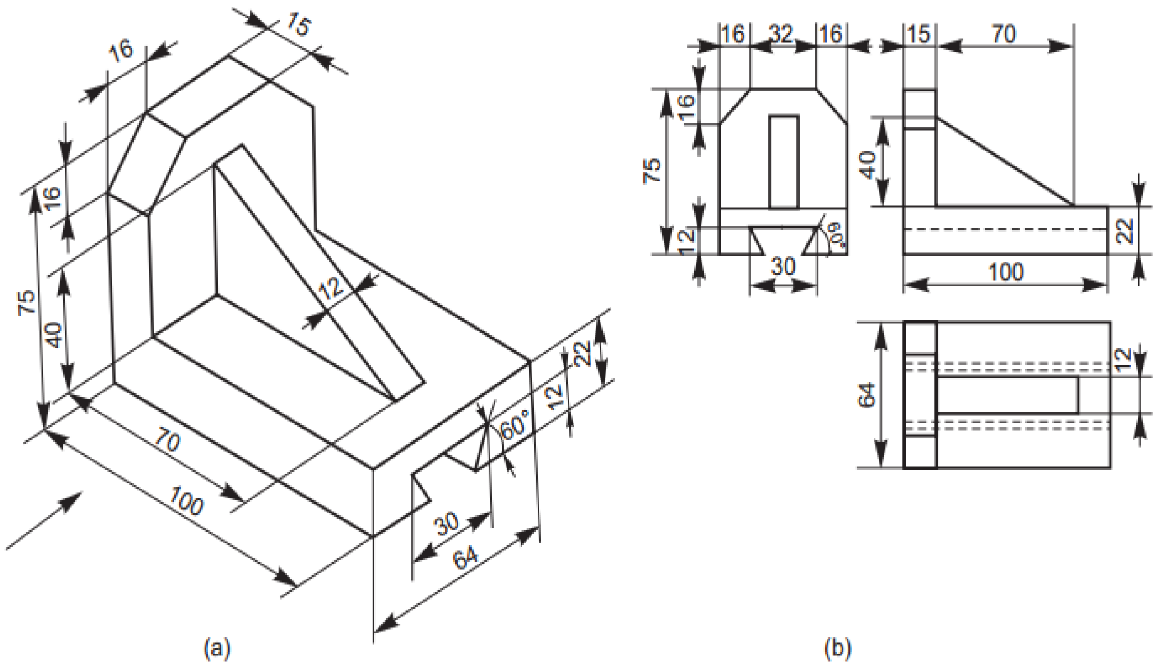


Figure 41

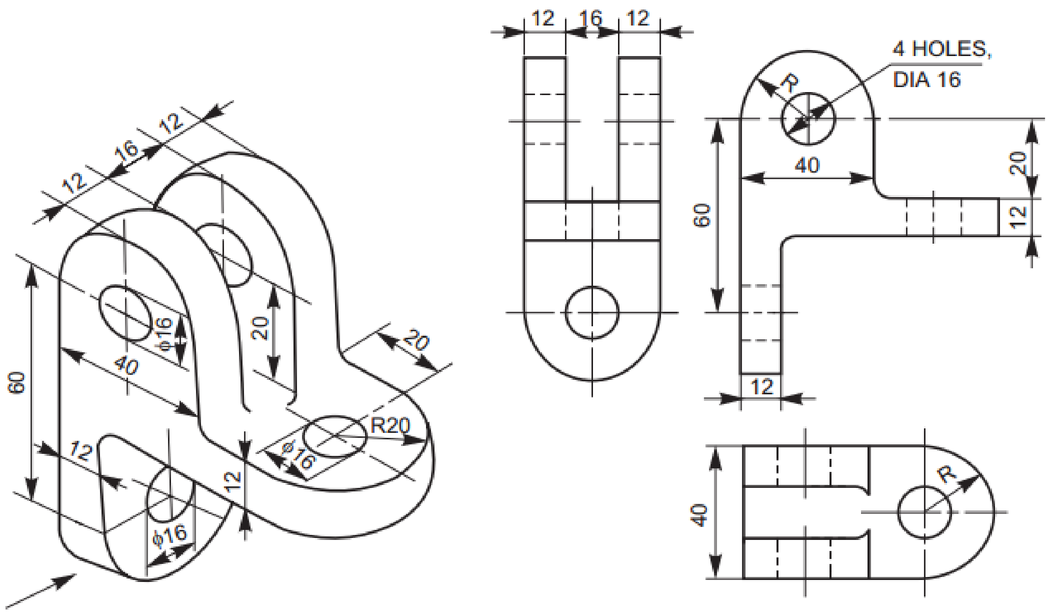
Examples 2



(a) (b)

Figure 42

Examples 3



(a) (b)

Figure 43.

Examples 4

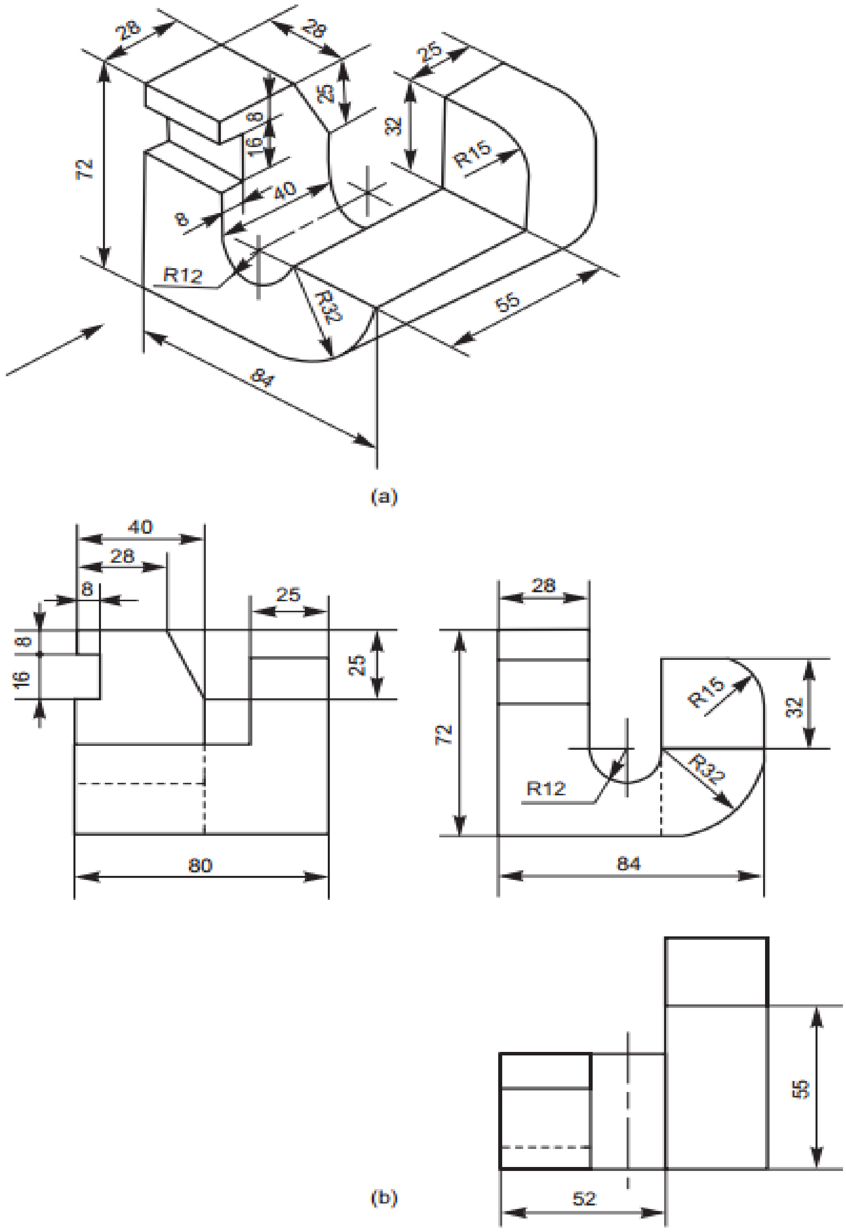


Figure 44

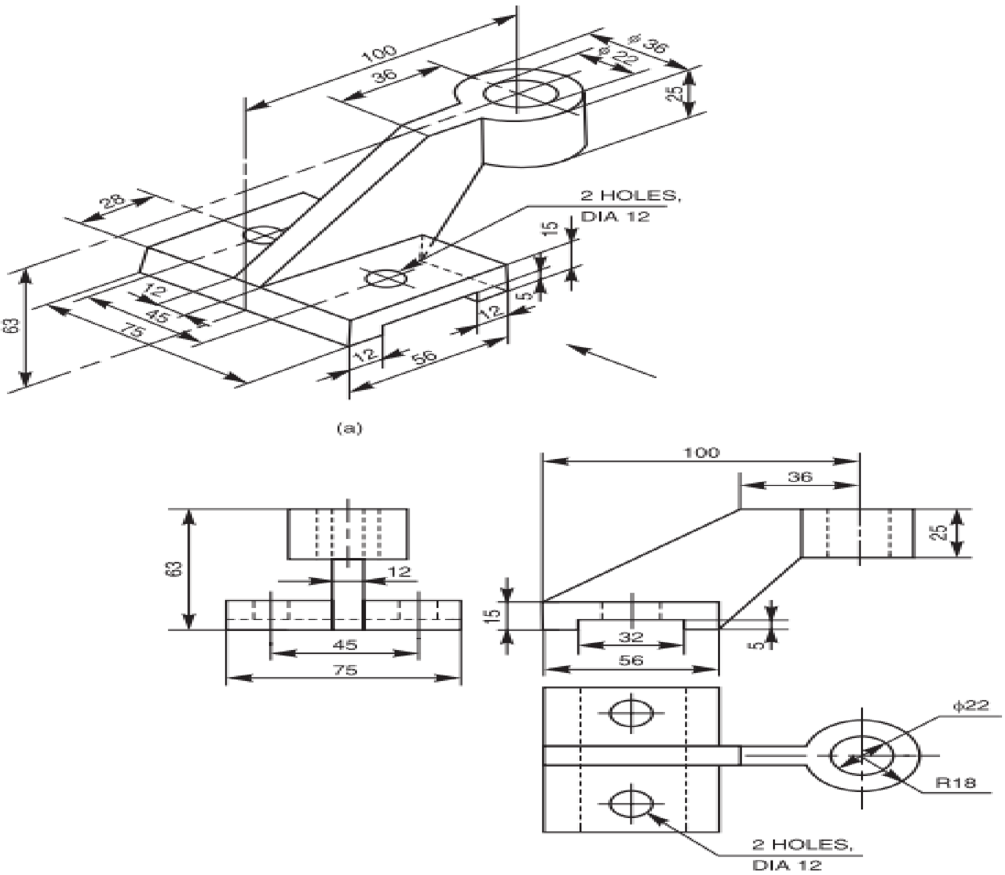


Figure 45

3. Dimensioning

It is a numerical value expressed appropriate unit of measurement and indicated graphically on technical drawings with lines, symbols and notes.

Dimensions are classified according to the following types:

- **Functional dimension** (F)**:** It is a dimension which isessential to the function of the component or space. They are generally shown with limits.
- **Non-functional dimension** (NF)**:** It is a dimension which is not essential for the function of the component or space.
- **Auxiliary or Reference dimension** (AUX/REF)**:** It is the dimension given for information only. It is derived from the values given on the drawing or related documents and it does not give in the production or inspection.

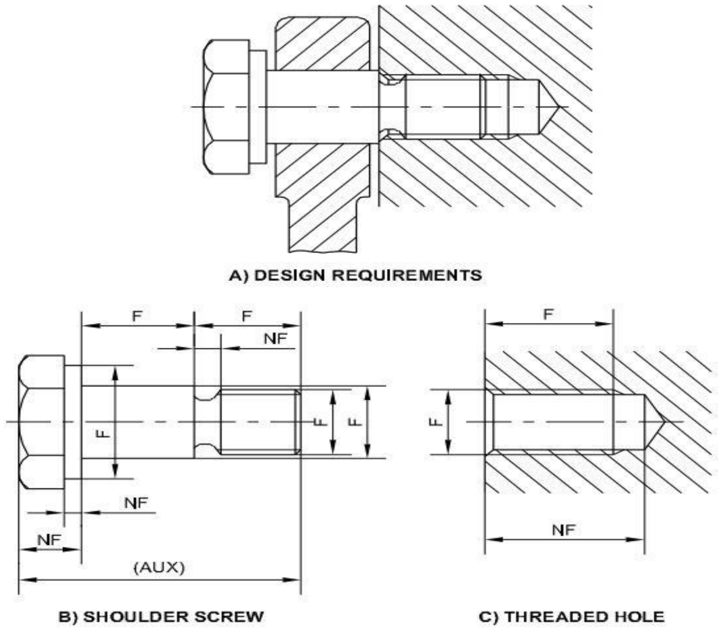


Figure 46.Functional, Non-functional and Reference Dimensions

- **Size dimensions:** Give the size of a component, part, hole, slot, depth, width, radius.
  e.g.: L1, L3, H, h1, S etc.
- **Location dimension:** Give or fixes the relationship of the features. Viz. centre of holes, slots and any significant forms.
  e.g.: L4, L5, L6

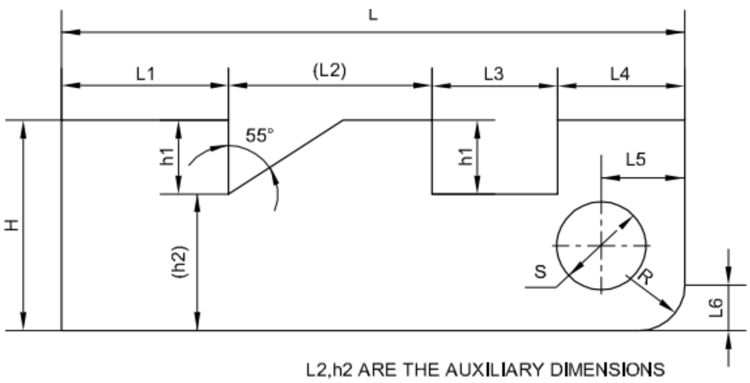


Figure 47.Size and Location Dimensions

The unit of measurement in general, unless or otherwise specified is mm (millimetres). On the dimensions of drawings, the abbreviation mm is omitted and a general note is given in an appropriate corner as "All dimensions are in mm".

Elements of dimensioning:

- ✓ Extension line – a
- ✓ Dimension line – b
- ✓ Leader line – c
- ✓ Termination of dimension line – d
- ✓ The original (starting point) indication and the dimension (a).

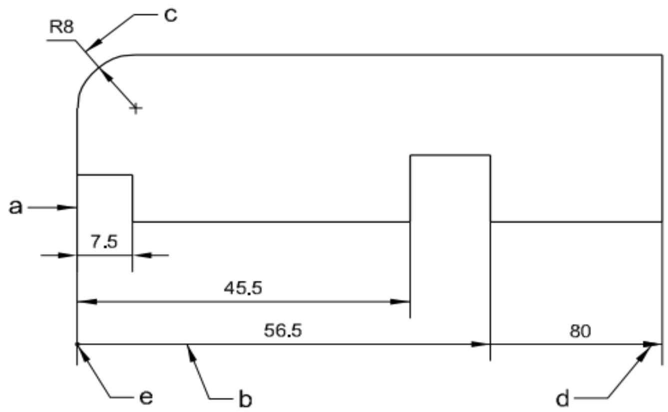


Figure 48.Elements of dimensioning

LO 2.2 – Identify tolerance, limits and fits

Introduction

The manufacture of interchangeable parts require precision. Precision is the degree of accuracy to ensure the functioning of a part as intended. However, experience shows that it is impossible to make parts economically to the exact dimensions. This may be due to:

- ✓ Inaccuracies of machines and tools,
- ✓ Inaccuracies in setting the work to the tool, and
- ✓ Error in measurement, etc.

The workman, therefore, has to be given some allowable margin so that he can produce a part, the dimensions of which will lie between two acceptable limits, a maximum and a minimum. The system in which a variation is accepted is called the limit system and the allowable deviations are called tolerances. The relationships between the mating parts are called fits. The study of limits, tolerances and fits is a must for technologists involved in production. The same must be reflected on production drawing, for guiding the craftsman on the shop floor.

- <u>Content/Topic 1: Definition of Terminologies</u>

1. **Tolerance**

The permissible variation of a size is called tolerance. It is the difference between the maximum and minimum permissible limits of the given size. If the variation is provided on one side of the basic size, it is termed as unilateral tolerance. Similarly, if the variation is provided on both sides of the basic size, it is known as bilateral tolerance.

2. **Limits**

The two extreme permissible sizes between which the actual size is contained are called limits. The maximum size is called the upper limit and the minimum size is called the lower limit.

3. **Deviation**

It is the algebraic difference between a size (actual, maximum, etc.) and the corresponding basic size.

4. **Actual Deviation**

It is the algebraic difference between the actual size and the corresponding basic size.

5. **Upper Deviation**

It is the algebraic difference between the maximum limit of the size and the corresponding basic size.

6. **Lower Deviation**

It is the algebraic difference between the minimum limit of the size and the corresponding basic size.

7. **Allowance**

It is the dimensional difference between the maximum material limits of the mating parts, intentionally provided to obtain the desired class of fit. If the allowance is positive, it will result in minimum clearance between the mating parts and if the allowance is negative, it will result in maximum interference.

8. **Basic Size**

It is determined solely from design calculations. If the strength and stiffness requirements need a 50mm diameter shaft, then 50mm is the basic shaft size. If it has to fit into a hole, then 50 mm is the basic size of the hole. *Fig.* illustrates the basic size, deviations and tolerances.

Here, the two limit dimensions of the shaft are deviating in the negative direction with respect to the basic size and those of the hole in the positive direction. The line corresponding to the basic size is called the zero line or line of zero deviation.

9. Design Size

It is that size, from which the limits of size are derived by the application of tolerances. If there is no allowance, the design size is the same as the basic size. If an allowance of 0.05 mm for clearance is applied, say to a shaft of 50 mm diameter, then its design size is (50 – 0.05) = 49.95 mm. A tolerance is then applied to this dimension.

10. Actual Size

It is the size obtained after manufacture.

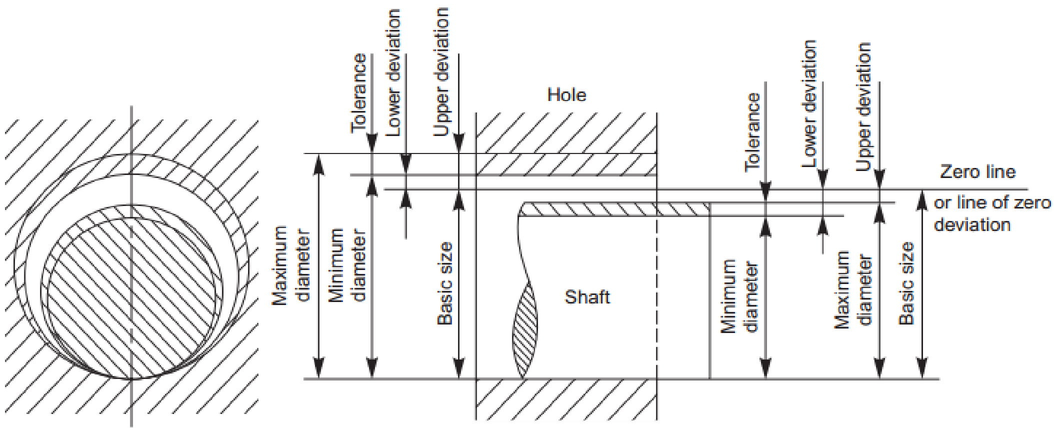


Figure 49.Diagram illustrating basic size deviations and tolerances

Content/Topic 2: Types of Tolerance

1. Geometrical Tolerance

Geometrical tolerance is defined as the maximum permissible overall variation of form or position of a feature.

Geometrical tolerances are used:

- ✓ to specify the required accuracy in controlling the form of a feature,
- ✓ to ensure correct functional positioning of the feature,
- ✓ to ensure the interchangeability of components, and
- ✓ to facilitate the assembly of mating components

Tolerance Zone

It is an imaginary area or volume within which the controlled feature of the manufactured component must be completely contained *(Fig. a, and b).*

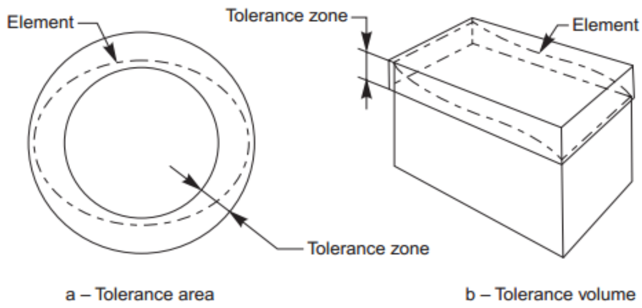


Figure 50.Tolerance Zone

Fundamental tolerances

Tolerance is denoted by two symbols, a letter symbol and a number symbol, called the grade. *Fig. II.2.2* shows the graphical illustration of tolerance sizes or fundamental deviations for letter symbols and *Table. II.2.1* lists the fundamental tolerances of various grades. It may be seen from *Fig. II.2.2* that the letter symbols range from **A** to **ZC** for holes and from **a** to **zc** for shafts. The letters **I, L, O, Q, W** and **i, l, o, q, w,** have not been used. It is also evident that these letter symbols represent the degree of closeness of the tolerance zone (positive or negative) to the basic size. For each nominal step, there are 18 grades of tolerances, designated as IT 01, IT 0 to IT 1 to IT 16, known as "Fundamental tolerances". The fundamental tolerance is a function of the nominal size and its unit is given by the empirical relation, standard tolerance unit, $i = 0.45 \times \sqrt[3]{D} + 0.001\,D$ where *i* is in microns and D is the geometrical mean of the limiting values of the basic steps mentioned above, in millimeters. This relation is valid for grades 5 to 16 and nominal sizes from 3 to 500 mm. For grades below 5 and for sizes above 500 mm, there are other empirical relations for which it is advised to ***refer IS: 1919–1963***.

Table. gives the relation between different grades of tolerances and standard tolerance unit

Table. Relative magnitude of IT tolerances for grades 5 to 16 in terms of tolerance unit i for sizes up to 500 mm

Grade	*IT 5*	*IT 6*	*IT 7*	*IT 8*	*IT 9*	*IT 10*	*IT 11*	*IT 12*	*IT 13*	*IT 14*	*IT 15*	*IT 16*
Tolerance values	$7i$	$10i$	$16i$	$25i$	$40i$	$64i$	$100i$	$160i$	$250i$	$400i$	$640i$	$1000i$

Example 1 *Calculate the fundamental tolerance for a shaft of 100 mm and grade 7.*
The shaft size, 100 lies in the basic step, 80 to 120 mm and the geometrical mean is
$D = \sqrt{80 \times 120} = 98$ mm
The tolerance unit, $i = 0.45\sqrt[3]{98} + 0.001 \times 98 = 2.172$ microns

For grade 7, as per the *Table. II.2.1*, the value of tolerance is, $16i = 16 \times 2.172 = 35$ microns

2. Tolerances of Form and Position

Tolerances of size are not always sufficient to provide the required control of form. For example, in *Fig. a,* shaft has the same diameter measurement in all possible positions but is not circular; in *Fig. b*, the component has the same thickness throughout but is not flat and in *Fig.c*, the component is circular in all cross-sections but is not straight. The form of these components can be controlled by means of geometrical tolerances.

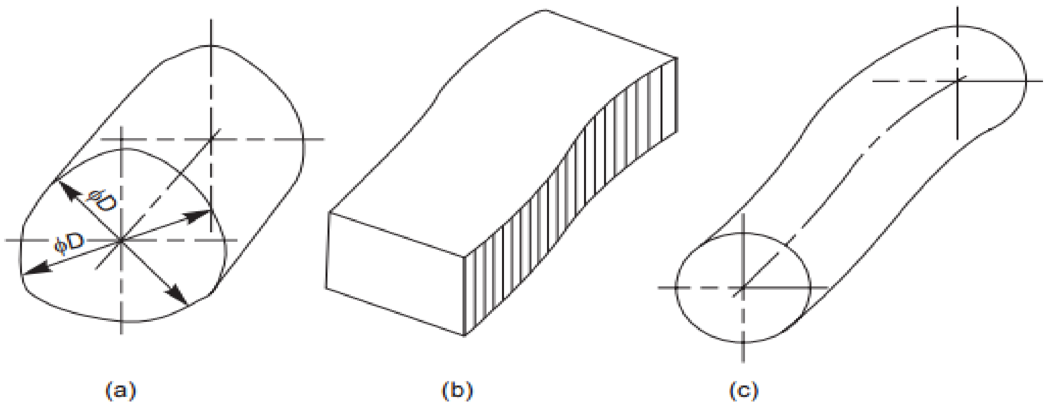


Figure 51.Errors of form

- **Form Variation**

It is a variation of the actual condition of a form feature (surface, line) from geometrically ideal form.

- **Position Variation**

It is a variation of the actual position of the form feature from the geometrically ideal position, with reference to another form (datum) feature.

- Content /Topic3: Types of Limits

There are three methods used in industries for placing limit dimensions or tolerancing individual dimensions.

Tolerance can be classified under the following categories:

- ✓ Unilateral tolerance
- ✓ Bilateral tolerance
- ✓ Limit tolerance

Symmetric limits

Symmetry is the condition where the median points of all opposed elements of two or more feature surfaces are congruent with the axis or center plane of a datum feature. In practice, this is not the case. Some tolerance is necessary. Symmetry control is a geometric tolerance that limits the symmetry error of a part feature. Note that symmetry control may only be applied to part features that are shown symmetrical to the datum center plane. And the tolerance zone is centered about the datum center plane. The width between the planes is equal to the symmetry control tolerance value. The media point must lie within the parallel plane tolerance zone. So, *Symmetry* – limits the extent to which the symmetrical axis of two planes is out of true between two parallel planes set a specified distance apart which are also symmetrical about the central datum axis.

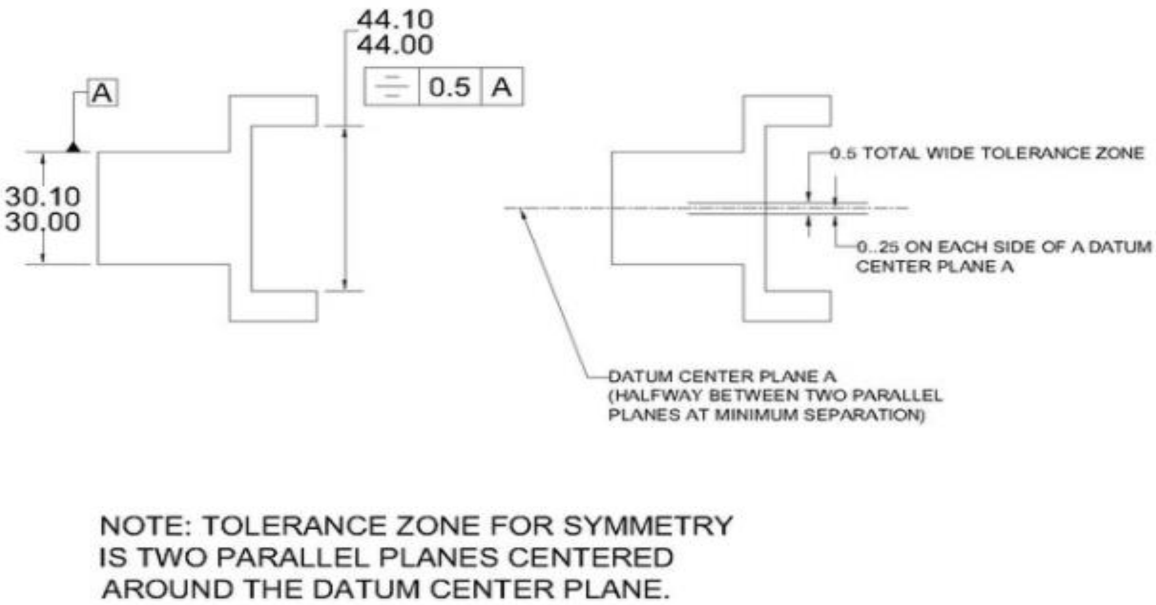


Figure 52.Symmetric limits

Unilateral Tolerance: When the tolerance distribution is only on one side of the basic size, it is known as unilateral tolerance. In other words, tolerance limits lie wholly on one side of the basic size, either above or below it.

Example: $40^{+0.02}_{+0.01}$, $40^{+0.02}_{-0.00}$, $40^{-0.01}_{-0.02}$, $40^{+0.00}_{-0.02}$

Bilateral Tolerance: When the tolerance distribution lies on either side of the basic size, it is known as bilateral tolerance. In other words, the dimension of the part is allowed to vary on both sides of the basic size but may not be necessarily equally disposed about it.

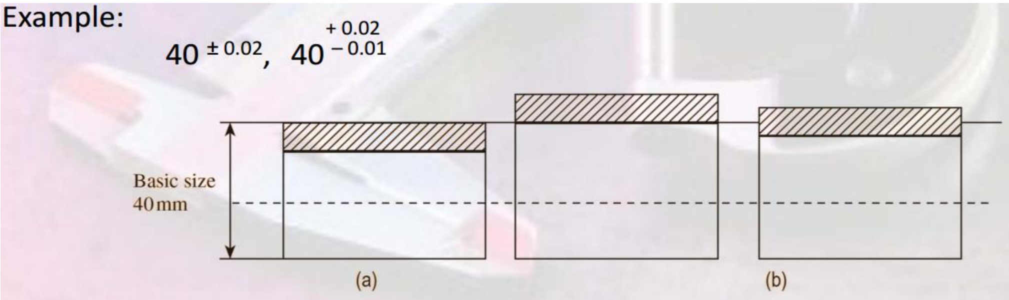


Figure 53.(a) Lateral, (b) Bilateral

- Content /Topic3: Types of Fits

The relation between two mating parts is known as a fit. Depending upon the actual limits of the hole or shaft sizes, fits may be classified as clearance fit, transition fit and interference fit.

1. **Clearance fits**

It is a fit that gives a clearance between the two mating parts.

✓ **Minimum clearance**

It is the difference between the minimum size of the hole and the maximum size of the shaft in a clearance fit.

✓ **Maximum clearance**

It is the difference between the maximum size of the hole and the minimum size of the shaft in a clearance or transition fit.

The fit between the shaft and hole in *Fig. II.2.6* is a clearance fit that permits a minimum clearance (allowance) value of 29.95 – 29.90 = + 0.05 mm and a maximum clearance of + 0.15 mm.

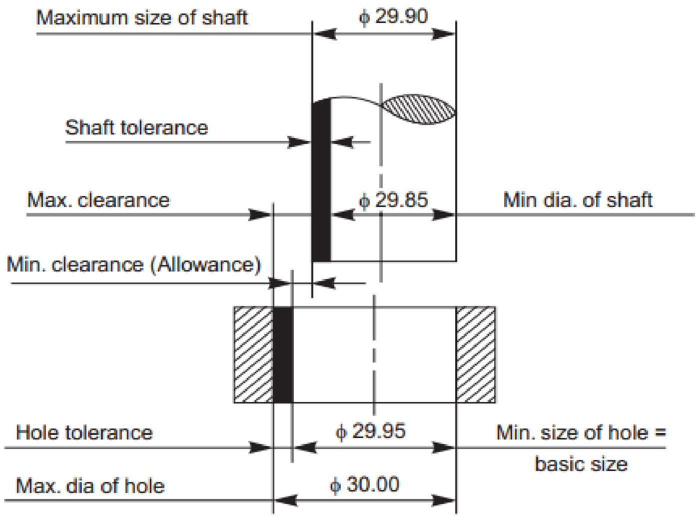


Figure 54.Clearance fit

2. **Transition Fits**

This fit may result in either an interference or a clearance, depending upon the actual values of the tolerance of individual parts. The shaft in *Fig.,* may be either smaller or larger than the hole and still be within the prescribed tolerances. It results in a clearance fit, when shaft diameter is 29.95 and hole diameter is 30.05 (+ 0.10 mm) and interference fit, when shaft diameter is 30.00 and hole diameter 29.95 (– 0.05 mm).

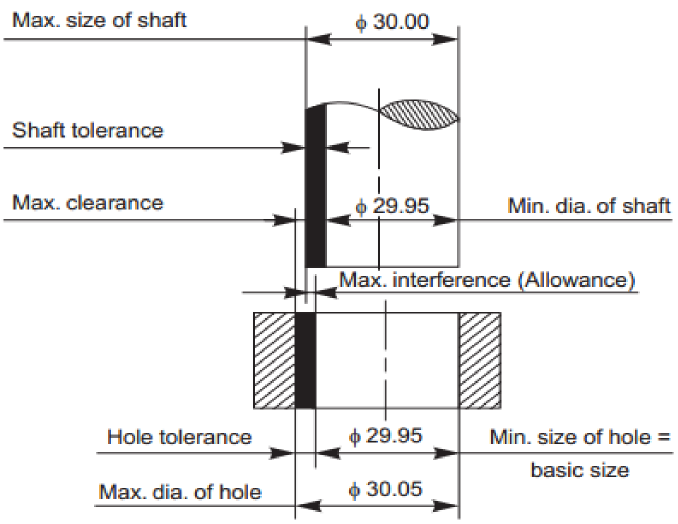


Figure 55.Transition fit

3. **Interference Fits**

If the difference between the hole and shaft sizes is negative before assembly; an interference fit is obtained.

- ✓ **Minimum Interference**

It is the magnitude of the difference (negative) between the maximum size of the hole and the minimum size of the shaft in an interference fit before assembly

- ✓ **Maximum Interference**

It is the magnitude of the difference between the minimum size of the hole and the maximum size of the shaft in an interference or a transition fit before assembly. The shaft in *Fig* is larger than the hole, so it requires a press fit, which has an effect similar to welding of two parts.

The value of minimum interference is 30.25 – 30.30 = – 0.05 mm and maximum interference is 30.15 – 30.40 = – 0.25 mm.

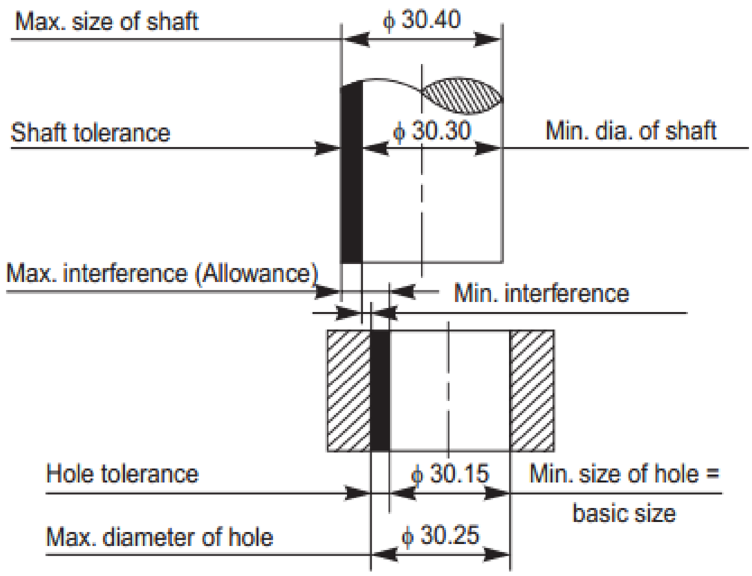


Figure 56.Interference fit

The conventional representation of these three classes of fits.

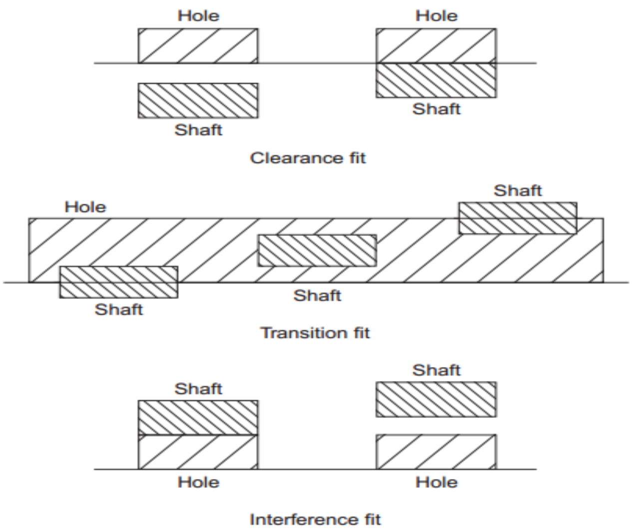


Figure 57.Schematic representation of fits

Hole Basis and Shaft Basis Systems

In working out limit dimensions for the three classes of fits; two systems are in use, *viz.*, the hole basis system and shaft basis system.

Hole Basis Systems

In this system, the size of the shaft is obtained by subtracting the allowance from the basic size of the hole. This gives the design size of the shaft. Tolerances are then applied to each part separately. In this system, the lower deviation of the hole is zero. The letter symbol for this situation is '*H*'.

The hole basis system is preferred in most cases, since standard tools like drills, reamers, broaches, etc., are used for making a hole.

Shaft Basis Systems

In this system, the size of the hole is obtained by adding the allowance to the basic size of the shaft. This gives the design size for the hole. Tolerances are then applied to each part. In this system, the upper deviation of the shaft is zero. The letter symbol for this situation is '*h*'. The shaft basis system is preferred by (*i*) industries using semi-finished shafting as raw materials, *e.g.,* textile industries, where spindles of same size are used as cold-finished shafting and (*ii*) when several parts having different fits but one nominal size is required on a single shaft. *Fig. II.2.10* shows the representation of the hole basis and the shaft basis systems schematically. *Table. II.2.2* gives equivalent fits on the hole basis and shaft basis systems to obtain the same fit.

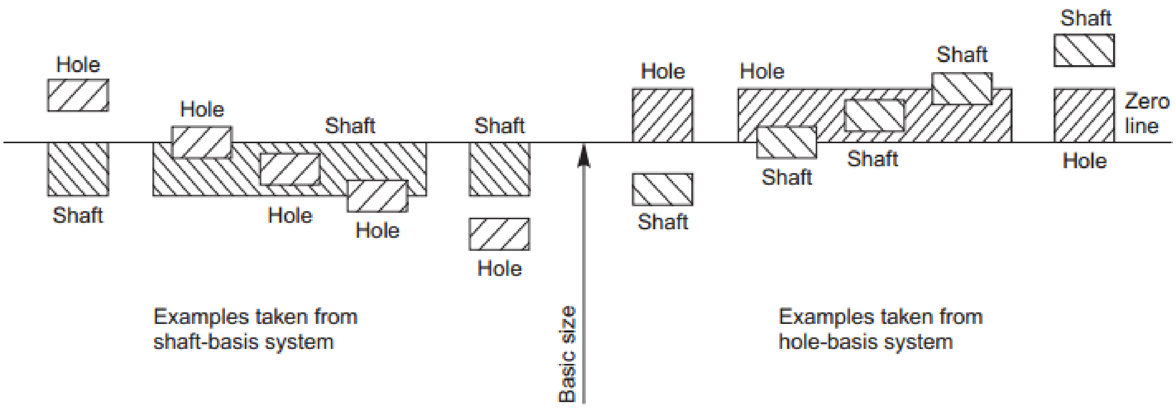


Figure 58.Examples illustrating shaft basis and hole basis systems

Clearance		Transition		Interference	
Hole basis	*Shaft basis*	*Hole basis*	*Shaft basis*	*Hole basis*	*Shaft basis*
H7 – c8	C8 – h7	H6 – j5	J6 – h5	H6 – n5	N6 – h5
H8 – c9	C9 – h8	H7 – j6	J7 – h6		
H11 – c11	C11 – h11	H8 – j7	J8 – h7	H6 – p5	P6 – h5
				H7 – p6	p7 – h6
H7 – d8	D8 – h7	H6 – k5	K6 – h5		
H8 – d9	D9 – h8	H7 – k6	K7 – h6	H6 – r5	R6 – h5
H11 – d11	D11 – h11	H8 – k7	K8 – h7	H7 – r6	R7 – h6
H6 – e7	E7 – h6	H6 – m5	M6 – h5	H6 – s5	S6 – h5
H7 – e8	E8 – h7	H7 – m6	M7 – h6	H7 – s6	S7 – h6
H8 – e8	E8 – h8	H8 – m7	M8 – h7	H8 – s7	S8 – h7
H6 – f6	F6 – h6	H7 – n6	N7 – h6	H6 – t5	T6 – h5
H7 – f7	F7 – h7	H8 – n7	N8 – h7	H7 – t6	T7 – h6
H8 – f8	F8 – h8			H8 – t7	T8 – h7
		H8 – p7	P8 – h7		
H6 – g5	G6 – h5			H6 – u5	U6 – h5
H7 – g6	G7 – h6	H8 – r7	R8 – h7	H7 – u6	U7 – h6
H8 – g7	G8 – h7			H8 – u7	U8 – h7

Table. 59Equivalent fits on the hole basis and shaft basis systems

Application of various types of fits in the hole basis system

Type of fit	*Symbol of fit*	*Examples of application*
Interference fit		
Shrink fit	H8/u8	Wheel sets, tyres, bronze crowns on worm wheel
Heavy drive fit	H7/s6	hubs, couplings under certain conditions, etc.
Press fit	H7/r6	Coupling on shaft ends, bearing bushes in hubs, valve
Medium press fit	H7/p6	seats, gear wheels.
Transition fit		
Light press fit	H7/n6	Gears and worm wheels, bearing bushes, shaft and wheel assembly with feather key.
Force fit	H7/m6	Parts on machine tools that must be changed without damage, *e.g.,* gears, belt pulleys, couplings, fit bolts, inner ring of ball bearings.
Push fit	H7/k6	Belt pulleys, brake pulleys, gears and couplings as well as inner rings of ball bearings on shafts for average loading conditions.
Easy push fit	H7/j6	Parts which are to be frequently dismantled but are secured by keys, *e.g.,* pulleys, hand-wheels, bushes, bearing shells, pistons on piston rods, change gear trains.
Clearance fit		
Precision sliding fit	H7/h6	Sealing rings, bearing covers, milling cutters on milling mandrels, other easily removable parts.
Close running fit	H7/g6	Spline shafts, clutches, movable gears in change gear trains, etc.
Normal running fit	H7/f7	Sleeve bearings with high revolution, bearings on machine tool spindles.
Easy running fit	H8/e8	Sleeve bearings with medium revolution, grease lubricated bearings of wheel boxes, gears sliding on shafts, sliding blocks.
Loose running fit	H8/d9	Sleeve bearings with low revolution, plastic material bearings.
Slide running fit	H8/c11	Oil seals (Simmerrings) with metal housing (fit in housing and contact surface on shaft), multi-spline shafts.

Table: Types of fits with symbols and applications

LO 2.3 – Identify surface roughness

- Content/Topic 1: Geometrical Characteristics of Surface Roughness

Introduction Surface Roughness

It is not possible to achieve in practice, a geometrically ideal surface of a component and hence, production drawings of components must also contain information about the permissible surface conditions. Machine components which have undergone machining operation, when inspected under magnification, will have some minute irregularities. The actual surface condition will depend upon the finishing process adopted. The properties and performance of machine components are affected by the degree of roughness of the various surfaces. The higher the smoothness of the surface, the better is the fatigue strength and corrosion resistance. Friction between mating parts is also reduced due to better surface finish

1. **The geometrical characteristics**

The geometrical characteristics of a surface include:

1. Macro-deviations,
2. Surface waviness, and
3. Micro-irregularities

The surface roughness is evaluated by the height, R_t and mean roughness index R_a of the micro-irregularities. Following are the definitions of the terms indicated in *Fig.*

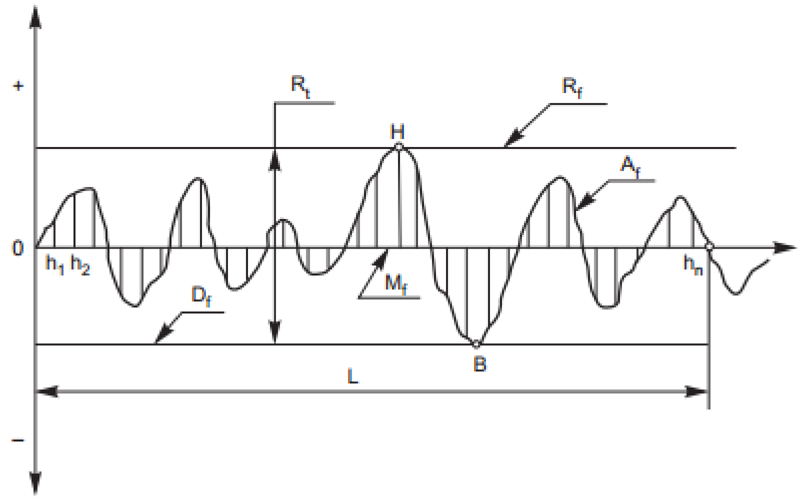


Figure 60. Geometrical characteristics of a surface

Actual Profile, *A_f*

It is the profile of the actual surface obtained by finishing operation.

Reference Profile, *R_f*

It is the profile to which the irregularities of the surface are referred to. It passes through the highest point of the actual profile.

Datum Profile, *D_f*

It is the profile, parallel to the reference profile. It passes through the lowest point B of the actual profile.

Mean Profile, *M_f*

It is that profile, within the sampling length chosen (*L*), such that the sum of the material-filled areas enclosed above it by the actual profile is equal to the sum of the material-void areas enclosed below it by the profile.

Peak-to-Valley Height, *R_t*

It is the distance from the datum profile to the reference profile.

Mean Roughness Index, *R_a*

It is the arithmetic mean of the absolute values of the heights *hi* between the actual and mean profiles. It is given by,

$$R_a = 1/L \int_{x=0}^{x=L} |h_i|\,dx \text{ , where } L \text{ is the sampling length}$$

Surface Roughness Number

The surface roughness number represents the average departure of the surface from perfection over a prescribed sampling length, usually selected as 0.8 mm and is expressed in microns.

The measurements are usually made along a line, running at right angle to the general direction of tool marks on the surface. Surface roughness values are usually expressed as the *Ra* value in microns, which are determined from *Fig. II.3.1.*

$$R_a = \frac{h_1 + h_2 + h_3 + \ldots + h_n}{n}$$

The surface roughness may be measured, using any one of the following:

- ✓ Straight edge
- ✓ Surface gauge
- ✓ Optical flat
- ✓ Tool maker's microscope
- ✓ Profilometer
- ✓ Profilograph
- ✓ Talysurf

Sl. No.	Manufacturing Process	R_a in μm	
1	Sand casting	5	50
2	Permanent mould casting	0.8	6.3
3	Die casting	0.8	3.2
4	High pressure casting	0.32	2
5	Hot rolling	2.5	50
6	Forging	1.6	28
7	Extrusion	0.16	5
8	Flame cutting, sawing & Chipping	6.3	100
9	Radial cut-off sawing	1	6.3
10	Hand grinding	6.3	25
11	Disc grinding	1.6	25
12	Filing	0.25	25
13	Planing	1.6	50
14	Shaping	1.6	25
15	Drilling	1.6	20
16	Turning & Milling	0.32	25
17	Boring	0.4	6.3
18	Reaming	0.4	3.2
19	Broaching	0.4	3.2
20	Hobbing	0.4	3.2
21	Surface grinding	0.063	5
22	Cylindrical grinding	0.063	5
23	Honing	0.025	0.4
24	Lapping	0.012	0.16
25	Polishing	0.04	0.16
26	Burnishing	0.04	0.8
27	Super finishing	0.016	0.32

Table. Surface roughness expected from various manufacturing processes

Indicating Geometrical Tolerances on the Drawing

To eliminate the need for descriptive notes, geometrical tolerances are indicated on drawings symbols, tolerances and datums, all contained in compartments of a rectangular frame, as shown in *Fig.*

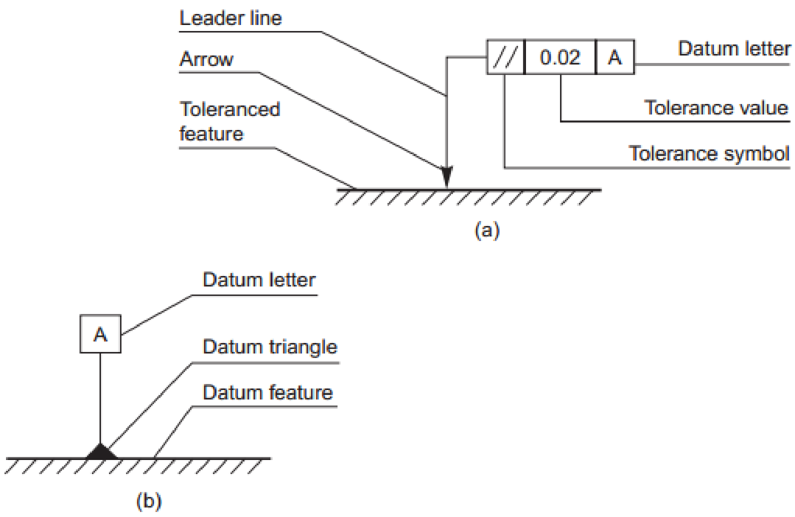


Figure 61.indicating geometrical tolerances

The tolerance frame is connected to the tolerance feature by a leader line, terminating with an arrow in the following ways:

1. On the outline of the feature or extension of the outline, but not a dimension line, when the tolerance refers to the line or surface itself *(Fig. a to c),* and
2. On the projection line, at the dimension line, when the tolerance refers to the axis or median plane of the part so dimensioned *(Fig.d)* or on the axis, when the tolerance refers to the axis or median plane of all features common to that axis or median plane *(Fig. e).*

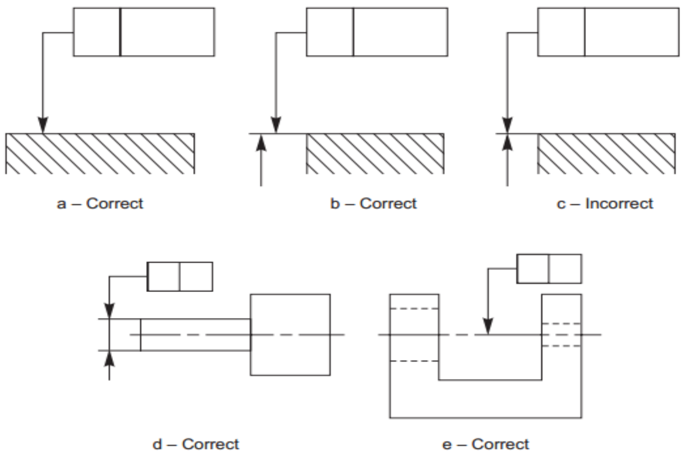


Figure 62.Indication of feature controlled (outline or surface only)

- <u>Content /Topic 2: Machine Symbols</u>

Standards Followed in Industries

Comparison of systems of indication of tolerances of form and of position as per IS: 3000 (part-1)-1976 and as prevalent in industry are shown in *Table.*

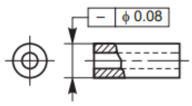
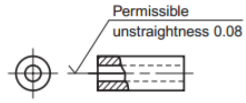
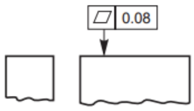
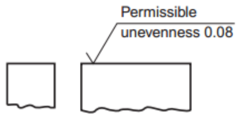
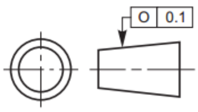
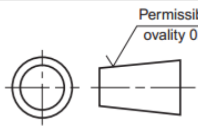
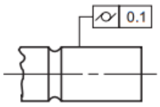
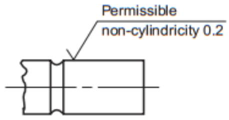
As per the standard	*As prevalent in industry*
1. Straightness tolerance	
	
2. Flatness tolerance	
	
3. Circularity tolerance	
	

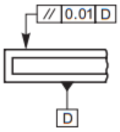
Table. Systems of indication of tolerances of form and of position (Contd.)

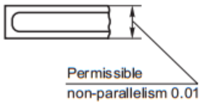
4. Cylindricity tolerance



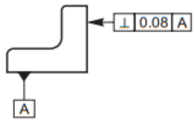


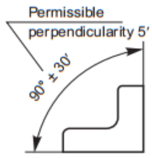
5. Parallelism tolerance



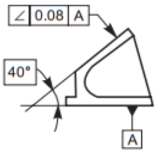


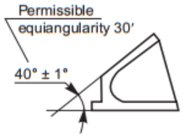
6. Perpendicularity tolerance



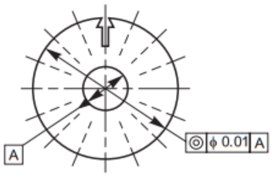


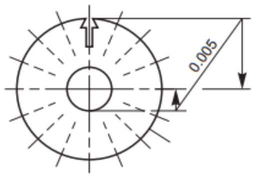
7. Angularity tolerance



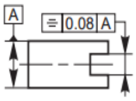


8. Concentricity and coaxiality tolerance

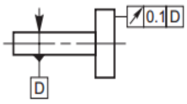


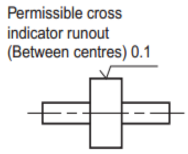


9. Symmetry tolerance

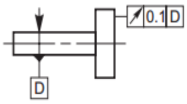


10. Radial run-out





11. Axial run-out



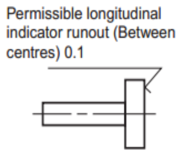


Table. Systems of indication of tolerances of form and of position.

- <u>Content /Topic 3: Indication of Surface Roughness Symbols</u>

1. Special surface roughness characteristics

When only one value is specified to indicate surface roughness, it represents the maximum permissible value. If it is necessary to impose maximum and minimum limits of surface roughness, both the values should be shown, with the maximum limit, *a*1, above the minimum limit, *a*2 *(Fig. a).*

In certain circumstances, for functional reasons, it may be necessary to specify additional special requirements, concerning surface roughness. If it is required that the final surface texture be produced by one particular production method, this method should be indicated on an extension of the longer arm of the symbol as shown in *Figb*. Also, any indications relating to treatment of coating may be given on the extension of the longer arm of the symbol. Unless otherwise stated, the numerical value of the roughness, applies to the surface roughness after treatment or coating. If it is necessary to define surface texture, both before and after treatment, this should be explained by a suitable note or as shown in *Fig.c*.

If it is necessary to indicate the sampling length, it should be selected from the series given in ISO/R 468 and be stated adjacent to the symbol, as shown in *Fig. d*. If it is necessary to control the direction of lay, it is specified by a symbol added to the surface roughness symbol, as shown in *Fig.e*.

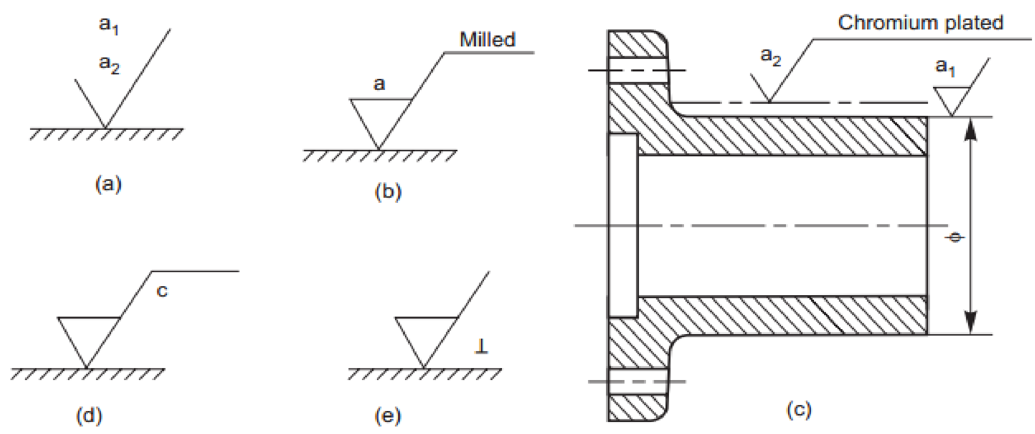


Figure 63.Special Surface Roughness Characteristics

NOTE The direction of lay is the direction of the predominant surface pattern, ordinarily determined by the production method employed.

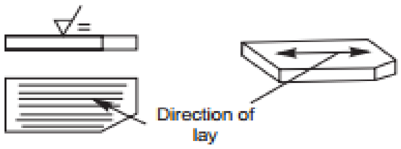
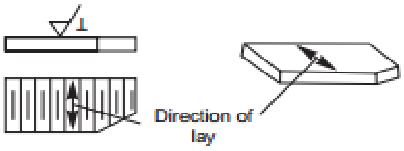
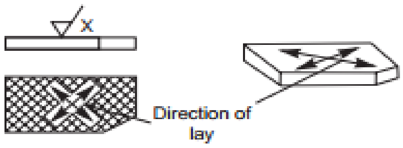
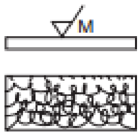
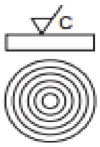
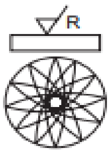
Symbol	Interpretation	
=	Parallel to the plane of projection of the view in which the symbol is used	
⊥	Perpendicular to the plane of projection of the view in which the symbol is used	
X	Crossed in two slant directions relative to the plane of projection of the view in which the symbol is used	
M	Multi-directional	
C	Approximately circular, relative to the centre of the surface to which the symbol is applied	
R	Approximately radial, relative to the centre of the surface to which the symbol is applied	

Table. Symbols specifying the directions of lay

2. Machining Allowance

When it is necessary to specify the value of the machining allowance, this should be indicated on the left of the symbol, as shown in *Fig. a*. This value is expressed normally in millimeters. *Fig. b* shows the various specifications of surface roughness, placed relative to the symbol.

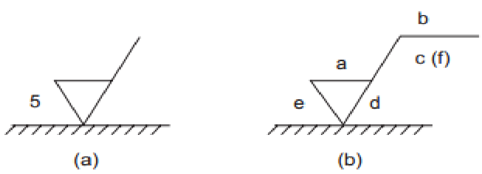


Figure 64.Machining allowance Indications

Learning Unit 3 – Perform assembly drawing works

LO 3.1 – Draw assembly components

- <u>Content/Topic 1: Types of Lines and Sketching</u>

Lines of different types and thicknesses are used for graphical representation of objects. The types of lines and their applications are shown in *Table.* Typical applications of different types of lines are shown in *Fig..1.1* and *Fig.1.2*

Line	*Description*	*General Applications*
A	Continuous thick	A1 Visible outlines
B	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching lines B6 Outlines of revolved sections in place B7 Short centre lines
C D	Continuous thin, free-hand Continuous thin (straight) with zigzags	C1 Limits of partial or interrupted views and sections, if the limit is not a chain thin D1 Line (see Fig. 2.5)
E	Dashed thick	E1 Hidden outlines
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H	Chain thin, thick at ends and changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin, double-dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines

Table. III. Types of lines and their applications

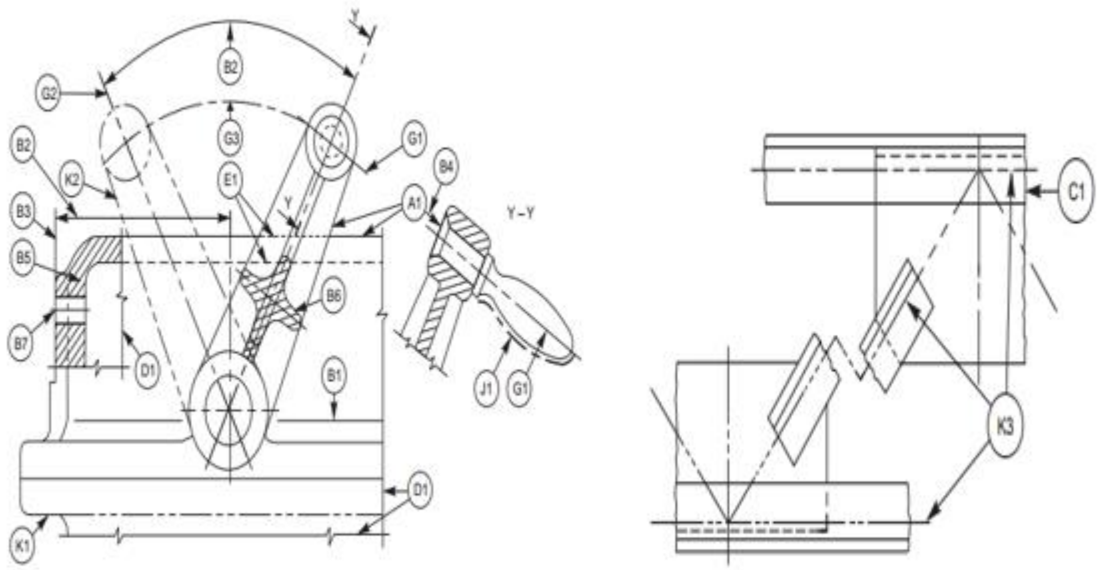


Figure 65.Applications of line

Thickness of Lines

Two thicknesses of lines are used in draughting practice. The ratio of the thick to thin line should not be less than 2:1. The thickness of lines should be chosen according to the size and type of the drawing from the following range:

0.18, 0.25, 0.35, 0.5, 0.7, 1, 1.4 and 2.

It is recommended that the space between two parallel lines, including hatching, should never be less than 0.7 mm.

- Content/Topic 2: Material Identifications

Conventional Representation

Certain draughting conventions are used to represent materials in section and machine elements in engineering drawings.

Materials

As a variety of materials are used for machine components in engineering applications, it is preferable to have different conventions of section lining to differentiate between various materials. The recommended conventions in use are shown in *Table. III.*

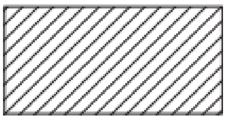
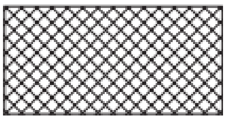
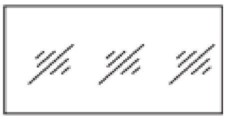
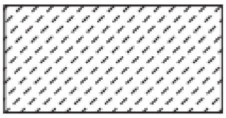
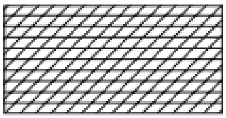
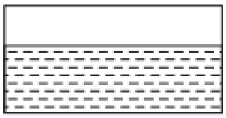
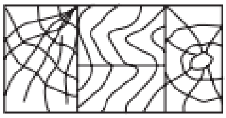
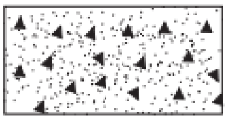
Type	Convention	Material
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminium and its Alloys, etc.
		Lead, Zinc, Tin, White-metal, etc.
Glass		Glass
Packing and Insulating material		Porcelain, Stoneware, Marble, Slate, etc.
		Asbestos, Fibre, Felt, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, Insulating and Filling materials, etc.
Liquids		Water, Oil, Petrol, Kerosene, etc.
Wood		Wood, Plywood, etc.
Concrete		A mixture of Cement, Sand and Gravel

Table. III. Conventional Representation of materials

Standard Abbreviations

Standard abbreviations in draughting are recommended as notes to provide a brief and clear instructions. *Table. III.* provides the material abbreviations for general terms and

Material	*Abbreviation*
Aluminium	AL
Brass	BRASS
Bronze	BRONZE
Cast iron	CI
Cast steel	CS
Chromium steel	CrS
Copper	Cu
Forged steel	FS
Galvanised iron	GI
Gray iron	FG
Gunmetal	GM
High carbon steel	HCS
High speed steel	HSS
High tensile steel	HTS
Low carbon steel	LCS
Mild steel	MS
Nickel steel	Ni S
Pearlitic malleable iron	PM
Phosphor bronze	PHOS.B
Sheet steel	Sh S
Spring steel	Spring S
Structure steel	St
Tungston carbide steel	TCS
Wrought iron	WI
White metal	WM

Table. III. Abbreviations for materials

Term	*Abbreviation*	*Term*	*Abbreviation*
Across corners	A/C	Maunfacture	MFG
Across flats	A/F	Material	MATL
Approved	APPD	Maximum	max.
Approximate	APPROX	Metre	m
Assembly	ASSY	Mechanical	MECH
Auxiliary	AUX	Millimetre	mm
Bearing	BRG	Minimum	min.
Centimetre	Cm	Nominal	NOM
Centres	CRS	Not to scale	NTS
Centre line	CL	Number	No.
Centre to centre	C/L	Opposite	OPP
Chamfered	CHMED	Outside diameter	OD
Checked	CHD	Pitch circle	PC
Cheese head	CH HD	Pitch circle diameter	PCD
Circular pitch	CP	Quantity	QTY
Circumference	OCE	Radius	R
Continued	CONTD	Radius in a note	RAD
Counterbore	C BORE	Reference	REF
Countersunk	CSK	Required	REQD
Cylinder	CYL	Right hand	RH
Diameter	DIA	Round	RD
Diametral pitch	DP	Screw	SCR
Dimension	DIM	Serial number	Sl. No.
Drawing	DRG	Specification	SPEC
Equi-spaced	EQUI-SP	Sphere/Spherical	SPHERE
External	EXT	Spot face	SF
Figure	FIG.	Square	SQ
General	GNL	Standard	STD
Ground level	GL	Symmetrical	SYM
Ground	GND	Thick	THK
Hexagonal	HEX	Thread	THD
Inspection	INSP	Through	THRU
Inside diameter	ID	Tolerance	TOL
Internal	INT	Typical	TYP
Left hand	LH	Undercut	U/C
Machine	M/C	Weight	WT

Table. III. Draughting abbreviations

- Content /Topic 3: Dimension Principles

A drawing of a component, 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.

General Principles

Dimension is a numerical value expressed in appropriate units of measurement and indicated on drawings, using lines, symbols, notes, etc., so that all features are completely defined:

1. As far as possible, dimensions should be placed outside the view.
2. Dimensions should be taken from visible outlines rather than from hidden lines.
3. Dimensioning to a centre line should be avoided except when the centre line passes through the centre of a hole.
4. Each feature should be dimensioned once only on a drawing.
5. Dimensions should be placed on the view or section that relates most clearly to the corresponding features.
6. Each drawing should use the same unit for all dimensions, but without showing the unit symbol.
7. No more dimensions than are necessary to define a part should be shown on a drawing.
8. No features of a part should be defined by more than one dimension in any one direction.

Methods of Execution

The elements of dimensioning include the projection line, dimension line, leader line, dimension line termination, the origin indication and the dimension itself. The various elements of dimensioning are shown in *Fig. III.1.3* and *Fig. III.1.4*.

The following are some of the principles to be adopted during execution of dimensioning:

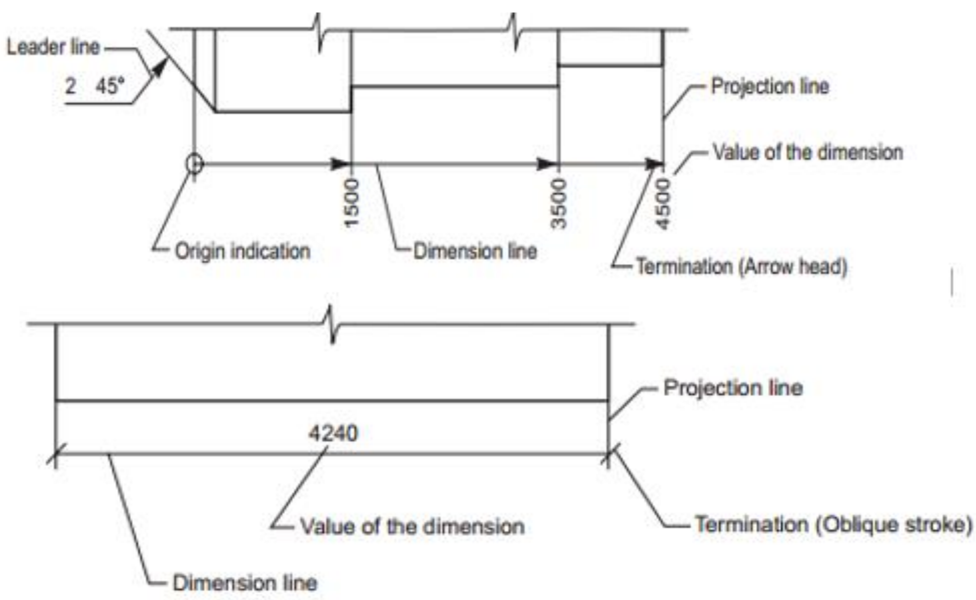
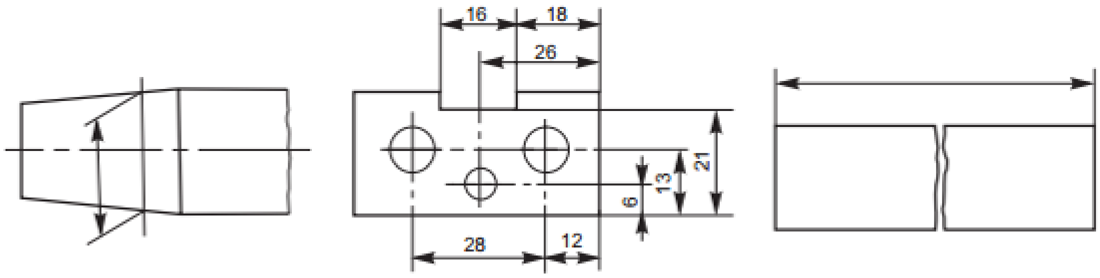


Figure 66.Elements of dimensioning

Dimensioning Principles

1. Projection and dimension lines should be drawn as thin continuous lines.
2. Projection lines should extend slightly beyond the respective dimension lines.
3. Projection lines should be drawn perpendicular to the feature being dimensioned. Where necessary, they may be drawn obliquely, but parallel to each other *(Fig.* However, they must be in contact with the feature.
4. Projection lines and dimension lines should not cross each other, unless it is unavoidable *(Fig)*
5. A dimension line should be shown unbroken, even where the feature to which it refers, is shown broken *(Fig.c).*
6. A centre line or the outline of a part should not be used as a dimension line, but may be used in place of projection line *(Figa)*.



(a) *(b)* / *(c)*

Figure 67.Dimensioning Principles

Dimension lines should show distinct termination, in the form of arrow heads or oblique strokes or where applicable, an origin indication. Two-dimension line terminations and an origin indication are shown in *Fig. III.1.6* in this,

1. The arrow head is drawn as short lines, having an included angle of 15°, which is closed and filled-in.
2. The oblique stroke is drawn as a short line, inclined at 45°.
3. The origin indication is drawn as a small open circle of approximately 3 mm in diameter.

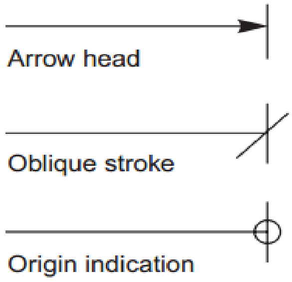


Figure 68.terminations and origin indication

The size of the terminations should be proportionate to the size of the drawing on which they are used. Where space is limited, arrow head termination may be shown outside the intended limits of the dimension line that is extended for that purpose. In certain other cases, an oblique stroke or a dot may be substituted *(Fig.)*. Where a radius is dimensioned, only one arrow head termination, with its point on the arc end of the dimension line, should be used *(Fig.)*. However, the arrow head termination may be either on the inside or outside of the feature outline, depending upon the size of feature.

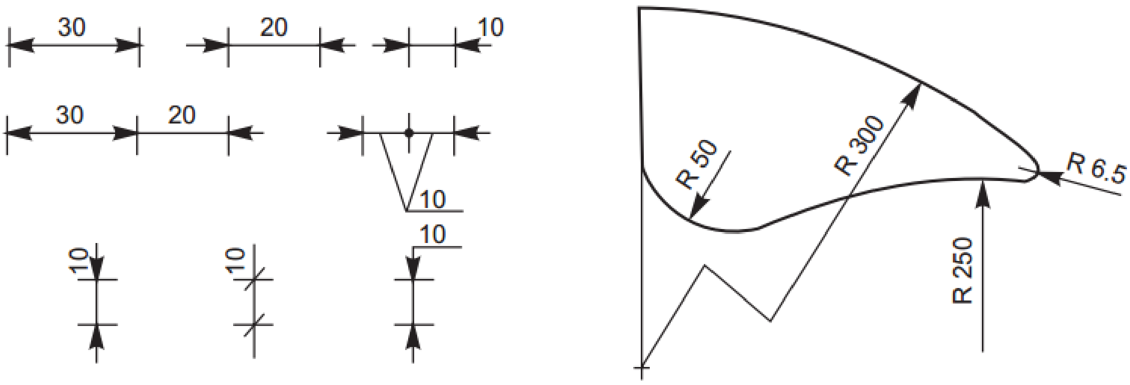


Figure 69.Dimensioning of small features and Radius Dimensioning

LO 3.2 – Dimension assembly drawing

- Content/Topic 1: Dimensioning Methods

1. Methods of Indicating Dimensions

Dimensions should be shown on drawings in characters of sufficient size, to ensure complete legibility. They should be placed in such a way that they are not crossed or separated by any other line on the drawing. Dimensions should be indicated on a drawing, according to one of the following two methods. However, only one method should be used on any one drawing.

(Aligned System)

Dimensions should be placed parallel to their dimension lines and preferably near the middle, above and clear-off the dimension line *(Fig).*

An exception may be made where superimposed running dimensions are used *(Fig. III.2.9 b)*

Dimensions may be written so that they can be read from the bottom or from the right side of the drawing. Dimensions on oblique dimension lines should be oriented as shown in *Fig. III.2.2*. Angular dimensions may be oriented as shown in *Fig. III.2.3*

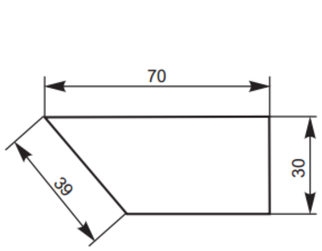


Fig. III.2.1 Placement of dimensions

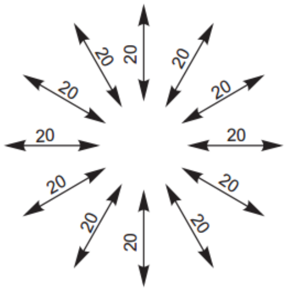


Fig. III.2.2 Oblique dimensioning

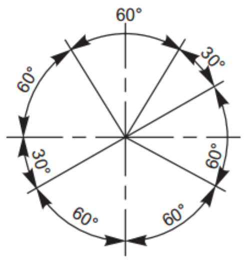


Fig. III.2.3 Angular dimensioning

2. **(Uni-directional system)**

Dimensions should be indicated so that they can be read from the bottom of the drawing only. Non-horizontal dimension lines are interrupted, preferably near the middle, for insertion of the dimension *(Fig. III.2.4).*
Angular dimensions may be oriented as in *Fig. III.2.5.*

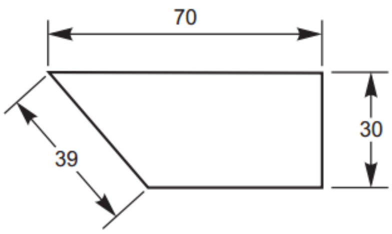


Fig. III.2.4 Placement of Dimensions

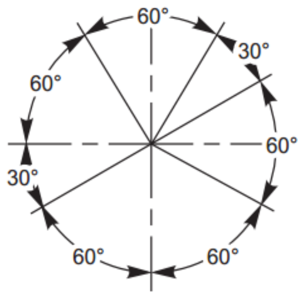
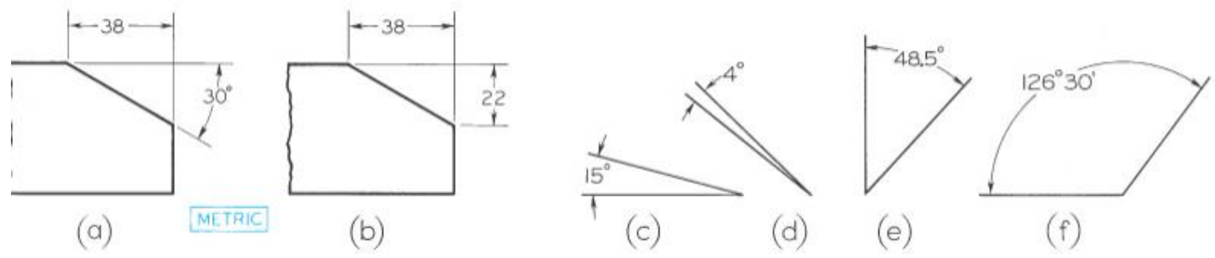


Fig. III.2.5 Angular dimensioning

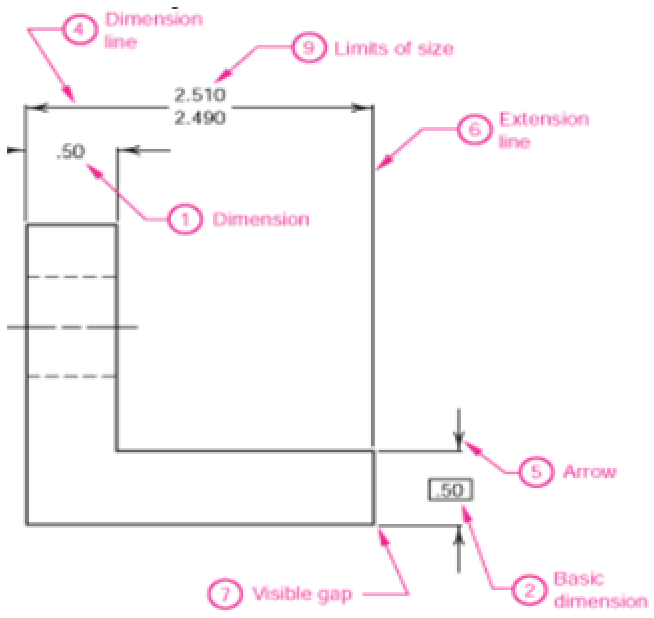
- <u>Content/Topic 2: Overall Dimensions Tips</u>

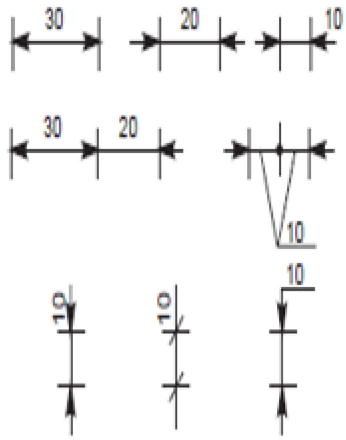
Angles We should dimension angles by specifying the angle in degrees and a linear dimension as shown in (a). We can also give coordinate dimensions for two legs of a right triangle, as shown in (b). Methods of indicating angles are shown on figures.



Arrowless

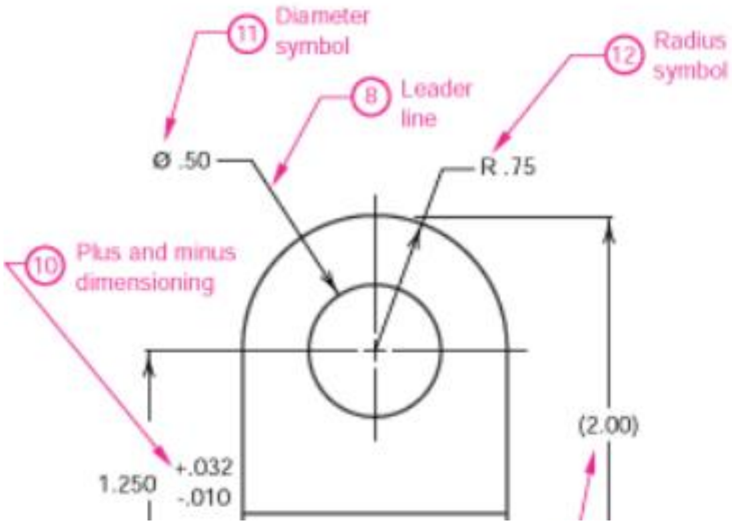
Arrows are placed at the ends of dimension lines to show the limits of the dimension.





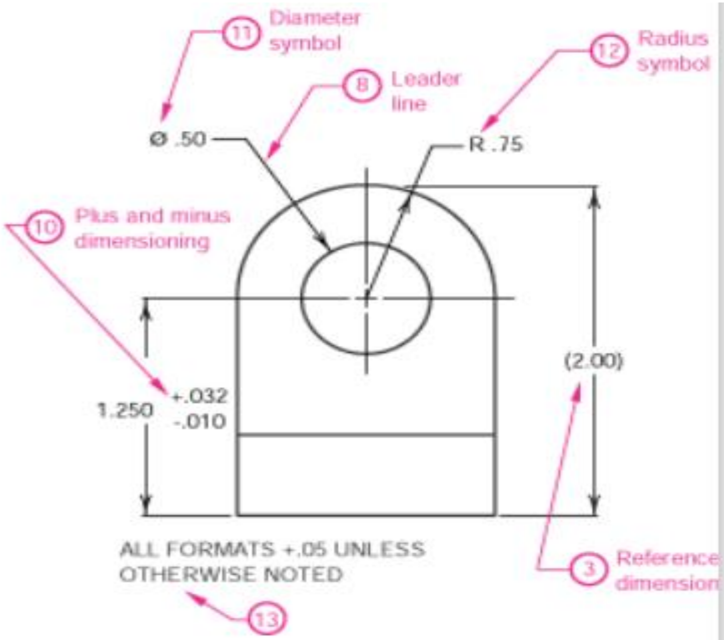
Diameter symbol is the symbol which is placed preceding a numerical value indicating that the associated dimension shows the diameter of a circle. The symbol used is the Greek letter phi. '

Radius symbol is the symbol which is placed preceding a numerical value indicating that the associated dimension shows the radius of a circle. The radius symbol used is the capital letter R.



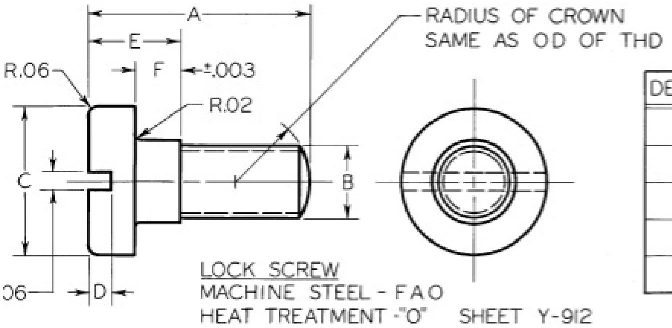
Reference dimensions

Reference dimension is the numerical value enclosed in parentheses provided for information only and is not used in the fabrication of the part.



Tabular

A serious of objects having like features but varying in dimensions may be represented by one drawing, as shown in figure below. Letters are substituted for dimension figures on the drawing, and the varying dimensions are given in tabular form. The dimensions of many standard parts are given in this manner in catalogs and handbooks.



DETAIL	A	B	C	D	E	F	UNC THD	STOCK	LBS
1	.62	.38	.62	.06	.25	.135	.312- 18	Ø.75	.09
2	.88	.38	.62	.09	.38	.197	.312- 18	Ø.75	.12
3	1.00	.44	.75	.12	.38	.197	.375- 16	Ø.875	.19
4	1.25	.50	.88	.12	.50	.260	.437- 14	Ø.1	.30
5	1.50	.56	1.00	.16	.62	.323	.5- 13	Ø1.125	.46

Chart

Steps in drawing any chart

1. **Access data**

   Look at the data structure and declare how to access the values we'll need

2. **Create chart dimensions**

   Declare the physical (i.e. pixels) chart parameters

3. **Draw canvas**

   Render the chart area and bounds element

4. **Create scales**

   Create scales for every data-to-physical attribute in our chart

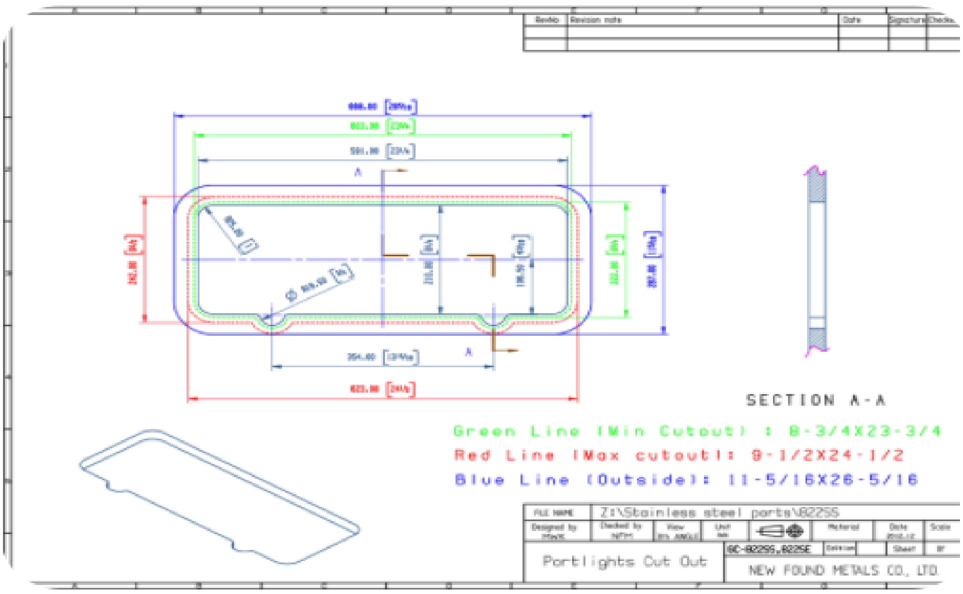
5. **Draw data**

   Render your data elements

6. **Draw peripherals**

   Render your axes, labels, and legends

7. **Set up interactions**



<u>Functional dimensioning principles</u>

Dimensions can be:

i. Above the extension of the dimension line, beyond one of the terminations, where space is limited *(Fig. III.1.8)* or

ii. At the end of a leader line, which terminates on a dimension line that is too short to permit normal dimension placement *(Fig. III.1.8)* or

iii. Above a horizontal extension of a dimension line, where space does not allow placement at the interruption of a non-horizontal dimension line *(Fig. III.2.6).* Values of dimensions, out of scale (except where break lines are used) should be underlined as shown in *Fig. III.2.6.*

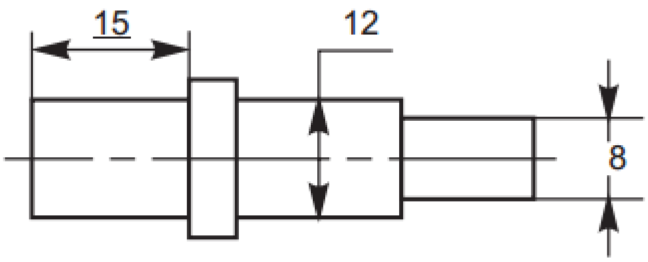


Figure 70.exception in dimensioning placement

The following indications (symbols) are used with dimensions to reveal the shape identification and to improve drawing interpretation. The symbol should precede the dimensions
(Fig).

Φ: Diameter SΦ: Spherical diameter R: Radius SR: Spherical radius □: Square

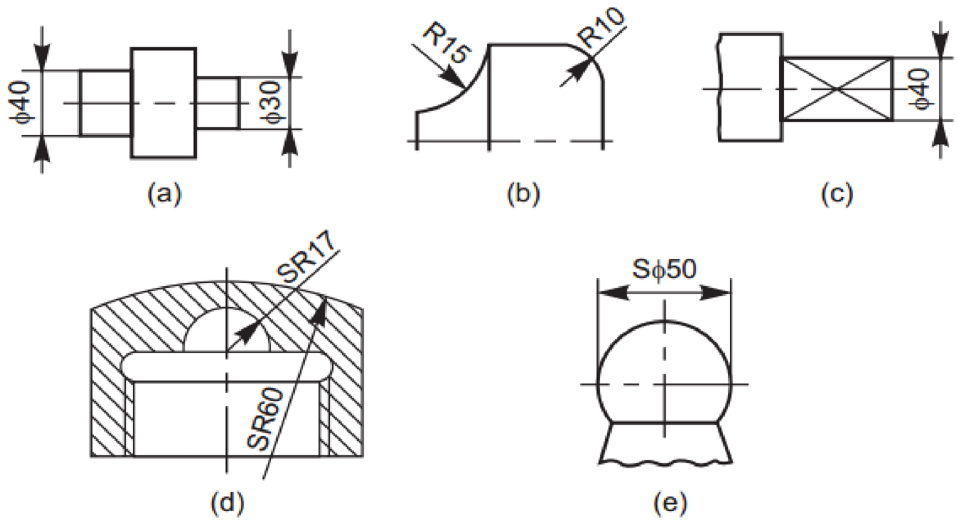


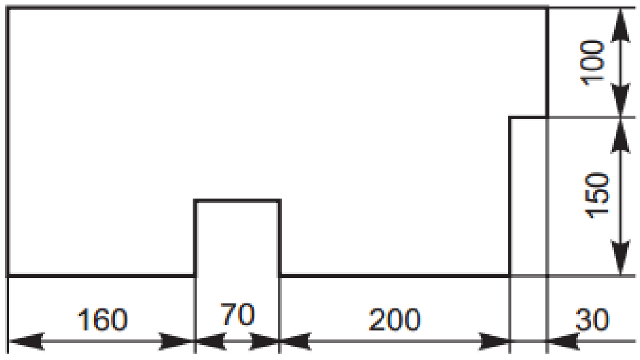
Figure 71.Shape identification symbols

Arrangement of Dimensions

The arrangement of dimensions on a drawing must indicate clearly the design purpose. The following are the ways of arranging the dimensions.

1. **Chain Dimensions**

Chains of single dimensions should be used only where the possible accumulation of tolerances does not endanger the functional requirement of the part *(Fig.*



Chain dimensioning

2. **Parallel Dimensions**

In parallel dimensioning, a number of dimension lines, parallel to one another and spaced-out are used. This method is used where a number of dimensions have a common datum feature *(Fig a).*

3. **Super-Imposed Running Dimensions**

These are simplified parallel dimensions and may be used where there are space limitations *(Fig.)*

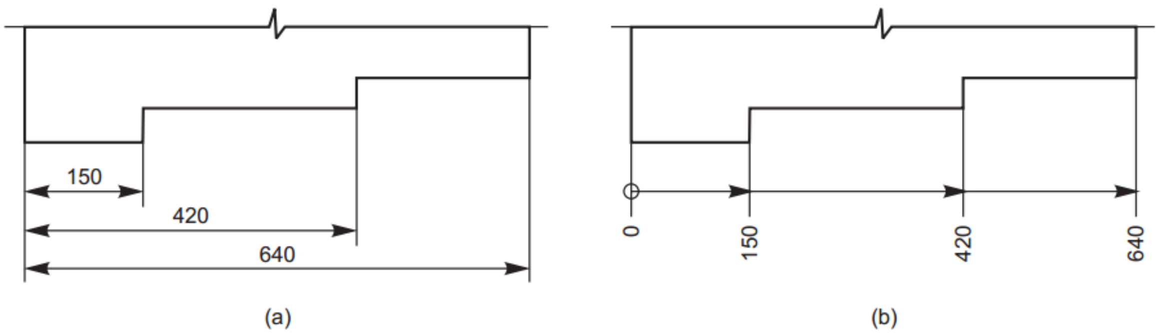


Figure 72.Parallel and Super-imposed Dimensioning

4. **Combined Dimensions**

These are the result of simultaneous use of chain and parallel dimensions

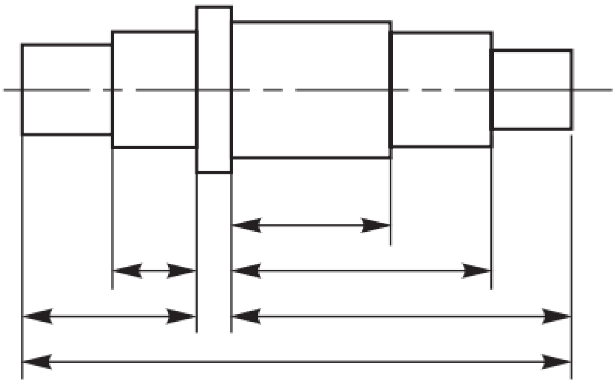
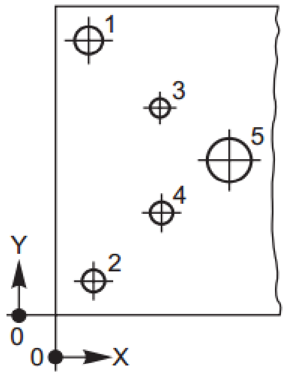


Figure 73.Combined dimensioning

5. **Co-ordinate Dimensions**

The sizes of the holes and their co-ordinates may be indicated directly on the drawing; or they may be conveniently presented in a tabular form, as shown in *Fig.*



	X	Y	ϕ
1	20	160	15.5
2	20	20	13.5
3	60	120	11
4	60	60	13.5
5	100	90	26
6			
7			
8			
9			
10			

Figure 74.Co-ordinate dimensioning

Special Indications

1. **Diameters**

Diameters should be dimensioned on the most appropriate view to ensure clarity. The dimension value should be preceded by ϕ. *Fig.* shows the method of dimensioning diameters.

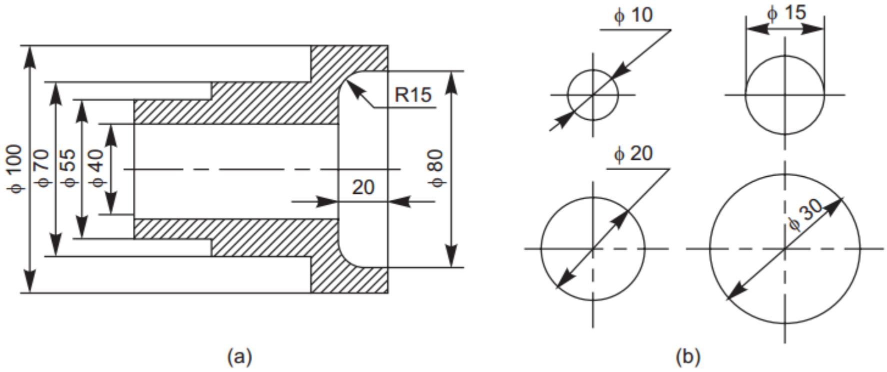


Figure 75.Dimensioning of diameters

2. **Chords, Arcs, Angles and Radii**

The dimensioning of chords, arcs and angles should be as shown in *Fig.*Where the centre of an arc falls outside the limits of the space available, the dimension line of the radius should be broken or interrupted according to whether or not it is necessary to locate the centre *(Fig.)*

Where the size of the radius can be derived from other dimensions, it may be indicated by a radius arrow and the symbol R, without an indication of the value *(Fig.).*

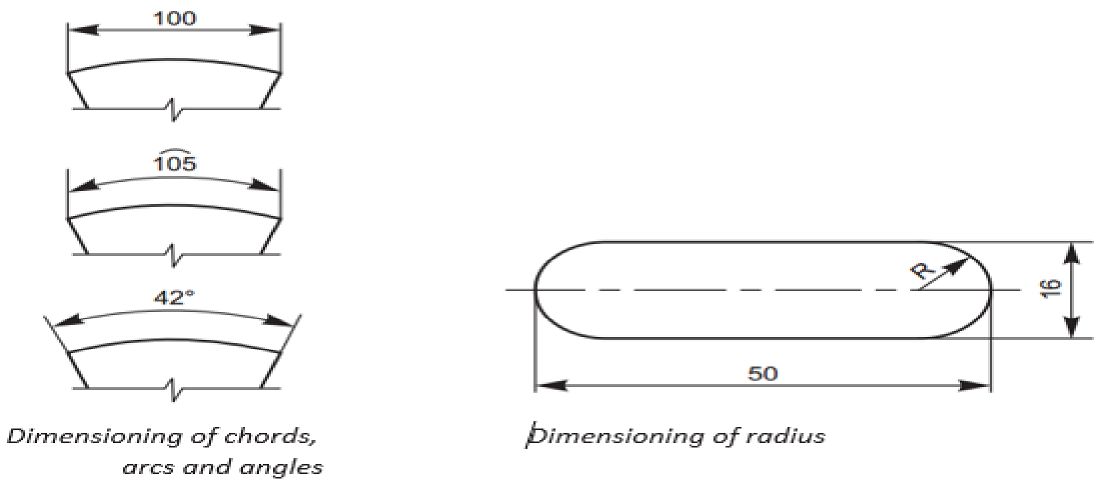


Figure 76.Chords, Arcs, Angles and Radii

3. **Equi-distant features**

Linear spacing with equi-distant features may be dimensioned as shown in *Fig. III.2.15*.

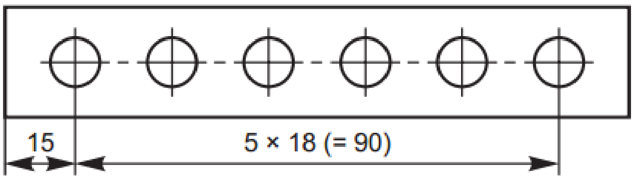
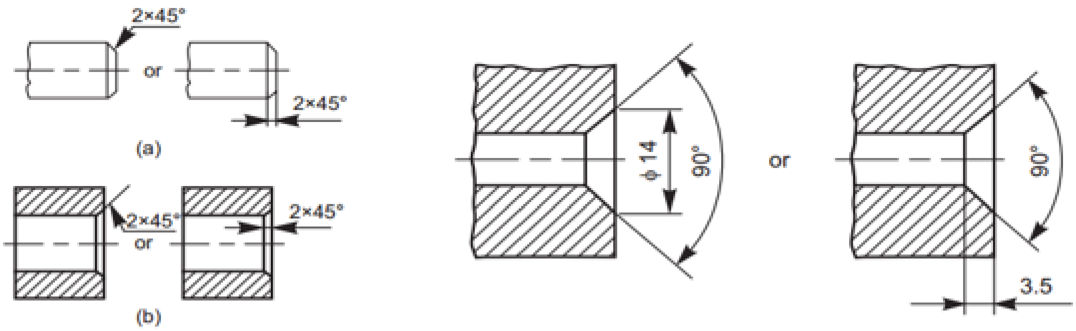


Figure 77,dimensioning equi-distant features

4. ***Chamfers and Countersunks***

Chamfers may be dimensioned as shown in *Fig. III.2.16* and countersunks, as shown in *Fig. III.2.17.*



Dimensioning chamfer

dimensioning countersunks

Figure 78.Chamfers and Countersunks

5. **Screw Threads**

Screw threads are always specified with proper designation. The nominal diameter is preceded by the letter M. The useful length of the threaded portion only should be dimensioned as shown in *Fig.* while dimensioning the internal threads, the length of the drilled hole should also be dimensioned *(Fig.).*

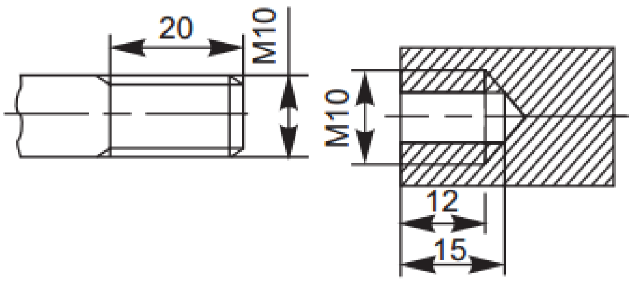


Figure 79.dimensioning screw threads

6. Tapered Features

Tapered features are dimensioned, either by specifying the diameters at either end and the length, or the length, one of the diameters and the taper or the taper angle *(Fig.a).* A slope or flat taper is defined as the rise per unit length and is dimensioned by the ratio of the difference between the heights to its length *(Fig.).*

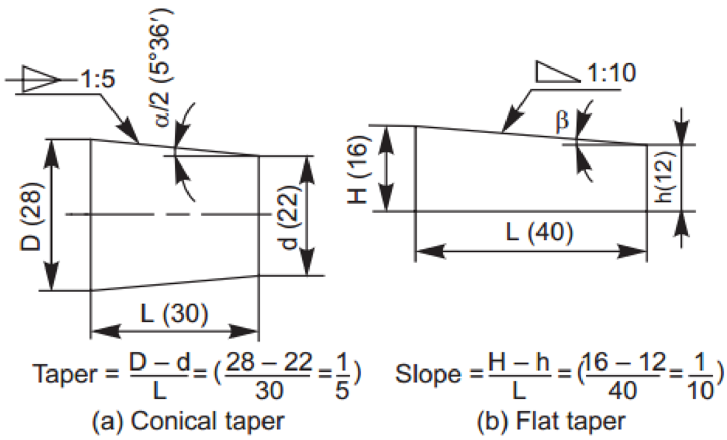


Figure 80.Dimensioning tapered features

Notes

Notes should always be written horizontally in capital letters and begin above the leader line and may end below also. Further, notes should be brief and clear and the wording should be standard in form. The standard forms of notes and the method of indication, for typical cases is shown in *Fig.* The meaning of the notes is given in Table 2.8.

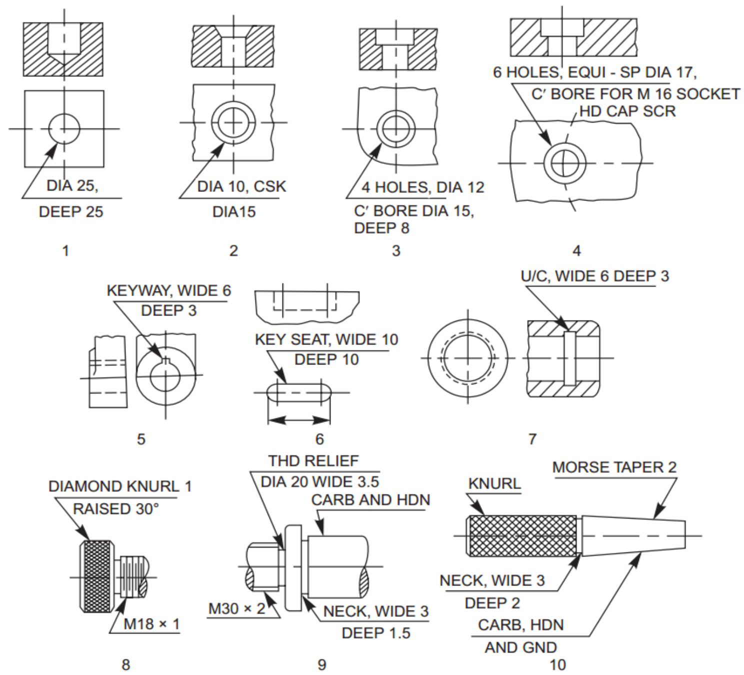


Figure 81.Method of indicating notes (Contd.)

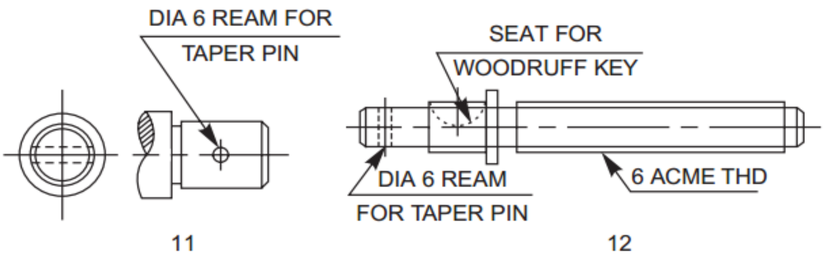


Figure 82.Method of indicating notes

S.No.	*Note*	*Meaning / Instruction*
1.	DIA 25 DEEP 25	Drill a hole of diameter 25 mm, to a depth of 25 mm.
2.	DIA 10 CSK DIA 15	Drill a through hole of diameter 10 mm and countersink to get 15 mm on top.
3.	4 HOLES, DIA 12 C BORE DIA 15 DEEP 8	Dirll through hole of ϕ 12 mm, counterbore to a depth of 8 mm, with a ϕ 15 mm, the number of such holes being four.
4.	6 HOLES, EQUI–SP DIA 17 C BORE FOR M 16 SOCKET HD CAP SCR	Drill a through hole of ϕ 17 and counterbore to insert a socket headed cap screw of M 16. Six holes are to be made equi-spaced on the circle.
5.	KEYWAY, WIDE 6 DEEP 3	Cut a key way of 6 mm wide and 3 mm depth.
6.	KEY SEAT, WIDE 10 DEEP 10	Cut a key seat of 10 mm wide and 10 mm deep to the length shown.
7.	U/C, WIDE 6 DEEP 3	Machine an undercut of width 6 mm and dpeth 3 mm.
8.	(*a*) DIAMOND KNURL 1 RAISED 30°	Make a diamond knurl with 1 mm pitch and end chamfer of 30°.
	(*b*) M 18 × 1	Cut a metric thread of nominal diameter 18 mm and pitch 1 mm.
9.	(*a*) THD RELIEF, DIA 20 WIDE 3.5	Cut a relief for thread with a diameter of 20.8 mm and width 3.5 mm.
	(*b*) NECK, WIDE 3 DEEP 1.5	Turn an undercut of 3 mm width and 1.5 mm depth
	(*c*) CARB AND HDN	Carburise and harden.
10.	(*a*) CARB, HDN AND GND	Carburise, harden and grind.
	(*b*) MORSE TAPER 2	Morse taper No. 1 to be obtained.
11.	DIA 6 REAM FOR TAPER PIN	Drill and ream with taper reamer for a diameter of 6 mm to suit the pin specified.
12.	6 ACME THD	Cut an ACME thread of pitch 6 mm.

***Table.* Meaning of notes given in *Fig*.**

- Content /Topic3: Functional Dimensioning Principles

Principles and application of dimensioning:

Before proceeding to give dimensions, consider the following steps:

- ✓ Mentally visualize the object and divide it into geometrical shapes such as prisms, cones, cylinders, pyramids etc.
- ✓ Place the size dimension on each form.

- ✓ Consider the relationship of mating parts and the process of production, then select the locating (reference or datum) centre lines and surfaces.
- ✓ Ensure that each geometrical form is located from a centre line and/or a finished surface.
- ✓ Place the overall dimensions.
- ✓ Add the necessary notes like surface finish, specific operations, material, fit, type of thread etc.

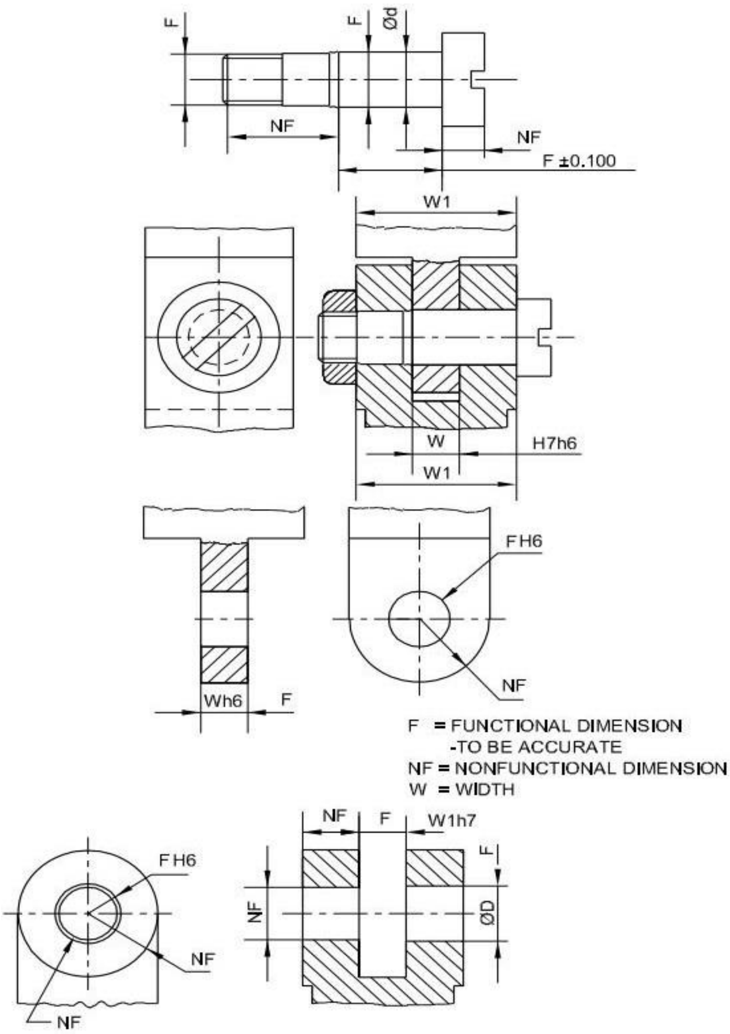


Figure 83.The necessary notes

- ✓ All dimensional information necessary to define a part or component clearly and completely shall be shown directly on a drawing unless this information is specified in relevant documents.
- ✓ Each feature shall be dimensioned once only on a drawing.
- ✓ Dimension shall be placed on the view or section that most clearly shows the features.

- ✓ Each drawing shall use the same unit (for example, millimetres) for all dimensions but without showing the unit symbol. In order to avoid misinterpretation, the pre-dominant unit symbol on a drawing may be specified in a note.
- ✓ No more dimensions than are necessary to define a part or an end product shall be shown on a drawing. No feature of a part or an end product shall be defined by more than one dimension in any one direction. Exception may, however be made:
  - Where it is necessary to give additional dimensions at intermediate stages of production (for example, the size of a feature prior to carburizing and finishing).
  - Where the addition of an auxiliary dimension would be advantageous.
- ✓ Projection lines should be drawn perpendicular to the feature being dimensioned. Where necessary, however, they may be drawn obliquely, but parallel to each other.

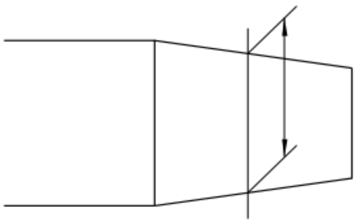


Figure 84.Parallel Oblique for Taper

- ✓ Dimension line shall be shown unbroken where feature to which it refers is shown broken, except in Method 2 (Unidirectional).

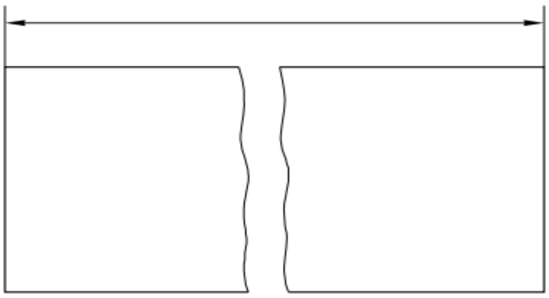


Figure 85.Partially Broken

- ✓ Avoid intersection of projection lines and dimension lines, where unavoidable neither line shall be shown with a break.

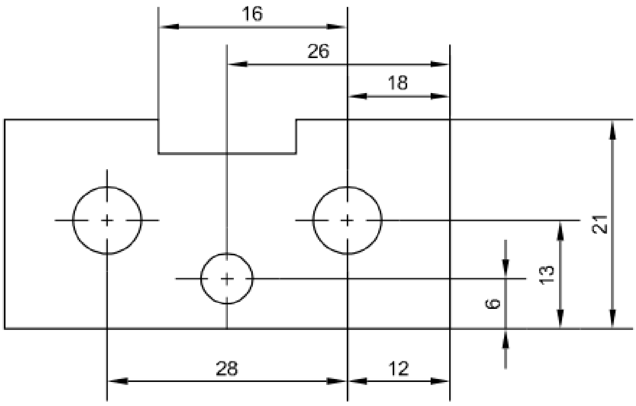


Figure 86.Avoid lines intersection

- ✓ Any one style of arrow head termination shall be used on a single drawing. However, where space is too small for arrow head, oblique stroke or dot may be substituted.

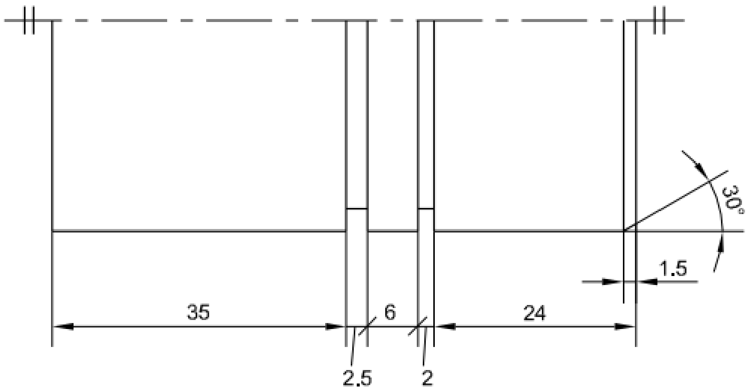


Figure 87.exception for head terminations

- ✓ Where the size of the radius can be derived from other dimensions, it shall be indicated with a radius arrow and the symbol `R' without an indication of the value.

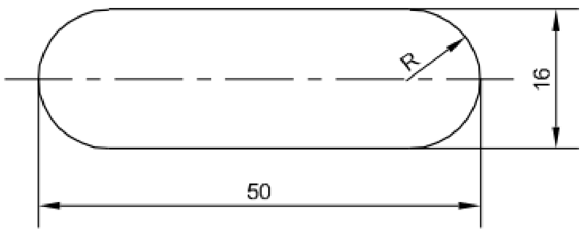


Figure 88.exception for radius dimensioning

- ✓ If it is possible to define a quantity of elements of the same size so as to avoid repeating the same dimensional value, they may be given as shown in *Fig.a, b.*

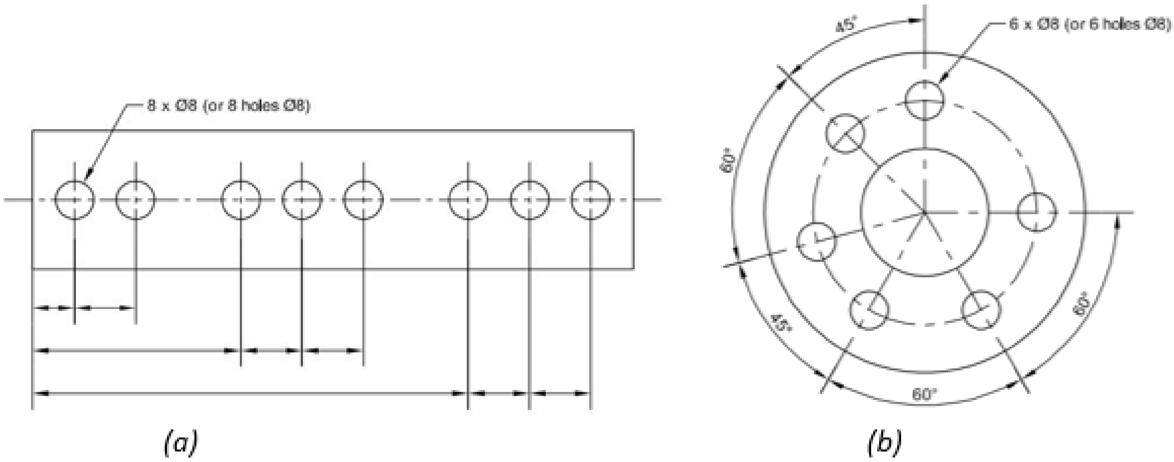


Figure 89.dimensioning of object with elements of the same size

- ✓ Where necessary, in order to avoid repeating the same dimensional value or to avoid long leader lines, reference letters may be used in connection with an explanatory table or note. Leader lines may be omitted.

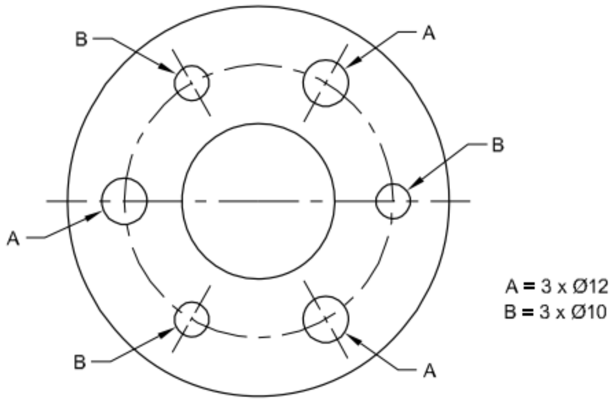


Figure 90.avoid repeating the same dimensional value and other features

LO 3.3 – Indicate drawing symbols

- Content/Topic 1: Methods of Drawing Symbols Indication

1. Extension

Extension lines are used to refer a dimension to a particular feature and are usually drawn perpendicular to the associated dimension line. Where space is limited, extension lines may be drawn at an angle.

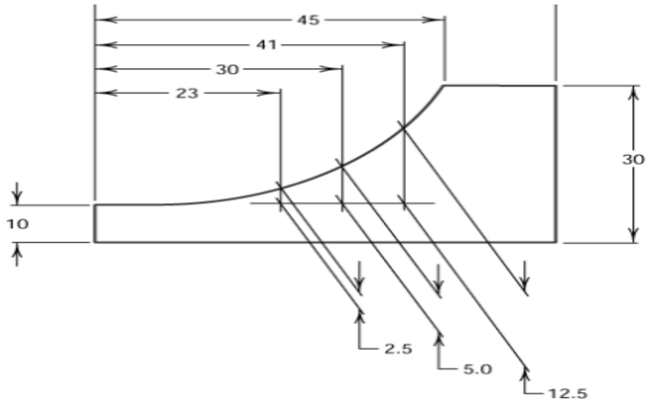


Figure 91.Extension

Extension lines should not cross dimension lines, and should avoid crossing other extension lines whenever possible. ′ When extension lines cross object lines or other extension lines, they are not broken. ′ When extension lines cross or are close to arrowheads, they are broken for the arrowhead.

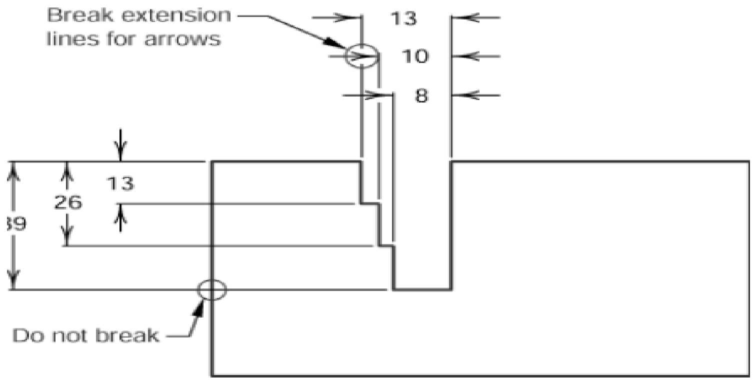


Figure 92.Extension

When the location of the center of a feature is being dimensioned, the center line of the feature is used as an extension line. ′ When a point is being located by extension lines only, the extensions lines must pass through the point.

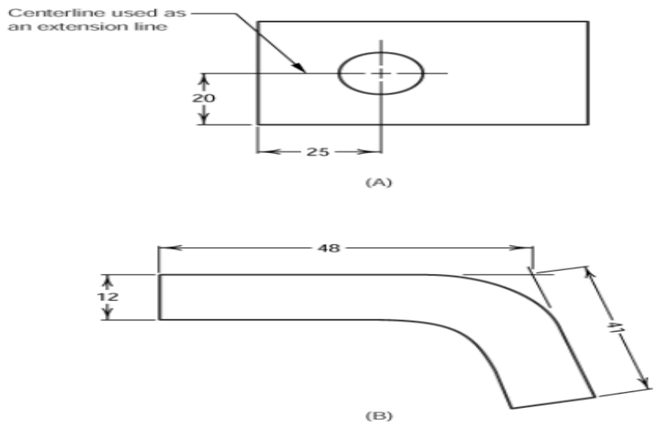


Figure 93.Extension

2. Surface

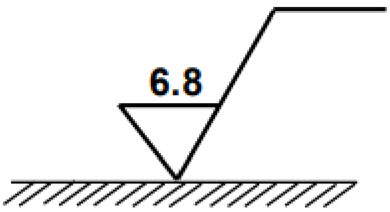


Figure 94.Surface symbol

The above slide shows the conventional method of indicating a surface finish requirement on a technical drawing, implying to someone measuring the surface that a maximum Ra value of 6.8µm is allowed. The symbol would also indicate the maximum allowable surface finish to the person producing the surface. This method of indication is open to a lot of interpretation. It does not tell the machinist how to achieve the required finish nor whether removal of any material to achieve the specified finish is allowed. No information is given to the person measuring the surface as to which parameter is being measured, which cut-off is to be used, which filter type should be used nor whether the specified value is in fact the maximum allowable value.

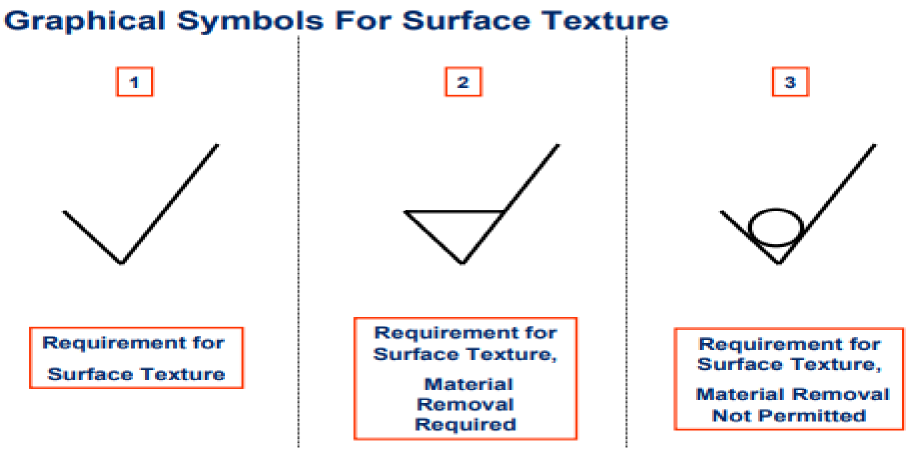


Figure 95.Surface symbol

To improve clarification of how surface texture is specified on technical drawings the international standard, ISO 1302:1999, has been produced. The above slide shows the three basic graphical symbols used with complementary information to indicate surface texture requirements. Each symbol has the basic following meaning:

1. Indicates that a requirement for surface texture exists but does not say if removal of material to achieve the specified finish is allowed or required.

2. Indicates that the removal of material by machining is required to obtain the required finish.

3. Indicates that removal of material is not permitted to obtain the required finish. This symbol would probably be used on a coated surface.

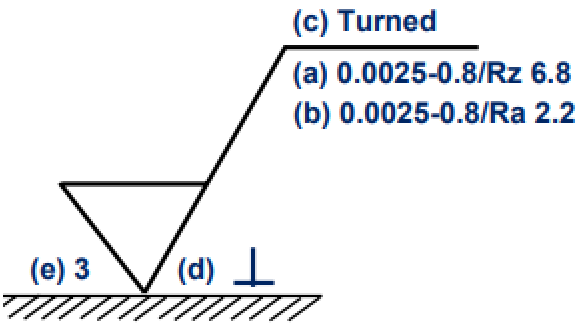


Figure 96.Surface symbol

In order to ensure unambiguity when specifying surface finish requirements, it is necessary to add the indication of the following:

(a)= Bandwidth/sample length/parameter numerical value

(b)= can be used for more parameter values

(c)= manufacturing method

(d)= surface lay & orientation

(e)= machining allowance The above symbol indicates that the removal of material by turning is required to achieve an Ra value of 2.2µm and an Rz value of 6.8µm when measured using a 0.8mm cut off and lower cut of value of 0.0025mm with Gaussian filtering. The maximum amount of material removal allowed to achieve the required finish would be 3mm. The surface lay direction and orientation would be perpendicular to the view of the symbol. Unless otherwise specified measurements should be made using a 0.8mm Gaussian filter with an evaluation length of five sample lengths

- Content/Topic 2: Types of Drawing Symbols

1. **Machining Symbols**

This article deals with the symbols and other additional indications of surface texture, to be indicated on production drawings.

The basic symbol consists of two legs of unequal length, inclined at approximately 60° to the line, representing the surface considered *(Fig.)*

This symbol may be used where it is necessary to indicate that the surface is machined, without indicating the grade of roughness or the process to be used. If the removal of material is not permitted, a circle is added to the basic symbol, as shown in *Fig. b*. This symbol may also be used in a drawing, relating to a production process, to indicate that a surface is to be left in the state, resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise. If the removal of material by machining is required, a bar is added to the basic symbol, as shown in *Fig. c*. When special surface characteristics have to be indicated, a line is added to the longer arm of the basic symbol, as shown in *Figd.*

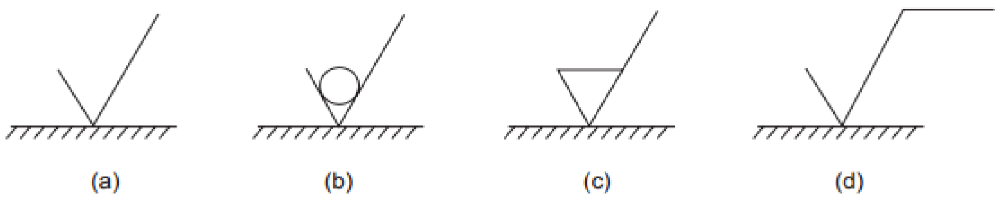


Figure 97.Machining Symbols

2. Surface Roughness Symbols

The value or values, defining the principal criterion of roughness, are added to the symbol as shown in *Fig.*

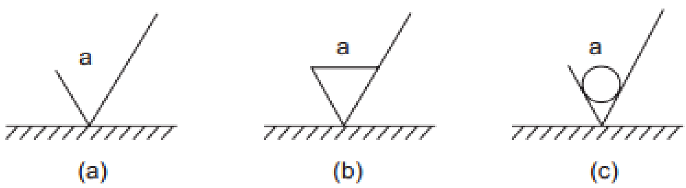


Figure 98.surface texture specification

A surface texture specified:

as in *Fig. a*, may be obtained by any production method,

as in *Fig. b*, must be obtained by removal of material by machining,

as in *Fig. c*, must be obtained without removal of material.

The principal criterion of surface roughness, R*a* may be indicated by the corresponding roughness grade number, as shown in *Table*.

Roughness values R_a µm	*Roughness grade number*	*Roughness grade symbol*
50	N12	∼
25	N11	▽
12.5	N10	
6.3	N9	▽▽
3.2	N8	
1.6	N7	
0.8	N6	▽▽▽
0.4	N5	
0.2	N4	
0.1	N3	▽▽▽▽
0.05	N2	
0.025	N1	

Table: Equivalent surface roughness symbols

<u>**Form and position symbols**</u>

Characteristics to be toleranced		*Symbols*
Form of single features	Straightness	⏤
	Flatness	▱
	Circularity (roundness)	○
	Cylindricity	⌭
	Profile of any line	⌒
	Profile of any surface	⌓
Orientation of related features	Parallelism	//
	Perpendicularity (squareness)	⊥
	Angularity	∠
Position of related features	Position	⌖
	Concentricity and coaxiality	◎
	Symmetry	⌯
	Run-out	↗

Table Symbols representing the characteristics to be tolerance

Learning unit 4. Clean and store tools, materials and Equipment

Learning Outcome 4.1: Clean tools and equipment.

- Content/Topic 1: Cleaning medium and tools

1. **Soft brushes**

There is a lot more to brushes than meets the eye. There are dozens of different types of brushes, each type has a specific use, and there are different bristles for every type of job.

Example soft brush:

- **Duster**

For use on all surfaces to remove dust particles and boost visual appeal

Figure 99Duster

- **Grout Brush**

For use on tile floors to clear heavy dirt and grime from between tiles

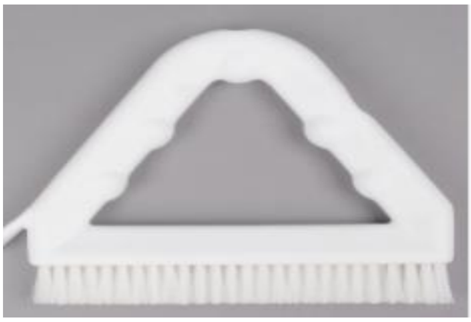


Figure 100.Grout Brush

- **Push Broom**

For clearing floors of dirt and dust before scrubbing and mopping

Figure 101.Push Broom

2. Soap solution

Making your own cleaning solutions can save money, reduce your exposure to excessive chemicals, and give you a sense of self-reliance if you can't get to a store for your usual favorite cleaner.We've put together five cleaning solutions to help you with house cleaning and some tips on how to use pantry items in ways you never thought possible to make your house sparkle Follow these general tips for the best results:

- Mix cleaning solutions in small batches. Since there are no preservatives added, mixing too much at once can cause the cleaner to lose potency.
- Add your favorite essential oil to give a fresh scent.
- Label every bottle including the ingredients. This is particularly important if you reuse spray bottles or something that could be mistaken as a food container.
- Store homemade cleaning solutions safely away from children, pets, and vulnerable adults.

3. Solvent

Solvent cleaning is a cleansing process that uses chemical solutions to remove unwanted grease, oil, residue, coatings or paint from the surface of a material. There is more than one type of solvent, and each individual type may be better suited than another is to clean a specific type of base material. Solvent cleaning is generally the first surface preparation method applied to the parts. Solvent cleaning removes release agents, such as silicone that may coat the part during molding, and any machine oil transferred to the part. Abrading surfaces coated with oil or grease drives the contaminants further into the parts, and chemical alteration of the surface is ineffective in the presence of contaminants.

4. Broom

Brooms and Brushes Brooms are available in different widths and with different bristle types. Soft bristle brooms are usually better on indoor hard floors and hard bristles better on outdoor areas. The wider the broom, the larger the area that can be swept in one pass.

Figure 102.4. Broom

5. **Mopes**

Always choose the right type of mop for the task you will be doing. There are cotton mops, cotton/polyester blends, sponge mops, dust mops and microfiber mops. Cotton and cotton polyester blends come in different weights. Female staff may use a lighter one than a male. Cotton mops are used for mopping as they are more absorbent and cotton/polyester ones are used for applying polishes to hard floor because they are lint free and so do not leave particles. Microfibre mops do not require the use of any chemicals. Sponge mops are not recommended for commercial heavy cleaning as they disintegrate quickly.

6. **cloth**

There are different variety of cloths which are used in the housekeeping department for performing various cleaning activities like wet and dry cleaning by the housekeeping staff.

Dust sheets are made of any thin cotton material, being about the size of a single sheet. Discarded bed sheets or curtains from the linen room are ideal for use as dust sheets. They are used to cover floors, furniture or other articles during spring cleaning or decorating.

Figure 103.cloth

- Content/Topic 2: Types of cleaning

1. **Air pressure cleaning**

compressed air to clean off clothing or any part of the body. Although many people know using compressed air to clean debris or clothes can be hazardous, it is still used because of old habits and the easy availability of compressed air in many workplaces. However, cleaning objects, machinery, bench tops, clothing and other things with compressed air is dangerous. Injuries can be caused by the air jet and by particles made airborne (re-enter the air). Many workplace injuries occur due to the misuse of compressed air. compressed air is extremely forceful. Depending on its pressure, compressed air can dislodge particles. These particles are a danger since they can enter your eyes or abrade the skin. The possible damage would depend on the size, weight, shape, composition, and speed of the particles. The pressure used to remove the particles from machines and surfaces is also strong enough to blow the filings, shavings, chips and particles of metal into the eyes, ears or skin of people. A compressed air or other compressed gas blowing device shall not be used for blowing dust or other substances, (a) from clothing worn by a worker except where the device limits increase in pressure when the nozzle is blocked; or (b) in such a manner as to endanger the safety of any worker

Addition, air guns should also be used with some local exhaust ventilation or facilities to control the generation of airborne particulates. When compressed air cleaning is unavoidable, hazards can be reduced by making adjustments to the air gun such as:

- chip guards or curtains that can deflect flying dust or debris,
- extension tubes that provide the worker a safer working distance, or
- air guns equipped with injection exhausts and particle collection bags.

2. **Cleaning with cloth rugs**

Cleaning with cloth rugs

- Dampen an old cloth in linseed oil. Wipe the dampened cloth over the tool, to thoroughly coat the metal with the oil
- Allow the linseed oil to soak into the metal for 10 minutes. Use a stainless steel brush to scrape off rust and dirt from the tool.
- Apply a couple of drops of liquid dish detergent to a clean cloth. Dampen the cloth with water, to create suds
- Clean the tool with the soapy cloth, to rinse off the linseed oil and remove remaining dirt. Rinse the tool with water, to remove the soapy solution

Learning Outcome 4.2: Store tools, equipment and materials

- Content/Topic 1: Housekeeping basics

1. **Overall cleanliness**

Cleanliness and Order. The type of operation will dictate the level and frequency of cleaning required. Many locations will only require cleaning once per day, but some manufacturing processes might require cleaning at the end of each shift, or possibly even periodically during the shift.

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibre glass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

2. **Adequate space and proper layout**

Good industrial engineering not only facilitates the movement of raw materials, in-process goods, and finished product but also concentrates the hazards associated with specific aspects of the product process in a single area. For example, in a woodworking facility, all handling of flammable liquids and associated cleaning materials are in one area of the plant. Wiping rags can be concentrated and stored in the appropriately listed waste material storage container (Figure 1). Doing so does not negate the importance of periodic removal of such waste material but does limit the exposure to these materials.

Figure 104.2.Adequate space and proper layout

3. **Correct storage and materials handling**

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one metre (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. All storage areas should be clearly marked.

Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction

Learning Outcome 4.3: Clean work place

- Content/Topic 1: Cleaning medium and tools

1. **Soft brushes**

Brushes are designed to remove dry, wet and or ingrained dust and dirt from hard or soft surfaces. There are two types of Brushes Hard Brushes and Soft Brushes each used for different purposes. Soft brushes have bristles that are fairly flexible and set close together.

They help to remove loose soil and litter on hard and smooth surfaces. Always use a holder to keep brooms stored off the floor or store with the bristles upright. If fibers are resting on the floor, they will flatten and reduce the cleaning effectiveness of the broom.

Figure 105.Soft brushes

2. **Soap solution**

Soaps often contain coloring matter and perfume and act by emulsifying grease and lowering the surface tension of water, so that it more readily penetrates open materials such as textiles. The soap needs to cure for four to six weeks. During this time the water used in the recipe evaporates. Cured soap has a firmer texture and lasts longer in the shower. While curing, soap should be stored in a cool, dry and well ventilated space. If the moisture cannot escape while curing, the chance for dreaded orange spots increases

3. **Solvent**

Solvents are contained within many detergents in small quantities for general cleaning. Used individually, solvents are one of the most dangerous categories of chemicals that may be used for specific cleaning purposes. the handling and storage of cleaning chemicals is often overlooked or mismanaged in safety evaluations and audits, which can have major consequences. Proper handling and storage of products is essential to a safe workplace, and routine inspections should be performed annually to remain efficient and protect your team. By following a few simple steps, you can ensure your facility is not only clean, but safe as well Some specifications of your storage space should include:

- Store in a clean, cool, dry space. Some cleaning chemicals can have hazardous reactions when they experience extreme temperature fluctuations or high levels of humidity.

- Store in well-ventilated areas, away from HVAC intake vents. This helps prevent any fumes from spreading to other areas of the facility.
- Store no higher than eye level, and never on the top shelf of a storage area.
- Do not overcrowd shelves and include anti-roll lips to avoid falling containers.
- Never store cleaning chemicals on the floor, even temporarily.

4. **Brooms.**

Comb out broom fibers regularly to remove any debris. For more thorough cleaning, brooms should be cleaned every 2-3 months. After shaking out any loose dirt, remove the broom handle if it is threaded, and place the broom head in a bucket filled with an oxygen bleach powder detergent solution (see cleaning tips of "Scrub Brushes"). The solution is safe for straw or nylon bristles. After soaking in the solution for about 30 minutes, rinse the bristles with clear hot water then let air dry, standing the broom with the bristles in an upright position. Let the broom dry completely before using again.

Storage. Always use a holder to keep brooms stored off the floor or store with the bristles upright. If fibers are resting on the floor, they will flatten and reduce the cleaning effectiveness of the broom. For push brooms which have two handle holes in the block head (one on each side), change the sides often so fibers wear evenly.

5. **Mopes**

These mops consist of acrylic, nylon or polyester strands fixed to a backing stretched over a metal frame. When in use, the fringes splay out to form a large surface area, holding dust by means of a static charge that builds up on the fringe. Static mops are more easily maintained than impregnated mops. If that's not possible, stand the mop upright in a bathtub or other well ventilated and dry area. The goal is to avoid mildew and bacteria growth. Store the mop properly. A cool, dry place is a perfect storage location.

Figure 106.Mopes

- Content/Topic 1 Types of cleaning

1. **Air pressure cleaning**

Compressed air used for cleaning in the workplace can be very dangerous if the necessary precautions are not taken. In the workplace, pressure to air guns can range from 55 to 160 psi.

Safe work practice

- ✓ Ensure all hoses and components are appropriately rated to handle the supplied pressure from the compressor. ALWAYS use the lowest pressure that will do the job.
- ✓ ALWAYS wear goggles or a face shield over safety glasses to protect the eyes.
- ✓ Use a noise reducing air gun and wear hearing protection when peak noise levels are greater
- ✓ wear the appropriate gloves to protect your hands.
- ✓ never use compressed air to clean your clothes or body.
- ✓ never tamper with air guns to modify them in any way.
- ✓ never point an air gun or direct air towards another individual or your skin.

2. **Cleaning with cloth rugs**

When storing your rug, it's important to keep it in a location off the ground, safe from any harmful elements.

You'll also want to make sure nothing else lays on top of it. Boxes and other supplies can cause cracks and destroy the rug's shape. It is vitally important to store your rug in a cool, dry environment without exposure to natural night.

Keep these cloth rug storage tips in mind:

- Use a fan or dehumidifier to avoid mildew problems.

- Block light from windows with shades or blinds.
- Consistently implement a housekeeping plan (vacuuming, dusting, etc.)
- Store your rug on an elevated surface, since carpet beetles like to reside between the floor and the back of your rug.

References

(Goetsch, C. &. (1999). *Architectural Working Drawings.* John Wiley and Sons.

Goetsch, D. L., Chalk, W. S., & Nelson, J. A. (2000). *Delmar Technical Graphics Series (4th Ed.).* Albany: Delmar Learning.

Jefferis, A., & Madsen, D. (2005). *Architectural Drafting and Design (5th ed.).* Clifton Park, NY: Delmar Cengage Learning.