21 Assemblies

SYLLABUS OUTLINE

Areas to be studied (in an applied context):

• Interpretation of exploded and assembled drawings. • Drawings – layout and conventions. • System of projection. • Sectional views. • Hatching. • Dimensioning. • Joining methods. • Machine surface and texture symbols. • Modelling assemblies in 3-D CAD.

Learning outcomes

Students should be able to:

Higher and Ordinary levels

- Understand product assembly drawings.
- Interpret assembly drawings.
- Draw assembled views from drawings of a small number of single components.
- Draw the views essential to the representation of an assembly.
- Draw single-plane sectional views.
- Hatch sectioned parts in each view.
- Fully dimension drawings.
- Measure components to be drawn and relate the model/drawing to the artefact.
- Generate CAD models of assemblies.
- Apply balloon detailing.
- Use abbreviations and symbols.

Higher level only

- *Draw a number of sectional views.*
- *Draw views that have been sectioned.*
- *Indicate on the drawing a surface finish as appropriate.*
- *Indicate methods of assembly.*

The understanding of machine and flat-pack assembly drawings is a necessary skill for many household and other common products. This chapter hopes to develop the skill of interpreting these types of drawings as well as the skill of producing these types of drawings. The student will become familiar with dimensioning, sectioning, hatching and joining as well as the use of appropriate symbols and abbreviations.

Working Drawings

A set of working drawings includes the **detail drawings** of the component parts and the **assembly drawing** which shows these parts in their correct position relative to each other. Working drawings will also include a **parts list**, brief **annotations** and **dimensions**.

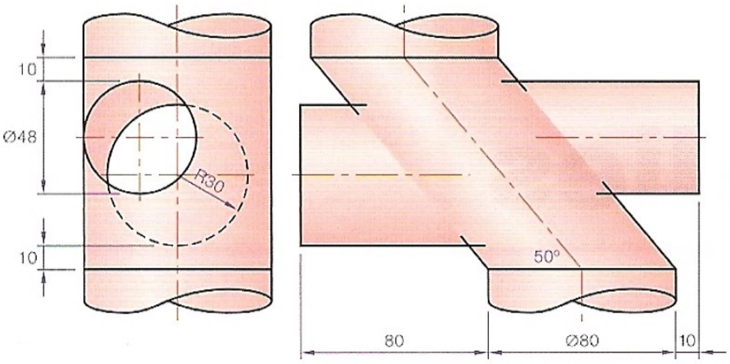


Fig. 20.107

Q41. Fig. 20.107 shows an oblique cylindrical duct penetrated by two different-sized cylindrical ducts.

(i) Draw the given views and project a plan.
(ii) Find the joint line in all views.
(iii) Make a complete surface development of both cylindrical ducts.
(iv) Develop the oblique cylindrical duct.

Q42. Shown in Fig. 20.108 is a transition piece in the form of a truncated oblique cone. This transition piece is penetrated by a square-sectioned duct of 45 mm side.

(i) Draw the given views and complete the plan.
(ii) Find the joint line in all views.
(iii) Develop the surface of the oblique cone.
(iv) Develop the surface of the square duct.

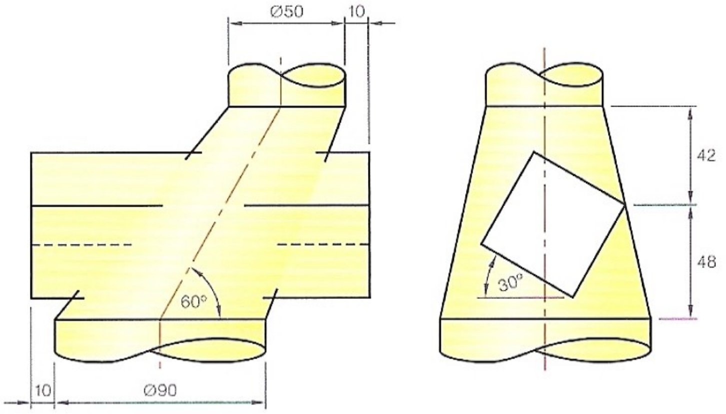


Fig. 20.108

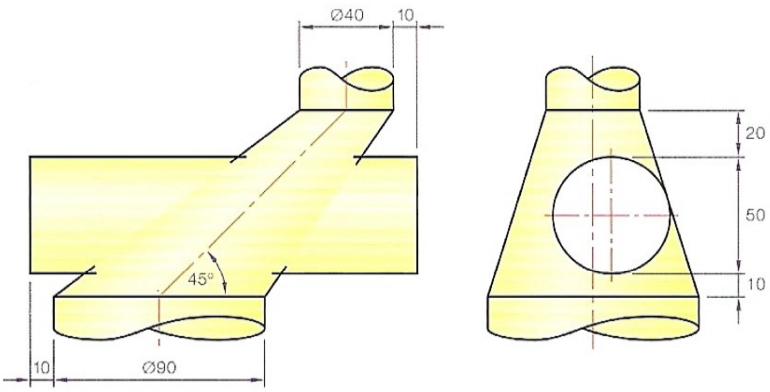


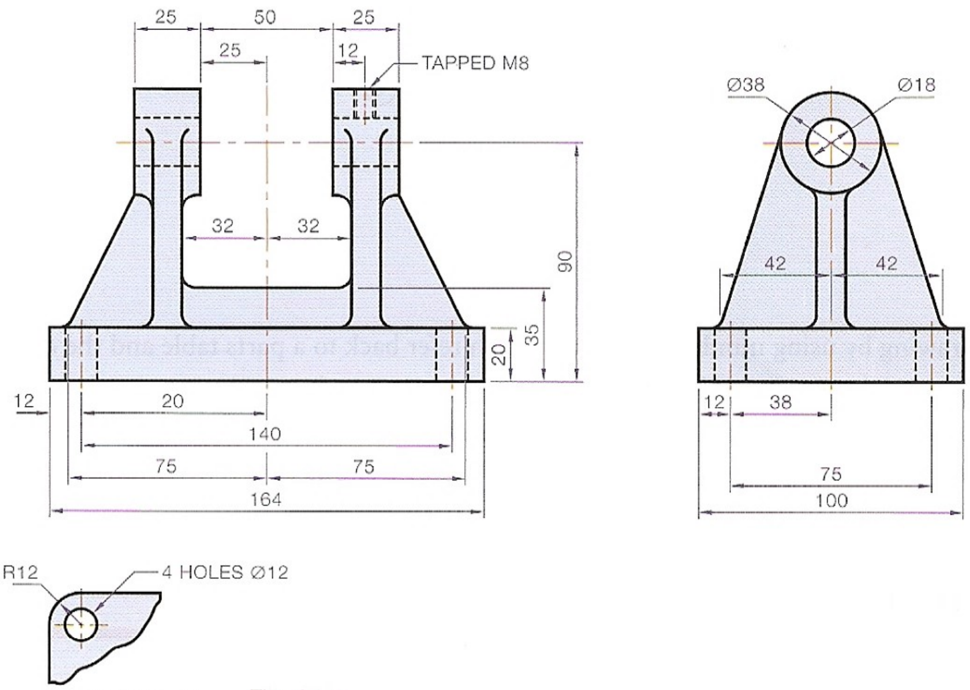
Fig. 20.109

Q43. A truncated oblique cone forms a transition piece. A cylindrical duct penetrates the transition piece as shown.

(i) Draw the given views and project a plan.
(ii) Find the joint line in all views.
(iii) Develop the surface of the cylindrical duct.
(iv) Develop the surface of the transition piece.

Detail Drawings

A detail drawing gives all relevant information about a component. Details of one part or a number of small parts may be given on each sheet. Detailed drawings usually show orthographic views, are fully dimensioned and show materials, finishes, tolerances and notes on manufacture. When several details are drawn on one sheet, careful consideration must be given to spacing. Ample space must be allowed around each component to allow for dimensions and notes. The same scale should be used for all details on a single sheet, if possible. When this is not practical the scale for each detail should be clearly noted under each component.



Part Number 1
Conveyor Bracket
Aluminium
Thickness of all ribs 10 mm
All fillets Radii 5 mm

Fig. 21.1

Assembly Drawing

As stated earlier, an assembly drawing shows the assembled parts in their functional positions. The views selected show how the parts fit together in the assembly and suggest the function of the entire unit. The assembly drawing does not attempt to describe the shapes of the individual parts but rather the relationship between the parts. The information on each of the parts can be found by referring to the **detail drawing**.

The views selected should be the minimum views or partial views that will show how the parts fit together. The views usually take the form of sectional views as these show more clearly how parts fit into each other or overlap each other. As a result of using sectional views, it is very rare to include hidden detail. If the clarity of the assembly can be improved by using hidden lines, then they should be used.

Dimensioning of an assembly is not necessary because all the parts have been fully dimensioned in the detail drawings. When dimensions are given, they are limited to some function of the object such as the maximum opening between the jaws or the maximum movement of a piston.

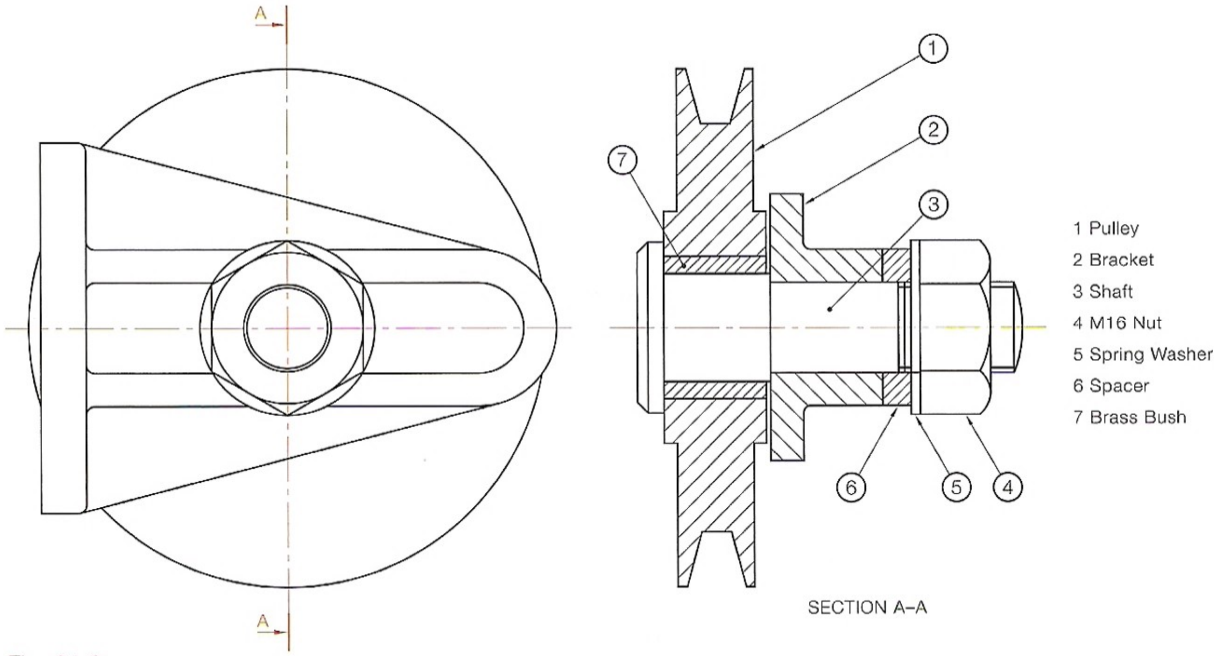


Fig. 21.2

Parts are identified in an assembly drawing by using numbers or letters which refer back to a parts table and the detailed drawings. Circles containing the part numbers are placed beside the parts with leaders ending with arrowheads touching the part. The circles should be placed in orderly, horizontal or vertical rows and should not be scattered over the sheet. The leaders should not cross each other and should be parallel or almost so. Fig. 21.2 shows an assembly drawing with parts list and identification numbers.

Sectioning of Assemblies

In the sectioning of assemblies it is important that the sectioning aids in the identification of the individual parts. Figures 21.3a, 21.3b and 21.3c show some of the principles involved when sectioning. The large area is sectioned at 45° in Fig. 21.3a. Spacings between lines should be even and judged by eye. The second large component in Fig. 21.3b is sectioned at 45° in the opposite direction. Care should be taken that the section lines do not meet on the intersection line. Additional components in Fig. 21.3c are sectioned at 30°, 60° or an odd angle. Section lines are placed closer together in smaller areas.

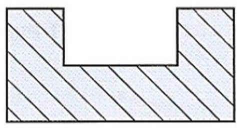


Fig. 21.

Some parts of an assembly section are not hatched even though they may lie on the section plane. It is standard practice to show these unsectioned or in the round.

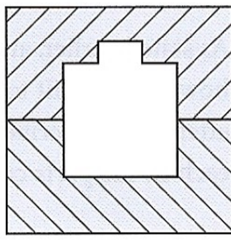


Fig. 21.

Components not to be sectioned:

(1) Bolts	(2) Nuts	(3) Washers
(4) Rivets	(5) Shafts	(6) Keys
(7) Screws	(8) Pins	(9) Gear teeth
(10) Spokes	(11) Ribs	

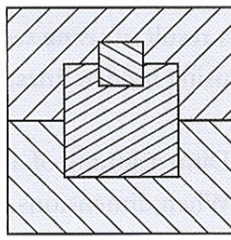
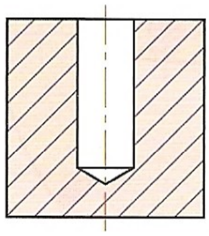


Fig. 21

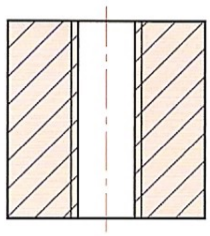
Sectioning of thin parts such as gaskets and sheet metal parts is both difficult and ineffective. Such parts should be shown in solid black.

Sectioning of Holes, Tapped Holes, Set Screws, Nuts, Bolts, Washers and Rivets



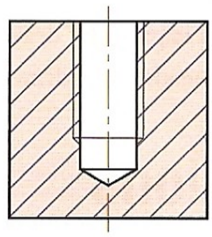
Section through a drilled hole

Fig. 21.4a



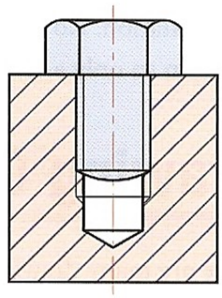
Section through a tapped hole. The sides of the hole formed by the tapping size drill are drawn dark.

Fig. 21.4b



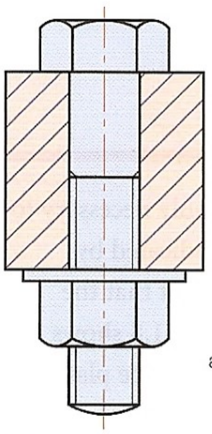
Section through a blind tapped hole. Note the section lines cross the thread to the sides of the hole.

Fig. 21.4c



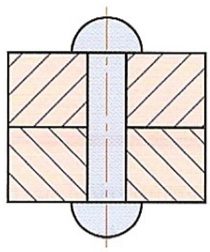
Section through a blind tapped hole with a set screw. Note the section lines are not drawn through the bolt screw thread.

Fig. 21.4d



Even though the section cuts through the nut, bolt and washer they are shown in the round

Fig. 21.4e



Section through a rivet. The rivet is drawn in the round.

Fig. 21.4f

Sectioning of Ribs

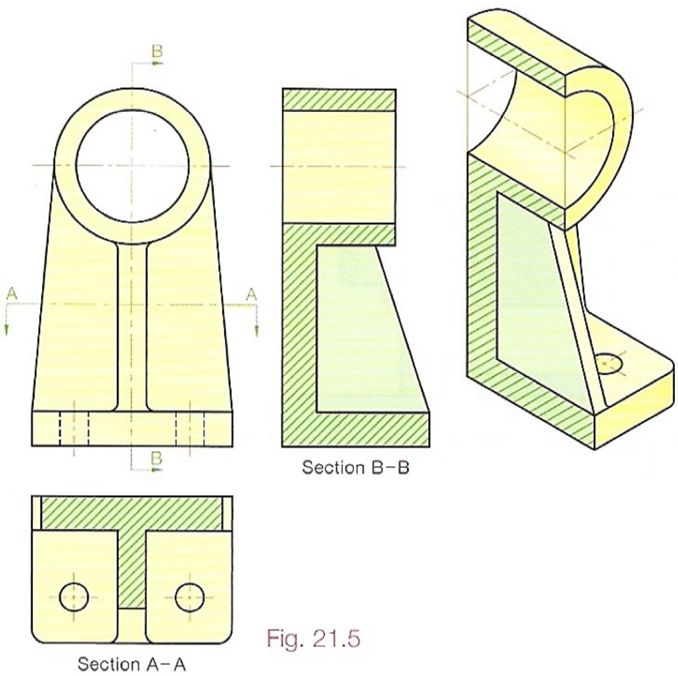


Fig. 21.5

To avoid a false sense of solidity, ribs, webs, gear teeth and other thin surfaces are not sectioned even though the section plane passes through their centre plane. Fig. 21.5 shows section plane B–B passing though the rib. Yet the rib is not hatched. When the section plane cuts across a rib or any thin member, then it is sectioned. Fig. 21.5 shows section plane A–A cutting crosswise through the rib and producing a hatched rib.

Sectioning of Spokes

Spokes, like ribs, are not sectioned. Fig. 21.6 shows a partial view of a valve wheel showing only those features that are needed for minimum representation. No further information is given by drawing the full elevation so only a small portion of it needs to be drawn.

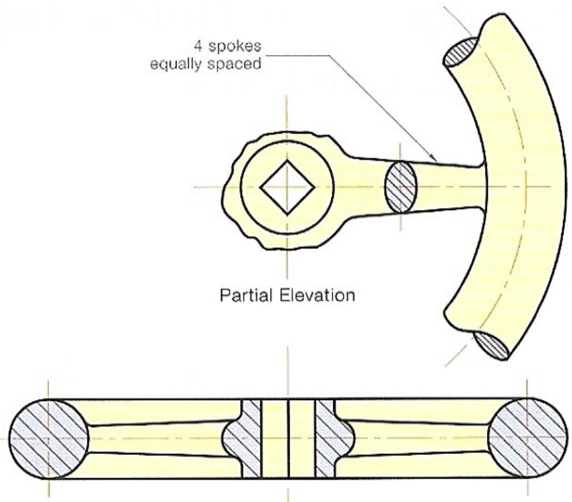


Fig. 21

Drawing Conventions

There are many drawing conventions used to help reduce the amount of drawing needed for a particular project yet not compromising on the amount of information provided. As a general rule, the drawing of repetitive details is avoided and every effort must be made to provide maximum information with minimum drawing.

Symmetrical Parts

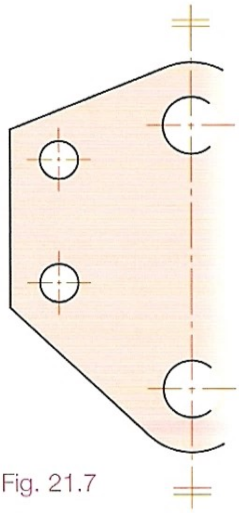


Fig. 21.7

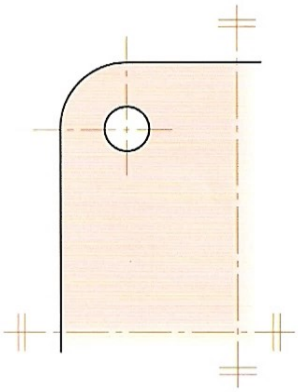


Fig. 21.8

For symmetrical parts about one axis (Fig. 21.7) it is only necessary to draw one side of the shape. The line of symmetry is indicated by placing two parallel lines at each end of it. It is important that the outline is extended slightly past the symmetry line. Fig. 21.8 shows a metal plate with two axes of symmetry. Only a quarter of the plate needs to be drawn.

Repetitive Information

Repeated drawing of identical features is avoided by drawing one object and indicating the position of the others by using centre lines, Fig. 21.9. When holes, bolts and rivets etc. form a pattern, enough centre lines are drawn to establish that pattern (Fig. 21.10). Detailing of a small area of a pattern is often sufficient. Enough of the pattern needs to be drawn to show that it is repetitive.

The shaft support needs only to be drawn once with bolt centre lines shown to locate second bracket.

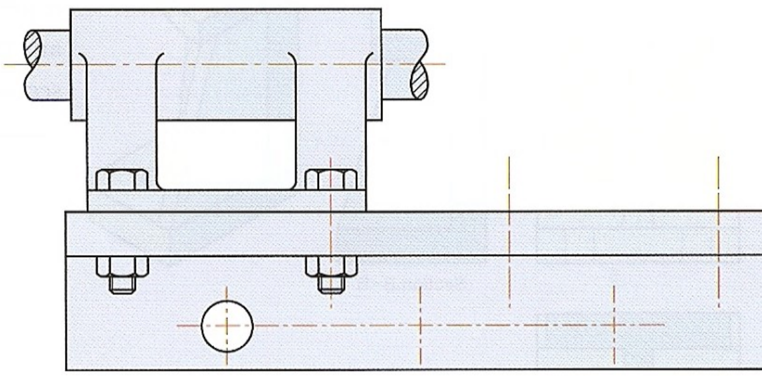


Fig. 21.9

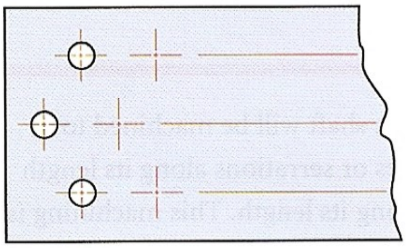


Fig. 21.10

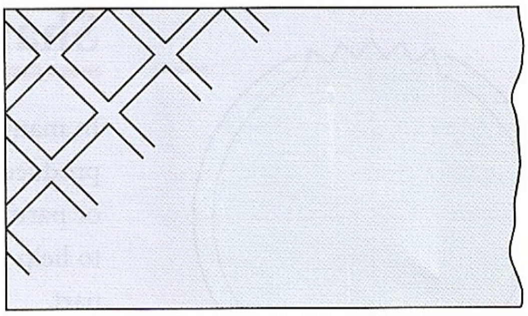


Fig. 21.11

For a regular pattern of holes, rivets etc. only the number necessary to establish the pattern are drawn. An accompanying note will provide sufficient information.

For repetitive patterns such as knurling, chequered plate, perforated sheet etc. it is sufficient to draw the pattern in a small area. A note indicating that the pattern covers a larger area will reduce the amount of drawing.

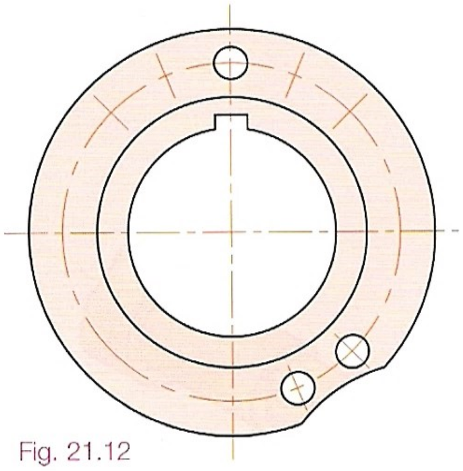


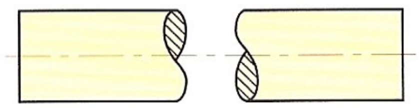
Fig. 21.12

When a special feature such as a keyway or a notch is near to a repetitive feature then the repetitive feature should be drawn in full. Fig. 21.12 shows an example. The repetitive feature, the holes, are drawn in full adjacent to the keyway and the notch.

Conventions for Breaks

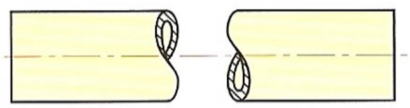
In order to shorten a view of an elongated object, it is recommended to use breaks. This often allows the object to be drawn to a larger scale.

If the full object was to be drawn it might have to be scaled down to fit on the sheet.



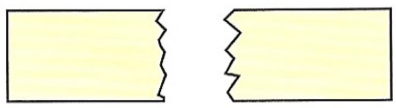
Round Solid

Fig. 21.13a



Round Tubular

Fig. 21.13b

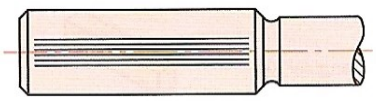


Square/Rectangular

Fig. 21.13c

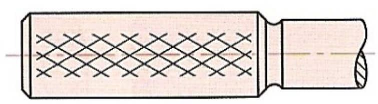
Conventions for Knurling

A knurl is a roughening of a cylindrical surface, usually to give a better handgrip for tightening/loosening a thread. There are two basic types, straight knurling and diamond knurling. These are shown in Figures 22.14a and 21.14b.



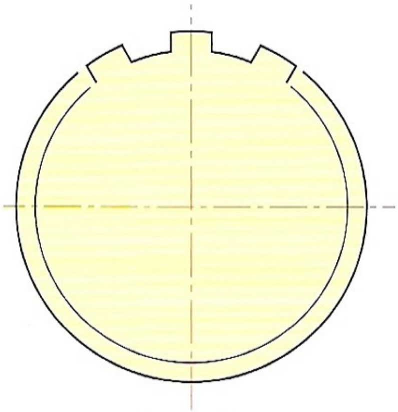
Straight knurling

Fig. 21.14a



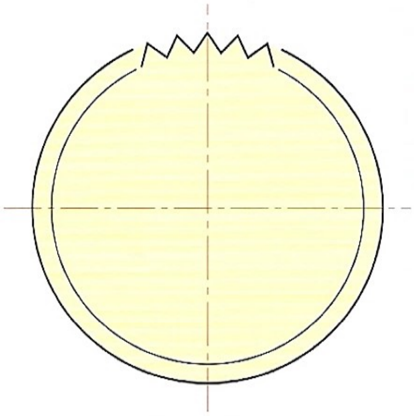
Diamond knurling

Fig. 21.14b



Splined Shaft

Fig. 21.15a



Serrated Shaft

Fig. 21.15b

Shafts

In many cases a shaft will be machined to produce splines or serrations along its length or partially along its length. This machining is to help the shaft transfer torque to another part.

Squared Shaft

The end of a cylindrical shaft will often be shaped to produce a square section to receive a handle or adjustment wheel.

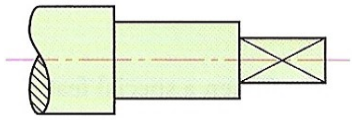


Fig. 21.16a

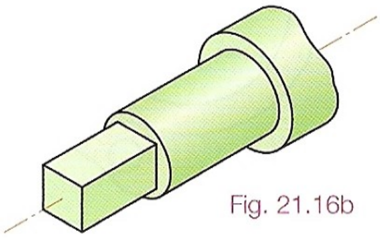


Fig. 21.16b

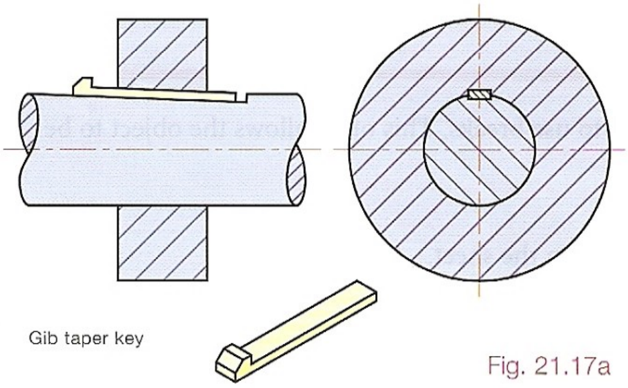


Fig. 21.17a

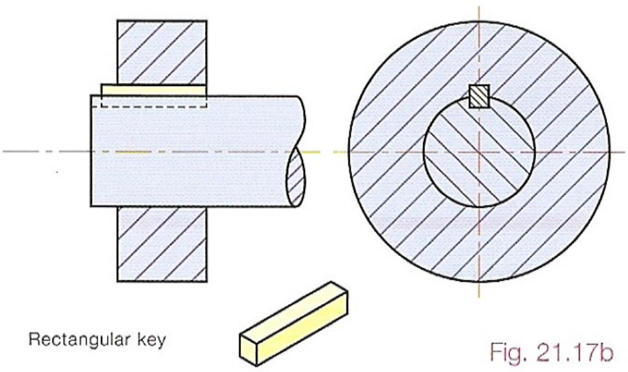


Fig. 21.17b

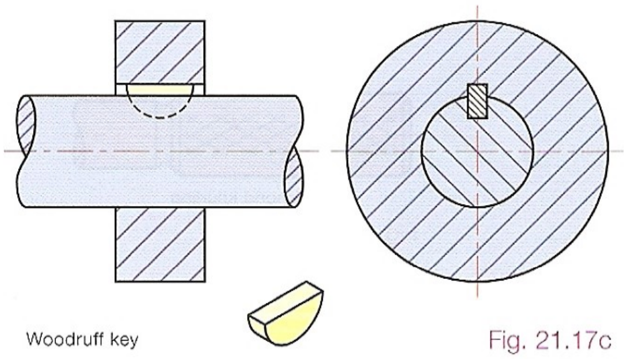


Fig. 21.17c

Shaft-fixing Devices: Keys and Keyways

One way of preventing a part from slipping on a shaft is to machine a slot, a keyway, into both pieces and to fit a third piece, the key, into this slot. The key ensures there is no relative movement between the two pieces. Figures 21.17a, 21.17b and 21.17c show a number of different types of keys and keyways.

The gib head key is easier to knock into place and to remove (Fig. 21.17a). The key itself may be parallel or tapered. A slope of 1:100 would be usual. Fig. 21.17b shows a rectangular key. Square or cylindrical keys are also used. This would be one of the more common key types. A woodruff key (Fig. 21.17c) is a segment of a disc and is often used on a tapered shaft. The size of the keys depends on the load to be carried.

Bearings

These are used to help to reduce friction. There are two basic types – ball bearings and roller bearings. Fig. 21.18 shows pictorials of each type. The hardened steel balls or rollers are held between an inner and outer ring. These rings are called races. Bearings are often sealed units containing the balls/rollers and a lubricant. Roller bearings are used where heavy loading occurs

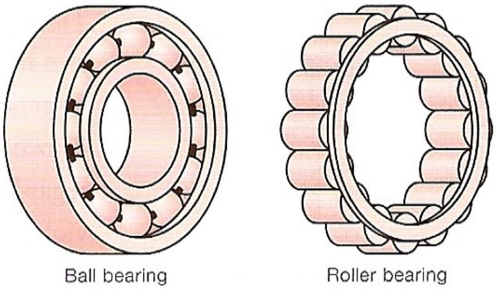


Fig. 21.18

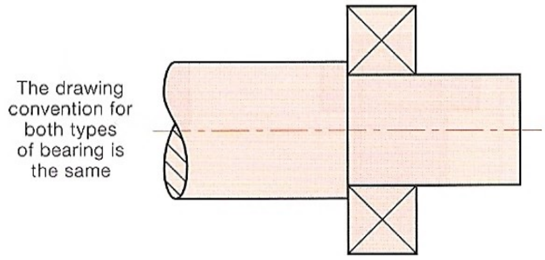


Fig. 21.19

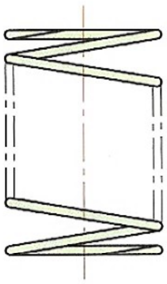


Fig. 21.20a

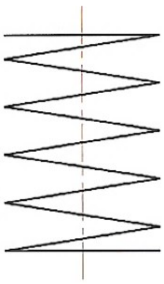


Fig. 21.20b

Springs

There are many spring shapes and sizes but they all fit into three categories according to function:

(1) compression,

(2) tension,

(3) torsion.

A few coils are drawn at either end, or the diagrammatic representation may be used.

Spur Gears

A working drawing of a spur gear is shown in Fig. 21.21. It is not necessary to show individual teeth on the drawing. The addendum and the root circles are drawn as solid circles with the pitch circle as a chain line.

In section, the teeth are not sectioned as this would give a false sense of solidity.

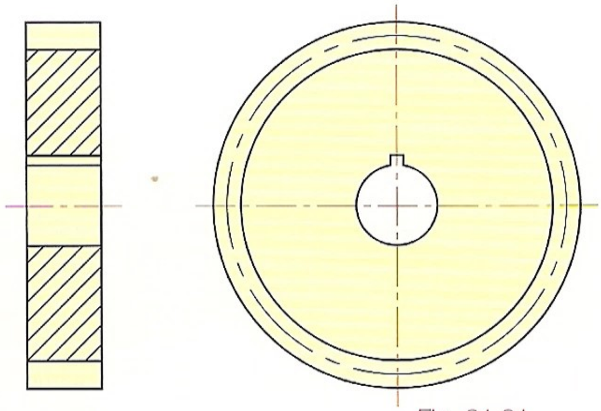


Fig. 21.21

The Drawing of Standard Bolts

Standard bolts and nuts are not shown on detail drawings but appear regularly on assembly drawings. The conventional way of drawing nuts and bolts is based on the body diameter as shown in Fig. 21.22a. the method of finding the centres for the curves on the bolt head is shown in Fig. 21.22b. Points C_1, C_2 and C_3 are all found with the 60° set-square.

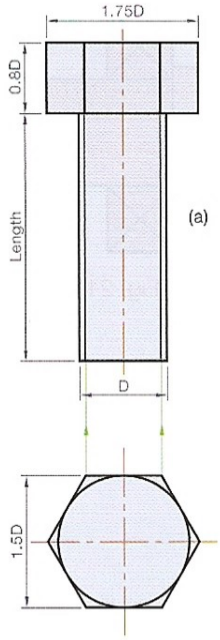


Fig. 21.22a

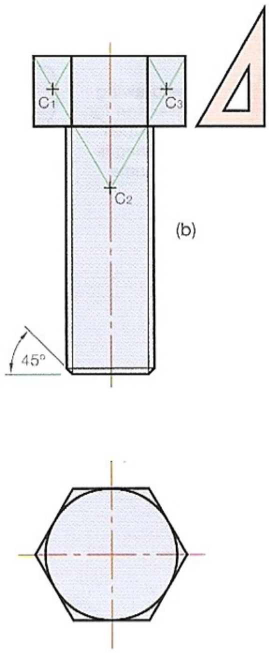


Fig. 21.22b

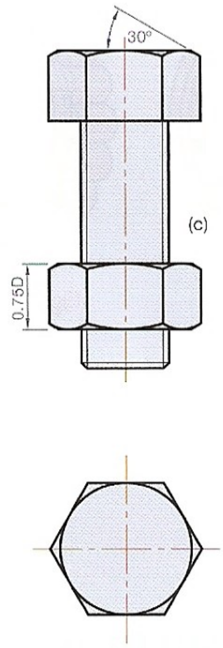


Fig. 21.22c

The inner thread lines are in line with the two inner edges of the hexagonal head. In general, bolt heads and nuts should be drawn across corners in all views, regardless of projection. This is a violation of projection rules but there are good reasons for it:

(1) It avoids confusion between hexagonal-head bolts and square-head bolts.
(2) It shows the clearance of both bolt heads and nut, in all views.
(3) It is faster to use the same construction in all views.

Bolt heads and nuts should only be drawn across the flats for a very special reason. Fig. 21.23 shows the construction convention used in such a view.

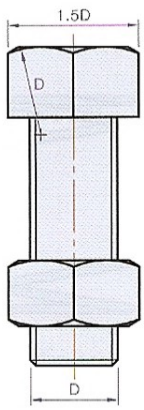
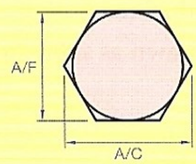
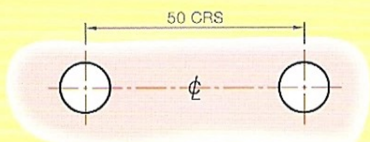
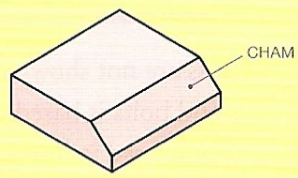
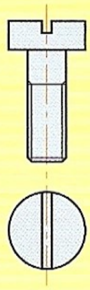
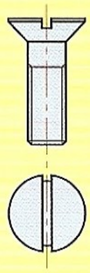
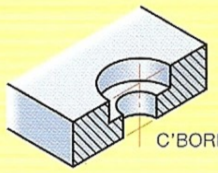
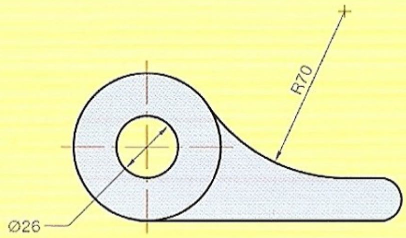


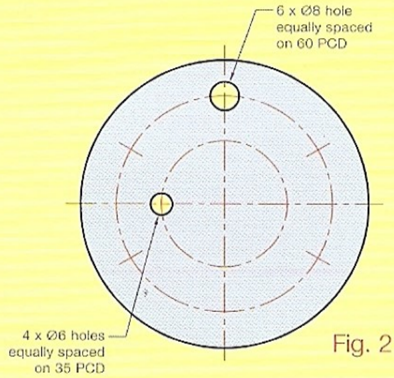
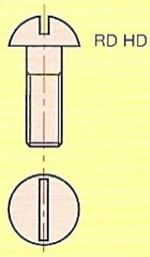
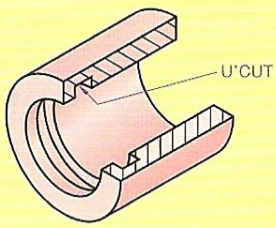
Fig. 21.23

Abbreviations and Their Uses

When producing engineering drawings there are many terms and expressions that need to be included on the drawings. Some of these are used frequently enough to justify the use of abbreviations. Many of these have been standardised.

Abbreviation	Explanation	Diagram
A/C	Across corners	
A/F	Across flats	
Hex HD	Hexagon head	
ASSY	Assembly	
CRS	Centres	
CL or ℄	Centre line	
CHAM	Chamfered	

Abbreviation	Explanation	Diagram
CH HD	Cheese head screw/bolt	
CSK	Countersunk head screw or countersunk hole	
C'BORE	Counterbore	
CYL **DIA** **Ø** **R**	Cylindrical Diameter (in a note) Diameter (preceding a dimension) Radius. Capital letter only.	
FIG	Figure	
DRG	Drawing	
HEX HD	Hexagonal head	
INSUL	Insulated or insulation	
INT	Internal	
EXT	External	
LH	Left hand	
LG	Long	
MATL	Material	
MAX and MIN	Maximum and minimum	
No.	Number	

Abbreviation	Explanation	Diagram
PCD	Pitch circle diameter	 Fig. 21.24
REQD	Required	
RH	Right hand	
RD HD	Round head	
SCR	Screwed	
SH	Sheet	
SK	Sketch	
SPEC	Specification	
SQ □	Square (in a note) Square preceding a dimension	
STD	Standard	
U'CUT	Undercut	
NTS	Not to scale	
RPM	Revolutions per minute	
FIM	Full indicated movement	

Drawings: Layout and Conventions

Title Block

Each sheet must have a title block, generally in the lower right corner. This title block will contain essential information for the identification and interpretation of the drawing. The actual layout of the title block does not matter and may be stamped on, pre-printed or drawn by hand. The following information would generally be given in the title block:

- name of firm,
- name of the object represented or assembly,
- drawing number,
- scale,
- date,
- signature(s),
- projection symbol,
- copyright clause.

As well as this information a whole body of additional information may be included such as material, quantity, treatment/hardness, finish, surface texture, screw thread forms etc.

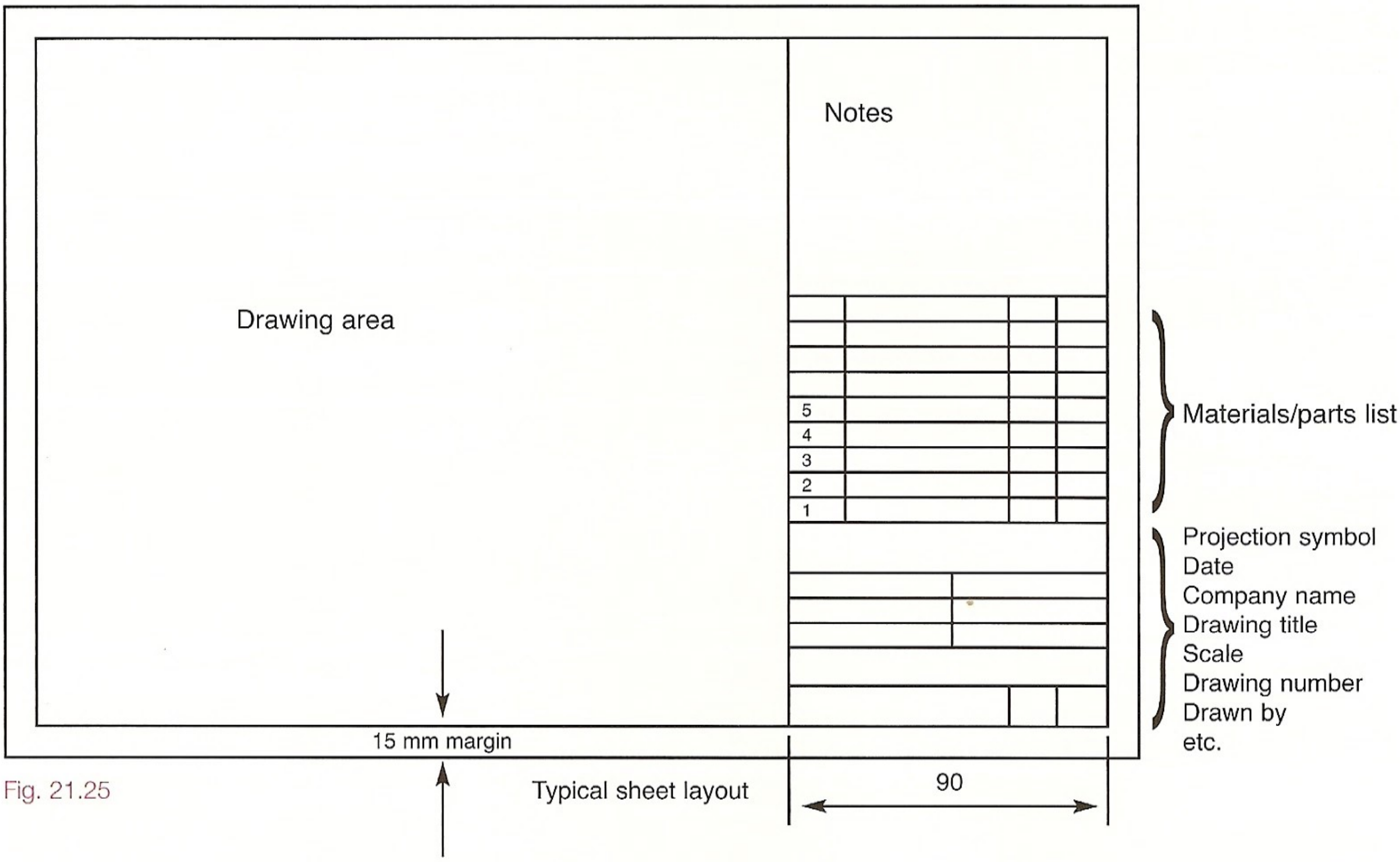


Fig. 21.25 Typical sheet layout

Parts List

A parts list consists of an itemised list of the parts shown on a detail drawing or an assembly drawing. The list should contain the part number, a descriptive title, quantity needed, material used, as well as other information as deemed necessary. The parts should be listed in order of size or importance. The main castings or forgings are listed first; parts cut from cold-rolled stock are second; and standard parts such as bolts, washers and bushing are third. If the parts list is

5	Pin	1	STEEL
4	Pulley	1	CI
3	Hook	1	STEEL
2	Trunnion	1	CI
1	Bracket	1	CI
No.	Part name	REQD	MATL

Fig. 21.26

placed as shown in Fig. 21.26 then the order of parts should be from the bottom upwards so that new parts may be added to the list later if necessary.

Standard parts such as bolts, screws and bearings are not drawn, but are listed, in the parts list.

Lines and Linework

All lines of a similar type should be consistently dense and bold throughout a drawing. Particular care should be taken with revisions of the drawing so that the new lines are not at variance with existing linework. The table below shows line types and their application.

Type of line	Example	Application of line
Thick continuous		Visible outlines and edges.
Thin continuous		Dimensions and leader lines, hatching, fictitious outlines and edges, outlines of revolved sections.
Short dashes (thin)		Hidden outlines and edges.
Chain (thin)		Centre lines, pitch circles, extreme positions of moving parts.
Chain (thin but thickened at ends and change of direction)		Cutting planes.
Continuous irregular (thin)		Limits of partial views and sections where the line is not an axis.
Thick continuous		A surface that must meet special requirements.

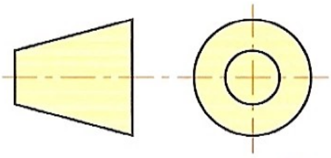
As a general rule, all chain lines should start and finish with a long dash. Centre lines should cross each other at solid portions of the line and should extend only a short distance beyond the feature. Centre lines should not continue through the spaces between views.

Lettering

Characters should be uniform and most importantly, legible. They should be of open form and free from serifs and other embellishments. Particular care must be taken with figures because, unlike letters, they rarely fall into patterns and must be read individually. The use of capital letters is preferred to lower case as they are less congested and, even when reduced in size, are less likely to be misread.

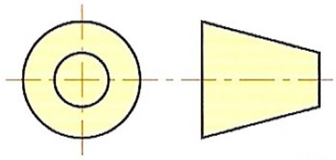
System of Projection

The system of projection used on the drawing must be clearly indicated by using the projection symbols.



First-angle projection

Fig. 21.27



Third-angle projection

Fig. 21.28

Dimensioning

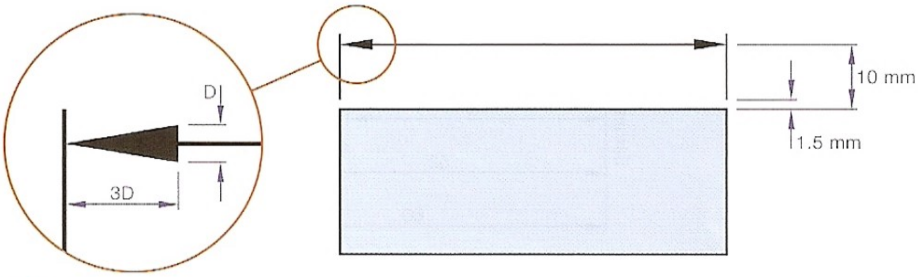
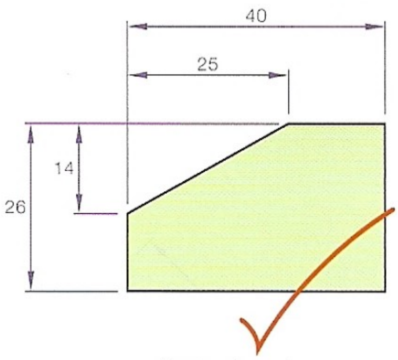


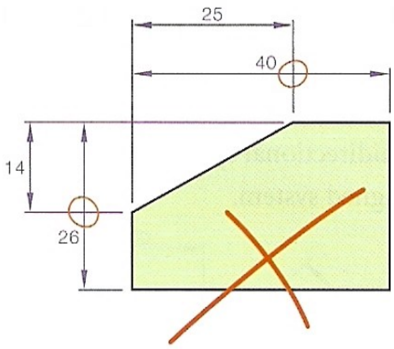
Fig. 21.29

A dimension line is a thin, solid, dark line which ends with arrowheads. The dimension line indicates the direction and extent of a measurement. The dimension nearest the object should be spaced about 10 mm away from the object outline. The extension lines 'extend' from the point on the drawing to which the dimension refers. A gap of about 1.5 mm should be left between the extension line and its reference point and it should continue past the arrowhead slightly. The arrowheads should be uniform in style and size throughout the drawing. Arrowheads should be drawn freehand and have a length and width in a ratio of 3:1.



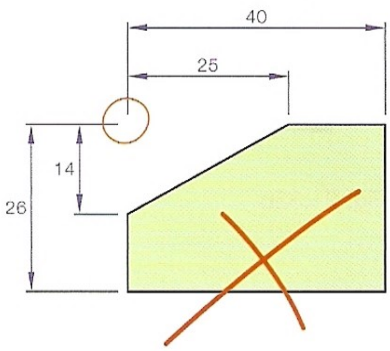
Shorter dimensions are nearest the object

Fig. 21.30a



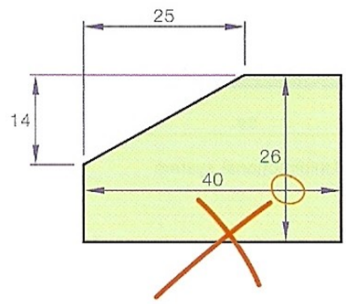
Dimension lines should not cross extension lines

Fig. 21.30b



Do not shorten extension lines

Fig. 21.30c



Avoid crossing dimension lines whenever possible

Fig. 21.30d

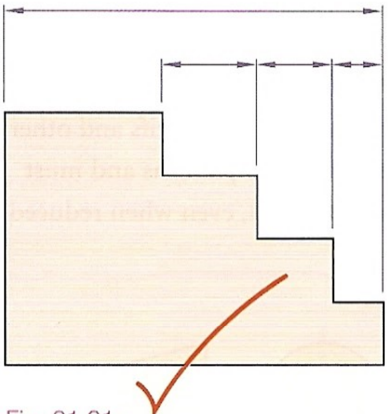


Fig. 21.31a

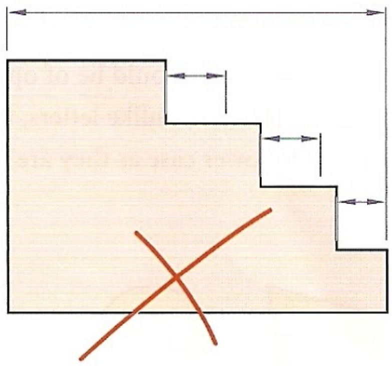


Fig. 21.31b

Fig. 21.31a shows how dimensions should be lined up and grouped together. The dimensioning shown in Fig. 21.31b does not show good practice

Fig. 21.32 shows a method of dimensioning which uses a datum or reference line. By referring all dimensions to a small number of reference lines/points the accumulation of slight inaccuracies can be avoided.

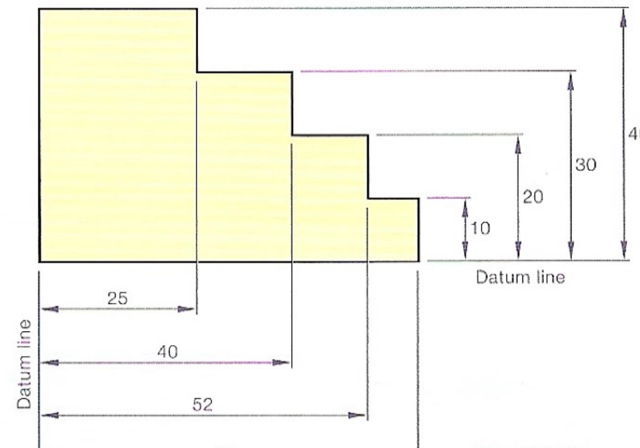


Fig. 21.32

Direction of Dimension Text

There are two accepted systems used for placing dimension text:

- The unidirectional system (preferred).
- The aligned system.

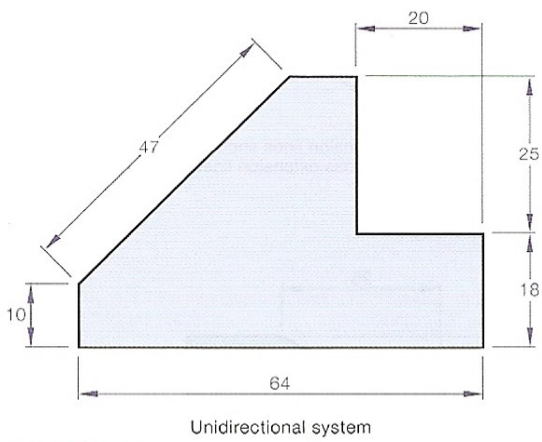


Fig. 21.33a

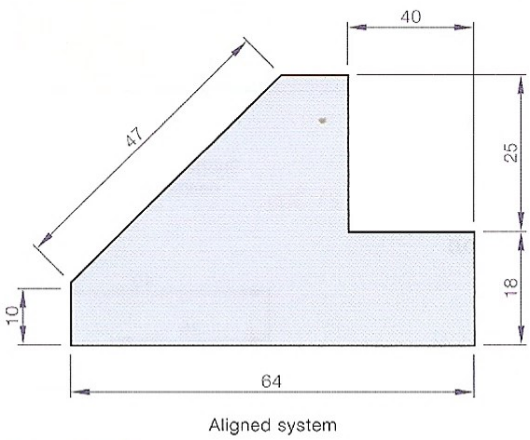


Fig. 21.33b

Fig. 21.33a shows a figure dimensioned using the unidirectional system. All figures and notes are lettered horizontal on the sheet and are read from the bottom of the sheet.

Fig. 21.33b shows a figure dimensioned using the aligned system. All figures are aligned with the dimension lines so that they can be read from the bottom or the right side of the sheet.

Leaders

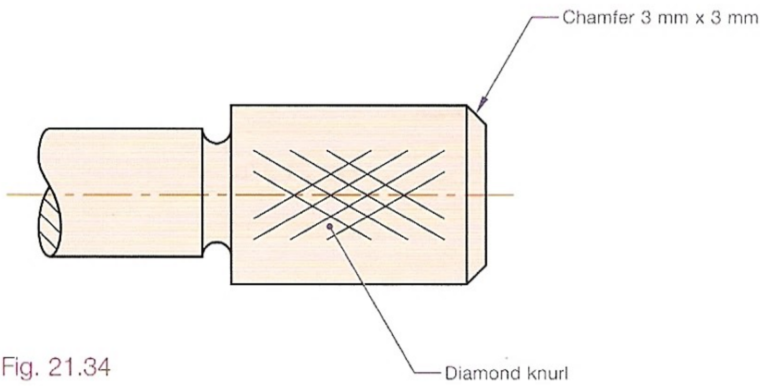


Fig. 21.34

A leader is a line leading from a note or dimension and ending with an arrowhead or a dot touching a part. Arrowheads should always terminate on a line such as the edge of a hole, while dots should be within the outline of the object, Fig. 21.34. The leader line itself should generally be inclined and should start from the beginning or end of a note.

Leaders should cross as few lines as possible and should never cross each other. If there are a large numbers of leaders beside each other on a drawing they should be drawn parallel. When a leader points to a hole or arc it should be radial so that if extended it would pass through the centre.

Dimensioning of Circles

When dimensioning holes and circles the method used depends on the circle size. Fig. 21.35 shows four different methods. Apart from the last example they are all radial.

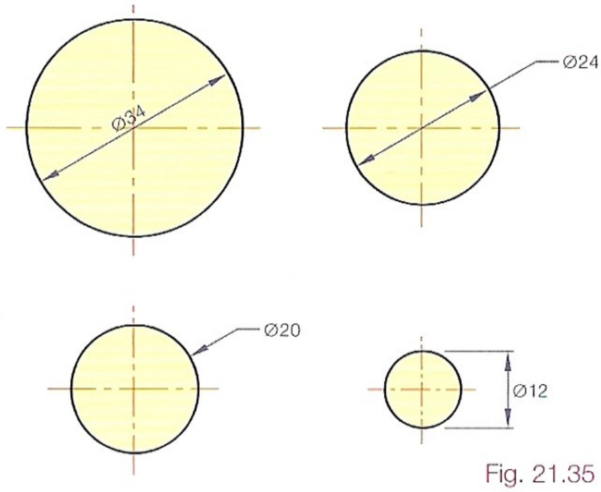
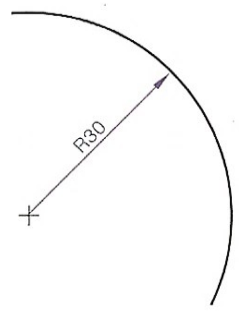


Fig. 21.35

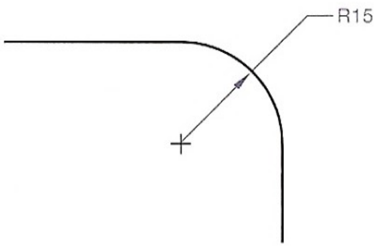
Dimensioning Arcs

Circular arcs are dimensioned in a view showing their true shapes. The centre of the arc may be indicated by using a small cross or centre lines but this is not done for small radii.



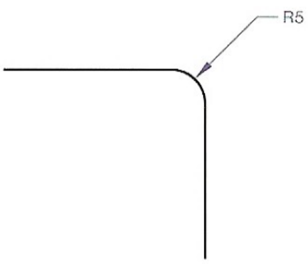
When there is room both the numeral and arrowhead are placed inside the curve

Fig. 21.36a



Here the arrowhead is left inside and the numeral is placed outside

Fig. 21.36b



Small radii mean that both the arrowhead and the numeral are placed outside

Fig. 21.36c

Fillets on a drawing are usually of a standard size throughout and rather than dimension each one it is customary to place a note in the lower portion of the drawing. 'FILLETS R6 UNLESS OTHERWISE SPECIFIED'.

Dimensioning Angles

One of the three methods indicated in Figures 21.37a, 21.37b and 21.37c is used depending on the space inside the angle for numerals and arrowheads.

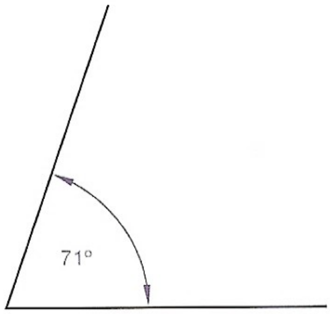


Fig. 21.37a

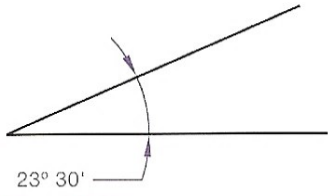


Fig. 21.37b

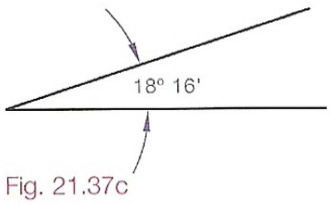


Fig. 21.37c

Chamfers and Tapers

Chamfers are dimensioned by giving the length of the offset and the angle, or in the case of a 45° chamfer, usually by note, Fig. 21.38.

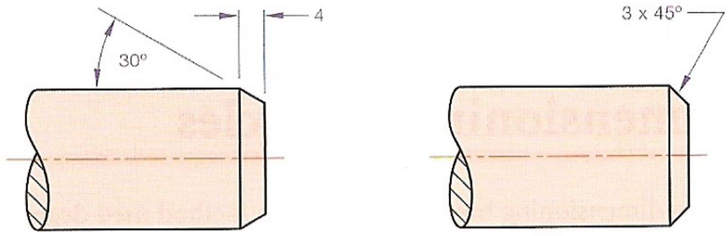


Fig. 21.38

Tapers, which are conical surfaces on shafts or in holes, are used on machine spindles, shanks of tools, pins etc. They are generally indicated using either of the two methods shown in Fig. 21.39.

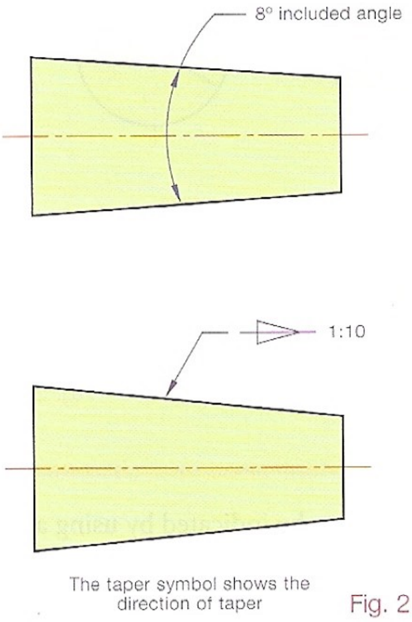


Fig. 21.39

Worked Examples: Sectional Views

There are many times when the interior detail of an object cannot be seen from the outside, Fig. 21.40. We get around this, as explained earlier in the chapter, by cutting the object by a plane and showing the sectional view. In Fig. 21.40 the cutting plane A–A slices through the object. Fig. 21.41 shows how the object looks when the front material is removed. The orthographic

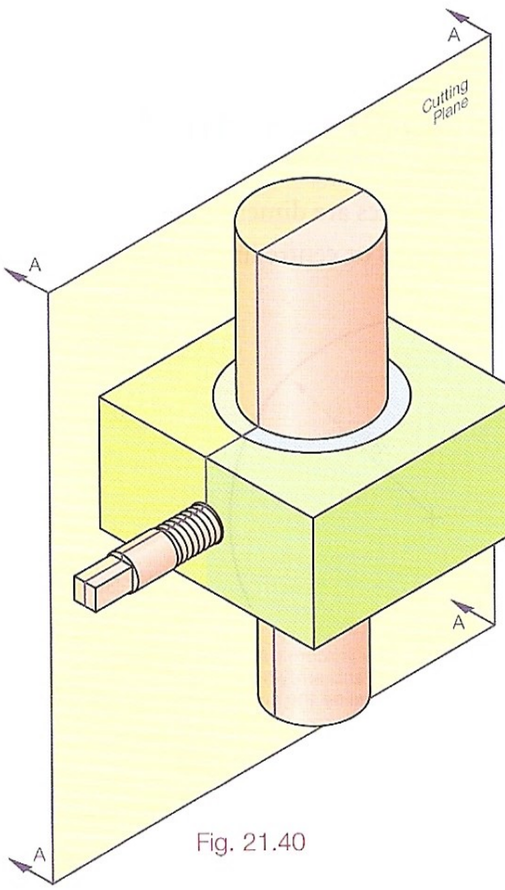


Fig. 21.40