BASIC DIMENSIONING

Introduction

Dimensioning refers to the addition of size values to drawing entities. Dimensions are required for points, lines, and surfaces that are related functionally or control relationship of other features. Basic dimensioning is the addition of only functional size values to drawing entities. This is good only for sketches and preliminary design drawings. Working drawings need tolerances in addition to functional size values. Today, many CAD software can automatically add dimensions to a drawing. ASME (ANSI) Y14.5M is the standard for dimensioning practice in the USA. The student should familiarize himself or herself with this standard.

Engineering Drawing

An engineering drawing is a precise technical graphic model that communicates design intent. It is used by manufacturers to make a product and inspectors use it to determine if the product should be accepted. An engineering drawing should convey the following information:

1. Shape or geometric characteristics of component (drawing views)
2. Overall size of component and its features
3. Tolerances on sizes
4. Material for the component
5. Specifications or notes for requirements such as heat treatment, surface finish, etc

Drawing Units

Dimensions in engineering drawings are shown in units of length and angle. The standard unit of length in SI Units is the meter. In drawing practice, the preferred SI unit of length is the millimeter. One meter (1 m) is equal to one thousand millimeters (1000 mm). Fractions are not allowed in SI units, only decimal values are allowed. Architectural drawings may be dimensioned in millimeter (mm) and meters (m). Meters and kilometers (km) are used for civil dimensioning.

The standard unit of length in I-P (English) units is the foot (ft, ‘). However, the inch (in, “) is the recommended unit of length for mechanical engineering drawings. There are 12 inches in one foot. In the U.S. architectural drawings are conventionally dimensioned in feet and fractional inches, while civil drawings are dimensioned in decimal feet. Decimal inches and feet should be preferred because of the easy in adding, subtracting, etc numbers in decimal system. Remember that 1” = 25.4 mm.

Angle refers to the relative orientation of lines on a plane or the relative orientation of planes in space. Angle is conventionally measured in degrees (^{o}). There are 360 degrees in a circle; 60 minutes in a degree; and 60 seconds in a minute. The radian is the SI unit of angular measure. One radian is approximately 57.3^o. However, the degree is the common unit of angular measure in Metric and English drawings.

Basic Size Descriptions

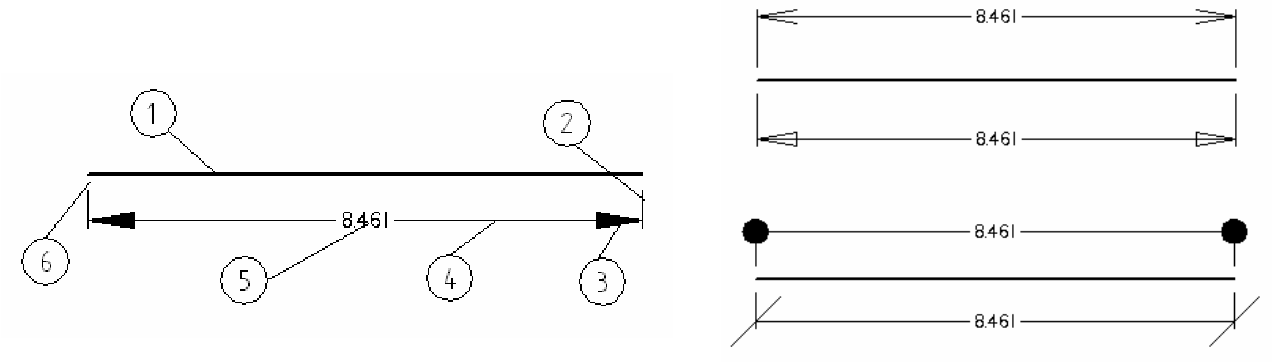
- A *dimension* is a number in a standard unit of measure shown on a drawing to indicate size, location, or orientation of graphic features.
- A *design size* is the functional size of an object and it is equal to the full-size value of the object. Only design sizes are shown as dimensions in engineering drawings.
- A *plot size* is the actual size of a graphic representation of an object on a drawing sheet. Plot sizes are not shown in engineering drawings. Usually a scale factor is indicated in an engineering drawing. The scale factor is the ratio between the design size and the drawing or plot size.

Basic Dimension Elements and Symbols

Several elements define a dimension in engineering drawings. Fig. 1a shows these elements. The sizes of dimension elements are related to the text height of the dimension value in CAD. The recommended text height for the dimension value is 3 mm (.125”).

1. Object feature (line in Fig. 1a)
2. Extension line
3. Dimension line terminator
4. Dimension line
5. Dimension value (number)
6. Visible gap

The object feature represents a dimensional entity in a view or image of a drawing. It may be a line, arc, circle, fillet, etc. The extension line connects the object feature with the dimension line. Sometimes, leaders are used in place of extension and dimension lines, especially when dimensioning arcs and circles. The dimension line terminators indicate the limits of a dimension. They occur in pairs, one at the end of the dimension line. It is a filled arrow in this figure but it could be an unfilled arrow, an open arrow, a slash (/), or a filled small circle (●) as shown in Fig. 1b. The dimension line is always parallel to a line feature in an object but perpendicular to the extension line. The dimension value is a number representing the size of the dimension. It may be placed above or under the dimension line. Sometimes, it is placed in a gap on the dimension line which is broken to allow this type of placement. It could be aligned with the dimension line or placed horizontally. The visible gap is a space that demarcates the object feature from dimensional elements. This is very important in dimension placement.



a) Elements of a dimension

b) Dimension line terminators

Fig. 1 Dimensional elements and terminators

Diameter	∅	Counterbore	⌴
Spherical Diameter	S∅	Countersink	⌵
Radius	R	Depth	↧
Spherical Radius	SR	Reference	( )
Conical Taper	⌲	Not To Scale	—
Square	□	Slope	⌳
Feature Repetition	2x	Arc Length	⌒

Table 1: Basic dimensioning symbols

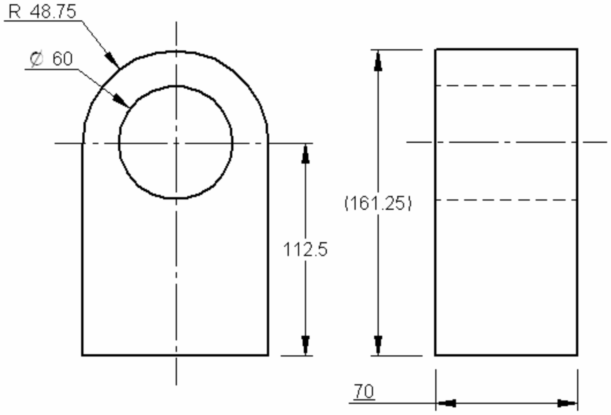


Fig. 2 Dimensioned component

Table 1 show some dimensioning symbols commonly associated with basic dimensioning. These symbols have been standardized so as to eliminate language translation. This makes it possible for drawings prepared in different countries to be read and interpreted correctly. Fig. 2 shows a dimensioned component, how many dimensioning symbols can you identify in it?

Dimension Types and Line Spacing

A dimension may describe size, location, or orientation (angle) of a feature. Fig. 3 shows the basic types of dimension: S-size, L-location, A-angle. The size dimension gives the design size of a feature. A location dimension gives the distance(s) of a key point on a feature from a reference point, line or plane. For example, the center point of a circle is a key point commonly used in dimensioning the location of a circle. An orientation dimension gives the angular position of one feature relative to another. Beveled and sloping features are common in many components. The orientation of the faces on which such features line need to be dimensioned with the size of the angles associated with the orientations.

Fig. 4 shows the recommended minimum gaps for dimension placement. The first dimension line should be at least 10 mm (0.375”) from a visible outline, others 6 mm (0.25”) from the next dimension line. Larger dimensions should be place over smaller ones as indicated in Fig. 4.

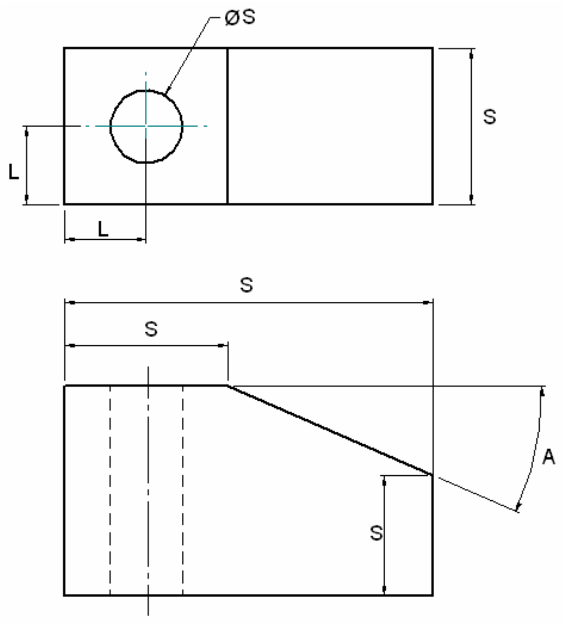


Fig. 3 Types of dimensions

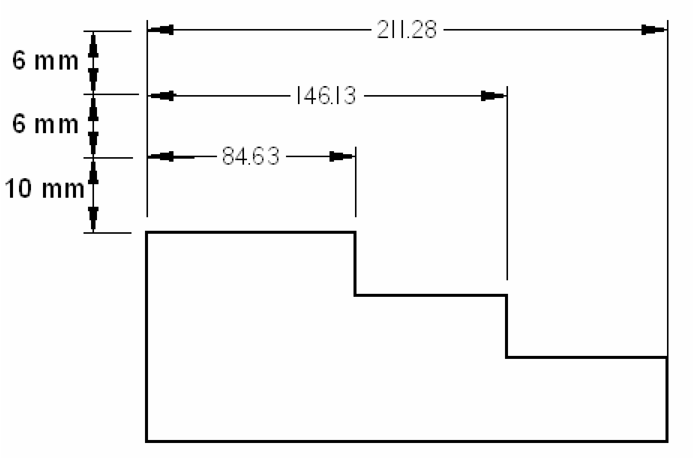


Fig. 4 Spacing of dimensions

Placing Dimensions on Object Features

Placing dimensions on the features of an object on a view must be done systematically and with thoughtfulness. The overriding concern is to present dimensions with clarity. A thought about how the dimension may be verified by measurement or inspection is not out of place when placing dimensions. The following guidelines should be considered when dimensioning.

1. There are two types of sizes and are linear and angular
2. Some features (e.g. hole, circle) have two types of dimensions, namely size and location.
3. Use visible lines only for dimensioning features.
4. Do not use hidden lines for dimensioning features.
5. Spacing between visible line and first dimension line should be at east 10 mm (3/8”).
6. Spacing between adjacent dimension lines should be at east 6 mm (1/4”).
7. Provide a visible gap between extension line and the feature referenced.
8. Place dimension outside views except it helps clarity placing them inside.
9. Dimensions common to two views should be placed between the views, except when clarity is impaired.
10. A feature dimension should be shown only on one view or once in a drawing. There should be no duplication of a dimension. However different features may have the same size and each must be shown separately.
11. Use of reference dimensions should be minimized or avoided completely.
12. Circles and arcs should be dimensioned in the view revealing their true shape.
13. Dimensions should be grouped together as much as possible.
14. Dimension values should not overlap themselves, dimension, extension, or visible lines.
15. Dimension text should be horizontal (preferred) or aligned with (parallel to) dimension line.
16. Smaller dimensions should be placed inside larger dimensions.
17. Minimize or avoid leader lines crossing dimension or extension lines.
18. Minimize extension lines crossing themselves or visible lines.
19. Leader lines should be inclined between 15^o to 75^o; but 30^o to 60^o is preferred.
20. Use datum dimensioning. Avoid chain dimensioning, especially for mechanical objects.

Dimensioning Arcs, Circles and Diameters

Fig. 5 shows the dimensioning of arcs. Arcs should be dimensioned on the view revealing the arc contour. The symbol R for radius must precede the value of the dimension of an arc. If the center point of an arc is not obvious, then it must be shown by dimensions. Fig. 6 shows the dimensioning of circles. The symbol Ø for diameter must precede the value of the dimension of a circle. The center points of a circle must be dimensioned for location reasons as shown in Fig. 6. Fig. 7 shows dimension placements for the diameters of some objects. Notice that the information in two views in Fig. 7a is presented in one view in Fig. 7b because the section view allows direct dimensioning of the bore. Fig. 7c could be sectioned also.

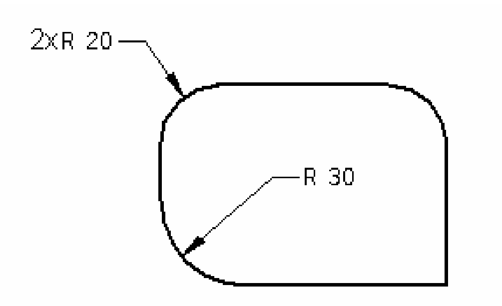


Fig. 5 Arc dimensions

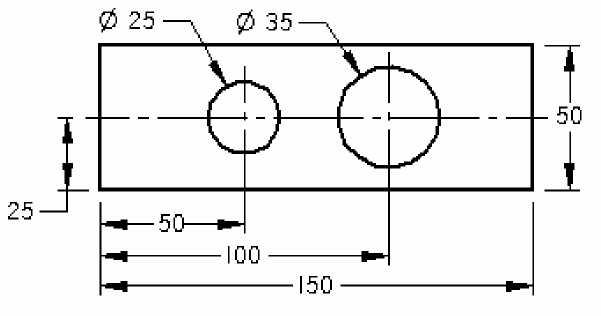
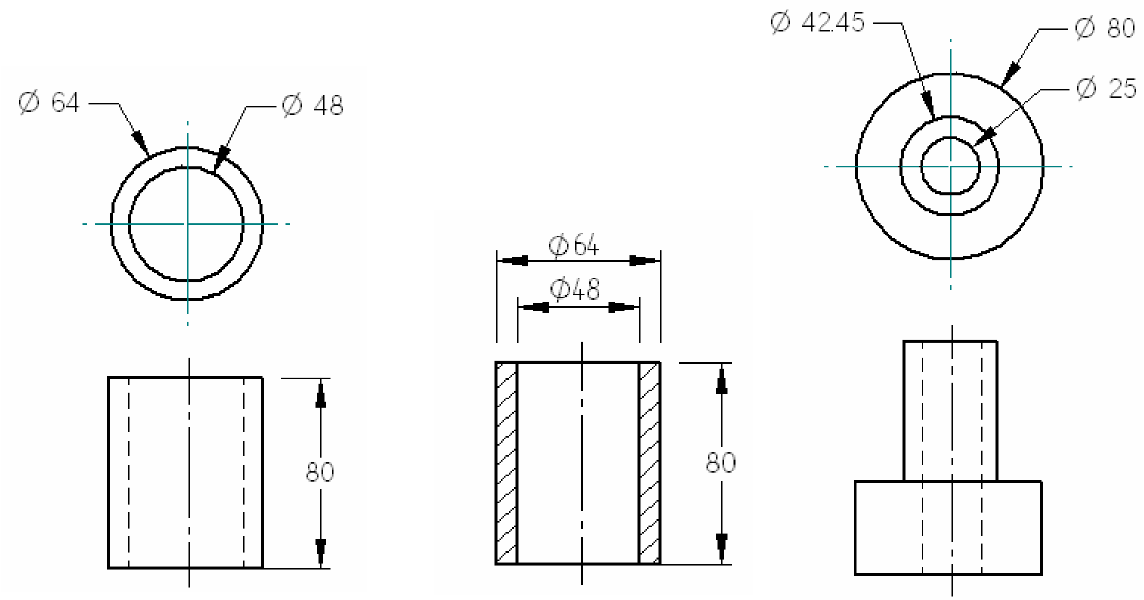


Fig. 6 Circle dimensions



a) b) c)

Fig. 7 Dimensioning diameters

Dimensioning Angles

Fig. 8 shows the dimensioning of angles. Angular dimensions should be expressed in degrees, minutes and seconds or the decimal equivalent. In mechanical drawings, angles are specified in decimal units.

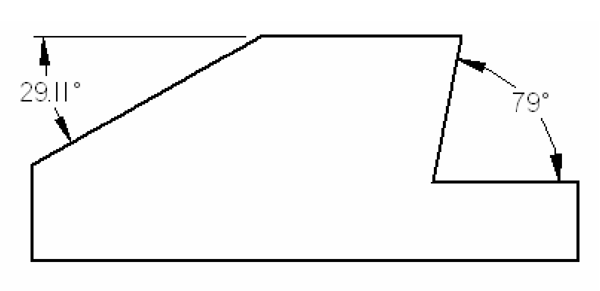


Fig. 8 Angular dimensions

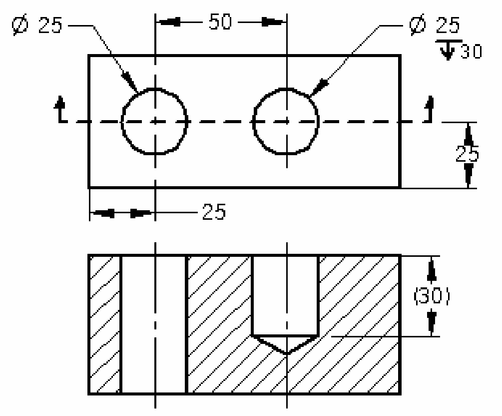


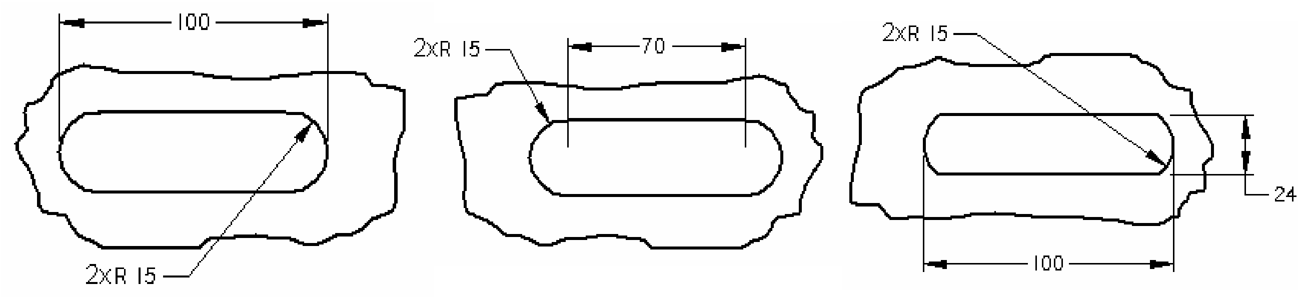
Fig. 9 Hole dimensions

Dimensioning Holes

Fig. 9 shows one through hole and one blind hole. Holes should be dimensioned on the view showing the circle outline. The depth of through holes is not specified on a drawing however, the depth of a blind hole must be specified either by the depth symbol or directly by the size. The depth of the blind hole in Fig. 9 is specified as a reference dimension because the depth symbol is used on the top view.

Dimensioning Slots

Slots are common features on shafts and other components. Proper dimensioning of slots depends on their function and form. Length shown may be between centers (Fig. 10a) or full depending on which is critical (Fig. 10b). If the end radii are larger than the width of the slot, they should be shown (Fig. 10c).

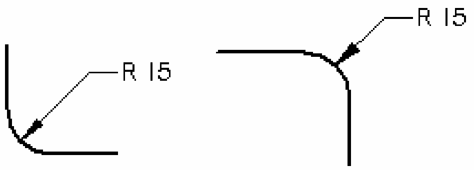


(a) Full length (b) Length between centers (c) Slot width

Fig. 3.10 Dimensioning slots

Dimensioning Fillets and Rounds

Fig. 11 shows a fillet and a round. Fillets and rounds are arcs provided for the smooth transition of faces on an object. Fillets are used for interior faces and are concave arcs. Rounds are used for exterior faces and are convex arcs. Fillets and rounds should be dimensioned on the view revealing the arc as shown in Fig. 12. The symbol R for radius must precede the value of the dimension of a fillet or round.



(a) Fillet (b) Round

Fig. 11 Fillets and rounds

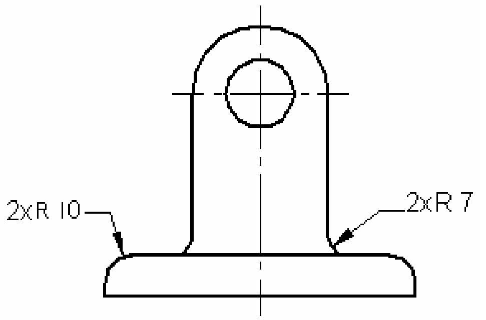
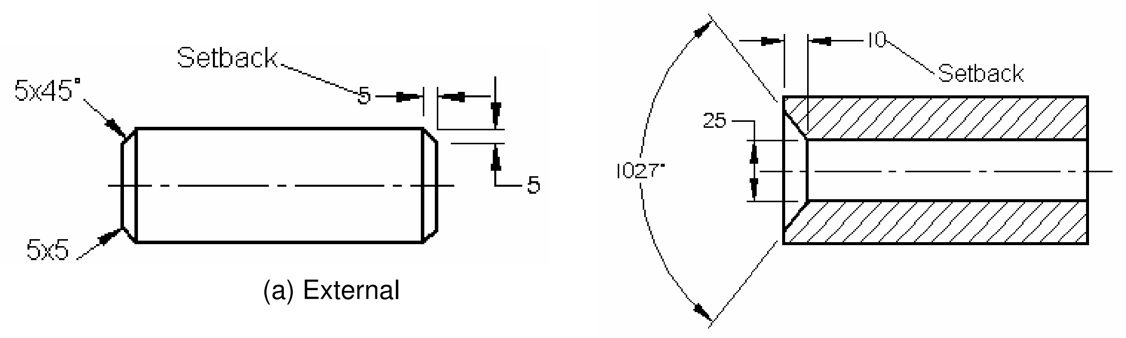


Fig. 12 Fillets and rounds on a component

Chamfer Dimensions

Fig. 13 shows external and internal chamfers. Chamfers are beveled edges on objects and they remove rough edges from components and make assembly easier. Chamfers may be specified by notes or dimensions as shown Fig, 13a for external chamfer. The setback lengths on the horizontal and vertical directions are used to specify a chamfer by dimensions. The horizontal length is given first (right end of Fig. 13a). Alternatively, the horizontal setback length and angle may be used for specification (left end of Fig. 13a). Fig. 13b shows the dimensioning of an internal chamfer. Notice that three dimensions are needed in this format by dimensions. Half of the included angle could have been used instead. If the specification or note format is used, the setback and half included angle are sufficient for dimensioning.



(a) External

(b) Internal

Fig. 13 Chamfers

Dimensioning Counterbores and Countersinks

A counterbore is a cylindrical recess on a face of an object. It is made by enlarging smaller holes with a boring tool. A countersink is a conical recess on a face of an object. It is made with a special tool and may be used as seats for screws and centers for cylindrical components like shafts and spindles. A spotface is like a counterbore except that the depth is much smaller. They act as seats for washers and screws. The appropriate symbols, depth, diameter or angle must be specified. See Fig. 14 for the features labeled A, B, and C.

A - Counterbore

B - Countersink

C - Spotface

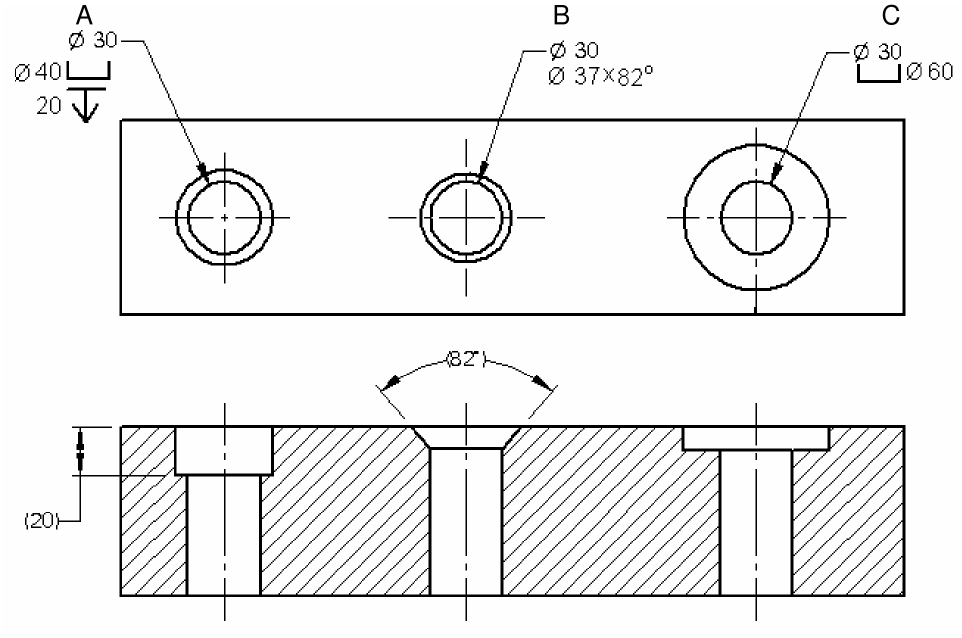


Fig. 14 Dimensioning counterbore, countersink and spotface.

Dimensioning Keyseats and Keyways

Keyseats are external slots on shafts, axles, etc. that accept keys. Keyways are internal slots on hubs of cranks, levers, gears, pulleys, sprockets, etc. Fig. 15 shows a keyseat and a keyway. Dimensions should be placed such that measurement or inspection of keyseats or keyways can easily be carried out. The length of the keyseat should be shown on the longitudinal view. A broken section is commonly employed for this as shown in Fig. 16 where three types of keyseats. If the keyseat does not start or end at the edge of the shaft, the location dimension must be included.

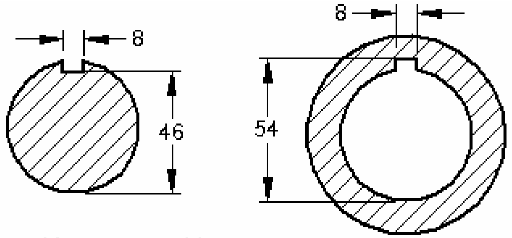


Fig. 15 Keyseat and keyway

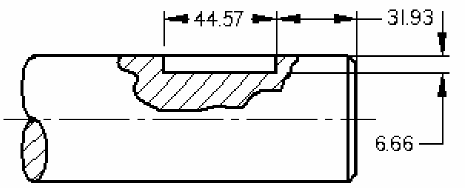


Fig. 16 a) Regular keyseat

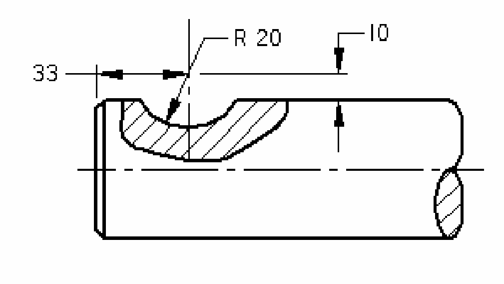


Fig. 16 b) Woodruff keyseat

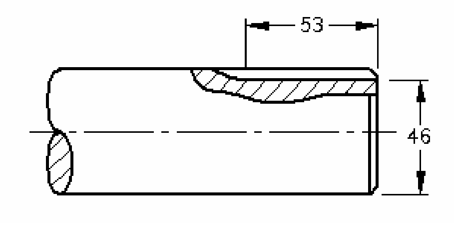
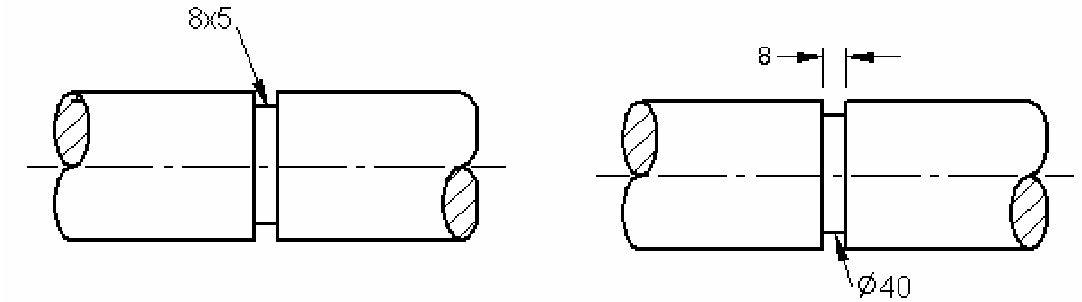


Fig. 16 c) Sledge runner keyseat

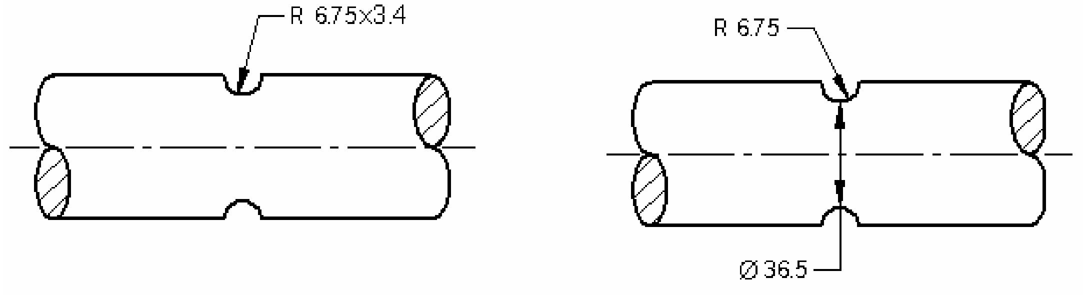
Dimensioning Necks and Undercuts

Necks and undercuts are used to alleviate the influence of stress concentration and relieve the ends of threads. Necks are common on cylindrical sections while undercuts are used on faces. There are rectangular, circular and truncated conical necks or undercuts and shown in Figs. 17, 18, and 19. The sizes of these features are specified by the width and depth, the width value preceding the depth value as indicated in Figs. 17a, 18a, and 19a. Alternatively, the diameter value of the neck section is given as shown in Figs. 17b, 18b, and 19b. This is the preferred method for dimensioning necks and undercuts because they can be measured or inspected easily this way.



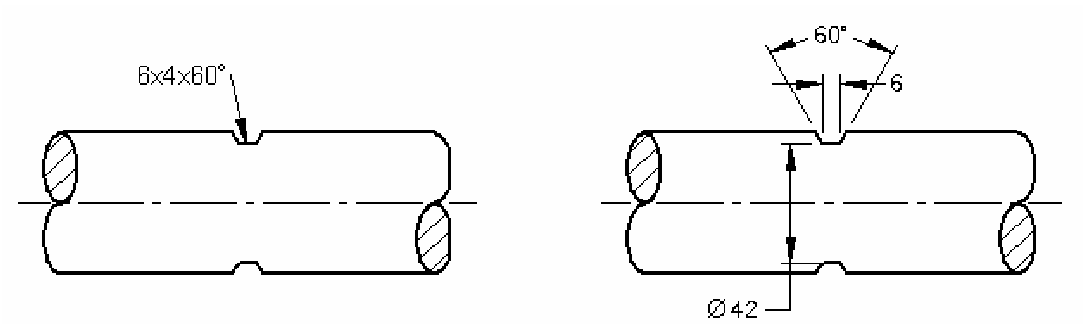
(a) Depth specified (b) Diameter specified

Fig. 17 Rectangular neck



(a) Depth specified (b) Diameter specified

Fig. 18 Circular neck

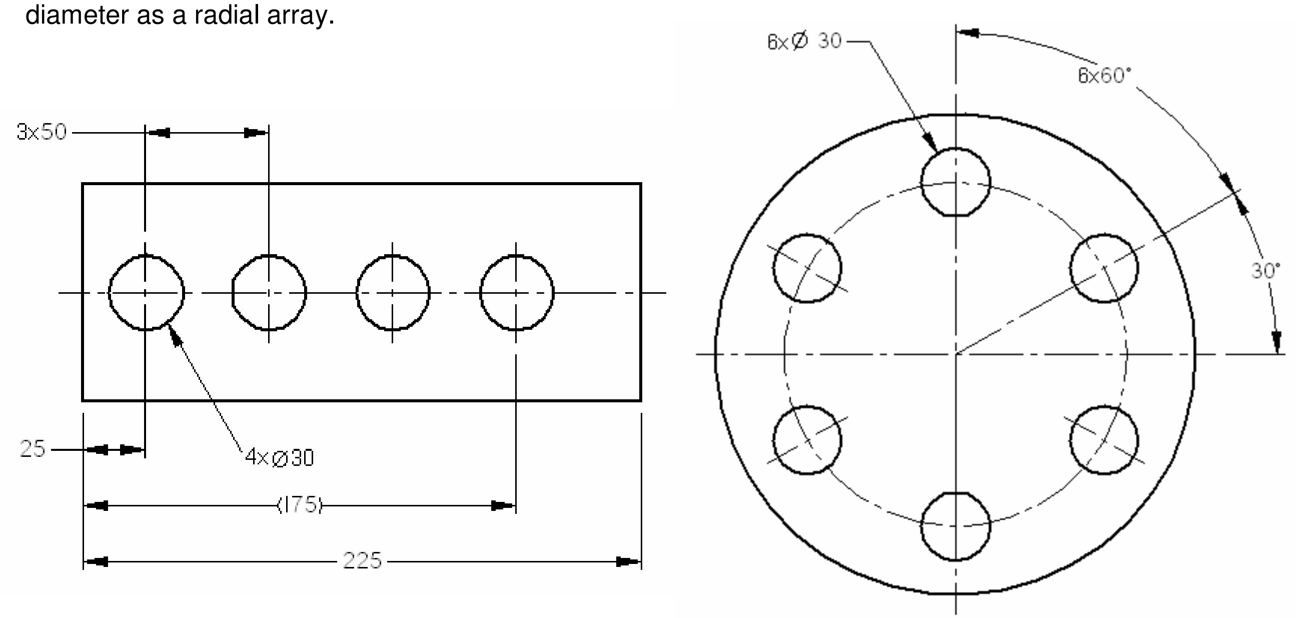


(a) Depth specified (b) Diameter specified

Fig. 19 Truncated conical neck

Dimensioning Repeated Features

Some features like holes are repeated on components. Each feature is not dimensioned separately. Instead, the location and or size for one of the features are given and then the total number is included. Fig. 20a has four holes spaced equally as a linear array. Fig. 20b has six holes spaced equally on a diameter as a radial array.

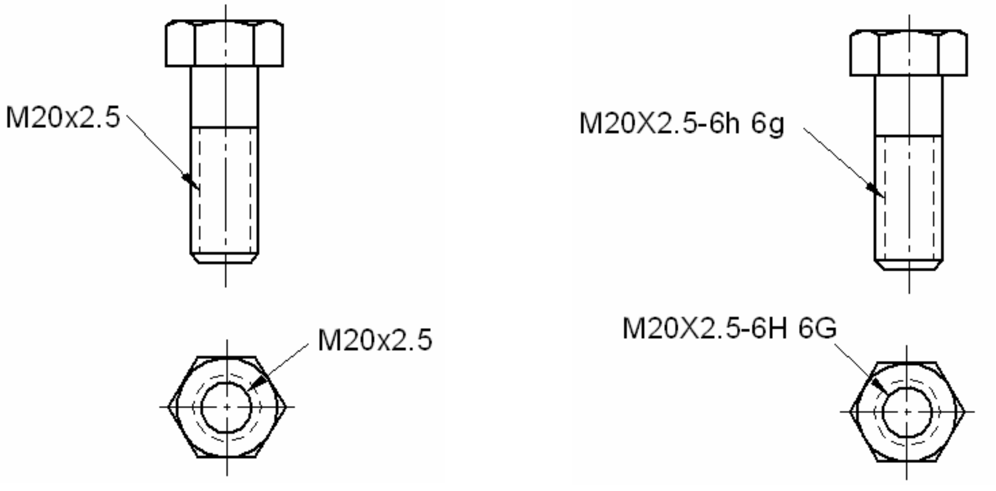


(a) Linear array (b) Radial array

Fig. 20 Repeated Features

Thread Specification

Fig. 21 shows a bolt and nut, a type of threaded fasteners. Metric threads are preferred to English threads in new designs. The specification of threaded fasteners are added as local note to their drawings, Basic or full thread specification must are given. The basic specification includes thread nominal diameter, pitch and length. In English threads, the pitch of the thread is replaced with threads per inch. More information is provided in detail specification which includes the class of fit, right or left hand, etc. See Fig. 21



Basic specification Full specification

Fig. 21 Threaded features

Dimensioning Methods

Three methods of dimensioning are in common practice. These are datum, chain and tabular. The datum method is depicted in Fig. 22a and is preferred. A datum may be a point, line, or surface on a component that is assumed to be exact. It is used as a reference for locating other features on the component. A datum point is often chosen at the far left and bottom point on a part in view. The chain method is illustrated in Fig. 23b and is popular in architectural drawings. This method is not recommended for mechanical parts. The tabular method is shown in and Fig. 23c. This is used in industry to save space and provide information clearly and concisely.

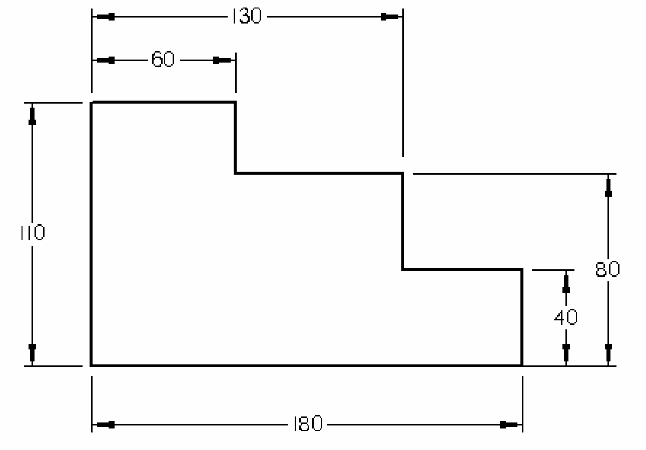


Fig. 23a Datum dimensioning.

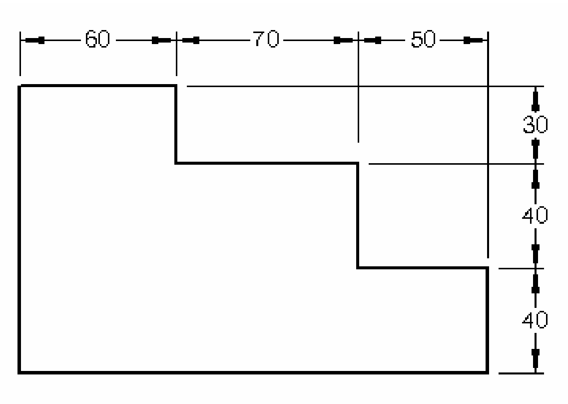


Fig. 23b Chain method.

Size	2	4	6
A	6.5	10	12.5
`B	.875	1.25	1.4375
C	2.75	3.375	3.875

Table 2: Values of dimensions

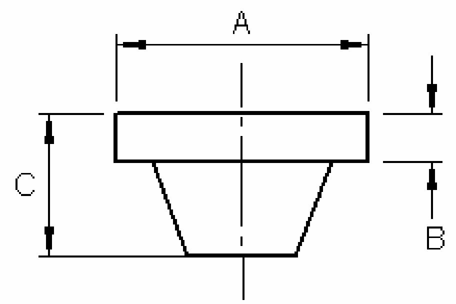


Fig. 23c Tabular method