TVET CERTIFICATE III in AUTO ENGINE TECHNOLOGY

TECHNICAL DRAWING

AUTTD301

Apply technical drawing

Competence

REQF LEVEL: 3

Learning hours: 30

Credits: 3

Sector: Transport and Logistic

Sub-sector: Automobile

Module Note Issue date: November 2020

Purpose statement

This general module describes the performance outcomes, skills and knowledge required to carry out basic technical drawing for an engine mechanic. In order to perform many of particular competences successfully, a mechanic must apply principles of technical drawing.

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Total Number of Pages: 40

Learning Unit 1 – Introduce technical drawing

LO 1.1 –Identify the different types of drawing instruments, equipment and materials.

- **Content/Topic 1 Drawing instruments, equipment and materials**

Drawing instruments are used to prepare neat and accurate Drawings. To a greater extent, the accuracy of the drawings depends on the quality of instruments used to prepare them. The following is the list of drawing instruments and other materials required.

(a) Drawing board
(b) T-square or Drafter(Drafting machine)
(c) Set squares
(d) Ruler
(e) Protractor
(f) Drawing instrument Box
(g) Drawing sheets
(h) Drawing pencils
(i) Compass
(j) Set of scales

1. T-square

This is one of the oldest drawing instruments that still finds wide spread use both in the industry and in schools.

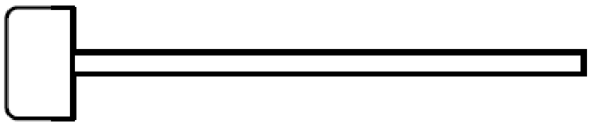


Figure1: T-square

The size of a T-Square is determined by its blade length. Blade lengths of **60mm**, **90mm**,**120mm** and **150mm** are common.

USES:

- The T-Square is used primarily as a guide for drawing horizontal parallel lines.
- It can also be used when drawing inclined lines, just like any other rule.

2. A Ruler

This is a straight edge that is permanently mounted on a drawing board or drafting table by means of pulleys and guide ropes. It enables us to draw horizontal lines quite fast.

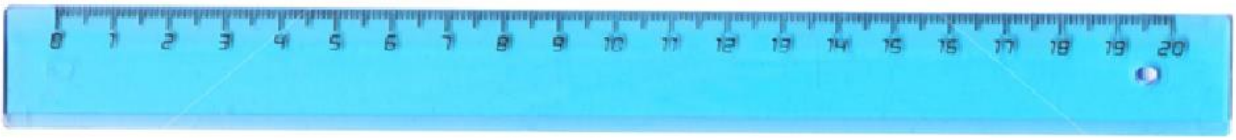


Figure2: Ruler

3. Set squares 60^0 and 45^0

Set Squares (SSs) are transparent, triangular-shaped drawing instruments with one corner, a right angle triangle, that are used with either a T-Square or parallel rule for drawing vertical or inclined lines.

There are two types of set squares and they are named according to the angles present on each. SSs contain angles most commonly used in technical drawing, i.e. 30^0, 45^0, 60^0 and 90^0.

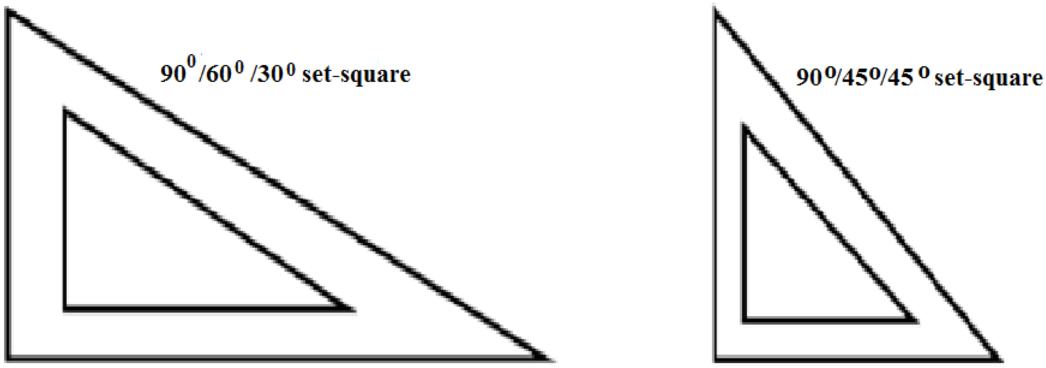


Figure3: set-square

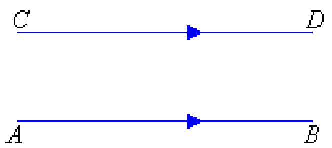
The height/length of SSs is typically 15cm, 20cm, and 25cm.

Set squares are useful for drawing parallel lines and perpendicular lines.

Drawing Parallel Lines using Set-square

Lines that lie in the same plane and do not meet one another are said to be parallel lines. In the accompanying diagram, the line *AB* is parallel to the line *CD*.

This is indicated by the similar arrows.

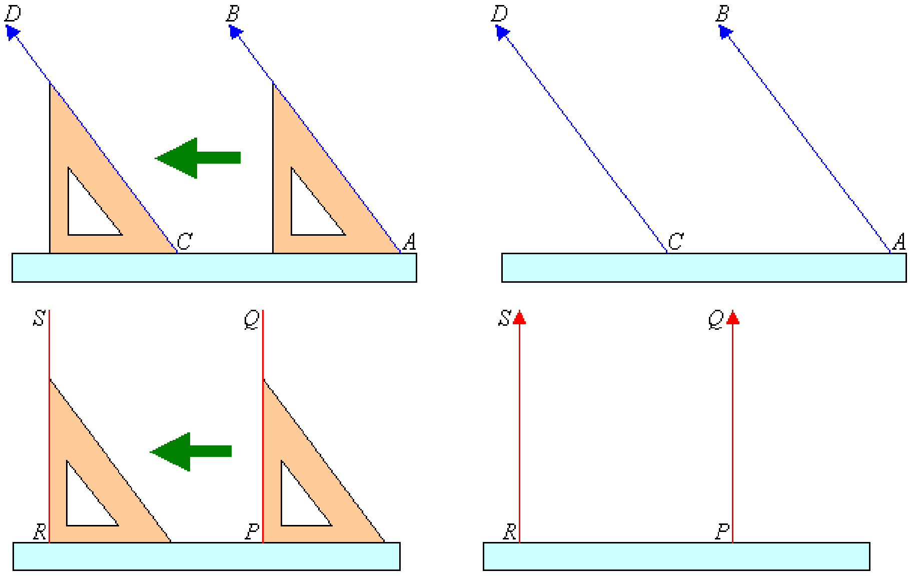


We write the line AB is parallel to the line CD as $AB \parallel CD$. The symbol ' || ' means 'is parallel to'.

Drawing Parallel Lines

A ruler and set square can be used to draw parallel lines as described below.

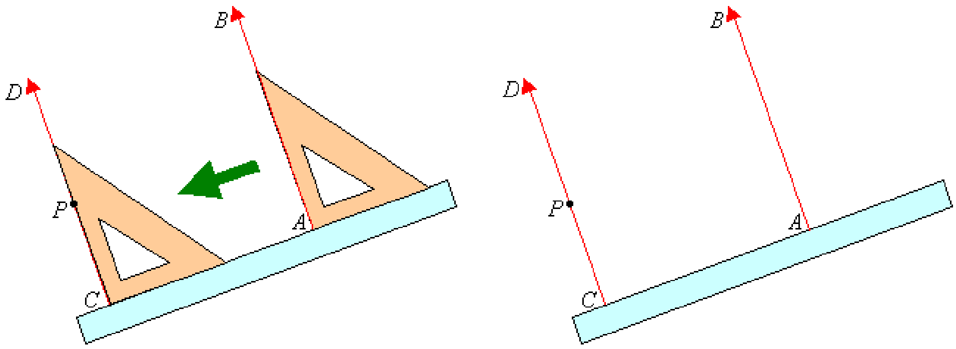
Step 1: Position an edge of the set square against a ruler and draw a line along one of the other edges.
Step 2: Slide the set square into a new position while keeping the ruler fixed exactly at the same position.
Step 3: Draw a line along the same edge that was used in Step 1.



$AB \parallel CD$ and $PQ \parallel RS$.

Example: Use a ruler and set square to draw a line that is parallel to a given line, *AB*, and passes through a given point, *P*.

Solution:



Step 1: Position an edge of the set square along the given line, *AB*.
Step 2: Place a ruler against one of the other edges.
Step 3: Slide the set square along the ruler until the edge used in Step 1 passes through the given point *P*.
Step 4: Draw the line *CD* through *P*.

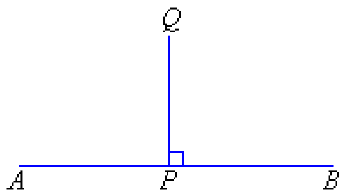
The line *CD* passes through the given point, *P*, and is parallel to the given line *AB*.

Drawing Perpendicular Lines using set-square

Lines that are at right angles to each other are said to be perpendicular lines.

Note that a vertical line is perpendicular to the horizontal, whereas perpendicular lines can be drawn in any position. Bricklayers use a plumb-bob to set out vertical lines and a spirit level to set out horizontal lines.

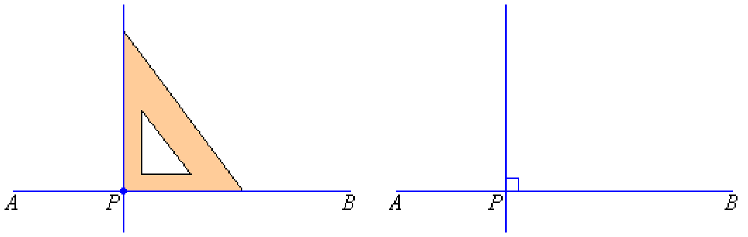
In the accompanying diagram, line is at right angles to line AB. The right angle is indicated by a small square. We say that PQ is perpendicular to AB; and is written as **PQ** $\perp$ **AB.**



Drawing Perpendicular Lines

A set square can be used to draw a perpendicular at a point on a given line as described below.

Step 1: Set an edge of the set square on the given line so that the other edge is just in contact with the point.
Step 2: Draw a line that passes through the given point with the help of the set square.

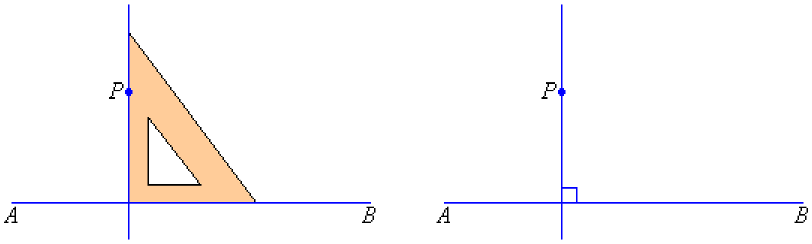


Example

Use a set square to draw a perpendicular to a given line, *AB*, through a point, *P*, not on the line.

Solution:

Step 1: Set an edge of the set square on the given line so that the other edge is just in contact with the point.
Step 2: Draw a line that passes through the given point with the help of the set square.



4. Protractor

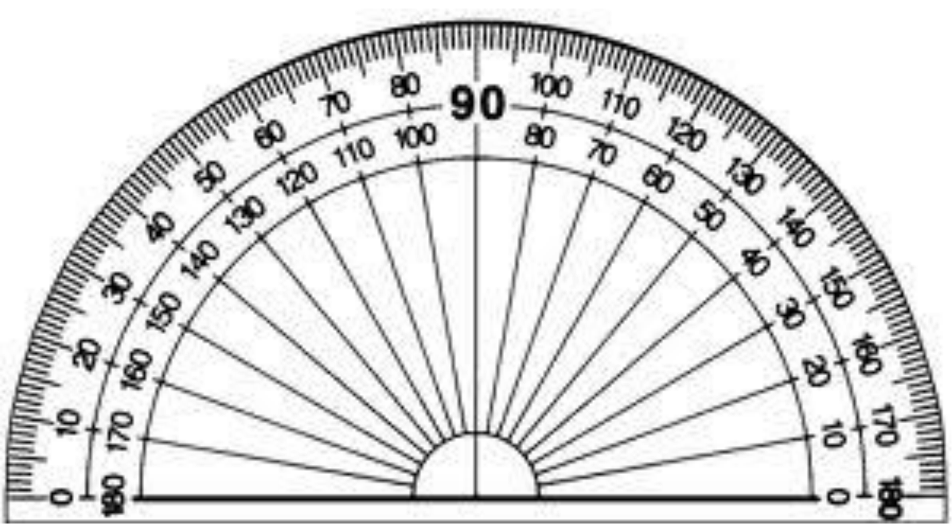


Figure4: protractor

Protractors are used to mark or measure angles between 0 and 180 degrees, they are semi-circular in shape (of diameter 100mm) and are made of Plastic or celluloid which has more life. Protractors with more circular shape capable of marking and measuring 0 to 360 are also available in the market.

5. **Drawing board**

Drawing board is made from strips of well seasoned soft wood generally **25 mm thick**. It is cleated at the back by two battens to prevent warping. One of the shorter edges of the rectangular board is provided with perfectly straight ebony edge which is used as used working edge on which the T-square is moved while making drawings.

Very often a drawing table could look like a **writing table** or **even a pedestal desk** when the working surface was set at the horizontal and the height adjusted to 29 inches (1 inch = 2.54cm), in order to use it as a "normal" desk.

Figure5: Drawing board

A **drawing board** (also **drawing table**, **drafting table** or **architect's table**) is, in its antique form, *a kind of **multipurpose desk** which can be used for any kind of drawing, writing or sketching on a large sheet of paper or for reading a large format **book** or other oversized document or for **drafting** precise technical illustrations*.

Drawing boards are made in various sizes. The selection of drawing board depends on the size of drawing paper used. The sizes of drawing board given below

Standard size of Drawing boards

Designation	**Size(mm)**
Bo	1500 x 1000
B1	1000 x 700
B2	700 x 500
B3	500 x 350
B4	250 x 350

6. Drafting Machine

This is a machine/device with two scales set at right angles to one another. It can be moved easily and quickly to any location on the drawing surface. The edges of the scale are used for measuring as well as for drawing.

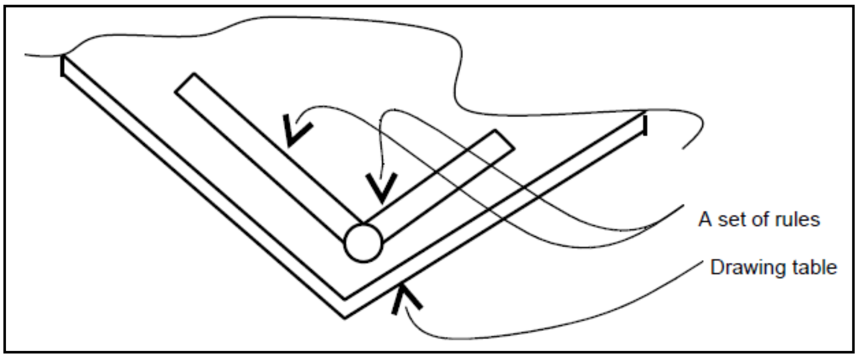


Figure6: Drafting machine

A drafting machine is a very useful tool in technical drawing, consisting of a **pair of scales** mounted to form a right angle on an articulated protractor head that allows an angular rotation.

The protractor head is able to move freely across the surface of the drawing board, sliding on two guides directly or indirectly anchored to the drawing board. These guides, which act separately, ensure the movement of the set in the horizontal or vertical direction of the drawing board, and can be locked independently of each other.

With the development of **Computer-Aided Design (CAD),** the use of drafting machines, especially in the professional sector, has been drastically reduced, and nowadays the role for achieving drawings on paper is relegated to the computer-driven plotter. (Reddy, 2012)

7. Drawing instrument box

It consists of the following instruments:

(a) Large size compass
(b) Large size divider
(c) Small size bow pen, bow divider, and
(d) Lengthening bar

8. Compass

A compass is a technical drawing instrument that can be used for **drawing circles or arcs.** As dividers, they can also be used as a tool to measure distances, in particular on maps. Compasses can be used for mathematics, drafting, navigation, and other purposes.

Construction

The compass has two legs hinged at one end. One of the legs has a pointed needle fitted at the lower end where as the other end has provision for inserting pencil lead. Circles up to 120mm diameters are drawn by keeping the legs of compass straight.

For drawing circles more than 150 mm radius, a lengthening bar is used. It is advisable to keep the needle end about 1mm long compared to that of pencil end so that while drawing circles, when the needle end is pressed it goes inside the drawing sheet by a small distance

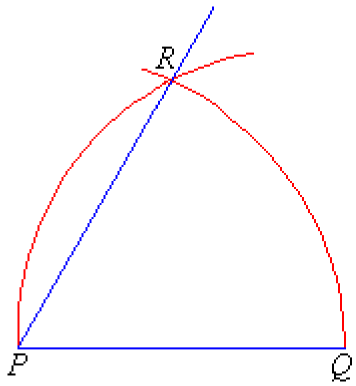
Compasses are usually made of metal, and consist of two parts connected by a **hinge** which can be adjusted. Typically one part has a **spike** at its end, and the other part a **pencil**, or sometimes a **pen**.

Constructing Angles of 60º, 120º, 30º and 90º

Constructing a 60º Angle

We know that the angles in an **equilateral triangle** are all **60º** in size. This suggests that to construct a 60º angle we need to construct an equilateral triangle as described below.

Step 1: Draw the arm *PQ*.
Step 2: Place the point of the compass at *P* and draw an arc that passes through *Q*.
Step 3: Place the point of the compass at *Q* and draw an arc that passes through *P*. Let this arc cut the arc drawn in Step 2 at *R*.
Step 4: Join P to R. The angle QPR is $60°$, as the $\Delta\, PQR$ is an equilateral triangle.



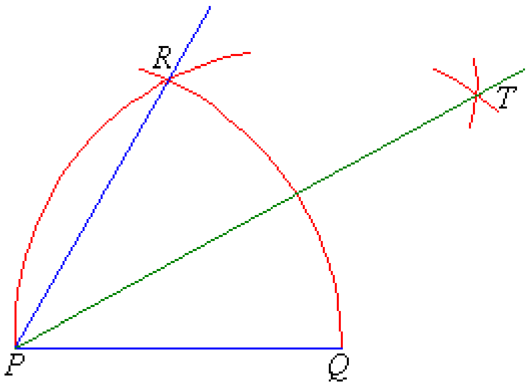
Constructing a 30º Angle

We know that:

$\frac{1}{2}$ of $60° = 30°$

So, to construct an angle of 30º, first construct a 60º angle and then **bisect it**. Often, we apply the following steps.

Step 1: Draw the arm *PQ*.
Step 2: Place the point of the compass at *P* and draw an arc that passes through *Q*.
Step 3: Place the point of the compass at *Q* and draw an arc that cuts the arc drawn in Step 2 at *R*.
Step 4: With the point of the compass still at *Q*, draw an arc near *T* as shown.
Step 5: With the point of the compass at *R*, draw an arc to cut the arc drawn in Step 4 at *T*.
Step 6: Join *T* to *P*. The angle *QPT* is 30º.

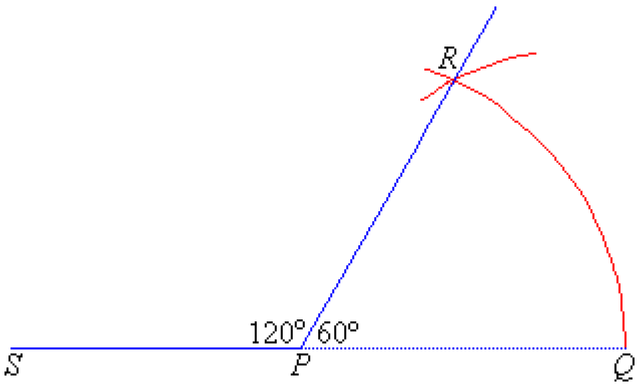


Constructing a 120º Angle

We know that:

$$60° + 120° = 180°$$

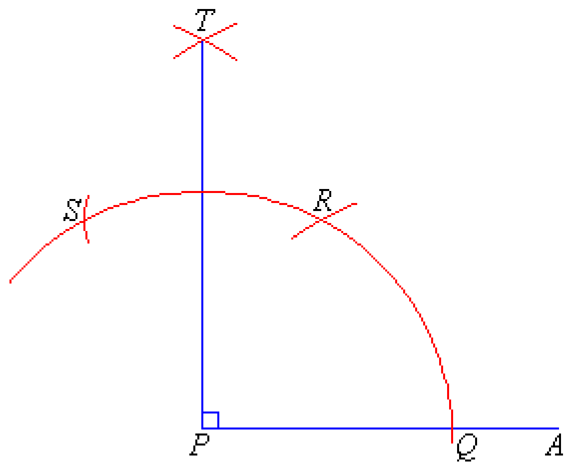
This means that 120º is the supplement of 60º. Therefore, to construct a 120º angle, construct a 60º angle and then extend one of its arms as shown below.



Constructing a 90º Angle

We can construct a 90º angle either by bisecting a straight angle or using the following steps.

Step 1: Draw the arm *PA*.
Step 2: Place the point of the compass at *P* and draw an arc that cuts the arm at *Q*.
Step 3: Place the point of the compass at *Q* and draw an arc of radius *PQ* that cuts the arc drawn in Step 2 at *R*.
Step 4: With the point of the compass at *R*, draw an arc of radius *PQ* to cut the arc drawn in Step 2 at *S*.
Step 5: With the point of the compass still at *R*, draw another arc of radius *PQ* near *T* as shown.
Step 6: With the point of the compass at *S*, draw an arc of radius *PQ* to cut the arc drawn in step 5 at *T*.
Step 7: Join *T* to *P*. The angle *APT* is 90º.

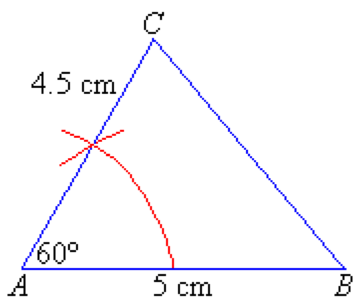


Example

a. Use a ruler and compass only to construct a triangle ABC with $AB = 5$ cm, $\angle BAC = 60°$ and $AC = 4.5$ cm.
b. Measure the size of $\angle ABC$ and the size of $\angle ACB$. Hence, calculate the angle sum of triangle ABC.
c. Measure BC to the nearest millimetre. Hence, find the perimeter of triangle ABC in millimetres.

Solution:

a. **Step 1:** Draw a line, AB, 5 cm long.
Step 2: Use the compass to construct a 60° angle at A.
Step 3: Use the ruler to find C such that AC is 4.5 cm long.
Step 4: Join B to C.
The ΔABC is the required triangle.



b. Using a protractor, we find that:
$\angle ABC = 55°$
$\angle ACB = 65°$
$\therefore$ Angle sum of the triangle $ABC = 60° + 55° + 65°$
$= 180°$

c. Using the ruler, we find that:

$BC = 48$ mm

$\therefore$ Perimeter $= AB + BC + CA$

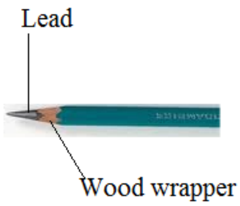
$$= 5\text{ cm} + 48\text{ mm} + 4.5\text{ cm}$$
$$= 50\text{ mm} + 48\text{ mm} + 45\text{ mm}$$
$$= 143\text{ mm}$$

9. Pencils

Your pencil is the most elementary object to draw, besides blank paper. It is it the one that stains the paper and pigments it, being able to create a trace after it, which is well known as line.

HOW ARE PENCILS FORMED?

The pencil is formed by a mixture of **powdered natural graphite** and **clay** baked in some specific temperatures.



Varieties of pencils

At the moment you can obtain 3 different varieties:

- The traditional one (graphite refill encapsulated inside a wooden wrapper of cedar),
- The propelling pencils (pens with very fine refills of graphite) or
- The bar pencil (similar to the propelling pencils but with thicker and more resistant graphite bars, Approximately 5mm in diameter)

Graphite*:* There are many artist grade graphite pencils to choose from these days. A 2B pencil of one brand may be vastly different than the 2B of another brand.

The student and professional man should be equipped with a selection of good, well-sharpened pencil with leads of various degrees of hardness such as:

9H, 8H, 7H, and **6H** (hard);

5H&4H (medium hard);

3H and **2H** (medium); and

H& **F** (medium soft)

The grade of pencil to be used for various purposes depends on the type of line desired, the kind of paper employed, and the humidity, which affects the surface of the paper. Standards for line quality usually will govern the selection. For instance,

♦ **6H** is used for light construction line.

♦ **4H** is used for re-penciling light finished lines (dimension lines, center lines, and invisible object lines)

♦ **2H** is used for visible object lines

♦ **F** and **H** are used for all lettering and freehand work.

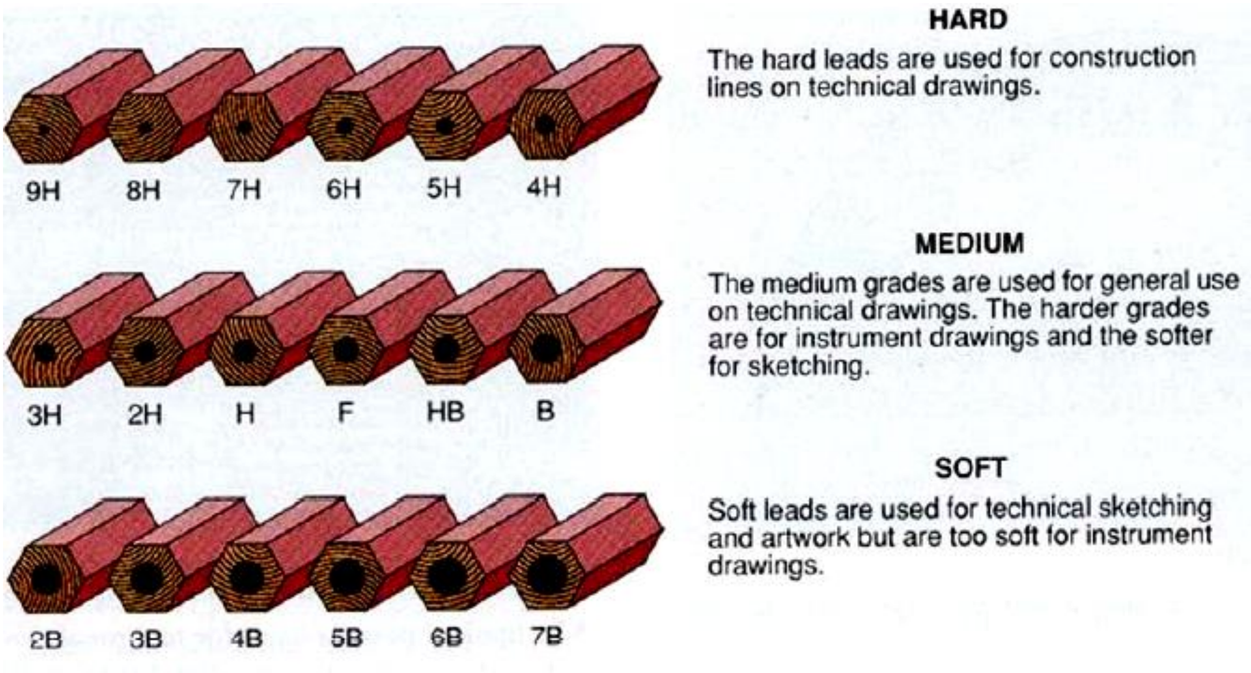


Figure: Pencil grades

LO 1.2 – Understand the graphic language techniques

- **Content/Topic 1 Importance of Graphic Language Need for Correct Drawings**

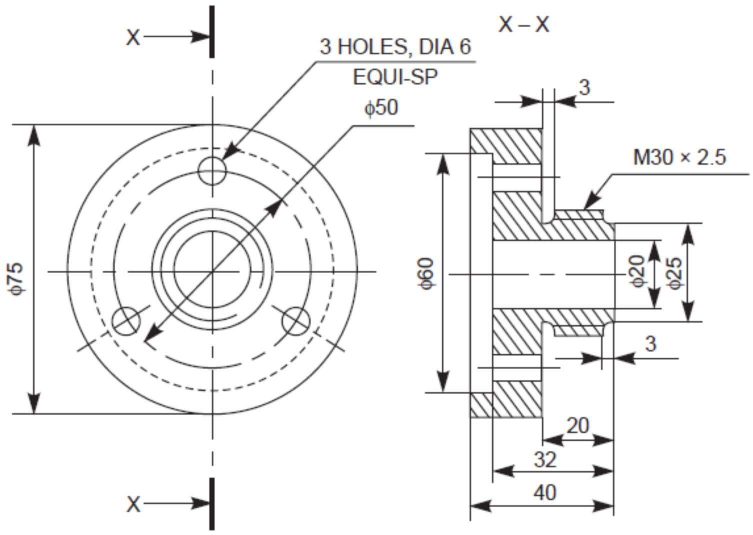
The graphic language had its existence when it became necessary to build new structures and create new machines or the like, in addition to representing the existing ones. In the absence of graphic language, the ideas on technical matters have to be conveyed by speech or writing, both are unreliable and difficult to understand by the shop floor people for manufacturing.
This method involves not only lot of time and labour, but also manufacturing errors. Without engineering drawing, it would have been impossible to produce objects such as aircrafts, automobiles, locomotives, etc., each requiring thousands of different components.
The drawings prepared by any technical person must be clear, unmistakable in meaning and there should not be any scope for more than one interpretation, or else litigation may arise. In a number of dealings with contracts, the drawing is an official document and the success or failure of a structure depends on the clarity of details provided on the drawing. Thus, the
drawings should not give any scope for mis-interpretation even by accident.
It would not have been possible to produce the machines/automobiles on a mass scale where a number of assemblies and sub-assemblies are involved, without clear, correct and accurate drawings. To achieve this, the technical person must gain a thorough knowledge of both the principles and conventional practice of

draughting. If these are not achieved and or practiced, the drawings prepared by one may convey different meaning to others, causing unnecessary delays and expenses in production shops.

LO 1.3 – Classify different types of drawing

- **Content/Topic 1 Machine Drawing**

It is pertaining to machine parts or components. It is presented through a number of orthographic views, so that the size and shape of the component is fully understood. Part drawings and assembly drawings belong to this classification. An example of a machine drawing is given in Fig. 1.1.



- **Content/Topic 2 Production Drawing**

A production drawing, also referred to as working drawing, should furnish all the dimensions, limits and special finishing processes such as heat treatment, honing, lapping, surface finish, etc., to guide the craftsman on the shop floor in producing the component. The title should also mention the material used for the product, number of parts required for the assembled unit,
etc. Since a craftsman will ordinarily make one component at a time, it is advisable to prepare the production drawing of each component on a separate sheet. However, in some cases the drawings of related components may be given on the same sheet. Figure 1.2 represents an example of a production drawing.

- **Content /Topic 3 Part Drawing**

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

- **Content /Topic 4 Assembly Drawing**

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing (Fig. 1.3). There are several types of such drawings.

Learning Unit 2 – Apply principles of drawing

LO 2.1 – Identify drawing sheets

- **Content/Topic 1 Lines**

Lines are straight elements that have no width, but are infinite in length (magnitude), and they can be located by two points which are not on the same spot but fall along the line.

Lines may be straight lines or curved lines. A straight line is the shortest distance between two points. It can be drawn in any direction. If a line is indefinite, and the ends are not fixed in length, the actual length is a matter of convenience.

If the end points of a line are important, they must be marked by means of small, mechanically drawn crossbars, as described by a pint in space.

Straight lines and curved lines are considered parallel if the shortest distance between them remains constant. The symbol used for parallel line is //. Lines, which are tangent and at 900 are considered perpendicular, the symbol for perpendicular line is ⊥.

Drawing of lines

Thickness of lines should be drawn according to the standards.

At free hand drawing:

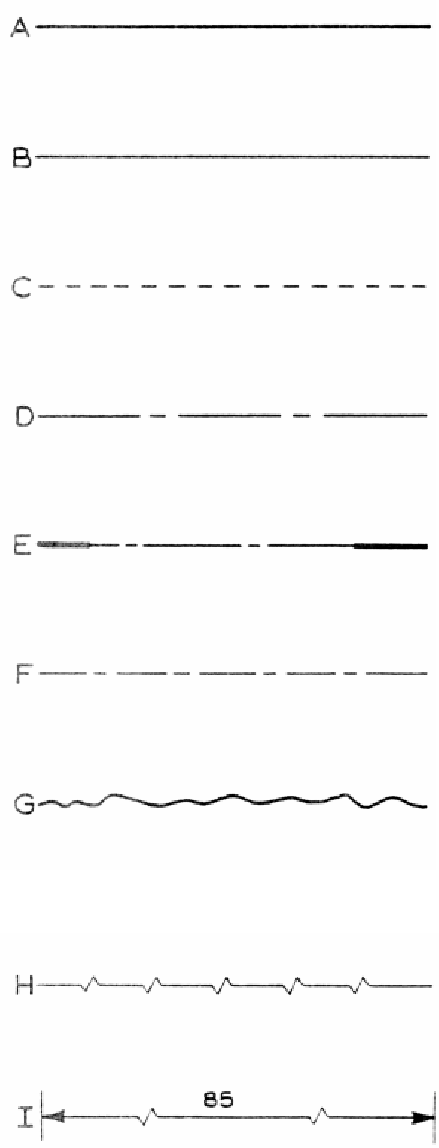
Continuous and thick lines should be drawn by **B** or **2B** pencil.

Continuous and thin lines should be drawn by **H** or **2H** pencil.

Dash lines should be drawn at equal spaces and thickness. They should be **3∼6 mm,** or **0,8~1,5mm**

Line styles or types

Each line on a drawing represents specific precise information regarding the components design.



Type: (thickness)	Example:	Application:
Continuous 0.7mm		Visible outlines
Continuous (thin) 0.3mm		Dimension lines
Short dashes 0.3mm		Hidden detail
Long chain 0.3mm		Center lines
Chain, thick at ends 0.7 – 0.3mm		Section cutting planes
Short chain 0.3mm		Developed views
Continuous wavy boundaries 0.3mm		Broken
Straight zigzag 0.3mm		Break lines
Straight lines with two short zigzags 0.3mm		Dimension lines

- **Content/Topic 2 Sheet Sizes**

The ISO most recommended paper sizes for technical drawings are known as A-FORMATS. Other series, like the B-Series, are of lesser importance. In the A-Format series, the largest size is A0. The size of an A1 paper is half the size of A0 while A2 is half the size of A1 and so forth. Note that a higher order paper size (which is always smaller in size) is obtained by simply halving the preceding size along its longer side. For technical drawings A4 is considered to be the smallest paper size. Smaller-sized A Format papers (i.e. A5, A6, etc) are very rarely used for technical drawings.

Paper Sizes and Folding

The A-Format Paper Sizes

Format	Cut Sheet (mm)
A0	841 X 1189
A1	594 X 841
A2	420 X 594
A3	297 X 420
A4	210 X 297
…….	…….

NOTES:

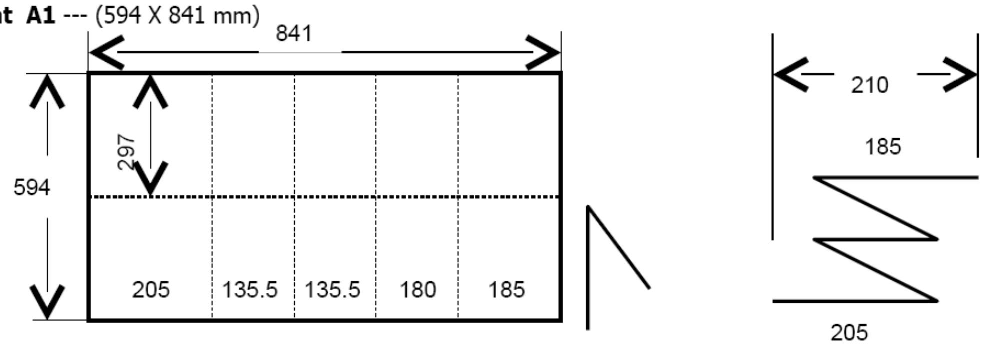
(i) When a format smaller than A4 is needed, it is obtained simply halving A$ along its longer side. For instance A5 has 210-mm as its longer side and (297/2 = 148- mm) as its shorter side.

(ii) Format A4 is exclusively used in an upright position. The other formats (which are lager in size than A4) may be used in an upright position or horizontal position.

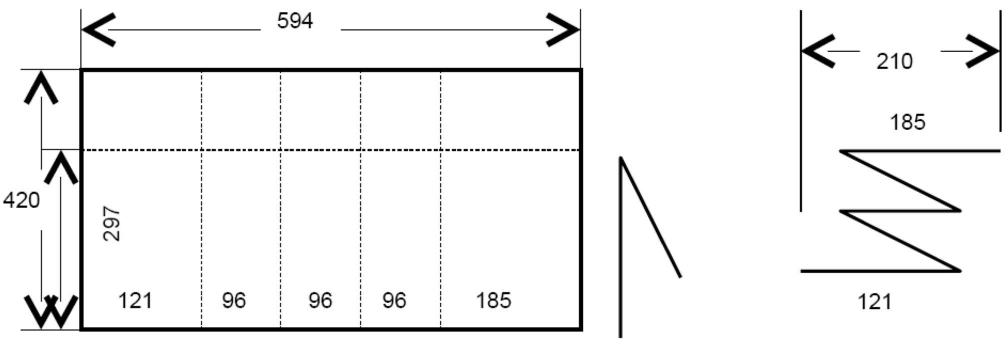
Folding

Only format A4 is convenient for filling. Other formats (larger in size) exceed the size of the file and thus must be folded before filing. Drawings which that do not need fastening are fold in a logical way to give an A4 size. However, for those drawings that must be fastened, they must be fold in a standardized way as follows.

Format A1 --- (594 X 841 mm)



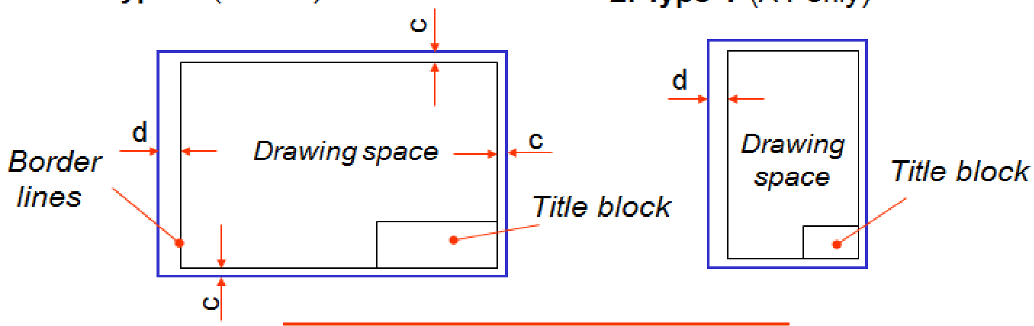
Format A2 --- (420 X 594 mm)



PAPER PRESENTATION

Orientation of drawing sheet

1. Type X (A0~A4) **2. Type Y** (A4 only)



Sheet size	c (min)	d (min)
A4	10	25
A3	10	25
A2	10	25
A1	20	25
A0	20	25

- **Content /Topic3 Designation of Sizes**

The original drawing should be made on the smallest sheet, permitting the necessary clarity and resolution. The preferred sizes according to ISO-A series (First choice) of the drawing sheets are given in Table 2.1. When sheets of greater length are needed, special elongated sizes (Second choice) are used (Table 2.2). These sizes are obtained by extending the shorter sides of format of the ISO-A series to lengths that are multiples of the shorter sides of the chosen basic format. (Dr.KL. Narayana, 2006)

Designation	*Dimensions* (mm)
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

Table 2.2 Special elongated sizes (Second choice)

Designation	*Dimensions* (mm)
A3 × 3	420 × 891
A3 × 4	420 × 1188
A4 × 3	297 × 630
A4 × 4	297 × 840
A4 × 5	297 × 1050

- **Content/Topic 4 Title Block**

Title Blocks and Parts Lists

Title block is a rectangular frame that is located at the bottom of the sheet. It is recommended that space should be provided in all title blocks for such information as **description of title of the drawing**, **dates, designer (drawer), and name of enterprise or educational institute, size (scale)**

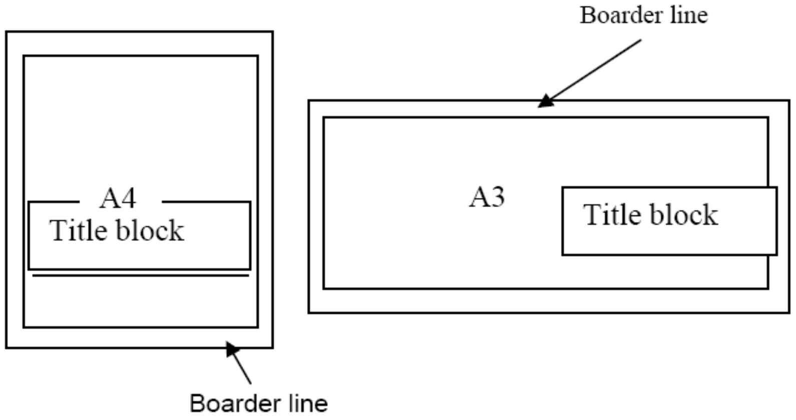


Figure: Sample for title block

In every engineering drawing, a Title Block is included at the bottom right-hand corner. The Title Blocks are locally standardized but should be designed in such a way that it can be easily understood. The information needed in any standard Title Block is normally:

- ✓ **Name of the Firm/School/College**
- ✓ **Name of the Object** (Work piece)
- ✓ **Number of the drawing** (particularly useful for reference where more than one drawing are concerned --- typically in assembly drawings)
- ✓ **Format of the paper used** (paper size)
- ✓ **Scale used**
- ✓ **Dimensioning unit** (usually millimeters --- mm)
- ✓ **Symbol for the method of projection used**
- ✓ **Date when the drawing was finished**
- ✓ **Name of the draftsman** (draughtsman) --- e.g. student name if it is a normal class exercise
- ✓ **Name of the person who checked the drawing**
- ✓ **Remarks**

- **Content/Topic 5 Borders and Frames**

Borders enclosed by the edges of the trimmed sheet and the frame, limiting the drawing space, should be provided with all sheet sizes. It is recommended that these borders have a minimum width of 20 mm for the sizes A0 and A1 and a minimum width of 10 mm for the sizes A2, A3 and A4 (Fig. 2.4). A filing margin for taking perforations, may be provided on the edge, far left
of the title block.

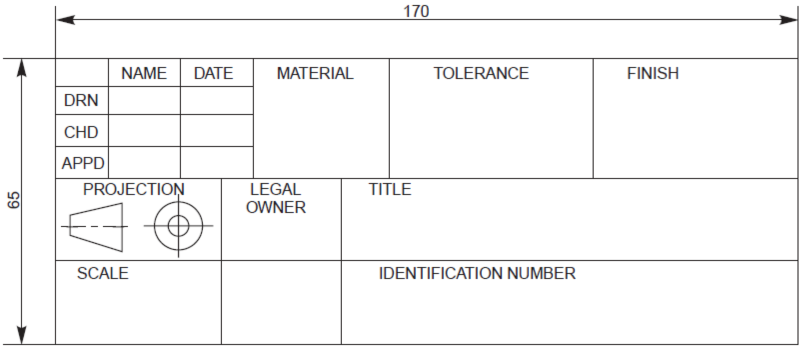
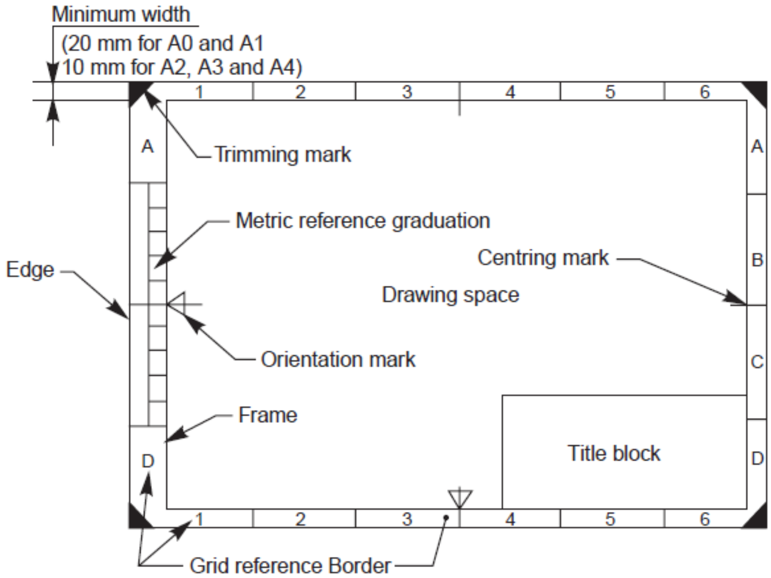


Fig. 2.3 Details in title block



- <u>**Content /Topic 6 Centering Marks**</u>

Four centering marks may be provided, in order to facilitate positioning of the drawing when reproduced or microfilmed. Two orientation marks may be provided to indicate the orientation of the drawing sheet on the drawing board.

- **Content/Topic 7 Metric Reference Graduation**

It is recommended to provide a figure-less metric reference graduation, with a minimum length of 100 mm and divided into 10 intervals on all the drawing sheets (Fig. 2.4) which are intended to be microfilmed. The metric reference graduation may be disposed symmetrically about a centring mark, near the frame at the border, with a minimum width of 5 mm.

- <u>**Content/Topic 8 Grid Reference System (Zoning)**</u>

The provision of a grid reference system is recommended for all the sizes, in order to permit easy location on the drawing of details, additions, modifications, etc. The number of divisions should be divisible by two and be chosen in relation to the complexity of the drawing. It is recommended that the length of any side of the grid should not be less than 25 mm and not more than 75 mm. The rectangles of the grid should be referenced by means of capital letters along one edge and numerals along the other edge, as shown in Fig. 2.4. The numbering direction may start at the sheet corner opposite to the title block and be repeated on the opposite sides.

- **Content /Topic 9 Trimming Marks**

Trimming marks may be provided in the borders at the four corners of the sheet, in order to facilitate trimming. These marks may be in the form of right angled isosceles triangles or two short strokes at each corner.

LO 2.2 – Apply drawing scales

Scale is the ratio of the linear dimension of an element of an object as represented in the drawing, to the real linear dimension of the same element of the object itself. Wherever possible, it is desirable to make full size drawings, so as to represent true shapes and sizes. If this is not practicable, the largest possible scale should be used. While drawing very small objects, such as watch components and other similar objects, it is advisable to use enlarging scales.

- **Content/Topic 1 Designation**

The complete designation of a scale should consist of the word Scale, followed by the indication of its ratio as:
SCALE 1 : 1 for full size,
SCALE × : 1 for enlarged scales,
SCALE 1 : × for reduced scales.
The designation of the scale used on the drawing should be shown in the title block.

- **Content/Topic 2 Recommended Scales**

The recommended scales for use on technical drawings are given in Table 2.3. The scale and the size of the object in turn, will decide the size of the drawing.

Category	*Recommended Scales*		
Enlarged scales	50:1	20:1	10:1
	5:1	2:1	
Full size			1:1
Reduced scales	1:2	1:5	1:10
	1:20	1:50	1:100
	1:200	1:500	1:1000
	1:2000	1:5000	1:10000

- **Content /Topic3 Scale Specification**

If all drawings are made to the same scale, the scale should be indicated in or near the title block. Where it is necessary to use more than one scale on a drawing, the main scale only should be shown in the title block and all the other scales, adjacent to the item reference number of the part concerned or near the drawings.

LO 2.3 – Use Lines

- **Content/Topic 1 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 Order of Priority of Coinciding Lines**

When two or more lines of different types coincide, the following order of priority should be observed:
(*i*) Visible outlines and edges (Continuous thick lines, type A),
(*ii*) Hidden outlines and edges (Dashed line, type E or F),
(*iii*) Cutting planes (Chain thin, thick at ends and changes of cutting planes, type H),
(*iv*) Centre lines and lines of symmetry (Chain thin line, type G),
(*v*) Centroidal lines (Chain thin double dashed line, type K),
(*vi*) Projection lines (Continuous thin line, type B).
The invisible line technique and aixs representation should be followed as per the recommendations given in Table.

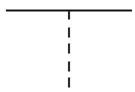
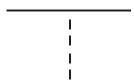
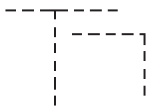
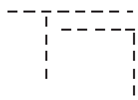
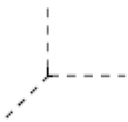
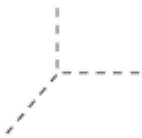
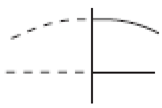
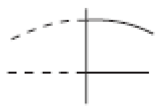
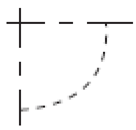
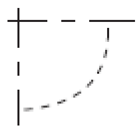
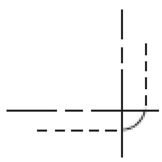
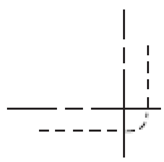
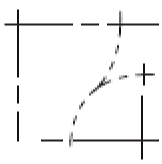
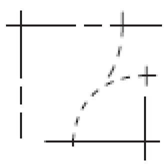
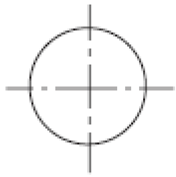
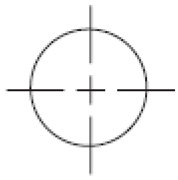
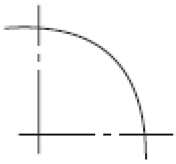
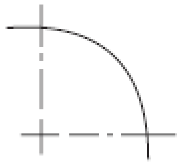
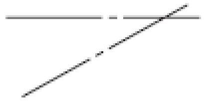
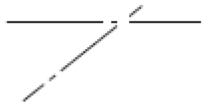
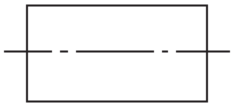
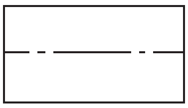
Instructions	*Correct*	*Incorrect*
Begin with a dash, not with a space		
Dashes intersect without a gap between them		
Three dashes meet at the intersection point		
As a continuation of a visible line/arc, begin with space		
Invisible arcs begin with a dash		
Small arcs may be made solid		
Two arcs meet at the point of tangency		

Table 2.5B Axis lines

Instructions	*Correct*	*Incorrect*
Axis line starts and ends with a longer dash		
Two axes intersect with longer dashes		
		
		
Axis extends the boundary with a longer dash		

- **Content /Topic3 Termination of Leader Lines**

A leader is a line referring to a feature (dimension, object, outline, etc.).
Leader lines should terminate (Fig. 2.7),
(*a*) With a dot, if they end within the outlines of an object,
(*b*) With an arrow head, if they end on the outline of an object,
(*c*) Without dot or arrow head, if they end on a dimension line.

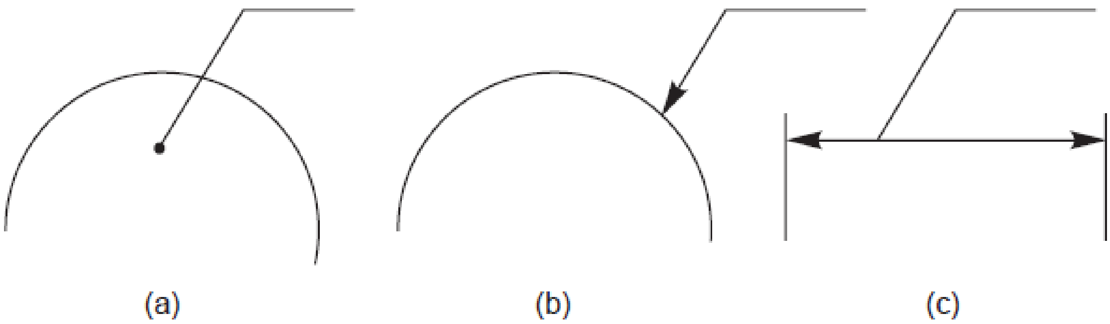


Fig. 2.7 Termination of leader lines

It is common practice to omit hidden lines in an assembled view, when their use tends to confuse an already complex drawing or when the feature is sufficiently clear in another view; but it is not advisable for a beginner to do the same and he will have to show the hidden lines in his drawing practice.

LO2.4: Respect drawing lettering standard rules

The essential features of lettering on technical drawings are, legibility, uniformity and suitability for microfilming and other photographic reproductions. In order to meet these requirements, the characters are to be clearly distinguishable from each other in order to avoid any confusion between them, even in the case of slight mutilations. The reproductions require the distance between two adjacent lines or the space between letters to be at least equal to twice the line thickness (Fig. 2.8). The line thickness for lower case and capital letters shall be the same in order to facilitate lettering. (Colin H Simmons, 2010)

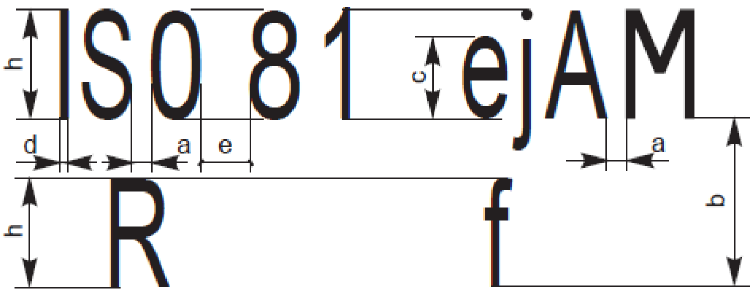


Fig. 2.8 Dimensions of lettering

- **Content /Topic 3 Dimensions**

The following specifications are given for the dimensions of letters and numerals:
(*i*) The height of capital letters is taken as the base of dimensioning (Tables 2.6 and 2.7).
(*ii*) The two standard ratios for *d/h*, 1/14 and 1/10 are the most economical, as they result in a minimum number of line thicknesses.
(iii) The lettering may be inclined at 15° to the right, or may be vertical.

Characteristic		*Ratio*	*Dimensions,* (mm)						
Lettering height (Height of capitals)	h	$(14/14)h$	2.5	3.5	5	7	10	14	20
Height of lower-case letters (without stem or tail)	c	$(10/14)h$	—	2.5	3.5	5	7	10	14
Spacing between characters	a	$(2/14)h$	0.35	0.5	0.7	1	1.4	2	2.8
Minimum spacing of base lines	b	$(20/14)h$	3.5	5	7	10	14	20	28
Minimum spacing between words	e	$(6/14)h$	1.05	1.5	2.1	3	4.2	6	8.4
Thickness of lines	d	$(1/14)h$	0.18	0.25	0.35	0.5	0.7	1	1.4

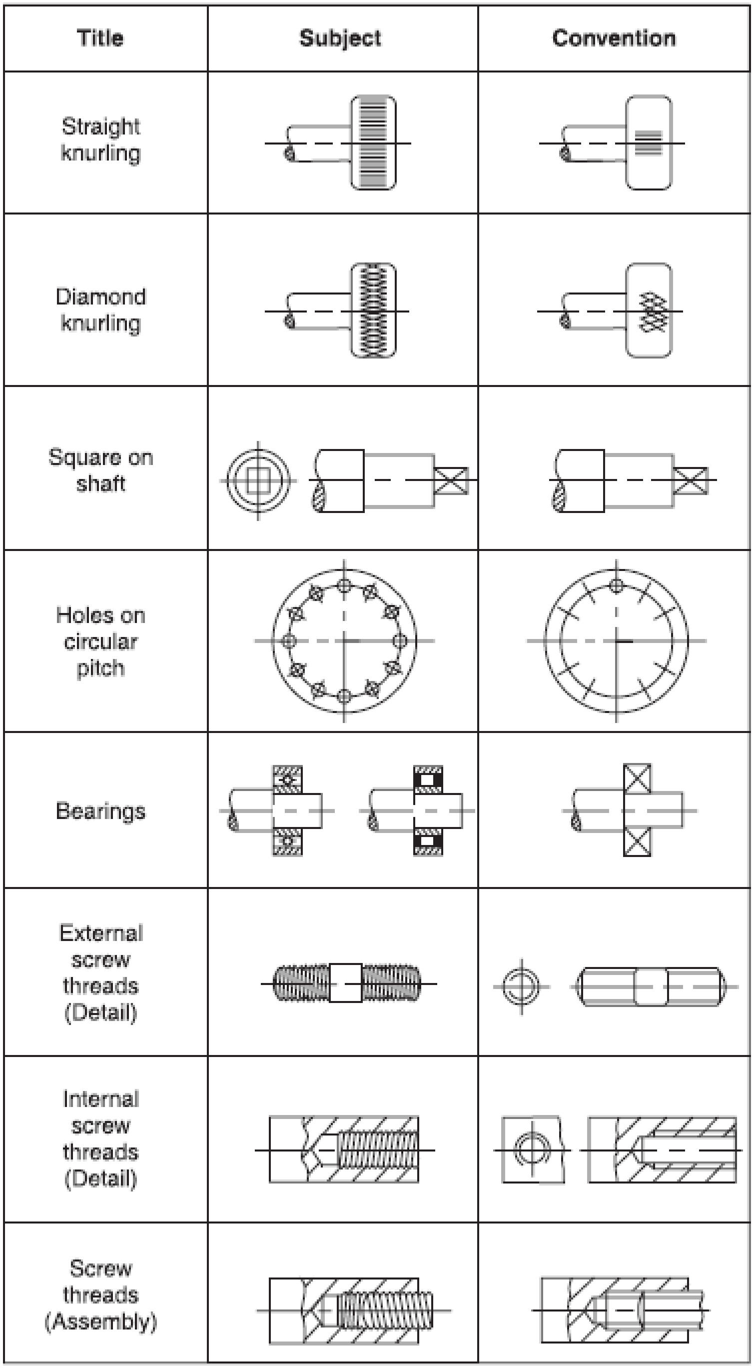
NOTE The spacing between two characters may be reduced by half, if this gives a better visual effect as for example LA, TV; it then equals the line thickness.

LO2.5: Apply dimension rules

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.

- **<u>Content/Topic 1 General Principles</u>**

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



(a)

Fig. 2.27 Conventional representation of machine components (*Contd.*)

- **Content/Topic 2 Method 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 Figs. 2.28 and 2.29. The following are some of the principles to be adopted during execution of dimensioning:

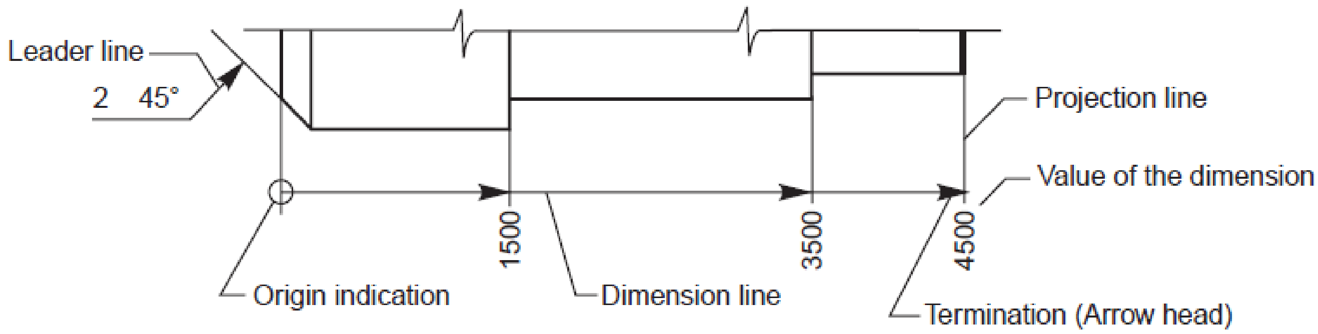
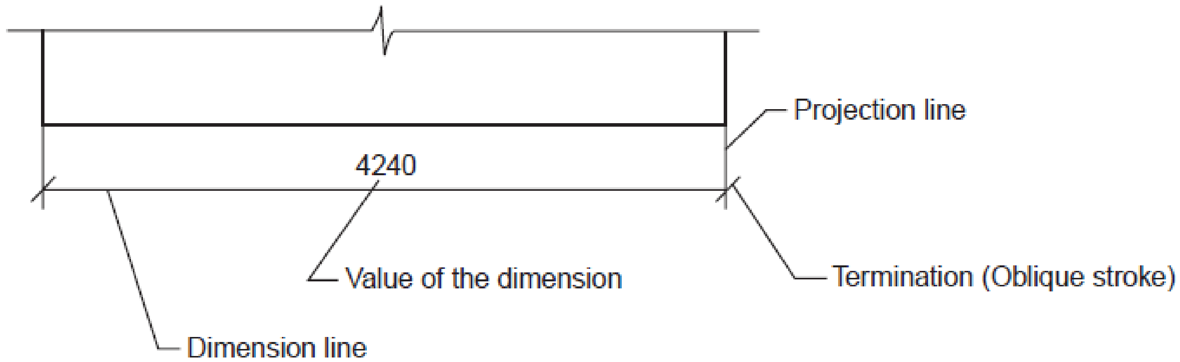


Fig. 2.28 Elements of dimensioning



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. 2.30). 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. 2.31).
5. A dimension line should be shown unbroken, even where the feature to which it refers, is shown broken (Fig. 2.32).
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 (Fig. 2.31).

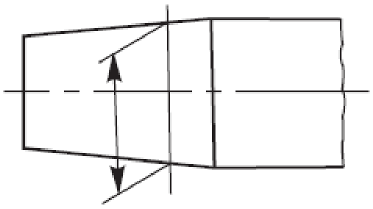


Fig. 2.30

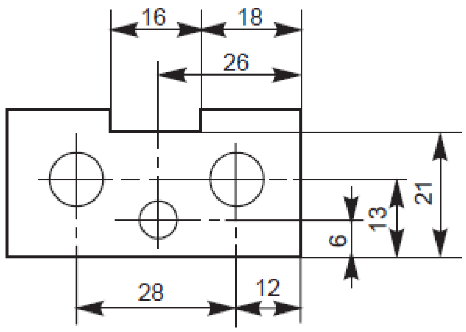


Fig. 2.31

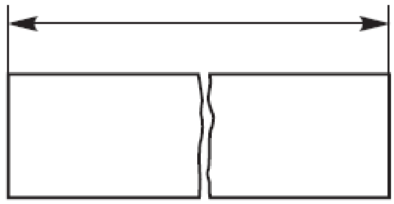


Fig. 2.32

- **Content /Topic3 Termination and Origin Indication**

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. 2.33. 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.

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. 2.34).

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. 2.35). However, the arrow head termination may be either on the inside or outside of the feature outline, depending upon the size of feature.

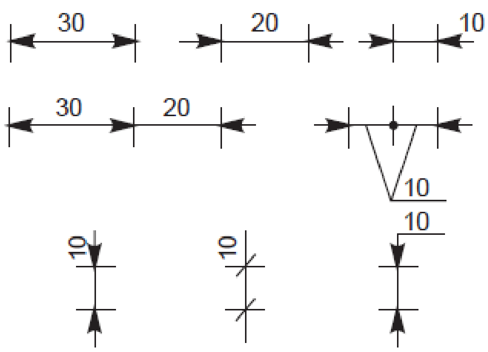


Fig. 2.34

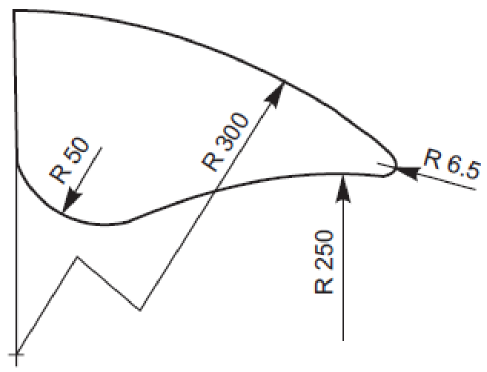


Fig. 2.35

- **Content/Topic 4 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.

METHOD–1 (Aligned System)

Dimensions should be placed parallel to their dimension lines and preferably near the middle, above and clear-off the dimension line (Fig. 2.36). An exception may be made where superimposed running dimensions are used (Fig. 2.44 *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. 2.37. Angular dimensions may be oriented as shown in Fig. 2.38.

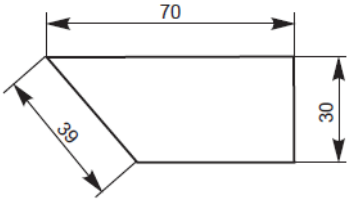


Fig. 2.36

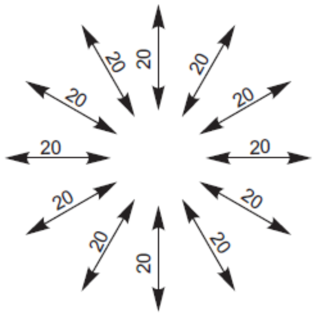


Fig. 2.37 Oblique dimensioning

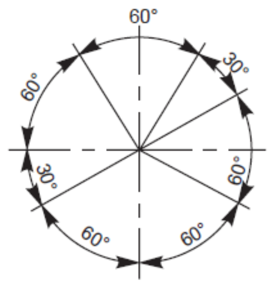


Fig. 2.38 Angular dimensioning

METHOD–2 (Uni-directional System)

Dimensons 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. 2.39).

Angular dimensions may be oriented as in Fig. 2.40.

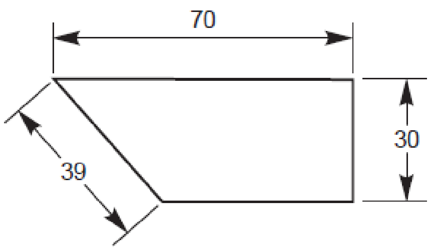


Fig. 2.39

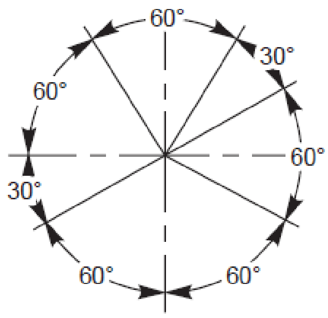


Fig. 2.40 Angular dimensioning

Dimensions can be, (*i*) above the extension of the dimension line, beyond one of the terminations, where space is limited (Fig. 2.34) or (*ii*) at the end of a leader line, which teminates on a dimension line, that is too short to permit normal dimension placement (Fig. 2.34) 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. 2.41). Values of dimensions, out of scale (except where break lines are used) should be underlined as shown in Fig. 2.41.

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. 2.42).

⍰⍰: Diameter S⍰⍰: Spherical diameter R : Radius SR : Spherical radius : Square

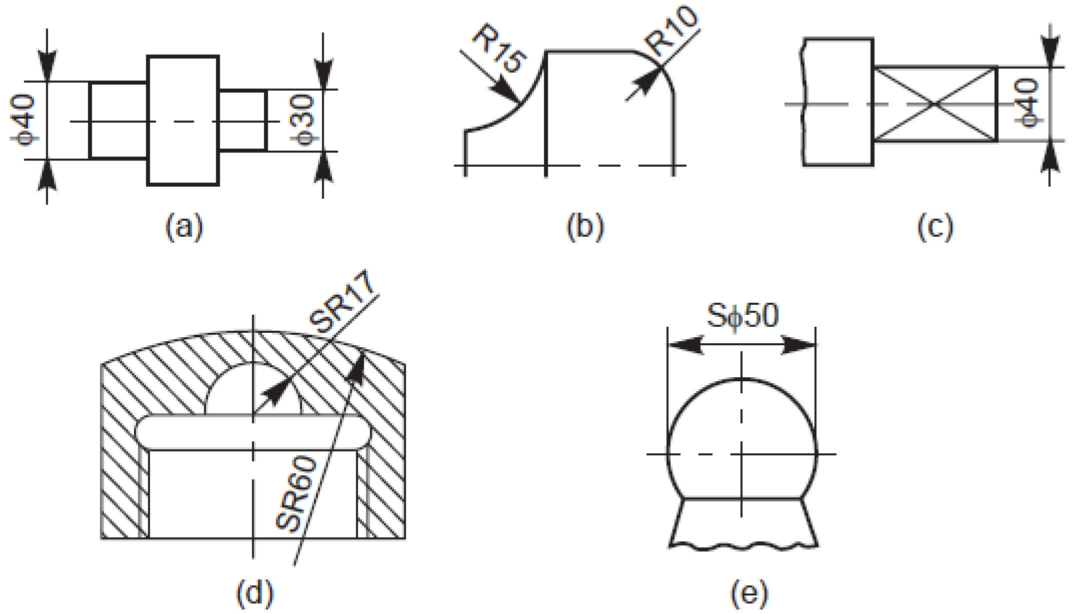


Fig. 2.42 Shape identification symbols

- **Content/Topic 5 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.

2.8.5.1 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. 2.43).

2.8.5.2 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. 2.44 *a*).

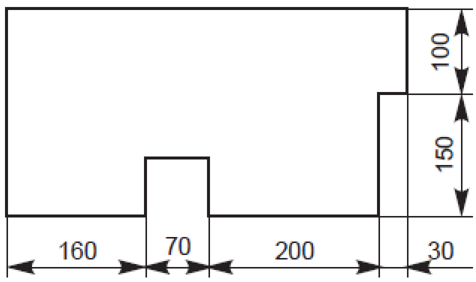


Fig. 2.43 Chain dimensioning

2.8.5.3 Super-imposed Running Dimensions

These are simplified parallel dimensons and may be used where there are space limitations (Fig. 2.44 *b*).

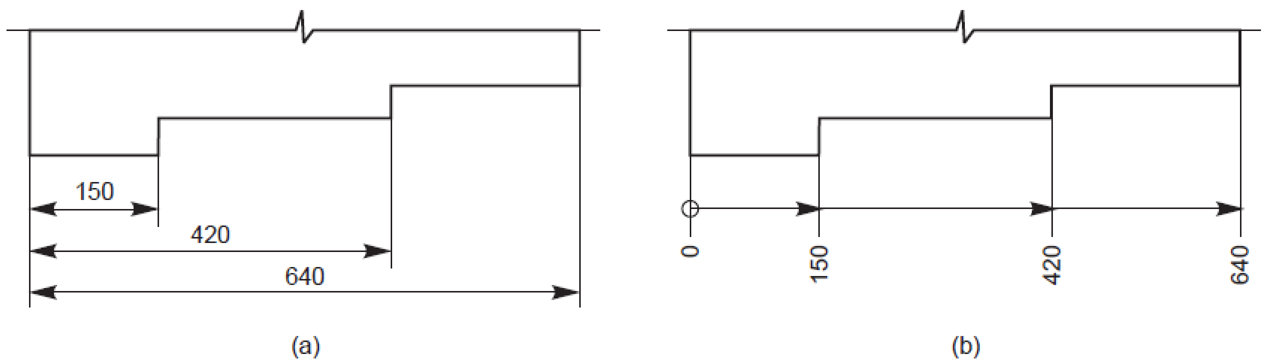


Fig. 2.44 Parallel dimensioning

- **Content /Topic 6 Special Indications**

Diameters

Diameters should be dimensioned on the most appropriate view to ensure clarity. Figure 2.47 shows the method of dimensioning diameters of Chord, Arc, Angles And Radii
The dimensioning of chords, arcs and angles should be as shown in Fig. 2.48. 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. 2.35).
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. 2.49). (Colin H Simmons, 2010)
Equidistant features

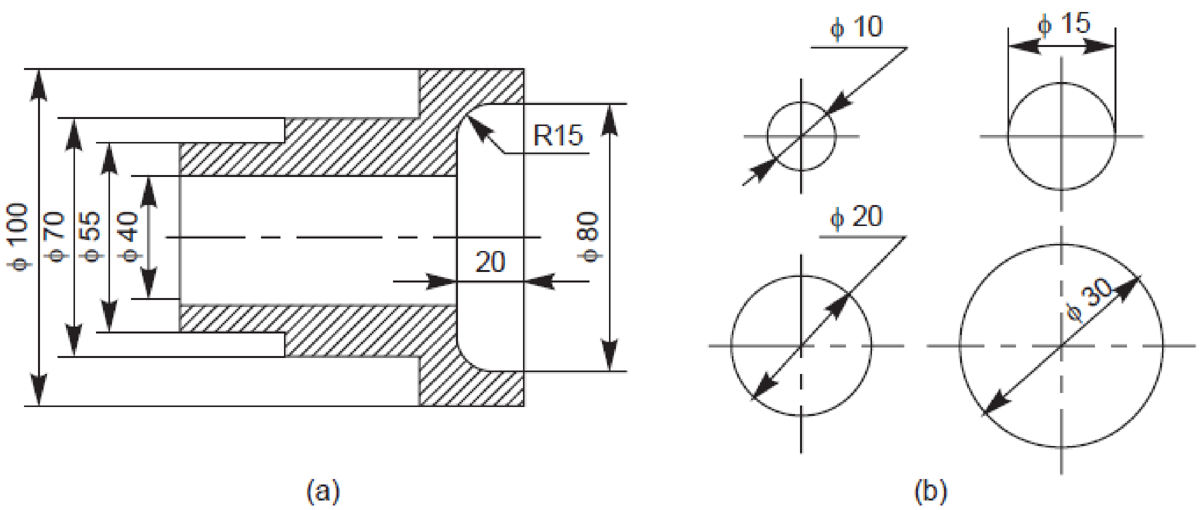


Fig. 2.47 Dimensioning of diameters

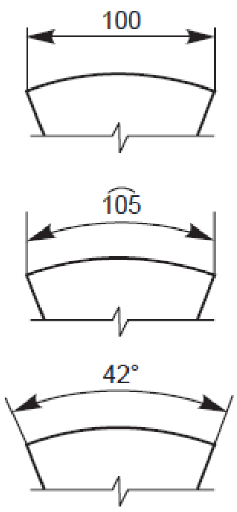


Fig. 2.48 Dimensioning of chords, arcs and angles

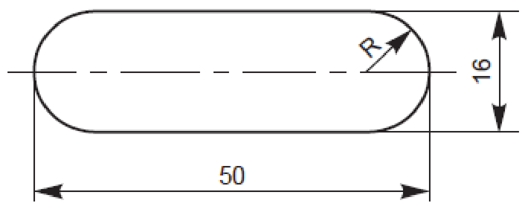


Fig. 2.49 Dimensioning of radius

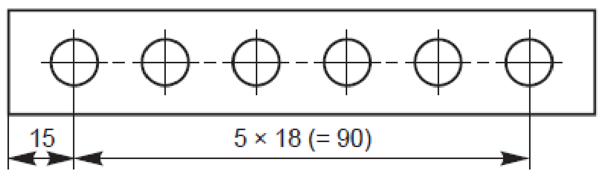


Fig. 2.50 Dimensioning equi-distant features

Chamfer and counter sucks

Chamfers may be dimensioned as shown in Fig. 2.51 and countersunks, as shown in Fig. 2.52.

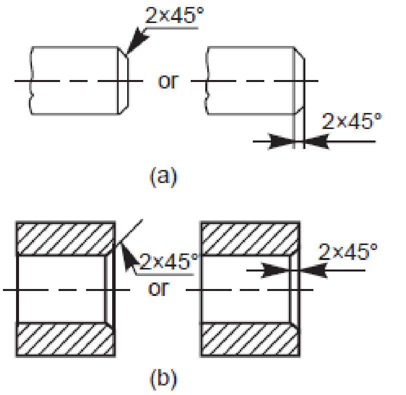


Fig. 2.51 Dimensioning chamfers

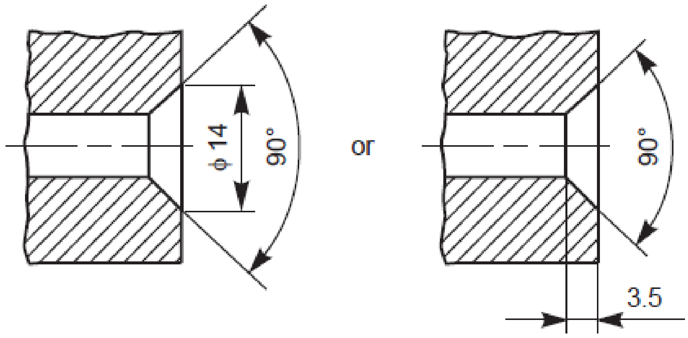


Fig. 2.52 Dimensioning countersunks

LO2.6: Design sections

In order to show the inner details of a machine component, the object is imagined to be cut by a cutting plane and the section is viewed after the removal of cut portion. Sections are made by at cutting planes and are designated by capital letters and the direction of viewing is indicated by arrow marks.

- **Content/Topic 1 Hatching of Sections**

Hatching is generally used to show areas of sections. The simplest form of hatching is generally adequate for the purpose, and may be continuous thin lines (type B) at a convenient angle, preferably 45°, to the principal outlines or lines of symmetry of the sections (Fig. 2.11).

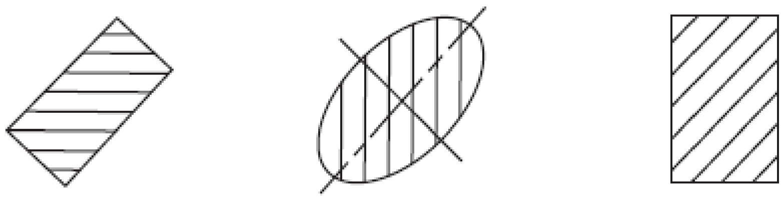


Fig. 2.11 Preferred hatching angles

Separate areas of a section of the same component shall be hatched in an identical manner. The hatching of adjacent components shall be carried out with different directions or spacings (Fig 2.12 *a*). In case of large areas, the hatching may be limited to a zone, following the contour of the hatched area (Fig. 2.12 *b*). Where sections of the same part in parallel planes are shown side by side, the hatching shall be identical, but may be off-set along the dividing line between the sections (Fig. 2.13). Hatching should be interrupted when it is not possible to place inscriptions outside the hatched area (Fig. 2.14).

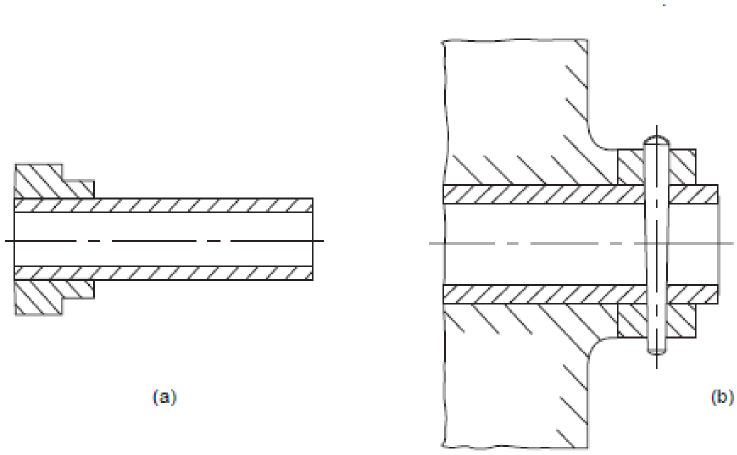


Fig. 2.12 Hatching of adjacent components

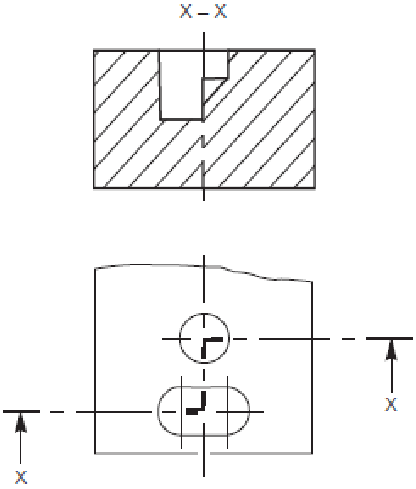


Fig. 2.13 Sectioning along two parallel planes

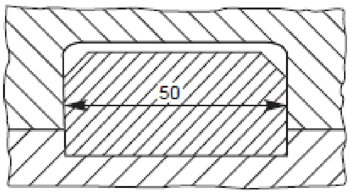


Fig. 2.14 Hatching interrupted for dimensioning

- **Content/Topic 2 Cutting Planes**

The cutting plane(s) should be indicated by means of type H line. The cutting plane should be identified by capital letters and the direction of viewing should be indicated by arrows. The section should be indicated by the relevant designation (Fig. 2.15). In principle, ribs, fasteners, shafts, spokes of wheels and the like are not cut in longitudinal sections and therefore should not be hatched (Fig. 2.16). Figure 2.17 represents sectioning in two parallel planes and Fig. 2.18, that of sectioning in three continuous planes.

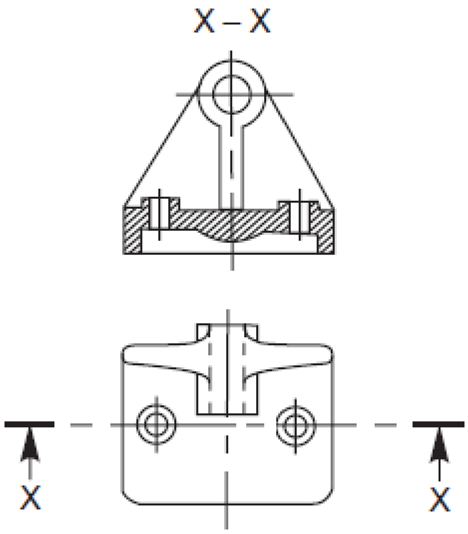


Fig. 2.15 Cutting plane indication

- **Content /Topic3 Revolved or Removed Section**

Cross sections may be revolved in the relevant view or removed. When revolved in the relevant view, the outline of the section should be shown with continuous thin lines (Fig. 2.21). When removed, the outline of the section should be drawn with continuous thick lines. The removed section may be placed near to and connected with the view by a chain thin line (Fig. 2.22 *a*) or in a different position and identified in the conventional manner, as shown in Fig. 2.22 *b*. (Dr.KL. Narayana, 2006)

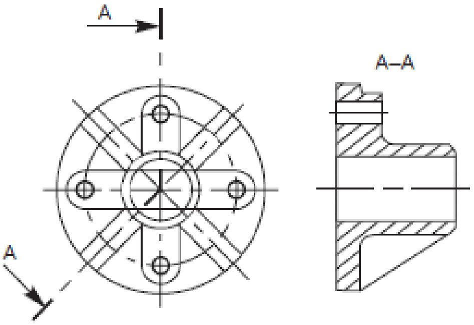


Fig. 2.19

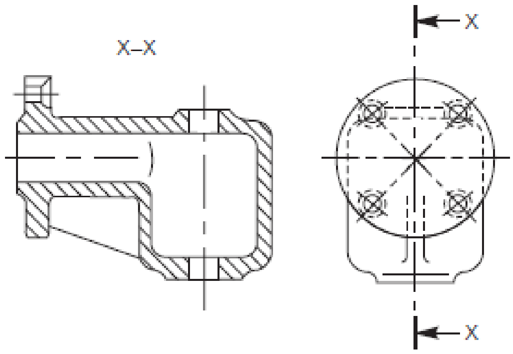


Fig. 2.20

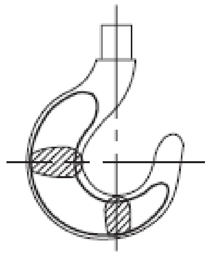


Fig. 2.21 Revolved section

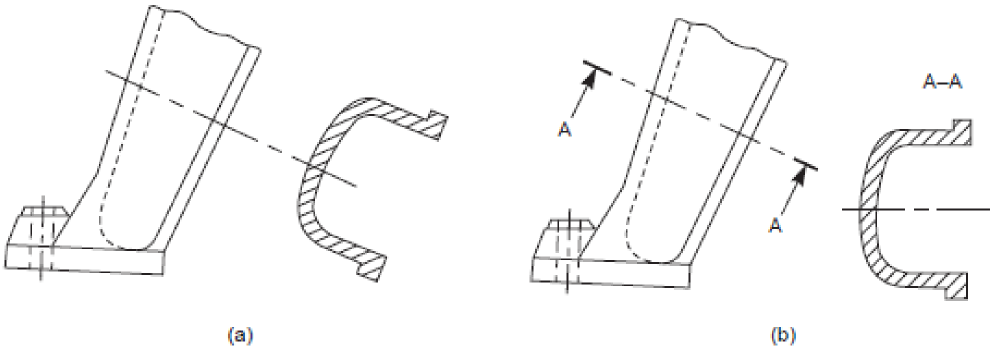


Fig. 2.22 Removed section

- **Content/Topic 4 Half Section**

Symmetrical parts may be drawn, half in plain view and half in section (Fig 2.23).

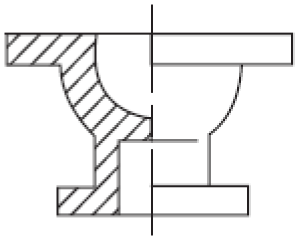


Fig. 2.23 Half section

- **Content/Topic 5 Local Section**

A local section may be drawn if half or full section is not convenient. The local break may be shown by a continuous thin free hand line
(Fig. 2.24).

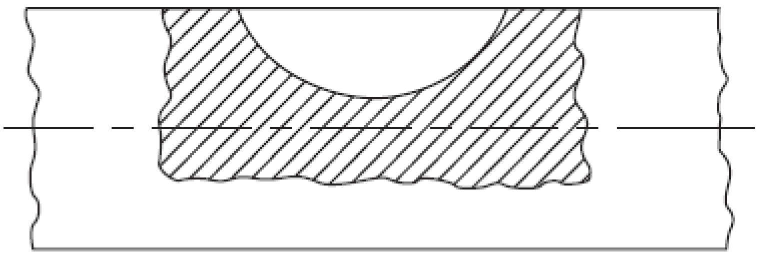


Fig. 2.24 Local section

- **Content /Topic 6 Arrangement of Successive Sections**

Successive sections may be placed separately, with designations for both cutting planes and sections (Fig. 2.25) or may be arranged below the cutting planes.

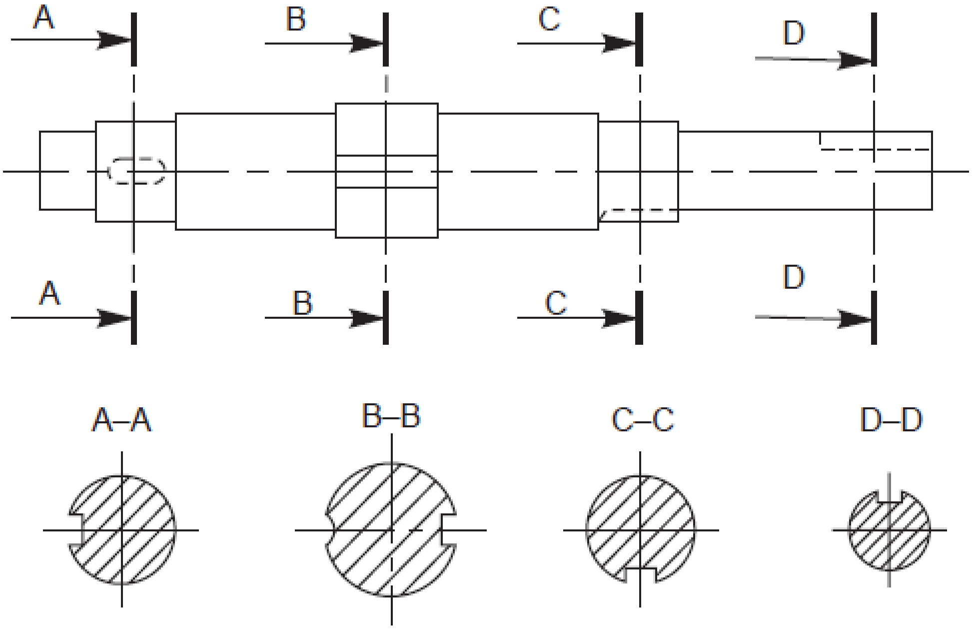


Fig. 2.25 Successive sections

LO2.7: Apply drawing conventional representations dimensioning and standard abbreviations

- **Content/Topic 1 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 Fig.2.26.

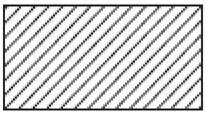
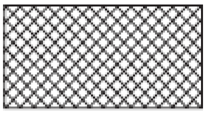
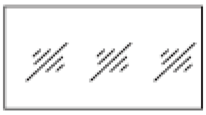
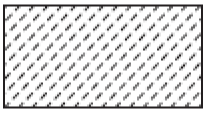
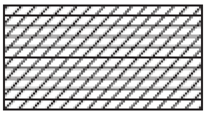
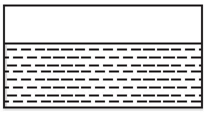
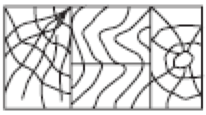
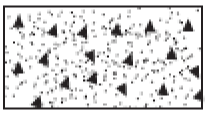
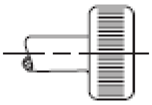
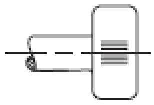
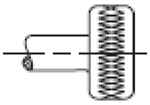
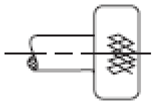
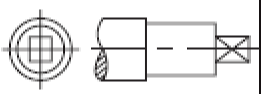
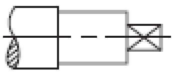
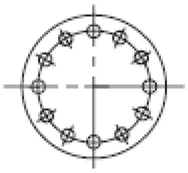
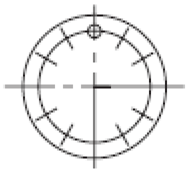
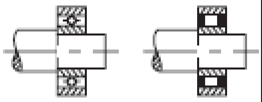
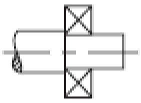
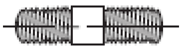
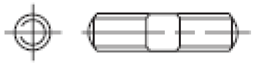
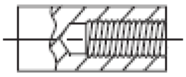
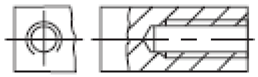
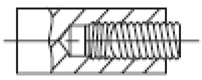
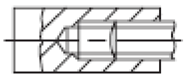
Type	Convention	Material
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminium and its Alloys, etc.
		Lead, Zinc, Tin, White-metal, etc.
Glass		Glass
Packing and Insulating material		Porcelain, Stoneware, Marble, Slate, etc.
		Asbestos, Fibre, Felt, Synthetic resin products, Paper, Cork, Linoleum, 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

Fig. 2.26 Conventional representation of materials

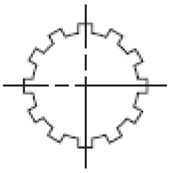
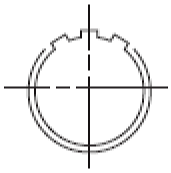
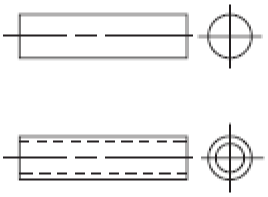
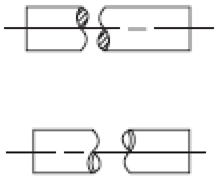
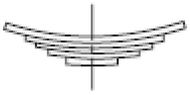
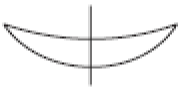
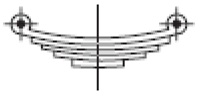
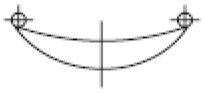
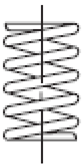
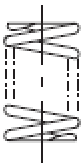
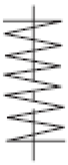
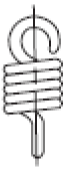
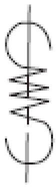
- **Content/Topic 2 Machine Components**

When the drawing of a component in its true projection involves a lot of time, its convention may be used to represent the actual component. Figure 2.27 shows typical examples of conventional representaion of various machine components used in engineering drawing. (Dr.KL. Narayana, 2006)

Title	Subject	Convention
Straight knurling		
Diamond knurling		
Square on shaft		
Holes on circular pitch		
Bearings		
External screw threads (Detail)		
Internal screw threads (Detail)		
Screw threads (Assembly)		

(a)

Fig. 2.27 Conventional representation of machine components (*Contd.*)

Title	Subject	Convention	
Splined shafts			
Interrupted views			
Semi-elliptic leaf spring			
Semi-elliptic leaf spring with eyes			
	Subject	Convention	Diagrammatic Representation
Cylindrical compression spring			
Cylindrical tension spring			

(b)

Fig. 2.27 Conventional representation of machine components (*Contd.*)

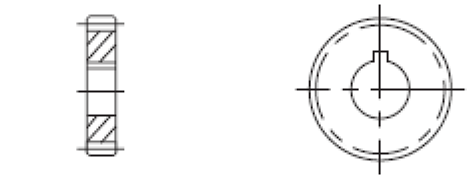
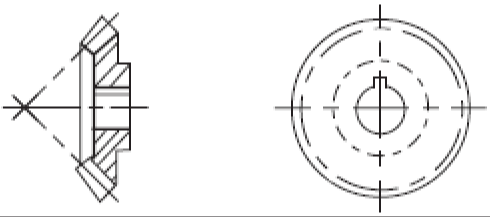
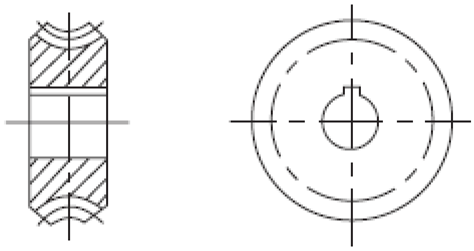
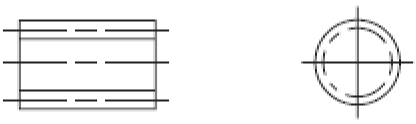
Title	Convention
Spur gear	
Bevel gear	
Worm wheel	
Worm	

Fig. 2.27 Conventional representation of machine components

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.

References

1) Colin H Simmons, D. E. (2010). *Manual of Engineering Drawing second edition.*

2) Dr.KL. Narayana, K. R. (2006). *Machine Drawing.* NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS.

3) Reddy, V. (2012). *Textbook of Engineering drawing.* BS Publications.